



***European Space
Agency***

EarthCARE Mission

***Announcement of
Opportunity***

***External Calibration and
Validation of the
EarthCARE Mission***



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EarthCARE Cal/Val Announcement of Opportunity

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1. Description of the Opportunity

The Earth Clouds, Aerosol and Radiation Explorer (EarthCARE) Mission is being implemented as the sixth Earth Explorer Missions. EarthCARE has been specifically designed with the basic objective of improving the understanding of cloud-aerosol-radiation interactions, so as to include them correctly and reliably in climate and numerical weather prediction models. EarthCARE will achieve this by providing global observations of atmospheric cloud and aerosol profiles with collocated measured as well as modelled long-wave and short-wave radiation.

Atmospheric cloud and aerosol properties will be retrieved from EarthCARE's 355nm lidar with a high spectral resolution (HSR) receiver with co- and cross-polar channels (ATLID), 94GHz Doppler cloud profiling radar (CPR) and a multi-spectral imager (MSI). Radiative transfer models will be used to derive atmospheric radiative properties and heating rates from the retrieved cloud and aerosol observations. Reflected solar and emitted terrestrial thermal radiation will furthermore be observed by EarthCARE's broad-band radiometer (BBR) and compared to their modelled equivalents.

The EarthCARE mission will be implemented in collaboration with the Japanese Aerospace Agency (JAXA) who will provide one of the core Instruments, namely the CPR, including the associated ground facilities in Japan to process their instrument data.

The nominal duration of the EarthCARE mission is three years, including a 6-months commissioning phase.

With both new sensor technology and retrieval approaches, there is the need to carefully assess the quality and validity of the generated data products before releasing them to the wider user community. This is even more relevant for the specific case of EarthCARE where the ultimate objective is to enable synergistic retrievals. This Announcement of Opportunity (AO) for EarthCARE is aimed at assessing and reducing the uncertainties in the EarthCARE measurements, by thoroughly assessing all aspects of instrument performance and stability, accuracy and suitability of the data processing, and comparison with independently acquired measurements.

2. Information Concerning the EarthCARE Mission – Objectives and Description

To support the user community of the EarthCARE mission, and in particular to support applications to this AO, a set of documents has been prepared to provide a detailed description of the mission as a whole. These documents are:

- The EarthCARE Science Report [RD 1]
- The EarthCARE Mission Requirements Document [RD 2]. This document contains a description of the scientific context of the mission, the scientific and measurement objectives and how these are related, as well as an outline of the satellite system and data products. This document contains information of general interest,
- The EarthCARE System Requirements Document [RD 3] which translates the (scientific) Mission Requirements into (technical) requirements as orbit and attitude, instrument performance, operability, etc.,
- The EarthCARE Instruments Description [RD 19], which provides a technical summary of instrument design and properties
- The EarthCARE Level 1 and Level 2 (atmospheric optical properties products), and Level 2b Algorithm Theoretical Baseline Documents which provide background information about the scientific algorithms [RD 9-13],
- The Level 1b, Level 2a, and Level 2b Input Output Data Definition documents (IODDs) present and describe the input and output data of the EarthCARE processing system [RD 14-18].
- The EarthCARE Validation Requirements Document [RD 4].
- The JAXA EarthCARE Research Announcement Summary [RD X]

3. Objectives of the Opportunity

This ESA Announcement of Opportunity solicits proposals for the validation of the EarthCARE ESA products, namely the ATLID, MSI, and BBR level 1 products and the ESA level 2 products, which are generated from ESA (ATLID, MSI, and BBR) and JAXA (CPR) level 1 input data. In addition to the direct validation of level 1 products, it is expected that the validation of level 2 products will also provide feedback on the level 1 input data quality of all four instruments. This announcement of opportunity is international and non-restrictive, i.e. it is open to participants from anywhere in the world.

The validation of the JAXA products, namely the CPR level 1 products and the JAXA level 2 products, that are generated from lower level ESA (ATLID, MSI, BBR) and JAXA (CPR) input data has been subject of a separate Research Announcement under JAXA responsibility. A second JAXA EarthCARE Research Announcement of Opportunity is in preparation for 2019. For more information on the past and upcoming JAXA Research Announcements, please refer to [RD 22]. The point of contact for the 2019 JAXA Research Announcement is the JAXA Earth Observation

Research Center (ec-eorc@ml.jaxa.jp). This same point of contact can be used by prospective Japanese Principal Investigators seeking advice on participation to the present ESA Announcement of Opportunity.

