esrin

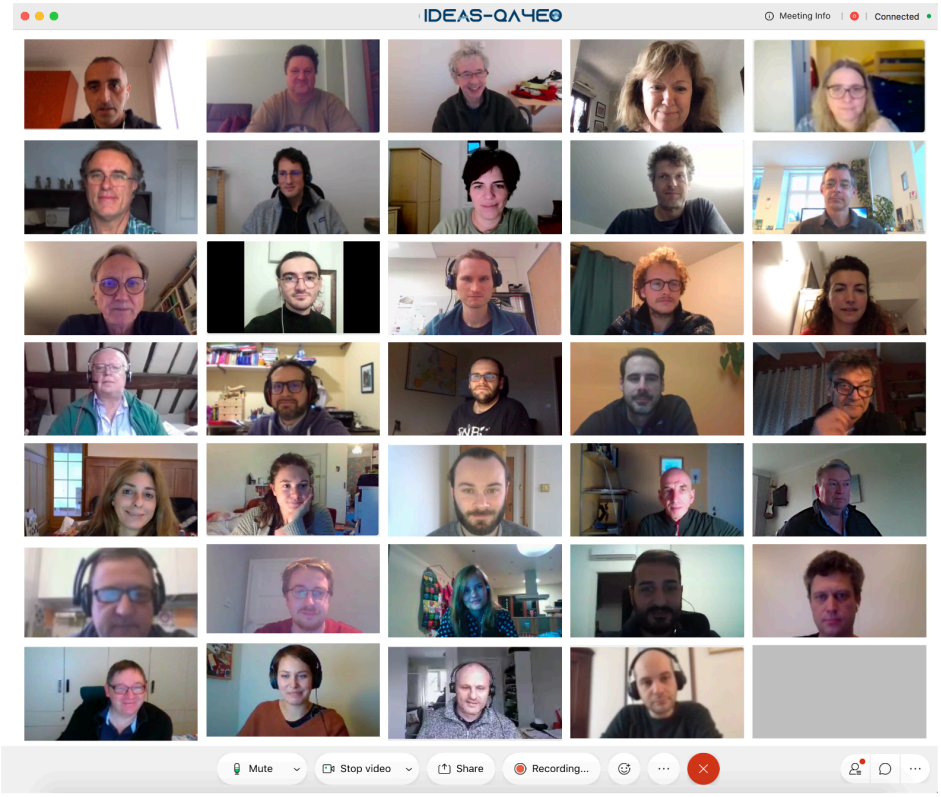
Largo Galileo Galilei Casella Postale 64 00044 Frascati Italy
T +39 06 9418 01 F +39 06 9418 0280 www.esa.int

DOCUMENT

IDEAS-QA4EO Cal/Val WS#2

Minutes of meeting - Virtual meeting

2 December 2020



Prepared by	**G. Brizzi, F. Niro (IDEAS-QA4EO)**
Approved by	**P. Goryl (EOP-GMQ)**
Issue	**1.0**
Date of Issue	**12/12/2021**
Status	**Final**
Document Type	**TN**

European Space Agency
Agence spatiale européenne

Table of Contents

1 INTRODUCTION

On December 2nd, 2020, the second IDEAS-QA4EO Task 2 workshop was held as a virtual teleconference to present and discuss Calibration and Validation (Cal/Val) and Metrology activities carried out during the first year of the IDEAS-QA4EO ESA contract. This document minutes the main highlights from the workshop.

Additional details, including all presentations, are available on-line at:
https://earth.esa.int/eogateway/events/ideas-qa4eo-cal-val-workshop-2

1.1 Background

The IDEAS-QA4EO service contract, follow-on of the former IDEAS+ service, was awarded by ESA to a large consortium of international partners lead by TVUK and Serco. The IDEAS-QA4EO service acts on behalf of the ESA-SPPA section for ensuring the best data quality of ESA operational EO missions; this includes a wide range of activities, spanning from Routine Quality Control to Algorithm Development and Cal/Val activities.

In the frame of the IDEAS-QA4EO consortium, Task 2 is the place where innovative ideas are promoted and incubated to further improve algorithm baseline, calibration and validation protocols, and data quality assessment procedures. In this respect, this task is a continuation of the previous IDEAS+ Task 3, with a reinforced focus on metrological aspects. The IDEAS-QA4EO Task 2 projects are extremely varied and cover a wide range of EO disciplines, ranging from characterization and calibration activities to product validation and algorithm development studies in the various EO domains: Land, Atmosphere, Water, and Cryosphere.

As part of IDEAS-QA4EO Task2 activities, regular meetings are organized on a 9-12 months basis, for reviewing the status of current projects, discussing potential evolutions, fostering synergies among the various groups, and collecting feedback and recommendations. The first of such meetings was convened at the University La Sapienza (Rome, Italy) in February 2020. Due to the Covid-19 pandemic, the second meeting was held as a virtual teleconference in December 2020.

1.2 Acronyms and Abbreviations

AAI	Absorbing Aerosol Index
AAH	Absorbing Aerosol Layer Height
AC	Atmospheric Correction
ACIX	Atmospheric Correction Intercomparison eXercise
AERONET	AErosol RObotic NETwork
ALH	Aerosol Layer Height
AOD	Aerosol Optical Depth
ARD	Analysis Ready Data
BOA	Bottom of Atmosphere
BPDF	Bidirectional Polarization Distribution Function
BRDF	Bidirectional Reflectance Distribution Function
BRF	Bi-directional Reflectance Factor
Cal/Val	Calibration/Validation

CMIX	Cloud Mask Intercomparison eXercise
CCN	Contract Change Notification
CDR	Climate Data Record
CEOS	Committee on Earth Observing System
C3S	Copernicus Climate Change Service
EARLINET	European Aerosol Research Lidar Network
ECV	Essential Climate Variable
EDAP	Earthnet Data Assessment Pilot
EO	Earth Observation
FCDR	Fundamental Climate Data Record
FDR	Fundamental Data Record
FIDUCEO	FIDelity and UnCertainty in climate data records from Earth Observations
FRM	Fiducial Reference Measurements
GCOS	Global Climate Observing System
GRASP	Generalized Retrieval of Aerosol and Surface Properties
HR	High-Resolution
IDEAS	Instrument Data quality Evaluation and Analysis Service
ISMN	International Soil Moisture Validation Network
LAI	Leaf Area Index
LOA	Laboratoire d'Optique Atmosphérique
MBASSS	Mer Bleue Arctic Surrogate Simulation Site
MM	Maturity Matrix
NMI	National Metrology Institutes
NN	Neural Network
NPL	National Physical Laboratory
OC	Ocean Colour
PFR	Precision Filter Radiometer
PGN	Pandonia Global Network
PMOD/WRC	Physikalisch-Meteorologisches Observatorium Davos – World Radiation Center
PROBA-V	Project for on-board Autonomy-Vegetation
PSR	Precision Solar spectro-Radiometer
QA	Quality Assessment
QA4EO	Quality Assurance for Earth Observation
QC	Quality Control
RTE	Radiative Transfer Equation
RTM	Radiative Transfer Model

