EarthCARE CalVal Project

ID	39211

Title	Evaluation of vertical-profiles and column integrated aerosol properties from EarthCARE in Spain using EARLINET/ACTRIS facilities and airborne data from field-campaigns.
Type	AO for EarthCARE CalVal call
Class	CAL/VAL - Quality
Cost	Free of Charge
Primary Application Domain	Calibration/Validation
Secondary Application Domain	Other
Location	Europe
Executive Summary	This proposal deals with the evaluation of aerosol vertical-profiles from EarthCARE using the facilities of the EARLINET/ACTRIS in Spain combined with other instruments and methods used by other participating groups EARLINET/ACTRIS in Spain includes several multiwavelength backscattering lidar systems that operate continuously, and also some Raman systems during nighttime that are able to provide independent profiles of extinction and backscattering at 355 nm, which is the operational wavelength of ATLID lidar system in EarthCARE. Here we propose to extend EARLINET/ACTRIS records including the use of polarized MicroPulse Lidar systems which belong to the MPLNET/GALION networks Moreover, the University of Valladolid operates an AERONET calibration center and is in charge of a portion of the network (about 50 sites) that includes all instruments in the Iberian Peninsula and others in Europe and Latin-America. There are stations in the Iberian Peninsula offering continuous data since more than 15 years. The AERONET calibration center at UVA will participate in this proposal maintaining instruments and providing data products following AERONET standards. Collocated AERONET and backscattering lidar systems allows the retrieval of aerosol extinction vertical-profiles by combining multiwavelength backscattering and sun/sky radiance measurements using the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm (Dubovik et al., 2014). This is critical for ATLID Level 2a products because Raman measurements at 355 nm are very difficult and practically absent during daytime. The proposed project includes coordinating different field campaigns developed in the framework of Spanish projects are intended which will include moving the different lidar systems to exact locations where EarthCARE overpasses. Due to the high cost of airborne campaigns, we propose here an intense coordination with the teams that acquire vertical profiles with lidar measurements. Ideally, the systems that are capable to provide vertical-profiles of extinction at 355 nm will be moved to the closest locations were EarthCARE/ATLID overpasses. Such field campaigns will have the support of the Barcelona Supercomputing Center (BSC) that will provide aerosol prediction using the NMMB-MONARCH model. Therefore, during these campaigns will be possible complete comparisons among EarthCARE, lidar and airborne in-situ measurements and model data. The scenarios we plan to evaluate are Saharan dust outbreaks which are the most important sources of natural aerosol in the Iberian Peninsula, and also pollution from big cities. Biomass-burning, also frequent in summer, is of special interest too. The data provide during this project will allow the evaluation of ATLID L1b data (Mie cross-polar channel absolute calibration, Rayleigh channel absolute calibration, Mie co-polar channel absolute calibration and spectral cross-talk calibration) and Level 2 products such as A-FM, A-AER, A-EBD, A-TC, A-ALD and A-CTH (mostly for thin clouds). The facilities of AERONET in Spain will allow the evaluation of aerosol optical depth (AOD) and Angstrom exponent from the Multi Spectral Imager (MSI) Level 2a data - particularly M-AOT. This proposal is linked to the proposal ‘ACTRIS for EarthCare L2 product evaluation (AECARE)’ that includes all the ACTRIS stations for the evaluation of EarthCARE products using ground-based stations with aerosols and clouds profiling activities. AECARE is the

	overall contribution of ACTRIS to the EarthCARE validation to this AO call. Since national funding is needed to execute the activities, the current proposal is aligned with AECARE main objectives. The consortium of this project is currently funded by different H2020 projects and by national and regional funds.

