Overview of CORECLIMAX results and expectations to the CM

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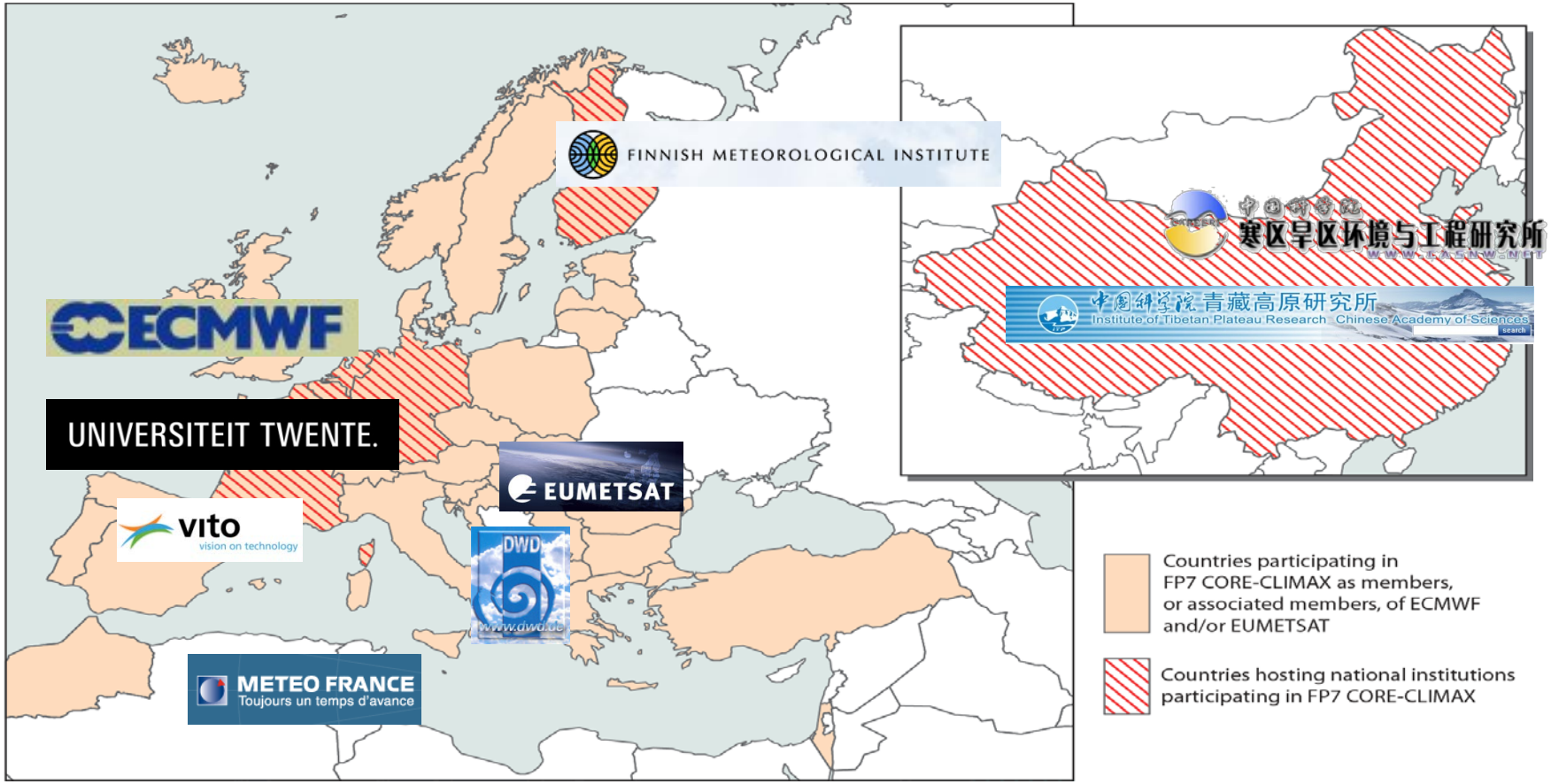
Outline

- What is CORE-CLIMAX?
- CORE-CLIMAX Results & examples:
  - WP2
  - WP3
  - WP4
  - WP5
- Expectations

CORE-CLIMAX

COordinating Earth observation data validation for RE-analysis for CLIMAte ServiceS



UNIVERSITY OF TWENTE.

PROJECT TEAM MEMBERS

ITC/UT: Bob Su, Wim Timmermans, Yijian Zeng, Joris Timmermans, Bert Boer

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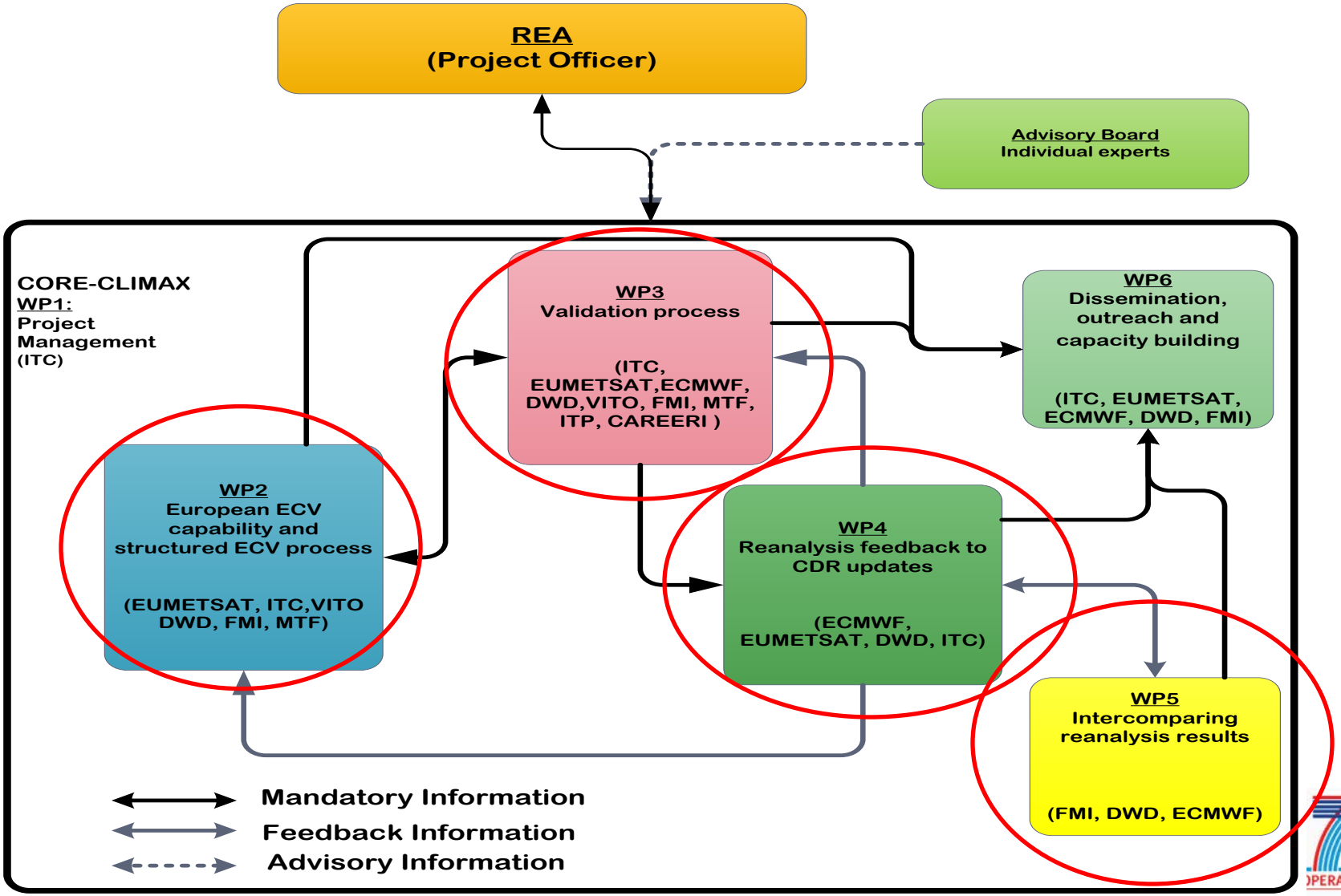
CAREERI: Jun Wen, Cai Ying, Gao Xiaoqing, Lu Shihua, Wei Zhigang, Hu Zeyong, Gao Yanhong

CORE-CLIMAX Objectives

1) Coordinate with **Earth Observation and climate change projects**;
2) Propose **a structured process for delivering ECVs** – *Essential Climate Variables*;
3) Propose **a validation process for qualifying the accuracy** of the climate variables;
4) Propose **a feedback mechanism ensuring that the results of the re-analysis process get appropriately reflected into updates of the CDR** - *Climate data Records*;
5) Propose **a process to compare re-analyses.**

CORE-CLIMAX work packages



WP2: European ECV capability and structured ECV process

D2.21 ✓	Template for ECV climate data record description	The most important facts relevant to ECV Climate Data
D2.22 ✓	Description of adapted maturity index	To provide instruction on how to use the CORE-CLIMAX SMM to assess the maturity of CDR
D2.23	Report containing the output of a self assessment of producers using the adapted maturity matrix	This is merged with De2.25
D2.24 ✓	Electronic Data Base containing the results of self assessment and independent assessment	Database containing data-sets and analysis output.
D2.25 ✓	Assessment of the European capability to derive GCOS ECV records based on the maturity analysis	To document the capacity assessment conducted on behalf of the CORE-CLIMAX consortium on the European ECV CDR development.
D2.26 ✓	White book on description of the structured process to derive ECV data records for GMES services	As the deliverable title, it is under preparation based on the existing CORE-CLIMAX project results.

✓ **Delivered**

✓ **Drafted**

✓ **Under Progress**

Tools Used by CORE-CLIMAX Project

- Three elements for a capability assessment:
  - **Data Record Inventories** that contain technical specifications and links to documented information on quality;
  - A **System Maturity Matrix (SMM)** that evaluates if the production of the ECV CDR follows best practices for science, engineering and utilisation;
  - An **Application Performance Metric (APM)** that evaluates the performance of an ECV CDR with respect to a specific application.
- In addition User Requirements for each application, Technical Specifications and validation and/or data quality assessment results for each record are needed to 'measure' the performance.

The CORE-CLIMAX System Maturity Matrix

Maturity	SOFTWARE READINESS	METADATA	USER DOCUMENTATION	UNCERTAINTY CHARACTERISATION	PUBLIC ACCESS, FEEDBACK, UPDATE	UTILITY
1	Conceptual development	Little or none	Draft description on the theoretical basis of the methodology. Peer reviewed paper on methodology in preparation	Little or None	Restricted availability from PI	Little or none
2	Research grade code	Research grade	Description on the theoretical basis of the methodology. Peer reviewed paper on methodology published; draft validation report and user guide	Standards defined, limited information on uncertainty and quality, preliminary validation	Data avaliable from PI, feedback through scientific exchange, irregular updates by PI	Science application demontstrated by publication
3	Research code following producers standards with some portability, reproducibility	Research grade. Meets international standards for metadata, file naming conventions and file format for the dataset	Public description on the theoretical basis of the methodology. Peer reviewed paper on methodology published. Peer reviewed Paper on the product in preparation; reviewed validation report and user guide	Standards partially applied, information on uncertainty and quality identified, validation for selected locations	Data, source code, and user documentation archived and publically available, feedback through scientifc exchange, irregular updates by PI	Product is used by scientific community. Potential benefits for climate services identified
4	Code with systematically applied standards, portability and reproducability tested	Exists at file and collection level. Stable. Allows provenance tracking and reproducibility of dataset; Meets international standards for the dataset	Public description on the theoretical basis of the methodology; Draft description on the operational concept of the methodology; Peer review papers on methodology and product published; public validation report and user guide	Standards systematically applied, information on uncertainty and quality quantified and documented, validation for widely distributed locations and times; representativity and redundancy of information characterised	Data, source code and documentation archived and under version control and publically available; Operational quality monitoring under development; Known issues are public; Data provider establishes feedback mechanism; regular updates by PI	Used by scientific community. Started to use in climate service.Societal and economical benefits discussed
5	Operational code following standards with known quality, documented, portable and reproducible	Complete at file and collection level. Stable. Allows provenance tracking and reproducibility of dataset. Meets international standards for dataset	All formal documents public and maintained by data provider; Several peer reviewed papers on methodology and product published.	Standards systematically applied, errors quantified, participation in an international assessment; representativity and redundancy of information optimised	Data, source code and documentation archived and under version control and publically available. Operational quality monitoring established; Known issues are public; Feedback mechanism and international data quality assessment are considered in periodical data record updates	Widely used by scientific community. Societal and economic benefits are demonstrated.
6	Operational code fully compliant with standards; Stable and reproducible; portable and operationally efficient	Updated and complete at file and collection level. Stable. Allows provenance tracking and reproducibility of dataset. Meets current international standards for dataset	All formal documents public and maintained by data provider; Multiple peer reviewed papers on methodology and product published.	Standards systematically applied, errors minimized, participation in multiple international assessments; representativity and redundancy of information optimised	As Level 5; capability for fast improvements in continuous data provisions established	Widely used by multiple scientific communities. Influencing decision and policy making.

