SaGHAA 5

The 5th Conference on
SCIENCE & GEOPOLITICS OF

Himalaya Arctic Antarctic

FEBRUARY 26-27, 2019
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Technological Innovations and Research Expeditions

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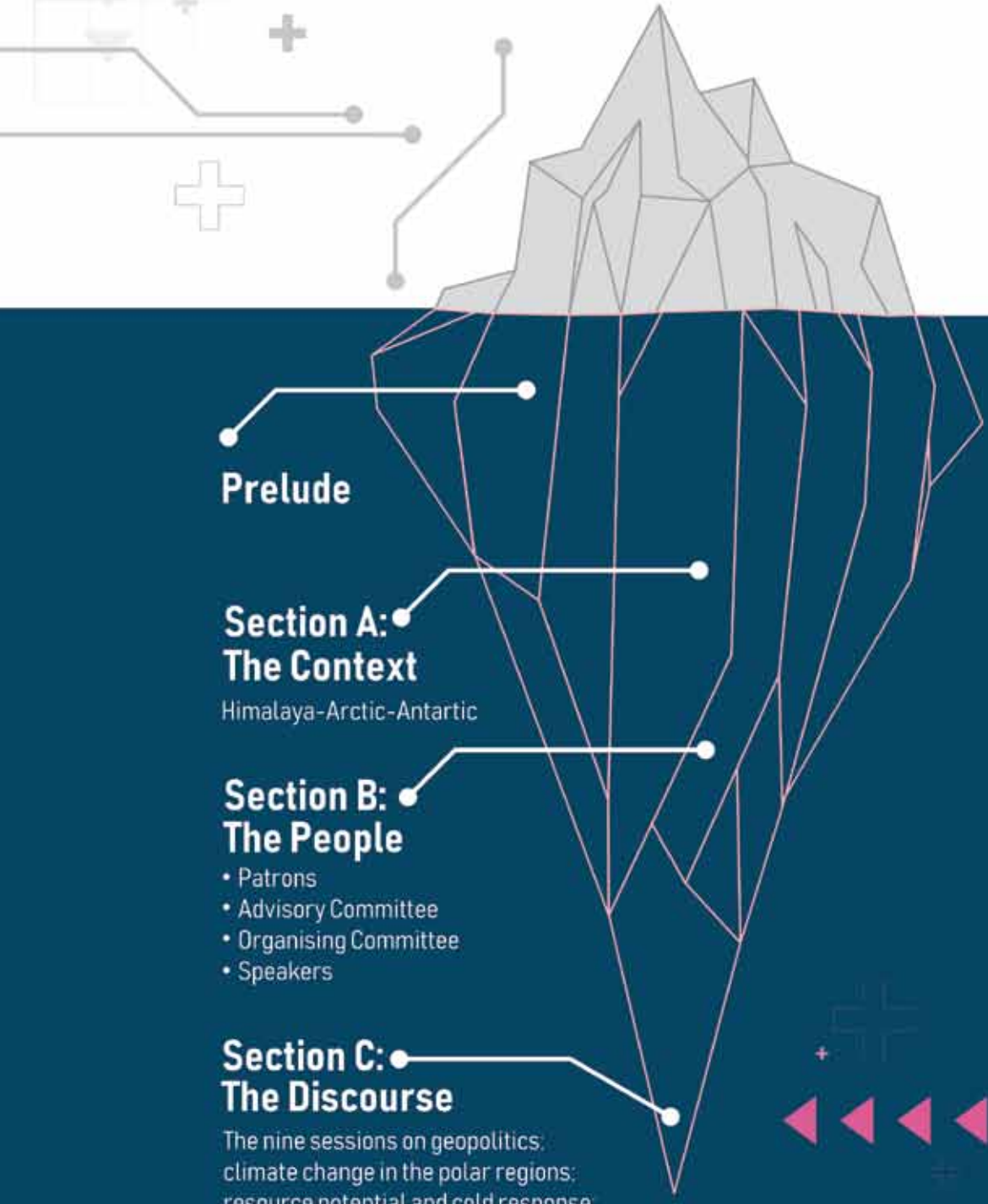
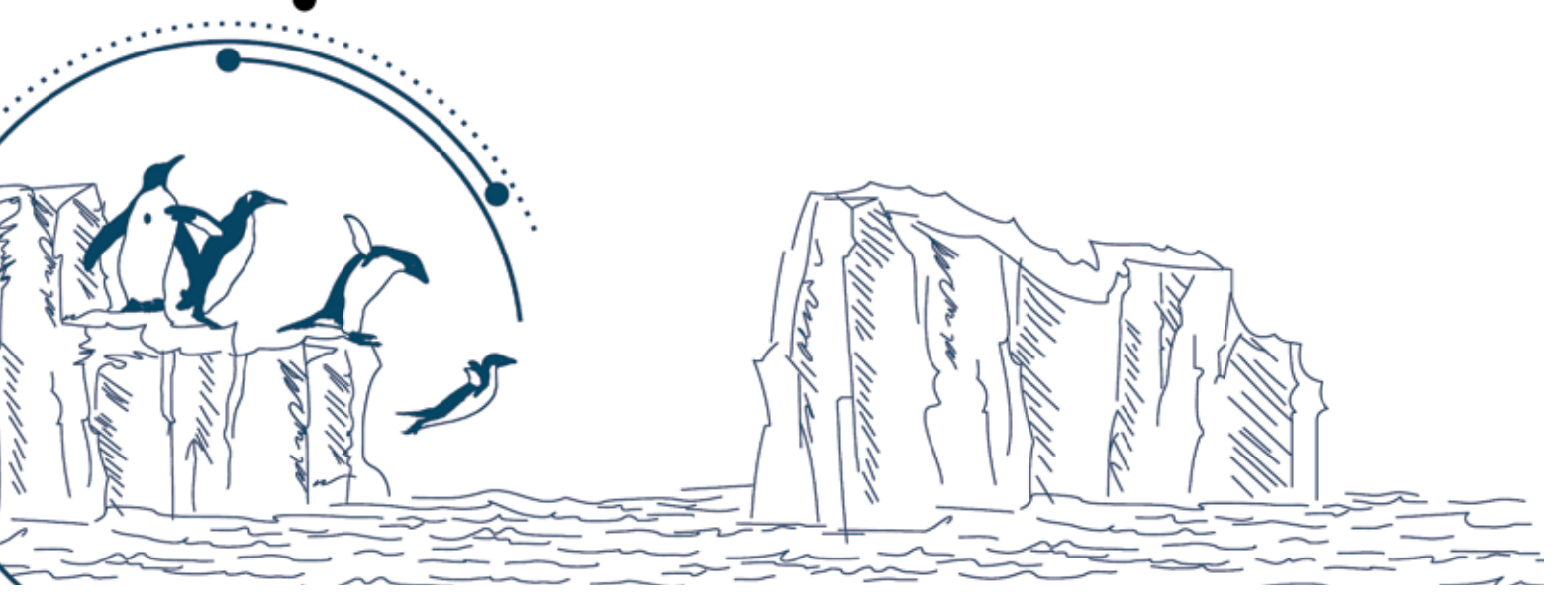


Prelude



The Prelude

The conference on the theme Science and Geopolitics of Himalaya-Arctic-Antarctic is being held with an objective to develop a synergy amongst scientists and policy makers towards the geopolitics and scientific understanding of Earth- atmosphere and ocean process in the cryospheric regions of the world. This will help to understand the processes that influence the variability in polar climate and influence our monsoon at millennial, decadal or even annual scales.

It is a well known now that the thermohaline circulation that originates in the North Atlantic and southern Arctic is a major force driving not only the oceanic circulation but also regulating the global climate. A link between cold episodes in the North Atlantic and weakened Asian monsoon during the last glacial period has indicated the links between Asian Monsoon. Scientists have also observed that deficient monsoon years were preceded by more than normal sea-ice extent and vice- versa. Indian scientists have braved the vagaries of harsh polar climate and added greatly to the international scientific knowledge of these areas. Glacial retreat in the Arctic has also opened new commercial avenues. India's interest in the Polar Regions is mainly driven by these backward-forward linkages in the form of climate, teleconnections, economic resources etc.

SaGHAA has been institutionalized to synergise research of several institutions and universities that are active in cryosphere studies in the country. The active participation of all the stakeholders starting from students, scientists to the policy makers reflects the growing concern of the nation towards climate changes on glaciers and ice caps around the world. LIGHTS has been successful in bringing eminent scientists working in these inter-related fields to a common platform, adding to better our understanding of these issues and giving relevant advocacy to policy making.

SaGHAA 5 has focused on Technological Innovations and Research expeditions, for the first time with a view to add another dimensions to the discourse.

(Sulagna Chattopadhyay)
Convener & President
LIGHTS Research Foundation

(Rasik Ravindra)
Chairman, Organising Committee
SaGHAA-V

C

Section A

The Context

Himalaya-Arctic-Antartic

Introducing the issues and concerns

"The year 2018 was fourth warmest year on record and that 18 of the 19 warmest years have occurred since 2001 has brought out the inconvenient truth about global warming and climate change that scientists have been warning about since long"[1] . The increasing evidences in the form of extreme weather events viz: increase in flashfloods, cloud bursts, hurricane and storms etc. point towards the bitter reality that the current trends in rise of temperature are much faster than envisaged by climate models. Though the climate change is a natural process and evidences of the earth warming in past have been recorded in the form of alternating interglacial and glacial periods, that the anthropological factors have accelerated the rate of global warming due to infusion of green house gases in the atmosphere, is now globally accepted. The climate change that the world is currently facing has caused more concern because of the rate at which these changes are happening, in the form of rise in average air temperature or sea level rises or glacial retreat etc. The worst affected regions that are facing the brunt of global warming are the cryospheric regions of the world such as Arctic, Antarctic and the mountain glaciers of the world such as the Alpine, Andes,Alaskan, Himalayan and Patagonian glaciers.

Role of SaGHAA

LIGHTS,through its SaGHAA (Science and Geopolitics of Himalaya-Arctic-Antarctic), a think tank for science policy and advocacy of the three poles,in association with leading research institutions of India, has not only been providing a national platform to such scientists and experts who are working in the cryosphere fields of these regions, but has also endeavoured to bring together all stakeholders like policy makers, glaciologists, social legal and political experts and students on the same page to discuss the issues so as to evolve a sustainable strategy that is based on scientific analyses and ground truth for the benefit of society at large.

Warming World

As the global community is unable to reduce carbon emissions, North Pole and its neighbouring regions record maximum warming.

1. NASA, 2019. 2018 fourth warmest year in continued warming trend, according to NASA, NOAA. https://go.nasa.gov/2tbjvuG (February 6, 2019).

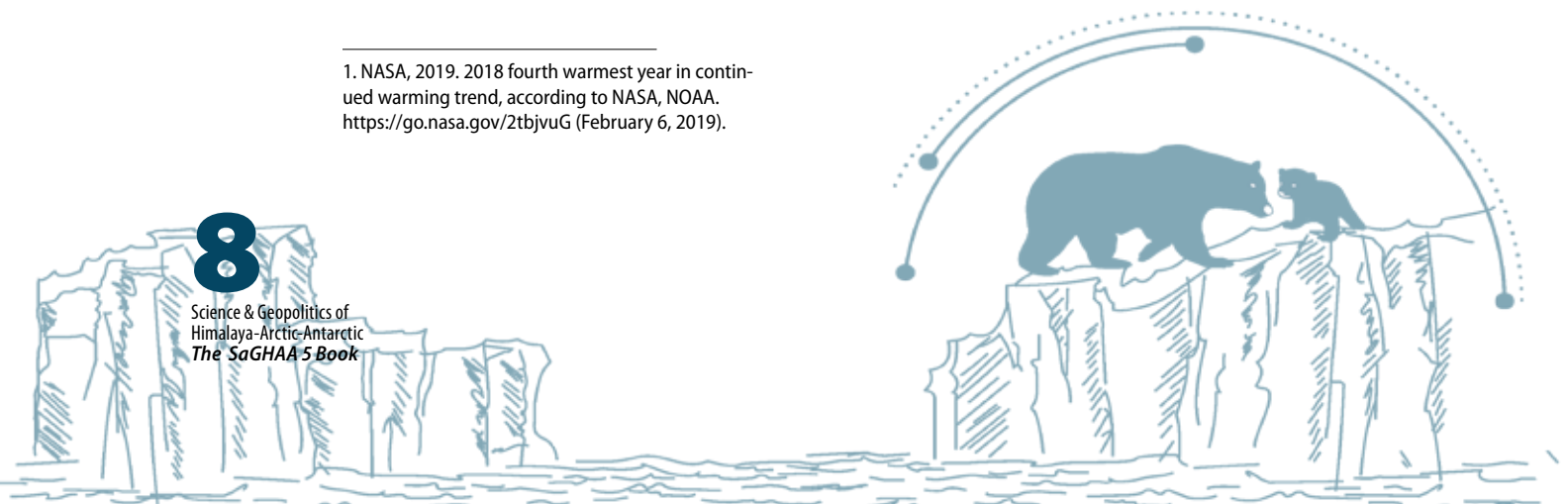
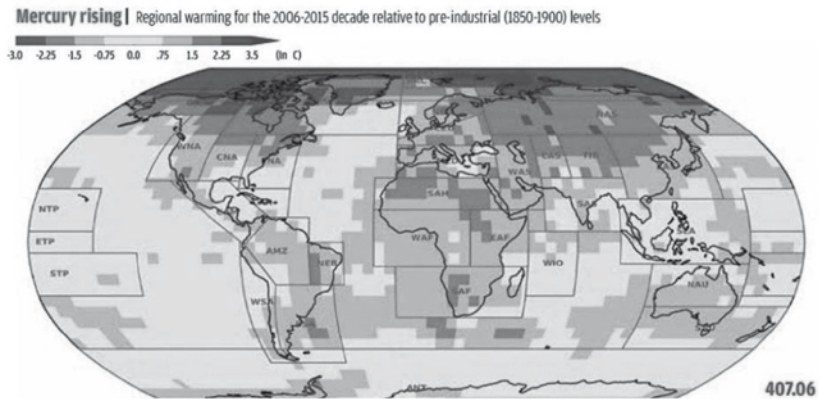


Fig. 1: IPCC Special Report on Global Warming 1.5°C



It is also important to clarify that climate change is not a new phenomenon. In fact, climate change has occurred quite a few times in earth's geological history. In the last 650,000 years, earth has experienced seven cycles of glacial retreat (warming) and advances (Ice Age), with the last ice age ending and marking the beginning of human civilization around 7000 years ago. But the current warming trend has attracted more concern because of the role of anthropogenic elements such as rapid industrialisation, mining, drilling for oil, release of green house gases etc in accelerating the process of warming phase and also because of the fact that impact of the global warming on the world's 7 billion people will be more catastrophic. Concerns on climate change and its impact on land, environment and mankind has been growing. Nowhere these changes are more prominent that the polar areas.

THE ARCTIC

Arctic -the legendary home of the endangered Polar Bears and many other unique and indigenous natural and cultural elements plays a larger role than being just an ocean of perennial ice and glaciers. The Arctic acts as the cooling system for the earth-as one of the engines for the global atmospheric-oceanic circulations, a major contributor in earth's heat budget etc. The region is also the harbinger of future climate changes, because evidences of global warming are more evident in its glaciers and sea ice. *"The Arctic is*

warming faster than any part of the world and the world is already feeling its effects. What happens in the Arctic doesn't stay in Arctic" [2]

After Antarctic, Arctic is the world's oldest and largest ice and snow reservoirs. The North Pole, which does not experience overhead sunlight for six consecutive months, according to recent reports had "experienced warm air influx which has pushed the temperature of northern Siberia up to 35^{0}C above historical winter average"[3]. The year 2018 saw Arctic winter ice at its lowest. There have been reports that world's northern most weather station located at the tip of northern Greenland experienced warmer temperature than London and Zurich for unusually long.

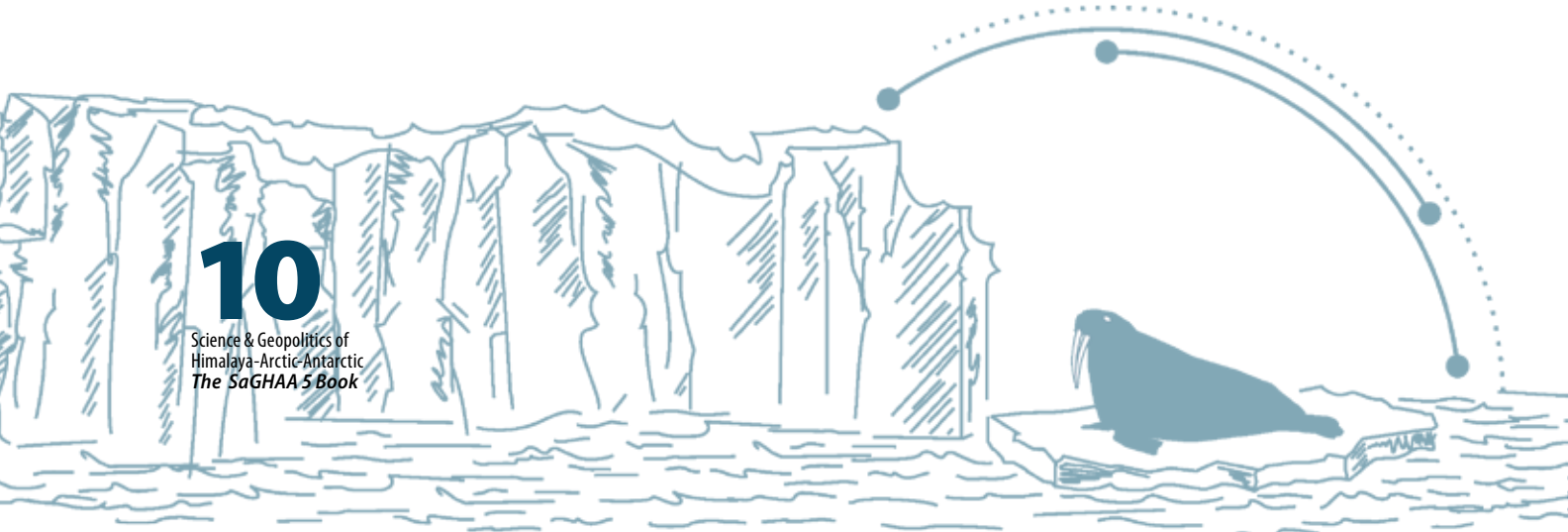
Evidences of Arctic Warming

Arctic warming is causing changes to sea ice, snow cover, and the extent of permafrost in the Arctic."The evidence of global warming is in no place more obvious than in the Arctic region. The Arctic has warmed rapidly during the last four decades. The magnitude of temperature increase in the Arctic is twice as large as the global increase. The effect of Arctic climate change will have profound local, regional and global implications".[4] Arctic is undergoing melting at much severe rate in comparison to the other poles because of its proximity to the industrially advanced and highly populated Northern Hemisphere.

"In the first half of 2010, air temperatures in the Arctic were 4° Celsius warmer than the 1968 to 1996. Satellite data show that over the past 30 years, Arctic sea ice cover has declined by 30 percent in September 2010. Satellite data also show that snow cover over land in the Arctic has decreased, and glaciers in Greenland and northern Canada are retreating. In addition, frozen ground in the Arctic has started to thaw out". [5]

Apart from retreat of snow cover, some of the other evidence of climate change in the Arctic are as follows:

2. World Wide Fund. "Living Planet Report 2018: Aiming Higher." World Wide Fund2018. AccessedFebruary21, 2019. https://bit.ly/2PoQjgv.
3. Inter-governmental Panel on Climate Change. "Special report Global warming of 1.5" Inter-governmental Panel on Climate Change,2018. Accessed February 21, 2019. https://www.ipcc.ch/sr15/.
4. Council, Arctic. "Arctic Council Archiving project. Submitted to the SAO meeting in Yellowknife, 26-27 March 2014. Arctic Council Secretariat–Library and Archives Canada." (2014).
5. National Snow and Ice Data Center. " Climate Change in the Arctic" All about Arctic Climatology, Accessed February 21, 2019. https://bit.ly/1lpm7z7.



Temperature: Increase in mean average annual surface temperature over the 50 years in Siberia and Alaska from -16° to 15°C.
Sea Ice and Glaciers: North America lost almost 108 cubic miles of ice in between 1961-2000.
Vegetation: Sharp decline in areal coverage of Boreal forests and white spruce because of excess summer temperature.
Fisheries: Warming of Bering Strait after 1980 has caused increase in the population of Herring, Skates, Pink Cod etc booming fishing industries.
Warming of the Oceans: Eutrophication and sea level rise.

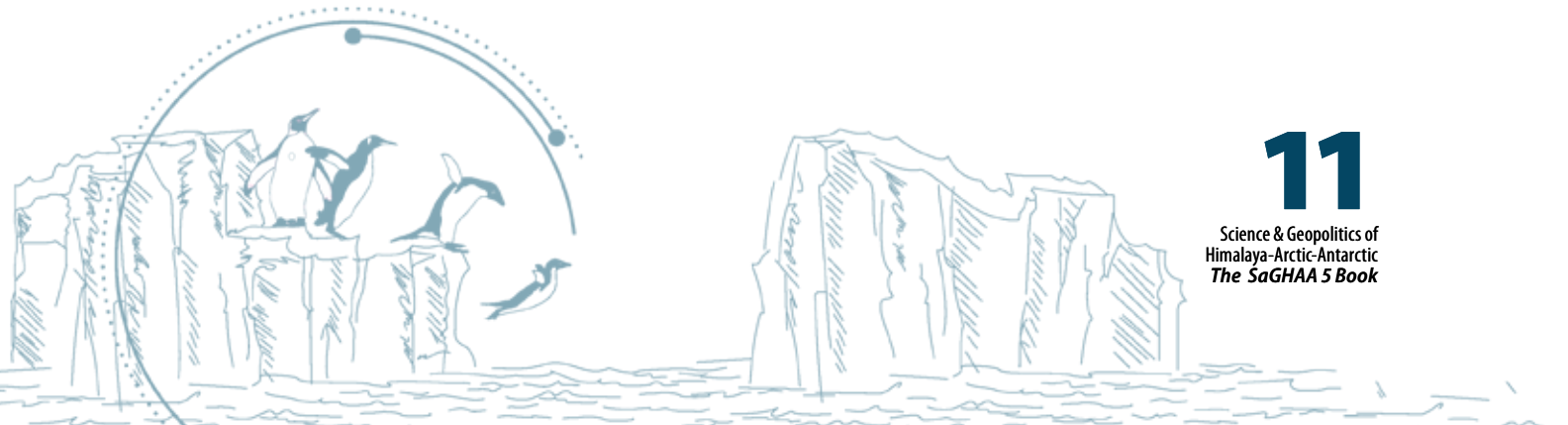
Causes of Rising Temperature Anomalies in Arctic

The main cause of such frequent anomalies is definitely global warming, whose impact is more pronounced in the poles especially Arctic because of its proximity to the populated and developed Northern Hemisphere. The Polar Vortex which insulates the Arctic from warm equatorial jet streams and air mass might be experiencing its collapse. The strength of this Polar Vortex depends on the temperature differential between Arctic and the Tropics, but this gap is reducing because of warming of the Arctic at a faster rate.
Though Arctic sometimes do experience temperature fluctuations depending on the strength or weakness of Polar Vortex or due to the Polar Jet Steams, but such temperature spikes are become more frequent and are lasting long in duration.

Climate Change in Arctic and its Global Impact

"Increasingly rapid melting of Polar ice caps is risking the triggering of 19 climate Tipping Points causing catastrophes around the world"[6]. Climate Tipping Point is when natural climate system like ice caps undergo dramatic change. The globe is an interconnected system, where any change in one corner is bound to send feedback (Arctic Amplification) to the other component, including further south. Some of its ripple effects are:
The Albedo Effect: The Earth is a giant black box, which balances the incoming solar radiations and outgoing ones, thus maintaining a normal average suitable temperature of 15°C. The albedo which is the reflective ability of any surface determines earth's terrestrial or outgoing radiation. Thick ice and clouds have high albedo of around 70-80 per cent,

6. GeoEngineering Watch. "Arctic Ice Melt Could Trigger Uncontrollable Climate Change At Global Level." November25,2016. Accessed February 21,2019. https://bit.ly/2NgVTxM.



which means that these reflect back most of the sun rays falling upon them. As compared to this barren surfaces, open sea have low albedo i.e. they absorb majority of incoming heat through sun rays. In this process, glaciers and snow help in maintaining the black box quality of the earth.

Sea Level Rise: Melting of sea ice, or ice floats do not raise sea levels. But the melting of continental or land based glaciers raise the level of sea. The process is evident in the frequent flooding in coastal areas of the USA. Island nations like Indonesia, Caribbean, Polynesia and even the India Ocean islands are at high risk of losing their land to sea water.

Extreme Weather Conditions: Increasing frequency and intensity of hurricanes, cyclones, cold and hot waves. Evidence of bomb-cyclones, record breaking cold temperatures and nor'easters in North America are evidences of abnormal weather conditions. It is not just in North America but similar incidences have been observed in other parts of the world also. Teleconnections between Arctic ice melt and Indian Monsoon has also concerned Indian meteorologists about the negative impact in terms of rainfall timings and amount.

Thawing Permafrost: Permafrost as the name suggests means permanent frost. When snowing exceeds melting, there is a formation of thick permanent layer of ice over the surface. Places above the Arctic Circle commonly experiences permafrost, which are hundreds of years old. Permafrost however hold large amount of methane or carbon and thawing of permafrost of the Arctic will release huge amount of these major greenhouse gases into the already stressed atmosphere, further increasing the atmospheric temperature.

Threat to Biodiversity and Economy: Arctic is home to world's endangered species like Polar Bear, walrus, reindeer etc. Also indigenous tribes will face a maximum loss if this crisis continues. Not only Arctic or the littoral states but its impact will be felt everywhere. Arctic Ice melt will distort global climatic and oceanic circulations, especially the Indian Monsoon, which is the lifeline of the Indian Economy.

New Economic prospects: The ice melting and retreat of Arctic ice however, has opened new economic avenues which include:

- New ocean and sea trade routes like Northern Sea Route
- Access to the hydrocarbons trapped in the permafrost of Arctic

Arctic's Ice Melt and Indian Climate Connect

Arctic's rapid ice melt has drawn attention of the whole world, including Indian scientists and policy makers. India's connection to Arctic glaciers is very important as it is one of the parameters driving the Indian Monsoon. According to scientists there is a teleconnection between both. Arctic oscillations which is a climatic pattern characterized by winds circulating counter clockwise around the Arctic at around 55°N latitude is also one of the drivers of the monsoon and melting of Arctic Ice.

"*Increased ice melting will affect the land-sea temperature differences, resulting in monsoon extremes*"[7].

This will increase the intensity of floods in India and consequent sea level rise world over. With substantial coastal population, India will face serious consequences. Weakening of Arctic, which acts as the air conditioner to the world, will increase the surface temperature and pose challenges towards food security.

Arctic Council and India

The Arctic Council is the leading intergovernmental forum promoting cooperation, coordination and interaction among the Arctic states, Arctic indigenous communities and other Arctic inhabitants on common issues, in particular on the matters of sustainable development and environmental protection in the Arctic. The Council has eight countries of the Arctic Circle i.e. Russia, Canada, Alaska (USA), Denmark, Finland, Iceland, Norway and Sweden as its permanent members and six organizations representing the indigenous people of the Arctic as its permanent participants. The latter include: the Aleut International Association, the Arctic Athabaskan Council,Gwich'in Council International, the Inuit Circumpolar Council,the Russian Association of Indigenous Peoples of the North and the Saami Council.

The Observer's status is open to all non-Arctic nations along with inter-governmental, inter-parliamentary, global, regional and non-governmental organizations which can contribute to the work of the council. The Council works through its several working Groups which are active in the fields of reducing the

7. Kumar, Vikash, Manish Tiwari, and R. Rengarajan. "Warming in the Arctic Captured by productivity variability at an Arctic Fjord over the past two centuries." PloS one 13, no. 8 (2018): e0201456.

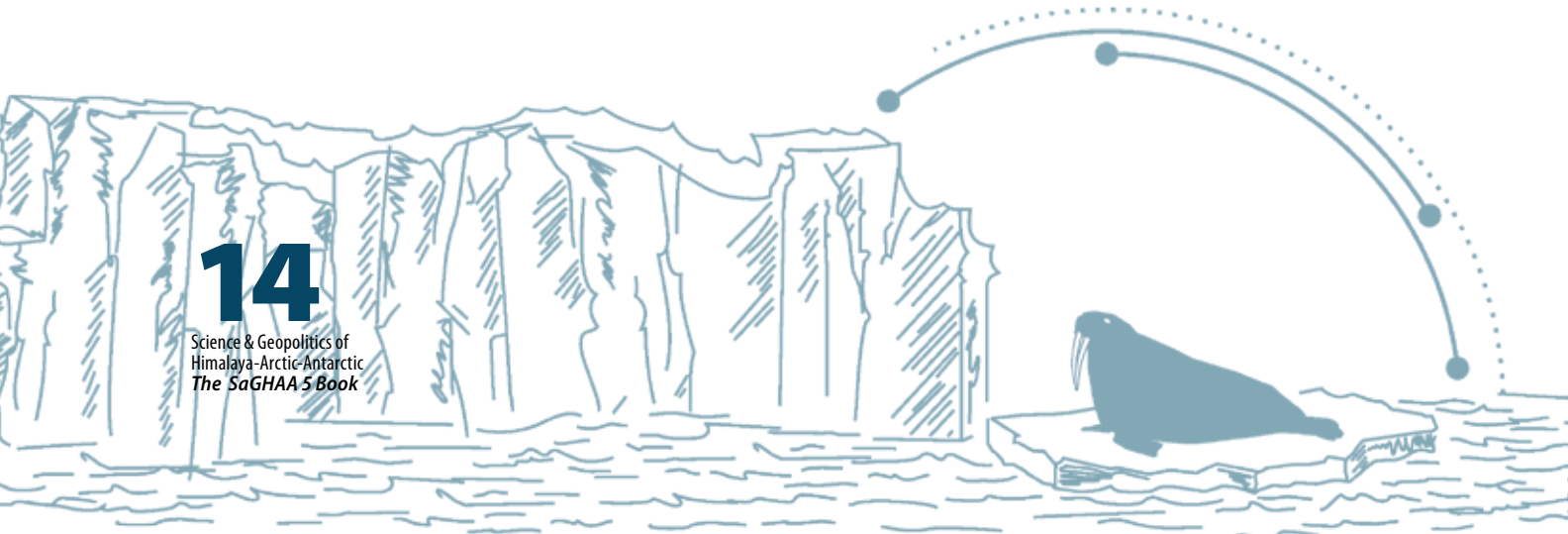
emissions and other pollutants, monitoring the Arctic and marine environment, adverse effects of climate change, conservation of Arctic biodiversity and ensuring the sustainability of the Arctic's living resources among others.

India was one of the original signatories of the Svalbard Treaty of February 1920 whereby it gets a right to use the Arctic islands of Svalbard (under the governorship of the Kingdom of Norway) for commercial activities. In the present day context this would mean that the country can carry out various scientific activities of global relevance at Svalbard. In the recent past it commenced ongoing scientific research endeavors in 2007 with a research base 'Himadri' at Ny-Alesund, Svalbard (Norway). India became a member of the international Arctic Science Committee in 2012 and an Observer at Arctic Council in 2013 (along with five new Asian nations-including China).India's entry has raised expectations from both sides about how will this observer status help India and what the Arctic nations can expect from India in return.

Firstly, India will have access to observe, though not influence, directly the developments in the Arctic sea region which is emerging as a new growth pole in the world. The Arctic Council, which was set up 1996 via Ottawa Declaration, had their initial objectives linked to addressing environmental issues and the concerns of the indigenous people in the region. But in recent years, with rapid melting of the Arctic ice due to global warming, opening of the shorter Arctic sea route for shipping between the Atlantic and the Pacific Oceans during summer months and the prospects of large-scale hydrocarbons in the Arctic sea has led to 'cold rush' and changed the complexion of the region, thus broadening the areas of interest for the Council. The Kiruna Declaration (2013) of the Arctic Council brought out issues which are of immediate concern with respect to the Arctic, empowering the Council itself to regulate the shipping lanes, hydrocarbon prospecting and marine resources exploitation.

The Benefits of the Observer status to India

India can collaborate with the Council on topics related to climate change and can deepen its scientific research in this region. The impact of Arctic ice melt on Indian monsoon is well known and India can use this forum to gain opportunity to get plugged into global, cutting edge research on these issues. Though India hasa different bio-climatic setting in comparison to that of the Arctic, but both the regions have a fragile glacial ecosystem in



Arctic and Himalaya. Participation in the Council will give India access to build up cordial relation with all the member nations. India has already begun this process with Russia. It has also opened up avenues with other countries like Norway with whom India is launching many collaborative programmes in the field of Polar Sciences, biotechnology, Earth sciences etc.

"India's status as an Observer of the council will boost its nascent field of Arctic research. Besides official involvement, an opportunity also comes for Indian think tanks, which can develop close co-operation with their Arctic counterparts to understand the evolution of the Arctic sea".[8]

In geopolitical context, India can gain the support of the Arctic council members in its demand for UN reforms and UNSC membership. Russia has always supported India's entry into UNSC and recently Norway has called out for UN reforms too.

What does India have to offer to the Arctic Council and the Arctic nations in future? Some of the field where India can /will partner with are:

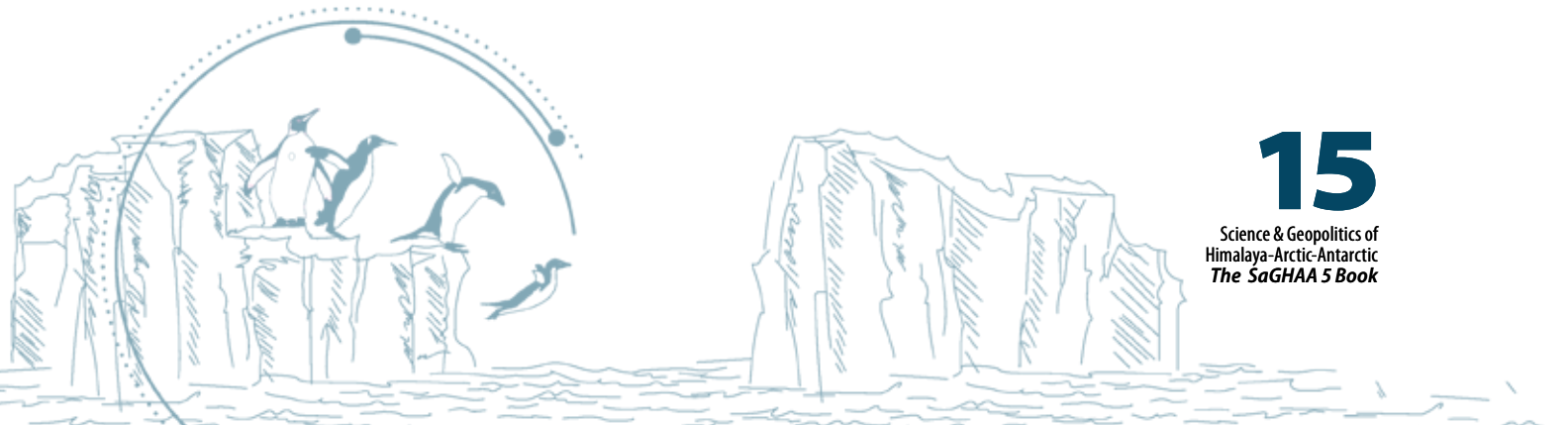
- Scientific research and development
- Oil exploration
- Tourism to showcase the natural pristine environment.
- India's support for the cause of Arctic nations in international forums.

After the Arctic Council, India needs to explore the option to become a part of the Arctic Economic Council (AEC) to strengthen its presence in the North Polar Region.

Global Efforts towards Saving the Arctic

"Saving Arctic ice is a complicated task. It is not a job only for Arctic countries. So we need global leaders from many countries – particularly an alliance between the most polluting countries and those most vulnerable to the impacts of climate change – to convene with industry and civil-society leaders to develop innovative, systemic solutions along with Arctic scientists working on the frontline" [9].

8. Pressreader. "India's Gains from Arctic Council."The New Indian Express, July 2013. Accessed February 21, 2019.https://bit.ly/2cPLqFZ
9. Whiteman, G. 3 ways you can save the Arctic ice. https://bit.ly/2DXVQm8, September 3, 2015



Arctic is a global common, and its responsibility lies on every one. International initiatives like COP21 Paris Agreement (2015), have pledged to help developing island nations in mitigating sea level rise due to global warming. Montreal Protocol on protection of Ozone (1989) to deal with Ozone Depletion was one of such initiatives in past. Efforts should also be taken to restrict economic exploitation of the fragile environment of the Arctic by keeping a balance between the sustainable development and environmental protection.

The Arctic Oil

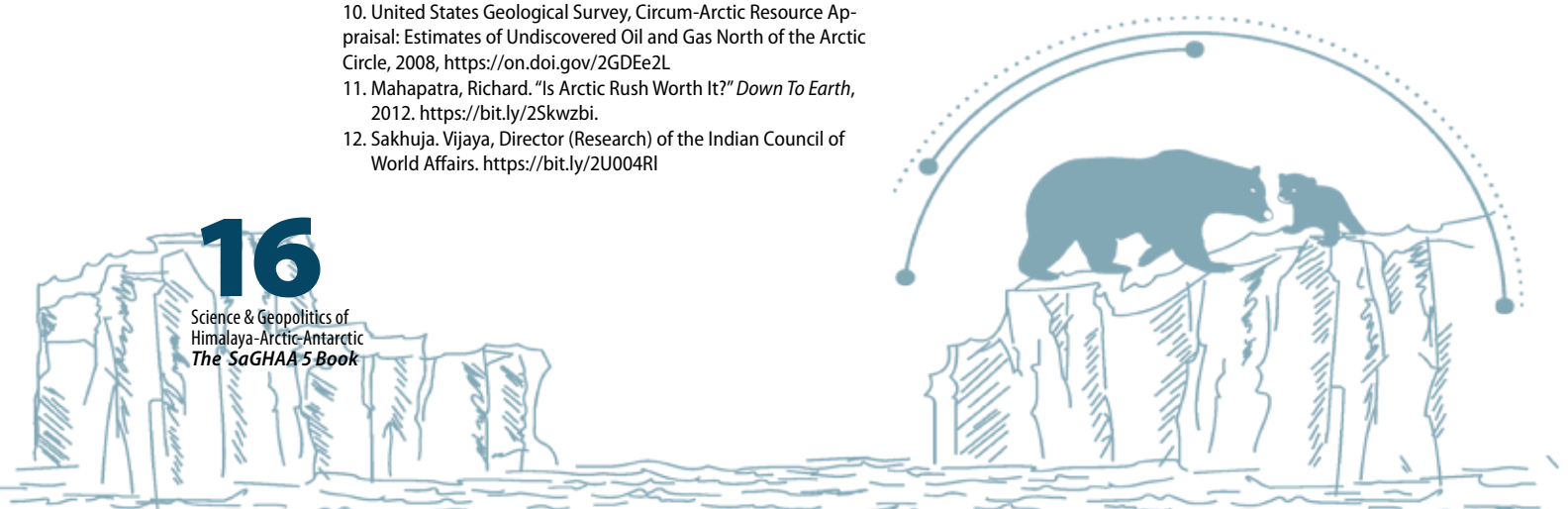
"The pristine Arctic holds an estimated 13 per cent(90 billion barrels) of the world's unexplored conventional oil resources and 30 per cent of undiscovered natural gas resources"[10]. The rise of Arctic's importance as a potential reservoir of hydrocarbons has been known for some time now. The presence of huge reserves of fossil fuels in a cold and barren region like the Arctic also confirms the Continental Drift Theory of Wegener, where continents have migrated across geological time scale and climatic zones. Discovery of oil in the Arctic has already created a lot of enthusiasm among the major world players, though countries like USA, Canada and Russia were already present in oil exploration in the Arctic by early 21st century.

"Along with the eight Arctic nations—Russia, Sweden, Norway, Iceland, Denmark (Greenland), Finland, Canada and the US and several others who explored the Arctic waters, have found over 400 oilfields with proven reserves of around 240 billion barrels of crude oil and natural gas. This is about 10 per cent of the world's known hydrocarbon reserves. They have also discovered significant deposits of various minerals on the seabed".[11]

New reserves will be added with further melting of the polar sea ice as per The US Geological Survey (USGS), as new areas will be available for exploration. According to USGS, around 80 per cent of these new discoveries are likely to be found offshore at an easy depth of 500 m. All this proves that Arctic is soon going to be the new site of geopolitics over energy resources.

These newly found resources and routes have initiated a new but hectic global geopolitics, not only among the Arctic nations, but others too. "North Pole melting indicates a big churning in world relations as this is arguably the largest oil and gas discovery in a long period in history," [12]

10. United States Geological Survey, Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle, 2008, https://on.doi.gov/2GDEe2L
11. Mahapatra, Richard. "Is Arctic Rush Worth It?" *Down To Earth*, 2012. https://bit.ly/2Skwzbi.
12. Sakhuja. Vijaya, Director (Research) of the Indian Council of World Affairs. https://bit.ly/2U004RI



The Race for the Arctic oil

The major Arctic oil players are all its littoral states especially USA and Russia, who derive a large amount of their energy revenue from the Arctic shelf. The new entries into this game include the Asians like China and India, especially China who likes to call itself as the 'Near-Arctic Nation. The stakes involved in this cold rush are manifold, but the major ones revolve around oil, trade and climate change.

"Russia is the most prominent country leading to develop the Arctic's resources. Gazprom became the first company to produce oil offshore in late 2013 in the Pechora Sea – becoming the first commercial offshore oil development in the Arctic".[13]

"As if the impacts of climate change weren't enough, big fossil fuel companies have now set their sites on exploiting the oil that lies deep in Arctic waters" .[14]

The beginning of this was started by Norway, back in 1960s, when it became world's one of the richest after striking oil in the North Sea. Norway's Songa Enabler oil exploration rig has the ability to drill oil even at -20 degree. Arctic oil drilling in Norway has attracted protest and lawsuits from environmental groups like Greenpeace and Nature&Young. According to them, the oil spills that come along with oil drilling are the major source of polluting the sea. Fragile environment and tricky weather conditions have already started to make oil spills in this region frequent.