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Funding and other data details for the call

Funding sources	The activities related to EARLINET/ACTRIS are funded through the H2020 ACTRIS-2 project. Activities related to the evaluation of GRASP radiative transfer code are funded through the Marie Curie RISE project GRASP-ACE grant number 778349. The different groups participating in the proposal also have national and regional funds to fulfill the research.
Other Data details (no ESA)	Data will be provided in the framework of EARLINET/ACTRIS, MPLNET and AERONET networks

Geophysical parameters

EC39211_Geophysical_ParametersTemplate.xlsx View

Detailed Description and additional info for the specific AO

• Relevance to the objectives of the EarthCARE Cal Val activity This project will provide a long-record of measurements for a statistical evaluation of different ATLID products and of MSI aerosol optical depth over land. Such activities will be done using current facilities of the different Spanish groups already operating in the H2020 ACTRIS-2 project. The coordinated efforts will allow further activities not included yet in ACTRIS-2 such as the use of MPLNET lidar instruments and the use of daytime aerosol extinction at 355 nm vertical profiles combining AERONET and multiwavelength backscattering lidar measurements. The project will coordinate airborne in-situ measurements acquired by the different groups within EarthCARE validation objectives, and will allow the set up of lidar instruments in more appropriate sites during airborne flights campaigns. Finally, this project will serve for submitting Transnational Access proposal to EUFAR and make complete field campaigns that also include airborne lidar observations, which is highly recommended in EarthCARE ATLID products evaluation. • Technical and scientific approach: Ground-based measurements Ground-based strategy observations This proposal continues the strategy of evaluating vertical-profiles of aerosols and clouds followed within the

Detailed Description

EARLINET/ACTRIS for CALIPSO satellite. In particular, EARLINET participating stations have to perform measurements, as close in time as possible, when CALIPSO overpasses (Pappalardo et al., 2010). AERONET OBSERVATIONS: A number of AERONET sites operate at the Iberian Peninsula. AERONET provide column-integrated aerosol properties. These measurements are critical for validating aerosol optical depth from EarthCARE Multi Spectral Imaging instruments, and also for closure aerosol studies. LIDAR & SUN PHOTOMETRY MEASUREMENTS: The multiwavelength lidar Raman systems operating at the Iberian Peninsula are currently limited to nighttime observations. During daytime, however, they can operate as multiwavelength backscattering lidar which is not enough for evaluating extinction profiles at 355 nm from EarthCARE/ATLID. Combination of multiwavelength backscattering lidar and AERONET measurements used as inputs in the Generalized Retrieval of Atmospheric and Surface Properties (GRASP) radiative transfer code. GRASP uses the heritage of AERONET and POLDER inversions and is capable to provide aerosol properties, particularly extinction vertical-profiles at 355 nm, through least-squares numerical inversions. Particularly, we propose to use the GRASP/GARRLiC scheme, originally developed in H2020 ACTRIS project, and whose evaluation is currently being done using a synthetic database generated by the Goddard Earth Observing System Model, Version 5 (GEOS-5) of the NASA Global Modeling and Assimilation Office. GRASP/GARRLiC is able to provide independent aerosol extinction and backscattering profiles without the assumption of constant extinction-to-backscattering ratio. GRASP/GARRLiC is also able to provide vertical profiles of aerosol microphysical properties, both for fine and coarse fine separately, and it is being evaluated its capabilities for single scattering albedo using GEOS-5 synthetic data.

Technical and scientific approach II: Mobile Facilities. FIELD CAMPAIGN COORDINATING EFFORTS Different field campaigns by IDEA, UGR and INTAand include flights with in-situ instrumentation. During this project we will coordinate future field campaigns in the Iberian Peninsula that include airborne in-situ instrumentation with intense observational periods with the EARLINET/ACTRIS and MPLNET stations. The Raman lidar systems will be moved to closest satellite overpass areas and therefore minimize the effects of aerosol spatial variability, and if possible they will be placed very close to the areas of flights. During the field campaigns, airplanes will follow EarthCARE trajectory. USE OF UNMANED AERIAL VEHICLES Remotely piloted aircrafts (RPAs) constitute a cutting-edge technology with many applications for monitoring the Earth. In this framework, in collaboration with the University of Extremadura and within several projects funded by the National Research Program, INTA shows a deep and long experience in developing and adapting scientific payloads for monitoring the radiation balance at different atmospheric levels. Thus, a gyro-stabilized nose cone equipped with radiometric instrumentation (such as spectro-radiometers, broadband radiometers and pyrgeometers) has been developed in order to accurately measure the downwelling and upwelling irradiances in the short- and long-wave ranges. This instrumentation allows a comprehensive description of the radiation field from the ground level up to 4500 m, which is the maximum altitude where our RPA can safely fly. These flights allow measuring the profile of the net radiation flux among others. The flights will be coordinated with intense observational periods associated with the previous field campaigns. EUFAR FLIGHTS For the campaigns proposed here we will apply to the European Facility For Airborne Research (EUFAR) for Transnational Access (TA) to their facilities. EUFAR brings together infrastructure operators of both instrumented research aircraft and remote-sensing instruments with scientific community user. Two schemes are proposed: First, we will submit a TA focussing on the evaluation of EarthCARE products and linked to the activities proposed here with ground-based lidar and sun photometry. The TA will provides an allocation of flight hours on EURFAR selected aircrafts. Ideally we plan to use airplanes which operate lidar instruments. The second option is to join to TA already in course and of interest to the project, being the most remarkable “Evaluating Dust forecasting over the eastern Mediterranean area” and “Evaluation of ground-based lidar methodologies for continuous profiling of Cloud condensation and Ice nuclei concentrations in the Mediterranean”. NMMB-MONARCH MODEL: This model is used for aerosol forecast during special field campaings and intensive observational period. The model is online available and operated by the Barcelona Supercomputing Center

