International Conference on

# Science & Geopolitics of Arctic-Antarctic-Himalaya

**SEPTEMBER 29-30, NEW DELHI**


# The SaGAA III Book

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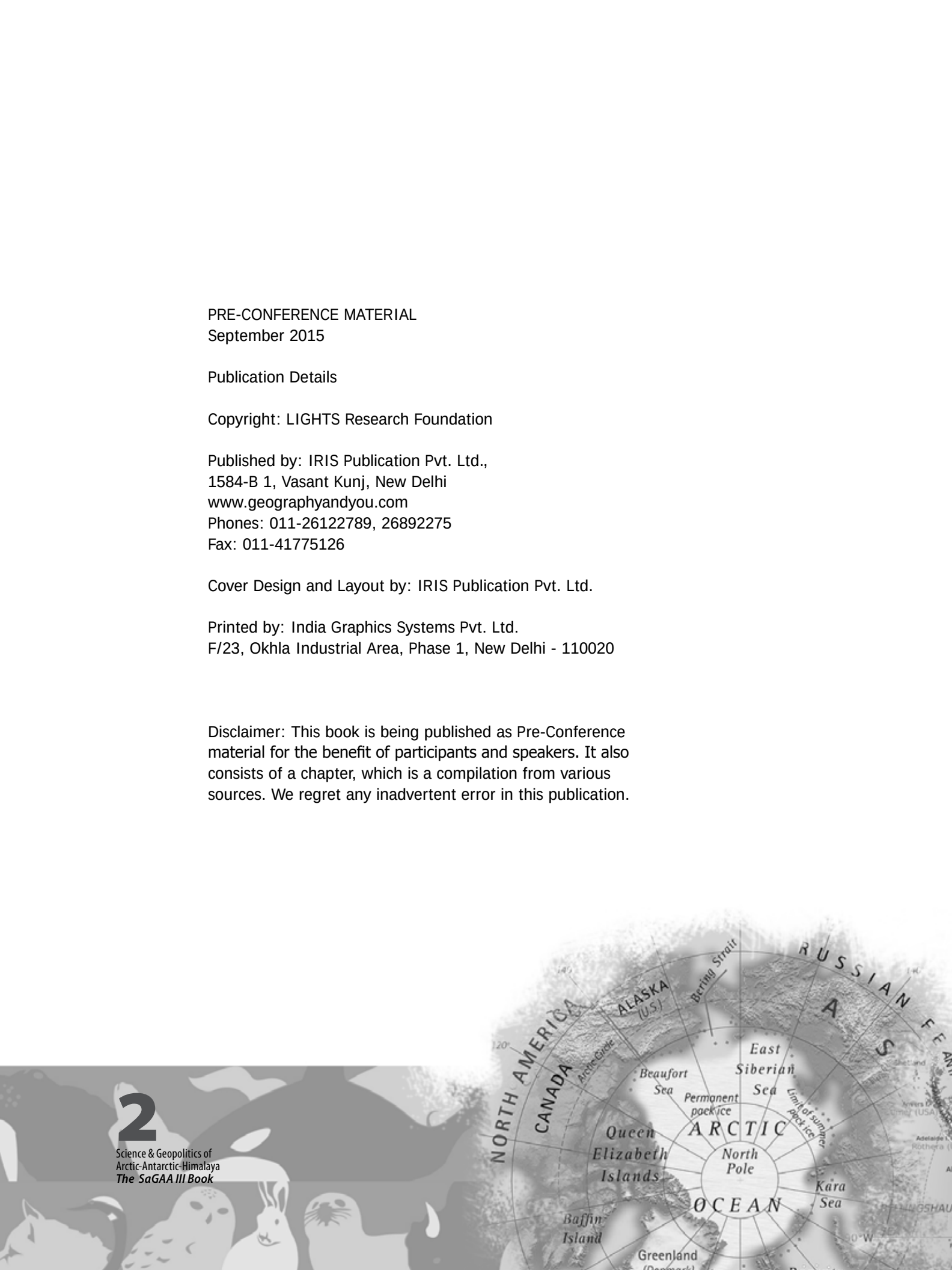

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डॉ. हर्ष वर्धन
DR. HARSH VARDHAN

सत्यमेव जयते

मंत्री
विज्ञान और प्रौद्योगिकी एवं पृथ्वी विज्ञान
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## MESSAGE

It was more than three decades ago that India started its expedition to the icy continent of Antarctic. India signed the Antarctic Treaty in 1983 and thereafter, the scientists of our nation relentlessly strived to reach the zeniths of research, braving the elements to learn more about an unknown territory. Today, India is one of nine elite nations to have multiple stations in the Antarctic.

In July this year scientists from the National Institute of Ocean Technology (NIOT) and National Centre for Antarctic and Ocean Research (NCAOR) as part of the Earth System Science Organization's (ESSO), the executive arm of the Ministry of Earth Sciences (MoES) for its policies and programmes have successfully retrieved data from India's pioneer submerged observatory 'IndARC', deployed in the Arctic Sea to record continuous real-time in-situ data for evaluating the Arctic climate process and its influence on the Indian monsoon system.

Today, Indian scientists, in their unrelenting search for knowledge, have transcended both the poles and have successfully illustrated our presence in the Arctic Council since 2008. India's growing prowess was further manifested when it became a permanent observer of the Arctic Council alongside China, South Korea, Singapore and Japan in May 2013. Increasing number of climatic anomalies globally point towards economic and geo political impacts in regions such as the Arctic. The potential opening up of the North Sea routes that can widen shipping lanes and increase global trade is one such area where alliances and understandings have to be built.

India's geographical proximity to the subnival Himalayan Region urges urgent development of scientific skill sets to respond to the research challenges of the glaciers in a timely and spatially coordinated manner. The Himalayan region is also the sole water reservoir of the South Asian nations, making it a valuable national and global resource.

I am glad that a Conference that links the geopolitical as well as the scientific aspects is being held. I wish it all success.

Harsh

**(Dr. Harsh Vardhan)**

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# A

# THE CONTEXT

## The SaGAA III

Arctic-Antarctic-Himalaya

**The bringing together of scientists** and the policy makers has been the seminal effort of LIGHTS since 2009. The idea is to formulate a comprehensive dialogue between the scientists, policy makers, geo-political experts and researchers on the subject. We have cherished the values of Common Heritage of Mankind as against individual acquisitions. The Science and Geopolitics of Arctic and Antarctic (SaGAA) is an effort towards understanding global issues in the light of new and emerging perspectives. We have organized SaGAA I in 2011 and SaGAA II in 2012. The present Episode has added the Himalaya in a comprehensive manner. The following paragraphs will throw light on the areas of interest and India's concerns on the Arctic, Antarctic and the Himalayan region from the strategic and environmental perspective.

**The Arctic**

One of the most dramatic effects of global warming is seen in the Arctic region. In recent years the ice in the Arctic Sea has been melting rapidly. In 2007, a large part of the Arctic Sea became ice free in summer months for the first time in living history. The Arctic region is experiencing warming at twice the rate of global average. The melting of the ice in the Arctic Sea has had two major geopolitical impacts. One, new shipping routes between the Atlantic Ocean in the west and the Pacific Ocean in the East, linking Europe with Asia in the north, have opened up. These consist of the Northern Sea Route (NSR) and the North West passage.

The NSR passes along Russia's northern coast in the Arctic Sea and connects Murmansk in the West to the Bering Strait in the east. This route is more promising of the two and is being regarded as an alternative to the present shipping route connecting Europe with Asia via the Suez Canal and the piracy infested Gulf of Aden. The second route, the

North West passage, will pass along the coast of Canada. But, this route is still underdeveloped unlike the NSR.

The second major geopolitical impact of the opening of the Arctic Sea is the scramble for the resources of the Arctic region. The Arctic Sea is estimated to have as much 10 to 20 per cent of the world's oil and nearly 30 per cent of natural gas. Russia and Norway have settled their maritime boundary in the Arctic Sea in 2011 and have accelerated the exploration of hydrocarbons in the region. Both have chalked out ambitious strategies for the exploration and exploitation of the 'high north'. The Russians have also discovered oil in the permafrost region of Yamal adjoining the Arctic sea. They have plans to invest in the Arctic Sea off the coast of Alaska.

The territories in the Arctic Circle regions of Russia, Norway, Sweden and Finland have large minerals, particularly, iron ore. Mineral exploration and exploitation is expected to pick up as Arctic shipping develops further in the future. Apart from the minerals, the Arctic regions will emerge as a new source of fishing. The region is already being called the 'kitchen of Europe'. The releases of new lands as a result of melting of ice will lead to development of the agriculture in the region. Polar tourism is picking up too. The small Norwegian town of Kirkenes attracts nearly 2,00,000 tourists each year.

The opening of the new sea routes and the scramble for resources makes for new geopolitics. The Arctic Council, an inter-governmental forum of eight countries—Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the US —set up in the 1996 to deal with Arctic issues has been transformed into an active organisation where the future of the Arctic might be decided. In the last ministerial meeting held in Iceland in May, the Arctic Council decided to set up a permanent secretariat in Tromso, Norway.

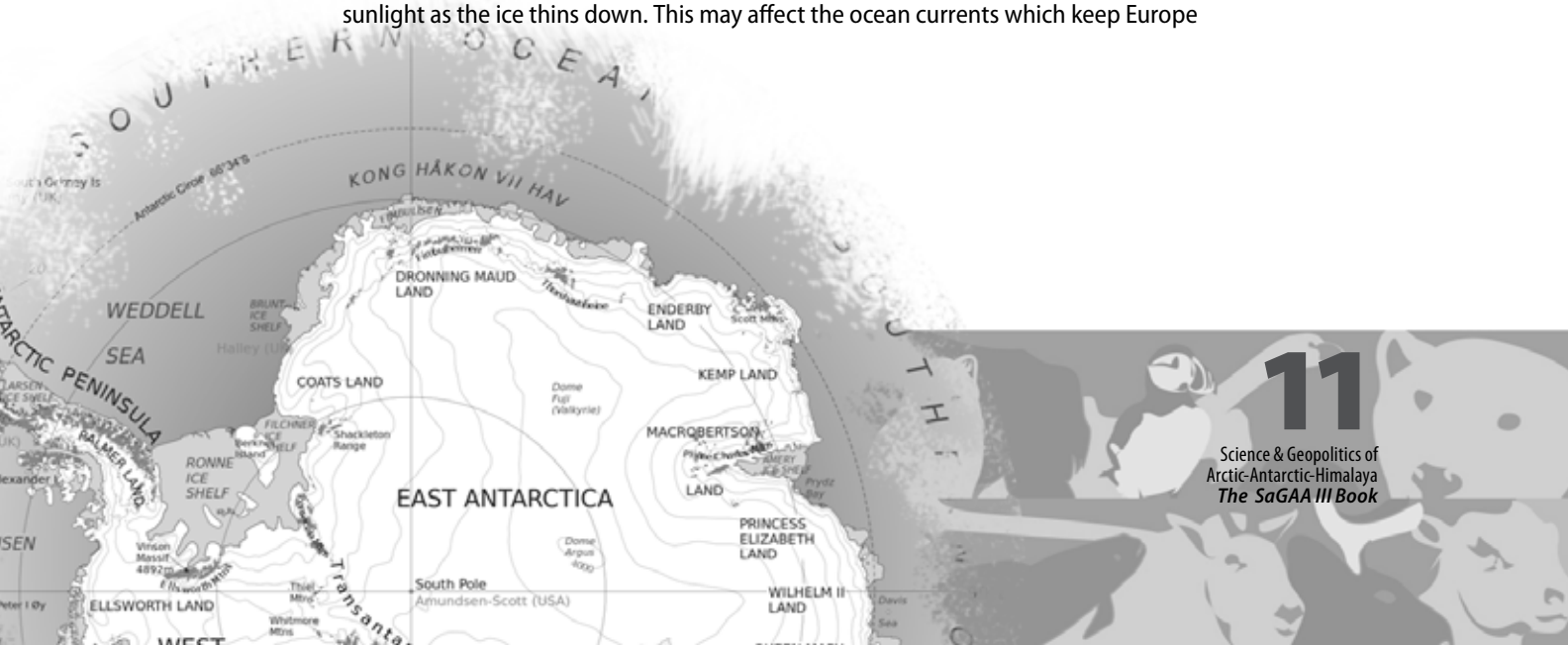
The opening of the Arctic provides for disputes over sovereignty over new territories and the freedom of navigation through the coastal waters and Exclusive Economic Zones. The Northern Sea Route passes through the waters close to the Russian coasts. The US has not yet ratified the UN Convention on the Law of the Sea (UNCLOS) but may do so soon because of the Arctic sea's opening up. During the cold war years, the Arctic Sea was highly militarised. The Russian Northern Fleet is based in the region along with nuclear powered submarines, ships and missiles. Norway and Canada are also paying attention to modernising their navies.

To capitalise on Arctic shipping, the Russians have already set up a North Sea Route administration, which issues permits to ships wanting to transit through the route. Atomflot, a Russian organisation, provides nuclear powered ice breakers to ships transiting through the Northern Sea Route. In 2011, 34 ships used the Northern Sea Route to ship bulk cargo weighing about 800,000 tonnes like iron ore, coal and gas condensate to customers in China. This number is likely to double this year. The route, though challenging, is open for about 3 or 4 months in a year. But it saves the shipping companies about 4,000-5,000 km of distance and 10-20 days of time as compared to the traditional route through the Suez Canal. China, Japan, South Korea will be the main beneficiaries of the route.

On account of the decision in oil output in the North Sea, Norway is now shifting its attention to the 'high north' in a big way. Both Russia and Norway have major plans to develop their respective northern regions. For them global warming has been a boon. The Arctic Region is expected to provide the next big push in the economic revival of Russia.

**India's Stake**

The ice melt in the Arctic is likely to accelerate global warming. Large amounts of methane will be released as permafrost melts. The waters of the Arctic Sea will absorb more sunlight as the ice thins down. This may affect the ocean currents which keep Europe



warm. The long term impact of the Arctic ice melt may not be pleasant for the planet. India cannot remain immune from the developments in the region even though the area is remote and far away. India has a long tradition of polar research. It maintains a permanent research station in Svalbard. Much of the naval equipment India imports from Russia is based and tested in the northern regions of Russia. The opening of the sea routes and the exploration of hydrocarbons present economic opportunities which Indian companies can also exploit. On the negative side, the enhancement of economic activity in the Arctic Region will accelerate global warming and lead to large sea level rise impacting the global climate to which India cannot remain indifferent.

Whether or not India likes, the Arctic Sea is unlikely to be governed by an Antarctica type international treaty which makes the region a global common. India should remain engaged with the leading organisations like the Arctic Council where many important decisions on the future of the Arctic region will be taken. These can have direct or indirect impact on India. Indian universities and think tanks should pay greater attention to the study of analysis of the developments in the Arctic Region. (Abstracted from an essay by Arvind Gupta,published in theIndian Express, 28 June 2012)

**India's Position and the Arctic**

On May 15, 2013, India became an Observer at the Arctic Council, which coordinates policy on the Arctic. (The Arctic Council has eight states as members, the five coastal states, Canada, Russia, the U.S., Norway and Denmark (through Greenland), and Sweden, Iceland and Finland. Other countries that joined India as Observers were China, Japan, South Korea, Singapore and Italy. The United Kingdom, France, Germany, Poland, Spain and the Netherlands are already Observers.

In becoming an Observer, India had to agree to the following criteria set by the Council:(i) recognise the sovereign rights of Arctic states;(ii) recognise that the Law of the Sea and the U.N. Convention on the Law of the Sea, constitute the legal basis and the legal framework

within which the Arctic will be managed;(iii) respect indigenous peoples, local cultures and traditions; and(iv) be able to contribute to the work of the Arctic Council.

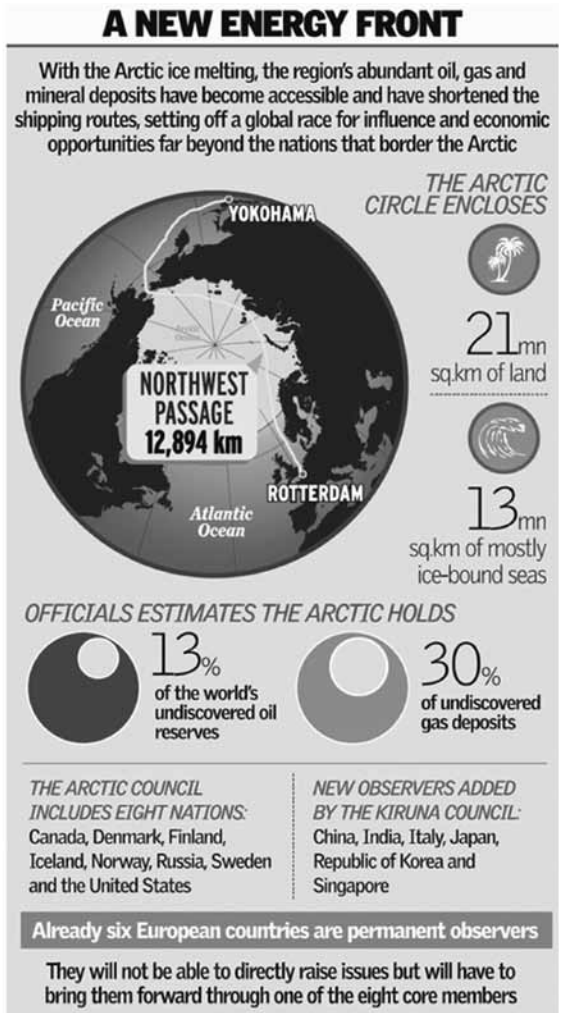
In accepting to abide by these criteria, India has recognised the territorial jurisdiction and sovereign rights of the Arctic littoral states and hence their pre-eminent and even pre-emptive role over the Arctic zone. The acceptance of the Law of the Sea as the governing instrument for the Arctic also implies that the extension of jurisdiction over the continental shelf as well as over maritime passage and the resources of the ocean space will lie with the littoral states. The Arctic has virtually become the inland water space of the five coastal states— Russia, Norway, Denmark, Canada and the United States. India has, therefore, no more room to argue that the region be treated in the same manner as the Antarctica. In the Antarctica Treaty of 1959, territorial claims have been kept in abeyance in favour of a global commons approach, respecting the pristine nature of the ice covered continent. The trends we see in the Arctic region may well come to pass in the Antarctic as well. The claimant states could reasonably argue that just as the Arctic space is being managed by the sovereign members of the Arctic Council, with well-defined norms and through cooperation among both the littoral and user states, why could this not serve as a template for Antarctica? Like the Arctic, the Antarctic, too, is a treasure house of resources. These are also being unlocked by the steady melting of the continent's ice cover. It may only be a question of time before the northern Gold Rush is followed by its rampant Southern version.

India seems to have succumbed to the temptation of sharing in the emerging opportunities for resource extraction as the Arctic continues to melt because of global warming, Yes, as the government argues, becoming an Observer would enable India to take part in scientific research into the changing Arctic environment, including its serious climate change effects. These effects will be global, whether in sea level rise, the acidification of the worlds' oceans and change in ocean currents and weather patterns.

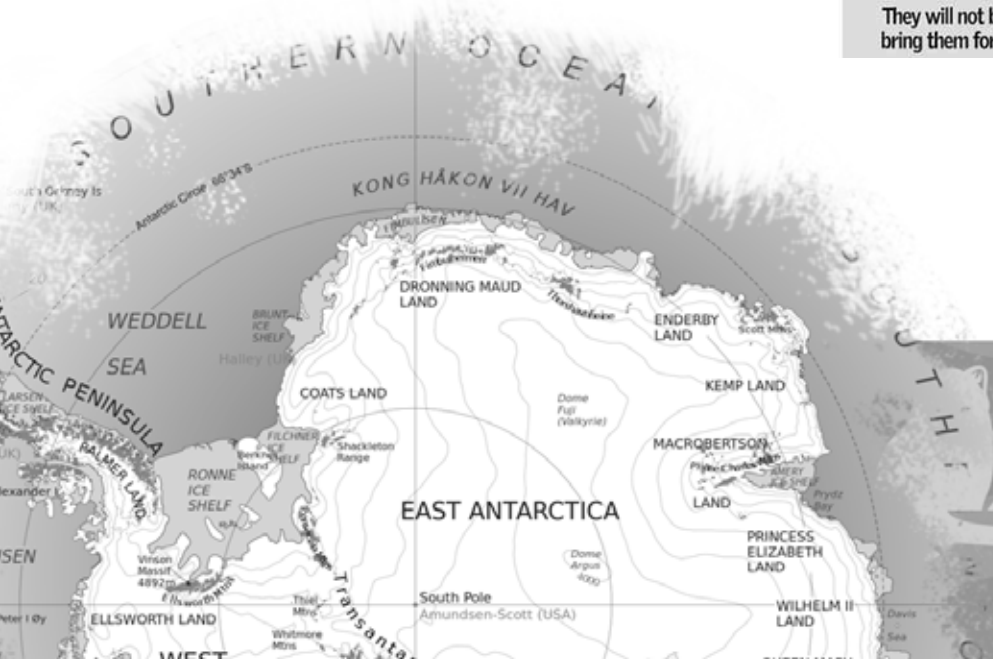
India's association with the Arctic Council puts it in a better position to understand these changes and be a part of efforts to minimise the adverse consequences of the Arctic being opened up to intensified human activity. However, both the members of the Arctic Council and the Observers, including India, have avoided confronting the obvious: the opportunities that they seek to exploit and profit from are the very activities which will exacerbate the climate change impact of a warming Arctic. The "on the one hand" and "on the other hand" approach that all these stakeholders are guilty of merely disguises the fact that the lure of profit has already triumphed over the fear of ecological disaster. China has lost no time in positioning itself through a number of asset acquisitions in several Arctic states, in particular, Russia and Canada.

The pertinent question will be 'what could be done to restrain this headlong rush into a potential ecological catastrophe of global dimensions? Oceanographer and Arctic expert Rick Steiner has made a practical and reasonable suggestion. This is for the U.N. to set up its own Arctic body. It may be on the lines of the Indian Ocean Commission, which may provide the international community the capacity to monitor what is happening in the region, draw up strict norms for activities, taking into account the "global commons" character of the Arctic, and put in place a credible and effective compliance mechanism. India could certainly push for such a global regime without violating its role of Observer at the Arctic Council.

It may also be worthwhile for India and other developing states to put the Arctic on the agenda of the ongoing multilateral negotiations on Climate Change under the U.N. Framework Convention on Climate Change. A separate resolution or decision of the Conference of Parties to the Convention could draw attention to the Arctic as a global commons, its impact on global climate and the need to ensure that the activities undertaken there do not harm the well-being of the vast majority of people around the world(Abstracted from an article by Shyam Saran in Dec 2013, Hindu).




*Source : Infographics, The Hindu*



**The Antarctic**

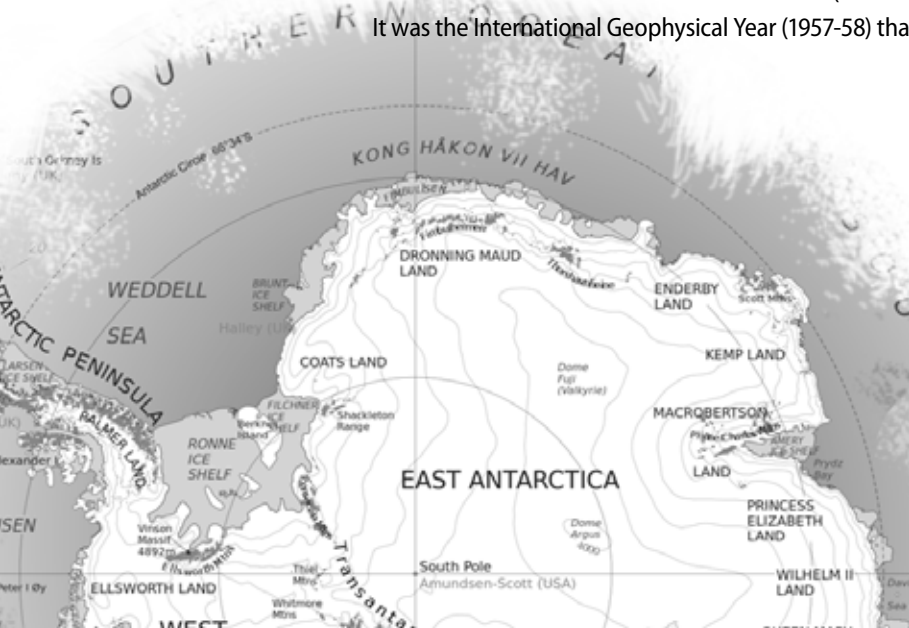
The panorama of ice-fields Antarctic regions is rich in resources and controversial in terms of geopolitical relations. Science and politics might seem opposite side of the coin but they are intertwined and more so in the frozen realms of Antarctic and Arctic where science is the currency. It has steadily acquired an extraordinary complexity due the fact that scientific activities have played, and continue to play, an important role in supporting and to an extent—defining most, if not all, states' political engagement with the continent. The seven states which maintain territorial claims to Antarctic—Argentina, Australia, Chile, France, New Zealand, Norway and the United Kingdom—all operate research stations within 'their zones' and, even today, fund more or less exclusive scientific research activities located therein. Thus science has been used a surrogate for occupation and, arguably, has facilitated the effective colonisation of Antarctic. Equally non-claimant states have used scientific activities and expeditions as a means to deny territorial claims, and this is perhaps no better illustrated by the US construction of the Amundsen-Scott research station at the South Pole; a location which manages to both physically straddle, and allow the United States to philosophically set itself above, all sovereign claims. Yet science also provides both the motive and the means to negotiate and adopt, at the height of the Cold War, the Antarctic Treaty, under the auspices of which, a successful, effective and enduring regime for Antarctic has been developed (Adapted from a paper by Sanjay Chaturvedi, published in Scientific and Geopolitical interests in Arctic and Antarctica, ISBN No. 978-93-5067-908-1).

