

## Work Package 1/5

# Global 20<sup>th</sup> century reanalysis & Service development

The logo for CRAClim2 is displayed in a large, stylized font. The letters are arranged in two rows: 'CRA' on top and 'CLIM2' on the bottom. The 'C' in the top row is blue, while the 'C' in the bottom row is red. The 'L' is blue, 'I' is light blue, 'M' is yellow, and '2' is grey.

Review Meeting - P. Laloyaux & M. Fuentes - 19 January 2017

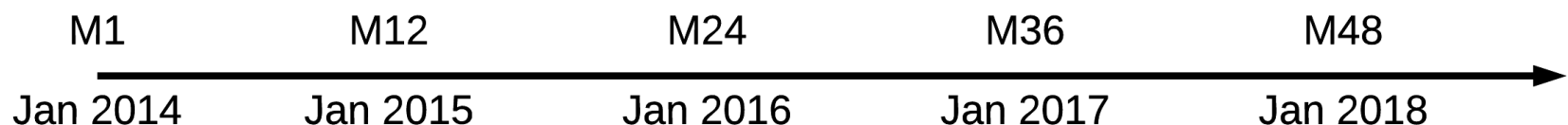


# WP1: Status of deliverables

| Deliverable | Description       | Delivery date | Comments  |
|-------------|-------------------|---------------|-----------|
| D1.1        | CERA-20C          | 36            | Delivered |
| D1.2        | CERA-20C/Carbon   | 48            | On track  |
| D1.3        | CERA-SAT          | 48            | On track  |
| D1.4        | CERA-SAT/Land     | 48            | On track  |
| D1.5        | Status report WP1 | 8             | Delivered |

Key achievements in the past 9 months

Work planned for the rest of the project



# Production of CERA-20C (D1.1)

Reconstruct the past climate/weather of the earth system of the 20<sup>th</sup> century



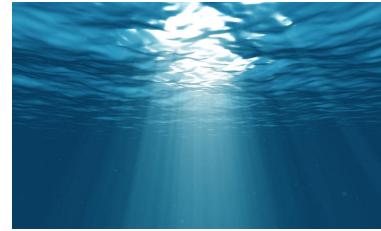
*Atmosphere*



*Land*



*Wave*



*Ocean*



*Sea ice*

Key achievements in the past 9 months



Production of CERA-20C is completed

7 months of production

400 Nodes (20,000 cores, 5% of ECMWF HPC system)

500,000 4D-Var problems to solve (one every 30 sec.)

## CERA-20C

[Expand all](#) [Collapse all](#)

CERA-20C is the ECMWF 10-member ensemble of coupled climate reanalyses of the 20th century, from 1901-2010. It is based on the [CERA](#) assimilation system, which assimilates only surface pressure and marine wind observations as well as ocean temperature and salinity profiles. It is an outcome of the [ERA-CLIM2](#) project.

