ERA-CLIM2

2nd General Assembly

9-11 December 2015 (EUMETSAT)

Report

The ERA-CLIM2 2nd General Assembly (GA2), held at EUMETSAT on 9-11 December 2015 and attended by 36 people, provided the ERA-CLIM2 partners and contributors the forum to assess progress since the 1st General Assembly (19-24 November 2014). During the meeting, open and outstanding scientific and technical issues were discussed, and the work-packages' plans to advance work were presented.

This GA2's report was prepared by the ERA-CLIM2 Coordinator (Roberto Buizza), the Leaders of work-packages 1-4 (Magdalena Alonso-Balmaseda, Matthew Martin, Stefan Brönnimann and Leopold Haimberger), and the external advisers (David Bromwich and Sakari Uppala) with input from all the GA2's participants. It aims to provide a *'working-text summary'* of where we are in the project and what are going to be the main activities in the forthcoming 24 months.

It has been organized as follows:

- Section 1 briefly reminds the main goal and the five key objectives of the project;
- Section 2 summarizes the progress and the plan for the next 12 months of the four main work-packages;
- Section 3 reports the main comments raised by the project external advisers;
- Section 4 summarizes some key points raised during the plenary discussion on how best to bridge the work planned within this project and the future reanalysis activities of Copernicus Climate Change Service;
- Section 5 lists the ERA-CLIM2 meetings that are going to be organized in 2016 and 2017 and the 'action point on a possible strategic outlook discussed at the meeting.

1 ERA-CLIM2 main goal and objectives

The main goal of ERA-CLIM2 is to apply and extend the current global reanalysis capability in Europe, in order to meet the challenging requirements for climate monitoring, climate research, and the development of climate services.

The five main objectives for the ERA-CLIM2 project (see Section B1.1 of Annex I of the Grant Agreement) are:

i. Production of an ensemble of 20th-century reanalyses at moderate spatial resolution, using a coupled atmosphere-ocean model, which will provide a consistent data set for atmosphere, land, ocean, cryosphere, including, for the first time, the carbon cycle across these domains;

ii. Production of a new state-of-the-art global reanalysis of the satellite era at improved spatial resolution, which will provide a climate monitoring capability with near-real time data updates;

iii. Further improvement of earth-system reanalysis capability by implementing a coherent research and development program in coupled data assimilation targeted for climate reanalysis;

iv. Continued improvement of observational data sets needed for reanalysis, in-situ as well as satellite-based, with a focus on temporal consistency and reduction of uncertainties in estimates of essential climate variables;

v. Development of tools and resources for users to help assess uncertainties in reanalysis products.

More information about the ERA-CLIM2 project and a copy of the GA2 talks (see Appendix A for the Agenda) can be accessed following the links below:

- Project: http://www.ecmwf.int/en/research/projects/era-clim2
- GA2 presentations: http://www.ecmwf.int/en/second-general-assembly-eumetsat-9-11-december-2015

2 Progress report and plan for 2016

The progress and plan for 2016 of the ERA-CLIM2 four main work packages, prepared by the ERA-CLIM2 Work-package leaders with input from all participants, are presented below.

2.1 Work-package 1 – Global 20th century reanalysis

2.1.1 Status and plans

The work in WP1 has been affected by the impact of two serious events during 2015 - the spin up of the Copernicus Climate Change Services at ECMWF (COP-C3S), and the migration to a new High Performance Computer (HPC). In spite of these disruptions, WP1 is now progressing well: the reanalyses system has started production, being on track for completion within the time-frame of the newly granted non-cost extension.

WP1 main two deliverables are the production of a Coupled Reanalyses of the 20 Century climate reanalysis (CERA-20C) and the development of a proof-of-concept coupled reanalysis system that can be used of the satellite period (CERA-SAT). During the GA, the status and plans were presented by the different members of WP1.

CERA-20C: This will be the main data product delivered by WP1. As its predecessor ERA-20C, it explores the ability of the reanalysis approach for reconstructing the history of the 20th century climate. Aside from the improvement in assimilation methods and observations, the main novelty of

CERA-20C is the inclusion of the ocean and sea-ice components, in an attempt to make better use of the surface observations, which continue being the backbone of these century reanalyses.

CERA-20C consists of a 10-member ensemble of coupled analyses spanning the period 1900-2010. Each member is produced by a coupled model of atmosphere-ocean-land-sea ice-waves, at a relatively low resolution (~100Km), assimilating surface observations in the atmosphere (from ICOADS and ISPD), in-situ profiles in the ocean (from EN4), and nudging the sea surface temperature to the monthly HadISST2 product. The ensemble generation samples uncertainty in ocean and atmosphere observations, ocean spin-up, SST (using different realizations of HadISST2), and model formulation (via stochastic physics in the atmospheric component). The ensemble provides an estimation flow-dependent background error for the atmospheric data assimilation, as well as a measure of uncertainty on the resulting reanalysis.

The production of CERA-20C has started, with 14 parallel streams (of 9 years each) currently running in the ECMWF supercomputer. These streams have been initialized using information from the previous ERA-20C reanalyses. Ocean and sea-ice initial conditions for the different CERA-20C streams are provided by a set of 10-member ensemble of uncoupled ocean reanalyses forced with ERA-20C surface fluxes and using the CERA-20C ocean configuration. For the atmosphere and land, the individual streams use ERA-20C initial conditions directly. This “iterative” method has been adopted to prevent (as much as possible) discontinuities between the parallel streams. Monitoring tools are being develop for quick checks on data usage, background departures, ensemble spread, and climate indices.

With the new extension of the project, the delivery of CERA-20C reanalysis has been modified (from M24 to M36). With the new schedule, the production is on-track.

Associated to CERA-20C there are separate carbon reanalyses over land and ocean. Due to the delays in CERA-20C, these reanalyses will now be prepared using fluxes from ERA-20C instead.

CERA-SAT: This is a prototype of state-of-the-art coupled global reanalysis of the satellite era at improved spatial resolution, which may provide a climate monitoring capability with near-real time data updates. It should be based on the up-coming reanalyses ERA5 (for atmosphere and land) and ORAS5 (for ocean and sea-ice). CERA-SAT will be prepared and tested during 2016.

2.1.2 Work-plan for 2016

Work in 2016 will aim to:

- Continue developing monitoring tools;
- Continue monitoring the quality of CERA-20C;
- Consolidate CERA-20C data (Q3);
- Liaise with WP5 for CERA-20C dissemination Q4;
- Prepare CERA-SAT (Q1-Q4);
- Start production of CERA-SAT (end of 2016/beginning of 2017);

- Start production of CARBON-LAND using ERA-20C surface fluxes;
- Start production of CARBON-OCEAN using ERA-20C surface fluxes.

2.1.3 Discussions

The discussions highlighted the need of more *"integration" and "consolidation*" actions, in order to fully exploit the efforts carried out during ERA-CLIM and ERA-CLIM2.

Integration is needed for the adequate archiving of rescued/quality controlled observations and for using and testing the new assimilation methods. In particular, the need to include the upper-air observations in the ECMWF Observation Feedback Archive (OFA) was strongly emphasized.

Two different suggestions were discussed for consolidation activities:

- Production of ERA-preSAT, assimilating surface *and upper-air* data. The upper-air data is considered instrumental for improving the quality of the reanalyses prior to the satellite era. A pre-SAT reanalyses will not compromise the temporal span of the reanalysis- a 100-year preSAT record (1920-2020) is an option.
- Preparation of the next generation of CERA systems using the newly developed assimilation methods.

It was advised to find non-conflicting ways of carrying out the above consolidation activities.

The evaluation and scientific exploitation of CERA was also discussed. Additional output was suggested for CERA-SAT (SST first-guess departures and non-linear heat/salinity transport terms). A few members volunteered for a possible "evaluation team", which will be able to access the CERA data to monitor key climate processes. Additional experiments were proposed to assist the scientific evaluation: CERA-20CM, CERA-20C-SSTonly, or a subset of longer CERA-20C streams. This extra experiments will be considered (depending on resources).

2.1.4 Actions

Five key action points were identified:

- Prepare a work-plan for integration of Upper Air Data in OFA (Q1);
- Facilitate CERA-20C access to the evaluation expert-group. (Q1);
- Implement archive of non-linear transport terms in the ocean for CERA-SAT (Q1-Q2);
- Explore the production and archiving of SST innovations in CERA-SAT (Q1-Q2);
- Define the interface and priorities for COP-C3S and ERA-CLIM research activities (Q1).