1 & 2
3 & 4
5 & 6

Research Capability (RC)
Initial Operations Capability (IOC)
Full Operations Capability (FOC)

CORE-CLIMAX V2.0 (12/05/2013)

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(J. Schulz)

COOPERATION

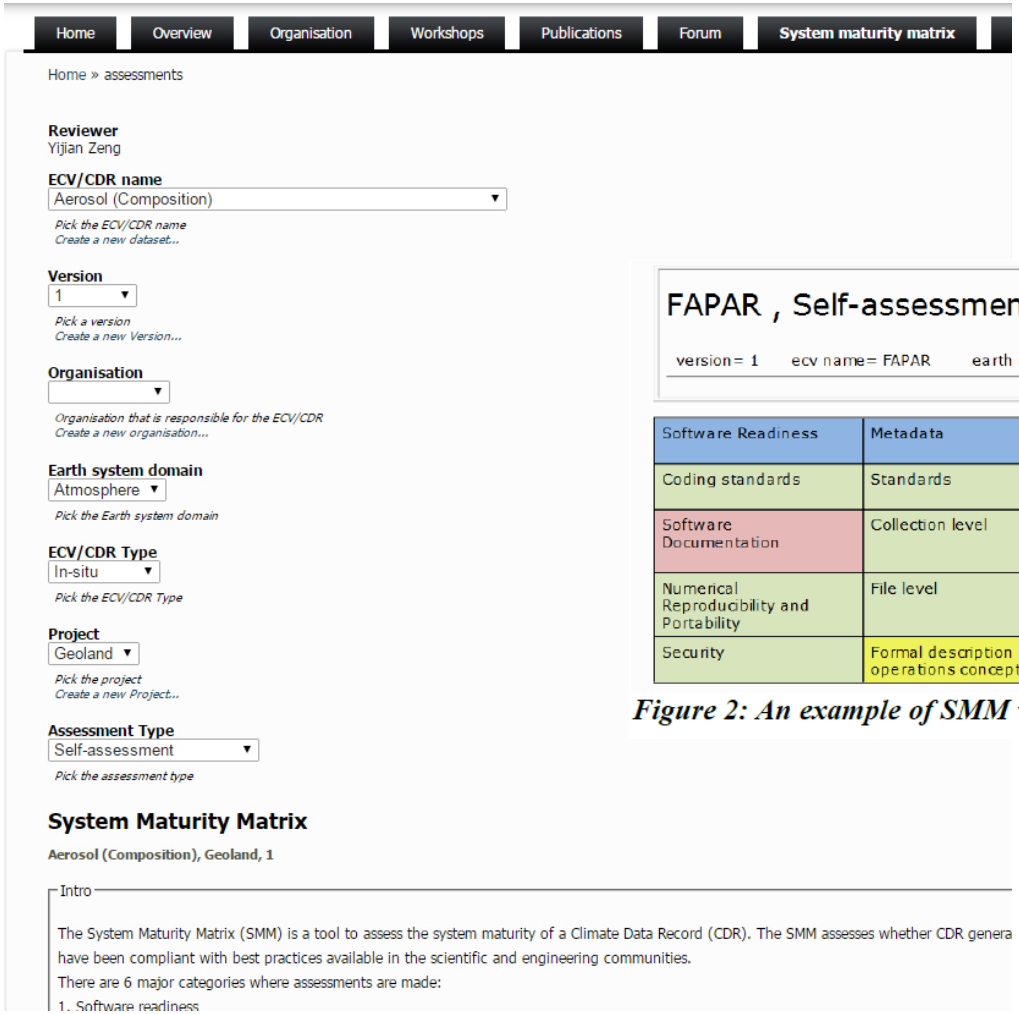
The CORE-CLIMAX Application Performance Metric

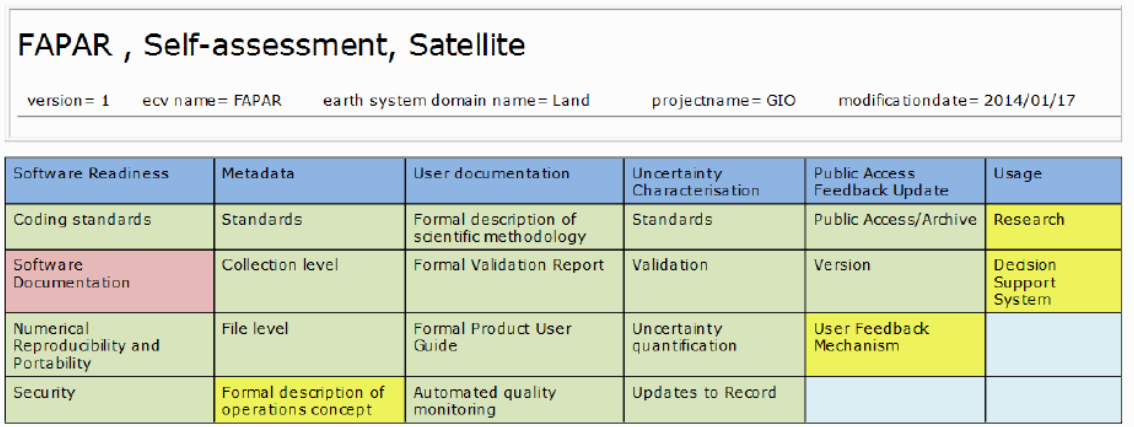
Performance Level	Length of Record	Spatial Coverage	Temporal Sampling	Spatial Sampling	Systematic Uncertainty (Bias)	Random Uncertainty (Precision)	Temporal Stability (Degree of Homogeneity)
1	very short	Too sparse/very limited coverage	Very infrequent with respect to user requirement	Very limited, only few locations	Large and not very well quantified	Much larger than UR and not very well quantified	Inhomogeneous
2	short	Sparse/limited coverage	Infrequent compared to user requirement	Limited, more locations but badly distributed	Large, but known	Larger tan UR, but known	Inhomogeneous
3	Not short, but not sufficient; may be used with care for some ECVs	Sparse	Frequent compared to user requirement, but not sufficient	Minimal, maybe suffucient to sample spatial representativeness in some areas	Above threshold UR, moderate and quantifiable	Above threshold UR, moderate and quantifiable	Homogenized, but there are still break-points
4	Close to be sufficient but use with care	Just sufficient	Close to user requirement, but parts of temporal variability not observed, e.g. day or night only;	Just suffiient to sample the spatial representativeness in certain areas	Close to UR, moderate and quantifiable	Close to UR, moderate and quantifiable	Homogenized, but there are still break-points
5	Sufficient, use with confidence	Sufficient	Matching user requirment e.g., but diurnal cycle is not fully sampled;	Just enough to sample the spatial representativeness	Matching UR	Matching UR	Sufficiently homogeneous
6	More than sufficient	More than sufficient	Much higher than user requirement, e.g., Diurnal cycle is fully sampled; no diurnal cycle aliasing	Enough and more to capture the spatial representativeness	Better than UR	Better than UR	Homogeneous

1 & 2	shall not be used
3 & 4	usable with care
5 & 6	perfectly suited for application

(J. Schulz)

SMM Web-Tool





Software Readiness	Metadata	User documentation	Uncertainty Characterisation	Public Access Feedback 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		

Figure 2: An example of SMM web tool generated overview of a dataset

Assessment Report

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

Category	Software Readiness	Metadata	User Documentation	Uncertainty Characterisation	Public Access, Feedback, Update	Usage
Range	1	2-3	2-3	2-3	3-4	3-4

Name	ESA Aerosol_cci datasets
Origin	ESA Aerosol_cci; thomas.holzer-popp@dlr.de
Spatial Characteristics	Global, different resolution (0.1 to 10 degrees)
Temporal Characteristics	~weekly-monthly sampling (between 1995 and 2012)

Category	Software Readiness	Metadata	User Documentation	Uncertainty Characterisation	Public Access, Feedback, Update	Usage
Range	1-3	4-5	3-4	2-4	3-5	1-2

CORE-CLIMAX European ECV CDR capacity assessment report

Doc.No. : CC/EUM/REP/14/004
Issue : v1A Draft
Date : 23 December 2014
WBSDBS:

EUMETSAT
Eumetsat-Allee 1, D-64295 Darmstadt, Germany
Tel: +49 6151 807-7

WP3: Validation process

✓ **Delivered**

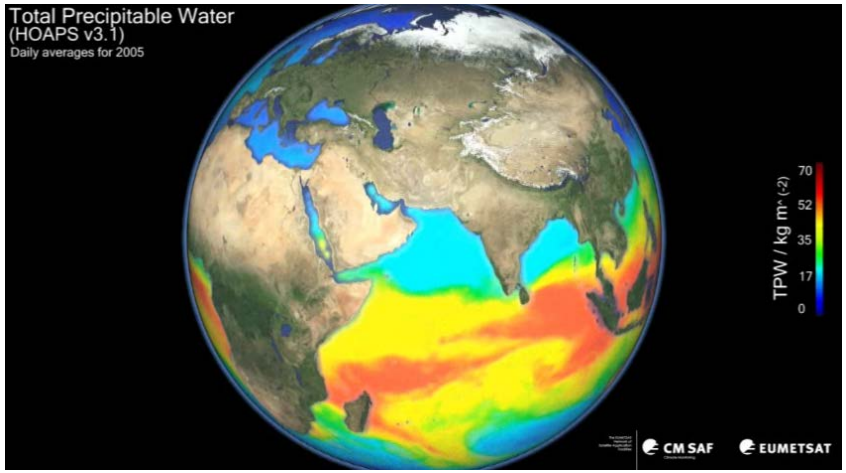
✓ **Drafted**

✓ **Under Progress**

D3.31 ✓	Protocol for verifying, monitoring, calibrating and validating FCDRs and TCDRs of the CDRs/ECVs	A harmonized approach for each ECV/CDR/FCDR, based on SMM.
D3.32 ✓	Generic list for validation strategy for CRDs/ECVs	Analysis of ECV/CDR validation network and strategy
D3.33 ✓	Assessment report on consistency of the CDRs/ECVs	Analysis of ECV/CDR consistency validation