### Product description

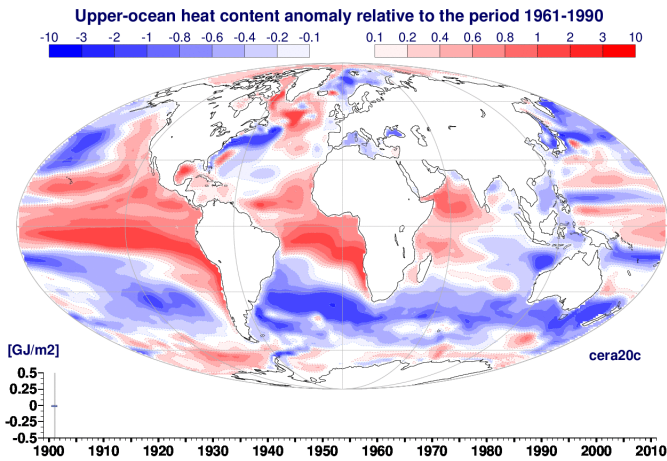
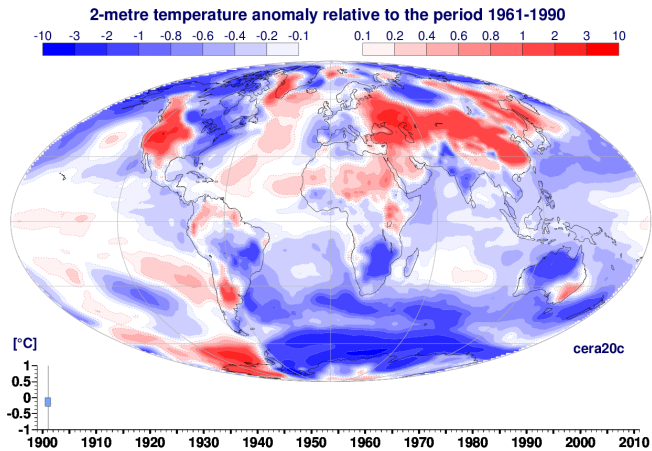
CERA-20C reconstructs the past weather and climate of the Earth system including the atmosphere, ocean, land, waves and sea ice. To account for errors in the observational record as well as model error, CERA-20C provides a 10-member ensemble of reanalyses.

CERA-20C was produced with [IFS version Cy41r2](#) and the atmospheric forcings as the final version of the atmospheric model integration [ERA-20CM](#) and [ERA-20C](#). The air-sea interface is relaxed towards the sea-surface temperature from the HADISST2 monthly product to avoid model drift while enabling the simulation of coupled processes. No data assimilation is performed in the land, wave and sea-ice components, but the use of the coupled model ensures a dynamically consistent Earth system estimate at each time.

User documentation online and report submitted

# Production of CERA-20C (D1.1)

## Data Visualisation



## Outreach: newsletter, website, seminar, ...

ECMWF Newsletter No. 146 – Winter 2015/16

NEWS

### CERA-20C production has started

**PATRICK LALOYVAUX**  
ECMWF has started the production of a new global 20th-century reanalysis, reconstructing the Earth's past weather from historical observations. This reanalysis, called CERA-20C, is based on a coupled atmosphere-ocean data assimilation system developed over the last few years in the Research Department. Twentieth-century reanalyses provide a long record of low-frequency climate variability and change using a consistent set of observations. They can serve to provide a longer-term perspective on more recent temperature anomalies. The evolution of the global weather for the period 1961-2010 will be

record and the forecast model to provide an indication of the confidence we can have in the data. The CERA-20C reanalysis is part of the EU-funded ERA-CLIM2 project, which builds on the ERA-CLIM project. The latter produced ERA-20C, a first 20th-century reanalysis for the atmosphere (ECMWF Newsletter No. 141).  
**From o**  
Climate  
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underst  
CLIM2"]  
dataset

international datasets is crucial to extend reanalysis activities far back into the past. Climate reanalyses follow a whitelisting approach to data selection, where observations are used only if they are known to be suitable for climate applications.

ECMWF Newsletter No. 150 – Winter 2016/17

DOI: 10.18412/ECMWF-NO-2016-10

METEOROLOGY

### CERA-20C: An Earth system approach to climate reanalysis

**PATRICK LALOYVAUX,  
ERIC DE BOISSESON, PER DAHLGREN**  
ECMWF has completed the production of a new global 20th-century reanalysis which aims to reconstruct the past weather and climate of the Earth system including the atmosphere, ocean, land, waves and sea ice. This coupled climate reanalysis, called CERA-20C, is part of the EU-funded ERA-CLIM2 project, which builds on the ERA-CLIM project. The latter produced ERA-20C, a 20th-century reanalysis for the atmosphere, land and waves only (Poli et al., 2016).

First results show that CERA-20C improves on the representation of atmosphere-ocean heat fluxes and of mean sea level pressure compared to previous reanalyses. At the same time, there are undesirable discontinuities in ocean heat content and an excessive accumulation of Arctic sea ice.

