

EarthCARE CPR Instrument Overview and Performance Update

TOMITA Eiichi

EarthCARE/CPR Project Manger

Space Technology Directorate I

Japan Aerospace Exploration Agency (JAXA)

1. EarthCARE/CPR Overview

- ❑ Earth, Clouds, Aerosols, and Radiation Explorer (EarthCARE) is an international joint mission by JAXA and ESA.
- ❑ Synergy observation by four instruments;
 - ✓ **CPR** : **C**loud **P**rofilin**R** **R**adar
 - ✓ ATLID: **A**tmospheric **L**idar
 - ✓ MSI : **M**ulti-**S**pectral **I**mager
 - ✓ BBR : **B**road-**B**and **R**adiometer



Cloud Profiling Radar (CPR)

- ❑ The CPR is the world's first cloud radar that measures the upward and downward flow velocity within a cloud while observing the vertical structure.
- ❑ CPR is developing by cooperation between JAXA and the National Institute of Information and Communications Technology (NICT).
- ❑ CPR have a 2.5 m-diameter main reflector with ultra-fine geometrical tolerance and W-band 1.5 kW transmitter and receiver.

1. EarthCARE/CPR Overview (cont'd)

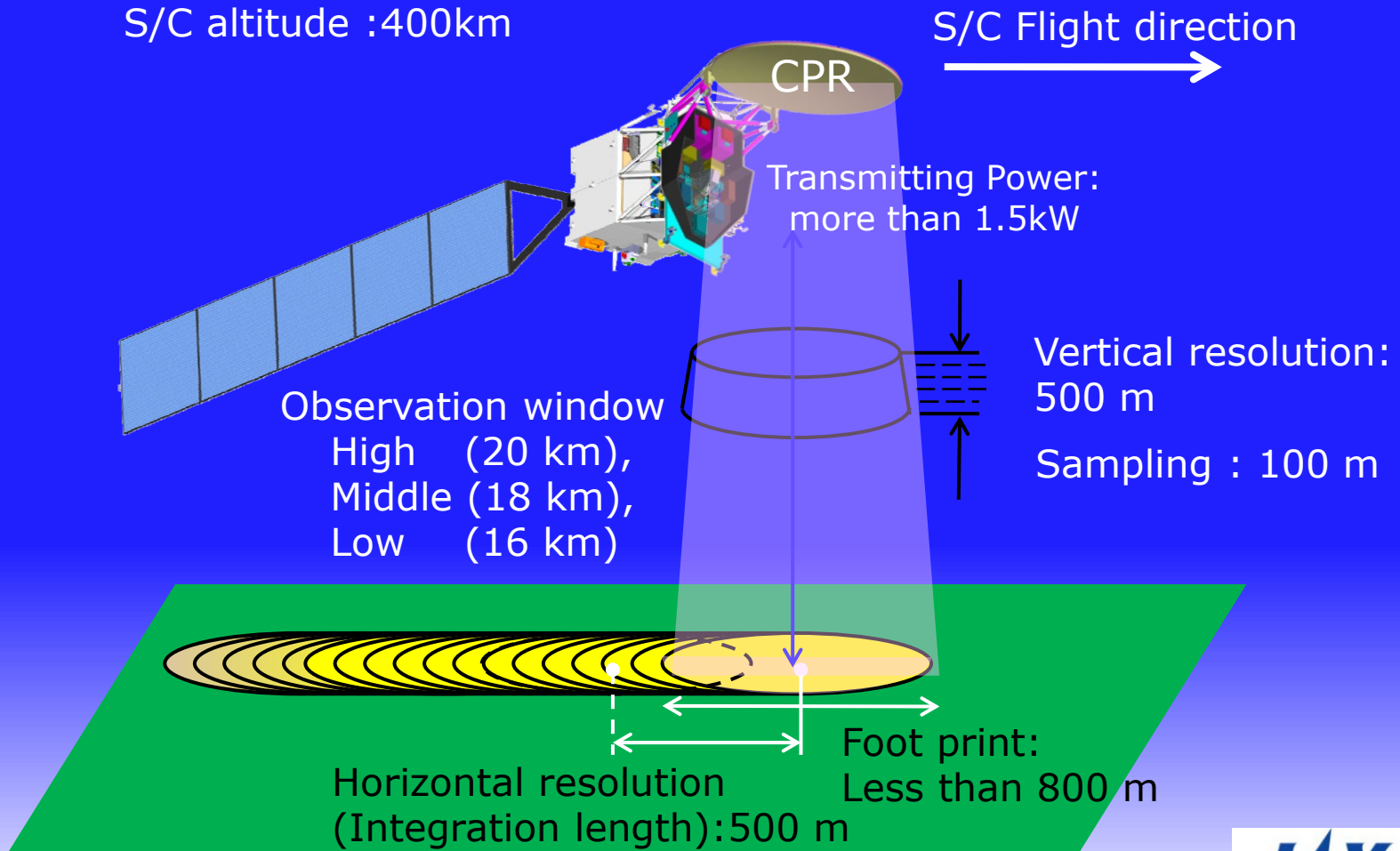
Major specifications of CPR:

