OCEANSAT-2 OCM  Feb 6, 2017
Irrawaddy River Delta, Bay of Bengal

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Ahmedabad-380015, INDIA

IOCS-2017 meeting at Lisbon, Portugal, May 15-18, 2017
ISRO- EARTH OBSERVATION SATELLITES

RESOURCESAT-2 (2011)
RISAT-1
RISAT-2 (2012)

LAND & WATER

CARTOSAT-2; 2A; 2B
CARTOSAT-1 (2005)

HIGH RESOLUTION

OCEANSAT-2 (2009)

OCEAN

KALPANA (2002)
MEGHA-TROPIQUES (2011)
INSAT-3A (2003)
INSAT-3D (2013)

WEATHER; CLIMATE

1 KM

IMAGING CAPABILITY

0.8 M

Resourcesat-2A, SCATSAT-1, Cartosat 2S series, INSAT-3DR already launched in 2016
Cartosat-3, Oceansat-3, GISAT being added during 2017-19

IOCS-2017 meeting at Lisbon, Portugal, May 15-18, 2017
RISAT-1 HRS Image over Effiel Tower, Paris
Update on Ocean Colour Activities in India

OCEAN COLOUR OPERATIONAL DATA PRODUCTS & DISSEMINATION FOR OCM-2

- Retrieval algorithms for Ocean colour parameters over case-1 waters, coastal and inland waters
- Inversion algorithms for quantifying absorption and backscattering process (IOP estimation)
- In-situ database on AOP, IOP and in-water constituent concentrations for seas around India
- Implementation of a data processing chain for OCM-2 at NRSC, Hyderabad for improved radiometry

AVIRIS-NG Airborne Hyperspectral data for Coastal / Inland waters

- More than 74 sites in India were covered by AVIRIS-NG airborne campaign, including 5 sites for coastal, inland waters and coral reefs
- Hyperspectral data is being analysed for algorithm development and retrieval of waters colour parameters

OCEANSAT-3 OCM sensor development

- OCEANSAT-3 satellite is approved by Government. It will carry a Ocean Colour Instrument and Ku band Scatterometer.
- OCM-3 sensor having 13 bands and a SST sensor is currently under development at ISRO.

Discussions on NASA-ISRO cooperation for PACE mission
OCEANSAT-2
OCEAN COLOUR MONITOR (OCM-2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launched</td>
<td>23 Sept 2009</td>
</tr>
<tr>
<td>Orbit</td>
<td>720 Km</td>
</tr>
<tr>
<td>Inclination</td>
<td>98.28 deg</td>
</tr>
<tr>
<td>Revisit cycle</td>
<td>2-days</td>
</tr>
<tr>
<td>Swath/Resolution</td>
<td>1420 Km /</td>
</tr>
<tr>
<td></td>
<td>360 m X 236m</td>
</tr>
<tr>
<td>Time of Pass</td>
<td>12 noon</td>
</tr>
<tr>
<td>Along track Steering</td>
<td>± 20 deg</td>
</tr>
</tbody>
</table>

**Instruments on Oceansat-2**
- OCM-2: Ocean Colour Monitor
- OSCAT: Ku-band Scatterometer
- ROSA: ASI’s Radio Occultation Sounder for Atmosphere

**OCM-2 Design**

(8 VNIR spectral bands)

- 8-element telecentric lens assembly per band
- f-length: 20 mm ; f/no. = 4.3
- FOV: ± 43 deg
- 2-element bandpass filter + 1 thermal filter
- 3730 of 6k element linear array CCD device
- 12 – bit quantisation
- Exposure (gains) : 16 levels
- SNR > 512 at saturation (land reflectance)
- Band-to-band registration : ± 0.25 pixel
- MTF > 0.26
- 4 LED’s as onboard cal source per band

(OCM-2 Optics side) (detector head side)
LEVEL-1 Product: Basic Data Products

- L1A RAW Products (Internal Use Only & DQE)
- L1B Radiance Product
- L1C Radiometrically and Geometrically corrected

LEVEL-2 Product: Geo-Physical Parameters

- Chlorophyll-α concentration
- Total Suspended Matter (TSM)
- Diffused Attenuation Coefficients ($K_d$ 490 nm)
- Aerosol Optical Depth (AOD) at 865 nm

Products supported in HDF 4 format can be Displayed and processed in SeaDas

• OCM-2 payload is working nominally
• Seven years of ocean colour data around India & Globe (Limited)
Land and Ocean Colour around Gujarat as captured by OCEANSAT-2 OCM sensor
23 January 2017

Turbidity shades around Gujarat coast

Blue Oceanic waters of Arabian Sea

Muddy Brown water of Gulf of Khambhat

Coastal Green waters

Indus Delta

Turbid waters GOK
Massive Outbreak of Noctiluca algal blooms in the Arabian Sea as captured by Indian OCEANSAT-2 OCM on Feb 11, 2017

Every year during winters north-western Arabian Sea experiences outbreak of Noctiluca algal blooms. This bloom at times causes fish mortality on Oman coast due to hypoxia.

