QA4ECV: A robust quality assurance service for terrestrial and atmospheric ECVs and ECV precursors

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The development of robust and community accepted Quality Assurance (QA) services for Earth Observation (EO) products is key to ensuring that QA information is provided in a clear and consistent manner throughout the community. Where the QA information includes comprehensive details of the processing algorithm and the estimation of uncertainties, this improves the communication of the products to end-users, ensuring suitable products are chosen for the end-user applications. The Quality Assurance for Essential Climate Variables (QA4ECV) project (which has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under QA4ECV grant agreement no. 607405) is developing such a QA service. This service will consist of various procedures, good practice guidance and specifications for suitable tools. All of these elements will be underpinned by robust and targeted scientific studies focusing on uncertainty estimation and propagation through ECV processing algorithms.

1. Introduction

Terrestrial and atmospheric Essential Climate Variable (ECV) and ECV precursor products derived from satellite-borne instrumentation are increasingly used both directly, and through incorporation into other products, for high level decision making. To ensure robustness in the decision making process, a full understanding of the ECV products is required. This full understanding allows an accurate interpretation of any information provided from the products (and derived products). A recent survey [1] concluded that data users believe such information is not readily available to them.

To address this, the communication between the ECV producers' and users' needs to be carefully considered and enhanced where possible. The Quality Assurance for ECVs (QA4ECV) project (which has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under QA4ECV grant agreement no. 607405) plans to address this through the prototyping of a robust and community-accepted QA service.

The current paper describes this service, focussing on the aims of the service (Section 2), the structure and main elements of the service (Section 3), the levels of traceability which will be assigned to the ECV product by the service (Section 4) and finally, the potential future of the service (Section 5).

2. Aim of the Service

The successful implementation of a QA service requires the aims of the service to be achievable and appropriate to the current needs of the community. The following have been identified as the main aims of the service:

1. To provide **ECV data product producers / science teams** with the necessary resources to develop products with embedded QA information that is presented in a clear and common format throughout the community, and,
2. To provide **ECV data users (scientists – policy-makers)** with robust QA information as a means to quantitatively assess uncertainty and fitness-for-purpose of the data and derived products.

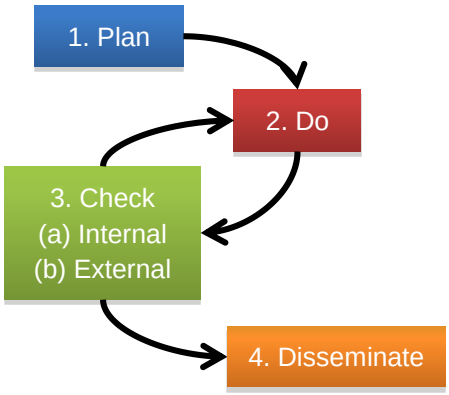
The QA service addresses both of these aims through both the compilation and subsequent dissemination of product information in a clear and consistent manner and through assessing each product in the same way thereby allowing the differences between them to be clearly highlighted.

3. The QA Service

3.1 Structure of the Service

The QA service adopts a "plan, do, check" approach as is commonly adopted in ISO 9001 compliant QA systems. The adoption of this approach ensures a robust and useful service is implemented whilst allowing the flexibility for future developments and improvements to the service. In addition, these three stages, a further stage, "disseminate", is included to ensure communication of ECV records to the ECV users. A summary of the system structure is provided in Figure 1.

Figure 1: Structure of the QA Service



The "**plan**" stage of the service is currently underway and is described within this paper. The stage includes the generation of procedures and good practice guidance as well as the implementation and testing of a prototype web portal and associated tools.

The "**do**" stage of the service will involve the ECV producers inputting all relevant information (termed "quality records") into the web portal. This will be tested under the scope of the QA4ECV project through the input of information concerning the six ECVs being developed within the project.

The "**check**" stage will consist of two parts:

1. Internal checking of the provided quality records by the ECV producers to ensure self-consistency and identify any potential improvements to the records.
2. External checking of the provided quality records by an independent body (termed the "QA office").

The aims of the checking stage are three-fold: to ensure that the records are appropriate for further dissemination, to allow potential improvements to be made to the records and to assess the level of traceability of the product (see further details in Section 4.1).

The "**dissemination**" will consist of ensuring that all of the records are available to ECV users as required.

3.2 Procedures and Good Practice Guidance

The backbone of the QA service will be a set of formal procedures and good practice guidance. The aim is to ensure that all users of the service (both ECV producers and users) have the information and tools that they need to provide, or use, QA information about a product.

The procedures under development cover the practicalities of using the system including: how to develop traceability diagrams, how to check that all QA records are appropriate, etc.

There are many aspects of ECV product QA which could be considered for development into a good practice guide. For example, the standardisation of relevant documentation or how to estimate uncertainties through part of an ECV processing chain. The exact guidance to be produced is currently being determined through consultation with relevant science teams. However, the service will be structured in such a way that

supplemental good practice guidance can be added to the service at any time.