| | |
|---------------------|--|
| Center Frequency | 94.050 GHz |
| Antenna Aperture | 2.5 m Φ |
| Beam Width | 0.095 degrees |
| Transmit Power | 1.43 kW or greater |
| PRF | Variable, 6,100 Hz to 7,500 Hz |
| Pulse Width | 3.3 μ s |
| Minimum Sensitivity | less than -35 dBZ (at 10km integration) |
| Doppler Range | \pm 10 m/s |
| Doppler Accuracy | 1.3 m/s (for -19 dBz clouds / at 10km integration) |
| Vertical Resolution | 500 m |
| Mass / Power | approx. 270 kg / 316 W |

1. EarthCARE/CPR Overview (cont'd)

Schematic image of CPR observation

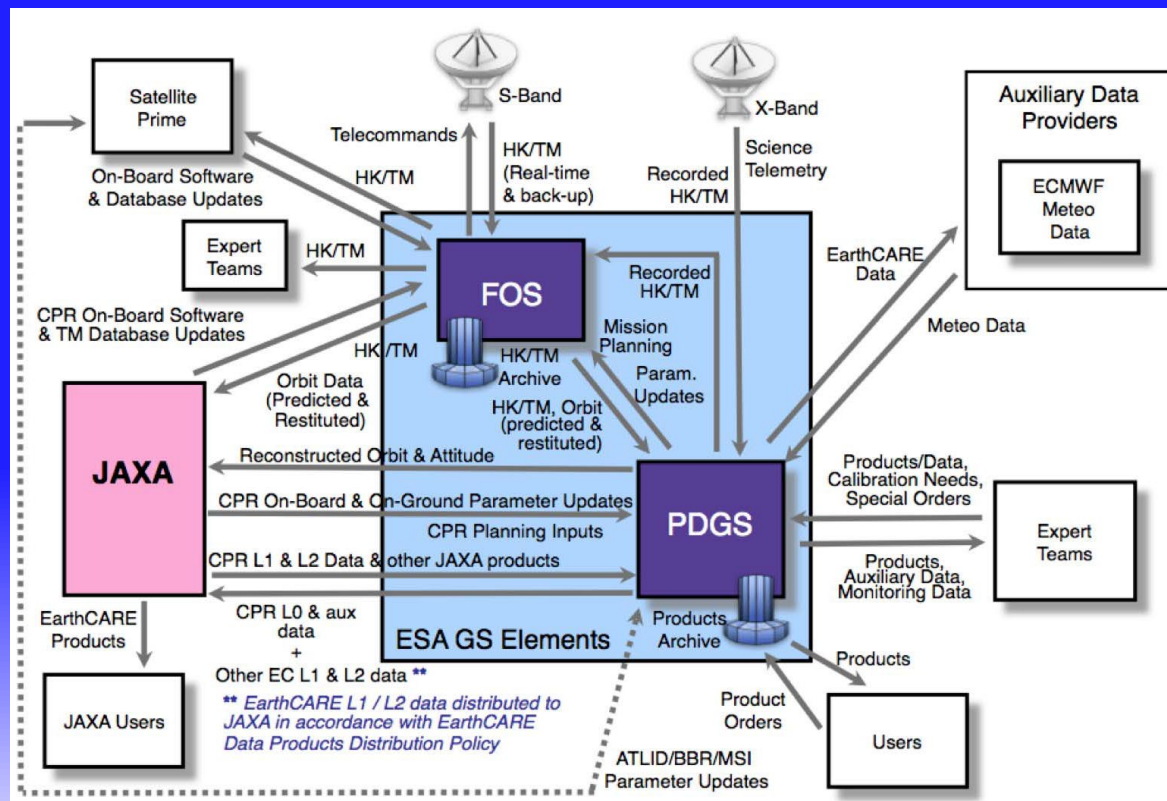
- ❑ CPR measures altitude and Doppler velocity from received echo.
- ❑ The observation altitude can be changed with Low (16 km), Middle(18 km), High (20 km).



