CALIBRATION AND DATA QUALITY ASSURANCE FOR QUANTITATIVE REMOTE SENSING

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List of Principal Investigators (PIs)

Topic Nr.	PIs	Title
32426_1	*Dr. Philippe Goryl,* *Dr. Lingling Ma*	***Advanced On-orbit Optical Sensor Calibration and Product Quality Traceability***
32426_2	*Dr. Frank Fell,* *Prof. Xiaolong Dong*	***Microwave RS sensor calibration and product generation (MIRSS-CAP)***
32426_4	*Dr. Michel Van Roozendael,* *Prof. Cheng Liu*	***MAXDOAS Fiducial Reference Measurements in Eastern China (MAXFRM)***
32426_4	*Dr. Bart Dils,* *Prof. Pucai Wang*	***Joint Optimization of Chinese ground-based FTIR Reference Measurements (JOCFRM)***

EXECUTIVE SUMMARY

In recent years, the earth observation by remote sensing techniques has evolved from simple image interpretation phase into quantitative analysis phase which can numerically model ecosystem of nature to investigate various complex problems such as global change, carbon cycling, and dynamic monitoring. As the number of Earth-observation satellites is ever increasing, one of the major challenges for the scientific community is to ensure that the absolute radiometric calibration of these sensors resides on the same SI-traceable scale. Individual teams, equipment, and sites are typically used to assess the post-launch radiometric calibration of instrument by simulating TOA signals from in-situ surface and atmosphere measurements based on a single site/instrumentation, which would lead to biases between satellite sensor radiometry. The lack of quality consistence of multi-source remote sensing data from different countries and different satellites will strongly restrict the applicable scope of RS application. Therefore, the issues on how to assess the remote sensing data quality, to make a feasible strategy for controlling the data quality become a critical scientific topic worth of investigating. Calibration and validation (Cal&Val) is one of the most important quality assurance means for satellite payload performance and data quality. It could guarantee the accuracy of the retrieved information, make the remote sensing data consistent and traceable, and maintain the sensor performance during the operational phase. Though China has made great progresses in manufacturing remote sensing payloads and propelling remote sensing applications, there are still gaps in the Cal&Val which limit the improvement of remote sensing data quality. The challenges include the lack of consistent RS assessment standards, the uncertainties introduced by atmospheric effect, as well as the gaps in non-synchronous measurements between satellite observation and field observation. The DRAGON programme has set up many remote sensing research topics on various application domains and in order to promote the effectiveness of the data modeling, its necessary for us engaged to solve various challenges in Cal&Val for quantitative RS applications. This proposed project aims to promote the cooperation of the Cal&Val experts from European and Chinese intuitions. On the one hand, draw on the experience of European partners in Cal&Val activities which was well applied in the ESA missions, and to carry out cooperative research on the high-frequency optical and microwave calibration methods, especially through the RadCalNet activities and permanent targets. On the other hand, cooperate in crosscalibration and product validation of the similar Chinese spaceborne sensors based on the ESAs and TPMs high-precision EO data with stable quality. Moreover, for the lack of remote sensing product quality characteristics in China, under the framework of the Quality Assurance for Earth Observation (QA4EO), to carry out the research on remote sensing data and product assurance. The proposed in-situ metrology station is a new concept based on the joint effects from Chinese and European institutions skilled in payload manufacture, calibration, data processing, and service. The research content proposed in this project has funding from the research projects like the National High Technology Research and Development Program of China. The project is divided into three topics, which are Advanced On-orbit Optical Sensor Calibration, Microwave Remote Sensor Calibration and Product Generation, Quantitative Remote Sensing Product Quality Assurance. The outcome of the project will benefit for the remote sensing modeling and product retrieval within the framework of DRAGON programme. It will also promote the application of RadCalNet and QA4EO so as to demonstrate the feasibility of the concept for global calibration traceable to SI. We will also promote RadCalNET to be an operational network used for calibration, intercalibration and validation for the benefit of the Global Earth Observation System of Systems (GEOSS) in the next few years.

