JAXA Level 2, Validation and Applications Preparation

Takuji Kubota

Earth Observation Research Center (EORC)

Japan Aerospace Exploration Agency (JAXA)
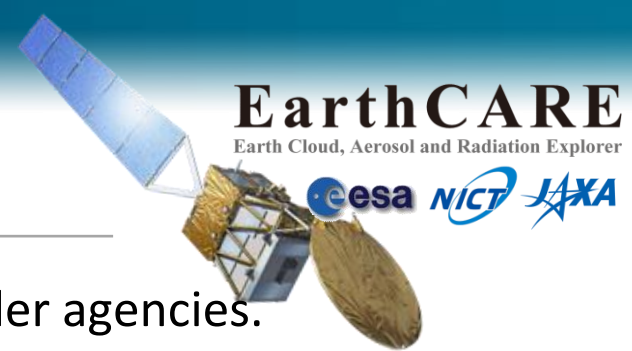
B2.06.1 EarthCARE Ready For Launch

2022 Living Planet Symposium
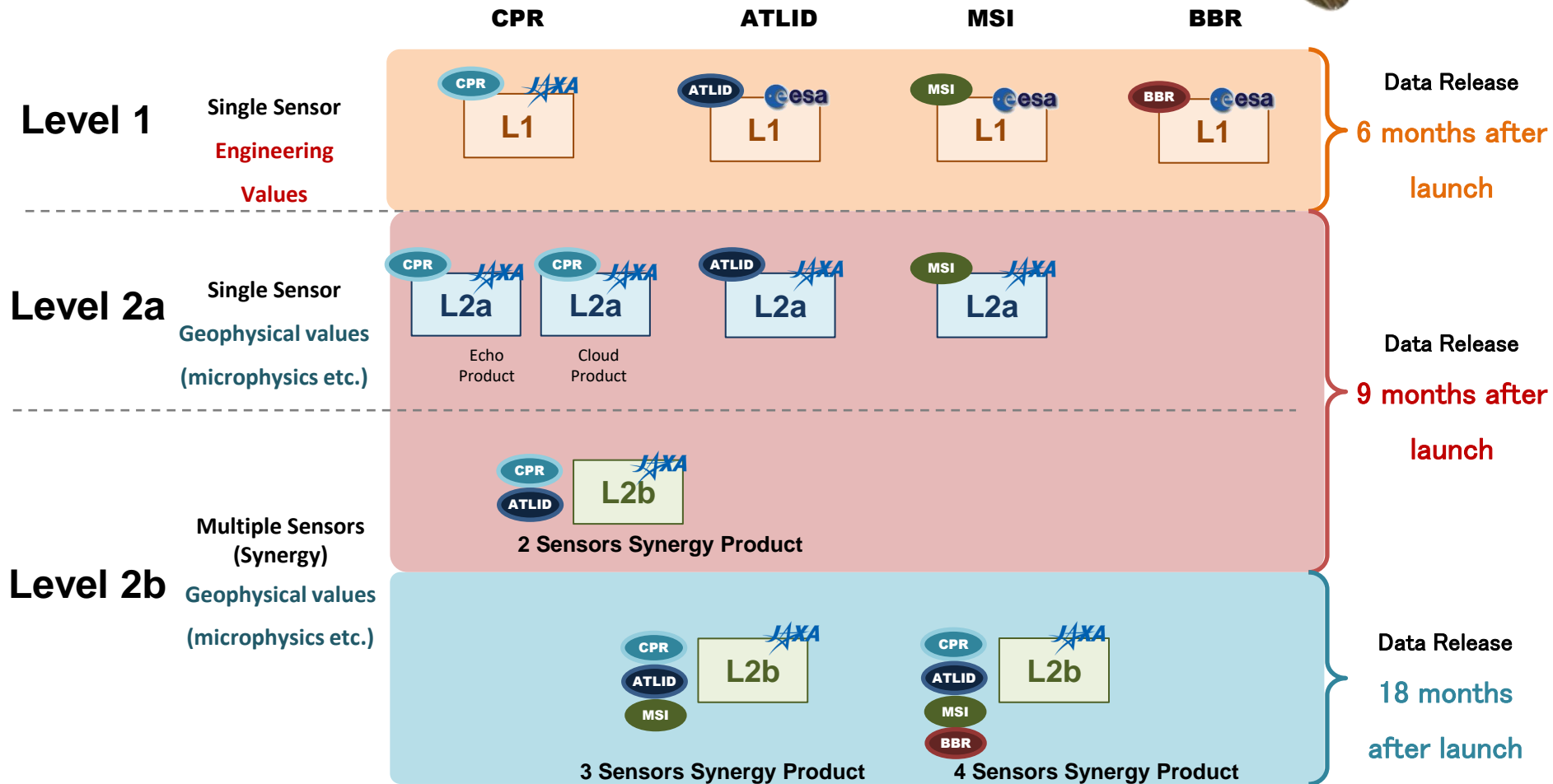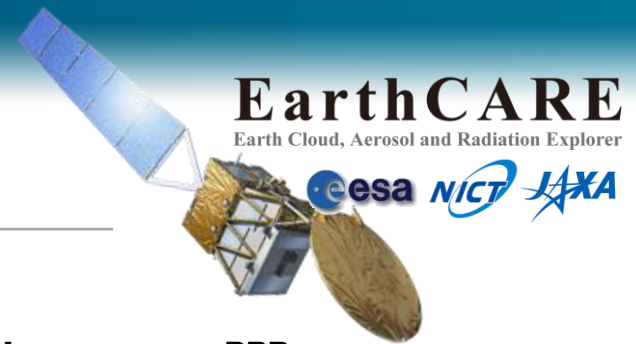
23-27 May 2022, World Conference Center Bonn