1. EarthCARE/CPR Overview (cont'd)

Ground segment

- ❑ EarthCARE will be operated by ESA Flight Operations Segment (called FOS).
- ❑ The observation data of EarthCARE will be received by ESA Ground Segment (called PDGS).
- ❑ JAXA users can receive EarthCARE products created by JAXA and ESA from the JAXA Ground Segment.



JAXA presentation at EarthCARE System

CDR 26th April, 2016

2. Performance of CPR

- CPR proto-flight test was completed by 2017 and refurbish and test was completed by the beginning of 2021.
- Through these tests, it was confirmed that CPR meets environmental conditions and performance requirements.
- The following is an example of performance analyzed based on the test.

| | | Requirement | Analysis results based on measurement | |
|--|------------------|--------------------|---------------------------------------|-------------|
| Antenna beam pointing accuracy | Cross-track (RX) | $<1.5E-2(1\sigma)$ | 4.04E-03 | |
| | Along-track (RY) | $<1.5E-2(1\sigma)$ | 9.08E-03 | |
| Minimum detectable radar reflectivity factor | | $<-35\text{dBZ}$ | -36.97dBZ | |
| Doppler Accuracy | | $<1.3\text{m/s}$ | 1.169m/s #1 | Case for #1 |

#1: Under the condition of 10 km integration, for a uniform target of greater than or equal to -19dBZ as input signal, satellite attitude knowledge accuracy and satellite radial velocity uncertainty defined in the satellite ICD

3. The latest status of preparation toward launch

3.1. CPR instrument

- CPR was transported to Europe in March 2021. Then CPR was handed over to ESA/Airbus in April 2021.
- CPR integration to EarthCARE satellite and test was completed by ESA/Airbus by June 2021.
- Repair of High power transmitter (HPT) redundant side of CPR which was found failure has been completed. It will be onboarded to CPR in coming July.
- Then CPR will be re-integrated to EarthCARE satellite by ESA / Airbus and will be started Satellite level environment test at ESTEC.

