History of the Indian Remote Sensing Programme

Ranganath Navalgund

Vikram Sarabhai Distinguished Professor
Indian Space Research Organisation
Bangalore, India

Workshop on Small Satellites & Sensor Technology for Disaster Management, Indo-US S&T Forum

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BEGINNING

Stared with the pioneering experiment of detecting Coconut Root Wilt Disease using Color Infrared Film in 1970s by Prof. P. R. Pisharoty.


The Result is operational Indian Remote Sensing Programme with the launch of IRS-1A on March 17, 1988.
NRSA established Earth Station Complex at Annaram Village, Shadnagar, 59 km from Balanagar in 1979 to receive Landsat Data during the 1980s.

**TERMINAL-1**
(10M DIA)

L & S Band
15 Mbps

1980-83: Landsat 2,3 & NOAA-2, 3
1983-88: Landsat 5, ERS, SPOT & NOAA

Today: Multimission Scenario - 4 Terminals (7.5m) - upto 960Mbps
EVOLUTION OF INDIAN EO SYSTEMS

IRS-1A/1B/P2 (1988, 1991, 1994)
- LISS-I: 72.5m, 4XS
- LISS-II: 36.5m, 4XS

IRS-1C/1D (1995, 1997)
- LISS-3: 23/70 m,
- Steerable PAN: 5.8 m,
- WiFS: 188 m

BHASKARA 1/2 (1979, 1981)
- TV Camera, Microwave Radiometer

Resourcesat-1/2 (2003, 2011)
- LISS-3: 23 m, 4 XS,
- LISS-4: 5.8 m, 3-XS,
- AWiFS: 56 m, 4-XS

- PAN: 2.5 m, 1m Fore
+26° Aft: -5°

IMS-1 (2008)
- HySI Sensor (64 bands, 506 m)
- TWSAT-MX (4 bands, 37 m)

RISAT-1 (2012)
- C Band SAR (5.35 GHz)

Land Applications

......towards enabling solutions

(High Spatial Resolution & Stereo Capability)

(High Repetivity/Revisit, High Spatial Resolution)

(Multi resolution, Frequent observations, Better radiometry)

(High Spatial Resolution & Stereo Capability)

(Microwave Capability)
Agricultural applications
(field size, frequent observations, better radiometry)

- **LISS-4 Mx camera**: 5.8m Resolution and 70 km swath
- **LISS-3**: 23.5m Resolution and 141 km Swath
- **AWiFS**: 56m Resolution and 740 km Swath
- **Repetitivity**: 5 days (AWiFS) to 24 days (LISS 3) &
- **Revisit**: 5 days (LISS 4) with tilting 26 deg tilt
Space borne SAR in C-band at 5.35 GHz

- Stripmap FRS-1 / FRS-2 (Range Doppler/ Chirp Scaling)
- ScanSAR MRS & CRS (Range Doppler/Specan)
- Spotlight (modified sub-aperture) modes.

Single/ Dual / Quad Polarisation imaging with 3-50 m Resolution & 10 - 240 km Swath
**EVOLUTION OF INDIAN EO SYSTEMS: OCEAN**

<table>
<thead>
<tr>
<th>System</th>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
</table>
| **SARAL (2012)**    |         | **Altika:**  
|                     |         | • Ka band (35.75 GHz) radar altimeter  
|                     |         | • Dual Frequency microwave radiometer (23.8 and 37 GHz)  
|                     |         | **ARGOS:** Data collection Platform                                           |
| **Oceansat-2 (1999)** |         | **OCM:** 360m, 1420km swath, 8 XS  
|                     |         | **OSCAT:** Ku Band Scatterometer  
|                     |         | • 50km resolution; Ocean surface wind speed 4 m/sec to 24 m/sec  
|                     |         | **ROSA:** Horizontal: 300 km; Vertical: 0.3 km  
|                     |         | (lower troposph.), 1-3 km (high troposph.)                                   |
| **IRS-P4 (Oceansat-1) (1999)** |         | **OCM:** 360m, 1420km swath  
|                     |         | 8 XS (0.402-0.885 μm)  
|                     |         | **MSMR:** Microwave Passive Radiometer  
|                     |         | • 6.6, 10.65, 18, 21 GHz  
|                     |         | • 150, 75, 50, 50 km resolution                                                |
| **IRS-P3 (1996)**   |         | **MOS-A/B/C Spectrometer:**  
|                     |         | • 500m, 200km swath,  
|                     |         | • 18 XS (0.40-1.6 μm)  
|                     |         | **WiFS:** 188m, 3 XS, 810 km                                                   |