SCE	Snow Cover Extent
SD	Snow Depth
SI	International System of units
SM	Soil Moisture
SKYNET	Sky radiometer network
SNR	Signal to Noise Ratio
SR	Surface Reflectance
SZA	Solar Zenith Angle
SWE	Snow Water Equivalent
TCDR	Thamatic Climate Data Record
TCWV	Total Column Water Vapour
TLS	Terrestrial Laser Scanning
TOC	Top Of Canopy
TPM	Third Party Mission
UAV	Unmanned Aerial Vehicle
UAV-LS	Unmanned Aerial Vehicle – Laser System
VHR	Very-High-Resolution
WV	Water Vapour

2 PROCEEDINGS

Minutes of the second IDEAS-QA4EO Task 2 workshop is presented in the next chapters following the chronological order of the Agenda (reported in Annex A). The main points arising from the presentations and discussions are summarised.

The main points arising from the presentations and discussions are summarised below. Highlights [**HGH**] and Recommendations [**REC**] are identified and underlined in yellow in the text.

2.1 Welcome and Introduction

Angelika Dehn (ESA) welcomed the participants to the 2nd IDEAS-QA4EO Workshop. The last meeting, held in Rome in February, was a very pleasant face to face workshop, while this meeting had, unfortunately, to be organized as a virtual teleconference due to the restrictions brought by the Covid-19 pandemic. The situation has caused delays in several activities, especially for field campaigns; ESA acknowledges the challenges being faced and is keen to learn about the current status and progresses of the Cal/Val activities.

Fabrizio Niro (Serco) briefly recalled the background and presented the objectives of the meeting. This is Cal/Val meeting number 9, the second in the IDEAS-QA4EO contract which started in November 2019. Gabriele Brizzi (Serco) has joined the coordination team, supporting the ever-growing Task 2 activities: from the baseline proposal, the number of WPs has doubled (18 -> 36). The contract already went through two CCNs (CCN2 in May and CCN3 in November) and another one is scheduled for Q1-2021. Eight (8) new Task 2 WPs have been agreed by ESA for CCN3 and they formally started on November 1st, 2020, while contracts need now to be prepared and signed. The new activities were briefly listed as they are not included in the present meeting with dedicated presentations.

Task 2 focus remains R&D in the Cal/Val domain, pushing towards innovation, and filling existing Cal/Val gaps for data, algorithms, and methods. The reinforced Metrological component is becoming a crucial aspect supporting the transition from incubation to operational maturity for several activities. The Task 2 project settles in the wide context of collaborations between ESA and Copernicus activities as well as with the CEOS. The current year has been extremely challenging, especially for people dealing with instrument procurement, field campaigns, and workshops. All delays in the schedule were transparently communicated, understood and accepted by ESA. The team demonstrated resiliency in adapting to the new way of working; activities have successfully restarted and are progressively catching up with the original plan. Now, within contract Phase 1, a 1.5-year time period remains ahead (potentially followed, after revision, by additional 2.5 years for extension in Phase 2).

It was stressed that the recommendations collected during the previous workshops are not forgotten but contribute to shaping the ESA-SPPA overall Cal/Val strategy. For example, a prototype platform for Cal/Val will be developed next year, basing on the requirements gathered from a user survey where many team members contributed last summer. Volunteers for use-case scenarios and pilot projects are welcome.

A specific outreach plan has been developed to communicate results. A Task 2 Cal/Val Twitter account (https://twitter.com/qa4eoCalVal) and a ResearchGate page for the Task 2 activities are now available. Regularly news articles related to Task 2 activities will be published on the ESA EO Gateway: the first news on Coastal Altimetry was released in November (https://bit.ly/3a5zzEc). Contributions from all WPs and teams are expected. This workshop will showcase advancements and achievements, and it is the context for your recommendations and to discuss the way forward. The agenda is ambitious and an extended discussion session at the end of the days will be difficult, but specific splinter meetings will follow next year to focus on the different topics.

2.2 Metrology and Traceability

Emma Woolliams (NPL) presented NPL activities in support of the IDEAS-QA4EO Task 2 projects and their broader framework. The acronym QA4EO has a long legacy before naming the current ESA project and refers to the 2008 project endorsed by CEOS to set the metrological foundations to EO climate records linking them to the SI reference system. This represents a clear legacy for the current contract. The role of metrology and its main aspects were briefly recalled (traceability, possibility for comparisons, and uncertainty estimates) also with the rationale for defining and building long and stabilized data records, i.e., Fundamental Climate Data Records. The process towards FDR/TDP has been formalized by NPL, as a 7 steps process described in a guideline document which was presented during two webinars in May 2020. A free training course on that was made available here: https://elearning.npl.co.uk/enrol/index.php?id=47. The importance of error correlation structure, one of the topics covered by the e-learning course, was stressed by showing example plots from FIDUCEO and FDR4ALT. The developed techniques are being implemented also to build uncertainty tree diagrams for, e.g., S3 OLCI and RadCalNet. The NPL team is keen to collaborate for consultancy on how to apply such an approach and to boost relevant metrological methods, as it was recently done for the Pandora network (see Luftblick presentation). Python tools will be soon developed to easily handle uncertainties. Fabrizio Niro suggested considering the CEOS Cal/Val platform as an environment for hosting and testing the Phyton Jupiter notebook and Paolo Castracane confirmed his availability to evaluate the feasibility and possible solutions. The proper place to store the NPL material is being considered and discussions will follow off-line.

[HGH-1] – Metrology is the fundamental element of IDEAS-QA4EO contract, with NPL providing support across different Cal/Val domains for adopting metrological practices in uncertainty estimation and traceability assessment. The vision is to enhance interoperability since Cal/Val data gathered in the frame of different field campaigns or ground-based networks can be reliably integrated to increase spatio-temporal coverage.

[REC-1] – FN/GB/PC in collaboration with NPL to investigate feasibility and identify technical solutions to host NPL-developed Python tools within CEOS Cal/Val portal. The tools are meant as tutorial material to guide users in the proper estimation of uncertainties for some relevant EO case studies.