2.2 Work-package 2 – Future coupling methods

WP2 aims to develop future coupling methods with four main tasks: improving assimilation of surface data (SST and sea-ice concentration), developing the ocean analysis system (including use of ensembles and 4DVar), developing the land and ocean carbon components, and investigating the potential for improving the coupled data assimilation framework. Three deliverables have been completed so far (shown in green in Table 1 below), with the other deliverable dates having been moved back by 12 months to allow for better quality results, associated with the extension of the project.

Deliverable number	Deliverable title	Delivery date
D2.1	Assimilation of sea-surface temperature observations [METO]	27 => 39
D2.2	Assimilation of sea-ice observations [MERCO]	27 => 39
D2.3	Ensemble-based covariance estimates [CERFACS]	34 => 46
D2.4	Ensemble-based covariances in coupled data assimilation [CMCC]	24 => 36
D2.5	4D-Var in NEMOVAR [INRIA]	27 => 39
D2.6	Optimised model parameters for the carbon cycle [UVSQ]	34 => 46
D2.7	Alternatives for coupling ocean Biogeochemistry [MERCO]	34 => 46
D2.8	Weakly coupled assimilation methods [UREAD]	18
D2.9	Covariances from weakly coupled data assimilation [METO]	18
D2.10	Coupled-model drift [UREAD]	34 => 46
D2.11	Fully coupled data assimilation [INRIA]	34 => 46
D2.12	Status report WP2 [METO]	8

Table 1. Status of deliverables and amendments associated with the project extension.

2.2.1 Progress of the partners:

- METO have delivered a report written jointly with UREAD describing work to investigate techniques for estimation of coupled error covariances [D2.9]. They have also made significant progress in implementing an EOF-based error covariance model in NEMOVAR. Theoretical work and idealized experiments have been carried out on the development of improved SST bias correction techniques, and observing system experiments have been run to understand the impact of SST assimilation within a coupled data assimilation system.

- MERCO have assessed the impact of sea-ice concentration assimilation using a simple approach, and have begun investigating the use of anamorphosis transformations which are expected to improve upon this, particularly with regard to unassimilated variables such as sea-ice thickness. They have also assessed the options for producing a biogeochemistry reanalysis consistent with the physical one produced with CERA, while avoiding spin-up issues associated with the physical reanalysis being run in 9-year chunks: various tests have been run and the option to run NEMO-PISCES off-line, forced by CERA-20C atmospheric outputs has been chosen.
- CERFACS have developed a new version of NEMOVAR which allows hybrid variational/ensemble data assimilation schemes to be implemented. The use of a diffusion operator for localizing the ensemble covariance estimates has been implemented and tested. Estimation of localization length-scales and of hybrid weights has been developed.
- CMCC have worked on understanding the impact of different perturbation strategies for ocean ensemble generation. They have also investigated generating coupled error covariance relationships in a coupled framework using linearized versions of the bulk formulae relationships.
- INRIA have tested the use of 4DVar within the ECMWF CERA system showing some improvements in accuracy from 4DVar compared with 3DVar-FGAT, although at extra computational cost. They have also made progress on developing an idealized framework to assess strategies for more fully coupled data assimilation.
- UVSQ have assessed options for improving the parametrizations of the land carbon model and have run a set of optimizations with various data-set inputs in order to produce an improved set of model parameters.
- UREAD have contributed to a report on techniques to calculate coupled error covariances together with METO [D2.9], and have also produced a deliverable report describing strengths and weaknesses of existing coupled data assimilation systems developed at various institutes including the CERA system [D2.8]. They have started work on developing existing bias correction schemes for improving the forecasts produced using coupled DA systems.

2.2.2 Issues Discussed

During the breakout sessions of the General Assembly, two science issues were discussed which required some coordination between partners:

1. Coupled error covariances:
    - Results from METO, based on error covariance estimates from the innovations from a weakly coupled DA system show that, despite strong variable-variable correlations, error-

error correlations are small, at least for some variable-pairs such as 2m air temperature and SST, and wind-speed and SST.

- It was suggested that UREAD should calculate similar statistics from outputs of the CERA system which requires output of SST nudging term from the first outer loop. ECMWF agreed to provide these outputs.

2. Ensemble generation:

   - ECMWF, CMCC, MERCO all have implemented various schemes to generate perturbations for ensemble generations and it was suggested that they be compared/combined.
   - In order to better coordinate the code developments, it would be useful if the groups use NEMO3.6 so that developments can be shared. It was recognised that there is a need to define a protocol for assessing/comparing the different perturbation methods.

2.2.3 Plans for 2016

The various outstanding R&D activities of WP2 will continue in 2016. For code merging/integration, the NEMOVAR code merging work by METO/CERFACS/INRIA/ECMWF will continue as already planned. Developments by MERCO on a modular version of the anamorphosis code will be made available next year, and they will make recommendations for implementation in the variational context. LSCE/UVSQ will continue to discuss developments/inputs with ECMWF.

It was agreed to be useful to have a WP2 coordination meeting in about 6 months time, to be held in conjunction with another meeting. Two suggested meetings were the GODAE OceanView joint DA-TT and MEAP-TT workshop in July 2016, and a WMO workshop on coupled DA. The location and date of these meetings need to be confirmed and a decision about the most appropriate place for the meeting made.

2.2.4 Publications/presentations related with ERA-CLIM2

Submitted papers or papers in preparation related to ERA-CLIM2 work:

- Mulholland, D. P., P. Laloyaux, K. Haines and M.-A. Balmaseda. Origin and impact of initialisation shocks in coupled atmosphere-ocean forecasts, 2015. Monthly Weather Review, **143**, 4631–4644.
- Lea, D.J., I. Mirouze, M. J. Martin, R. R. King, A. Hines, D. Walters and M. Thurlow. Assessing a new coupled data assimilation system based on the Met Office coupled atmosphere, land, ocean, sea ice model, 2015. Monthly Weather Review, **143**, 4678–4694.
- Weaver, A. T., Tshimanga, J. and A. Piacentini, 2015. Representing correlation operators using an implicitly formulated diffusion equation solved with the Chebyshev iteration. In press in Q. J. Roy. Met. Soc.

- Peylin et al., A new multi-data stream Carbon Cycle Data Assimilation System part 1: system description. In preparation.
- Storto, A., C. Yang, S. Masina: Sensitivity of global ocean heat content from reanalyses to the atmospheric reanalysis forcing: a comparative study, in preparation for submission to GRL.
- Other papers relevant to WP2 work by Laloyaux included in WP1.

Presentations made at various conferences/workshops:

- World Weather Open Science Conference, Montreal, Canada, 16-21 August 2014.
- EGU General Assembly 2015, Vienna, 12-17 April 2015
- GODAE OceanView Data Assimilation Task Team workshop, Exeter, UK, 20-22 May 2015
- Copernicus Workshop on Climate Observation Requirements, ECMWF, Reading, UK, 29 June - 2 July 2015.
- The Year of Polar Prediction (YOPP) Summit, Geneva, Switzerland, 13-15 July 2015.
- Workshop on “Trait-based approaches to ocean life" Woods Hole Oceanographic Institution, 5-8 October, 2015
- GODAE OceanView Science Team meeting, Sydney, Australia, 2-6 Nov 2015.

2.2.5 Potential for a future ERA-CLIM3 project

It was clear from discussions that a future project would significantly benefit from WP2 work. Most of the existing developments in WP2 will need integrating/implementing in the CERA system. The focus for the development work in a future project will be determined to some extent by the relationship with the Copernicus climate service reanalysis. A more clearly defined relationship with Copernicus would therefore help to define the R&D for coupled data assimilation to improve future coupled reanalyses. It was also noted that it would be useful to have more atmospheric expertise within the development WP of a future project.

2.3 Work-package 3 – Earth-system observation

WP3 is well on track with most of the deliverables. For many data sets, prototypes were produced and are now in the phase of being checked, corrected, updated and extended. With the amendment, some deliverables were postponed in order to allow higher quality products or to be able to rescue or ingest additional data (some of them concern ‘nice to have’ datasets that were not foreseen in the proposal). All other delays (e.g., data rescue at MeteoFrance) have well justified technical reasons.

