PROCEDURES FOR FEEDING BACK REANALYSIS RESULTS AND PLANS TO CDR PRODUCERS

ABSTRACT – The advent of operational climates services increases the need of producers of Climate Data Records (CDRs) to know about the needs of reanalyses, particularly regarding desirable CDR updates. The purpose of this document is to explain how reanalysis teams can best communicate and exchange their needs for CDR updates.

EU FP7
Core-Climax
Deliverable
D4.43

Document history

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Procedures for feeding back reanalysis results and plans to CDR producers

I. Introduction

The advent of operational climate services increases the need of producers of Climate Data Records (CDRs) to know about the needs of reanalyses, particularly regarding desirable CDR updates (i.e. improvements). An iterative life-cycle framework for mutual improvement of both reanalyses and CDRs is shown in Figure 1. Two assumptions implicit in this framework are (1) that reanalysis needs are communicated effectively to CDR producers, and (2) that updated/improved CDRs are realized.

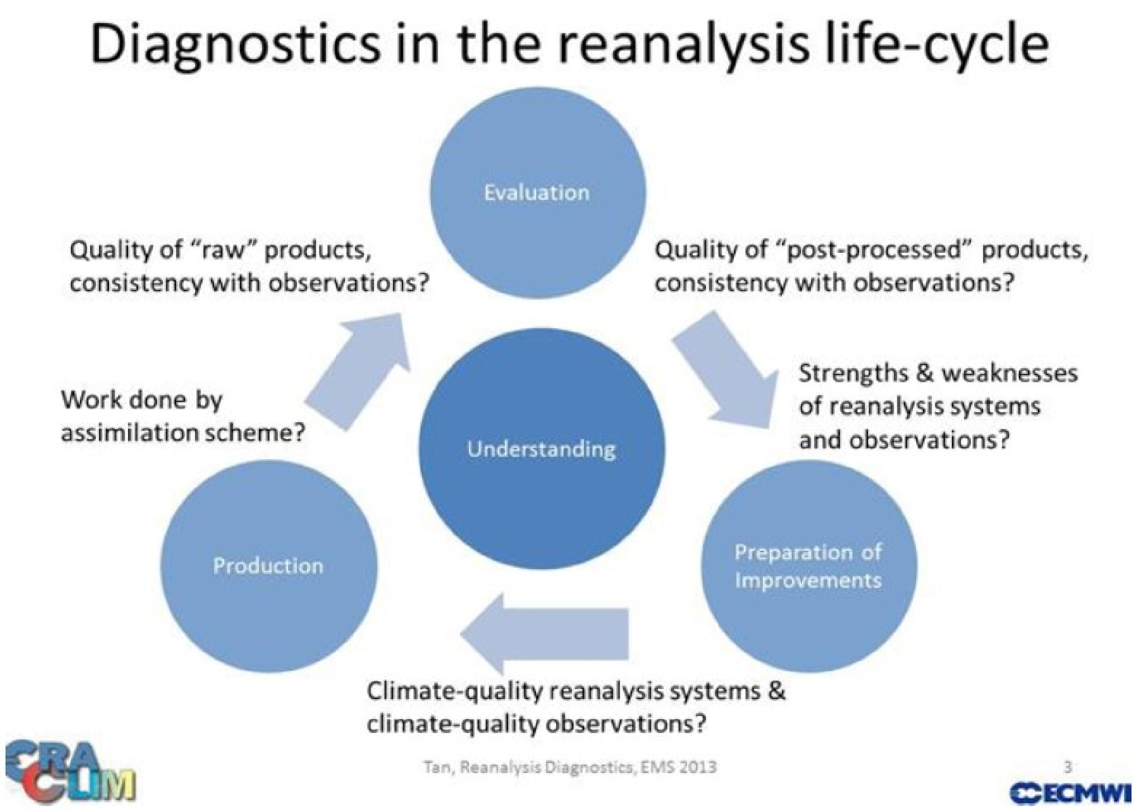

Figure 1: An iterative life-cycle framework for mutual improvement of both reanalyses and climate data records. From Core-Climax Document D5.52 "Reanalysis user needs with respect to Climate Services".

This document summarizes our recommendations on how reanalysis needs can be effectively communicated to CDR producers. The document is structured in a way that reflects our principal conclusion, which is that effective communication of reanalysis needs should involve procedures at two levels:

1) peer-to-peer level: to communicate feedback from reanalysis results, particularly the results of CDR quality assessment arising from the reanalysis environment. Peer-to-peer level communication is appropriate for ensuring that detailed feedback on scientific and technical weaknesses of a CDR is both conveyed and understood. Procedures to generate reanalysis feedback, and to incorporate such feedback into CDR update plans, have been described in separate Core-Climax documents. Effective peer-to-peer level communication essentially requires the co-ordinated (formalized) implementation of the combined set of procedures. To make explicit the mutual interplay and importance of co-ordination, the relevant procedures are re-iterated together in Section II.