Julian Gröbner (PMOD/WRC) presented the PMOD/WRC WPs concerning validation of Aerosol and Ozone measurements from various instruments, also with laboratory calibration and characterization of filter radiometers for traceability to AERONET-Europe. The activities since the last meeting were recaptured; field campaigns had to be postponed to 2021 except for the campaign at the Observatoire de Haute-Provence (OHP) which is currently running. Total column ozone measurements in Davos are performed by a large variety of instruments. Deviations from the Brewer reference instrument (B156) were shown. Consistency between Dobson and Brewer was investigated using different absorption cross-sections to significantly reduce the impact of the seasonal variability. A paper on that will be submitted. For the Aerosol Optical Depth (AOD) measurements, a PFR (Precision Filter Radiometer) Triad (the WMO reference), a CIMEL from AERONET, and a PSR (Precision Spectro-Radiometer) Triad are operated. Performances were briefly summarized. The PFR sensor, installed in summer 2020 and operated at the AERONET-Europe calibration OHP site, provides traceability to the WMO GAW PFR Triad. Real-time evaluation between the AERONET CIMEL master sun photometers and the collocated PFR is provided online. So far, the agreement is very good, well within the required WMO limits. A larger project MAPP (Metrology for Aerosol optical Properties) which started in June is run in parallel to apply rigorous metrological practices to atmospheric remote sensing of aerosol optical properties and to provide full SI-traceability for three networks: GAW-PFR, AERONET-Europe and SKYNET-Europe. For next year, field campaigns will be resumed also with specific developments for CIMEL to be effectively calibrated in the laboratory. Fabrizio encouraged the possibility to advertise the impressive number of results via an ESA web news, highlighting the relevance of bringing an operational network of measurements to SI standard traceability as well as the impact of ozone cross-sections on seasonal variability. The OHP activities could be promoted and results easily linked. A collocation campaign at the Baqunin site in Rome is also planned for next summer.

[HGH-2] – The collaboration between PMOD and LOA, started in the frame of IDEAS+ and further continued within QA4EO, allowed to significantly advance in applying metrological practices to aerosol remote sensing. The long-term objective is ensuring full traceability and interoperability of current aerosol ground-based measurements in order to enhance their integrated use for satellite Cal/Val.

Stephen Mackin (EOSense) reported on the activities performed by EOSense for the statistical analysis of raw data from EO optical satellite sensors. The quantization effects in SNR for Sentinel-2 MSI affected the developed algorithms and had to be specifically addressed. The blocky nature of some imageries is evident also in the radiance (x-axis) vs SNR (y-axis) plots where a data cloud appears with a fairly well defined upper boundary, modelled as shot noise for the sensor. In the plots, linear features (same noise level for different radiances) are present especially for homogeneous scenes (i.e., Dome C) and can be attributed to signal quantisation. EOSense SNR estimates based on the shot noise limited model are in line with ESA, but some bands present poor estimates. Cleaner results are expected from an algorithm update planned next year. Generally, when the data clouds are reasonably well defined, we can clearly see the data cloud boundaries and estimate quite well the SNR using a shot noise limited model. The results for these bands are in line with previous published values (table 1) and are very similar for most bands.

[HGH-3] – The use of statistically-based methods for assessing the in-flight performances of optical sensors demonstrated successful in a number of use cases. The results agree well with traditional methods, while allowing to detect some minor quality issues, which are not observable with standard diffuser-based or vicarious techniques. The main advantage of such approaches is the possibility to assess performances over the full dynamic range, in particular in the low radiance regime, without the need of ad-hoc calibration acquisitions.

Paolo Castracane (RHEA) presented the status and recent updates of the CEOS Cal/Val portal (http://calvalportal.ceos.org/) which was launched in December 2019. The CEOS Cal/Val portal maintains the role as the main forum for exchanging and sharing information on the CEOS Calibration and Validation activities both for the CEOS-WGCV (Working Group on Calibration and Validation) but also outside. The restyling and reorganization covered the PICS (Pseudo-Invariant Calibration Sites) entry page, the migration of the CEOS SAR subgroup web site into the portal, the inclusion of new wiki sections for the terminology and new pages for specific events. Feedback from Cal/Val users, in particular from the QA4EO teams, is strongly encouraged to further improve the portal and enrich the content. Several actions are currently in progress to expand functionalities. Fabrizio pointed out that data from the Speulderbos forest field database (from Wageningen University) will be soon linked to the portal. Such dataset has an associated DOI and that represents a best practice also for Cal/Val in situ data (DOI attribution can be requested from ESA, but applicability to data resulting from IDEAS-QA4EO activities has to be further verified). The possibility for the CEOS Cal/Val platform to host the NPL Phyton Jupiter notebook shall be investigated.

[HGH-4] – The ambition of CEOS Cal/Val portal is to become the central repository for Cal/Val campaign data, community-endorsed best practices and relevant tools, fostering the adoption of common methods across the science community and building the consensus on the underlying basic terminology.

[REC-2] – IDEAS-QA4EO to work towards a standardized methodology for providing a DOI associated to Cal/Val data generated in the frame of QA4EO projects. The CEOS Cal/Val portal should be used as the centralised repository for disseminating such Cal/Val data.

2.3 Atmosphere Cal/Val

Philippe Goloub (LOA) presented an overview of the activities performed since the last meeting for the metrological improvement of AERONET and aerosol field campaign validations. The Sun photometer calibration platform at the AERONET-Europe calibration facility - Observatoire of Haute Provence (OHP) continued operations during the Covid-19 lockdown period. The campaign for daytime AOD traceability to

WORCC, in collaboration with PMOD, started in July 2020 with the installation of the PFR. Routine comparisons between AERONET/ACTRIS-FR and WORCC/GAW-FR AOD measurements permit monitoring the difference between the two networks. The first comparison looks quite good. The quality of the global network is also ensured by regular comparison exercises between the AERONET-NASA and AERONET-FR reference instruments. Every 3 months, CIMEL master sensors from GSFC and CNRS are cross-calibrated at Mauna Loa and sent back in order to verify and maintain the link between the two network branches. The AOD difference in July and October 2020 was smaller than 0.001 (GSFC - CNRS). Regarding the observational campaigns, adjustments were applied to the original schedule due to Covid-19 restrictions. In May, the testing of the ship photometer started on a small fishing boat in the North Sea/Channel, as a preparatory activity for the setup of the Marion Dufresne ship campaign with operations expected from January 2021 (MAP-IO campaign) sounding aerosol properties mainly over the Indian Ocean. A new collaboration for next year will possibly allow having a photometer installed on an Australian ship. Publications based on aerosol field observations have been submitted or are in preparation. In September 2020, AOD from the Californian smoke plume was detected by 2 weeks of continuous observations at Lille with LILAS QL for a wide range of altitudes applying a fluorescence lidar prototype technique.