	Description (Lead beneficiary)	Original	Amend	Comment
D3.1	Data catalogue (UBERN)	6	6	delivered
D3.2	Priorities for data rescue (UBERN)	6	6	delivered
D3.3	Meta-database update (UBERN)	36	48	continuous
D3.4	In-situ data for reanalysis (UBERN)	75% 24	36	Spanish Ebro and North African upper air not in time
D3.5	In-situ data (other) (UBERN)	75% 30	42	Chile data not in time
D3.6	Quality-controlled version of D3.4 (UBERN)	75% 36	48	Allows more data from French overseas, Intl. days
D3.7	Quality-controlled version of D3.5 (UBERN)	75% 33	48	Allows more data from French overseas, Intl. days
D3.8	RTTOV updates (METO)	36	36	No change in deadline required
D3.9	Early satellite data (METO)	36	36	No change in deadline required
D3.10	AVHRR polar winds (EUMST)	80% 24	36	Slower due to dependence on other EUMST activities
D3.11	SSM/T2 and AMSU-B/MHS radiance data (EUMST)	24	24	No change in deadline required
D3.12	Geostationary radiance data (EUMST)	36	36	No change in deadline required
D3.13	AMV from MFG (EUMST)	80% 36	42	Slower due to small resources
D3.14	Radio occultation data (EUMST)	36	36	No change in deadline required
D3.15	HadISST2 update (METO)	18	18	delivered
D3.16	Ice thickness data (METO)	12	12	delivered
D3.17	Ocean database update (METO)	24	30	Extension allows higher quality deliverable
D3.18	Snow data product (FMI)	24	36	Extension allows higher quality deliverable
D3.19	QC version of snow data base (in situ) (FMI)	36	48	Extension allows higher quality deliverable
D3.20	HadISD update (METO)	12	12	delivered

Table 2. Amendments to the deliverables

2.3.1 Progress of the partners:

- UBERN has already delivered all data to ECMWF (and has already spent 100% of the money). There are no further plans of UBERN in WP3 with respect to digitizing data.
- FFCUL has already delivered a large amount of data, but some sources (Spanish upper-air, which is additional to the proposal, and Chilean data) are not yet fully done. Furthermore, several data sets still need to undergo QC.
- FFCUL has produced a global registry (Metadata-base) that can list sources of historical meteorological observations useful for Reanalyses, including surface, upper air, maritime and other relevant data that will prove very useful for future digitizing efforts as well as future reanalysis efforts. It includes inventories from large data rescue projects such as ERA-CLIM, ISPD, ISTI, ECA&D, ICA&D, ICOADS, CHUAN, IGRA, IEDRO, ACRE, and I-DARE (WMO Portal for Data Rescue).
- METEOFR has delivered a considerable amount of upper-air data, although there has been (and still is) the problem of inaccessible archives. Imaging of data sheets is mostly finished. The focus in 2015 was on formatting and digitizing. Two large chunks of data will be delivered in spring and summer 2016. Further digitizing efforts of upper-level wind will take place in 2016. Large amounts of data from around 1920 will be available, as well as extensive data form the overseas territories. The French National Project ARCLIM will continue digitization efforts of climate data.
- RIHMI has delivered most of its upper-air data (ca. 400’000 soundings, most of them not contained in IGRA and in IGRA2 beta). They also have done surface station data (516 stations, sub-daily prior to 1965) as well as snow data (20 stations, 1930s to present).

– EUMETSAT’s work is well on track. Some products are in the testing phase (e.g. AVHRR winds) or algorithms have been tested on one data set and must now be applied to others (e.g. for radio occultation using "WaveOptics" data for the Metop-A GRAS instrument have been delivered, processing for other instruments is still ongoing). The delivery of the Atmospheric Motion Vector data set from Meteosat data was postponed to 2017 because of the implementation of a new computing system for reprocessing at EUMETSAT.

– FMI is about to release a prototype of their assimilated snow data. They will produce a data set of station data as well as two versions of assimilated (GlobSnow variational assimilation) data set, one using only satellite information and the other using satellite as well as in situ data.

– METO has brought many of their data sets to a pre-release stage (papers submitted; data will be released upon acceptance of the papers). However, they have taken on a new data rescue task that will take two years (Southern Ocean Ship Data rescue of the 1930s, based on sources find in UK, Norwegian and Irish archives).

Figure 1. Upper-air data being rescued, digitised and formatted in ERA-CLIM and ERA-CLIM2 by all partners (Map created within the registry).

2.3.2 Issues Discussed

– *Delivery* - The form of data delivery from WP3 to ECMWF (and the responsibility at ECMWF) is not clearly specified for the surface station, and upper-air data and recently also satellite data.

– *Use of Upper-air data* - ERA-CLIM and ERA-CLIM2 have spent large efforts on rescuing historical upper-air data, whose sole purpose is reanalysis (see Fig. 1). Despite these huge efforts, which could be seen as the leading edge of European long-term reanalyses, the upper-air data are not used in any of the official ERA-CLIM or ERA-CLIM2 products. An experimental reanalysis (ERA-PreSAT) incorporating the upper-air data (and spanning 1939-1967) showed very good results, although some issue would still have to be fixed. WP3 therefore strongly recommends performing a long-term reanalysis product using upper-air data.

- *ERA-20C* - Various analyses reveal weaknesses in ERA-20C. While the focus is on fixing these errors for CERA-20C, this leaves behind an unsatisfactory reanalysis product. The long European uncoupled surface reanalysis – the one that will be compared with 20CRv2c – has bugs and is not updated (it is not clear whether the community will see the coupled CERA-20C as a new version of ERA-20C). The question is raised whether there shouldn't be a version ERA-20Cv2 with issues fixed.
- *Continuation of data rescue efforts* - The current data rescue efforts should be continued in some form, perhaps within an ERA-CLIM3 project.

2.3.3 Plans for 2016

WP3 has some important product deliverables next year. While the work seems progressing well, the delivery phase starts now. A workshop on observations for reanalyses will be organized early summer 2016 by WP3 and WP4.

2.3.4 Publications with ERA-CLIM2 Acknowledgement (not ERA-CLIM)

- Brönnimann S (2015) Climatic Changes Since 1700. Springer, Adv. Global Change Res 55, 375 pp.
- Brönnimann S, Fischer AM, Rozanov E, Poli P, Compo GP, Sardeshmukh PD (2015) Southward shift of the Northern tropical belt from 1945 to 1980. Nature Geoscience 8:969-974.
- Brugnara Y et al (2015) A collection of sub-daily pressure and temperature observations for the early instrumental period with a focus on the “year without a summer” 1816. Clim Past 11:1027-1047.
- Schmocker et al (2015) Trends in mean and extreme precipitation in the Mount Kenya region from observations and reanalyses. Int. J. Climatol doi:10.1002/joc.4438.
- Stickler A et al (2015) Upper-air observations from the German Atlantic Expedition (1925–27) and comparison with the Twentieth Century and ERA-20C reanalyses. Meteorol. Z. 22:349-358

2.3.5 Potential for a future ERA-CLIM3 project

It is clearly preferred that a future ERA-CLIM3 project would retain the observational component. Data rescue efforts for surface station, upper air data should be continued including the ERA-CLIM2 Global Registry. Data rescue should also be continued for satellite data and some experimental products might be derived from historical data sets. In addition, assessment of additional environmental parameters that are potentially valid for future prospective reanalyses and needing rescue efforts, should be provided.

2.4 Work-package 4 – Quantifying and reducing uncertainties

The objective of the work package is making optimal use of observations in reanalysis, and providing end users with meaningful information about uncertainties in reanalysis products. The first part of the work focuses on assessment of input data uncertainties as well as on providing improved input data. Development of QC and bias adjustment algorithms for data assimilation is an equally important task.

The work package involves seven ERA-CLIM2 partners: European Centre for Medium-Range Weather Forecasts (ECMWF), University of Vienna (UNIVIE), University of Bern (UNIBE), University of Versailles Saint-Quentin-en-Yvelines (UVSQ), Deutscher Wetterdienst (DWD), Fundacao da Faculdade de Ciencias da Universidade de Lisboa (FFCUL) and All-Russian Research Institute of Hydrometeorological Information-World Data Centre (RIHMI).

2.4.1 Summary of technical achievements

Together with ECMWF a bias model for radiosonde temperature biases has been developed at UNIVIE that can be used for variational bias correction within IFS. It has been extensively tested ‘’offline’’ using ERA-CLIM background departures (Milan and Haimberger, 2015). Very recently it has been implemented within IFS and is now being tested in low resolution assimilation experiments. In addition a new experimental version of the RAOBCORE/RICH dataset covering the period 1939-2014 has been developed. It uses a combination of ERA-preSAT, JRA55 and ERA-Interim reanalyses as reference for break detection. For adjustment of the breaks it uses neighboring radiosonde records. Annual variations of the biases are assumed equal to the annual cycle of the climatology of background departures, at least in the satellite era. Fig. 2 shows an example of these adjustments.