ABSTRACT 32426_1: "Advanced On-orbit Optical Sensor Calibration and Product Quality Traceability"

European Principal Investigator	***Chinese Principal Investigator***
Dr. Philippe Goryl	Dr. Lingling Ma
(ESA,Italy)	(AOE-CAS,CHINA)

The accuracy in acquiring ground targets' quantitative information through remote sensing technology is greatly dependent on the remote sensor's performance and its stability, so the on-orbit calibration of remote sensor during its long-term operational phase is an essential quality assurance work needed to be performed regularly. China has launched several series of Earth observation satellites (CBERS, HJ, FY, etc.). These satellites have reached to a certain level of performance, but their calibration technology relevant to the data quality is still hard to meet the requirements of practical remote sensing applications. In future twenty years, China has planned many airborne/spaceborne missions (high geometric resolution sensors; hyperspectral sensors; wide coverage sensors; stereo imaging sensors; etc.). In order to guarantee the application efficiency of these novel remote sensors, it is necessary to follow the development trends (characterized by high stability, high frequency, and high accuracy) of calibration technology, and make further innovation on traditional on-board calibration / vicarious calibration / cross-calibration technologies. This project will carry out research with emphasis on: (1) Apply the standard reference sources used in laboratory to the satellite platform, so as to become the spaceborne radiometric calibration benchmark, which works like "TRUTHS" or "CLARREO", then research effective traceability transfer method based on it. (2) Develop testing devices which can automatically and traceably acquire ground targets' radiometric characteristics or atmospheric parameters, improve uncertainty analysis method on the calibration results, and assure the consistency of automated radiometric calibration site network, so as to provide high frequency, automatic, traceable calibration services, and expectedly develop into a in-situ metering station, in which the instruments can be traced to SI (Systeme International) and the uncertainties for the whole calibration chain are well documented. (3) Perform cross-calibration among Chinese earth observation satellites and those ESA or ESA TPM satellites which have high calibration precision and reliable data quality (such as Sentinel, RapidEye, ALOS), to better understand impact factors in cross-calibration and evaluate Chinese EO sensors' performance. (4) Study on novel calibration methods using the moon or stars as reference object, which having been attracting much attention in recent years.

In addition, as to remote sensing product validation techniques, this project will conduct research on the validation method and the corresponding quality tracing method for typical remote sensing products, including: (1) Research the ground true value acquisition in pixel-scale and step-wise validation technique for land remote sensing product technique, especially on the ground-based instrument configuration, spatial sampling and temporal resolution's requirements for different surface parameters, efficient estimate method of remote sensing pixel-scale true value, temporal-spatial-spectral-angular scaling transforming method and the step-wise validation technology with the help of medium-scale airborne/spaceborne data. The preliminary candidate ground/atmospheric parameters may be surface temperature, leaf area index, evapotranspiration, aerosol optical thickness, carbon dioxide, wind field, ocean color, etc. (2) Carry out research on quality tracing & transferring of quantitative remote sensing product. Study multiple factors like payload performance, data quality, scaling effect, forward modelling error, backward retrieval error's influence on quality of quantitative information product. Resolve the uncertainty factors' tracing transferring & quantification of remote sensing product.

In realistic implementation of the project, the team will make full use of available funding supports such as the National High-tech R&D Programme (863 Programme) and National High Resolution Major Program, so as to carry out academic and technical exchanges, perform China-EU cooperative joint experiments, and support training of young scientists. These funding include:

(a) "Hyperspectral infrared consistent transfer calibration techniques";
(b) "Synchronous acquiring technology on the hyperspectral infrared imaging test benchmark";
(c) "Hyperspectral infrared payload transfer calibration technology";
(d) "Developing a high precision spaceborne solar spectral radiation benchmark traceable to SI";
(e) "Lunar calibration technique in visible spectrum";
(f) "Calibration and validation sub-system in the ground section processing system";
(g) "Remote sensing payload performance and data quality evaluation techniques";
(h) "Key technologies on evaluation of remote sensing application product quality and service quality";
(i) "Satellite LiDAR for CO2, aerosol, atmospheric parameter";
(j) "Satellite LiDAR for atmospheric wind field".