2) synthesis level: to co-ordinate and improve efficiency of peer-to-peer level communications, and to provide an essential link to programmatic considerations. We see the need for two types of synthesis: (a) in situations where the reanalysis need for consistent CDR products calls for co-ordinated effort between multiple CDR producers, and (b) in situations where a CDR provider formulates CDR update plans on the basis of feedback collected from multiple users. We elaborate on these in Section III.

In Section IV we identify elements of the international context that are informative for guiding future developments. Summary and conclusions are given in Section V.

II. Peer-to-peer procedures

One of our principal recommendations for communicating reanalysis needs to CDR producers is to have effective peer-to-peer procedures, particularly for ensuring that feedback from reanalysis-based CDR assessments is both conveyed and understood.

The Core-Climax document D4.42 described procedures for assessing CDR quality in a reanalysis environment. Figure 2 (adapted from D4.42) is shown to remind the reader that the procedures are invariably iterative in nature and that there is a distinction between CDR assessment via pre-assimilation offline comparison with an existing reanalysis and CDR assessment via full assimilation and comparison in a new reanalysis. Offline comparison is usually a pre-requisite for full assimilation.

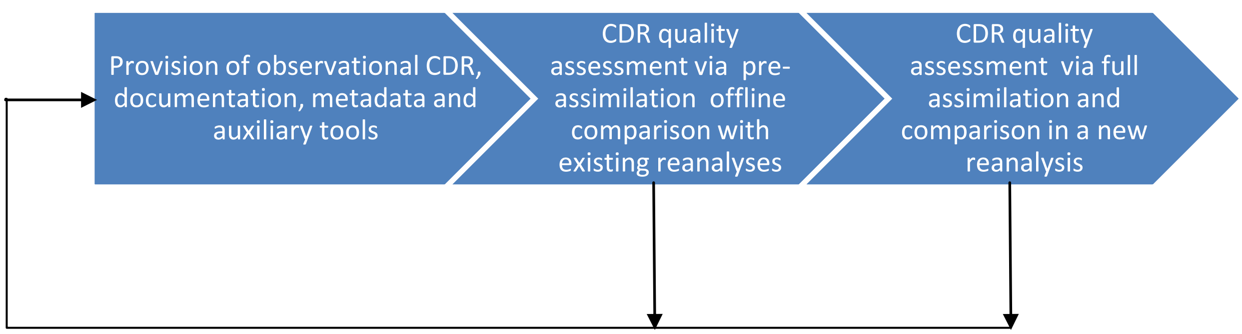

Figure 2: Progress of an observational CDR to quality assessment via full assimilation in a new reanalysis. Progress is contingent upon satisfactory assessment in pre-assimilation/offline comparisons. The arrowed lines represent the feedback loop for stimulating improved CDRs and/or supplementary materials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

Figure 3 illustrates offline quality assessment in more detail. The iterative loop linking "Comparison & Assessment" and "Response by CDR provider" encapsulates the fundamental peer-to-peer communication needed to convey and understand reanalysis needs. It is through this loop that (a) CDR weaknesses are reported (D4.42 provided a template for CDR Assessment Reports), and (b) the CDR producer's response can be developed to a level at which CDR update plans can be formulated.

