



Validation of the EarthCARE mission

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Preamble



Due to the transition from the workshop to an online session, the following adaptations have been made to this contribution:

- It is presented as a set of slides, in stead of the poster format mentioned in the abstract
- Verbosity is enhanced, to compensate for the absence of oral explanation
- [Hyperlinks](#) are used extensively, considering that this presentation will be viewed on a computer rather than projected on a screen
- The scope has slightly been broadened compared to the original abstract, by including a mission and product summary, in order to partially compensate for the cancellation of the [mission presentation](#)



Presentation structure



1. The EarthCARE Mission
2. The EarthCARE Data Products
3. The Joint ESA-JAXA Validation Plan
4. Validation of the ESA Data Products
5. Validation Timeline



1.1 The EarthCARE Mission: Objectives

Earth **C**louds, **A**erosols, and **R**adiation **E**xplorer

EarthCARE is a joint ESA-JAXA mission that aims at understanding of cloud-aerosol interactions and radiation balance.

The scientific objectives of the mission are:

- To observe vertical profiles of natural and anthropogenic aerosols on a global scale, their radiative properties and interaction with clouds

- To observe vertical distributions of atmospheric liquid water and ice on a global scale, their transport by clouds and their radiative impact

- To observe cloud distribution, cloud-precipitation interactions and the characteristics of vertical motions within clouds

- To retrieve profiles of atmospheric radiative heating and cooling through the combination of the retrieved aerosol and cloud properties

EarthCARE Satellite Datasheet

Orbit:

- 393 km mean altitude
- Sun Synchronous frozen orbit
- 97° Inclination
- 14h00 DSN MLST
- 25-days repeat cycle

Lifetime:

- 3 years + 1
(incl. 6-months commissioning)

Space Links:

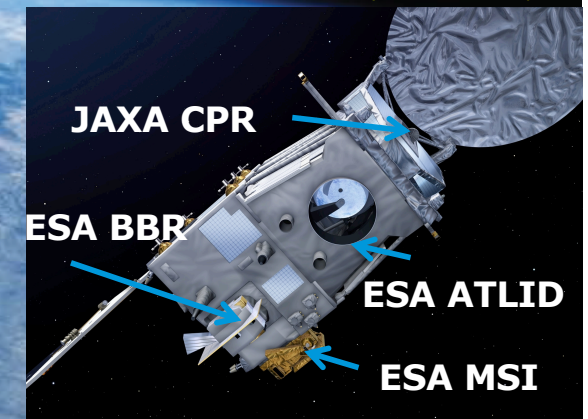
- S-Band:
 - Kiruna KIR1 / KIR2 Ground stations
 - 64 kbps uplink
 - 128 kbps / 2 Mbps downlink (with/without ranging)
- X-Band:
 - Kiruna-Esranges & Inuvik Ground stations
 - 150 Mbps downlink

Satellite:

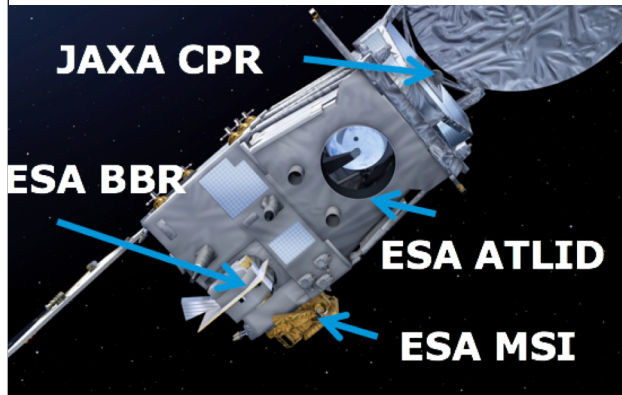
- 2350 kg (incl. 313 kg propellant)
- 3-axis stabilized / yaw-steering
- 1700W
- On-board data rates average:
 - <15 kbps (HKTM)
 - <2.5 Mbps (science)

Payload:

- 2 active instruments (ATLID & CPR)
- 2 passive instruments (BBR & MSI)



1.2 The EarthCARE Mission: Payload



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1.3 The EarthCARE Mission: Payload

Active Instruments

ATLID: ATmospheric LIDar

- Backscatter UV lidar (355 nm) with high spectral resolution receiver, bistatic design
- 3 receiver channels: molecular, co-polar and cross-polar particle backscatter → backscatter and extinction measured independently
- Pulse repetition frequency 51 Hz, pulse energy >34 mJ
- Sampling: 290 m (=2x145 m integrated) horizontal, 103m vertical
- Receiver footprint on ground <30m
- 3 degree off-nadir (backwards) pointing to reduce specular reflection on ice clouds
- Level 1 product: attenuated backscatter profiles

CPR: Cloud Profiling Radar (JAXA/NICT)

- High power W-band (94 GHz) nadir-pointing
- Doppler capability (accuracy 1m/s)
- Antenna aperture 2.5 m
- Variable pulse repetition frequency: 6100-7500 Hz
- Sensitivity at least -35 dBZ at 20 km height
- Sampling: 500 m horizontal, 100 m vertical
- Beam footprint on ground <700 m
- Level 1 product: reflectivity & Doppler profiles

Passive Instruments

MSI: Multi-Spectral Imager

- Nadir-viewing push-broom imager
- 4 solar channels: 670 nm, 865 nm, 1.65 μ m, 2.21 μ m
3 thermal infrared channels: 8.8 μ m, 10.8 μ m, 12.0 μ m
- 150 km swath tilted away from sunglint
- Sampling 500 m x 500 m
- Level 1 product: radiances (solar), brightness temperatures (thermal IR)

BBR: Broad-Band Radiometer

- 2 channels: total-wave 0.25-50 μ m, short-wave (solar) 0.25-4 μ m
- 3 fixed telescopes: nadir, forward (+50 deg), backward (-50 deg)
- Integrated pixel size of 10 km x 10 km
- Radiometric accuracy: SW 2.5 W/m²sr, LW 1.5 W/m²sr
- Level 1 product: solar and thermal TOA radiances

