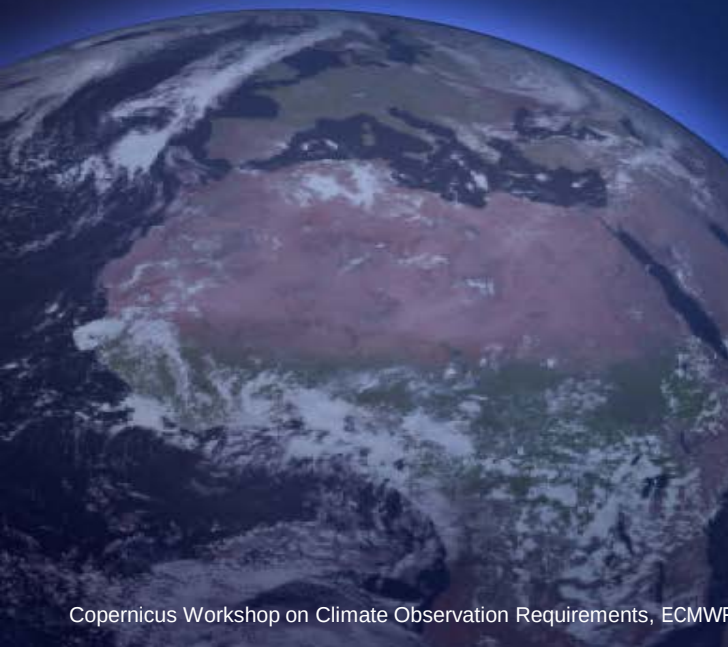
SYSTEM MATURITY ASSESSMENT



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And all participants of the FP-7 CORE-CLIMAX European Capacity Assessment for Climate Data Records

Overview

- Motivation for process quality control
- The Maturity Matrix Approach
- CORE-CLIMAX capacity assessment
- Fitness for Purpose – The Application Performance Metric Approach
- Relation to GCOS guidelines and monitoring principles
- Conclusion

User Perspective

I need good new data … and quickly. A new data product could be very good, but if it is not being conveniently served and described, it is not good for me…
So I am going to use whatever I have and know already.

User

10/21/2011 Leptoukh QA4EO'11

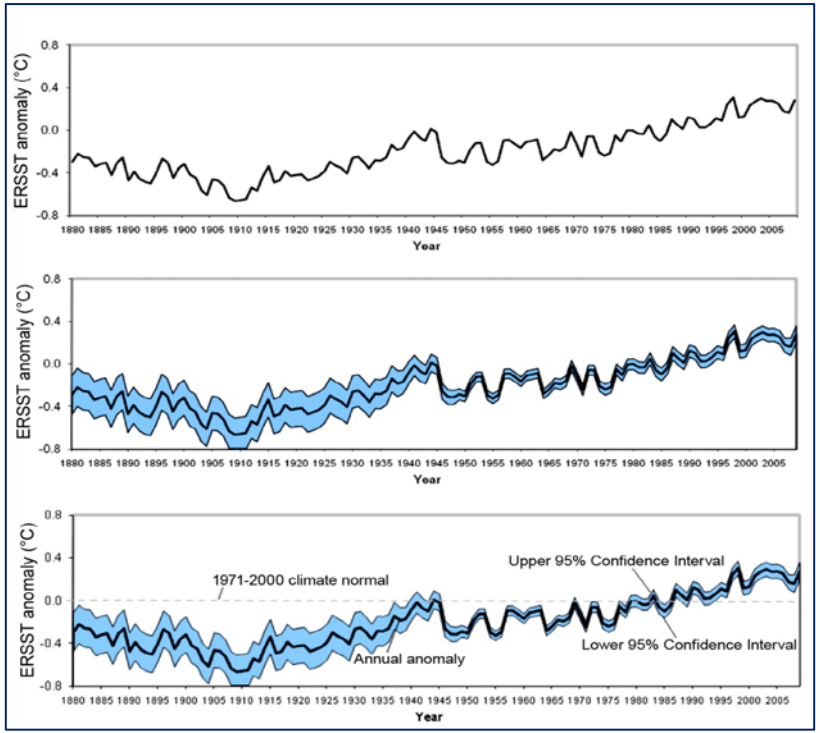
Adapted form Folkert Boersma, KNMI

Motivation for Process QC

- Increasingly complex observing systems and resulting data records require more process control to ensure quality, access, and preservation;
- Software Engineering is also increasingly complex and process management is required to optimise cost, schedule, productivity and quality;
- Users deserve very good documentation, openness and transparency;
- It is imperative that Climate Services respond with quantifiable metrics that inform about both the scientific quality and process maturity of CDRs.