Why validate ? – consistency of ECVs

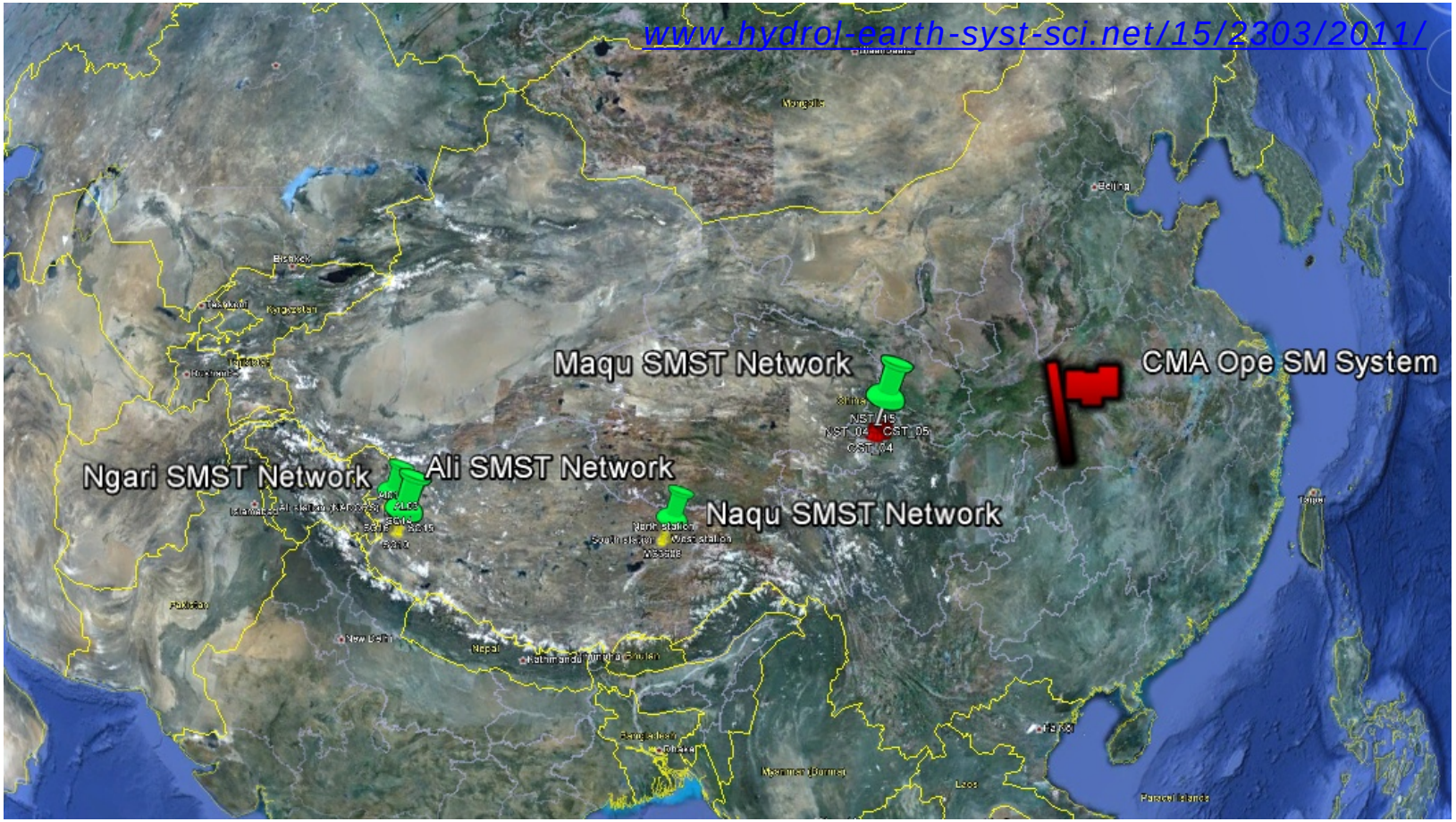
(A. Cross-validation of multiple independent datasets)



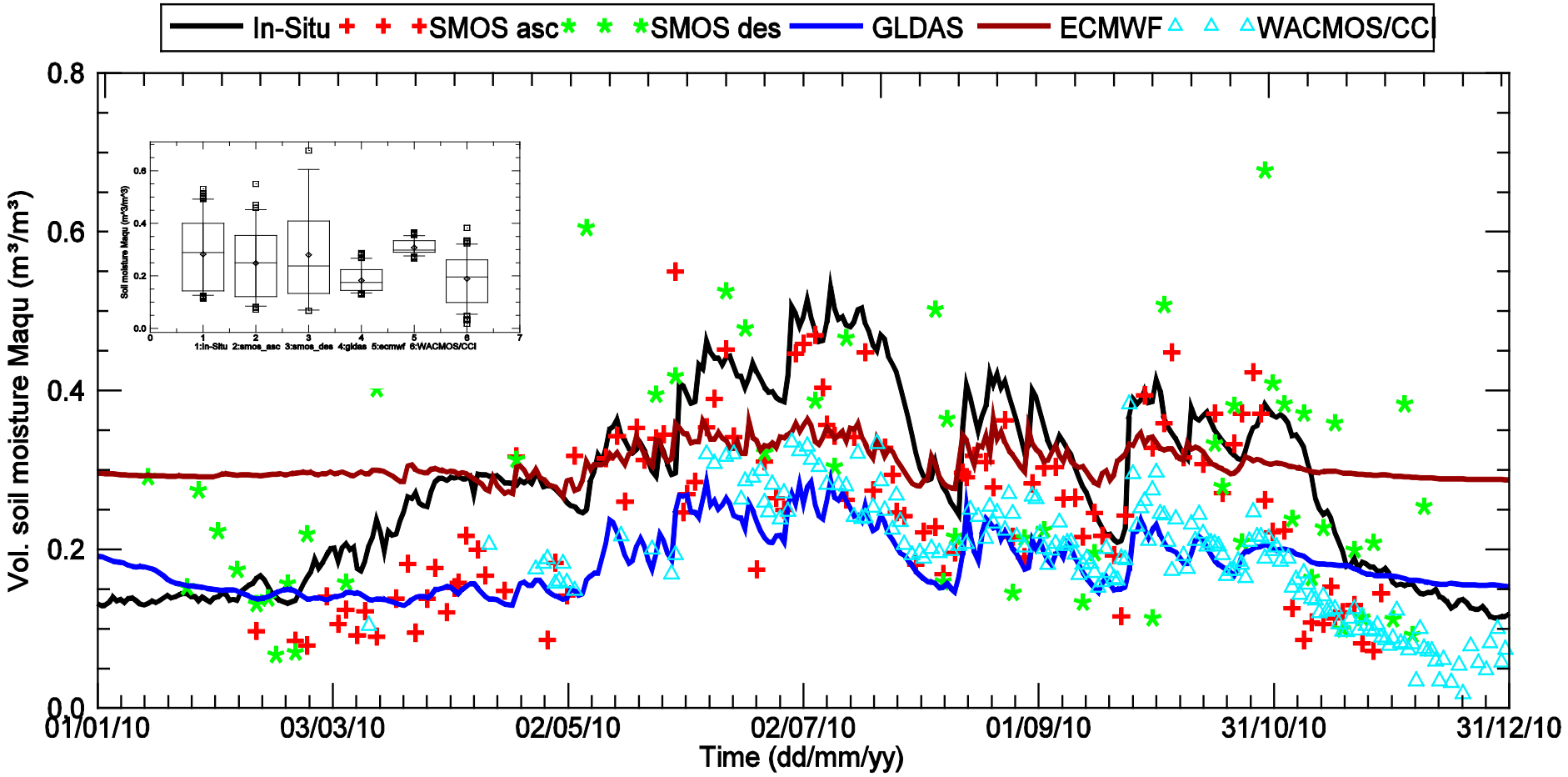
Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs)

Su et al. 2011, Hydrol. Earth Syst. Sci.,

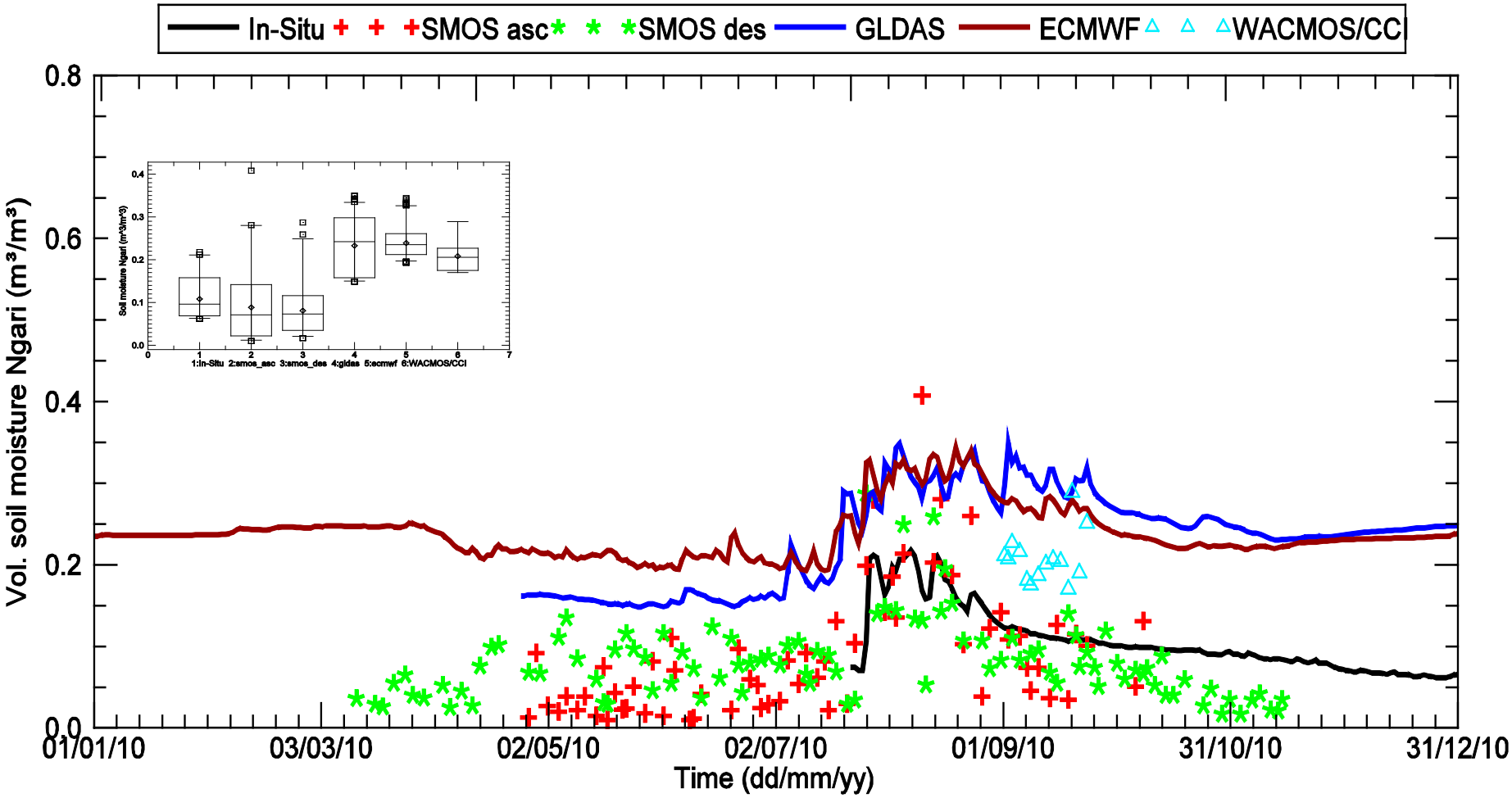
www.hydrol-earth-syst-sci.net/15/2303/2011/



