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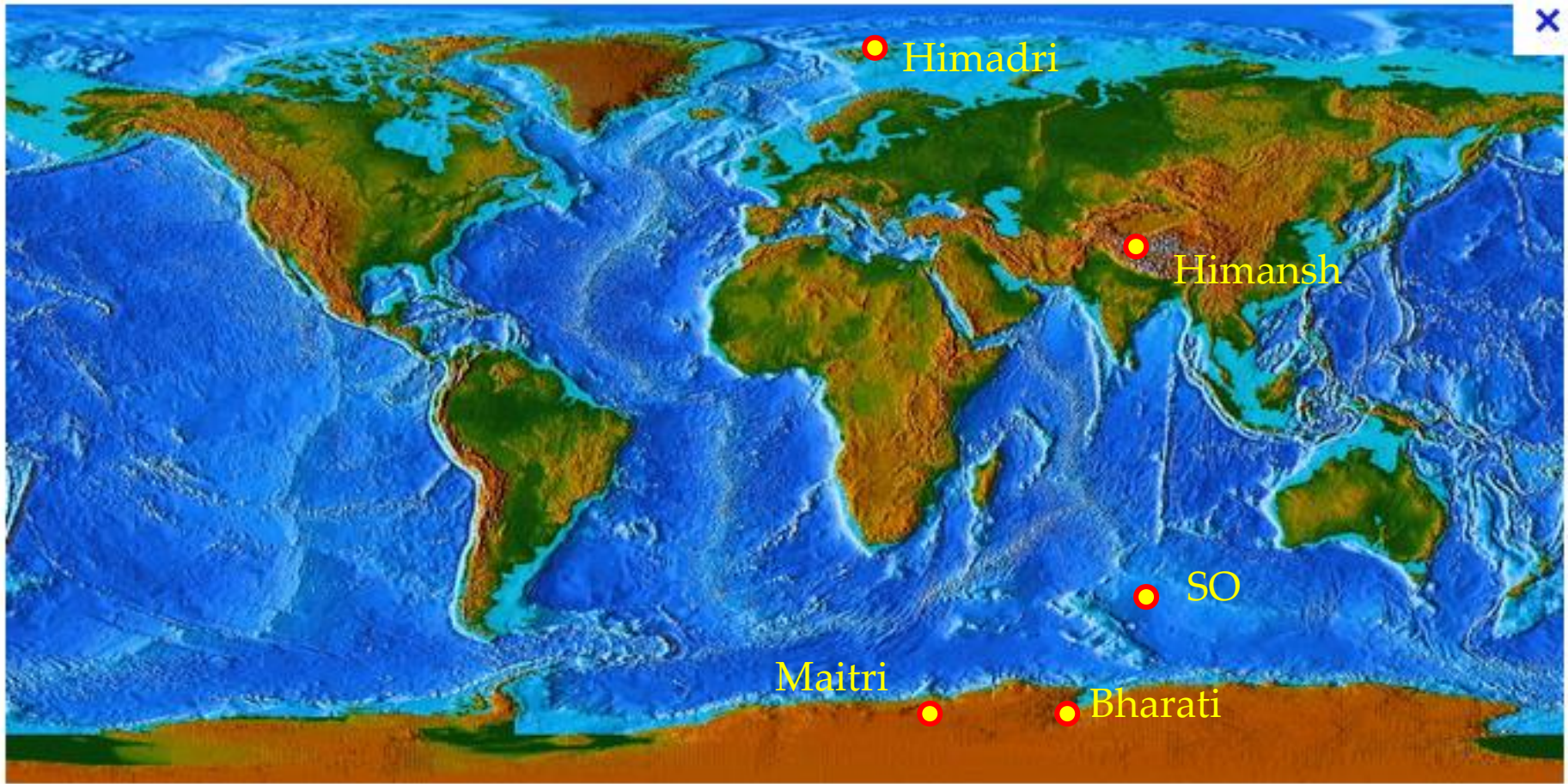


- **ESSO-NCAOR : Indian Gateway to Polar Regions** •

ESSO-NCAOR and its mission

- **Plan, promote, co-ordinate and execute** scientific research in polar regions and surrounding waters.
 - Support to the participating organizations
 - Scientific endeavour in cold climate
 - Platform for scientists in Antarctica, Arctic and Himalaya
 - Ocean platform - Ocean Research Vessel
- **Survey and Exploration of Non-Living resources**

