



QA4ECV

Quality Assurance for Essential Climate Variables

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QA4ECV Quality Checklist Procedure

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TERMS & ACRONYMS

ATBD	Algorithm Theoretical Basis Document
BHR	Bi-Hemispherical Reflectance
C3S	Copernicus Climate Change Service
CCI	ESA's Climate Change Initiative
CDR	Climate Data Record
CEOS	Committee on Earth Observation Satellites
Core Climax	Coordinating earth observation data validation for re-analysis for climate services (EU FP7 Project)
DHR	Direct Hemispherical Reflectance
ECV	Essential Climate Variable
EM	Electromagnetic
EO	Earth Observation
ESA	European Space Agency
EU	European Union
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FCDR	Fundamental Climate Data Records
GCOS	Global Climate Observing System
LAI	Leaf Area Index
LPV	Land Product Validation
MISR	Multi-angle Imaging Spectro-Radiometer
MODIS	Moderate-Resolution Imaging Spectroradiometer
MSSL	Mullard Space Science Laboratory
NIR	Near Infra-Red
NPL	National Physical Laboratory (UK)
NRT	Near Real Time
PDF	Probability Distribution Function
PUG	Product User Guide
QA	Quality Assurance
QA4ECV	Quality Assurance for Essential Climate Variables (EU FP7 Project)
QI	Quality Indicator
ROI	Region of Interest
SDR	Surface Directional Reflectance
SMM	System Maturity Matrix
TCDR	Thematic Climate Data Record
UCL	University College London
WGCV	Working Group on Calibration and Validation

EXECUTIVE SUMMARY

In support of the European Union's Earth Observation Programme's Copernicus Climate Change Service (C3S), the Quality Assurance for Essential Climate Variables (QA4ECV) project aims to fulfil a current gap in the delivery of satellite derived climate data products. The project will prototype a system for the implementation and evaluation of QA measures for 6 satellite-derived ECV and ECV precursor datasets, thus providing confidence in their application for climate monitoring studies and climate change assessments.

The purpose of developing and implementing a QA4ECV system is two-fold:

1. To provide **ECV data product producers / science teams** with the necessary resources (internationally accepted tools, standards, methodologies) to develop products with embedded QA information that is presented in a clear and common format throughout the Earth Observation (EO) 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.

A QA service has been provided under the QA4ECV project. The **QA system** implemented is an interactive web-service and the **documentary framework** is a series of documentation including procedures, good practice guidance and training which support the QA system.

This document provides details of the process for undertaking and communicating the results of the checking of quality records by a quality "office". This document is intended as a procedure for those persons undertaking the checking and as a reference for the data providers.

1 Introduction

1.1 Quality Assurance for Essential Climate Variables

Climate change mitigation and adaptation has risen to the top of the agenda for many governments and international organisations. This has led to the establishment of projects and programmes dedicated to the development of long-term global records of Essential Climate Variables (ECVs) using space-borne assets.

In support of the European Union's Earth Observation Programme's Copernicus Climate Change Service (C3S)¹, the Quality Assurance for Essential Climate Variables (QA4ECV) (<http://www.qa4ecv.eu/>) project aims to fulfil a current gap in the delivery of satellite derived climate data products. The project will prototype a system for the implementation and evaluation of QA measures for 6 satellite-derived ECV and ECV precursor datasets, thus providing confidence in their application for climate monitoring studies and climate change assessments.

The purpose of developing and implementing a QA4ECV system is two-fold:

1. To provide **ECV data product producers / science teams** with the necessary resources (internationally accepted tools, standards, methodologies) to develop products with embedded QA information that is presented in a clear and common format throughout the Earth Observation (EO) 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.

Provision of such QA information will demonstrate traceability of products and simplify comparisons, including round-robin selection, between the same ECV produced by independent science teams. It will also provide data users with evidence-based confidence in the products and enable judgement on the fitness-for-purpose of various ECV Climate Data Records (CDRs) for their specific applications.

1.2 QA Service and System

One of the main aims of the QA system being developed under QA4ECV is to bridge the gap between data users and data producers, i.e. allow the transfer of information between the two in easy-to-use and consistent formats (as far as practicable)². Taking this into account, the QA system is split into two main "paths":

- Data providers will follow a series of pages through the QA system to provide evidence relating to their ECV data product. This evidence will be included in a central repository.
- Data users will be able to search and download quality reports about a range of ECV data products from the central repository for comparison.