The principal means to provide estimates of uncertainty are by comparison to independent ground-based, airborne, and satellite-based measurements and to models, combined with detailed investigations of the retrieval methods applied to the target satellite measurements.

The European Space Agency is announcing the opportunity for interested groups to participate in these activities. Specific areas in which the contribution of the participants is sought are:

- validation using other satellite, airborne or ground-based experiments providing independent measurements;
- experiments to assess accuracy, resolution, and stability of the EarthCARE instruments;
- assessment and validation of the EarthCARE retrieval and processing

The Agency anticipates that this AO will stimulate the response from a wide cross-section of the international science community with experience in conducting field experiments and campaigns measuring atmospheric properties, and in geophysical research using remote sensing data. One outcome of the AO process and the subsequent validation team formation is to connect groups with field and satellite expertise, respectively. The AO is open to groups and individuals; group responses are particularly welcome. The invitation is open to scientists worldwide.

The needs for EarthCARE validation have been expressed in the Validation Requirements document. Contributions that meet those needs in the following (non-exhaustive) list of areas of investigation are expected:

- assessment of methods/algorithms for instrument calibration
- assessment of proposed methods/algorithms for external calibration
- independent estimates of achievable localisation and co-alignment errors
- independent determination of instrument stability
- comparison of geophysical products (cloud, aerosol, precipitation, and radiation properties) with independent ground-based, airborne or satellite measurements, including consideration of representativity errors
- impact of auxiliary information used in the processing (temperature, backscatter data bases, ...)
- comparison with other space-borne sensors (at level 1 and level 2)
- characterisation of major error sources and their dependencies on secondary parameters (e.g. solar zenith angle, land-sea error dependency, etc.)
- error budget compilations

Principal Investigators (PIs) whose proposals are accepted will be invited to become members of the EarthCARE Calibration and Validation Team (ECVT). Members of the ECVT are expected to participate in some, or all, of the following activities:

- Integration of their proposed work within a wider scientific and technical framework, and the establishment of collaboration between specialists
- Participation in the establishment of detailed validation planning well in advance of the launch, presently planned for August 2019
- Participation in post-launch data product and retrieval algorithm validation, and independent monitoring of satellite performance and data quality
- Support to the Agency in the planning and execution of special satellite operations in conjunction with ground experiments
- Support to the Agency in the definition, in the light of post launch experience, of reprocessing algorithms to be applied to the level 1b, level 2a, and 2b data
- Support to ESA in dedicated ECVT meetings and workshops
- Participation in pre-launch rehearsal activities

Members of the ECVT will be expected to play an active role in the validation of data products. A description of their proposed contribution and experience forms part of the response to this AO.

Members of the ECVT will have access to EarthCARE data products starting at Level 1b up to Level 2. Also, it has to be noted that during the commissioning phase of the satellite, data access will be limited to the ECVT members.

4. Organisation of Activities

Following the evaluation of the responses to the AO and the confirmation of the selected proposals, the ECVT will be established. The Team, in agreement with the Agency, will plan and execute the independent validation and external calibration, and contribute to the monitoring of the EarthCARE satellite system and data products.

Based on the proposals of each Principal Investigator, detailed agreements will be drafted based on the template [RD 5]. The sum of the final agreements will form the basis of the EarthCARE Validation Plan.

This plan, to be consolidated in the 18 months prior to the launch, will identify the calibration and validation activities, the group or groups responsible for their implementation, their schedule, and the related schedule of satellite and / or ground segment operations, (if any), and data exchanges. This plan and the state of readiness will be reviewed 4 months before launch at a dedicated Cal/Val Readiness Review.

During the commissioning phase that immediately follows the launch, the ECVT will provide a first assessment of the data products, and report on external calibration activities where these have been performed. It may also be requested to support the check-out of the satellite-ground segment system. The ECVT will provide an input to the Commissioning Phase Review, which will be held after completion of the commissioning phase.

During the mission phase that follows, the ECVT will continue to support the validation of the data products, investigations of retrieval algorithms and ongoing monitoring of the instrument system and data products. Evaluation of the performance of retrieval algorithms is also greatly helped by comparison to co-located ground-based, air-borne, and satellite observations.