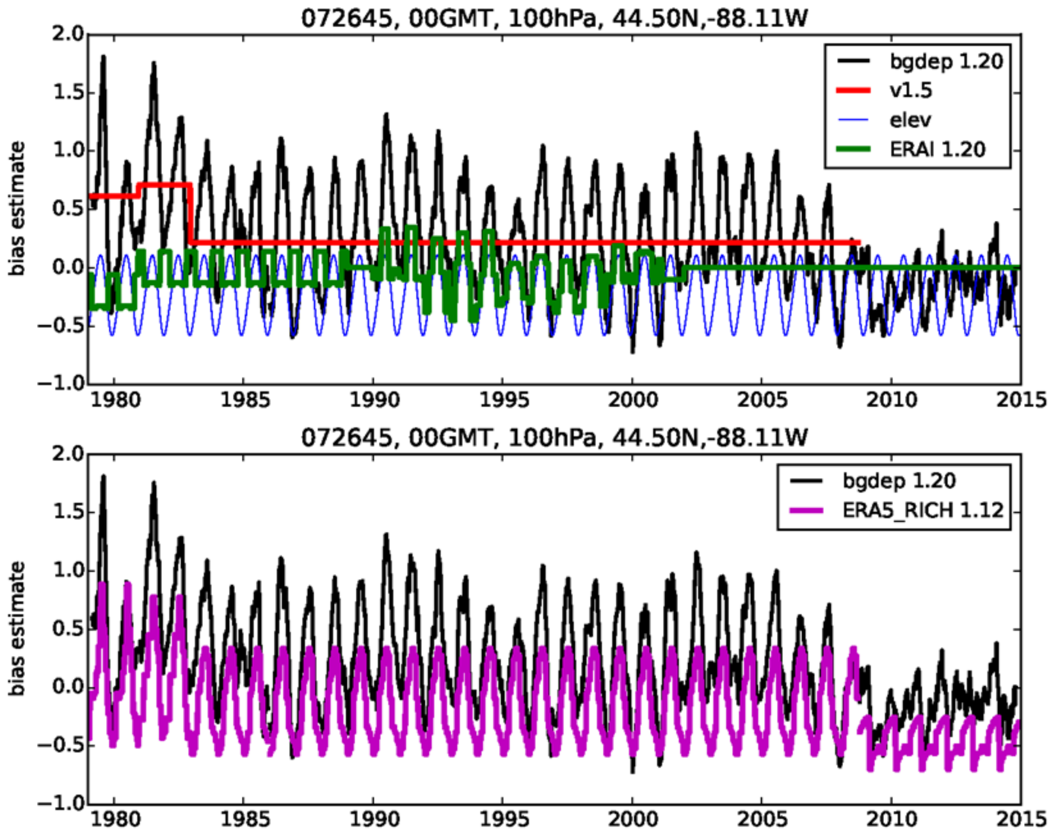

Figure 2. a) Time series of ERA-Interim background departures (black, 30 day running means, both panels), as well as time series of adjustments used in ERA-Interim (green curve) and in RAOBCORE v1.5 (red step function). Time series of solar elevation at this station in the US is also shown for reference (blue). Panel b) shows proposed bias correction for ERA5. It is based on RICH v1.5 adjustments (constant between breaks) + adjustment of solar elevation dependency of bias (variable, zero mean). Numbers in legends are standard deviations of background departures before and after adjustments.

They will be used in the upcoming ERA-5 reanalysis. Ingestion of the bias correction values into the assimilation system is technically working. The report on D4.1 describes the progress made with both the traditional and the variational radiosonde temperature bias correction approaches.

UVSQ reported on its work to provide uncertainty estimates for the main input drivers of the carbon re-analysis apart from the meteorology. UVSQ worked i) on the land cover changes and defined different plausible scenarios covering the past century, ii) on collecting and gathering forest management practices and iii) on the uncertainties of major ecosystem model parameters (e.g. photosynthetic capacity, respiration related parameters,…). UVSQ also started with the task T4.2 on "Diagnostics and uncertainty assessments of reanalysis output". They first assessed the uncertainty on the net ecosystem carbon fluxes from different land cover change scenarios and from model parameter uncertainties.

FFCUL has timely delivered its surface data Quality Control software with documentation in December 2014. After the implementation of the Windows FORTRAN and GNUplot code, a Linux version has been developed and is fully running on Ubuntu and other OS. RIHMI has further developed its statistical quality control methods for upper air, surface and snow data. Both have compared the observations with neighboring gridpoint values from ERA-20C and NOAA-20CR and presented the results at the GA.

Deliverable number	Deliverable title	Delivery date
D4.1	RS bias adjustments (UNIVIE)	20
D4.2	Updated RS bias adjustments (UNIVIE)	48
D4.3	Visualization tool for QC (FFCUL)	12
D4.4	QC for obs from FFCUL (FFCUL)	48
D4.5	QC for upper-air, surface and snow obs (RIHMI)	36
D4.6	Methodology for quantifying obs error (UBERN)	36
D4.7	Verification of precipitation against GPCC (DWD)	48
D4.8	Global energy, water, carbon cycles (ECMWF,UNIVIE, UVSQ)	48
D4.9	Upper air data qc (UBERN, RIHMI)	24
D4.10	Comparison with other reanalyses (UNIVIE; ECMWF)	48
D4.11	Low frequency variability and trends (ALL)	48
D4.12	Uncertainty of input parameters for carbon budget (UVSQ)	20
D4.13	Confidence intervals on carbon fluxes (UVSQ)	48
D4.14	Comparison of CTESSEL, ORCHIDEE flux estimates (ECMWF, UVSQ, UNIVIE)	48

Table 3. Status of all the deliverables in WP4. Green highlights deliverables provided on time, while orange highlights deliverables with a delay.

GPCC validated monthly precipitation totals from ERA-20C. Based on ERA-20C data, procedures to estimate differences in monthly precipitation totals between reanalysis and in-situ observations were developed, focusing on bias, correlation, trends and their differences as well as several skill scores, applying additional information like number of observations or precipitation type.

2.4.2 Status of all deliverables and deviations from the work plan

Deliverables 4.1, 4.3, 4.12 have been completed and D4.9 will be available on time (month 24 or 25). D4.5 and D4.6 are on track to be delivered on time. Deliverable D4.4 has been postponed to month 48 due to FFCUL personnel recruitment difficulties that delayed the extensive surface data digitization tasks and subsequent QC processing. The other deliverables D4.7, D4.10, D4.11, D4.14, D4.8 have been postponed to month 48 since they are strongly dependent on CERA-20C and ERA-5 which will not be completed until the end of 2016. This is in accord with the cost neutral amendment of the project granted by the EC.

2.4.3 Preliminary results

UBERN and ECMWF performed several detailed intercomparisons of surface and upper air observation data, the NOAA-20CR and ERA-20C, ERA-preSAT which showed the overall good quality of surface data only reanalyses but also revealed some difficulties, such as the assimilation of surface pressure observations near tropical cyclones, where too strict quality control led to overestimation of central pressure. This issue is fixed now in the IFS assimilation system but clearly showed the value of prompt validation of assimilation results through project partners.

The ability to diagnose changes of large scale circulation features with surface data only reanalyses has been demonstrated in study a published in Nature Geoscience (Brönnimann et al., 2015). It was found that the northern tropical belt had shifted southward in the 1980s compared to the 1940s. Major hydroclimatic changes such as droughts in Europe and the USA in the 1940s and 1950s as well as droughts in the Sahel in the 1970s were related to this change in the tropical circulation, which is well depicted in reanalysis data sets (ERA-20C, 20CR v2, and 20CR v2c) as well as upper-level reconstructions and surface observations.

UBERN and UNIVIE paid special attention to ERA-preSAT, an experimental assimilation of early upper air data for the period 1939-1967. Several evaluations highlighted the potential of assimilating the early upper air data but also some of the difficulties that must be expected. Fig. 3 shows that ERA-preSAT is the first multiyear assimilation product that has a realistic depiction of the Quasi-biennial oscillation back to the late 1940s, 10 years more than was possible before.