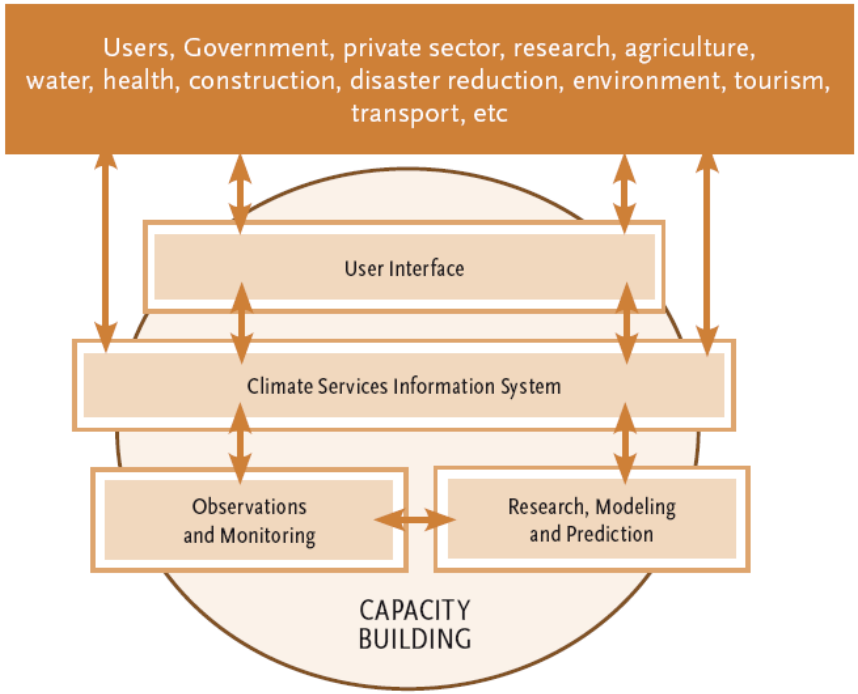
Maqu SMST Network – validation results



Ngari SMST Network – validation results



Global Framework of Climate Services



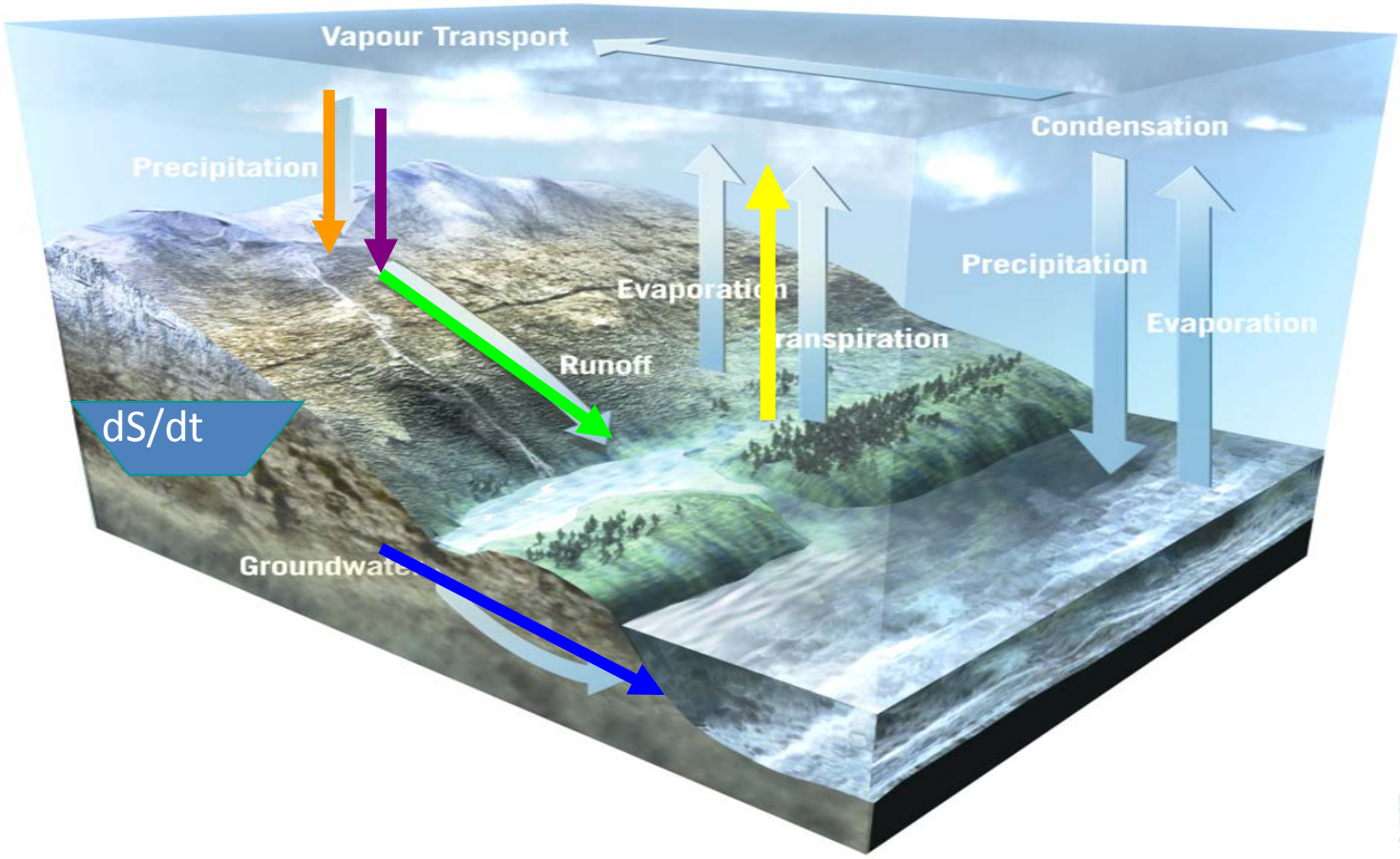
Our response

FP 7 CORE-CLIMAX:
COordinating Earth observation data validation for RE-analysis for CLIMAte ServiceS

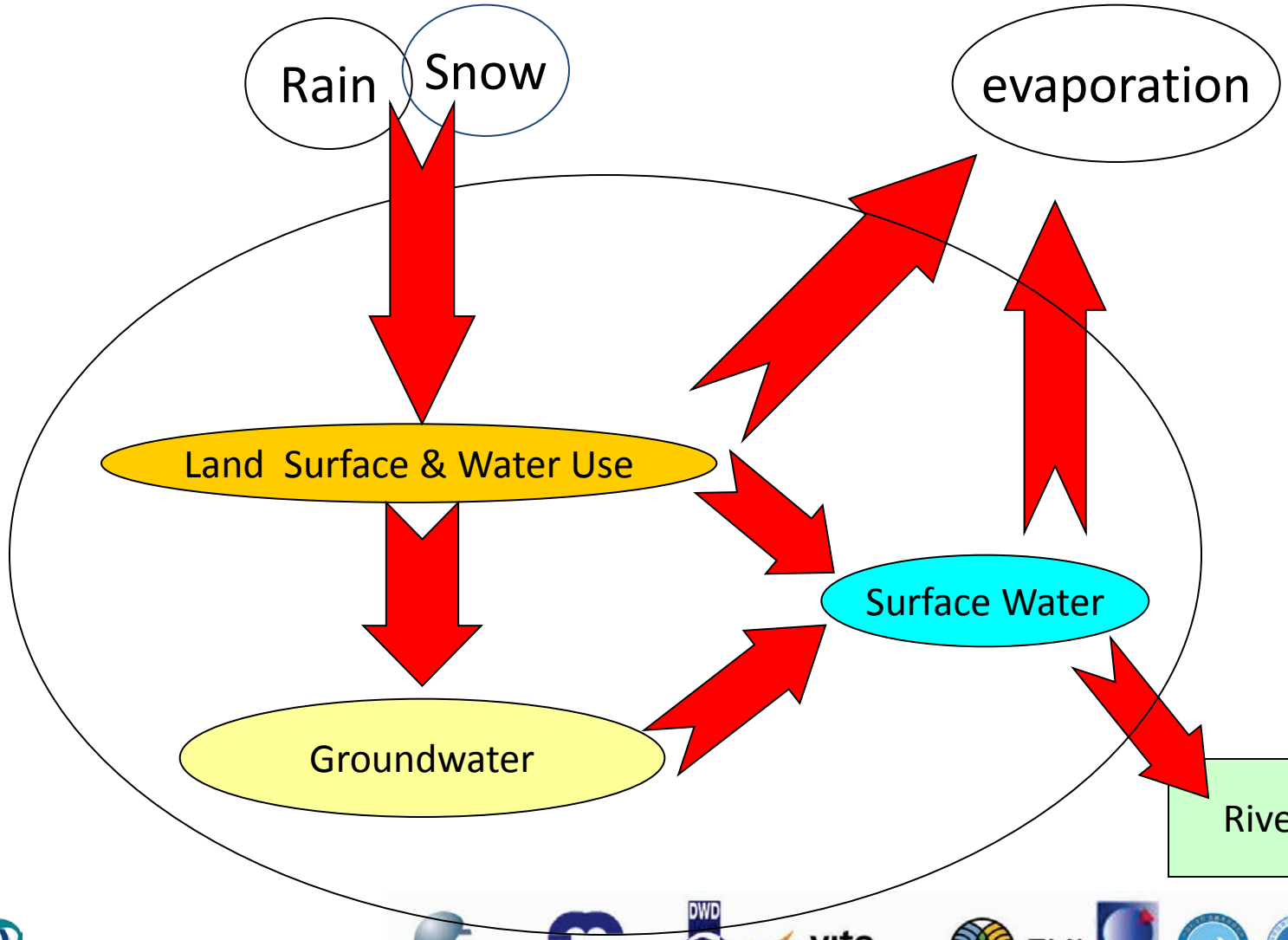
A schematic illustration of the pillars of the Framework, with the indication that the Capacity Development component encompasses the other components. Arrows depict flows of information and feedback.

B. Cross-validation among different physically interrelated variables

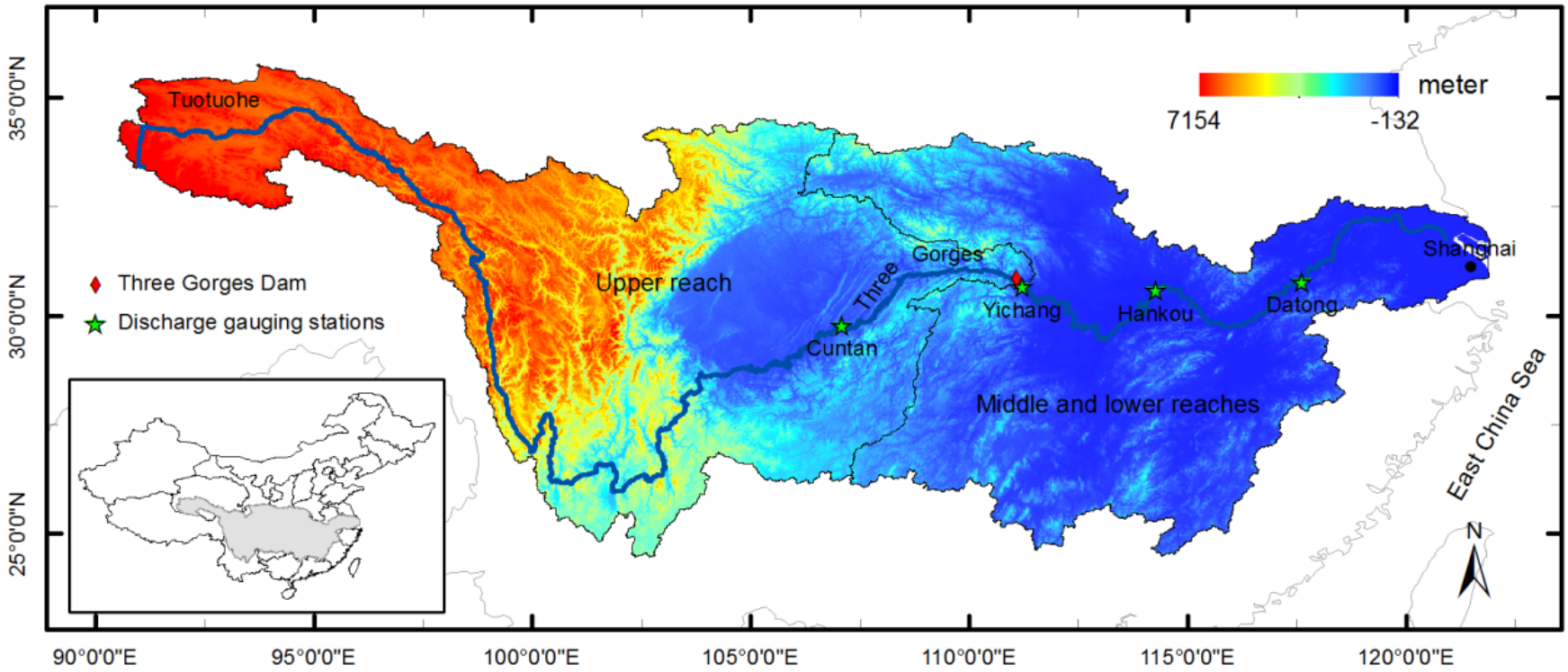
Spatial Water budget of the Yangtze River Basin



Changes in Water Budget



Yangtze River Basin



- Upper Yangtze reach, from Tuotuohe, to Yichang.
- Middle reach from Yichang to Hukou.
- Lower reach extends from Hukou to the river mouth near Shanghai.
- Cuntan, Yichang, Hankou, and Datong are four gauging stations located along the mainstream of the Yangtze.

Core Climax

European Commission

Copernicus The European Earth Observation Programme

Ex 3: Closure of Water Cycle over a river basin

Total water Storage(TWS)

$$\frac{\partial S}{\partial t} = P_{GPCP} - E_{SEBS} - R_{Obs} * f(P_{i,j}, E_{i,j})$$

For this study we used the following datasets.

GPCP: Global Precipitation Climatology Project (P),
SEBS: SEBS derived land evaporation (E),
In-situ: River discharges (R),

→ In-situ & satellite Observations

REA-Interim: ECMWF reanalysis (P, E, R),

→ Reanalysis

Storage change: The Gravity Recovery and Climate Experiment (GRACE) observations (dS/dt).

