EUFAR goes hyperspectral in FP7

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ABSTRACT

Two FP6 initiatives i) HYRESSA, HYperspectral REmote Sensing in Europe Specific support Action, and ii) EUFAR, European Facility for Airborne Research in Environmental and Geo-sciences, have joined forces in FP7. The FP7 Integrating Activity EUFAR (including HYRESSA) is now a network of 33 European airborne data providers and experts in airborne measurements. With the support of the European Commission, EUFAR provides European scientists with trans-national access to 6 airborne instruments (including hyperspectral imaging sensors) and 20 instrumented aircraft and early-stage researchers and university lecturers with training courses on airborne measurements. This paper reports on EUFAR activities and opportunities for European researchers with special attention to activities and opportunities related to airborne hyperspectral imaging.

Index Terms— airborne, access, hyperspectral, processing, quality layers, water, soil

1. EUROPEAN FACILITY FOR AIRBORNE RESEARCH (EUFAR)

EUFAR (www.eufar.net) is an Integrating Activity funded by the 7th Framework Programme of the European Commission. The FP7 EUFAR project (33 partners) runs from 2008-2012 and aims at providing and improving the access to airborne facilities (i.e. aircraft, airborne instruments, data processing centers) for researchers in environmental and geo-sciences through Networking Activities (NA), Trans-national Access (TA) Activities and Joint Research Activities (JRA). The long term objectives of EUFAR are to lay the groundwork of a European distributed infrastructure for airborne research in environmental and geo-sciences for each European scientist to get access at "equal terms" to the airborne facility the most suited to his scientific objectives, irrespective of his origin and of where the facility is operated.
Figure 1: Schematic representation of EUFAR Networking Activities and link with users, operators, experts and research funding institutions.

The Networking Activities (Figure 1) are for eminent scientists to provide recommendations to the operators on the long term development of their activities (N1-SAC) and for expert users to provide recommendations to operators and research funding institutions on good practice and future challenges (N4-EWG). For the operators to provide users with a coordinated access to the infrastructures (N2-TAC), opportunities of education and training (N5-ET), and a distributed database for airborne measurements (N7-DB). To provide the research funding institutions with technical solutions for the future development of the fleet (N3-FF) and a sustainable management structure for EUFAR (N9-SST). Operators will also develop standards and protocols for a better quality of the service (N6-SP). Finally the activity on E-communication (N8-EC) develops for all the actors efficient collaborative tools, from a unique public portal to secured workflows for the working groups activities.

More than 400 flight hours of Trans-national Access (TA) will be allocated to European scientists.

Finally, three Joint Research Activities will focus on the improvement of airborne humidity measurements (JRA1), the development of quality layers for hyperspectral products (JRA2) and the development of a new cloud drop spectrometer (JRA3).

2. TRANS-NATIONAL ACCESS OPPORTUNITIES FOR RESEARCHERS

Trans-national Access (TA) funding provides researchers with access to research aircraft or airborne instrumentation that are not available to them via their own national research funding. The principle criterion for eligibility is that the applicant and the majority of the user group should be working at an institution established in an EU Member State or Associated State which is different from that of the aircraft or instrumentation to which they propose access.


Three types of proposals can be submitted:

1) Science projects are proposals for specific research projects that involve the use of airborne measurements for atmospheric or geo-science. They may be submitted both by groups that are already expert in airborne measurements or by new users. In the latter case, assistance will be provided by EUFAR experts to develop the scientific quality of the proposal prior to its independent review.

2) Instrument development proposals involve the testing or development of novel instrumentation in any area of airborne atmospheric or geo-science research.

3) Training courses are proposals to host a 1 week to 10 days training course including flight experiment on any topic for which the measurement capabilities of the EUFAR fleet and instruments are relevant.

Further guidelines for applicants are available from the EUFAR website (www.eufar.net).

3. EDUCATION AND TRAINING OPPORTUNITIES

EUFAR aims through its Networking Activity on Education and Training to attract early-stage researchers but also university lecturers to airborne research and to train them theoretically and practically in airborne research.