1.4 The EarthCARE Mission: Information

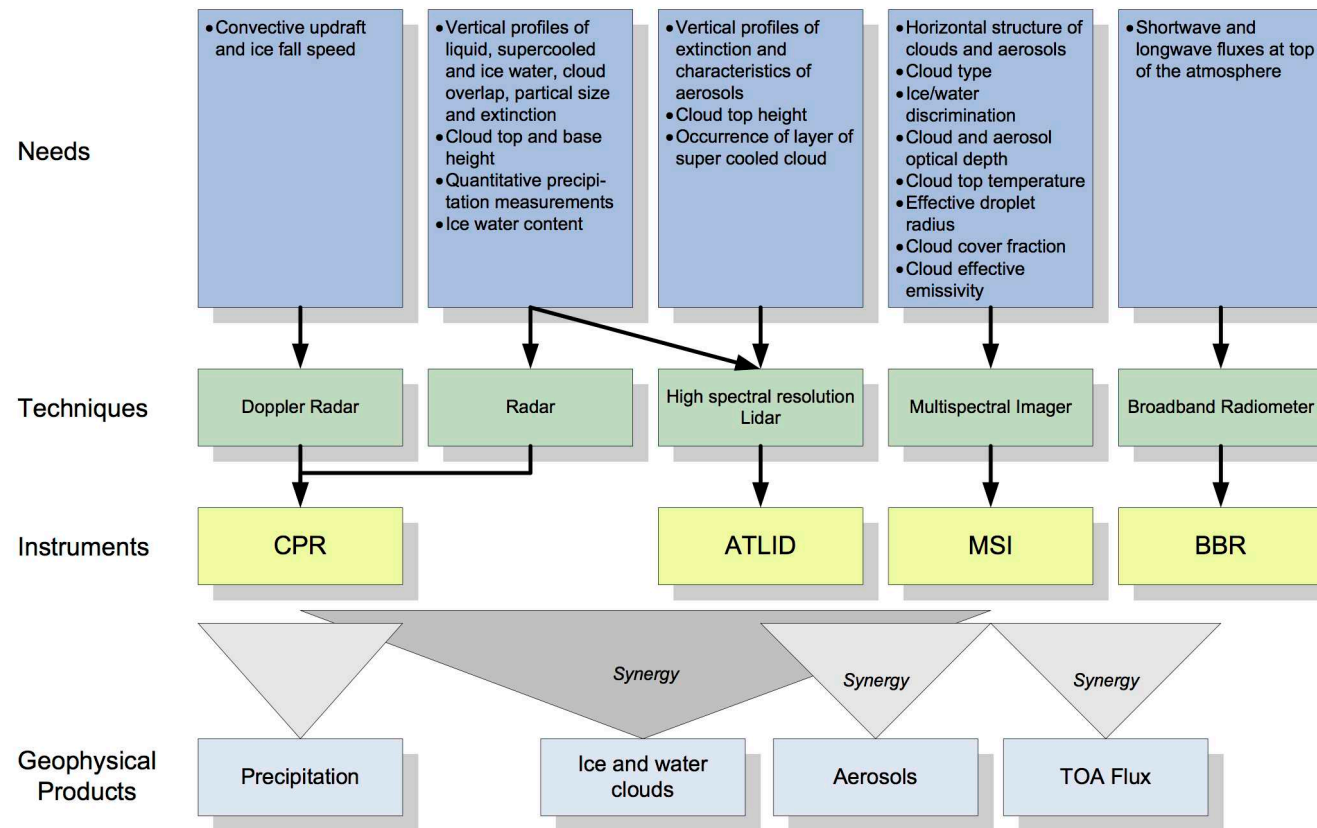
Detailed information on the EarthCARE mission is available at:

- 💧 The ESA EarthCARE website at https://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/EarthCARE
- 💧 The ESA Earthnet portal at <https://earth.esa.int/web/guest/missions/esa-future-missions/earthcare>
- 💧 The EarthCARE site at the EOportal <https://directory.eoportal.org/web/eoportal/satellite-missions/e/earthcare>
- 💧 The JAXA EarthCARE website at <https://global.jaxa.jp/projects/sat/earthcare/>

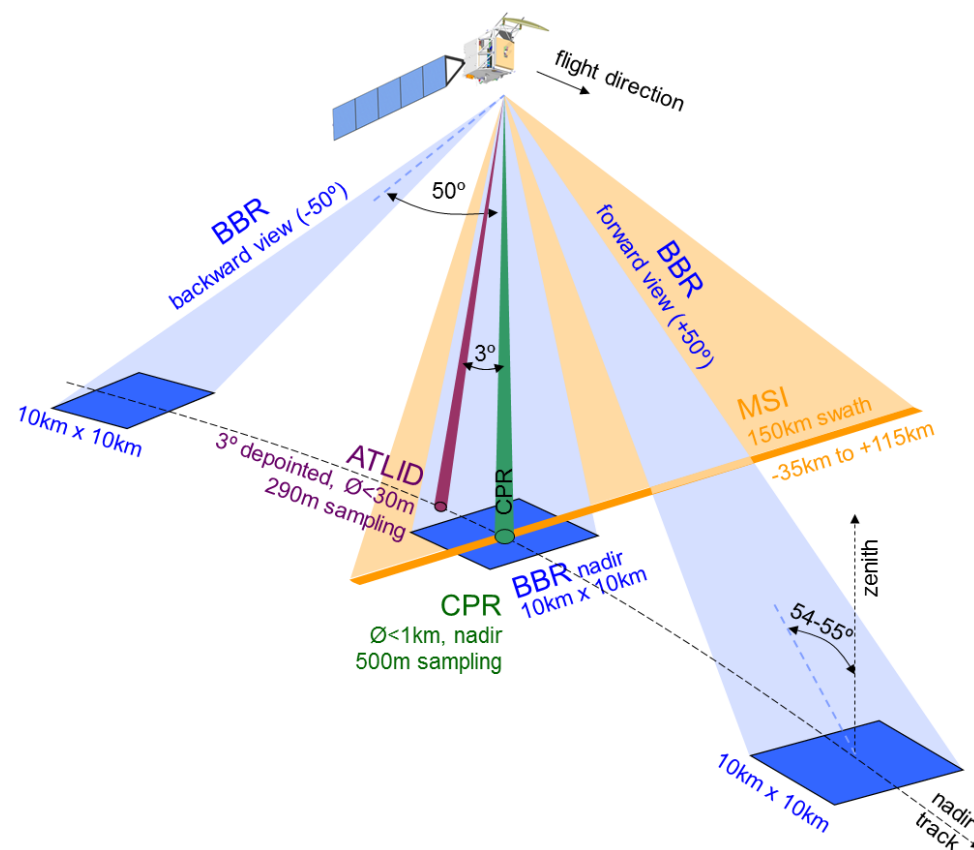
Please also consult:

