A guide to establish a Quality Indicator on a satellite sensor derived data product

QA4EO-QAEO-GEN-DQK-001

GROUP ON EARTH OBSERVATIONS

QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

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A guide to establish a Quality Indicator on a satellite sensor derived data product

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1 Abstract

This guideline provides a generic "top level" set of activities or requirements that should be performed with all satellite-based Earth Observation (EO) sensors to enable a reliable Quality Indicator (QI) to be established and maintained for its delivered data products. These data products are the principle starting point for many EO knowledge information products. Their reliability is thus a key issue, not only within the confines of a specific mission's goals but also as a component of an international partnership as envisaged by the Group on Earth Observations (GEO)'s Global Earth Observation System of Systems (GEOSS). To ensure maximum benefit from the relatively high cost of developing and operating space assets such as these, it is essential that all reasonable steps are taken to reduce the risk of instrument / mission failure. However, as part of this process, it is crucial that we also establish an appropriate coordinated programme of calibration and validation throughout all stages of the mission from sensor build to end-of-life. Where possible, this should anticipate sensor degradation and the likelihood of unforeseen issues and/or modifications as a result of new knowledge at some future point during or after the mission's life. Although this guideline is specifically written to address the needs of satellite-based sensors, it provides an example, at high level, of the application of the underpinning principles of the Quality Assurance Framework for Earth Observation (QA4EO) to a full product lifecycle, which can be translated to other disciplines within the GEO community.

2 Scope

The key requirement driving the data quality assurance aspects of the Quality Assurance Framework for Earth Observation (QA4EO) is the need for interoperability and the means to allow all the Group on Earth Observations (GEO)'s stakeholders to be able to readily assess (on receipt) the suitability of a data (or derived) product for their particular application. This requires a Quality Indicator (QI), which must be unequivocal and universal in terms of its definition and derivation. In practise there is likely to be a wide range of actual descriptors and terms used (e.g. text or numeric) dependant on the specific application or users' needs, but all should be based on a statistically derived value. This value should be the result of an assessment of its traceability to an agreed reference standard (ideally SI) as propagated through the data processing chain. Where practical and when interoperability is a driving requirement, the reference standard should, if not SI, be internationally agreed by a representative community body (see QA4EO-QAEO-

GEN-DQK-003). However, in many cases the choice of reference standard only needs to be agreed between the provider of the task and the authoriser of the task.

The starting point for most EO products, particularly those that are global in nature, is satellite-based sensors. These sensors often take many years to build from conception to launch and generally have planned operational lifetimes of around five years. Although such sensors can provide global geographical coverage, with the exception of the geo-stationary satellites, no individual satellite can provide full temporal coverage. Therefore, as we move into an era where users demand operationally delivered services and require in many circumstances access to "near temporally continuous" datasets, we must establish an internationally coordinated global observation system. This is the vision of GEO's Global Earth Observation System of Systems (GEOSS).

For such an integrated observing system to become established requires the seamless interface of datasets from similar and different sensors from all the GEO members. To achieve this requires any sensor specific signature (bias, observation characteristics, etc.) to be removable from the data in an efficient, robust manner. This places severe constraints on the sensor builders and operators to ensure that all the necessary information is available in a timely and harmonised manner to facilitate this process. Users will increasingly require datasets that extend beyond the lifetime of any one mission and in some cases, due to new knowledge, this may require reprocessing archived data, including the calibration coefficients. It is therefore essential that sufficient information is provided to enable this to take place.

The detailed activities needed to achieve the above will, in the case of space, be specific to each sensor domain and in some cases to individual sensors. This may be similar for other GEO sectors. This top-level "key guideline" simply provides, as an example, the generic requirements for a space-based sensor and this would progressively lead onto the generation of a number of more detailed guidelines. These latter guidelines would be developed within the various GEO communities under the authority and guidance of the appropriate international representative organisations.

The practical implementation of this guideline (or in reality its sensor specific derivatives) will draw heavily on the other key guidelines within the QA4EO framework. This guideline sets out to establish the requirements, with QA4EO-QAEO-GEN-DQK-002 providing the structure for demonstrating compliance, supported by the other QA4EO guidelines for the detail.