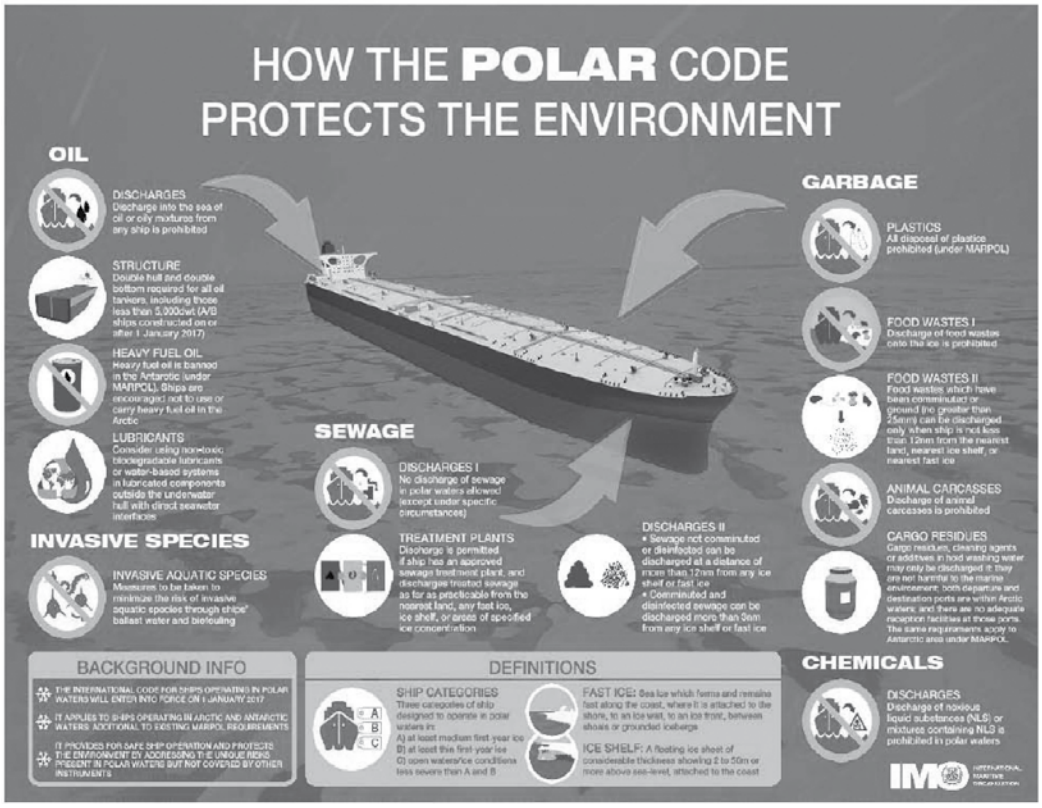
Secondly, majority of the Arctic oil reserves lie off-shore and lack of significant infrastructure and remote location of the drilling sites demand the need of contingency plans against the oil spills. Apart from that, the large off-shore drilling sites are at risk due to shifting ice bergs, while the on-shore drilling requires additional cost and expertise. Improper oil drilling through the permafrost may also release methane gas hydrates located beneath it and stimulate global warming and black soot deposition on the glaciers. Similarly the impact of broken ice platforms, oil spills or any blowout catastrophe has the potential to create havoc on the Arctic ecosystem. Polar bears, walrus, seals, beluga whales and Arctic fox etc will be all at losing their habitat. Apart from the Arctic animals, oil spills can cause tremendous marine pollution and further pollute the food chain."There have also been reports of declining population of pink salmon and herring in the Prime William Sound because of oil spills"[15]. Another segment of this concern is

13. Kutcko, Barbara. "The Good, the bad and the ugly- Petroleum Exploration in the Arctic: The New Cold War" American Association of Petroleum Geologists, 2016.
14. Greenpeace. "Arctic Oil Drilling." Greenpeace International, 2010. Accessed February 21, 2019. https://bit.ly/2EmbmtH.
15. Ward, Eric J., Milo Adkison, Jessica Couture, Sherri C. Dressel, Michael A. Litzow, Steve Moffitt, Tammy HoemNeher, John Trochta, and Rich Brenner. "Evaluating signals of oil spill impacts, climate, and species interactions in Pacific herring and Pacific salmon populations in Prince William Sound and Copper River, Alaska." PloS one 12, no. 3 (2017): e0172898.

related to the impact of the growing unsustainable economic extravaganza on Arctic's indigenous people, who fear losing their livelihood.

Despite its growing prominence in geopolitics of energy resources there are few grey areas in its blueprint of economic growth as most of the territorial waters of the Arctic nation have overlapping claims, creating future possibilities for confrontations under UN Convention for Laws of the Sea (UNCLOS). The UN IMO Polar Code which came into power in 2017 is a key guidelines for Arctic shipping and acts to supplement the existing guidelines like International Convention for the Prevention of Pollution from Ships (MARPOL) and International Convention for the Safety of Life at Sea (SOLAS) conventions.

Fig. 2: An illustrative guide of the Polar Code to the protection of the environment designed by the IMO to raise awareness



Source: IMO

Arctic-India-Oil Trinity

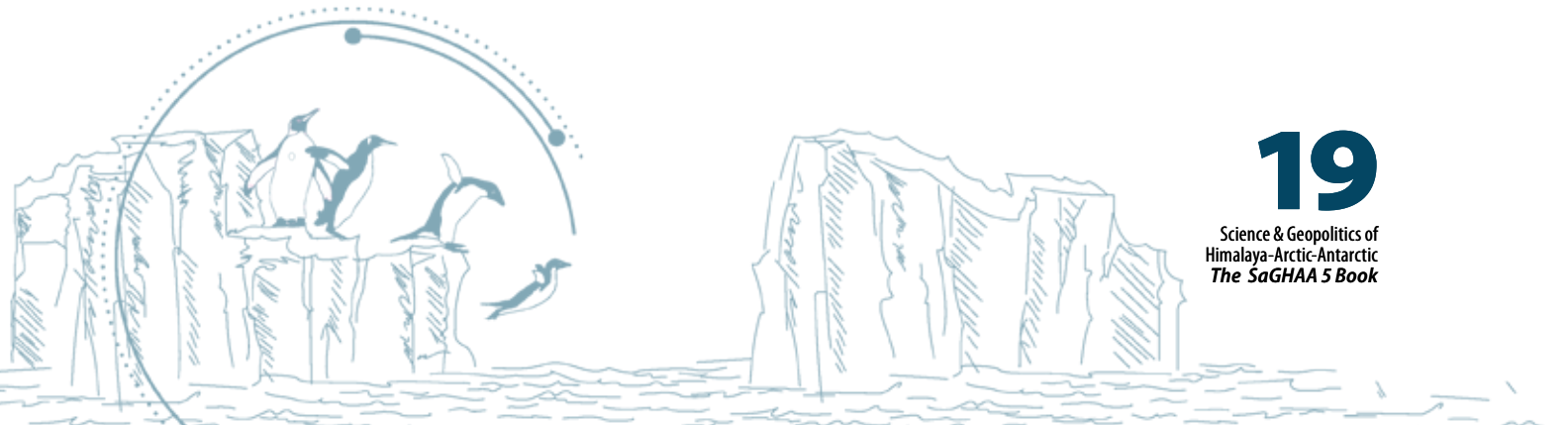
"The Polar Region is, veritably, the new hot real estate; and it is only getting hotter, quite literally, due to climate change and global warming".[16]

India's goodwill towards the Nordic nations and its continued presence since 2007 as a research partner, granted it the privilege of being an Observer in Arctic Council. This new alliance may facilitate way towards legitimizing India's oil and gas exploration through partnership mode in Arctic. An Indian endeavour towards 'Make in India' has forced it to look for more avenues of Energy Security. Asian countries like India and China have already highlighted the potential for oil and gas cooperation with Russia and other Arctic nations. "In fact, India's ONCG Videsh Ltd is already a 20 percent stakeholder in Sakhalin-1 project in Russian Sub-Arctic North Pacific, while China is building ice breaker ships for the Poles."[17] India's entry into this trinity began with Russia, when both pledged to co-operate in oil and gas projects in Russia, including Russia's Arctic Shelf and Okhotsk Sea shores in 2017 and later on giving India access to the Northern sea routes for trade and additional supplies of natural gas and joint development of oil fields. India's quest to reduce its dependence on the politically unstable Gulf for oil supply and to surpass US sanctions on its major oil supplier like Iran, means broadening of options for unhindered oil supply and Arctic nations are its potential destinations. This new economic relation over fossil fuels also brings new challenges to India's commitment towards Paris Agreements and Kigali Amendment in controlling global warming, forcing India to reconsider its priorities and balance economic growth and environment protection as well.

The Northern Sea Route (NSR) and its Geopolitics

The Northern Sea Route (NSR) basically is a shipping lane which, according to Russia, extends across the Russian Arctic coast between the Barents Sea and the Kara Sea, along Siberia, to the Bering Strait. NSR can become the alternative to the shipping corridor that goes via Suez Canal. It can form the shortest sea route between the Eurasia and the Far East. The NCR will take only 14000 km in contrast to the 23,700 km route via Suez Canal. NSR will save money and time for the industrially developed countries. Arctic offers an alternative to Suez "But the Arctic route has drawbacks: a navigation season of three to four months each year,

16. Ramachandran, Ramesh." India China in Arctic: The New Great Game? "*Institute for Peace and Conflict Studies*, 2013, https://bit.ly/2U0PYQ2.
17. Filimonova, Nadezhda and Krivokhizh Svetlana. "How Asian Countries are making their way into the Arctic." *The Diplomat*, 2016. https://bit.ly/2E0IEgB.



unpredictable ice conditions, high insurance fees, costly specialized vessels, and a lack of search-and-rescue teams and support infrastructure".[18]

Threats posed by this new route

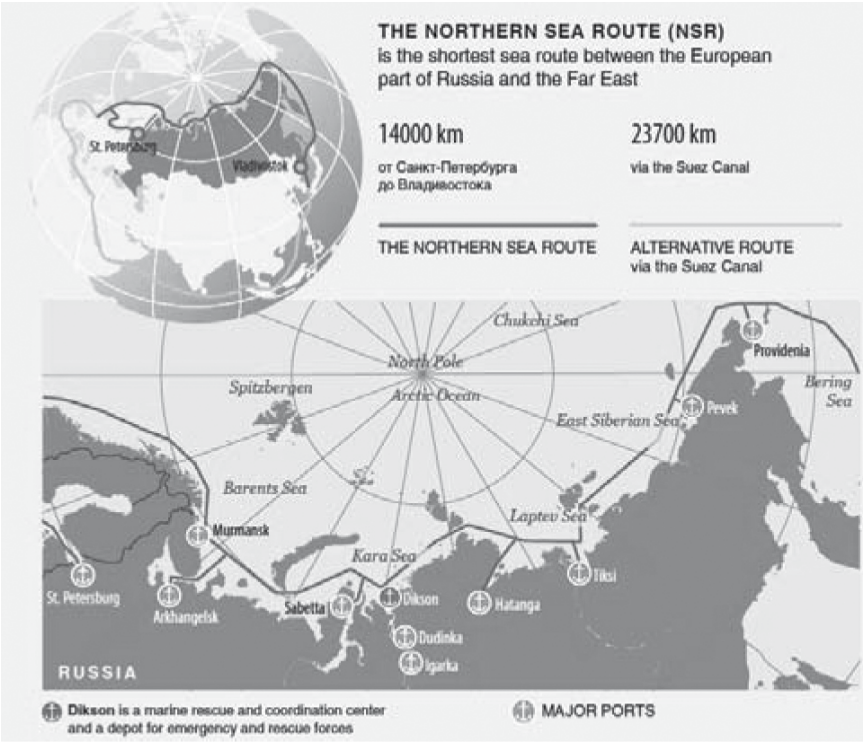
• Opening up sea routes into a fragile ecosystem is bound to create ecological externalities

• Emissions from cargo ships which include black carbon and aerosols will get deposited in the snow and this will reduce the Albedo of the snow. This will fasten up ice melt and delay seasonal snow build up in the Arctic.

• Oil spills and threat to its biodiversity.

• This new ocean route will definitely hasten the snow melt in the Arctic as with rising human footprint, Arctic biodiversity will be weakened to the core, and it will be difficult to recover back the lost ground.

Fig. 3: The Northern Sea Route



18. L.G. What is the Northern Sea Route?, The Economist, Accessed February 20, 2019, https://econ.st/2Vdc7uE

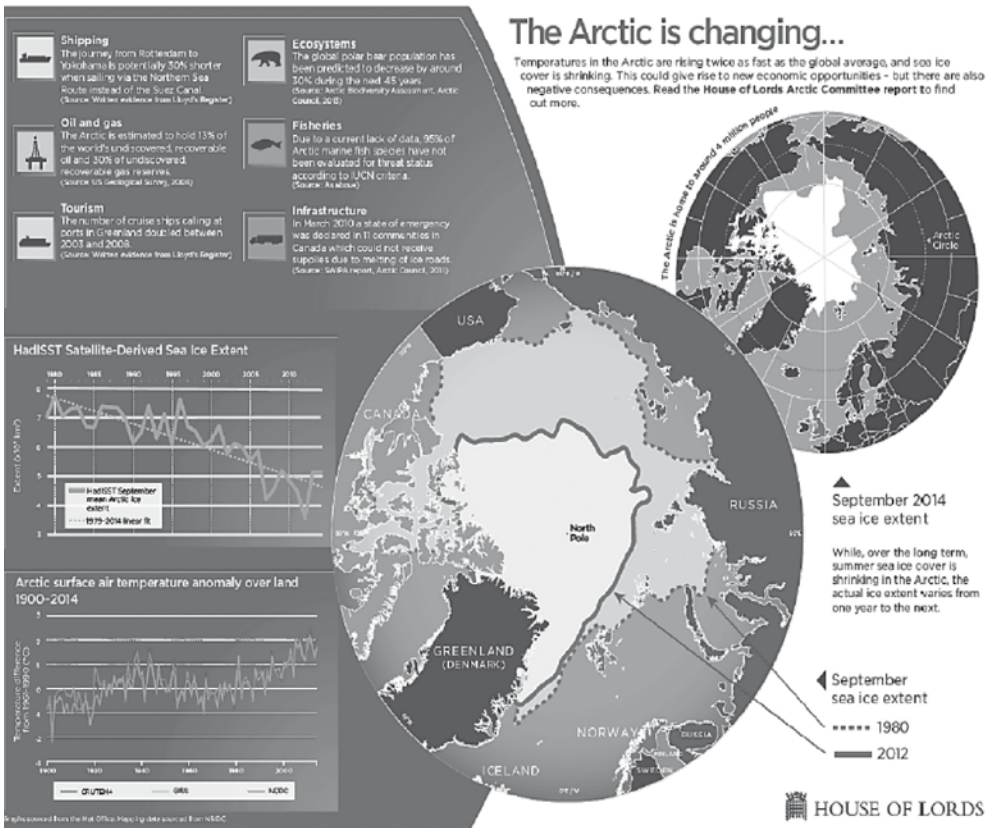
The Arctic Ocean is surrounded by the Arctic States and major part of it stands to be claimed by these states as their Exclusive Economic Zone (EEZ) or the extended EEZ as per the United Nations Convention on the Law of the Sea (UNCLOS).Over the last few years it rose to prominence for being considered by various geopolitical strategists as the next hunting ground of the world's powers. The debates and discussions on the Arctic cover many opportunities in the economic and commercial sectors for the Arctic members and the members with Observer status in the Arctic Council. The Arctic is known to possess one-quarter of the world's undiscovered energy resources. The Arctic ice melting has opened up navigational opportunities through the Northern Sea passage providing easy access for shipping. It also enabled exploration of the vast energy resources and gets access to the huge fish stocks in the Arctic Region.

Presently, the opportunities for accessing huge fish reserves, shortening of shipping routes and exploring energy resources has made the Arctic a favoured destination. However, with Russia holding the major share in terms of the area and the rest being mostly held by Nordic nations who do not have a history of territorial issues, there are low possibilities of confrontation in terms of territorial water limits. The potentials of Arctic to be the next big thing in global geopolitics also depends on the extent of climate change impact and the political and security situation in the region. However, since this circle includes two of the earlier Cold War opponents, it won't be hard to imagine territorial challenges in the near future, with the other smaller countries being forced to succumb. With rising India-China's interest in the Arctic,one can imagine future potential complications in this Frigid Zone. At present of course, no country owns the Arctic snow bound areas but with the disappearance of the ice cover, there might be confrontation on who owns the waters and has the right to exploit its resources, including delimitation of sea routes across the Arctic.

The public perception of the Arctic is of extensive ice, unique species and cultures, and untouched pristine landscapes. While largely true, the Arctic is also home to some 4 million people and an annual economy of roughly 230 billion USD (World Economic Forum 2014). "Trans-Arctic routes are shorter and may lead to savings in travel time and fuel, and hence potential economic savings, however it currently requires specialist knowledge and flexibility not suited to some markets. Incentives for destination shipping include the development

of natural resources spurred by global commodity prices, resupply to remote Arctic communities, fishing, research voyages, and marine tourism. The major impediment to Arctic shipping is operating in the freezing and remote Arctic environment which requires experienced Arctic crews, specialist equipment, and vessels"[19].

Fig. 4: Infographic Summarising House of Lords (2015) "Responding to a Changing Arctic"



Source: Committee on Arctic, House of Lords, UK .

19. Depledge, D. "UK House of Lords Report on 'Responding to a Changing Arctic': A More Confident Statement of British Interest? March, 2015. Accessed February 21, 2019.

THE HIMALAYA

The Himalaya, home to the enchanted and mythical Shangri-La, is also the reservoir of the largest continental glaciers outside the Polar Regions, thus making it the Third Pole. This majestic highest mountain chain extends from the Hindukush in Afghanistan in the west to Northern Myanmar in east, stretching ~2500 km, covering countries like Pakistan, India, China, Nepal, Bhutan and Myanmar. After the Polar ice caps, the Himalayas have the largest ice cover. The region is covered with rich pristine forests, a diverse flora and fauna, and is home to innumerable medicinal plants and herbs, though it is now much degraded and under tremendous stress. The diversity can be seen in the 13,000 species of flowering plants, of 8000 alone are in the eastern Himalayas and over 5000 species in Western Himalayas. The continuous threat to it has forced international community to tag several of its flora and fauna under threatened category of Red Data Book (IUCN).

Eastern Himalaya has also been allotted the title of 'Ecological Hotspot', given the severity of its threat and biodiversity loss.The Himalaya hold very crucial and multiple importance for the world and more specifically, to the South Asian Region. To summarise, the Himalaya is crucial for the entire Indian subcontinent because of the following:

Firstly,it acts as a natural climatic divider between the tropical monsoon South Asian region and the dry temperate regions of western China and Siberia, above. With respect to this position, the Himalaya not only stops the moisture laden clouds from Indian Ocean, forcing it to shed its rain in the Northern plains, supporting its groundwater reservoir and green forestry every summer but also stops the dry cold airmass from Siberia during Northern winters, thus maintaining the winter atmospheric temperature above freezing level in the Northern plains.

Secondly, it forms the drainage divide and forms the source of many perennial rivers of South Asia like the Indus, Brahmaputra, Ganges, Irrawady, Mekong, Salwen etc. These rivers support more than 3 billion population on its river plain and delta. These are densely populated and form the 'Rice Bowl'of their respective nations.

Thirdly, they support many hydrological power plants associated with dams built on some of these rivers such as Tehri dam (Uttarakhand), Subansari Hydropower (Arunachal Pradesh), Bakra Nangal Dam (HP), Pong Dam(HP) etc. These 'Temples of Modern India 'provide energy,

water for round the year irrigation, aquaculture, recreation etc.

Fourthly, Himalaya has rich forest resources and its pristine climate has favoured the development of tourism, both recreational and religious tourism.

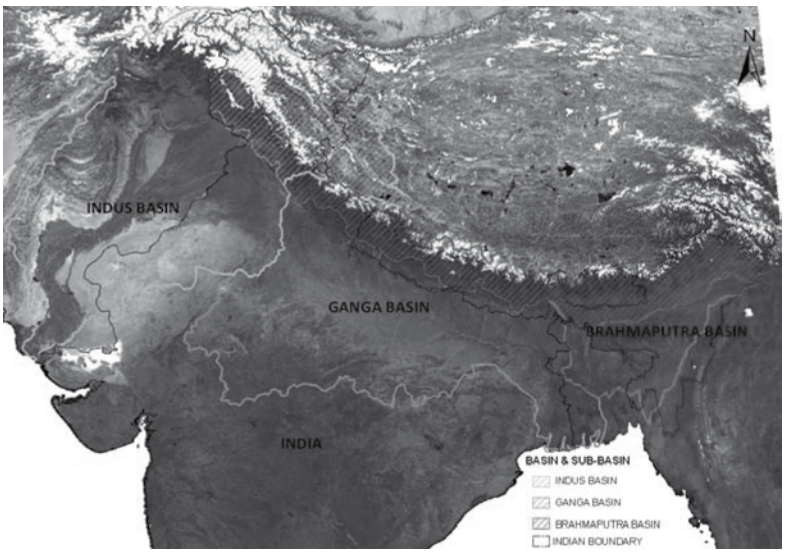
The Himalaya is also undergoing changes and the impact of climate changes and global warming will be definitely more here than the other two poles because of its location that supports a great number of population. The Himalayan ecosystem is highly vulnerable and susceptible to the impacts and consequences of excessive anthropogenic emissions and developmental paradigms of modern society. Some of the issue pertaining to the Himalayas are as under:

Climate Change Impact on Himalayas: By far the most serious issue impacting the Himalaya is climate change.. "Almost 35 percent of glaciers of this region could retreat by 2100, even if global temperature rises by 1.5^{0}C and it could destabilize the hydrology of large parts of South Asia, China and Myanmar"[20]. The impact of global warming is already being felt much more in the Himalayas than in other parts of the world. This is resulting in the accelerated melting of glaciers and the depletion of the massive water store of the region. The controversy on the health of Himalayan glaciers, given rise to by IPCC 2007 Report, saw the publication of large number of scientific papers in national and international journals, outlining collective and independent behavior of glaciers. On the long term monitoring of snout of glaciers in three main basins- "Ganga, Indus and Brahmaputra- in the two periods of 1989-90 to 2001-04 and 2001-02 to 2010-11 has presented a contrasting picture. During the period of 1989-90 to 2001-2004, 76 per cent of the glaciers have shown retreat, 7 per cent have advanced and 17 per cent have shown no change. As compared to this, during the next decade i.e. 2001-02 to 2010-11, only 12.3 per cent glaciers have shown retreat, 86.6 per cent of glaciers have shown stable front and 0.9 per cent have shown advancement"[21].

Apart from SAC, multiple agencies in India, such as Geological Survey of India, Wadia Institute of Himalayan Geology, National Institute of Hydrology, National Centre for

20. ICIMOD, "Summary of the Hindukush-Himalaya Assessment Report."Hindu Kush Himalayan Monitoring and Assessment Programme,2019. Accessed February 21, 2019. https://bit.ly/2V83hhD.
21. Space Application Centre, ISRO

Fig. 5: The spread of Hindukush-Himalaya Source : Ajai, 2018

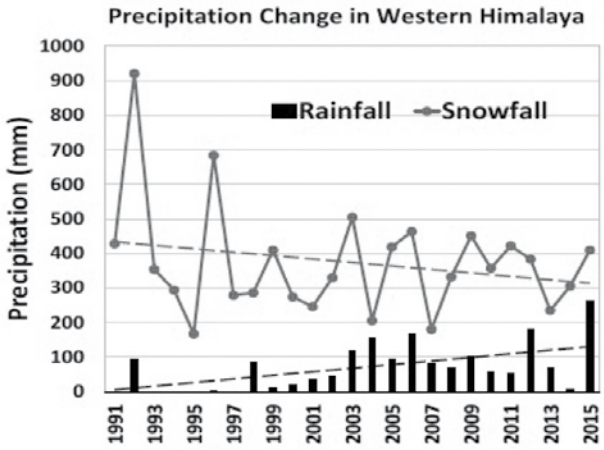


Antarctica and Ocean Research and several universities are monitoring some glaciers by field and remote sensing techniques showing a wide mismatch in the findings. There are real fears that the 'abode of snow' would be significantly depleted.[22] This would have tremendous impacts on the plains, especially the highly populated Indo-Gangetic Plains. The impact of climate change will be aggravated by the construction of hundreds of dams. As glaciers melt, water in the rivers will rise, and dams will be subjected to much higher flows, raising concerns of dam safety, increased flooding and submergence. With the subsequent depletion of glaciers there will be much lower annual flows, affecting the performance of such huge investments. Climate change will also increase the threats of Glacial Lake Outburst Floods (GLOFs) and possible cascading failures of downstream dams.

Avalanches In Himalayas: Researchers have found that winter temperatures in the northwestern Himalayas have risen on an average 0.65 °C over a period of 25 years from

22. UNESCO. '' Case Studies on Climate Change and World Heritage. '' UNESCO World Heritage center,2007. Accessed February 21,2019.

Fig. 6: Changes in winter rainfall and precipitation in the Western Himalayas from 1991 to 2015 (25 years). Over this period, total precipitation is increasing with less snowfall and more rainfall.



Source: Kulkarni et al. (2018) and Negi et al. (2018).

1991—higher than the global average rise of 0.44 °C. During this period, total winter precipitation has increased with greater rainfall and lesser snowfall.[23] Rising temperatures have led to an increase in the frequency of avalanches since 1970.[24] Climate in the mighty yet fragile snow-covered Himalayas has been changing rapidly. Hence, monitoring the trends and effects has been challenging because of the high altitudes and the rugged terrain. Winters in the northwestern Himalaya is getting warmer and wetter with less snowfall. This warming is leading to a greater risk of wet avalanches in the western Indian Himalayas.[25] "Almost no avalanches occurred in the region from 1940 to 1960, but high activity was recorded between 1970 to 1977 and 1989 to 2003 with more than 0.87

23. Gautam, Mahesh R, Govinda R. Timilsina, and Kumud Acharya. *Climate change in the Himalayas: current state of knowledge*. The World Bank, 2013.https://bit.ly/2SSO5IK
24. Jain, Neha. "Warmer winters in the Himalayas are triggering avalanches." *Mongabay*, 2018. Accessed February 21, 2019.https://bit.ly/2Xc59YN.
25. Bajracharya, SamjwalRatna, Pradeep Kumar Mool, and Basanta Raj Shrestha. "Global climate change and melting of Himalayan glaciers." *Melting glaciers and rising sea levels: Impacts and implications* (2008): 28-46.

avalanches per year, on an average"[26]. Using statistical modeling, the research team from University of Geneva has linked increased air temperatures in late winter and early spring to a higher probability of avalanches. They stress that "the transformation of dry snow packs into wet snow packs is decisive for the release of snow avalanches in the region". Specifically, the rise in liquid water content of the snowpack, makes it unstable and thus prone to trigger wet snow avalanches. Also, moving snow with more water has less friction so it slides downhill easily, which can increase the distance traveled by the snow, known as run-out distances.

Permafrost in the Himalayas

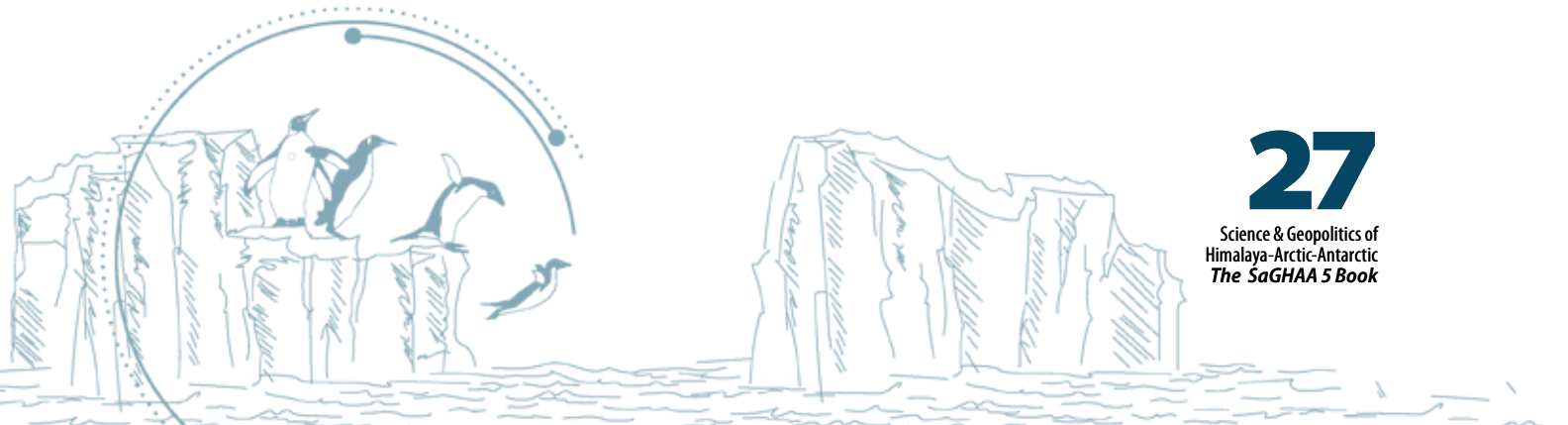
Permafrost is frozen ground that remains at or below 0° C for two or more years. In high-altitude regions, permafrost can underlie much of the landscape. Many people in the Hindu Kush Himalayas live near permafrost or in areas potentially affected by changes in permafrost.

Permafrost under high altitude pastures can retain water in the active layer, the uppermost ground layer that freezes in the winter and thaws in the summer, supporting vegetation such as mosses, lichens and dwarf shrubs. But when permafrost disappears, the water can drain freely, the ground becomes drier and vegetation changes, with impacts on herding communities and the ecosystem as a whole.

In the mountains, permafrost stabilizes rock slopes, moraines and debris-covered slopes. For instance, moraines consist of loose sediment often held together by permafrost. When permafrost thaws, slopes become more vulnerable to erosion. Debris and sediment may deposit slowly in nearby rivers or slide downhill catastrophically, destroying homes, bridges and roads. Loss of permafrost can also increase the likelihood of outburst floods of glacial lakes.

Permafrost thaw influences a broad range of systems, including hydrology, landscape evolution, vegetation, water chemistry, sediment loads in torrents and rivers, debris flows and rock fall. As a consequence, it can strongly affect regional livelihoods and economies.

26. Ballesteros-Cánovas, J. A., D. Trappmann, J. Madrigal-González, N. Eckert, and M. Stoffel. "Climate warming enhances snow avalanche risk in the Western Himalayas." *Proceedings of the National Academy of Sciences* 115, no. 13 (2018): 3410-3415.



GLOF: Threat to the Himalayan Ecosystem

GLOF is an acronym used to refer to Glacial Lake Outburst Flow which occurs due to breaching of naturally dammed lakes located at the mouth or near the glacier. It occurs when the moraine dam, made of unconsolidated moraine materials and ice, give way due to increase in pressure created by the water column stored in the artificial lake. The breach could be due to cloudburst, excess of water beyond the capacity of the lake, earthquake, avalanches, natural seepage etc which can initiate wave surges in the lake. GLOF is a serious hazard in high, mountainous regions of the Himalayas and its catastrophic risks have increased in recent years because most excessive melting of Himalayan glaciers under a warming climate.

"Glacial lakes in the Himalaya are known to have formed mostly within the last 5 decades. Warming in the Himalayas in the last three decades has been between 0.15°C and 0.60°C per decade because of the resultant glacial recession the glacial lakes in all the areas including Himalayas-Hindukush regions are experiencing increase in size and number."[27], There are no well accounted inventories maintained on the amount of GLOFs in the Himalayan area.,

"The Hindu Kush-Himalayan region does not have any early flash flood warning system in place despite being surrounded by over 8,000 glacial lakes, around 200 of them potentially dangerous"[28]

"Though relatively unknown or, perhaps, not adequately recorded in the upper Ganga basin, the last 100 years have witnessed at least 50 glacial lake outburst floods at several places across the Hindu Kush Himalayas, from Afghanistan to Myanmar"[29]. North Indian states such as Uttarakhand, Himachal Pradesh, Sikkim and Jammu and Kashmir, all have recorded extreme rainfall event in recent years and stand at threats of GLOF.

There are approximately 20,000 glacial lakes formed by melting ice, out of which around 200 of them have the tendency to cause catastrophic GLOF. They are like time bomb, which can release millions of cubic meter of icy water that was been stored in the lake for decades within seconds without any prior warning to the people downstream.

27. Shrestha, Badri Bhakta, Hajime Nakagawa, Kenji Kawaike, Yasuyuki Baba, and HaoZhang . "Glacial lake outburst due to Moraine Dam failure by seepage and overtopping with impact of climate change." Disaster Prevention Research Institute Annuals(2010).
28. Ives, Jack D, Rajendra B. Shrestha, and Pradeep K. Mool. *Formation of glacial lakes in the Hindu Kush-Himalayas and GLOF risk assessment*. Kathmandu: ICIMOD, 2010.
29. Jolly, Asit. " Kedarnath Calamity a Proof of long Ignored Threat by Melting Himalayan Glaciers." *India Today*, 2013. Accessed February 21, 2019. https://bit.ly/2VcYHyW.

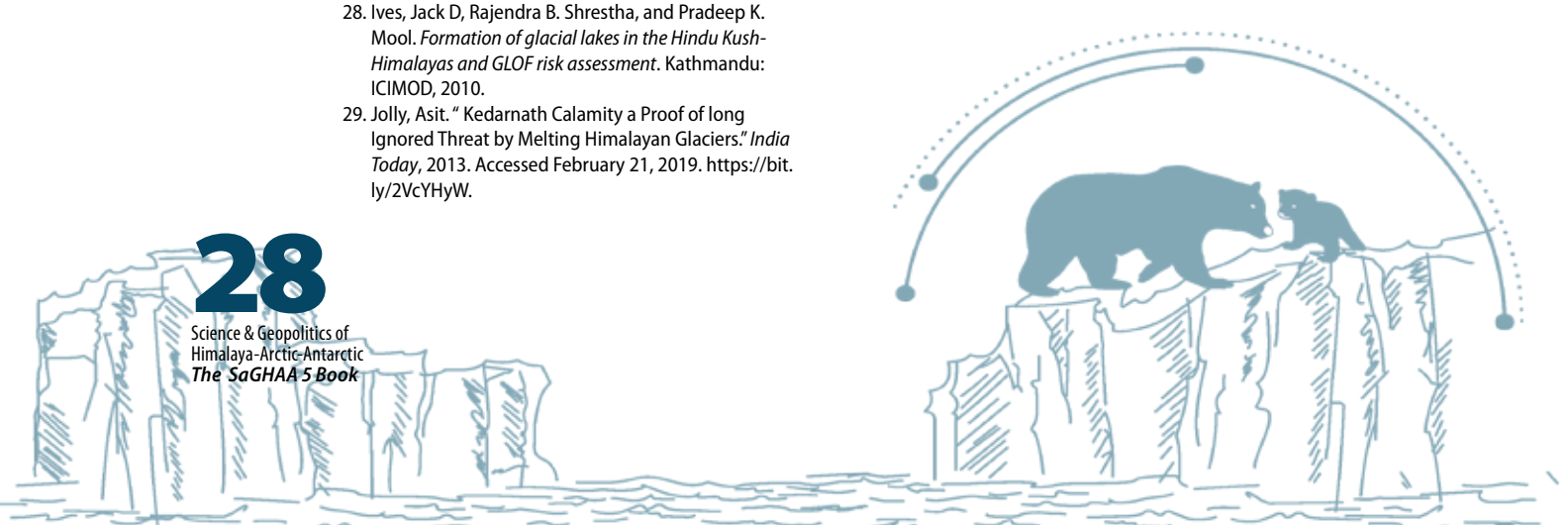
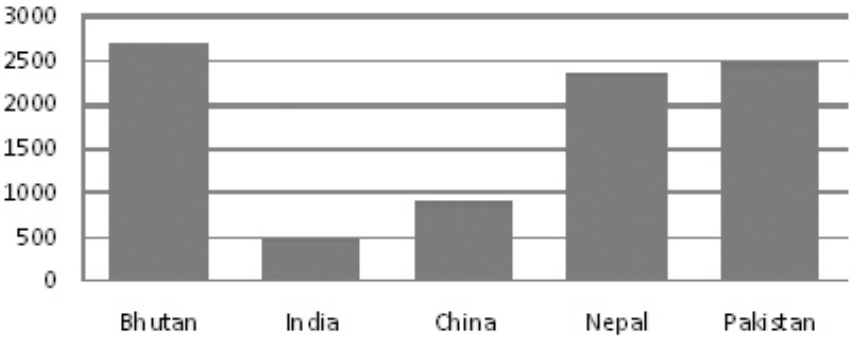


Fig. 7: Glacial lakes in the Himalayas (Number)



Source: ICIMOD

Table 1: Criteria to identify potentially dangerous or critical glacial lakes

Dam condition	Glacier condition	Physical surroundings
Narrow crest area	Condition of associate glacier	Potential rockfall/slide (mass movement) sites around the lake
Drainage poorly defined	Large glacier area	Large snow avalanche sites immediately above the lake
Steepness of slope of moraine walls	Rapid glacial retreat	Neo-tectonic and earthquake activities around or near the lake
Stability of permafrost within moraine	Debris cover on lower glacier tongue	Climatic conditions
Height moraine	Gradient of glacier tongue	Sudden advance of a glacier towards a lower tributary
Mass movement	Crevasses or ponds on glacier surface	
Past breaching, closing or refilling of lake		

Source: Ives. J, Shrestha.R and Mool.P (20100; "Formation of Glacial lakes in Hindu Kush-Himalayas and GLOF Risk Assessment.

Unlike in Nepal and Bhutan, among the first countries in the world to make glacial outburst floods a national priority, information on basic glaciology and more specifically the threat from GLOF in the Indian Himalayas is scattered and of little real value.
The Kedarnath incident of June 2013 is one of the classic GLOF case where the Chorabari lake located upstream breached due to cloudburst. The flood killed more than 6000 people, displaced many more and destroyed the entire pilgrim town of Kedarnath.
Most GLOF events documented in the Himalayas occurred in the central Himalayas and typically consisted of outburst floods from moraine-dammed glacial lakes. The central Himalayas form a natural boundary between China and Nepal, as well as between China and India. Few documented GLOF events that has happened in the central Himalayas destroyed a downstream hydropower station, road and bridge, killed hundreds of people and caused millions of dollars in economic losses.

Global warming and the Himalayan Glacial lakes

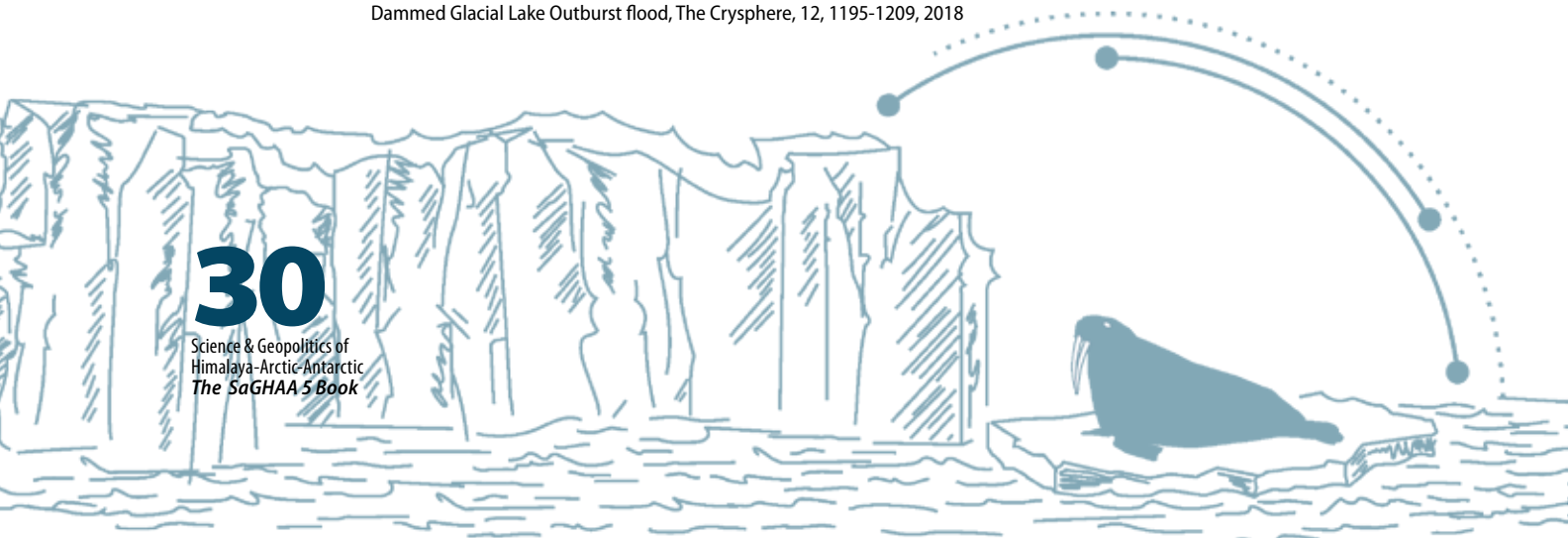
GLOF involves a complex set of factors but definitely global warming causing ice melting is one of the dominant reasons for the lake outbursts in recent times. GLOF triggers also commonly involve extreme weather, such as extreme heat and extreme precipitation, which are intuitively linked to climate change as well.

The vast majority of these GLOFs occurred since the beginning of the 20th century, at a time of climate warming and increasing glacier recession (Harrison et al, 2017). "In the Pamir and Tien Shan mountains in central Asia, there were reports of around 20 GLOFs, with most of these dating from the late 1960s to the early 1980s. The largest number of GLOFs (55) is reported from the Hindu Kush Himalaya (HKH) including the mountains of Bhutan and Tibet, dated from the 20th and 21st century."[30]

Early Warning and Monitoring of GLOFs

Identification of potentially dangerous glacial lakes and recognition of risks associated with them, including ranking of the critical lakes, has become a priority task. Once the critical lakes are identified, the planners, developers, and scientists involved need to develop and implement appropriate measures to reduce the potential risks from these lakes given the

30. Harison, Kargal, Huggel, Reynolds, et al., Climate Change and Global Pattern of Moraine Dammed Glacial Lake Outburst flood, The Crysphere, 12, 1195-1209, 2018



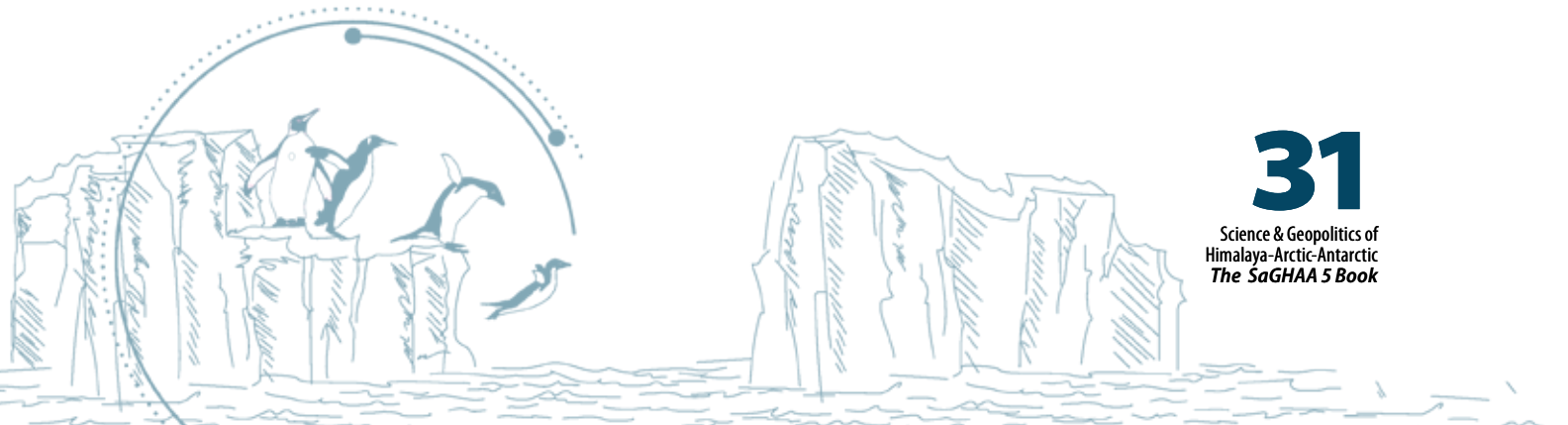
global warming challenges at present and in the future. Measures include: monitoring, to provide an early indication of changes; early warning systems, to provide downstream residents and owners of infrastructure time to take avoidance action; and mitigation measures, to physically change the situation and thus reduce the risk. Effective GLOF monitoring and early warning systems are an important part of disaster preparedness; they have the potential to greatly reduce loss of life and property and such work involves the application of remote sensing tools, telecommunication and broadcasting. Countries like Bhutan, Nepal and India have, already initiated programmes in this field, e.g. National Action Plan for Adaptation (NAPA) to Climate Change (Bhutan) and National Communication on Climate Change Mitigation and Adaptation (India).