Improvements in ocean models, data assimilation methods and forcing fluxes.

The various reanalysis products have proven to be an important resource for weather and climate-related research as well as societal applications at large. Reanalyses also support numerical weather prediction since they can be used for the initialisation of reforecasts, the calibration of ensemble forecasts and model validation and verification. Reanalyses make it possible to study the inter-annual variability of forecast skill and to test new model versions on past severe weather cases. ERA-Interim and ERA5 are the current operational reanalyses at ECMWF for the atmosphere and the ocean, respectively. They are created via an unchanging frozen data assimilation system and model, which ingest all available observations to provide the best state estimate over the target period.

Extending these reanalyses further back in time is a tremendous scientific challenge as the observing system

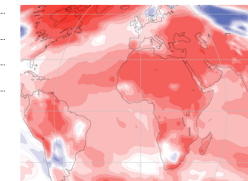
ECMWF

About Forecasts Computing Research Learning Patrick Laloyaux Search site Go



### Production of new 20th century climate reanalysis is complete

3 August 2016



ECMWF has completed a new, innovative reanalysis of the global climate in the 20th century.

Work to produce the CERA-20C reanalysis has been funded by the [EU FP7 project ERA-CLIM2](#).

Scientists will now study the data to see what new insights CERA-20C brings.

Reanalyses provide a comprehensive description of the climate by combining models with observations.

ECMWF has developed a coupled data assimilation system for climate reanalysis (CERA), in which ocean and atmospheric observations are assimilated simultaneously into a coupled atmosphere-ocean model.

"It will be interesting to see how this new way of using observations can contribute to our understanding of the global climate over the last 100 years," says Patrick Laloyaux, one of the scientists working on the project.

"By analysing the results, we also expect to learn more about how well the coupled data assimilation performed and how it can be improved," he adds.

One of the features of CERA-20C is the ability to provide information about uncertainties in the reanalysis. This is achieved by producing an ensemble of slightly perturbed reanalyses.

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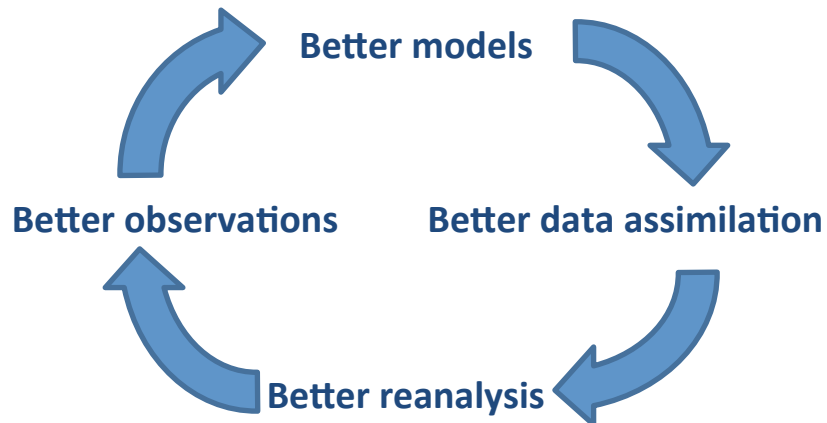
Contact us

# Production of CERA-20C (D1.1)

Coupled atmosphere-ocean part of the new ECMWF roadmap and acknowledge by the Scientific Advisory Committee (SAC)



*“Whilst Earth system modelling is already in its early stages, its application to data assimilation is very novel and results could be ground-breaking”  
Roadmap to 2025*



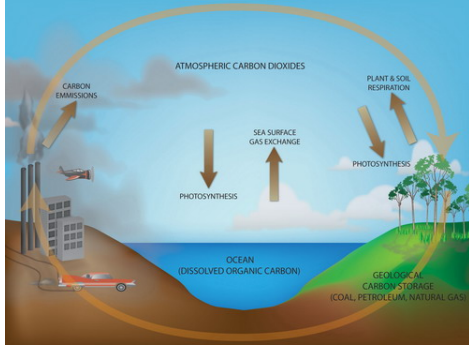
Observation feedback sent to data provider to improve QC