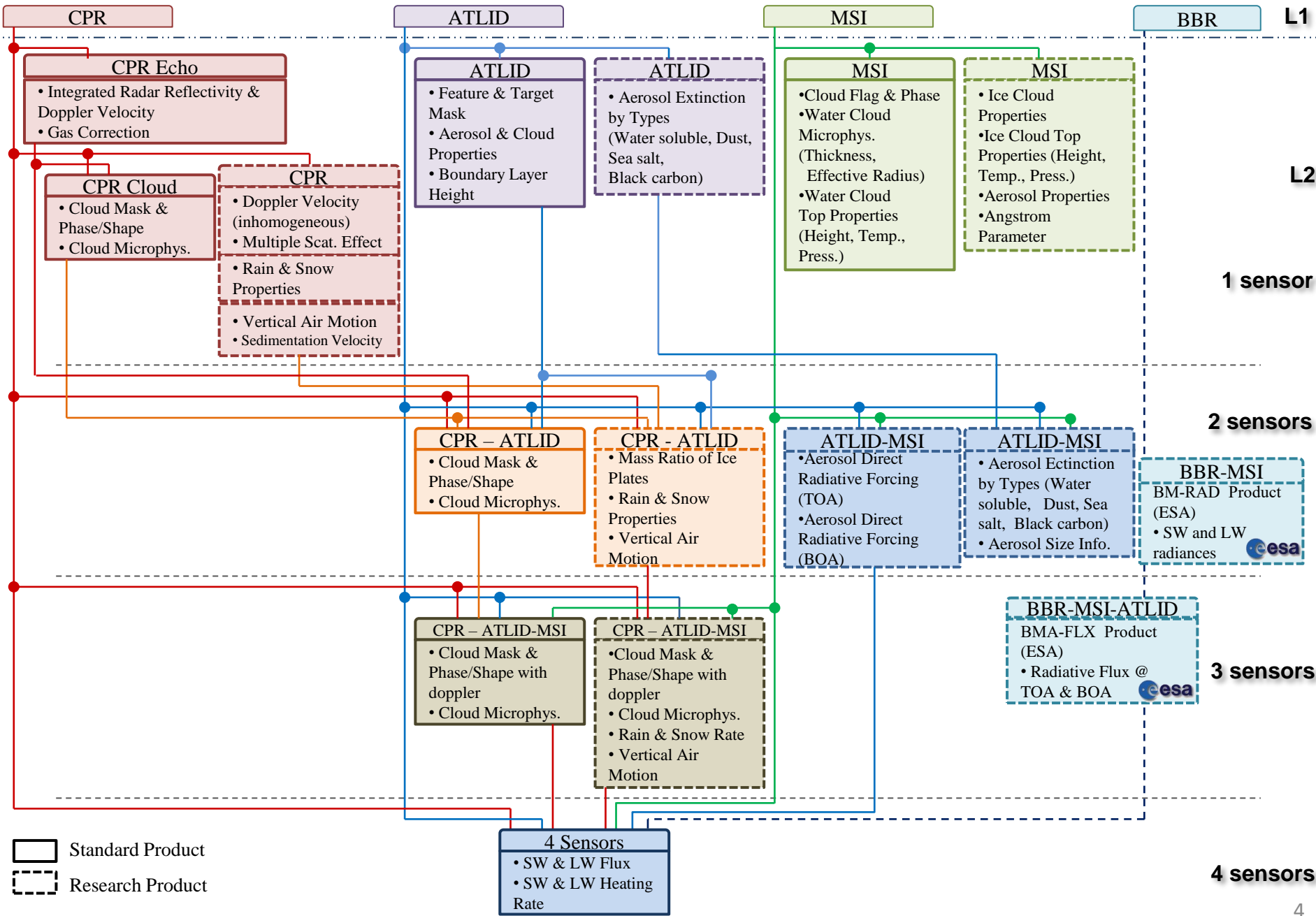Bonn, Germany

EarthCARE JAXA Product

- Level 1 product will be developed by sensor provider agencies.
  - ✓ i.e. JAXA will provide CPR Level 1 product
- JAXA and ESA develop Level 2 geophysical products individually, under the Joint Algorithm Development Endeavour (JADE) in the framework of the Joint Mission Advisory Group (JMAG).
- JAXA and ESA products will be distributed by both agencies.

- For JAXA Level 2 Products, it is consisted by two categories;
  - ☐ **Standard Products**
    - – strongly promoted to be developed and released
    - – processed and released from JAXA G-Portal
    - – all data will be able to be sent to ESA when produced
  - ☐ **Research Products**
    - – promoted to be developed
    - – released from JAXA Earth Observation Research Center(EORC)
    - – some are planned to be upgraded to standard products

EarthCARE JAXA L2 Production Model

CPR   **ATLID**   **MSI**   **BBR**   **L1**

CPR Echo
• Integrated Radar Reflectivity & Doppler Velocity
• Gas Correction

ATLID
• Feature & Target Mask
• Aerosol & Cloud Properties
• Boundary Layer Height

ATLID
• Aerosol Extinction by Types (Water soluble, Dust, Sea salt, Black carbon)

MSI
• Cloud Flag & Phase
• Water Cloud Microphys. (Thickness, Effective Radius)
• Water Cloud Top Properties (Height, Temp., Press.)

MSI
• Ice Cloud Properties
• Ice Cloud Top Properties (Height, Temp., Press.)
• Aerosol Properties
• Angstrom Parameter

L2

CPR Cloud
• Cloud Mask & Phase/Shape
• Cloud Microphys.

CPR
• Doppler Velocity (inhomogeneous)
• Multiple Scat. Effect
• Rain & Snow Properties
• Vertical Air Motion
• Sedimentation Velocity

1 sensor

2 sensors

CPR – ATLID
• Cloud Mask & Phase/Shape
• Cloud Microphys.