The **QA service** includes:

- The **QA system** is a physical system implemented as an interactive web-service through which data products will be assessed, and,
- The **documentary framework** is a series of documentation including procedures, good practice guidance and training which support the QA system (and are linked to

¹ Details of the Copernicus climate change service are available at: <https://climate.copernicus.eu/>

² Note that several other EU funded projects including EUPORIAS and Core Climax have identified this as a key factor which could improve the overall use of climate data sets. See [1].

throughout the QA system).

The structure of the **QA service** is summarised in Figure 1³ (in green) within the context of ECV production (yellow) and dissemination (blue and purple). The **documentary framework** which is the associated guidance etc. is within the “Tools & Guidance to establish and evaluate QA” box (in green).

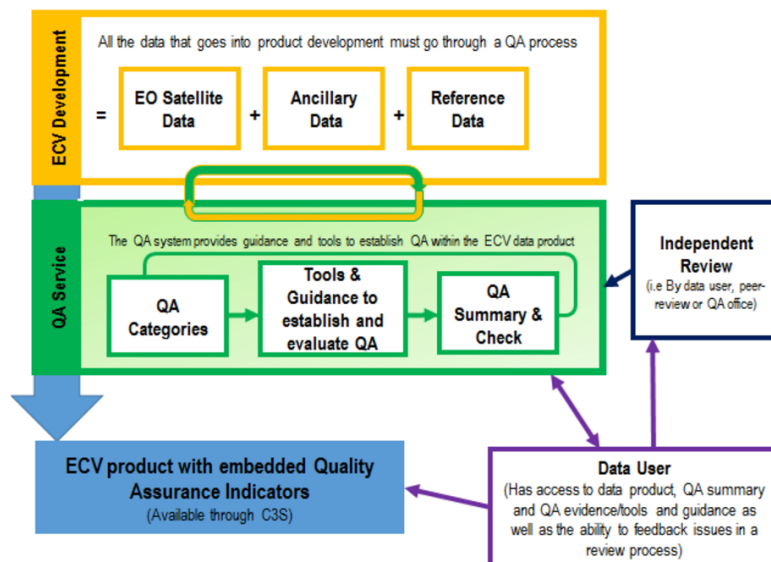


Figure 1: Diagram of system.

In addition to the data providers and users, a third organisation is considered within the current document:

- **QA office** – an independent organisation which undertakes the checking of QA records to ensure there is consistency between records provided by different data providers and between different ECV datasets.

1.3 Objective

This document provides details of the process for undertaking and communicating the results of the checking of quality records by a quality “office”. This document is intended as a procedure for those persons undertaking the checking and as a reference for the data providers.

This document contains details of the following:

- How the process will work, including details of roles within the process.
- The levels which may be assigned depending on the different quality information available for a product.
- Guidance and tools available to aid in the checking of quality information.

³ Note this diagram is also provided at www.qa4ecv.eu.

2 Quality Checking Process

Once records associated with a product have been submitted through the QA system web portal, they will be subjected to a checking process. The aim of this process is:

Checking of quality records is undertaken to ensure the consistency of records between data providers and ECV datasets.

The process for checking records is described in Figure 2. The diagram distinguishes between actions which need to be undertaken by the data providers (in blue) and those which need to be undertaken by the QA office (in green). The process is designed to be iterative which data providers given the chance to update and improve their quality records throughout the process, with checking being undertaken more than once to achieve an optimum outcome for both the QA office and the data providers.

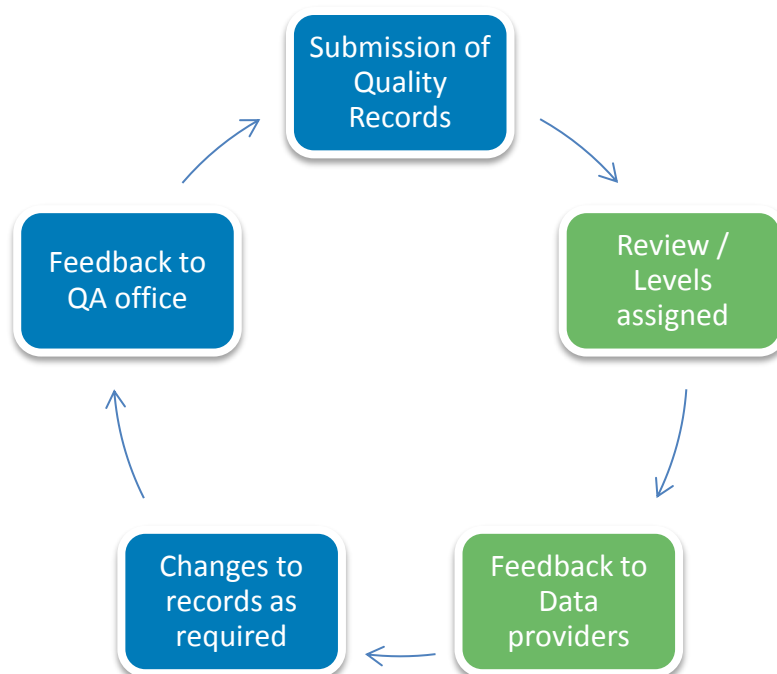


Figure 2: Quality records checking process showing interaction between the QA office and the data providers (green are actions by the QA office and blue are actions by the data providers).