NCAOR IS A TRANS-HEMISPHERIC ORGANISATION



- Vertical – Upper atmosphere to Sediment/Ice Core
- Spatial: North to South
- Temporal - hours to Millions of years
- All branch of Science – phys,chem,biology & maths
- Solid Earth/Ice, Liquid Ocean and gaseous atmosphere

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Why India is in Antarctica

India's interest in Antarctica is motivated by the following:

- Antarctica – A Global Barometer: Earth system processes are significantly influenced by the poles.
- Climate Change: Ice sheets losing mass over past 20 years, 20 cm sea level rise in the past 100 years
- Antarctica as a unparalleled laboratory
- Unique Life forms in Extreme Environments
- Home to amazing biodiversity and life adaptations
- Linkages between India and Antarctica
- Connectivity/Proximity to the India Ocean
- Geopolitical Reasons

Big Questions

*Why Antarctica/Arctic/Himalaya (Three Poles) lose Ice mass?
How will this change in the future?
What are the impacts of Sea level rise and weather patterns?*

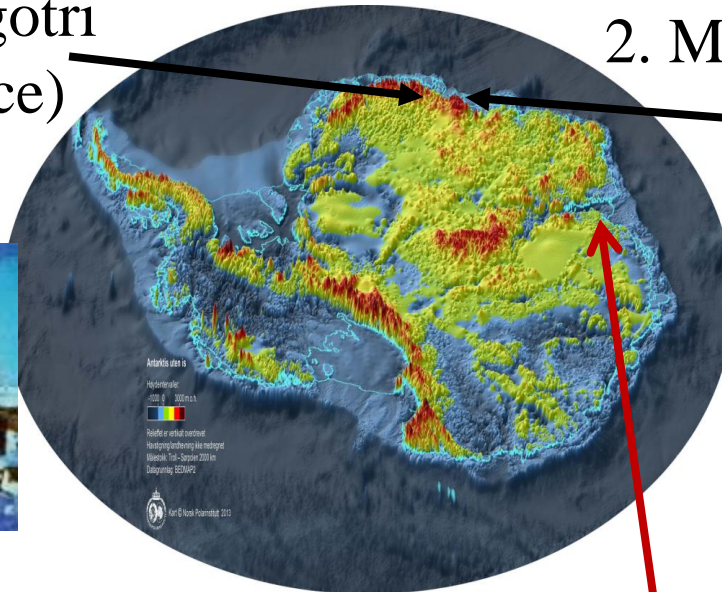


- A unique Land mass – 98 % covered by ice and 2 % is ice-free.
- Once contiguous with India as a part of Gondwanaland
- Important area to understand global and environmental change
 - Pristine area
 - No major anthropogenic activities
 - A number of countries (31) have their research stations in different parts of Antarctica

Indian Research Stations in Antarctica

1. Dakshin Gangotri
(buried under ice)

2. Maitri (Schirmacher Oasis)



1983

1

1988

2012

3. Bharati

(Larsemann Hills)

Country	No. of Research Stations
China	05
USA	05
Russia	09

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Antarctica: What we do?

- **Ice and sediment core** based climate reconstruction
- To establish the relation between poles and tropics and to **explore teleconnection** between them at centennial to millennial timescales.
- To monitor the **long-term effect of climate change and anthropogenic activity on the lake ecosystem** of the Polar regions
- Generation of DEM of glaciers using satellite data & **quantify interannual & seasonal trends** in surface elevation changes
- Mapping **Upper ocean heat content** during Summer (Polar Ocean)
- Assessment of **microbial diversity** (bacteria and yeast) of glacial cryoconites, ice cores & permafrost and their identification up to the species level.
- Antarctic **Environment** monitoring
- Magnetic and Electric flux measurements to study solar storms

P1: Antarctica

Scientific Projects @ NCAOR

- Dynamics of Ice rise on the shelves & reconstruction of past climate from Ice core
- Polar Biodiversity and Evolution
- Long term monitoring and Modelling of Precipitation
- Satellite-based Digital Elevation Model for monitoring cryospheric ice/ glacier topography
- Hydrodynamics of the Indian Ocean sector of choke point between Africa and Antarctica and coastal Antarctica
- Past Climate and Oceanic variability
- Environmental Impact Assessment of Indian Antarctic Stations
- National Polar Data Center (NPDC)

NCAOR offers opportunity to Indian scientists for working in Antarctica...