Working Package 1 (WP1) –Measurement plan preparation for systematic ground-based measurements: The alerting system will be adapted to EarthCARE overpass and a measurement plan will be delivered each week. The three different scenarios of measurements described above will be applied. The

	MPLNET lidar systems will participates as cases B or C. Working Package 2 (WP2) – Database set-up and data exchange: An optimal mechanism for data exchange will be negotiated between the project team and ESA. Working Package 3 (WP3) – Correlative observational period from ground instrumentation: We expect to provide preliminary results since phase E1. Taking into account approximately 2 overpass per week in the region which typically 75 % coverage due to weather and technical limitations (this percentage could even increase depending of period of launch), 6 weeks of observations + 4 weeks of data evaluation + 2 weeks of data review/synergy will allows us to provide approximately 20 vertical profiles cases at L+12 weeks and can serve for a very first quality check by the end of phase E1. We also plan to provide ground-based data during all the period which EarthCARE will be operating (Phase E2), Working Package 4 (WP4) – Field campaigns developments: The resources for developing field campaigns will be discussed and evaluated. Ideally, we plan to develop at least three different field campaigns which involve airplane. Field campaigns are planned for the periods 2020-2022 and therefore will coincide with EarthCARE operation. Working Package 5 (WP5) – Data evaluation phase I Long-term observational periods: Measurements from all stations will be used in this task to study the temporal and regional variability of aerosol and cloud scenes. Aerosol and clouds backscatter and extinction vertical profiles will be the key parameters provided during this project, and of particular interests are these at 355 nm that coincides with ATLID HSRL system. Also, lidar depolarization measurements will allow the evaluation of aerosol typing algorithms. On the other hand, evaluation of aerosol optical depth from AERONET measurements will allow the evaluation of the values obtained MSI. Working Package 6 (WP6) – Data evaluation phase II Field campaigns: During the first campaigns lidar systems will be set up at exact locations where satellite overpass, and as several instruments will be moved to exact locations all the data will serve for accurate EarthCARE evaluation when passing over the Iberian Peninsula. The use of airborne lidar will provide minimum 2 hours of correlative data with EarthCARE that will allow detailed evaluation of geometrical and optical properties of aerosol and clouds. Working Package 7 (WP7) – Communication and Dissemination: The dissemination actions will broaden the impact of the project. It will include attendance to CalVal validation workshops and symposiums. When appropriate, we will publish in open access the results in conference proceedings and peer-review publications. For the working packages described above, the following deliverables and milestones are proposed: Deliverable 1.1 .- Report the plan for lidar measurements acquisition. Deliverable 2.1.- Report database and data exchange structure Deliverable 3.1.- Release of data for EarthCARE Phase E1 Deliverable 3.2.- Release of data for EarthCARE Phase E2 Deliverable 4.1.- Report field campaigns organization Deliverable 5.1.- Release of aerosol vertical-profiles and AOD for EarthCARE validation Deliverable 6.1.- Release of data from field campaign measurements. Deliverable 7.1 - Plan for the communication and dissemination of the results Deliverable 7.2.- Report the activities performed Milestone 1.- Release data for ATLID Level 1b Validation Milestone 2.- Report final instrumentation and objectives of field campaigns Milestone 3.- Release data for the EarthCARE Level 2 validation Milestone 4.- Report of the overall research.
Schedule	The activities proposed are planned for four years (48 months) approximately starting on the first semester of 2018. The exact launch date is not decided yet and therefore we refer it as ‘L’. WP01 – Measurement plan preparation for systematic ground-based measurements Starts in pre-launch phase (L-3m) and continues throughout the observational period (Phase E1, L+36 m) (Proposed Lead: CIEMAT) WP02 – Database set-up and data exchange Starts in pre-launch phase and continues throughout the observational period (Phase E1 and Phase E2). Data file structure will be defined in month 12. (Proposed Lead: UV) WP03 – Correlative observational period from ground instrumentation Starts in pre-launch phase and continues throughout the observational period (Phase E1 and Phase E2). The activity will be done during the entire project (Proposed Lead: UVA) WP04 – Field campaigns developments Two field campaigns are planned during the third and fourth year of the project. The plan for the field campaigns will be finished after the first year, approximately in month 18 (Proposed Lead: UGR) WP05 – Data evaluation phase I: Long-term observational periods Data evaluation from ground based measurements at fixed stations will last the entire project. Proposed Lead: UGR). WP06 – Data evaluation phase II: Field campaigns Data evaluation from field campaigns will star after they finish and will take at least six months. Proposed Lead: INTA). WP07 – Communication and Dissemination This working package will last during the project starting approximately in month 6. (Proposed Lead: UPC)