The review / levels assigned stage of the process will be undertaken by the QA office by testing the information provided against the levels stated in Section 3. This will be achieved using an online tool which is part of the QA system. To ensure consistency of the process, a three-stage approach will be employed:

1. First run through – a quick assessment of the data available to provide a rough assignment of levels.
2. Check by second person – a repeat of the first stage, using a second person who has not seen the results of the first stage.
3. Comparison and agreement – comparison of the results from stage one and two and

discussion to come to an agreement on the levels which should be assigned.

The final data is then input to the QA system with any relevant comments and this is sent back to the data providers.

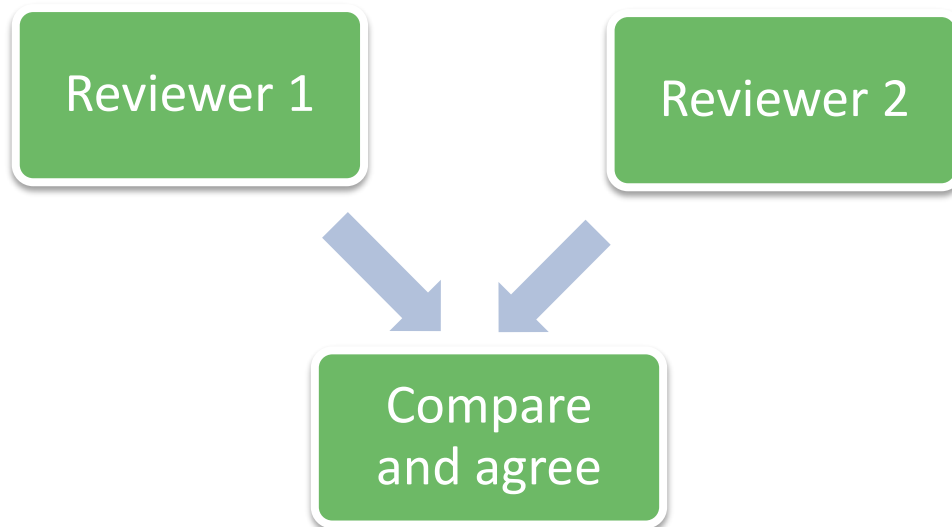


Figure 3: Quality records checking process showing interaction between the QA office and the data providers (green are actions by the QA office and blue are actions by the data providers).

Once the data providers have the feedback (levels and comments) from the QA office, an iterative process will follow. This will include discussion between the data providers and the QA office on the meaning of the levels and any comments which have been made and potential ways in which the quality information could be improved. The data providers will then have the chance to update their information and resubmit. Once this has been done, the original review results will be considered and amended as necessary.

3 Quality Checklist Levels

The main portion of the quality checking procedure which needs to be undertaken by the QA office is the review of the data and the assignment of the levels (see Figure 2). To aid in this process, a quality checklist has been derived which allows three different levels to be assigned to quality records:

- **Basic** – Some information is provided on the quality of the product to allow the users to make a simple distinction between the product and others.
- **Intermediate** – Detailed information is provided on the product, allowing the user to understand how it was made and the quality and uncertainty information available to them.
- **Advanced** – Significant detailed information is provided on the product, providing the user with enough information to make an informed decision about how the product should be used.

In addition to the above, there is a baseline amount of information required for each product providing basic information about what the product is; this helps to distinguish the product from others. Details of what is required for each of the steps is given in Annex A, including details of this baseline information.

In addition to the details provided in Annex A, there is guidance available (shown in Figure 4) which provides a short description of the levels. This is available on the QA system portal and the aim is to provide data users with the information they need to understand how their quality records are assessed.