In terms of instrumentation, the ship photometer currently adopted is CIMEL-based, close to the commercial version. An advanced mobile photometer (AMP) is under development and will be suited to all types of vectors/platforms. Concerning the Lidar systems, work is ongoing to include a dedicated fluorescence detection channel to identify organic particles and better discriminate aerosol layer within clouds. Additionally, synergistic use of multiple instruments (a combination of lidar and photometer) will further improve aerosol properties retrievals. Finally, it was mentioned that the Lille infrastructure is candidate as ACTRIS national facility for aerosol remote sensing. The intention to contribute to the CEOS Cal/Val portal and the outreach activities was expressed. Fabrizio Niro highlighted the number of achievements so far obtained and stressed the importance to reference papers funded by the IDEAS-QA4EO project on the ResearchGate profile. It was clarified that the AERONET AOD uncertainty provided is not associated with individual measurements but is the uncertainty of the retrieved parameter (the website is referred for documentation). For the next CCN, the possibility to refurbish the CIMEL robots at OHP will be discussed with ESA. The possibility to promote the achievements as news article will be discussed off-line.

[HGH-5] – Thanks to the fruitful collaboration between LOA and PMOD, promoted within IDEAS-QA4EO, the AERONET network is approaching now the state of FRM in terms of SI-traceability. Besides that, the LOA effort in prototyping advanced mobile systems allowed supporting a wide range of aerosol field campaigns improving, our understanding of the atmospheric chemical and dynamic processes.

[REC-3] – IDEAS-QA4EO to work on promoting the recent achievements from LOA in advancing in aerosol traceability and Cal/Val campaigns [**CLOSED**: two web stories published].

Oleg Dubovik (LOA) started recalling the LOA activities for the retrieval of surface atmospheric properties. The main tasks cover: development and validation of surface reflectance models for the interpretation of satellite observation (e.g., S5P, S3), generating a new reference database over AERONET stations for satellite-based surface reflectance quality assessment, and validating aerosol and other retrieval assumptions relating to the GRASP (Generalized Retrieval of Aerosol and Surface Properties) tool. The team is developing a synergistic inversion technique of coincident ground-based and satellite observations to explore the joint retrieval of aerosol and surface properties, also assessing quality of measurements and identifying calibration issues. GRASP is a highly versatile algorithm allowing to analyse measurements from a wide range of ground-based and space-borne sensors; it will be expanded within CCN3 (with support from Spectral Earth) to accurately simulate molecular absorption and thermal IR measurements, extending the tool's domain to trace gases retrievals for application to hyperspectral instruments. Pavel Litvinov (LOA) continued presenting applications of the GRASP combined inversion to satellite measurements (e.g., S5P or S3 OLCI) and direct-sun and Almucantar Total Optical Depth (TOD) measurements from the nearest co-located AERONET sites. The combined method was tested for different surface types and aerosol loads, investigating different forward

models and retrieval setups. Consistent retrievals of aerosol and surface parameters were obtained. Fabrizio recalled that surface reflectance validation was discussed at a specific ESA Land validation workshop in the past few days; for the next workshop, the GRASP team will be invited to attend as the tool has proven to be relevant for the land community as well and the method is really advanced. The approach is not limited to land but could be used for coastal areas as long as there are co-located measurements from an AERONET station.

[HGH-6] – GRASP proved to be a valuable tool for generating "synthetic" reference data for validation of satellite-based surface reflectance, filling a long-lasting data gap of ground-based observations. The joint retrieval of space-borne and ground-based data offer the possibility to better characterize surface and atmospheric properties. Furthermore, the planned evolutions, with the inclusion of trace gases in the retrieval, open the door for expanding applicability of GRASP to atmospheric sensors, notably S-5P.

Alexander Cede (Luftblick) reported the status of WP 2125 and recalled its main tasks: analyse the maturity level of the Pandonia Global Network (PGN) and the metrological improvement obtained in the project with NPL support, especially in terms of terminology and uncertainty uptake for the output data products, and also investigate the impact of uncertainties in laboratory calibration on the PGN O3 and NO2 total columns products by mean of sensitivity studies. The Maturity Matrix assessment for PGN done in October 2019 (begin of Phase 1) presented a poor score for the "uncertainty quantification"; this aspect has been improved during the last year (Oct. 2020), moving the score up to one level with evident benefit for the users. The new version of the Blick Software Suite (v1.8) will implement a revised nomenclature (Total uncertainty = Independent + Structured + Common), and will use data uncertainty as recommended by NPL (e.g., now provided with SI units). As a result of this activity, a quantitative measure of uncertainty is associated with PGN operational products, improving their use for validation of air-quality products**.** Analysis of the impact of the Level 1 correction steps on the retrieved column amounts has shown that effects can be split into three groups where stray light has the major contribution (up to 3% for O3). The study led to a list of suggested improvements to further reduce uncertainty in the PGN products. A major point to focus on is that the number of spectral lines covered by the lasers for the stray light calibration should be increased in the PGN laboratories. A report details all such recommendations and some of them will be addressed during Phase 2. Fabrizio queried on the reaction of the science community to the new terms. Moving to a shared terminology for uncertainty will represent a clear milestone for the EO community. The metrological community is not compact but the new nomenclature proposed by NPL represents a good solution to classify the different effects and is appreciated. It shall be promoted within our activities and adopted by all teams.

[HGH-7] – The improvement in uncertainty estimate for PGN data represents a clear example of synergy among different IDEAS-QA4EO projects and it goes along the lines of fostering metrological practices within EO Cal/Val. The effective collaboration between Luftblick and NPL allows to enhance maturity of PGN dataset, and to identify the most important source of uncertainty within the calibration and processing chain.

Jürgen Fischer (Spectral Earth) presented the activities for developing PGN advanced products. The Pandora-2S system performances are verified for harsh environmental conditions in five locations around the World (Barbados, Palau, Namibia, Lindenberg, and Berlin) but none of the instruments are currently working due to maintenance. Operations will resume as soon as possible also when the refurbishment with new sun trackers is completed. Some effort was put to provide a recommendation to improve the Pandora sensor design for operating on a ship (new steel housing), and also to define the changes in the operational software for the updated system. Simulations of PSR measurements at 3 different wavelengths (based on Lindenberg data) permitted advancing the development of the new retrieval algorithm for precipitable water vapor (PWV) and Total Column Water Vapour (TCWV) retrieval using Optimal Estimation technique. The agreement is still loose – also with GPS acquisitions - and further investigations are required additionally evaluating results from direct solar observations. The retrieval scheme could be also applied to CIMEL but priority is now for Pandora. The activities to improve the PGN operational products with advanced SO2, and CH2O, retrievals have still to be worked out.

[HGH-8] – The testing of Pandora-2s sensors in harsh conditions contribute in improving robustness and resilience of the PGN network. The expansion of PGN suite of operational products, by including TCWV, SO2 and CH2O will further enhance its applicability for atmospheric monitoring and Cal/Val applications.