**Changes in OCM2:**  
• Band 765 nm → 740 nm to avoid O₂ absorption  
• Band 670 nm → 620 nm for better quantification of suspended sediments  

**Global Wind Vector Product**

**OCM Chlorophyll-a**

**MOS-B**

**CANEUS SSTDM 2014**
Altika/SARAL mission belongs to the global altimetry system for the precise and accurate observations of ocean topography, circulation and sea surface monitoring.

**Mission:**
- Sun-synchronous, polar orbiting satellite
- Inclination: 98.38 Deg.
- Altitude: ~800 km
- Repeat cycle: 35 days

**Altika Payload:**
- Ka-band (35.75 GHz, BW 500 MHz) radar altimeter
- Dual-frequency microwave radiometer (23.8 & 37 GHz)
- DORIS
- Laser Retro-reflector Array

SARAL/AltiKA SSHA observation overpass over Indian Ocean on Feb 28, 2013 and SLA from POM model at 0.5 degree resolution.
### EVOLUTION OF INDIAN EO SYSTEMS: ATMOSPHERE

<table>
<thead>
<tr>
<th>System</th>
<th>Time Period</th>
<th>VHRR Details</th>
<th>CCD Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSAT-1A/1B/1C/1D</td>
<td>1982-1990</td>
<td>2.75 km Vis, 11 km IR</td>
<td></td>
</tr>
<tr>
<td>INSAT-2A/2B/2C</td>
<td>1991-1995</td>
<td>2.75 km Vis, 11 km IR</td>
<td></td>
</tr>
<tr>
<td>INSAT-2D/2E</td>
<td>1996-2000</td>
<td>2.0 km Vis, 8 km IR, WV</td>
<td>1 km MS</td>
</tr>
<tr>
<td>Kalpana (VHRR) and INSAT-3A</td>
<td>2001-2005</td>
<td>2.75 km Vis, 11 km IR</td>
<td>(only 3A) 1 km MS</td>
</tr>
<tr>
<td>INSAT-3D</td>
<td>2013</td>
<td>Imager and Sounder</td>
<td></td>
</tr>
<tr>
<td>Meghatropics</td>
<td>2011</td>
<td>MADRAS, SCARAB, SAPHIR, GPS OCC.</td>
<td></td>
</tr>
</tbody>
</table>

**CCD**
- Insat-3D: 1 km MS
- Kalpana and INSAT-3A: (only 3A) 1 km MS

**VHRR**
- INSAT-1A/1B/1C/1D: 2.75 km Vis, 11 km IR
- INSAT-2A/2B/2C: 2.75 km Vis, 11 km IR
- INSAT-2D/2E: 2.0 km Vis, 8 km IR, WV
- Kalpana (VHRR) and INSAT-3A: 2.75 km Vis, 11 km IR