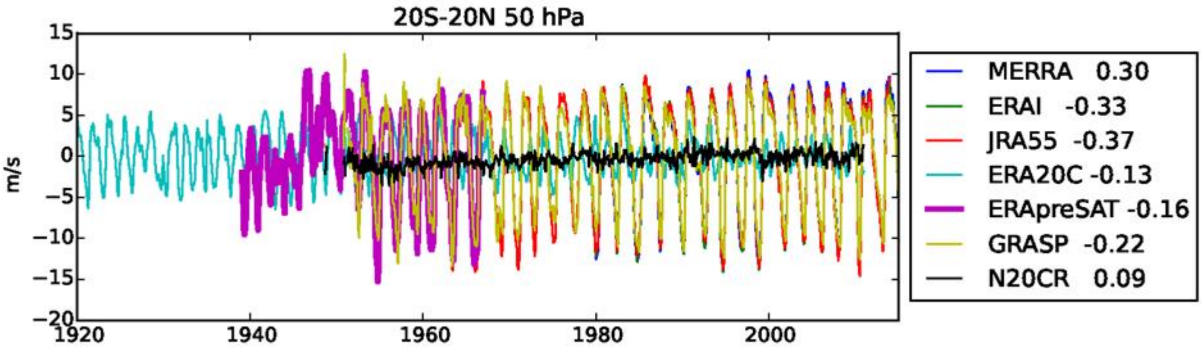

Figure 3. Time series of 50hPa u-wind component averaged zonally and over tropical belt for different reanalyses and one wind observation data set (GRASP). Note that ERA-preSAT is the only reanalysis that captures QBO from late 1940s up to 1957.

The very asymmetric distribution of observations in the 1940s appears to induce some spurious global mean north-south gradient of temperature (see Fig. 4) and, as a consequence, also spurious air-sea fluxes and meridional energy transports. It may be necessary to ensure that the ‘’climate’’ of the assimilating model is reconciled with the climate suggested by the upper air observations. This could be through bias adjustment of the early upper air data, which suffer from radiation errors or through bias correction or tuning of the assimilating model. This should help to avoid the development of such spurious patterns.

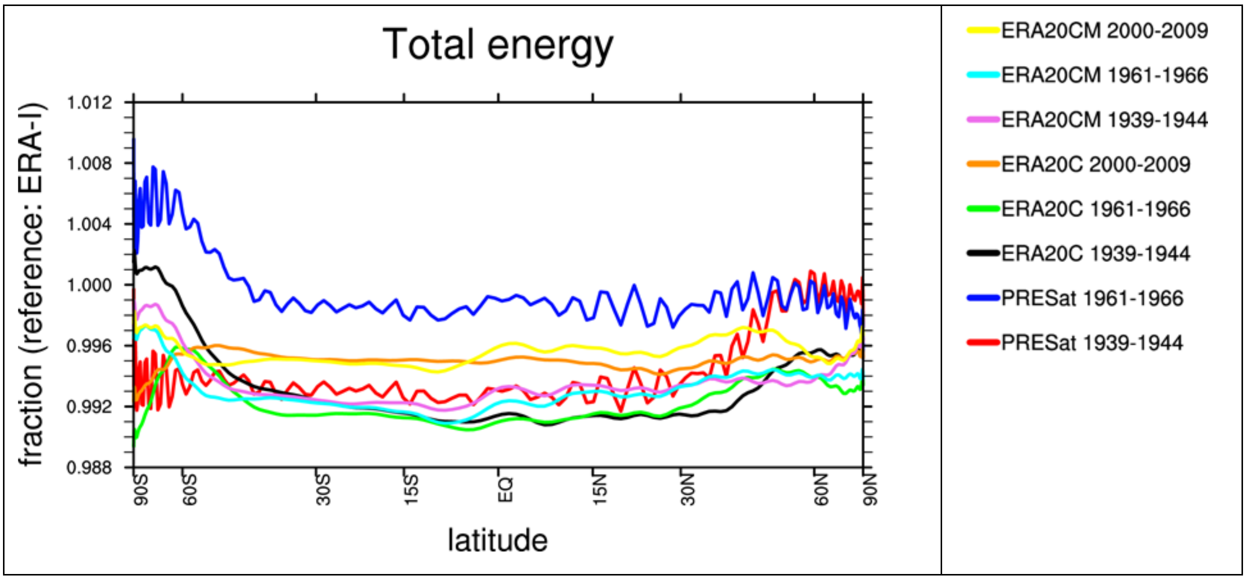

Figure 4. Zonal means of total energy (cpT+Lq integrated over whole atmosphere) from ERA-preSAT, ERA20C and the AMIP-type ERA-20CM runs for different periods. The 2000-2009 average of ERA-Interim is used as reference. A difference of 1% can be roughly converted into a difference of 2.5K in the column mean. Note that averages are generally warmer in later periods due to the warming climate. The big jump in ERA-preSAT is likely related to the improved observing system in the 1960s compared to the early 1940s.

DWD performed extensive comparison of the GPCC precipitation Full Data Monthly (Version 7, doi: 10.5676/DWD_GPCC/FD_M_V7_100) data set with monthly aggregated precipitation from ERA-20C. Special focus was set on bias and correlation, but also on trends and trends in differences. Not surprisingly, bias and correlation depends on the station density. The Alps in Europe, as an example of an orographic difficult region, shows a very good agreement between reanalysis and in-situ data, because the station density in both data sets is high. On the other hand, the difference between both data sets in the South American Andes is large, as the reanalysis was almost unsupported by observations there. The same was found for the correlations. To summarize, the largest differences are found in data sparse regions, mountainous regions and the tropics. As expected, changes in the number of used observations caused breaks in the time series of both data sets. Recently, a data set based on homogenized precipitation observations for Europe was produced by GPCC and applied to investigate the trends and their differences. First analyses indicate smaller drying trends in the central and eastern Mediterranean and lower wetting trends in Northern Europe in ERA-20c than in the new GPCC data set. On the other hand, wetting trends in Central and Western Europe are larger in ERA-20C than in the new GPCC data set. The largest differences are found in data sparse regions, near mountain ranges and in the tropics.

UVSQ investigated the uncertainties in estimating the effect of Land Use Change (LUC) on the global carbon cycle. The net transitions from natural to cropland ecosystems are provided by Hurtt et al.

(2011) but the adaptation to the 13 Plant Functional Types of ORCHIDEE requires additional hypothesis such as whether the crop land comes from forest or from natural grasses. Six LUC scenarios have been defined over the past century using different possible assumptions for these transitions. Details can be found in the report to D4.12

2.4.4 Collaboration between partners

The general assembly demonstrated close collaboration between WP1 and WP4 as well as between WP3 and WP4. The performance of ERA-20C and preliminary results of an extended assimilation run (ERA-preSAT) were discussed. ECMWF distributed an extensive documentation of its observation feedback archive for ICOADS and ISPD, which has been reviewed mainly by WP4 partners. FFCUL delivered documentation of its quality control software, which has then been tested by work package participants. ECMWF and UNIVIE worked closely together on an implementation of a variational bias adjustment scheme for radiosonde temperatures. UNVIE and ECMWF also collaborated on estimating coupled energy budgets from preliminary assimilation runs (ERA-preSAT as well as ORAP5, so far not CERA). RIHMI and FFCUL looked at departure statistics between their collected observations and reanalyses. Furthermore, FFCUL provided digitalized precipitation data to GPCC.

2.4.5 Risks and expectations

ERA-CLIM/ERACLIM2 have been launched with the intention of capacity building for the recently established COPERNICUS Climate Change Service. This has indeed been achieved as one can see from the fact that several key persons in ERA-CLIM2 have assumed office in COPERNICUS. Discussion in the general assembly revealed that due to this shift in personnel some important links between project partners have been broken. Most notably there is currently nobody in ERA-CLIM2 who can convert the upper air data collected in WP3 into the so-called odb2 format, which is necessary before the data can be assimilated and made available via the ECMWF web portal. As a result a large amount (about 1000 station records with different (mostly short) length, corresponding to ¾ of the newly digitized upper air data so far collected in ERA-CLIM and ERA-CLIM2) has been delivered but not converted. Many of them are from remote places, such as the Southern Ocean, the Atlantic and Siberia, and are expected to have quite some impact on a reanalysis of the early period.

Due to high priority obligations within the project, most notably completion of CERA-20C and start of CERA-SAT, and the limited available human resources there is some risk that the conversion of the digitized data into odb2 format and publication on the web portal may not happen. There is an even higher risk that the data will not be ingested in an assimilation run over the early period within the duration of ERA-CLIM2 unless a moderate amount of resources is allocated for such an assimilation in the upcoming months.

