Calibration and Validation Activities for Earth Observation Mission Future Evolution for GMES

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ABSTRACT

Calibration and Validation are major element of any space borne Earth Observation Mission. These activities are the major objective of the commissioning phases but routine activities shall be maintained during the whole mission in order to maintain the quality of the product delivered to the users or at least to fully characterise the evolution with time of the product quality.

With the launch of ERS-1 in 1991, the European Space Agency decided to put in place a group dedicated to these activities, along with the daily monitoring of the product quality for anomaly detection and algorithm evolution. These four elements are all strongly linked together.

Today this group is fully responsible for the monitoring of two ESA missions, ERS-2 and Envisat, for a total of 12 instruments of various types, preparing itself for the Earth Explorer series of five other satellites (Cryosat, Goce, SMOS, ADM-Aeolus, Swarm) and at various levels in past and future Third Party Missions such as Landsat, J-ERS, ALOS and KOMPSAT.

The Joint proposal by the European Union and the European Space Agency for a 'Global Monitoring for Environment and Security' project (GMES), triggers a review of the scope of these activities in a much wider framework than the handling of single missions with specific tools, methods and activities. Because of the global objective of this proposal, it is necessary to put in place Multi-Mission Calibration and Validation systems and procedures.

GMES Calibration and Validation activities will rely on multi source data access, interoperability, long-term data preservation, and definition standards to facilitate the above objectives.

The scope of this presentation is to give an overview of the current Calibration and Validation activities at ESA, and the planned evolution in the context of GMES.

1. INTRODUCTION

Calibration and Validation activities are of major importance for Earth Observation satellite missions.

These activities and in particular the former, have been in the past seen as an Engineer requirement for in-flight characterisation with the main objective to confirm that the satellite and the instruments are working within the specifications set at the beginning of the project.

The users in general and the scientific community in particular have a different point of view. These activities are required to continuously progress in the knowledge of the instruments characteristics and the algorithms used to process the acquired data sets in order to get the maximum quality from the satellite launched in space by the engineers. The point of view is not the characterisation of the hardware and its specifications but the quality of the data and all the potential applications that can be built using this data.

A major consequence of this is that these activities cannot be limited to a short period of time at the beginning of the satellite lifetime, the commissioning phase, but shall last for the complete mission in order to increase the knowledge on the overall system (satellite, instrument, algorithms and processors), to continuously characterise the instrument to take into account any evolution due to ageing and to dialogue with the end user to better understand their requirements and to propose new products of higher quality to better match their needs.

2. CALIBRATION

Because of the engineering approach for Calibration, often the tools were built and the sites were chosen with the unique objective to serve that mission. A new mission was leading to the design of new tools and the definition of new Calibration sites.

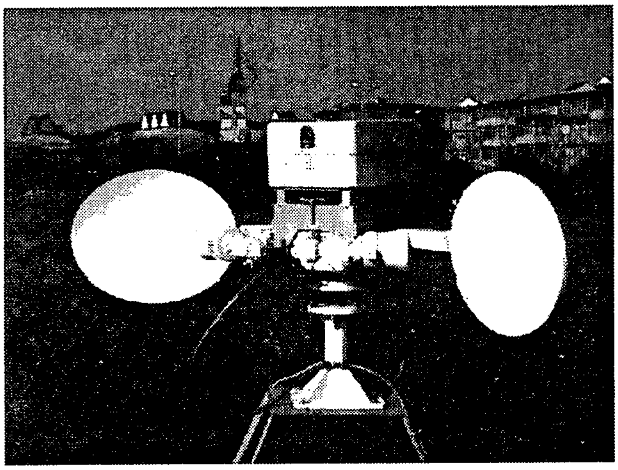

Figure 1. Envisat Active transponder during testing at Estec.

With the increase of the number of missions this strategy cannot be sustained for two reasons. The overhead cost and the necessity to ensure comparable calibration of these various sensors.

In fact the multiplication of sensors is mainly due to the fact that Earth Observation is becoming a fundamental tool for deciders and the increase number of applications. This evolution leads to an increasing number of users that are not interested in understanding the details of the instrument and/or the processing chains by which this data has been produced, but are mainly interested in directly using this data in their application. Often, they even don't want to know which sensor has been used to acquire this data.

As a result it is not enough to calibrate the various sensors, but there is an increasing need to really make the various data set characteristics identical. Earth Observation satellite operators shall give the possibility to the users to merge data of multiple sources without going through lengthy processes.

Inter-calibration is the only way forward to provide an answer to our customers

3. INTERCALIBRATION

Inter-calibration defined as the process of comparing the characterisation of the various sensors is not enough to reach the level of quality required by the users. In fact the user has still to spend time to understand the two or more sensors and apply various corrections to make the data comparable is only a poor level of inter-calibration.

Inter-calibration defined as the process of relieving the user of all this tasks requires a much higher level of standardisation not only in term of product format but also in terms of calibration definition, procedures and method.

For interoperability and "operational services" common methods / protocols "best practise" need to be established.

4. CALIBRATION SITES

One aspect where standardization is also required is in the definition of calibration sites. It is of course necessary to identify a few spatially uniform, temporally stable and radiometrically "large" sites at various latitudes. For optical instruments some examples could be the Railroad valley, the Libyan Desert, La Crau in France, or the Dome C in Antarctica. For other instruments in particular Radars (SAR's and Scatterometers), vegetated sites are required for example the Amazonian Rain Forest.

These sites shall be characterised using common protocols and "traceable calibrated instruments" (in-situ team, aircraft, satellites themselves) at multi-angle and time. Ideally this could be done using instrument with automated monitoring equipment.