- 💧 [A scientific paper about the EarthCARE Mission in the Bulletin of the American Meteorological Society](#)

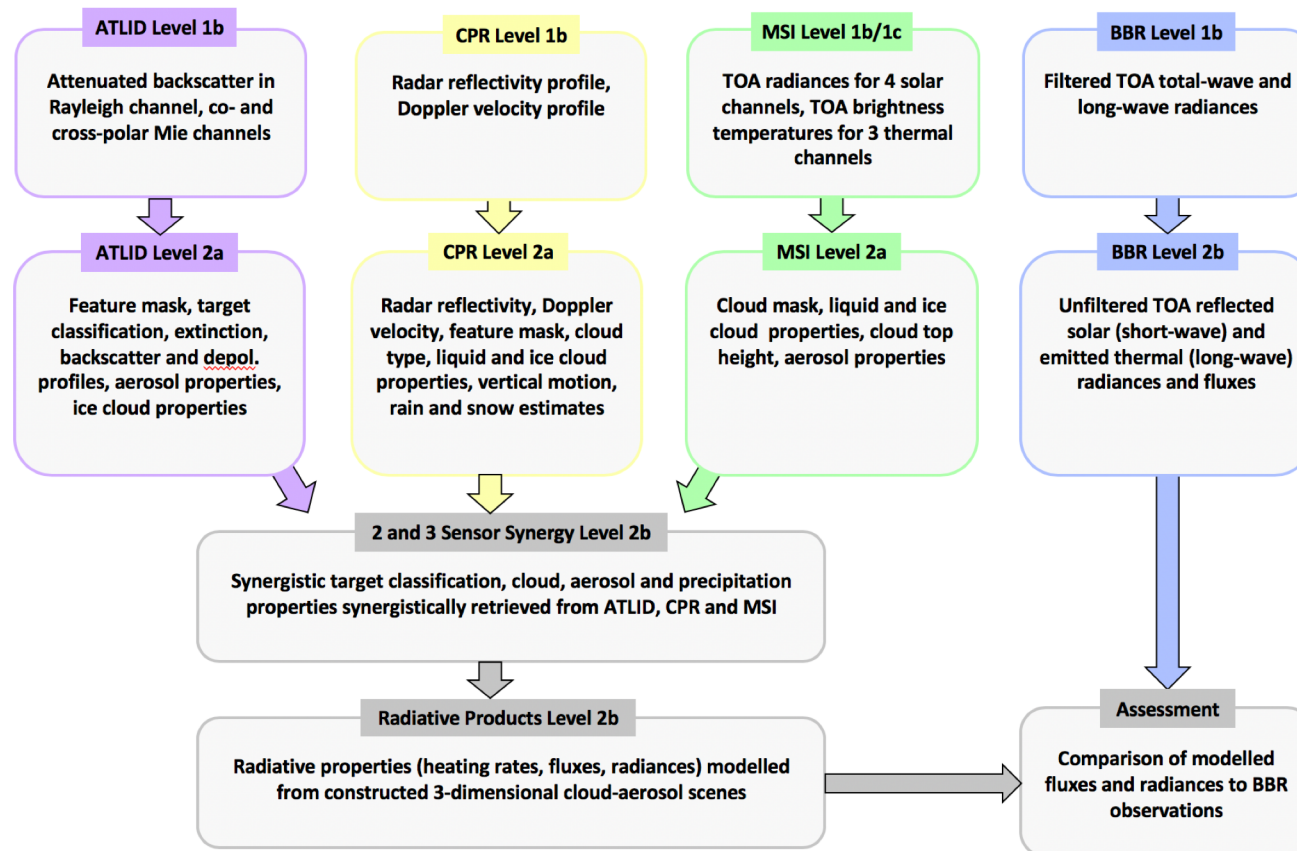
2.1 EarthCARE Data Products: Context



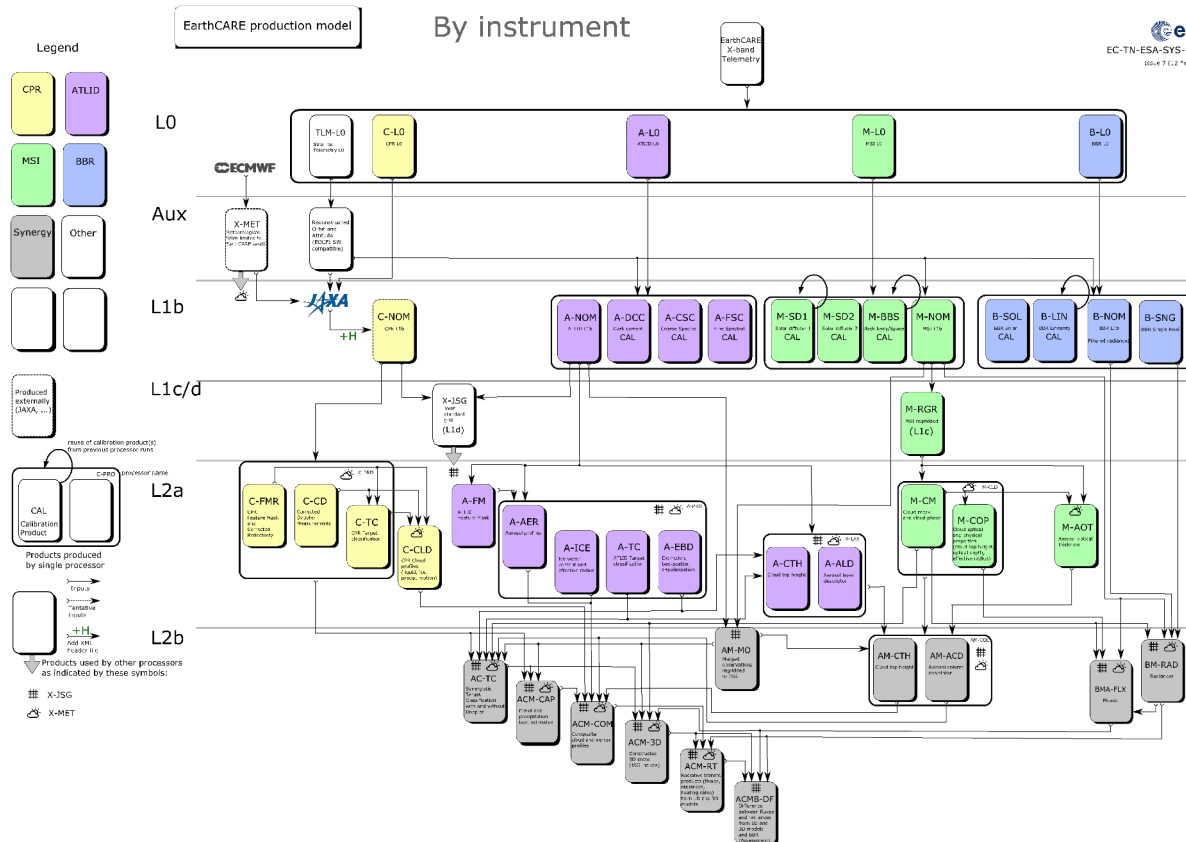
2.2 EarthCARE Data Products: Sampling



2.3 EarthCARE Data Products: Parameters



2.4 EarthCARE ESA Data Products: Production Model