Dam Building in the Himalayas

The Himalayas are the highest and among the most spectacular mountains in the world. In the absence of a geographically precise definition, the Himalaya may be taken to mean the mountain ranges that separate the Indian sub-continent from the Tibetan Plateau. By extension, it is also the name of the massive mountain system which includes the Karakoram, the Hindu Kush, and a host of minor ranges extending from the Pamir Knot. Water and rivers know no political boundaries and they have existed long before the emergence of Nation State, but with the rise of modern state, river flow have undergone many modifications only to fit the need of the state which owns technology advanced enough to tame the mighty rivers. Asia is home to some of the world's largest rivers like Indus, Ganges, Mekong, Yangtze, Brahmaputra etc, which criss-cross the continent, on which thrived some of the oldest civilizations of mankind. At present these rivers support millions of people and through its rejuvenating nature replenish the river valleys year after year.

It has also been observed that the same river which can become the seed for the rise of human civilization can also become the cause of its destruction for example, the Indus Valley Civilization.

At present, rivers around the globe are under severe stress, climate change, glacial retreat, river pollution, and many anthropogenic induced threats. With already several



problems looming around water demand-supply mismatch, "it has been projected that two out of three people in the world will live in water-stressed conditions by the year 2030"[31]. The scarcity and unequal distribution of water over space and time makes it potential topic for conflict. The fact that rivers, which are an important source of fresh water, do not follow political boundaries and mostly transboundary in nature makes the situation more complicated. If all the planned capacity expansion materializes, the Himalayan region could possibly have the highest concentration of dams in the world[32]. Himalayan rivers have always been looked upon as having large potential to generate hydroelectric power. Some of the earliest and largest hydropower stations in the countries of the Indian subcontinent have been built on Himalayan rivers; for example, the Bhakra Nangal project in India and the Tarbela project in Pakistan. Recent years have seen a renewed push for building dams in the Himalayas. Massive plans are underway in Pakistan, India, Nepal and Bhutanto build several hundred dams in the region.

Implication of Dams in the Himalayas

With the rise of dams and reservoirs in trans-national rivers, such as the Brahmaputra river, water has become a diplomatic tool and may be a military toolin the future. The implications can be summarized as followings:

a. Submergence of land and forested areas.

b. Loss of livelihood and resources base for the locals, especially the tribal communities

c. Changes in the river regime, affecting the productivity of wetlands downstreams and river ecosystem.

d. Construction of large dams in tectonically active zone also puts a pressure on the isostatic balance, creating risk for reservoir induced tremors and risking downstream region with probability of dam failures.

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31. Sinha, Uttam Kumar. "*Riverine Neighbourhood: Hydro-politics in South Asia*". Pentagon Press, 2016.
32. International Rivers. Mountains of Concrete: Dam Building in the Himalayas (2008) https://bit.ly/2d9U8EQ

e. Displacement of indigenous peoples and tribal community.The customs, traditions and the very character of local tribal communities are closely tied to the lands, rivers, forests and other elements of the natural ecosystem, which will take a down ward plunge.
f. Himalayas especially Eastern Himalayas are identified as Ecological Hotspot, because of the endemic nature of its flora-fauna and the level of threats to them. Anthropogenic presence like dams and reservoirs will severely affect their survival.

Unregulated Tourism in the Himalaya

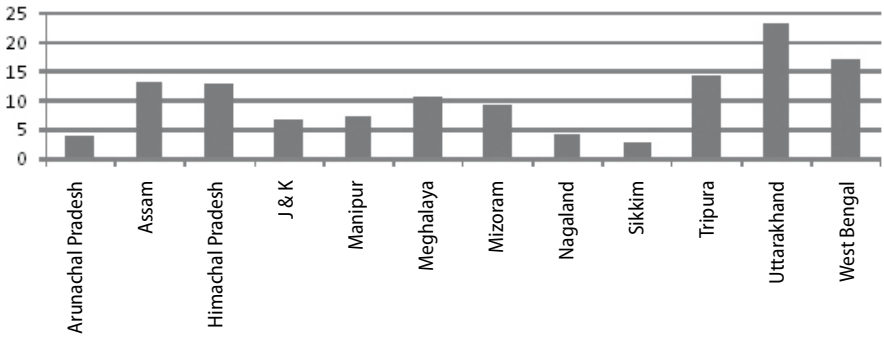
With its towering peaks, majestic landscapes and rich biodiversity and cultural heritage, the Himalaya has attracted visitors and pilgrims from the subcontinent and across the world. The Himalayan Region has attracted those who seek adventure, cooler climates in summer, sport, spiritual solace, peace and the many cultural assets of mountains – built to take advantage of the natural grandeur it manifests. Tourism is being considered as the major engine driving the economy of Himalayan states. These states are lagging behind the other Indian states, when it comes to state's share in total GDP, largely due to inhospitable terrain, harsh climate which restricts infrastructure development. But tourism, over the last few years has provided valuable economic and livelihood opportunities to the locals with revenue for the state governments going up.

The 11th Five-Year Plan document of India's Planning Commission recognized that "Tourism is the largest service industry in the country. Its importance lies in being an instrument for economic development and employment generation, particularly in remote and backward area"[33] . Tourism can stimulate faster, sustainable and inclusive growth. "International tourist arrivals touched 1.2 billion in 2016, 46 million more than in the previous year"[34]. Various initiatives have been taken by the Government to promote tourism.

Recent measures include the introduction of the e-Visa facility under three categories – Tourist, Medical and Business, launch of Global Media Campaign for 2017-18 on various international TV channels, launch of 'The Heritage Trail' to promote the World Heritage Sites in India, launch of Swadesh Darshan and PRASAD(National Mission on Pilgrimage Rejuvenation and Spiritual, Heritage Augmentation Drive)scheme and celebration of 'Paryatan Parv'.

33. 11th Five-Year Plan Document, Planning Commission
34. Venkatesh,Shreeshan. "Stranded on Top." Down to Earth, June 2016. Accessed February 21, 2019.https://bit.ly/2XfFbna.

Fig. 8: Contribution of Tourism to state's GDP (2010-11)



Source: Report of Working Group II: Sustainable Tourism in the Indian Himalayan Region, NITI Aayog.

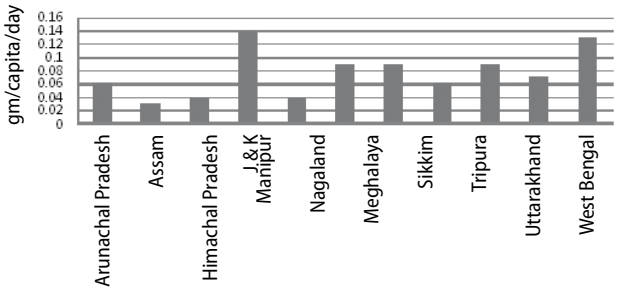
Apart from foreign tourists, the Himalayan states are receiving heavy flow of domestic tourists too as the per capita income of people rises and rise in luxury and recreation time. As a result, issues such as, traffic congestion and air and noise pollution, overbooked hotels, non-availability of parking places, and local water and energy security, are becoming recurrent problems.

Waste Management in the Himalaya

With the increasing trend in tourist footfall to the Himalayan states, it is likely that environmental and social trends along with standards will be subjected to change. Apparently, these developmental trends and activities in the Himalaya have direct or indirect impact such as pollution, overexploitation of natural resources, food insecurity, traffic congestion, loss of indigenous culture, natural disasters, increase of human foot prints and consequent increase in municipal sewage and so on are bound to impact the Himalayan ecology.

Sustainable tourism should focus on waste disposal primarily. Cold climate in the mountains also restrict faster decomposition of garbage, thus often leading to their draining into rivers, which contaminates aquatic life downstream and degrades the quality of the river water on which depends a large population for multiple uses. Himalaya is becoming

Fig 9: Municipal solid waste generation in Indian Himalayan region



Source: ENVIS

top destination for tourists and given its fragility, efforts should be taken to deal with various types of pollutions in there. . Increasing and unregulated tourist footfall, urbanization, haphazard infrastructure and construction without taking into the ecological cost has already unleashed disaster in this region. Places like Shimla are already battling with water crisis and outbreak of water borne hepatitis, because of improper sewage and garbage management. "Efforts of National Green Tribunal (NGT) in limiting the number of vehicles crossing Rohtang pass in a day, banning stone crushers near waterbodies in Himachal Pradesh and ordering the state government to take actions against illegal dumping of garbage are some positive steps in this direction".[35] Similar efforts should be made to harmonize economic activities and ecological conservation.

Environment Impact Assessment (EIA) should be done for every developmental projects in such regions. Involvement of multi-level stakeholders especially villagers and youths in generating awareness can create better acceptance of the need of curbing pollution. Protecting Himalayas has also been prioritized under India's National Action Plan for Climate Change.

Earthquakes in the Himalayas

Earthquakes pose the greatest threat to the Himalayan region. Almost the entire Himalayas are prone to high seismic activity or earthquakes. Earthquakes have hit the region several

35. Venkatesh. S; "Stranded on Top"; Down to Earth, June 2016 https://www.down-toearth.org.in/news/air/stranded-at-top-54413

times in the past and similar threats remain inevitable in the future too. The Himalaya, as we know, were formed by the head-on collision of Indian and Eurasian plates. The mountain building process is still going on because the Indian plate is still moving towards the Eurasian plate." The Indian plate is pushing the Asian plate northward at the rate of about 2 cm per year. This means that in every 100 years India moves 200 cm north against the Asian plate".[36] This colliding force builds up pressure continually for several years and this pressure is released in the form of earthquakes from time to time. The entire Himalayan-Hindukush Mountain region lies in zone 4 and 5 of Richter Scale. The HHK region is tectonically active zone and because of rising human pressure this region has been undergoing several changes making it prone to frequent tremors like construction of dams, dynamite blasting, deforestation.

China and the Himalayan Rivers

Himalaya is the source of all the major perennial rivers of Asia and hence is called the Water Tower of Asia. But, interestingly China has an advantage of being the upper riparian power for majority of the Asian Rivers, which originate from its lands. China doesn't have a single water-sharing agreement or cooperation with the lower riparian nations. By, building dams and initiating river diversion projects, China has unilaterally been re-engineering the flows of these rivers, especially Brahmaputra (YarlungTsangpo).

Climate change and population growth has reduced the per capita availability of water. With the total availability of water being limited, its per capita availability decreases in direct proportion to the increase in population. From 5,177 cubic min 1951, when India's population was 361 million, it is likely to fall to 1,140 cubic min 2050, when the population is projected to be 1,640 million.[37]

According to the UN World Water Development Report,2018 since the 1990s, water pollution has worsened in almost all rivers in Africa, Asia and Latin America. The deterioration of water quality is expected to further escalate over the next decades and this will increase threats to human health, the environment and sustainable development.

36. https://www.geolsoc.org.uk/Plate-Tectonics/Chap3-Plate-Margins/Convergent/Continental-Collision
37. Bansal, Pawan Kumar. "And not a drop to drink", *The Indian Express* (9 April 2015). Accessed on February 2019. https://bit.ly/2E0VrQ9.

China is facing severe water crisis and this will be choking point for its development and with this they have begun to exploit the rivers within their territories to the fullest, starting with Brahmaputra. Brahmaputra is a special case, because it supports the population of both India and Bangladesh."China has already built Zangmu dam (510 MW capacity) on the upper reaches of YarlungTsangpo. Another three: Dagu(640 MW), Jiacha(320MW) and Jeixu are under construction. Except for Zangmu dam for which the information exists, China hasn't officially communicated to India or Bangladesh about the other dams".[38]

Communities of HinduKush Himalayan Regions

The population of the Hindu Kush Himalayan region is approximately 210 million. The communities are largely agrarian, relying heavily on local natural resources and subsistence farming on small plots of land. Like many agrarian mountain societies, they experience high levels of poverty making them vulnerable to both rapid environmental and socioeconomic changes. "Already situated in one of the poorest regions of the world, poverty in the mountains is on average 5 per centmore severe than the national average of the respective HKH countries, with 31per centof the HKH population living below the official poverty line."[39] With Himalayan region undergoing climate change, its indigenous communities who are mostly agrarian and traditionally pastoralist are also going to be affected with it. Loss of pasture frequent forest fires, drying up of spring , loss of forests, and other human aided changes have already put on a large pressure on the mountain ecosystem.

HKH Region is also experiencing migration. "Across the HKH countries population movement is widely perceived as a challenge. However, there is a growing understanding that it can also open up new opportunities for development for those who migrate, their left behind families, communities of their origin as well as to the national economies of origin and destination areas and countries. Emerging research shows that a large number of climate change affected households in this region have been using labour migration as one of the many adaptation tools. Remittances sent by the migrants are being used in disaster risk reduction".[40]

38. Bhattacharya.S; "China's Hydro Ambitions and the Brahmaputra", *IDSA,* (2018).
39. The Himalayan Climate and World Atlas (2015); http://www.grida.no/resources/6678.
40. Bhagat,R, Siddique.T, Banerjee.S, Migration in the Hindu Kush Himalaya: Drivers, Consequences, and Governance; Hindukush- Himalayan Assessment , Springer Open (2019). https://bit.ly/2XePfwA

THE ANTARCTICA

The only land of massive continental glaciers and ice to be categorised as a continent-the Antarctica encircling the South Pole- was the first among the other Polar regions to be the centre of concerns regarding impact of global warming and climate change. The word Antarctica is derived from the Greek word 'Ant-arktike', meaning 'opposite to north' i.e., opposite to the Arctic.Its territorial isolation has kept it outside the human interference for long, but the importance of Antarctica and the threats looming over it could not keep scientists and researcher away from this 'No Man's Land'.Antarctica - the white continent - is the fifth largest continent in the world with its unique wildlife, extreme cold, dryness, windiest and still some unexplored territories.

Antarctica is the home to 90 percent of our planet's ice thoughsome parts of it such as Antarctic Peninsula and the Western Antarctica are art the risk of losing its ice at much faster rate. The overall global warming and the process of climate change are having a perceptible impact on Antarctica.

The temperature warming of 2.50C observed in the Antarctic Peninsula over the last 40 years has been the largest surface warming on the planet. In response, nearly 90 per cent of the glaciers in this region are in retreat with a succession of ice shelf disintegrations. The increase in surface run off, as a consequence of melting, has damaged the structural integrity of the ice shelves, leaving these vulnerable to collapse. The disintegration of these ice shelves has cascading effect on the ice sheet dynamics. "The breaking away of parts of Larsen 'B' Ice shelf in the Antarctic Peninsula in 2002 was followed in 2008 by the loss of parts of Wilkins Ice shelf. The ice sheets in the west Antarctic too are also getting eroded."[41] Though east Antarctica does not show alarming ice mass loss as compared to Antarctic Peninsula and west Antarctica, but on a regional scale in Antarctica, average change in mass for the period 1992-2011 have been estimated to be -71+ 53 Gt yr-1. There has been an increase in the rate of ice loss at 21 +2 Gt yr-1.[42]

41. E. Rignot, E, , . Mouginot1 J, . Scheuchl ,B. and others 2011. Ice Flow of the Antarctic Ice Sheet Science 09 Sep 2011: Vol. 333, Issue 6048, pp. 1427-1430 DOI: 10.1126/science.1208336
42. Sheherd, Andrew, Erik R. Ivins,*, Geruo A, Valentina R. Barletta ant others.. 2012. A Reconciled Estimate of Ice-Sheet Mass Balance, Science. Vol. 338, Issue 6111, pp.:. 1183-1189. DOI: 10.1126/science.1228102

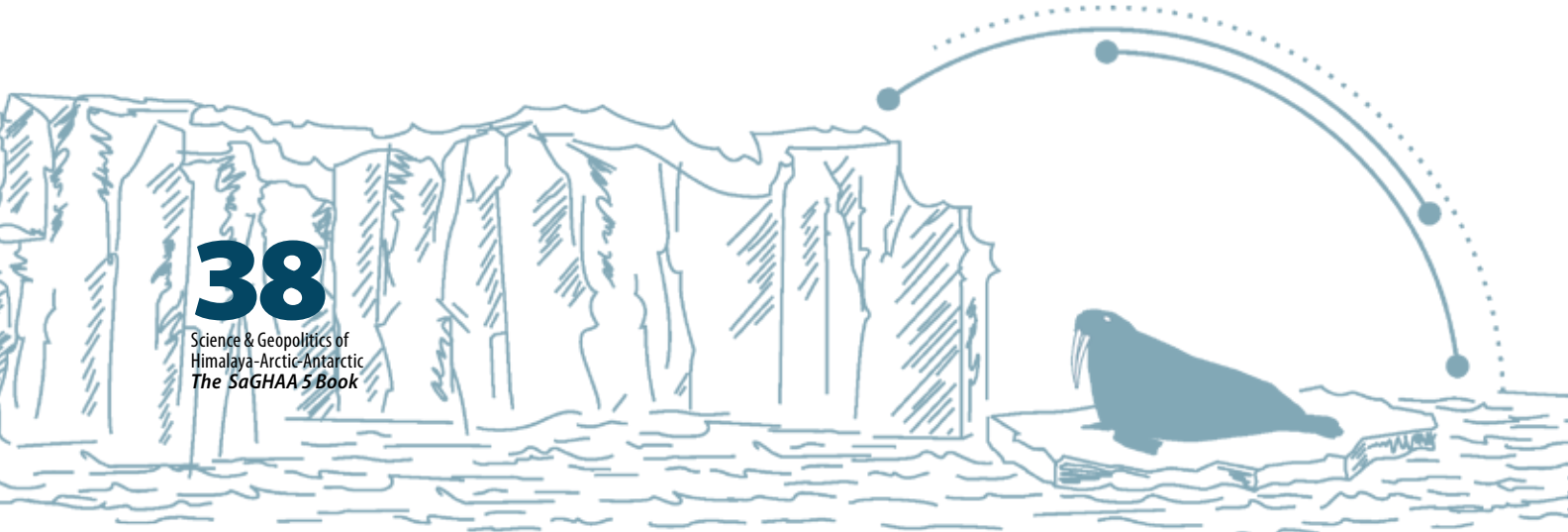
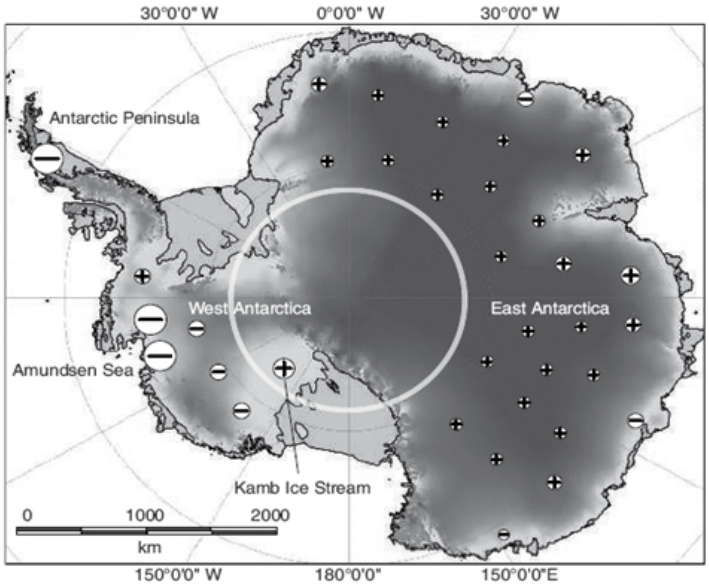


Fig. 10: Changing Mass balance in Antarctica.



Source : Davis et al., Science, 2005

60Th anniversary of the Antarctic Treaty

The Antarctica is one of the last pristine, cold deserts of the earth which till now has been kept free of any military discord. Thanks to the Antarctic Treaty of 1959, Antarctic is recognized as a continent dedicated to peace and science. The Antarctic environment and its associated ecosystem is fully protected. Antarctic governance, administration and environmental protection must be based on scientific data. Antarctica and the Southern Ocean have a fundamental role in regulating processes such as climate and carbon uptake, and research in the Antarctic is crucial to understanding processes of global significance and

to advancing science. Additionally, rapid changes are occurring in parts of Antarctica that could open the continent to a new level of activities in the coming decades..

Antarctica that is defined as "all of the land and ice shelves south of 60°S latitude", is governed by a unique Antarctic treaty that has stood the test of the times. It is governed internationally through the Antarctic Treaty System(ATS). The Antarctic Treaty was signed in 1959 by the 12 countries who were active and involved in IGY in and around Antarctica at the time. Among the original signatories of the Antarctic Treaty were the seven countries – Argentina, Australia, Chile, France, New Zealand, Norway and the United Kingdom – with territorial claims to parts of Antarctica, some overlapping.

The Treaty that entered into force in 1961 that has 53 parties as of 2016, set aside Antarctica as a scientific preserve promising freedom of scientific investigation and prohibiting any military activity, has been hailed as one of the most successful Treaties of modern times forming the basis for treaties of oceans and space. The treaty, is surprisingly short, but remarkably effective. Through this agreement, the countries active in Antarctica consult on the uses of a whole continent, with a commitment that it should not become the scene or object of international discord.

The Antarctic Treaty of 1959, over the past five decades and more, has evolved into a fairly complex, multilayered governance regime (termed as the Antarctic Treaty System–ATS) with several compelling issues on its current agenda demanding serious attention, including the effective implementation of 1991 Madrid Protocol and its annexes, regulation of tourism, biological prospecting and climate change. The transformed geopolitical context of the ATS in terms of an increasingly diverse membership (with Malaysia and Pakistan having acceded to the Antarctic Treaty recently) as well the growing complexity of its governance agenda, demand an urgent focus on the changing nature and role of 'Antarctic Science', and a critical examination of existing knowledge-power equations underlying agenda setting, dialogic politics and consensus based diplomacy. It is going to be its 60th years since the signing of

the treaty, nevertheless security continues to drive and shape the laws and policy regime, which governs the region.[43]

"Antarctic has arguably been constructed through science as a geopolitical and legal space."[44] In a geo-historical perspective, the so called 'discovery' voyages, cartographic practices, setting up of scientific bases and geopolitical rituals such as flag planting and naming practices ably contributed towards making Antarctic legible for colonial-imperial project of staking territorial claims on the continent. If on the one hand, science has performed the strategic role as "the glue of the Antarctic Treaty System"[45], then, on the other hand, it remains the fact that "the external history of Antarctic science is …by and large a history of great power rivalry fired by imperialist ambitions which have been contained and sublimated in science" (ibid. 87).

"The International Geophysical Year [IGY] had indeed achieved the unexpected. Science as an international social system had never before revealed itself to be so powerful"[46]. And the site where this achievement happened so graphically was Antarctic, which "was at the threshold of two ages: one of competitive nationalism and the other of cooperative internationalism. Antarctic could be seen as the site of both the latest phase of imperial partition and the first expression of planetary awareness. ATS regime has become the model for management of the sea and outer space" (ibid. 146). It has successfully protected the Antarctica, from politics of power and modern militarisation for 60 years and hopefully will continue for another few coming decades. ATS has set a benchmark for formulating similar treaty based system for governing other global common like Outer Space, Oceans, Himalayas, and Arctic etc.

Apart from ATS, there are other conventions which have been entrusted with the work of protecting the Antarctic. As the ATS become mature with every passing year it has been recognized as one of the most successful sets of international agreements, setting an example of peaceful cooperation for the rest of the world.

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43. Hemmings and Rothwell. Antarctic Security in the Twenty-First Century: Legal and Policy Perspectives assess Antarctic security from multiple legal and policy perspectives, 2012.
44. Scott. K, Vanderzwaag.D "Polar oceans and Law of the sea". *Oxford Handbook of Law of the sea* (March, 2015)
45. Elzinga, Aant. Interplay of science and politics: the case of Antarctica, *In Society and the Environment: A Swedish Perspective*. ed. by U. Svedin and B.H. Aniasson, 275–83. Dordrecht: Klewer, 1992.
46. Griffiths, Tom. Slicing the Silence-Voyaging to Antarctica. Harvard University Press. 2007

Protocol on Environmental Protection to the Antarctic Treaty (1991) or Madrid Treaty

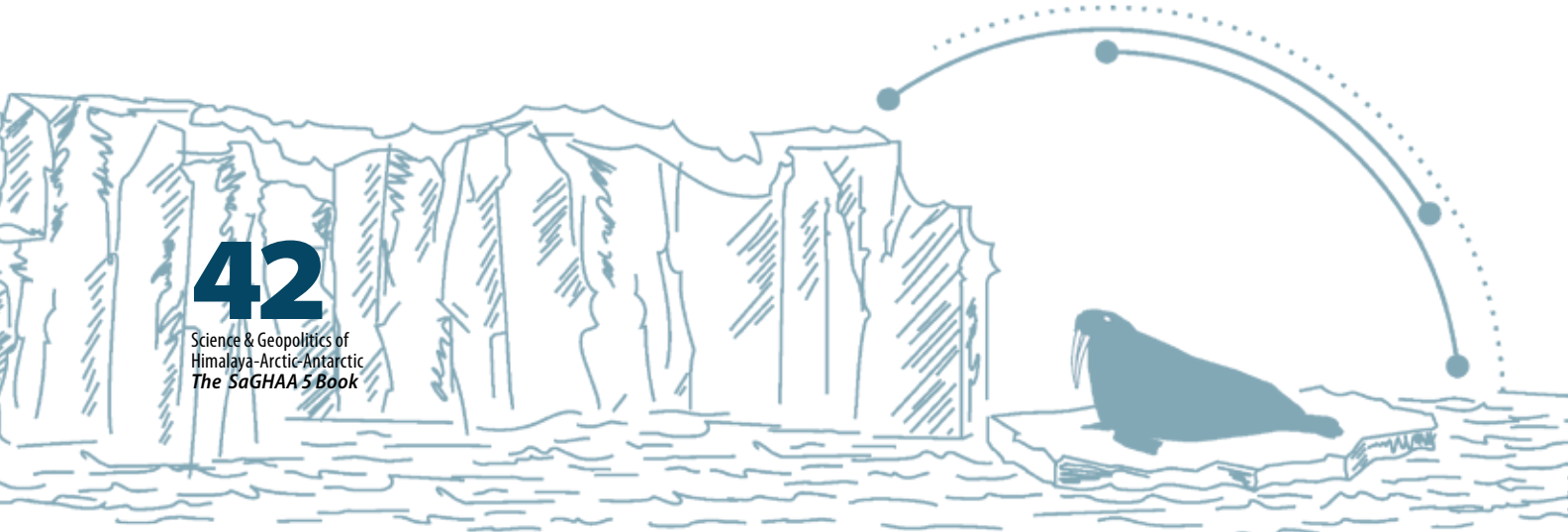
The Protocol on Environmental Protection to the Antarctic Treaty was signed in Madrid on October 4, 1991 and entered into force in 1998. At the heart of the Protocol is recognition that the Antarctic environment is something worth protecting. It designates Antarctica as a "natural reserve, devoted to peace and science" (Art. 2). Article 3 of the Environment Protocol sets forth basic principles applicable to human activities in Antarctica and Article 7 prohibits all activities relating to Antarctic mineral resources, except for scientific research. It also mandates Environment Impact Assessments (EIA) for all activities that may have any significant impact on the eco system. This protocol too has completed 27 years and has also proved to be a successful one.

Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) yet another significant tool came into force in 1982, as part of the Antarctic Treaty System. It was established mainly in response to concerns that an increase in krill catches in the Southern Ocean could have a serious effect on populations of krill and other marine life; particularly on birds, seals and fish which mainly depend on krill for food. The aim of the Convention is to conserve marine life. This does not exclude harvesting as long as such harvesting is carried out in a rational manner. The uniqueness of the CCAMLR rests on its development of "Ecosystem Approach" for regulation of fisheries and this approach also does not concentrate solely on the species fished, but also seeks to avoid situations in which fisheries have significant adverse effects on "dependent and related species".

Ozone Depletion over Antarctica:

Under the ATS, each party has enjoyed peaceful cooperation and freedom of scientific research. That research has contributed significantly to knowledge of the Earth and is contributing to the protection of the global environment. Environmental monitoring in Antarctica has, for example, led to the discovery of the seasonal depletion of atmospheric ozone over the Antarctic.

Antarctica was the first region where ozone hole was observed back in 1980's. To everyone's surprise Antarctica, which rests thousands km away from the industrial regions of the Earth had become the victim of ozone depleting gases like Chloroflurocarbons(CFCs). The stratospheric ozone layer protects life on the Earth by absorbing ultraviolet light,



which damages DNA in plants and animals (including humans) and leads to sunburns and skin cancer. Prior to 1979, scientists had not observed atmospheric ozone concentrations below 220 Dobson Units. But in the early 1980s, through a combination of ground-based and satellite measurements, scientists began to realize that Earth's natural sunscreen was thinning dramatically over the South Pole each spring. This thinning of the ozone layer over Antarctica came to be known as the Ozone Hole. Year-to-year fluctuations in area and depth are caused by variations in stratospheric temperature and circulation. Colder conditions result in a larger area and lower ozone values in the center of the hole. The ozone hole opened the world's eyes to the global effects of human activity on the atmosphere. Scientists found out that chlorofluorocarbons (CFCs)—long-lived chemicals that had been used in refrigerators and aerosol sprays since the 1930s—had a dark side. In the layer of the atmosphere closest to Earth (the troposphere), CFCs circulated for decades without degrading or reacting with other chemicals. When they reached the stratosphere, however, their behavior changed. In the upper stratosphere (beyond the protection of the ozone layer), ultraviolet light caused CFCs to break apart, releasing chlorine, a very reactive atom that repeatedly catalyzes ozone destruction(earthobservatory.nasa.gov.in).

Various agreements and protocols were signed to deal with the ozone hole trauma like Vienna convention for Protection of ozone layer(1985) and Montreal Protocol(1987), which was followed by several revisions. As a result of this, the Ozone hole over the South Pole is recovering(Center of Oceans, Rivers, Atmosphere and Land Science,IIT Kharagpur).

India's Presence in the Antarctica:

Indian Antarctic Programme, was initiated in 1981 when a select team of 21 members landed on the Antarctic coast under the leadership of Dr S Z Qasim, Secretary of Department of Environment and former Director of National Institute of Oceanography (NIO) with the aim of conducting scientific research in the frozen continent.

India's operates two year round research stations –Maitri and Bharati in Antarctica, while the first Station-Dakshin Gangotri- has since been buried under the snow and ice. India has a dedicated research Institution, National Centre for Polar and Ocean Research (NCPOR), a

premier R&D institute under Ministry of Earth Science, Government of India to deal with Polar studies and infra-structure development and maintenance. India also become a member of CCAMLR in 1986, occupying its chair for two years, following this it also became a member of the Scientific Committee on Antarctic Research (SCAR) in 1983 and again in the 1987 it ratified the Protocol on Environmental Protection to the Antarctic Treaty.

Fight against Climate Change: Geo-engineering solutions for Climate Changes

"To counteract anthropogenic climate change, several schemes have been proposed to diminish solar radiation incident on Earth's surface. These geo- engineering schemes could reverse global annual mean warming".[41] According to UN Climate Report, the world may increasingly look to geo-engineering to be adopted as temporary remedial measure as the world is heading towards dangerous level of warming. The report also observed that if mitigation efforts do not keep global mean temperature below 1.5°C, solar radiation modification can potentially reduce the climate impacts of a temporary temperature overshoot, in particular extreme temperatures, rate of sea level rise and intensity of tropical cyclones, alongside intense mitigation and adaptation efforts.

Geoengineering proposals fall into at least three broad categories:

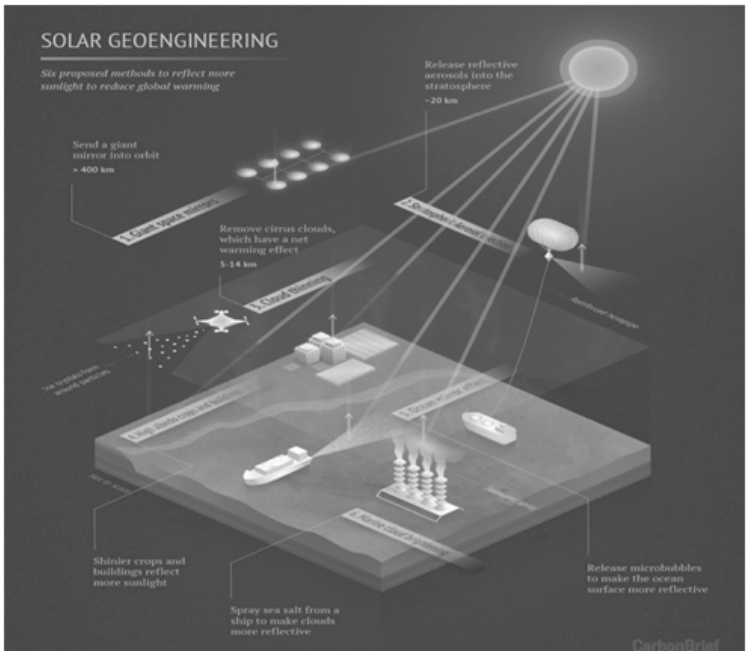
1. Reducing the levels of atmospheric greenhouse gases through large-scale manipulations (e.g., ocean fertilization or afforestation using non-native species).
2. Exerting a cooling influence on Earth by reflecting sunlight (e.g., putting reflective particles into the atmosphere, putting mirrors in space, increasing surface reflectivity, or altering the amount or characteristics of clouds) and
3. Other large-scale manipulations designed to diminish climate change or its impacts (e.g., constructing vertical pipes in the ocean that would increase downward heat transport).

The various types of geo-engineering include:

• Aerosol Injections

41. Govindawamy.B and Caldeira.K(2000); "Geoengineering Earth's radiation balance to mitigate CO2-induced climate changes".

Fig. 11: Solar Geo-engineering options



Source: Carbon Brief

- Marine Cloud Brightening
- High Albedo crops and buildings
- Ocean Mirror
- Cloud Thinning
- Space sunshades.

Geoengineering proposals however differ widely in their potential to reduce impacts, create new risks, and redistribute risk among nations. Techniques that remove CO2 directly from the air would confer global benefits but could also create adverse local impacts. Reflecting sunlight would likely reduce Earth's average temperature but could also change global circulation patterns with potentially serious consequences such as changing storm tracks and precipitation patterns.

SaGHAA – the think tank

Sustainable Action Group for Himalaya-Arctic-Antarctic (SaGHAA) – a think tank for science policy and advocacy of the three poles is emerging as a multi-stakeholder group in the country for varied members of the civil society, institutions, government bodies and private sector. Discussions and meetings with people from around the world to share their innovative research to help formulate polices for future trajectory of inclusive development has been the mandate of SaGHAA. The précis of each of its academic meetings are summed in books and briefs which are freely distributed. SaGHAA also showcases the current research infrastructure and provides a gamut of ideas and opportunities for young researcher to pursue.

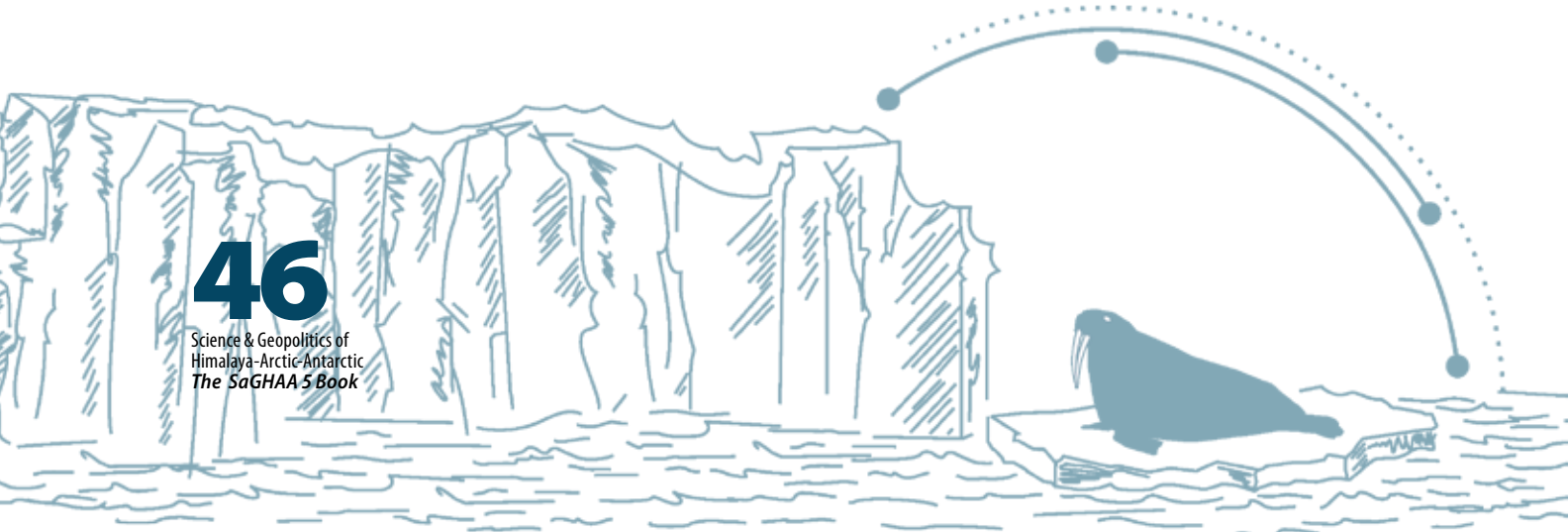
SaGHAA has held several national and international conferences since 2011. The conferences have been appreciated by national and international dignitaries and have witnessed participation of eminent delegates from various countries—Norway, Germany, Iceland, Sweden, United Kingdom, Australia, New Zealand, Russia and Chile. The conferences were disseminated over social media through live webcasts and other platforms.

First conceptualised in 2011, SaGHAA began as an international bi-annual conference committed to addressing one of the most challenging issues facing the global community. The event was named the Science and Geopolitics of Himalayas-Arctic-Antarctic – thefirst of its kind in India to focus exclusively towards the cyrospheric issues. It is the brainchild of LIGHTS and its members range from government officials, private sector executives, to members of the media and academics who belong to the highest level of decision and policy formulation strata in India. SaGHAA is an initiative under the LIGHTS Research Foundations, an NGO cum think tank focusing on science policy formulation since 2003.

SaGHAA has invited a broad spectrum of scientists, administrators, and students that reflects the growing awareness and concern of the country towards climate change. Every second year, global leaders in policy, business, media and civil society are hosted in New Delhi to discuss on a wide range of pertinent international policy matters.

The SaGHAA legacy...

2011 SaGAA was the first of the series where a consortium of scientists, policy makers and activists gathered to put forward balanced and enabling views on global positions outlining



the role of developing nations like India in Arctic and Antarctic.

2012 SaGAA was held in New Delhi which successfully bounded the session on geopolitics: UNCLOS and the Global Commons; Geopolitics of Global Realms ; Biotechnology and microbial resources in polar regions; Dynamics in Polar marine Biodiversity, Information exchange and Intellectual Property Rights, ozone Depletions and many more themes. It was SaGHAA's first international exposure to stakeholders involved in the poles.

2015 SaGHAA was the 3rd conference where the Himalayas was added which covered more broad areas related to the polar regions like diplomacy and related dilemma with respect to use of polar resources, emphasizing India's role and perspective. It stressed on the environmental risk in Antarctic region and ways of compensating such damages. It emphasized the role of Indian legislatives regarding the international laws on Arctic and Antarctic region.

2017 SaGHAA was another major milestone in the history of this conference, as it marked the broadening its scope as the think tank. The conference provided the necessary understanding about the importance of the emerging perspectives. It also put in perspective the role of a think tank such as SaGHAA as an addition to the existing data base.

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Section B

The People

Patrons

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Dr M. N. Rajeevan has contributed significantly in developing several application tools and prediction models for societal applications like long-range prediction models, gridded climate data sets, and diagnostic studies on the Inter-annual variability of southwest and northeast monsoons (tele-connections) for regional climate services. These models and application tools are being utilized by the India Meteorological Department for operational use. His currents research interests includes Monsoon prediction using coupled models, decadal variability and prediction , Land surface processes and monsoon predictability (role of land surface processes on monsoon variability and prediction) , Extreme climate events.

He is also the recipient of 2001 START Young Scientist Award for his paper in Journal of Climate, Young Scientist Award in Atmospheric Sciences by the Ministry of Earth Sciences (MOES), in 2007, 20th Biennial Mausam Award (2001) by Department of Science and Technology and many others. He is a Fellow of the Indian Academy of Sciences (IASc), Fellow of the Indian National Science Academy (INSA), Fellow of the National Science Academy of India (NASI) and a member of several international and national bodies including International Academy of Astronautics (IIA) High-level Adviser on Climate Services for the Commission on Climatology, WMO; Chairman, Council of the Regional Integrated Multi-Hazard Early Warning System (RIMES) for Africa and Asia, Bangkok etc.

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Prof. Ashutosh Sharma's research contributions are highly interdisciplinary, spanning a wide range in nanotechnology. He is the current Secretary of Department of Science and Technology, Government of India. He received his Ph. D. from the State University of New York at Buffalo (SUNYAB; 1988). He was a professor (1997¬), an Institute Chair Professor (2007¬) and the Head (2003¬-05) of Chemical Engineering and the founding Coordinator of Nanosciences Center and Advanced Imaging Center at IIT, Kanpur. He has a broad international experience as a research faculty at SUNY Buffalo School of Medicine (1988¬-90), visiting faculty at University of Texas at Austin, University of Western Ontario, University of Erlangen ¬Nuremberg and the World Class University Programme of South Korea and as a Member of the European Research Commission. Dr Ashutosh is recipient of numerous honours and awards including Bhatnagar Prize, the inaugural Infosys Prize in Engineering and Computer Science, TWAS Science Prize, Award of the Humboldt Foundation, J. C. Bose Fellowship, Homi J. Bhabha Award UGC, Syed Husain Zaheer Medal of INSA and the Lifetime Achievement Award of the Indian Science Congress among several others. He is an elected Fellow of INSA, The Indian Academy of Sciences, The National Academy of Sciences, and Indian National Academy of Engineering etc. He has published over 300 peer reviewed papers, filed over 15 patents, given over 100 invited or key note conference presentations.

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Shri C K Mishra led the Indian negotiations at important Forums such as United Nations Framework Convention on Climate Change (Conference of the Parties (COP)) to assess progress in dealing with climate change; Montreal Protocol on Substances that Deplete the Ozone Layer and various other multilateral events. He leads the government initiative for air pollution mitigation in Delhi and indeed all pollution control strategies for the country. He is also the administrative head of Forest & Wildlife conservation efforts in India. In more than 30 years of public service, C. K. Mishra has served as an administrator, policy-maker and public health strategist holding a wide range of assignments in the fields of Health, Education, Industry and Power.