It is anticipated that some validation activities, together with ongoing system and data monitoring, may continue throughout the mission lifetime.

It is foreseen that the work of the ECVT will require Working Meetings at intervals in addition to the Reviews described above.

Funding of the activities solicited through this AO is to be covered by national/institutional resources.

5. Guidelines for Proposal Preparation

The proposal can only be submitted in electronic form using the ESA AO Web site in a pre-defined format. Detailed submission guidelines are available at <https://earth.esa.int/aos/EarthCARECalVal>.

The **submission deadline is 15 October 2017**. Proposals submitted after this deadline shall not be considered.

ESA recommends that institutes group their efforts into joint proposals, based on common themes, or instrumentation.

6. Evaluation of Proposals

6.1 Evaluation Procedure

Proposals received in response to this Announcement of Opportunity will be reviewed by panels composed of:

- ESA experts
- selected and independent individuals with widely recognised expertise in geophysical validation, and EarthCARE science

6.2 Evaluation Criteria

The following criteria will be used in the evaluation of the proposals:

- relevance of the proposed project to the Validation Description of the EarthCARE calibration, validation and/or retrieval activity
- contribution to the objectives of the EarthCARE calibration, validation and/or retrieval activity
- maturity of the instrumentation and algorithms for the purpose of EarthCARE validation

- background and experience of the proposers
- feasibility and probability of success
- funding commitment status.
- agreement to mutual (preliminary) data exchange

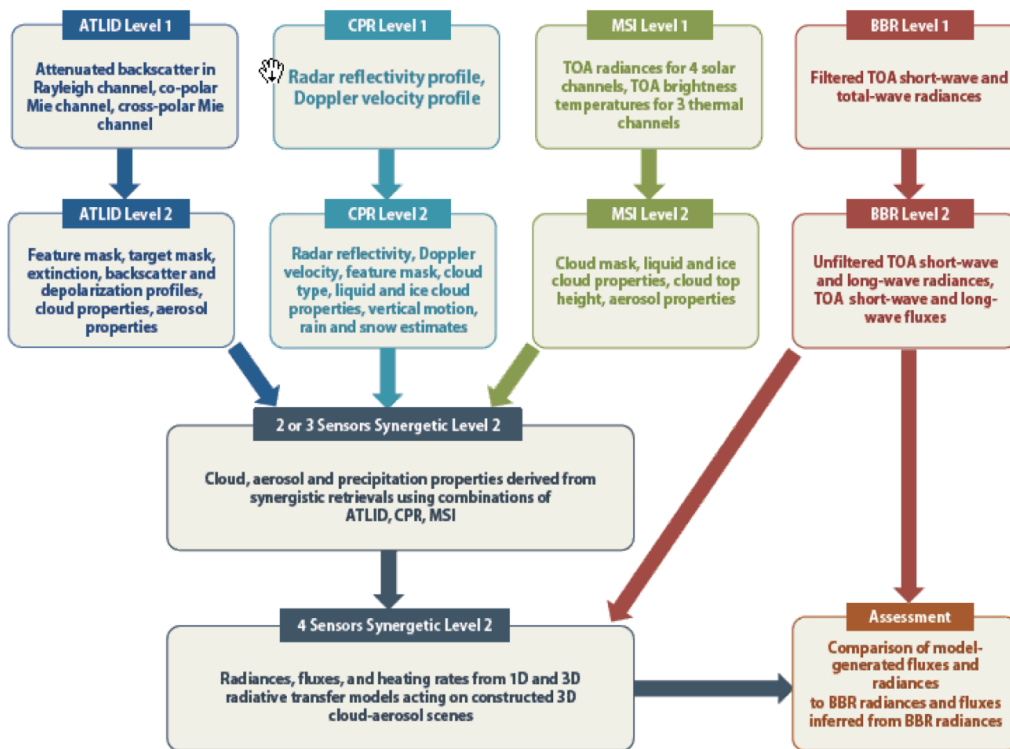
After the completion of the evaluation, prospective Principal Investigators will be notified of the outcome, or contacted to provide clarification. Principal Investigators of accepted proposals will then be contacted to establish in their contributions, resources and data needs in greater detail and to provide further evidence of funding, in order to arrive at individual work agreements [RD 5], which will in turn form the basis of the EarthCARE Validation Plan.