To reach these objectives, EUFAR offers three Education and Training opportunities:

3.1. Training Courses on airborne research (ET-TC) including flight experiment

Four Training Courses will be organised in the frame of this Networking Activity. All EUFAR Training Courses with each a duration of 1 week to 10 days should have an equal focus on theory and practical training/demonstration. Invited experts should cover the complete chain from acquisition to interpretation of airborne data. Aircraft or instrument providers and invited experts will teach the Training Course participants in flight planning, on how to operate the instrumentation and data analysis.

3.2. Invited access to Existing Campaigns (ET-EC)

Students not familiar with airborne research can join an existing campaign and will be trained during the campaign by the aircraft and instrument operators and experts in airborne research.

3.3. Participation in the design of a new field campaign, in the frame of Trans-national Access (TA). Tutoring by experienced scientists (ET-TA)
Researchers can also join a host research group and contribute already in the proposal phase to the design of a new campaign.

EUFAR provides 100% support for training, flight costs of research aircraft and instruments (financed through TA) and Travel and Subsistence (T&S) expenses (reimbursement rules are available at the EUFAR website).

4. HYPERSPECTRAL IMAGING ACTIVITIES IN EUFAR

4.1. Trans-national Access Activities

EUFAR offers Trans-national Access to 5 airborne hyperspectral imaging sensors. In FP7 EUFAR access to instruments already available in FP6 EUFAR like AHS (INTA), CASI (FUB) and Eagle/Hawk (NERC) will be continued and extended by next generation imaging spectrometers like ARES (DLR/GFZ) and APEX (RSL/VITO) [1].

4.2. Networking Activity Education and Training

Within the frame of the Networking Activity on Education and Training 2 training courses on airborne hyperspectral imaging will be organised. Proposals to host a training course including flight experiment can be submitted to Trans-national Access - Training Course.

Two training courses covering the complete chain of imaging spectroscopy from acquisition to interpretation of data will be organized for early-stage researchers as well as lecturers in airborne research. Each training course will be accompanied by a “student” flight campaign.

4.3. Networking Activity Expert Working Groups

In EUFAR a number of Expert Working Groups (EWG) are dedicated to imaging spectroscopy: “Imaging sensors”, “Cal/Val”, “Processing (incl. data quality)”, “Vegetation applications”, “Water applications” and “Soil applications” which will enable experts to disseminate their knowledge to users and operators. In addition a high-level textbook on “Airborne Measurements – Methods and Instruments” will be issued by EUFAR and other experts giving high attention to the hyperspectral imaging technology.

4.4. Networking Activity Standards and Protocols

Building further on the FP6 HYRESSA activities on Standards and Protocols [2], the EUFAR Networking Activity on Standards and Protocols will give recommendations on best practices and processing software and will develop toolboxes for Level 3 products and data processing. In addition, a glossary for terms on airborne hyperspectral remote sensing is conducted. This glossary ensures a common understanding of terms within EUFAR, and supports end users to understand the technical terminology.

5. QUALITY LAYERS FOR HYPERSPECTRAL IMAGING PRODUCTS (HYQUAPRO)

Finally, the JRA2, also called HYQUAPRO, with 11 partners aims at the development of harmonized quality layers for Level 1 and Level 2 hyperspectral imaging data and higher performing water and soil products including quality measures. The impact of this activity will be more transparency on the processing and quality of hyperspectral imaging data and products identified as a gap at the FP6 HYRESSA SWOT and User Needs workshop [3].