## Work planned for the rest of the project

- continue the outreach
- submit a peer-reviewed paper
- provide user support

# Production of CERA-20C/Carbon (D1.2)

Produce associated reanalyses to reconstruct the evolution of the carbon fluxes

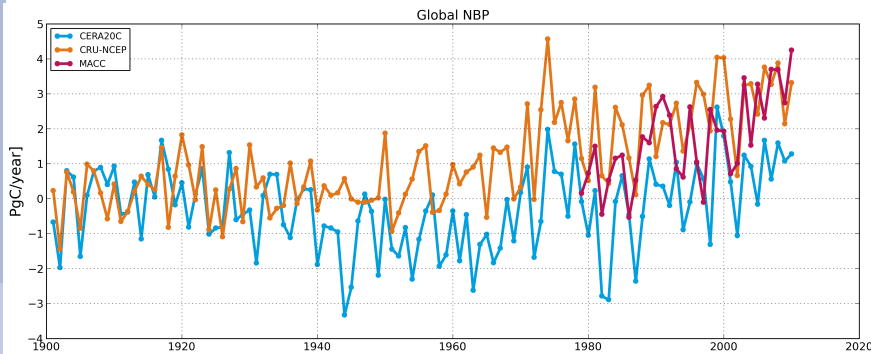


estimate carbon flux anomalies over the 20<sup>th</sup> century based on forcings from CERA-20C

## Key achievements in the past 9 months

A first carbon reanalysis for the ocean has been produced  
*assessment of the sea-air CO<sub>2</sub> flux shows promising results when compared to observations*

A first carbon reanalysis for the land has been produced  
*Good agreement when compared to other products*



Global Net Carbon fluxes  
ORCHIDEE forced by CERA-20C  
ORCHIDEE forced by CRU-NCEP  
MACC2 atm. CO<sub>2</sub> inversion

Work planned for the rest of the project

New and improved version to be delivered by M48

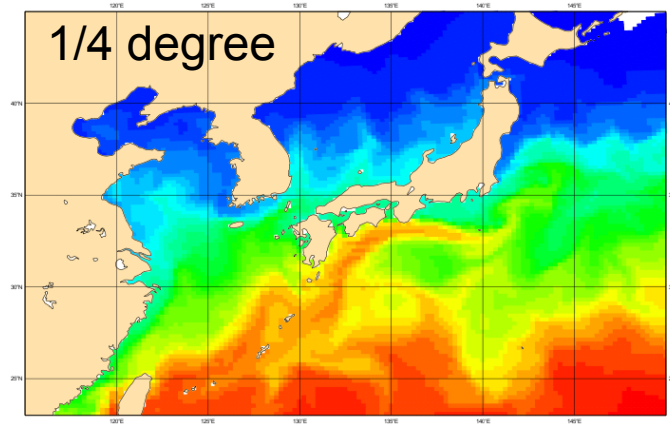
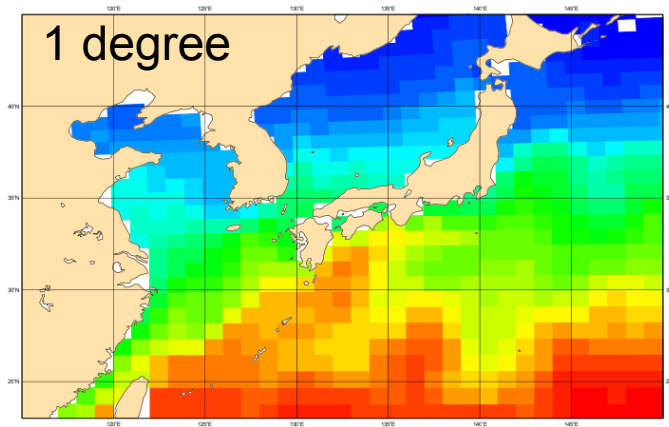
# Production of CERA-SAT & CERA-SAT/Land (D1.3 & D1.4)