7. Overview of available data

7.1 EARTHCARE data

In support of the validation and algorithm development activities, the Agency will make preliminary EarthCARE data available to the investigators selected in response to this AO.. During the Commissioning Phase, access to preliminary EarthCARE data will be restricted to Members of the ECVT and ESA contractors (instrument developers, algorithm developers, ground segment developers) only.

Details of the EarthCARE data products available to ECVT Members are described in the algorithm theoretical baseline documents (ATBD's) [RD9-13] and Product Definition documents (IODDs) [RD14-18]. The dependencies between these products is as follows:



It should be noted that this announcement of opportunity solicits proposals for the validation of the ESA EarthCARE products. The ESA products are ATLID, MSI, and BBR Level 1 products and Level 2a and synergetic Level 2b products for the four instruments (i.e. including the CPR). The JAXA products have been subject of a separate JAXA Research Announcement. The JAXA products are the CPR Level 1 product, and level 2a products for ATLID, MSI and CPR, and synergetic products for the four instruments.

For collocation planning, ECVT members will be provided with access to overpass prediction tools. Intercomparisons between EarthCARE products and correlative data (the independent measurements contributed by the Principal Investigator) will be facilitated by a toolbox to be made available by the Agency (TBC).

As part of the proposal submission, applicants are requested to indicate their needs for satellite data products in terms of geographical areas but also data volumes. However, it is recognised that at this early stage in the mission, detailed understanding of the data products, and detailed campaign plans may be lacking. Consequently, ECVT Members will be required to refine their data requirements as part of the planning activity, also taking account of any constraints arising from the capabilities of the data processing and distribution facility.

The delivery of ESA data to ECVT Members under this AO will need to satisfy the general ESA Terms and Conditions covering Earth Observation data which are available at <https://earth.esa.int/files/terms>. It is necessary for ECVT members to satisfy these conditions (which are drawn up in agreement with ESA member states) in order to receive data free of charge. It should be noted in particular that no data

supplied in the framework of this AO may be transferred, sold or given to third parties other than approved co-investigators, without the written authorisation of the Agency. Prior to receiving data, ECVT Members will need to provide:

- confirmation of the funding of the project, where appropriate;
- confirmation of their acceptance of the Terms and Conditions for receiving the data;
- confirmation of agreement to the allocated data quantities and delivery conditions.
- confirmation of acceptance of the EarthCARE correlative data protocol [RD 6]

7.2 Data from other missions

In addition, the Agency will make available data of other Earth Observation satellites where these are required in support of the validation and algorithm activities. Access to data from other satellite missions needs to be duly justified in the proposal. Such data will be made available free of charge.

7.2.1 ADM-Aeolus

The Atmospheric Dynamics Mission “Aeolus” (ADM-Aeolus) hosts the **ALADIN** LIDAR which operates at the same wavelength (355nm) as ATLID on EarthCARE, but in pulsed mode (100Hz). The ADM-Aeolus Level 1b (calibrated wind measurements), Level 2a (atmospheric optical properties products), and Level 2b (quality controlled temperature and pressure corrected wind measurements) products will be made available to this AO. More information on ADM-Aeolus data products is available at: <https://earth.esa.int/web/guest/missions/esa-future-missions/adm-aeolus>

7.2.2 ENVISAT

Systematically available products derived from the following instruments onboard the ENVISAT satellite, in operation from 1st March 2002 until 8 April 2011 can be made available to this opportunity. The following Envisat instrument can be of relevance:

- **MEDium Resolution Imaging Spectrometer Instrument (MERIS)**. It measures the solar radiation reflected by the Earth, at a ground spatial resolution of 300m and 1200m, in 15 spectral bands. It allows global coverage of the Earth in 3 days. All the Reduced Resolution data products will be made available to this AO, while only European coverage of Full Resolution products is envisaged for this opportunity.

