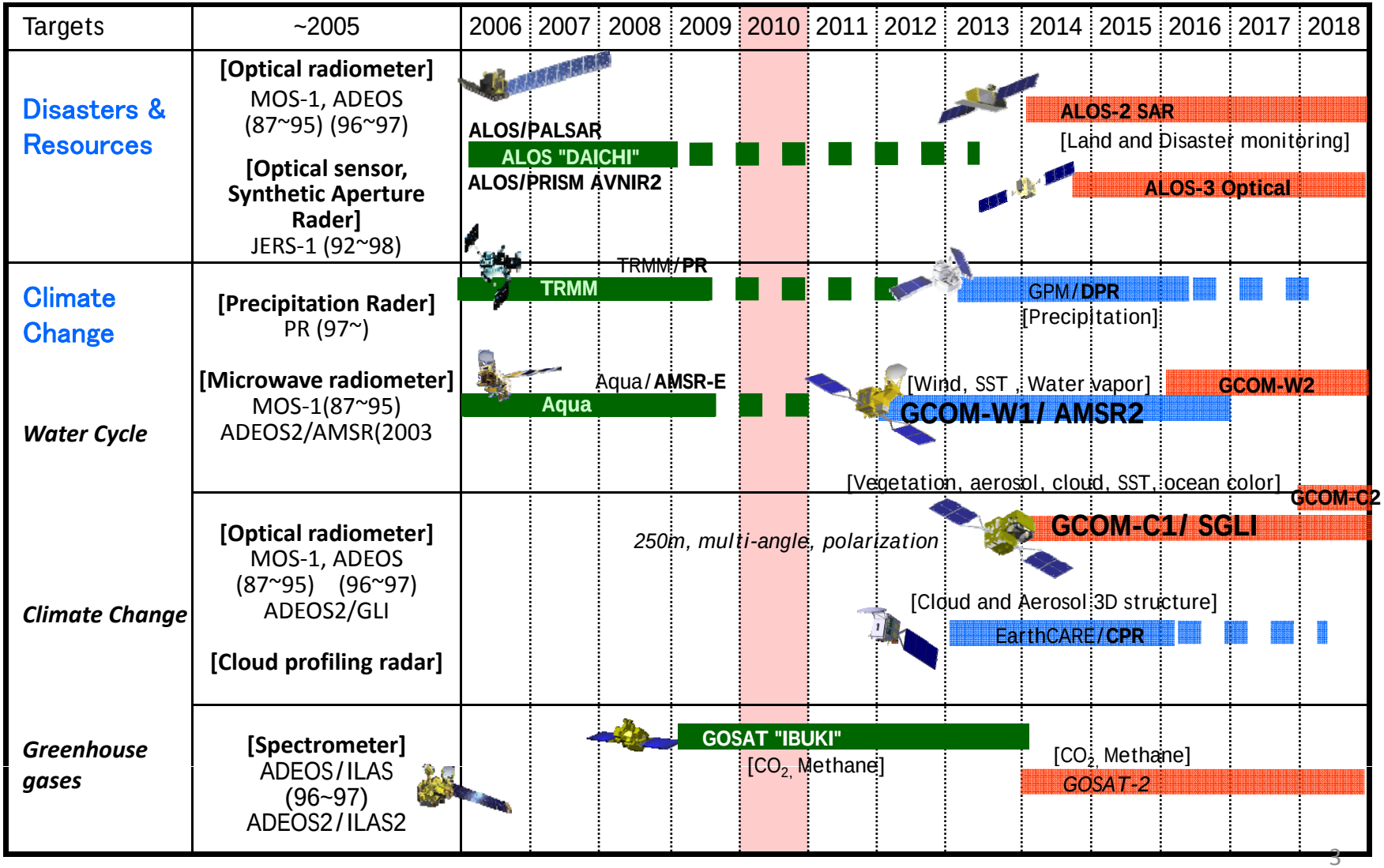
JAXA's Activities on Climate Observations and ECV Derivation

CEOS Climate Ad-hoc Group Meeting
ESA Harwell Centre, United Kingdom
July 22nd – 23rd 2010

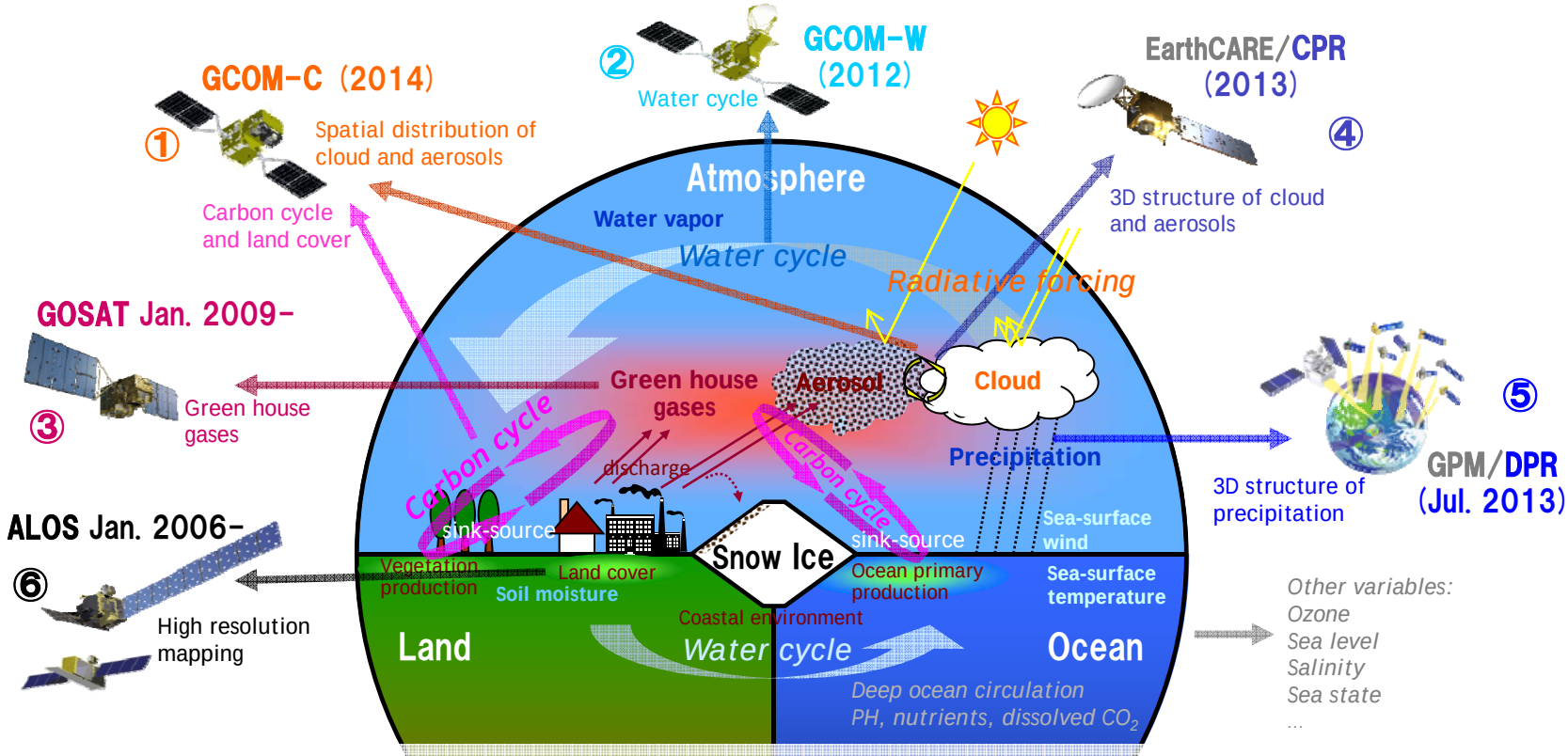
Tamotsu Igarashi
JAXA

- the next CEOS ACC meeting is scheduled on Sep. 9-10 2010 at Oxford
- main emphasis on Atmospheric Essential Climate Variables (ECVs)
- The basic draft outline for this meeting is: Sep. 09:
- Status of ongoing ACC activities:
- - Volcanic Ash Monitoring/Support to Aviation
- - The ACC Webportal (transfer to WGIS)
- - Status of the position paper on an Air Quality Constellation
- - Status of ACC contributions to the CEOS response to the GCOS Implementation Plan
- Ongoing Projects on Climate Data: this should include presentations of dedicated projects with the aim to generate Atmospheric Fundamental Climate Data Records or Essential Climate Variables - each oral presentation should end with 1-2 slides specifying where international cooperation would be needed, which could lead to an ACC project by targeted Space Agencies funding
- ESA:
- - Clouds
- - Aerosols
- - Ozone
- - GHGs