3.1 Validation: Definition / Scope of presentation



CEOS Definitions:

- **Calibration:** the process of quantitatively defining the system response to known controlled signal inputs.
- **Validation:** the process of assessing by **independent means** the quality of the data products derived from those system outputs.

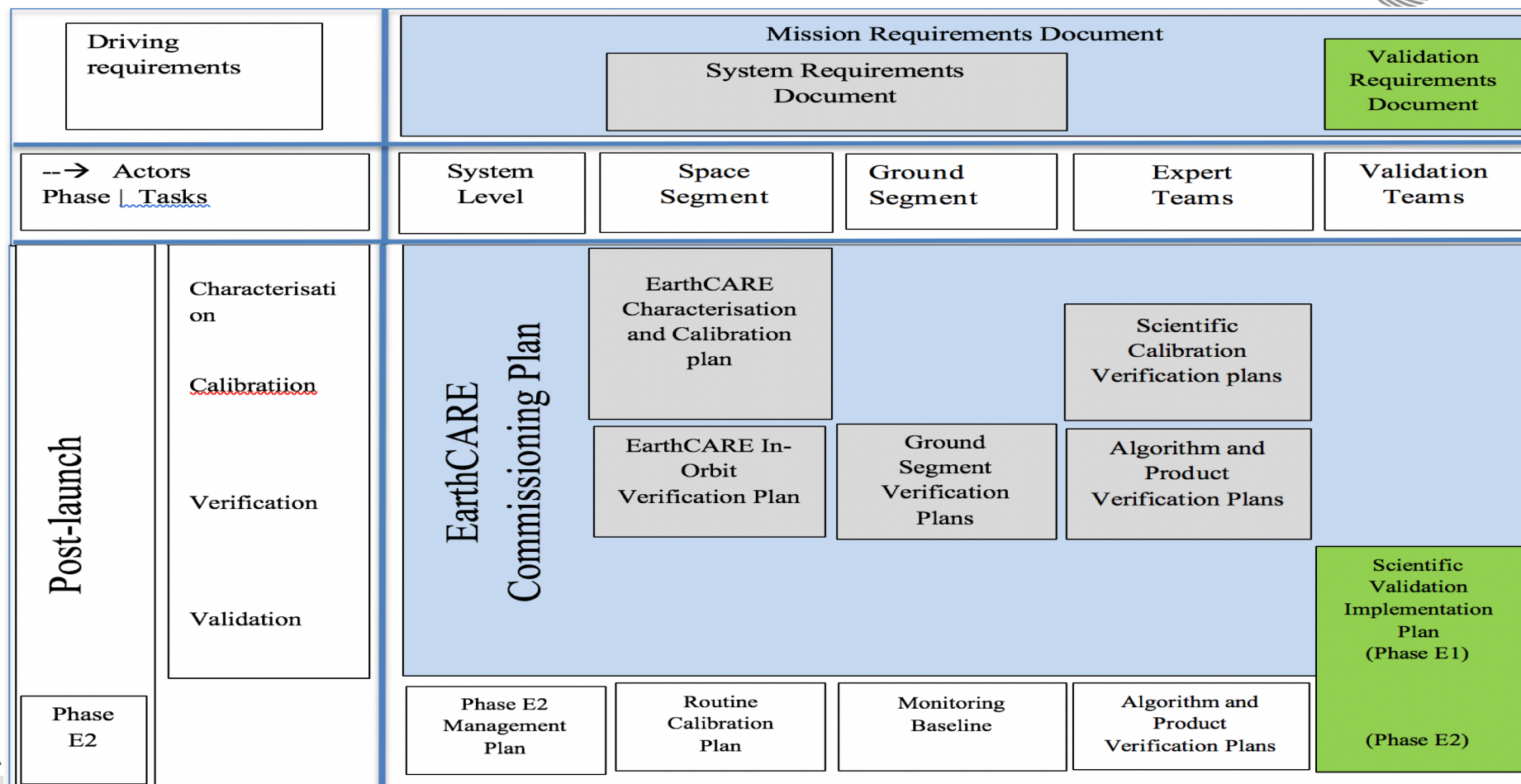
Other:

- **Commissioning:** the process of assuring that all systems are tested and operated according to the mission requirements.
- **Characterisation:** the process of probing the properties of a system as a function of expected operating conditions (e.g. non-linearity, degradation, etc.). A prerequisite for most calibrations.
- **Verification:** the process of assessing whether a system or product meets its specification (IEEE)

Correlative observations

This presentation only addresses **Validation**

3.2 Validation: Context



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3.3 ESA-JAXA Validation: Roles

In scope of the EarthCARE inter-Agency cooperation, ESA and JAXA have agreed that:

- within the commissioning of the EarthCARE spacecraft, JAXA will perform the commissioning of the JAXA Cloud Profiling Radar (CPR) instrument, including a validation plan to be defined by JAXA under the ESA-JAXA collaboration.
- ESA will integrate the JAXA-defined CPR validation plan into the overall EarthCARE validation plan.

Each Agency is responsible for the validation of its own EarthCARE data products.

The ESA-JAXA collaboration is laid down in the joint EarthCARE Scientific Validation Implementation Plan that is being finalised at present:

3.4 ESA-JAXA Validation: Implementation Plan



This Scientific Validation Implementation Plan captures the mission validation objectives, schedule, context, and definitions, and details the activities under the auspices of each Agency for the validation of its respective data products.

Each Agency has solicited validation contributions from the scientific community:

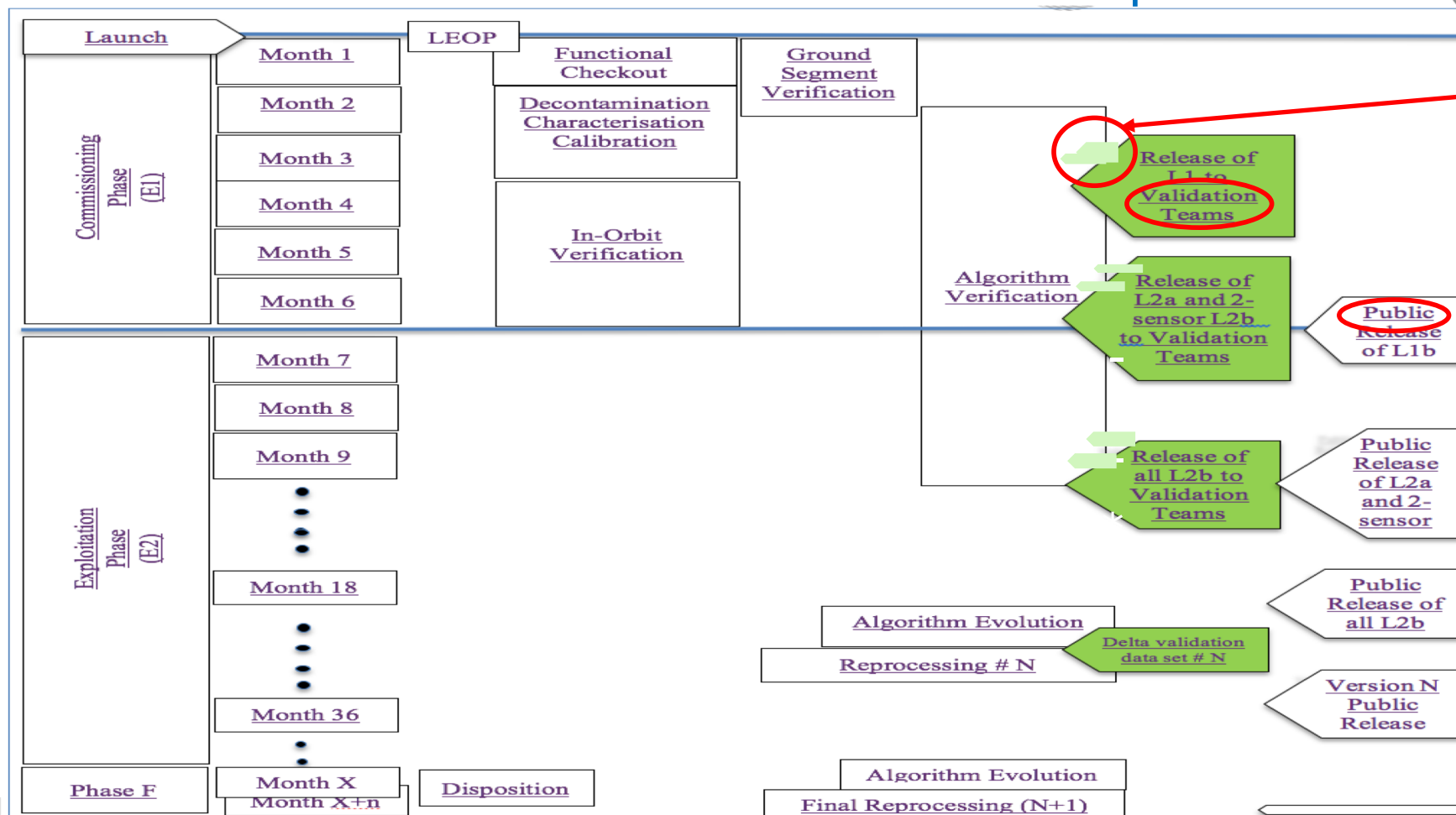
- ESA organised an [Announcement of Opportunity in 2017](#)
- JAXA organised two Research Announcements, in 2013 and in 2019. JAXA has contracted additional support for tasks not covered by the Research Announcements

The ESA activities will be described in this presentation (item 4).