## Production of coupled reanalysis at higher resolution

Resolution upgrade:

- atmosphere from 110km to 65km
- ocean from 1 degree (42 levels) to 1/4 degree (75 levels)

Satellite assimilation



## Key achievements in the past 9 months

Implementation of CERA-SAT is completed  
Production is ongoing (2008-2016)

## Work planned for the rest of the project

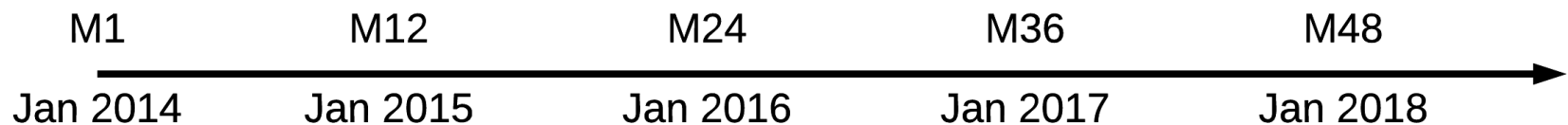
CERA-SAT production to be completed by M42  
Dissemination and offline carbon reanalysis by M48

## WP5: Status of deliverables

| Deliverable | Description             | Delivery date | Comments  |
|-------------|-------------------------|---------------|-----------|
| D5.1        | MARS support for NetCDF | 30            | Delivered |
| D5.2        | CERA Data Servers       | 48            | On track  |
| D5.3        | Data services usage     | 48            | On track  |

Key achievements in the past 9 months

Work planned for the rest of the project





# MARS support for NetCDF (D5.1)

## Implemented solution

NetCDF files are split into individual 2D NetCDF files

- Resulting NetCDF files must follow an agreed convention based on CF
- Resulting NetCDF files are annotated with MARS specific information. These attributes are used by MARS to index the NetCDF files, and treat them as simple binary records

On retrieval, those records will be assembled in a single NetCDF file to be delivered to the user

## Key achievements in the past 9 months

The screenshot shows the MARS Catalogue interface. At the top, there is a navigation bar with 'Home', 'Chart dashboard', 'Contact', and a search box. Below the navigation bar, there are tabs for 'About', 'Forecasts', 'Computing', 'Research', and 'Learning'. The main content area is titled 'MARS Catalogue' and displays a table of search results. The table has four columns: 'Date (1 values)', 'Time (8 values)', 'Parameter (3 values)', and 'Number (1 values)'. The data row shows a date of '1900-02-03', times from '00:00:00' to '21:00:00', parameters 'Ocean potential temperature', 'Ocean salinity', and 'Sea surface temperature', and a count of '1'. Below the table, there are links for 'Check for availability', 'View the MARS request', 'Estimate download size', and 'Retrieve the selection in GRIB or NetCDF (experimental)'. A section titled 'Note about availability' explains that some fields may not be archived at all levels or all forecast time steps. A 'Retrieving' section states that at least one item must be selected in the lists above. At the bottom, a 'Current selection:' section shows a list of attributes: `leveltype dp`, `month feb`, `year 1900`, `type an`, `expver 2366`, `stream enda`, and `class ep`.

The screenshot shows the 'Additional filtering' interface. At the top, there is a navigation bar with 'Home', 'Chart dashboard', 'Contact', and a search box. Below the navigation bar, there are tabs for 'Computing', 'Research', and 'Learning'. The main content area is titled 'Additional filtering' and shows a 'Current request' section with the following details: `Stream: Atmospheric model`, `Parameter: Ocean salinity`, `Year: 1900`, `Number: 1`, `Month: February`, `Version: 2366`, `Type of level: Depth`, `Time: 00:00:00, 03:00:00, 06:00:00, 09:00:00, 12:00:00, 15:00:00, 18:00:00, 21:00:00`, `Date: 19000203`, `Type: Analysis`, and `Class: ERA-CLIM2 coupled reanalysis of the 20th-century (CERA-20C)`. Below the 'Current request' section, there is a section titled 'The request will be done using the following attributes:' with the following details: `Area: Default (as archived) (change)`, `Grid: 1x1 (change)`, and a 'Retrieve now' button.