**Meghatropics**
- (2011)
  - MADRAS, SCARAB, SAPHIR, GPS OCC.
INSAT 3D Sounder

Sounder

Imager

**19 channel Sounder**

**Advanced 6-channel imager**

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Bands (μm)</th>
<th>Spatial Res.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imager</td>
<td>VIS (0.55-0.75), SWIR (1.55-1.70)</td>
<td>1km x 1km</td>
</tr>
<tr>
<td></td>
<td>MIR (3.8-4.0)</td>
<td>4km x 4km</td>
</tr>
<tr>
<td></td>
<td>WV (6.5-7.1)</td>
<td>8km x 8km</td>
</tr>
<tr>
<td></td>
<td>TIR1 (10.2-11.3), TIR2 (11.5-12.5)</td>
<td>4km x 4km</td>
</tr>
<tr>
<td>Sounder</td>
<td>19 channels</td>
<td>10km x 10km</td>
</tr>
</tbody>
</table>

**Applications**: Improved estimation of water vapour content, cloud, wind vector, upper tropospheric humidity, sea surface temperature and surface insolation.
AIRBORNE MISSIONS

- **DMSAR**
  Freq: 5.35 GHz;  Swath: 90, 56, 8 km;  Resol: 10, 5, 1 m;  Look Angle: 84.5 MX;  Altitude: 8 km.

- **ALTM**
  ALS50 System;  Laser: Nd-YAG;  Wave length: 1064 nm;  Altitude: 500-4000 m;  FOV: 75 deg;  IFOV: 0.33 mrad

- **AIRBORNE HYPERSPECTRAL**

  - **AIMS**
    Altitude: 6.473 km;  Resol.: 4.4 m;  Spectral Range: 456-889 nm;  Bands: 143;  Band Width: 3.3-4.1 nm

  - **AHySi**
    Spectral Range: 420-950 nm;  Spectral sampling interval: 1.2 nm;  Number of Bands: 512

- **AIRBORNE TMC**
  IFOV: 50 microRad;  Swath @ 5 km: 1 km;  Spectral Range: 0.5-0.75 µm;  Stereo Mode: Alongtrack Triplet

- **AIRBORNE DIGITAL CAMERA**
  Pixel: 9 microns;  Focal length: 105 mm;  FOV: 40 deg
INDIAN EO SYSTEM: ACHIEVEMENTS

- Institutional Mechanism: National Natural Resources Management System
- Generating National level Inventories: Biennial Forest Cover, Land use, Wetland, Snow & Glaciers, Coastal Zone, Crops, Wasteland...
- Action Plans for Sustainable Development: Watershed, Ground water...
- Creating Decision Support Centre for Disaster Monitoring & Mitigation
INDIAN EO SYSTEM: ACHIEVEMENTS

- Development of Delivery Mechanisms for grass-root reach (Village Resource Centre)
- Development of Indigenous software for Data processing
- Building up indigenous EO Infrastructure: Satellites, Payloads, Data Acquisition Systems, Data Processing and Application Capability
- Capacity Building: National and International (CSSTE-AP, Dehradun)
INDIA IN INTERNATIONAL PARTNERSHIP

• Bilateral and multilateral cooperation with Countries and International Organisations
• International sensors/satellites on Indian EO Satellites/launch vehicles

1st sounding rocket launch from the Indian soil - Nike-Apache

1963

DLR's MOS on IRS-P3

ISRO-DLR Airborne SAR Mission

Chandrayaan-1
• UK: Low Energy X-Ray Spect.
• Germany: Infrared Spect. (SIR-2)
• Sweden: Sub KeV Atom reflect. Analyser
• Bulgaria: Radiation Dose Monitor
• USA: Miniature SAR
• USA: Moon Mineralogy Mapper

ISRO-CNES
Megha-Tropiques
SARAL
**RESOURCESAT-2A**

To provide continuity for Resourcesat-2

**Payloads**
- LISS 4 (5.8 m, 70 km swath, 10 bit)
- LISS 3 (23 m, 141 km swath, 10 bit)
- AWiFS (56 m, 800 km swath, 12 bit)