A detailed description of available ENVISAT data products is provided at the address: <https://earth.esa.int/web/guest/data-access/browse-data-products?selectedTags=envisat&selectedEarthTopicTag=&selectedMissionTag=envisat>

7.2.3 Copernicus

Data from the Copernicus Sentinel missions is not available through this AO but can be obtained (and used for the purpose of EarthCARE validation) by registering at <https://scihub.copernicus.eu/>. The Sentinel 3 mission is of particular relevance to EarthCARE validation. It hosts 4 instruments working in synergy:

- The **Sea and Land Surface Temperature Radiometer (SLSTR)** measures global sea- and land-surface temperatures every day to an accuracy of better than 0.3 K. It delivers measurements at a spatial resolution of 500 m for visible/near-infrared and short-wavelength infrared channels and at 1 km for the thermal infrared channels.
- The **Ocean and Land Colour Instrument** is based on heritage from Envisat's Medium Resolution Imaging Spectrometer and features 21 distinct bands in the 0.4–1.02 μm spectral region (or 400 - 1020 nm) tuned to specific ocean colour, vegetation and atmospheric correction measurement requirements. It has a spatial resolution of 300 m for all measurements and a swath width of 1270 km, overlapping the SLSTR swath. OLCI's new eyes on Earth will allow ocean ecosystems to be monitored, support crop management and agriculture and provide estimates of atmospheric aerosol and clouds – all of which bring significant societal benefits through more informed decision-making.
- The Sentinel-3 topography package includes a dual-frequency (Ku and C band) **synthetic aperture radar altimeter (SRAL)** supported by a **microwave radiometer (MWR)**.

7.2.4 Third Party Missions

ESA has a Third-Party Mission programme whereby it distributes data from non-ESA missions. A detailed description of data products available via the ESA TPM scheme is provided at the address: <https://earth.esa.int/web/guest/pi-community/apply-for-data/3rd-party>

7.2.5 CALIPSO and CloudSat

The NASA **Cloud –Aerosol Lidar and Infra-Red Pathfinder Satellite Observation (CALIPSO)** satellite combines an active lidar with passive visible and infra-red sensors. The NASA CloudSat mission was launched at the same time as CALIPSO, and hosts a **Cloud-Profiling Radar** operating at 94 GHz.

The missions CALIPSO and CloudSat are not part of the ESA Third-Party Mission programme, hence their data are not available through this AO. Data from CALIPSO can be obtained from the NASA Atmospheric Science Data Centre at

<https://eosweb.larc.nasa.gov/more-about-asdc>. Data from CloudSat can be obtained from the CloudSat Data Processing Centre at <http://www.cloudsat.cira.colostate.edu/>

7.2.6 GERB

Each of the Meteosat Second Generation (MSG) platforms hosts an instance of the **Global Earth Radiation Budget** (GERB) instrument. GERB is a Geostationary Broadband Radiometer. GERB data are not covered by the ESA Third-Party Missions scheme. Data from GERB can be applied for by registering at:

<http://ggsp.srl.ac.uk/registration.html>

7.2.7 EPATAN

In September and October 2016 an EarthCARE PrepAraTioN cAmpaign took place over Iceland. Joint Lidar and Radar measurements were obtained, in some cases over the CALIPSO/Cloudsat ground track. The platforms involved were:

- HALO, with HSR Lidar, DIA Lidar, Doppler Cloud Radar, HS Radiometer, MW Radiometer as payload.
- SAFIRE, with HSR Lidar (355nm), Doppler Cloud Radar, IR Radiometer, Dropsondes
- DLR Falcon with Doppler Wind Lidar

8. Deliverables and Reporting

The progress and accomplishments of the proposals selected through this Announcement will be monitored by ESA. All selected projects will be required to submit quarterly progress reports describing the status of their project and to prepare a final report at the end of the project period, in accordance with a given format to be defined by the Agency. Recommendations for improvements in the system, e.g. processor updates, would be of particular importance. PI's may also be asked to present results or part of their results at a limited number of specialised workshops to be organised by the Agency.

A key aspect of the Opportunity is that no EarthCARE(-derived) data or products used or produced in the framework of any of the tasks, nor the scientific results derived thereof, shall be disseminated to external entities prior to approval by the Agency.

In return for the access to preliminary EarthCARE data and algorithms, projects are expected to deliver preliminary data from their instruments to the ESA Atmospheric Data Centre at a timescale to be agreed with the Agency. As soon as available, they have to deliver consolidated data.

The investigators of projects are to perform scientific inter-comparison analysis and describe the results in reports to ESA, and in presentations, posters and papers at EarthCARE validation workshops. Contributions to conferences not specific to EarthCARE are welcomed.

Results of projects must also be provided in computer readable form to be defined by the Agency, so that they may be made available to other users.