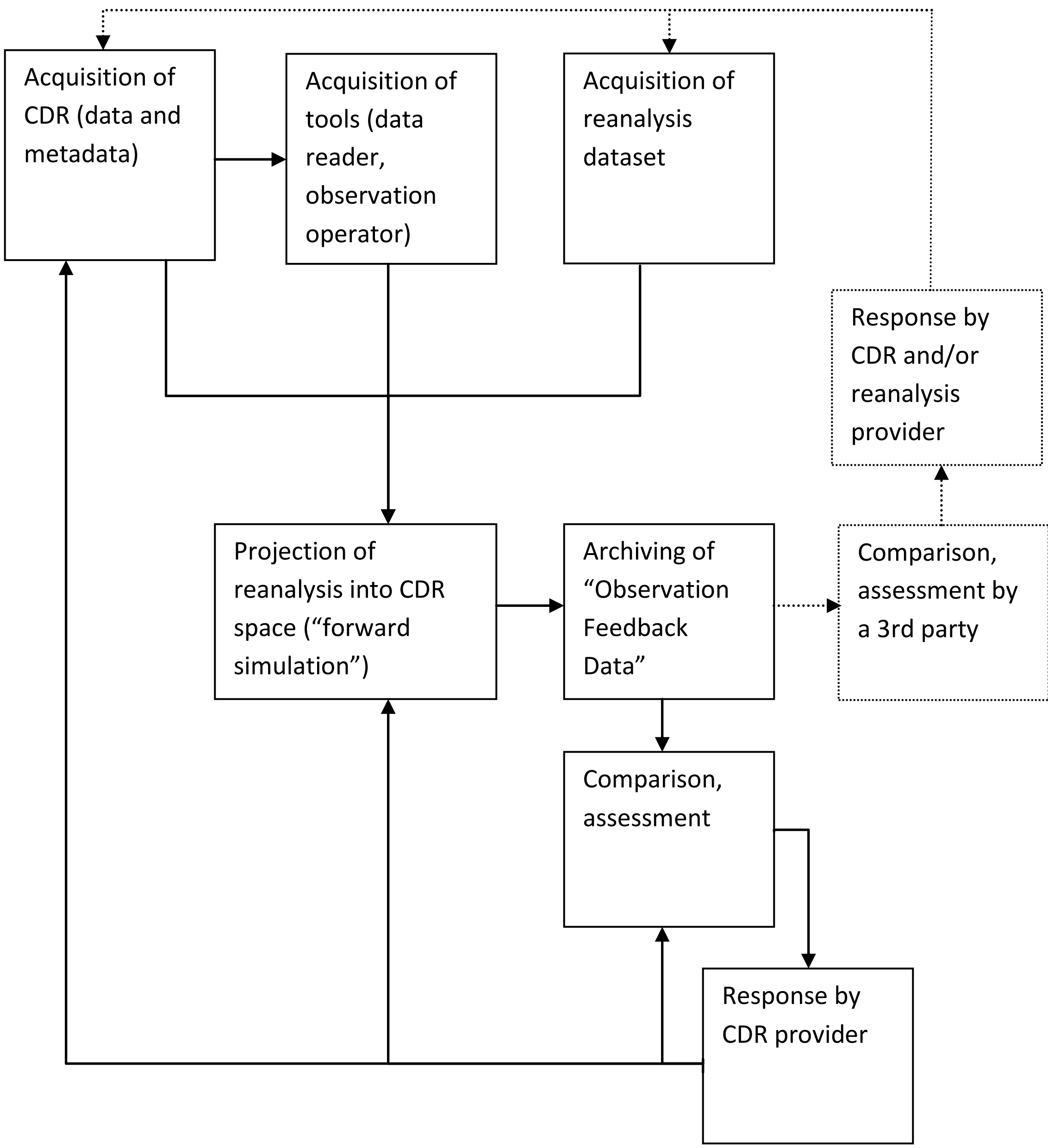

Figure 3: Process for comparing a CDR with a pre-existing reanalysis ("pre-assimilation, off-line assessment"). From Core-Climax Document D4.42 "Design of Support Infrastructure for CDR Quality Assessment in a Reanalysis Environment".

The Core-Climax System Maturity Matrix describes various levels of sophistication for the procedures implemented by the CDR producer to (a) gather user feedback and (b) incorporate such feedback into CDR update plans. Current procedures for User Feedback and CDR Updates are typically in the range 2 to 4 and 1 to 3 respectively (Figures 4 and 5).

Score	*Description*
1	None
2	PI collects and evaluates feedback from scientific community
3	PI and Data provider collect and evaluate feedback and from scientific community
4	Data provider establishes feedback mechanism such as regular workshops, advisory groups, user help desk, etc. and utilises feedback jointly with PI
5	Established feedback mechanism and international data quality assessment results are considered in periodic data record updates
6	Score 5 + Established feedback mechanism and international data quality assessment results are considered in continuous data provisions (Interim Climate Data Records)

Figure 4: User Feedback ratings in the Core-Climax System Maturity Matrix

Score	**Description**
1	None
2	Irregularly by PI following scientific exchange and progress
3	Irregularly by PI following scientific exchange and progress
4	Regularly by PI utilising input from established feedback mechanism
5	Regularly operationally by data provider as dictated by availability of new input data or new methodology following user feedback
6	Score 5 + capability for fast improvements in continuous data provisions established (Interim Climate Data Records)

Figure 5: CDR Update ratings in the Core-Climax System Maturity Matrix

Our recommendations to all CDR producers involved in operational climate services are to (a) move towards maturity levels 4 to 6 with all practical speed, and (b) incorporate the reanalysis feedback described here within the feedback gathering and update planning processes. These recommendations highlight our recognition that CDR producers have a critical role in ensuring that reanalysis needs for CDR updates are systematically captured and effectively actioned.