**Orbit**: 817 km  
**Local time**: 1030 hrs

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**CARTOSAT-2E**

High Resolution panchromatic and Multispectral Imaging

**Payloads**
- PAN (0.60 m, 10 km swath, 11 bit)
- Mx (2m, 10 km swath, 4 Xs, 11 bit)

**Orbit**: 500 km  
**Local time**: 0930 hrs

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**CARTOSAT-3**

Very High Resolution Panchromatic, Multispectral and Hyperspectral Mission

**Payloads**
- PAN (0.25 m, 16 km swath, 11 bit)
- Mx (1m, 16 km swath, 11 bit)
- HySI (12m, 5 km swath, 200 Xs)

**Orbit**: 450 km  
**Local time**: 1030 hrs

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**GISAT/ GeoHR imager**

**Geosynchronous Orbit**

**Payloads**
- High resolution multi-spectral VNIR: 50m
- Hyper spectral VNIR: 320m
- Hyper spectral SWIR: 192m
- High resolution Multi-spectral: 1.5km

**Orbit**: 36000 km  
**Every 30 min observations over India**
Thank You
INDIAN EO SCENARIO IN NEAR FUTURE

**Resourcesat – 1**
LISS III, LISS IV, AWiFS

**Scatsat (2015)**

**Cartosat-1**

**Cartosat-2**

**Cartosat-2E (2016)**
0.65 m PAN, 2 MX

**Cartosat-3 (2017)**
0.25 m PAN, 1m MX, HYSI

**Oceansat-3 (2018)**
OCM, SCAT

**INSAT-3DR (2015)**
Imager, Sounder

**INSAT-3D**
Imager, Sounder

**GISAT-1 (2017)**
MX, Hyperspectral, Thermal

**KALPANA-1**
VHRR, CCD

**Oceansat-2**
OCM, SCAT, ROSA

**Megha -Tropiques**
SAPHIR, SCARAB & ROSA

**RISAT-1A**
C-band

**RISAT-1**
C-band

**Resourcesat – 2**
LISS III, LISS IV, AWiFS

**Resourcesat -2A (2015)**
LISS III, LISS IV, AWiFS

**INSAT-3A**
VHRR, CCD

**INSAT-3**
LISS III, LISS IV, AWiFS

**CANEUS SSTDM 2014**
CANEUS SSTDM 2014

Resourcesat – 1
LISS III, LISS IV, AWiFS

Resoucesat – 2A (2015)
LISS III, LISS IV, AWiFS

Resourcesat-3
LISS III, LISS IV, AWiFS

In-orbit
Approved
Considered
INDIAN EO PROGRAMME: DIMENSIONS

Space Infrastructure
- Launch vehicle (PSLV, GSLV)
- Spacecrafts (LEO, GEO and beyond)
- Sensors (optical/microwave)

Ground Segment
- Data Acquisition and Processing
- International Ground stations
- TTC Network
- Cal-Val Programme

Applications
- Natural Resources & Environment
- Advanced R&D for land-atmosphere-ocean interactions
- Synergy between EO, Communication & Navigation

Institutionalization
- National Natural Resources Management System
- Involvement of stake-holders from the planning level

Capacity Building
- Formal education through CSSTE-AP, IIRS, IITs....
- On-the job training

International Cooperation
- Bilateral & Multilateral cooperation with various Countries & Int’l Organizations
SPACE INPUTS FOR SUSTAINABLE DEVELOPMENT

• Remote Sensing of Land
  – Multi resolutions, multispectral bands and high repetivity – Optical and Microwave
  – Time series, long term observations

• Atmospheric Observations
  – Cloud motion vectors, rain rate, vertical profiles of temperature and humidity

• Ocean Measurements
  – Ocean colour, sea surface temperature, wind vector, fishery prospects

• Communication and Navigation
  – Broadcasting, Data Dissemination, Geolocation

• In-situ Measurements
  – AWS, Flux Towers, GT Sites

• Image Processing and GIS Software - IGiS
EO APPLICATIONS FOR SOCIETAL BENEFITS

**Agriculture & Soils**
- Crop Production Forecast
- Saline/ Sodic Soils mapping
- Agro-Met Services & Disaster Surveillance (pest, floods, drought)
- Horticulture development