		QA4ECV-Basic	QA4ECV-Intermediate	QA4ECV-Advanced
Aim	Checking the level of detail provided about an ECV data product helps to improve the available information. The checklist provided here states what information should be provided and details levels against which the information provided can be assessed.			
Details	Documentation available with source code and details on product completeness + consistency	Parameter details provided; ATBD / PUG provides significant detail; forum provided for users	Parameter details split spatially / temporally; ATBD / PUG in line with guidance; forum is monitored	
Traceability	High level diagrams with basic information on algorithm provided	Detailed diagrams with relevant sub-chains; detailed information for steps	Detailed information on most steps as well as uncertainty information provided	
Flags	Simple flags available in the product with basic information available on derivation and usage	Several flags provided allowing easy distinction of data quality; details provided for each flag	Comprehensive set of flags / ancillary data provided to allow detailed understanding of quality	
Validation	Assessed against LPV hierarchy; validation report available and some campaign details	Justification for LPV hierarchy provided; good level of detail provided for validation and intercomparison.	Validation guidance closely followed and comprehensive information on campaigns provided	
Uncertainty	Details of uncertainty calculations provided including how they are made available in product and how they should be used	Contributors to uncertainty analysis and calculation details provided with enough information to allow immediate use	Uncertainty significance estimates for all contributors	
Assess	Maturity matrix filled in to some extent; GCOS – basic details provided.	All maturity matrix filled in; comments provided for GCOS.	All boxes filled with consensus between producer and auditor.	

QA4ECV Help: QA4ECV_helpme@npl.co.uk Version 1.0 – July 2017

Figure 4: Simple guidance available on the QA system portal which provides details of the quality levels.

4 References

- [1] T. Scanlon, S. Douglas, J. Nightingale, S. Compernelle, and J.-C. Lambert, “QA4ECV: Linkages between the QA Service of QA4ECV and Other Projects and Initiatives,” 2017.
- [2] Core Climax, “Core Climax: Climate Data Record Assessment Instruction Manual,” 2013.
- [3] O. BIPM, IEC and IFCC, ILAC and IUPAC, IUPAP and ISO, *Evaluation of measurement data—guide for the expression of uncertainty in measurement. JCGM 100: 2008*, no. September. 2008.
- [4] Joint Committee For Guides In Metrology (JCGM), “International vocabulary of metrology — Basic and general concepts and associated terms (VIM),” *VIM3 Int. Vocab. Metrol.*, vol. 3, no. Vim, p. 104, 2008.

Annex A: Quality Information Levels – Detailed Version

Aspect	QA4ECV-Basic	QA4ECV-Intermediate	QA4ECV-Advanced
Base line information required: ECV, ECV product, Product name, description, Level, version number, DOI (if available), acquisition method information including instrument data and information on the availability of data provided.			
Product Details			
Available Parameters	Basic information provided, for example the parameter names.	All parameters provided for the product, but not expanded by all temporal and spatial resolutions.	All parameters provided with listings for all temporal and spatial resolutions.
Documentation	ATBD URL provided or uploaded.	ATBD review: detailed information on the algorithm provided, set out in sections.	ATBD review: information on the quality and / or uncertainty analysis / data provision provided.
	ATBD review: overview of the algorithm provided.		
	PUM URL provided or uploaded.	PUM review: information provided on how to use the product, including simple processing, obtaining flag information etc. Details of the validation provided.	PUM review: Provides case study information on how the data could be used including intended usage and intended audience. Real-life use cases should be included where possible.
	PUM review: lists available products and how to obtain them.		
Data Availability	Code repository / source code provided.	Forum provided for data users.	Evidence that forum is updated by data providers and queries answered.
Product completeness and consistency	Basic / general statements provided on the completeness of the product.	More detailed information provided on the completeness and consistency of the product provided.	Detailed information plus maps showing consistency and completeness provided.
	Basic / general statements provided on the consistency of the product.		
Points Available:	8	10	15

Traceability			
Diagrams	High level diagrams provided with basic information on the algorithm.	Detailed diagrams with relevant sub-chains provided.	
Information	Basic information provided on some steps of the diagram	Detailed information provided for steps of the diagram	Detailed information provided for all but a few steps in the diagram including links back to documentation.
			Information provided on uncertainty analysis for relevant steps.
Points Available:	2	4	6
Quality Flags			
Flagging Approach	Simple flags provided with the product.	Several flags provided in the product which provide information to allow the easy distinction between good / bad data.	Comprehensive set of flags and ancillary data provided for the product which will allow the data users to understand the product in detail.
Flag Details	Basic information on flag provided, i.e. it is included in the product.	Details of the format of the flag provided and the values are stated either in documentation on the website.	Details on the derivation of the flag provided as well as recommendations for use
Points Available:	2	4	6
Validation			
LPV Validation Hierarchy	Assessment against the LPV hierarchy.	Provides basic justification for selection of LPV level.	Provides a detailed justification for selection of LPV level