We have also considered the need to specify timelines for reprocessed products to be made available for reanalysis production activities. While there is little harm in communicating reanalysis production schedules to CDR producers, the conversion of schedule milestones into due dates for CDR updates has limited practicality at present. Reanalysis production schedules are liable to change, and meeting the requests for CDR updates can involve substantial research for a duration that is hard to predict. We envisage far greater use in future of the pre-assimilation CDR assessments (Figures 2 and 3, and Core-Climax Document D4.42 “Design of Support Infrastructure for CDR Quality Assessment in a Reanalysis Environment”), which mitigates much of the need to prescribe deadlines tied to reanalysis production schedules.

We remind the reader that the nature of the requests for CDR updates may extend beyond scientific/technical characteristics of the dataset values themselves, to the supporting infrastructure including auxiliary tools such as observation operators and statistical analysis tools (again, see Core-Climax Document D4.42 “Design of Support Infrastructure for CDR Quality Assessment in a Reanalysis Environment” for more details).

III. Synthesis procedures

The peer-to-peer procedures for communicating reanalysis needs to CDR producers (Section II) are essential elements for conveying/understanding detailed feedback on scientific and technical weaknesses of a CDR, but must also be complemented by synthesis-level procedures to address situations where co-ordination will improve efficiency, and to provide an essential link to programmatic considerations. We see the need for two types of synthesis: (a) in situations where the reanalysis need for consistent CDR products calls for co-ordinated effort between multiple CDR producers, and (b) in situations where a CDR provider formulates CDR update plans on the basis of feedback collected from multiple users. We elaborate on these in this section.

III.1 - Synthesis procedures to co-ordinate reprocessing from multiple CDR producers

In this sub-section we address those situations where the reanalysis need for consistent CDR products calls for co-ordinated effort between multiple CDR producers, for example where satellite agencies and related CDR producers have mutually inconsistent data spanning several decades from a group of similar but non-identical instruments, or from a variety of processing algorithms. These situations are becoming increasingly common, because lack of mutual consistency between the observational inputs provided to a reanalysis is detrimental to the long-term fidelity of reanalysis outputs and the associated use of reanalysis products for climate applications. To obtain a co-ordinated response in such situations, we recommend that reanalysis centres complement peer-to-peer level procedures with synthesis-level procedures. A typical synthesis procedure would be to convene working-level co-ordination meetings with participation from the relevant CDR producers and one or more reanalysis centres.

An example of a working-level co-ordination meeting was given through the Core-Climax Visit Program, in which ECMWF convened and hosted a co-ordination meeting on reprocessing of atmospheric motion vectors (AMVs). As summarized in the meeting report (available from the Core-Climax project and website), the goal of the meeting was to assist the co-ordination of the reprocessing efforts of satellite imagery data records from geostationary and polar orbits into climate data records of atmospheric motion vectors for use by reanalyses. A complementary goal was to accelerate a reprocessed data quality assessment strategy using reanalysis and observation feedback archives. Crucial to the success of the meeting was to bring together two major AMV producers, namely EUMETSAT and CIMSS (Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison, USA). Their joint participation facilitated thorough working-level documentation/comparison of the programmatic context (data holdings, completed reprocessing, in-progress and committed reprocessing plans), of reprocessing methods and algorithmic variations (including but not limited to input and output interfaces, source of background information, scope of the use of background information, feature tracking methods, height assignment methods, post-processing, quality indicators/control), and of practices employed for validation and uncertainty estimation (sources of validation data, participation in intercomparison exercises, etc). An important function of the meeting was to share experience obtained from experimentation with different options, thereby developing greater consensus on the most suitable choices for consistent processing. Based on the success of this meeting, we see potential for conducting similar co-ordination meetings in future, for AMVs and/or other CDRs. (A modest increase in the number of CDR producers participating could be accommodated relatively easily, but beyond a certain point additional logistical support would be required.)

The participants of the AMV co-ordination meeting also recognized the need for better communication and co-ordination of AMV reprocessing activities at the level of international programs. In the case of AMVs, relevant bodies include the International Winds Working Group (IWWG), the Co-ordination Group for Meteorological Satellites (CGMS), the WCRP Data Advisory Council, and the network known as SCOPE-CM ("Sustained and coordinated processing of Environmental Satellite data for Climate Monitoring"). Extending to other CDRs, many of these bodies remain relevant but are not exhaustive. Where consistency of ECV products depends on inter-calibrated radiance data, enabling initiatives such as the Global Space-based Intercalibration System (GSICS) would also become relevant. Further discussion of these issues is deferred to Core-Climax Document D2.26 (White book on description of the structured process to derive ECV data records).