**Bio Resources & Environment**
- Forest Cover & Type mapping
- Wetland Inventory & Conservation plans
- Biodiversity Characterization
- Desertification Status mapping
- Coastal, Mangroves, Coral related
- Snow & Glacier studies

**Cartography**
- GCP Library for IRS Data correction
- Large Scale Mapping
- Topo-map updation - Satellite-based
- Digital Elevation Model (Carto-DEM)
- Cadastral Level mapping

**Geology & Mineral Resources**
- Landslide Hazard Zonation
- Mineral/ Oil Exploration, Mining Areas,
- Seismo-tectonic Studies
- Engineering & Geo-Environmental studies

**Ocean and Meteorology**
- Ocean Primary Productivity
- Ocean State Forecast (OSF)
- Storm Surge Modeling
- Regional Weather prediction
- Tropical Cyclones & Mesoscale studies
- Extended Range Monsoon Prediction

**Rural Development**
- National Drinking Water Mission
- Wastelands Mapping/ Updation
- Watershed Development & Monitoring
- Land Records Modernization Plan

**SC-A**

**SC-B**

**SC-C**

**SC-G**

**SC-O&M**

**SC-R**
EO APPLICATIONS FOR SOCIETAL BENEFITS

**Urban Development**
- Urban Sprawl Mapping of Major Cities
- Master/ Structure Plans
- Comprehensive Dev. Plans (CDP) of selected Cities/ Towns
- Base Map generation for Towns
- National Urban Information System

**NR Census**
- Periodic Inventory of Natural Resources under NR Census Programme:
  - Land use/ Land Cover, Soil, Geomorphology, Wetland, Land degradation, Snow & Glaciers, Vegetation

**Disaster Management Support**
- Operationally addressing various natural disasters like Flood, Cyclone, Drought, Landslide, Earthquake and Forest Fire
- R&D Studies on Early warning Systems, Decision Support Tools

**Water Resources**
- Irrigation Infrastructure assessment
- Water Resources Information System
- Command Area/ Irrigation Performance Evaluation
- Snow-melt Run-off Estimation
- Reservoir Capacity Evaluation
- Site Selection for Hydro-Power

**Climate Change Studies**
- Mapping the indicators, Monitoring the agents and Modelling the Impact
- Characterisation of climate variables (Land, Atmosphere & Oceans)
- Methane Emission, Timberline study, LU LC Change dynamics, etc.
REMOTE SENSING APPLICATIONS IN AGRICULTURE

• **Crop monitoring**
  – Identification, inventory, regional change detection, yield forecast

• **Crop intensification**
  – Cropping pattern, crop rotation, crop diversity

• **Wastelands & Watershed development**
  – Extent and types, soil salinity and water logging

• **Water resources**
  – Surface water, ground water, command area management

• **Precision farming and horticulture**
  – Yield and nutrient variability, site suitability

• **Drought Assessment**
  – Soil moisture availability

• **Climate Change in Agriculture**
  – Methane emission
INDIAN EARTH OBSERVATION SYSTEM: GOALS

Provide Leadership and Continuity in Earth Observations through an Operational EO Infrastructure to

- Conduct periodic natural resources inventory, enable the national spatial data infrastructure and provide state of environment reports to the nation
- Maximize outreach of natural resources information in support of developmental efforts of government, industry and voluntary agencies
- Enable establishing ocean state forecasting system and facilitate improved weather forecasting
- Support information needs for disaster monitoring and mitigation
- Develop a better scientific understanding of the earth system, its processes and global change
INDIA’S PRIORITIES

- Sustainable Agriculture
- Inland & Marine Fisheries
- Horticulture

- Forest Status
- Biodiversity
- Coastal Zone
- Environmental Impact

- Disaster Monitoring & Mitigation

- Surface Water Resources
- Ground Water Prospecting
- Snow & Glaciers

- Weather Forecasting
- Ocean State Forecasting

- Urban Planning
- Rural Roads
- Infrastructure Development

- Global change Indicators
- Regional Climate Model
- Impact Assessment
CROP MONITORING - FASAL PROGRAMME - MNCFC