Sr.No	Discipline
1.	Climate Processes and Linkages to Change
2.	Crustal evolution
3.	Environmental Processes and Conservation
4.	Ecosystem of Terrestrial and Nearshore
5.	Observational Research
6.	Polar Technology
7.	Capacity building

Agenda for the Future – Polar Science

Explore the Polar Regions by monitoring and predicting the variability of the fragile global cryosphere system.

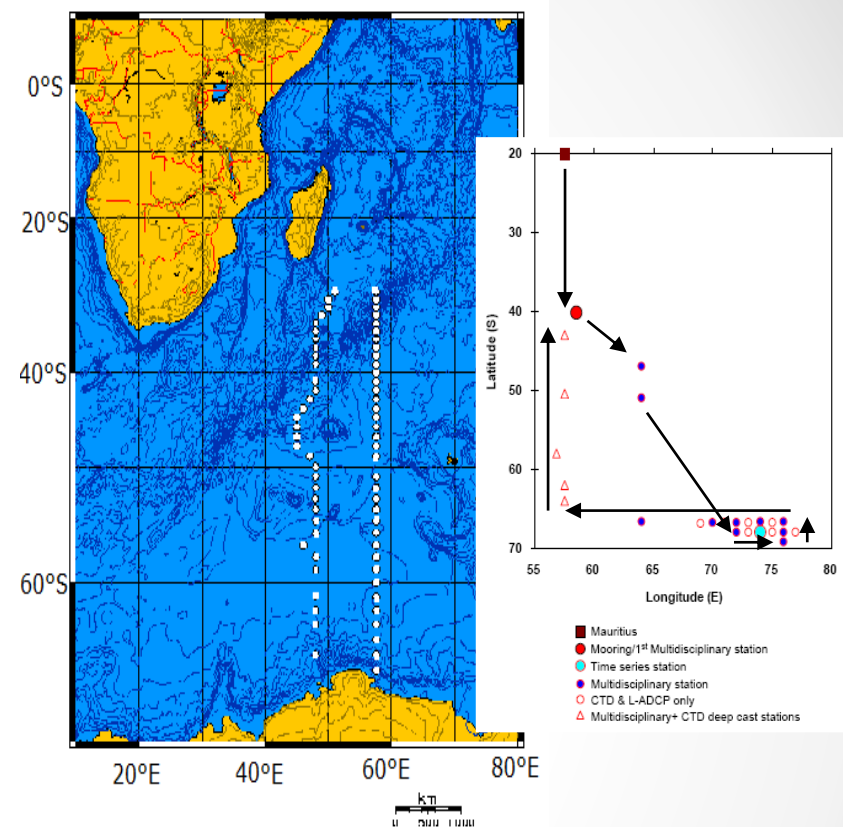
- Conduct cutting-edge research to better understand
 - *How the Antarctic Ice sheet has changed in the past and what does tell about future*
 - *India-Antarctica connection & to understand how, where and why Ice sheet lose mass*
 - *Reconstruct past history from sediment and Ice core*
 - *Explore and determine the teleconnection between the polar regions and the tropics for improving weather and climate predictions*
 - *Ecosystem response in a changing climatic regime*
 - *Role of microbes in modulating carbon cycling both in snow and water column*
 - *Sea-Ice Variability*
 - *Space weather and its linkages to Solar storms*

Open ended research to Focused research

Southern Ocean

Main Focus

- Role and response of Southern Ocean to the regional and global climate variability (mainly observational study)
- Conduct cruise every year during southern summer and observe various Atmospheric and Ocean variables along the track (mainly Mauritius to Antarctica)
- New insights in terms of publications



Southern Ocean - Future plan

Major questions to be addressed

- How does the atmospheric and oceanic dynamics in the Polar regions including Southern Ocean affect the tropical weather and climate ?
- How the physical processes and atmospheric aerosols and other trace gases are modulated by Biological pump / Biogeochemistry & Vice versa ? (North Indian Ocean productivity and Tropical weather/climate) (ISO, Seasonal, inter-annual, decadal,...)