→ Satellite Observations

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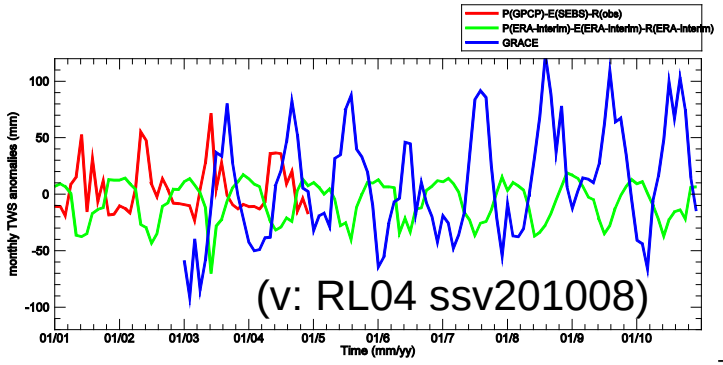
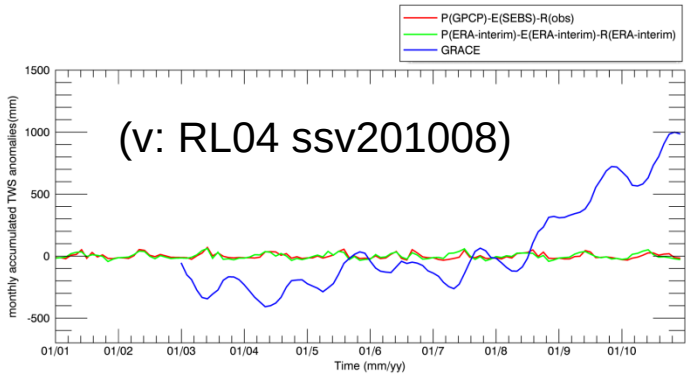
Upper reach TWS anomaly



Cumulative TWS anomaly at Upper Reach (Yichang station)



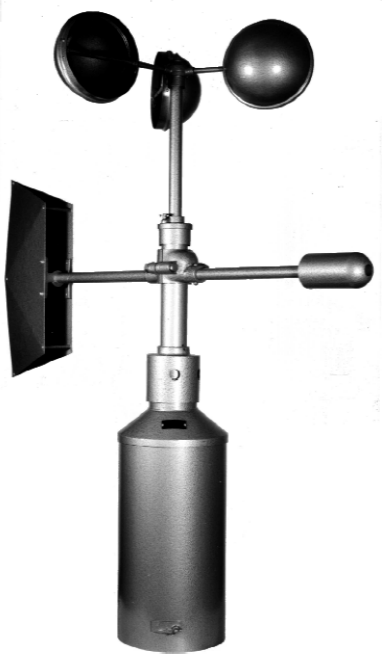
P(GPCP)-E(SEBS)-R(obs)
P(ERA-interim)-E(ERA-interim)-R(ERA-interim)
GRACE

monthly accumulated TWS anomalies(mm)

Time (mm/yy)

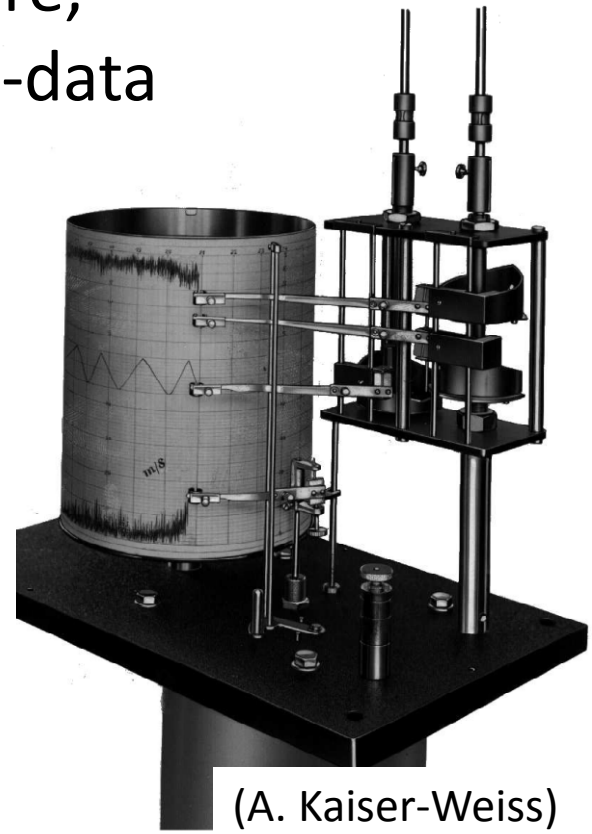
GRACE data
(V: RL05.DSTvSCS1401)

Or shall we just use in-situ data?



+ collected over many decades (also beyond 1900)
+ measured with great care, documented with meta-data

- Diverse collections (national)
- Changes in: measurement practice, instrumentation, station location, total number of stations, ownership, archives and storage systems, and quality control



(A. Kaiser-Weiss)

WP4: Reanalysis feedback mechanism to CDR updates

✓ **Delivered**

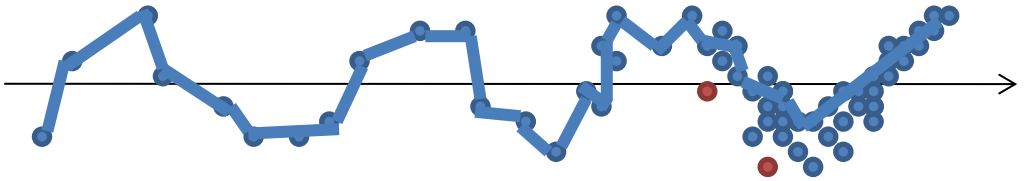
✓ **Drafted**

✓ **Under Progress**

D4.41 ✓	Procedure for feeding back improved ancillary data to assist CDR updates	A range of measures was proposed to improve the CDR generation with ancillary data from reanalysis products, by using improved and consistent data from reanalysis products.
D4.42 ✓	Design of support infrastructure for CDR quality assessment in a reanalysis environment	The main elements assisting CDR providers in making appropriate preparations for receiving maximum benefit from the feedback that the reanalysis environment can provide.
D4.43 ✓	Procedure for feeding back reanalysis results and plans on CDR updates	How reanalysis teams can best communicate and exchange their needs for CDR updates

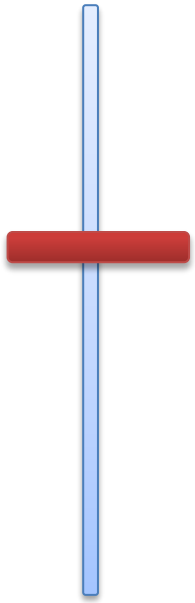
Reanalysis Objective: Reconstruct the past

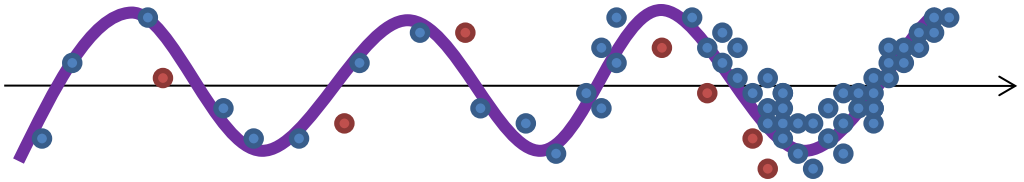
"Observations-only" climatology



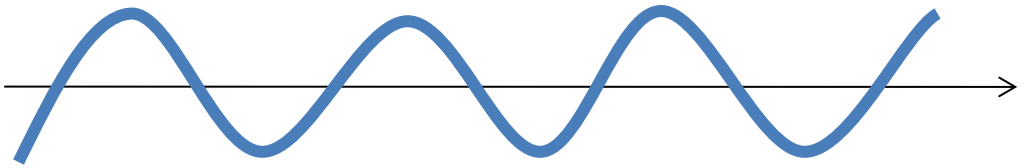
Gross exaggeration towards discontinuity

Reanalysis





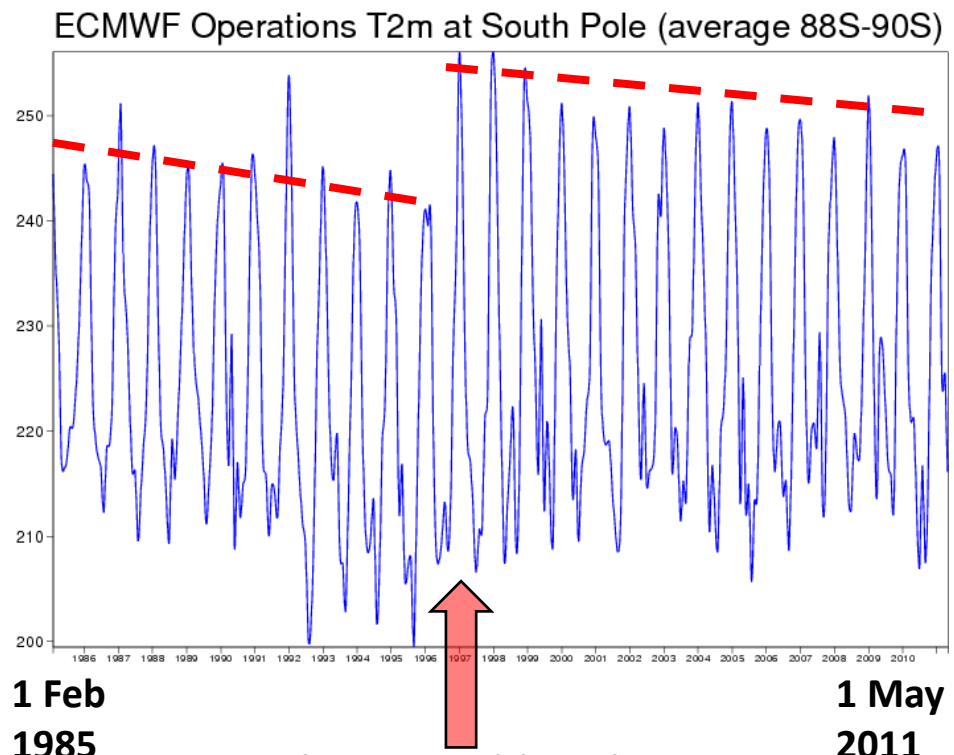
"Model only" integration



Gross exaggeration towards continuity

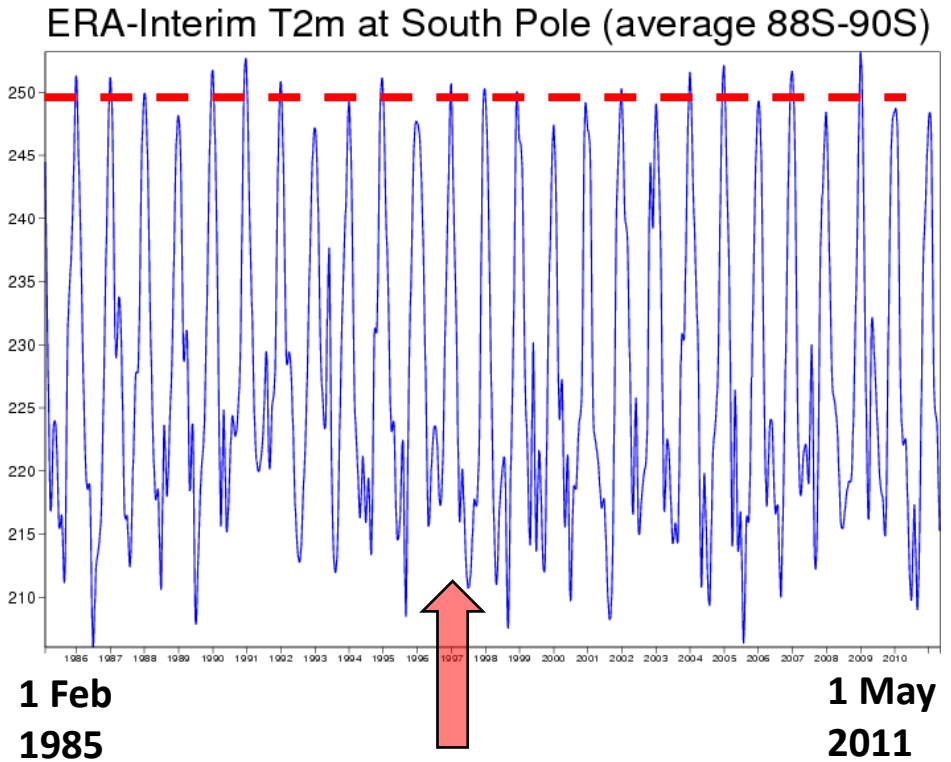
Why re-analyze?

Overall aim is a greater time-consistency of the products AND improved understanding of past events (including extremes) by using state-of-the-art models and tools



1 Feb 1985 — **1 May 2011**

Was there a sudden change in South Pole summer variability in 1997?