CPR - ATLID
• Mass Ratio of Ice Plates
• Rain & Snow Properties
• Vertical Air Motion

ATLID-MSI
• Aerosol Direct Radiative Forcing (TOA)
• Aerosol Direct Radiative Forcing (BOA)

ATLID-MSI
• Aerosol Ectinction by Types (Water soluble, Dust, Sea salt, Black carbon)
• Aerosol Size Info.

BBR-MSI
BM-RAD Product (ESA)
• SW and LW radiances
esa

BBR-MSI-ATLID
BMA-FLX Product (ESA)
• Radiative Flux @ TOA & BOA
esa

3 sensors

CPR – ATLID-MSI
• Cloud Mask & Phase/Shape with doppler
• Cloud Microphys.

CPR – ATLID-MSI
• Cloud Mask & Phase/Shape with doppler
• Cloud Microphys.
• Rain & Snow Rate
• Vertical Air Motion

4 Sensors
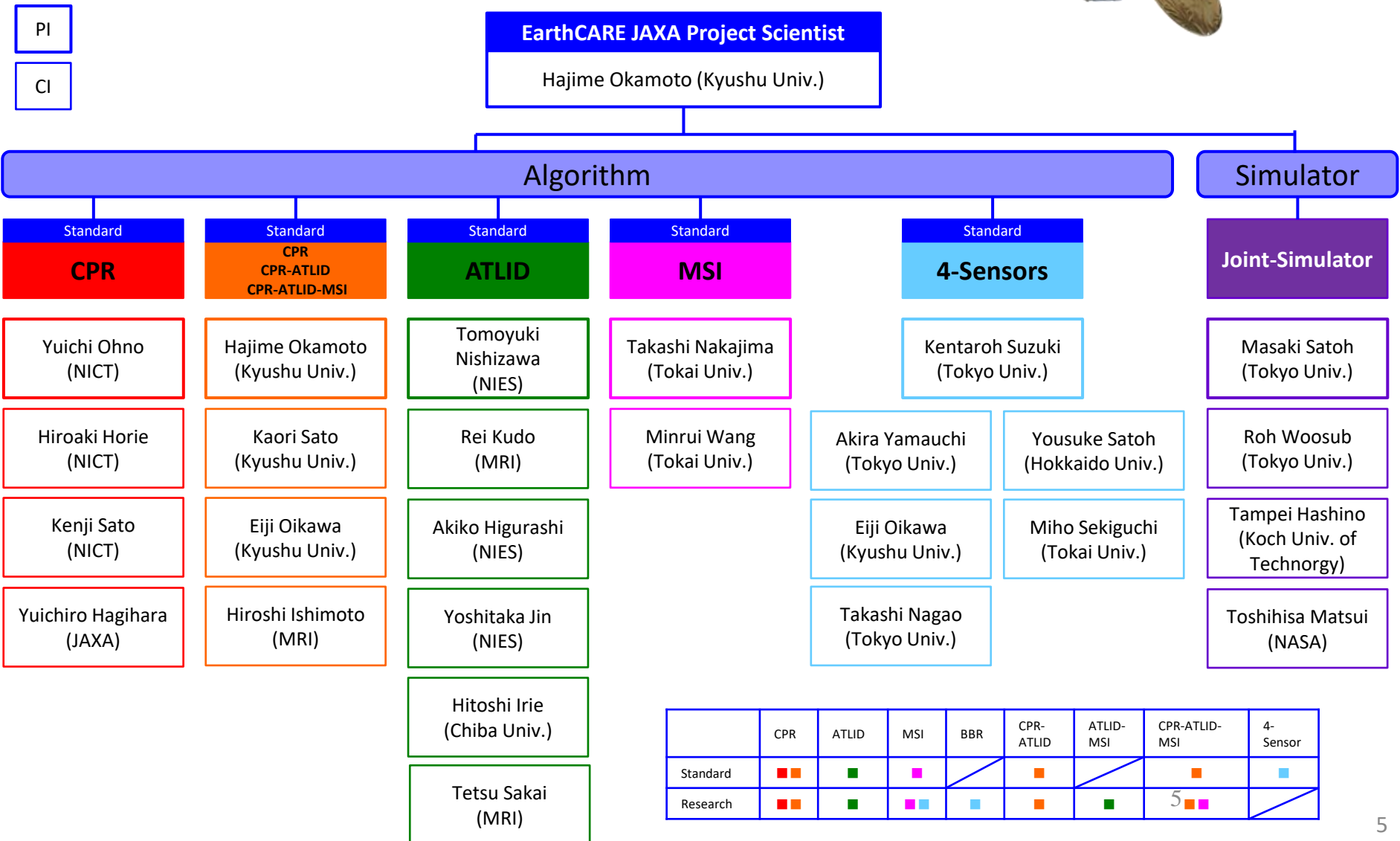• SW & LW Flux
• SW & LW Heating Rate

4 sensors

☐ Standard Product

⬚ Research Product

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EarthCARE JAXA Science Team Algorithm & Simulator (as of 2022)

EarthCARE
Earth Cloud, Aerosol and Radiation Explorer
esa NICT JAXA

PI
CI

EarthCARE JAXA Project Scientist

Hajime Okamoto (Kyushu Univ.)