Stefano Casadio (Serco) presented two new WPs supported by the BAQUNIN (Boundary-layer Air Quality-analysis Using Network of Instruments) super-site in the frame of QA4EO CCN3 activities. For the ACIX/CMIX WP, in collaboration with Brockmann Consult, two sky-cameras developed by NASA GSFC will be installed on the roof of two Physics Department buildings in University La Sapienza (200 m apart) to estimate cloud bottom height and cloud fraction. These measurements will be coupled with collocated Lidar Ceilometer measurements, to validate the stereo-based estimation of the cloud bottom height. The data analysis will contribute to the CMIX cloud mask validation exercise for Sentinel-2 and Landsat-8. For the Lunar WP, advanced retrieval techniques for the analysis of night-time (lunar) trace gases and aerosol loads based on PGN, AERONET, and EUBREWNET measurements will be developed and tested by a big team, additionally made of Luftblick, and two Italian research institutes (ARPA and CNR-ISAC). The WP will permit to investigate the day-night transition of photo-chemically active species and validate satellite products retrieved from nocturnal (eclipsed) orbit measurements (e.g., from TIR, Aeolus, EarthCARE). A relevant number of instruments hosted in the super-site will be involved in this activity. Results from a 3-day test dataset of DAY+NIGHT NO2 Total Column retrieval from Pandora direct Sun and night-time measurements were shown to highlight the expected diurnal cycle. A list of additional new scientific collaborations was presented also with a proposed candidate WP for the next CCN, aiming to investigate the impact of the NO2 absorption (400-490 nm) on the AERONET aerosol parameters retrievals. A correction from the BAQUNIN PGN NO2 data could be obtained to replace the OMI NO2 climatology used in AERONET and also to derive a correction for TROPOMI. Preliminary results support the need for such an activity.

[HGH-9] – The collaboration between BAQUININ and CMIX is another example of successful cross-fertilization between different IDEAS-QA4EO projects, reinforcing also international collaboration with NASA. Accurate characterization of cloud optical properties from combined use of sky camera and lidar can address a long-lasting problem in optical Cal/Val, such as defining what is a “cloudy pixel” in optical satellite remote sensing.

Dimitris Balis (University of Thessaloniki) presented the activities implemented within QA4EO in support of the S5P operational validation. For the validation of Aerosol Layer Height (ALH), an automated tool for data extraction and analysis based on the Wavelet Covariance Transform method was developed both for GOME-2 and TROPOMI. The validation of GOME-2 Absorbing Aerosol Height (AAH) against EARLINET lidar aerosol products was already presented at WS#1 (paper currently under review; overall bias less than 0.5 km), and adjustments for TROPOMI are now implemented. TROPOMI has closer overpass time to the stations but currently its ALH data over land are unreliable and comparisons had currently to focus on selected events (desert dust, and fires plumes) for stations close to the sea with a limited number of collocations. Promising results for preliminary studies over Barcelona and Evora stations were presented (agreement better than 1 km). Investigations for the optimal setup will be carried out next, also using data from the COVID-19 lidar campaign that took place in May 2020. For the validation of satellite ozone profiles using Umkher observations, two approaches were set up for Dobson and Brewer spectro-photometers, and tested on selected stations from the WOUDC and EuBrewNet databases. For the Dobson ozone profiles, 10 stations (out of 18) have long enough data records. The ground-based datasets need to be optimized, corrected for stray light entering the spectrometer, and AK corrected before comparing to satellite data. Reprocessed Dobson Umkehr ozone profile observations compared to NASA SBUV profiles from aggregated overpasses (2007-2019) agree within 5%. For the Brewer ozone profiles, Umkher time series only from Thessaloniki were reprocessed. Extension to other stations will be carried out. Soon comparisons to GOME2 and TROPOMI.

[HGH-10] – The use of EARLINET lidar data for validating Aerosol Layer Height satellite products fill a gap in availability of good reference data for this product, the method was initially applied to GOME-2 and is now being extended to TROPOMI, showing very promising results.

2.4 Cryosphere Cal/Val

David Small (University of Zurich) presented the activities supporting the definition of Analysis Ready Data (ARD) for SAR imagery within the context of the CEOS ADR for Land Processes (CARD4L) project which has the goal to enable dense time-series analyses and broaden the user community, providing SAR data products that do not require expert knowledge. The main SAR products and the applied corrections were recaptured: Geometric Terrain Correction (GTC - orthorectified backscatter), Radiometric Terrain Correction (RTC - flattened backscatter), and Local Resolution Weighting (LRW – wide-area backscatter composites). The standardization of product types is ongoing: the Product Family Specification (PFS) for Normalised Radar Backscatter (NRB – Level 1 RTC) was revised in multiple iterations and approved (v5.0) in May 2020. For the Multi-Source Backscatter LRW Analysis Ready Data (Level 3 composites) the PFS is being discussed within the LSI-VC community. RTC is the main component for ARD and is normalized using local scattering area instead of incident angle which is a bit more effort. A paper describing the backscatter composite methodology is under revision and several presentations were given. Examples of backscatter composites for snow and sea ice monitoring over the Alps and Ellesmere Island (Canada) were presented for Sentinel 1-A/B and Radarsat-2 data. Systematic L3 SAR ARD composite data generation is proceeding. The 30m DEM at global scale is now open and free as the 90m one. RTC is applied independently in the case of composite products

[HGH-11] – The recent development of ARD for SAR is essential for establishing common pre-processing practices to SAR data and to enhance user uptake of SAR products for a range of applications, notably for cryosphere studies, where SAR can complement information from optical and microwave sensors.

Cemal Melih Tanis (FMI) presented the progress for the FMI Sodankyla Cal/Val super-site and the operational camera network for snow products validation. The FMI site is composed of distributed stations in different geographical settings, and hosts a wide range of sensors. This super-site is crucial to support Cal/Val activities of current and future EO satellite missions, notably to prepare the Cal/Val infrastructure for CIMR (Copernicus Imager Microwave Radiometer). The ESA SnowPex-II exercise was kicked off in October 2020 for the continuation of earlier activities and the assessment of newly developed satellite-based Snow Cover Extent (SCE) and Snow Water Equivalent (SWE) products. The FMIPROT tool (http://fmiprot.fmi.fi) for the automated acquisition and processing of images from camera networks is an open-source software, used for NRT analyses and tested for the future operational validation of satellite-based land and snow products, e.g., Vegetation Index, Fractional Snow Cover (FSC) and Snow Depth (SD). The system needs further development to extend geographical coverage and to automatize the validation processing flow for the inter-comparison of satellite and webcam-based snow cover products. Functionalities of the service portal and plots were briefly presented. Initial validation of CGLS snow products are promising and this dataset could be an additional source of reference data in the frame of SnowPex-II.

[HGH-12] – The use of ground-based real-time imagery from existing webcam networks could be a valuable source of reference data for the validation of satellite-based snow products, notably for SCE and SD. This is a cost-effective solution and can provide timely and geographically spread validation data, fulfilling the Cal/Val needs of the land services.

[REC-4] – FMI to explore the interest of FMIProt tool as source of reference data in the frame of the SnowPex-II exercise.