1 Feb 1985 — **1 May 2011**

… probably not

(P. Poli)

Procedure for feeding back improved ancillary data to assist CDR updates

Current practice	Considera-tions	Comments	Issues identified
Some CDR products do not specify which information from which reanalysis was used as ancillary input	Scientific/ Technical	Blame lies partly on the reanalysis producers themselves, for they do not properly identify/tag their products in the metadata	• Need for Algorithm Descriptions and Input Data Specifications • Traceability of reanalysis data being used as ancillary input to CDR generation
CDR generators develop their own handling tools of ancillary data	Scientific/ Technical	Sometimes leads to duplication of effort and sometimes to inconsistency with other CDRs	• Data formats • Need to develop/adopt common toolboxes. Some functionalities exist, e.g. the CDO package, but more are required, and on a sustained basis
Ad-hoc arrangements to access reanalysis data for use as ancillary input to CDR generation	Technical	Ad-hoc arrangements are flexible, but are time-consuming at best and can be showstoppers at worst.	Access to reanalysis data for use as ancillary input to CDR generation
Use of reanalysis data as ancillary input could be better-informed	Scientific	Difficult for CDR generators to take into account the strengths and weaknesses of a particular reanalysis.	Informed use of reanalysis data as ancillary input
Production schedules are not coordinated	Program-matic	Not a problem as long as each process can be iterated, and there is always a "next opportunity" to take onboard or generate a CDR	Better visibility of reanalysis and CDR production schedules would help one another to align their proposals with each other's application (feeding CDR into reanalysis and vice-versa, feeding reanalysis ancillary data into CDR)

Table 2: Summary of the current practices and issues in feeding ancillary data to CDR generation

Issue	Category	Proposed Mechanism	Actions for	Comments
Traceability of reanalysis data being used as ancillary input to CDR generation	Technical	Reanalysis datasets to have DOIs	Reanalysis producers	Urgent need to define in a coordinated way the granularity of the DOI (e.g., per geophysical variable, or per reanalysis)
Data formats	Technical	Provide data in a variety of well-established formats Provide format conversion tools	Reanalysis producers, CDR Generators and/or User Community	
Access to reanalysis data for use as ancillary input to CDR generation	Technical	Further development of "public access", retain bi-lateral exchange where appropriate	Reanalysis producers in consultation with CDR Generators and User Community	
Informed use of reanalysis data as ancillary input	Scientific	Dialogue between reanalysis producers, "scientific" users, and climate service providers.	Reanalysis producers, scientific users, climate service providers	Dialogue to be supported by Quality Assessments.
Coordination of production schedules	Programmatic	Effective communication channels between stakeholders	Reanalysis providers in consultation with CDR Generators and User Community	Stakeholder representatives (CEOS, WCRP, ?)

Table 3: Solutions proposed to improve CDR generation through consistent and well-identified ancillary reanalysis data

Design of support infrastructure for CDR quality assessment in a reanalysis environment

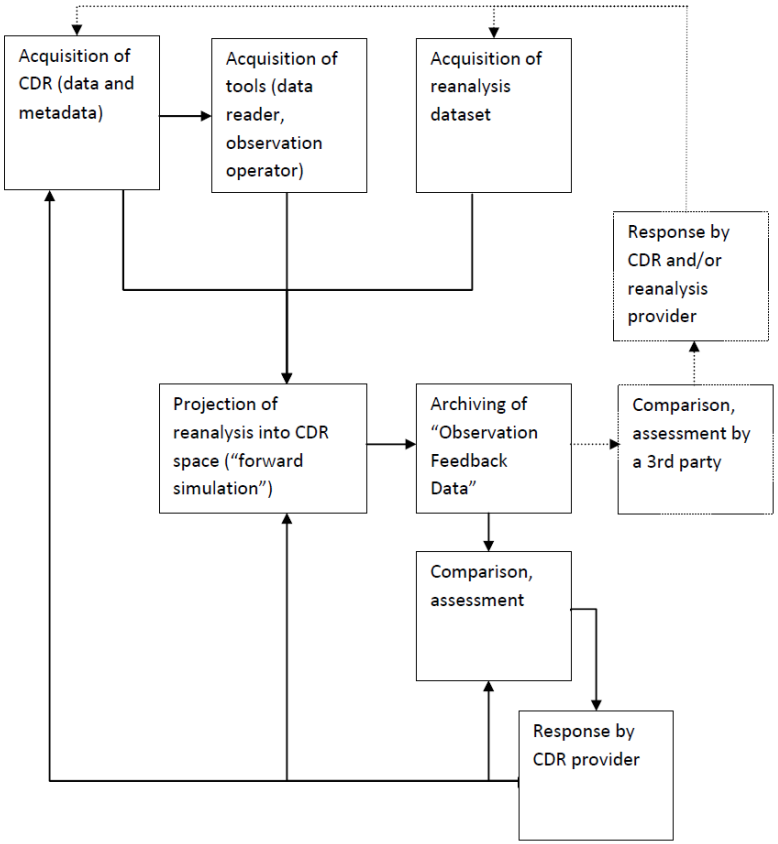


Figure 2: Process for comparing a CDR with a pre-existing reanalysis ("pre-assimilation, off-line assessment"). Projection ("forward simulation") typically involves a collocation step.

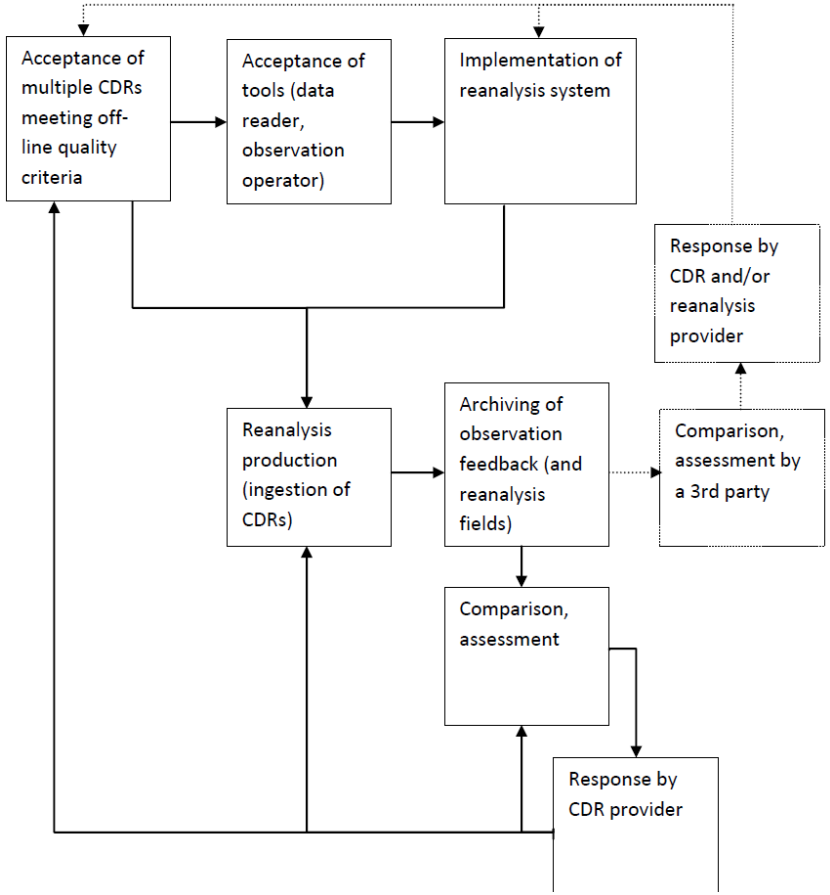


Figure 3: Procedure for CDR assessment via full assimilation in a reanalysis production (on-line assessment)

Procedure for feeding back reanalysis results and plans on CDR updates

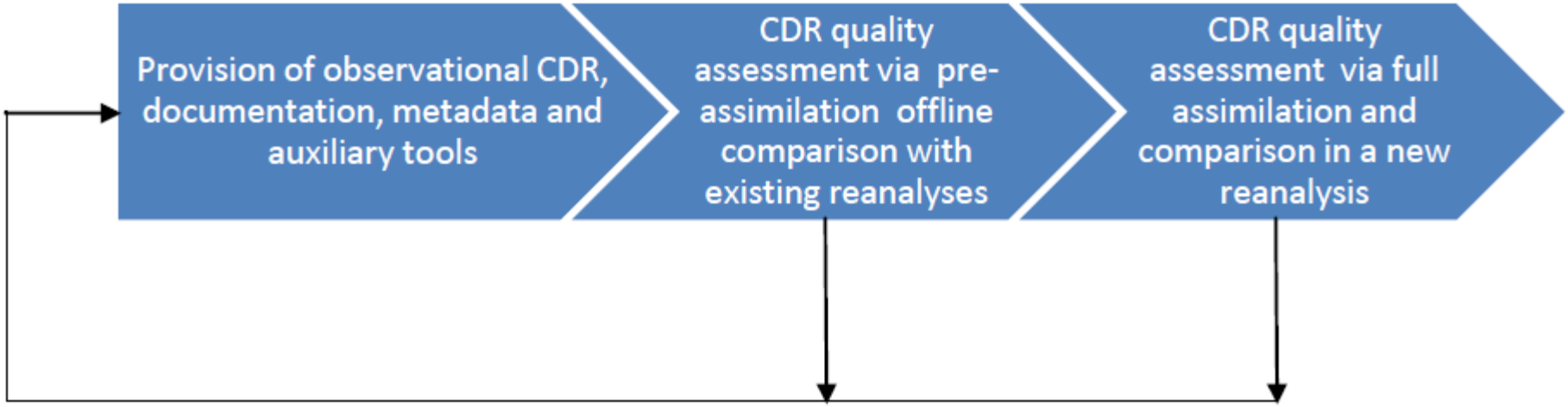
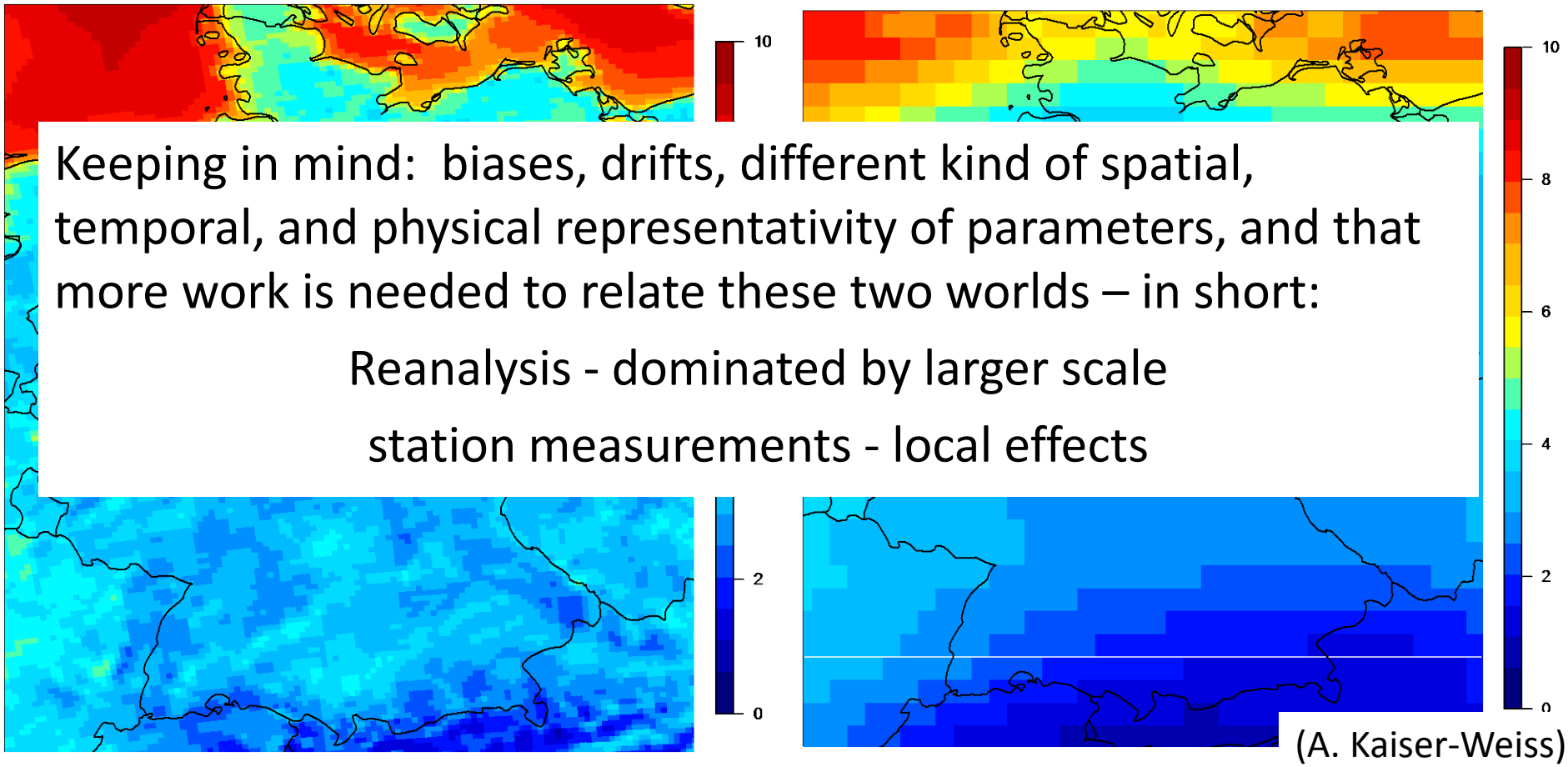


Figure 2: Progress of an observational CDR to quality assessment via full assimilation in a new reanalysis. Progress is contingent upon satisfactory assessment in pre-assimilation/offline comparisons. The arrowed lines represent the feedback loop for stimulating improved CDRs and/or supplementary materials (documentation, metadata, auxiliary tools etc). Adapted from Core-Climax Document D4.42 "Design of Support Infrastructure for CDR Quality Assessment in a Reanalysis Environment".