Long-Term Plan of Earth Observation by JAXA



JAXA Future Environment Missions



① **GCOM-C**: Long-term observation of the horizontal distribution of aerosol, cloud, and ecosystem CO_2 absorption and discharge

② **GCOM-W**: Long-term observation of water-cycle such as the snow/ice coverage, water vapor, and SST

③ **GOSAT**: Observation of distribution and flux of the atmospheric greenhouse gases, CO_2 and CH_4

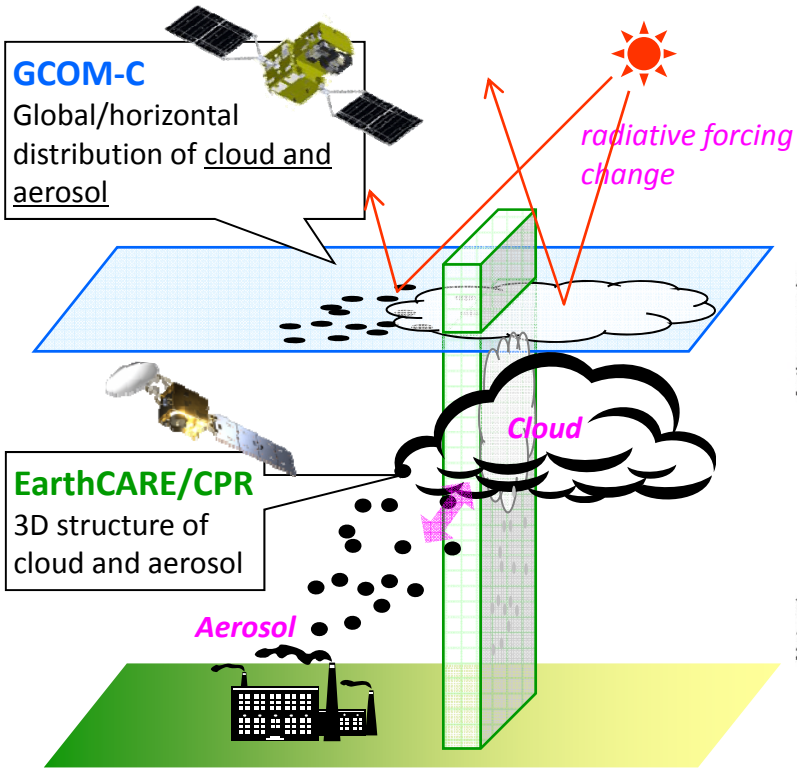
④ **EarthCARE/CPR**: Observation of vertical structure of clouds and aerosols

⑤ **GPM/DPR**: Accurate and frequent observation of precipitation with active and passive sensors

⑥ **ALOS**: Fine resolution mapping by optical and SAR instruments

GCOM-C Science Targets

Radiation budget of the atmosphere-surface system



Today's the most significant factor: atmospheric CO_2

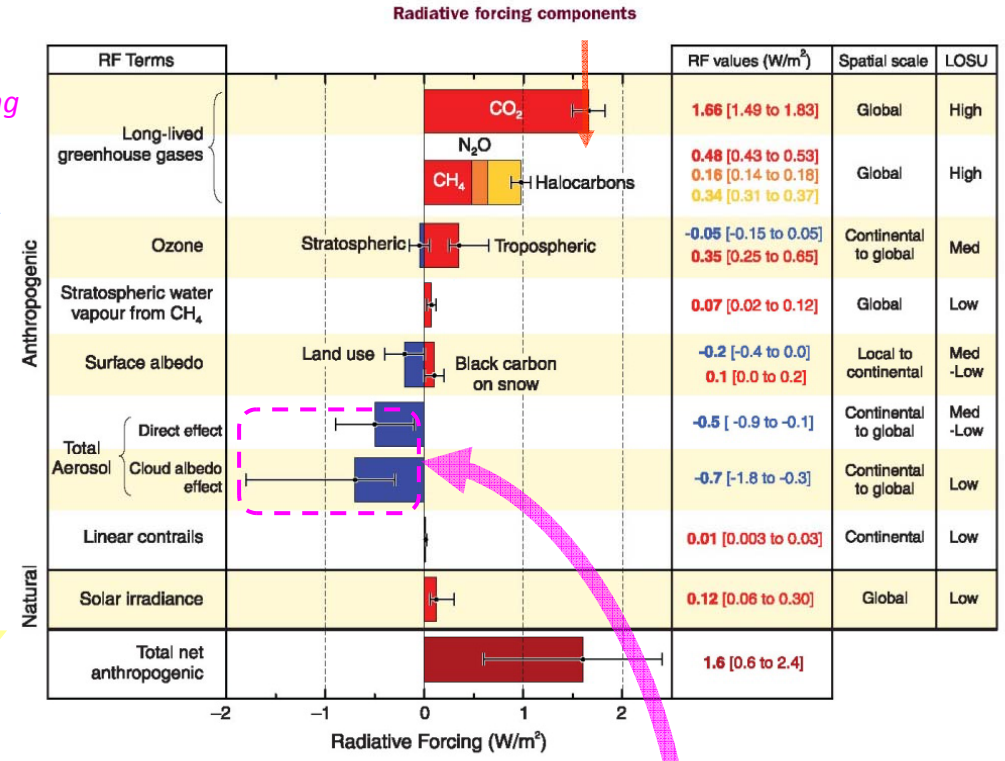


Figure 2.4. Global average radiative forcing (RF) in 2005 (best estimates and 5 to 95% uncertainty ranges) with respect to 1750 for CO_2, CH_4, N_2O and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). Aerosols from explosive volcanic eruptions contribute an additional episodic cooling term for a few years following an eruption. The range for linear contrails does not include other possible effects of aviation on cloudiness. {WGI Figure SPM.2}

Monitoring and process investigation about **cloud and aerosol by GCOM-C & EarthCARE**

Improvement

Evaluation of model outputs and process parameterization

Climate models
present and future cloud and aerosol roles in the global warming scenarios

Today's the most significant uncertainty of radiative forcing is direct/indirect role of cloud-aerosol system

Climate Observations

- Climate Change and Water Cycle
  - GCOM-W1(2011)/GCOM-C1(2014)/GPM(2013-)/ EarthCARE(2013)
- Global Warming and Carbon Cycle
  - GOSAT(2009-)/ALOS(2006-)/GCOM-C1(2014)
- JAXA will provide 17 operatinally and 12 experimentally out of 45 ECVs, saving 16 for the future possibility.
  - Standard products (17): Observed, processed and disseminated, operationally.
  - Research products (12): Observed, processed and disseminated,experimentally, or indirect or partial retrieval.

45 ECV Derivation (JAXA:17, 12, 16)

Domain	Essential Climate Variables (Red: Standard, Blue: Research/Indirect/Partial)
Atmospheric (over land, sea and ice) (9, 4, 3)	Surface (3, 1, 2): Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapor.
	Upper-air (3, 2, 0): Earth radiation budget (including solar irradiances), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapor, Cloud properties.
	Composition (3, 1, 1): Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties.
Oceanic (3, 2, 10)	Surface (3, 0, 5): Sea-surface temperature, Sea-surface salinity, Sea-level, Sea state, Sea ice, Current, Ocean color (for biological activity), Carbon dioxide partial pressure.
	Sub-surface (0, 2, 5): Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial (5, 6, 3)	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photo synthetically active radiation (fAPAR), Leaf area Index (LAI), Biomass, Fire disturbance, Soil moisture.

GCOS -107 Systematic Observation Requirements for Satellite-based Products for Climate, p. 81, Sep. 2006.