Science and Geopolitics share bi-polar relation but geo security acts as magnifying force to club them together to hold the sovereignty of all creatures all abstract resources of the Polar Regions. It's a hard challenge for the researchers to pursue the research as well as interconnect those with another discipline in a feedback loop system. The countries undertaking research on the polar realms have developed specialized scientific skills that today counted as a shared resource for humankind. The co-existence of distinctive scientific thoughts of different countries sharing the hostile environment has been made the regions further geopolitically relevant.

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 (Brady, 2012a). The Antarctic Treaty (1959) was adopted for the purpose of bringing peace and stability to Antarctica and to facilitate cooperation in scientific research conducted on and around the continent. It has now been over fifty years since the signing of the treaty, nevertheless security continues to drive and shape the laws and policy regime, which governs the region. Antarctic Security in the Twenty-First Century: Legal and Policy Perspectives assess Antarctic security from multiple legal and policy perspectives (Hemmings and Rothwell 2012).

Karen N. Scott (2012:284) has aptly argued that, "described as both a land for science and a land of science, Antarctic has arguably been constructed through science as a geopolitical and legal space." 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" (Elzinga 1992: 75), then, on the other hand, 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).

It was the International Geophysical Year (1957-58) that opened the floodgate of Cold



war 'international politicking' (Chaturvedi 1990), tempered by the gentleman's promise of maintaining the boundary (even though quite blurred) between science and nationalism on the 'white' continent. As Tom Griffiths (2007:145-146) points out insightfully, "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". 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. Its treaty regime became the model for management of the sea and outer space" (*ibid*. 146).

Some scholars have argued that, "the dawn of the twenty-first century is often referred to as the advent of a global knowledge society. In this society, knowledge, having become the major factor of production in the new economy, is expected to flow more freely than ever before, no longer limited by national constraints" (Meyer, Kaplan and Charum 2002). It is precisely the labyrinth of transborder, transnational, non-hierarchical knowledge flows, anchored in the notion of global public good, that constitutes one of the most important facets of the idealised state of mutual trust and sharing described as global knowledge commons.

**Continuity and Change in Antarctic geopolitics: Territoriality, Resources and 'Scientific Nationalism'**

It was during the 1970s that Antarctic went through a major discursive transformation and values associated with global knowledge commons were partially eclipsed by resource geopolitics and related contestations over access and sovereign rights. Largely as a result of an extensive geological and biological research, a rather impressive outline of Antarctic resources became available and was soon filled in by perceptions of the burgeoning

population in terms of consumption and depletion of resources in the wake of the oil crisis. When early initiatives for a minerals regime surfaced during early 1970s, there were not many who would dare to think that commercial activity was likely, or feasible, let alone imminent, for decades to come. The prevailing economic, technological and geopolitical climate at the time ruled out any prospects of mining the Antarctic. Few would have the slightest idea about the sites and structures for the purpose, the costs involved, and the environmental-ecological consequences that might follow (Chaturvedi 1996).

The moment ATCPs turned to the question of Antarctic minerals in 1970, to be joined by India and Brazil as consultative members in 1983, the division between claimant and non-claimant states surfaced in all its intricacies. It was far from being certain whether the legal status quo under the Treaty could be reconciled with an equitable plan to develop mineral resources. India, Brazil, China and Uruguay, once admitted as consultative members, formed a lobby of countries in their condition to watch and promote third world interests in the minerals negotiations. No wonder that the ATCPs, faced with delicate negotiations, marked by such dilemmas, felt compelled to reiterate that under no circumstances their respective positions on the question of territorial claims in Antarctic could/should be compromised.

The Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) was opened for signature in Wellington, New Zealand, in November 1988. It prescribed tough procedures to be adopted before any patch of land or offshore area could be identified for exploration and development. Provisions having a direct or indirect bearing on the environmental [protection] aspect of potential minerals activity were inserted in various sections of CRAMRA. Whereas some of these provisions qualified as purely environmental in nature, others were general but carried implications for the environment.

In January 1988, when CRAMRA seemed a virtual certainty, the knowledge-power interface in Antarctic governance acquired a new dimension with the dispatch of an expedition to service the Greenpeace's World Park base at Cape Evans. This marked the

persistent and well articulated campaign of the Greenpeace movement, along with many other national and international environmental groups, against the very idea of mining the Antarctic (*ibid*). This also announced the arrival of a new non-state contributor and claimant to knowledge production, value addition and representational practices in the ATS; what would eventually become ASOC.

The prospects of CRAMRA dimmed and disappeared eventually, when, in May 1989, the Government of Australia refused on sign on the grounds of environmental conservation. Australia now felt strongly committed to the view that mining should be prohibited in and around Antarctic and instead the urgent negotiations of a comprehensive environmental protection convention within the framework of the ATS should commence. As Australia sought international support for this position, including the establishment of an 'Antarctic Wilderness Park', the French support promptly followed. CRAMRA, in order to enter into force, had to be ratified by all the countries having territorial claims in Antarctic. With the consensus within ATS under serious threat, the 'U' turns by Australia and France on CRAMRA brought into question the collective understanding of the ATCPs to abide by the norms of the system, seriously undermined the capability of the ATS to resolve intra-system conflicts, and exposed the soft underbelly of Antarctic governance in the form of dubious and disputed ownership of a continent larger than India and China put together and its resource endowment. From another perspective, the crisis of consensus was a powerful but painful reminder that the Antarctic Treaty, despite its overall legal-geopolitical innovation, had under Article IV made the first order value of pursuit of science and scientific knowledge a 'permanent' hostage to the colonial legacy of territorial claims and counter-claims.

The announcement on 4 July 1991, of the U.S. decision to sign the Protocol on Environmental Protection to the Antarctic Treaty restored not only the dialogic politics and consensual diplomacy to the ATS but also the state and status of Antarctic as global knowledge commons. This crisis of consensus over the minerals issue had been much more

threatening than the campaigns of the critical lobby in the UN, for the obvious reason that this time, the divide and dispute was internal to the ATS and not between the ATS and those opposed to it (*ibid*).

The 1991 Protocol on Environmental Protection to the Antarctic Treaty (hereafter cited as the Protocol), concluded by consensus on 4 October 1991 at Madrid designates Antarctic as a 'natural reserve devoted to peace and science' and binds its present and future signatories to total protection of the Antarctic environment—its intrinsic and extrinsic worth, including its wilderness, aesthetic value, and its value as an area for scientific research, especially that which is essential to understanding global environment. It categorically prohibits any activity relating to mineral resources, 'other than scientific research'.

The Protocol sets out some basic environmental principles to govern all human activity in Antarctic be it scientific, tourism related, governmental, non-governmental or related to logistic support. The Protocol, vide its Article 11, has established a new institution of immense value and considerable competence: the Committee for Environmental Protection [CEP] comprising all signatories to the Protocol. The Protocol relies upon its State parties in addressing questions of monitoring and compliance, who must take 'appropriate measures within [their] competence' to ensure compliance with the provisions of the Protocol. Regular and effective monitoring is encouraged but centralised responsibility for this is lacking. Inspections are to be conducted under the terms of the Antarctic Treaty, on an individual and collective basis.

Linked organically to the Antarctic Treaty and other components of the ATS, the Protocol in no way changes the 'special legal and political status of Antarctic'. Still, it does break new ground in terms of geopolitics of knowledge production, while raising certain pertinent questions about the protection of the Antarctic environment. It is difficult to deny at the same time that in the wake of mounting global awareness and interest of all kinds, certain ATCPs have acquired a new scientific and technological capability to devise new uses or

find new values and sub-values (including scientific, intrinsic, aesthetic) of the area. As Alan Hemmings puts it,

"A consequence of the process of abandonment of CRAMRA was the emergence and legitimisation of new sorts of Antarctic scientific focus (as well as the broadening of intellectual engagement by non-science disciplines, different parts of national bureaucracies and wider civil society), most obviously the appearance of both taxa-specific and systems-oriented ecological and environmental sciences. Particularly during the 1990s and early 2000, environmental and biological sciences moved into the vanguard of operationalising the new environmental standards resulting from the Madrid Protocol. The picture is now changing again with the increased prominence of new biological sciences, and something of a resurgence of earth sciences as mineral interests awaken" (Hemmings2012a: 145).

**Changing Nature, Role and Uses of 'Antarctic Science'**

The changing nature of Antarctic science is likely to challenge the common good principle anchoring global knowledge commons in ways hitherto un-imagined and unanticipated. One major challenge is already on the horizon, namely biological prospecting. At the beginning of the 21st century, ably assisted by a new revolution in the filed of biotechnology, the industries of the future are increasingly targeting the materials and processes in plants, animals and microorganisms. Unique biodiversity of Antarctic and surrounding Southern Ocean has already started attracting bioprospectors but not without raising complex questions with regard to access, ownership, legitimate use, equity, benefit sharing (Chaturvedi 2009, Joyner 2012).

The role of science and the scientists in the case of Antarctic bioprospecting is going to oscillate between the value of fundamental science and the lure of commercial-corporate interests. As Alan D. Hemmings (2010: 11) notes, "Here, for the first time, science wears two hats, its traditional Antarctic bonnet, and the hard-hat of commercial self-interest." In his

view, in order to pre-empt 'conflict of interests' some 'formal mechanism' would be required along with "some deliberate mechanism to ensure that the interests of science as exploiter are not laundered through its standing as privileged participant in the ATS."The Antarctic regime, argues Hemmings, cannot afford to be complacent and will have to continuously reinvent itself at regular intervals to meet the new challenges.

As far as marine scientific research is concerned, it "may also raise other–more traditional–security concerns",(Scott 2008: 113). Whereas the ATCPs have been discussing recently whether to locate biological prospecting within the category of pure or applied scientific research, the activity remains regulated at all levels. Future disputes arising over complex issues such as access, equity and rights in connection with, the exploitation of these biological resources cannot be ruled out (*ibid*.). "Indeed, the most confrontational dispute to date over scientific research taking place within the region in fact relates to biological resources: the legitimacy of Japanese scientific whaling taking place within the Australian Antarctic Territory (AAT). Furthermore, the distinction between MSR and hydrographic surveying for military purposes is disputed and, in the Antarctic region, this engages yet another layer of complexity through them application of Article I of the 1959 Antarctic Treaty" (*ibid*.).

**Rise of Asia and the ATS: Power Shifts in International Geopolitical Economy and Emerging Geographies of Mistrust**

A new geopolitics of fear is in the making it seems. It is a truism that there are discernible shifts in the global geopolitical tectonic plates and the "centre of gravity' has shifted to Asia. Kishore Mahbubani (2008) has argued that, "the era of Western domination has run its course, bringing good as well as harm and destruction to human history. It is futile for the 12 per cent of the world's population who live in the West to imagine they can determine the destinies of the remaining 88 per cent, many of whom feel newly energised and

empowered" (*ibid*. 336). Whereas according to a recent futuristic study on the rise of Asia,

It is Asia where global savings take place and will continue to be the place, 'offering it the pleasant policy dilemma of how to use the money available, rather than pondering where to get the money from'. Not only will Asia be the world's creditor, but Asia will take over a large part of global economic activity....most of the new multinationals entering the list of the world's largest and most important enterprises will grow out of Asia (Møller 2011: 105-106).

The sheer pace and scale at which some of the fastest growing economies in Asia (especially China), are investing in Antarctic science and logistics are indeed noticeable. Anne Marie-Brady, for example, has argued that, "while the budgets of traditional players such as the United States [with the largest Antarctic budget] have remained static, Russia's has declined from its days when as the USSR it rivalled the USA; China, India, and Korea have made major increases in their investment and reach in Antarctic activities and Australia has also increased its spend" (Brady 2012b: 1). Having noted that, it needs to be acknowledged at the same time, in my view, that the return of Asia, especially in the context of international geopolitical economy, is yet to be fully reflected in various multilateral institutions and agencies including the ATS. May be it is not so much a question as to whether but when this would change. The following comment made by Anne-Marie Brady deserves attention in this context:

"Budgets are not the only way to measure power and influence in Antarctic. Research output is a key indicator of a nation's level of influence and engagement in Antarctic. This is for two reasons: (1) engaging in scientific research in Antarctic is the institutional fig leaf justifying a state's participation in Antarctic governance; and (2) knowledge, as always, is power, and states which can come up with scientific evidence to back up any policy changes they wish to promote are likely to be more influential" (Brady 2012b: 2).

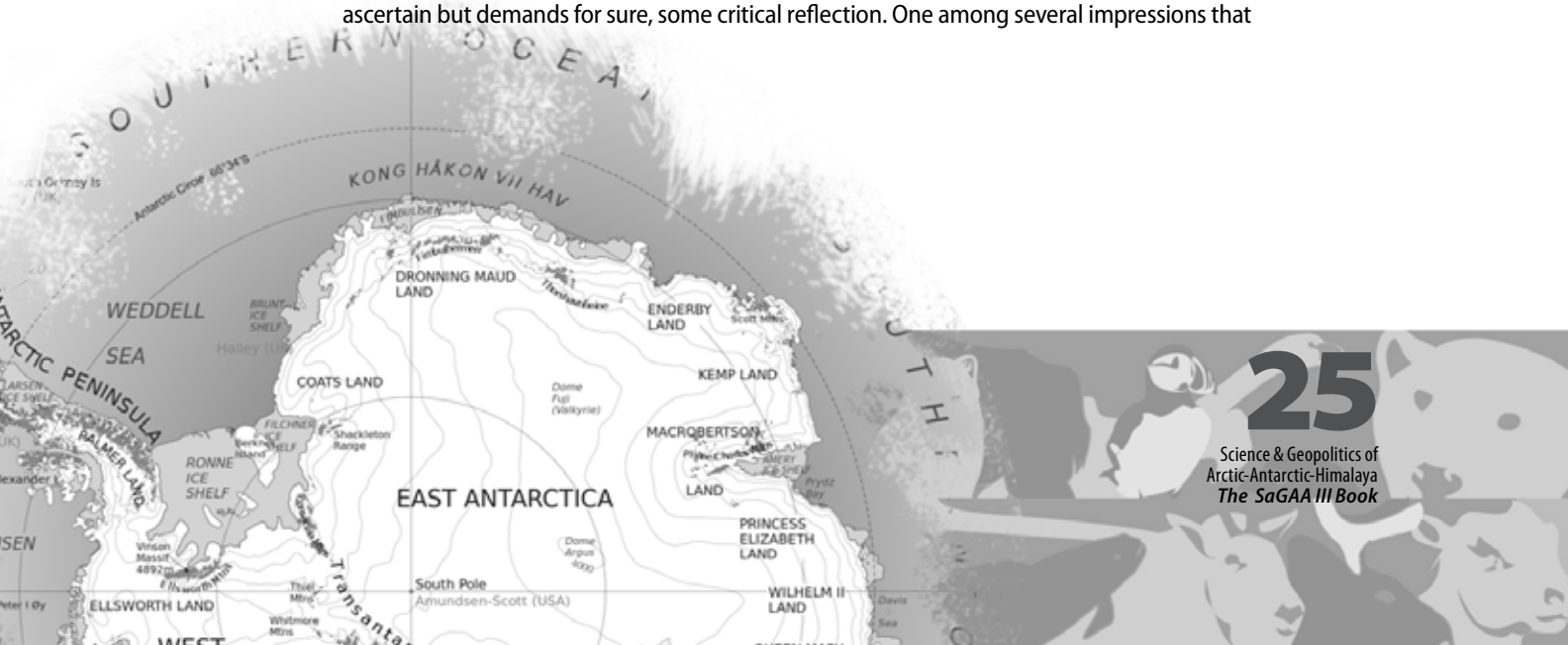
What about Asian countries? Can we anticipate an Asian grouping that will coordinate not only scientific pursuits but also policy initiatives and interventions in the ATS? It is useful to

take note of how 'Asian' presence in the ATSis being approached and interpreted by some of the claimant states. According to a note dated 24 September 2012 authored by Jason Mundy (Australian, Antarctic Division Department of Sustainability, Environment, Water, Population and Communities) and Tony Press (Antarctic Climate and Ecosystems Cooperative Research Centre), "As Asian interests in the Antarctic expand as the 'Asian Century' unfolds, Australia is well placed to take advantage of its geographic proximity to both Asia and Antarctic, strong bilateral links with prominent Asian players and multilateral opportunities through the Antarctic Treaty System to continue to build on our scientific, logistic and diplomatic collaboration with these key nations and remain a leading Antarctic nation throughout the years ahead" (Mundy and Press 2012: 2). It was also pointed out that, "The interests of Asian players in Antarctic are often divergent, and even though an Asian science and logistics group meets regularly to discuss common interests, Asian countries do not operate as an homogenous bloc in Antarctic affairs" (*ibid*. 1).

In some contrast to the above mentioned note (conveying a subtle mix of hope and fear), a geopolitical analysis in the form of a narrative, raising questions marks in terms of 'motives' before the physical-scientific presence of Asian member states, especially China and India, is being presented by some analysts in following terms:

"The emerging Asian powers are increasing their presence in Antarctic…Both China and India have active Antarctic programmes and are seeking to increase the number of their Antarctic bases…India's bases are in the Norwegian and Australian claimed areas. One of them already has a monitoring role though this is claimed to be for scientific observation and experimentation purposes"(Bateman 2012: 121).

The extent to which such imaginative geographies of 'insecurities' are prompted and legitimised by the persisting mismatch between growing Asian physical-scientific presence on Antarctic and a rather minimal geopolitical-policy profile at the ATCMs may be difficult to ascertain but demands for sure, some critical reflection. One among several impressions that



one gathers from such realist-alarmist accounts is that the interest of rising Asian powers in the Antarctic is going to be largely dictated and driven by strategic-military calculations and/or natural resource exploitation. Whereas the 'original signatories' to the Antarctic Treaty are seen as motivated by a different set of values and priorities. They are the ones who are being compelled by a vast majority of Antarctic Treaty member states to carry on their shoulders almost the entire burden of peacefully securing the 'values' of Antarctic regime, including agenda setting and science diplomacy.

It is further argued that the 'Great Game' between China and India in the Indian Ocean Region is going to spill over into the Southern Ocean and could destabilise the delicately maintained geopolitical equilibrium on which the ATS rests. The emerging strategic competition between China and India on the one hand, and India and Japan on the other, is one development that could impact on activities in Antarctic. China is looking more to the Indian Ocean while India is seeking a role in the Pacific. There is increased risk of geopolitical competition in and around Antarctic. All major Asian powers have problems of energy security and are seeking access to untapped sources of energy, wherever they might be (Bateman 2012: 120).

Whether and how through a dialogic politics and diplomacy the 'emerging Asian powers' will encounter and question such geopolitical narratives (Bateman 2012, Bateman and Bergin 2012) remains to be seen. What remains more or less certain however is that lack of mutual trust among the ATCPs, in both its intended and unintended effects could seriously undermine the spirit of international cooperation and exchange of information and knowledge in the ATS. In short the fear of being misconstrued on the part of some could not only perpetuate further silence on their part in the ATCMs but also contribute to the tragedy of global knowledge commons; governance not only in the absence of full knowledge but also mutual trust.

**The Himalaya**

The Himalayan ecosystem is fragile and diverse. It includes over 51 million people who practice hill agriculture and remains vulnerable. The Himalayan ecosystem is vital to the ecological security of the Indian landmass, through providing forest cover, feeding perennial rivers that are the source of drinking water, irrigation, and hydropower, conserving biodiversity, providing a rich base for high value agriculture, and spectacular landscapes for sustainable tourism. The Himalayan eco system is vulnerable and susceptible to the impacts and consequences of a) changes on account of natural causes, b) climate change resulting from anthropogenic emissions and c) developmental paradigms of the modern society.

The Himalaya house one of the largest resources of snow and ice and its glaciers, which form a source of fresh water for the perennial rivers such as the Indus, the Ganga, and the Brahmaputra. Glacial melt may impact their long-term lean season flows, with adverse impacts on the economy in terms of water availability and hydropower generation. Recession of Himalayan glaciers will pose a major danger to the country. Currently available data gathered by multiples of institutions without a coordinated effort do not indicate systematic trends of recession of Himalayan glaciers. The National Action Plan on Climate Change (NAPCC) has enunciated the launch of a National Mission for Sustaining the Himalayan Ecosystem. The Mission needs to deliver better understanding of the coupling between the Himalayan ecosystem and the climate factors and provide inputs for Himalayan Sustainable development while addressing also the protection of a fragile ecosystem. This will require the joint effort of climatologists, glaciologists and other experts. Exchange of information with the South Asian countries and countries sharing the Himalayan ecology will also be required. There is a need to establish an observational and monitoring network for the Himalayan environment to assess freshwater resources and health of the ecosystem. The mission attempts to address some important issues concerning a) Himalayan Glaciers and

the associated hydrological consequences, b) Biodiversity conservation and protection, c) Wild life conservation and protection, d) Traditional knowledge societies and their livelihood and e) Planning for sustaining of the Himalayan Ecosystem.

The challenge of adapting to climate change requires a coordinated response from the Union Government and governments of the Himalayan States. This will require a regular and focused dialogue among these States as well as the Union Government. The National Mission for Sustaining the Himalayan eco system will establish a platform for a periodical dialogue among the various stake holders. The dialogue will focus on the elaboration of a comprehensive and practical strategy appropriate to the current immediate and long-term challenge involved in sustaining a fragile eco system. These strategies may include management of the Himalayan river-basins, cooperation in water resources management to adapt to climate change, the promotion of sustainable agriculture and industrial development in the Himalayan region. Governance systems will need to select the most sustainable path of human development without endangering a fragile ecosystem. Coordinated responses are required between the Central and State Governments and this aspect will be covered directly by the Prime Minister's office. A dedicated Mission Cell on Himalayan Ecosystem will be constituted for the purpose of coordination and reporting to the various committees and oversight groups. This cell will be responsible for coordination with nodal institutions coordinating thematic work elements and report to the Committee of Secretaries as well as submit periodic reports to the PMO. The mission demands also regional cooperation and policy implications. A close coordination with Ministry of External Affairs (MEA) and Ministry of Environment and Forests (MoEF) will be essential (Abstracted from Mission Document Government of India Department Of Science & Technology, Ministry Of Science & Technology, New Delhi June, 2010).

**History of SaGAA**

**SaGAA II 2012:** The International Conference on Science and Geopolitics of Arctic and Antarctic (I- SaGAA 2012) in New Delhi held between March 9 and 11, 2012 successfully bounded the session on Geopolitics: UNCLOS and the Global Commons; Geopolitics of the Global Realms; Biotechnology: Microbial resources in Polar Regions; Dynamics in Polar Marine Biodiversity (Prokaryotes, vertebrates and invertebrates) Information Exchange and Intellectual Property Rights, Resources of the Southern Ocean; Ice Core for Paleo Climate, Southern Ocean and Solar Impact: Sea ice melting, Ice core studies, Southern Ocean Experiments;Paleo climate studies; Polar Atmospheric Research: Ozone depletion Meteorological Studies. Theses identified themes helped for enhancing the holistic understanding of the Polar realms by synergising geopolitics and science.