3.3 QA Service Web Portal and Tools

The QA service will be implemented through a web portal. The web portal will essentially be an easy to use webpage which provides both ECV producers and users with the information they need to either provide or use ECV QA information appropriately.

For the ECV producers, the web portal will host a unique environment in which the producer can document their product, including any relevant traceability information. This will be achieved primarily through the Traceability and Uncertainty Propagation Tool (TUPT) which is currently in development. This tool will allow a user to draw out traceability diagrams and attach relevant information including links to associated papers and datasets. The web-portal will allow all information to be uploaded such that the QA office can then check the information as required.

For the ECV users, the web portal will be a means of viewing information about a range of ECV products in an interactive format. For example, a user will be able to navigate through the traceability diagrams and associated information.

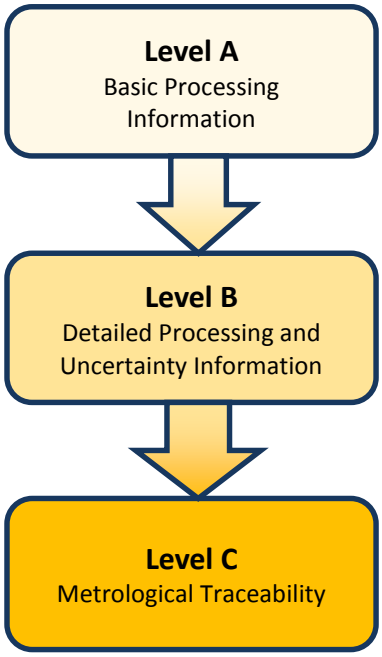
4. Traceability in QA4ECV

4.1 Definition of Traceability

One of the key aims of the QA service is to encourage the enhancement of traceability of ECV products. Within QA4ECV, traceability is defined as:

> *A property of an often multistep process whereby the result can be related to its source(s) (and ideally to international standards) through a documented unbroken chain of operations including calibrations.*

Figure 2: Levels of traceability in QA4ECV



Three "levels" of traceability (summarised in Figure 2, with details in Table 1) are defined within QA4ECV. Each ECV product will be assessed against these levels and this information will be made available to ECV users. It will serve as a metric against which the user can quickly assess the product, noting that the other available information should also be used to make a full assessment.

Table 1: Requirements of Levels of Traceability

	Requirements of Level
A	1. Algorithm traceability diagrams created. 2. Basic processing information on each ECV algorithm processing step. 3. Provenance information for all input and ancillary datasets.
B	All aspects of Level A + 1. Detailed information on each ECV algorithm processing step including justification for use for all input and ancillary datasets. 2. Detailed information provided on decisions made by algorithm developers in implementing the algorithm.

	Requirements of Level
	3. Information provided on uncertainty analysis including the propagation of uncertainties through the ECV algorithm.
C	All aspects of Level B + "Metrological Traceability", which in the context of QA4ECV is: *For each step of the ECV processing chain, the result of that step (and the associated uncertainties) are demonstrably derived from the output of the previous processing step.* Traceability to an international agreed reference standard, ideally SI, should be achieved where possible.

4.2 Enhancement of Traceability

It is recognised that many ECV products currently available are likely to achieve traceability Level B. A recent gap analysis [2] of ECV products has found that this is due to several factors including, but not limited to, the difficulties associated with relating the Level 1 satellite data back to SI standards and the complexity of estimating uncertainties at every stage of a processing chain.

As part of the QA4ECV project, several scientific studies of uncertainty estimation and propagation will be undertaken with the aim of improving the identified gaps. The specific details of the studies will be determined in close collaboration with the ECV producers involved in the project.

5. Future of the Service

Within QA4ECV, a prototype of the service described within this paper will be implemented. This will be tested by the partners involved in QA4ECV through the documentation and assessment of their products.

Once the service has been proven in use and recommendations accommodated, the QA service and framework may, at least in part, be considered for adoption by the Copernicus climate change service (C3S). It is noted that the system has been designed to ensure it has sufficient flexibility to be developed further for a range of applications and to allow the incorporation of relevant recommendations and good practice.

It is hoped that the service will, over time, provide a meaningful and useful service to both ECV producers and users, encouraging and fostering a culture of transparency and openness between ECV producers and users.

6. References

[1] Marks, A. Nightingale, J. De Rudder, A. Origo, N. Boersma, F. Farquhar, C. Muller, J.P. and Fox, N. 2014. Results from the QA4ECV User Requirements Survey on Quality Assurance in Satellite Data Products. NPL internal report #6529.

[2] Tracy Scanlon, Joanne Nightingale, Anne De Rudder, Jean-Christopher Lambert, Jan-Peter Muller (2015), Gap Analysis of QA4ECV Land and Atmosphere Products, Version 1.