GCOM-W1 (8, 0)

◆Atmospheric (4)

<Surface> (2)

- Precipitation [Standard; surface precipitation]
- Wind speed and direction [Standard; sea surface scalar wind speed]

<Upper-air> (2)

- Water vapor [Standard; Columnar water vapor]
- Cloud properties [Standard; Columnar cloud liquid water]

◆Oceanic (2)

<Surface> (2)

- Sea-surface temperature [Standard]
- Sea ice [Standard; sea ice concentration]

◆Terrestrial (2)

- Snow cover [Standard; snow depth]
- Soil moisture [Standard; surface soil moisture]

GCOM-C1 (9, 8)

Atmospheric (2, 2)
- Surface radiation budget [Research; SW/LW downward radiation, surface temp, and surface albedo]
- Wind speed and direction [indirectly by cloud tracking; undefined]
- Cloud properties [Standard; optical thickness, top temperature, and phases]
- Aerosol properties [Standard; aerosol optical thickness, angstrom exponent, and types]

Oceanic (3, 2)
- Sea-surface temperature [Standard]
- Sea ice [Standard: as a cloud/snow ice flag]
- Ocean color (for biological activity) [Standard]
- Carbon [indirectly from Ocean color as dissolved and particulate organic carbon]
- Phytoplankton [indirectly from Ocean color as classification of major types]

Terrestrial (4, 4)
- Snow cover [Standard]
- Glaciers and ice caps [Research; large ones]
- Albedo [Research]
- Land cover (including vegetation type) [Research; global dynamic (e.g., monthly) land cover]
- Fraction of absorbed photo synthetically active radiation (fAPAR) [Standard]
- Leaf area Index (LAI) [Standard]
- Biomass [Standard; as above-ground biomass]
- Fire disturbance [Research; as hot spots and Land-cover changes]

GPM (1, 2)

Atmospheric (1, 2)

- Precipitation [Standard; surface and vertical precipitation]
- Surface radiation budget [Research; surface lantent heating rate]
- Upper-air radiation budget [Research; vertical latent heating rate]

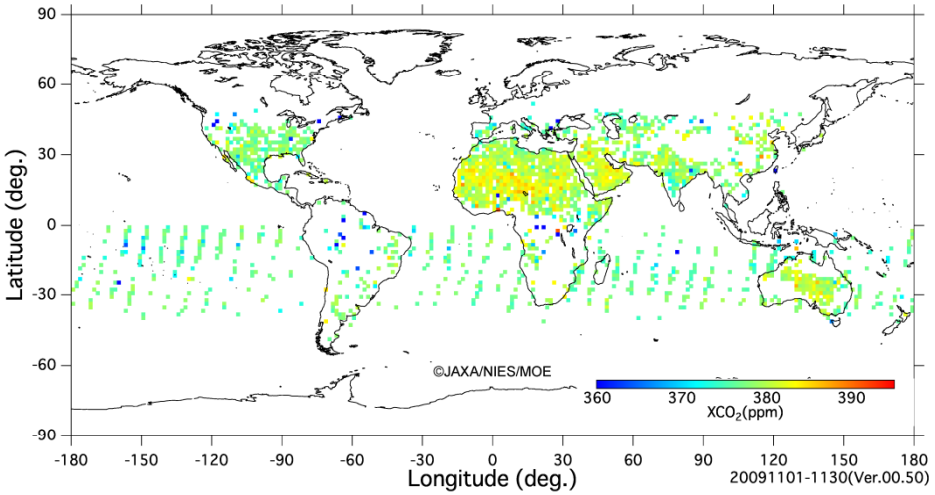
GOSAT(3, 7)

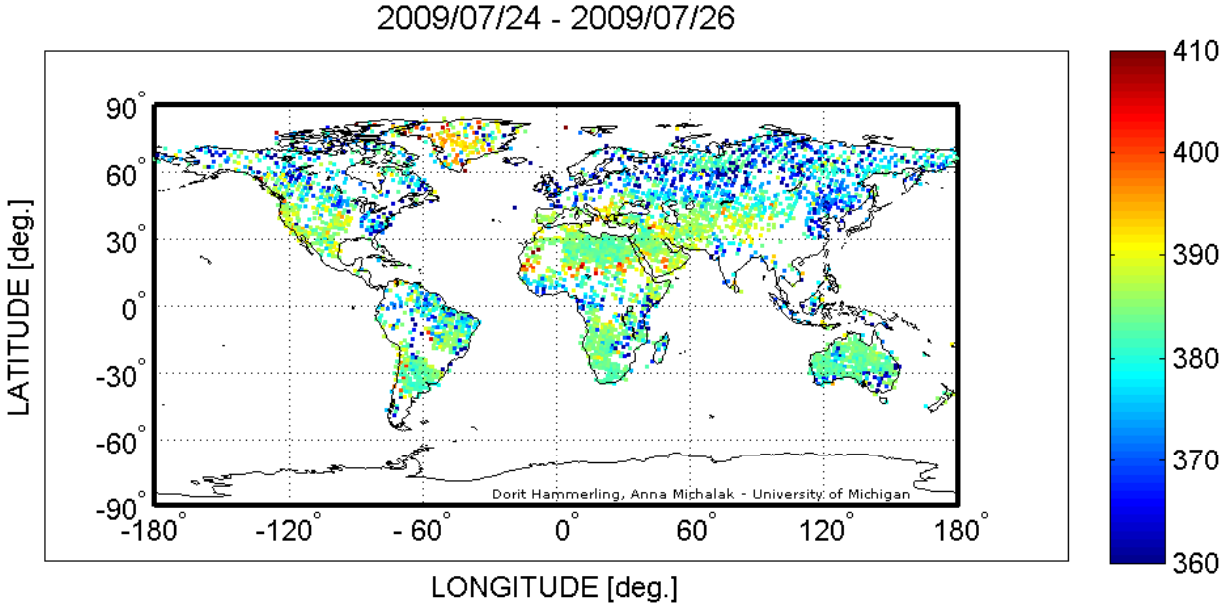
Atmospheric
Composition (2, 1): Carbon dioxide, Methane, Aerosol properties
Standard product
FTS L2 CO_2 column amount (SWIR)
FTS L2 CH_4 column amount (SWIR)
FTS L2 CO_2 profile (TIR)
FTS L2 CH_4 profile (TIR)
Research product
FTS L2 CO_2 column amount (TIR)
FTS L2 CH_4 column amount (TIR)
CAI L2 aerosol property
Upper-air (1, 2): Upper-air temperature, Water vapor, Cloud properties (cloud flag, cloud properties)
Standard product
CAI L2 cloud flag
Research product
CAI L2 cloud property
FTS L2 temperature profile (TIR)
FTS L2 H_2O column amount (SWIR)
FTS L2 H_2O profile (TIR)
FTS L2 H_2O column amount (TIR)
Terrestrial (0, 1): Land cover (including vegetation type),
Standard product
CAI L3 global NDVI

For the L2 proructs, L3 producst are also produced.
The following products would be produced as research products.(0, 3)
Composition: Ozone, Oceanic: Sea-surface temperature, Upper-air: Earth radiation budget

CO_2 Column Density

Upper panel: Data on November 2009, processed by JAXA/NIES/MOE
Lower panel: Data on July 2009, processed by ACOS Team





EarthCARE (3, 4)

EarthCARE has 4 sensors on board (CPR, ATLID, MSI, BBR). Products will be yielded from 1 sensor or synergestic use of several sensors.Products include vertical parameters and horizontal parameters.