Senior scientists such as Dr. P S Goel, Dr. ShaileshNayak, Dr. S.W.A. Naqvi, Prof. S. K. Tandon, DrRasikRavindra, Prof. John Turner, Dr. TimoKoivurova, Dr. Victor Smetacek, Dr. John P. Bowman, Prof. NalanKoc, Prof. John M. Reynolds, Dr. George John, Dr. M. Sudhakar, Dr. S. Shivaji, Dr. AjitTyagi, Prof. Sanjay Chaturvedi, Dr. Vijay Sakhuja, Dr. AjaiSaxena, Dr. P.A. LokaBharathi, Dr. Maria Judith, Dr. SavitaKerkar, Dr. B. Meenakumari, Dr. C. N. Ravishankar, Dr. PravinPuthra, Prof R. Ramesh, Prof. A. K. Gwal, Dr. T. Meloth, AbhinavSrivastava, Dr. C.G. Deshpande, Dr. SandipOza, Dr. Nityanand Singh, Dr. S Rajan, Dr. R.P. Lal, Jai PrakashChaubey, Prof. A. L. Ramanathan and Dr. D.P. Dobhal attended apart from representatives from all the countries such as United Kingdom, Finland, Germany, Australia, Norway and Chile. The participation of about 100 scientists was recorded in the Conference including many reputed and renowned scientists from all over the world along with students, and research scholars from different parts of India. Dr. P. S. Goel discussed the global consequences of science and geopolitical issues of Arctic and Antarctic and the aspect of career opportunities for

young researchers and scholars in this field of study which is yet unexplored in the country. He remarked that the Polar Regions contain 70 per cent of the world's water resources and future resources of untapped minerals and hydro resources. The region has huge environmental implications and requires an equitable floor of the benefits for all. This makes the geopolitics of the regions a major subject for consideration and needs an active deliberation by all the nations of Earth. Dr. P. S Goel further said that the space treaty is derived from the Antarctic treaty. We know that the geopolitical issues of the Antarctic are clearly drawn but there is no such clarity in the context of the Arctic region. As for Arctic it is very different in nature because it is surrounded by many developed countries. Dr. SaileshNayak focused India's interest in Arctic and Antarctic purely stands on science because whatever happens in these areas largely effects India as well and since the earth behaves as a single system the effects are felt worldwide. Dr. B. Meenakumari said that there is no need of influencing politics with science. However, when there is a discussion on the Arctic and Antarctic one cannot do away with politics, as these regions come under no man's land or territory, thereby politics cannot be excluded in this area. Dr. AjitTyagi said that the paramount for the scientists is the credibility and the confidence of the layman and the politicians around the world. The larger goal of the society should be emphasized in this field of research and study that can benefit the world as a whole. Dr. M. Sudhakar stated that the way to deal in the area of Antarctic and Arctic is with the complete hand in hand approach of science and politics towards the issues. To establish the relation between science and geopolitics in Polar Regions.Dr. TimoKoivurova said that, there exists a very widely accepted strong governance of Geopolitics in National and International level in both the Polar Regions. He said that the presence of Arctic Council and Convention for Biological Diversity (CBD) is not enough as there is much more International space and we require more ambitious government interventions. Dr. John P. Bowman opined that the area of Polar geopolitics and science is very vast and wide and that there are many commercial interests that also combine with various geopolitical

aspects, thereby harnessing the actual resources of the Arctic and Antarctic in some form or the other. He spoke about the 'future crisis' to be brought by the ever increasing trend of world population, resulting to scarcity of resources and shortage of food supply, the consequences and effects of which will be detrimental and this situation will be the same everywhere around the world. RasikRavindra told that there is no such platform that deals with subjects on Arctic and Antarctica in the External Affair Ministry or Ministry of Foreign Affairs in India. He also told that in 1970s' the importance of divulgence in this field was realized by Smt. Indira Gandhi, and that science was the currency to the Antarctic. He said that understanding that the global atmospheric processes are very intricately linked and that environmental changes in the Tropical or Polar regions will eventually affect the whole planet as one, and therefore it is important for India to recognize these regions and the scientific work undertaken by India here.

**SaGAA I (2011)**

The first National Conference on Science and Geopolitics or Arctic and Antarctic was held between January 14 and 15, 2011. 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 such as India. The Plenary Session/ Technical Session 1 titled " Changing Global Positions and Legal Framework of the Polar Realms" began with Dr. Sanjay Chaturvedi's presentation of his paper titled "Emerging Science-Geopolitics Interface in the Antarctic: The Indian Challenge". The sessions were graced with the presence of Dr. ShaileshNayak, Prof. Pandey, Dr. AjitTyagi, Dr. N.C. Mehrotra, Dr. Anil K. Gupta, DrRasikRavindra, Dr. S. Shivaji, Dr. S.L. Jain, Dr. V.M. Tiwari, Dr. T. Meloth, Dr. SubbaRao, S. K. Mehta, Prof. DhruvSen Singh, and Dr. IML Das. The last session saw Prof. G.N. Nayak, Dr. R. Ramesh, Dr. R.P. Lal, Prof. A.K. Gwal, Dr. V.D. Mishra, Prof. Mihir K. Dash and Dr. B.C. Arya.

DrS.K. Das and DrRavindran and Dr. M.Sudhakar.

Discussion on multiple issues of Global Climate change and its impact on India by several eminent researchers have made the event an extremely successful event. Dr. P C Pandeylaid emphasis on the fact that in this post-colonial, multipolar and peaceful era of independence, the twin concerns of governance was 'Science' and the 'Protection of the Antarctic Environment'. Science and related research was the order of the day. Dr.AjitTyagi laid stress on were the linkages between the Southern Ocean and the Antarctic as regards the issue of the monsoons and the impact of the changing Arctic weather on the Southern Hemisphere. In the nutshell, the issue of Climate Change and the Southern Ocean. Dr. Anil K Gupta said both science and geopolitics was equally important. Changes in the Arctic influenced the monsoons and the Himalayan glaciers. And hence, this region was important not only for its mineral and other natural resources but also for future climatic changes. He called Himalayas the third pole and added that atmospheric studies should include Himalayas within its purview. Dr.ShaileshNayak spoke of the factors affecting the glaciers which were affected not only by changes in temperatures but also by human intervention. Dr. M Sudhakar stated that the Southern Ocean needed to be studied more. The Antarctic was already being researched upon for the last 30 years and the geology of the region was more-or-less understood. Successful expeditions to the Southern Ocean had been undertaken since 2004 but just talking of those was not enough. Researchers needed to find the problem areas regarding the Southern Ocean and conduct studies on those Dr.RasikRavindra, talked of the paradigm shift of the Govt. Of India (GOI) since 1983 when India acceded to the Antarctica Treaty stressed that one needed to be cautious in taking a very aggressive/assertive stand as it needed to be supported by facts. According to him it was the duty of the Parliament to decide legislation and policy-making regarding these issues and liability annex of the GOI was a rather complex and difficult area. Dr. S K Das, MoES in drawing the discussion

to a close said that in the exchange of knowledge that had taken place in the workshop, it had provided a platform for new ideas and programmes which the Ministry could take up as the 3rd station's programme. He harped on the need for long-term multi-dimensional programmes involving several institutional actors within its ambit. Dr. P C Pandey, IIT, Kharagpur commented that though it would indeed be a hard task competing with the rest of the world, the sky was the limit. The 3rd station in the Antarctic was only the beginning. He too was of the opinion that the need of the hour was to focus on science and microbiology and not talk of Bioprospecting and highlighting controversial issues. In the words of the country's erstwhile President- Dr.A.P.J. Abdul Kalam he said that science was empowering.

**Arena of SaGAA 2015**

The broad arena covered by the SaGAA 2015 has been divided into fiveinterlinked broad themes. Session I deals with geopolitics of the Polar Region in global context and also how India is responding to it. Session I builds a platform to explore the multi coloured personality of Arctic Region and how the coexistence of different roles of Arctic in International relations. The geopolitical significances of the region is so vast and handled by multiple units that the protection of resources as well as the intervention should be carefully controlled and restricted to create a sustainable and ecological protected space. This session also talks about diplomacy related dilemma regarding resource use of Polar Regions in global context emphasizing the perspective of India on it. It focuses on current debates of intermingling the two streams—science and geopolitics and how they are going to be implemented in the most efficient manner. The strategies of India regarding Polar issues are unfolded and analyzed in a critical way,which helps to understand the key challenges and controversies regarding that. This session thereby focuses on the hurdles of adapting Article 16 of Madrid Protocol as well as Annex VI. It stresses on the environmental risk in Antarctic region and how the damages in those regions can be compensated. It emphasizes the decision making

process of Indian legislation regarding the International laws on Antarctic Region.

Session II broadly deals with the impact of Global Climate Change in Polar Regions. The time series study of meteorological parameters of Polar Region is the key way to trace the little changes in climate and its impact on global climate change. It covers the climate change patterns in both the polar realmsconstructing different efficient models to predict the future. It also focuses on the degree of melt of polar ices and its spatial variation. It interconnects higher latitudes phenomenon within a concrete shell to understand the mutual coherence of the climatic attributes.

The following Session III connects the global circulation system with regional climatic phenomenon and analyzes the sensitivity of regional climatic phenomena in relation with the global one. The inter connectivity between Indian Summer Monsoon and Polar indices should be studied more focused way to provide valuable information to the policy makers. The role of Southern rim of Himalaya on Southern monsoon is reanalyzed and how the climatic change is inducing random catastrophic events is being investigated. To give the platform a chronological tint the history of Himalaya of 10,000 years is being discussed taking the glacier as the indicator of climate change. Holding the concept of "The Present is the key to the Past" the history has been traced to predict the future of the glaciers of Himalaya. The speed of glacial advance or retreat and the time interval between two successive events is utmost important to study to understand the process of geomorphic change and its impact on climate and vise-e-versa. Moving to Antarctic Oceanthis session also focuses on the temperature distribution in the Southern Ocean and its impact on global climate. The physical attributes, chemical composition of this ocean need to be studied to get the idea of the impact of global warming and ice-melting.

Session IVcovers the themes of Living and Non-living Resources Potential in marine protected areas and its relation with geopolitics. The extraction of those resources without destroying the ecosystem is a very sensitive task. The over exploitation of fish resources, herbs intervene the normal functioning of marine eco-system. The Southern Ocean has

experienced notable collapses of marine species following exploitation, including seals in the 19th century, the great whales in the middle of the 20th century, the marbled rockcod (Notothenia rossii) in the early 1970s and, most recently, some stocks of the Patagonian toothfish (Dissostichuseleginoides). Amidst this background of over-exploitation, regulation of harvesting activities in the Antarctic has been attempted through a series of international conventions: the 1946 International Convention for the Regulation of Whaling, administered by the International Whaling Commission (IWC), the 1972 Convention for the Conservation of Antarctic Seals (CCAS) and the 1980 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). Antarctic krill (Euphausiasuperba) is central in the Antarctic food chain. The different components of the Antarctic marine ecosystem are made up of predators that rely, directly or indirectly, upon the health of the krill populations. Antarctic krill has a circumpolar distribution and is very abundant in the Southern Ocean. This session also deals with the positive impact of climate change. The melted ice is widening the gateway of sea routes which is going to open large resource pool of hydrocarbon to many countries. Hence efficient involvement in policy making process is needed to take a stand in the geo-political forum centered on this zone.

Session Vhas been focused on the issues of tourism industry in Polar Regions. The notion of "Antarctic Tourism" came into existence from 1960s with the ease of sea route transportation. The non-scientific expedition purpose pulls huge tourists which is creating troubles to natural environment. Waste disposals, water transport pollution are damaging the health of marine ecosystem. Due to arrival of flights, ships in the Polar Regions water, snow are getting contaminated. Hence proper management policies and restrictions should be taken into account to deal with such issues.

# B

# THE PEOPLE

## The SaGAA III 2015

Few luminaries and the rest
in the making

**Dr. Shailesh Nayak**
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**Fmr Secretary to the Government of India,**
**Ministry of Earth Sciences,**
**New Delhi.**

**Dr. Shailesh Nayak** was the Chair, Earth System Science Organisation (ESSO) and Secretary to the Government of India for Ministry of Earth Sciences (MoES), between August 2008-2015. He provided leadership for programmes related to science of climate change, weather services, polar science, geoscience, ocean science and modelling, ocean survey, resources, and technology. He chaired an expert group and conceptualised to establish National GIS in the country.

Dr. Nayak obtained Ph. D. degree in Geology from the M.S University of Baroda in 1980. 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. He was mainly responsible for conceptualising, formulating and executing many national level projects related to application of satellite data on ocean colour, integrated coastal zone management, snow and glacier studies and water resources.

Dr. Nayak was appointed as the Director, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, an autonomous institution under ESSO, in May 2006. At ESSO-INCOIS, he set up a state-of-the-art Early Warning System for Tsunami and Storm Surges in the Indian Ocean. He was responsible for the conceptualisation and development of Marine GIS. He 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 has been member of many national committees related to earth science, coastal protection, mangrove, coral reef, and coastal

zone management.

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. He has been awarded honorary degree of Doctor of Science by the Andhra University in 2011, by the Assam University in 2013, and by the Amity University in 2015. 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 by the Indian Society of Remote Sensing, Dehradun, and the National Mineral Award for the year 2005. He is recognised as a Ph.D. guide by six universities, and 11 students have obtained Ph. D. under his supervision.

Dr. Nayak is the President, Federation of Indian Geoscientists Associations and the President, Indian Geophysical Union, Hyderabad. During his tenure he held senior positions in the Regional Integrated Multi-hazard Early Warning System (RIMES), the Inter-Governmental Coordinating Group on Indian Ocean Tsunami Warning System (ICG-IOTWS) (2007-2011); the ISRS, Dehradun, Indian Meteorological Society (IMS), the Indian Society of Geomatics (ISG), Ahmedabad, the Indian Ocean–Global Ocean Observing System (IO-GOOS) (2006-10) and the Indian Ocean Observing System Resources Forum (IRF) (2009-2013). He has represented Indian Space Research Organization (ISRO) in the International Ocean Colour Coordinating Group and International Global Observation Strategy-Coastal theme. Dr. Nayak has published about 150 papers in International and National journals and atlases.

**Dr. P. S. Goel**
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**Distinguished Professor,**
**Indian Space Research Organisation, HQ,**
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**Dr. P. S. Goel** is currently designated as Honorary Distinguished Professor at Indian Space Research Organisation (ISRO) HQ, Bangalore. He developed the spin axis orientation system, Bhaskara I & II satellites, magnetic control for spinning satellites, momentum biased 3axis control system for APPLE, zero momentum biased 3axis control system for IRS. V, and, configuration momentum biased altitude control system for highly stabilised INSAT2. Dr Goel developed a very agile control system with step and stare capability to spot imaging mission TES and guided the evolution of reentry capability for SRE Mission. He 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 was Chairman, Spacecraft System Advisory Board for IRS1, Project engineer AOCS for APPLE and Associate Project Director INSATII. 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 Padmashree in 2001. He received several other 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.

**Dr. Debajit Sarma**
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**Principal Scientist (Fish & Fisheries Science)**
**ICAR-Directorate of Coldwater Fisheries Research**
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**Dr. Debajit Sarma**, Principal Scientist in the Directorate of Coldwater Fisheries Research has fifteen years of research and teaching experience. His field of working area focuses on aquaculture, nutrient profiling and conservation with a specialization in fish and fishery science. He has published 54 papers, 31 articles, 6 books and 16 book chapters apart from brochures and popular writings. He has attended 37 National and International Seminars. He has organized seven national conferences as secretary and convenor. He has membership of large number of professional bodies in various national institutions like Inland Fisheries Society of India, Academy of Environmental Biology, Assam Bhoreli Angling and Conservation Association, Asian Fisheries Society, Coldwater Fisheries Society of India, Assam Science Society, A Society for Biodiversity Conservation, Guwahati. He applied for patent on 'A novel feed formulation for improved growth in fish'. He received Fellowship from Academy of Environmental Biology(AEB), Lucknow in 2010. He achieved Gold Medal in 2011 from AEB.

**Dr. Ajai**
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**Professor,**
**MWRG, Space Applications Centre, ISRO,**
**Ahmedabad.**

**Dr. Ajai,** a doctorate in physics has served Indian Space Research Organisation (ISRO) for about 36 years in various capacities. He is presently Professor, Space Applications Centre, Ahmedabad. He is also an honorary professor and Ph.D guide at CEPT, Nirma and Gujarat University. His field of research is snow and glaciers, desertification, and coastal ecosystem. He has led the national team to study snow and glaciers of the Himalaya, which carried out detailed inventory of the glaciers of the entire Himalaya, monitored large number of glaciers for their retreat/advance and snow cover of the Himalaya. He has also monitored the entire coastal zones of India including its vital habitats (coral reef and mangroves) using satellite data. Dr. Ajai is on the panel of experts on desertification at United Nations and European Commission. He laid the foundation of modernisation of India Meteorology Department with state-of-the-art atmospheric observation system. He was instrumental in numerical modelling based modern forecasting system, establishing Indian Tsunami Warning System, commissioning Third Station at Larsemann Hills at Antarctica, the Technology Development Programme for low temperature thermal desalination from sea water and development of ocean technologies like deep ocean drilling and manned submersible. Recent awards and honours to his credit include Padmashree by Government of India (2001), Outstanding Achievement Award of ISRO 2007, GP Chatterjee Memorial Award for design and development of satellite technologies by Indian Science Congress Association (2003), National Remote Sensing Award (1997), ISRO's Team Excellence Award (2008), Vikram Sarabhai Award-Indian Science Association (2007), Aryabhata Award of Astronautical Society of India 2005, among many others. Dr. Ajai has more than 400 publications and authored 11 books and atlases. He is Chief Editor of the Journal of Geomatics and editorial board member of 'Word Atlas of Desertification'.

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

**Air Vice Marshal (Dr.) Ajit Tyagi,** has served as Director General of Meteorology, India Met Department, Assistant Chief of Air Staff (Meteorology) and Principal Director (Information Technology) in Indian Air Force. Dr. Tyagi has successfully executed first phase of modernisation programme of India Meteorological Department and has formulated Himalayan Meteorology Programme. He is on the Monsoon Panel of World Weather Research Programme of World Meteorological Organisation (WMO). He has served as Permanent Representative of India with WMO and was member of WMO Panel on Monsoon Meteorology. He is member of many scientific committees of Department of Science and Technology. Dr. Tyagi is a fellow of India Meteorological Society. He has been commended by Chief of Air Staff and awarded Vishistha Sewa Medal by President of India for his distinguished services to the nation.

**Dr. Anil Vishnupant Kulkarni**
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**Distinguished Visiting Scientist,**
**Divecha Center for Climate Change,**
**Indian Institute of Science, Bangalore.**

**Dr. Anil Vishnupant Kulkarni** is a distinguished visiting scientist, presently working at the Divecha Centre for Climate Change. His journey in glaciology and cryosphere science started in 1979, when he joined Space Applications Centre (SAC), Ahmedabad, as a Junior Research Fellow. His career took shape as a scientist in SAC, where he served for a period of 30 years, between 1980 and 2010. Prior to his career as a Scientist, he acquired a post graduation degree in Applied Geology from University of Roorkee , now known as Indian Institute of Technology-Roorkee. In 1987, he was awarded a Commonwealth fellowship at McGill University, Montreal, Canada. Dr. Kulkarni has developed a vast number of remote sensing based methods and models to understand the Himalayan cryosphere. He developed a snow and glacier melt runoff model to assess hydropower potential of small Himalayan streams and the study has provided hydropower potential of all glaciated streams in Himachal Pradesh. His snow melt runoff model has also shown impact of climate change on hydropower generation, indicating reduction in power potential in all the seasons.
Dr. Kulkarni has been conferred with the prestigious National award in Polar Science and cryosphere in 2014 and National Geosciences award in 2009 as a recognition of his outstanding contribution in the field of Applied Geosciences. He has also received a Team Excellence award in 2008 from Indian Space Research Organisation for his contribution as a team leader of Snow and Glacier project. Dr. Kulkarni has been appreciated by the President of Iceland for his great contribution in developing training programme for young Indian glaciologists with Iceland.

**Dr. Anoop K. Tiwari**
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**Scientist D,**
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**Dr. Anoop K. Tiwari** is Scientist D in ESSO-National Centre for Antarctic and Ocean Research (NCAOR), Goa. Dr. Tiwari has over 18 years of experience in the areas of Carrying Capacity Project, Environmental Impact Assessment (EIA) Studies for Cement, Thermal Power Plant, Steel, Fertilizer and Hydro carbon Industries, in EIA of Antarctic Stations, Environmental Monitoring, Aerosol Study etc. He represented India in Committee for Environmental Protection/Antarctica Treaty Consultative Meeting as Leader of the Environmental Expert Group (EEG) of Council of Managers of National Antarctic Programme (COMNAP). He pursued Bachelor of Engineering in Civil Engineering followed by Master of Engineering in Environmental Engineering and completed Ph.D in Marine Science. He participated in the 19th, 23rd, 31st, 32nd, 33rd and 34th Indian Scientific Expedition to Antarctica. Dr. Tiwari has worked on environmental quality at Maitri, invasive alien species: threat to Antarctic biodiversity, effect of glacier melting at Priyadarshini Lake and environmental monitoring and enhancement of EIA Laboratory at Maitri. He was awarded with Shrimati Shiromadevi prize (2008), for the paper 'Water Abundance and Effect of Glacier Melting at Priyadarshini Lake in Antarctica', in the Environmental Engineering Journals of the Institutions of Engineers. He also won 'The Rekha Nandi and Bhupesh Nandi prize' (2009) for the paper 'Waste water fate at Maitri in Antarctica, Journal of the Institution of Engineers India' (Environmental Engineering). He holds prestigious position in The Indian Science Congress Association, National Environmental Science Academy and in Indian Aerosol Science and Technology Association. Dr. Tiwari has published in various national and international journals during the last five years.

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**Professor,**
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**Dr. A. P. Dimri** is currently professor in environmental science department in Jawaharlal Nehru University (JNU). His research area focuses on regional climate dynamics, change and variability, climate and numerical modelling, statistical and dynamical downscaling of numerical model outputs, science of climate and climate change, extreme events and their physical understanding and Indian winter monsoon and western disturbances. He pursued his Ph.D from the Indian Institute of Tropical Meteorology (IITM). Dr. Dimri completed his M.Phil from Environmental Sciences, Jawaharlal Nehru University. He is involved in the ongoing projects on the study of extreme precipitating events (cloudburst) leading to natural hazards and disasters; measurements and modelling of evapo-transpiration and other hydrological processes in the lesser Himalayas; and, Development of Dynamical Mass Balance Model for Gangotri Glacier. Dr. Dimri was the recipient of the Commonwealth Academic Fellowship, 2014-2015. He was elected as Council Member, Indian Geophysical Union (IGU), during 2014-2016 and Indian Meteorological Society (IMS) during 2014-2016. He has been awarded a fellowship in Japan Society for the Promotion of Science and Indian Geophysical Union (IGU) and has received the Technology Award 2006 from Defense Research and Development Organization (DRDO). Dr. Dimri has a total of 58 publications in different renowned journals. His area of expertise for climatic research falls in the Ladakh, Himachal, Uttarakhand and Jammu region.

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**Scientist–F,**
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**Dr. Ashis Kumar Mitra** is an eminent scientist currently positioned as Scientist-F, National Center for Medium Range Weather Forecasting (NCMRWF) in the Ministry of Earth Sciences, India. He pursued his masters in physical oceanography and completed Ph.D in 'Ocean Modelling'. Dr Mitra has 26 years of research experience in global atmospheric modelling including global data assimilation system. He is experienced in monsoon system studies and has worked in model verification and diagnostics. He was involved in development of gridded rainfall datasets for model verification for monsoon. This was achieved by merging satellite and rain-gauge daily rainfall data. Several research papers have been published related to the said topics. Dr. Mitra's current interest is in simulation/prediction of monsoon as a coupled land-ocean-atmosphere system for different space-time scale. He worked as a visiting scientist at FSU, USA on coupled ocean-atmosphere modelling for monsoon. During the tenure he gained experience on multi-model ensemble forecasting. Dr. Mitra has also worked under the UKIERI programme and on UKMO's latest coupled model. Following that currently he is involved in monsoon research with HadGEM3AO coupled model, which is installed at NCMRWF HPC. He is also involved in implementing NEMOVar at NCMRWF, the ocean initialization scheme for coupled model. These coupled models have good potential to improve the monsoon precipitation forecasts from days to a season. As monsoon simulation is like a bench-mark for any model, by improving the skill of monsoon in coupled model, the overall performance of the model could be improved. Realistic simulation of sea-ice in coupled model is very important for short-term climate prediction.