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Dr. Shailesh Nayak is currently the Director of National Institute of Advanced Studies and a Member of the Governing Council of TERI. He has held the position of Chair, Earth System Science Organisation (ESSO) and Secretary to the Government of India for Ministry of Earth Sciences (MoES), between August 2008-2015. He has made outstanding contributions in improving advisory services related to potential fishing zones, ocean state forecast, and Indian Argo project. Dr Nayak was the Chairman of the Research Advisory Committee of the National Institute of Oceanography, Goa (2008-2015), Centre for Earth Science Studies (2007-2013) and Defence Terrain Research Laboratory, Delhi. He joined the Space Applications Centre, Indian Space

Research Organisation (ISRO) in 1978 as a scientist, and was subsequently elevated as the Director of Marine and Water Resources. Dr Nayak took over as the Director, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, in May 2006, where he set up early warning system for Tsunami and Storm Surges in the Indian Ocean. Dr Nayak is Fellow of the Indian Academy of Sciences, Bengaluru, the International Society of Photogrammetry and Remote Sensing (ISPRS), and elected Member of the International Academy of Astronautics. Dr. Nayak is recipient of IGU, Hari Narain Lifetime Achievement Award in Geosciences-2013, the ISCA Vikram Sarabhai Memorial Award 2012, the Bhaskara Award for 2009, the Indian National Remote Sensing Award for 1994, and the National Mineral Award for the year 2005. Dr Nayak is the President, Federation of Indian Geoscientists Associations and the President, Indian Geophysical Union, Hyderabad apart from several other national scientific bodies. Dr Nayak has published about 150 papers in reputed international and national journals.

HE Nils Ragnar Kamsvåg
Ambassador of Norway to India

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HE Nils Ragnar Kamsvåg is Norway's Ambassador to India. In a career spanning 35 years, Kamsvåg has worked as a diplomat in Beirut, Rome, Brussels, Beijing, Jerusalem and Belgrade before becoming Ambassador in New Delhi in 2015. In September 2015, he was elected as the Ambassador to the Republic of India after serving a five-year term as Ambassador to Serbia, Macedonia and Montenegro Royal Norwegian Embassy, Belgrade from 2010- 2015. In October 2006, he became the Deputy Director General, Section for West Balkan Affairs, MFA. Between 2005 – 2006, he was the Project Manager, Crisis Management, MFA while prior to this he served as the Norwegian Representative to the Palestinian Authority from 2003- 2005. He has also been the Minister Counsellor, Royal Norwegian Embassy, Beijing from 1997 –2001. Between the years of 1994 – 1997, he was the Counsellor, Norwegian Delegation to the European Union, Brussels.Before that he has also served as the Head of Information Division, MFA, Director of Public Affairs, Norsk Hydro, Senior Executive Officer, Political Department, MFA, Secretary of the Royal Norwegian Embassy, Rome and Secretary of the Royal Norwegian Embassy, Beirut. He has pursued his M.A. in History from the University of Oslo.

Dr. P. S. Goel
Raja Ramanna Chair Professor
Indian Space Research Organisation, HQ
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Dr. P. S. Goel, former Secretary to Government of India, Ministry of Earth Sciences is currently Raja Ramanna Chair Professor at NIAS, Indian Space Research Organisation (ISRO) Bangalore. He has contributed significantly to the development of magnetic altitude control system, mission planning for remote sensing, communication and scientific missions and authored over 100 research papers in referred journals and conferences. Dr Goel developed the spin axis orientation system, Bhaskara I & II satellites, magnetic control for spinning satellites, momentum biased 3-axis control system for APPLE, zero momentum based 3¬axis control system for IRS. V, and, configuration momentum biased altitude control system for highly stabilised INSAT-2. Dr Goel developed a very agile control system with step and stare capability to spot imaging mission TES and guided the evolution of re-entry capability for SRE Mission. Dr. Goel was Chairman, Spacecraft System Advisory Board for IRS-1, Project engineer AOCS for APPLE and Associate Project Director INSAT-I. He was Head, Control System Division, Group Director AOCS, Deputy Director Mission and Control Area, Associate Director of ISAC and was Director ISRO Satellite Centre from 1997 to 2005. He was DRDO Chair at RCI/ DRDO Hyderabad pursuing space for National Security. Dr Goel was awarded Padma Shri in 2001. He has received several awards including Life Time Achievement Award of the Aeronautical Society of India and Distinguished Scientist Award of ISRO. He is fellow of Indian Academy of Sciences, Bangalore, National Academy of Sciences, Allahabad; Indian National Science Academy (INSA), New Delhi; Institution of Electronic & Telecommunication Engineers, New Delhi; Aeronautical Society of India, Bangalore and Third World Academy of Sciences. He has recently been honoured with Fellowship of Indian Society of Systems for Science and Engineering.

P

Section B

The People

Advisory Committee

Dr. B. Meenakumari
Former Chairperson
National Biodiversity Authority
Chennai

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Dr. B. Meenakumari has contributed immensely to the development of deep sea demersal trawls and towards improved material for lobster making traps—helping the traditional fishermen gain better economic returns. She has popularised new and cheaper materials like polypropylene and nylon monofilament for gill net fisheries in both inland and marine sector. She is responsible for research and development / policy support and decisions in the inland and marine fisheries sector, fish production from aquaculture and fishing industry in India. She commercialised combination of wire ropes for deep sea demersal trawls thus substituting import of the ropes. Dr Meenakumari is actively working to conserve resources for the sustainable development of Indian fisheries and is interested in impact assessment and environmental monitoring. She has worked on Ecobiology of Fouling and received a gold medal. She is the recipient of prestigious awards like the Young Scientist Award by Kerala State in 1989, Panjab Rao Desmukh Women Scientist Award 2002 instituted by ICAR, the Marie Curie Mahila Vijnana Puraskar, 2010, the Bhoominirman Award-2011, and Dr R. S. Paroda Gold Medal for outstanding contributions in Fisheries, 2012. She has published more than 180 articles in reputed national and international journals.

Dr. K. J. Ramesh,
Director General of Meteorology
India Meteorological Department
Ministry of Earth Sciences, New Delhi
kj.ramesh@nic.in

Dr K. J. Ramesh is the current Director General of Meteorology in India Meteorological Department. He obtained his Ph D from IIT Delhi on Monsoon Dynamics and M.Sc. (Meteorology) from Andhra University. He specialized in Numerical Weather Prediction that includes hazard and climate risk assessment and early warning. He has worked on Model Diagnostics, Monsoon Dynamics and Disaster Mitigation Modelling.

He was involved in Monsoon Research at IIT Delhi for 10 years followed by Group Head position in NCMRWF and Head Disaster management Unit of Government of Andhra Pradesh. In Ministry of Earth Sciences he was heading Atmospheric Science Services and Climate Change Research Programme Development before taking over as DGM, IMD. He is an elected Fellow of Andhra Pradesh Academy of Sciences, elected Member of National Academy of Sciences, Allahabad and has more than 50 papers in peer reviewed journals to his credit.

Dr. Akhilesh Gupta
Adviser & Head, SPLICE & Climate Change Programme
Department of Science & Technology
Government of India, New Delhi
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Dr. Akhilesh Gupta is currently heading the Climate Change Programme (CCP) of DST coordinating two National Missions on Climate Change under National Action Plan on Climate Change. He obtained his PhD degree in Atmospheric Sciences from IIT, Delhi and has worked in the India Meteorological Department; National Centre for Medium Range Weather Forecasting and Disaster Management Cell of DST during 1985-2007 in various capacities. During 2007-09, Dr Gupta was Adviser to the Union Minister for Science and Technology and Earth Sciences.

Dr Gupta was Secretary, University Grants Commission (UGC) during 2012-13. He was a member of National Coordination Team, which drafted India's National Action Plan on Climate Change in 2008. Dr Gupta is a member of over 70 national level committees in various capacities and is also a Fellow of Indian National Academy of Engineering (INAE) and Indian Meteorological Society. He was awarded D.Lit (Honoris Causa) by JRH University in 2013 and Honorary Professorship by Amity University Rajasthan. He has published over 110 research papers in various national and international journals. He is co-editor of 3 books, author of over 200 articles and nearly 300 reports.

Dr. S. C. Shenoi,
Director, ESSO- Indian National Centre for Ocean Information Services (INCOIS)
Hyderabad, Government of India
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Dr. S. C. Shenoi's professional interests include observational oceanography, ocean currents, impact of oceans on monsoons and satellite oceanography. He played a lead role in DST-Arabian Sea Monsoon Experiment (ARMEX), which changed our traditional view from a passive role for the ocean in monsoonal processes to an active role in the monsoonal air-sea coupling. After the tsunami struck the Indian coast in 2004, he coordinated the research that described quantitatively the tsunami off the Indian coast and enabled an improved estimate of the extent of the tsunami source region. He obtained his M.Sc. (Physical Oceanography) and Ph.D. from Cochin University of Science & Technology, Kochi. Dr Shenoi has more than 30 years of research experience in Physical Oceanography. He was a senior member of the group that carried out hydrographic observations during 1987-1994 to map the seasonal cycle of circulation off the Indian coast. He also made limited current-meter observations to provide a quantitative description of coastal currents. Prior to joining INCOIS, he was leading a major programme making direct current measurements off the Indian coast to enable a quantitative description of the variability within a season and across years, marking a paradigm shift in our knowledge of

the seas around India. He has received the National Award in Ocean Science & Technology in 2018. He is currently the Co-chair of International Indian Ocean Expedition-2. He is a Fellow of Indian Academy of Sciences and has authored/co-authored more than 70 research papers in journals of international repute.

Dr. M. A. Atmanand,
Director of National Institute of Ocean Technology (NIOT)

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Dr. M. A. Atmanand has done pioneering work in the area of deep sea technologies in India. An instrumentation and control engineer by profession, he took Master's and Doctorate degrees from Indian Institute of Technology, Madras. He led a team of engineers for the design and development of underwater crawler for deep sea operation. The team developed the in-situ soil tester, which was tested at a depth of 5200 m in the Central Indian Ocean Basin. It was under his supervision that the design of Electrical, Instrumentation and Control system of the India's first Remotely Operable Vehicle was completed. This was later tested at a depth of 5289 m under water. He has also guided various indigenisation programmes for ocean observation and under water systems. His areas of interest include development of underwater vehicles with specific reference to their control; development of components for deep sea applications; and development of test protocols for testing of deep sea devices. He received the IEEE-Oceanic Engineering presidential Award in 2016, National Geoscience award 2010 from Ministry of Mines and the International Society for Offshore and Polar Engineers (ISOPE) Ocean Mining Symposium Award - 2009. He is Associate Editor of IEEE Journal of Oceanic Engineering. He has widely travelled in capacities like technology transfer, as part of delegations etc. to various countries. He received United Nations Fellowship in 1985 – 86 and is the founder Chair of IEEE Oceanic Engineering Society in India. He has served IEEE Madras section in various capacities and he is the current Chair. Dr Atmanand has presented and published more than 100 papers in international journals, international conferences, book chapters, national conference and others.

Dr M. Sudhakar
Director
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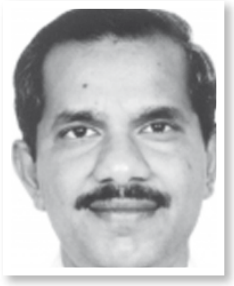
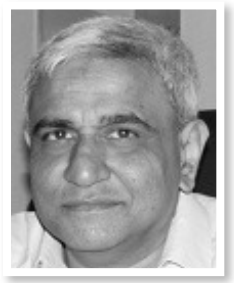
Dr M. Sudhakar has served two premier research institutions of the country — National Institute of Oceanography (NIO) & National Centre for Antarctic and Ocean Research (NCAOR) in Goa, before taking charge of Director, CMLRE, Kochi. A veteran Oceanographer, he has occupied various positions such as project leader and scientist and has spent more than 1500 days at sea on-board research vessels, as leader of expeditions to Southern Ocean and Antarctica. He represented India at the Preparatory Commission for the United Nations Law of the Sea (PrepCom) and was an Elected Member of the Legal and Technical Commission (LTC) of the International Seabed Authority (ISBA) for the term 2007-2011 and (2012-16). Dr Sudhakar was also a member of Scientific Committee on Ocean Research (SCOR), ICSU, serving for second term until 2014. He was a visiting scientist to the Aachen University of Technology, Germany; a resource person of the International Ocean Institute, Malta; Member, National Steering Committee for Science and Astronomy Olympiads and Member, Scientific Committee, International Geological Congress (2020 to be held in India). He was the 'Commissioner General' of Govt. of India for the Yeosu (World) Expo 2012 held in Republic of Korea. He published over 60 research papers in referred International/National Journals, books and equal numbers presented in conferences and seminars.

Dr. M. Ravichandran
Director
ESSO-National Centre for Polar and Ocean Research,
Vasco da Gama, Goa *mravi@ncaor.gov.in*



Dr. M. Ravichandran is the current Director of National Centre for Polar and Ocean Research Goa. He has worked as a Scientist in Indian Institute of Tropical Meteorology (IITM) in the field of Atmospheric Science, National Institute of Ocean Technology (NIOT) in the field of Ocean Observing System (Marine Meteorology) and Indian National Centre for Ocean Information Services (INCOIS) in the field of ocean observing System and ocean modelling. His research interests include atmospheric physics and ocean dynamics, marine meteorology and air-sea interaction, ocean observing systems and ocean modelling among others. He is Co-Chair, CLIVAR/IOC-GOOS, Indian Ocean Region Panel; Member, International Argo Steering Team, Member, SIBER (Sustained Indian Ocean Biogeochemical and Ecological Research) Scientific Steering Committee. He is also the current Vice-Chair of Scientific Committee on Antarctic Research (SCAR).

Prof Ravi S Nanjundiah
Director,
Indian Institute of Tropical Meteorology (IITM) *director@tropmet.res.in*



Prof Ravi S Nanjundiah is currently the Director of IITM, Pune. He has also served as the Chairman, Centre for Atmospheric & Oceanic Sciences, Indian Institute of Science. His areas of expertise includes Monsoon variability and predictability. He has done his Phd on atmospheric science from Indian Institute of Science (1992). He has also received awards like Nvidia Innovation Award (2013) and Sir C V Raman Young Scientist Award by IISc (2000).

Dr Sunil Kumar Singh
Director
National Institute of Oceanography, Dona Paula, Goa

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Dr Sunil Kumar Singh is a geochemist and the director of the CSIR - National Institute of Oceanography. He is known for his studies on low temperature elemental and isotope geochemistry and biogeochemistry of trace elements and isotopes in the Indian Ocean. His researches are reported to have assisted in widening the understanding on the impact of origin and evolution of the Himalaya on the ocean biogeochemistry and the climate change. Dr Singh's studies have been documented in several peer-reviewed articles. He completed his bachelor and master studies in BHU, Varanasi and pursued PhD from Physical Research Laboratory, Ahmedabad. He spent about three years in France as post doctoral fellow. He worked at PRL as scientist for about 15 years. Dr Singh, is a former Scientific Steering committee member and the incumbent member of the Data Management Committee of GEOTRACES, an international forum for research on the marine biogeochemical cycles of trace elements and isotopes. He is the coordinator of the GEOTRACES-India programme. He is a recipient of the National Geoscience Award and an elected fellow of the Indian National Science Academy and Indian Academy of Sciences. He has been awarded the Shanti Swarup Bhatnagar Prize for Science and Technology, one of the highest Indian science awards for his contributions to Earth, Atmosphere, Ocean and Planetary Sciences in 2016 by the Council of Scientific and Industrial Research, the apex agency of the Government of India for scientific research. He is serving as associate editor for several international journals.

Dr. Kalachand Sain
Director
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Dehradun

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Dr. Kalachand Sain did his Ph.D. in Controlled Source Seismology from the Osmania University (CSIR-NGRI), Hyderabad. He is the Chief Scientist and Head Seismic Group at CSIR-NGRI, and working on seismic attributes, travel time & full

waveform tomography, AVO modeling, impedance inversion, prestack depth migration, rock physics modeling. He has been recognized by a number of awards/fellowships/ honours notable among them are Fellow of National Academy of Sciences, Telangana State Academy of Sciences and awards like Distinguished Alumnus Award of IIT (ISM), AP Scientist Award, Swarnajayanti Project Award by DST among others. He is the Chief Scientist & Professor at Academy of Scientific & Innovative Research and is a member of numerous Committees like the Bureau Member of International Lithosphere Program under IUGG Hon. Secretary of Indian Geophysical Union, Indian National Gas Hydrates Program along with been a part of Editorial Boards of International Journals such as Journal of Geological Society of India, Journal of Geophysics & Remote Sensing etc.

Shri Naresh Kumar
Director
Snow and Avalanche Study Establishment (SASE)

Shri Naresh Kumar *director@sase.drdo.in* assumed the charge as the Director of Snow and Avalanche Study Establishment(SASE), H.Q.Manali and Research and Development Centre, Chandigarh on 1st March 2018. Prior to his appointment as Director SASE, he has served as Associate Director of Research & Development Establishment (R&DE), Pune, where he has contributed in design and development of Military Bridging Systems, RDE 40M Aluminium Alloy, productionization of Sarvatra Bridging System and many more other projects. He has three patents to his credit on multi-span and vehicle mounted extendable span re-deployable bridges and authored more than 15 publications in national/international symposiums and journals of repute. He is Fellow of Institution of Engineers (India). He has been awarded prestigious DRDO scientist of the year award in 2014 for outstanding contribution in design and development of Military Bridging Systems.

Dr. Lokesh Kumar Sinha
Director
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Dr Lokesh Kumar Sinha, Scientist-G, is the Director, Defence Terrain Research Laboratory (DTRL) since 2018. He has obtained MSc in Geology in 1984 and PhD in 1988 with specialisation in Structural Geology from Banaras Hindu University (BHU), Varanasi. He has specialisation in spectroscopy from BHU in 1985 and in remote sensing from Indian Institute of Remote Sensing (IIRS), Dehradun in 1991. Dr LK Sinha joined DRDO on 27th July 1989 as Scientist B at DTRL, Delhi. He has more than 20 publications in peer-reviewed journal and conferences of repute. He has to his credit two patents on terrain evaluation and projectile based tool for evaluation of terrain condition remotely. He has authored chapter in book on Landslide Hazard Zonation mapping and technical reports on Area Analysis Studies published by Military Intelligence. He has more than 30 years in terrain studies with research interest including Structural Geology, Terrain Diagnosis, Disaster Mitigation and Management, 3-D Modelling, Trafficability Analysis, Hyper-spectral Remote Sensing, Optical and Thermal Image analysis, Infiltration Modelling and Groundwater prospecting

Dr. N Purnachandra Rao
Director, ESSO-National Centre for Earth Science Studies (NCESS)
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Dr. Purnachandra Rao's area of expertise relate to seismic ambient noise correlation tomography, reservoir triggered seismicity and earthquake forecast, deep drilling for earthquake studies, seismic hazard assessment and microzonation studies, moment tensor inversion studies for

earthquake source mechanism and seismic waveform modelling to study earth's internal structure , Stress field and seismotectonics. Prior to taking over new position at NCESS, he has worked at National Geophysical Research Institute (NGRI) from 1989 to 2017 at various scientific positions. He is the proud recipient of National Geoscience Award (2016) from Ministry of mines, Government of India; Alexander von Humboldt (Avah) fellow, Germany; Visiting Professor, Univ. of Tokyo, Japan; Professor, Academy of Scientific Innovative; Raman Research Fellow at University of California, USA and many more. Dr Rao is Fellow of Geological Society of India, Andhra Pradesh and Telangana Akademi of Sciences, Member of Editorial Board, Journal of Asian Earth Sciences, Advisory member of Editorial Board, Indian Journal of Earth Sciences Studies etc.

Dr. R. C Mehrotra
Director
Birbal Sahni Institute of Palaeoscience
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Dr. R. C Mehrotra is a Scientist G and is holding the additional charges as the Director of Birbal Sahni Institute of Palaeoscience. He has been associated with the institute as a scientist since 1996, prior to which he has also served as Scientific Assistant. He has completed his Phd in Botany from Lucknow University. His research interest includes topics like Tertiary plant megafossils, palaeoclimate, CLAMP analysis . He has also published in more than 150 research papers in various national and international journals. He is also the member of prominent international associations like the International Association of Paleobotany, International Association of Wood Anatomists etc.

Dr. Vijay Kumar
Scientist F
Ministry of Earth Science
New Delhi
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Dr Vijay Kumar's area of research includes groundwater modelling, analysis of hydro-meteorological variables, climate change, spatial modelling, lake hydrology etc. At MoES he is responsible for monitoring and coordination of programmes related to Polar Science & Cryosphere (comprising Arctic, Antarctic and Himalaya) as also the programmes on Southern Ocean, Water Cycle, Ocean Survey & Mineral Resources (Geo-scientific studies of the Exclusive Economic Zone, Delineation of India's Continental shelf, Gas Hydrates Exploration, Poly-Metallic Nodules (PMN), and Studies on Hydrothermal Sulphides) etc. He obtained his Ph.D. in Water Resources Engineering from the Indian Institute of Technology, Delhi. Prior to joining MoES, he has worked in National Institute of Hydrology (NIH) where he contributed significantly in many consultancy and sponsored projects. He has conducted many specialized training courses hydrological aspects for field engineers. He has more than 100 papers in various International and National journals, conferences etc. to his credit.

Dr. Gufran Beig
Scientist G & Program Director
System of Air Quality and Weather Forecasting And Research (SAFAR)
Indian Institute of Tropical Meteorology (IITM)
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Dr. Gufran Beig's field of research interest includes Air Quality, Weather and Climate Sciences with special focus on short Term Climate Predictions, changing climate with changing Atmospheric Chemistry and Impact of Climate and Air Quality on Health and Agriculture. He was also involved in the development of the first ever Air Quality Forecast System for Indian metro cities called the SAFAR. He was

also the first Indian Citizen to win the WORLD METEOROLOGICAL ORGANIZATION (WMO, United Nations). He is also the recipient of coveted SHANTI SWARUP BHATRNAGAR AWARD in the discipline of Earth, Atmosphere, Ocean & Planetary Sciences conferred by the Council of Scientific and Industrial Research, Govt. of India for outstanding scientific contributions.

Dr Virendra Mani Tiwari
Director
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Dr V. M. Tiwari is currently the Director of CSIR-National Geophysical Research Institute. His research interests primarily focus on deciphering subsurface mass distribution and mass transport relevant to a wide range of scientific and societal applications such as elucidating structure and dynamics of different geological settings in Indian lithosphere, variation in water storage over Indian subcontinent and mapping of sub-basaltic sediments. Besides he has contributed for many well cited research papers in leading national and international journals. He has also held other important positions like Director of National Centre for Earth Science Studies (MoES), Professor at AcSIR, NGRI along with holding position of Scientist with CSIR-NCESS too. He has also contributed significantly to the projects of Oil and Mineral Industries. He also holds membership of several national and international associations like Indian Geophysical Union, Association of Exploration Geophysicists, India etc along with being conferred with awards for his contributions in this field of Geophysics.

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Section B

The People

Organising Committee

Dr. Rasik Ravindra
Fprmer Director
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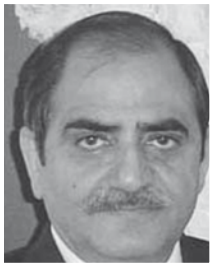

Dr. Rasik Ravindra held the position of the Director of NCAOR between January 2006 and August 2012 after relinquishing the post of Deputy Director General in Geological Survey of India, an organization that he served from 1971 to 2005.

A veteran Antarctican, he participated in Indian Expedition to Antarctica in 1987-88 for the first time and subsequently led Ninth Antarctic Expedition in 1989-91, visiting the icy continent again in 1996-97, 2003-04, 2007 and 2009 in various capacities for specific assignments, contributing to different facets of Antarctic science, logistics and policy of this mission. He has led the first Indian Expedition to South Pole and the first Indian Arctic Expedition. He was Chairman of the DST constituted Program Monitoring Committee on "Dynamics of Himalayan Glaciers from 2007 to 2012 and was appointed Chair, Panikkar Professor in October 2012 by Ministry of Earth Sciences. He has served as an elected Member of the U N Commission on Limits of Continental Shelf for 2014-2017 Term. He has received National Award for Polar Sciences and Cryosphere, 2013, National Mineral Award- 1990, Antarctic Award- 2002, H. N. Siddiqui Gold Medal from IGU in 2011, Prof Prem Bahadur Verma Memorial Lecture award , Prof R C Mishra Memorial Gold Medal 2017 and DR W D West Oratory Award, 2018.

Dr. Gopal Raman Iyengar
Adviser and Scientist G
Ministry of Earth Sciences (MoES)
Government of India
gopal.iyengar@nic.in

Dr. Gopal Raman Iyengar is involved in Planning and Coordination of atmospheric science programmes in MoES. His area of expertise includes weather and climate modelling. Prior to joining MoES, he has worked in National Centre for Medium Range Weather Forecasting (NCMRWF) from 1990 to 2015 in various scientific positions.

Dr. Ajit Tyagi
Air Vice Marshal (Retd.)
Former Director General Meteorology
India Meteorological Department

ajit.tyagi@gmail.com

Dr. AjitTyagi, is currently Senior Advisor at Integrated Research and Action for Development, New Delhi and Member of Monsoon Panel of World Meteorological Organisation. He has served as Koteswaram Chair Professor with Ministry of Earth Sciences, Director General of Meteorology, India Meteorological Department and Assistant Chief of Air Staff (Meteorology), Indian Air Force. He was Permanent Representative of India (2009-2013) with World Meteorological Organisation and member of its Executive Council. He has served on the Governing Councils of SAARC Meteorological Research Centre, Indian Institute of Meteorology and National Atmospheric Research Laboratory.

Prof Tyagi played key role in modernisation of India Meteorological Department and brought significant improvements in weather forecasting and warning of high impact weather events in the country. Under his leadership Agro Advisory Services were extended to 640 districts and Nowcast system was implemented during Commonwealth Games 2010. He was the member of Core Group constituted by National Disaster Management Authority engaged for preparing Guidelines for the management of Tropical Cyclones and Urban Flooding. He has been Chairman of Governing Board of SAARC Meteorological Centre (SMRC) Dhaka and played important role in capacity building in south Asian region and organizing South Asian Climate Outlook Forum. As a member of Executive Council of WMO, Dr Tyagi has contributed to the cause of promoting weather, environmental and climate services worldwide. He has been involved in strategic and operational planning of WMO and developing Global Framework of Climate Services. Dr Tyagi has been actively involved in operational meteorology and has about 100 research papers and technical reports to his credit. His areas of expertise are High Impact Weather, Disaster Risk Reduction, Public Weather Service and Climate Change. Dr. Tyagi has been conferred with Vishistha Seva Medal by President of India for his distinguished services and leadership.

Ms. Sulagna Chattopadhyay
President, LIGHTS
Founder & Editor, Geography & You
editor@geographyandyou.com

Ms. Sulagna Chattopadhyay is known for internationally reputed journo-magazine on environment and development titled 'Geography and You', (G'nY) that she founded in 2001. An M.Phil. from Jawaharlal Nehru University, New Delhi, she has published 123 issues of the magazine so far. She is also a founding President of an NGO, Learning in Geography, Humanities, Technology and Science (LIGHTS) and has been organising national and international conferences/ seminars, notable among these are: Round table conclave on seas and oceans around India, National Conference on Science & Geopolitics on Arctic and Antarctic (SaGAA) in 2011, SaGAA in 2012, SaGHAA in 2015 and SaGHAA in 2017. The LIGHTS has organised a multi-city GIS training programme for school teachers in seven locations under her leadership. She was nominated as the Member of the Working Group for Disaster Management in Planning Commission in 2011. She also won an Environmental Documentary Short Film Contest, STL-2 : 2015 for her short film titled 'O Bhai Saab'. Sulagna has edited 12 books, prominent among them are 'the Scientific and Geopolitical Interests in Arctic and Antarctic' co-edited with Dr R Ramesh and Dr M Sudhakar in 2103 and the' Science and Geopolitics of White World co-authored with Dr P S Goel and Dr Rasik Ravindra' published by Springer in 2017.

Dr. Mirza Javed Beg
Scientist-G and Group Director (Expeditions & Operations), ESSO-National Centre for Antarctic and Ocean Research (NCAOR), Goa
mjbeg@ncaor.gov.in

Dr. M. Javed Beg has contributed significantly to Indian Antarctic Program by organizing logistics, development of infrastructure facilities at Indian Research Stations and facilitating research output of scientists. He was the project manager for construction of third Indian Research Station-Bharati in Antarctica. He is a geologist by profession and holds

MBA degree from Maastricht School of Management, The Netherlands. Prior to joining NCAOR, he served in Geological Survey of India where he conducted geological investigations in J&K Himalayas and Antarctica. He has participated in several Indian Expeditions to Antarctica including the First Indian Expedition to South Pole and has undertaken geological and glaciological studies including those on melt water lakes of Schirrmacher and Larsemann Hills areas. Recipient of National Mineral Award (National Geoscience Awards) 2004. He is the current Vice Chair of Council of Managers of National Antarctic Programs (COMNAP) and has several research publications in peer reviewed journals.

Dr. Vimlesh Pant
Associate Professor
Centre for Atmospheric Science
IIT Delhi

vimlesh@cas.iitd.ac.in

Dr. Vimlesh Pant has obtained his PhD degree in Atmospheric and Space Sciences from the University of Pune in 2009. He has participated in several national and international scientific expeditions over land, sea, and airborne platforms. He also participated in thewas a member of the 24th Indian Scientific Expedition to Antarctica (2004-05) and conducted study on the marine aerosols over the Indian Ocean and at Maitri, Antarctica. He was also a member of the first Pilot Expedition to the Southern Ocean (PESO) conducted in Dec 2003 - Mar 2004. He has carried out research on marine aerosol size distributions in relation to the meteorological phenomenon such as cyclones, sea fog, snowfall, blizzard etc. Apart from the research in aerosol science, Dr. Pant worked in the areas of physical oceanography and ocean observations at the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad .Dr. Pant served as Scientist-C at Aryabhatta Research Institute of Observational Sciences (ARIES, DST Govt. of India). His research interests include physical oceanography, air-sea interaction, ocean modelling, and marine aerosols.

Dr. N. Prasad
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Dr. N. Prasad is currently Director, Parliamentary & Administrative Research Institute, constituted under LIGHTS Research Foundation. The Institute is engaged in research and training in parliamentary processes and holding capacity building programmes for Central and State government officials. Formerly Additional Director at Rajya Sabha, Parliament of India, Dr Prasad has obtained his Ph.D. from the Centre for International Politics, Organisation and Disarmament, Jawaharlal Nehru University, New Delhi in 2001. He has two books to his credit and has been the honorary editor of Bhugol aur Aap, an environment and development magazine in Hindi, from its inception in 2002.

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Section B

The People

Speakers

Mr. Cristian Agustin Davis Acosta
Third Secretary
Foreign Service , Political and Economic Affairs
Embassy of Chile in India

Mr. Cristian is currently the Third Secretary, Political and Economic Affairs, Foreign Service. He has also acted as the Third Secretary, Desk Analyst in the direction of the Middle East and Africa, Ministry of Foreign Affairs. He also possesses experiences of diplomatic practices in General Direction of Consular Affairs and Immigration, Legal Consular Department, Ministry of Foreign Affairs, Chile. Apart from his role in the diplomatic field, he also holds rich experiences as Assistant in course in Administrative Law, Practical Legal Assistance to Enterprises and Legal Profession in the University of Chile. He is also a Lawyer by education.

Dr. Rajesh Asthana
Deputy Director General
Geological Survey of India
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Dr. Rajesh Asthana, Deputy Director General, Geological Survey of India has done pioneering work in Ice core and systematic lake sediment coring in Antarctic. He also specializes in crucial Antarctic logistics. As a part of 2 members Team, in 1992, he raised ice cores in Antarctica that generated significant palaeoclimatic data from Antarctica by Indian Scientists. Dr. Asthana remained associated with Indian Antarctic Programme in various capacities in eight Antarctic Expeditions, once as the Leader and Station Commander in 24thISEA and as the Voyage Leader in 3

consecutive expeditions from 29th to 31st ISEA along with supervision of the construction and commissioning of third Indian Antarctic Research Station – Bharati at Larsemann Hills. He was a nominated Indian Member in the Secretariat during XXX Antarctic Treaty Consultative Meeting in 2007. He has published 12 research papers in International Journals, 22 in National Journals and Book chapters. Currently, he is holding the charge of Regional Mission Head – III and an additional charge of Mission – I at Northern Region of Geological Survey of India Lucknow. He is also a recipient of National Geoscience Award.

Dr. D. K. Aswal
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Dr. D. K. Aswal , is currently the Director, CSIR-National Physical Laboratory, New Delhi. He has served as the Secretary of Atomic Energy Education Society, Mumbai and as Head, Thin Films Devices Section, Technical Physics Division, Bhabha Atomic Research Center (BARC), Mumbai. He obtained Ph.D. in Physics from Mumbai University for his work on "Thin films of high temperature superconductors", and subsequently carried out post doctoral research work at Research Institute of Electronics, Hamamatsu, Japan. His current area of research interests includephysics of organic films and their applications for solar cells, conducting polymer films for flexible electronics, thermoelectric power generators and gas sensors & electronic nose. He has edited books and also contributed to several book chapters and published over 200 peer reviewed journal papers. He is recipient of several national and international awards/ fellowships.

Mr. Agnew David
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Convention for the Conservation of Antarctica
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Mr. David Agnew took up the post of Executive Secretary of CCAMLR in April 2018. His previous posts include Science and Standards Director at the Marine Stewardship Council (MSC), Fisheries Director at MRAG Ltd, Senior Lecturer at Imperial College London, and Data Manager at CCAMLR. He has taken a number of international leadership roles, including Chair of the CCAMLR Scientific Committee, Chair of the MSC Technical Advisory Board and Board member of the International Seafood Sustainability Foundation.

Dr. Agnew has extensive experience working with global fisheries science and management issues, including stock assessment, ecosystem-based fisheries management and fisheries governance. He has more than 20 years experience working with CCAMLR, is an acknowledged expert on Antarctic fisheries and Illegal, Unreported and Unregulated (IUU) fishing. He is a visiting Professor at the University of Florida and the University of Tasmania, and a Fellow of the Marine Biological Association.

Dr. Mahesh S Badanal
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Dr. Mahesh Badanal has done his Ph. D. in Marine Sciences from Goa University on 'Evolution of Surface Hydrography in the eastern Arabian Sea during the Late Quaternary. He is currently working as a Project Scientist B, at National Centre for Polar and Ocean Research (NCPOR), Goa since 2011. He has also worked as a Project Assistant, at National Institute of Oceanography, Goa.. He has received awards and recognitions including"Yuva Vignanashree" award for Environmental awareness and Sundarlal Bahuguna Environmental Award for contribution towards Environmental Science. He has a first-hand experience of handling Inductively Coupled Plasma-Atomic Emission Spectroscopy, at National Institute of Oceanography, Goa. He has participated in several Antarctica bounded expeditions as a scientific member .He has also been a member of the organizing committees for the scientific workshops concerning Polar Sciences. Several of his papers have been published in SCI Journals.

Dr. Rakesh Bhambri
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Dr. Rakesh Bhambri is currently working as Scientist B at Centre for Glaciology, WIHG. He did his Phd in Analysis of Glaciers Changes in Garhwal Himalayas using Remote Sensing and GIS from WIHG. He has also a rich teaching experiences in colleges in Karnal. He has also worked as GIS Experts and Analyst with both governmental and private organisations. He has been a part of many Research expeditions to several glaciers in the Himalayas. He has also been a Scientific Editor of Journal of Glaciology , International Glaciology Society including authoring several research papers , peer reviewed articles and projects .

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Dr. M. R. Bhutiyani obtained his M Sc degree in Geology and PhD in Environmental Science from University of Pune on "the response of glaciers to the climate change and its implications on NW Himalayas". Starting his career as a lecturer in Geology in Science College, Karad, he worked as a geo-scientist in Groundwater Surveys and Development Agency (GSDA) of Government of Maharashtra and in Geological Survey of India. He joined DRDO as Scientist 'B' in December 1984 at Snow and Avalanche Study Establishment (SASE), Manali and headed Hazard Assessment and Forecasting Division in Snow and Avalanche Study Establishment (SASE) in Chandigarh. He has also worked as Head of the Department of Geology in CME, Pune. He has authored many research papers in various high impact factor international journals of repute and national journals, international and national conferences and also book chapters on this subject.

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Ms. Asha Devi is currently with CMLRE, her research interests includes Plankton Ecology (Microzooplankton and Mesozooplankton) in the tropical and polar waters, Trophic interactions between the microbial and classical food webs and Systematics of zooplankton community especially ciliates. She is also involved in several projects like Marine Ecosystem Dynamics of eastern Arabian Sea, Plankton Ecology of Arctic Fjord, Monitoring and Modelling of Marine Ecosystem.

Dr. Sanjay Chaturvedi
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Dr. Sanjay Chaturvedi specialises in the area of theory and practices of geopolitics; with special reference to Polar Regions and the Indian Ocean Region. His current area of research is geopolitics of climate change. He was awarded the Nehru Centenary British Fellowship, followed by Leverhulme Trust Research Grant to pursue his post-doctoral research at Scott Polar Research Institute, University of Cambridge, England (1992-95). He has been recipient of several visiting professorships/fellowships abroad including University of Wurzburg, Germany; India-China Institute, The New School, USA; The University of Adelaide, Australia; Institute of Southeast Asian Studies, Singapore; University of Durham, UK; Columbia University Institute for Scholars, Paris; Faculty of Law, University of Sydney etc. He serves on the international editorial board of many leading peer-review journals such as The Polar Journal, Geopolitics and the Journal of the Indian Ocean Region. He has been a Visiting Speaker at the National Defence College, New Delhi and Foreign Service Institute, New Delhi. He is a member of the Core Group of Experts on Antarctic and Southern Ocean set up by the Ministry of Earth Sciences, Government of India, and has served on the Indian delegation to the Antarctic Treaty Consultative Meetings since 2007. He is also a member of the Scientific Committee on Antarctic Research (SCAR) Humanities and Social Sciences Expert Group. Author of widely cited book "The Polar Regions: A Political Geography" (John Wiley & Sons, 1996). Dr Chaturvedi has contributed on polar issues to several edited volumes and peer-review journals. His latest co-authored book is "Climate Terror: A Critical Geopolitics of Climate Change" (Palgrave Macmillan 2015). More recently, he has been selected/invited as a Lead Author for Chapter 10: (Asia) of the Working Group II Contribution to the IPCC Sixth Assessment Report (2019-2021).

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Dr. A. P. Dimri is currently working at the School of Environmental Science, JNU. Prof. A. P. Dimri has been actively working in the field of Atmospheric Science from the past three decades. His main research interest is on winter weather and climate using observations and modeling tools. His other research interests include regional climate dynamics and its variability, statistical and dynamical downscaling of numerical model outputs, extreme events and their physical understanding as well as Western Disturbances. He is a leading expert on winter time extra-tropical cyclones called 'Western Disturbances', their manifestation and interplay with existing Himalayan topography. He has also defined the concept of Indian Winter Monsoon and its occurrence. Apart from it, he has worked extensively on topics like Cloudburst in Himalayas and investigated spring predictability barrier in the context of Indian Summer Monsoon (ISM).

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Dr. Cheryl has completed her Phd in Marine Sciences from Goa University and her field of specialization is sediment geochemistry. Her current research activities includes Antarctic lake paleoclimatology and lake sediment geochemistry. She has also published articles for several journals and magazines like Environmental Earth Science, Marine pollution bulletin, Environmental Earth Sciences etc. She has also participated in cruises and expeditions of Indian Oceans apart from been a part of the mangrove and mudflat sample survey of Zuari river estuary.

Dr. Aswagosha Ganju
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Dr. Aswagosha Ganju started his career as a scientist in Defence Research & Development Organization at Snow and Avalanche Study Establishment (SASE), Manali, India. He took up Cold Regions Science and Engineering related work and gained proficiency in Snow Science, Avalanche Forecasting, Artificial Triggering of Avalanches, Snow Hydrology, Glaciology and Remote Sensing of Cryosphere. He has completed several projects with respect to glacier, snow and avalanche studies. He is also the associated with several notable bodies like Indian Science Congress, Glaciological Society of India, Aeronautical Society of India, IGS Council (UK) etc. He has also authored a book on Avalanche Accidents in India- An analysis. He has also been awarded several awards and recognitions for his work. He has about sixty publications to his credit in national and international journals.

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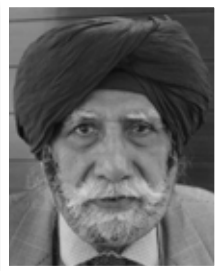

Capt. Gill, a Master Mariner was a SRD D G/Addl D.G Shipping. He has also served as a nautical Advisor to Government of India. He was the Ex-Vice Chairman of the Chartered Institute of Logistic and Transport, a member of the Governing Body of Indian Society of International Law and Treasure . He was also the Captain of ports GOA Daman DIU, Chairman River Navigation Deptt Goa, Vice President of Institute Marine. He has also served as a Visiting faculty to the Indian Maritime University.

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Mr. Emil Grimsson is currently Director and Owner of 'Arctic Trucks', a motor company specializing in re-engineering of four wheeler meant for challenging terrain. Arctic Trucks is based in Iceland with operations spreading across UK, Norway, Finland, Poland, Russia and UAE. He was also the former President of Toyota Iceland. He has been involved in several Polar expeditions and adventures, especially to Antarctica and Greenland including arranging private expeditions for other private parties including logistics arrangements.

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Shri Ashwani Gupta is a post graduate in Structural Engineering from University of British Columbia, Canada and holds a B.Tech. degree in Civil Engineering from IIT, Delhi. Prior to joining the Government of India in 1990, he had a 5 year stint with TCE Consulting Engineers Ltd. where he handled a number of prestigious Civil Engineering consulting assignments. He is presently Scientist "G" and Adviser in the Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology and is engaged in promotion of industrial research, innovations, technology development and transfer. During 29 years of service with the government, he has been involved in formulation of schemes aimed at promoting industrial R&D and nurturing innovations. He has steered many projects aimed at technology development and demonstration of innovative products and processes with a view to improve the country's industrial competitiveness. He has been particularly involved in promoting international technology trade and has been instrumental in sensitizing Indian industries and R&D institutions towards increasing the technology content in the products and services offered by them and enhancing country's technology intensive exports. Some of his papers and articles on technology transfer and trade have been published in reputed journals

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Mr. Niklas Hallgren has been with Light Structures since August 2016. He has more than 15 years of experience from the offshore and petrochemical industry. Prior to Light Structures he has held a number of management positions, the latest as Senior Manager in National Oil well Varco where he managed and lead highly skilled managers, software engineers, hardware engineers and product engineers. He holds a Bachelor of Science in Advanced Automation Technology and numerous of management and leadership certificates such as MSc (Management Science and Engineering), LSE (Leadership for Strategic Execution), PMP (Project Management Professional), SDRM (Strategic Decision and Risk Management). With work experience from Singapore / USA / Portugal / Sweden and Oslo, Niklas has an extensive network all over the world.

Mr. Antti-Pekka Sakari Hyvärinen
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Mr. Antti Hyvärinen is currently the Head of the Group Aerosols and Climate, Composition of the Atmosphere, which focuses on The group studies aerosol particles in various national and international collaboration projects, develops and tests new measurements methods in laboratory conditions and simulates the observed aerosol processes with mathematical models. He has also been a Senior Research Scientist for the Finnish Meteorological Institute and Adjunct Professor in University of Eastern Finland. He holds a Phd in Atmospheric Science. He has also represented Finland in projects of World Meteorological Organization (WMO). He has been a peer reviewer for international journals and projects. He has around 65 peer reviewed journals to his name.