Algorithm

Simulator

Standard **CPR**	Standard **CPR / CPR-ATLID / CPR-ATLID-MSI**	Standard **ATLID**	Standard **MSI**	Standard **4-Sensors**	**Joint-Simulator**
Yuichi Ohno (NICT)	Hajime Okamoto (Kyushu Univ.)	Tomoyuki Nishizawa (NIES)	Takashi Nakajima (Tokai Univ.)	Kentaroh Suzuki (Tokyo Univ.)	Masaki Satoh (Tokyo Univ.)
Hiroaki Horie (NICT)	Kaori Sato (Kyushu Univ.)	Rei Kudo (MRI)	Minrui Wang (Tokai Univ.)	Akira Yamauchi (Tokyo Univ.) / Yousuke Satoh (Hokkaido Univ.)	Roh Woosub (Tokyo Univ.)
Kenji Sato (NICT)	Eiji Oikawa (Kyushu Univ.)	Akiko Higurashi (NIES)		Eiji Oikawa (Kyushu Univ.) / Miho Sekiguchi (Tokai Univ.)	Tampei Hashino (Koch Univ. of Technorgy)
Yuichiro Hagihara (JAXA)	Hiroshi Ishimoto (MRI)	Yoshitaka Jin (NIES)		Takashi Nagao (Tokyo Univ.)	Toshihisa Matsui (NASA)
		Hitoshi Irie (Chiba Univ.)			
		Tetsu Sakai (MRI)			

	CPR	ATLID	MSI	BBR	CPR-ATLID	ATLID-MSI	CPR-ATLID-MSI	4-Sensor
Standard	🟥🟧	🟩	🟪		🟧		🟧	🟦
Research	🟥🟧	🟩	🟪🟦	🟦	🟧	🟩	5 🟧🟪	

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JAXA Algorithm development with the Joint-Simulator L1 synthetic data

- Level 2 algorithm development ongoing
  - Developments by 6 Algorithm PIs are ongoing.
  - Now All JAXA EarthCARE L2 algorithms can input synthetic data with the JAXA/ESA L1 formats from the Joint-Simulator and output physical variables in the JAXA L2 format.
- JAXA L2 ATBD is provided in the JAXA/EORC Website:
  http://www.eorc.jaxa.jp/EARTHCARE/index.html

EarthCARE L1 data construction in Japan

Algorithms have been developed using the synthetic data by the Joint-Simulator in the JAXA EarthCARE Science team.

Track & swath

Time since epoch (sec)

Time is in UTC.

Tb10.8 μm

- NICAM 3.5 km simulation, 2008 June 19th 00Z
- The data was interpolated based on the sampling procedure of each sensor.
- The orbit was simulated such a way that EarthCARE passes equator at 14:00 local time in the descending node.
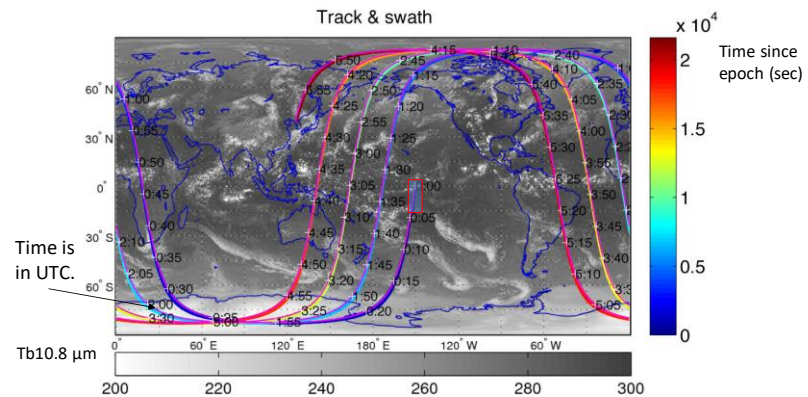
EarthCARE L1 Simulation by the Joint-Simulator using NICAM-SPRINTARS data

Lidar Simulation from NICAM (Last version: only cloud signals simulated)
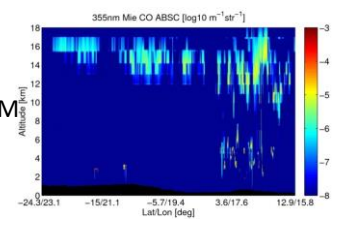
CPR Radar reflectivity Simulation from NICAM

MSI simulation

JAXA A-Train Product for EarthCARE

- JAXA has provided the "**EarthCARE Research A-Train Product**" since Oct. 2017.
  - *http://www.eorc.jaxa.jp/EARTHCARE/research_product/ecare_monitor_e.html*

Latest algorithms for EarthCARE

↓

Algorithms for A-Train satellites

↓

JAXA A-Train Product
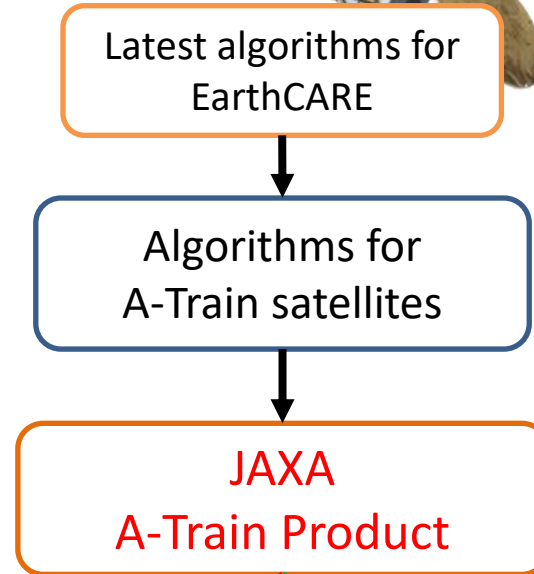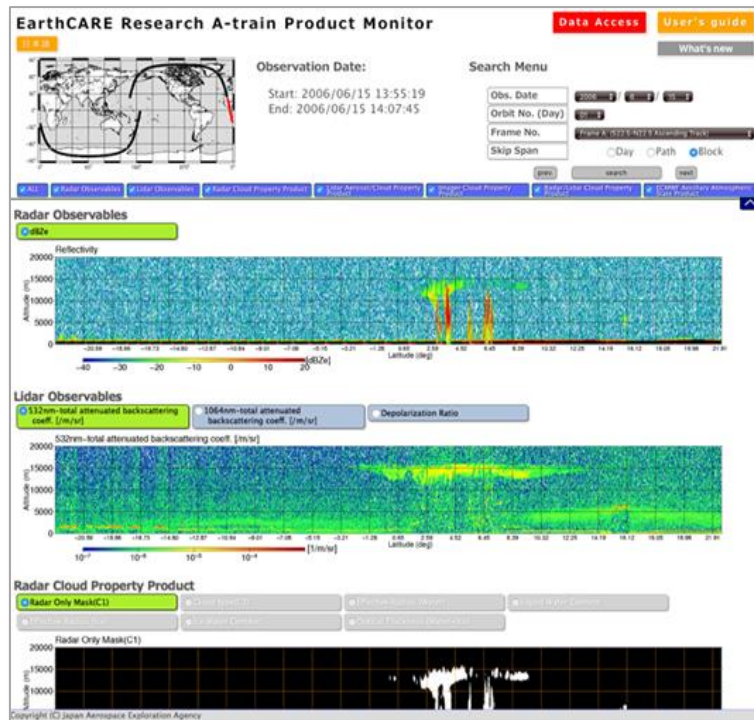
Validation using heritages of the ground observations, *"Japanese validation rehearsal"*

