JAXA Earth Observation Program

The Coordination Group for Meteorological Satellites
CGMS-47 Plenary

Hitoshi Tsuruma
Advisor for Senior Chief Officer of Satellite Applications
Japan Aerospace Exploration Agency
Japan’s Earth Observation Schedule

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>National Security Disaster</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation, Aerosol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clouds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenhouse Gases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **ALOS-2/PALSAR-2**
- **ALOS-4 (SAR)**
- **ALOS-4 Follow-on**
- **ALOS-3 (Optical)**
- **ALOS-3 Follow-on**
- **GCOM-W/AMSR-2**
- **GPM/DPR**
- **GCOM-C/SGLI**
- **GPM/DPR**
- **GOSAT/TANSO**
- **GOSAT-2/TANSO2**
- **AMSRS3 (hosted by GOSAT-2 Follow-on Mission)**
- **EarthCARE/CPR**
- **GOSAT-2 Follow-on Mission**

Legend:
- Black: Extended Life Period
- Red: On Orbit
- Orange: Development
- Gray: Study
Current JAXA Earth Observation Satellites Contributing to Societal Benefit

**Climate Change**
- **GCOM-C**
  - Launched: 23 December 2017
  - Cloud/Aerosols/Vegetation
- **GCOM-W**
  - Launched: 2012
  - Water Cycling
- **GOSAT**
  - Launched: 2009
  - Greenhouse Gases
- **GPM**
  - Launched: 2014
  - DPR: Dual Frequency Radar

**Disaster Risk Management**
- **GOSAT-2**
  - Launched: 29 October 2018
- **ALOS-2**
  - Launched: 2014
  - Land Surface (Radar)

**Greenhouse Gases**
- **GOSAT**

**Water Cycling**
- **GCOM-W**

**Climate Change**
- **GCOM-C**
  - Cloud/Aerosols/Vegetation
- **GCOM-W**
  - Water Cycling
- **GPM**
  - DPR: Dual Frequency Radar

**Greenhouse Gases**
- **GOSAT**

**Land Surface (Radar)**
- **ALOS-2**

**Launched**
- **GCOM-C**: 23 December 2017
- **GCOM-W**: 2012
- **GOSAT**: 2009
- **GOSAT-2**: 29 October 2018
- **GPM**: 2014
- **ALOS-2**: 2014

**Courtesy of NASA**
Satellite Observation in Support of Improvement of GHG Inventory

[Old] 2006 IPCC Guidelines for GHG Inventories

Volume 1 Chapter 6: Quality Assurance /Quality Control and Verification

[6.10.2 Comparisons with atmospheric measurements]
- Considering the limited monitoring network currently available for many of the greenhouse gases and the resulting uncertainties in the model results, inverse modeling is not likely to be frequently applied as a verification tool of national inventories in the near future. Even the availability of satellite-borne sensors for greenhouse gas concentration measurements will not fully resolve this problem, due to limitations in spatial, vertical and temporal resolution (*).

[New] Refinement to 2006 IPCC Guidelines for GHG Inventories

Volume 1 Chapter 6: Quality Assurance/Quality Control and Verification

- **Delete:** Descriptions about limitation on availability of satellite observations (* the left)
- **Add:** Many descriptions on usability and roles of satellite data as a comparison tool of inventories. Particularly, a new section of “Satellite Observations” are included.
  - Improvement of estimation accuracy of model by satellite data utilization at the area that in-situ data is not ready fully.
  - Prospects that satellite data estimation will quickly improve because of increase in the number of observations by new GHG observation satellites (TROPOMI, GOSAT-2, GeoCarb, TanSat etc.)

- **Changes may be made due to copyediting and to ensure consistency with the approved Overview Chapter.**
CO$_2$ Emission in Lower Troposphere Observed by GOSAT
GPM/DPR Improves Operational Meso-scale Numerical Weather Prediction

© Japan Meteorological Agency (JMA)
GCOM-C Data: Available for Public

- Water-cloud optical thickness
- Aerosol optical thickness
- Leaf area index
- PAR
- Chlorophyll-a conc.
- Water-cloud effective radius
- Snow grain size
- Above ground biomass
- Land surface temperature
- Sea surface temperature

▲ GCOM-C provides 29 data products.

◆ GCOM-C/SGLI 250-m resolution captured fine structures of ocean current and eddies.
### Essential Climate Variables (ECVs) Measured by GCOM-W & C, GOSAT & GOSAT-2, GPM/DPR, and ALOS-2

<table>
<thead>
<tr>
<th>Total Essential Climate Variables (ECVs)</th>
<th>54</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECVs measured by GCOM-C, GCOM-W, GOSAT, GOSAT-2, GPM/DPR, and ALOS-2</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Atmosphere</th>
<th>Land</th>
<th>Ocean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface</strong></td>
<td><strong>Upper-air</strong></td>
<td><strong>Atmospheric Composition</strong></td>
</tr>
<tr>
<td>Precipitation</td>
<td>Earth radiation budget</td>
<td>Aerosol and ozone precursors</td>
</tr>
<tr>
<td>Pressure</td>
<td>Lightning</td>
<td>Aerosols properties</td>
</tr>
<tr>
<td>Radiation budget</td>
<td>Temperature</td>
<td>Carbon dioxide, methane &amp; other greenhouse gases</td>
</tr>
<tr>
<td>Temperature</td>
<td>Water vapour</td>
<td>Cloud properties</td>
</tr>
<tr>
<td>Water vapour</td>
<td>Wind speed &amp; direction</td>
<td>Ozone</td>
</tr>
<tr>
<td>Wind speed and direction</td>
<td><strong>Earth radiation budget</strong></td>
<td><strong>Aerosol and ozone precursors</strong></td>
</tr>
<tr>
<td><strong>Biosphere</strong></td>
<td><strong>Hydrosphere</strong></td>
<td><strong>Ocean</strong></td>
</tr>
<tr>
<td><strong>Biogeochemical</strong></td>
<td><strong>Cryosphere</strong></td>
<td><strong>Biological/ecosystems</strong></td>
</tr>
<tr>
<td>Inorganic carbon</td>
<td>Transient tracers</td>
<td>Marine habitat properties</td>
</tr>
<tr>
<td>Nitrous oxide</td>
<td>Nutrients</td>
<td>Plankton</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Ocean colour</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Land surface temperature</td>
<td>Ice sheets and ice shelves</td>
<td></td>
</tr>
</tbody>
</table>
Future JAXA Earth Observation Satellites