Validation Report	Validation report URL provided or uploaded.*	Validation report review: report includes some details of the method and results for each validation study.*	Validation report review: report includes detailed information on the validation and intercomparison of product including details of best practices followed.*
In-Situ Validation	Some information provided on a small number of in-situ validation campaigns.	Detailed information provided on some campaigns, including details of spatial coverage and measurements taken.	Comprehensive information provided for each campaign, including sampling methods and other information.
Inter-Comparison Validation	Some information provided on a small number of inter-comparisons.	Detailed information provided on some comparisons, including details of the spatial and temporal extent.	Comprehensive information provided for each comparison including method descriptions.
Points Available:	4	8	12
Uncertainties			
Uncertainties provided with the Product	Details of the uncertainties provided with the product are available.	-	-
Using the Uncertainty Analysis	Details on using uncertainties provided.	Details of uncertainty usage clear enough to allow immediate use of product.	-
Basis of Uncertainty Analysis	Details of uncertainty calculations in product provided.	Contributors to uncertainty listed and description of calculation provided.	Uncertainty significance estimated.
Points Available:	3	4	3
Assessment against Standards			

Maturity Matrix	Maturity Matrix filled in to some extent, above which would have been automatically filled in by the system	Evidence that all boxes of the Maturity Matrix have been filled in.	All matrix boxes filled in and common consensus agreed between product developer and auditor on the levels achieved.
GCOS requirements	GCOS requirement information filled in on a basic level (i.e. yes / no).	Comments given for all GCOS requirements.	
Points Available:	2	4	3
Total Points Available:	21	34	45

* Note: Where information is provided by the data providers across more than one document, for example, several papers on validation provided for the product, this should be assessed as a single validation report (i.e. between all of the documents, are all of the points of the validation template covered?).

Annex B: System Maturity Matrix Requirements

The “System Maturity Matrix” (SMM) was developed as a way of assessing satellite derived data products as part of the Core Climax project (for further details see <http://www.coreclimax.eu/>, [1] and [2]). The QA system requests that the data provider undertake an assessment against this matrix as part of the “Assessment against Standards” section of the QA system. To ensure the checking undertaken as part of the system is applied equally to all products, this section provides some guidance on what is expected from all parts of the matrix to achieve the different levels specified, building on the information available in the instruction manual for the SMM [2].

As shown in **Figure 5**, the SMM consists of 6 areas divided into subsections; details of how to reach the different levels (as assessed as part of QA4ECV) are given on the next page.

Software readiness	Metadata	User documentation	Uncertainty characterisation	Public access, feedback and update	Usage
Coding standards	Standards	Formal description of scientific methodology	Standards	Public Access/Archive	Research
Software Documentation	Collection level	Formal Validation Report	Validation	Version	Decision Support System
Numerical Reproducibility and Portability	File level	Formal Product User Guide	Uncertainty quantification	User Feedback Mechanism	
Security		Formal description of operations concept	Automated Quality Monitoring	Updates to Record	

Legend



Figure 5: The SMM on the QA system webpage.

Aspect		1	2	3	4	5	6
Software Readiness							
Coding Standards	SMM	No coding standard or guidance identified or defined	Coding standard or guidance is identified or defined, but not applied	Score 2 + standards are partially applied and some compliance results are available	Score 3 + compliance is systematically checked in all code, but not yet compliant to the standards.	Score 4 + standards are systematically applied in all code and compliance is systematically checked in all code. Code is not fully compliant to the standards. Improvement actions to achieve full compliance are defined.	Score 5 + code is fully compliant with standards.
	QA4ECV	Automatically achieved	Standards listed in the software documentation	Based on assertion from data providers, not to be assessed by reviewing team.			
Software Documentation	SMM	No documentation	Minimal documentation	Header and process description (comments) in the code, README complete	Score 3+ a draft software installation / user manual	Score 4 + enhanced process descriptions throughout the code; software installation/user manual complete	As in score 5
	QA4ECV	Automatically achieved	Some comments in code, no README or other documentation provided	Score 2 + README which is useable by basic users	Score 3 + basic manual allowing use of code by basic users	Score 4 + additional information provided describing how the code works.	