III.2 - Synthesis procedures for CDR producers serving multiple users

For communicating CDR needs from reanalysis and other users, exclusive reliance on peer-to-peer procedures lacks efficiency if the CDR producer becomes inundated with similar feedback and update requests from a multitude of users. We therefore see an important need for CDR producers to implement synthesis procedures that will make visible any received feedback and associated producer responses, particularly CDR update plans.

A typical situation arising from the peer-to-peer procedures (Section II) will involve specific items of user feedback triggering corresponding actions to realize improvements in future updates of the CDR. A synthetic view would be achieved by the CDR producer recording on an on-going basis all such formulated actions, and the underlying triggers, in a living CDR update plan, and making this plan visible to all users. Through the synthetic view, users would be aware of feedback already passed to the CDR producer and so duplication of effort arising from repeating existing requests would be reduced. In particular, it will save time for the CDR producer who would otherwise need to respond separately to many similar update requests.

As an example of a synthetic view of CDR update plans from one CDR producer, Figure 6 shows an extract from a EUMETSAT inventory. It is implemented as a spreadsheet but does not contain traceable links to the user feedback that has influenced the update plan. While a spreadsheet is relatively simple to implement, it may instead be worthwhile to develop an inventory database. This would be important preparation for a greater level of co-ordination and synthesis between CDR producers, in particular to facilitate a global view of CDR activity. It would be useful for design of the database to take into account the structure/contents of the Dataset Description Documents formulated by Core-Climax in WP2, supplemented by extensions to accommodate user feedback.

A valuable functionality of a global inventory database for reprocessed/updated CDRs would be to facilitate interactive synthetic views of reprocessed datasets from multiple CDR providers. Figure 7 shows an extract from http://reanalyses.org/observations/list-satellite-datasets (which is a manually constructed table, and hence illustrative rather than prescriptive) and has been chosen to show what an interrogable database could provide. The WMO Space Programme's Product Access Guide is an interactive portal (https://www.wmo-sat.info/product-access-guide/) with emphasis on near-real-time un-reprocessed data products, but could in principle be adapted/co-ordinated to accommodate reprocessed and updated CDRs.

EUMETSAT Data Set Generation Plan (Planned Commited Products)
Version 6.0
14 March 2014