This image is captured by Indian OCM sensor on OCEANSAT-2 satellite on Feb 11, 2017.
Trichodesmium spp. is nitrogen fixing marine blue-green algae commonly found in tropical oceans. They form massive blooms during summer period, when surface waters are warm and devoid of nitrate. These blooms are important for nitrogen bio-geo-chemistry of oceans.
AVIRIS-NG data over Veraval Fishing Harbour in Gujarat

Spectral variability of different water types
Hyperspectral Data Analysis using AVIRIS-NG

Water Quality and Bathymetry estimation over Chilika lagoon from AVIRIS-NG
(Forward simulation & Inversion)

Forward simulations of remote sensing reflectance for varying water optical properties and depth

False Color Composite image of Chilika lagoon acquired by AVIRIS

Water was found more turbid in the northern sector due to the river input and resuspension from shallow bathymetry

Water turbidity

Depth was found to be varying between 0.1 (northern sector) to 2.6 meter (southern sector)

Bottom depth

Benthic substrate was assumed to be sandy and abundance was found in the northern sector with highly reflecting bottom

Bottom albedo
Sargassum Habitat over Pirotan Reef: AVIRIS NG data

Macroalgae Habitat around Pirotan

Floating Sargassum in the Gulf of Kachchh
Achievements

- Aerosol optical depth (AOD) retrieval has been developed using INSAT-3D imager data.
- AOD maps are operationally available at every ½ hour interval during daytime on Vedas air quality web portal of ISRO.
- Extensive validation of INSAT-3D derived AOD with ground measurements encompassing more than 1700 collocated points has been done.

Way Forward

- Technique development to derive particulate matter concentration using remote sensing data.

Key outcome

- PM2.5 and PM10 maps over metropolitan cities.
- AOD maps at high spatial resolution (<2km)

Benefits to Stake holders

- Air pollution monitoring and mitigation.
**In-situ Bio-Optical data collection**

- In-situ data collection in collaboration with other National Institutes and Universities.
- Measurement & Analysis according to Ocean Optics Protocols

- Radiometric measurements
- Spectrophotometric measurements
- HPLC
- Fluorometry
- CTD
- Microscopy
- Nutrients
- pH
- DO
- Ancilliary data
- Aerosol optical depth
- C$^{13}$ and N$^{15}$ Measurements
- POC & DOC

Meeting at Lisbon, Portugal, May 15-18, 2017
A Bio-optics laboratory is developed at SAC/ISRO. The laboratory is equipped with State-of-art equipment such as High Performance Liquid Chromatography (HPLC), Total Organic Carbon Analyser (TOC), UV-VIS Spectrophotometer, Probe sonicator, Cool centrifuge, Inverted Microscope & hyperspectral radiometer to meet the in-situ data requirements of OCM and future Ocean Colour missions of ISRO.
## DATA PRODUCTS

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Swath</th>
<th>Cell Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1B</td>
<td>Scan mode $\sigma^o$</td>
<td>1800 Km</td>
<td>--</td>
</tr>
<tr>
<td>Level 2A</td>
<td>Swath grid mode $\sigma^o$</td>
<td>1800 Km</td>
<td>50kmx50km, 25kmx25km</td>
</tr>
<tr>
<td>Level 2B</td>
<td>Swath grid Wind product</td>
<td>1800 Km</td>
<td>50kmx50km, 25kmx25km</td>
</tr>
<tr>
<td>Level 3W</td>
<td>Global wind product</td>
<td>Global</td>
<td>0.5°x0.5°, 0.25°x0.25°</td>
</tr>
<tr>
<td>Level 3S</td>
<td>Global $\sigma^o$ product</td>
<td>Global</td>
<td>0.5°x0.5°, 0.25°x0.25°</td>
</tr>
<tr>
<td>Level 4</td>
<td>Value added Products</td>
<td>Global</td>
<td>Variable</td>
</tr>
</tbody>
</table>

Launched on Sep 26, 2016

Data available at [www.nrsc.gov.in](http://www.nrsc.gov.in)

[www.mosdac.gov.in](http://www.mosdac.gov.in)

First Global Coverage of SCATSAT Wind (m/s)
04-October-2016 to 05-October-2016

IOCS-2017 meeting at Lisbon, Portugal, May 15-18, 2017
Future EO Satellites for Ocean Observation

Continuity of space observations.....