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Dr. Anand jain completed his Ph D on Microbiology (Bacterial biofilms on non-living surfaces immersed in marine waters) from Goa University in the year 2009. Currently he is working as a Project Scientist at NCPOR, Goa. His area of research includes Marine microbial ecology, Microbial Conductivity, Bioelectrochemistry , Biofouling and Marine bacterial biofilms. He has participated in several India-Arctic Expeditions (2015-2018) and also in the 7th Indian Southern Ocean Expedition (2013). He has written articles for several peer reviewed publications.

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Dr. Sridhar Jawak, during his tenure with the National Centre for Polar and Ocean Research (ESSO-NCPOR), Goa, India hasworked with the development and operational implementation of remote sensing methods for rapid geo-information extraction in Polar Regions.. His research, leading to Ph.D. was in the field of Antarctic geospatial applications using very high-resolution satellite data- a growing field with international interest. He has participated in three expeditions to Antarctica and one to the Arctic. He has won various fellowships and awards like the Indian National Geospatial Award by Indian Society of Remote Sensing for the year 2018, Young Geospatial Scientist Award for the year 2017, and International Arctic Science Committee (IASC) fellowship for the year 2017.

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Dr. Abul Amir Khan did his Ph D on the topic "A study of variability of Himalayan Cryosphere and precipitation and estimation of glacial melt fraction in the upper Ganga basin" fropm University of Delhi. He is currently, working as a Research Associate in a Ministry of Earth Science funded project in the Department of Geology, University of Delhi, Delhi. He has also co-authored several articles on topics like climate change and water dynamics in Himalayas, glacial melting in Himalayas, Cyrosphere-Hydrosphere interaction in Himalayas etc published by Springer and Geosciences Frontiers, amongst others.

Dr. Ekaterina Kim
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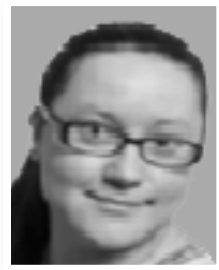

Dr. Ekaterina Kim is currently working as an Associate Professor in risk based marine system design for Arctic operation; she is also an Onsager fellow at NTNU. She has earned her doctorate on marine technology from NTNU. Kim has also undertaken several research projects on marine environment, the current one, Norway-South Korean Consortium for Arctic Operations called High North project. Dr. Kim has also received several awards for the work and has been an active member of committees involved with arctic like Ocean Space Utilization (ISSC), Specialist committee on Arctic Technology (ISSC), committee for the 6th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC,2015).

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Dr. Pankaj Kumar has completed his Phd from Delhi School of economics in 2013. He has also served as an Assistant Professor of Geography at Shaheed Bhagat Singh College, DU. He has also published for several journals like Journal of Physics and Chemistry of Earth, Advances in Meteorology, Springer, ACCST Research Journal , ANNALS NAGI etc. He is also guiding several M.Phil and Phd research scholars, apart from being member of several committees of Geography Department of DU.

Dr. Avinash Kumar
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Dr. Avinash Kumar is presently working on "Coastal dynamics, ocean processes and ice shelves extent variability & forecast of Polar Regions using satellite remote sensing and model reanalyses". He has done his PhD in Marine Geology from Mangalore University, India. He has participated in six major research expedition and cruises as a Scientist. He has served as the Chief Scientist and Deputy Chief Scientist in projects involving hydrothermal studies on Indian Ocean.. He has co-authored and published in many papers in international and national journals like Geoscience Frontiers, Journal of Earth Science etc.

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Mr. Shubhang has perused an integrated M.Tech in Geoinformatics . his areas of interest lies in Glacier studies using remote sensing and GIS, Remote sensing for landuse mapping, Urban mapping, water resource management using GIS and Microwave remote sensing. He has also been involved in numerous projects involving application of Interferometric sar to derive digital elevation model (DEM) and velocity of glaciers and Spatio-temporal mapping and Monitoring of surface water resources.

Dr. R. Krishnan
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Dr. Krishnan Raghavan specializes in climate modeling studies on scientific issues relating to the "Dynamics and variability of the Asian monsoon, Climate change and impacts on monsoon precipitation extremes, Phenomenon of monsoon-breaks and droughts". Currently he is leading the Centre for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology, Pune and is involved in developing in-house capability in Earth System Modeling for addressing the science of climate change. He carried out his Ph.D. research in Atmospheric Sciences at the Physical Research Laboratory, Ahmedabad and obtained Ph.D. degree from the University of Pune in 1994. He has so far published more than 100 scientific articles / papers, and supervised 11 Ph.D degrees and 6 Master dissertations. He is a fellow at Indian Academy of Science, Bengaluru and Indian Meteorological Society. He is also the Associate Editor of Journal of Indian Society of Remote Sensing.

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Mr. Kari Laukia has been the Head of Ship Design & Engineering at Aker Arctic Technology Inc. since 2011and is in charge of the development and delivery of all technical design and consulting projects. He previously worked at KONE Marine where he was Head of Design and Project Management Operations. During the 1980 and 1990 Kari developed his expert knowledge in ice technology especially in Arctic Ship Propulsion system whilst working for Wartsila Helsinki Shipyard (later Kvaerner Masa-Yards). He has been involved in the development and delivery of propulsion solutions for over 20 icebreaking ships. Kari was also responsible for the overall development of azimuthing electric propulsion unit which is called the Azipod. Main references where Kari was heading the Azipod design are icebreaking tanker Uikku, icebreakers Rothelstein, Arcticaborg, Botnica and Svalbard and several cruise liners built in Finland, Italy and Germany during the 1990s.

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Dr. Ajay Dhar is currently working as a consultant for Polar Research and Science outreach programme at Indian Institute of Geomagnetism. He has been associated with the India Antarctic Programme since 1985. He has been a member of National Committee on Scientific Committee on Antarctic Rsearch (SCAR) from 1990 to 1993. He has published more than 75 papers in referred Scientific Journals and Technical Reports. He has participated in 12 Indian Scientific Expeditions to Antarctica in various capacities. He was the member of the First Scientific Expedition to South Pole in 2010. He received Antarctic Award from Ministry of Earth Sciences, Govt. of India, for excellence in Geomagnetic Studies in Antarctica in 2002.

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Dr. C.M Laluraj is currently Scientist E at NCPOR and has been associated with NCPOR as a Scientist since 2006. He completed his Ph.D in Marine Science from Cochin University of Science & Technology. He has also undertaken several expeditions to Antarctica, Arctic and Himalayas. His work which are related to fields like Cryosphere Science, Marine Science and Oceanography has been published in several national and international journals. His research interests lies in Holocene Antarctic climate variability, ice core proxies, Air-Snow Interactions, Atmospheric Chemistry, Marine Biogeochemistry.

Mr. Stephan Lanzinger
Counsellor and Head of the Science and Technology Section,
Embassy of Federal Republic of Germany

Mr. Stephan Lanzinger took over as Counsellor and Head of the Science and Technology Section at the German Embassy, New Delhi in 2015. From 2009-2012 he headed the Press Division at the German Embassy in Cairo, before being stationed as an Officer at the Human Rights Desk in the German Foreign Ministry, Berlin, till mid-2015. Mr. Lanzinger did his Masters in Oriental Studies, Political Studies and Philosophy in Berlin and in Damascus.

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Dr. Pradip Malhotra is currently member of National Coordination Committee of Polar Science Programme (NCPP) under Ministry of Earth Science. He is the only doctor from India who has performed an Appendicectomy in Antarctica. He joined Central Health Services , Government of India, 1980 and retired from it in 2012. He has also acted as a state advisor for Dept of Health and Family Welfare for Government of West Bengal. He has been a part of the 28th Indian Scientific Expedition to Antarctica in 2008-09 and worked on the "Effects of Antarctic Environment on Immune Response of Indian Expeditions Member".

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Dr. Varunendra Dutta Mishra holds a PhD in Physics from IIT Delhi. He has been holding the position of Scientist at SASE, DRDO since 1996. He specialises in fields like Multi-spectral, Hyperspectral and passive microwave Remote Sensing -Satellite and Airborne. Avalanche Dynamics. He has received several appreciations and awards for his work from DRDO, Indian Society of Remote Sensing, Dehradun etc. He also holds membership/fellowship of several scientific groups like Indian Society of Remote Sensing and Society of Cryospheric Science. He has also published more than 50 national and international journals. He is also supervising research and PhD scholars.

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Dr. Abhijit Mazumder has done his PhD in Marine Sciences from Goa University on 'Paleoclimatic Reconstruction through the study of Foraminifera in Marine Sediments off Central West Coast of India". He has worked as Research Scientist at National Centre for Antarctic and Ocean Research (NCAOR), Goa,. He has contributed to various International and National Journals like Marine Pollution Bulletin, International Journal of Geology, Geoscience Journal , Journal of Geological Science of India etc including authoring many popular articles in Hindi. Dr Mazumder is a member of various scientific bodies such as Paleontological Society of India, Indian Geophysical Union, Indian Science Congress Association, Palaeobotanical Society of India, Gondwana Geological Society etc. He has been awarded the Young Scientist Award, 2004 by Indian Science Congress Association at 91st Indian Science Congress, Chandigarh. His current research involvement includes: deciphering the Quaternary Climatic History of the Polar Regions, macro and micro-phytodiversity and behavioral pattern of pollen deposition in and around endangered wetlands of Assam, geophysical and limnological investigation of Antarctic lakes etc.

Ms. Inger Midtkandal.
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Ms. Midtkandal is the Science and technology Counsellor for the Innovation Norway, commercial section of the Royal Norwegian Embassy in New Delhi. She has more than 15 years of experience of working with research and innovation policy at regional, national and international level from India. She has also held responsibilities for governance and tool-development related to design and implementation of R&I strategies and for international collaboration and learning within research and innovation. She has experience from private SME manufacturing enterprises. She has an educational background of Economics and Political Geography from University of Oslo, University of Pavia and Roskilde University Centre.

Ms. Nelli Mikkola
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Ms. Nelli Mikkola works as Second Secretary in the political team of the Embassy of Finland in New Delhi. Prior to joining the Finnish Foreign Service, Ms. Mikkola served as Research Fellow under the Nordic Council of Ministers, engaging in Nordic policy development and strategic research with a focus regional development and cohesion. In her research she specialised in the Arctic region, cross-border cooperation, green growth, and innovation. Ms. Mikkola has also worked at the Committee of the Regions of the European Union in Brussels. She holds Master's Degrees both from University of Helsinki, Finland and Centre International de Formation Européenne, France, with dissertations focusing on Arctic geopolitics and collaboration.

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Dr. Nalan Koç, is serving as Research Director at the Norwegian Polar Institute (NPI) since September 2011. She is also adjunct professor at the University of Tromsø. She received her doctoral degree in marine geology/palaeoceanography from the University of Bergen in 1993 and qualified as professor in 2003. Nalan has over 20 years of experience with climate interpretations from polar marine sediment cores and has participated and led many cruises in the Nordic Seas, Arctic Ocean and the Southern Ocean and also participated in several ODP and IODP cruises. She has extensive experience in polar climate research and management through her previous positions at NPI as leader of the Polar Climate Programme (2004-2009) and as head of Centre for Ice, Climate and Ecosystems (ICE), NPI (2009-2011) and in her present position as research director. She has also served in several international science panels (i.e. CLIVAR, PAGES, ESSAC).

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Dr. Ravi Mishra is presently working as Scientist D at National Centre for Polar and Ocean Research (NCPOR), Goa. He did his post graduation from Govt Model Science college, Rewa, Madhya Pradesh and was is awarded M.Phil. and PhD degrees in Geology from the School of Studies in Geology, Vikram University, Ujjain, Madhya Pradesh. He has worked in various fields of ground water and has prepared the environmental management plan for Pachmarhi and Amarkantak Biosphere Researves, while working with CSIR laboratory and EPCO- a State Govt organisation in Bhopal. Dr Mishra was awarded the MP Young Scientist Award 2000 by the Madhya Pradesh Council of Science and Technology and ISCA Young Scientist Award 2001 by the Indian Science Congress Associatiion. He has spent more than 900 days onboard various research vessels for scientific studies such as Indo-Oman cruise, Post Tsunami cruises, International Ocean Discovery Program. He has also lead curises for Multibeam Bathymetric surveys, Seismic surveys, NCAOR-ONGC joint cruises and also participated in special expedition to the Larsemann Hills Antarctica.

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Dr. A.K Mitra is currently working at National Centre for Medium Range Weather Forecasting (NCMRWF), Ministry of Earth Sciences, as a Scientist. He has obtained his Ph D from IIT, Delhi and has thirty years research experience in global modeling including global data assimilation system. He has rich experience in monsoon system studies with various physical processes. He has also worked in model verification and diagnostics especially for monsoon. He was involved in development of gridded rainfall datasets of rainfall for model verification for monsoon.. Dr.Mitra has published more than 70 research papers in peer reviewed national and international scientific journals.

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Dr. G. Raghava, after an illustrious career of 34 years,retired in July 2017 as Chief Scientist and Head of the Fatigue & Fracture Laboratory of CSIR – Structural Engineering Research Centre, Chennai, one of the national laboratories under the Council of Scientific & Industrial Research, Government of India. FFL, CSIR-SERC is a state-of-art national facility for specialised experimental investigations on large size structural components and structures, particularly fatigue and fracture studies. Dr Raghava is a recipient of DAAD Fellowship for advanced studies in Germany (1988-90), Corrosion Awareness Award for Best Ph.D. Thesis by the Corrosion Society of India (2000), and NIGIS Corrosion Awareness Award for Excellent Laboratory (2014). He has the distinction of participating in the XXIII Indian Scientific Expedition to Antarctica and carrying out structural assessment of the second Indian research station 'Maitri' in Antarctica (December 2003 to April 2004). He was Chairman of the Technical Core Group for the construction of the third Indian Research Station 'Bharati' in East Antarctica. He has published around 130 technical papers in reputed journals and proceedings of conferences. The awards to his papers include Suchit Kumar Ghosh Memorial Prize and Certificates of Merit by the Institution of Engineers (India), and Dr M. Ramaiah Prize and Certificates of Merit for Best Technical Paper published by the scientists of CSIR-SERC. He is a Life Member of Institution of Engineers (India), Indian Concrete Institute, Indian Society for Non-Destructive Testing, Computer Society of India, Indian Structural Integrity Society, Society for Failure Analysis, Instrument Society of India, Indian Nuclear Society, Indian Association of Structural Engineering and Indian Association for Computational Mechanics.

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In terms of Polar research, he is interested in intricacies of climatic fluctuations (past and present) with respect to all aspects of the kinematic analysis of deformed rocks: how to use geometric data to obtain quantitative progress of deformation. He is also a recipient of National Geoscience Award in 2018 for his work on Arctic-Antarctic research.

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Dr. Parmanand Sharma has completed his Phd in Glaciology from JNU. He has been associated with NCPOR as a Scientist since 2012. Some of his significant contributions involved Pioneering the mass balance studies in Indian Himalaya using steam drill to understand glacier – climate inter-relationship. He has also undertaken more than ten expeditions to Arctic and Himalaya as station Coordinator and Team leader along with making substantial contributions to the field of glacier studies in Himalaya.

He is also a member of The International Arctic Science Committee (IASC) -Cryosphere Working Group(CWG) . He has more than 20 publications in peer reviewed national and international journals in his name and also published many proceedings papers, book chapters including books. He has also contributed in establishing India's first Field Research Lab named "Himansh" at an altitude more than 4000m in remote location of Himalaya to monitoring Himalayan glaciers.

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Dr. A. K. Singh has pursued 36 year long Scientific career while serving different organizations in
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He has completed over 28 research projects and monitored several other inter-institutional and institutional research programmes. Conferred with several prestigious Awards such as Vigyan Ratna, S. Z. Quasin Gold Medal, Dutta Munshi Gold Medal, Eminent Indian Zoologist and also Fellowship awards of several Professional Societies/organizations.

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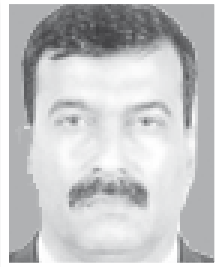

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He contributed significantly to establish aerosol monitoring network in India for measurement of aerosol optical properties and estimation of aerosol radiative forcing. He is taking a lead role in developing a high altitude observatory at Ranichauri in Uttarakhand. He has contributed immensely in setting up a modern meteorological observatory at Bharati station in Antarctica. He was actively involved in establishment of GPS based Ozonesonde system at New Delhi and Bharati, Antarctica. He was awarded Certificate of Merit by Ministry of Earth Sciences for his outstanding scientific contributions. He is also serving as a committee member/reviewer for various national and international agencies/journals. He has also published 46 research papers in peer reviewed journals, 5 Meteorological Monographs on various subjects and 4 chapters in books. His research interests include Polar Meteorology, Aerosols, Solar Radiation, Air Quality and Precipitation Chemistry.

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Dr. Anoop Tiwari is a Scientist in National Centre for Polar and Ocean Research. He holds a Ph D in Environmental Sciences and has over 20 Years of experience in multiple areas like 'Carrying Capacity Project, Environmental Impact Assessment Studies for Cement, Thermal Power Plant, Steel, Fertilizer and Hydro carbon Industries. Dr Tiwari was awarded Shrimati Shiromadevi Prize for his Paper 'Water Abundance and Effect of Glacier Melting at Priyadarshini Lake In Antarctica' and the Rekha Nandi and Bhupesh Nandi prize for his Paper on 'Waste water fate at Maitri in Antarctica'. He has participated in several Indian Scientific Expedition to Antarctica. Apart from conducting EIA Studies, he has also conducted R&D studies for development of Industrial wastewater discharge standard into river and preparation of EMP for Indian Antarctic Research Station Maitri. He has several publications in various national and International Journals during the last seven years. He holds prestigious position in the Indian Science Congress Association, National Environmental Science Academy and in Indian Aerosol Science and Technology Association.

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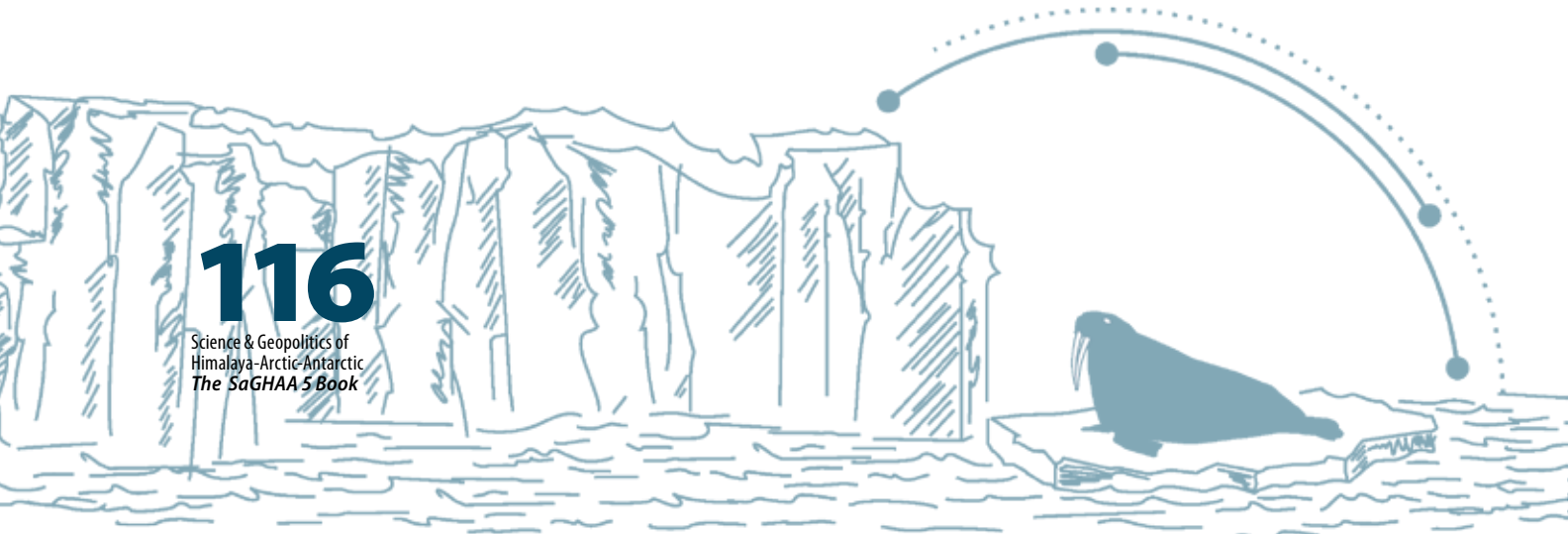

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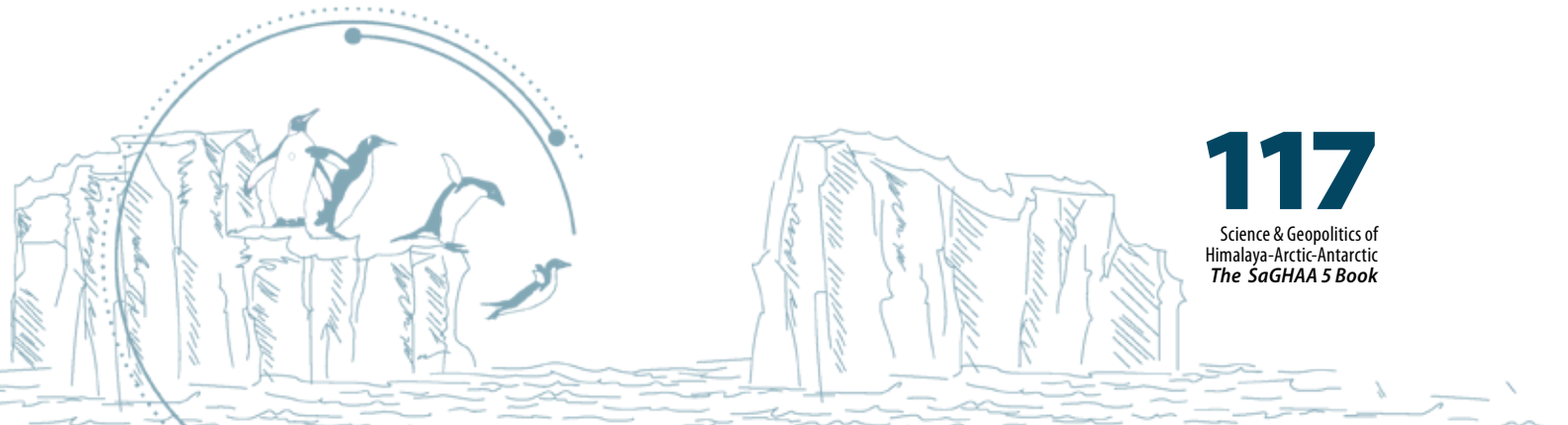

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Section C

The Discourse

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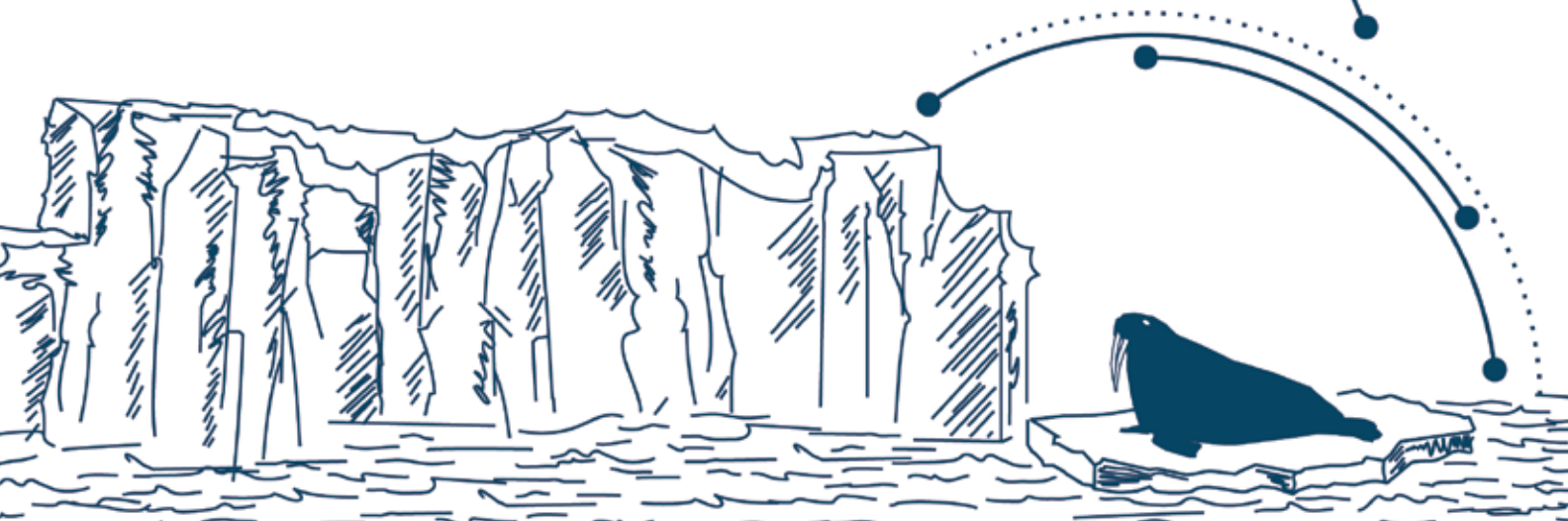
The nine sessions on geopolitics;
climate change in the polar regions;
resource potential and cold response;
technology in the polar realms;



Conference on

Science and Geopolitics of Himalaya-Arctic-Antarctic

February 26 and 27, 2019

ABSTRACTS

Dr. M. A. Atmanand,
Director, National Institute of Ocean Technology

Present and Future directions of Polar research by India

This pa per gives an insight about how a floating laboratory [i.e., Polar Research Vessel] is designed and built to meet the mission requirements for the Indian Polar Research Programmes. Observations in Polar Regions are essential for understanding climate change and the changing weather patterns. The cold remote Polar Regions remain difficult places for humans to live and work, and are places where governments maintain small but expensive research stations. The logistics of polar research (including transport, food, fuel, hardware, safety and communications) also require extraordinary efforts and cooperation at all levels. Various aspects with respect to challenges and emerging trends in designing a Polar Research Vessel to minimise the impact and foot print of vital scientific research in the sensitive polar environment and the cost–benefit studies for chartering vs. owning a Polar Research Vessel are discussed explicitly.

Dr. Rajesh Asthana
Deputy Director General,
GSI, Lucknow

Challenges during Construction of Bharati: lessons learned

Construction of a multipurpose structure needed to meet diverse requirements, has its own constraints, more so when the site is located at one of the most inaccessible and hostile locations of the world. Construction in Antarctic has to abide by strict environmental protocols and adhere to the Comprehensive Environmental Evaluation (CEE) approved by the Antarctic Treaty Consultative Meeting (ATCM). Though the site selected for Bharati station had several advantages in terms of logistics, such as absence of ice shelf, proximity to an ice runway and comparatively better weather conditions, the transportation of heavy equipments and manpower and abiding to the legal terms and conditions of the construction firms were a challenge. To add to these constraints, the working days at the site were limited to good weather days during the summer- a highly rare 'commodity' in Antarctic.

In spite of the involvement of two different firms, one for the preparation of foundation and the other for the superstructure, a perfect coordination and synergy between the firms, NCPOR –the nodal agency at Headquarters and the logistic personnel at site, helped in attainment of the target within a strict time schedule. The construction of the station that commenced in Austral season 2009-10 was completed by 2012-13 enabling a maiden wintering of team of scientists and logistic personnel- a record achievement.

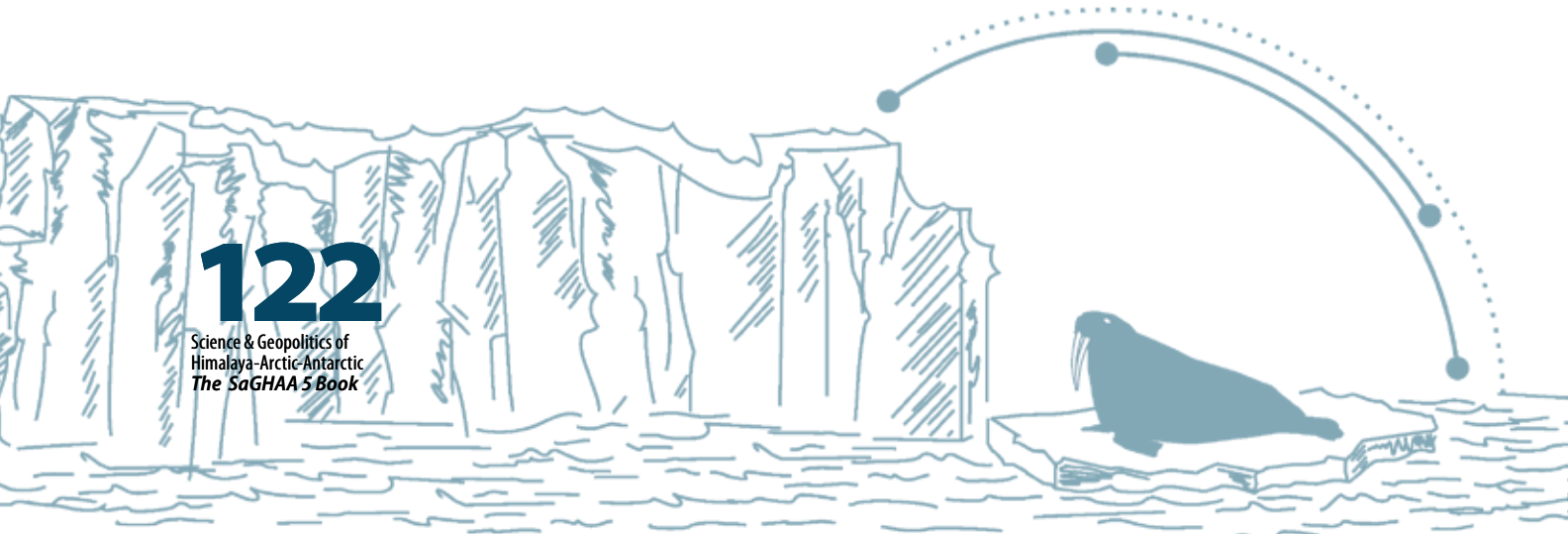
Some of the major issues that required in-depth planning as also on-site decision making, such as wind tunnel test, minor changes to approach of station, attempts to place a barge at the entry point, placing heavy Mantis crane at the construction site, intake of potable water etc were tackled successfully.

Dr. D. K. Aswal
Director, NPL,
New Delhi.

Quality-Infrastructure of India

A quality-infrastructure of a Nation is comprised of internationally recognized metrology, standards and accreditation, which essentially is the basic enabling system of a nation for providing the conformity assessment (calibration and testing, certification and inspection). A robust quality infrastructure is built on a technical hierarchy and is essential for forming effective national policies and their implementation, to attract foreign investments, industrial development, international trading of products, food safety, environment and climate change, health, and efficient utilization of natural and human resources. As a result, a strong quality infrastructure contributes to the national economy and brings prosperity, health and well-being.

In this talk, I will present recent contributions made by National Physical Laboratory - the National Metrology Institute of the country, in establishing several primary/ national measurements essential for the national quality-infrastructure. Some of these include: generation of Indian Standard Time (IST) with 7 ns accuracies using primary atomic clocks and its dissemination to ISRO for the indigenously fabricated-GPS (NAViC) applications, development of various Indian certified reference materials - trademarked as Bhartiya Nirdeshak Dravya (BND®) in the areas of water, gas, cement, petroleum, gold, coal etc, primary standards for the calibrations of air pollutants, biomedical equipment, fluid flow, etc.



Dr. Mahesh Badanal,
National Centre for Polar & Ocean Research, Earth System Science Organization (ESSO), Goa

Paleolimnological records from the ice-free regions of Schirmacher Oasis and Larsemann Hills, East Antarctic

The Antarctic continental margin is marked with ice-free areas which are host to numerous freshwater lakes. These lacustrine systems are rich in sedimentary deposits which archive in them the regional and general climatic variations. These lakes respond to the seasonal variations in climate over glacial-interglacial timescales and can be inferred from biogenic and authigenic sedimentary proxies. These proxies are a good tool to decipher and understand climate changes in the cold environments of Antarctica. The use of various proxies such as sedimentary organic stable isotopes, particle size variation and diatoms as a paleoclimate indicator in lacustrine systems of Antarctic ice free areas is well documented. In this study, we report paleolimnological variations from two sediment cores retrieved from freshwater lakes viz., L-49 (Schirmacher Oasis) and Stepped Lake (SL-3: Larsemann Hills) of East Antarctica. The cores collected from different geomorphologic settings. The former is located ~80 km inland while the latter is located ~ 200 m from the coast. The L-49 core spans the last 43 kyr while the SL-3 covers mid-Holocene (4-8 kyr). We report d13C, d15N, sand-silt-clay content and diatom abundance and species variation. In the former, the transition in values (Corg, Norg, C/N ratio, 13COM, sand content) starting at 16.6 kyr BP closely following Antarctic deglaciation to reach Holocene optimum values at 11.3 kyr BP documents the influence of Antarctic climate on regional areas. While in SL-3 records, the diatom community shows similar shift with the major part of Holocene (8.3–5.5 kyr BP) dominated by sea-ice and open-ocean diatoms, the core-top sections (5.5–4.6 kyr BP) transitions to lacustrine diatoms (Stauroforma inermis). These observations confirm that the basin was marine, and later became isolated as a result of postglacial isostatic uplift after 4.7 kyr BP.

Dr. Rakesh Bhambri
Centre for Glaciology
Wadia Institute for Himalayan Geology

Monitoring of Himalaya - Karakoram Glaciers and Associated Hazards from Ground and Space

The Himalaya-Karakoram has one of the largest concentrations of glaciers outside the polar regions. The melt water discharge from these glaciers is of interest for several reasons (e.g. irrigation, sustaining ecosystem and hydropower generation). These glaciers also pose significantly larger hazards in the downstream areas. Avalanches and glacial lake outburst floods (GLOFs) are the most destructive types of glacier disasters that have affected people in mountain ranges. For water resource planning and hazards mitigation in Indian sub-continent, it is essential to monitor the Himalayan and Karakoram glaciers. Therefore, we present the fluctuation (e.g. length, area and volume) of selected glaciers in the Himalaya-Karakoram using ground and space observations. Glaciers in the Karakoram exhibit irregular behavior as compared to central and eastern Himalayan glaciers. Terminus fluctuations of individual glaciers lack consistency and, unlike other parts of the Himalaya, total ice mass remains stable or slight increase since the 1970s. These seeming anomalies are addressed through a comprehensive mapping of surge-type glaciers and surge-related impacts, based on multiple satellite images (e.g. Landsat and ASTER), DEMs (e.g. SRTM, ASTER and Cartosat 1), ground observations, and archival material since the 1840s. Active phases range from some months to over 15 years. Surge intervals are identified for 27 glaciers with two or more surges, including 9 not reported previously. Surge cycle timing, intervals and mass transfers are unique to each glacier and largely out-of- phase with climate. Mass balance of Central and Eastern Himalayan glaciers show mass reductions in recent decades that destabilize the pro-glacial area and influencing the occurrence of glacier hazards. Some case studies of glacier hazards in the Central Himalaya (e.g. Gangotri Glacier) and Karakoram (Kumdan group of glaciers) are also presented. In the Karakoram, about 150 floods from ice-dammed lakes are identified in historical records and remote sensing images. These ice dammed lakes generated through the barriers made by the advancing glaciers. This differs from Himalayan GLOFs highlighted recently, attributed to climate change with rapidly retreating or thinning glaciers and mainly moraine dams. The former occur in the Karakoram, but episodes of glacier thickening and advance still occur making ice dams a continuing threat.

Dr. M. R. Bhutiyani
Visiting Professor,
Department of Geology,
Fergusson College, Pune
Ex-Director, DTRL, Delhi.

Karakorum Anomaly - A myth or Reality

Studies have confirmed that the glaciers in the north-western Himalaya (NWH) were in a state of retreat in the last century. The larger glaciers appear to have receded at a comparatively lower rate than the glaciers with smaller length. This conforms to the global trend of the world's mountain glaciers which have undergone negative mass balance and terminal recessions. The rate of recession of glaciers appears to have accelerated in the last three decades of the last century. Interestingly, during the same period, the rate of downward movement of some transverse or tributary glaciers in the Karakoram Himalaya has enhanced, causing them to surge.

From the 1920s to the early 1990s, most glaciers of the Karakoram Himalaya were also observed to diminish, except for some short-term advances in the 1970s and surges. However, in the late 1990s widespread evidence of glacier expansion was found in the central Karakorum in contrast to a worldwide decline of mountain glaciers. This anomalous behaviour, termed as 'The Karakoram anomaly', was first described in 2005 and has been attributed to prevalence of the "Karakoram Vortex" (KV), a large-scale atmospheric circulation system related to warmer (cooler) near-surface and mid-lower troposphere temperatures above the Karakoram in the western Tibetan Plateau (TP). Our studies in the Nubra Valley of the eastern Karakorum Himalayas have yielded some contrasting results which puts a big question over the very existence of "the Karakorum Anomaly". Studies indicate substantial Elevation Dependent Warming (EDW) with increasing rate of warming with altitude up to certain altitude, both in winter as well as summer. Significant rate of warming in summer coupled with decreasing precipitation trends in winter point towards declining trends in mass balance of the glaciers in this part of the Karakorum Himalayas. Ground investigations on thinning of glaciers also indicate significant ice loss and their negative mass balance in the recent past. The most plausible explanation for few observed advancing glaciers could be that the rising temperatures may have enhanced the plastic deformation of their glacier ice. Since majority of them are transverse glaciers with high gradient, their downward movement as a result of enhanced plastic deformation appears to be mistaken as their advancement and positive mass balance.

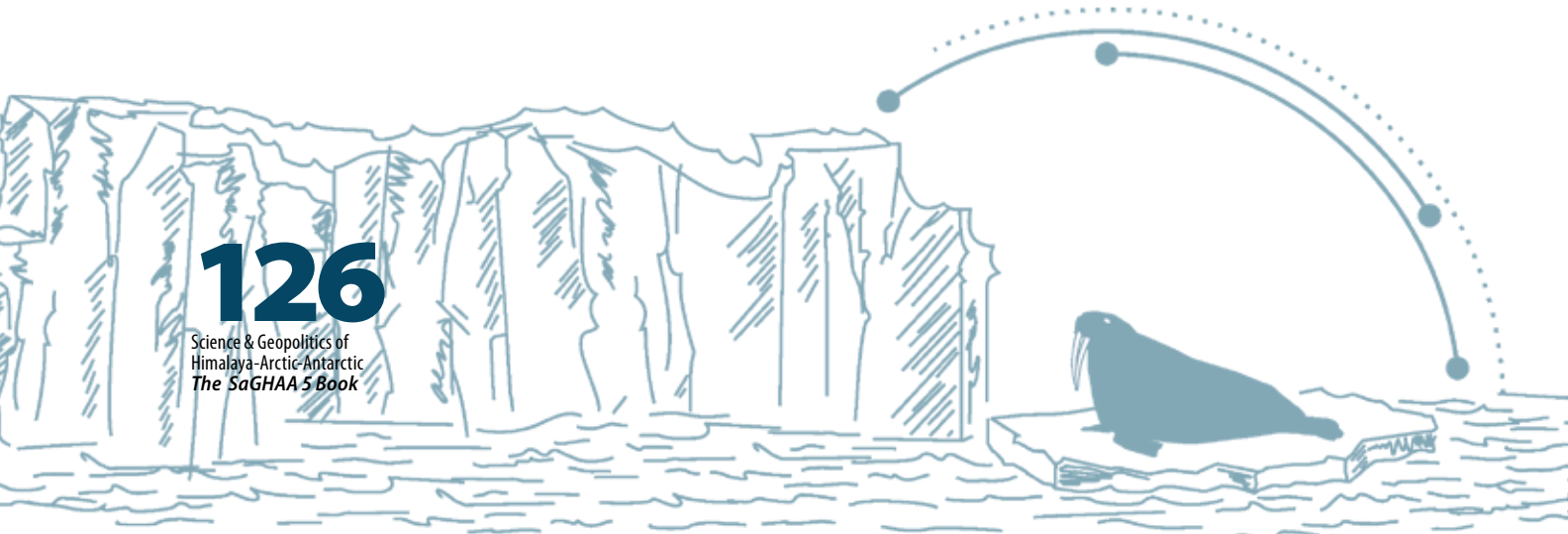
Dr. Javed Beg
National Centre for Polar & Ocean Research (NCPOR)
Goa.

A Peep into Logistic Operations in Antarctica

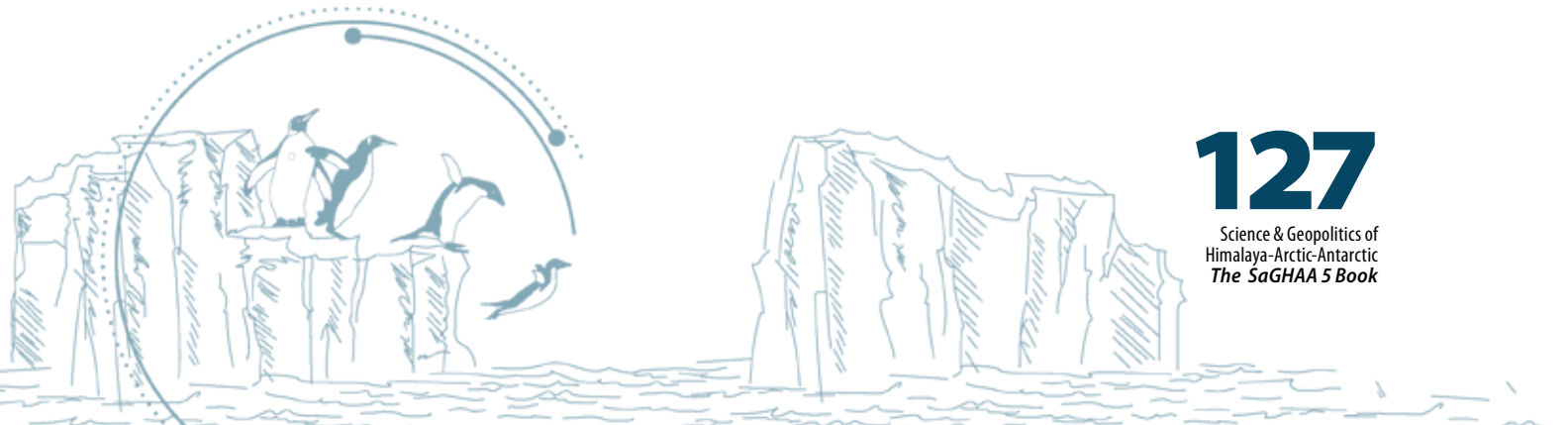
Logistics is the art of careful organization of a complicated activity so that it happens in a successful and effective way. Its definition varies with the nature of activity or kind of operation, be it; Business, Government, Military, Construction, Social, Travel, Health Care, Transportation, Scientific, Religious etc. Managing logistics in civilized areas of the globe is relatively simpler compared to harsh, unsympathetic, desolate and forsaken place like Antarctica perhaps, because of lack of opportunity for year round connectivity with the mainland.

Most campaigns engage in one or few aspects of logistic activity but the Indian Antarctic Operations handles multi modular responsibility as enabler of scientific research in Antarctica which primarily incorporates planning and optimization of resource including team building and trainings. It manages Indian infrastructure in Antarctica; organises procurement &transportation of inventories; hiring, deployment and management of ship, helicopter and air-networks and also maintaining public relations, collaborations with national and international agencies.