Aspect		1	2	3	4	5	6
Numerical Reproducibility and Portability	SMM	Not evaluated	PI affirms reproducibility under identical conditions	PI affirms reproducibility and portability	3rd party affirms reproducibility and portability	Score 4 + 3rd party can install the code operationally	Score 5 + Turnkey system
	QA4ECV	Automatically achieved	Based on assertion from data providers, not to be assessed by reviewing team.				
Security	SMM	Not evaluated	PI affirms no security problems	Submitted for data provider's security review	Passes data provider's security review	Continues to pass the data provider's review	As in score 5
	QA4ECV	Automatically achieved	Based on assertion from data providers, not to be assessed by reviewing team.				
Metadata							
Standards	SMM	No standard considered	No standard considered	Metadata standards identified and/or defined but not systematically applied	Score 3 + standards systematically applied at file level and collection level by data provider. Meets international standards for the dataset	Score 4 + meta data standard compliance systematically checked by the data provider	Score 5
	QA4ECV	Automatically achieved		Metadata standards listed in software documentation.	Based on assertion from data providers, not to be assessed by reviewing team.		

Aspect		1	2	3	4	5	6
Collection level	SMM	None	Limited	Sufficient to use and understand the data independent of external assistance; Sufficient for data provider to extract discovery metadata from meta data repositories	Score 3 + Enhanced discovery metadata	Score 4 + Complete discovery metadata meets international standards	Score 5 + Regularly updated
	QA4ECV	Automatically achieved	Based on assertion from data providers, not to be assessed by reviewing team. Note: this category primarily relates to the meta information about the product such as DOI, spatial extent etc. which is collected on the Product Details page of the QA system.				
File level	SMM	None	Limited	Sufficient to use and understand the data independent of external assistance	Score 3 + Limited location (pixel, station, grid-point, etc.) level metadata	Score 4 + Complete location (pixel, station, grid-point, etc.) level metadata	Score 5
	QA4ECV	Automatically achieved	Based on assertion from data providers, not to be assessed by reviewing team.				

Aspect		1	2	3	4	5	6
User Documentation							
Formal description of scientific methodology	SMM	Limited scientific description of methodology available from PI	Comprehensive scientific description available from PI and Journal paper on methodology submitted	Score 2 + Journal paper on methodology published	Score 3 + Comprehensive scientific description available from Data Provider	Score 4 + Comprehensive scientific description maintained by data provider	Score 5 + Journal papers on product updates published
	QA4ECV	ATBD uploaded / URL provided	ATBD has all sections / information required in QA4ECV template + journal article or conference proceeding submitted on method.	Score 2 + published paper for method. Note: if based on an old algorithm, this can be claimed as relevant to this version of the product.		Evidence of update(s) to the ATBD since first publication.	Score 5 + updated paper on method published.
Formal validation report	SMM	None	Report on limited validation available from PI	Report on comprehensive validation available from PI; Paper on product validation submitted	Report on inter-comparison to other CDRs, etc. Available from PI and data Provider; Journal paper on product validation published	Score 4 + Report on data assessment results exists	Score 5+ Journal papers more comprehensive validation, e.g., error covariance, validation of qualitative uncertainty estimates published
	QA4ECV	Automatically achieved	Validation report uploaded / URL provided.	Validation report includes sections / information specified in QA4ECV guidance.	Intercomparisons report provided. Journal paper(s) published on validation.		Journal paper(s) published on validation of uncertainties.

Aspect		1	2	3	4	5	6
Formal product user guide	SMM	None	Limited product user guide available from PI	Comprehensive User Guide available from PI	Score 3 + available from data provider	Score 4 + regularly updated by data provider with product updates and/or new validation results	Score 5
	QA4ECV	Automatically achieved	PUM uploaded / URL provided.	PUM includes sections / information specified in QA4ECV guidance.		Evidence of updates to PUM with updates to product.	
Formal description of operations concept	SMM	None	None	Limited description of operations concept available	Comprehensive description of operations concept available	Operations concept and description of practical implementation available	Score 5 + Operations concept regularly updated
	QA4ECV	Automatically achieved		Based on assertion from data providers, not to be assessed by reviewing team. Note: considered this is not relevant to research products.			
Uncertainty Characterisation							
Standards	SMM	None	Standard uncertainty nomenclature is identified or defined	Score 2 + Standard uncertainty nomenclature is applied	Score 3 + Procedures to establish SI traceability are defined	Score 4 + SI traceability partly established	Score 5 + SI traceability established
	QA4ECV	Automatically achieved	Uncertainty, error, etc. used in correct manner in line with GUM [3] and VIM [4]. List on FIDUCEO ¹ website will be used.		Details of traceability provided in ATBD or other documentation.	Traceability discussed in detail in documentation or shown on traceability diagram.	Fully demonstrated traceability back to SI standards.