3 Terminology

All terms within this document are based on internationally-agreed definitions that are, in many cases, derived directly from formal standardising bodies such as the International Organization for Standardization (ISO). These agreed definitions can be found on the QA4EO website (http://QA4EO.org/).

4 Background and Context

This key guideline is written as part of a set, based on the adoption of existing best practise, to form a Quality Assurance Framework for Earth Observation (QA4EO). The QA4EO was developed to meet the current and aspirational needs of the societal themes of the GEO's GEOSS. It was prepared as a direct response to GEO task DA-06-02 (now DA-09-01-a) to "Develop a GEO data quality assurance strategy, beginning with space-based observations and evaluating expansion to *in situ* observations, taking account of existing work in this arena".

5 Outcomes

In the case of the EO community, the outcome of this key guideline will be a set of calibration / characterisation requirements that should be established for each sensor in order to ensure that a QI can be assigned to its delivered products and enable this to be maintained throughout the sensor lifetime.

6 Inputs

The key inputs that need to be considered when writing detailed guidelines to follow the generic ones described here are:

1. User / Mission requirements,
2. Historical knowledge of previous similar sensor performance,
3. Reference standards and methods to enable traceability to be established.

7 Standards and Traceability

The requirements outlined in this document have no quantitatively assessable outcomes nor are there any appropriate generic reference standards to which traceability should be demonstrated. However, detailed sensor and domain specific procedures written to implement this key guideline will make use of the other key guidelines in QA4EO and will require a number of specific reference standards to facilitate traceability. For example, reference test sites will play a significant role in post-launch validation.

8 Establishing a Quality Indicator for a satellite sensor derived data product

8.1 Introduction

In drafting this generic key guideline, it is assumed that every effort is made during development of a satellite sensor to ensure that an instrument and all its components are comprehensively characterised before flight. This document simply serves to reinforce that process. However, there are numerous examples where retrospective correction of parameters / characteristics post-launch is essential due to change or degradation. In these cases, detailed knowledge of the pre-flight characteristics, and ideally the ability to re-evaluate copies of instruments and/or components, is invaluable.

It is noted that the relatively high cost and time associated with the development of these space assets means that often, following launch, there is a significant expansion in the range of applications for which delivered data is used. This, of course, should be encouraged. However, to maximise the benefit, one should seek to ensure that, where possible and without excessive cost, there is sufficient knowledge about the sensor to allow this to occur in a quality assured manner. It is also imperative that satellite sensors and/or agencies are not considered as “islands” but as contributors to a global effort. Facilitation of the means not only to characterise the performance of individual sensors but also to evaluate any biases between other similar sensors in-flight should be encouraged. This effort must extend sufficiently to ensure that any delivered dataset can transcend the lifetime of any individual sensor and that a means of bridging both short and long term data gaps, caused by unexpected satellite failure or launch delays, is provided.

8.2 Requirement

To establish a QI for satellite sensor delivered data products the following activities are recommended:

8.2.1 Pre-Flight

All aspects of a sensor involved in the production of data or its transition into other derived products should, where possible, be traceably calibrated / evaluated against international standards (ideally SI) at system level and as integrated "end-to-end". Where appropriate, sensor simulator / models and witness samples of key calibration sensitive components should be stored and maintained for potential later evaluation.

8.2.2 Post-Launch

Sensor builders and operators should seek to demonstrate and document the performance of their sensors for the following three aspects:

- **Characteristics** compared to pre-flight specifications and simulated / modelled results,
- **Biases** to similar in-flight sensors,
- **Stability** of delivered data products during mission life and its correlation with data from historical and future missions.

This can best be achieved through comparison to (or by using) a community endorsed reference standard that employs an endorsed methodology. Where a formerly endorsed standard does not exist the reader is directed to QA4EO-QAEO-GEN-DQK-003 for guidance (see also QA4EO-QAEO-GEN-DQK-002).

9 Conclusion

This key guideline provides the "top-level" requirements that should be carried out for each sensor during its development and operation in order to meet the data quality key guidelines of QA4EO. Subsequent sensor and characteristic specific guidelines / procedures will translate the requirements of this key guideline into practical implementation strategies.