Atmospheric (3): Cloud properties, Aerosol properties, Earth Radiation budget (33 Standard products)

- Cloud Profiling Radar Basic L1b Data [Received Echo Power, Radar Reflectivity, Surface Radar Cross Section, Doppler Velocity, Covariance of Pulse Pair]
- Cloud Profiling Radar L2 Data [Integrated Reflective factor, Gas correction factor, Integrated Doppler Velocity]
- Cloud Properties [Cloud Mask, Cloud Particle Type, Radar Reflectivity with Attenuation Correction, Effective Rdius of Liquid & Ice, and Liquid Water Content & Ice Water Content, Optical Thickness, Cloud Flag including Cloud Phase, Effective Radius of Liquid (1.6μm & 2.16μm from MSI), Cloud Top Temperature & Pressure & Height, Rain & Snow Products]
- Aerosol Properties (Extinction & Backscatter Coefficient, Depolarization Ratio, Mode Radius (Fine-mode), (Mode Radius (Fine-mode))]
- Radiation Budget (CPR, ATLID, MSI) Radiative Flux at TOA & BOA
- Vertical Motion [Doppler Velocity (inhomogenious) , Vertical Velocity]

Atmospheric (4): Aerosol properties, Earth radiation budget, precipitation, Cloud properties (25 Research products)

- Aerosol Properties (Aerosol Extinction Coefficient (Water Soluble, Dust, Sea Salt, Black Carbon), Mode Radius of Fine-mode & Coarse-mode]
- Radiation Budget (BBR) [Radiative Flux at TOA & BOA]
- Vertical Motion [Doppler Velocity (inhomogenious), Vertical Air Motion, Sedimentation Velocity, Multiple Scattering Effect]
- Rain & Snow [Rain & Snow Water Content, Rain & Snow Rate]
- Ice Cloud (MSI) [Optical Thickness (Ice) with Reflection-Method, Effective Radius of Ice with Reflection-Method (1.6 & 2.1μm channel), Ice Cloud Top Temperature & Pressure & Height]
- Aerosol (MSI) [Aerosol Optical Thickness (Ocean & Land), Angstrom Parameter (Ocean)]
- Ice Cloud Property (CPR) [Mass Ratio (2D_Ice/IWC)]

ALOS(0, 9)

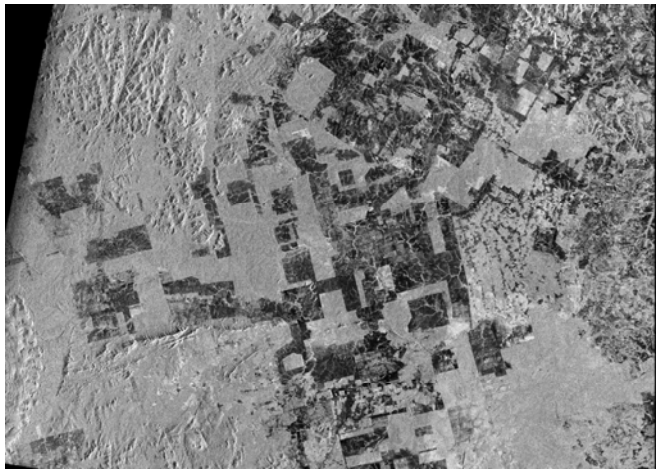
Terrestrial (8)

- River discharge [indirectly: provide DEM; regional scale]
- Lake levels [Research; regional scale]
- Snow cover [Research; regional scale]
- Glaciers and ice caps [Research; regional scale]
- Albedo [Research; regional scale]
- Land cover (including vegetation type) [Research; ; regional scale]
- Leaf area Index (LAI) [Research; regional scale]
- Biomass [Research; as above-ground biomass]

Oceanic (1)

- Sea ice [Research; semi-global scale, 50m/500m mosaic global sacle]

Deforestation Monitoring in Amazon

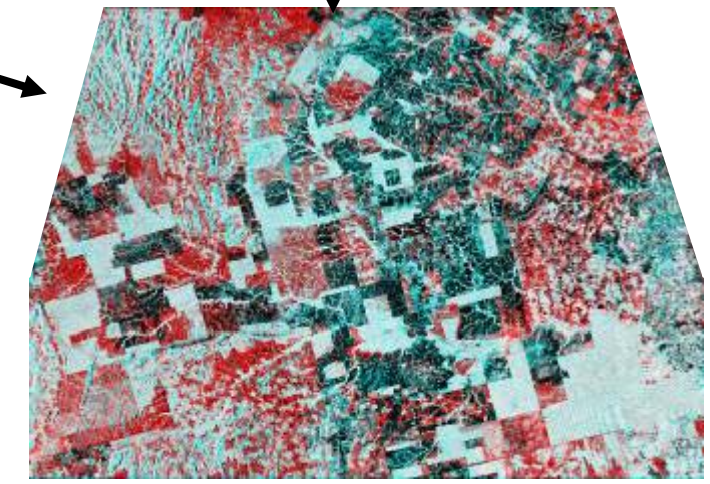


JERS-1 SAR (Oct., 1996)

ALOS PALSAR (Jun., 2006)

Above image shows one of most popular deforestation site.

Red shows deforestation area during 10years



100km

10 year image comparison using JERS-1/SAR with ALOS/PALSAR.

Goals

- GCOM: 13-year long-term observation on climate change to contribute Climate Record Data (CRD)
- GPM: Continuous long term (15+ years) and high-accurate precipitation data record from TRMM to GPM, and improvement of retrieval accuracy of multi-microwave radiometers by DPR
- EarthCARE: Cloud-Aerosol-Radiation Interaction and integrated use with GCOM/GPM to improve GCM
- ALOS: Forest, Land Cover and Sea Ice Mapping
- GOSAT: Global Distribution of CO_2 and CH_4 in Column Density and Carbon Flux in sub-continental scale

Priorities

GEOSS 10yr Implementation Plan

GEOSS

Earth System Models
- Oceans
- Cryosphere
- Land
- Atmosphere
- Solid Earth
- Biosphere