	The schedule for deliverable and milestones is: o Deliverable 1.1: Month 6 o Deliverable 2.1: Month 18 o Deliverable 3.1: Month 18 o Deliverable 3.2: Month 48 o Deliverable 4.1: Month 18 o Deliverable 5.1: Month 48 o Deliverable 6.1: Month 48 o Deliverable 7.1: Month 12 o Deliverable 7.2: Month 42 o Milestone 1: Month 18 o Milestone 2: Month 24 o Milestone 3: Month 48 o Milestone 4: Month 48
Collocation criterion	Collocation protocols of EARLINET/ACTRIS similar to that used for CALIPSO validation. Lidar systems will be moved to exact EarthCARE overpass locations during some periods Airborne field-campaigns following EarthCARE orbit
Peer reviewed publications of reference	Pappalardo et al. EARLINET correlative measurements for CALIPSO: first intercomparison results, J. Geophys. Res.- Atmos., 115, D00H19, doi:10.1029/2009JD012147, 2010.

Team composition Experience and Contribution -

Team composition and experience	The team of the University of Granada leads the overall activity. Dr. Pérez-Ramirez is the PI and focuses his research in the fields of studying retrievals of aerosol microphysical properties from multiwavelength lidar inversion and the in study of such measurements to retrieve vertical profiles of aerosol single scattering albedo. Currently, Dr. Perez-Ramirez is coordinating a Marie Curie RISE project to develop a joint inversion in the GRASP code for the combination of space multi-wavelength lidar and polarimetry measurements. Dr. Lucas Alados-Arboledas is currently member of ACTRIS-2 council and has large experience in aerosol research with more than 120 peer-review paper. The UGR team leads In ACTRIS2 the Spanish Join Research Unit that includes five relevant Spanish research institutions. Dr. Michael Sicard from the Politechnic University of Catalonia (UPC), Dr. Jose Luis Gomez Amo from the University of Valencia and Dr. Manuel Pujadas from CIEMAT currently participate in the EARLINET/ACTRIS activities for CALIPSO satellite evaluation and will be in charge of EarthCARE/ATLID evaluation from ground-based lidar. Dra. Carmen Cordoba from INTA will be in charge of incorporating MPLNET systems for ground-based evaluation in cooperation with UPC team. Prof. Victoria Cachorro is the scientific leader of the Atmospheric Optics Group of Valladolid University (GOA-UVa). Since 2006 the GOA group operates an AERONET calibration facility, in close collaboration with AERONET headquarters in NASA, the Laboratory of Atmospheric Optics in Lille and the Izaña Atmospheric Research Center. Dr. Benjamin Torres is the head of GRASP.SAS and his expertise is critical for the appropriate use of GRASP code. Dr. Andres Alastuey is vice-director of IDAEA since 2012. He has more than 25 years of experience on environmental geochemistry, namely on atmospheric pollution. He will coordinate the field campaigns with Dr. Jose Manuel Vilaplana from INTA. Dra. Sara Basart from Barcelona Supercomputing Center will provide aerosol forecast using NMMB-MONARCH model