OCEANSAT-1
GISAT

OCEANSAT-2  RISAT-1  SARAL  INSAT-3D

OCEANSAT-3  INSAT-3DR  GISAT

1999  2009  2018

OCEANSAT-3
Global Ocean Coverage

Payloads
- 13 Band Ocean Colour Monitor
- 2 Bands for SST
- Ku Band Scatterometer

Status
- PSLV Launch 2018-19

GISAT
Multiple acquisition from Geosynchronous Orbit

Payloads
- High resolution MX (50 m) - VNIR (HRMX-VNIR):
- Hyper spectral VNIR & SWIR: 320m and 192m Res.
- TIR 1.5km (HRMX-TIR)

Status
- PSLV Launch
### Oceansat-3 Spacecraft

#### Mission Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Payloads</strong></td>
<td>OCM-3, Scat-3, SSTM-1 and Argos -4</td>
</tr>
<tr>
<td><strong>Spacecraft Class</strong></td>
<td>Standard I-1K bus</td>
</tr>
<tr>
<td><strong>Mission Life</strong></td>
<td>5 years</td>
</tr>
<tr>
<td><strong>Spacecraft Mass</strong></td>
<td>~1200 kg (Mainframe: 800 kg, P/L : 400 kg)</td>
</tr>
<tr>
<td><strong>Power Generation</strong></td>
<td>2414 W @ BOL; 2100 W @ EOL (with 1 S/F)</td>
</tr>
<tr>
<td><strong>Spacecraft Load</strong></td>
<td>450 W for Mainframe; 950 W for Payloads</td>
</tr>
<tr>
<td><strong>Orbit type</strong></td>
<td>Sun Synchronous Orbit (SSO)</td>
</tr>
<tr>
<td><strong>Altitude</strong></td>
<td>720 km or 735 km in case of marching orbit</td>
</tr>
<tr>
<td><strong>Inclination</strong></td>
<td>98.28°</td>
</tr>
<tr>
<td><strong>No. of orbits per day</strong></td>
<td>14 + ½</td>
</tr>
<tr>
<td><strong>Local time</strong></td>
<td>12:00 Noon at descending node</td>
</tr>
</tbody>
</table>
### OCM-3 Spectral Bands

<table>
<thead>
<tr>
<th>Band No.</th>
<th>Central Wavelength</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>412 nm</td>
<td>Differentiate yellow substance from chlorophyll</td>
</tr>
<tr>
<td>B2</td>
<td>443 nm</td>
<td>Chlorophyll absorption maximum; low chlorophyll</td>
</tr>
<tr>
<td>B3</td>
<td>490 nm</td>
<td>Moderate chlorophyll</td>
</tr>
<tr>
<td>B4</td>
<td>510 nm</td>
<td>High chlorophyll; Total Suspended Matter (TSM)</td>
</tr>
<tr>
<td>B5</td>
<td>555 nm</td>
<td>Weak chlorophyll absorption</td>
</tr>
<tr>
<td>B6</td>
<td>566 nm</td>
<td>Phycoerythrobilins (PEB)</td>
</tr>
<tr>
<td>B7</td>
<td>620 nm</td>
<td>Turbidity in coastal Case 2 waters</td>
</tr>
<tr>
<td>B8</td>
<td>670 nm</td>
<td>Baseline for chlorophyll fluorescence</td>
</tr>
<tr>
<td>B9</td>
<td>681 nm</td>
<td>Chlorophyll fluorescence for high concentration</td>
</tr>
<tr>
<td>B10</td>
<td>710 nm</td>
<td>Baseline for chlorophyll fluorescence; extrapolation to visible bands for atmospheric Correction</td>
</tr>
<tr>
<td>B11</td>
<td>780 nm</td>
<td>Atmospheric correction; avoids O2 absorption Band</td>
</tr>
<tr>
<td>B12</td>
<td>870 nm</td>
<td>Atmospheric correction; good assessment of spectral scattering</td>
</tr>
<tr>
<td>B13</td>
<td>1010 nm</td>
<td>Atmospheric correction, aerosol – white foam discrimination</td>
</tr>
</tbody>
</table>

**SSTM bands**

<table>
<thead>
<tr>
<th></th>
<th>11 µm</th>
<th>Sea surface temperature detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2</td>
<td>12 µm</td>
<td>Sea Surface Temperature detection</td>
</tr>
</tbody>
</table>
GISAT: Sensor System

GISAT Payload Features

<table>
<thead>
<tr>
<th>Sensors</th>
<th>Spectral Bands</th>
<th>Spectral Region (um)</th>
<th>Spatial Res. (m)</th>
<th>Swath (km)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX- VNIR</td>
<td>6</td>
<td>0.45 – 0.86</td>
<td>&lt;50</td>
<td>470</td>
<td>MX-Optical</td>
</tr>
<tr>
<td>HySI- VNIR</td>
<td>154</td>
<td>0.38 – 1.0</td>
<td>320</td>
<td>160</td>
<td>Hyperspectral (5 nm)</td>
</tr>
<tr>
<td>HySI- SWIR</td>
<td>256</td>
<td>0.90 – 2.5</td>
<td>200</td>
<td>190</td>
<td>Hyperspectral (10 nm)</td>
</tr>
<tr>
<td>MX- LWIR</td>
<td>6</td>
<td>8.20 – 12.5</td>
<td>1500</td>
<td>470</td>
<td>Thermal</td>
</tr>
</tbody>
</table>

Scan modes of GISAT

18°*18°  10°*10°  5°*5°  3000km*3000km  1000km*1000km

Thank You

IOCS-2017 meeting at Lisbon, Portugal, May 15-18, 2017