- Institutionalizing the operational Use of Remote Sensing data.
- Crop assessment and forecasting using various sources of information for multiple in-season crop assessment in near real-time.
- Integrated use of modern tools such as GIS, large data bases, modelling and networking

Mahalanobis National Crop Forecast Centre

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (Mha)</th>
<th>Production (Mt)</th>
<th>Date of Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute, 2012</td>
<td>0.79</td>
<td>0.79</td>
<td>Aug, 1, 2012</td>
</tr>
<tr>
<td>Rice (2011-12) 2012-13</td>
<td>37.13 (kharif) 37.96 (Kharif)</td>
<td>80.27 (kharif) 79.77 (kharif)</td>
<td>Jan. 06, 2012 Oct 4, 2012 (F2)</td>
</tr>
</tbody>
</table>
WASTELAND MONITORING

A Targeted Rural Development Programme: with village & watershed boundaries

- Bring culturable wastelands under cultivation
- Enhance food grain production
- Bring 30% under green cover

- National Wasteland Inventory Project (1986 - 2000)
- Monitoring of the wasteland areas (2005-06)
- Wasteland Change Analysis - using three season LISS-III data of 2008-2009
- Coverage : Entire India in 1:50,000 scale
- No. of Wasteland categories : 28

<table>
<thead>
<tr>
<th>Area (Mha)</th>
<th>% of TGA</th>
<th>Year of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>63.85</td>
<td>20.17%</td>
<td>1986-2000</td>
</tr>
<tr>
<td>55.27</td>
<td>17.45%</td>
<td>2003</td>
</tr>
<tr>
<td>47.22</td>
<td>14.91%</td>
<td>2005</td>
</tr>
<tr>
<td>46.73</td>
<td>14.76%</td>
<td>2009</td>
</tr>
</tbody>
</table>
IDENTIFICATION OF PROBLEMATIC SOILS

- Problematic soils have been mapped.
- Monitoring of the reclamation of the salt affected soils has also been done using multi-date satellite imagery.
- Waterlogged areas – Mapped and monitored.

Salt-Affected Soils in Part of Sharda Sahayak Command Area (Indo-Gangetic Plains), Jaunpur (UP)

1975 – 46,029 ha
1999 – 28,749 ha
Integrated Mission for Sustainable Development (IMSD)

- Land & Water resources development plans for 84 Mha in 175 districts in country
- Detailed planning and implementation in many watersheds

Space data in conjunction with collateral data has been used for

- **Characterisation** - land cover, morphometry, soil degradation, ground water availability
- **Prioritisation** - erosion
- **Development Plans** - Soil and moisture conservation plans
- **Monitoring** - Vegetation cover, Ground water level, Productivity
Creation of GW data base (GW prospects maps) for identifying potable drinking water sources on sustainable basis for the problematic habitations.
WATER RESOURCES

- Inventory of surface water bodies
- Performance evaluation of irrigation commands
- Groundwater exploration and recharge
- Snowmelt run-off (BBMB)
- Glacier inventory, retreat
GLACIER INVENTORY, RETREAT

Jamdhar Glacier, Tons Basin

<table>
<thead>
<tr>
<th>Basins</th>
<th>No. of Glaciers</th>
<th>Area (km²)</th>
<th>1962</th>
<th>2001/04</th>
<th>Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chenab</td>
<td>359</td>
<td>1414</td>
<td>1110</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Parbati</td>
<td>88</td>
<td>488</td>
<td>379</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Baspa</td>
<td>19</td>
<td>173</td>
<td>140</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>466</td>
<td>2075</td>
<td>1629</td>
<td></td>
<td>21</td>
</tr>
</tbody>
</table>
FORESTRY, ECOSYSTEM AND ENVIRONMENT