**Dr. Ashit Kumar Swain**
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**Geologist,**
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**Dr. Ashit Kumar Swain** obtained his M.Sc (Applied Geology) from University of Allahabad and submitted his Ph.D. (Geology) in Ravenshaw University. He was engaged in research at Indian Statistical Institute, Kolkata on structural and petrological studies of rocks of Eastern Ghats in Odisha and continued his studies in Southern Granulite Terrain in South India after joining Geological Survey of India at Chennai in 2001. He worked at Indian Institute of Technology (IIT), Kharagpur as a young scientist under DST scheme to carry out AMS studies on the rocks of SGT. He joined Antarctic Division of Geological Survey of India in 2006 and is till date continuing his research on geological, geomorphological and glaciological investigations in and around Schirmacher Oasis, East Antarctic. Dr Ashit participated in 27th, 29th, 30th, 32nd and 34th Indian Scientific Expedition to Antarctic including a continuous stay of 15 months. He was a member of the 1st Indian Scientific Expedition to South Pole in 2010. He also worked in the geological and glaciological studies in Arctic region by participating in Indian Arctic Expeditions in 2011 and 2014. Dr Ashit worked at Hamtah glacier of the Himalayan region and imparted training to the trainees of field glaciology course. Apart from his regular field assignments, he also worked in collaboration with Delhi Police and Archaeological Survey of India for specific investigations after Kedarnath tragedy.
Dr Ashit is a recipient of Youth Inspiration Award.

**Dr. B. Meenakumari**
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**OSD Agricultural Education and**
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**Dr. B. Meenakumari** 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 has secured her Ph.D from the University of Kerala in 1989 on Ecobiology of Fouling and received a gold medal. She has developed and commercialised combination of wire ropes for deep sea demersal trawls thus substituting import of the ropes. Contributions were made 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 actively working to conserve resources for the sustainable development of Indian fisheries and is interested in impact assessment and environmental monitoring. She has been 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 the 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.

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**Dr. C. N. Ravishankar** is presently working as Director, Central Institute of Fisheries Technology (CIFT), Cochin. Born in Karnataka in 1963, Ravishankar earned his Bachelor Degree in Fisheries Sciences from College of Fisheries, Mangalore under the University of Agricultural Sciences, Bangalore in 1984 followed by post-graduation and Ph.D from the same university in 1986 and 1990. He joined CIFT, Cochin as Scientist in 1991 and has been working ever since in various capacities in the fish processing division. He had participated in the First Indian Antarctic Expedition and travelled abroad widely for training and consultancy programmes. His areas of specialisation include fish processing and packaging technologies and has developed, popularised and transferred many technologies to the seafood industry. Throughout his career, Dr. Ravishankar has remained a highly active and successful scientific researcher. He has more than 200 International and National publications to his credit and has filed 17 patents. So far, he has guided six students for Ph.D and 28 students for their post-graduation. Dr. Ravishankar received the Outstanding Team Research award in the field of Fish Products Technology from the Indian Council of Agricultural Research, and K. Chidambaram Memorial Award from Fisheries Technocrats Forum, Gold Medal for his Ph.D, and, Merit Certificate from Royal Institute of Public Health & Hygiene, London. He is a Fellow of National Academy of Agricultural Sciences, New Delhi and Society of Fisheries Technologists (India). He was instrumental in establishing a Business Incubation Centre with office and pilot plant facility for the entrepreneurship development in fish and other food products. In addition to his many other activities, he has delivered numerous invited talks on fish preservation techniques, food packaging, business Incubation and other related areas.

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**Dr. David Rheinheimer** is a Fulbright-Nehru Postdoctoral Fellow at the Indian Institute of Technology, Roorkee, where he is exploring sustainable hydropower development in the Himalaya. Since completing his doctoral studies in 2011 at the University of California, Davis, Dr. Rheinheimer's research has focused on various aspects of hydropower systems in the Sierra Nevada in California and the Three Gorges Reservoir in China, emphasising the water-energy-environment nexus and climate change. He has worked for U.S. Department of Energy, the National Oceanic and Atmospheric Administration, and the World Wildlife Fund on projects related to water and environmental management, hydrology, and data management.

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**Dr. G. A. Ramadass** is a senior scientist at National Institute of Technology (NIOT), Chennai. His research areas include Deep Sea Technology, Underwater Acoustics and Marine Instruments. At NIOT he is the head Deep Sea Technology Group. In 2010 Dr. Ramdass won the National Geoscience award under the Exploration of Oil and Natural Gas category. He led NIOT team during the 34th Indian Scientific Expedition to Antarctica in February- March 2015. Polar Remotely Operated Vehicle (PROVe), developed indigenously at NIOT, was used for exploration in the lake and shelf area of Antarctica during this expedition. A doctorate from Indian Institute of Technology, Madras, he handled technology development programmes leading to products and patents. He has been the Chief Scientist of 15 cruises and scientific explorations on-board various research vessels. His work includes publications in the international journals, international conferences and four international patents.

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**Dr. Geir Moholdt** is a researcher at the Norwegian Polar Institute (NPI) in the fields of remote sensing and glaciology. He received his Ph.D from the University of Oslo in 2011 and has since then worked two years as a postdoc at the Scripps Institution of Oceanography in California, before starting at NPI in 2014. His research has focused on the integration of satellite altimetry with other remote sensing techniques for determining the global glacier contribution to sea level rise and basal melt rates of Antarctic ice shelves. He has conducted fieldwork on glaciers in Alaska and Svalbard, and is now involved in the planning of an Indian-Norwegian research project to be carried out in 2016-2018 from the Maitri Station in Dronning Maud Land, East Antarctica.

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**H E Mr.** Grahame Morton joined the Ministry of Foreign Affairs and Trade (MFAT) in 1996. Grahame was announced New Zealand's High Commissioner to India, Sri Lanka, Nepal and Bangladesh in March 2014 by Hon Murray McCully, Minister of Foreign Affairs. Prior to his current role he was Director General and Divisional Manager, North Asia Division, MFAT, Wellington (2011-14) Head of China, Asia Division, MFAT, Wellington (2009-2010),Deputy Director, Australia Division, MFAT Wellington (2007-2009), First Secretary, New Zealand Embassy, Beijing (2004-2007), Senior Policy Officer (marine policy), Antarctic Policy Unit, MFAT, Wellington (2002-2004). He was New Zealand's representative to the Commission for Antarctic Marine Living Resources Administration and Finance Committee. He was Deputy High Commissioner and manager of the New Zealand aid programme to the Cook Islands, Rarotonga (1999-2002). Mr. Morton was policy officer in Nuclear issues, International Security and Arms Control Division, MFAT Wellington, Vienna, New York (1998-99) and he was Policy Officer of Japan and Korea economic affairs in North Asia Division (1997). In addition to his official roles Mr Morton has been a board member and contributor to a number of New Zealand University, public and private sector affiliated organisations. Mr Morton holds a first class Honours degree in History from Otago University.

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**Professor and Head at Department of Geology, HNB Garhwal University, Srinagar Garhwal.**

**Prof. H. C. Nainwal** is currently serving as Professor and Head of Department of Geology, H. N. B. Garhwal University (A Central University). He is an expert in Glaciology, Geomorphology, Paleo-climate studies and Engineering Geology (Natural hazards). He has more than 30 years' teaching and research experience. He has about 50 journal publications. He worked on the geomorphological aspects and retreat of the Gangotri group of glaciers in a project funded by Department of Science and Technology, New Delhi. He also carried out the glacier studies in Upper Alaknanda-Saraswati basin in a programme sponsored by Space Application Centre (ISRO) Ahmedabad. Since 2005, he is working on the retreat, paleo-glaciation and geomorphology of the Satopanth and Bhagirath Kharak glaciers (Upper Alaknanda basin). Presently, he is also working on mass balance, surface flow studies, retreat and Ice thickness studies of Satopanth glaciers. About ten students received their Ph.D. degree under his supervision in the different fields of Geology including Glaciology and five students are registered for Ph. D. Degree under his supervision. He is also a Member of Program Advisory Committee on Himalayan Glaciology of DST (Govt. of India) New Delhi.

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**Dr. H. S. Negi** received the M.Sc. (Physics) and M.Tech.(Cold Region Science and Engg.) degrees from G. B. Pant Univ. of Agriculture & Technology, Pantnagar. He obtained his Ph.D degree in remote sensing of snow from H. N. B. Garhwal University, Srinagar. He has more than 15 years experience in remote sensing of snow and glaciers. Presently he is working as Scientist E at SASE, DRDO, Chandigarh. His areas of research are: optical properties of snow, hyperspectral remote sensing for snow characteristics, snow cover monitoring, snow avalanche, avalanche hazard and glacier study. He is the recipient of BOYSCAST fellowship of DST and worked at University of Bremen, Germany. He is the recipient of DRDO Young Scientist Award. He also participated in Indian Science Expedition to Antarctica. He has around 38 research papers in peer reviewed journals and symposia.

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**Dr. Luther Rangreji** is on deputation to the Faculty of Legal Studies, South Asian University from the Legal and Treaties Division, Ministry of External Affairs. He has obtained his L.L.M from Pune University and M.Phil. and Ph.D. in International Law from Jawaharlal Nehru University(JNU), New Delhi. Earlier, he worked as Legal Adviser at the Secretariat of the Asian-African Legal Consultative Organization (AALCO) New Delhi, an intergovernmental organisation devoted to study of international legal issues of concern to the Asian-African countries. His areas of specialisation include – law of the sea, international organisation and international environmental law. In the Legal and Treaties Division, he had occasion to deal with diverse matters relating to extradition, International Criminal Court, work of the International Law Commission, United Nations, collective security, narcotics and international terrorism, international environmental issues such as climate change, biodiversity, biosafety, atomic energy, water disputes, Antarctic matters, disarmament etc. Dr. Rangreji is a Visiting Faculty at the Indian Society of International Law, Indian Law Institute, New Delhi, WWF-Centre for Environmental Law, National Law School, Bangalore, University of Pune and Symbiosis International University. He has presented and published papers on various problems of international law issues in National and International journals.

**Dr. Madhavan Nair Rajeeven**
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**Director,**
**Indian Institute of Tropical Meteorology,**
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**Dr. Madhavan Nair Rajeevan** is an eminent scientist currently designated as the Director of the Indian Institute of Tropical Meteorology, Pune. His scientific career started as Senior Scientific Assistant during 1983-85 at the Tata Institute of Fundamental Research (TIFR), Mumbai. In 1985,he joined the India Meteorological Department and was posted initially at Ahmedabad and later at the National Climate Centre, Pune. In 2008 after serving for 23 years at IMD, he moved to the National Atmospheric Research Laboratory, Department of Space, Tirupati as a senior scientist. At the Laboratory at Tirupati, he developed a modelling group and established an observational system for severe convective systems. In 2012, he moved to the Ministry of Earth Sciences as scientist-G/ Adviser, where he continued till February 2015. In 2015, he moved to IITM, Pune as its Director. He pursued his PhD from the University of Pune in 1997 in the stream of Physics. His research area focuses on Monsoon Variability and Monsoon Prediction, Cloud-radiation Interaction and Climate Variability and Climate Change. Dr Rajeevan is the recipient of many awards including the 'START Young Scientist Award' by START Foundation, USA for Best Research paper in 2001. He received the '20th Biennial Mausam Award' by Department of Science & Technology, for Best Research paper in 2001. He also received the Young Scientist Award by Ministry of Earth Sciences, for research contributions in Atmospheric Sciences in 2007. For his research contributions, Dr Rajeevan was elected as the Fellow of the Indian Academy of Sciences in 2012. He is the high level advisor to the Commission of Climatology of the World Meteorological Organization.

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**Dr. Maruthadu Sudhakar** presently is the Director, Centre for Marine Living Resources & Ecology (CMLRE), Cochin, the Ministry of Earth Science, Govt. of India and also has been the Director, National Centre for Earth Science Studies (NCESS, Thiruvananthapuram) as additional charge. He is an M.Tech and Ph.D in Applied Geology from Indian School of Mines, Dhanbad and holds a Master's degree in Law of the Sea and Marine Policy from the London School of Economics and Political Science, UK as a British Council Fellow. He has contributed extensively in the field of oceanography/ offshore surveys/ polar sciences/ marine technology and spent about 1500 days at sea as a leader/member of various expeditions including Southern Ocean and Antarctica. Dr. Sudhakar is a veteran oceanographer and was a project leader of major national thrust programmes such as the Survey and Exploration of Polymetallic Nodules in Indian Ocean, Oceanography studies of Southern Ocean, Delineation of Continental Shelf demarcation, Multibeam Swath Bathymetric Surveys of Exclusive Economic Zone of India, Arctic research etc. His major scientific contributions include delineation of major nodule deposits in Central Indian Basin, demarcation of potential areas for resource development; discovery of a large pumice field, zeolite deposits microcrates on Australasian microtektites, mapping the seabed and charting the bathymetry of Prydz Bay, Eastern Antarctica. He bagged many awards for the MoES Pavilion in Indian Science Congress during 2009-2015 as the Head, Outreach & Awareness Programme of the Ministry. He was the 'Commissioner' of Govt. of India for the Yeosu World Expo (Republic of Korea, 2012) and organised an international pavilion for more than 100 days. He has published over 100 research papers in national/international journals, presented papers in reputed symposia/conferences, delivered key-note speeches and chaired many technical sessions, authored three books.

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**First Secretary,**
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**Mr. Marcus Holknekt,** First Secretary at the Embassy of Sweden in New Delhi, is responsible for foreign policy issues. His prior postings include Bosnia and Herzegovina and for the United Nations —Liberia and Indonesia. Here Mr. Marcus worked on strategy and communication issues. He graduated in the Fletcher School of Law and Diplomacy at Tufts University. Before that, Mr. Marcus was in the account management sector and served as a market analyst in the private sector.

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**Dr. M. R. Bhutiyani** obtained his M.Sc in Geology with specialisation in Engineering Geology and Groundwater Hydrology in 1981 and Ph.D in Environmental Science on the Response of Glaciers to the Climate Change and its Implications on NW Himalaya from the University of Pune in 2005. He started his career as a lecturer in Geology in Science College, Karad, and later worked as a geo-scientist in Government of Maharashtra and in Geological Survey of India. He joined DRDO as Scientist B in 1984 at Snow and Avalanche Study Establishment (SASE), Manali, and carried out research on the Himalayan Training Programme on Precision Manufacturing Techniques and GD&T Principles RCI, Hyderabad. He also organised a special training programme on Precision Manufacturing Techniques and GD&T Principles in 2014. His work on the natural hazards such as avalanches, rockfalls, ice avalanches, crevasses and glacier-melt water floods afflicting the troops deployed in the glaciated terrain of the eastern Karakoram Himalaya has resulted in preparation of route maps of all glaciers of that region and ensured the safety of pedestrian routes and camp sites for the troops. His work on glaciological studies on the Siachen Glacier, have culminated in development of methodology of estimation of mass balance of very long glaciers by an innovative hydrological method and suspended sediment transport studies in the Nubra River. His research papers published in International Journal of Glaciology and Journal of Hydrology are now the most widely cited papers on this subject the world over. His pathbreaking work on the Siachen Glacier has paved the way for exploring many other large glaciers in other parts of the Himalaya.

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**Prof. Milap Chand Sharma** is an eminent researcher on the Himalayan Cryosphere Region, currently teaching as professor of Geomorphology in the Centre for Regional Development of Jawaharlal Nehru University, New Delhi. He was honoured with the Ph.D degree by University of London in 1996 on his work on the 'Glacial History of Gangotri Glacier'. He is a skeptic of human induced climate change. His research focuses on the Reconstruction of Quaternary Environments in the Alpine areas, Assessment of Geomorphological hazards, hazard mitigation in the mountain environments and palaeo and contemporary geomorphic processes in relation to landscape evolution, and application of Remote Sensing & GIS in Environmental Impact Assessment. He has implemented many national and international projects on the above listed focus areas.

**Prof. Manju Mohan**
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**Dr. Manju Mohan** is Professor at the Centre for Atmospheric Sciences at IIT Delhi and has about 35 years of research experience in the area of Air Quality Modelling, Urban Meteorology, Fog Prediction and Environmental Impact and Risk Assessment from various industries and Application of Remote sensing to air quality. Her current interests are Urban Climate, Chemical Transport Modelling for Aerosols and Ozone with WRF/Chem Model, Emission inventories, Fog Modelling. Prof. Mohan has made significant contributions in these areas which are widely recognised. She has bagged prestigious scholarships, awards and medals such as Fellow, Institute of Environmental Engineers in 1998. Institution of Engineers (India) awarded her Nawab Zain Yar Jung Bahadur Memorial medal for the best paper in Environmental Sciences. Prof. Mohan is currently Member, Indian National Committee on Climate Change (INCCC), Ministry of Water Resources, Government of India. Earlier she has been a member of Environmental Appraisal Committee (Industry-I) of Ministry of Environment and Forests (MoEF), Govt. of India; Member, Subject Expert Committee in Earth and Atmospheric Sciences for the Women Scientist Scheme (WOS-A) of Department of Science and Technology (DST) etc. At IIT Delhi, she also holds a position of administrative responsibility as Associate Dean (Student Welfare). Prof. Mohan has been a post-doctoral fellow at the Royal Netherlands Meteorological Institute. Besides having guided large number of Ph.D., M.Tech. and B.Tech projects, she has published about 65 research papers in peer reviewed journals of international repute and about 75 publications as book chapters, conference proceedings, technical newsletters, popular science articles etc.

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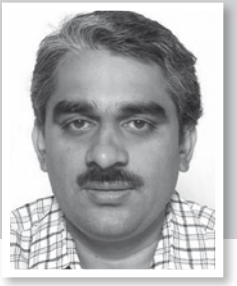
**Prof. P. C. Pandey** obtained his doctorate in Physics on Microwaves from Allahabad University in 1972 and has also been conferred D. Sc. (hc) from Purvanchal University, Jaunpur, Uttar Pradesh. He is credited with the initiation of the satellite borne Microwave Remote Sensing of Ocean Atmosphere and Cryosphere research in India. Professor Pandey was the Founder Director of National Centre for Antarctic and Ocean Research, Goa from 1997 to 2005. He has spent a major part of his career at Space Application Centre (ISRO), Ahmedabad, and has worked for about five years at the NASA's world famous Jet Propulsion Laboratory, USA, before joining IIT Bhubaneswar. Prof Pandey was visiting and Professor Emeritus at IIT Kharagpur. He was also responsible for setting up K Banerji Center for Ocean and Atmosphere Studies (KBCAOS) at Allahabad. Professor Pandey has carried out extensive research in the areas of satellite oceanography, atmospheric science, climate change and polar science. He has published more than 100 papers in reputed national and international peer reviewed journals. Professor Pandey is a Fellow of the Indian Academy of Sciences, Bangalore, The National Academy of Sciences, Allahabad, Indian Society of Remote Sensing, Indian Geophysical Union, Geological Society of India, India Meteorological Society and also host of other societies. Professor Pandey is the recipient of the prestigious Shanti Swarup Bhatnagar Award in 1989, K. R. Ramanathan Memorial Gold Medal of IGU, Rekha Nandi and Bhupesh Nandi Prize 2010, Professor Vikram Sarabhai Award and Gold Medal, Om Prakash Bhasin Award and Vigyan Ratna Samman Award of U.P. Council of Science and Technology as well as the NASA award.



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**Dr. R. Krishnan** specializes in climate modelling on scientific issues relating to the 'Dynamics and variability of the Asian monsoon'. His interests include: Monsoon dynamics and variability; phenomenon of monsoon-breaks and droughts; large-scale organization of monsoon convection; global climate change and impacts on the Asian monsoon; and, regional climate extremes. Currently Dr. Krishnan is leading the Centre for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology, Pune and is deeply involved in developing in-house capability in Earth System Modelling to address climate change and related scientific issues. He carried out his Ph.D. research in Atmospheric Sciences at the Physical Research Laboratory, Ahmedabad and obtained Ph.D. degree by the University of Pune in 1994. He was an eminent Senior Scientific Officer, Natl. Centre for Medium Range Weather Forecasting, and Delhi for next five years. Dr. Krishnan is Senior Scientist in Indian Institute of Tropical Meteorology, Pune from 1995 till present. He was honoured with Frontier Outstanding Research Award, FRSGC, Japan (Twice: 1999 and 2000), IITM Golden Jubilee Biennial Award, 2014—Outstanding Research Contributions, IITM Silver Jubilee Award for best research paper, IITM, Pune (thrice: 1998, 2005, 2009), Prof. Anandu Vernekar Award, India Meteorological Society (IMS). Dr. Krishnan was a member of the prestigious Asia Australia Monsoon Panel (AAMP), CLIVAR, World Climate Research Programme. He occupied the chair of CORDEX Science Advisory Team, World Climate Research Programme. He was part of Scientific Steering Committee, Monsoon Asia Integrated Regional Study (MAIRS). He was an editor, Earth System Dynamics, Open Access Journal, European Geophysical Union. Dr. Krishnan has published over 80 scientific articles (63 in peer-reviewed Journals & book chapters; 17 Research Reports).

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**Pannikar Professor at ESSO**
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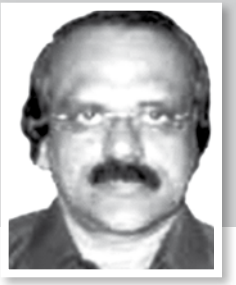
**Dr. Rasik Ravindra** was the Director of the National Centre for Antarctic and Ocean Research, an autonomous research institute under the Ministry of Earth Sciences, Government of India between 2006 and 2012. He has worked in Rajasthan, Haryana, and Meghalaya and led geological expeditions to higher Himalaya during his 35 years of service in Geological Survey of India. His association with Antarctic dates back to 1987, when he joined Seventh Indian Expedition to Antarctic. Subsequently, he led the Ninth Antarctic Expedition in 1989-91 and visited the icy continent again in 1996-97, 2003-04, 2007 and 2009 in different capacities. In 2010 he led the First Indian Expedition to South Pole. He is also credited with leading an Environmental Task Force in Antarctic, Task Force on selection of site for Bharati, the third Indian Station in Antarctic, the First Indian Arctic Expedition and establishing 'Himadri' the Indian station in Arctic. He was the Vice President of Scientific Committee on Antarctic Research (SCAR), the Chairman of INSA Committee of SCAR, and the Chairman of Asian Forum on Polar Sciences. He has led Indian delegations to international Polar bodies such as ATCM, COMNAP and IASC since 2006. He has received National Mineral Award-1990, Antarctic Award-2002 and Rajiv Gandhi Excellence Award-2011, National Award for Polar Sciences and Cryosphere-2013 for his contributions to advancement of Polar sciences in India. He holds, currently, the Chair Panikkar Professor in Ministry of Earth Sciences and is the Member of the United Nations Commission on limits of continental shelf.

**Dr. S Rajan**
**Email: rajan.ncacor@gmail.com**



**Former Director,**
**National Centre for Antarctic and**
**Ocean Research, Goa.**

**Dr. S. Rajan** is a former Director of National Centre for Antarctic and Ocean Research (NCAOR). He holds a Ph.D degree in Geology and Geophysics from the University of Hawaii, USA. A marine geologist by profession, Dr. Rajan has been involved in marine geoscientific surveys and research since 1984. As the Project-Director in charge of the Indian Continental Shelf Programme since 1999, he has been responsible for coordinating all aspects related to the collection, processing, interpretation and documentation of the requisite geoscientific data to define and substantiate India's claims for an extended continental shelf under the provisions of UNCLOS. Dr. Rajan is also India's sole elected representative to the United Nations Convention on the Law of the Sea. In addition, he is the national coordinator for the Indian Scientific endeavours in the Arctic besides being the Principal Investigator of a multi-institutional national initiative of long term monitoring programme of the Kongsfjorden system for climate change studies.

Dr. Rajan was also a member of the Task Force constituted by the Government in 2003 which carried out the reconnaissance surveys in East Antarctic for identification of a suitable site for India's Third Research Base in Antarctic. Dr.Rajan is the recipient of the National Geoscience Award 2010 for his contributions in the field of Ocean Development as well as the 2014 Dr. H. N. Siddiquie Medal of the Indian Geophysical Union for his contributions in the field of Marine Sciences.