Gap Areas

- Observations (spatial and temporal)
- Modeling (ocean, atmosphere, sea-ice, ecosystem)

Implementation

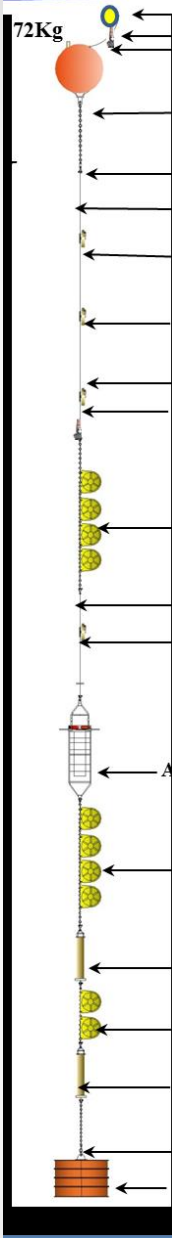
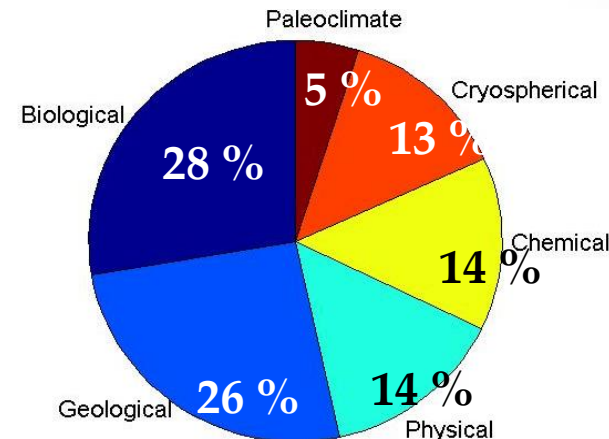
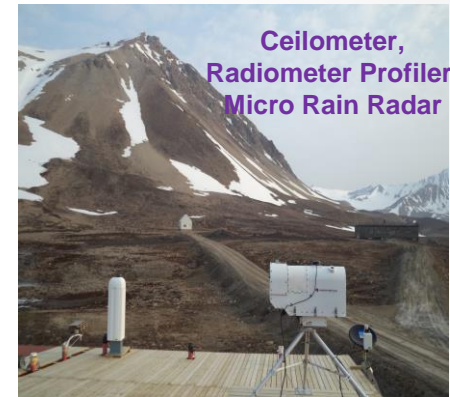
- In-situ Observations (moorings, gliders, Argo, microstructure profilers, Ships) including coastal Antarctica heat and salt content monitoring
- Satellite observations
- Modeling (Analysis from existing coupled / ocean-sea ice models, Implement southern ocean model, coupled with atmosphere and Ecosystem model)
- National/International collaborations

Why India in the Arctic

- **Tele-connection** between the Arctic/North Atlantic and the Indian Summer monsoon on Intra-seasonal, Inter-annual and decadal time scales
- Short term **Atmospheric Bridge** and long term **Ocean tunnel** between Arctic and Asian Continent
- Reveal past History from **Tripolar region** (Arctic, Antarctic and Himalaya) from Ice /Sediment Core
- Tele-connection between Tropical Indian Ocean and the Arctic for better understanding monsoon dynamics (Signals of Climate change is stronger in the Arctic [melting Ice] and in the Indian Ocean [Warmest trend])

P2: Arctic

- **Marine Science:** Dynamics and functioning of Arctic fjords (Physics and Biology) (Kongsfjorden)
- **Cryospheric studies:** Snow and ice chemistry, glaciology
- **Atmospheric Science** precipitation measurements over the Arctic and study of aerosols
- **Mass Balance studies** (GPS / DGPS Surveys)
- **>200 days / 50 Scientists/5 Batches**



Goals for near future

- **Improve our understanding**

- Teleconnection between Polar regions and Tropics
- Air-sea-Ice exchanges
- Mechanisms of cloud formation and precipitation
- Glacier melting: Remote Vs. Local forcing & Quantification of Atmosphere and Ocean contribution