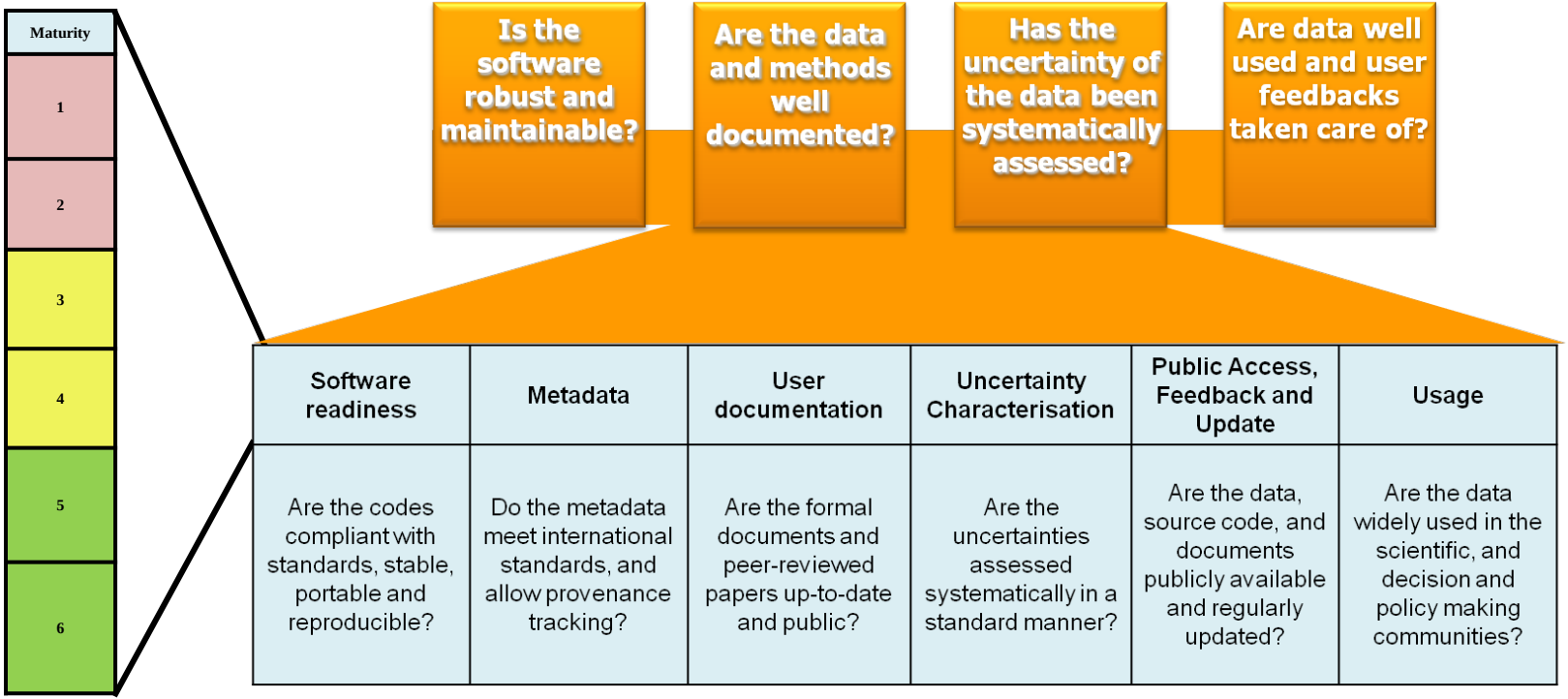
Climate Observation Best Practices

- Steps to long-term monitoring:
  - Over the last 20-30 years many investigators have developed methods for seaming together observations with evolving coverage and accuracies
  - From these experiences, common elements are emerging on best practices for Climate Data Records
- How do we capture and make available these best practices and ensure their application?
- How do we pass them to new generations?



Adapted from a slide from John Bates, NOAA NCEI, USA

Maturity Matrix Concept



Software readiness	Metadata	User documentation	Uncertainty Characterisation	Public Access, Feedback and Update	Usage
Are the codes compliant with standards, stable, portable and reproducible?	Do the metadata meet international standards, and allow provenance tracking?	Are the formal documents and peer-reviewed papers up-to-date and public?	Are the uncertainties assessed systematically in a standard manner?	Are the data, source code, and documents publicly available and regularly updated?	Are the data widely used in the scientific, and decision and policy making communities?