Prediction and Analysis
High Performance Computing;
Communication
Visualization

Other Data Sources
Socio-economic data

Assimilation

Earth Observation Systems
- In Situ
- Airborne
- **Space-based**

Standards & Interoperability

Observations

Decision Support
- Assessment
- Decision Support Systems

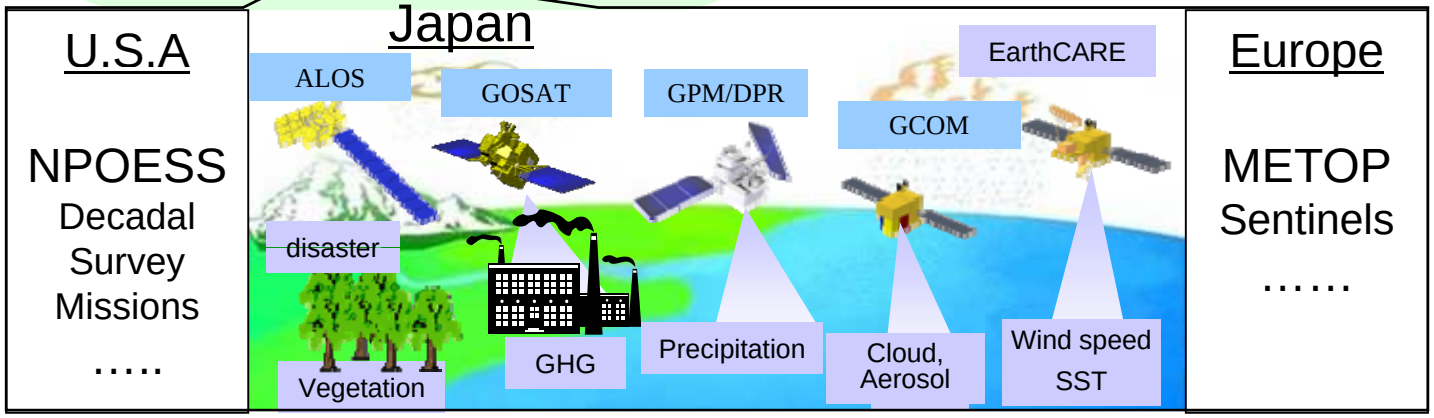
Policy Decisions

Management Decisions

Ongoing feedback to optimize value, reduce gaps, and account for human activity

9 Societal Benefit Areas

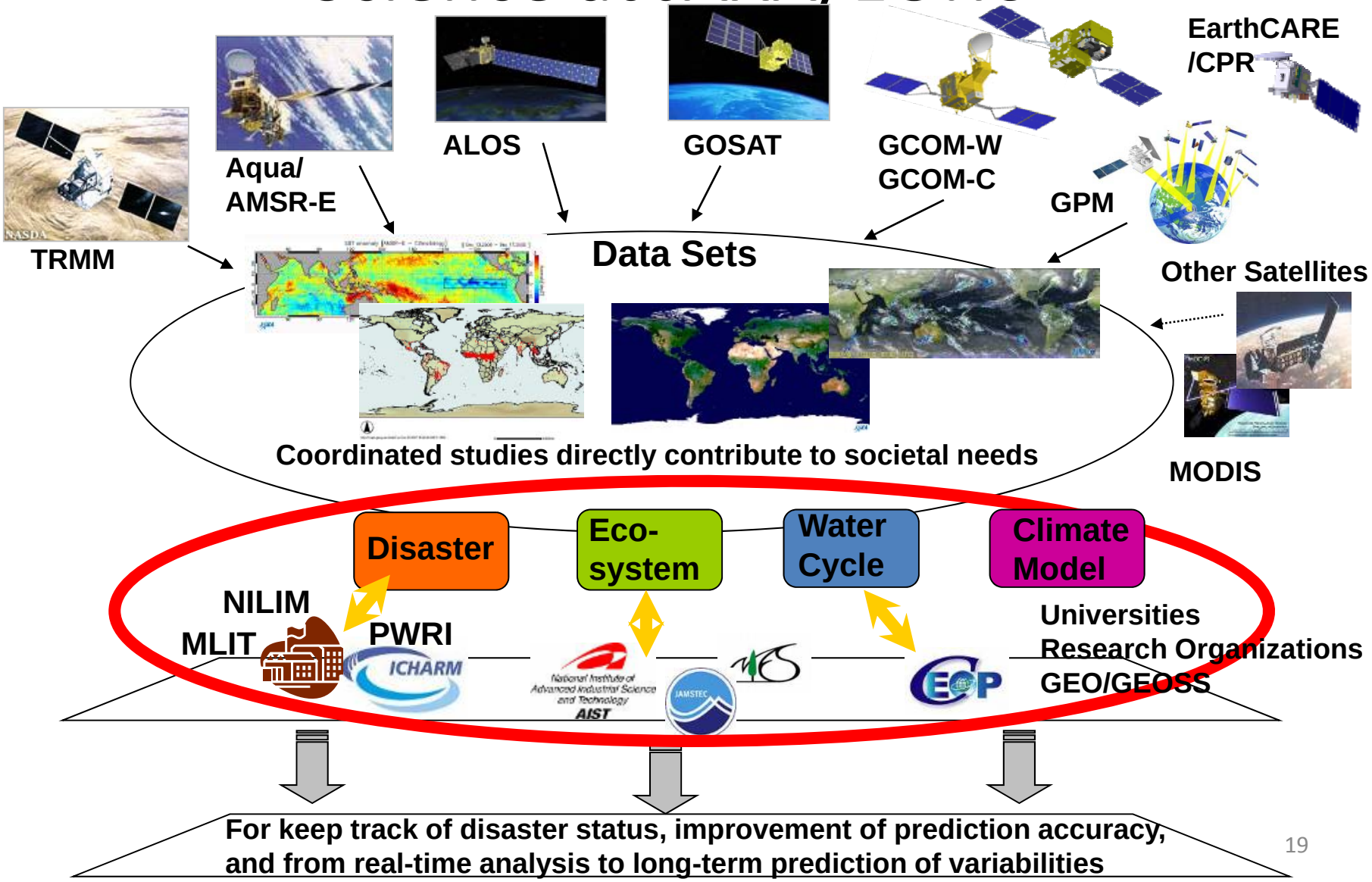
Red: Japanese priority areas



Key Assets

- Comprehensive Data Sets on Climate and Environmental Change in geospatial scale of Global, Regional, Local, by monthly, daily in time scale over 13 years (in GCOM).
- Reprocessing with updated algorithm reflecting latest Cal/Val results.
- Cross-cutting data integration of EO satellites and in-situ data and climate models.

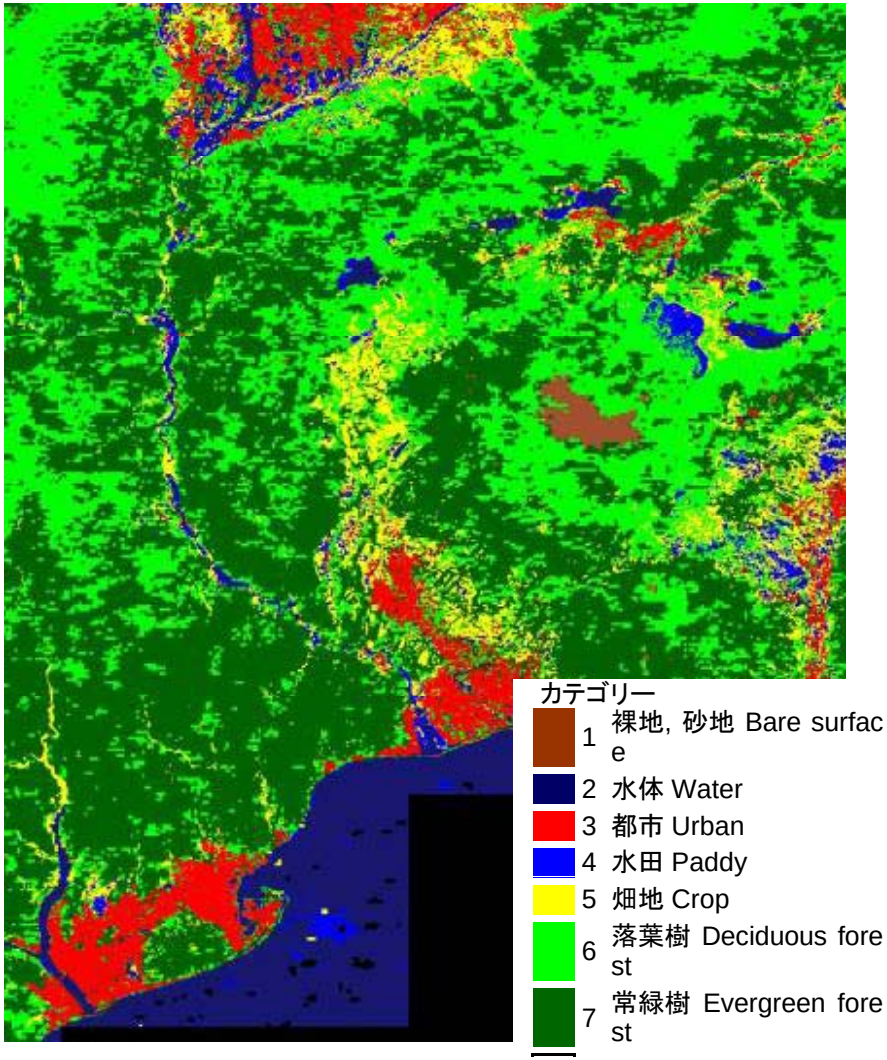
Cross-Cutting/Interdisciplinary Science at JAXA/EORC