Indian Antarctic Programme commenced in 1981 and after operating from ship and temporary shelters for two years the first permanent research station "Dakshin Gangotri" was established in 1983 followed by Maitri in 1987 and Bharati in 2012. Dakshin Gangotri got buried, in about three years, under accumulated snow but continued until 1991 when it was decommissioned and abandoned. With commissioning of Bhartai and start of regular year round operations the logistic activities have grown manifolds mainly because of diverse requirements at both stations and management of inventories. With a narrow window of opportunity between November and February for both stations, Maitri and



	Bharati, which are more than two thousands kilometres apart, have to be manned and stocked with food, medical supplies, diverse spares for life support systems and all sorts of inventories that can be imagined and with no scope for inaccuracies, slips and oversights. With rapid advances in technology, though the delivery systems have become faster but the beneficiary expectations astronomically elevated and the processes have become more complex. Process design and its implementation has always been a challenge especially for the most beautiful and most unforgiving continent of Antarctica which keeps throwing newer challenges by the day and that added with years of experience and passion has helped evolve a self-propelling system for accurate planning, efficient execution and effective management of its operations which keeps the mission going.



Dr. Asha Devi C. R.
Centre for Marine Living Resources & Ecology (CMLRE), Kochi

Ecology of microzooplankton in the Arctic Fjord Kongsfjorden and comparison with major ecosystems

The Kongsfjorden marine ecosystem functions under the balance of influx of Atlantic and Arctic waters, and as a consequence, the pelagic food web is composed of both Boreal and the Arctic species. Studies conducted during the summer monsoon on the two size classes of planktonic components viz. micro- and mesozooplankton (20-200µM and 200µM to 20mm) for years 2015 & 2016 revealed inter-annual variability in community as well as composition. The significance of microzooplankton mediated food web in the Kongsfjorden was elucidated for the summer season, with significant top - down controls on ciliates by the Copepods, which is envisaged as a factor to be considered while defining the planktonic food web. Among the ciliates, Parafavella sp. which dominated the microzooplankton community was observed in both years. A comprehensive understanding on the different size class of plankton (pico to mesozooplankton) will provide an overview on the effects of environmental variability on ecosystem structure. The high degree of seasonality in environmental conditions are key elements that determine the diversity of organisms in the Arctic and plankters being the drifters in the ocean and due to their rapid response to environmental changes can be considered as proxy to understand such changes. The latitudinal gradient in ciliate diversity was also assessed, in defining the functional role of ciliates, and was found to be discrete for different ecosystems. These studies can form the basis for understanding the foreseen changes in the Arctic fjords with warming trends which is expected to have direct and indirect effects on species life cycles and prey-predator interactions.

Prof. Sanjay Chaturvedi
Professor and Dean ,Faculty of Social Sciences,
Department of International Relations
South Asian University,

Revisiting Antarctic Geopolitics: Continuity and Change

Revisiting Antarctic geopolitics involves looking back as much as looking forward. The former relates to factors such as various waves of imperialism, disputed territoriality of the continent and consequential jurisdiction over the surrounding Southern Ocean, resource diplomacy of the Antarctic regional regime during 1980s and 90s, and the key role played by the movers and shakers of the Antarctic Treaty System (ATS). Whereas the latter is shaped by unfolding global/regional dynamics in international geopolitical economy, trends in global demography, and contested issues of access, ownership entitlement and equity cutting across the issues of minerals, fisheries and bioprospecting. The seven territorial claims and counter claims, legally frozen, under Article IV of the Antarctic Treaty, not only remain geopolitically alive for all practical policy purposes but in some cases have become far more assertive.

With climate change making the Antarctic more accessible, geopolitically driven perceptions of resource-hungry Asian economies, intricately combined with the ethical imperatives of providing human security especially to billions in the 'Majority World' or the Global South are also on the rise and demand scrutiny. The broadening and deepening of 'Asian' interest in the Antarctic, despite the persistent gap between the physical/scientific presence in the region and geopolitical/ diplomatic influence at the ATCMs appears to have aroused a good deal of concern, bordering on anxiety, in some quarters over the 'actual' and 'long-term' intentions of Asian states like China, South Korea and India in the Antarctic. This kind of unexamined speculative geopolitics could result in functional paralysis in the ATS. The club mentality of the Antarctic regime and the twelve originals has been questioned in several ways including the fact that as of today the number of 'latecomers' –the new consultative parties with proven credentials of 'substantial scientific interest' – stands surpassed by seventeen, with a significant number from the Global South including India, China and Brazil. No doubt the ATS has earlier managed an extremely intense and divisive geopolitics of the Cold War better than anywhere else on the globe. But the future appears to be far more challenging. What would happen to a consensus-based governance system confronted with an increasingly complex agenda including climate change, bioprospecting and tourism is difficult to predict. Will the ATS, already showing the symptoms of 'hollowing' out remain robust enough to face new ethical and geopolitical challenges to its authority, legitimacy and effectiveness in an increasingly warming world, inhabited by 7 billion people (and even more by 2050), with a vast majority living on the continents of Asia and Africa.

Ms. Sulagna Chattopadhyay
Lights Research Foundation,
New Delhi

Need for Regional cross-border cooperation in Himalaya: drawing inspiration from Arctic Council

The 2,400 Km long Hindukush- Himalaya mountain belt, passes through the areas falling under the sovereign control of several Asian countries. It behaves as an integrated mountain system that is spread over beyond the sovereign control of one nation and imbibes in its folds a multitude of scientific and social issues that are common to most of the Asian nations, such as - Afghanistan, Bhutan, China, India, Nepal, Pakistan as also Myanmar and Bangla Desh that depend upon the Himalaya in many ways. The Himalaya plays a significant role in the sociao-economic development of these Asian stakeholders apart from supporting nearly 2 billion people in one of the most densely populated region of the world.

The magnitude of the problems faced by indigenous population and geographical spread is such that no single stakeholder can do justice to the subject that has a great relevance to the indigenous people inhabiting the inaccessible and inhospitable high altitudes area with rich biodiversity and hostile climate. The Himalaya as a whole has a profound impact on regional climate. It affects wind circulation and storm tracks over large distances. Due to its unique geographic position and high altitude, it faces rapid changes in the weather patterns and ecosystem affecting the glaciers, snow cover, permafrost soils etc. Being geologically a young mountain belt, Himalaya faces extreme natural hazards like earthquakes, landslides, avalanches, cloud bursts and glacial lake outbursts.

It is therefore of prime importance that earth processes having pronounced effect on Himalayan system be identified and monitored by stakeholders by establishing a permanent forum that can think beyond the geographical boundaries. An excellent example for such a cross- border amalgamation of likeminded nations exists in the form of Arctic Council where all the nations that encircle fragile Arctic ocean, have come together to preserve and protect the Arctic eco-system through a geopolitical solution based on a clear science policy.

Prof. A. P. Dimri
School of Environmental Science, JNU, New Delhi

Himalayan Climate: Past and Future

Himalayan region is distinctly known as the "Water tower of Asia" or the third pole of the world for its unique bio-geophysical, climatic and hydrological setup. Besides its importance in influencing the large-scale hydro meteorological systems like monsoon, it is abode to a large mass of population under its trans-boundary extent in Asia. The recent IPCC report suggests that Himalayas are one of the most vulnerable systems to climatic changes, which may result into the irreversible changes to the hydrology, climate, demography and the underlying ecosystem. With the recent generation of high-resolution climate models, it has been shown that such changes may have wide range of variability in space as well as time due to unique setup of the Himalaya. Although there are weaknesses in the models, these are capable of reproducing the mean variability as well as the long-term trend of climatic parameters in more realistic manner than the previous general circulation models (GCMs). In a series of efforts to underline the recent climate changes over Himalayas, regional climate model simulations from COordinated Regional climate Downscaling Experiments South-Asia (CORDEX-SA) has been used. Many of the models are able to represent the mean, seasonal cycle as well as the spatial variability of precipitation as well as near surface air temperature. Also, for the future climate, there exists a wide range of uncertainty pertaining to different model experiments, time slices and the range of scenarios. Interestingly, season specific response to warming with peculiar warming behavior for different altitude regions of Himalayas has been found to prevail during present and future climate. This may have further implications for the climate and hydrology of region and needs proper attention for more organized mitigation and adaptation strategies for future.

Dr. Ajay Dhar
Indian Institute of Geomagnetism Navi Mumbai.

Logistic difficulties in construction of New Maitri Station

The Government of India decided to construct a new Antarctic Station in 2003-04 and a committee was chosen to select the place. The committee undertook reconnaissance of the coastal area between India Bay and Davis station in the eastern Antarctica. It carried on detail survey of nearly 200 sq. km area in Westford Hills and Larsemann Hills area zeroing on an Grovnes promontory for various logistic reasons. Four expeditions were launched to this site from 2005 to 2009 to collect the base line data for preparing a CEE (environmental) report for seeking clearance from ATCM. As the expedition vessel could reach within 100 m of the station, unloading and transportation of construction material to site could be completed simultaneously. There were a few nervy situations while transporting heavy machinery (~50 Tons) over fast ice, which were accomplished taking due safety measures. The construction was completed in two summer expeditions of 2010-11 and 2011-12.

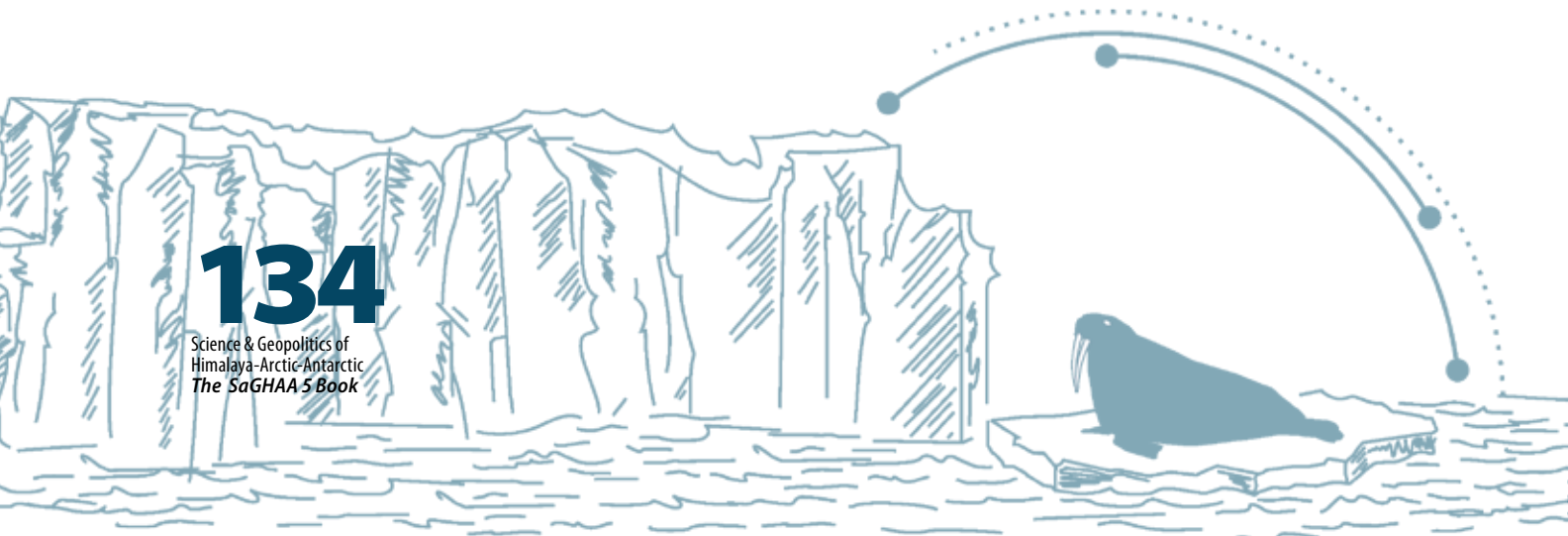
However, as compared to this, construction of new station at Maitri is going to be more challenging for logistic reasons. Schirmarchar Oasis of central Dronning Maud Land is separated by a vast ice shelf of ~100 km from the ship's berthing point and all the heavy material need to be transported over land to the new construction site. Over the years, the ice shelf has started breaking up and new crevasses have come up on the convoy route. The convoys can be undertaken between mid March till mid June and later in November till mid December. July - October months are too cold to operate vehicles. January - March is the warmer period resulting in a number of water channels opening up on the convoy route, making it unsafe for operating convoys. Transportation of material and site preparation will be time consuming and may take a couple of seasons before starting actual construction.

Dr. Cheryl A. Noronha D'Mello
National Centre for Polar & Ocean Research, Goa

Subglacial Lakes: Scope for Indian Exploration in Antarctic

Subglacial lake exploration has recently attracted the interest of the scientific community owing to their unique and extreme nature. These are the lakes beneath the ice sheet or glacier with low temperatures, elevated pressures, limited nutrient supply, absence of sunlight and no direct exchange with the atmosphere. Subglacial lakes in Antarctica mainly exist where temperatures at the glacier bed are maintained at the pressure-melting point from a combination of geothermal or frictional heating and the thermal insulation provided by the thick ice cover. These lakes are proving to be attractive models to explore fundamental themes in limnology as well as have direct global implications such as landscape–lake interactions, the viability and adaptation organisms to environmental extremes, and subglacial aquatic environments as a planetary storehouse of ancient microbes and past climate records. Recent studies have shown that these lakes host abundant unique microbial life such as that in Lake Whillans in West Antarctica that house globally relevant pools of carbon and microbes that can mobilize elements from the lithosphere and influence Southern Ocean geochemical and biological systems. Subglacial lake environments could be analogous to extraterrestrial systems such as the icy worlds beneath the Martian ice cap and Jupiter's moon Europa that could help decipher the existence of life alike. Furthermore, the sediment records from subglacial lakes, owing to their low sedimentation rates, may provide a detailed record of palaeoenvironmental information and may help fill hiatuses in the glacial and palaeoclimatic history of Antarctica and the Earth. In order to further the knowledge of subglacial environments, there is a necessity to address various questions, challenges and

	technological needs for clean requirements for entry, observatory, deployment, and sample retrieval procedures. Exploration of subglacial environments requires careful and meticulous planning, organization, and international cooperation. along with many man months of repeated visits to the icy continent. This can be achieved by a coordinated program, that is multi- and interdisciplinary in scope as per the scientific goals of SALESGOS. India needs to initiate a multidisciplinary subglacial exploration program in order to assess the scientific potential of these lakes and thus fill in the existing knowledge gaps.



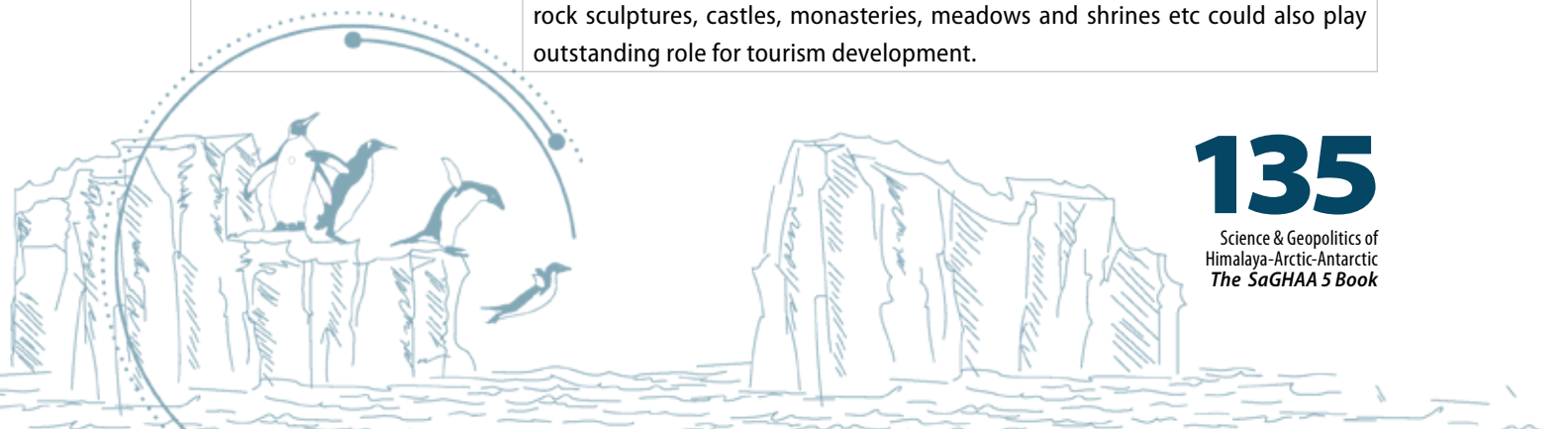
Dr. Aswagosha Ganju
Former Director, SASE,
DRDO, Chandigarh

Inner Himalaya: An opportunity to turn the terrain to economic fortune

A number of indicators have revealed that India is facing regional imbalances that have left a large portion of its population economically backward. There are various factors responsible for this imbalance among which slow growth in infrastructure development in certain regions of India, is one of the prominent factor.

The Himalayan states have suffered because of the remoteness of the areas and difficulty in execution of infrastructure development plans in a limited time frame of 5-6 months in a year primarily because of the severe weather conditions that produce avalanches during winter and landslides due to incessant monsoon rains in these areas. In view of the above, there is a need to draw a comprehensive plan for the development of less developed interior areas in hill states. For example, in addition to the identified backward districts of Baramulla and Kupwara, the districts of Doda and Kargil have a huge potential to grow and contribute to the GDP of the nation. Environmental friendly industries such as tourism have a great potential in such areas. We have examples of Leh and Kulu districts of J&K and HP respectively, which have seen tremendous rise in income due to development of tourism. Leh, for example, recorded a high of 30% annual growth between 2014 and 2017. The potential of tourism in bringing backward regions of India into mainstream can be inferred from the international tourism data where India's foreign exchange earnings from tourism has shown more than $23 billion in revenue in 2015, a significant hike from the $3.5 billion it made in 2000.

The need of the hour is to strengthen basic infrastructure ensuring road and air connectivity throughout the year. Secondly, the remote, picturesque and approachable areas have to be identified and private entrepreneurs invited to establish state of the art accommodation and related services at the identified locations Activities such as adventure tourism, mountaineering, trekking, rafting etc, need to be encouraged and supported. The historical legacies of rock sculptures, castles, monasteries, meadows and shrines etc could also play outstanding role for tourism development.



Capt. J.S. Gill
Former Nautical Advisor,
Govt. of India, Sr. DDG/Addl.
D.G. Shipping

Marine Scientific Research Vs UNCLOS'82

The age of ocean discovery is the voyages of HMS CHALLENGER (1872-1876). Before Law of the Sea (LOS) convention (1958), marine scientific research was not considered as being among the major fields of maritime activity. Research within maritime zones under coastal State sovereignty was conducted on the basis of ad hoc arrangements with the coastal State. Seaward of the territorial sea, maritime scientific research was regarded mostly as an expression of the freedom of the high seas (subject to possible coastal state rights and obligations regarding the continental shelf). Consequently, customary and conventional law of the sea with respect to marine scientific research was limited in scope. Technological and scientific advances following World War II, however, gave new significance to marine scientific research in general, and to its economic in particular. Signs of this appeared in 1958.

There was absence of any provision on marine scientific research in the draft articles on the law of the sea adopted by the International Law Commission in 1956. Reference was made at LOS 58 to [marine] scientific research in the on the articles relating to the continental shelf. UN Resolution 2750 C (XXV) of 17 December 1970 paved way to undertake the preparatory work for the Third United Nations Conference on the Law of the Sea. The major conflict of this concerned the distinction between "fundamental" and "applied" research. Concept was reflected in the Informal Single Negotiating Text (ISNT). Prior to the 1958 Geneva Convention on the Continental Shelf, there were no global instruments regulating the conduct of marine scientific research.

UNCLOS 82 convention on the law of the sea retained the basic principle of consent by coastal States for research on the continental shelf and extended it also to the exclusive economic zone. It has further expanded considerably the provisions on marine scientific research,

	adding general principles as well as detailed rules governing its conduct. In the process of drafting exclusive economic zone legislation, some States have adapted their older fishing laws and regulations by redefining the jurisdictional zone to which they apply. A practical result is that fishing codes and regulations which were applicable to previously defined fishing zones now apply to the exclusive economic zone. Because there is no definition of what constitutes marine scientific research in the Convention, the result of adapting older fishing laws to the exclusive economic zone is the creation of two consent regimes: one regime to be generally applied to marine scientific research and another to be specifically applied to scientific research relating to fishing. The focus is, however, on procedures to be followed for research activities in the exclusive economic zone and extended fishery zones as well as on the continental shelf. Legislation which places restrictions on "exploration and exploitation" of resources has traditionally been applied to continental shelf minerals, usually hydrocarbons. Unless a State has indicated by some other means that it consider this type of legislation to cover marine scientific research, it has not been included. In particular, several of the European States which do not formally have consent regimes do in fact require consent for marine scientific research using this type of legislation as a basis for requiring information. During the deliberations in the Sea-bed Committee, the development of this subject evolved. The basic concepts of international cooperation in marine scientific research activities were repeated and further developed in a series of General Assembly resolutions, notably resolution 2749 (XXV) of 17 December 1970 which enunciated that" States shall promote international co-operation in scientific research exclusively for peaceful purposes"

Mr. Emil Grimsson
Director,Arctic Trucks
Iceland

Operational Benefits of 4x4 vehicle over conventional Belt Vehicle in Antarctica

During and after the second world war, Icelander's learned to use the 4x4 vehicles to their benefits. Due to the poor infrastructure the 4x4 vehicles quickly revolutionized transportation in the rural areas. However, the usability of these 4x4 vehicles was very limited when it came to heavy snow conditions, big rivers and various other challenges that people faced in the difficult terrain conditions of Iceland. In the 1970's experiments with larger tires under the 4x4 drive conditions were started which became more popular during 80's and sought after both for utility and recreation.

The Arctic Trucks operation was established by M/S Toyota Iceland in 1990 to bring structure and customer satisfaction to a "chaotic" market and dangerous, ill serviceable vehicles running on the streets.

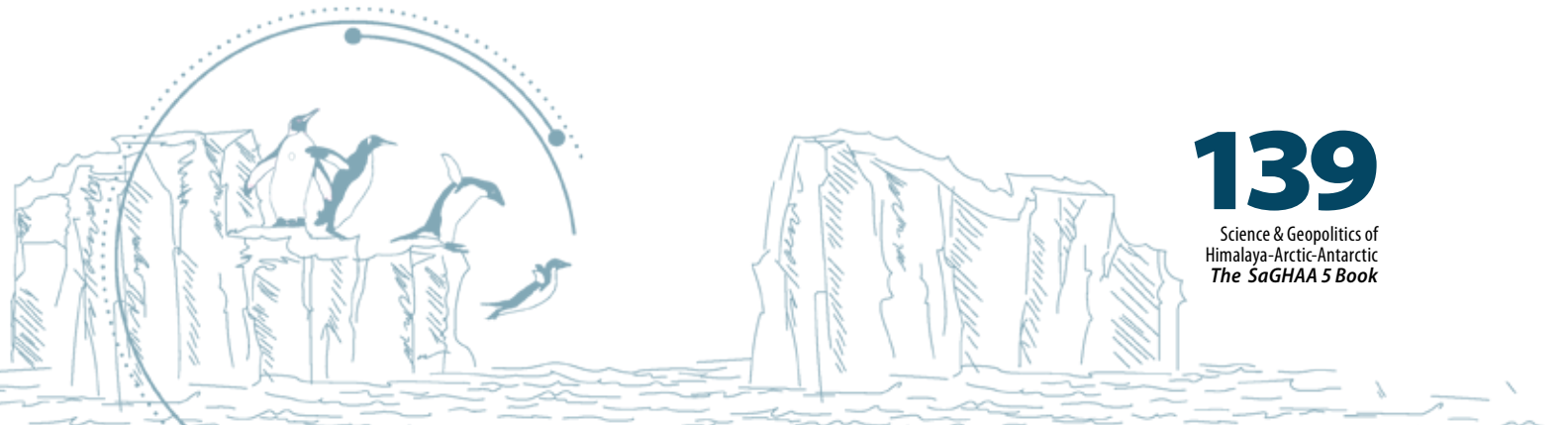
In the present work, I will review how these 4x4 vehicles made the second revolution in Iceland, improving various type of logistics and introduced the remote areas of Iceland to local public and boost business such as tourism.

I will also focus on how The Arctic Trucks took this development forward and adapted it to use in other Polar Regions and the key benefits these vehicles have over the traditional belt vehicles. In Antarctica the Arctic Trucks have covered over 300,000 km with impressive statistics in fuel economy and speed over traditional belt vehicles. I will talk about where I see potential for our solutions to benefit scientific operation in tandem with current equipment and or independently in Antarctica and other Polar Regions.

Mr. Niklas Hallgren
CEO, Lights Structures,
Norway

Monitoring the effects of ice forces with the Ice Class Research Vessel for Polar Code

Light Structures will present our fiber optic Ice Load Monitoring (ILM) system that is implemented on several Ice Class Research Vessels around the globe. We will discuss the typical scope of monitoring, the real-time processing and presentation of results onboard. An overview of typical parameters will be presented with a discussion of which ones may be interesting to share with Vessel Monitoring System and possibly other systems onboard. Some examples of results from similar installations on previous projects will be shown as illustrations of the performance that is expected for the ILM system on Ice Class Research Vessel for Indian Polar Programme.



Dr. Sridhar Jawak
Svalbard Integrated Arctic Earth Observing System (SIOS), Norway

Technological innovations in Earth observation and remote sensing to provide geo-information in Svalbard

The Norwegian archipelago Svalbard is the utmost data-rich area in the Arctic in terms of availability of in situ measurements. Nevertheless, these datasets are spatially irregularly distributed and there are still enormous data gaps. To address these gaps and improve the network of Earth System Science observations, 26 institutions from 11 countries have joined forces in a multidisciplinary teamwork, the Svalbard Integrated Arctic Earth Observing System (SIOS) Our presentation primarily focuses on recent Earth Observation and remote sensing activities of SIOS and member institutions. We will highlight efforts from SIOS members in the operationalisation of remote sensing products. This presentation will cover a few selected technologically innovative applications in Svalbard e.g. (1) understanding permafrost movement using microwave and unmanned aerial vehicle data, (2) estimation of glacier velocity over Svalbard using interferometric synthetic aperture radar.Both of these applications are of wider interest for the remote sensing community in Svalbard to address broad Earth system science questions and SIOS remote sensing services emphasise the mutual benefits to field scientists and satellite owners. Therefore, SIOS is planning to make these remote sensing products available for the wider research community by collaborating with members from different nations. The limited funding available to individual institutions to conduct dedicated cal/val studies in Svalbard highlights the need for an international collaboration like SIOS, which optimises the use of existing infrastructure and data.

Dr. Anand Jain
National Centre for Polar and Ocean research, Goa.

Bacterial communities involved in complex organic carbon cycling in a high Arctic fjord: A small beginning towards a larger goal

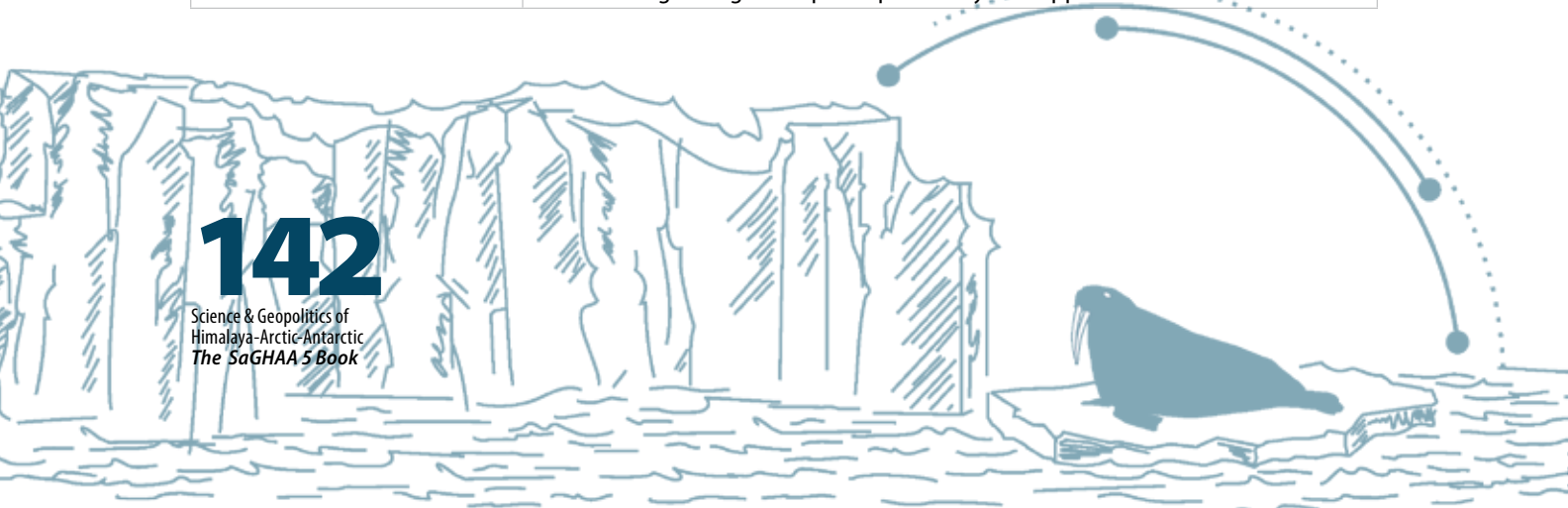
Warming of Arctic Ocean has large implications for the ecosystem functions and carbon cycling. It has been shown that warming induced increase in primary production, macroalgae biomass, glacier and permafrost melting contributes significant amount of complex particulate and dissolved organic carbon of marine and terrestrial origin to the coastal Arctic ecosystem. Marine heterotrophic bacterial communities hydrolyze these complex organic carbon via secretion of extracellular hydrolytic enzymes to yield sufficiently smaller and simpler substrates (<600 Da) for the bacterial uptake, thus, playing a crucial role in the transfer of complex/refractory carbon to higher trophic level and reducing the carbon export and storage. Moreover, with the continued rise in temperature and concurrent increase in complex organic matter inputs it is anticipated that microbial cycling of complex organic matter will play a decisive role in regulating the carbon export, storage and food web dynamics in the Arctic region. However, despite enormous biogeochemical significance of heterotrophic bacteria not much is known about the bacterial communities involved in complex organic carbon cycling in the high Arctic fjord environment. This presentation will decipher the importance of tiny living creatures (bacteria) under Arctic warming scenario and discuss the results obtained from our field as well as experimental studies conducted in Kongsfjorden. In addition, importance of holistic and collaborative microbiological research program in the Arctic region will be discussed.

HE Nils Ragnar Kamsvag
Ambassador of the Royal Norwegian Embassy in India
New Delhi

The Arctic Strategy of Norway

The Arctic has always been important for Norway and is increasingly so for the world as a whole. Foreign and domestic policy is intertwined in the region, and people's everyday lives are affected both by high politics and by day-to-day issues.

The Arctic offers major opportunities for development. We find them in traditional sectors such as the seafood sector and oil and gas exploration and in new industries such as marine bioprospecting and seabed mining. The tourism industry is growing, with visitors coming to the region from all over the world. Realizing the importance of the Arctic, the Government of Norway has developed its Arctic Strategy, which emphasizes on geopolitics of the Arctic, as well as social development in the region. The key aims of the Strategy are "creating value, managing resources, confronting climate change and fostering knowledge". Norway has set up a number of institutions that work towards sustainable development of the Arctic. Technology and innovation are integral parts of such development and Norway puts great emphasis on this aspect. The Government of Norway is giving greater priority to business development in the north. We want to enhance the links between research and the business sector, with a view to ensuring that investment in research also creates more new jobs. Our aim is to develop Northern Norway into one of our most innovative and sustainable regions. The changes taking place in the Arctic pose new challenges and give rise to new opportunities. As a responsible coastal state, Norway strives to address the challenges and make use of the opportunities in a safe and environmentally sound way. India is an important partner for Norway. Increased trade, investments and economic cooperation and cooperation on global challenges, are the topmost priorities for the two countries. Norway and India share many values, and a deep commitment to democracy and a rules-based world order. Norway's cooperation with India is growing. This opens up for many new opportunities for both countries.



Dr. Ekaterina Kim
Norwegian University of Science and Technology, Norway

Automated Vehicles in Arctic Marine Research and More

Arctic is changing, it is cold, dark for half of the year, and there are challenges and uncertainties not commonly found in other development areas. Scientific explorations in this harsh environment will push technology to its limits. There is a need for innovative approaches, in part because we cannot operate in conventional ways in Arctic areas. Norwegian University of Science and Technology has more than 20 years of extensive experimental investigations in Svalbard, the Barents and Kara Seas regions. Our AUR- and UAV-Lab is running a common pool of advanced aerial and underwater equipment and provide robotic platforms and instruments for deployment in Arctic. In this talk, we will discuss challenges of UAV and AUV operations in the remote and harsh conditions. I shall describe a generic recipe for successful use of automated vehicles in Arctic marine research.

Dr. Abul Amir Khan
Department of Geology, University of Delhi, New Delhi

Estimation and comparison of glacial melt in the central and western Himalaya using two and three component isotope mixing model

It is not always easy to identify the different components that constitute river discharge. In the present study, hydrograph separation was carried out using two-component and three component isotope mixing models. Electrical conductivity of river water provides an instant, on-site approximation of the relative contribution of different components of drainage water. Two domains were studied. The first study site represents the upper Ganga river basin, central Himalaya while the second site lies in the Chandra sub-basin in the Lahaul-Spiti district of Himachal Pradesh in western Himalaya. These two Himalayan regions differ in climate and topography. The results of the hydrograph separation suggest that the surface runoff (snowmelt and rainfall) is the major contributor to the total river flow in both the domains. Also, there is a significant temporal and spatial variability in the δ18O and electrical conductivity in the end member components. River water isotopic composition becomes depleted post-monsoon and electrical conductivity remains low in the post-monsoon season. Due to mixing rainfall modifies the actual isotopic signature of glacial ice. Careful selection of end members provide glacial melt (<10% at Rishikesh) that are consistent with the expected thinning rates of Himalaya. Result show higher glacial melt fraction in the western Himalaya.

Mr. Shubhang Kumar
Centre for Land Resource Management
Central, University of Jharkhand., Jharkhand

A short-term assessment of summer and winter velocities of glaciers in the Amery Ice Shelf, Antarctica

Robust monitoring of the glacier dynamics plays an important role to understand the changes that occur in the glaciers using a large archive of remote sensing as a most effective tool for monitoring glacier parameters. The primary objective of this study was to derive the velocity of the eastern tributary glaciers of the Amery ice shelf using C-band Synthetic Aperture Radar (SAR). The secondary objective was to compare the winter and summer velocity of the glaciers for 2017-2018. The study was conducted using the European Space Agency's (ESA) Copernicus program Sentinel-1 satellite's SAR data that operates in the C-band. The Offset tracking method has been applied to the ground range detected product obtained from Sentinel-1 satellite. The eastern tributary of Amery Ice Shelf comprises of two glaciers near the Clemence Massif and one glacier near the Pickering nunatak that drains ice from the American Highland, East Antarctica. The glaciers near the Clemence Massif have low annual velocity of 100 myr–1 in the initial portion of the glacier to around 300 myr–1 near the end of the glacier where it merges with the Amery ice shelf. The glacier flowing near the Pickering Nunatak have moderate annual velocity ranging from 150 myr–1 at its head reaching up to 450 m yr–1 near the tongue of the glacier. The velocity in summer was observed to be higher than the velocity in winter and the difference between the summer and the winter velocities was found to be between 50 and130 myr–1. The accuracy of the derived results was calculated based on bias measurements and by using the RMSE (Root Mean Square Error) method by comparing it to the previous MEaSUREs (Making Earth System Data Records for Use in Research Environments) yearly velocity (at 450 m and 1 km resolution) available on the NSIDC (National Snow & Ice Data Center) portal. The bias in the results did not exceed 20 myr–1 for the three glaciers and the accuracy exceeded 85% for most of the regions.

Dr Pankaj Kumar
Dept of Geography, Delhi School of Economics

Glacial Lake Outburst Flood in Lahaul and Spiti district, Himachal Himalaya, India

Sudden, large river flow caused by an outburst of a glacier lake is generally termed Glacier Lake Outburst Flood (GLOF). The outburst may be caused by the failure of the damming moraine due to its own instability or glacier and/or snow collapse into the lake and may lead to overtopping and eventually to failure of the damming barrier. GLOFs are not a new phenomenon but with the worldwide receding of glaciers and rising temperature the probability of their occurrence has risen in many mountain ranges. Lahaul and Spiti district is tectonically very fragile and totally comes under mountainous ranges of Central/Inner Himalaya and Trans Himalaya. Most of the glacial lakes in the Himalayan region are known to have formed within the last 5 decades, and a number of Glacial Lake Outburst Flood (GLOF) events have been reported in this region. Glacial lake formation is currently being observed in the glaciated regions of the Lahaul and Spiti district and is the most visible and probably the most dramatic consequence of climate change in the area. Glacial lake outburst floods and associated geo hazards like flashflood, landslide and avalanches are common in the district. Mapping of glacial lakes has been done using Normalized Difference Water Index (NDWI) and Normalized Difference Pond Index (NDPI). Two major glacial lakes Samudratapu glacial lake and Geepang Gath glacial lakes have been identified as area of interest as both are showing increase in their areal coverage.

Dr. R. Krishnan
Indian Institute of Tropical Meteorology, Pune

Possible role of Arctic amplification on weather extremes in the Himalayan region

One of the prominent manifestations of climate change is the rapid warming of the Arctic in recent decades as compared to rest of the globe. This accelerated warming of the Arctic, also referred to as Arctic Amplification (AA), is associated with strong reductions in the Arctic snow cover, sea-ice extent and decrease of poleward temperature gradient. A number of recent studies have drawn attention to the impacts of AA on changes in the boreal summer atmospheric circulation and high-impact extreme events over the Northern Hemispheric (NH) mid-latitudes. Although the Himalayan region has witnessed several flood-producing precipitation extremes in recent times, it is not yet clear whether the Himalayan precipitation extremes have linkages to climate change and AA. This talk will focus on this scientific issue and present future plans related to climate change attribution of Himalayan precipitation extremes using the IITM Earth System Model (IITM ESM).

Dr. Nalan Koc
Norwegian Polar Institute
Norway

Planning for multi-disciplinary observations

Understanding and quantifying the impacts of climate change on the Polar Oceans and ecosystems, and their global consequences, are of paramount importance. Changes in the physical and biogeochemical state of the Polar Oceans are already underway. To achieve enhanced understanding of the state and to predict future changes, sustained multi-disciplinary observations are essential. Integrated observing systems for the polar oceans have been advocated for a while (SOOS, CLIVAR, CliC). Moored arrays, autonomous platforms, remote sensing and ship-based observations are all required for this purpose. Norway`s efforts towards this goal in the Southern Ocean off Dronning Maud Land will be highlighted with ongoing ocean observatories and RV Kronprins Haakon 2019-cruise.

Dr. Avinash Kumar
National Centre for Polar and Ocean Research,Goa

An Accelerated decline in the Arctic sea ice cover: A record minimum in Summer 2018

Arctic and Antarctic have seasonal sea ice extent, which plays a crucial role in regulating the global climate. Arctic sea ice extent typically attains a seasonal maximum in March and minimum in September. During the course of the modern satellite record (1979 to present), sea ice extent has declined significantly (-0.55 million km2/decade i.e., -4.73%) in all the months, with the decline being most pronounced in September (-0.80 million km2/decade i.e., -12.48%). Arctic sea ice extent declined rapidly to an unprecedented low in the summer of 2018, raising a concern of its disappearance. The maximum Arctic sea ice extent was recorded 7.67 million km2 in September 1980, however, Arctic sea ice extent in September 2018 dropped to 4.59 million km2, tying for the sixth lowest minimum in the satellite record along with 2008 and 2010. This year's minimum extent (September, 2018) ranked behind 2015 (fifth lowest), 2011 (fourth lowest), 2007 and 2016 (tied for second lowest), and 2012 (lowest, 1.20 million km2). Incidentally, the events of twelve lowest extents in the satellite era have occurred in the last twelve years. These conditions could have likely resulted from (1) anomalous warm southerly winds during spring, advecting ice poleward from the Siberian Sea, and (2) persistent low pressure and high temperatures over the Arctic Ocean in summer, promoting ice divergence and rapid melt. The current study demonstrates that the sea ice variability is linked to warming-cooling processes, and in turn supplemented by the cumulative effect of ocean currents, winds and other ocean-atmospheric parameters.

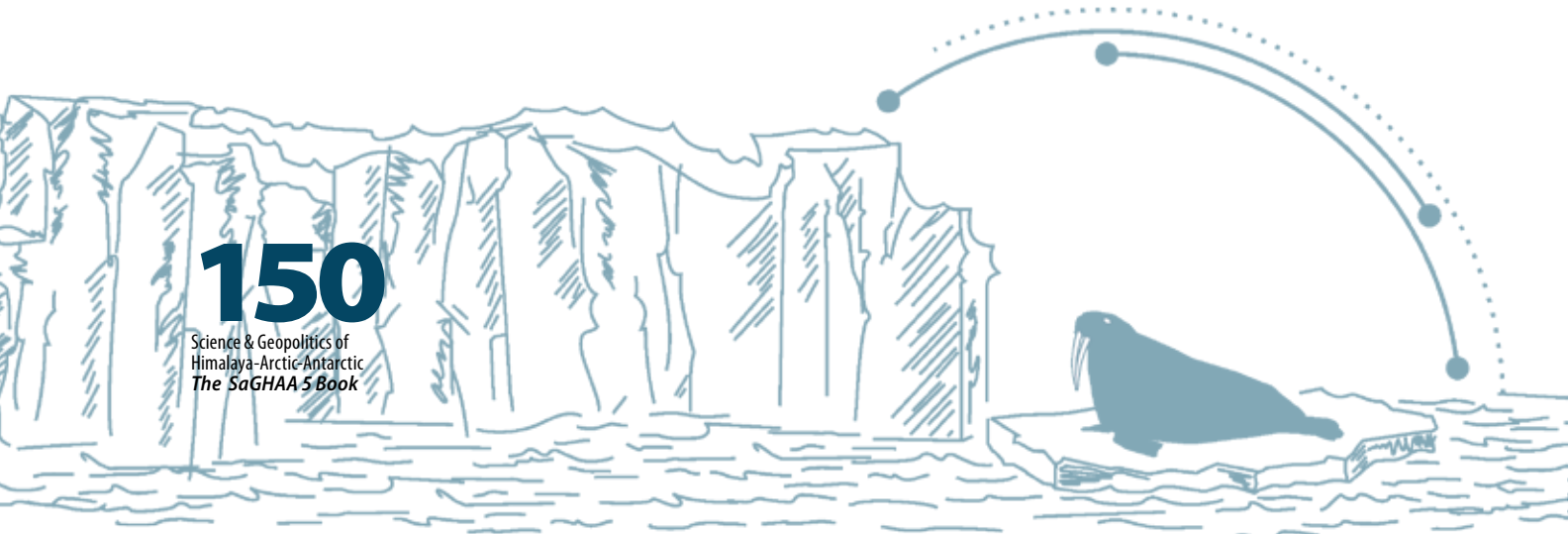
Mr. Stephan Lanzinger
Head of Science Section
Embassy of Federal Republic of Germany in India.