ESA and JAXA will provide their preliminary products exclusively to the Validation Scientists well before the public release of the consolidated ESA and JAXA EarthCARE data products. This is explained in the timeline on the following slide.



3.5 ESA-JAXA Validation: release of data products



Intention is to release preliminary products to the validation scientists as soon as they are stable, with description of caveats



4.1 Validation of the ESA EarthCARE Products



The following slides focus on the validation of the ESA Products.

ESA and JAXA solicit recommendations from Mission Advisory Groups (MAG).

The **Joint MAG** (JMAG) advises both Agencies, The **European MAG** (EuroMAG) advises ESA.

The EuroMAG has formulated **Validation Requirements** for the ESA products.

In 2017, the scientific community has been [requested to propose contributions](#) to meet these validation needs.

The activities resulting from this Announcement of Opportunity are summarised in this fourth part of the presentation.



4.2 Validation Activities for the ESA Products: PIs



Principal investigator	Institution	Principal investigator	Institution
N. Clerbaux	BIRA, BE	E. Welton	NASA-GSFC USA
F. Marengo	Met Office, UK	M. Gausa	Andoya Sp.C, NO
U. Wandinger	Tropos, DE	D. Josset	NRL, USA
C. Genthon	CNRS, FR	X. Hu	NSMC, CN
A. Apituley	KNMI, NL	V. Chandrasekar	FMI, FI
N. Loeb	NASA-LARC, USA	T. Nishizawa	NIES, JP
E. Landolfo	IPEN, BR	V. Amiridis	NOA, GR
D. Moiseev	Un. Helsinki, FI	H. Chepfer	UPMC, FR
J-B. Renard	LPC2E-CNRS, FR	D. Donovan	KNMI, NL
J. Delanoe	LATMOS, FR	S. Tanelli	NASA-JPL, USA
G L. Liberti	CNR-ISAC	D. Perez-Ramirez	U.Granada, ES
M. Tesche	U Hertfortshire UK	Y. Markonis	U. Life Sciences, CZ
G. Ancellet	CNRS-LATMOS, FR	N. Scott	LMD/IPSL, FR
A. Apituley	KNMI, NL	D. Winker	NASA-LARC, USA
Ph. Gouloub	CNRS/Lille, FR	H. Barker	Environment Canada
A. Devasthale	SMHI, SE	C. Hostetler	NASA-LARC, USA
		P. Völger	IRF, SE

A total of 33 Principal Investigators lead as many scientific teams contributing to the Validation of the ESA products.

(one of the PIs leads 2 proposals)

These teams make correlative observations (see next slides) collocated with EarthCARE measurements, and perform scientific analyses of the deviations

4.3 Airborne platforms and instruments contributing to EarthCARE Validation



FAAM	CTH/Aerosol LIDAR, MARSS radiometer, various in-situ
HALO	WALES LIDAR, Cloud radar, imager, various in-situ, Cloud radar, MWR, solar radiation,
DLR Falcon	in-situ cloud probes , hygrometer, dropsondes, etc.
LOAC Voltaire	Light Optical Particle Counter
Strateole	BeCOOL lidar, backscatter tethered sonde, etc.
ATR42	RASTA and BASTA radars, LNG Lidar (355nm), ALIAS LIDAR (355nm) Radiometers etc.
STRATOBUS	BASTA
Polar 6	in-situ probes, MIRAC RADAR (95), AMALI LIDAR (355nm)
Vulcanair (TBC)	Nd-YAG system at 532 (TBC)
TBC	355 lidar (CNES – Russia collaboration) (TBC)
Norwegian Aircraft	Nezerov probe (LWC, TWC)
NASA LaRC Aircraft	HSR Lidar
NASA JPL Aircraft	Precipitation and Cloud Radar
EUFAR (TBC)	Various Lidars (TBC)
Canadian Convair	94GHz cloud radar, (355nm) backscatter Lidar
various UAVs	Various instruments , including WALI Lidar, etc.

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4.4 Pre-Launch Airborne Campaigns for EarthCARE



Campaign	Location	Date
NARPEX EPATAN	North Atlantic	2016
A-CARE	Mediterranean	2017
Tropical Campaign	Cape Verde	2021



4.5 Ground-based instrumentation contributing to ESA EarthCARE validation



instrument	instrumen	instrument
(Multiwavelength) Raman-(polarisation) Lidar	(Profiling) Cloud radar	(Microwave)/(visible) radiometer
Backscatter Lidar	Ceilometer	radiosonde
Doppler Lidar	(micro) rain radar (profiler)	Pyrometer
(multi channel) (multi-wavelength) RMR Lidar	Precipitation radar	Pyranometers and Pyrgeometers
Aerosol Lidar	Radar wind profiler	Optical distrometer
Micro-Pulse Lidar	Weather radar	Sun sky radiometer
Nephelometer	Aethalometer	Sun photometer
(Pandora)(Precision) spectrometer	(Optical) Particle (Counter)/(Sampler)	



4.6 Ground-based sites involved in EarthCARE Validation

(**lidars** and **radars**. Dense networks and other instrument types are not shown)