2020-2021
ALOS-3, ALOS4
Launch

2022
EarthCARE
Launch

2022-2023
GOSAT-2 Follow-on Mission
/ AMSR3
Launch

Land Surface

ALOS-3
(Optical)

ALOS-4
(Radar)

CPR: Cloud Profiling Radar

Cloud/Aerosol Radiation Budget

Water Cycling

GHG

(TANSO-3
(MOE Mission))
AMS3 onboard GOSAT-2 Follow-on Mission

- Share the satellite bus with GOSAT-2 follow-on mission
  - GOSAT-2/TANSO-2 follow-on mission is led by Ministry of Environment

AMS3 will have new high-frequency channels (166 & 183 GHz) for solid precipitation retrievals and water vapor analysis in numerical weather prediction.

GOSAT-2/TANSO-2 successor sensor will improve observation capability of greenhouse gases.

Mission Targets
- Understanding water cycle variation and impacts of climate change
- Improvements in numerical weather prediction, typhoon analysis, etc.
- Contributions to fisheries near coast
- Contribution to navigation support in polar oceans
JMA-JAXA Collaboration
Ground x Space
JMA x JAXA

Operation
Installation
Development
Research
JMA-JAXA Collaboration
Integration of ground-based & spaceborne rainfall

JMA and JAXA are closely collaborating for developing regional integrated precipitation product by using ground/space observation

Effect by “JMA x JAXA”

Effect by “Ground x Space”

Maximize the advantage of each dataset!

one-stop approach from R&D to operation & application
Himawari aerosol optical thickness (AOT) algorithm and the AOT assimilation system have been developed jointly by Kyushu University, Meteorological Research Institute and JAXA.

The satellite AOT assimilation has improved the forecast of aerosol arrival in 24 hours, thus JMA will start operational aerosol forecast in JFY 2019.

In addition to Himawari, GCOM-C, GOSAT-2 and EarthCARE data will be assimilated in the future.

based on Yumimoto et al. 2018
<table>
<thead>
<tr>
<th>Portal Name and URL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>G-Portal R</strong></td>
</tr>
<tr>
<td>Provides products of GPM, GCOM-W, GCOM-C, GOSAT, and Past Satellites and Sensors (MOS-1/1b, JERS-1, ADEOS, ADEOS-II, Aqua/AMSR-E, TRMM/PR)</td>
</tr>
<tr>
<td><a href="https://gportal.jaxa.jp/gpr/">https://gportal.jaxa.jp/gpr/</a></td>
</tr>
<tr>
<td>(Contacts : <a href="mailto:z-gportal-support@ml.jaxa.jp">z-gportal-support@ml.jaxa.jp</a>)</td>
</tr>
<tr>
<td><strong>GSMaP: Global Satellite Mapping of Precipitation</strong></td>
</tr>
<tr>
<td>Provides hourly Global Rainfall Map in Near-Real-Time (GSMaP_NRT), available four hours after observation. (GPM-Core GMI, TRMM TMI, GCOM-W1 AMSR2, DMSP series SSMIS, NOAA series AMSU, MetOp series AMSU, and Geostationary IR)</td>
</tr>
<tr>
<td>(Contacts : <a href="mailto:Z-trmm_real@ml.jaxa.jp">Z-trmm_real@ml.jaxa.jp</a>)</td>
</tr>
<tr>
<td><strong>JAXA Himawari Monitor</strong></td>
</tr>
<tr>
<td>Provides multi-satellite products from the Himawari Standard Data provided by the Japan Meteorological Agency (JMA) as well as the geophysical parameter data (Aerosol Optical Thickness, Sea Surface Temperature, Short Wave Radiation, Chlorophyll-a, Wild Fire, Photovoltaic Power, Cloud Optical Thickness and Cloud Type) produced by JAXA.</td>
</tr>
<tr>
<td>(Contacts : <a href="mailto:Z-trmm_real@ml.jaxa.jp">Z-trmm_real@ml.jaxa.jp</a>)</td>
</tr>
<tr>
<td><strong>GDAS: GOSAT Data Archive Service</strong></td>
</tr>
<tr>
<td><em>(Operated by National Institute for Environmental Studies)</em></td>
</tr>
<tr>
<td>Provides GOSAT products (Methane and CO2).</td>
</tr>
<tr>
<td><a href="https://data2.gosat.nies.go.jp/index_en.html">https://data2.gosat.nies.go.jp/index_en.html</a></td>
</tr>
<tr>
<td>(Contacts: <a href="mailto:gosat-support@nies.go.jp">gosat-support@nies.go.jp</a>)</td>
</tr>
</tbody>
</table>
For Our Sustainable Future

Images of the Earth about 340,000 km from the center of the Earth took by the Hayabusa2 after the swing-by on December 4, 2015.

Australian continent on the upper right, and Antarctica on the lower right.
Thank you for your attention.