German Polar Research

Germany operates an extensive polar research program. German polar research is based on a modern high-tech infrastructure, including permanent research stations in the Arctic and Antarctic as well as several research vessels. Germany commands one of the most advanced research fleets in the world. Numerous German research institutions, universities and companies conduct polar research, in particular the Alfred Wegener Institute / Helmholtz Centre for Polar and Marine Research (AWI).

International cooperation is of particular importance to Germany, as the example of the forthcoming MOSAiC project ("Multidisciplinary Drifting Observatory for the Study of Arctic Climate") shows. MOSAiC - the biggest Arctic expedition of all times – will involve scientists from 17 nations. The German research vessel "Polarstern" will be at the centre of the mission which will start in September 2019.

In addition, the "Year of Polar Prediction" (YOPP) research initiative will be studying climate changes at both Poles until mid-2019. Its findings are to be used as a basis for improving weather forecasts. This would minimize dangers – for example, to shipping.



Dr. Abhijeet Mazumder
Birbal Sahni Institute of Palaeosciences,
Lucknow, India

Record of paleo-sea level change based on diatom study from a lake of Vestfold Hills area, East Antarctica

The lacustrine sediment samples of 47 cm long core from the shelf area of Vestfold Hills regions, Antarctica were studied. The core reached 6.48 kya of age at the bottom. The major objective of this study was to reconstruct the palaeoclimatic change during mid- to late-Holocene, with special emphasis on the influence of marine water in this inland lake. A very restricted range of 13 diatom species were identified which gives a lacustrine environmental significance with marine intrusion event and climatic change of the area. These 13 species are grouped mainly under nine genera Amphora Ehrenberg ex Kützing, 1844 (1 species), Cocconeis Ehrenberg, 1836 (1 species), Diploneis Ehrenberg ex Cleve, 1894 (2 species) Fragilariopsis Hustedt, 1913 (2 species) Paralia Heiberg, 1863 (1 species), Navicula Bory, 1822 (3 species), Pinnularia Ehrenberg, 1843 (1 species), Thalassiosira Cleve, 1873 (1 species) and Trachyneis P.T.Cleve, 1894 (1 species). The relative percentage of total marine diatoms as well as the change in sedimentation rate confirmed the marine influence of this lake in the mid-Holocene, which got lessened after ~4.5 ka BP. This is also supported by the CONISS cluster analysis (considered abundance of species as variables) which shows two distinct zones divided around the same time. This can be correlated with the major Antarctic glacial retreat event ending at ~4 ka BP.

Dr. Pradip Malhotra
Director, Life Saving Society of India, Kolkata

Value of Detailed Medical check- up and Pre Antarctic Training

The value of detailed medical check- up and pre Antarctic training depends upon its members, their involvement, sincerity, experience and expertise. Training in various sectors helps to improve the output.

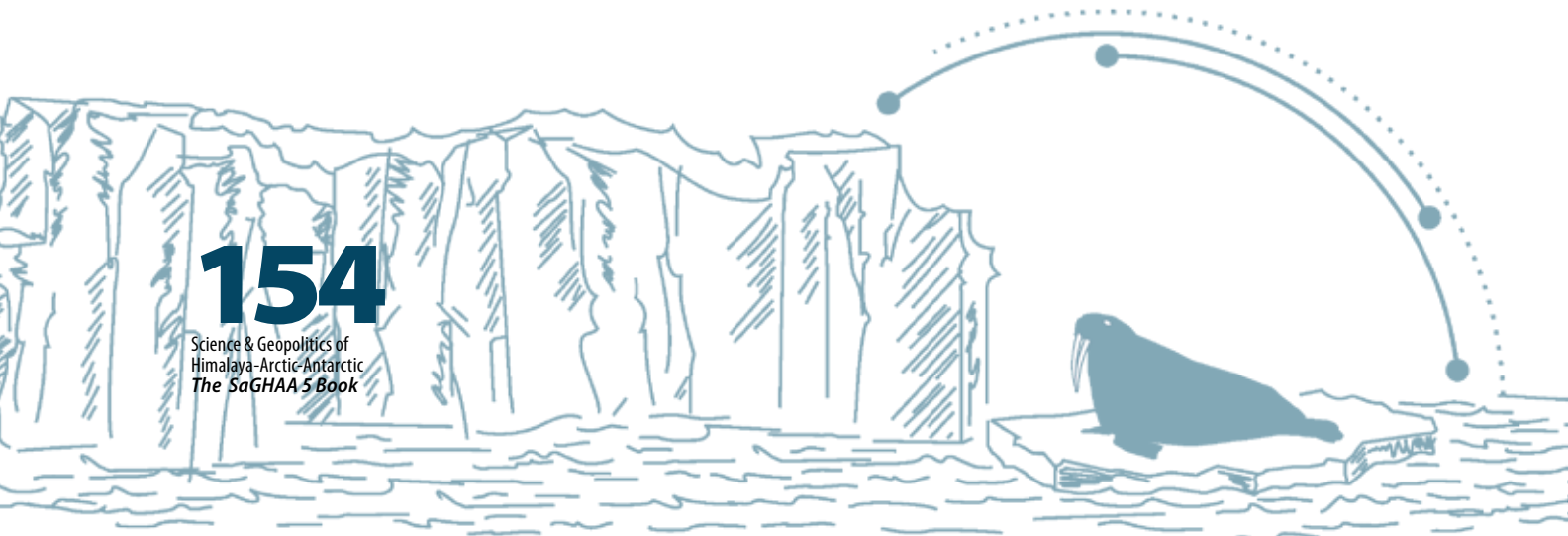
In general all the participants of any expedition and the organizers, want the best results and best outcome. In spite of all the efforts, the means and the desire, sometimes things may go wrong if the health of the expedition members is affected. The efforts in the pre expedition medical check-up and training are to screen the members for any potential health hazards, inculcate the hygienic habits among the members and to make them aware of preventive health aspects so that they can avoid various diseases and tackle health issues specific to Antarctica. An elaborate psychological assessment is very important specially for wintering team members. It is absolutely necessary to screen and exclude people with damaged psyche or those who may be carrying a psychological baggage to Antarctic expedition. In the opinion of many, an Antarctic wintering is more difficult from psychological aspect in comparison to physical challenges. Pre Antarctic Training, at Auli, acts as a team building exercise and develops a sense of bonding and comradeship among the participants who belong to different areas of our vast country and are often unknown to each other before this event. In this discussion we intend to evaluate the value of Detailed Medical check-up and Pre expedition training along with a glimpse of the future of health care in our Antarctic stations and expeditions.

Dr. Ashis K. Mitra
ESSO-NCMRWF,
Noida.

Real-Time Polar Sea-Ice Prediction with NCMRWF Coupled Model

NCMRWF has implemented a coupled climate model with sea-ice model as an interactive component. With advent of satellite data and high performance super computers, now it has become possible to include the large-scale processes of atmosphere, ocean, land-surface and cryosphere including the polar sea-ice of Arctic and Antarctic regions into high resolution numerical global simulation models. These high resolution coupled earth-system models are able to capture the short-term climate variability including the polar sea-ice in a reasonable way. The state-of-art coupled HadGEM3AO based model has been implemented at NCMRWF and is being run in real-time for polar predictions at short and extended range. The global coupled model has UM atmosphere, NEMO Ocean, CICE sea-ice and JULES land surface components as the respective sub-models for atmosphere, ocean, sea-ice and land surface respectively. Several years of hind-cast data having few ensemble members are also generated to study the skill of the model in various seasons of the Polar Regions. For south-Asian summer mean monsoon rainfall (variability) simulation and its tele-connection with many other remote atmosphere/oceanic parameters is still a challenge to world modeling community. Recent studies suggest a strong link of monsoon rainfall variability to polar sea-ice processes. Reduction of Arctic sea-ice in recent years is another cause of concern to climate community. It's possible link to south-Asian monsoon has to be studied for a realistic prediction of monsoon rainfall in extended and seasonal time-scales. A version of the said coupled model is used to study the quality of sea-ice simulations for Polar Regions

	at seasonal time-scale also. Using several years of hind-cast data from the said coupled model the sea-ice simulation for Arctic and Antarctic regions are evaluated against observed estimates from satellites. The model simulates the mean sea-ice concentration, extent and thickness in both the poles in a realistic way. The simulation of inter-annual variability of sea-ice is also seen to be realistic. The model has the potential to be used as a prediction model for sea-ice related parameters for both Arctic and Antarctic regions in real-time for seasonal scale also.



Dr. Rahul Mohan
National Centre for Polar and Ocean Research (NCPOR), Goa

Southern Ocean Paleoceanography using diatoms

Diatoms are unicellular algae made up of siliceous cell wall known as "frustule". They are the major contributor (75%) of Southern Ocean primary productivity and hence the major biogenic phase available in the sediments as siliceous frustules. Higher diatom abundance in the Southern Ocean phytoplankton leads to the formation of circumpolar "siliceous ooze/opal belt" at ~ 60 S latitude. This opal belt forms the major diatom archive system which is indicative of surface water conditions and bears the ecological and climatic signal to reconstruct paleoclimate. Generally, 1-10% of the diatoms produced in the surface water reach the sediments due to dissolution in water column and water-sediment interface and lateral transport. Despite this, various studies have shown that the residual sedimentary assemblages are still indicative of surface characteristics in the Southern Ocean. Diatoms therefore are the major tools to infer the past oceanographic and climatic changes in these regions. In Southern Ocean diatoms generally show north–south gradients of increasing or decreasing abundances depending upon their ecological preferences for warmer or colder temperatures. Fossil diatoms experience distribution in gradients from high abundances indicating favourable overlying conditions, to low abundances indicating unfavourable conditions. In addition to diatom abundance, diatom valve size is also known to respond to the varying climatic conditions. For instance there are studies from Southern Ocean suggesting that the sizes of Fragilariopsis kerguelensis (pennate diatom) and Thalassiosira lentiginosa (centric diatom) are larger at the proximity of Antarctic Polar front (APF). Hence the study of the sizes of these two diatoms in a sediment

	core can be used to trace the past latitudinal changes in the position of APF. Such studies using Southern Ocean sediment cores have been done and suggest a glacial shift in the Antarctic winter sea-ice limit and Polar Front respectively up to the modern day Polar Frontal Zone of Indian sector of SO. Studies have also revealed that glacial periods north of the Polar Front were characterised by high diatom productivity and larger Fragilariopsis kerguelensis and Thalassiosira lentiginosa sizes. The larger and highly silicified diatoms such as F. kerguelensis and T. lentiginosa may have effectively contributed in transporting biogenic silica and organic carbon to the sea bed.

Dr. Shyamlal K. Nandi
Former Scientist 'G' & Group Head-EACC, G.B. Pant National Institute of Himalayan Environment & Sustainable Development, Uttarakhand

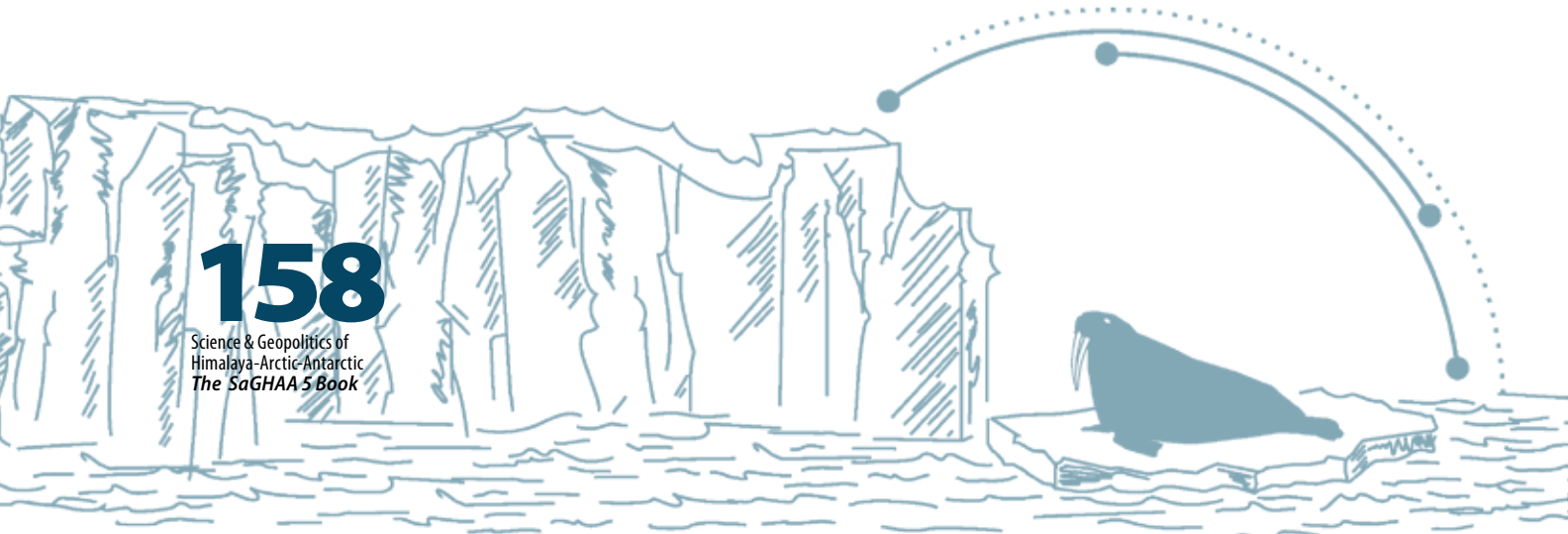
Forest ecosystems and plant biodiversity: Climate change and implications in the Indian Himalaya region

The Indian Himalayan Region (IHR) with over 5.3 lakh km2 of vast mountain range extending over 2500 km in length and 220-300 km width, between Indus and Brahmaputra river system and rising from low lying plains to over 8000 m, covers partially or completely twelve states of the Indian Republic and is amongst the 35 global biodiversity hotspots for its unique and rich biodiversity. About 8,000 angiosperms, 44 gymnosperms and 600 petridophyte species have been reported in the IHR, and of these, 1,748 species are known to have some medicinal uses. The region is very sensitive to changing climatic conditions, partly due to also human induced perturbations. While continuous rise in earth's atmosphere is accepted, evidence does indicate that Himalaya is warming at a much faster rate. As a consequence, the forest ecosystems and plant biodiversity in the region is predicted to respond to this rapid warming. Nevertheless, information of these responses and possible consequences is very limited. Therefore, it is important to have knowledge on distribution and abundance of forest resources and plant biodiversity as a consequence of climate change. The work focuses on changing status of forest cover, forest composition and regeneration status, the trends of climate change, it's possible impact on forest ecosystems. and possible strategies for conservation of this diversity in the IHR.

Mr. Prashant H. Pandit
National Bureau of Soil Survey and Land Use Planning , Indian Agriculture Research Institute, Delhi

Mapping Blue-Ice areas using multiple indices approach: A case of Polar Record glacier, Antarctica

Blue Ice Area (BIA) are characterized by hard ice in a cryospheric environ which appears blue due to net ablation dominated by sublimation and wind scouring exceeds the accumulation by precipitation and snowdrift deposition. BIAs is characterized by negative surface mass balance. They are scattered widely over the Antarctic continent and cover only 1% of surface area, but the ice is of great interest for paleoclimatic studies and they are sensitive to climate change. Antarctic BIAs acts as meteorite traps: meteorites that fall in the surface in accumulation zone are transported to and concentrated in the BIAs by ice flow, so these are popular among glaciologist, meteorologist, geologist, environmentalist and climatologist. For the research stations in the Antarctic, BIAs is the main source for drinking water and serves as airplanes runway. This research has attempted to map the BIA of Polar Record Glacier, East Antarctica using spectral band indices approach derived from satellite-based remote sensing data. This study estimated that more than 30% of the total surface area of the Polar Record Glacier is covered with BIAs, and multiple factors are influencing the variation of BIAs. The total area is also depending upon the climatic and season changes, while the reliable knowledge of parameters like katabatic wind direction, the rate of sublimation and ablation, wind pattern and surface temperature, etc. can increase the accuracy of the result. This study also found that there is a high impact of surface albedo on the BIAs, causing significant variation in the spatial extent and total surface area of BIAs.



Dr. Luvkush Kumar Patel
ESSO-National Centre for Polar & Ocean Research, Goa

Thermal behaviour of debris covered glaciers, Western Himalaya

Debris are one of the unavoidable components of the Himalayan glaciers and have a critical role in glacier dynamics. As contrast to normal ablation pattern over glaciers, debris covered glaciers of this region have experienced inverse ablation rate due to significant control of debris cover. Considering complex nature of debris materials, surface temperature becomes crucial factor to estimate thermal resistance of debris to calculate ablation under debris covered glacierised area. In this investigation, an attempt has made to quantify the thermal resistivity of supraglacial debris of Chandra basin by using heat flux method. The ablation and temperature (surface and subsurface) data was obtained from stake networks and T-data logger installed over glaciers in different altitude ranging from of 4100 to 5100 m .a.s.l. during the year 2016-17. The Chandra basin has 702 km2 glacierised areas and almost ~22% of this area is covered by the debris of various thicknesses (10-150 cm). The major component of the debris in this basin is Quartzite, Phyllite, Mica, Slate, Gneiss and feldspar. Observation revealed lower temperature at the debris surface and debris- ice interface during November to May and vice –versa during June to August. There is significant diurnal variation in thermal resistance of debris, higher during day than night, may be caused by variation in vapour pressure in the debris layer under the saturated water pressure condition.

Shree Manish Pandey
University Centre for Research & Development, Chandigarh University, Mohali, India

Surface facies analysis vis-à-vis melting of a Western Himalaya Glacier

We analysed WorldView-2 PAN as well as multi-spectral satellite imagery of the Chhota Shigri Glacier situated in Chandra Valley of Western Himalaya to quantify different surface facies using three different image classification algorithms. Glacier surface facies identified in this study are: 1) Clear Snow, 2) Dirty Snow, 3) Snow Mixed Debris (SMD), 4) Debris Mixed Snow (DMS), 5) Dark Debris, and 6) shadow. Three variants of ultra-high resolution (0.46 m at Nadir) WorldVew-2 data of 3rd October 2010 i.e. Panchromatic, multispectral, and pan merged multispectral have behaved differently on accuracy levels in distinguishing the different types of surfaces. The images were classified using k-means, ISOCLUSTER and maximum likelihood classifier (MLC) algorithms embedded in ENVI and ArcGIS 10.3 software packages' classification modules. It was found that the PAN data analysed with k-means classifier has yielded highest level of accuracy in surface facies classification. Area of the glacier delineated using data from Google Earth Pro was used in this study. The debris cover percentage over the entire glacier surface was found to be ≈ 12.24 as compared to the reported debris cover of~4% by Vincent et al. (2013) and (Laha et al., 2017) if calculated using area delineated from Google Earth Pro). Melting rate of glacier surface computed using glaciological method was compared with different surface types and the results show that dirty snow has higher melting as compared to clean snow and in the same way, DMS melts faster than SMD. Results of this study have important implications in reducing uncertainty in mass balance and energy balance models.

Dr. B.W. Pandey
Department of Geography,
Delhi School of Economics,
University of Delhi

Himalayan Geosystem: Features, Challenges and Initiatives an Overview

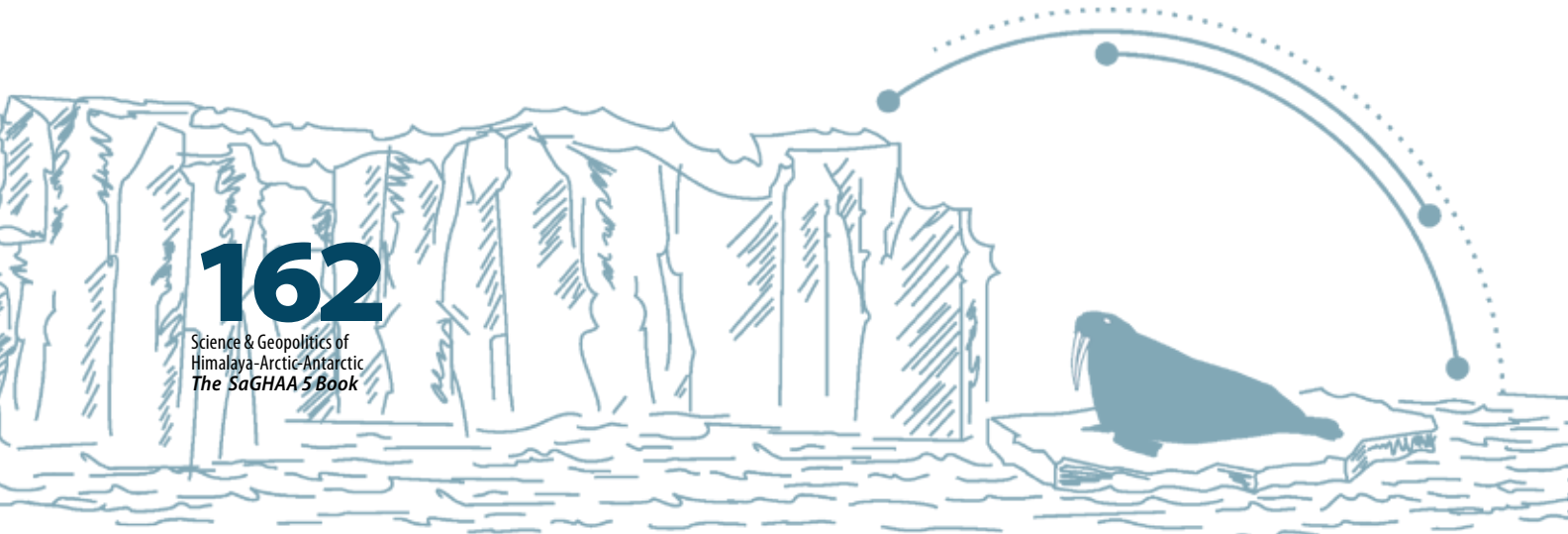
The mountain systems are complex and highly fragile ecosystems with vast resources that provide ecological and economic support to its own population as well as the population of the lowland areas At the same time these are highly sensitive to hydrological and climatic changes. Tourism is an important part of the economy of all mountain areas and it is also the main driver of urbanization and the consequent land use and land cover changes. Himalaya is one of the most delicate and fragile mountain ecosystems of the world and is under threat due to rapid increase in population, urbanization and uncontrolled tourism expansion. This has resulted in irrational land transformation and overutilization of natural resources like land, forest and water. This unprecedented increase in the number of human population as tourists in Himalaya shows immediate impact on its fragile environment. Increased population exerted huge pressure on existing natural resources. It has been found that the recent constructions and other developmental works are not suitable for such a tectonically active mountain like Himalaya which being a young fold mountain belt with humid climate, is highly vulnerable to landslides and other kinds of mass wasting hazards. Facing windward conditions to Indian Summer Monsoon, it is highly affected by High Flow Hazards (HFH) such as cloud burst and flash floods. Urban consumerism behaviour has altered the land use and land cover in Himalaya at a large scale, resulting in negative impact on the local indigenous community and their livelihood. New initiatives of ecological restoration and livelihood options have become dire need of the time for Himalayan conservation and sustainable livelihood of the local indigenous community.

Dr. Vimlesh Pant
Centre for Atmospheric Sciences, Indian Institute of Technology Delhi, New Delhi

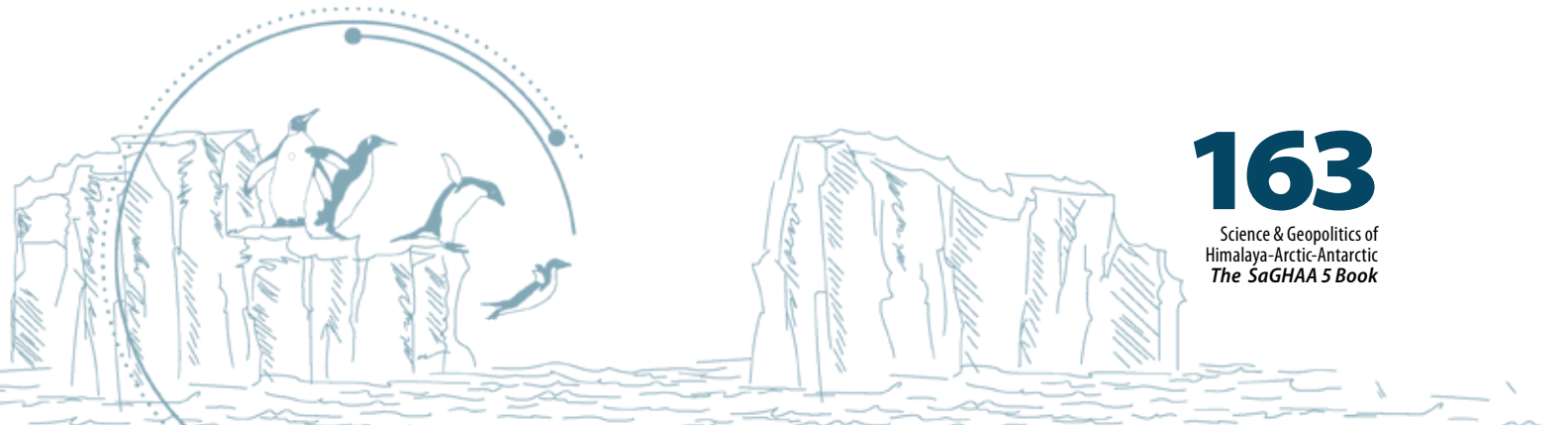
Impact of Arctic sea-ice changes on oceanic physical-biological characteristics in the Arctic Ocean

The unprecedented changes in the Arctic sea-ice in the recent years have significant impact on the circulation pattern, physical and biological parameters in the northern high latitudes. One of the important implications of the ice-melt is the variation in upper-oceanic freshwater content. The air-sea exchange of gases in the Arctic Ocean found to have important contribution in regulating carbon between atmosphere and ocean. The excess load of anthropogenic carbon dioxide (CO_2) into the ocean affect biogeochemistry of the surface waters and may lead to oceanic acidification. The difference in partial pressure of CO_2 ($DpCO_2$) between the atmosphere and ocean determines the oceanic uptake of CO_2. The seawater temperature, and turbulence in upper ocean affect the solubility of CO_2 in ocean. The dissolved inorganic carbon (DIC) supports the growth of phytoplankton. A larger melting of sea-ice alter the oceanic stratification, mixed layer depth and significantly impact the oceanic $DpCO_2$. The continental freshwater discharge adds nutrients to the seawater which are crucial for the oceanic primary productivity. The variability of freshwater discharge into the Arctic Ocean due to climate change would, therefore, impact the biological productivity of northern high latitude.

Using the climate model data from the Community Earth System Model (CESM) with the biogeochemical module (CESM1-BGC), the changes in physical and biological parameters in the Arctic oceanic regions are analysed for the years 1850-2100. Different processes responsible for the variations in oceanic parameters are explained in view of ice-melt, freshwater transport, and warming of the Arctic Ocean in the changing climate. The differences in the $DpCO_2$, surface



	temperature, Chlorophyll, Phytoplankton concentration, and DIC are analysed over the Arctic Ocean for the past (historical), present, and future climatic scenario. The time-series analysis carried out over the Bering strait, Barents Sea, and at the location of cold dense water formation in the north Atlantic Ocean. In response to the warming surface waters, the model shows a decline in CO2 flux after year 2050. The enhanced oceanic stratification due to accelerated melting of sea-ice may lead to weakening of density driven overturning circulation. The oceanic productivity reduces in most of the Arctic Ocean as the chlorophyll concentration reduces up to -2 mg m-3 in the future climate as compared to the present climate.



Dr. Raghava, G.
CSIR - Structural Engineering Research Centre, Chennai

Structural assessment of the second Indian Research Station 'Maitri' in Antarctica and need for immediate replacement

Maitri, the second Indian Research Station was built in Antarctica during 1988-89. As against the original design life of ten years, it has already served as a permanent station for the last thirty years. Because of some damage observed in the structure, CSIR - Structural Engineering Research Centre (CSIR-SERC), Chennai, was asked to carry out 'Structural assessment of the Maitri Building in Antarctica' in 2003. Two scientists from CSIR-SERC participated as team members of the XXIII Indian Scientific Expedition to Antarctica and carried out the structural assessment of the Maitri Station during January-March 2004. During visual examination of the supporting structure, cracks were identified in nine supporting columns. Length of crack in the supporting columns of the main block varied from 7 cm to 50 cm and extended below ground level in some columns. It was physically seen that some cracks were through-thickness cracks for part of the length. An evaluation of safety of cracked columns was made and a possible repair measure was suggested. Blocks A and C of the station warranted immediate replacement. Data of acceleration obtained from Maitri during gusty winds was analysed using Fast Fourier Transform. The analysis showed that the structure was sensitive to dynamic wind action. This paper gives the details of work carried out, defects, damage and deterioration found in the structure, and observations made during the study. It is strongly recommended that an immediate replacement for the structure be taken up.

Dr. D. Rajasekhar
National Institute of Ocean Technology, Chennai.

Research Ship Management Strategy and Innovative Engineering Solutions

This paper discusses about ship management strategy and various innovative engineering solutions implemented for improving the performance of Oceanographic Research Vessel (ORV) SagarNidhi. The key focus techniques viz., Energy management system (EMS), Ballast water management (BWM) and Integrated automation (IA will be covered. Energy management system collects the data from major ship equipments viz., Engines, Propellers, Thrusters, HVAC and Deck machineries. This data is plotted in a graphical format along with historical bench mark. Factors such as ship operations, ship conditions and fuel management are considered for energy saving. Implementation of Energy management system onboard Sagarnidhi complies with Ship Energy Efficiency Management Plan (SEEMP) - a regulation set by International Maritime Organization (IMO). The Ballast water management system provides stability, improves propulsion, manoeuvrability and prevents the transfer of aquatic micro-organisms. Integrated automation takes input from sensors, radar and satellites. It optimizes performance, reduces over all ship operation and maintenance cost, improves efficiency, reliability and safety. Apart from these merits, the overall advantages are as fuel savings, reduction in harmful pollutants viz., SOx, NOx, CO, CO2 etc., and enhancing ship utilization by minimizing time required for operation and maintenance. The innovative engineering solutions implemented onboard ORV Sagarnidhi enabled highly reliable Position keeping. Use of Nano-materials blend for reducing ship emission, development of innovative model for reducing NOx/SOx in ships as part of Green Technology and Energy efficient parallel pumping system in Ballast water management for reduction of ship emission. In this paper individual Technology/Management strategy and its merits are explained in detail.

Dr. Rasik Ravindra
Former Director, National Centre for Polar & Ocean Research, Goa.

The alternate site and conceptual design for new Maitri Station

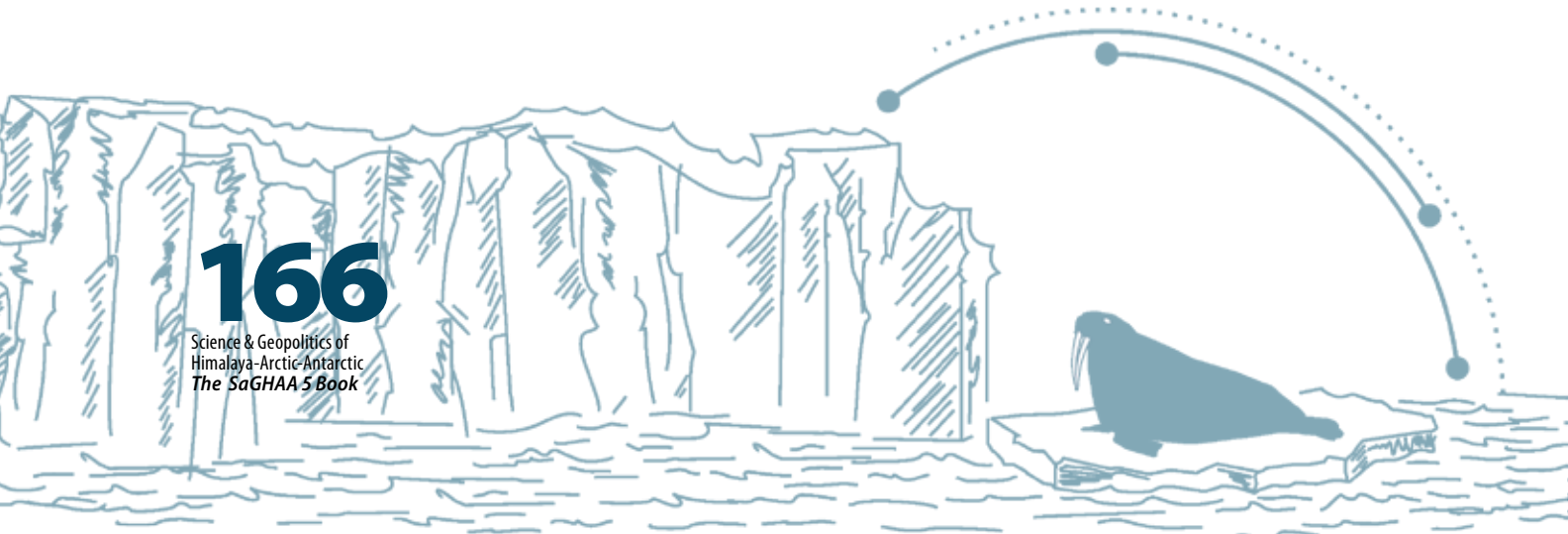
The Indian research station Maitri, located in an ice free Schirmacher Oasis and built with indigenous material and expertise during 1987-91, has since lived its stipulated life. An expert team comprising structural and environmental engineers that inspected the station pointed out cracks in several telescopic columns supporting the station, sagging of cap plates and problems of leakages etc. The international teams from many Antarctic State Parties, that inspected the facilities at Maitri under laws of Antarctic Treaty, have also pointed out certain corrective measures in line with protocol on protection of Antarctic environment and associated ecosystem that are needed to be taken. India has more than once made its intentions of building a replacement of Maitri Station known to Treaty nations in ATCMs to justify not investing heavily in modernizing a four decade old station.

Among the many sites investigated by author and veteran Antarcticans between 1996 and 2011, it was found that the area north of Priyadarshini Lake, is most suitable in view of following points:

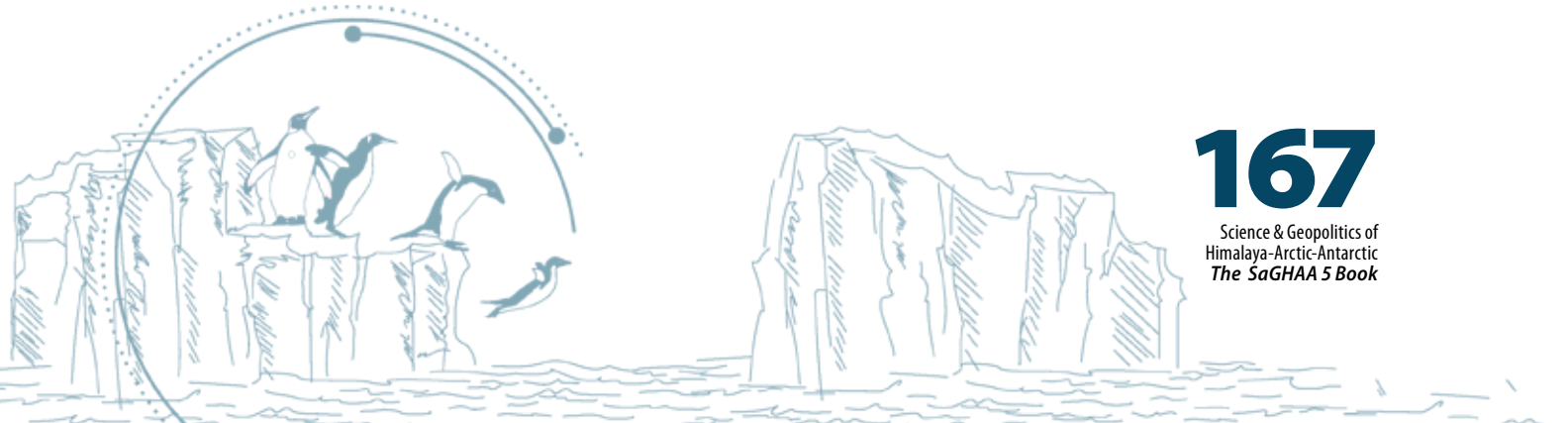
a. the existing facilities need not be demolished and removed from Antarctic (a condition imposed by Antarctic laws) as these can be earmarked for the emergent back- ups, thus saving huge costs,

b. the existing scientific infrastructure such as that of IIG, IMD, SASE and logistic facilities, such as vehicle parking, repairs, fuel storage, summer camps etc, can be continued to be used

c. the potable water can be pumped from Priyadarshini lake located up stream (against the existing scenario) and liquid waste can be discharged downstream towards shelf, after treatment.



	d. the existing track to Ice margin and India Bay for convoys can continued to be used with a minimum of road building skirting the western margin of Lake. e. the flat valley west of 125m hill offers a suitable location for helipads additional to those existing. The site identified exhibits three monds disposed in a pattern that resemble the English letter "Y", with the two hills on the eastern side having an elevation of 119 m above m.s.l. while the third hill at 125 m elevation is located towards west. The near E-W alignment of the proposed station design goes well with the prevailing wind direction.



Dr. A. L. Ramanathan
School of Environmental Science, Jawaharlal Nehru University, New Delhi 110067

Monitoring of the Himalayan and Arctic Cryosphere: a multidisciplinary approach through in-situ observations

Various studies on the Himalayan glaciers have been recently initiated as they are of particular interest in terms of future water supply, regional climate change and as well as the catastrophic mountain hazard such as glacial lake outburst floods. In 2002, a long-term monitoring program was initiated on Chhota Shigri glacier in Himachal Pradesh for multidisciplinary studies under the framework of DST, Govt. of India. The glacier is now recognised as one of the best-studied glaciers as a climate change indicator having the longest record of in-situ glacier mass balance dataset in Hindu-Kush-Himalayan region. So far, our results reveal that the Chhota Shigri glacier has lost a mass of ~7 m w.e. (-0.53 m w.e. yr-1) over the last decade. The timing and intensity of snowfall events during the summer monsoon season play a key role on controlling the annual mass balance of the glacier in the western Himalaya. The lower ablation part close to 4425 m a.s.l. (excluding debris-covered area) experienced the highest melting throughout the entire measurement period (since 2002) with cumulative value of ~50 m w.e. at Chhota Shigri glacier

Over the time we have expanded our network to monitor few more glaciers to understand the influence of different climate regime and circulations such as Indian summer monsoon and mid-latitude westerlies. We have initiated the monitoring of long-term mass budget for Patsio glacier (Himachal Pradesh) since 2010, Stok glacier (Ladakh, J&K) since 2015, Lato glacier (Ladakh) since 2018 and one glacier in Eastern Sikkim. Besides the Himalaya, we are a part of national polar glacier research programme under which Vestre Broggerbreen and Feiringbreen glaciers in Svalbard, High Arctic have been taken up for long-term monitoring.

Dr. M. Ravichandran
National Centre for Polar and Ocean Research, Goa

Himalayan Cryosphere in a changing Climate

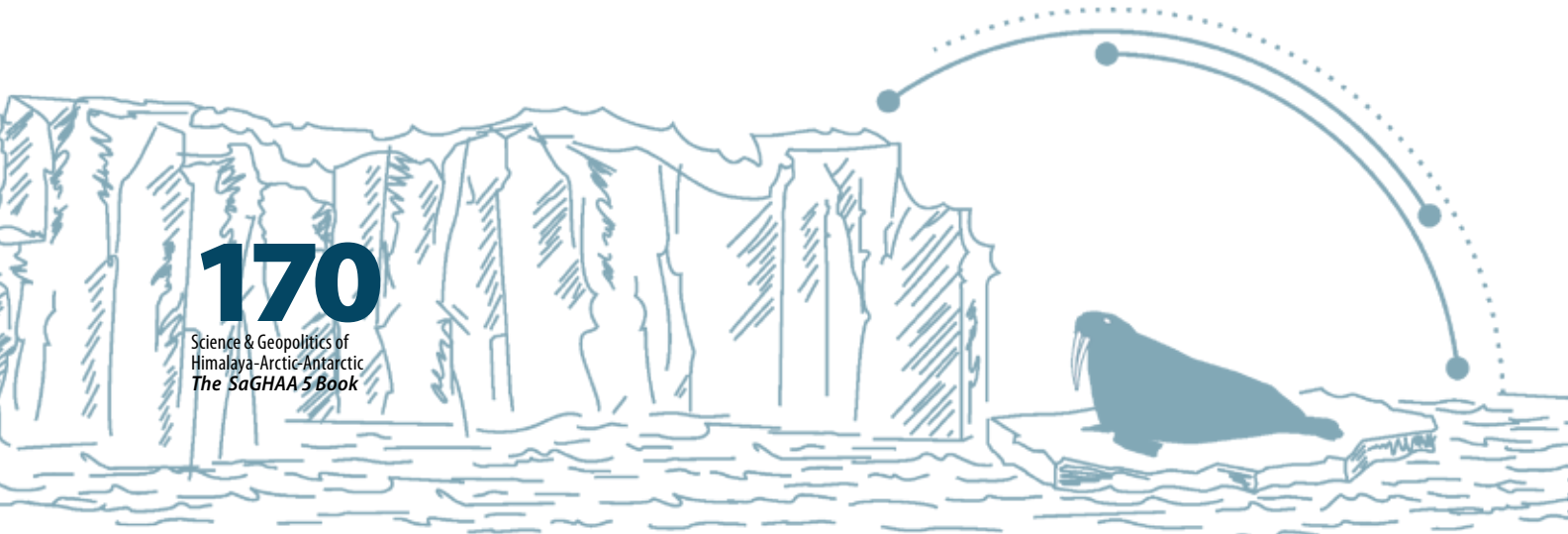
The unique geographic region centred around the Himalayas and Tibetan Plateau is known as the Third Pole, because its ice fields contain the largest reserve of fresh water outside the polar regions. This region is the source of the 10 major river basins that form the lifeline of approximately 1.9 billion people (The Hindu Kush Himalaya Assessment, 2019), including 240 million in the mountain and hills of the Hindu Kush Himalaya. The importance of this region, major characteristics of Himalayan Glaciers and its retreat will be reported. The contributions from Base flow, glacier melt, snow melt, rainfall runoff for the stream flow during the recent decade will be highlighted, along with future projection of mass loss of Himalayan glaciers during different warming scenario. Finally, the objective and way forward of Himalayan program of Ministry of Earth Sciences will be highlighted.

Dr. Yogesh Ray
National Centre for Polar and Ocean Research
Goa, India

The Science of Logistics: Insight to logistical challenges faced during 37thISEA

The Scientific and the logistics activities at Polar Regions require advance planning, coordination and execution at right time, at right place. The right time in the broader context shall be referred as the weather and sea ice conditions. The sea ice thickness is a crucial parameter to consider. Too thick will restrict the passage of vessel and too thin will create danger for completion of safe cargo operation. Depending upon the quantum of load safe manoeuvring of vessel, man and machinery over sea ice may be planned after studying the available satellite imageries, geophysical surveys like GPR profiling cross checked at places with physical assessment of sea ice.