5.1. Uncertainty Propagation Analysis (UPA)

The processing of airborne hyperspectral data, from sensor calibration up to geo-referenced atmospherically corrected reflectance, requires a large number of input parameters. As each of the input parameters has an uncertainty associated with it, the processing of airborne hyperspectral data introduces uncertainty. In order to quantify this uncertainty, a concept for Uncertainty Propagation Analysis (UPA) of hyperspectral data processing was developed and applied. First, the input parameters of the processing chains at VITO, DLR, INTA, FUB, TAU and PML were identified and a selection of uncertain input parameters was made. Secondly, the UPA was applied to a set of input parameters of the VITO Central Data Processing Center (CDPC) [4]. Probability Distribution Functions (PDFs) were derived using geostatistical simulation (using R), bootstrapping [5] (using Mathcad) or upscaling of field spectrometer measurements to at-sensor radiance (using MODTRAN4-based tools). Next, a Monte Carlo stochastic simulation was performed by sampling a large number of possible inputs from these PDFs and subsequently processing the data using these inputs, creating a large number of outputs (processed data). Starting from these outputs a statistical analysis can be performed of which the result will lead to a quality indicator or quality layer. Furthermore, the UPA can identify which processing steps and inputs introduce most uncertainty in the corrected hyperspectral imagery.

5.2. Quality layers for hyperspectral data

The aim of this task is to establish a core set of quality indicators (QI) for pre-processed hyperspectral data sets which will be adapted for every JRA2 PAF. Also PAF- and instrument-specific QIs [6], as well as the outcome of the UPA, will be included in a harmonized way.

To ensure and to document a high standard of data quality, measures based on scene and sensor characteristics are applied. In addition, extended metadata is distributed with the imagery for a complete documentation.

The harmonized generation and distribution of such standardized data reports as well as per-pixel quality flag images with every hyperspectral Level 1 and 2 dataset is a step towards a more transparent processing resulting in well characterized data.
5.3. Higher performing Level 3 products

HYQUAPRO partners will also contribute to research to deliver selected robust and higher performing algorithms for application to airborne hyperspectral data. This research will focus on the areas of algorithms for Case 2 water quality and for soils, areas where hyperspectral remote sensing has already been shown to make significant improvements over conventional multispectral remote sensing techniques. The approach to both these application areas will take a common form involving: reviews of the up-to-date literature and expert workshops, followed by the selection, development and validation of soil and water quality algorithms and quality indicators. The validated algorithms will then be integrated into the PAFs of DLR (soil algorithms) and VITO (water quality algorithms) for further testing.

5.3.1. Water
For the accurate estimation of water quality in Case 2 waters (co-dominated by phytoplankton, dissolved organic matter and suspended sediment), the evidence suggests that the best algorithms are derived from narrow band and fine high spectral resolution reflectance features. Initial reviews of the up-to-date literature reveal empirical and model inversion approaches, both of which will be evaluated for their abilities to accurately and robustly derive a range of optical water quality parameters. An initial meeting of the EUFAR Expert Working Group – Water applications has already confirmed this approach. The algorithms will be tested and validated in focused campaigns involving multiple hyperspectral airborne sensors and concomitant ground campaigns undertaken in 2010 on selected European sites.

5.3.2. Soil
In the line with soil science, JRA2 is focused to provide the hyperspectral data user with higher performing soil algorithms, integrated in an easy to use software, to extract decisive information for some important soil product. The capability of mapping crucial pedogene parameters (selected in the scope of being critical input for degradation modeling or for soil fertility assessment) makes hyperspectral imagery attractive for soil scientist with respect to reduce time- and cost-intensive field campaigns. A EUFAR Expert Working Group – Soil applications meeting will be organized to open up new frontiers for innovative soil analysis and mapping through hyperspectral remote sensing.

6. CONCLUSION

The overall objective of the FP7 EUFAR initiative is to improve the access to airborne facilities for the European research community and thus to advance airborne research in Europe. Building further on the user needs identified in the frame of the FP6 HYRESSA project, a number of building blocks to improve access to hyperspectral imaging data were identified and integrated into EUFAR. Through i) Networking Activities as the Expert Working Groups, Education and Training, Standards and Protocols, ii) Trans-national Access to hyperspectral imaging sensors and iii) a Joint Research Activity focusing on the development of Level 3 soil and water products we aim to advance research in airborne hyperspectral imaging in Europe. The EUFAR project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 227159 (EUFAR: European Facility for Airborne Research in Environmental and Geo-sciences).

7. REFERENCES