**Dr. Sanjay Chaturvedi**
**Email: csgiorg@gmail.com**

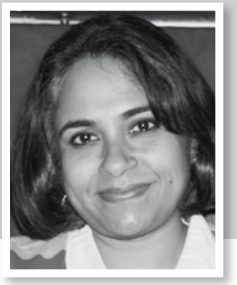
**Professor, Department of Political Science Panjab University, Chandigarh.**

**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; Ben Gurion University of the Negev, Israel; and Henry L. Stimson Centre, Washington D.C., USA. Dr. Chaturvedi serves on the international editorial board of many leading peer-review journals such as The Polar Journal, Geopolitics, 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) of 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).

**Dr. S. K. Parcha**
**Email: parchask@gmail.com**

**Scientist-F**
**Group Head Biostratigraphy Division**
**Wadia Institute of Himalayan Geology,**
**Dehradun.**

**Dr. S.K Parcha** is currently designated as Scientist F in Group Head Biostratigraphy Division in Wadia Institute of Himalayan Geology. His area of specialization is Paleobiology, Paleoecology, Paleoenvironment and Stratigraphy. His thrust Area of work is on Tethyan and Lesser Himalayan regions. He delivered Invited lectures in various National and International conferences, seminars and in various research organizations including various universities, colleges and schools and in ITBP, RIMC, IMA, IFS trainees, etc. Dr. Parcha has guided two Ph.D students, eight M.Sc dissertations and four B.Tech petroleum and exploration students. He completed six DST sponsored projects and two International Collaborative National Science Foundation Projects funded by USA International Project with Astria. He has UNESCO Merit Certificate, Merit Scholarship, and University Fellowship from DST. Dr. Parcha is the recipient of the medal and Certificate from Army Headquarters for the Expedition in Himalayan terrain (trekking 465Km) in the Tethyan Himalayan regions of Ladakh Zanskar, Lahaul, Kinnaur and Spiti . He received Award by the Geological Society of India on its Golden Jubilee Celebration for contribution to Geosciences. He is life Member in large number of institutions like Geological Society of India, Paleontological Society of India, Journal of Himalayan Geology, Indian Science Congress Association, the Indian Metrological Society. Dr. Parcha is also developing the Children's Science Corner in the Museum of Wadia Institute. He has 78 pubications in National/ International Journals and in proceeding volumes and one book publication.



**Sulagna Chattopadhyay**
**Email: editor@geographyandyou.com**

**President,**
**LIGHTS Research Foundation ,**
**Editor, geographyandyou.com**

**Sulagna Chattopadhyay** did her M.Phil from Centre for Study of Regional Development, Jawaharlal Nehru University, New Delhi. She founded an internationally reputed journo-magazine on environment and development titled Geography and You, popularly known as G'nY in 2001. Till date she has published 91 issues of the magazine. She is also a founding President of an NGO, Learning in Geography, Humanities, Technology and Science(LIGHTS). She has been organising national and international conferences/seminars, notable among them are Round Table Conclave on Seas and Oceans Around India, National Conference on Science & Geopolitics on Arctic and Antarctic (SaGAA) in 2011, followed by an international version of SaGAA in 2013. LIGHTS has organised a multi-city GIS training programme for school teachers in 7 locations. She has edited 12 books and international reports, prominent among them is 'the Scientific and Geopolitical Interests in Arctic and Antarctic' co-edited with Dr. R. Ramesh and Dr. M. Sudhakar in 2103. She was nominated as the Member of the Working Group for Disaster Management in Planning Commission in 2011. She has been the Member of the Anti-Ragging Committee at JNU. She also won an Environmental Documentary Short Film Contest, STL-2:2015 organised by CREESS-International Journal of Environment and Natural Science for her short film titled *'O Bhai Saab'*.

**Prof. Tanu Jindal**
**Email: tjindal@amity.edu**

**Director, Amity Centre for Antarctic Research and Studies,**
**Amity University, Noida.**

**Prof. Tanu Jindal**, Director of Amity Institute of Environmental Sciences, Amity Institute for Environmental Toxicology, Safety and Management and Amity Centre for Antarctic Research and Studies, is an eminent environment scientist. She obtained her Ph.D from Department of Zoology, Delhi University as a Gate fellow and was designated as guest lecturer in Delhi University 1999-2007. She is working on the project of Environmental Toxicological Studies on Schirmacher (Maitri) Station in Antarctic Region in collaboration with National Centre of Antarctic and Ocean Research. She is engaged in the project of 'Development of a Cost Effective Lysimeter & Method for Leaching Studies to Estimate Risk Assessment of Groundwater Contamination , 'Mobile Phone and Tower exposure measurement and Biological Correlations' funded by Department of Science and Technology (DST) apart from various other studies. She has completed three projects from Ministry of Environment and forests, Ministry of Earth sciences and DST on surface and groundwater contamination. She has life memberships of 9 prestigious societies. Amongst the more recent accolades, she won the Environmentalist of the Year Award-2014 by National Environmental Science Academy (NESA); 'New Investigator Award presentation' at prestigious "American Chemical Society", Philadelphia, USA, 'Young Scientist' Project (DST). She has five patents on environment friendly techniques and products including simple and cost effective water testing kit. She convened three national conferences and has organized various environmental awareness events. She presented over 74 papers nationally and internationally (USA, Netherlands, Germany, and Singapore) and published 16 papers in refereed journals, 1 book and several articles.

**H.E. Mr. Thorir Ibsen**
**Email:thorir.ibsen@utn.stjr.is**

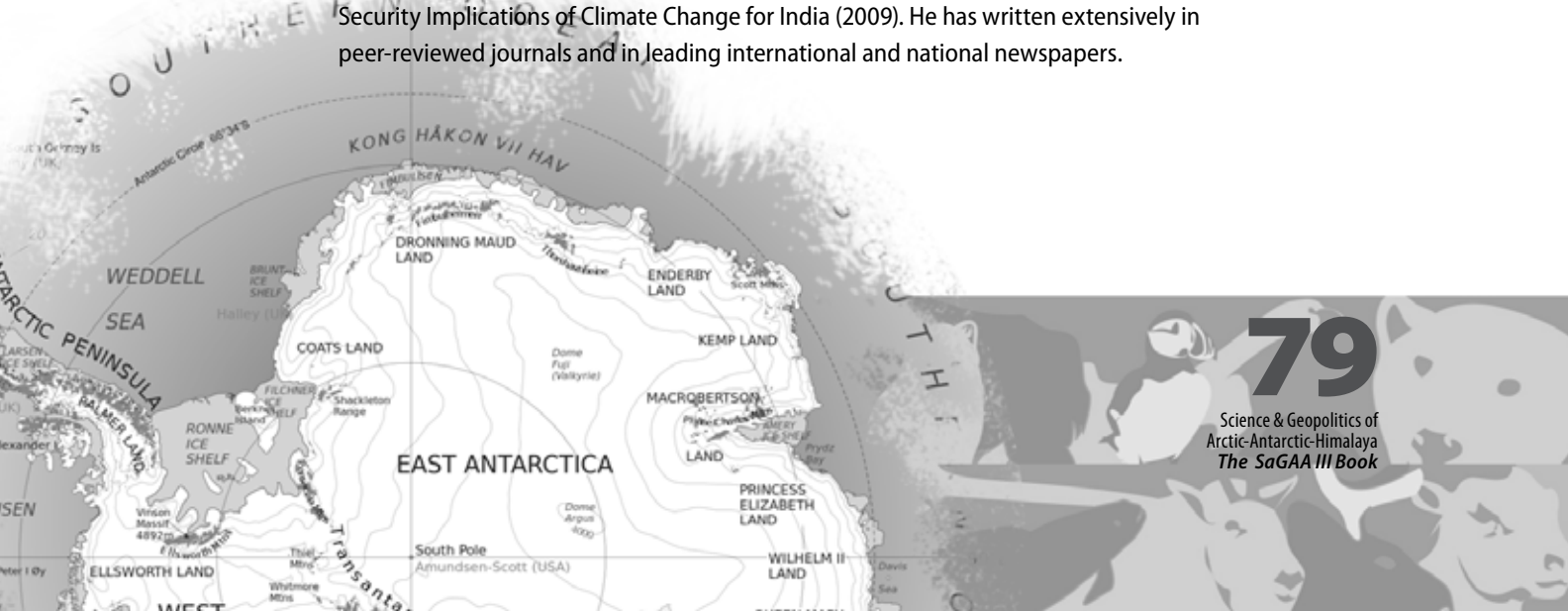
**Ambassador of Iceland to India,**
**New Delhi.**

**H. E. Mr. Thórir Ibsen** took up his duties as Ambassador of Iceland to India in September 2014. With more than twenty years of experience of multilateral relations, his career has brought him to Arctic issues on several occasions dealing with such issues as the Arctic Environmental Protection Strategy, marine protection, fisheries, security cooperation, the Arctic Council and climate change. Previous positions include Ambassador of Iceland to the European Union and to Belgium with accreditation to Luxembourg, the Netherlands and Switzerland, Ambassador of Iceland to France with accreditation to Italy and Spain, Permanent Representative of Iceland to the OECD, Chief Negotiator and Ambassador for Climate Change, Director of the Defence Department, Deputy Permanent Representative of the Delegation of Iceland to NATO, Director of the Department of Natural Resources and Environmental Affairs, and Head of the International Department of the Environment Ministry of Iceland.

**Dr. Uttam Kumar Sinha**
**Email: uksinha2001@gmail.com**

**Research Fellow ,**
**Institute for Defence Studies and Analysis (IDSA),**
**New Delhi.**

**Dr. Uttam Kumar Sinha** is a Fellow at IDSA and holds an adjunct position at the Malaviya Centre for Peace Research, Banaras Hindu University. His research areas focus on non-traditional aspects of security with particularly attention on climate change, transboundary water issues and the Arctic region. At IDSA, he is the Managing Editor of Strategic Analysis (Routledge) and edits the Strategic Digest. In 2006, he was a visiting fellow to the International Peace Research Institute Oslo (PRIO) and in 2008 he was a Chevening 'Gurukul' Scholar at the London School of Economics and Political Science. Recently he was at the Harvard Kennedy School, Harvard University on a US-South Asia Leaders Engagement Programme. He is actively involved with policy shaping and interface with various ministries. From 2011-12, he was a CSCAP-India representative for the study group on water resources security. CSCAP is a Track 2 dialogue forum of ASEAN. He was elected Chair of the Working Group on Climate Change; Security and Governance in 2015. Earlier he was the Chair of the Water Dispute Resolution Mechanism. A doctorate from Jawaharlal Nehru University, he worked in the daily Pioneer and wrote the weekly space, 'Strategic Eye'. His recent work includes edited volumes,Non-Traditional Security Challenges in Asia: Approaches and Responses (Routledge 2015); Arctic: Commerce, Governance and Policy (Routledge, 2015); Emerging Strategic Trends in Asia and a monograph Climate Change Narratives: Reading the Arctic. His single authored book titled as Riverine Neighbourhood: Hydropolitics in South Asia is under publication. He co-authored the IDSA Report on India and Water Security: External Dynamics (2010) and also the IDSA Report on Security Implications of Climate Change for India (2009). He has written extensively in peer-reviewed journals and in leading international and national newspapers.



**Dr. U. Sreedhar**
**Email: sreedharcift@gmail.com**

**Principal Scientist,**
**Central Institute of Fisheries,**
**Cochin.**

**Dr. U. Sreedhar** is Principal Scientist at Visakhapatnam Research Centre of Central Institute of Fisheries Technology, under Indian Council of Agricultural Research, which is an Autonomous Organisations under Ministry of Agriculture. He was honoured with doctorate degree from Agricultural Research Service (ARS) from Acharya Nagarjuna University,in 2009. He completed Master of Science (M.Sc.) in Fisheries Management from Central Institute of Fisheries Education, Mumbai in the year 1991. He is pursuing research on Exploitation and Assessment of Demersal Fishery Resources along the Continental Slope area (200-1500m) of Indian EEZ and Central Indian Ocean. Dr. Sreedhar researched on validation of Tuna advisories off East Coast, Reduction of Environmental Impact from trawling systems through By-catch Reduction Technologies and development of region specific sustainable fishing systems for east coast of India. He conducted work on responsible fishing, fishing technology, innovations in fishing technology, satellite data dissemination, interpretation of satellite data, deep-sea fishing grounds and deep-sea resources. He developed 'Appropriate Fishing Systems' for inland water bodies. He participated in six cruises of FORV 'SagarSampada' scientific expedition as Chief Scientist. He has life membership in 'Society of Fisheries Technologists of India (SOFTI)', Cochin, Kerala, India and 'Forum of Fisheries Professionals (Visakhapatnam)', Andhra Pradesh, India. He held the position of 'Secretary, Forum of Fisheries Professionals (Visakhapatnam)', Andhra Pradesh, India. Dr. Sreedhar has over 45 publications in different National and International journals, 6 popular articles and 7 book chapters.

**Dr. V. N. Sanjeevan**
**Email: sanjeevanmoes@gmail.com**

**Former Director,**
**The Centre for Marine Living Resources**
**and Ecology (CMLRE), Cochin.**

**Dr. V. N. Sanjeevan** is the former Director of CMLRE. He completed his Ph.D from Central Institute of Fisheries Education, Mumbai and Post-doctoral research on Climate Change and Fisheries at the Climate Research Centre, University of Norwich, U.K. in 1995. Dr. Sanjeevan was conferred with 'Fellow Academy of Science, Engineering and Technology' (FASET) in 2012. He served as official representative of Governemnt of India in various international committees such as Commission for Conservation of Antarctic Marine Living Resources (CCAMLR), Australia, Census of Marine Life, Belgium, Indo-US collaboration on S&T, Washington for two years. Currently he is Member, International Group of Experts on World Ocean—Assessment of Assessments; Member Antarctic Legislation Committee of Govt. of India; CSIR Committee on BIO-fuels; Committee on Biodiversity of MoEF, New Delhi; Member, Governing Council, KUFOS; Board of Studies Andhra University; and, Secretary General, World Ocean Science Congress. He is a recognised guide of Cochin University for Doctoral research and has more than 50 papers in international journals to his credit. Last year he contributed chapters to the following books Smith, S., Zang, C.I., Banks, M., Costello, M., Sohou, Z., Sanjeevan,V.N. (2014). He wrote a Chapter on 'Marine Biodiversity of Indian Exclusive Economic Zone'. Dr. Sanjeevan has visited various laboratories and research centres in USA, UK, Australia, Spain, France, Belgium, Brazil, Malaysia, Singapore, Mauritius, South Africa, Kenya,Sri Lanka etc representing GOI in meetings related to Marine Biology.

## The Faculty

Dr. Punam Behari, Associate Professor, specialising in Urban and Population Geography, Miranda House, Delhi University.

Dr. Sudeshna Bhattacharya, Associate Professor, specialising in Geomorphology, Miranda House, Delhi University.

Dr. Nitasha Malhotra, Associate Professor, specialising in Medical Geography, Climatology, Oceanography, Cartography, Human and Economic Geography, Kamala Nehru College, Delhi University.

Dr. Sachchidanand Tripathi, Associate Professor, specialising in Plant Ecology (eco-physiology, resource ecology, restoration ecology, forest ecology, functional traits analysis in dry tropical environment and aquatic ecology), Deen Dayal Upadhyaya College, Delhi University.

Dr. Rajkumari Sanayaima Devi, Associate Professor, specialising in Biology -1, 2 , Plant Resource Utilisation, Environmental Science,Plant Morphology and Anatomy, Deen Dayal Upadhyaya College, Delhi University.

Dr. Charu Kalra, Associate Professor, specialising in Plant Biotechnology, Deen Dayal Upadhyaya College, Delhi University.

Dr. Pramod Kumar, Associate Professor, specialising in Environmental Pollution And Control, Deen Dayal Upadhyaya College, Delhi University.

Dr. Sandeep Kumar, Associate Professor, specialising in Plant Physiology, Deen Dayal Upadhyaya College, Delhi University.

Shekhar Kumar, Guest Faculty, Assistant Professor of Geography, Govt. College, Hoshiarpur, Punjab.

## The Research Scholars

Anant Pandey, Senior Research Fellow, working in the area of nesting ecology of Antarctica sea bird in Wildlife Institute of India, Dehradun, Uttarakhand.

Souda Hassan, Junior Research Fellow working in marine bio-optics in Central Institute of Fisheries Technology, Cochin.

Nuvodita Singh, Research Fellow, working in the area of environment and development from the Center for Ecology Development & Research, Dehradun , Uttarakhand.

Saheed P P, Project Scientist working in the area of Ocean Modeling and Sea Ice, in NCMRWF, MoES, Noida , U. P.

Anoop Jaiswal, Junior Research Fellow working in the area of Eco restoration of Coal Mines, in Forest Research Institute, Dehradun, Uttarakhand.

Priyanka Khanna, Junior Research Fellow, working on Gangotri Glacier in the Centre for the Studies of Regional Development (CSRD), Jawaharlal Nehru University, Delhi.

Varuni Pathak, M.Phil, working on GLOF (Glacial lake outburst flood) in CSRD, Jawaharlal Nehru University, Delhi.

Ritu Dalal, M.Phil, working in the area of Climate change in Himalayan Glacier, in CSRD, Jawaharlal Nehru University, Delhi.

Elora Chakraborty, M.Phil, working in the area of Climate change in Himalayan Glacier, in CSRD ,Jawaharlal Nehru University, Delhi.

Ishita Manna, M.Phil, working in the area of Climate Change in the Himalayan Region, in CSRD ,Jawaharlal Nehru University, Delhi.

Sandeeptanu Mondal, M.Phil working on Himalayan Glaciers in CSRD ,Jawaharlal Nehru University, Delhi.

Suresh Das, M.Phil, working on Himalayan Glaciers in CSRD, Jawaharlal Nehru University, Delhi.

Alexander Gewelt, Masters, working in the area of South Asia Studies, in the Department of Culture Studies and Oriental Languages, University of Oslo.

Sejuti Basu
Research Assistant, Area of Work: Manager, Research and Advocacy Team, Pragya (NGO).

SaGAA III 2015

## The Students

Devyani Hada, B.A Hons. Geography, Miranda House, Delhi University.

Vasudha Singh, B.A Hons. Geography, Miranda House, Delhi University.

Shahnaz Parveen, B.A Hons. Geography, Miranda House, Delhi University.

Vedika Maheshwari, B.A Hons.Geography, Miranda House, Delhi University.

Saloni Ranka, B.A Hons. Geography, Miranda House, Delhi University.

Vijay Laxmi, B.A Hons. Geography, Miranda House, Delhi University.

Shweta Movalia, B.A Hons. Geography, Miranda House, Delhi University.

Sreenidhi Rao, B.A Hons. Geography, Miranda House, Delhi University.

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Sreedevi N. Kurur, B.A Hons. Geography, Kamala Nehru College, Delhi University.

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Nandita Paul, B.A Hons. Geography, Kamala Nehru College, Delhi University.

Lisa Agarwal, B.A Hons. Geography, Kamala Nehru College, Delhi University.

Aparajita Singh, B.A Hons. Geography, Kamala Nehru College, Delhi University.

Anjul Singh, B.A Hons. Geography, Kamala Nehru College, Delhi University.

Aastha Arya, B.A Hons. Geography, Kamala Nehru Collage, Delhi University.

Aakash Dogra, BSc. Hons. Botany, Deen Dayal Upadhyaya College, Delhi University.

Talib Kamal, BSc. Hons. Botany, Deen Dayal Upadhyaya College, Delhi University.

Harsh Raman Pathak, BSc. Hons. Botany. Deen Dayal Upadhyaya College, Delhi University.

Shubham Goel, B.Tech. Civil Engineering, G. B. Pant University, Pant Nagar, Uttarakhand.

Yashvi Malhotra, Bachelors of Engineering Electronics, UIET, Chandigarh , Punjab.

Pragyan Deep Agarwal BA (LLB), USLLS, GGS Indraprastha University, Delhi.

# C

# THE DISCOURSE

## The SaGAA III 2015

The five sessions on geopolitics; climate change in the polar regions; in the Himalayan regions; resource potential; and, tourism in the polar realms.

**International Conference on**
## Science and Geopolitics of Arctic-Antarctic-Himalaya
September 29th, 2015
**SESSION - 1 GEOPOLITICS OF THE POLAR REGION**
Time: 12:15 pm to 1:45 pm

**Chair: Dr. Shailesh Nayak**

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| 1. | H.E. Thórir Ibsen, Ambassador of Iceland. | The Arctic Experience and the Third Pole: A Perspective from Iceland | Iceland has the unique strategic position of being the only nation state placed entirely within the Arctic. More so, the fate of Iceland as a nation state is inherently linked with the development of the Arctic. This very fact explains the specificities of Iceland´s Arctic Policy, namely its principal emphasis on human and sustainable development. Ever since the island was settled in the 9th century, Icelanders have based their livelihood on the Arctic nature. Today they have built a highly modern and affluent society using their natural resources. The Arctic is therefore one of the main priorities of Iceland´s foreign policy and Iceland has taken an active part in building the Arctic cooperation embodied in the Arctic Council. It can be argued that the bottom-up and science based evolution of the Arctic cooperation, which proved so successful, could also benefit other regions were tensions need to be bridged. Already five Asian countries are observers to the Arctic Council. Apart from benefitting the Arctic cooperation, the engagement of the Asian countries can also endow them with a rich and pragmatic experience that can benefit constructive cooperation in the Himalaya-Third Pole region. |

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| 2. | Dr. Sanjay Chaturvedi, Professor Department of Political Science, Panjab University. | India's Polar Challenge: Geopolitics and Challenging 21st Century Science Diplomacy. | India, one of the fastest growing economies in the world with expanding geopolitical ambitions, should continue to deploy a carefully crafted 'science diplomacy' at ensuring that 'Polar Geopolitics' (Antarctic & Arctic) becomes increasingly 'multi-polar' in the era of climate change and scarcities. This in turn also demands proactive, robust and sustained policy interventions by India in both the Antarctic Treaty System and the Arctic Council to ensure that diversity (interests, actors and perspectives) and dialogue, the two guiding principles of a truly multi-national governance of the Polar Regions, remain resilient. The paper begins with brief critical reflection on the concept of science diplomacy, highlights the dynamics and dilemmas it acquires in polar (especially Antarctic) geopolitical settings/contexts, and pinpoints the relevance of the ongoing debate on integrating the communities of science and diplomacy in innovative ways for India's bi-polar mission. The paper concludes by making a few policy recommendations, including India appointing a Polar Ambassador to meet both the challenges and opportunities posed by fast changing contours of polar geopolitics-science-diplomacy interface to better serve both India's enlightened national interests and imperatives of internationalism. |

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| 3 | Dr. M Sudhakar, Director, CMLRE. | Laws of the Seas and UNCLOS | The vast deep oceans are a repository of myriad mineral resources, the mapping and exploration of which is done by an international milieu. Nations around the world seek intellectual prowess and technological breakthroughs to procure resources that will be of utmost important in the future. India occupied its position on geo-political map under the regime established in the Third United Nations Convention on the Law of the Sea (UNCLOS-III) in 1982. Apart from the benefits of an agreed Law of the Sea, India's EEZ became the twelfth largest in the world and the extension of the EEZ to 350 miles or 100 miles beyond the 2500-m isobath added 2 million square km to India's jurisdiction. In accordance with the `pioneer investor' status, the International Seabed Authority allotted to India a 150,000 square km mine site in the central Indian Ocean for the seabed mining of polymetallic nodules. The richest area at this site has a density of 21 kilograms of nodules per square metre. India should increase its level of technologies in harnessing mechanisms to compete with Japan, China, Papua New Gini in exploration. The Indian Ministry of Earth Sciences is also investigating the deposition of rare earth elements (REE) and suitable recovery technologies when developed would harness these metals as well for the country. Resource excavation for territorial region is active in coastal region of Southern India but deep sea extraction still needs better infrastructure facilities and scientific research. In recently concluded meetings of the ISA during its 17th session (July 2011), China and Russia have claimed areas of hydrothermal sulphide for exploration in Southwest Indian Ridge and Mid-Atlantic Ridge respectively and an area of 3,00,000 sq km each has been approved. Another milestone in the history of ISA is the claim of two islands nation in the Pacific Ocean, for allocation of reserved areas in the CCZ. This marks a new beginning of seabed mineral regime and India should be more active in collaborations with International organisations to expand its territorial jurisdiction. |