Applications: Cloud/Aerosol/Radiation Process study, Model evaluations, …etc.

Toward long-term dataset with the A-Train and the EarthCARE…

Overview of JAXA validation activities

Long-term observation network

- Ground-based doppler CPR at NICT
- Multiple-field-of-view multiple-scattering polarization lidar (MFMSPL)
- Lidar network (AD-Net) by the National Institute for Environmental Studies (NIES)
- SKYNET observation stations
  etc.
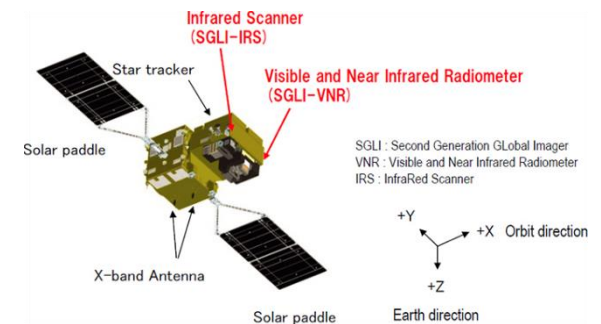
Location of ground-based instruments described in Vol.3

→which can provide detailed validations of the JAXA EarthCARE products

Campaign observation

- Ground-based doppler CPR developed by the NICT is located in NICT Tokyo with other ground instruments.
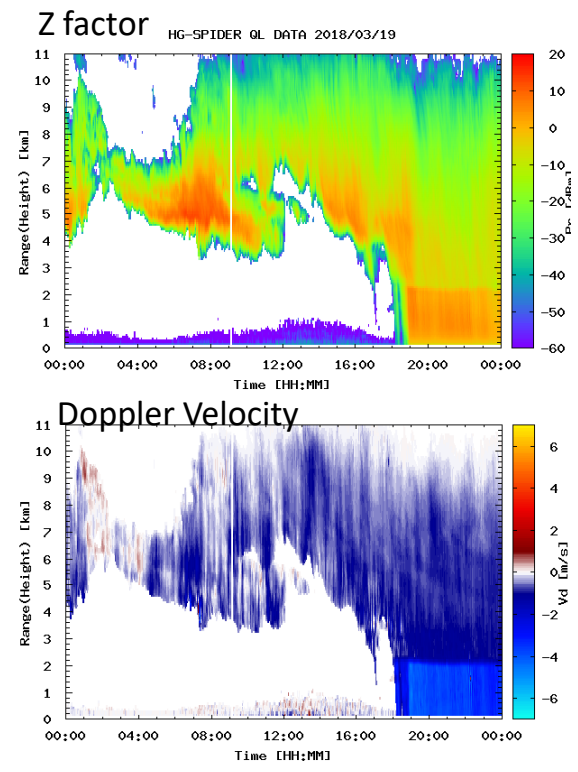

Comparison with other satellite data (CloudSat, CALIPSO, GCOM-C/SGLI, MODIS, VIIRS, CERES, etc.)
→which can provide global evaluations of the JAXA EarthCARE products

JAXA' GCOM-C satellite (carrying **SGLI sensor**)

SGLI : Second Generation GLobal Imager
VNR : Visible and Near Infrared Radiometer
IRS : InfraRed Scanner

Validation of the CPR with the NICT
HG-SPIDER（NICT's Ground-based validation CPR）

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Earth Cloud, Aerosol and Radiation Explorer