**Mangroves**

- Deltaic mangroves
- Open coast mangroves

**Coral Reef**

- Reef flat
- Algae/sea grass
- Coralline shelf
- Sand
- Mud on reef
- Vegetated RF
- Coral head/
- Reef patch
- Lagoon
- Cays

**Mangrove area (km²) in different states**

<table>
<thead>
<tr>
<th>Region</th>
<th>Area (1986)</th>
<th>Area (1990-93)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andaman &amp; Nicobar</td>
<td>922.0</td>
<td>762.0</td>
</tr>
<tr>
<td>West Bengal</td>
<td>2067.0</td>
<td>1838.0</td>
</tr>
<tr>
<td>Orissa</td>
<td>203.0</td>
<td>187.0</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>322.0</td>
<td>380.0</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>30.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Karnataka</td>
<td>11.3</td>
<td>8.7</td>
</tr>
<tr>
<td>Goa</td>
<td>5.5</td>
<td>6.7</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>124.0</td>
<td>222.0</td>
</tr>
<tr>
<td>Gujarat</td>
<td>767.0</td>
<td>1012.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4451.8</strong></td>
<td><strong>4439.4</strong></td>
</tr>
</tbody>
</table>

CANEUS SSTDM 2014
- Potential Fishery Zone Forecast (integration of Chl, SST, winds)
- Primary productivity modeling
- Deep water productivity (Tuna)
- Bio-geo-chemical analysis for nitrate & carbon cycle
**Observational Systems**
Satellite (GEO, LEO, All-weather), Aerial, Ground

**Emergency Commn, Detection, Disaster Early Warning/ Alert, ..**
CWDS, Ocean Databuoy, Seismic Stns networking, Tsunami Sensor (BPR), Digital/ DTH based DWS, Sat-Phone, Messaging terminal, Fishermen DAT, ...

**Disasters - Operationally addressed - Enabling States in mitigation efforts**

- **Flood**
  - Inundation monitoring
  - Damage assessment
  - Hazard zonation
  - Bank erosion studies

- **Cyclone**
  - Inundation mapping
  - Damage assessment

- **Earthquake**
  - Damage Assessment

- **Landslide**
  - Damage Assessment
  - Hazard zonation

- **Drought**
  - Monthly & End-of-Season Agri Drought Assessment

- **Forest Fire**
  - Active fire detection
  - Damage assessment

**Multi-tier databases with query/ decision tools**

**Satellite Data & GIS layers**
Damage assessment, Hazard zonation, mitigation planning, International Charter, Sentinel Asia, UN-SPIDER, ...

**Secured Commn**
Fixed/ VPN, Mobile

**Inundation monitoring**
Damage assessment
Hazard zonation
Bank erosion studies

**Drought**
Monthly & End-of-Season Agri Drought Assessment

**Forests Fire**
Active fire detection
Damage assessment

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CANEUS SSTDM 2014

**Post-SIDR Nov 20, 07**
SPACE APPLICATIONS FOR CLIMATE CHANGE

Himalayan Glacial Retreat

GHG Assessment (Methane)

Sustainable Habitat

- Biodiversity Characterisation
- Carrying Capacity Models
- Coastal Ecosystems

Water Mission

- Water Resources Assessment
- Flood Inundation & Damage Assessment

Himalayan Ecosystem

- Species Composition, Tree line
- Ecosystem Characterization
- Snow/ Glacier Dynamics

Green India

- Clean Development Mechanism
- Sites For Bio-fuel Plantations
- Biodiversity Conservation

Sustainable Agriculture

- Cropping Systems Analyses
- Precision Agriculture
- Land Degradation

Strategic Knowledge

- Sensor System Studies
- Model Calibration
- Aerosol Loading

Upward Shift in Timberline & Vegetation in Alpine Zone

Aerosol Optical Thickness Distribution