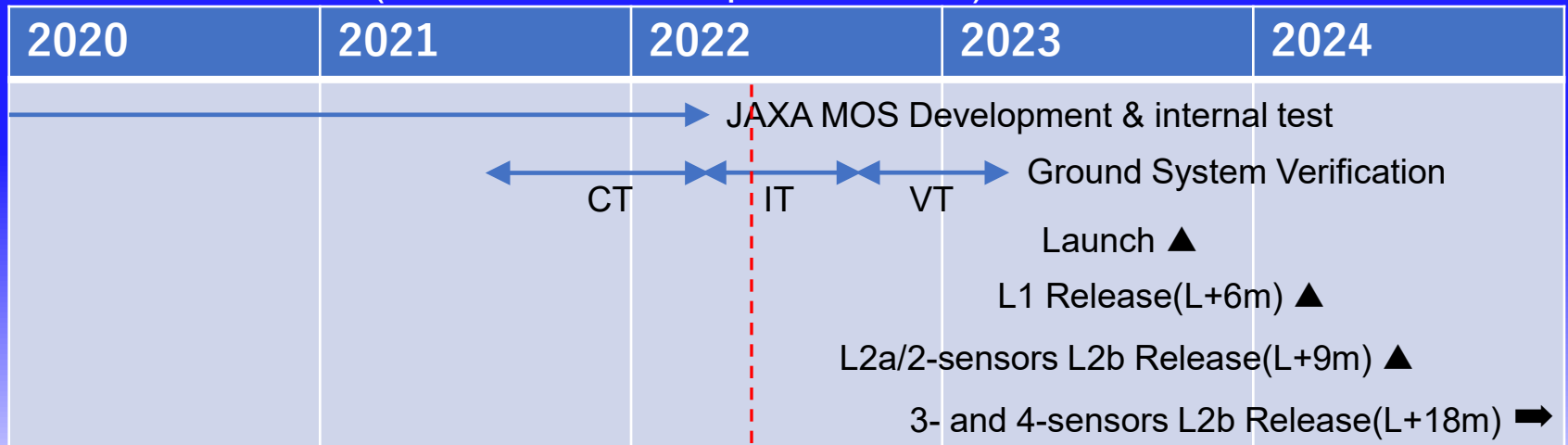


EarthCARE@ Airbus (April. 2021)
©Airbus

3. The latest status of preparation toward launch

3.2. Ground Segment

- Development and internal test of JAXA Mission Operation System completed in JFY2021 (Mar. 2022).
- Ground System Verification Test between JAXA and ESA is ongoing.
 - Compatibility Test (data format confirmation, offline) started July 2021 and completed March 2022.
 - Integration Test (facility to facility data exchange test, online) formally kicked-off on 10th March 2022. This test is planned from April 2022 to September 2022.
 - Validation Test (scenario-based operation test) will start from October 2022.

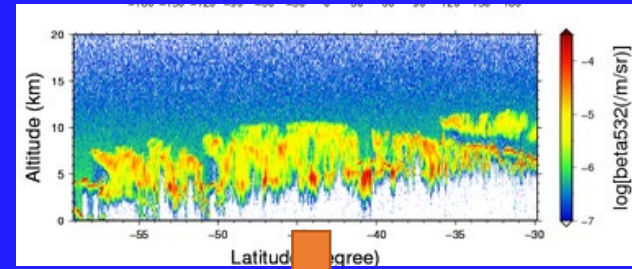


3. The latest status of preparation toward launch

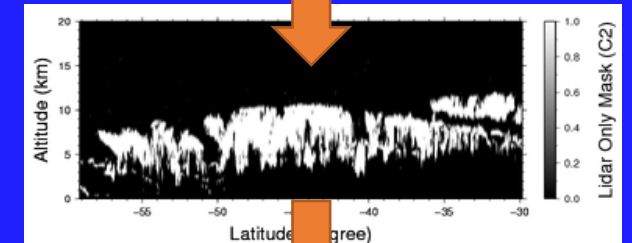
3.3. product

- CPR L1 product is developed by the JAXA
- Algorithms for L2 geophysical products are developed by the JAXA Science team.
- L2 status
 - ✓ Developments by 6 Algorithm PIs are ongoing.
 - ✓ Now All JAXA EarthCARE L2 algorithms can input synthetic data with the JAXA/ESA L1 formats and output physical variables in the JAXA L2 format.
 - ✓ Algorithm ver. 0.22 was developed and ver. 0.3 which will be applied to Ground segment testing is under development.

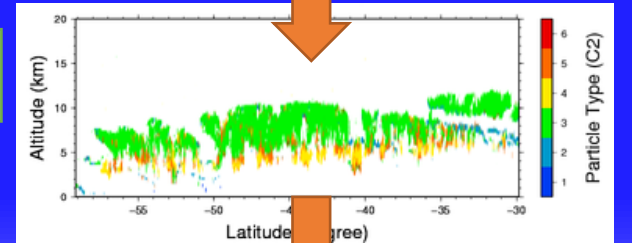
Observed data of the CPR



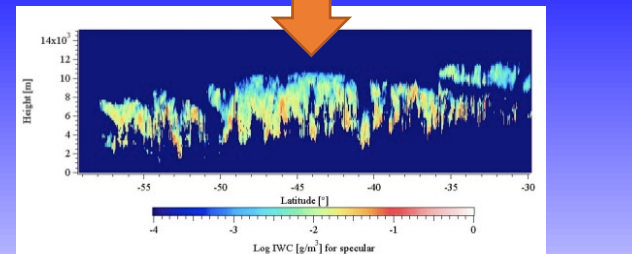
Cloud mask



Cloud Particle Type



Cloud Microphysics



(Figures provided by Prof. Okamoto, Kyusyu Univ.)