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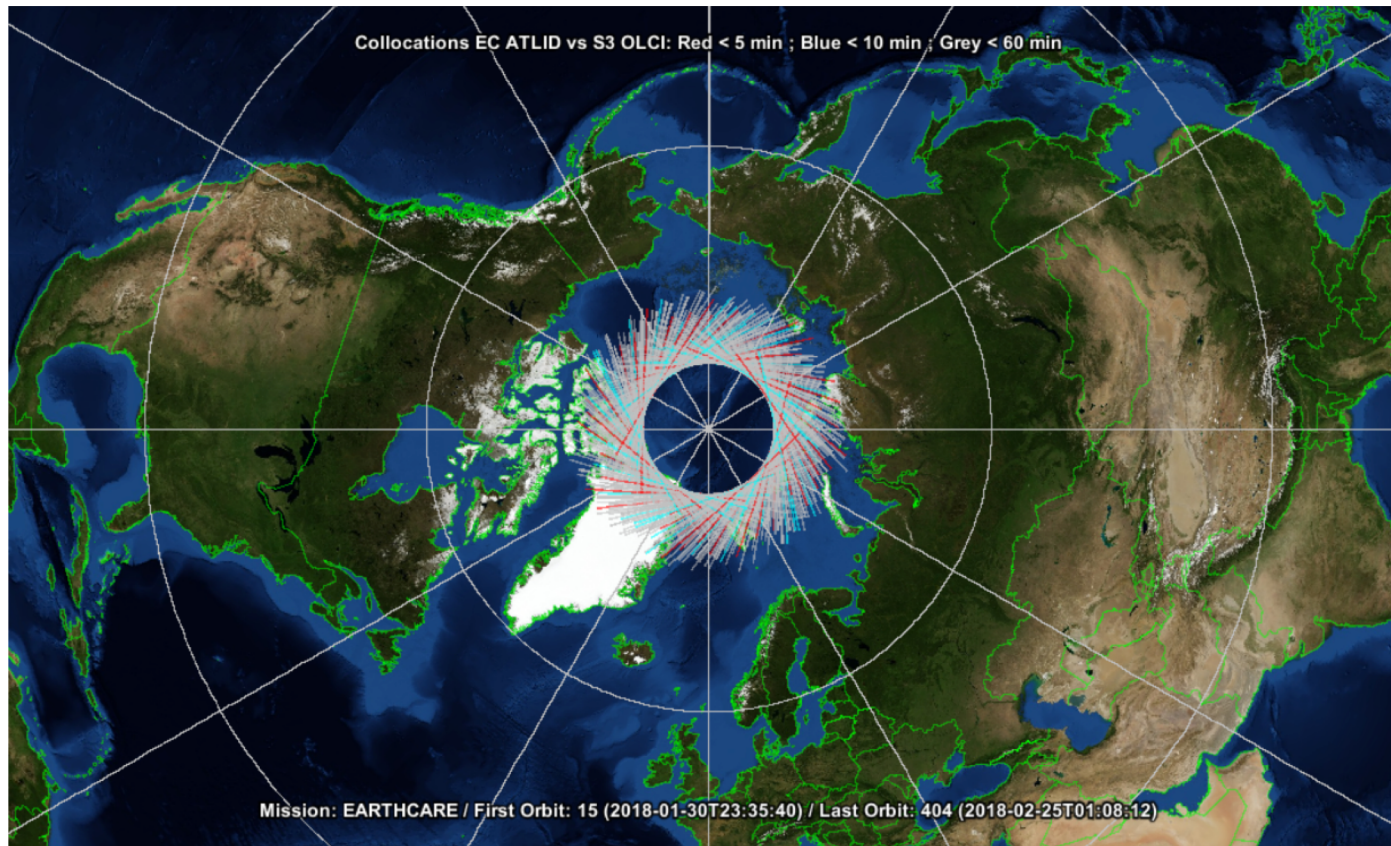
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4.7 Satellite intercomparisons for EarthCARE Validation

AVHRR	GERB
CALIPSO (*)	GPM/DPR
CATS	SCARAB
CERES	SEVERI
CLARREO	Sentinel 3 (OLCI+SLSTR)
MODIS	VIIRS

(*) = several proposals will use CALIPSO even in case there would be no Mission overlap in time. In that case they will use the CALIPSO Dataset in a statistical manner

4.8 Caveat: for some satellites – few collocations with EarthCARE (example below is Sentinel 3/OLCI – EarthCARE/ATLID)



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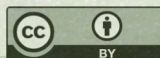
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4.9 Validation Activities for ESA EarthCARE Products: Assessment



The validation contributions have been presented during the [1st ESA EarthCARE Validation Workshop](#) from 13 to 15 June 2018 in Bonn, Germany. The workshop conclusion was that the combination of all proposed contributions will form an **adequate** validation programme for EarthCARE, with the following areas requiring further attention:

- The sum of all contributions is **needed in full** to avoid gaps. It is imperative that full funding is achieved.
- Better coverage is needed for the Tropical regions
- The geographical coverage of Lidars is considered good, whereas the coverage of Cloud Profiling Radars could benefit from additional instruments
- Many of the Cloud Profiling Radars are not equipped with Weather Radars for context. Improving on this would reduce the representativity error



4.10 EarthCARE Validation Support Functions



- **Correlative Data Repository:** [ESA Atmospheric Validation Data Centre \(EVDC\)](#)
- **EVDC data conversion tools:** Correlative data are to be shared using [GEOMs](#) metadata and common templates. Conversion tools are available at the EVDC
- **Tools for data decoding, data analysis, and data intercomparison:** a suite of tools is under development to assist with the following operations:
 - 🌐 Discover EarthCARE Products
 - 🌐 Intercompare correlative with EarthCARE data products
 - 🌐 Subsetting of EarthCARE data products
 - 🌐 Visualisation of EarthCARE data products
- **EarthCARE Simulator:** Simulates EarthCARE data based on a geophysical scene
- **Service for overpass prediction:** Principal Investigators can request predictions (or calculate themselves using tools on the next slide