Regional and global reanalysis gives us a standard for comparing a multitude of in-situ data



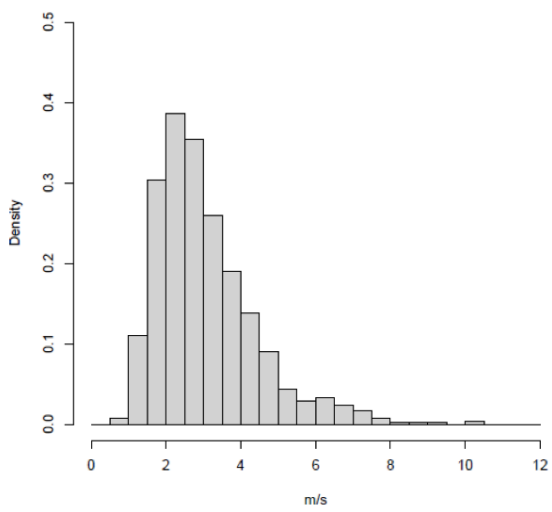
Keeping in mind: biases, drifts, different kind of spatial, temporal, and physical representativity of parameters, and that more work is needed to relate these two worlds – in short:

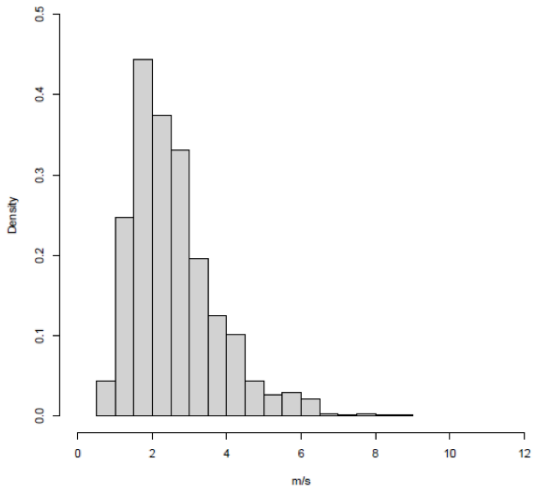
Reanalysis - dominated by larger scale

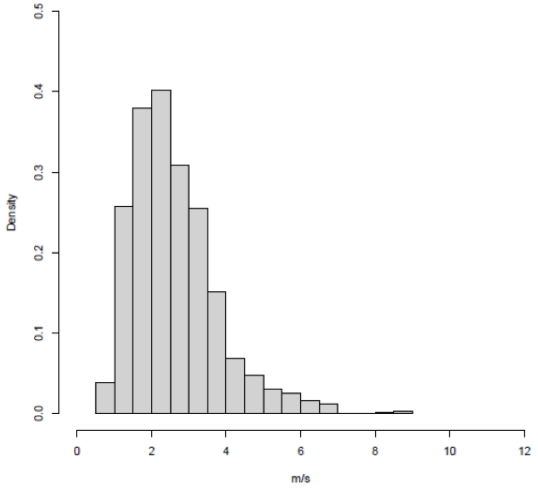
station measurements - local effects

(A. Kaiser-Weiss)

Frequency distributions of “good stations” match reasonably well with the reanalyses





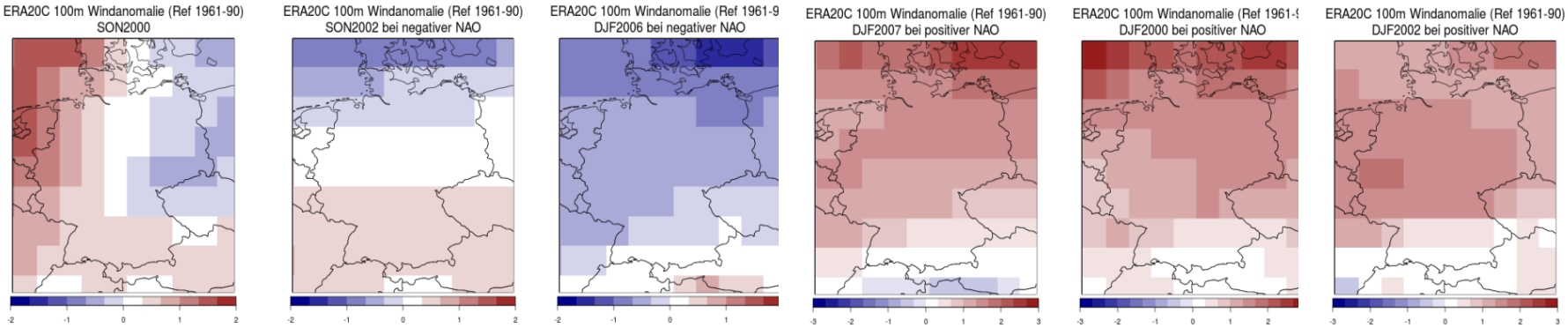


Daily mean wind speed between 2007 and 2009 at the Nuremberg station

Can you guess which is from the station data, which from regional reanalysis, which from global reanalysis?

(A. Kaiser-Weiss)

Reanalysis for inter-annual variability



Inter-annual variability of anomaly in seasonal mean wind speed from ERA-20C

Example application: Some stations in the early eighties had suspiciously many calms in the 10m station winds. ERA-20C data did not confirm this change in frequency distribution. Conclusion: In earlier years, at some “bad stations”, there might not always have been properly distinguished between instrument failure and calm.

(A. Kaiser-Weiss)

Summary of feedback to CDR generation and comparison of reanalyses

* Reanalysis can serve as a historical data quality control tool (among other ways of searching for problems in historical data).
* Though 10m winds is surely not the best parameter to use from reanalysis, in our case (DWD station data) it was good enough to spot a bug, and to motivate search for more metadata.

(A. Kaiser-Weiss)

WP5: Intercomparing reanalysis results

✓ Delivered

✓ Drafted

✓ Under Progress

D5.51 ✓	Webportal enquiry on uncertainties in the reanalyses and the effects of these to climate services	An on-line survey was implemented with >2500 respondents.
D5.52 ✓	Analysis and summary of webportal survey	The analysis focused on the awareness, skills and requirements of the respondents regarding utility and uncertainties in reanalyses, and the implications for delivering future climate services.
D5.53 ✓	Procedure for comparing reanalyses to asimilated observations and CDRs	It presents a set of procedures for comparing reanalyses, and comparing reanalyses to assimilated observations and CDRs.
D5.54 ✓	Uncertainties and gaps in the different reanalyses and the effects of these to climate services	Synthesis of what has been done in WP 5, and identify the uncertainties and gaps in reanalysis systems that need to be addressed in order to deliver better climate services.

Analysis and summary of webportal survey

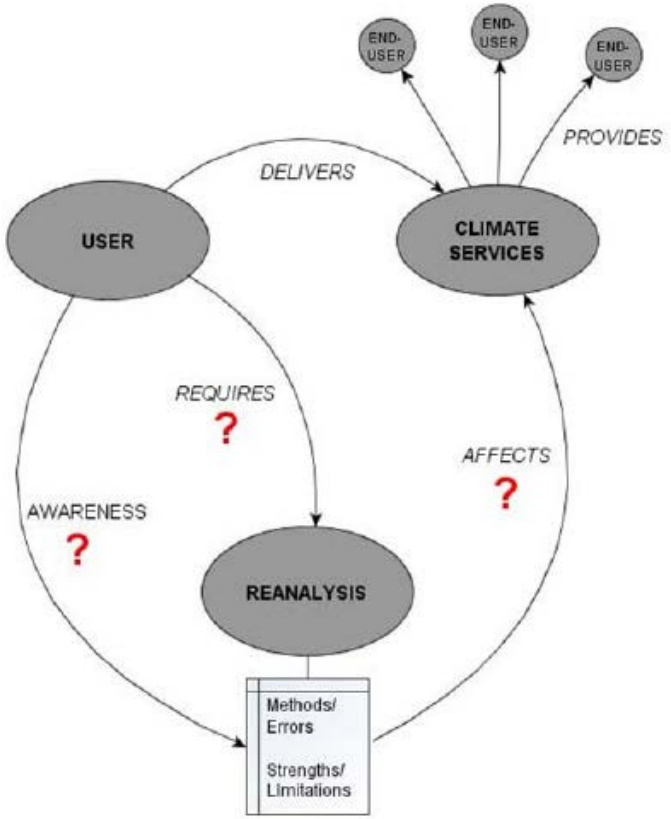


Figure 3.1. Schematic graph illustrating the purpose of the questionnaire.

Analysis and summary of webportal survey

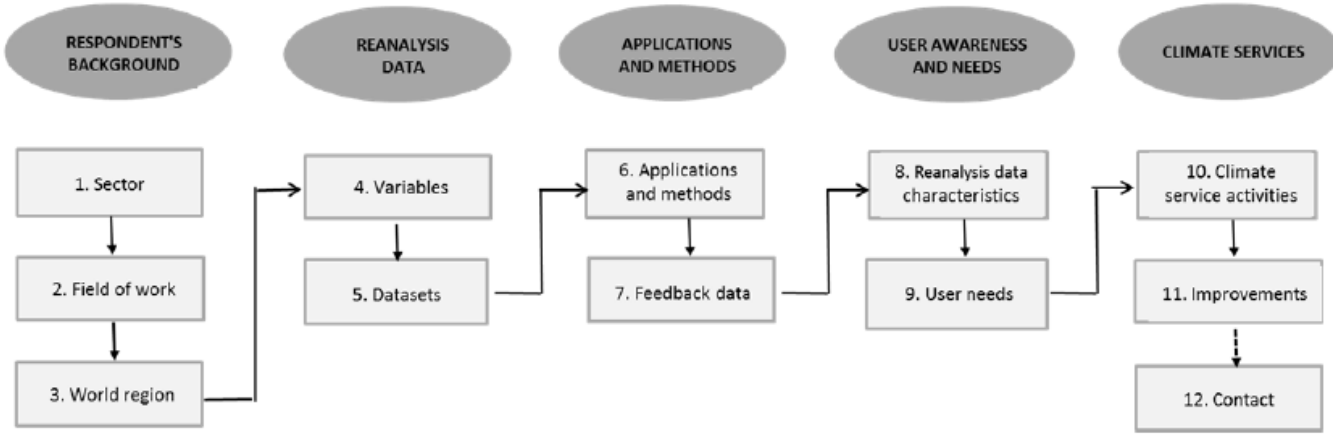
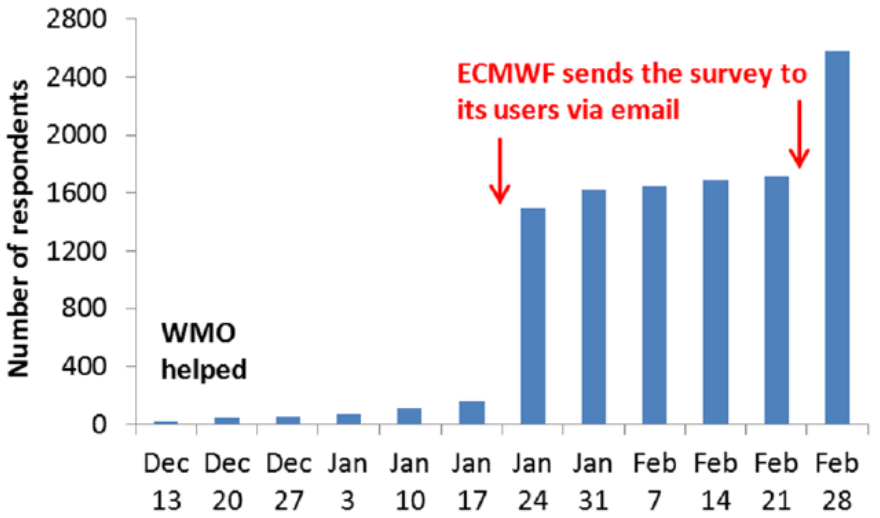


Figure 3.2. Flowchart of the questionnaire.