3. The latest status of preparation toward launch

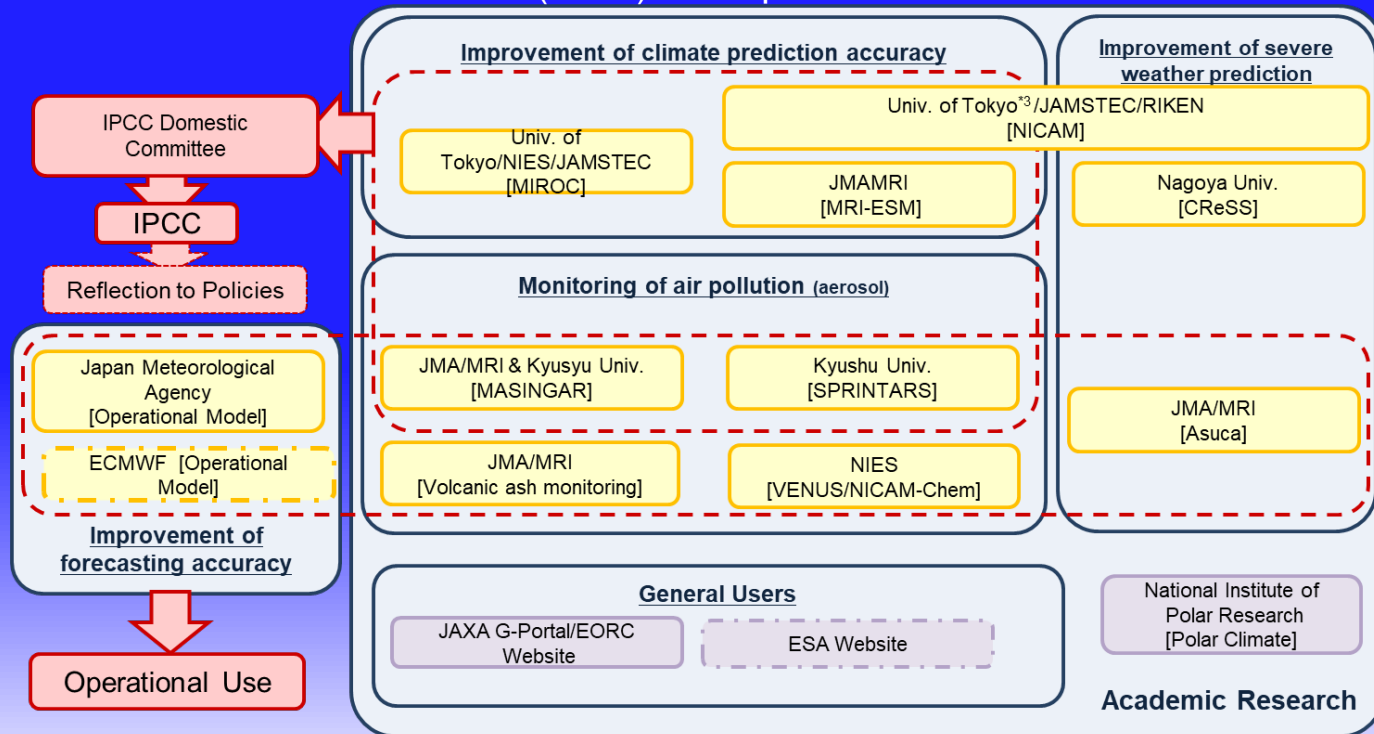
3.4. Preparation for commissioning phase

- JAXA are also participating in the System verification test 2 which EarthCARE satellite is operated by ESOC as on-site support.
- Preparation for commissioning phase have been progressed since last December in cooperation between ESA and JAXA.

3. The latest status of preparation toward launch

3.5. Promotion for weather/climate model communities

- JAXA began collaborating with various research institutes in Japan to apply EarthCARE observations to climate modeling and other applications.
 - The joint-research activities to improve cloud processes of the climate model with the University of Tokyo and MRI/JMA, which are developing climate models used in the IPCC report.
 - The joint researches for use in the fields of weather forecasting and atmospheric environment.
 - The joint research with the MRI on cloud processes in JMA weather models, with Kyushu University on aerosol forecasts, with the MRI on volcanic ash monitoring, and with the National Institute for Environmental Studies (NIES) on air pollution forecasts.



4. Conclusion

All work related to CPR is proceeding smoothly according to the plan toward launch and the realization of the EarthCARE mission.

Thank you for your attention!