All the test-site radiometric data and its associated uncertainties (ideally with high spectral and spatial resolution to allow easier reformatting to spectral bands and pixels of other sensors) including the environmental conditions shall be archive and easily accessible to all users for example via the web.

All Earth Observation satellite sensors shall be encouraged to view and to compare readings with those of ground site and to publish results in order to understand biases, to allow lower cost sensors and to improve the user confidence.

Constant effort shall be made to improve the accuracy of test site data including the environmental conditions (e.g. the atmospheric transmission).

5. VALIDATION

In the ESA terminology Calibration and Validation are terms dedicated to two well separated concepts.

Calibration is linked to the instrument and the Engineering part of the system. At the end of that process the instrument is tuned to obtain the best trade-off, all the instruments characteristics are measured and used and applied to derive the first level of products. The terminology used refers to radiometry, brightness temperature, backscattering or time delays.

Validation deals with the geophysical part of the process. Often models are used to link the engineering part of the system and the geophysical values derived. Validation deals in that example with the determination of the variables describing that model.

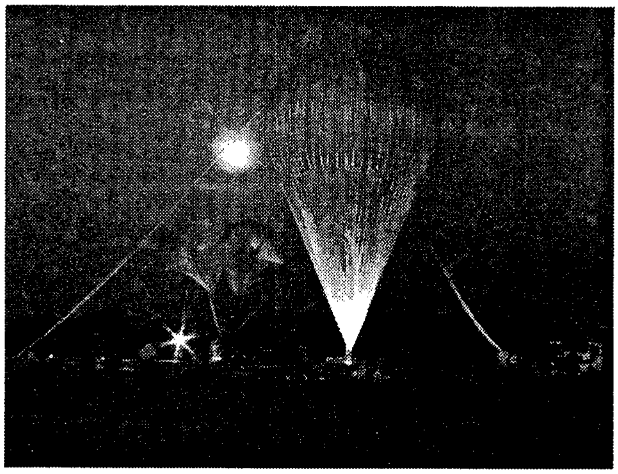

Figure 2. Teresina Campaign June 2005

ESA has always considered that Validation shall be maintained all along the satellite mission. In the framework of Envisat regular balloon and aircraft campaigns are planned for atmospheric chemistry (Figure 2) and buoys have been developed and deployed for sea colour and sea surface temperature (Figure 3).

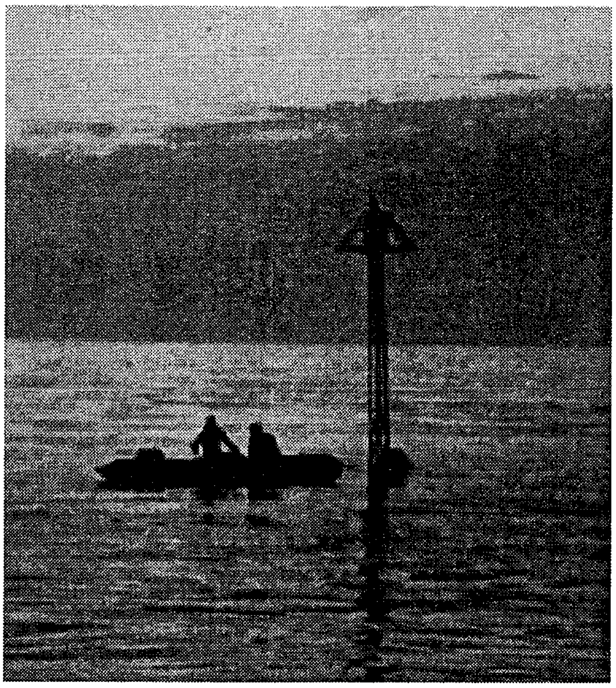

Figure 3. The buoy Boussole during maintenance

6. GMES

GMES will be Europe's contribution to a better coordinated Global Earth Observing System (GEOS). GMES relies on multi source data access, interoperability, long-term data preservation, and definition standards to facilitate the above objectives. In this framework, the calibration and validation are two essential steps for the correct use and understanding of the Earth observation data. Applications in the GMES context are based on multi sources data and can be addressed only if the calibration and validation process is well defined and controlled through common standards. GMES requires the use of fusion of similar sensor data to guarantee the sustainability of the services. Cross-calibration is needed to ease the calibration process and therefore will increase the comparability of similar instruments data, helping matching the above key GMES objectives.

On the background of these requirements for sensor calibration, inter-calibration and product validation, the Committee on Earth Observing System (CEOS) Subgroup for Calibration and Validation has formulated a recommendation to set-up and operate an internet based system to provide sensor data, protocols and guidelines. This shall support worldwide activities on calibration and validation, and specifically ensure that sensor inter-calibration is favoured in a standardised way, so that GMES can be served with information products regardless of the sensor providing the source measurements.

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The Committee for Earth Observation Satellites (CEOS) is the primary international organization that provides forum for the co-ordination of the Earth observation programmes of space agencies around the world.

7. CONCLUSION

Following this philosophy, ESA is proposing to put the emphasis on the following points: the standardization of Product format and content in order to support the user applications; the development of a common approach for Calibration and Validation activities.

This second element can be derived in the following activities:

- the definition of specific products to support Quality Control, Calibration and Validation activities
- Definition of Quality Products to support inter-comparison.
- Requirement definition for multi-mission Routine Quality Control system
- Inter-comparison protocols and guide lines definition for Calibration and Validation

These activities will be initiated in the coming month, the main objective being to create a large cooperation between all the agencies involved in the acquisition of Earth Observation data.