Precise Land-Use and Land-Cover (LULC) Map using ALOS/AVNIR-2

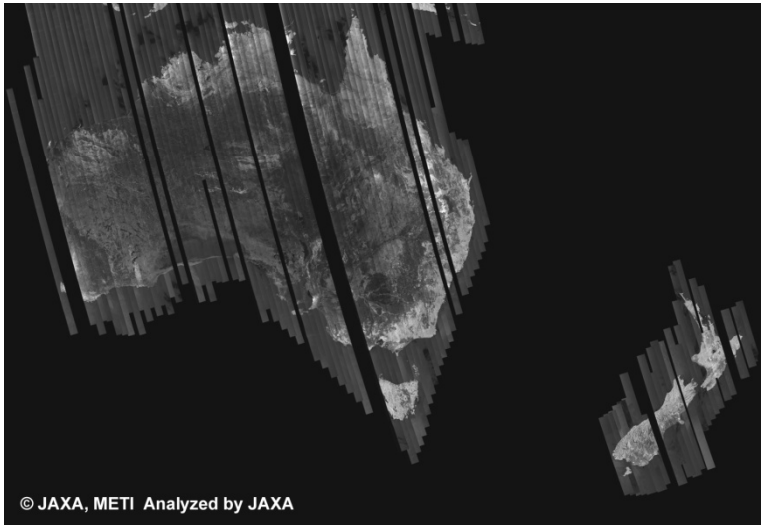
Land-Use and Land-Cover Map

by AVNIR-2 20m spatial resolution



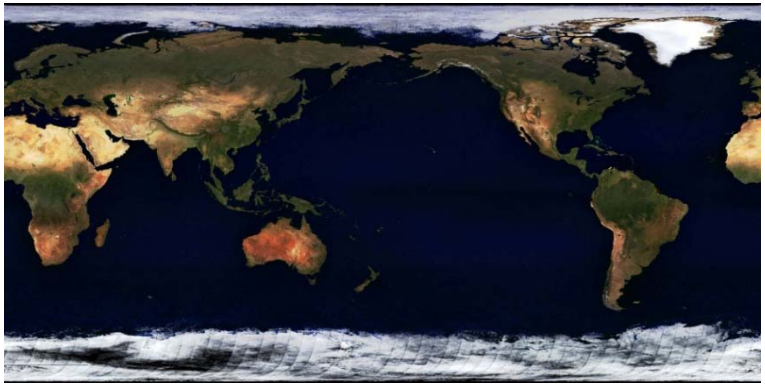
Continental Scale Mosaic

PALSAR 500m Browse by Kyoto & Carbon Initiative



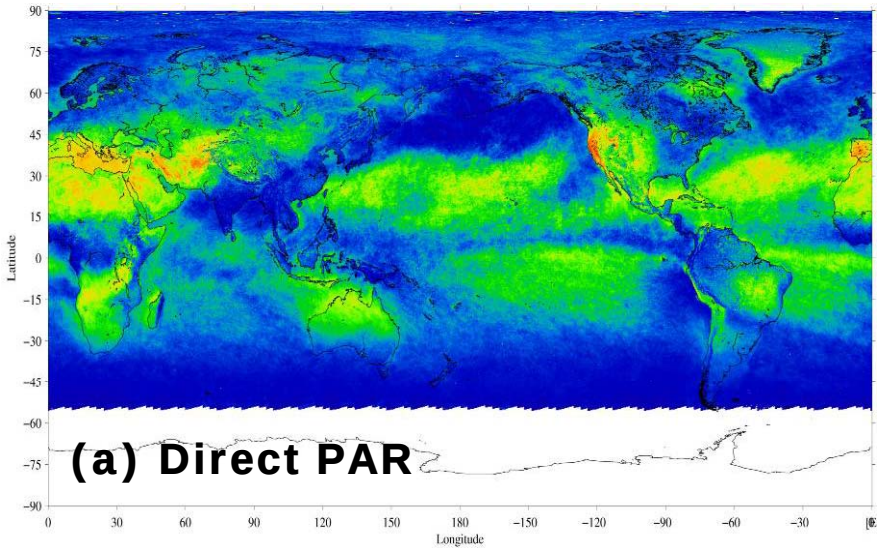
Future Idea: Global LULC Map

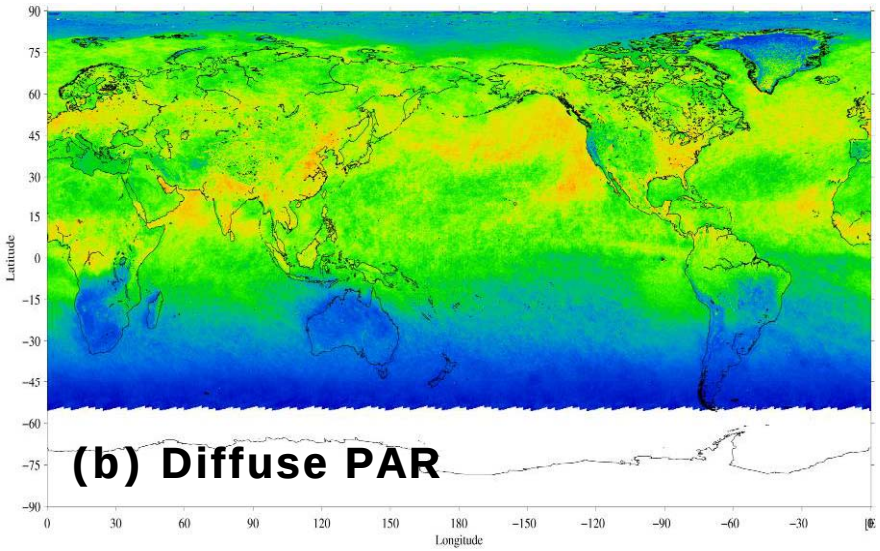
Image by ADEOS-II/GLI Global Radiance

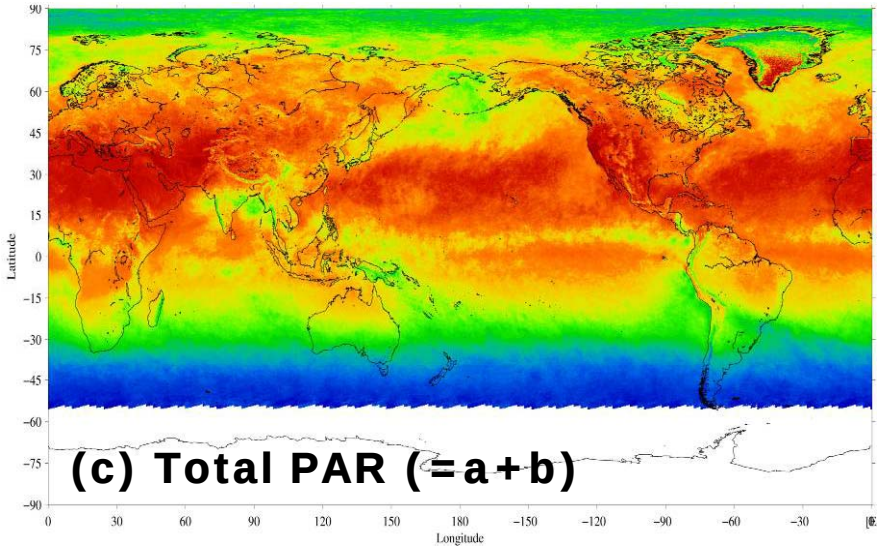


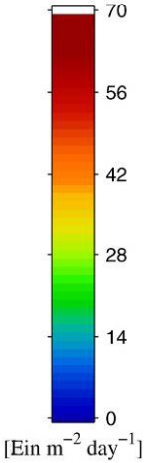
Estimation of Total, Direct and Diffuse Components of PAR

July 2009 Monthly (Aqua MODIS)





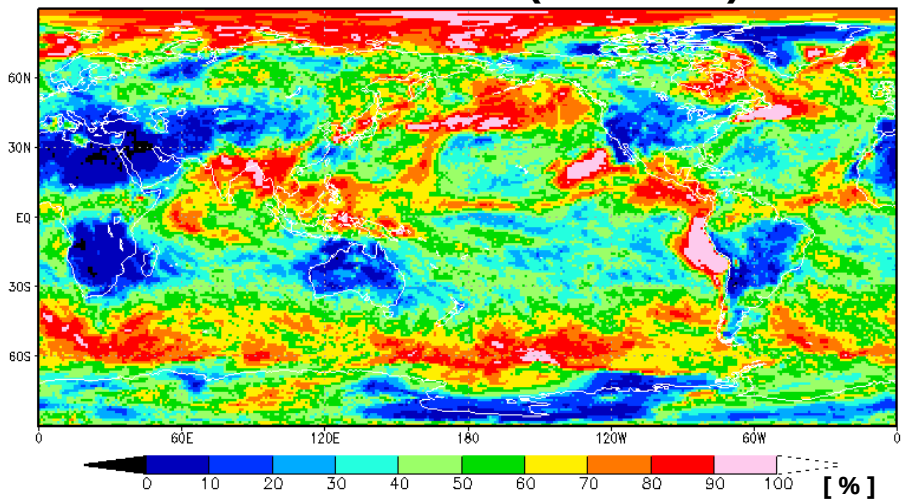




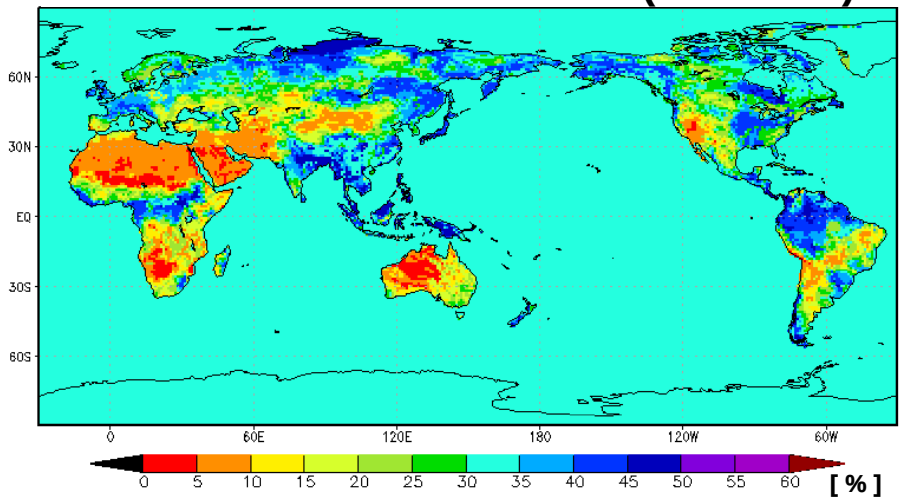
(Courtesy of Dr. Murakami, JAXA / EORC)