Sub-Matrix - Uncertainty

SOFTWARE READINESS	METADATA	USER DOCUMENTATION	**UNCERTAINTY CHARATERISATION**	PUBLIC ACCESS, FEEDBACK, UPDATE	USAGE

	Standards	Validation	Uncertainty quantification	Automated Quality Monitoring
1	None	None	None	None
2	Standard uncertainty nomenclature is identified or defined	Validation using external reference data done for limited locations and times	Limited information on uncertainty arising from systematic and random effects in the measurement	None
3	Score 2 + Standard uncertainty nomenclature is applied	Validation using external reference data done for global and temporal representative locations and times	Comprehensive information on uncertainty arising from systematic and random effects in the measurement	Methods for automated quality monitoring defined
4	Score 3 + Procedures to establish SI traceability are defined	Score 3 + (Inter)comparison against corresponding CDRs (other methods, models, etc)	Score 3 + quantitative estimates of uncertainty provided within the product characterising more or less uncertain data points	Score 3 + automated monitoring partially implemented
5	Score 4 + SI traceability partly established	Score 4 + data provider participated in one inter-national data assessment	Score 4 + temporal and spatial error covariance quantified	Score 3 + monitoring fully implemented (all production levels)
6	Score 5 + SI traceability established	Score 4 + data provider participated in multiple inter-national data assessment and incorporating feedbacks into the product development cycle	Score 5 + comprehensive validation of the quantitative uncertainty estimates and error covariance	Score 5 + automated monitoring in place with results fed back to other accessible information, e.g. meta data or documentation

Assessment of European Capacity for CDRs

- Provides consistent view on strengths and weaknesses of the process to generate, preserve and improve CDRs to each individual CDR producer, agencies and EC;
- Provides information to the user community on:
  - Status of individual records;
  - Collective state of assessed records;
- Provides this information for the first time across different observing and production systems (satellite, in situ and reanalysis);
- Increases transparency and openness towards the user;
- Potentially supports selection of CDRs for Copernicus Climate Change Service.

Assessment Facts

- Experienced great community support (EUM SAF, ESA CCI, Copernicus Services, National weather services, EU projects) leading to a successful assessment;
- Assessment methodology was applied to 40+ data records including satellite, in situ and re-analysis;
- Provided consistent description of all data records involved;
- Provided self assessment which was performed with high honesty;
- Review process of assessment report led to self-regulatory update of assigned maturity in some cases.

Name	SSU Level 1b radiances (FCDR)
Origin	NCDC/CLASS; Cheng-Zhi Zou cheng-zhi.zou@noaa.gov
Spatial Characteristics	Global
Temporal Characteristics	Dec 1978 – Jan 2006; Instantaneous

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					
1	2	3	4	5	6

Name	SSM/I FCDR
Origin	CM SAF; contact.cmsaf@dwd.de
Spatial Characteristics	Pixel resolutions varying with channels.
Temporal Characteristics	Jul 1987 – Dec 2008

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					
1	2	3	4	5	6

Name	ESA SST CCI Analysis long-term product V 1.0
Origin	ESA-CCI; c.j.merchant@reading.ac.uk
Spatial Characteristics	Global; 0.05° lat-lon grid resolution
Temporal Characteristics	~20 years; Daily

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					
1	2	3	4	5	6

Name	CM SAF CLARA A1 cloud properties
Origin	CM SAF; contact.cmsaf@dwd.de
Spatial Characteristics	Global, 0.25 x 0.25 grid
Temporal Characteristics	daily and monthly mean, 1982 – 2009

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					
1	2	3	4	5	6

Name	NKDZ station data, historical version v002
Origin	Deutscher Wetterdienst; datenservice@dwd.de
Spatial Characteristics	Stations covering Germany
Temporal Characteristics	1/1/1781 to 31/12/2013; hourly, daily, monthly, annual

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	
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Legend					
1	2	3	4	5	6

Name	ERA-Interim
Origin	ECMWF; Data.Services@ecmwf.int
Spatial Characteristics	Global, gridded
Temporal Characteristics	1979 – now; 6-hourly, with daily and monthly averages

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	
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Legend					
1	**2**	**3**	**4**	**5**	**6**

Major Results

- Results per data record clearly illustrate individual status and improvement potential;
- Assessment provides collective and detailed information across all GCOS ECV domains;
- FCDR: high variance in all scores, the more operational the higher scores are for software readiness, meta data, documentation and public access;
- Operational TCDR: high scores for Meta Data, User Documentation, Public Access and Usage, medium scores are sometimes observed for Software Readiness and Uncertainty Characterisation;
- Scientific TCDR: high scores for Uncertainty Characterisation, and Usage. Medium scores for User Documentation and lower scores for Software Readiness and Public Access - Getting consistently high scores for TCDR in all categories is a matter of environment and time;
- Maturity of *in situ* data largely depends on the selection of a set of stations or time period.