Direct-detection 355nm-wind lidar
Coherent 2μm-wind lidar
94GHz radar ES-SPIDER
355nm-MFMSPL
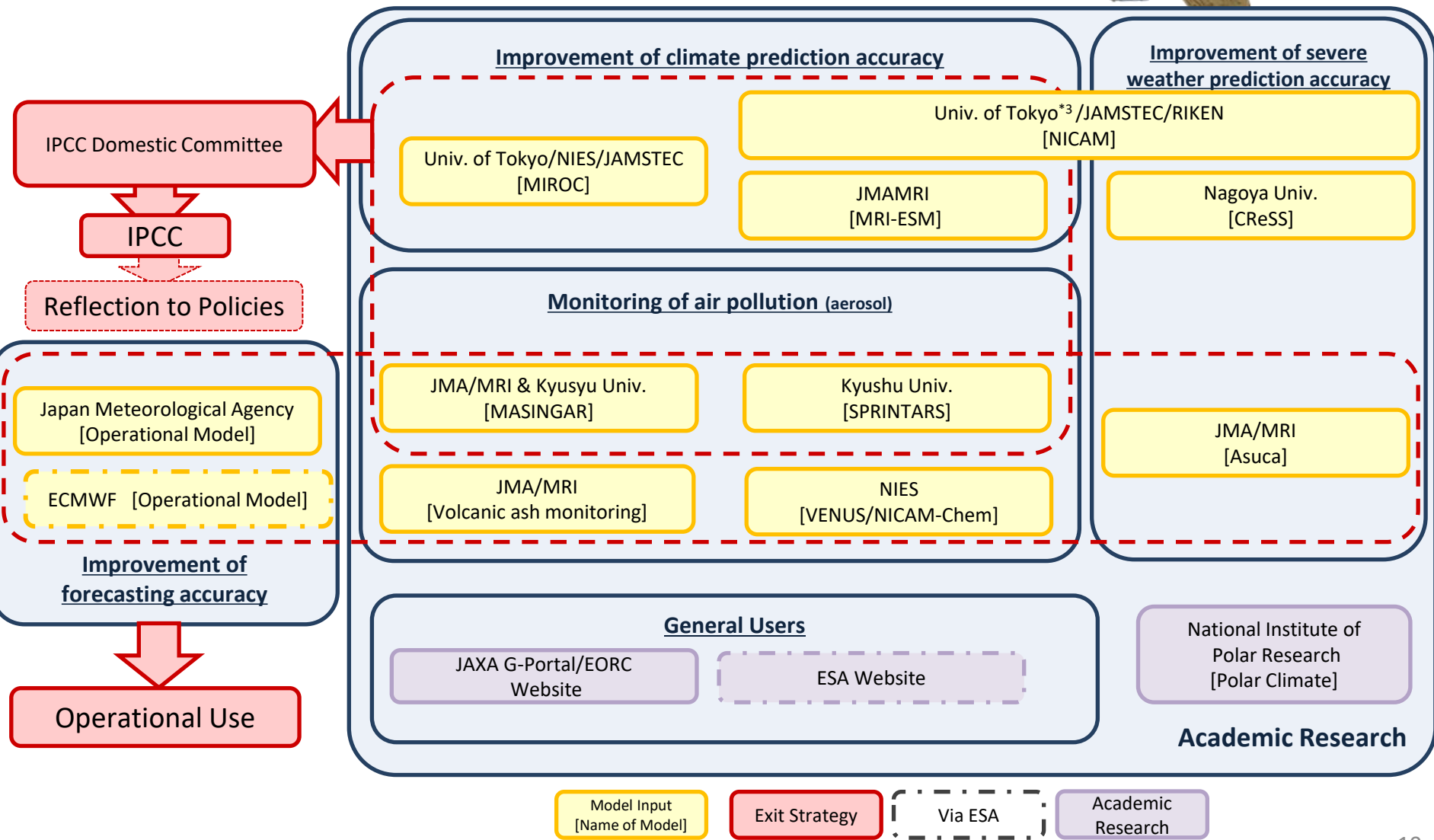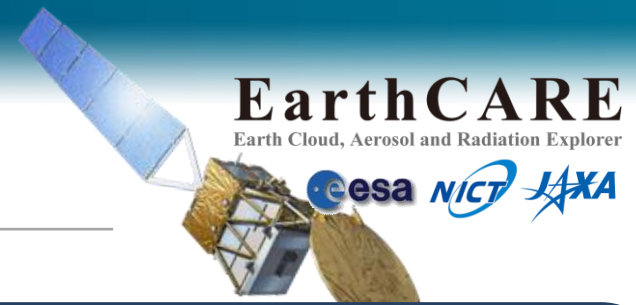94GHz radar HG-SPIDER
355nm-HSRL

EarthCARE/CPR is under development by cooperation between JAXA and the **National Institute of Information and Communications Technology (NICT),** and JAXA will conduct CPR validation activities with the cooperation with the NICT.

NICT will operate several ground instruments including the ground cloud radar (HG-SPIDER).

HG-SPIDER: High sensitivity Ground-based SPIDER (CPR)

Item	Specification
Frequency	94.090GHz
Tx Power	1500W at EIK (peak)
Antenna Gain	55.9 dBi
Beam Width	0.3 degrees
Polarization	Linear Polarization
Pulse Width	0.5/1.0/2.0μs
PRF	3,000 - 10,000 Hz
Sensitivity	-40dBZ@15km (Integ. 1sec.)
Antenna Scanning	Fixed (zenith pointing)
Range	150m - 20km
Doppler Function	Pulse-Pair Processing

Z factor

Doppler Velocity

Better sensitivity than EarthCARE/CPR

・The HG-SPIDER is located in NICT Koganei (Validation Site) with other Instruments; lidar, wind profiler, microwave radiometer, all-sky camera, etc...

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Promotion for weather/climate model communities

EarthCARE
Earth Cloud, Aerosol and Radiation Explorer
eesa NICT JAXA

Improvement of climate prediction accuracy

Univ. of Tokyo[*3] /JAMSTEC/RIKEN
[NICAM]

Univ. of Tokyo/NIES/JAMSTEC
[MIROC]

JMAMRI
[MRI-ESM]

Improvement of severe weather prediction accuracy

Nagoya Univ.
[CReSS]

IPCC Domestic Committee

IPCC

Reflection to Policies

Monitoring of air pollution (aerosol)

JMA/MRI & Kyusyu Univ.
[MASINGAR]

Kyushu Univ.
[SPRINTARS]

JMA/MRI
[Volcanic ash monitoring]

NIES
[VENUS/NICAM-Chem]

JMA/MRI
[Asuca]

Japan Meteorological Agency
[Operational Model]

ECMWF [Operational Model]

Improvement of forecasting accuracy

Operational Use

General Users

JAXA G-Portal/EORC Website

ESA Website

National Institute of Polar Research
[Polar Climate]

Academic Research

| Model Input [Name of Model] | Exit Strategy | Via ESA | Academic Research |

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Joint works with cloud resolving model groups

JAXA is collaborating with the **Japanese global cloud resolving model (NICAM)** for the EarthCARE data utilization with the Joint-Simulator.