In this paper we are discussing the logistical challenges faced during the summer season of 37 Indian Scientific Expedition to Antarctica (37 ISEA) and methods and strategies sorted out to overcome the hardships and accomplish all planned tasks safely with flying colours. The major challenge of 37 ISEA was to deliver the heavy machinery and construction material for the construction of second Data Reception System (DRS) antenna of remote sensing satellite ground station of ISRO at Bharati Station. As the task was mammoth and the time was short, timely delivery of all heavy machinery and construction material over the sea ice was crucial and had to be carried out in an unflawed manner. Any setback or loss of equipment could jeopardize the whole mission and force to shift the construction activities to next season. The safety of individuals working has also to be taken care of as even a minor injury may lead to loss of good weather days in a terrain where men and material both are at minimal.



Dr. Sandip Roy
Geological Survey of India,
Nagpur

Geology of Schirmacher Oasis, cDML in light of the Passage of East African Orogeny through Antarctica- A review

Neoproterozoic ages granulite grade of metamorphism is reported from the Schirmacher Oasis and Humboldt Mountains in central Dronning Maud land area of East Antarctica by a number of workers. A review of the tectonothermal events during the passage of East African Orogeny, through Schirmacher Oasis, was carried out by detailed mapping and studying a portion of the Oasis. The rock types exposed comprise an interbanded sequence of granite gneisses, charnockite, enderbite, pyroxene granulite and metaultramafics, metapelites along with intrusives like lamprophyre, dolerite dykes and quartz veins.

Three tectonothermal episodes have been observed in this part. Evidences of earliest possible foliation (D1) and associated metamorphism (M1) are recorded at few places. The earliest recognisable metamorphic assemblage which possibly represents the pre-peak metamorphic event (M1) is that of quartz+fibrolite+biotite occurring as inclusions within the garnet porphyroblasts in metapelite from near the mapped area.The prograde M1 metamorphic condition is based on the kyanite-to-sillimanite progression and appearance of garnet in metapelites.

D2 gave deformation gave rise to regional folds which govern the map patterns. Assemblage of oriented grains of orthopyroxene-clinopyroxene-plagioclase-amphibole± quartz±ilmenite indicates that the D2 and associated granulitic facies metamorphism M2 may be at least part-synchronous. D3 is represented by development of a) upright open folds and b) shear zones. M3 event is manifested by the retrograde metamorphism of granulite facies rocks to amphibolite facies rocks. This tectonothermal event is placed as D3/M3 and is probably the last of the event.

	A compilation of the metamorphic P-T-t paths and reported ages from Dronning Maud Land indicates that 500-600Ma orogenic activity was widespread in the area. Neoproterozoic age (~640Ma) granulite grade of metamorphism is also reported from the Schirmacher Oasis and Humboldt.). Granulites representing the 600-660Ma East African Orogeny have been correlated with Schirmacher by Ravikant et al., 2004).

Dr. T. P. Sabin
Center for Climate Change Research,
Indian Institute of Tropical Meteorology, Pune, India

High-resolution global climate modeling for the Himalayan region

With a consistent warming trend in surface temperature, changes in precipitation pattern and increase in weather extremes, the Hindu Kush-Himalaya Mountain Ranges perceive climate change signals profoundly from the second half of the twentieth century. This talk will be giving a brief overview of the status of climate change over the high mountainous ranges and examine the state of the art climate models providing consensus views in the observed and projected future changes in a warming world. We are exploring the information from CMIP5, dynamically downscaled CORDEX-SA (50km), statistically downscaled NEX-GDDP (25km), variable resolution simulation from LMDZ (35 km over SA) and High-Resolution IITM-GFS (27km) in this study, to understand the sizeable spatial heterogeneity in precipitation and temperature-related indices over this complex mountainous belt. High-resolution climate models show specific value addition compared to the coarse resolution CMIP5 models and are more skilful in simulating observed patterns and changes in the present day climate. The simulations hint a possible anthropogenic induced warming over the Hindu Kush Himalaya which is likely to be at least 2.5 to 4.5 °C warmer than present, by the end of the 21st century. The extreme precipitation due to the increased WD activity may positively contribute to glacier mass gain over the western Himalaya compared to the other Himalayan sectors. Even though there is considerable inter-model spread, the consensus among different projection strategies gives confidence in the projected increasing signal in mean (30-50%) and extremes (15-30%) in precipitation by the end of the 21st century, which will have severe cryospheric and hydrological implications in socio-economic conditions of billions of life in South Asia.

Dr. Rajeev Saraswat
National Instituite of Oceanography, Goa

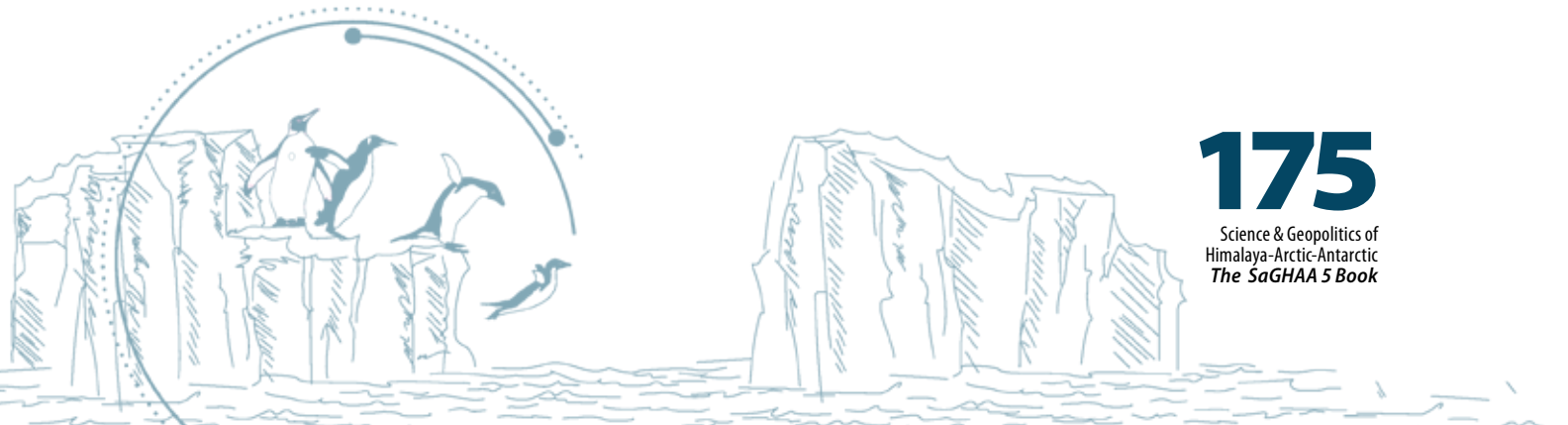
Did Polar Regions modulate glacial-interglacial transitions in the northern Indian Ocean

Earth's climate oscillated between short, warm interglacial and long, cold glacial intervals during the Quaternary. The changes in insolation due to a variation in eccentricity, precession and obliquity are the major factors responsible for glacial-interglacial transitions. The changes in the extent of huge Polar ice-sheets, as a result of insolation, are suggested as the pace-makers of the glacial-interglacial transitions at ~100 kyr periodicity. The mechanism driving the glacial-interglacial transitions is, however, debated. Although atmospheric CO2 is a key link in warming during deglaciation, the lead-lag relationship between warming and increase in CO2 is ambiguous. A couple of past seawater temperature records from the northern Indian Ocean, has a clear lead of warming over the rise in atmospheric CO2 during the last glacial-interglacial transition. In a new multi-decadal record of the last glacial-interglacial transition reconstructed from the central equatorial Indian Ocean, the first phase of significant deglacial warming is synchronous with a rise in local summer insolation. This phase completely predates the rise in global atmospheric CO2. Incidentally a large increase in upwelling and a resultant rise in CO2 outgassing from the northern Indian Ocean, accompanies this first phase of deglacial warming. The implications of this record in the global glacial-interglacial transition will be discussed in the talk.

Dr. N. Saravanane
Centre for Marine Living Resources and Ecology

Recent trends and renewed interest in establishing Marine Protected Areas in Southern Ocean – Indian perspective

The Southern Ocean that covers approximately 32 million Km2 is rich in marine living resources such as krill etc. A Commission on Conservation of Antarctic Living Marine Resources (CCAMLR) came into existence in 1982 and was mandated under the Convention the task of management of living resources with a concept of "Ecosystem Approach" as also with provision for resources exploitation.,It has provisions for conservation, including creating special areas for protection and scientific study by bringing-out legal guidelines as "Conservation Measures". Although CCAMLR is existing for more than a quarter century, it was after "Madrid Protocol" came into force, that the first ever Marine Protected Area (MPA) namely the South Orkney Islands Southern Shelf MPA, was declared in the year 2009 and later implemented in 2011.When both the CAMLR convention and the Madrid Protocol of Antarctic Treaty System constitute legal responses to perceived threats from increasing human activity in the Antarctic regions and have mandate for establishing marine protected areas, the Antarctic Treaty System (ATS) under the 6.2 Article of Annex V of the Madrid protocol allowed CCAMLR to deal with the proposal for declaring protected areas in marine realm around the Antarctic continent. It has resulted in a situation where the competing interest of CCAMLR members on commercial fishery subdued the interest on establishment of MPAs for marine ecosystem protection. Hence, out of four proposed MPAs through CCAMLR viz. Ross Sea by New Zealand & USA, East Antarctic MPA by Australia & France, Weddle



	Sea by European Union & Germany, and MPA covering about 40% areas of southern Ocean by Antarctic Ocean Alliance (AOA), only Ross Sea MPA has been declared as an MPA during the year 2016 while other proposals are under consideration of the Commission of CCAMLR. This illustrates the notion that whatever be the difficulties, Antarctica being the land with no sovereign rights, an easier place to designate MPAs has been proven wrong. But still, countries are pushing every year their proposal for MPAs under CCAMLR because there is always economic gain through fishery if the MPA are declared under CCAMLR convention rather than establishing MPAs using provision of Madrid Protocol under ATS. The present work further describes the pros and cons of using MPA as an ecosystem conservation under Madrid Protocol of ATS or fishery management tool under CCAMLR from the perspective of India.

Dr. Parmanand Sharma
National Centre for Polar and Ocean Research, Goa, India

Glacier Mass and climate change in the Himalaya and their effects on the humans and the Environment

Himalaya known as the "Water Tower of the world" has one of the highest glaciated areas outside the Polar Region. It is also the source of many perennial rivers that are crucial for livelihood of the densely populated region of the Asia. The Climate change has influenced glaciers thinning and retreat in the Himalaya impacting hydrology of the region. The data collected from various sources show an average mass loss for the Western Himalaya between -0.5 m w.e.to -0.7 m w.e. during last two decades while for Eastern Himalaya it is little higher, ranging between -0.6 to -0.7m w.e. As per the projection, Himalayan glacier may lose 60-90% of their mass by 21st century due to changing climate, including anthropogenic impact. Increase in snow line altitude has a potential impact to increase mass loss by changing Accumulation Area Ratio (AAR) of majority of glaciers and also impose critical threats for disappearance of manysmaller and lower elevation glaciers.

Due to the high mass loss from glaciers, numerous new lakes have formed including significant increase in already existing proglacial lakes,which has increased the threat of GLOFs in Himalayan regions.

Prof. Milap C. Sharma
Center for the Study of Regional Development, JNU, New Delhi

Understanding Cryosphere-Climate Interaction and Societal Response in the NW Himalaya, India

Human activities in the world have certainly brought about a discernible change not only in the natural landscape that he/she lives on but also on the atmosphere and hydrosphere that make this the only known habitable planet. It is now a reality that global ice/snow cover, the most sensitive climatic indicator to climate change, has shown large scale shrinkage and recession post industrial revolution. Almost half a billion population of India and South Asia depends on the snow/glacier melt waters for the basic livelihood, i.e. agriculture and food and energy, of late. One also has to remember that these rivers glaciers/snow are the future source of green-energy that our country intends to harness in the immediate future.

The Miyar, our monitoring watershed, is a major watershed of River Chandrabhaga (Chenab) in Himachal Pradesh, India. This basin of ~936 km2 contains 76 ice bodies, with 16 valley glaciers of varied dimensions. Glaciers still cover ~25% (232 km2) of the total basin area and provide year-round availability of water. Ironically, being a designated cold desert, this region is entirely dependent on the snow and glacier melt for irrigation and the domestic purposes. Population of 2330 is spread over 11 census villages, ranging from 2890 m (Shakoli) to 3500 m (Khanjar) above sea level. Most of these villages are located on the glacial deposits of the early Holocene Advance, thus making existence precariously vulnerable to climate induced disasters. There is irrevocable evidence of settled

	population activity on a higher altitude (3700 m asl) until about middle of the 18th Century, close to the glacier terminus. Our results indicate that the Dark Ages Period (12-17th Century) was warmer compared to the present day, allowing them to grow traditional crops, before they were ousted by climate change, that too, towards cold. This basin remained isolated until late 1990s. Given such exclusivity, this basin was selected for an experimental study to evaluate the impact of climate change, cryosphere reserve and the process of adaptation and resilience. The present recession and waning of glaciers in the basin, and other regions of the Himalaya, is in consonance with the rest of the world trend of losing this fresh water resource. The rivers originating from the Himalaya support over a billion population in the frontal areas of the Himalaya!!! Therefore, this losing trend of cryosphere area may lead to measurable consequences downstream; however, the terminuses still stand above 4000 m above sea level and considerable ice still exists throughout, which invariably receive considerable precipitation in solid state year round. This small piece of research would illustrate; a) Cryosphere changes in recent past and on a millennial scale; b) Probable climate induced migrations in the recent past; c) Diversification in agriculture & resilience; d) and the future promise for development within this basin and beyond (trans-national rivers), be it a positive or negative climate change scenario.

Er. Joseph Silveira
Ex Chief Engineer, Mormugao Port Trust, Goa

The Bharati Experience and Reconstruction of Maitri 2

The construction of the state of the art Bharati Station at Larsemann Hills having a very small foot print under extreme weather conditions had many challenges before, during and after construction of the station. The building management system has become a very important tool for ensuring that all the life supporting systems are kept operational and in working condition. The reconstruction of Maitri-2 would need to be viewed in a different perspective than Bharati, as the site conditions, logistics and resources required are totally different.

The architectural/structural design, scientific requirements required within and outside the station would be the key for a successful reconstruction of Maitri 2.

Dr. Dhruv S. Singh
Centre for Advanced Study in Geology, University of Lucknow

Geomorphology, Sedimentology and its implication for Climate change, Gangotri Glacier, Garhwal Himalaya, India

Gangotri glacier is one of the longest and well studied glaciers known Internationally for its rapid rate of retreat. It is located in Uttarkashi district of Kumaun and Garhwal Himalaya. It has been observed that the glacial landforms and landscapes are modified by the paraglacial processes which evolve as soon as the glacier vacates its valley. The paraglacial processes, though secondary in origin in a glaciated terrain, are very active and control the landscape evolution of a glaciated region. The important paraglacial processes are: mass movement, fluvial, lacustrine landslide lake outburst flooding and glacial lake outburst flooding. These paraglacial processes modify the landforms and so create problems in identification of original landforms. The sedimentary facies are important tool to differentiate between various types of landforms. However, little attention has been given to the sedimentary facies of a glaciated terrain.

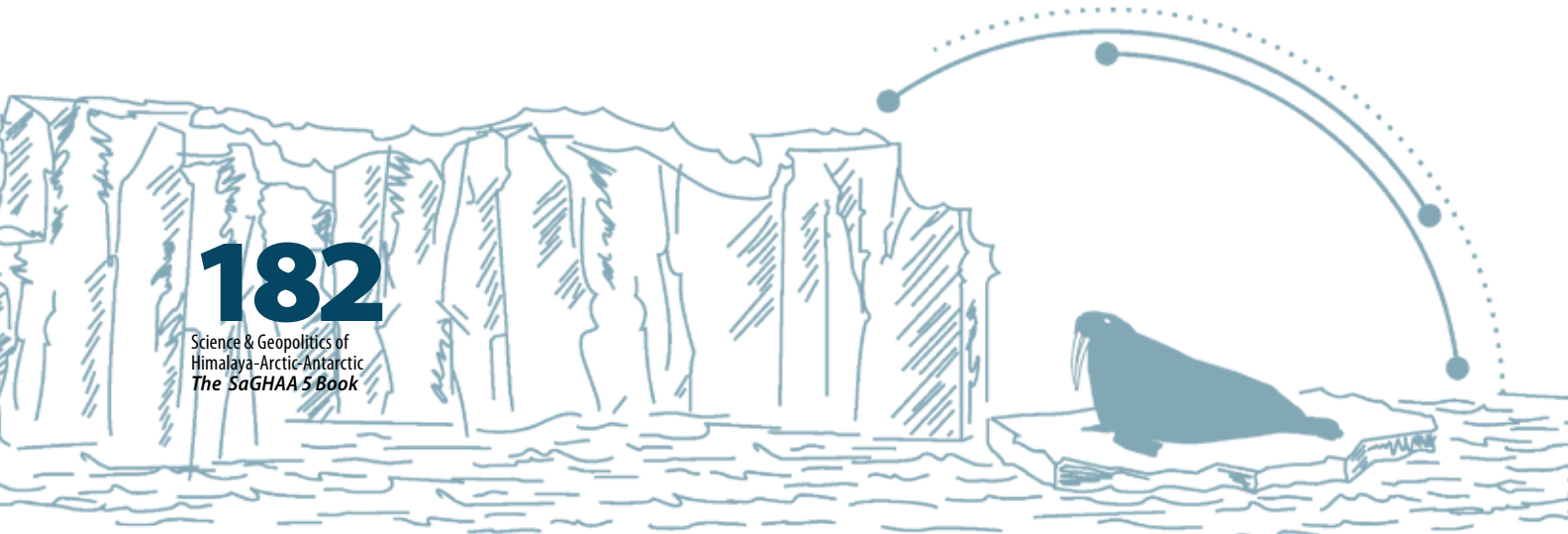
The study explains the sedimentary facies that describe the physical characteristics of the sediments and associated surface processes for the evolution of geomorphic features and depositional environments of the glacial and paraglacial landforms in the Gangotri Glacier region. The glacial events have resulted in the evolution of lateral moraine (LM), recessional moraine (RM) and outwash plain (OWP), while the paraglacial processes are responsible for the formation of debris cone (DC), pillar structures (PS), fluvial deposits (FD), lacustrine deposits (LD) and the flash flood deposits (FFD). The sedimentary facies for all the geomorphic features have been described for the first time from the Gangotri Glacier region which could be used as a model to interpret the ancient glacial sequences and landforms in other regions.

The results indicate that the Gangotri Glacier region exhibits complex and varied geomorphic features evolved by glacial and paraglacial sedimentary environments. The glacial and paraglacial sedimentary environments are characterised by a distinctive set of processes and sedimentary facies. It has been concluded that apart from glacial the lacustrine, mass movement, fluvial and flash flood processes are very active and important sedimentary environments in a glaciated region.

Dr. Neelu Singh
Formerly with National Centre for Polar and Oceanic Research, Goa

Diisopropylnaphthalene in the surface sediments of an Arctic fjord: environmental significance

Diisopropylnaphthalene (DIPN) has highly persistent and bioaccumulative properties. DIPN in the environment has not been thoroughly investigated. This is the first such report of DIPN in the sediments of Kongsfjorden. In this study, surface sediments were analyzed to track the presence of DIPN in Kongsfjorden, an Arctic fjord fringing the International Arctic Research Facilities of Ny-Ålesund, Svalbard. Increasing anthropogenic impacts in the form of Persistent Organic Pollutants (POPs), related to human activities and increased use of fossil fuels have been observed at many places along the Arctic Regions. Outcomes of this study suggest that the source of DIPN in the fjord could be a result of human activities at Ny-Ålesund and its environs. While its present-day concentrations may not be alarming, considering the increasing activities at Ny-Ålesund, it might be prudent to exercise caution to ensure that the levels do not increase over time.



Dr. Atul Kumar Singh
Former Director,
National Research Institute,
ICAR-DCFR

Strategic Approaches to Promote Rainbow Trout Farming in India

There is a vast scope and potential for enhancing fish production in hills. The important aquaculture species in hills is trout, which are cultivated in ice-melt cold-water of J&K, Himachal Pradesh, Sikkim, Uttarakhand and Arunachal Pradesh. Rainbow trout farming is fast becoming the most remunerative coldwater fish that provides livelihood and food security to the hill population. During the decade, a number of farmers adopted trout farming practices elevating the production of trout from mere 147 tonnes to over 1000 tonnes per annum. There are over 62 government trout farms and over 660 private trout production units distributed across the states of Jammu & Kashmir, Himachal Pradesh, Sikkim, Uttarakhand and Arunachal Pradesh. Catering the need of seed and feed for trout production, there are 32 government affiliated rainbow trout hatcheries with an estimated production capacity of 13 million eyed ova and 3 well equipped feed mills with an installed capacity of nearly 10 tons per day. Considering the huge gap between the actual and potential trout production, the ICAR-Directorate of Coldwater Fisheries Research is undertaking concerted research and development efforts to expand and intensify rainbow trout production, in partnership with the concerned state fisheries departments. Spatial decision support system has been employed to generate GIS based site suitability maps for trout culture. To minimize land and water usage in trout culture, water recirculation system has been developed on trial basis. Laying the base for genetic improvement programs, genetic variability in different rainbow trout stocks has been characterized using DNA marker technologies. The concept of cluster farming modules and

	culture chains are also gradually introduced and promoted by sharing technical knowledge and science base culture technology that facilitate high returns on investment. All these multipronged strategies will stimulate vertical and horizontal expansion of trout production in India. Some of the Himalayan states such as Sikkim and to lesser extent Uttarakhand are deemed as Organic states. It is important to develop protocols for organic fish farming including Organic trout farming in these states. This endeavor will attract the buyers and add value to the produce ultimately benefitting the farmers. Due to the increased health consciousness and increased purchasing power of the consumers, demand to ensure mass scale production in future will boost up.

Dr. Uttam Kumar Sinha
Research Fellow, Nehru Memorial Museum & Library, Auditorium

India and Arctic: Building an Arctic Culture

The tales of risk, adventure and enterprise from the Arctic/North Pole has always captured the imagination of the public. Arctic is an interesting ground for popular imaginaries and textual interpretations. English literature in the 19th century with its popular writers like the Brontes, Samuel Taylor Coleridge, Arthur Conan Doyle, Jules Vernes, Edgar Allan Poe, Wilkie Collins and even Charles Dickens often described the Arctic as a backdrop in their works. The most popular has been Mary Shelley's Frankenstein which actually begins and ends in the Arctic. Unlike the European experience where a collective idea of the Pole came through, the detailed notes and diaries of the explorers inspired many Polar prose and verses.

In India, the Vedas (oldest scriptures of Hinduism written in Sanskrit)were the fountain head of knowledge of the Arctic. Bal Gangadhar Tilak was the pioneer in relooking at the Vedas and 2020 will mark 100 years of his death. Tilak's research remains the most striking interpretation of Indo-Aryan history and through his valuable works, Orion or the Antiquity of the Vedas (1892) and The Arctic Home of Vedas (1903) refuted the argument that the European culture developed earlier than the Indian culture and used the Vedic texts to assert the superiority of the Indo-Aryan culture.

What should be India's dominant frames in representing its Arctic interests? And how are these frames being (re)interpreted and received and to what affective consequences? Answering this, the paper will investigate the need for India to build an 'Arctic culture' involving civilizational and cultural connect as well as commerce and business, education, training and media coverage.

Dr. Vijay Kumar Soni
Indian Meteorological Department, New Delhi.

Perspectives of Polar Weather Monitoring and Research Efforts of India Meteorological Department

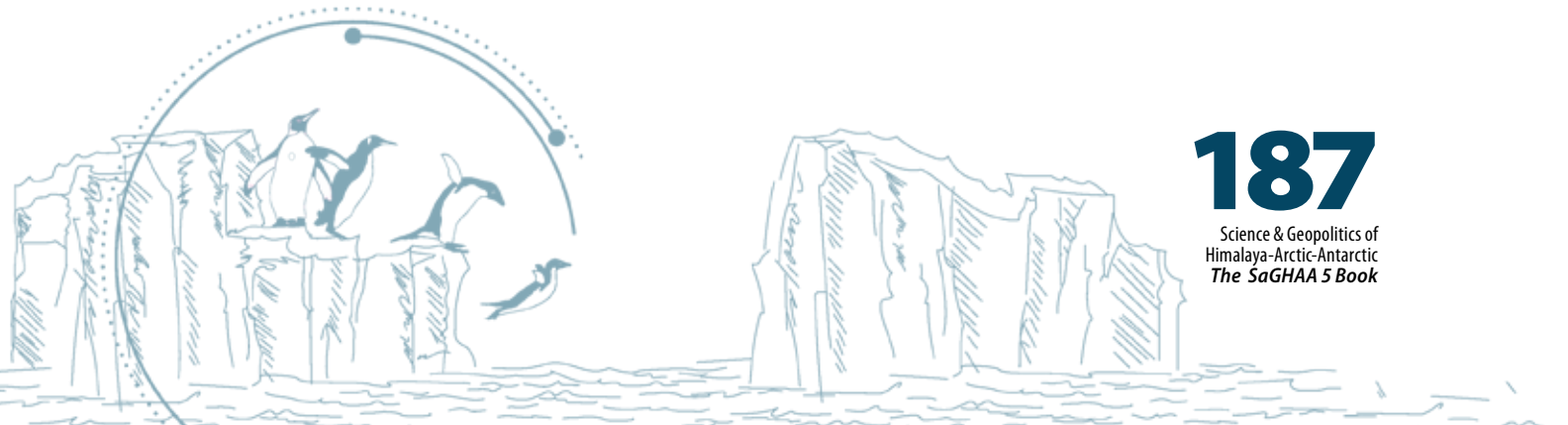
The Polar meteorology plays a significant role in the global climate system. In recent years, there has been an unprecedented level of interest in the climate and environmental conditions of the Polar Regions. Moreover, climate model predictions indicate that high-latitude areas will warm more than any other region over the next century as a result of increasing levels of greenhouse gases. Shrinking sea-ice, melting ice sheets, the discharge of glaciers and thawing of permafrost are all dramatic changes that have been taking place in the Polar Regions owing to the global warming. Changes at high latitudes can have an impact on ecosystems and human society through factors such as sea-level rise and variations in atmospheric and oceanic circulations.

India Meteorological Department (IMD) started meteorological observations since the very first expedition of India to Antarctica. IMD operates meteorological observatory at Maitri and Bharati round the clock throughout the year. This presentation reviews the progress of India's scientific research in polar meteorology. The analysis of 25 years meteorological data collected at Maitri station for the period 1991–2015 is presented in the paper. The observed trend in the temperature data of 19 Antarctic stations obtained from READER project for the period 1991–2015 has also been examined. The 25 years long term temperature record shows cooling over Maitri station. The Maitri station showed cooling of 0.054 °C per year between 1991 and 2015, with similar pronounced seasonal trends. The nearby Russian station Novolazarevskaya also showed a cooling trend of 0.032 °C per year. The trend analysis of other meteorological parameters for the period 1991–2015 is also presented. The Antarctic Peninsula and almost all of West Antarctica showed warming during 1991–2015. The majority of stations in East Antarctica close to the coast show cooling or no significant trend. The analysis also found slight decreasing trend in the pressure over the 1991–2015 time periods which is not statistically significant. The wind speed, however, does show a significant declining trend of 0.14 knots/year over the same period.

Dr. Ashit Kumar Swain
Geological Survey of India, SU, Sikkim

Need to worry about polar lakes

Polar lakes are important not only because of their unique geographical position, but also due to the persistent low temperatures, freeze-thaw cycles, seasonal and inter-annual variations in the lake cover changes. However, the presence of epi-shelf lakes and tidal fresh water lakes are restricted to the high latitude regions only. The focus of the recent scientific research suggest that the Polar Regions of the world, including that of the high latitudes and high altitudes of Himalaya, experience more rapid climate change than elsewhere in the world. This is certainly reflected in the Polar lakes located in these regions. These lakes begun to show striking impact in terms of gradual loss of perennial ice cover extent, increasing time duration of open water conditions, increment in lake water temperatures, increasing mixing and stronger water column stratification. In the Schirmacher Oasis of East Antarctica, many evidences show the complete drainage or drying up of lakes and lake basins as well as changing pattern in presence or absence of standing water. But in the high altitude regions such as the Himalayas face the increasing risk due to the threat of Glacial Lake outburst Flood (GLOF). Lakes being the downward integrator of all substance from the upper reaches can also serve as the monitoring laboratory for environmental parameters. All these suggest that we need to thrust our research on Polar Lakes in a more focused way.



Dr. Sarat Chandra Tripathy
National Centre for Polar & Ocean Research (NCPOR), Goa

Salient findings from the Indian Southern Ocean Expeditions

Each oceanic region has different significance in influencing the global climate change scenario with their potential for drawing-down the atmospheric CO2. In this context, the Southern Ocean (SO), being the world's largest high-nutrient low-chlorophyll (HNLC) regions, plays a significant role as a sink for atmospheric CO2 via its solubility and prevailing biological pumps. It thus plays a pivotal role in the global carbon cycle and climatic regulations through biogeochemical fluxes of carbon, nutrients etc. from the ocean surface to the deep interior. The efficiency of the biological pump depends on a range of environmental and biological factors (such as type of phytoplankton/zooplankton inhabiting), which in turn are influenced by climate change. It is observed that the productivity in SO regions is closely related to the hydrodynamics across the fronts and convergence zones. Scientific insight gained from physicochemical and biological studies performed during Indian Southern Ocean Expeditions (ISOE) in the last decade highlights some interesting findings and emphasizes India's research activities in the SO Region for better understanding of the oceanographic processes, biogeochemical cycles, marine productivity and global climate change scenario. Under the aegis of Ministry of Earth Sciences, Government of India, concerted efforts are put in place by NCPOR to carryout research in the Indian sector of the SO since 2004, with a primary focus to comprehend the role (response) of the SO in (to) regional and global climate variability. Till date 10 successful cross-disciplinary and multi-institutional (national/international) scientific expeditions have been carried out in the Indian sector of SO. This talk would touch up on some of the salient findings of ISOE.

Dr. Manish Tiwari
National Centre for Polar & Ocean Research, Goa

Pliocene Arctic Climate Teleconnection (PACT) – A Joint Indo-Norwegian Endeavour

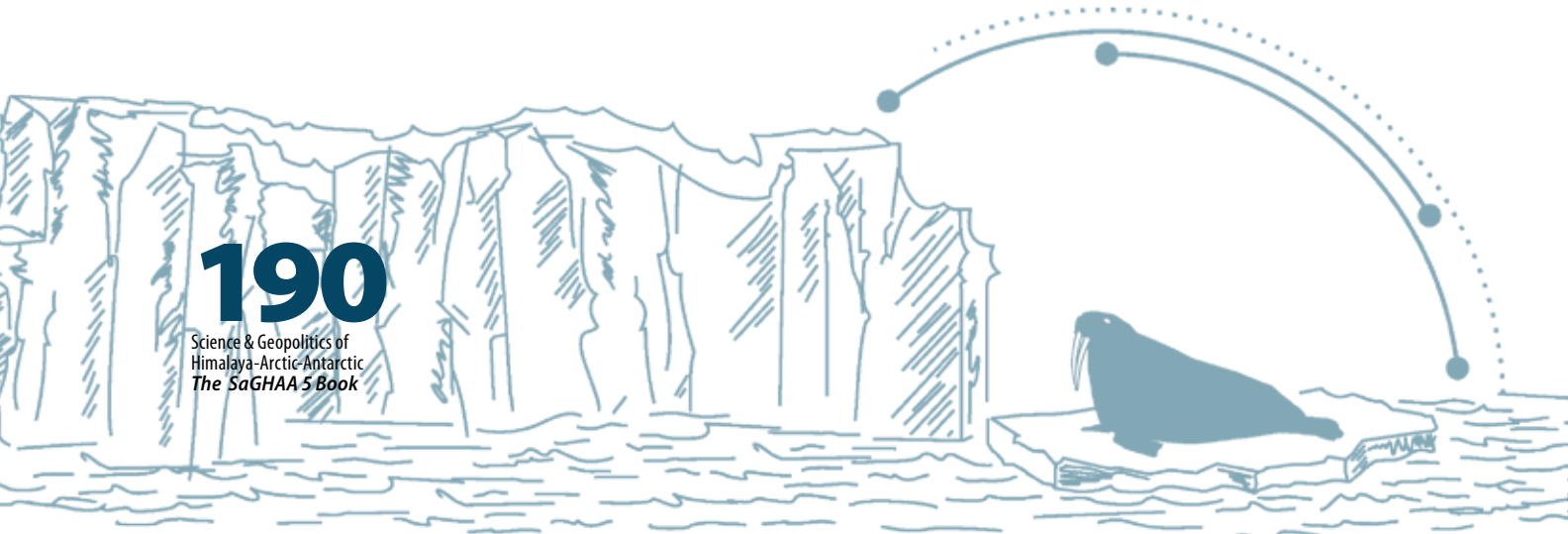
The Pliocene Arctic Climate Teleconnection (PACT) project aims to reconstruct the Arctic climate variability in high-resolution during the Mid-Pliocene Warm Period (MPWP) and explore its teleconnections with the South Asian and Australian Monsoon systems using sediment samples from the various IODP Expeditions in the Arctic Ocean, Eastern Arabian Sea (EAS), and North-Western shelf of Australia. MPWP was a warm period around 3.0 to 3.3 million years ago (Ma) when CO2 levels were similar to present or higher so it can provide an insight into the response of the climate system to the future global warming. Our results based on denitrification and productivity proxies from the EAS show that, during the MPWP, stronger summer monsoon occurred with less sea ice in the Arctic. New climate proxy data (Neodymium isotopes for past ocean circulation, highly-branched isoprenoid biomarkers for sea ice reconstruction, total organic carbon and nitrogen isotopes for productivity and nutrient utilization) shows enhanced Atlantic water inflow during MPWP into the Arctic Ocean and its effect on the sea ice retreat and productivity increase. These results have an enormous impact on analogous observations of ongoing melting of sea ice in the Arctic Ocean and predictions for future heat transport through increased Atlantic water inflow. The pollen abundance data suggest that overall vegetation was poor in the vicinity of the core site or the dispersal and deposition was restricted. The focus is now on the high-resolution response of the monsoon system during this phase of Atlantification of the Arctic Ocean during the MPWP. Further, data - model inter-comparison in PACT will improve model prediction of the Arctic climate and monsoon system in the future warming scenario.

Dr. Anoop Kumar Tiwari
National Centre for Polar and Ocean Research, Goa, India

Indian Polar Stations, Environmental Protocol and Challenge in Introduction of Treatment System and Advance Monitoring Instruments

India established its first research station Dakshin Gangotri in year 1983 and second permanent station "Maitri" in year 1988-89 at Schirmacher Oasis Soon after establishing Dakshin Gangotri station, India acceded to Antarctica Treaty and obtained consultative status in Antarctic Treaty Consultative Meeting. India is now one out of 29 countries who have got the consultative status out of 53 member countries of the Antarctica Treaty. India also acceded and ratified the Antarctic Environmental Protocol in the year 1998 and approved all five annexes to this Protocol. India established its third permanent station "Bharati", in 2012 and now proposes refurbishment of Maitri station as it is more than 30 years old. Environmental Monitoring is an integral and essential part of Madrid Protocol to observe the changes in the environment due to anthropogenic activities in Antarctica. Stringent standards are to be followed while commissioning and operating machineries and life supporting system in Antarctic stations. These standards may be adopted from national, United States Environmental protect Agency (USEPA) or European Union (EU) standards.

Since Antarctica is being used as datum for environmental monitoring and observation of pollutants which may be attributed to local or global long –range transportation, it has become d mandatory to use sophisticated monitoring instrument with low detection level. .. Renovation of Maitri station would pose challenges in processing of waste generation and treatment as well as disposal system in view of it being an inland station on ice free terrain.



Mr. Udhayaraj A. D.
Wildlife Institute of India
Dehradun

Mapping vegetation extent in the Antarctic oasis using Multispectral Remote Sensing data

Vegetation forms the active foundation of all terrestrial ecosystems. Vegetation mapping of plant communities at fine spatial scales is increasingly supported by remote sensing technology in cryospheric regions. A robust monitoring of the changes in the distribution and density of cryospheric plant species requires accurate and high-resolution baseline maps of vegetation. Mapping such change at the landscape scale is often problematic, particularly in the remote Antarctica/ Himalayas and Arctic. Less frequent imaging with high-spatial resolution satellite sensors enable more detailed analyses of vegetation change frequently. This study uses high-resolution satellite imagery to map vegetation as an imperative indicator for environmental change. Multispectral imagery and panchromatic imagery from very high-resolution satellite data have been used for mapping of vegetation. A range of supervised and unsupervised classification methods have been executed using pan sharpened data. This study statistically and comparatively evaluates the vegetation mapping results using supervised and unsupervised classification methods to extract vegetation in Schirmacher oasis, east Antarctica. We also focused on the use of supervised pixel-based classifiers and textural measures, in addition to standard multispectral information, to improve the classification of Antarctic vegetation communities. Classification results were validated with independent reference datasets. The present research indicates that the overall accuracy of mapping vegetation using high resolution imagery and semiautomated target extraction methods exceeded 90%.

	Full-capacity operation of heavy equipment during the construction will reduce pollution and advance the time of construction. The water supply required was calculated to be 150ℓ/day per person, which includes water needed for cooking, washing and personal hygiene. While the water may continue to be drawn from the Priyadarshini Lake, a tank inside the station complex should have sufficient water storage capacity for 7 days to deal with emergency situations. In view of large distance of sea from the station, the disposal of liquid and degradable waste has to be planned. A large capacity bio-treatment and incineration plant will be required for waste treatment. The station design will largely depend upon all above criteria and may have to be different from existing Maitri or Bharati Stations.

Shree Verma
CN Technologies,
New Delhi

New Maitri Station: Concept Feasibility and Conceivability

C N Technology has been associated with the Indian Antarctic Program for two decades. We participated as a local design support for the Consortium of M/S IMS, BOP Architekten and m+p consulting, Germany, selected by NCPOR for Bharati-the the prestigious 3rd Antarctic Research Station of India. Being our first project of such a challenging magnitude, we gathered lot of knowledge on Antarctic terrain and the design complexities. The weather data at Maitri region shows strong westerly wind that can reach a maximum speed of 322 Km/s. The minimum annual average wind speed is 120 Km/s while the temperature is of the order of -23.1. The new station must take also into cognizance the local topography orography, speed and direction of wind direction and other logistic and scientific requirements while short listing the site and freezing the design of the station. Being an inland research base, its waste disposal policy has to be entirely different from a coastal station like Bharati. Some of the key factors that need serious consideration are: snow and Ice conditions viz snow-drift and snow accumulation, temperature and Wind Chill, detailed topography of the site, postulated human activities –noise, scenery, aesthetic natural Values and cumulative Impacts, building area including requirements of living accommodation and laboratory space, estimated atmospheric emissions, estimated waste (solid and liquid) generation, major transportation routes The new station should be able to use heat generated from the generators for heating the station. The use of fossil fuels should be minimized by increasing renewable energy and maximizing the indoor use of natural sunlight and recycling the waste heat. Full-capacity operation of heavy equipment during the construction will reduce pollution and advance the time of construction. The water supply required was calculated to be 150ℓ/day per person, which includes water needed for cooking, washing and personal hygiene. While the water may continue to be drawn from the Priyadarshini Lake, a tank inside the station complex should have sufficient water storage capacity for 7days to deal with emergency situations. In view of large distance of sea from the station, the disposal of liquid and degradable waste has to be planned. A large capacity bio-treatment and incineration plant will be required for waste treatment. The station design will largely depend upon all above criteria and may have to be different from existing Maitri or Bharati Stations.

CSIR-National Geophysical Research Institute
(Council of Scientific & Industrial Research)

Established in the year 1961, the CSIR-National Geophysical Research Institute (NGRI), Hyderabad is a premier earth science research institute of the Council of Scientific & Industrial Research (CSIR) under the Ministry of Science & Technology, Government of India. As per its mandate, the institute has been carrying out innovative basic and applied research encompassing the broad disciplines of Geology, Geophysics, Geochemistry & Geochronology. Its multidisciplinary earth science research programs are in tune with the mission of the CSIR and frontier global challenges.

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- Exploration of Hydrocarbons, Minerals and Groundwater
- Seismology, Earthquake Hazard Assessment & Earthquake Processes
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- Provide comprehensive understanding of shallow and deep earth processes
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- Undertaken R & D program for exploration of coal, coal-bed methane (CBM) and uranium
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- Active and passive seismology for structure of the Indian lithosphere Simulation of Core & Mantle Dyanmic Mathematical Modeling
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- Reconstruction of Lithospheric Evolution through Paleomagnetic, Geochronology, Stable and Radiogenic Isotope Geochemistry

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Norwegian Embassy in India

Norway with its extensive scientific and technical capabilities has always been ahead when it comes to polar research in the global arena. Norwegian polar researchers have been publishing world-class research on the myriad changes taking place in the Arctic. Svalbard, a Norwegian archipelago between mainland Norway and the North Pole plays an essential role as a research platform. The areas where Norway spearheads research include climate system, ecosystem and biogeochemical environment. It also focuses on the glacier and ice-sheet dynamics and marine ecosystems in Antarctica. Research on wide-ranging environmental changes and commercialization of the polar regions are areas where the Norwegian Embassy engages with India, leading well-coordinated and scientific national and international polar research programmes. The Norwegian polar research embarked on a new era in 2018 with the development of a state-of-the-art 100 m long ice-breaker vessel Kronprins Haakon, which is amongst the most advanced vessels in the world. This ship with its remotely operated vehicle (ROV) is yielding highly nuanced and stunningly detailed information about little known facts in the polar waters.

Ministry of Earth Science Government of India

The Ministry of Earth Sciences (MoES), formerly known as the Department of Ocean Development (DOD) was established in 1981 with the mandate to create a deeper understanding of the oceanic regime of the northern and central Indian Ocean and also developed technology and technological aids for harnessing resources and understanding of various physical, chemical and biological processing in the icy realms of Arctic and Antarctic in 2006. Indian Meteorological Department(IMD), established in 1876 to provide meteorological agencies and services to the country was integrated with MoES by bringing meteorological agencies and ocean development department under one umbrella considering the importance of ocean atmospheric interfaces. The MoES , aims at looking at the planet in the holistic way in as much as understanding of the interplay of earth dynamics and systems phenomenon.

National Centre for Polar and Ocean Research

National Centre for Polar and Ocean Research (NCPOR, erstwhile NCAOR) is an autonomous body under the Ministry of Earth Sciences, Government of India situated in Goa. The mandateof the Centre is to plan, promote, coordinate and implement scientific research in the polar regions and the surrounding realms. Besides organising expeditions, NCPOR also maintains the Indian research bases in Antarctica (Maitri and Bharati), Arctic (Himadri) and Himalayas (Himansh). Through the national polar programmes, the Institute promotes the multi-institutional and multi-disciplinary approach to enhance the quality of Indian polar research, including that in the Southern Ocean. NCPOR spearheads research on paleoclimatology (using ice and sediment cores), teleconnection between polar regions and tropics, polar biology, remote sensing, sea-ice interactions, polar environment, Southern Ocean studies, etc. Apart from polar sciences, NCPOR is also the nodal agency for geo-scientific studies which include the Extended Continental Shelf Programme,

mapping Indian Exclusive Economic Zone, Deep Sea Exploration (Hydrothermal and Polymetallic Nodules) to harness the ocean's non-living resources, understanding Indian Ocean Geoid Low and the International Ocean Discovery Programme.

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