Procedure for comparing reanalyses to asimilated observations and CDRs

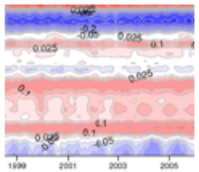
DESCRIPTIVE

Comparison tables

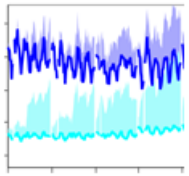
MERRA	NOAA CIRES 20CRv2	ERA Interim	ERA-20C ensemble
Atmospheric reanalysis	Atmospheric reanalysis	Atmospheric reanalysis	Atmospheric reanalysis
1979-present	1871-2012	1979-present	1899-2010
Comprehensive set of observations, including in situ and satellite for land and ocean surfaces and the upper-air	Surface pressures, and sea-surface forcing (temperature and ice cover)	Comprehensive set of observations, including in situ and satellite for land and ocean surfaces and the upper-air	Surface pressures, marine surface winds, and sea-surface forcing (temperature and ice cover)
2/3 degree longitude x 1/2 degree latitude	T62 truncation (approx. 300 km)	T255 truncation (approx. 80 km)	T159 truncation (approx. 125 km)

INTERNAL METRICS

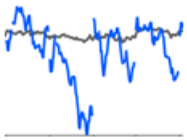
Analysis increments



Feedback statistics



Error estimates

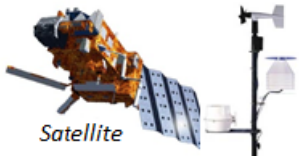


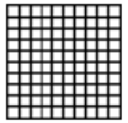
Level of production expertise

Reanalysis

Intercomparison

3rd party CDRs



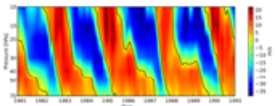


In situ

DIRECT

User applications

Natural processes



THEMATIC

Uncertainties and gaps in the different reanalyses and the effects of these to climate services

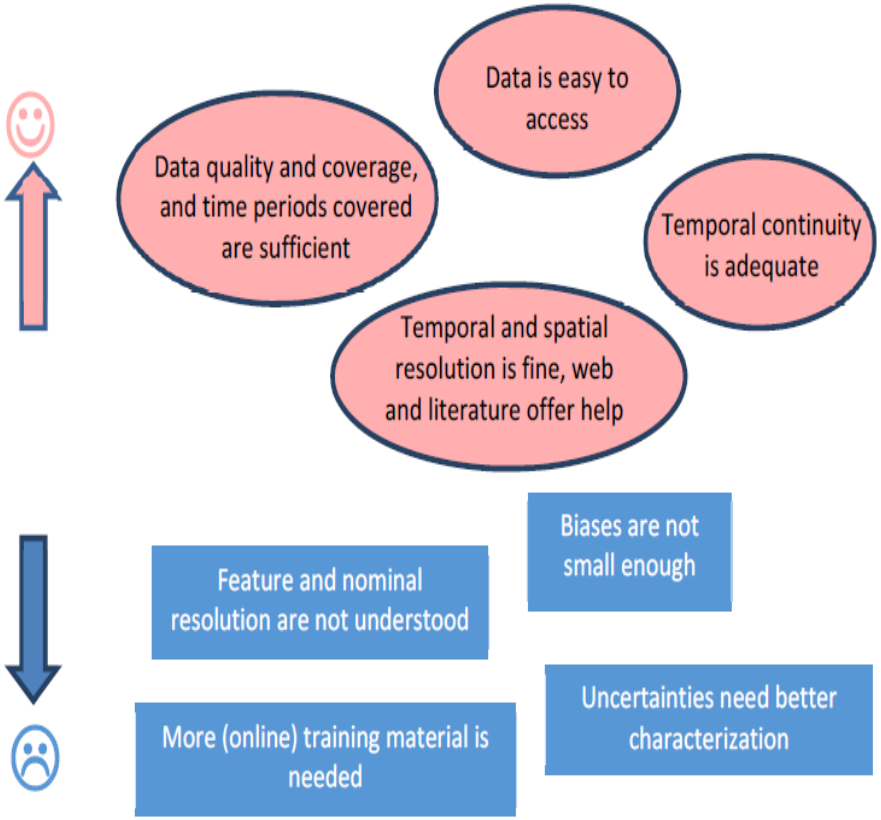


Figure 1. Summary of the rating of characteristics of reanalysis products.

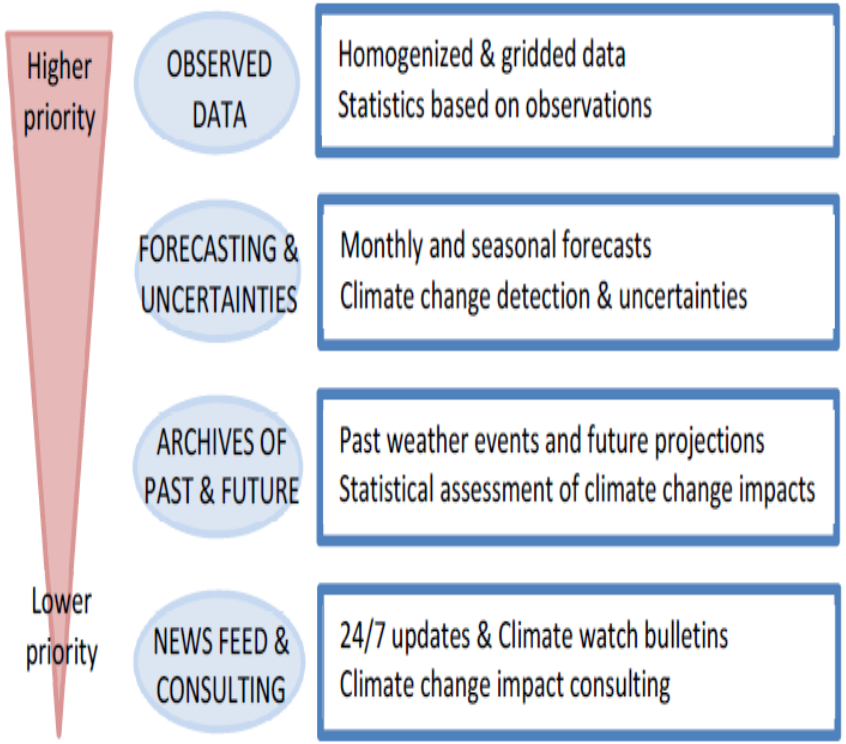


Figure 2. Priority of different climate service areas according to the questionnaire responses.

Summary overview

1) CORE-CLIMAX has proposed a structured process for assessing European capability in delivering ECVs;

- Using and contributing to data record inventories;
- Using an updated System Maturity Matrix approach of 'measuring' if data records are produced with best practises for science and engineering;
- Using a novel approach of an Application Performance Metric to break down comprehensive information on data record quality into a performance index;

2) CORE-CLIMAX has proposed a validation process aiming at qualifying the accuracy of the climate variables;

3) CORE-CLIMAX has created a feedback mechanism ensuring that the results of the re-analysis process get appropriately reflected into updates of the CDR.

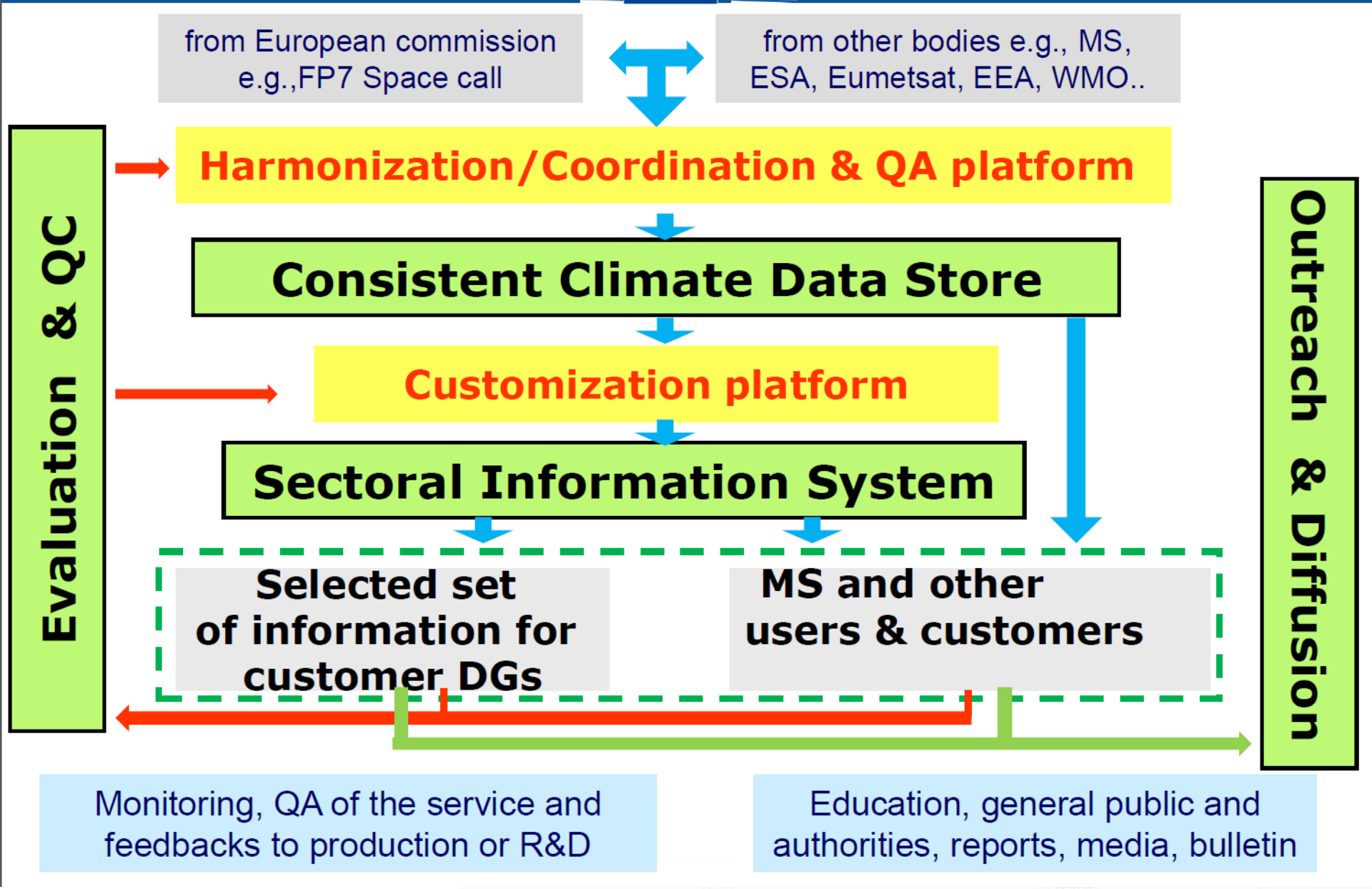
4) CORE-CLIMAX has developed a process to compare re-analyses.

Expectations to co-location meeting

1) To solicit comments to the CORE-CLIMAX approaches & results
2) To get updated with other relevant European projects
3) To seek opportunities to take up achievements of CORE-CLIMAX
4) To coordinate further developments in generating CDRs
5) To contribute to the C3S

Architecture of the Copernicus Climate Change service

A logical view



Copernicus Climate Change service

Road map stage II

Consistent Climate Data Store - 20 ECVs & 7 indicators -

Observed, re-analyzed and model projected products

ATMOSPHERE

- Surface Air Temperature
- Surface Precipitation
- Water Vapor
- Surface Radiation Budget
- Earth Radiation Budget
- Carbon Dioxide & Methane
- Ozone & Aerosols
- Cloud properties

OCEAN

- Ocean Color
- Sea Ice
- Sea Level
- Sea Surface Temperature
- Global Ocean Heat Content

LAND

- Snow Cover
- Glaciers & Ice Caps
- Albedo
- FAPAR
- Fire Disturbances
- Ice Sheets

What is the missing link? **Essential Water Variables!**

Sectoral Information System – 8 sectors & 18 indices

Agriculture and forestry

Health

Energy

Infrastructure

Coastal areas

Water management

Tourism

Insurance

Impacts and projections in water resources

- *Q1: What are observed impacts to water resources in Yangtze due to climate and human changes ?*
- *Q2: Will the changes in the Yangtze River Basin influence the East Asian monsoon patterns?*
- *Q3: What will be the spatial/temporal distribution of water (sediment) resources in 21st century ?*