- Prof. Satoh (Univ. Tokyo) group
- Dr. Seiki (JAMSTEC) group
- Dr. Miyoshi (RIKEN) group

"Joint-Simulator" (Hashino et al. (2013, JGR) is helpful for evaluating cloud resolving models.

Source codes of the Joint-Simulator are open for science community with registration from
http://www.eorc.jaxa.jp/theme/Joint-Simulator/userform/js_userform.html
Team home page:
https://sites.google.com/site/jointsimulator/

NICAM has attended the DYAMOND activity.
DYAMOND: *The DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains* (Stevens et al. 2019)

Snapshot of high-resolution DYAMOND models
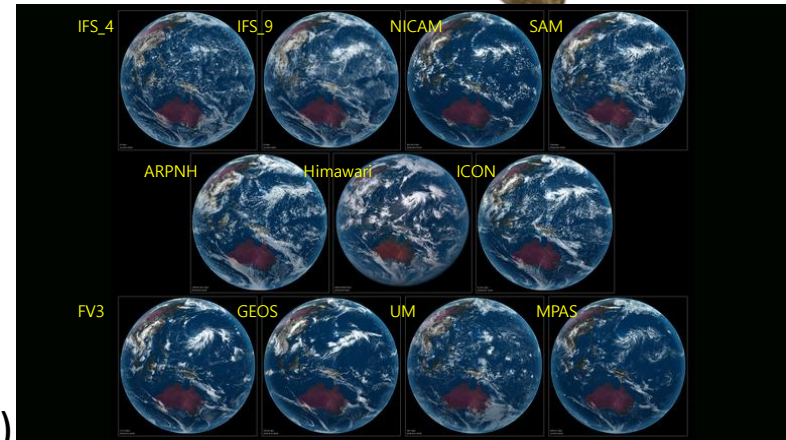
EarthCARE data simulation from NICAM (GCRM) + Joint-simulator

CPR & ATLID   EarthCARE Active SEnsor simulator (EASE)

94GHz Radar reflectivity [dBZe]

532nm backscattering coef [log10 m⁻¹str⁻¹]
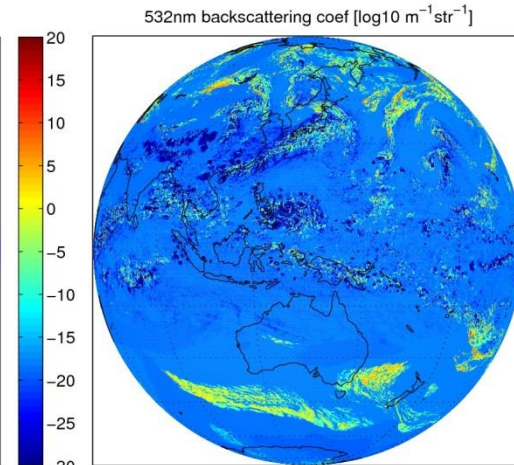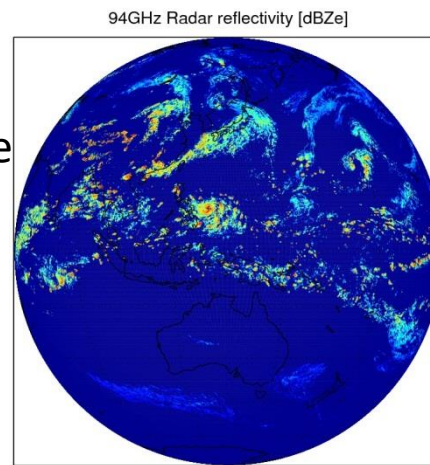
Okamoto et al., (2007, 2008); Nishizawa et al., (2008)

Signals at 10km height

Joint works with climate model groups
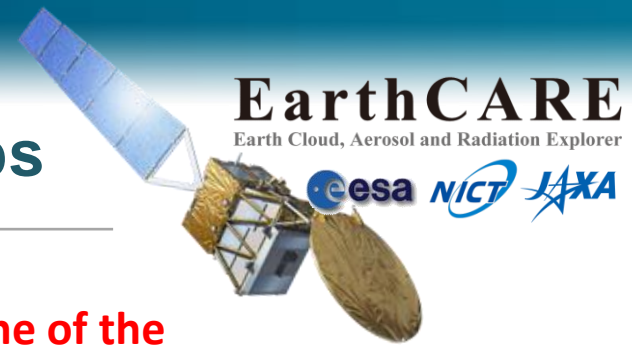
JAXA is collaborating with Prof. Suzuki (Univ. Tokyo) group for developing the **Japanese climate model (MIROC), which is one of the IPCC models,** for the EarthCARE data utilization.
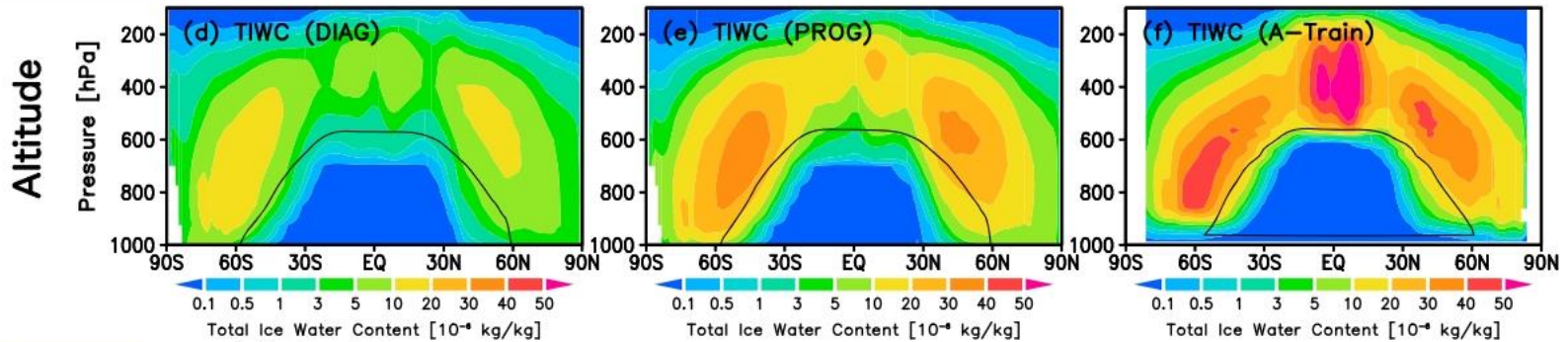