ABSTRACT 32426_2: "Microwave RS sensor calibration and product generation (MIRSS-CAP)"

European Principal Investigator	***Chinese Principal Investigator***
Dr. Frank Fell	Prof. Xiaolong Dong
(Informus GmbH,GERMANY)	(NSSC-CAS,CHINA)

Objectives:
The proposed research is focused on the calibration and validation of microwave sensors (18.7 GHz, 23.8 GHz, 36 GHz, 50-60 GHz, 89 GHz, 118 GHz, 150 GHz, 183 GHz) and relevant derived products (water vapour, precipitation, and snow cover over land and ocean).
Area of study:
- Beijing China, 39°9'N, 116°3'E, 20km x 20km
- Baotou China, 40°51'8"N, 109°37'50"E, 20km x 10km
- Qinghai-Tibet Plateau, 25-40°N, 75-105°E
- Part of Northwest Pacific, 0-40°N,100-160°E
- Global approach for calibration / validation / evaluation of microwave radiometers and retrieved products
Methods:
- Thermal/vacuum calibration aiming at ensuring that the sensor meets the performance specifications, particularly the nonlinearity parameter u, which is needed for accurate in-orbit data processing.
- In-orbit cross-calibration and validation between various international passive microwave instruments, among others SUOMI ATMS, GPM-GMI, Altika, Jason, MWR onboard ERS-1,2, Envisat, and Sentinel-3, NOAA-AMSU-A/B, MHS, FY-3B/C MWHS, HY-2 ACMR.
Deliverables:
- The main project deliverable will consist in guidance and best practise procedures for Cal/Val for passive microwave radiometers.
- While the development of retrieval algorithms will not be part of the proposed project itself, we will perform inter-comparisons and long-term time series analyses of retrievals performed in related projects. The proposed project will be embedded in on-going GEWEX activities, such as the GEWEX Water Vapor Assessment (G-Vap) and an upcoming GEWEX assessment of high-latitude precipitation.
Funding China:
Sufficient funds are available for working on the collaboration with Europe in the framework of Dragon-4.
Funding can be provided from the follwoing sources:
1. Design and development of FY-3D microwave humidity sounder.
2. NSSC-CAS key breeding program.
3. NSSC-MISLAB open issues.
4. Union of Youth Innovation Promotion.
5. Young Scientists special fund project by Science and Technology Association.
6. National High Technology Research and Development Program of China.
Funding Europe:
Co-funding is obtained in the context of related projects, among others:
1. LTDP-EMiR: Long Term data preservation: ERS/Envisat MWR recalibration and water vapour thematic data record (ESA).
2. ANPAC: Study on antenna pattern correction for ICI and MWI (EUMETSAT).

ABSTRACT 32426_4: "MAXDOAS Fiducial Reference Measurements in Eastern China (MAXFRM)"

European Principal Investigator	***Chinese Principal Investigator***
Dr. Michel Van Roozendael (BIRA-IASB,BELGIUM)	Prof. Cheng Liu (University of Science and Technology of China,CHINA)

