Towards Building Climate Services

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Climate System, Processes and Interactions

- A single, interlinked and self-regulating system.
- The energy and material transport within and across components occur on a local to global scale with varying time scales.
- These interactions are significant and complex.
How and Why the global environment is changing?
Observed Changes in the Climate System

The warming of the climate system is unprecedented. The atmosphere and ocean has warmed, glaciers are retreating and sea level has risen. Increasing anthropogenic emission of GHGs after industrial revolution are most likely cause.
Impacts of Climate Change

- Widespread changes in extreme temp. have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent.

- The frequency of heavy precipitation events has increased over most land areas consistent with warming and observed increase of atmospheric water vapor.

- The ratio of severe storms to TCs is increasing, suggesting when a storm forms, there is a high probability that it will intensify into a severe storm.

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Variability in Precipitation or Impact of Climate Change?

Indian Monsoon is a stable system, however it does show a multi-decadal trend. A significant multi-decadal oscillation is shown by the red line. Now, we are in the low phase.

Variability in Precipitation or Impact of Climate Change?

ALL INDIA SOUTHWEST MONSOON RAINFALL

1965 CHANGE POINT SIGNIFICANT
Impacts on Ocean Biology

Regime Shift in Oil Sardine and Indian Mackerel

A radical shift in the composition of winter-spring phytoplankton blooms from diatom to green dinoflagellate,

Off Trivandrum showing Dead Jellyfish washed ashore

Alarming jellyfish explosion
What we need to do?
Towards Sustainability

<table>
<thead>
<tr>
<th>Sustainable Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth System Knowledge</td>
</tr>
<tr>
<td>Social System - Governance</td>
</tr>
<tr>
<td>Human System - Consciousness</td>
</tr>
</tbody>
</table>
Earth System Knowledge

• Critical knowledge to address challenges posed by global environmental change (due to natural and human activities).

- Observing, understanding, modeling and projecting environmental and societal changes

- Interactions between social and environmental changes at various scales
Climate Observing System

- The dynamics and interactions of the Earth system affect at various spatial and temporal scales to humanity.
- Framework or synergy in earth observation required to address how and why environment is changing. Development of global and regional climate observing system
  - Climate Reference stations
  - Constellation of satellites to monitor climate variables
  - Coordination of orbits – temporal resolution
  - Calibration of instruments/sensors, development of new sensors, e.g. wind profile
  - Standardization of data products of earth system variables. Calibration of past data.
  - Continuity of observations for long-term monitoring
Quantification of Physical Processes (Tropical regions)

- Long-term trend of aerosol loading
- Interaction of aerosols and clouds and rainfall process.
- Ocean Mixing and Monsoon
- Monitoring of biogeochemical processes and modeling.
- Marine ecosystem dynamics and carbon cycling
- Tele-connections with polar regions
Climate Change Projections

Projected Temperature Change

An increase of 1.6$^\circ$ - 2.0$^\circ$ C over India by 2050
Summer monsoon (JJAS) Precipitation

Revised SAS cumulus convection improves simulation of mean monsoon precipitation over India in ESMv2 relative to ESMv1.

Annual cycle of precipitation over India.
Future Change in Precipitation Rate

- Models suggest a decrease in light rain (10 mm) and increase in heavy (> 40 mm) precipitation.
Paleo-climatic Perspective

- Climatically sensitive indicators used to infer past changes in climate on time scales ranging from decades to millions of years.
- Paleo-climatic information supports that warmth of the last half century (0.6-1°C per century), is unusual in least the previous 1300 years.
- About 125,000 years ago, reductions in polar ice volume led to 4-6 m of sea level rise. Ice core data indicate that temp. at that time were 3-5°C higher than present.
- Sediment cores from 1.1 km deep cores in the Arabian Sea allowed to reconstruct patterns and rates of erosion, how and when continental environmental conditions changes, etc.
- High-resolution continuous records on millennial scale generated from this cores indicate the ~ 8 Ma climatic transition and beginning of monsoon in India.
A RAMP DEM is improved by synergistic use of ground-based GPS measurements, Laser altimetry (ICESat). The accuracy of height measurements is 0.27 m. The multi-date models are used to compute volume changes for mass balance studies.
Climate Services

Climate Service for Decision Makers
Water, Agriculture, Fisheries, Health, Forestry, Transport, Tourism, Energy, Disaster Risk Management

Climate Information Service, Climate Products - Monthly Mean Temp, Precipitation anomaly, standardized precipitation index for each station, Daily Max. and Min., etc. Significant weather and climate events,

Data Analysis & Coupled Regional Modeling

Climate Observations - Satellite & In situ, Paleoclimatic Studies
Climate Products

Monthly Mean Temp

Monthly Total precipitation Monthly – Daily Min Temp. Anomaly

Standardised Precipitation Index - 2014


Significant Event
Multi-Hazard Vulnerability
Marine Biodiversity and Ecosystem Modeling

Census of Marine Life and Development of Marine Biogeographical System

Ecosystem Model

Physical forcing
- Tides, Currents, Winds
- Solar Energy
  - Surface Solar Radiation
  - Forcing Function

Nutrients Inputs
- Temperature, Transparency, pH, Saliency, Volume

Nutrients

State Variable

Higher Predation

Gain
- Photosynthesis
  - Phytoplankton

Loss
- Phytoplankton Respiration
- Zooplankton Respiration

Gain
- Zooplankton

Loss
- State Variables
Potential Fish Yield for EEZ

- Trophodynamic model to estimate tertiary production and MSY from Indian EEZ developed. MSY for Indian EEZ revalidated to 4.32 million tons from the 2000-2010 figures of 3.82 million tons.
- 10 years Chlorophyll data integrated with insitu data.
- Estimated from Carbon available at Tertiary level.
- Transfer Efficiency from 5 to 33%.
- Estimates separately for each ecosystem covering all seasons.
Digital Earth
Integrate and Manage Heterogeneous Data

Time series Graphs
Cross Sections
Along the Ship tracks
3D/4D Visualisation
Animations
Visualization of multiple parameters
Overlay in-situ data on Remote-Sensing images for comparison and validation
Future Goals

• What are risks and implications for human development and for diversity of life on earth?
• Define opportunities to reduce risks and vulnerabilities.
• Knowledge for sustainable stewardship of food, water, biodiversity, energy, materials, ecosystem functions and services.
- Impact of human activities and environmental change on well-being of people and societies
- Interactions of global environmental change and development
• Transformation towards sustainability: Understanding transformation processes and options.
- Solution oriented science
- Governing global environment
- Institutional, economic, social, technological and behavioral changes
- Build capacity in the area of scientific aspects of climate change research