9. AO Time Table

The time table for this announcement of opportunity and the subsequent ECVT process is outlined in the table below. It should be noted that only the first two dates are fixed, and all other dates are tentative.

Release of the call (opening of Submission Website)	15 June 2017
Closing of the call (closing of Submission Website)	15 October 2017
Notification of the evaluation results to PIs	15 January 2018
1 st Validation Workshop (combined w. Science)	June 2018
Pre-launch ESA-JAXA validation workshop	February 2019
Validation Rehearsal	March 2019
Validation Rehearsal Review / Validation Readiness	June 2019
Launch	August 2019
Preliminary Validation Results Review	February 2020
Long-term Validation Phase	February 2020 until End-of-Mission

10. Requests for Information Concerning the AO

Further information regarding this Announcement may be found on the Web site dedicated to the EarthCARE Announcement of Opportunity (<http://earth.esa.int/aos/EarthCARECalVal>) and can also be obtained from the EO Help Desk:

EO Helpdesk	
ESRIN	Tel: +39 06 941 80 777
Via Galileo Galilei – CP 64	Fax: +39 06 941 80 272
00044 FRASCATI	
ITALY	email: eohelp@esa.int

Reference Documents

The following documents provide valid background information for the activities solicited through this Announcement.

- [RD 1] The EarthCARE Science Report ESA-SP-1279
- [RD 2] EarthCARE Mission Requirements Document, EC-RS-ESA-SY-012 v5.0
- [RD 3] EarthCARE System Requirements Document, EC-RS-ESA-SY-001 v1a
- [RD 4] EarthCARE Validation Requirements Document, EOP-SM/3125/TW-tw, v1.1
- [RD 5] Work Agreement template for EarthCARE Cal/Val Projects EC-SOW-ESA-SYS-0900, v1.0
- [RD 6] EarthCARE Correlative Data Protocol, EC-CO-ESA-SYS-885 (Draft)
- [RD 7] EarthCARE Production Model, EC-TN-ESA-SYS-0380, v6
- [RD 8] EarthCARE Product List, EC-ICD-ESA-SYS-0314, v4
- [RD 9] ATLID Level 1b ATBO, EC-TN-ESA-ATL-740, 6.1
- [RD 10] BBR Level 1b ATBD, EC-TN-SEA-BBR-0005, v11
- [RD-11] MSI Level 1b ATBD, EC-TN-SSTL-MSI-00014, v14
- [RD 12] CPR Level 1 ATBD, SEC-140039 rev B
- [RD 13] EarthCARE ESA Level 2 ATBOs (zip file) EC-DP-ESA-SYS-893, v1.0
- [RD 14] Product Definitions (Volume 2b) ATLID L1, EC-ICD-GMV-ATL 00001 v1.3
- [RD 15] Product Definitions (Volume 3b) BBR L1, EC-ICD-GMV-BBR-00001 v1.2
- [RD 16] Product Definitions (Volume 4b) MSI L1, EC-ICD-GMV-MSI-00001 v1.2
- [RD 17] CPR Level 1b Product Definition Document, MAS-110009 rev B
- [RD 18] EarthCARE ESA Level 2 Product Definitions (zip file) EC-DP-ESA-SYS-894, v1.0
- [RD 19] EarthCARE Instruments Description EC-TN-ESA-SYS-891 v1.0
- [RD 20] ESA EarthCARE Product List, EC-ICD-ESA-SYS-0314, v5.0

[RD 21] JAXA EarthCARE product list, NDX-110003 rev E

[RD 22] Summary of JAXA EarthCARE 1st Research Announcement (RA) (Validation) and Plan of the JAXA's validation activity for JAXA EarthCARE Products, NDX-170004

Copies of all documents can be downloaded from the Announcement of Opportunity web site <http://earth.esa.int/aos/EarthCARECalVal>

A scientific paper about the EarthCARE Mission has been published in the August 2015 issue of the Bulletin of the American Meteorological Society and can be downloaded here: <http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00227.1>

Applicable documents

[AD1] Terms and Conditions for the Utilisation of Data under the ESA Category-1 scheme (<https://earth.esa.int/files/terms>)

[AD2] Earth Explorers Data Policy (<https://earth.esa.int/web/guest/-/revised-esa-earth-observation-data-policy-7098>)