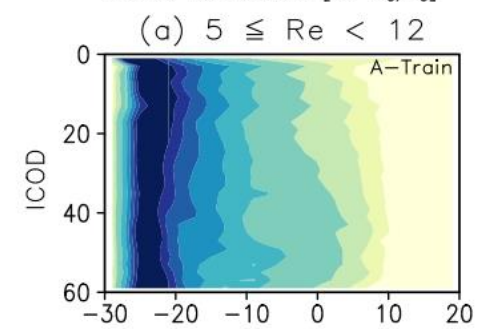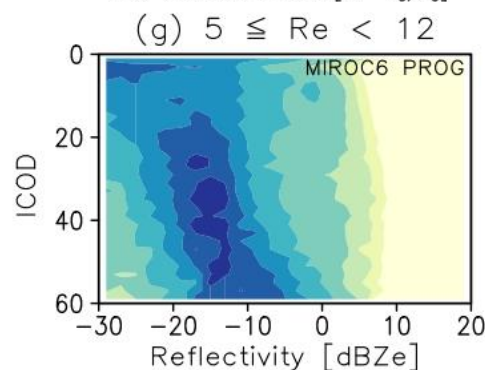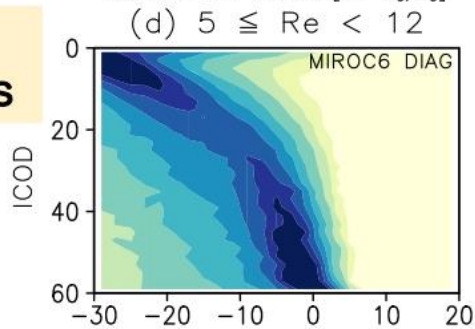Climate model improvement using A-train data. Michibata et al. (JAMES '19; ACP '20), Michibata & Suzuki (GRL '20). Cloud Ice and Rain process comparisons between Old MIROC6, New MIROC6, and Satellite Obs.

Joint works with weather/aerosol model groups

EarthCARE
Earth Cloud, Aerosol and Radiation Explorer
eesa NICT JAXA
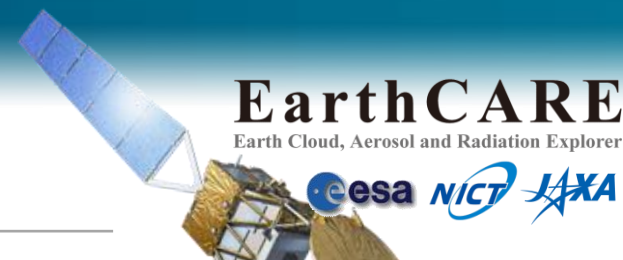
JAXA started the following 4 joint works for Numerical Weather Prediction (NWP) and aerosol monitoring and prediction in April 2022.

- Joint research with the Japan Meteorological Agency (JMA) Meteorological Research Institute (MRI) for the NWP
  - We will evaluate and improve the cloud and precipitation processes of numerical models and develop assimilation techniques of EarthCARE data for the NWP systems.
    - PI: Dr. K. Okamoto (JMA/MRI) for global JMA model
    - PI: Dr. Y. Ikuta (JMA/MRI) for regional JMA model

- Aerosol monitoring and prediction
  - Volcanic ash monitoring
    - PI: Dr. H. Ishimoto (JMA/MRI)
  - Aeolian Dust (Kosa) Prediction
    - PI: Prof. K. Yumimoto (Kyusyu Univ.)
  - Air pollution prediction
    - PI. Dr. D. Goto (National Institute for Environmental Studies/ NIES)

Summary
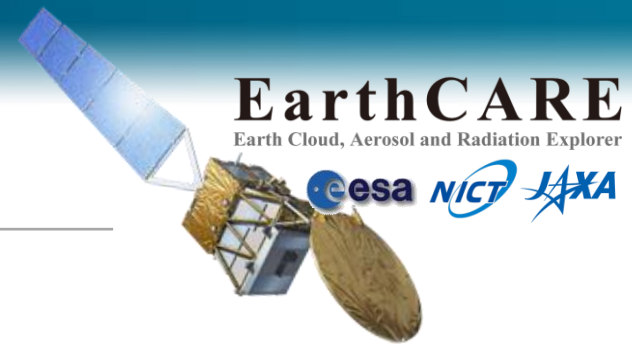
- ## JAXA Product Overview
    - Developments by 6 Algorithm PIs are ongoing.
    - JAXA L2 ATBD is provided in the JAXA/EORC Website:
      http://www.eorc.jaxa.jp/EARTHCARE/index.html

- ## JAXA A-Train Product for EarthCARE
    - http://www.eorc.jaxa.jp/EARTHCARE/research_product/ecare_monitor_e.html

- ## Validation status
    - Utilization of the existing observation network
    - Campaign observation (NICT Tokyo will be our super site.)
    - Cross comparison with other satellite data

- ## Applications with weather/climate models
    - Joint works with cloud resolving model groups
    - Joint works with climate model groups
    - Joint works with weather/aerosol model groups