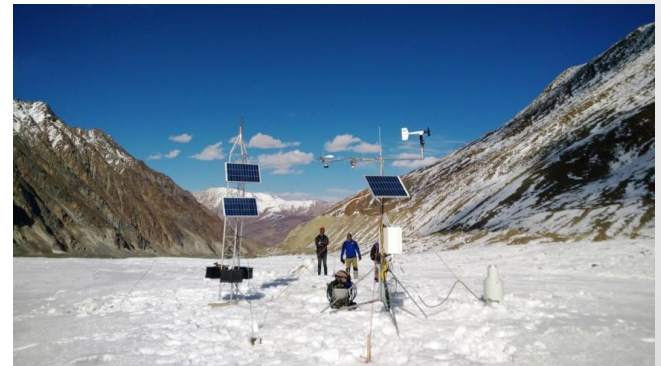
- **Observations and Modeling**

- Detect the climate anomalies (Mooring, AUV, climate reference stations, Green house and aerosols)
- Proxy data to investigate past variability of polar climate and Tropics (Monsoon)
- Mass balance / Discharges from Glaciers
- Modeling: Process studies / Sensitivity studies and prediction of sea-ice changes (different time scales)
- Facilitate Universities / Institutes to do research in the Arctic

P3-Himalaya

Objective: To study the dynamics and the rate of change of benchmark glaciers in Himalaya to understand its impact on hydrology and climate.

- Established a new Field Station “Himansh” a high altitude cryosphere research station in Sutri Dhaka (Lahaul-Spiti)
- Installed various instrumental facilities (AWS, water level recorder, TLS, thermal data logger, Stakes, etc) for the energy balance and hydrological monitoring
- GPR survey to monitor the thickness of Ice/Glacier. Also, bathymetric survey of Glacier lakes in Chandra basin
- Study focus on the mass, energy, and hydrological balance to differentiate climatic and non-climatic factors influencing the Himalayan glaciers.
- Monitoring Glaciers velocity & thickness and Lake expansion from remote sensing data



Himalaya – Near Future

Major Questions to be addressed

- Why there are differential glacier responses across Himalaya and what are the driving forces?
- What are the dynamics and control of snow cover changes in Himalaya?
- What is the response of Himalayan cryosphere to climate change/variability and associated hydrological impacts?

Work Plan (NCAOR, JNU, IISER, IIT,)

- Integrated mass balance studies on benchmark glaciers from sub-basins of Western, Central and Eastern Himalaya using glaciological, geodetic, geospatial and modelling approaches;
- Glacio-hydrological budgeting and modelling of selected basins
- Snow cover and volume estimation in major basins of Himalaya

Polar Science: Antarctica –SCAR

- SCAR Horizon Questions?

- *Define the global reach of the Antarctic atmosphere and Southern Ocean*
 - *Teleconnection between High and Low latitudes including Monsoon systems*
 - *Solar wind distribution in space and time*
- *Understand how, where and why ice sheets lose mass*
 - *How the Antarctic Ice sheet has changed in the past and what does tell about future*
- *Reveal Antarctica's history*
 - *India-Antarctica connection & to understand how, where and why Ice sheet loss mass*
 - *Reconstruct pas history from sediment and Ice core*
- *Learn how Antarctic life evolved and survived*
 - *Biodiversity and Molecular Biology*
- *Observe space and the Universe*
- *Recognize and mitigate human influences*

Task ahead (Polar Science)

- Southern Ocean Sea-Ice modeling / Arctic ocean – regional model
- Reconstruct high resolution past climate from Antarctic sediment & Ice core to understand the link between Indian Monsoon and Antarctic climate
- Polar Bio-diversity
- Understanding the variability of physical processes of the ocean and sea ice shelf in the coastal regions of Antarctica (Glacier melt Vs Climate change)
- Science Projects with Universities / Institutes: (i) Teleconnection, (ii) reveal past history, (iii) Himalayan Cryosphere (iv) Space weather

Strengthening National and International Collaboration

Task ahead (Operational/Facilities)

- Construction of New Maitri station
- Acquisition and commissioning of Ice class Polar Research vessel
- Dedicated atmospheric / Astrophysics Lab with Ground station for EOS.
- Real-time monitoring of Atmospheric, GH gases and Aerosol measurements (Antarctica, Arctic, Himalaya and NCAOR).
- Climate Reference Stations and Coastal mooring
- Satellite Observations of Cryosphere and Southern Ocean
- Arctic observations (Alaska / Greenland) / Southern Ocean mooring
- Polar Biology Lab and National Polar Data Center

Strengthening National and International Collaboration

Thank You for your attention

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