Antoine Laforge (Serco) presented the activities on Polar Altimetry recently started for the analysis of NASA ICESat-2 and ESA Cryosat-2 resonant orbits. The context is the CRYO2ICE project for the periodic alignment of the two polar altimetric missions. In July 2020 the orbit of Cryosat-2 was modified to overlap the ICESat-2 track over the Arctic Ocean every 1.5 days, providing radar and lidar measurements of the same ice, at nearly the same time. This is a great opportunity for sea-ice research and Cal/Val purposes to compare the two payloads (difference in footprint, penetration, …). The existing sea-ice products will be evaluated and the most suited will be adopted for the comparison. A protocol is being defined and tested on near-collocated tracks (real wintertime data are not yet available). Preliminary results were shown: IS2/CS2 freeboard differences will provide estimates from space of the snow depth over sea ice (or of the CS2 Ku-radar snow-penetration). Tommaso Parrinello (ESA) expressed his please for such results: now this type of comparison is available also at ESA. Data after September 2020 should be soon made accessible. Results need to be advertised asap using the animations and contacting the Cryosat-2 media manager. Jerome Bouffard (ESA) suggested testing the protocol also on a few cases before the change of orbit. The development of a tool to extract collocated observations for the two missions is being evaluated by ESA and could be a complementary tool, easing part of the work just presented. The possibility to communicate the freeboard results is fully supported by ESA.

[HGH-13] – The Cryosat-2 polar campaign (CRYO2ICE), performed in summer 2020, allows to acquire nearly space-time collocated radar and lidar measurements, from Cryosat-2 and IceSat-2 missions, over the Arctic. This dataset is of great value for sea-ice research and preliminary results were presented, showing the complementarity of the two techniques for sounding snow depth over sea ice. The QA4EO work was instrumental to foster the uptake of this invaluable dataset from the science community.

[REC-5] – QA4EO to support communication activities and enhance awareness about the CryoSat-2/ICESat-2 polar campaign and the relevant tools for extracting collocated radar-lidar measurements [**CLOSED**: web story and tweets published].

2.5 Land Cal/Val

Raymond Soffer (NRC) reported on the activities at the Mer Bleue Arctic Surrogate Simulation Site (MBASSS) and introduced the integration and validation of UAV-based hyperspectral acquisitions into the bottom–up validation methodology previously developed. The UAV-based approach will fill in the spatial resolution/sampling mismatch between the field spectroscopy measurements and the airborne and satellite spectral image acquisitions. The upscaling process from field to airborne presents limitations in terms of sampling (number of samples / site locations / coverage) that could be overcome by UAV system. The UAV payload adopted is a HySpex Mjolnir VS-620 (400-2500 nm). The sensor will be accurately characterized in laboratory conditions and in the field using traceable calibration devices. The field campaign over Mer Bleue super site is currently planned for summer 2021, collocated with Sentinel-2 overpasses. Multi-sensor data will be acquired during the campaign, including UAV-based, airborne and field spectroscopy measurements. The calibration and processing methodologies previously developed will be adapted to UAV-based data. The project has a one-year delay for the Covid-19 restrictions and intensive field acquisition activities are now planned for June-July 2021. The expansion of the project scope with the development of an uncertainty budget and Best Practice protocols (supported by NPL and WUR) is under implementation in the frame of the CCN-4. The proposed way forward is relevant in view of the FRM4VEG project Phase 2 activities.

[HGH-14] – The use of multi-sensor multi-scale validation strategy, prototyped in the frame of IDEAS-QA4EO, has proven effective for the validation of satellite-based surface reflectances, notably with UAV-based spectrometric measurements for filling the gap between in-situ and airborne data. Yet, challenges remain in the consolidation of UAV-based measurement protocols. These challenges will be tackled in the frame of future QA4EO activities with the objective to contribute to the FRM4VEG project.

Benjamin Brede (WUR) presented the UAV-based Land Cal/Val activities over temperate and tropical forest sites. For the field campaign in French Guyana, data analysis progressed mainly with co-registration in 3D of the large dataset from the Paracou research station (4ha, 900 TLS positions and data from 6 UAV-LS flights) and tree segmentation based on an ad-hoc solution. Results are very promising and represent a step forward with respect to the airborne lidar-based algorithm. The analysis has been also applied to the Speulderbos dataset and results are available online https://dx.doi.org/10.4121/13061306.v1. For the Leaf Area Index (LAI) monitoring activities at Speulderbos, the use of innovative open-source low-cost community sensors, based on Raspberry-Pi technology systems, is being tested for continuous canopy monitoring. New instruments have been also purchased: a LEAF MkI in-situ monitoring LiDAR, a NIR lidar (905 nm), and TreeTalker (~20 sensors) for tree movement and canopy light transmission. A UAV-LS field campaign was done in 2020 over cropland in The Netherlands. For next year, two sessions on UAV monitoring were accepted at the IGARSS. Clement suggested comparing the field data acquired over the tropics with ICESAT-2 or GEDI data. This will be considered but match-ups could be limited.

[HGH-15] – The use of UAV-based lidar system provide accurate point-measurements for AGB estimation, overcoming the limitations of the laborious TLS field work, as successfully demonstrated within this IDEAS-QA4EO project. Similarly, low-coast automated sensors are being largely used for vegetation parameters estimation and validation, allowing cost-effective and dense temporal sampling.

Fabio Del Frate (University Tor Vergata) presented the activity for the acquisition of UAV-based multi-spectral and multi-looking observations for surface BRDF characterization over vegetated sites (but measurements over water will be also considered). Motivations are briefly recalled: BRDF in-situ measurements from drones are a cost-effective solution for the validation of BRDF models and offer the opportunity to develop and consolidate protocols for UAV-based multi-looking observations. Within the WP, UAV-based measurements will be carried out for different seasonal conditions to study spatial/temporal evolution of surface anisotropy and build accurate reference data with increased spatial representativeness for validation of satellite BRDF-corrected products. A MAIA multi-spectral imaging camera was purchased, installed on a UAV hexacopter, and tested on a field flight in the vicinity of the University of Tor Vergata. Images are acquired in 9 spectral channels overlapping the VIS to NIR bands of Sentinel-2 with a controlled gimbal orienting the camera between 0° and 90° with respect to the surface normal direction. The MAIA camera is coupled with an Incident Light Sensor (ILS), measuring irradiance data at the same time for the radiometric correction of each image and providing georeferencing information. Radiometric calibration is performed with the MAIA proprietary software application. The preliminary test (altitude 90m, FOV 60x45m, GSD 5cm) focused over a low vegetated area and images are compared with a coincident S2 acquisition. Spectral profiles are in good agreement. A literature survey has also started in order to identify a BRDF reference model. Systematic acquisitions will start soon and will be repeated in Springtime.