Aspect		1	2	3	4	5	6
Validation	SMM	None	Validation using external reference data done for limited locations and times	Validation using external reference data done for global and temporal representative locations and times	Score 3 + (Inter)comparison against corresponding CDRs (other methods, models, etc.)	Score 4 + data provider participated in one inter-national data assessment	Score 4 + data provider participated in multiple inter-national data assessment and incorporating feedbacks into the product development cycle
	QA4ECV	Automatically achieved	Validation report / information on QA system shows limited number of sites / times used.	Validation information provided in report or in system.	Intercomparison information provided in report or in system.	Based on assertion from data providers, not to be assessed by reviewing team.	
Uncertainty quantification	SMM	None	Limited information on uncertainty arising from systematic and random effects in the measurement	Comprehensive information on uncertainty arising from systematic and random effects in the measurement	Score 3 + quantitative estimates of uncertainty provided within the product characterising more or less uncertain data points	Score 4 + temporal and spatial error covariance quantified	Score 5 + comprehensive validation of the quantitative uncertainty estimates and error covariance
	QA4ECV	Automatically achieved	Basic questionnaire filled in on the QA system, but no other information provided in product documentation.		Per pixel uncertainty provided or information discussed in detail in product documentation.	Information provided in the documentation on covariance.	Detailed information provided in documentation including demonstrable validation of uncertainties.

Aspect		1	2	3	4	5	6
Automated quality monitoring	SMM	None	None	Methods for automated quality monitoring defined	Score 3 + automated monitoring partially implemented	Score 3 + monitoring fully implemented (all production levels)	Score 5 + automated monitoring in place with results fed back to other accessible information, e.g. meta data or documentation
	QA4ECV	Automatically achieved		Based on assertion from data providers, not to be assessed by reviewing team.			
Public access, feedback and update							
Public access / archive	SMM	Data may be available through request to PI	Data available through PI	Data and documentation archived and available to the public from PI	Data and documentation archived and available to the public from Data Provider	Score 4 + source code archived by Data Provider	Score 5 + source code available to the public from Data Provider
	QA4ECV	No information provided through QA system on availability.			Data availability section filled in on QA system and details verified.	Source code link provided on QA system and verified.	

Aspect		1	2	3	4	5	6
Version	SMM	None	Preliminary versioning by PI	Versioning by PI	Version control institutionalised	Fully established version control considering all aspects	Not used
	QA4ECV	Automatically achieved	Version provided on the QA system	Based on assertion from data providers, not to be assessed by reviewing team.			
User feedback mechanism	SMM	None	PI collects and evaluates feedback from scientific community	PI and Data provider collect and evaluate feedback and from scientific community	Data provider establishes feedback mechanism such as regular workshops, advisory groups, user help desk, etc. and utilises feedback jointly with PI	Established feedback mechanism and international data quality assessment results are considered in periodic data record updates	Score 5 + Established feedback mechanism and international data quality assessment results are considered in continuous data provisions (Interim Climate Data Records)
	QA4ECV	Automatically achieved	Forum provided for the data users to comment on product. Contact information available in PUM.	Based on assertion from data providers, not to be assessed by reviewing team.			

Aspect		1	2	3	4	5	6
Updates to record	SMM	None	Irregularly by PI following scientific exchange and progress	Irregularly by PI following scientific exchange and progress	Regularly by PI utilising input from established feedback mechanism	Regularly operationally by data provider as dictated by availability of new input data or new methodology following user feedback	Score 5 + capability for fast improvements in continuous data provisions established (Interim Climate Data Records)
	QA4ECV	Automatically achieved	QA4ECV products will be new at the first implementation of the checking procedure; it will be difficult to assess this, however, it should be determined if data providers have thought of how this might be achieved.				
Usage							
Research	SMM	None	Benefits for research applications identified	Benefits for research applications demonstrated by publication	Score 3 + Citations on product usage occurring	Score 4 + product becomes reference for certain applications	Score 5 + Product and its applications becomes references in multiple research field
	QA4ECV	Automatically achieved	Applications of product listed including description.	Documentation provided on how the product has been used.	Search of web of science, science direct and google scholar shows citations of product. Details provided on QA system.	QA4ECV products will be new at the first implementation of the checking procedure; it is unlikely that such a level will be achieved.	

Aspect		1	2	3	4	5	6
Decision support system	SMM	None	Potential benefits identified	Use occurring and benefits emerging	Score 3 + societal and economical benefits discussed	Score 4 + societal and economical benefits demonstrated	Score 5 + influence on decision (including policy) making demonstrated
	QA4ECV	Automatically achieved	The QA4ECV products are most likely to be used as the input to scientific research, in particular climate modelling, therefore it is unlikely that this category is useful here.				