Impact on Community

- Copernicus related projects QA4ECV, GAIA-CLIM, and EUSTACE started utilising the maturity matrix approach;
- Past FP7 projects CHARMe and CORE-CLIMAX projects had the potential to insert the assessment results as commentary meta-data;
- WMO SCOPE-CM uses it to monitor development progress;
- The obs4mips activity discusses the Maturity Matrix as starting point for a Model Evaluation Readiness Level Matrix to evaluate suitability of CDRs for CMIP experiments;
- The Deutsche Klimarechenzentrum GmbH, Hamburg, Germany has started to define a similar maturity model for climate model data stewardship;
- CEOS-CGMS WG Climate has the potential to assess the ECV inventory content (220 data records) - CORE-CLIMAX assessment will be added for European data records.

Fitness for Purpose?
Motivation for Application Performance Metric (APM)

- System Maturity Matrix provides assessment of whether the data set can be sustainable in terms of engineering, scientific and usage aspects;
- There is no guarantee that a data set with high System Maturity is suitable for all applications!
- How do we assess the performance of a data set for a particular application?
- Can we develop a tool that supports the user directly by informing about available data and how good they fit to user requirements?

Support User's to Select Data

- User requirements collection exercises show a large variability in the stated requirements of users with nominally similar applications;
- But a core set of typical questions may always be isolated:

Coverage	Sampling	Uncertainty	Stability
Are the record length and spatial coverage meeting the application's requirements?	Do the spatial and temporal sampling meet the applications requirements?	Do the random and systematic uncertainties meet the requirements?	Do the temporal and spatial stability meet the requirements?

General Concept of APM

Application Specific User Requirements

Database of CDR
Technical Specification +
Uncertainty Summary Information

CDRs matching the URs best

Do We Address GCOS-143 Guidelines?

GCOS Guideline	Covered in
Full description of all steps taken in the generation of FCDRs and ECV products, including algorithms used, specific FCDRs used, and characteristics and outcomes of validation activities	Inventory and SMM on if its done
Application of appropriate calibration/validation activities	Inventory and SMM on if its done
Statement of expected accuracy (uncertainty), stability and resolution (time, space) of the product, including, where possible, a comparison with the GCOS requirements	Inventory or database for APM, SMM
Assessment of long-term stability and homogeneity of the product	SMM is informing if it has been done, APM is informing if sufficient quality has been reached
Information on the scientific review process related to FCDR/product construction (including algorithm selection), FCDR/product quality and applications7	Inventory and Product Quality in APM
Global coverage of FCDRs and products where possible	Inventory and APM
Version management of FCDRs and products, particularly in connection with improved algorithms and reprocessing	SMM
Arrangements for access to the FCDRs, products and all documentation	SMM
Timeliness of data release to the user community to enable monitoring activities	Inventory and SMM
Facility for user feedback	SMM
Application of a quantitative maturity index if possible	Self evident
Publication of a summary (a webpage or a peer-reviewed article) documenting point-by-point the extent to which this guideline has been followed	Information in the Inventory and provided by SMM is almost the summary

Link to GCOS Climate Monitoring Principles

Nr.	GCOS Principle	Covered In
1.	The impact of new systems or changes to existing systems should be assessed prior to implementation.	Different Process
2.	A suitable period of overlap for new and old observing systems is required.	Inventory (ECV and FCDR), Impact in APM
3.	The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.	SMM and Inventory
4.	The quality and homogeneity of data should be regularly assessed as a part of routine operations.	SMM, Impact in APM
5.	Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities	Different process
6.	Operation of historically-uninterrupted stations and observing systems should be maintained.	Impact in APM
7.	High priority for additional observations should be focused on data-poor regions, poorly-observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.	Impact in APM
8.	Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.	Impact in APM
9.	The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.	Impact in APM
10.	Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.	SMM

Link to Satellite Specific GCOS Principles

Nr	GCOS Principle	Covered In
11.	Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained.	Impact in APM
12.	A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations.	Impact in APM
13.	Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured.	Impact in APM
14.	Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured.	Impact in APM
15.	On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored.	Inventory (FCDR) has information, Impact in APM
16.	Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate.	Inventory, SMM and APM
17.	Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained.	SMM
18.	Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on de-commissioned satellites.	Inventory (FCDR)
19.	Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation.	Inventory
20.	Random errors and time-dependent biases in satellite observations and derived products should be identified.	SMM

Conclusion

- Evaluation and QC needs to consider both scientific and process quality;
- FP7 CORE-CLIMAX assessment provides consistent descriptions of Climate Data Records and assessment of completeness w.r.t. best practices;
- System Maturity estimates always need some interpretation, they must not be used for a beauty contest by adding up or averaging scores or doing ranking;
- Process maturity indicators can be added to data record inventories;
- Application Performance Metric approach looks promising but needs field test;
- It is suggested that Copernicus C3S considers the use of the developed assessment system in the context of its Evaluation and Quality Control.