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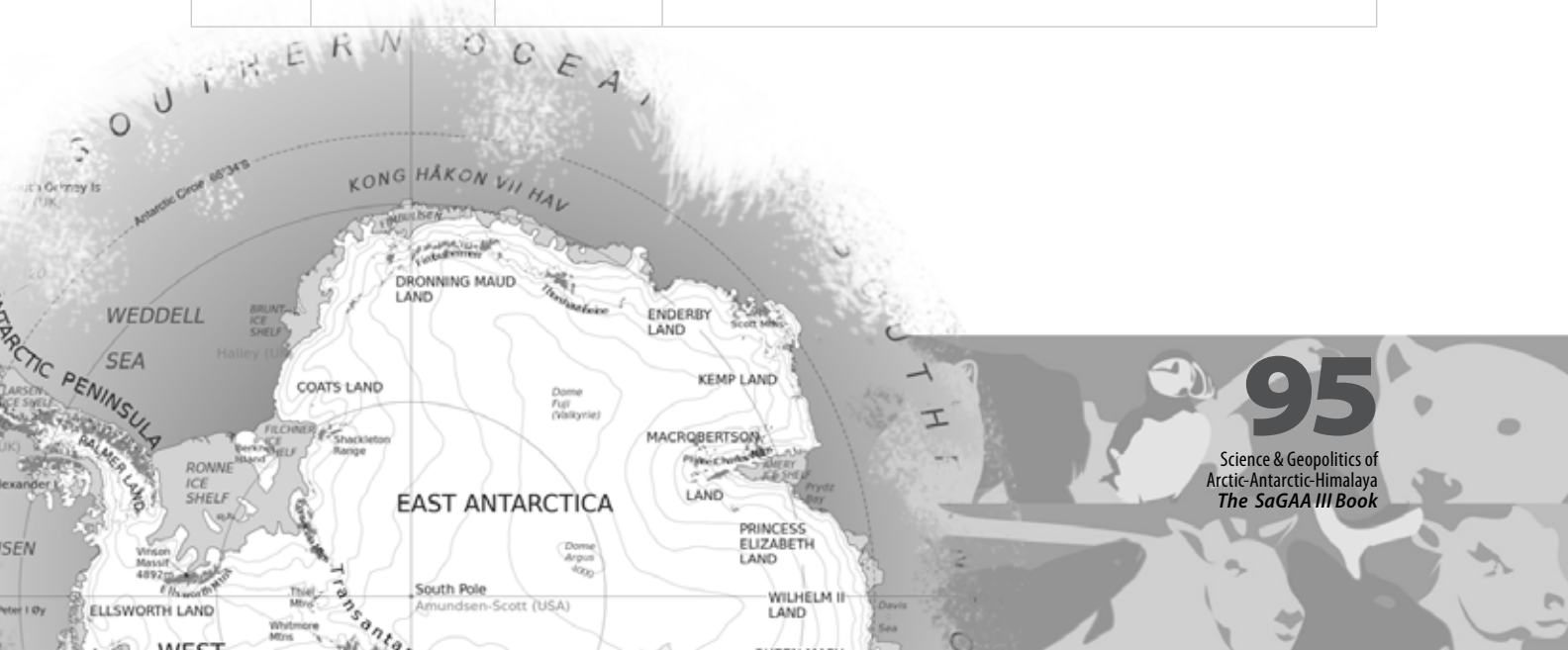
| 4. | Dr. Luther M Rangreji, Associate Professor, Faculty of Legal Studies (FLS), South Asian University. | India and Annex VI to the Madrid Protocol: Some Preliminary Thoughts | Article 16 of the Madrid Protocol provides a mandate "to establish a comprehensive liability regime for the protection of the Antarctic environment" and the same has been met by the adoption of Annex VI. It is important to understand that adoption of any liability regime is always a difficult task and so was the case of the adoption of Annex VI to the Protocol on Environmental Protection to the Antarctic Treaty: Liability Arising from Environmental Emergencies (Madrid Protocol). It remains a landmark achievement signalling the commitment of the international community as a whole and Antarctic Consultative Treaty Parties in particular to protect the Antarctic environment from environmental emergencies. The 13 years taken to adopt Annex VI is an indication of the contentious issues involved, which to name a few were: the scope of Annex VI; definition of damage; standard of liability; how do you compensate for harm to the Antarctic environment; who can bring a suit for claim of damages; channeling of liability; triggering of liability; extent of liability-joint or several; who decides quantum of compensation. These were the main issues that went into the negotiation and drafting of Annex VI. Even has India has signaled its commitment to implement the remit of Annex VI by ratifying it, would have to look at drafting a domestic law on the subject. Do we need a law only on Annex VI to the Madrid Protocol or do we need a comprehensive domestic legislation on Antarctica, as a whole including liability provisions? How would becoming a party to Annex VI help India? Are the obligations onerous in terms of financial implications? Can we learn from the experiences or lessons learnt from other Consultative Parties? The paper would attempt to article some of these questions and more. |



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| 5. | Dr. Uttam Sinha, Research Fellow, Institute for Defence Studies and Analysis (IDSA). | Arctic: A Paradox and Antithesis | The Arctic is witnessing the convergence of the geophysical, the geo-economics and the geo-strategic in strange and dramatic ways making it a paradox and an antithesis. The changing landscape is keeping countries, particularly those within the rim and some beyond, honest in their engagement. Inevitably, competition and cooperation will emerge, along with positioning and posturing. Four reasons for increasing attention on the Arctic can be highlighted.<br>First, the Arctic will continue to remain a large geo-strategic tract. Whether it is new resource finds or new emerging transport routes, the Arctic's strategic value will only amplify. Second, since the Arctic is a semi-enclosed ocean surrounded by land, and like all high seas, governed by the laws of the sea (UNCLOS). Understanding the legal regimes that applies for navigation in new shipping routes and those that governs the exploitation of the vast oil and gas resources will be challenging as it will directly confront states' interest. Third, relates to the question of resource finds. The Arctic holds vast untapped gas reserves, potentially large undeveloped oil reserves and mineral wealth, making it the final frontier for energy development. Any resource development will require building massive infrastructure through areas that are ecologically sensitive. The fourth Arctic attention concerns the sea routes. Clearly, the Arctic is becoming accessible to a number of different actors with varied, and not mutually beneficial, agendas. How then does the world navigate through this 'interplay' and move towards a global knowledge commons that includes scientific understanding and learning, ecological protection and sustainable use of resources—what can be described as an 'Arctic governance web'. |

**International Conference on**
## Science and Geopolitics of Arctic-Antarctic-Himalaya
September - 29th, 2015
**SESSION-II Global Climate Change and the Polar Region**
Time: 2:30 pm to 6:00 pm

**Chair: Dr. M. N. Rajeeven**

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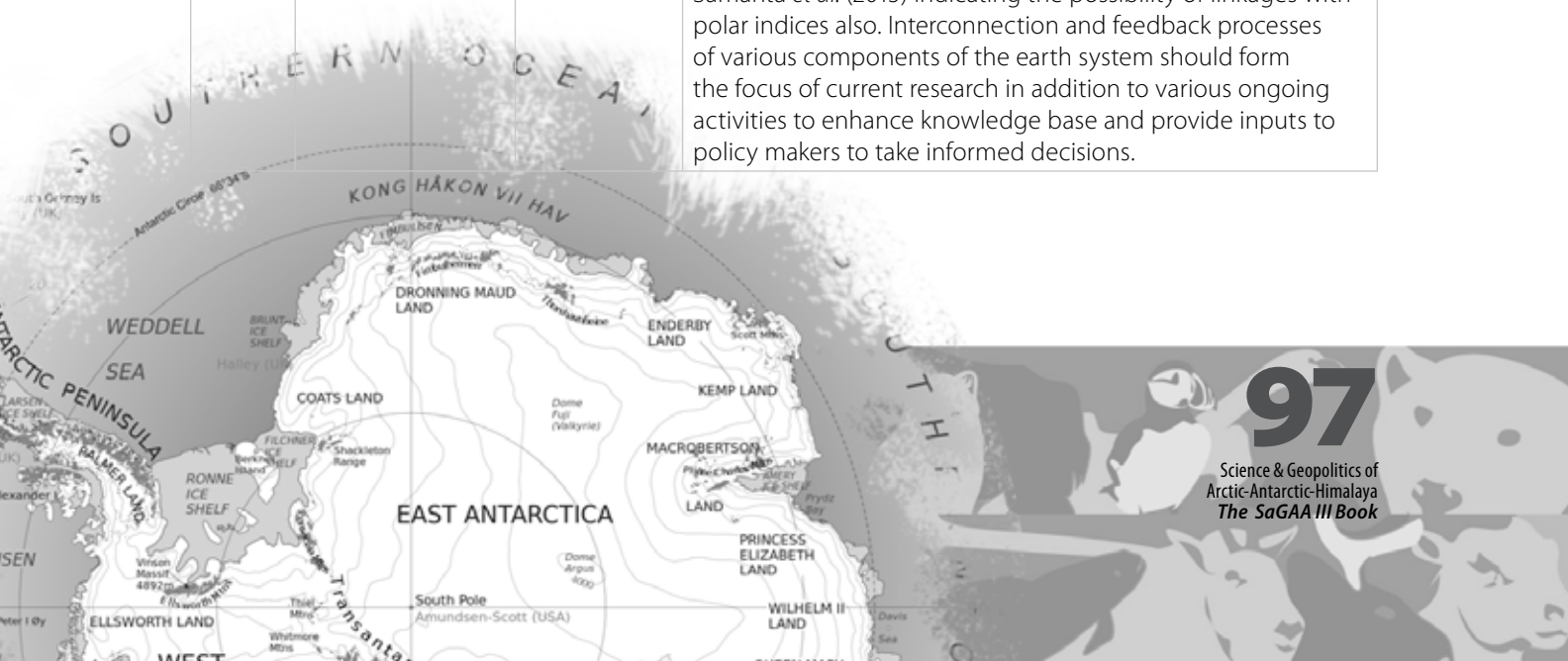
| 1 | Dr. P. C. Pandey<br>Professor<br>Earth, Ocean & Climate Sciences<br>IIT Bhubneshwar | Thoughts on Priority Research in the Context of the Indian Antarctic Programme | Polar science is global in nature and large scale programme in Polar Regions are managed by Scientific Committee on Antarctic Research (SCAR) in addition to individual nationally driven polar programmes. International Council of Scientific Unions (ICSU) has chalked out five grand challenges for Polar Regions which is a welcome move. India should siege this opportunity to become a global player in Polar science. Indian Antarctic programme is now more than three decades old and science of Polar Regions got a big boost with setting up of National Centre for Antarctic and Ocean Research (NCAOR) at Goa with a mandate for polar and southern Ocean Research.<br>The various research portfolios of NCAOR and scientific achievements are quite commendable. However there is a need to focus our effort towards teleconnections that might exist between polar phenomena and Indian Summer Monsoon for which Ministry of Earth Science has launched "Monsoon Mission" a national mission coordinated by Indian Institute of Tropical Meteorology (IITM), Pune. The teleconnection linkages between mid-latitude phenomena of Rossby waves breaking with Active and Break cycle of Indian Summer Monsoon has recently been demonstrated by Samanta *et al.* (2015) indicating the possibility of linkages with polar indices also. Interconnection and feedback processes of various components of the earth system should form the focus of current research in addition to various ongoing activities to enhance knowledge base and provide inputs to policy makers to take informed decisions. |



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| 2 | Dr S. Rajan, Fmr Director, National Centre for Antarctic and Ocean Research, Goa | Abrupt Climate Shifts Over the Past 10,000+ years: An Arctic Antarctic-Asian imbroglio? | The Asian Monsoon climate system and accompanying precipitation play a significant role in large-scale climate variability and water supply over much of the globe. For instance, the Indian agriculture, which accounts for 25 per cent of the GDP and employs 70 per cent of the population, is heavily dependent on the monsoon rains, 80 per cent of which arrives during the summer. A delay of a few days in its arrival can badly affect the economy, as evidenced in the numerous droughts in India in the 1990s. While our predictive capabilities of the monsoon have improved by leaps and bounds over the past few years, perhaps a major missing link in our understanding of the phenomenon of the monsoons is knowledge of the forcing functions behind the short-term monsoon variabilities.<br>To predict the evolution of inter-regional climate linkages on decadal and shorter timescales, it is crucial to understand how they evolved in the past. Paleoclimatic studies using proxies from the marine and terrestrial records present large variations of the monsoon systems during the last glacial period and over the Holocene, which can be linked to abrupt millennial-scale warm-cold episodes over Greenland and the North Atlantic. Cooling episodes in the North Atlantic region have been documented to be generally associated with warming in Antarctica, giving rise to the concept of a "bipolar seesaw". On shorter, inter–annual to decadal time scales, an atmosphere-ocean linkage has also been postulated. For example, speleothem records from China indicate the links between Asian monsoon and solar input and North Atlantic ice-rafting events, during the Holocene. The Chinese records also appear to correlate fairly well with corresponding short-term variations in the Indian summer monsoon. A physical link between the intense monsoon convection over the NW India and the melting of Arctic Sea ice has also been postulated recently. |

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| | | | Studies of the annual sea-ice variability over Antarctica also seem to indicate that deficit monsoon years are preceded by more than normal sea-ice extent and vice versa.Has such a linkage between the polar regions and the Asian monsoon persisted through time and if so, what has (have) been the forcing function (s)? Is there a synchronous or time-lagged inter-hemispheric linkage between the Arctic-Antarctic and the Asian monsoon? In this paper, I focus on these and related questions and highlight the importance of understanding the role of polar and high latitudinal regions on the monsoon phenomena. |

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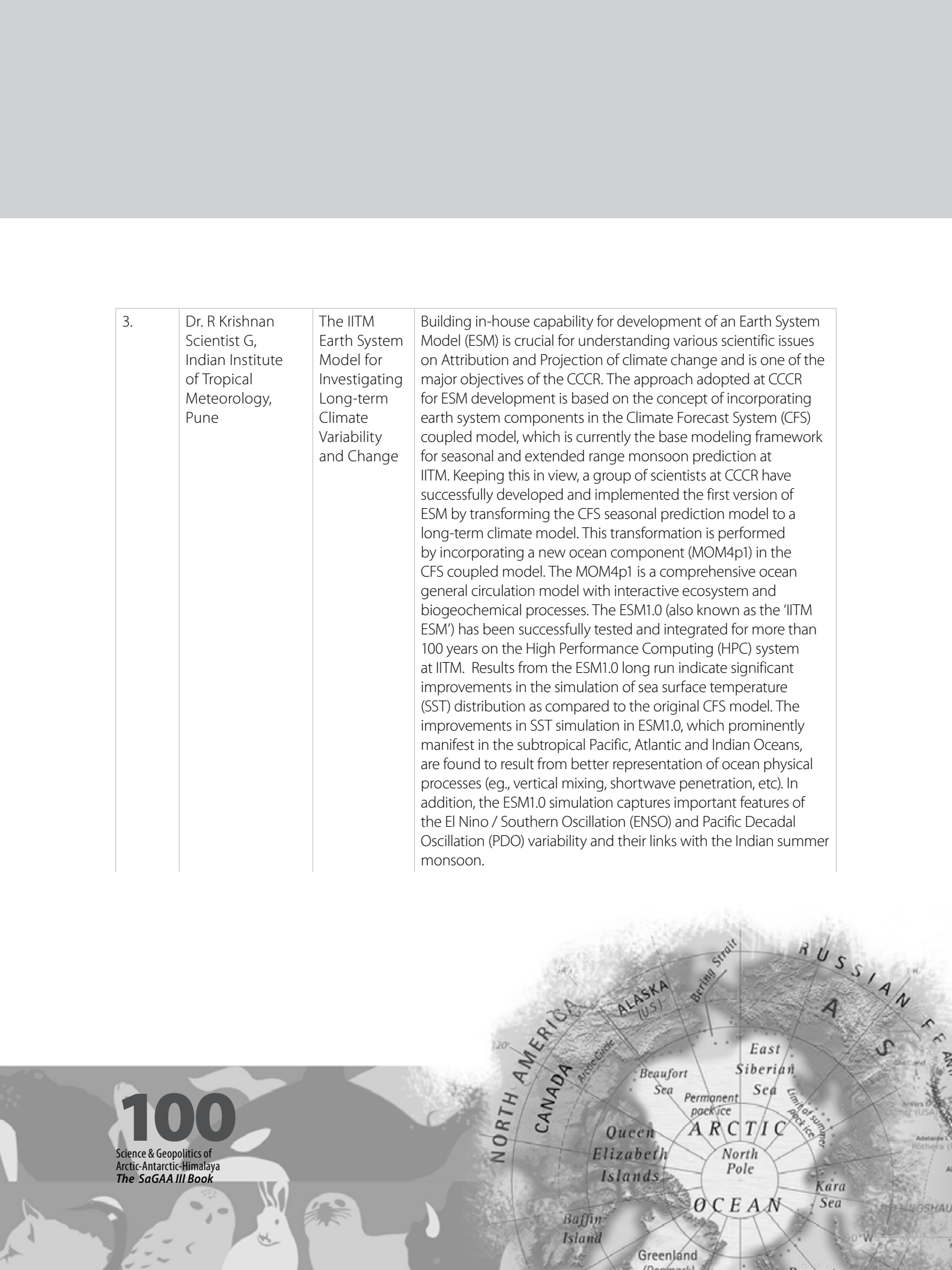
| 3. | Dr. R Krishnan Scientist G, Indian Institute of Tropical Meteorology, Pune | The IITM Earth System Model for Investigating Long-term Climate Variability and Change | Building in-house capability for development of an Earth System Model (ESM) is crucial for understanding various scientific issues on Attribution and Projection of climate change and is one of the major objectives of the CCCR. The approach adopted at CCCR for ESM development is based on the concept of incorporating earth system components in the Climate Forecast System (CFS) coupled model, which is currently the base modeling framework for seasonal and extended range monsoon prediction at IITM. Keeping this in view, a group of scientists at CCCR have successfully developed and implemented the first version of ESM by transforming the CFS seasonal prediction model to a long-term climate model. This transformation is performed by incorporating a new ocean component (MOM4p1) in the CFS coupled model. The MOM4p1 is a comprehensive ocean general circulation model with interactive ecosystem and biogeochemical processes. The ESM1.0 (also known as the 'IITM ESM') has been successfully tested and integrated for more than 100 years on the High Performance Computing (HPC) system at IITM. Results from the ESM1.0 long run indicate significant improvements in the simulation of sea surface temperature (SST) distribution as compared to the original CFS model. The improvements in SST simulation in ESM1.0, which prominently manifest in the subtropical Pacific, Atlantic and Indian Oceans, are found to result from better representation of ocean physical processes (eg., vertical mixing, shortwave penetration, etc). In addition, the ESM1.0 simulation captures important features of the El Nino / Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) variability and their links with the Indian summer monsoon. |



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| | | | Furthermore, the ESM1.0 also shows realistic features of the SST-chlorophyll variations associated with (a) Seasonal cycle of monsoon winds over the Indian Ocean (b) ENSO variability in the Pacific. In a more recent version of the model (ESM2.0), we have made significant improvements in the radiation balance of the climate system. The development of the IITM ESM is an important step towards understanding global and regional climate response to bio-geochemical processes and the mechanisms that control the ocean carbon cycle. This also marks a successful climate modeling development for contributing to the forthcoming IPCC-AR6 simulations, a first from India. |

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| 4. | Dr. Geir Moholdt<br>Norwegian Polar Institute, Tromsø, Norway | Remote Sensing of Glacier Changes at the Three Poles—how much ice are we losing and why? | Glaciers and ice caps respond directly to climate variations, and studying their behaviour can give important insights to the patterns and consequences of recent climate change. Field measurements from the last ~50 years indicate that glacier mass losses are increasing over most of the world, but there are fewer records from the polar regions and they vary greatly from site to site. This presentation will show how satellite measurements can be used to derive reliable estimates of regional glacier changes and contribution to river flow and sea level rise. Satellite altimetry (ICESat and CryoSat-2) is used to determine glacier elevation changes along repeated surface profiles, and satellite gravimetry (GRACE) to estimate large-scale glacier mass changes after removing other gravitational signals. The results show a general glacier imbalance with current climate, characterized by rapid thinning at the lower parts of glaciers where surface melting is strongest. Unlike the Greenland and Antarctic ice sheets, we find no widespread difference between glaciers that terminate on land and those that terminate in the ocean. There are, however, several examples of rapid glacier dynamics or surging with localized iceberg calving rates that are orders of magnitude higher than normal. These isolated events may have a major impact on their local environments, but on a larger scale their associated mass losses are relatively insignificant. For the Arctic as a whole, excluding the Greenland ice sheet, we estimate a total glacier mass loss of ~175 gigatons per year between 2003 and 2009, which represents about 20 per cent of the observed sea level rise over the same period. This amount is almost as high as the typical annual mass loss of the much larger Greenland ice sheet. |

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| | | | Glaciers in High Mountain Asia are thinning as fast as in the Arctic at average, but show a larger regional variability of change due to complex climate patterns. The regional glacier mass loss is estimated to ~30 gigatons per year for the same period, but the sea level contribution remains uncertain due to extensive internal drainage systems and heavy water usage along the major rivers. The contribution of glacier imbalance to river run-off is typically less than 10 per cent, but can be higher locally and during dry periods. Moving south to the Antarctic; mountain glaciers along the Antarctic Peninsula are influenced by significant surface melting and seem to shrink in a similar way as in the Arctic. Along the colder coasts of West and East Antarctica, surface melting is more limited, and most glaciers are in near-balance condition. The exception are some ocean-terminating glaciers and ice streams, mainly in the Amundsen Sea region, that are dynamically thinning in response to reduced buttressing from ice shelves that melt rapidly at their base due to inflow of warm deep water. This important effect causes an overall mass loss from Antarctica and needs to be better understood to predict the future evolution of the ice sheet. |

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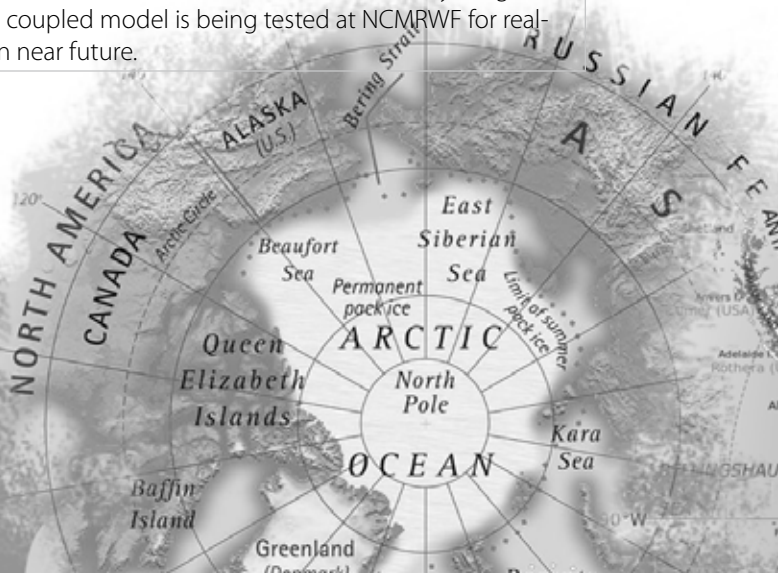
| 5. | Dr. A K Mitra, Scientist-F, NCMRWF, Noida | Short Term Climate Prediction of Polar Sea-Ice with a Coupled Model | Numerical simulation of weather and climate has advanced significantly in last two decades. With advent of satellite data and high performance super computers, now it has become possible 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. However, for south-Asian summer mean monsoon rainfall (variability) simulation and its teleconnection with many other remote atmosphere/oceanic parameters is still a challenge to world modelling 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. At NCMRWF a state-of-art coupled HadGEM3AO model has been used to study the quality of sea-ice simulations for Polar Regions at seasonal time-scale. The global coupled model has UM atmosphere, NEMO ocean and CICE sea-ice components as the respective sub-models for atmosphere, ocean and sea-ice. Using several years of hindcast 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 short-term climate forecast. Currently a higher resolution coupled model is being tested at NCMRWF for real-time use in near future. |



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| 6. | Dr. Ashit Kumar Swain, Geologist, Geological survey of India. | Effects of Global Climate Change on Polar Glaciers | The impacts of climate change in the Polar Regions are reflected in terms of glacier ice and snow melt, permafrost warming, sea ice decrease This paper analysed the effects of global climate change on Polar glaciers. Three glacier sites and their adjoining areas were selected, one each from a region. Dakshin Gangotri glacier being a part of the East Antarctic Ice sheet in the Schirmacher Oasis of central Dronning Maud Land has shown overall recession since more than last 2 decades. An average annual recession of 1.41 m per year is recorded from 1996 till date showing a total recession of 26.77 m with an indication of a cyclic pattern of recession with higher average annual recession recorded nearly every 5 years. The glaciological measurements on the ice shelf and the Polar ice sheet around Schirmacher Oasis in CDML suggests that snow accumulation takes place on the ice shelf region is continuously on annual basis, whereas the Polar ice sheet to the south of Schirmacher Oasis experiences both a net accumulation as well as ablation on annual basis. During 2014-15, the snow ablation from Polar ice sheet is 116.48 kg/m$^2$, while during 2013-14, an amount of 175.625 kg/m$^2$ of snow accumulation were recorded on the same area. Similarly, during 2014-15, snow accumulation on the ice shelf is 315.951 kg/m$^2$, while that during 2013-14 was calculated to be 94.56 kg/m$^2$.VestreBroggerbreen glaciers in the Svalbard Arctic region show a negative mass balance from -0.6 + 0.2m to -0.94 + 0.20m weq during 2011-13 with the upward shifting of ELA. However, the retreat of the glacial front is faster showing a recession of an average of 0.11 m with some points showing a recession of 0.7 m. |

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| | | | These glaciers behave like many other Svalbard glaciers and are in coherence with the patterns of Pacific North American and the Tropical Northern Hemisphere circulation variability due to the good correlation. Climate change in the Arctic is faster as the average air temperature in the region have increased by about 1° C over the last 100 years and decrease of summer sea ice. The lack of reflective ice shield results in faster warming and retreat of glaciers. In contrary, Himalayan glaciers show a fluctuation in the mass balance data, with some glaciers to showing negative mass balance for a longer period. |

**International Conference on**

## Science and Geopolitics of Arctic-Antarctic-Himalaya

September 30th, 2015

**SESSION III - Global Climate Change and the Himalayan Region**

Time: 9:30 am to 11:30 am

**CHAIR: Dr. Ajit Tyagi**

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| 1. | Dr. Anil V Kulkarni, Divecha Center for Climate Change,Centre for Atmospheric & Oceanic Sciences, Indian Institute of Science, Bangalore | Himalayan Cryosphere and Climate Change | The Himalaya has one of the largest concentrations of glaciers and many rivers like Indus, Ganga and Bramhputra originate from the glacier bound regions. However, this source of water may be influenced in future, as Himalayan cryosphere is constantly changing. The contribution of glacier melt in annual stream runoff is almost 72 %in the Upper Indus river basin and 59 % at Bhakra reservoir. The overall contribution is lower in the Ganga and Brahmaputra basins. However, well developed canal network in the Indus and Gaga basins produces significant amount of food production in India and surrounding countries. Therefore changes in runoff pattern of Himalayan Rivers due to melting glaciers can significantly influence the water and food security of the region.<br>Distribution of glaciers is normally influenced by the mass budget and changes in precipitation and temperature can influence this budget. In the Himalaya, numerous investigations have shown increasing trend in temperature. However, trend in precipitation is not clear, possibly due to large variability. This can influence mass budget, however mass estimates are available for relatively few glaciers and for short duration. The data suggest negative mass budget over past decades. The glaciers in Himalayan region are losing mass approximately at the rate of -6.6 ± 1Gt per year. However, the loss in mass for many small glaciers located in low altitude range could be as high as 1000 kg m-2y-1. |

These small glaciers and ice fields are important source of water for many mountain communities. In future, glacial retreat and mass budget will also be influenced local geomorphologic and climate changes. If more glacier lakes are formed due to increase in debris cover and if Black Carbon is transported in accumulation areas of the glaciers, it can significantly influence mass budget and distribution of glaciers. Therefore, continuous monitoring is needed to understand changing dynamics of Himalayan glaciers.In my talk, I will discuss these issues, present state and possible conservation of Himalayan glaciers,if Green House Gas (GHG) emission is shifted from RCP 8.5 to 2.6 pathways.