Contribution	The products that we will obtain during this project will serve to validate both Level 1 and Level 2 data. ATLID Level 1b Validation: The EARLINET stations used here equipped with 355-nm Raman and high-spectral-resolution lidars are suitable for long-term ground-based ATLID validation. The proposed strategy followed here is that proposed in EARLINET and specifically required as suitable in EarthCARE Level 1b statistically evaluation. The ground-based measurements proposed here will serve for checking ATLID calibrations, particularly in Mie cross-polar channel absolute calibration, Rayleigh channel absolute calibration, Mie co-polar channel absolute calibration and Spectral cross-talk calibration. ATLID Level 2a Products: The ATLID instrument measures vertical profiles of thin clouds and aerosols. The profiles observed have a vertical resolution of 103 m and a sampling along-track of approximately 280 m. The validation of the ATLID L2 products will require the use of collocated data from ground-based air-borne instrument. The strategy of lidar measurements, GRASP retrievals and special campaigns will serve directly to these objectives, and particularly to the following products: • ATLID Feature Mask (A-FM) • ATLID Aerosol (A-AER) • ATLID Extinction, Backscattering and Depolarization (A-EBD) • ATLID Target Classification (A-TC) • ATLID Cloud Top Height (A-CTH) • ATLID Aerosol Layer Detection (A-ALD) MSI L2a Products: The MSI shall provide scene context information around the ATLID cross-section measurements along the nadir ground track. The use of AERONET products that will be generated here will serve to validate aerosol optical thickness (AOT) at 670 nm (M-AOT product). ATLID-MSI L2b Products: ATLID and MSI are synergistically used to retrieve cloud and aerosol parameters, to which both instruments are sensitive. A synergistic cloud top height product is retrieved by exploiting the profiling capability of the lidar with the swath of the imager, and aerosol optical properties are retrieved by adding spectral information from the imager to the lidar observations. From the data generated in this proposal

will be possible to validate: • ATLID-MSI Cloud Top Height (AM-CTH) • ATLID-MSI Aerosol Column Descriptor (AM-ACD), particularly spectral AOT 355-670 nm (over land) and Ångström exponents. L2b Radiation Products: The use of remotely piloted aircrafts with radiometric instrumentation and their combination with ground-based vertical profiles of aerosol will allow the validation of EarthCARE heating rate profiles and TOA fluxes. Particularly, the data generated here will be benefit for the ACM-RT product. Closure Products: The retrieval of cloud and aerosol profiles and, eventually, three-dimensional scenes are subject to numerous uncertainties in the retrieval assumptions itself, such as microphysical properties of the scatterers and a priori information. Aerosol measurements by in-situ instrumentation provided by the different groups will serve to fulfill these objectives. The data acquired by airborne in-situ instrumentation during special field campaigns will particularly serve to determine the optical depth associated with the aerosol for a threshold of 0.05 and accuracy of 10-15%, and profiles with 500 m accuracy. Also, analyses of microphysical properties and aerosol size distribution will serve to validate aerosol types derived from EarthCARE.

Product of EarthCARE / Atmospheric Lidar (ATLID)

Product
ATLID Level 1
ATLID Level 2a (FM, AER, ICE, TC, EBD, CTH, ALD)

Product of EarthCARE / Multi-Spectral Imager (MSI)

Product
MSI Level 2a (CM, COP, AOT)

Product of EarthCARE / Synergy (ATLID - BBR - MSI)

Product
Level 2b (FLX)

Product of EarthCARE / Synergy (ATLID - MSI)

Product
Level 2b (MO, CTH, ACD)