(1) FIDUCEO vocabulary available at: <http://www.fiduceo.eu/content/fiduceo-vocabulary>

Annex C: Printable Checking Procedure

Product:		Submitted By:		Date / Time Submitted:	
-----------------	--	----------------------	--	-------------------------------	--

Aspect	Achieved	Comments
Baseline Information		
ECV		
ECV product		
Product name		
Description		
Level		
Version number		
DOI (if available)		
Acquisition method information including instrument data		
Information on the availability of data		

Aspect	Achieved	Comments
Product Details		
Available Parameters		
Basic information provided, for example the parameter names.		
All parameters provided for the product, but not expanded by all temporal and spatial resolutions.		
All parameters provided with listings for all temporal and spatial resolutions.		
Documentation		
ATBD URL provided or uploaded.		
ATBD review: overview of the algorithm provided.		

Aspect	Achieved	Comments
PUM URL provided or uploaded.		
PUM review: lists available products and how to obtain them.		
ATBD review: detailed information on the algorithm provided, set out in sections.		
PUM review: information provided on how to use the product, including simple processing, obtaining flag information etc. Details of the validation provided.		
ATBD review: information on the quality and / or uncertainty analysis / data provision provided.		

Aspect	Achieved	Comments
PUM review: Provides case study information on how the data could be used including intended usage and intended audience. Real-life use cases should be included where possible.		
Data Availability		
Code repository / source code provided.		
Forum provided for data users.		
Evidence that forum is updated by data providers and queries answered.		
Product completeness and consistency		
Basic / general statements provided on the completeness of the product.		

Aspect	Achieved	Comments
Basic / general statements provided on the consistency of the product.		
More detailed information provided on the completeness and consistency of the product provided.		
Detailed information plus maps showing consistency and completeness provided.		
Traceability		
Diagrams		
High level diagrams provided with basic information on the algorithm.		
Detailed diagrams with relevant sub-chains provided.		

Aspect	Achieved	Comments
Information		
Basic information provided on some steps of the diagram		
Detailed information provided for steps of the diagram		
Detailed information provided for all but a few steps in the diagram including links back to documentation.		
Information provided on uncertainty analysis for relevant steps.		
Quality Flags		
Flagging Approach		
Simple flags provided with the product.		

Aspect	Achieved	Comments
Several flags provided in the product which provide information to allow the easy distinction between good / bad data.		
Comprehensive set of flags and ancillary data provided for the product which will allow the data users to understand the product in detail.		
Flag Details		
Basic information on flag provided, i.e. it is included in the product.		
Details of the format of the flag provided and the values are stated either in documentation on the website.		
Details on the derivation of the flag provided as well as recommendations for use.		

Aspect	Achieved	Comments
Validation		
LPV Validation Hierarchy		
Assessment against the LPV hierarchy.		
Provides basic justification for selection of LPV level.		
Provides a detailed justification for selection of LPV level		
Validation Report		
Validation report URL provided or uploaded.		
Validation report review: report includes some details of the method and results for each validation study.		

Aspect	Achieved	Comments
Validation report review: report includes detailed information on the validation and intercomparison of product including details of best practices followed.		
In-Situ Validation		
Some information provided on a small number of in-situ validation campaigns.		
Detailed information provided on some campaigns, including details of spatial coverage and measurements taken.		
Comprehensive information provided for each campaign, including sampling methods and other information.		
Inter-Comparison Validation		
Some information provided on a small number of inter-comparisons.		

Aspect	Achieved	Comments
Detailed information provided on some comparisons, including details of the spatial and temporal extent.		
Comprehensive information provided for each comparison including method descriptions.		
Uncertainties		
Uncertainties provided with the Product		
Details of the uncertainties provided with the product are available.		
Using the Uncertainty Analysis		
Details on using uncertainties provided.		
Details of uncertainty usage clear enough to allow immediate use of product.		

Aspect	Achieved	Comments
Basis of Uncertainty Analysis		
Details of uncertainty calculations in product provided.		
Contributors to uncertainty listed and description of calculation provided.		
Uncertainty significance estimated.		
Assessment against Standards		
Maturity Matrix		
Maturity Matrix filled in to some extent, above which would have been automatically filled in by the system		
Evidence that all boxes of the Maturity Matrix have been filled in.		

Aspect	Achieved	Comments
All matrix boxes filled in and common consensus agreed between product developer and auditor on the levels achieved.		
GCOS requirements		
GCOS requirement information filled in on a basic level (i.e. yes / no).		
Comments given for all GCOS requirements.		