										Data Set Description		
	Product Identifier	DOI Identifier	Product Family/Activity Name	Physical Parameter(s)	Units	Satellites	Sensors	Spatial Coverage	Spatial Resolution	Vertical Resolution	Record start	Record
	Unique product identifier for referencing and monitoring purposes (uses SAF PRT identifiers)	*Unique product identifier (will contain the doi that will be implemented into the meta data of the data record)*	*Short name (this parameter can be used to group several PRT entries into one product family or processing event)*	*Give the name of the physical variable preferably using the ECV terminology*	*Give the units of the physical parameter*	*Provide complete list of series of satellites to be used, including start and end date for each satellite*	*Provide complete list of sensors matching the series of satellites*				*Date*	*Date*
7	CF-001		IASI Level 1 R1	Radiance spectra	$W m^{-2} sr m^{-1}$	METOP-A (01/01/2007 - 31/12/2012)	IASI	Global	Full sensor resolution varying with viewing angle	N/A	01/01/2007	31/12/20
8	CF-002		GRAS Level 1 R1	Bending angles	deg.	METOP-A (01/01/2007 - 31/12/2012)	GRAS	Global		N/A	01/11/2006	31/12/20
9	CF-010		MFG Intercalibration IR R1	Radiance	$W m^{-2} \mu m^{-1}$	Meteosat-2 (01/08/1982 - 31/08/1988) Meteosat-3 (01/08/1993 - 31/08/1989) Meteosat-4 (19/06/1984 - 02/02/1994) Meteosat-5 (04/02/1994 - 13/02/1997) Meteosat-6 (14/02/1997 - 03/06/1998) Meteosat-7 (03/06/1998 - 10/11/2006) Meteosat-5 IODC () Meteosat-7 IODC ()	MVIRI	0°E SSP full disk	Full sensor resolution varying with viewing angle	N/A	01/08/1982	10/11/20
10	CF-011		MFG/MSG Intercalibration VIS R1	Radiance	$W m^{-2} \mu m^{-1}$	Meteosat-2 (01/08/1982 - 31/08/1988) Meteosat-3 (01/08/1993 - 31/08/1989) Meteosat-4 (19/06/1984 - 02/02/1994) Meteosat-5 (04/02/1994 - 13/02/1997) Meteosat-6 (14/02/1997 - 03/06/1998) Meteosat-7 (03/06/1998 - 10/11/2006) Meteosat-5 IODC () Meteosat-7 IODC () Meteosat-8 (01/01/2004 - 25/09/2006) Meteosat-9 (25/09/2004 - 31/12/2012) Meteosat-10 (01/01/2013 - xx/xx/xxxx)	MVIRI	All SSPs (0°E, 57° E, 63° E, 50° W, 75° W) full disk	Full sensor resolution varying with viewing angle	N/A	01/08/1982	31/12/20
11	CF-012		MFG AMV-CSR R1	Winds, Clear Sky Radiance	$m s^{-1}$, hPa, deg (AMV) mW m-2 sr cm-1 (CSR)	Meteosat-2 (01/08/1982 - 31/08/1988) Meteosat-3 (01/08/1993 - 31/08/1989) Meteosat-4 (19/06/1984 - 02/02/1994) Meteosat-5 (04/02/1994 - 13/02/1997) Meteosat-6 (14/02/1997 - 03/06/1998) Meteosat-7 (03/06/1998 - 10/11/2006)	MVIRI	0, 57and 63 deg full disk	Full sensor resolution varying with viewing angle	N/A	01/08/1982	10/11/20
12	CF-016		CHAMP Level 1 R1	Bending angles	deg.	CHAMP (2001-09/2010)	BlackJack	Global		N/A	01/09/2001	30/09/20
13	CF-017		GRACE Level1 R1	Bending angles	deg.	GRACE (2005 -	BlackJack	Global		N/A	01/01/2005	31/12/20
14	CF-018		COSMIC Level1 R1	Bending angles	deg.	COSMIC (2006 -till date)	IGOR	Global		N/A	01/04/2006	31/12/20
15	CF-019		GOME-2/IASI Ozone Total Column R1	Total ozone column	$kg m^{-2}$	METOP-A (01/01/2007 - 31/12/2012)	GOME-2/IASI	Global	TBD	N/A	01/01/2007	31/12/20
16	CF-020		MFG Level 1.5 Image R1	Reflectance Radiance	$W m^{-2} \mu m^{-1}$	Meteosat-2 (01/08/1982 - 31/08/1988) Meteosat-3 (01/08/1993 - 31/08/1989) Meteosat-4 (19/06/1984 - 02/02/1994) Meteosat-5 (04/02/1994 - 13/02/1997) Meteosat-6 (14/02/1997 - 03/06/1998) Meteosat-7 (03/06/1998 - 10/11/2006) Meteosat-5 IODC () Meteosat-7 IODC ()	MVIRI	All SSPs (0°E, 57° E, 63° E, 50° W, 75° W) full disk	Full sensor resolution varying with viewing angle	N/A	01/08/1982	10/11/20
17	CF-021		MFG/MSG Intercalibration IR R2	Radiance	$W m^{-2} \mu m^{-1}$	Meteosat-2 (01/08/1982 - 31/08/1988) Meteosat-3 (01/08/1993 - 31/08/1989) Meteosat-4 (19/06/1984 - 02/02/1994) Meteosat-5 (04/02/1994 - 13/02/1997) Meteosat-6 (14/02/1997 - 03/06/1998) Meteosat-7 (03/06/1998 - 10/11/2006) Meteosat-5 IODC () Meteosat-7 IODC () Meteosat-8 (01/01/2004 - 25/09/2006) Meteosat-9 (25/09/2004 - 31/12/2012) Meteosat-10 (01/01/2013 - xx/xx/xxxx)	MVIRI/SEVIRI	All SSPs (0°E, 57° E, 63° E, 50° W, 75° W) full disk	Full sensor resolution varying with viewing angle	N/A	01/08/1982	10/11/20
						Meteosat-2 (01/08/1982 - 31/08/1988) Meteosat-3 (01/08/1993 - 31/08/1989)						

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Figure 6: Synthetic view of CDR update plans from Eumetsat