4.11 Validation Support Functions: Overpass tools



Usage	Desktop	Command Line	Web Applications
Overpass table generation for fixed, ground based sites	ESOV	GroundSitePass	OPOT
Overpass table generation for Balloon Trajectories	ESOV	BalloonOverPass (still being prototyped)	OPOT
Identification of overpass geolocations and times inside (airborne) campaign area	ESOV	ZoneOverpass	OPOT
Identification of overlapping sampling volumes between EarthCARE and another satellite instrument		Instrument Collocation	
High-Image-Quality Orbit Swath Visualisation	SAMI		



4.12 Interactive EarthCARE Validation Portal



Objectives of this portal are to:

- Present the EarthCARE validation activities
- **Solicit new contributions**
- support coordination of the ESA EarthCARE Validation Team (ECVT)
- structure the interactions between ECVT scientists, subgroup leaders, instrument experts, algorithm developers, and campaign participants
- provide the latest information on instrument (un)availability, mission planning, instrument/product/algorithm changes

The portal landing page is at <https://earthcare-val.esa.int>

Please contact esa-ecvt@earthcare.esa.int if you are interested in participating in the validation of EarthCARE

Teams with accepted proposals are incorporated into the ESA EarthCARE Validation Team, and benefit from early and exclusive access to preliminary EarthCARE data (well before the public release of the consolidated data) and from close interaction with instrument and algorithm experts



5. EarthCARE Validation Timeline



Milestone	Period
ESA-JAXA Validation Implementation Plan 1.0	Q2 2020
Pre-launch ESA-JAXA validation workshop	Q4 2021
ESA-JAXA Validation Implementation Plan 2.0	Q1 2022
ESA Validation Rehearsal	Q2 2022
ESA Validation Rehearsal Review / Readiness Review	Q2 2022
EarthCARE Launch	June 2022
ESA-JAXA Preliminary Validation Results Review	January 2023
EarthCARE Long-term Validation Phase	January 2023 until End-of-Mission



Contact esa-ecvt@earthcare.esa.int and visit the [validation portal](#): 



Welcome to the EarthCARE ESA Validation Portal.

This part of the EarthCARE validation website serves as introductory information for scientists interested in EarthCARE validation, and also acts as a landing page for the (restricted) [collaboration environment for the Principal Investigator access](#). Scientists that are interested to collaborate on EarthCARE Validation are requested to contact esa-ecvt@earthcare.esa.int in order to obtain information on how to join the EarthCARE Validation Team.

EarthCARE Validation Team Principal Investigator access
(in preparation)

Introduction to the EarthCARE mission

EarthCARE, ESA's Clouds, Aerosols and Radiation Explorer mission developed in co-operation with JAXA, the Japanese Aerospace Exploration Agency, will address the need for a better understanding of the interactions between clouds and aerosols in climate regulation. That ESA-JAXA Joint mission was selected as the 6th Earth Explorer Mission and 3rd ESA Earth Observation Core Mission during the Granada ESA meeting in October 2004.

The EarthCARE mission aims to improve the representation and understanding of the Earth's radiative balance in climate and numerical weather forecast models by acquiring vertical profiles of clouds and aerosols, as well as the aerosols control cloud properties, while clouds control the production of precipitation and convection influences stratospheric humidity. The observations of EarthCARE will therefore lead to more reliable climate predictions and better improved representation of processes involving clouds, aerosol and radiation.

The satellite will weigh about 2350 kilograms (including propellant) and will be placed in a quasi-polar orbit of 97° inclination at an altitude of about 400 kilometres. Its launch is scheduled for 2022. The four instruments of the payload include a Broad-Band Radiometer and a Multi-Spectral Imager developed by ESA, and a Cloud Profiling Radar developed by JAXA. This instrument suite has been optimised to provide co-located samples of the state of the atmosphere along with

News

- 29 April 2020: The EarthCARE validation portal has been opened.

EarthCARE Mission resources

Further information about the EarthCARE mission in general can be obtained from the following resources:

- The ESA EarthCARE website at https://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/EarthCARE
- The ESA Earthnet portal at <https://earth.esa.int/web/guest/missions/esa-future-missions/earthcare>
- The EarthCARE site at the EOportal <https://directory.eoportal.org/web/eoportal/satellite-missions/e/earthcare>
- The JAXA EarthCARE website at <https://global.jaxa.jp/projects/sat/earthcare/>
- A scientific paper about the EarthCARE Mission in the Bulletin of the American Meteorological Society

EarthCARE Validation

The geophysical validation of EarthCARE involves a suite of correlative instruments and methods. This portal provides an **overview of the validation activities**. These activities are resulting from the responses to the 2017 ESA Announcement of Opportunity for EarthCARE.

The activities have been presented and reviewed during the 1st ESA EarthCARE Validation Workshop in June 2018 in Bonn, Germany.

The scientists in the EarthCARE validation team will collaborate with ESA algorithm and instrument experts and will be provided with preliminary EarthCARE data products as soon as available, hence well before public release of the

Scientists that are interested in collaboration and joining the ESA EarthCARE Validation Team are invited to contact esa-ecvt@earthcare.esa.int

EarthCARE Validation Resources

Websites

- A Summary of activities in the ESA EarthCARE Validation Programme
- The (restricted) [portal for the ESA EarthCARE Validation Team Principal Investigators](#) (in preparation)
- The ESA Atmospheric Validation Data Centre (EVDC)

Documents

- The Scientific Validation Implementation Plan (in preparation)
- The reference documents of the EarthCARE Validation Announcement of Opportunity (the proposal submission function is now deactivated, but you can still contact esa-ecvt@earthcare.esa.int in case you are interested in collaboration)

Meetings/Workshops

Date	Venue	Title (link to workshop home page)	Report
13-15 June 2018	Bonn, Germany	1st ESA EarthCARE Validation Workshop	20180613-15 ESA CaVal Workshop Report (1.0).pdf
2021	Noordwijk, Netherlands	(2nd ESA EarthCARE Validation Workshop) under consideration but not yet confirmed	
Between 12 and 15 Months before Launch		ESA-JAXA Prelaunch Validation Workshop	

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