The project aims at establishing a data base of MAXDOAS-based reference fiducial measurements for the validation of air quality measurements by the upcoming Copernicus Sentinel-5 Precursor (S5P) in Europe and the EMI sensor in China. The focus will be on monitoring NO2, SO2 and HCHO columns and profiles using standardised operation protocols and retrieval methods applied to a network of MAXDOAS instruments operated at several sites in Eastern China. These ground-based reference data will be used to provide an assessment of the precision, accuracy and stability of the NO2, HCHO and SO2 data products generated operationally from S5P and EMI. Upon MAXDOAS data availability back in time at some of the sites, this will also be extended to an assessment of the historical data sets from the OMI, GOME-2 and SCIAMACHY sensors.
A strong focus will be put on the standardisation of the MAXDOAS measurements and data retrievals in order to maximize the consistency of the resulting data sets and arrive at fiducial reference measurements. To this aim, maximum benefit will be taken from ongoing activities in projects such as the EU FP7 NORS and QA4ECV, as well as the ESA NIDFORVal and FRM4DOAS project, the latter concentrating on the establishment of standards for MAXDOAS operation and data processing. Exchange of knowledge, tools and retrieval software will take place, and access to facilities such as the FRM4DOAS processing system will be offered.
Validation methodologies will be developed and applied, making use of all available source of information such as the averaging kernels of the satellite products, cloud information, and the vertical profiles of the various trace gases complemented by aerosol data (which will be derived from MAXDOAS measurements). Based on this comprehensive uncertainty budgets will be derived, addressing accuracy, precision and long term stability. Based on validation results, recommendations for satellite product quality improvement will eventually be formulated.
The project will contribute to both the validation of early satellite products during the Commissioning phase of the instruments immediately after launch, and to longer-term validation during the full duration of the project (2017-2020). In this phase, the progressive accumulation of data will allow for improved statistics and refinement of the validation results. This will include analysis of e.g. seasonal cycle effects and longer-term stability. Representativeness effects will also be investigated especially for urban sites. The link with the relevant satellite communities will be ensured via the participation of BIRA-IASB in the S5PVT and S5P MPC (Mission Performance Center) and the participation of USTC and AIOFM in the EMI project.
The main outcomes of the project will be (1) the creation of a database of standardised MAXDOAS column and profile measurements of NO2, SO2 and HCHO columns at several sites in Eastern China, and (2) an assessment of the quality of the S5P and EMI sensors, complemented by validation results addressing historical data sets from the OMI, GOME-2 and SCIAMACHY sensors.
MAXDOAS activities at BIRA are supported by institute funds and contributions from EU, ESA and EUMETSAT projects. In particular BIRA is funded by PRODEX and ESA for participation in S5P validation and algorithm developments. It is also the lead of the FRM4DOAS project.
USTC is funded by the National Nature Science Foundation of China (Remote sensing of Atmospheric polluted gases from multi-platform measurements) and by the National Natural Science Foundation of China (Remote sensing of tropospheric ozone form the combined observation of satellite and ground-based lidar). Likewise, AIOFM is funded by the National Nature Science Foundation of China as part of the project "Investigation of air pollution temporal- spacial distribution and transfer in the eastern China by MAX-DOAS network".
IAP-CAS has two funding sources which can support this project: (1) A funding granted by the Chinese Foundation of Natural Sciences on the "Assessment of the effect of high aerosol loading in northern China on satellite measurement of atmospheric greenhouse gases and atmospheric pollutants". This can support the operation of the MAXDOAS and IFS125HR instruments at the Xianghe Station. (2) A funding granted by the Ministry of Science and Technology of China for the "Comprehensive observational study of nucleation of aerosol to CCN". This project can partly support the project members for participating the workshops and annual meetings of Dragon 4.

ABSTRACT 32426_4: "Joint Optimization of Chinese ground-based FTIR Reference Measurements (JOCFRM)"	
European Principal Investigator Dr. Bart Dils (BIRA-IASB,BELGIUM)	***Chinese Principal Investigator*** Prof. Pucai Wang (IAP-CAS,CHINA)
A crucial aspect in the proper employment of satellite retrieval data, is the assessment of their quality through validation with independent reference measurement data. For atmospheric total column measurements from space of species such as CO2 (SCIAMACH	