Observable or Geophysical variable	Instrument	Satellite	Time period	Reprocessing, if any	…
Total column ozone	TOMS	NIMBUS-7	Nov 1978-May 1993	NASA v8.6 retrievals http://ozoneaq.gsfc.nasa.gov/nimbus7Ozone.md	
…					
Bending angles	GPS radio occultation receiver	METOP-A	Sep 2007-Dec 2011	UCAR CDAAC version 2011.2980 reprocessed dataset	
…					
Atmospheric Motion Vector (AMV)	MVIRI	METEOSAT-7	June 1998-present	EUMETSAT for June 1998-Dec 2000	
….					
Atmospheric Motion Vector (AMV)		GMS-3	Dec 1984-Feb 1987	JMA for Mar 1987-Dec 1989	
…					
Atmospheric Motion Vector (AMV)	AVHRR	NOAA-7	Jan 1982-Fev 1985	CIMSS ftp://stratus.ssec.wisc.edu/pub/winds/histavhrr/newversion/noaa-7/	
…					
Brightness temperature	SSM/I	DMSP block 5D F-8	Sep 1987-Dec 1991	CM-SAF http://wui.cmsaf.eu/safira/action/viewDoiDetails?acronym=FCDR_SSMI_V001	
… (ctd)					

Observable or Geophysical variable (ctd)	Instrument (ctd)	Satellite (ctd)	Time period (ctd)	Reprocessing, if any (ctd)	…
Brightness temperature	SSM/I-S	DMSP block 5D F-16	Nov 2005-Sep 2013 (as of 25 Oct 2013)	CM-SAF, or CSU http://rain.atmos.colostate.edu/FCDR/	
…					
Brightness temperature	TMI	TRMM	Dec 1997-Dec 2011	JAXA	
…					
Brightness temperature	SSM/T-2	DMSP block 5D F-11	Jan 1993-May 2000 Note: NOAA NGDC seems to have data before 1993, from Apr 1992 (http://ngdc.noaa.gov/eog/availability.html)	Met Office	
…					
Brightness temperature	HSB	EOS-Aqua	May 2002-Feb 2003	NASA JPL AIRS v5 or v6 reprocessed dataset of L1B	
…					

Figure 7: Synthetic view of CDR holdings from multiple CDR providers. Extracted from http://reanalyses.org/observations/list-satellite-datasets

IV. Further remarks

In this Section we highlight the over-arching international context that will be addressed in more detail in Core-Climax Document D2.26 (White Book on Description of the Structured Process to Derive ECV Data Records for Climate Services), and point out some of the differences that must be taken into account between satellite and in-situ CDRs.

IV.1 The international context

We anticipate that the procedures described in previous sections will take time to gain traction, and that they will continue to evolve taking into account ongoing developments in best practice and the surrounding international context in which related co-ordination mechanisms already exist or are emerging.

One noteworthy example is the Joint CEOS-CGMS Working Group on Climate (WGClimate, http://www.ceos.org/index.php?option=com_content&view=category&layout=blog&id=168&Itemid=278). WGClimate is a CDR producer coordination body that coordinates and encourages collaborative activities between the world's major space agencies in the area of climate monitoring. It gathers user needs, identifies capability gaps, develops actions plans and passes them to the relevant agencies for implementation via initiatives (leading to programmes such as GSCICS and SCOPE-CM). We encourage greater use of such bodies and their mechanisms by reanalysis and other CDR users, and further development of the mechanisms to cover new aspects as the needs arise.

The objective of the WMO's Space Programme (http://www.wmo.int/pages/prog/sat/index_en.php) is to promote availability and utilization of satellite data and products for weather, climate, water and related applications to WMO Members. It coordinates environmental satellite matters and activities throughout all WMO Programmes and gives guidance on the potential of remote-sensing techniques in meteorology, hydrology and related disciplines. In-situ data are also important for reanalysis but are out of scope of the WMO Space Programme.

The mission of World Climate Research Program Data Advisory Council (WCRP DAC, WDAC, http://www.wcrp-climate.org/WDAC.shtml) is to act as a single entry point for all WCRP data, information, and observation activities with its sister programmes, and to coordinate their high-level aspects across the WCRP, ensuring cooperation with main WCRP partners such as GCOS and other observing programmes. Its remit includes strengthening the coordination and synergies between the various observational and data analysis efforts across the WCRP. WDAC thus has a significant role in co-ordinating/communicating user needs to CDR producers, so we encourage reanalysis centres to synthesize their needs for onward transmission to WDAC.

GEWEX is a Core Project of WCRP on Global Energy and Water Exchanges (http://www.gewex.org/). Dataset assessment exercises conducted through GEWEX Data and Assessment Panel play an important role in the update planning by CDR producers, and we recommend that reanalysis centres keep informed about such assessments, and feed into such processes where possible. We note that there are variations between the GEWEX approach and those of the other WCRP core projects (SPARC, CLIVAR, CLiC), so another possible role for reanalysis centres and other data users would be to encourage WDAC to promote consistent best practice among all of these. Complementing the WDAC is the WCRP Modelling Advisory Council (WMAC), and we advise reanalysis centres to keep informed about its activities which include model intercomparison projects and associated observation datasets projects such as Obs4MIPS (http://www.wcrp-climate.org/modelling-wgcm-mip-catalogue/modelling-wgcm-mips/266-modelling-wgcm-catalogue-obs4mips).