[HGH-16] – There is a recognized lack of reference data for validating BRDF-correction, this IDEAS-QA4EO project is primarily intended to fill this gap, using a UAV-based solution. The measuring system is specifically tailored for S2 validation and preliminary results are encouraging, showing the capability to characterize the anisotropy of vegetated surfaces. As outlook, this UAV system and the proposed protocol could support the FRM4VEG endeavour in establishing community-agreed practices for SR validation using drones.

Georgia Doxani (Serco) summarized the status of ACIX-II (Atmospheric Correction Intercomparison eXercise) and CMIX (Cloud Masking Intercomparison eXercise), both initiated in the frame of the CEOS cal/val working group and implemented by ESA and NASA. The ACIX-II expands the results of the first exercise in the spatial and temporal domains, with the aim to validate the accuracy of the different AC algorithms at global scale and for a wide range of surface and environmental conditions. As a matter of fact, the number of considered AERONET stations was significantly increased, as well as the S2 and L8 scenes. Clear improvements were observed in the considered AC algorithm as respect to the first exercise, owing to the recent upgrade of the relevant SW or ancillary data. This is fully in line with the original objective of

ACIX, which was to identify strengths and weakness of the various algorithms, supporting the providers to improve their codes. Within ACIX-II two distinct exercises were organized on land and water surfaces and the reference dataset was enlarged including ground-based reflectance measurements, when available. The water exercise is now completed and the relevant paper published on RSE, while for the land part, the report is being finalized and will be distributed among the participants for gathering feedback. One of the lessons learnt from ACIX-II is that the lack of an adequate validation dataset, notably for land, is still limiting our ability to assess the quality of current AC algorithms.

[HGH-17] – ACIX was instrumental in supporting algorithm developers improving their code, working towards harmonisation across S2 and L8 SR products. Yet, challenges remain in fully understanding the observed discrepancies, mostly due to the lack of an adequate reference ground-based dataset, in particular over land. This challenge is now being tackled with high priority in ESA and various project have started, notably HYPERNETS, in order to fill this data gap.

Jan Wevers (Brockmann Consult) presented the project gathering new ground-based reference observations in support to cloud mask validation activities in the optical domain, in particular as part of CMIX (Cloud Mask Inter-comparison Exercise). Motivations and structure are briefly recalled. The project will contribute to establishing protocols for measurement and processing methods. The pilot project will also define requirements and guidelines to scale up to a global network. Experimental operations based on twin sky-camera systems are being prepared at two sites: NASA Goddard Space Flight Center (US), La Sapienza University, (Italy). The system is a low-cost sensor based on a Raspberry-Pi with a wide FOV lens with two modules synchronized which provide a real-time stereo view of the cloud cover. Such measurements are coupled in Rome with a lidar to validate the estimated cloud base height. The classification method was done by hand during CMIX and is now being automated. The classified ground-based sky-cam image is mapped onto the satellite acquisition according to the shape of the cloud. The Covid-19 pandemic has caused a 6-month delay to the schedule but requirements and state of the art analysis could be advanced despite the restrictions (i.e., the CMIX final report will be available begin of next year) as well as on the automated method for classification which was recently published in a paper in IJRS. Due to the lockdown and delayed shipment of the cameras to Italy, a revised schedule has been presented to ESA. Highlights from the additional activity for MERIS cloud mask validation (within QA4EO Task 1) were presented. A collection of 19000 pixels (PixBox) has been prepared from the 4th RP full mission reprocessed dataset and validation will be done in the next month. The outcome will be detailed in a report and made available to users. From the ESA side, Philippe stated that there are no issues with the adjusted planning as long as the project accords with the planned CMIX-II activities. Philippe also suggested exchanging results on the MERIS cloud validation with the GRASP team.

[HGH-18] – CMIX exercise demonstrated that the current ability to assess the quality of a cloud mask is still hampered by the lack of a physically based definition of "cloud" and of a reliable ground-based reference data. This QA4EO WP aims to address this challenge, paving the way for a global network of ground-based sky-camera for cloud mask validation.

Irene Himmelbauer (TU Wien) presented a status update of the International Soil Moisture Validation Network (ISMN) project which is a key element of the SMOS Cal/Val plan and is widely used for validating satellite-based soil moisture products. The ISMN is a global in-situ soil moisture database for surface and subsurface measurements established in 2009 and funded by ESA. The project ensures a consistent and harmonized format for the data and applies a screening for quality. Data are open-and-free with timeseries from 1952. Seven new networks have been integrated this year. The geographical data gap for Africa has been recently addressed by the inclusion of the Trans-African Hydro-Meteorological Observatory (TAHMO), a network of 20000 weather stations in the Sub-Saharan area across Africa, that is directly providing the ISMN with near real-time SM measurements from 79 stations in 6 countries. A paper is being prepared for the HESS journal summarizing the status and impact of the ISMN and future needs. The ESA funding within QA4EO is until March 2021, covering no R&D but operations under Task 1. Afterward, it is being considered

the transfer of operations under ICWRGC, hosted by the Federal Institute of Hydrology (BFG, Germany), maintaining at TU Wien the scientific development of the ISMN, coupled with QA4SM (Quality Assurance for Soil Moisture) within the frame of the future FRM4SM ESA project. An API to acquire the ISMN data will be set up in a short time.

[HGH-19] – The ISMN network is largely used within the scientific community for the validation of satellite-based soil moisture products owing to the reliability and spatio-temporal consistency of the provided reference dataset and the global coverage. Evolution of the Cal/Val protocols will be sustained in the frame of the FRM4SM projects moving towards enhanced traceability and uncertainty budget estimate.

2.6 Water Cal/Val

Constant Mazeran (Solvo) presented the activities to review the inverse problem of ocean colour going beyond the constraints of an operational software. The final objective is to develop an advanced prototype algorithm and to deliver the relevant ATBD. The challenges associated to atmospheric correction in OC applications are recalled. The current algorithms mainly rely on NIR bands to retrieve aerosol, which is then extrapolated to the visible channels, these methods introduce uncertainties due to the extrapolation process and the approach is notably not suitable for complex water cases. The alternative approach being tested within QA4EO is to use the full information available over the whole spectral range to retrieve the aerosol optical and micro-physical properties. The method is based on a coupled-ocean-atmosphere model, which is then fitted on the observations using a least-square fit, following the methodology developed within POLYMER algorithm. Sensitivity tests with a linear atmospheric model are presented showing that three linear components allow to reconstruct very well various marine spectra, although ambiguity remain in some components between the marine and the atmospheric signal. The ambiguity can be resolved by introducing a non-linear spectral model based on a multiple scattering approximation (MSA). The MSA outperforms the linear atmospheric model in terms of relative errors in the retrieved water leaving reflectances in the various bands. In the coming months additional improvements are planned, improving the inversion scheme and considering constrained based retrieval to enhance the robustness of the algorithm.