The assimilation run should cover at least the period 1939-1978, ideally as a backward extension of the ERA5 reanalysis. An alternative would be an extra assimilation run with conventional data only, covering the period 1918-2017, which could be termed “ERA100”. Both options are expected to realize the following enhancements compared to ERA-preSAT:

i. Close the gap between 1967 and 1978 that has never been assimilated at ECMWF since ERA-40. This would be straightforward if only conventional data were assimilated but may be a somewhat larger effort if also the early satellite data were (at least passively) assimilated.

ii. Assimilate tropical cyclone track data (this is already implemented)

iii. Assimilate all digitized upper air data collected so far and avoid ingestion of inconsistent duplicates as it happened with CHUAN data in ERA-preSAT

iv. Fix the issue of spurious interhemispheric gradients caused by the uneven distribution of upper air data before the IGY and by the inconsistency between model climate and those observations. This may require some experimentation since it is possible that either the early upper air observations are biased high or the model climate is biased low or both. Also the error covariance specification may have some impact.

It should be noted that the ''offline'' generation of upper air feedback information from ERA-20C or CERA-20C is no satisfactory alternative to a full assimilation of upper air data since the departures would be much larger than from a full assimilation. This may be seen from Fig. 5 which shows background departures from ERA-preSAT compared to analysis departures from ERA-20C at a station in the US.

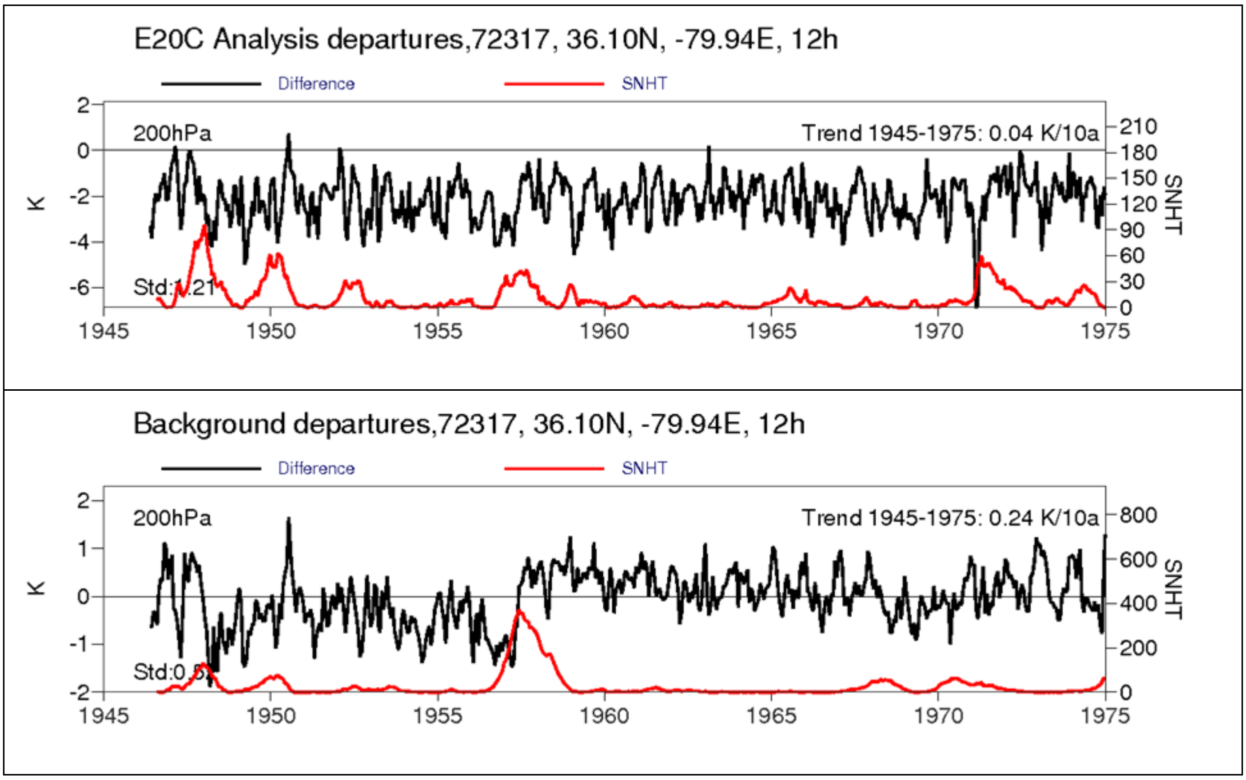

Figure 5. Time series of obs-ERA-20C analysis departures and obs-ERA-preSAT background departures for station Greensboro in the eastern US. Standard deviation of departures in upper panel is 1.21K, in the lower panel it is 0.52K. Note also that the break in 1956 is hardly detectable in the upper panel.

The consortium is well aware of these risks, and a workshop is planned in April 2016 to address them. There is still the expectation among WP3 and WP4 members that publication of the collected observations via the ECMWF web portal as well as the generation of observation feedback information, particularly for the upper air data, will happen within the project duration of ERA-CLIM2. There was agreement among WP3 and WP4 members that this would greatly enhance the value of deliverables D4.7, D4.10, D4.11, D4.14 and D4.8 and would contribute enormously to the project's outreach. Most project partners in WP3 and WP4 can wait until mid-2017 for such a reanalysis of the early period to be at least partially completed. In the meantime WP4 members will engage in the monitoring of the CERA-20C reanalysis as well as the ERA5 reanalysis that will be started very soon already under the COPERNICUS framework.

Waiting longer, e.g. for an EU-funded follow-on project of ERA-CLIM2 that would most likely not start before 2019, would mean that European reanalysis efforts of the early period fall behind other centres such as JMA, who have published a modern reanalysis that assimilated upper air data back to 1958 and are planning a reanalysis back to at least 1939. Also it would mean that an important added value of this collaborative project, namely the integration of the data digitized in WP3 and the quality control of these data and the assimilation runs using them, had not been realized.

UVSQ has been impacted by the delay on the provision of this reanalysis to estimate the uncertainties on the land carbon fluxes due to the meteorological forcing. ERA-20C forcing will therefore be used as a backup before the CERA-20C reanalysis becomes available. Now that the amendment will be granted, it is very likely that CERA-20C can be used as input for carbon cycle related products within the duration of the project.

DWD is going to validate precipitation of ERA-20C against in situ data, moving its focus from monthly comparisons to the validation of trends in Europe, as a new homogenized analysis for substantiated trend estimations is now accessible, as well as daily precipitation amounts. Additional information like precipitation type as well as wind speed and direction would give a further possibility to analyze the performance of the reanalysis with respect to daily data. As ETCCDIs (Klein Tank et al., 2009) are established as a measure for change in climate and extremes based on daily data, these would also be applied. As soon as CERA-20C becomes available, GPCC will validate including appropriate reporting and documentation within the time limits potentially enforced by a further delayed delivery of CERA-20C. If there is still time spare and a sufficiently long time series can be constructed from the reanalysis streams, GPCC will also start to validate ERA5, as a kind contribution to ERA-CLIM2. One WP4 member also asked also for ensembles of the gridded precipitation product since there are uncertainties not only in the spatial interpolation but also in the treatment of outliers/extreme values of this quantity. Although the ensemble approach has become an established method of uncertainty assessment, the elaborated quality control procedure, the large data base and setup of interpolation procedure of GPCC warrant a high-level of a priori control on outliers in the monthly GPCC precipitation analyses, in contrast to other data sets published in the field. Therefore the improvement potential of the ensemble approach is limited. Comprehensive uncertainty estimations for the daily analyses have been developed and published by Schamm et al. (2014) and will be used in the validation. In addition, GPCC can estimate the uncertainty of the monthly analyses through adaptation of the interpolation techniques it already applies for its daily analyses, or through ensemble procedures.

2.4.6 Outreach and dissemination

The observation feedback archive is now available for two important surface data sets, the ISPD and ICOADS. It includes not only the observations but also background departures from ERA-20C and is accessible via http://apps.ecmwf.int/datasets/ . Comprehensive documentation is provided in the respective report by Hersbach et al. (2015). This has been acknowledged by many. A quite large number papers have been submitted covering research topics of WP4. These have been listed already in the midterm review report of ERA-CLIM2 and are not repeated here. Results have been presented at many occasions at conferences, workshops etc.