Major international conferences and workshops organized by such international programs are useful opportunities for reanalysis centres to communicate their CDR needs and co-ordinate them with other users. We foresee a growing need for preparatory meetings to synthesize reanalysis needs and in this regard we encourage reanalysis centres to learn from the upcoming Data Needs Workshop to be conducted in the frame of the ERA-CLIM2 project.

IV.2 Contrasts between satellite-based and in-situ-based CDRs

To conclude this section, we note that the satellite-based and in-situ-based CDR producer communities face different challenges in meeting reanalysis needs, in light of their current differences in data stewardship. The satellite-based community is sizeable, but nevertheless stewardship is administered by a relatively small number of institutions. Communication and co-ordination of CDR update planning is non-trivial, but remains feasible through the procedures summarized above. By contrast, the in-situ-based community is far more heterogeneous in structure, and faces distinctive challenges in producing historical CDRs reaching back to 1900 or earlier. Data stewardship for historical in-situ data currently requires significant efforts in data rescue, digitization, and quality control. Associated metadata characterizing the in-situ instruments and historical observing practices are of critical importance for generating high-quality CDRs suitable for reanalysis use, but are often lacking/incomplete. Data rescue does not automatically yield climate-quality datasets. Homogeneization of rescued in-situ data is vital, but is arguably more difficult to co-ordinate given the heterogeneity of the contributing sources. It will be important for reanalysis centres to strengthen links with in-situ initiatives such as ICOADS (for surface marine data, http://icoads.noaa.gov/), ISPD (for surface pressure, https://reanalyses.org/observations/international-surface-pressure-databank), and ACRE (http://www.met-acre.org/), so that progress can be made on these issues. These will serve to promote best practice for subsequent extension to in-situ datasets for other parameters, e.g. snow.

V. Summary and Conclusions

This document summarizes our recommendations on how reanalysis needs can be systematically communicated to CDR producers and effectively actioned within CDR update plans. Our principal conclusion is that effective communication of reanalysis needs should involve procedures at two levels:

1) peer-to-peer level: to communicate feedback from reanalysis results, particularly the results of CDR quality assessment arising from the reanalysis environment. Procedures to generate reanalysis feedback, and to incorporate such feedback into CDR update plans, have been described in separate Core-Climax documents. Effective peer-to-peer level communication essentially requires the co-ordinated (formalized) implementation of the combined set of procedures, and so these are brought together in this document.

2) synthesis level: to co-ordinate and improve efficiency of peer-to-peer level communications. We see the need for two types of synthesis: (a) in situations where the reanalysis need for consistent CDR products calls for co-ordinated effort between multiple CDR producers, and (b) in situations where a CDR provider formulates CDR update plans on the basis of collective feedback from multiple users. A range of synthesis-level procedures are recommended, including (i) the convening of meetings to bring together multiple CDR producers where the reanalysis need is for consistency between their CDR products, and (ii) procedures to provide synthetic views of CDR update plans, with traceable links to the underlying user feedback that motivated the update requests, such as synthetic views to be compiled at both the institutional level for individual CDR producers and the level of global inventories for collecting the plans of multiple CDR producers.

While elements of these procedures currently exist, they are typically applied in an ad-hoc manner, lacking visibility, traceability and co-ordination. Implementing systems that make reanalysis feedback and CDR update plans visible on an on-going basis and at synthetic levels, via information repositories, will be valuable. We advocate simple and lightweight frameworks, guided by pragmatism rather than ideology, and in this regard we recommend wider adoption of the iterative "off-line" reanalysis feedback process as an effective mechanism to enhance collaboration/communication between CDR producers and reanalysis users. Radical change from the status quo is not required, but rather incremental changes to consolidate and extend existing good practice. We recommend further effort to build the underlying technical solutions (e.g. design and implementation of suitable databases and tools). Progress will be reflected by increased maturity ratings in the Core-Climax System Maturity Matrix.

The current international context contains a number of programs and initiatives with mechanisms for conducting CDR assessments and compiling user needs. There is further work required to foster consolidated best practice and improve co-ordination within and between such activities. Further consideration of programmatic issues is deferred to Core-Climax Document D2.26 (White book on description of the structured process to derive ECV data records).