Test Processing of Real Time Offline Simulation System of a Land Surface Model

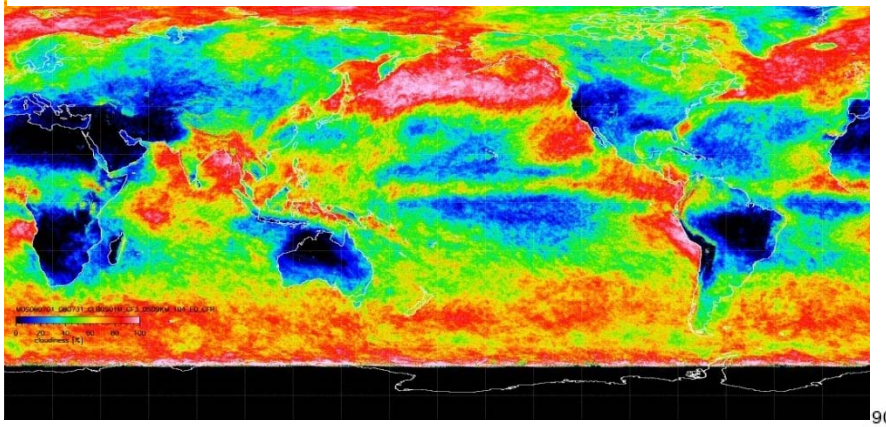
GPV Total Cloud Cover (Jul.2008)



MATSIRO 5cm Soil Moisture (Jul.2008)

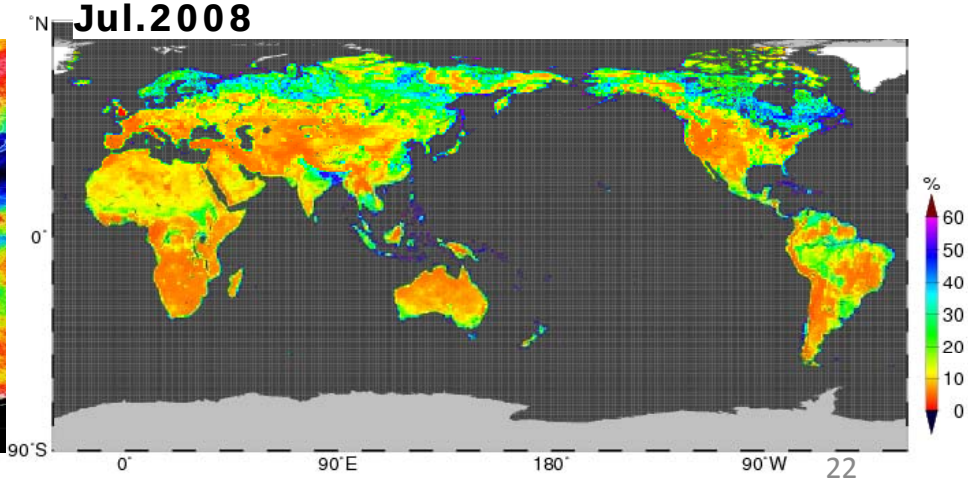


(Reference)
Terra/MODIS Cloudiness (Dsc. only)
Jul.2008



(Courtesy of Dr. Hori, JAXA/EORC)

(Reference)
Aqua/AMSR-E Soil Moisture (Asc/Dsc)
Jul.2008



(Courtesy of Dr. Fujii, JAXA/EORC)

Critical Issues

- Continuous operation without gaps of long-term data sets by cooperation of space R&D agencies and metrological operational agencies.
- Due funding for efficient agencies to develop and operate satellites, sensors, data processing and analysis and dissemination of common, standard and research products.
- Collaboration between development, operation and science communities of researches, observations and models.

Time-scales

- In short-term (present - 5 years)
  - TRMM/PR (1997-), Aqua/AMSR-E (2002-), ALOS (2006-), GOSAT (2009-) to achieve some threshold and breakthrough requirements.
  - GCOM-W1 (2011), GPM/DPR (2013-), EarthCARE/CPR (2013), GCOM-C1 (2014) to achieve some threshold and breakthrough requirements.
- In middle-term (1-2 decades)
  - ALOS-2, 3, GCOM-W2, 3, C2, C3, post GOSAT, post GPM, Geostationary Atmospheric and Meteorological Satellite, space-marine cooperation missions, EO from ISS, etc. to challenge critical issues to achieve goals of requirements in CEOS cooperation.

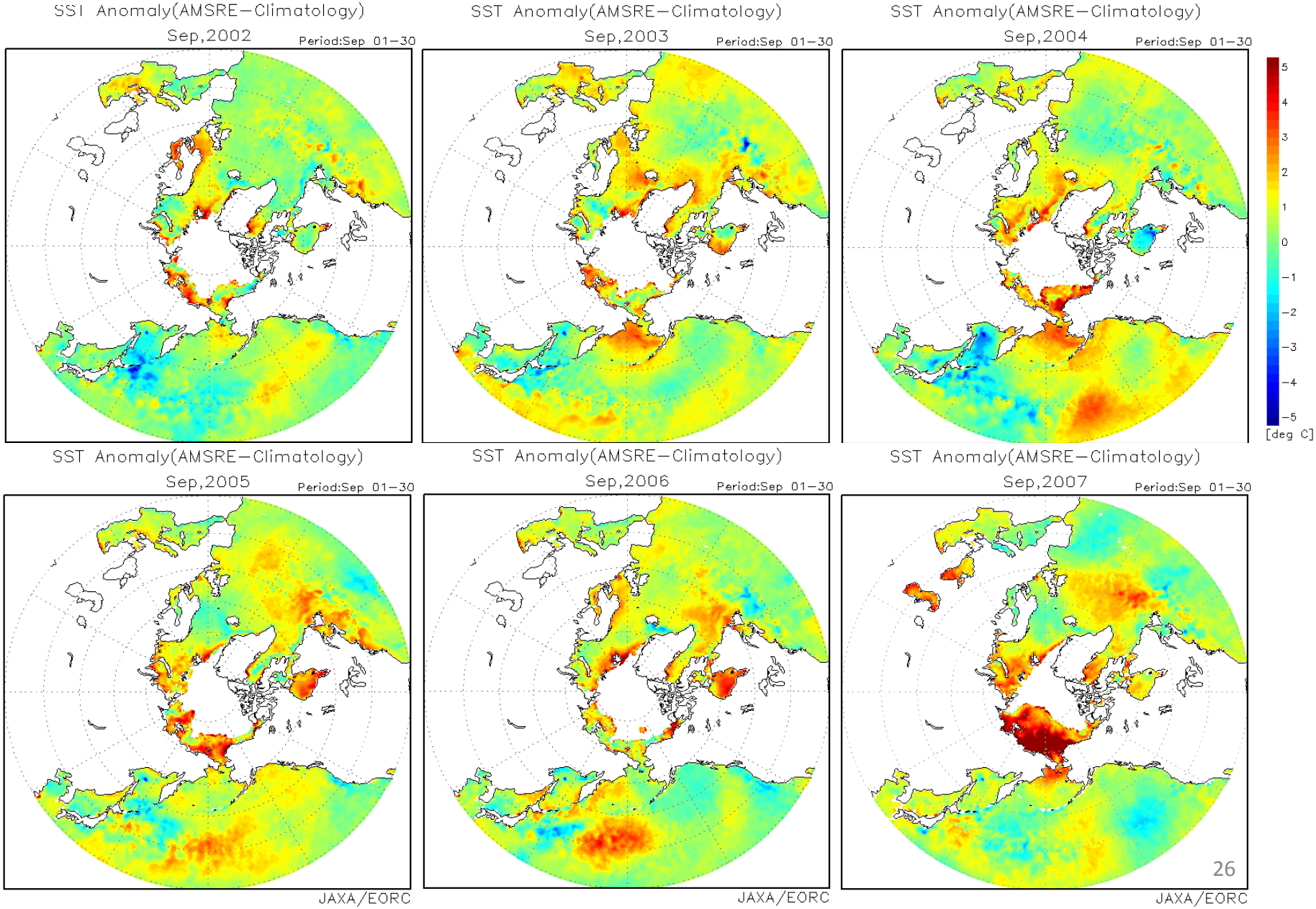
JAXA's Offer to Support the Goals of other Agencies