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| 2. | Dr M. R. Bhutyani Director, DTRL, DRDO | Combatting Climate Change in Himalaya Perspective-Adaptation and Mitigation Strategies | The high mountain areas such as the Alps, the Rockies, and the Himalayas etc. are considered as the 'hotspots' over the surface of the earth where impacts of climate change are likely to be felt significantly. With regard to the Himalayas, their vulnerable ecosystem appears to have reacted to even the slightest possible changes in the temperature and precipitation conditions. The cascading effects of these changes on the vast expanse of water existing in the form of glacier-ice and snow in Himalayas, the forest cover, the health and the socio-economic conditions of the population inhabiting the Indo-Gangetic plains, have been the issues of serious concern.The analyses of the temperature data collected manually at different observatories during the period from 1866 to 2012 show significant rate of warming during the winter season (1.4°C/100 years) than the monsoon temperature (0.6°C/100 years), due to rapid increase in both, the maximum as well as minimum temperatures, with the maximum increasing much more rapidly. Annual rate of warming (1.1°C/100 years) is abnormally higher than the global rate (about 0.7°C/100 years) during this period. N ot all regions of the NW Himalayas have reacted uniformly to the specter of climate change. Studies have confirmed significant spatial and temporal variations in magnitude of winter as well as summer warming in different ranges. While windward side of the Pirpanjal and parts of Greater Himalayan and Karakoram ranges have shown statistically significant winter and summer warming, leeward sides of these ranges have not shown much change. The most remarkable finding of this study is the significant decreasing trend experienced at almost all stations above equilibrium line (>5300 m in altitude) in winter warming as well as winter precipitation in higher reaches of the Karakoram Himalayas in last three decades. |

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| | | | From the precipitation point of view, significant decreasing trends (at 95 per cent confidence level) in the monsoon and overall annual precipitation during the study period are indicated. In contrast, the winter precipitation has shown an increasing but statistically insignificant trend (at 95 per cent confidence level).Rising winter air temperatures have caused decreasing snowfall component and increasing rainfall component in total winter precipitation on the windward side of the Pirpanjal Range, parts of Greater Himalayas and the Karakoram ranges. The analyses also show that although winter precipitation in the NWH has remained trendless in last 140 years, there are significant increasing trends in the extreme snowfall events during winters and rainfall events during summers in Pirpanjal and Shamshawari Ranges in last three decades and insignificant but increasing trends in the Great Himalayan and Karakoram Range. Decrease in winter snowfall amounts and increasing rainfall component at almost all stations has been affected to some extent, by the increase in winter air temperature during this period. The spatial and temporal variations in winter and summer warming and consequent precipitation changes in different ranges/regions of the NW Himalayas are attributed to varying scales of anthropogenic activities and growing urbanization of the areas. Decreasing temperatures in last three decades in the Karakoram Himalayas with altitudes above the equilibrium line (>5300m) are attributed to prevalence of permanent snowcover which appears to have influenced their micro-climatology. These studies have significant bearing on the mass balance of the glaciers in the region and the hydrological behavior of various river systems in the Himalayas. |

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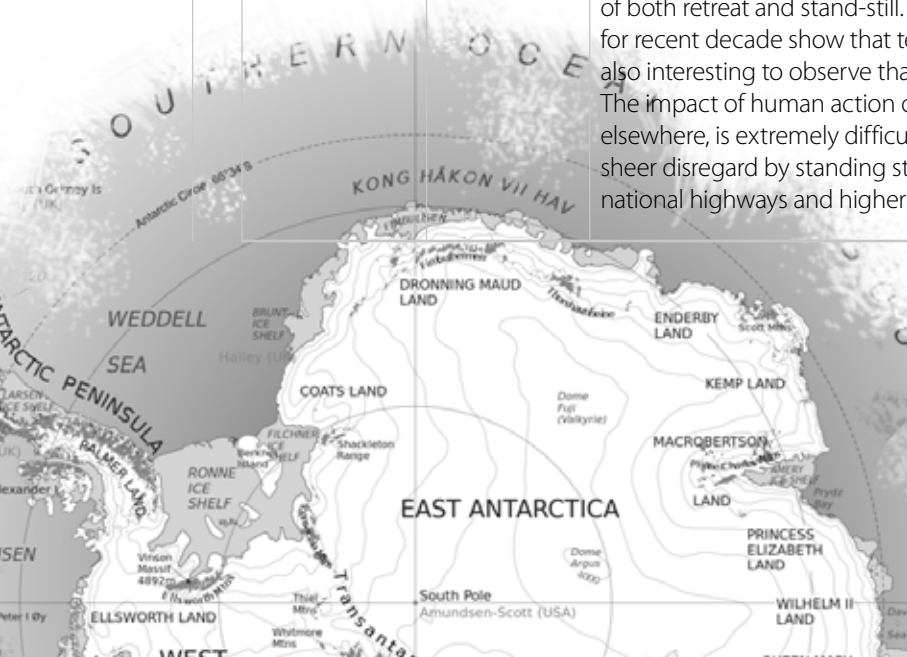
| 3. | Dr. Milap Sharma, CSRD, Jawaharlal Nehru University. | Response of Glaciers to Climate Factors in the Himalayan during last 10000 years | Glaciers are one of the key indicators of Climate Change which respond to miniscule variability in weather parameters, faster than any other medium that can be measured. These have waned and waxed during the Quaternary, leaving behind mesmerizing landscapes. These landscapes, if rightly identified, are a great wealth to determine both the oldest and youngest phases of growth and decay of glaciers. Large amount of these Quaternary deposits and contemporary landforms are potential sites for chronostratigaphic reconstruction of episodes of climate, glaciers and inter-glacial phases, magnitude and frequency of reoccurrence. One of the most intriguing aspects on the climate change is to quantify past episodes and magnitude of environmental conditions, without disturbing the present or future.<br>Reconstructions of climate and magnitude, based on the only visible repository of the past, are engraved as landforms on the terrestrial landscape, and in the deep sea deposits. However, it is the terrestrial records that hold the simplest key to measure and build on the palaeo records of climate and climatic signatures, being easy to access. Therefore, methods of precise mapping of such records and proxy timing of episode have been adopted in our studies in understanding the past magnitude, type of climate and nature of extent in the Central and Western Himalaya. The glacial and non-glacial deposits have been dated using OSL and CRN techniques for constraining precise timings of fluctuations and duration of each episode. Timings and frequencies thus worked out may ultimately help in modeling the future trends and cycles. We addressed the timings only to the Holocene, in order to assess impact of the glacials and deglacials in the Himalaya, using Optically Stimulated Luminescence and Cosmogenic Radionuclide exposure techniques.<br>Glaciers and ice bodies, being sensitive indicators to climate parameters, are in a phase of recession for past one and a half century. Our study on the geomorphic history of the Bhagirathi and Miyar basins, primarily dominated by glacial processes assesses climatic variations on a decadal and millennial scale. The earliest Holocene glaciation in either of the basins is constrained within ~8-6 ka, expanding within 5-6 kilometers of present terminus. |

However, major advance earlier had all tributaries coalesced to cover ~680 & ~500 km2 area of the basins i.e. almost 2.5 times as compared to the contemporary glacier cover. The Holocene advances, termed here as Shivling and Khanjar, are well represented by extensive depositional features such as lateral and terminal moraines, hummocks, drumlins and lacustrine fills, typically constrained within 9-6 ka OSL ages; bracketing it to the early Holocene glacial event elsewhere. This event was followed by a phase of recession between ~6-4 ka, resulting in evolving a new local base-level that created staggering paraglacial fan complexes in the basin. This phase of large waning that started with ~4 ka had caused glaciers to recede to higher altitudes as compared to the contemporary levels. Succeeding advance ~1.5 ka had descended to altitudes of 3785 meters asl. The terminus appears to have remained stand-still for almost a millennial before the recession, that continues even today, started almost 400 years ago. We provide CRN ages and historical records to validate this finding. These landforms and extents were earlier misinterpreted by us as the Little Ice Age expansions. The role of the ISM and MLW has been correlated with the waxing of the Himalayan glaciers for last 10000 years. In the recent decades, however, the rate of retreat of the large glaciers (>25 km) has accelerated in both these basins. But smaller glaciers in the basins show complex trend of both retreat and stand-still. The LST assessed for some of these glaciers for recent decade show that temperatures have dropped fractionally. It is also interesting to observe that some of the glaciers reveal are showing recovery. The impact of human action on increased glacial recession, as proposed elsewhere, is extremely difficult to establish as some of these glaciers show sheer disregard by standing still and tall to increased activity along the national highways and higher Himalaya. In the recent decades, however, the rate of retreat of large glaciers (>25 km) has accelerated in both these basins. But smaller glaciers show complex trend of both retreat and stand-still. The LST assessed for some of these glaciers for recent decade show that temperatures have dropped fractionally. It is also interesting to observe that some of the glaciers are showing recovery. The impact of human action on increased glacial recession, as proposed elsewhere, is extremely difficult to establish as some of these glaciers show sheer disregard by standing still and tall to increased activity along the national highways and higher Himalaya.



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| 4. | Dr. A. P. Dimri Associate Professor Jawaharlal Nehru University, New Delhi | Himalayan Cryosphere and its Role in Defining Indian Weather | Southern rim of the Himalayas controls Indian weather and climate. Many researches pertaining to its manifestation on Indian weather and climate are deliberated. It's step topography lead to influence Indian summer and winter monsoon and thus modulate the associate flow and corresponding precipitation patterns. In the recent decades due to significant global changes in climate there are impeccable signatures seen in extreme events viz., cloudbursts, floods etc., thus changing the hydrological and glaciological balance. This paper debates on the recent and future changes in the precipitation and temperature patterns over the Himalayas which will provide an insight on local to regional to global changes in the present scientific deliberations on climate change. |

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| 5. | Dr. Ajai, Group Director, MWRG Space Application Centre ISRO, Ahmedabad | Monitoring the Status of Snow and Glaciers of the Himalaya. | Snow and glaciers are vital to human beings as they play a critical role in making our river perennial, controlling global and regional climate, and serve as a sensitive indicator of climate change. Snow and glacier ice covers almost 10 per cent of the world's land area and contain about 26 million cubic kilometers of ice. The Himalayas contain one of the largest concentration of ice outside the polar regions and large areas of the Himalayan mountain range are also covered by snow during winter. Therefore this region is also called as the "Third Pole". Snow and glacier ice melt from these frozen reservoirs makes the rivers , originating from the Himalaya, perennial and helped in flourishing the civilizations along the banks of these rivers from time immemorial. Indus, Ganga and Brahmaputra are the three major river systems originating from the Himalayas. Snow precipitation, in addition to feeding the glaciers plays an important role in earth's radiation budget. However, this source of water is not permanent as glacial dimension change with climate. Therefore, mapping and monitoring of these natural frozen water resources is required for planning of water resources and also in understanding the impact of climate variations. However, the in-accessible terrain and the harsh climate prevailing in the Himalayas make the task of data collection extremely difficult. Space-based monitoring of these resources has been found to be an extremely viable alternative. |

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| | | | Inventory, monitoring and assessment of the snow and glaciers of the Himalaya have been done by Space Applications Centre, ISRO using satellite data and the results are discussed here. Detailed inventory of the Himalayan glaciers on 1:50,000 scale has been carried out using Resources at-1 AWiFS data. As per this inventory, the total number of glaciers in the Indus, Ganga and Brahmaputra basins are 32392 and the total glaciated area is 71182 sq km. More than 20 per cent of the glaciers in these three basins are debris covered. Among these three basins, Indus has the highest number of small size glaciers and Ganga has the highest number of large size glaciers.<br>A very large number of glaciers, well distributed across the Himalaya have been monitored for their retreat/advance using IRS satellite data of 2001 and 2011 time frame. This study indicates that about 86.8 per cent of the glaciers have stable front (no change in the snout position and the area of ablation), only 12 per cent of the glaciers exhibited retreat while 0.9 per cent have shown advancement in their snout position. Snow cover has been monitored in the Indus, Ganga and Brahmaputra basins for the period of 13 years using satellite data. The trends in the snow cover have been monitored during the peak accumulation and at the end of the ablation. The study indicates that there has been slight increasing trend in the snow cover for Indus basin whereas there has been no trend in the snow cover for Ganga and Brahmaputra basins during this period. Detailed study on the snow cover pattern have been carried out at sub basin level using AWiFS data. |

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| 6. | Dr. Harendra Negi, Scientist-'E' Snow & Avalanche Study Establishment, DRDO, Chandigarh | Changes in Climate and Snow Cover over Western Himalaya' | The impact of climate change on Indian Himalayas has received a great deal of attention worldwide. The current study focuses the recent trends of weather and climate over north-west (NW) Himalaya and its explanation in the context of climate change and global warming. Significant variations in temperature and snowfall have been observed over different ranges of NW-Himalaya during the period from 1992-2012. Results confirm the decreasing trends in annual and seasonal precipitation thereby confirming the establishment of global climate change and regional warming of the NW- Himalayan region. Strong negative precipitation tendency rate is dominated for different altitude zones of NW-Himalaya by more than 80 per cent of stations. Increase in liquid precipitation and decrease in solid precipitation are seen in all the altitudes and ranges of NW-Himalaya since two decades thereby confirming the setting up of the global warming over the region. The Lower Himalaya (PirPanjal and Shamshawari ranges) shows increasing trends in heavy precipitation events. Analysis of data also shows increasing trend in Diurnal Temperature Range (DTR) during winter over all the ranges of NW-Himalaya thereby confirming regional warming of the NW-Himalaya due to present Climate Change and Global Warming.<br>The snow cover area (SCA) in NW-Himalaya has been monitored using MODIS sensor for the period 2001-14. An overall decreasing trend of mean annual SCA was found in the NW- Himalaya. Decreasing trend of SCA was found prominent during early winter (Oct-Dec) and monsoon period (Jul-Sep). Whereas, an increasing trend during peak winter (Jan-Feb) and spring-summer (Mar-Jun) was observed. The SCA analysis for different parts of NW-Himalaya i.e. Lower Himalaya (LH), Great Himalaya (GH) and Karakoram Himalaya (KH)indicated decreasing trend for LH and GH, and increasing trend for the KH. |

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| | | | Winter snow albedo (Jan-Apr) collected in field locations was also analysed for a period of approximately two decades for different parts of NW-Himalaya. A significant decrease in albedo of GH approximately by 0.2 was observed in two decades (1993-2010). The temperature condition of GH (mean air temperature -1° to 0°C) with significant increasing trend was attributed to decreasing albedo due to thermal metamorphism. The insignificant change was observed in albedo of LH of approx. 0.02 in two decades (1991-2010). The rise in winter mean temperature was found significant but as the snowfall in this Himalayan range occurs in warmer temperature regime (winter mean air temperature > 0°C since beginning of the study period (1991 onward)), which did not help in discerning the effect on change in albedo. The persistent very low temperature of KH (mean air temperature < -10°C) and more frequent occurrences of snowfall events during winter period are attributed to insignificant change in albedo. Thus overall increasing temperatures, decreasing SCA and reduction in snow albedo confirms the climate change impact on Himalayan cryosphere. The study of climate change on Himalayan snow cover assumes geopolitical connotations since a large portion of mankind is dependent on waters from many major perennial rivers emanating from the region. |

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| 7. | Dr. David E. Rheinheimer, Fulbright Nehru Postdoctoral Fellow, Indian Institute of Technology, Roorkee | Himalayan Hydropower: Challenges, Uncertainties, and Threats to Sustainable Development | To meet growing demand for energy, particularly renewable energy, many South Asian countries are increasingly turning toward the Himalaya for its vast hydropower potential, as yet largely untapped. Understanding the challenges to hydropower and its sustainable development across the Himalayan region is critical for long term energy, environmental and social planning. This talk reviews the major challenges and uncertainties that affect hydropower planning and development in the Himalaya, with a particular focus on threats to its sustainable development. Discussion of uncertainties will focus on natural resources (the general hydrologic regime, glaciers, glacial lake outburst floods, monsoon floods, etc.), yet also will include social, economic, and regulatory/political aspects. Climate change, a major driver of uncertainty, will be discussed as needed. Finally, this talk will offer broad implications for regional hydropower development and suggest future research needs. |

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| 8. | Dr. H. C. Nainwal, Professor and Head at Department of Geology, HNB Garhwal University, Srinagar Garhwal, Uttarakhand | Shrinkage of Satopanth and BhagirathKharak Glaciers in the Recent Past | In the context of recent trend of global warming in Himalaya, we have discussed about the recession of the Satopanth (SPG) and Bhagirath-Kharak (BKG) glaciers. Long term records of glacier fluctuations are scarce in Indian part of the Himalaya. In most of the records of changes in length of glaciers 1962 Survey of India (SOI) topographic map is used as a baseline. Thereafter, more or less regular data is available during end of the 20th century and beginning of this century, often because of the availability of good quality satellite images. So, there is a clear need for concerted efforts to collate existing scattered information on recent glacial extents for various glaciers in Indian Himalaya and also to cross-check with other independent measurements whenever they are available. A number of studies have discussed the effect of recent warming on Uttarakhand glaciers. Several studies have been done on Satopanth and BhagirathKharakGlaciers. However, a systematic study incorporating all these data is lacking. Studies also indicate that glaciers with a thick debris cover respond qualitatively differently to a warming climate as compared to debris free glaciers. Thus we studied the shrinkage, i.e. length and thickness loss of these two glaciers In this paper, we have used accounts and maps produced by past explorers in the region, published/unpublished records, satellite images, and our own field data to obtain a coherent picture of the shrinkage of the twin glaciers. We have investigated the accuracy of the 1962 Survey of India Toposheet boundaries for these glaciers and have revised the previously reported retreat rates of the twin glaciers in the recent past. We have compiled and analyzed available records and data on the shrinkage of Satopanth and Bhagirath-Kharak Glaciers, Uttarakhand, India, during the period 1936–2013. We estimate the mean retreat rates of the snouts of Satopanth and BhagirathKharak Glaciers for this period at 9.7±0.8ma$^{-1}$ and 7.0±0.6ma$^{-1}$ respectively. |

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| | | | We have also revised the estimates of the area vacated during the period 1956–2013 to be 0.27±0.05 km$^2$ and 0.17±0.04 km$^2$ for Satopanth and Bhagirath-Kharak Glaciers respectively, corresponding to front-averaged retreat rates of 5.7±0.6ma–1 and 6.0±0.9ma$^{-1}$. The study revealed an average thinning of glacial ice in the lower ablation zone of Satopanth of 9±11m in the past 51 years. We observed that while the fronts of Satopanth and Bhagirath-Kharak Glaciers depicted in the Survey of India topographic map published in 1962 are inconsistent with other available records, the elevation contours are consistent with them. |

**International Conference on**

## Science and Geopolitics of Arctic-Antarctic-Himalaya

September 30th, 2015

**SESSION - IV Living and Non-Living Resource Potential; Marine Protected Area and Geopolitics**

Time: 12:00 noon to 2:00 pm

**CHAIR: Dr. B. Meenakumari CO-CHAIR: Dr. M Sudhakar**

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| 1. | H. E. Mr. Grahame Morton, New Zealand High Commissioner | New Zealand and Marine Protected Areas in Antarctica | For a decade New Zealand has prepared the establishment of marine protected areas in the water of Antarctica, as allowed for under the Convention for the Conservation of Antarctica Marine Living Resources (CCAMLR). Progressing this has been challenging and highlights issues pertinent to access and rational use of the global commons. |

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| 2. | Dr. C. N. Ravi Shankar Director, Central Institute of Fisheries Technology, Cochin | Potential and Prospects of Krill Utilisation | Potential and Prospects of Krill Utilisation Considerable attention is given to Krill due to its nutritional significance as it contains good quality protein, lipid and minerals. Krill resembles other seafood in being rich source of high-quality protein, with the advantage of being low in fat and good source of omega-3 fatty acids and antioxidants. Krill is the single largest under-utilized commercial marine resource as the present level of harvest is far below the regulatory catch quota. There vigorous commercial interests to utilize Krill in development of pharmaceutical and nutraceutical products as well as in aquaculture feeds. Empirical estimate shows that out of the total global krill catch, about 45 per cent is used for sport fishing bait, 43 per cent for aquaculture feed, and 12 per cent for human consumption, primarily in the form of supplements. In Japan, nearly 43 per cent of Antarctic krill is used for direct human consumption. Currently krill is consumed as frozen raw krill, frozen boiled krill and peeled krill meat in many parts of the world, which is expected to diversify further with technological advancements. This paper deals with nutritional significance of krill; concerns associated with utilization of Antarctic Krill and also discuss the possible approaches for utilization of krill resources. |