[HGH-20] –An advanced algorithm is being developed within this project, fully exploiting the information available in the whole spectral range with a coupled ocean-atmosphere radiative transfer and a constrained least square fitting procedure. This method aims at solving the limitation of the standard A/C methods, such as the one being used for OLCI, notably over complex water and atmospheric conditions.

2.7 Recommendations

A summary of the recommendations gathered during the workshops is provided here after, based on the discussion held during the meeting and the final discussion session.

[REC-1] – FN/GB/PC in collaboration with NPL to investigate feasibility and identify technical solutions to host NPL-developed Python tools within CEOS Cal/Val portal. The tools are meant as tutorial material to guide users in the proper estimation of uncertainties for some relevant EO case studies.

[REC-2] – IDEAS-QA4EO to work towards a standardized methodology for providing a DOI associated to Cal/Val data generated in the frame of QA4EO projects. The CEOS Cal/Val portal should be used as the centralised repository for disseminating such Cal/Val data.

[REC-3] – IDEAS-QA4EO to work on promoting the recent achievements from LOA in advancing in aerosol traceability and Cal/Val campaigns [**CLOSED: two web stories published**].

[REC-4] – FMI to explore the interest of FMIProt tool as source of reference data in the frame of the SnowPex-II exercise.

[REC-5] – QA4EO to support communication activities and enhance awareness about the CryoSat-2/ICESat-2 polar campaign and the relevant tools for extracting collocated radar-lidar measurements [**CLOSED: web story and tweets published**].

3 APPENDIX A: AGENDA

MEETING - 2 December 2020 (Webex)

Introduction and Metrology

Welcome and meeting objectives	P. Goryl, ESA (Italy)
QA4EO Task 2 Cal/Val framework: status, achievements and outlook	F. Niro, Serco (Italy)
Metrological support across various EO domains for FDR and FRM activities	E. Wolliams, NPL (UK)
SI-Traceable ground-based observations for ozone and aerosol properties	J. Gröbner, PMOD (Switzerland)
Statistically based approach for estimation of sensor performance indicators: status and way forward	S. Mackin, EOSense (UK)
The CEOS Cal/Val portal: status and updates	P. Castracane, RHEA (Italy)

Atmosphere Cal/Val

Traceability for AERONET network and Aerosol field campaigns validation	P. Goloub, LOA (France)
Jointly retrieval of aerosol and surface properties using satellite and ground based observations	O. Dubovick, GRASP (France)
Improved uncertainty estimation in support to Pandonia Global Network (PGN)	A. Cede, Luftblick (Austria)
Support to Pandora-2S system testing and to the retrieval of new products	J. Fischer, SpectralEarth (Germany)
Boundary-layer Air Quality-analysis Using Network of Instruments Super-Site (BAQUNIN)	S. Casadio, Serco/Uni. La Sapienza (Italy)
Aerosol Layer Height and Ozone profiles validation in support to S5P	D. Balis, U. Thessaloniki (Greece)

Cryosphere Cal/Val

Support to CEOS CARD4L for SAR and snow mapping over Alps and Ellesmere Island	D. Small, Uni. Zurich (Switzerland)
Operational camera network for snow products validation: status and applications	C. M. Tanis, FMI (Finland)
Recent progresses on the IceSat-2 / CryoSat-2 collocated tracks comparison	A. La Forge, Serco (Italy)

Land Cal/Val

Land Cal/Val activities in the Mer Bleue Arctic Surrogate Simulation Site (MBASSS)	R. Soffer, NRCC (Canada)
UAV-based Land Cal/Val activities over temperate and tropical forest sites	B. Brede, WUR (Netherlands)
UAV-based multi-spectral/multi-looking observations for Surface BRDF characterization	F. Del Frate, Uni. Tor Vergata (Italy)
Atmospheric Correction and Cloud mask Inter-comparison for S-2 and L-8 (ACIX-II/CMIX)	G. Doxani, Serco (Italy)
Ground-based sky-camera observations for cloud-mask validation in support to CMIX	J. Wevers, Brockmann Consult (Germany)
The International Soil Moisture Network (ISMN) for satellite-based products validation	I. Himmelbauer, TUW (Austria)

Water Cal/Val

Development of advanced non-linear model for ocean color applications	C. Mazeran, Solvo (France)

Discussion

QA4EO Cal/Val: synergies, opportunities and way forward for Phase 1	ESA, ALL
Meeting Wrap-up	ESA, ALL

4 APPENDIX B: PARTICIPANTS

The list of participants is provided in the following table.

	Name	Affiliation	Country
1.	Philippe Goryl	ESA-ESRIN	Italy
2.	Angelika Dehn	ESA-ESRIN	Italy
3.	Steffen Dransfeld	ESA-ESRIN	Italy
4.	Jerome Bouffard	ESA-ESRIN	Italy
5.	Tommaso Parrinello	ESA-ESRIN	Italy
6.	Clement Albinet	ESA-ESRIN	Italy
7.	Britta Themann	ESA-ESRIN	Italy
8.	Philippe Goloub	LOA	France
9.	Oleg Dubovick	LOA	France
10.	Benjamin Torres	LOA	France
11.	David Fuertes	GRASP	France
12.	Yana Karol	GRASP	France
13.	Constant Mazeran	Solvo	France
14.	Didier Ramon	Hygeos	France
15.	David Small	Uni. Zurich	Switzerland
16.	Julian Groebner	PMOD-WRC	Switzerland
17.	Raymond Soffer	NRC	Canada
18.	Nigel Fox	NPL	UK
19.	Emma Woolliams	NPL	UK
20.	Sam Hunt	NPL	UK
21.	Bernardo Mota	NPL	UK
22.	Stephen Mackin	EOSense	UK
23.	John Swinton	Telespazio	UK
24.	Alexander Cede	Luftblick	Austria
25.	Irene Himmelbauer	TU Wien	Austria
26.	Juergen Fischer	SE/FUB	Germany
27.	Jan Wevers	Brockmann	Germany

28.	Benjamin Brede	WUR	Netherlands
29.	Yves Govaerts	Rayference	Belgium
30.	Cemal Melih Tanis	FMI	Finland
31.	Dimitris Balis	Uni. Thessaloniki	Greece
32.	Fabrizio Niro	Serco	Italy
33.	Stefano Casadio	Serco	Italy
34.	Massimo Cardaci	Serco	Italy
35.	Georgia Doxani	Serco	Italy
36.	Gabriele Brizzi	Serco	Italy
37.	Antoine La Forge	Serco	Italy
38.	Erminia De Grandis	Serco	Italy
39.	Annamaria Iannarelli	Serco	Italy
40.	Gabriele Mevi	Serco	Italy
41.	Massimo Valeri	Serco	Italy
42.	Paolo Castracane	REHA	Italy
43.	Fabio Del Frate	Uni. Tor Vergata	Italy
44.	Daniele Latini	GEO-K	Italy
45.	Leonardo De Laurentiis	Uni. Tor Vergata	Italy