- Follow up of WCRP 4th WOAP
  - Microwave SST data continuity:

    GCOM-W1/AMSR2 will be launched in 2011, if Aqua/AMSR-E is alive, inter-calibration is available to confirm data continuity and consistency in the same afternoon orbit of A-Train.
  - Lack of limb sounders

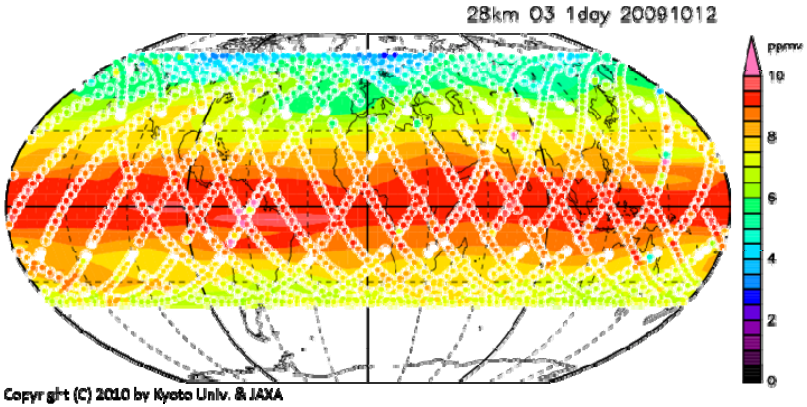
    SMILES on ISS have demonstrated applicability of sub millimeter wave limb sounding capability of atmospheric components; O_3 etc.

SST Anomaly in Northern High Latitudes

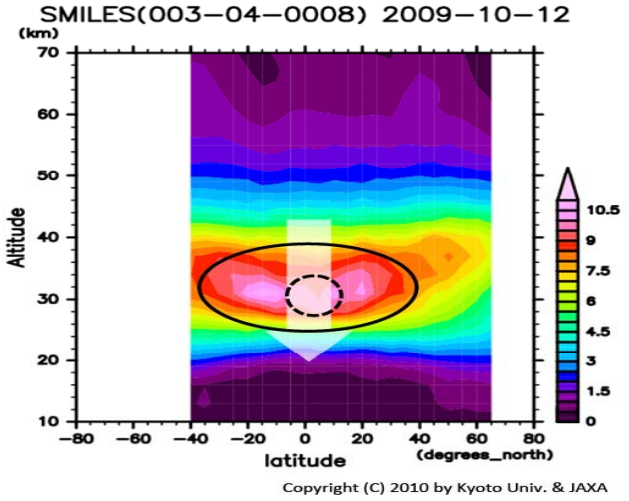


Early Results from SMILES onboard JEM/ISS, Oct. 12, 2009

- High sensitivity in detecting atmospheric limb emission in the submillimeter wave range (624-650GHz)
- Vertical profiling (~3km) from JEM/ISS with latitudinal coverage from 65N to 38S



- Standard products:
  - **Single-scan: O_3, HCl, ClO, CH_3CN, O_3 isotopes, HOCl, HNO_3**
  - **Multi-scan: HO_2, BrO**
    (* spectrum signals are too weak to retrieve in single-scan)
- Research products: **volcanic SO_2, H_2O_2, Humidity in upper-troposphere, ice clouds**



- Global Ozone Layer Map at altitude 28km
- Ozone Latitude-Altitude Distribution

http://smiles.tksc.jaxa.jp/news/indexj.shtml
http://smiles.tksc.jaxa.jp/indexe.shtml

JAXA's Offer to Support the Goals of other Agencies

- Cooperation between Space Agencies and Meteorological Agencies
  - GCOM-W1, C1, and GPM data use by meteorological agencies as well as space agencies, in mutual cooperative frameworks.
  - For the exchange of information on Cal/Val activities between Space and Meteorology, JAXA is participating in GCICS as an observer and other meetings as well as in CEOS Cal/Val Working Group.
- Cooperation with WMO/GCOS/WCRP
  - Information exchange in meetings such as WCRP WOAP, etc.

JAXA's Offer to Support the Goals of other Agencies

- CEOS Satellite Constellation
  - Precipitation

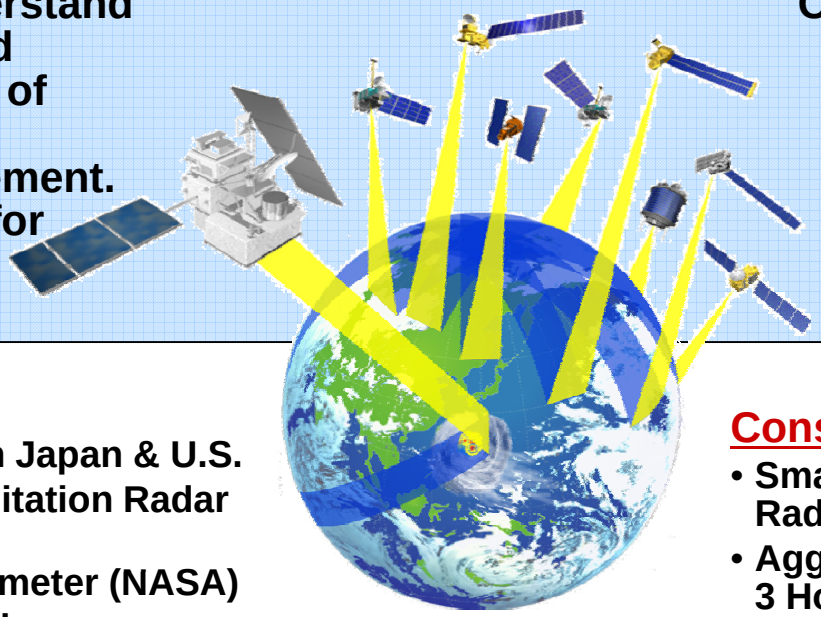
    JAXA will participate with GCOM-W1/AMSR2 (launch in 2011) and GPM/DPR (launch in 2013)
  - Ocean color and SST

    JAXA will participate with GCOM-C1/SGLI (launch in 2014)
  - Atmospheric Components (ACC)

    JAXA is considering to participate with Geostationary Atmospheric and Meteorological Satellite (in pre-phase A at present)

Global Precipitation Measurement (GPM)

OBJECTIVE: Understand the Horizontal and Vertical Structure of Rainfall and Its Microphysical Element. Provide Training for Constellation Radiometers.



OBJECTIVE: Provide Enough Sampling to Reduce Uncertainty in Short-term Rainfall Accumulations. Extend Scientific and Societal Applications.

Core Satellite

- Joint mission between Japan & U.S.
- Dual-frequency Precipitation Radar (JAXA and NICT)
- Multi-frequency Radiometer (NASA)
- July 2013, H2-A Launch
- Non-Sun Synchronous Orbit
- ~65° Inclination
- ~407 km Altitude

Constellation Satellites

- Small Satellites with Microwave Radiometers
- Aggregate Revisit Time, 3 Hour goal
- Sun-Synchronous/Non-sun-synchronous orbit
- 500~900 km Altitude
- International Partners; NOAA, NASA, JAXA, CNES/ISRO, etc.

Precipitation Validation Sites

- Global Ground Based Rain Measurement

Global Precipitation Processing Centers

- Capable of Producing Global Precipitation Data Products as Defined by GPM Partners

Specific Actions
JAXA would welcome from others

- MODIS data use as the precursor of SGLI algorithm development and inter calibration and validation.
- Cooperative activities of science communities of CloudSAT, CALIPSO and EarthCARE. Also data use is helpful for the evaluation of SGLI polarization channels availability.
- TRMM and Aqua continuous operation to maintain observation of PR on TRMM and AMSR-E on Aqua.