2.4.7 References

- Brönnimann, S., A. M. Fischer, E. Rozanov, P. Poli, G. P. Compo, P. D. Sardeshmukh (2015): Southward Shift of the Northern Tropical Belt from 1945 to 1980. Nature Geoscience.
- Hersbach, H., Poli, P. and Dee, D. P., 2015: The observation feedback archive for the ICOADS and ISPD data sets. ERA report series 18, http://www.ecmwf.int/sites/default/files/elibrary/2015/9871-observation-feedback-archive-icoads-and-ispd-data-sets.pdf
- Hurtt, G. C. et al. (2011) Harmonization of Land-Use Scenarios for the Period 1500-2100: 600 Years of Global Gridded Annual Land-Use Transitions, Wood Harvest, and Resulting Secondary Lands, Climatic Change, DOI: 10.1007/s10584-011-0153-2
- Klein Tank, A. M. G., Zwiers, F. W. and Zhang, X., 2009: Guidelines on Analysis of extremes in a changing climate in support of informed decisions for adaptation, WMO-TD 1500, http://www.wmo.int/pages/prog/wcp/wcdmp/documents/WCDMP_72_TD_1500_en_1.pdf
- Milan, M. and L. Haimberger, 2015: Predictors and grouping for variational bias correction of radiosondes. J. Geophys. Res. D, in press.
- Schamm, K., Ziese, M., Becker, A., Finger, P., Meyer-Christoffer, A.,Schneider, U., Schröder, M. and Stender, P., 2014: Global gridded precipitation over land: a description of the new GPCC First Guess Daily product, Earth System Science Data, Vol. 6, Is. 1, pp 49-60, DOI: 10.5194/essd-6-49-2014

3 Advisers' comments

3.1 General comments

The understanding of climate change is highly dependent of the available global satellite and conventional observational data. The other component in the understanding of climate is the development of atmospheric and ocean models and the assimilation of observational data using these models.

The earlier reanalyses ERA-15 and ERA-40 have received many input data and all input data for the pre-1979 period from outside sources mainly from NCAR. The ERA-CLIM and ERA-CLIM2 have initiated an important European program to identify, collect, digitize and homogenize historical global oceanic/ land observations. Valuable expertise has been developed within the program and during the work new observation sources have been identified in the archives. Reprocessing of satellite data and upgrading of radiative transfer models allow reanalyses to use satellite more accurately and in a more consistent way. Also the sea surface temperature and ice limit data are more accurately analysed than before.

That is why this critical work on observations can by no means seen as finished. Rather it needs to be seen as an ongoing iterative activity in support of Copernicus Climate Change Service and needs to a secure funding for a considerable time into the future.

Before the new/ reprocessed observational data can be used in the data assimilation they have to be ingested into a "clean" input database together with other data. Currently there seems to be a lack of human resources for this technical task and also for testing of the new data sources within the data assimilation. It is likely that some of the new data have to be included in the first assimilations in passive mode for the homogenization purposes and monitoring purposes.

In order to replace ERA-Interim with the next reanalysis system a careful evaluation has to be done of what assimilation components and the observational data to be used and to test the system with long assimilations. For the evaluation of the performance both internal and external experts should be used.

As a priority task is to allocate enough resources in creating of the "clean" observation database. It would be useful if the external expert groups (EUMETSAT, UBERN, UVIE, METFR, FMI, …) would carry out an independent evaluation of their data.

3.2 CERA-20C

One of the main products for the scientific community from ERA-Clim2 will be CERA-20C. There are a number of substantial atmospheric issues in ERA-20C that will propagate into CERA-20C unless addressed and potentially have a major negative impact on the top part of the ocean circulation as a result of the atmosphere-ocean coupling over the 9 years of each stream. If feasible, investigation and understanding of these shortcomings to ERA-20C using both ECMWF personnel and external partners is a desirable undertaking that should start now with a survey and a synthesis of issues identified by the community. It is important for ECMWF's scientific credibility to deliver CERA-20C that fixes the major issues in ERA-20C and hopefully is an advance on 20CR.

Other aspects related to CERA-20C:

- Initial conditions and spin-up of the ocean model for each stream? Can discontinuities between streams be avoided?
- Will sea ice assimilation over the 100 years be consistent and reliable?
- Initial conditions and spin-up of the land model for each stream? Can discontinuities between streams be avoided?
- Will snow cover assimilation over the 100 years be consistent and reliable?
- Production of CERA-20CM to complement CERA-20C is desirable.
- Continued digitization of surface data for data sparse areas is highly desirable, e.g., Orcadas and South Georgia.

4 Looking ahead: bridging between R&D and operational production

Figure 6 illustrates the reanalyses production stream currently running and plan for the future five years at ECMWF:

- ERA-Interim (European ReAnalysis, Interim version): ECMWF on-going reanalysis (planned to be replaced by ERA5 in 2018);
- CERA-20C (Coupled ocean-land-atmosphere European ReAnalysis of the 20th Century) and CERA-SAT (Coupled ocean-land-atmosphere European ReAnalysis of the SATellite era): ERA-CLIM2 is now producing CERA-20C (planned to be completed by the end of 2016) and plans to establish a prototype CERA-SAT, to be run for a sub-period of the satellite era (say few years).
- ERA5 (European ReAnalysis version 5): Copernicus Climate Change Services (C3S) should start in Q1-2016 the production of ERA5 (European Re-Analysis version 5), that will replace ERA-Interim. The plan is for ERA5 to reach real-time at the end of 2017, and then replace ERA-Interim sometime in 2018.
- 1918-2018 CERA-PreSAT/1979-2020 CERA: possible deliverables of the proposed project ERA-CLIM3;
- ERA6 or CERA6: future reanalysis to replace ERA5 in 2019/20, to be built on ERA-CLIM3 work and reanalyses;

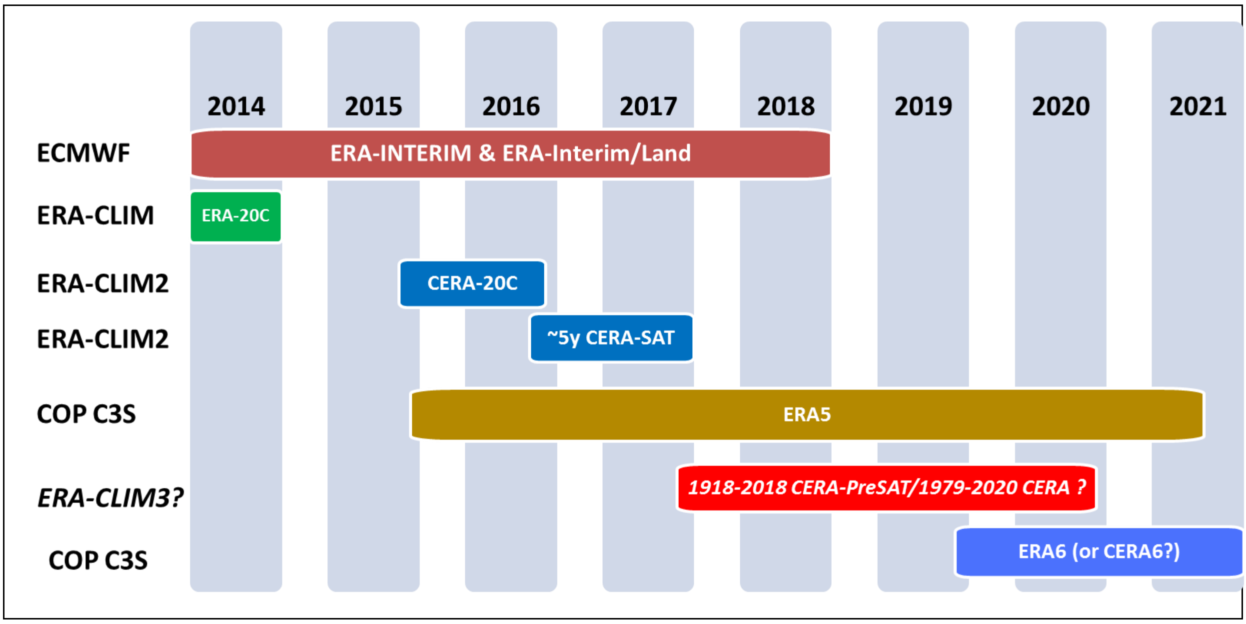

Figure 6. Reanalyses streams produced at ECMWF.

Figure 6 illustrates how the proposal discussed at the 2nd General Assembly to establish a project (let's call it for now ERA-CLIM3), starting at the end of 2017 and lasting for four years (say 1/1/2017 to 31/12/2020), could help bridging the Research and Development activities funded by EU project [ERA-CLIM2, and follow-on H2020 project(s)] and the operational activities funded by Copernicus services. The follow-on project ERA-CLIM3 could help to achieve three key goals:

i. Prepare CERA6, by upgrading the CERA-SAT prototype system developed in ERA-CLIM3; CERA6 should include all the developments and improvements that are now developed within ERA-CLIM2, should test them, and prepare CERA6 to be able to assimilate all the observations recovered within ERA-CLIM and ERA-CLIM2;

ii. Test CERA6 for few years and deliver it to C3S for operation production of the next reanalysis that will replace ERA5;

iii. Produce a 100-year CERA-Pre-SAT (a Coupled European Reanalysis of the Pre-SATellite era), to be run for e.g. from 1918 to 2018, using also all the Upper-Air (UA) data recovered within ERA-CLIM and ERA-CLIM2.