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| 3. | Dr. V. N. Sanjeevan, Former Director, The Centre for Marine Living Resources and Ecology (CMLRE) Cochin, Kerela | Fishery Resources of Antarctica - Conservation & Management. A Geopolitical Perspective | Exploitation of Antarctic Marine Living Resources for economic gains started way back in 1786, targeting mainly on the Antarctic seals. Within a century the stock size of Antarctic seals declined to the extent that sealing was no more economically viable. Subsequently the focus shifted first to whaling, then to fin-fishing and in the recent years to krill harvesting. With the coming into force of the International Whaling Convention (IWC) in 1948, the Antarctic Treaty System (ATS) in 1961, the Convention on the Conservation of Antarctic Seals (CCAS) in 1978 and the Convention on Conservation of Antarctic Marine Living Resources (CCAMLR) in 1982 various conservation measures were adopted to protect the Antarctic species and their natural ecosystems which to a great extent have ensured the recovery of many of those exterminated stocks, especially the fur seal. Nevertheless, the fact that subtle geopolitical connotations are embedded in the ATS and CCAMLR systems is evident from the deliberate avoidance to fix liabilities on the perpetuators of Antarctic vandalism and the effective steps taken to transfer the onus of recouping Antarctic ecosystems to the international community who are Members to these Conventions. The uncertainties associated with the territorial claims/ rights on several Antarctic/ sub Antarctic islands, diminishing catch quotas of CCAMLR that are far and wide making fishing in Antarctic a non-profitable venture for distant water fishing fleets, failure to effectively stop the on-going Illegal, Unreported and Unregulated (IUU) fishing in Antarctic waters, a loose Catch Documentation Scheme (CDS) and the continuing illegal international trade on Antarctic fish/ fish productsetc., are critically analysed and presented. |

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| 4. | Dr. U. Sreedhar Principal Scientist, Central Institute of Fisheries (CIFT), Cochin | Distribution of Deep Sea Trawl Resources from the Exclusive Economic Zone (EEZ) of India and Prospects of Exploring Untapped Deep Sea Resources from Central, Southern Indian Ocean and Antarctica seas. | Studies were carried on deep-sea fishery resources in the Exclusive Economic Zone of India through scientific cruises with FORV Sagar Sampada. Expo and HSDT trawls were deployed for the present study. An inventory of deep-sea fishery resources from the Indian EEZ is presented based on the specimens collected between the depths from 177 to 1070 mts. A total of 156 species belonging to 88 families are listed in the study. Antarctica seas and the Indian Ocean are unique in several marine resources of great scientific importance. Of the nearly 20,000 kinds of modern fish, no more than about 100 are known from seas south of the Antarctic Convergence. Antarctic fishes are well adapted to the cold waters; the bottom fish are highly endemic, 90 percent of the species being found nowhere else. This supports other biological and geologic evidence that Antarctica has been isolated for a very long time. Southern ocean krill is one of the oceans greatest unexploited fisheries stocks. In this paper the prospects of exploring the untapped resources of Central, Southern Indian Ocean and Antarctica seas are discussed.<br>Key words: deep-sea fisheries, Indian EEZ, checklist, Central Indian Ocean, Southern Indian Ocean, Antarctica seas |

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| 5. | Dr. Debajit Sarma Principal Scientist (Fish & Fisheries Science) ICAR-Directorate of Coldwater Fisheries Research Bhimtal, Nainital, Uttarakhand | Cold Water Fisheries in Himalayan | Rainbow trout (*Oncorhynchus mykiss*) is one of the promising cultivable fish species in coldwater and has considerable scope for its expansion. Being a low volume high value commodity, the trout has good potential for domestic consumptions as well as foreign export. In spite of having excellent positive traits, the development and expansion of trout farming has yet to be done on large scale. Trout culture is intensive type of farming which requires more input resources compared to other species for survival and growth. The feasibility of achieving required production naturally depends on a number of factors including seed, feed, health management and environmental consideration. Potential success in trout production requires better governance and significant improvement in the management practices.<br>Trout farming in India is over a century old and there are several species of trout but rainbow trout is a species of choice. Rainbow trout is relatively easy to and has better growth and maximum cultivable traits. This amazingly versatile species can tolerate a wide range of water temperatures (from 0-27˚C) and there are numerous freshwater sources in which they can be grown: they thrive in water originating from aquifers, springs and streams – as well as in lakes. Trout farming has progressed steadily in last 50 years in India amid different constraints. The total trout production in the country was about 147 tonnes during 2004-05 which has increased about four-fold in last ten years, and has reached up to 700 tonnes during 2014-15.The growth rate of trout production in this duration remained over 31.0 percent per annum. Troutova production has increased from 1.85 million during 2004-05 to 10.17 million during 2013-14. The increase in total production has a significant contribution from the private sector mainly from Himachal Pradesh and Jammu and Kashmir. |

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| | | | Over the years these two north-western Himalayan states remained the main contributor to the rainbow trout production (81.2%), however, Sikkim, a north-eastern state has shown significant increase in trout production in recent years while other states such as Uttarakhand, Arunachal Pradesh and states of southern India contribute a meagre production. This paper elucidates the constraints in the expansion of trout culture as well as identification of potential areas for the introduction of trout farming. The initiatives undertaken by the DCFR is presented here. It is to mention that there is ample scope for further enhancement of trout production in hill states through participatory approach and scientific management. Potential success in trout production requires better governance and significant improvement in the management practices through adequate R & D support. |

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| 6. | Dr. G. A. Ramadass, Principal Scientist, NIOT, Chennai | Technologies for Exploration and Harvesting of Ocean Resources. | The major seas surrounding Indian peninsula are reservoirs of resources such as Gas hydrates, Polymetallic Nodules, hydrothermal sulphides. National institute of Technology(NIOT), Chennai, an autonomous body under MOES is responsible for developing technology for mining of these resources from the deep seabed. A crawler based mining machine with a flexible riser system was developed to prove the nascent mining concept, which was also being pursued across the world in China, Japan and S Korea. The underwater crawler was developed and successfully demonstrated in Sep 2010 at a depth of 512 m. NIOT is presently involved in upgrading the system to 6000 metres depth to mine the polymetallic nodules from the Central Indian Ocean Basin (CIOB). An in-house developed in-situ soil tester, for testing the sea bed soil parameters was successfully tested at a depth of 5462m. A deep ocean, remotely operated submersible – ROSUB 6000 was developed and successfully deployed at CIOB at a depth of 5289m to map the sea bed and collect scientific data and samples of water and soil. ROSUB 6000 was used for the exploration of hydrates at 1000 metres depth in the Bay of Bengal, polymetallic nodules at a depth of 5280 m at Central Indian Ocean Basin and hydrothermal sulphides at Rodriguez Triple Junction in Central Indian Ridge system at a depth of 2813 m.<br>The Polar Remotely Operated Vehicle (PROVe), designed and developed indigenously at NIOT for operation in shallow water depths up to 500 m in open ocean and in polar environmental conditions, was deployed at lakes and Ice Shelf of Antarctica during 34th Indian Scientific Exploration at Antarctica in 2015. NIOT is in the process of identifying the joint partner to develop Human submersible for 6000 m depth rating which can accommodate three human occupants with an endurance of 12 hours for operation in deep ocean basins. |

**International Conference on**
## Science and Geopolitics of Arctic-Antarctic-Himalaya
September 30th, 2015
**SESSION V- Tourism Industry and the Poles**
Time: 2:45pm to 3:45 pm

**CHAIR: Dr. M. Sudhakar**

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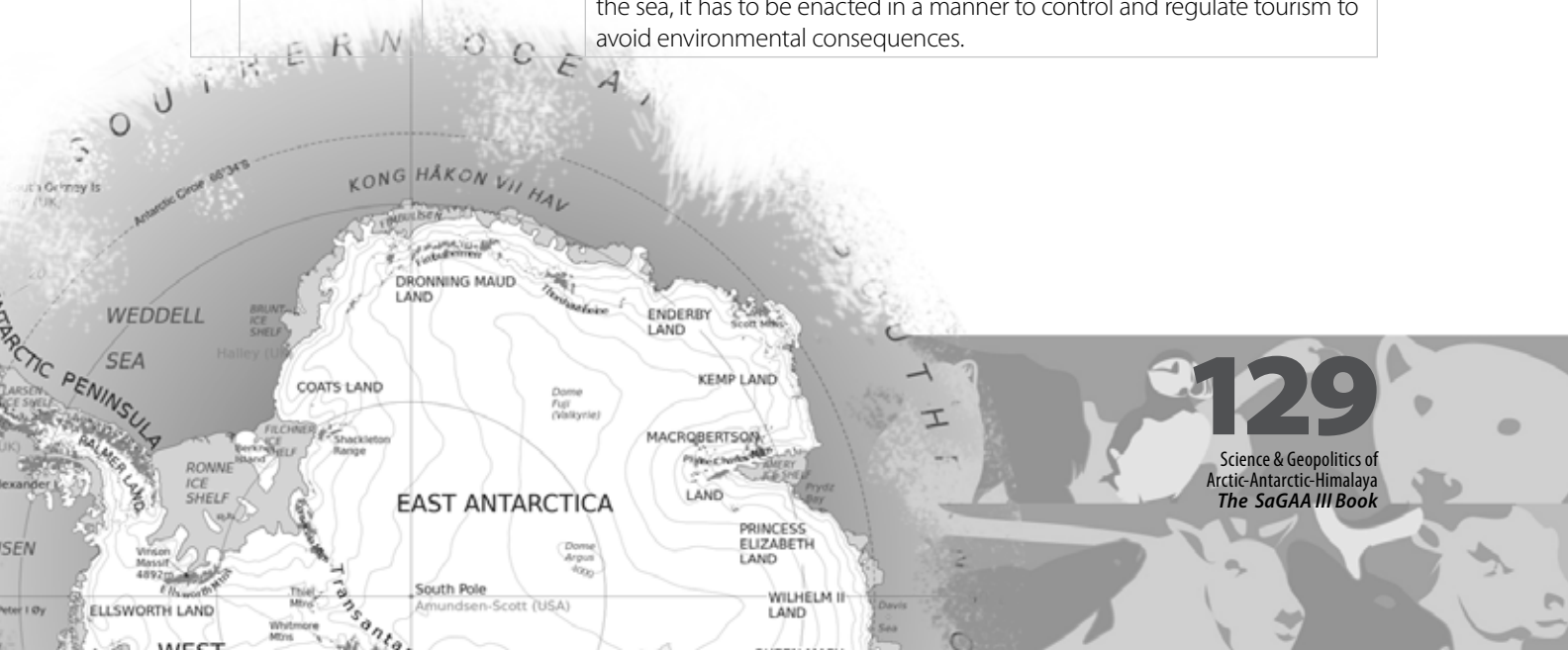
| 1. | Dr. Anoop Tiwari, Scientist D , Department of Polar Environment, NCAOR | Implications of Tourism in Pursuance of Annex vi - An Environmental Perspective | Antarctica, a place for scientific studies and cooperation designated to be used for peaceful purpose. With change of time, since Antarctica Treaty has been adopted, as an adventure non-scientific expedition started, this has been given name "Antarctic Tourism". Realizing the impact of tourism activity first recommendation on tourism adopted in 1966 during ATCM-IV (27) at Santiago. It is estimated that during austral summer total population in Antarctica in nearly 5000 and during winter period it is nearly 1000, however non-scientific activities involving tourism touched figures as high as 30,000-35,000 persons in a year, which concentrate on few places. In recent years proliferation in the tourist activities resulted in environmental effects over sea as well as on mainland. Though International Association of Antarctic Tour Operators (IAATO) put efforts to regulate these kinds of activities in systematic environmentally manner, yet detrimental effect on air, water, land and flora and fauna cannot be averted due to various reasons. Major environmental impact of tourism activity in recent years has been noticed as marine pollution, ship accidents, inadequate waste disposal and interference with flora and fauna.<br>Liability Annex (Annex VI) has been key issue in Antarctica Treaty Consultative Meeting (ATCM) and being adopted by various treaty parties to safeguard the environment. It makes states responsible for environmental damage and cleaning, but within jurisdiction of treaty over the sea, it has to be enacted in a manner to control and regulate tourism to avoid environmental consequences. |



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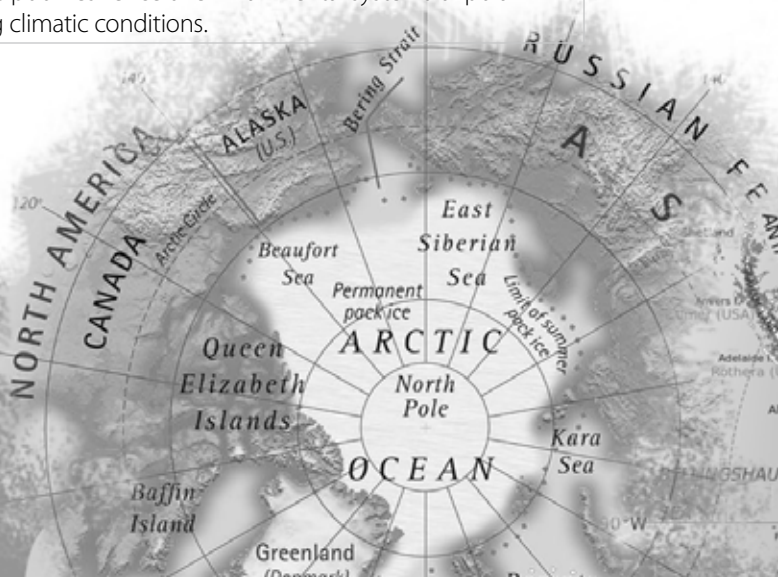
| 2. | Prof. Manju Mohan, Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi | A Concept note: Heat Island Trans-formation and Tourism in the Three Pole | Climate change is the single most important global environmental and development issue facing the world today and has emerged as a major topic in tourism studies. Climate change is anticipated to have profound implications for tourism in the twenty-first century, including consumer holiday choices, the geographic patterns of tourism demand. The polar tourism industry is enticing an increasing clientele with expanding numbers of attractions, recreational activities, international destinations, and visitor accommodations. And now that regularly scheduled excursion travel is provided to both the Arctic and Antarctic, year-round polar tourism has become a reality. There are serious concerns that tourism is promoting environmental degradation in the Polar Regions (especially in the Arctic) by putting extra pressures on land, wildlife, water and other basic necessities. In Antarctica, tourism activities also pose a risk to the marine environment as well as to terrestrial ecosystems as over 80 % of the tourists land one or more times during their journey. Thus, due to growing demand of tourist visits and migration leading to increase in populations of arctic countries has resulted in the warming of Polar Regions. The Arctic is warming twice as fast as other parts of the world. Urban heat index shows that in Alaska (USA) average temperatures have increased 3.7°C between 1970 and 2005. In the opposite hemisphere, the Antarctic Peninsula has also warmed rapidly, five times faster than the global average. Thus, increasing anthropogenic activities in the polar regions increases greater possibilities in future for the emergence of heat islands which are the zones depicting higher temperatures than their surroundings in quite an analogous manner to the urban areas developing heat islands due to changing land-use land cover and anthropogenic heat emissions. IPCC Assessment Report 5 has revealed linkages between climate change and heat islands. Moreover, small changes in climatic condition in the polar region may have greater consequences of adverse nature to its highly sensitive marine life, biodiversity and atmospheric dynamics. Thus comprehensive analysis of likely formation of heat islands in this region shall be given due attention keeping in mind the poor resilience of environmental systems of polar regions to changing climatic conditions. |



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| 3. | Dr. Rasik Ravindra, Pannikar Professor at ESSO, MoES | Should India Encourage Tourism in Antarctica? | The global tourism, in Antarctica, has been growing rapidly due to ever increasing curiosity and splendor of Antarctic region. Antarctica remains awe inspiring pristine land of unparallel beauty that has to be seen and explored to be believed.<br>Ever since the regulations of Environmental Protection measures became an essential component of tourism policy in Antarctica, the tourism industry has grouped itself under an organized non-governmental activity and arranged to adhere to CEP guidelines on landings, visits to sites of historical and intrinsic values and maintaining safe distance from wild life. This has encouraged State sponsorship from some countries in the form of issuing permits for visits to Antarctica which in turn has had visible contribution in the development of travel market and ancillary industries linked to shipping, port development etc in the gateway centres that act as departure points for Antarctica. The tourist inflow to Antarctica is essentially concentrated to Antarctic Peninsula, South Shetland Islands and sub-Antarctic islands which are accessible from Argentina's port of Ushuaia or Punta Arenas of Chile by air. Cape Town, Christ Church and Hobart are other gate ways to Antarctica. For tourists from northern hemisphere, especially Asia, Antarctic travel is expensive since they have to undertake a costly journey to South America to avail a cruise to Antarctica.<br>The data provided by International Association of Antarctica Tour Operators (IAATO) to ATCM show that the 36,271 tourists that visited Antarctica during 2014-15, belonged to nearly one hundred nationalities. Most of these visitors were from eight countries namely USA, UK, Australia, China, Canada, France, Germany, Switzerland and others with little contribution from India and Middle East countries. Lack of infrastructure facilities and governmental support may be one reason for this poor response. |

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| | | | A suggestion to the affect of "Regulated Tourism" in Antarctica was mooted during the meeting of Antarctic Treaty Consultative Meeting at New Delhi in 2007, which recognized that tourism has got both educational and commercial advantage to mankind and therefore needs to promoted , provided it is regulated so as to ensure safety of environment and associated eco system. It is opined that India should take a lead and fill up the geographical gap existing in this arena. There exists a lot of potential for India to support and encourage regulated tourism to Antarctica, especially as it has two operational research stations and one abandoned historical site of its first permanent station<br>Goa, which is an all time favorite destination for tourists and is the seat of a leading Indian R & D Institute for Antarctic research, can be developed as an Asian gate way to Antarctica to serve as a departure point for cruises. It has high potential for attracting local and foreign travelers to icy continent because of existing port and logistic facilities and scientific and technical knowhow required for such an activity. This would not only come as a boon to tourism industry in India but will also make travel financially viable for interested people as there will no longer be a need to spend on costly travel to South American gate ways. As the Indian activities for Antarctica (expeditions) are managed from Goa, the Indian tourism industry can gain immensely from the expertise available with India due to its presence in Antarctica for more than three decades. The industry can get the local experts (guides) in the fields of science and logistics who also have geographical and historical knowledge of sites, wild life and biological diversity, since it is mandatory that all landings of tourists in Antarctica are made under supervision of experts. Considering that there is a substantial educational and commercial value associated with tourism in Antarctica, India will gain by encouraging regulated tourism in Antarctica. |

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| 4. | Ms. Tanu Jindal, Director, Amity Institute of Environmental Toxicology, Safety and Management, Amity Centre for Antarctic Research and Studies | Anthro-pogenic activities and Environmen-tal con-tamination in Antarctic regions | Snow, water and soil contamination in Antarctica is caused by the anthropogenic activities such as energy generators, flights, ships, vehicles etc. due to establishment of various research stations. It is necessary to monitor persistent contaminants i.e. PCBs, PAHs, dioxins, pesticides and heavy metals as well as microbial contamination by non-native species to check further contamination. Selected international studies show the high concentrations of 5beta(H)-cholestan-3beta-ol (coprostanol) an indicative of sewage pollution found in sediments within 200 m of the sewage outfall of Rothera Research Station (Hughes and Thompson, 2004). Sterol and coprostanol ranging from 0.9 to 19.6 µg.g-1 and <0.01 and 14.0 µg.g-1dry weight have been reported within 400 m of sewage out fall near Ferraz station, Admiralty Bay, Antarctica.(Martin et al 2005). Organisms such as krill, fish, birds, dolphins and seals have also been reported to be contaminated by DDTs and PCBs (Chiuchiolo et al 2004) . The SCAR action group on environmental contamination has reported Pb, Cd, Zn, Cu, and other metals which were significantly found in LTER region in Antarctic Peninsula( Bargagli et al , 2000). Among national studies,Acidic pH ranged between 5.8-6.5 for glacial lakes and 6.3 -6.5 for samples from Priyadarshini lake was studied by Tiwari *et al* (2004). Kureishy *et al* (1993) emphasized the affects by industrial and agricultural activities of other continents on Antarctic. Environmental studies have been undertaken in the area around Maitri Station to establish base line parameters on several environmental issues by NEERI, NCAOR and SRIIR etc., but the data is scarce in newly established Bharti Station. Amity Institute of Environmental Toxicology, Safety and Management has joined research initiatives in environmental monitoring of POPs with National centre for Antarctic and ocean research (NCAOR) in Bharti and Maitri stations in Antarctica. |

National Institute of Ocean Technology (NIOT) is the technical arm of the Ministry of Earth Sciences, Government of India, carrying out technological development activities for harnessing the ocean resources. NIOT has a mandate to develop and demonstrate technologies for utilizing the ocean resources for security towards energy, food, water, minerals and coastal protection. With multi-disciplinary manpower and a 'laboratory to industry' approach, several projects are being executed by the NIOT while also focusing on capacity building and infrastructure development in the area of ocean technology.

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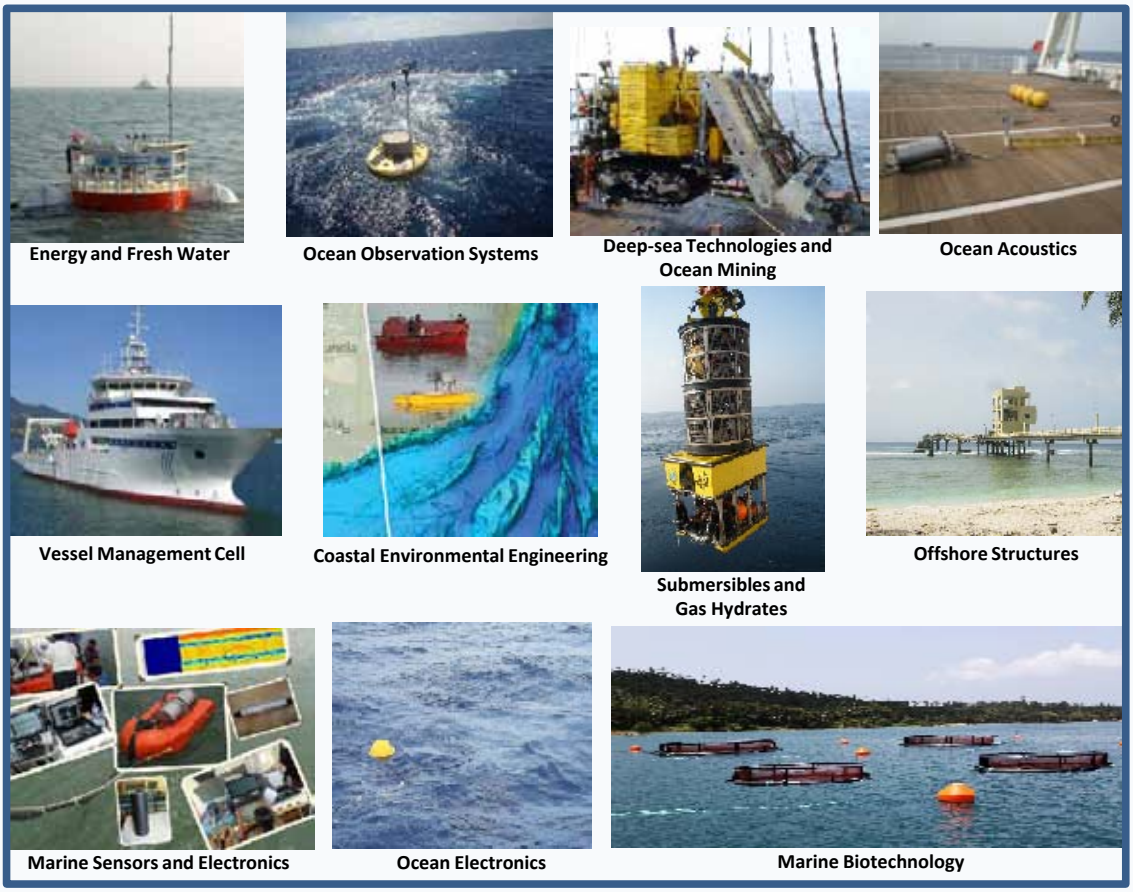
Clean and green technologies for energy and water
Met ocean data and tsunami warning system
Shoreline management and coastal protection
Pipelines/risers/mooring designs
Underwater electronics, acoustics and sensors
Societal programmes for marine bio resources and biodiesel
Research vessels, one with dynamic positioning

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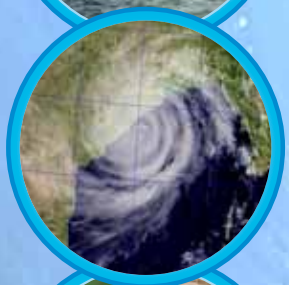
## Key Activities

Early Warnings for Tsunamis and Storm Surges

Potential Fishing Zone Advisories for Fishermen



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