ERA-CLIM3 could include:

1. More data rescue: e.g. sea-level data from tide gauges; Atmospheric Motion Vectors from Nimbus satellite instrument THIR going back to early '70s, or addressing radiance records from older microwave instruments (NEMS and SCAMS) also covering early 1970s, ...
2. The addition of more existing data (e.g. for the ocean/sea-ice CRYOSAT, SMOS, Altimeter, ..)
3. The assimilation of new data (e.g. from SENTINELS, deep ARGO, ..)

4. The development and testing of new/better ways of assimilating sea-surface data:
    a) Assimilation of high-frequency satellite data
    b) Assimilation of historical and sparse data (sea level and sea-surface temperature)
5. The testing of existing assimilation methods and of new ones:
    a) Assessment/development of more fully coupled DA methods
    b) R&D of hybrid methods (flow dependent background error stats) in the ocean (e.g. from the EDA)
    c) R&D of 4D-Var methods in the ocean (including sea-ice)
    d) R&D of weak-constraint, multi-temporal-scales methods
    e) Development of more scalable/flexible methods (e.g. OOPS)
    f) Better handling/simulation of observation errors
6. Better integration of carbon, bio-chemistry and aerosols:
    a) observational constraints on fluxes in these subsystems
    b) still above average improvement can be expected in remote sensing of these constituents/subsystems
7. Higher-quality, higher-frequency output data (if asked for)

Research and developments in all these areas should deliver improvements to be included in COP-C3S first coupled re-analysis (CERA6) and will advance our knowledge for the future (higher-quality) systems.

5 Forthcoming meetings and strategic outlook

5.1 ERA-CLIM2 meetings planned for 2016 and 2017

It was decided to organize the following meetings in 2016:

- 25 April 2016: ERA-CLIM2 Review Meeting – To be organized at ECMWF, and to be attended by the Project Coordinator, WP Leaders, the EU Representative and the project reviewers;
- 26-27 April 2016: Progress meeting (1 or 2 day meeting) – To be organized at ECMWF, and to be attended by the Leaders of WP1-3-4 and whoever is interested;
- Q2-2016: User WS on observations for reanalysis (project’s deliverable D5.5, due by M30) – To be organized by L Haimberger and S Broennimann, possibly jointly with ACRE Meeting (Ireland?)

- Q2-2016: WP2 Progress Meeting – Q2-2016, outside Europe? TDB
- 2016 or 2017: WS on Coupled Data-Assimilation (one of the project's deliverables) – Could be joint WS with WMO/DAOS in 2016, or joint with ECMWF WS in 2017 (TDB)

Looking ahead to 2017, the following meetings are planned:

- 16-20 or 23-27 Jan 2017: ERA-CLIM2 3rd General Assembly (one of the project's deliverables, to be held by M36) – To be organized by L Haimberger in Wien (TBC)
- Q4-2017 - ERA-CLIM2 4th General Assembly (2017 – M48) – (close to the WCRP/WWRP 5th International Reanalysis Conference)? At ECMWF

5.2 Action point on the strategic outlook

As mentioned above, it was clear from the GA2's discussions that there is a gap between the end of ERA-CLIM2 and the operational activities in coupled reanalysis foreseen within Copernicus Climate Change Services. During the plenary discussion, it was decided to prepare a short document to summarize this view and highlight the potential value of having a follow-on project that could fill the gap and bridge between ERA-CLIM2 and the future operational coupled reanalysis of the pre-satellite and satellite eras. The project Coordinator will prepare a first draft of this document by the end of February 2016 with the help from the work-package leaders.

6 Appendix A – Agenda of the ERA-CLIM2 2nd General Assembly

Wednesday 9 December (1300-1800)		
1300	Start of General Assembly	
1300–1330	01 - Introduction	R Buizza
1330-1530	***WP1** (Global 20th century reanalysis) and **WP5** (Service developments)*	
1330-1345	02 - Overview of WP1	P Laloyaux
1345-1415	03 - Status, plans and first CERA results	P Laloyaux
1415-1430	04- Ocean initialisation and monitoring for CERA	E de Boisseson
1430-1440	05 - Initial diagnostics on CERA-20C ensemble performance	P Dahlgren
1440-1450	06 - Monitoring tools for CERA	D Schepers
1450-1505	07 – Surface observations' usage	S Hirahara
1505-1520	08 - CERA-LAND	P Peylin
1520-1530	09 - CERA data servers	P Laloyaux
1530-1600	Coffee break	
1600-1800	***WP3** (Earth system observation)*	
1600-1610	10 - Overview of WP3	S Brönnimann
1610-1625	11 - Upper Air, surface and snow data deliverables contributed by RIHMI to WP3	A Sterin
1625-1640	12 - Progress on Météo France work	S Jourdain
1640-1655	13 - Progress on digitising Portuguese and Chilean surface data plus Spanish pilot balloon data	M A Valente
1655-1700	14 - ERA-CLIM2 Global Registry	M A Valente
1700-1715	15 - Progress on Met Office work	N Rayner
1715-1730	16 - Satellite data records for ERA-CLIM2	R Roebeling
1730-1745	17 - Progress on FMI work	J Pulliainen
1745-1800	Questions and Discussion	
1800	End of first day	
1830	WS Dinner (at EUMETSAT) offered by EUMETSAT	

Thursday 10 December (0900-1800)		
0900-1100	***WP2** (Future coupling methods)*	
0900-0910	18 - Overview of WP2	M Martin
0910-0920	19 - Improved assimilation of SST observations	M Martin
0920-0930	20 -Improved assimilation of sea-ice observations	C-E Testut

0930-0950	21 - Use of ensemble information and development of efficient 4D-Var in ocean analysis	A Weaver
0950-1000	22 - Generation of ocean ensemble information	A Storto
1000-1010	23 - Land carbon developments	P Peylin
1010-1020	24 - Ocean biogeochemistry in reanalysis	M Gehlen
1020-1040	25 -Strengths/weaknesses of weakly coupled DA, coupled error covariance estimation and developing bias correction methods for coupled reanalysis	K Haines
1040-1050	26 -Strongly coupled DA in simplified systems	F Lemarié
1050-1100	Questions	
1100-1130	Coffee break	
1130-1430	***WP4** (Quantifying and reducing uncertainties)*	
1130-1135	27 - Overview of WP4	L Haimberger
1135-1155	28 - Homogenization tests on surface data using 20CR and ERA20C as reference series	M A Valente
1155-1215	29 - Precipitation assessment with focus on station density, convective and stratiform precipitation	E Rustemeier
1215-1230	30 -Input uncertainties for carbon estimates	P Peylin
1230-1330	Lunch break	
1330-1345	31 - On reproducing rescued UA data for the 50's of last century and IGRA dataset by reanalyses	A Sterin
1345-1400	32 - Radiosonde humidity bias adjustments using reanalysis background departures	M Blaschek
1400-1415	33 - Radiosonde bias adjustments as input for ERA5	L Haimberger
1415-1430	34 - Results from ERA-preSAT – Chances and challenges of assimilating pre-IGY upper air data	S Brönnimann (presented by L Haimberger)
1430-1500	Coffee break	
1500-1800	***Working Groups** (break-out sessions, WP1/WP2/WP3/WP4)*	
1700-1715	35 - Report of WG discussion: WP1 and WP2	
1715-1730	36 - Report of WG discussion: WP3 and WP4	
1730-18.00	Discussion	
18.00	End of second day	

Friday 11 December (0900-1300)		
0900-1100	***Plenary discussion** (WP Leaders to present plan for next 12 months)*	
0900-0915	37 - WP1 plan for 2016	M Alonso-Balmaseda
0915-0930	38 – WP2 plan for 2016	M Martin
0930-0945	39 – WP3 plan for 2016	J Schulz

0945-1000	40 – WP4 plan for 2016	L Haimberger
1000-1030	41 - Review and comments	S Uppala and D Bromwich
1030-1100	Discussion	Chaired by R Buizza
1100-1130	Coffee break	
1130-1300	***Project summary***	
1130-1145	EU comments to ERA-CLIM2 project	M Kacik
1145-1300	42 – Looking ahead	Chaired by R Buizza
1300	End of 2nd General Assembly	

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(Completed on 18 January 2016)