# MARS support for NetCDF (D5.1)

## Work planned for the rest of the project

Other projects require NetCDF support

- Sub-seasonal to Seasonal project (S2S) requires archiving in MARS of Ocean output from 11 production Centres (near real-time + reforecast)
- Other forecasting systems producing ocean output (HRES, ENS, ....)
- All data being served from ECMWF Data Portals within a common framework

Challenges:

- Define what variables to archive, focusing on user service (not all output is interesting to users)
- Find CF standard names (not only for NEMO, but for any ocean field)
- Find correct metadata to enable assembling records on retrieval

# CERA data server (D5.2)

## Key achievements in the past 9 months

CERA-20C goes public for 1901–2010



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[GRIB decoder](#)

## Public Datasets

Access to these datasets is provided free of charge. Terms and conditions may apply, please check with each individual dataset.

### Global Reanalyses

- ▶ [ERA5 test \(Jan 2016 - Feb 2016\) \*\*NEW\*\*](#)
- ▶ [CERA-20C \(Jan 1901 - Dec 2010\) \*\*NEW\*\*](#)
- ▶ [ERA-20C \(Jan 1900 - Dec 2010\)](#)
- ▶ [ERA-Interim \(Jan 1979 - present\)](#)
- ▶ [ERA-Interim/LAND \(Jan 1979 - Dec 2010\)](#)
- ▶ [ERA-20CM \(Jan 1900 - Dec 2010\) Final](#)
- ▶ [ERA-20CM \(Jan 1900 - Dec 2010\) Experimental](#)
- ▶ [ERA-40 \(Sep 1957 - Aug 2002\)](#)
- ▶ [ERA-15 \(Jan 1979 - Dec 1993\)](#)

### Observation Feedback

- ▶ [ERA-20C \(Jan 1900 - Dec 2010\)](#)
- ▶ [ISPD v2.2](#)
- ▶ [ICOADS v2.5.1 with interpolated NOAA 20CR feedback](#)

### Multi-model

- ▶ [S2S](#)
- ▶ [TIGGE](#)
- ▶ [TIGGE LAM](#)

### Atmospheric composition

- ▶ [MACC Reanalysis](#)
- ▶ [CAMS Near-real-time](#)
- ▶ [CAMS Global Fire Assimilation System](#)
- ▶ [MACC GHG flux inversions](#)
- ▶ [CAMS GHG flux inversions](#)

### Miscellaneous

- ▶ [DEMETER Project](#)
- ▶ [ENSEMBLES project](#)
- ▶ [YOTC](#)



# CERA-20C goes public for 1901–2010

## Select time

00:00:00  03:00:00  06:00:00  09:00:00  12:00:00  15:00:00  18:00:00  21:00:00

[Select All](#) or [Clear](#)

## Select number

0  1  2  3  4  5  6  7  8  9

[Select All](#) or [Clear](#)

## Select parameter

- |   |   |
|---|---|
| <input type="checkbox"/> 2 metre dewpoint temperature                     | <input type="checkbox"/> 2 metre temperature                              |
| <input type="checkbox"/> 10 metre U wind component                        | <input type="checkbox"/> 10 metre V wind component                        |
| <input type="checkbox"/> 10 metre wind speed                              | <input type="checkbox"/> 100 metre U wind component                       |
| <input type="checkbox"/> 100 metre V wind component                       | <input type="checkbox"/> Albedo   |
| <input type="checkbox"/> Boundary layer height                            | <input type="checkbox"/> Charnock   |
| <input type="checkbox"/> Convective available potential energy            | <input type="checkbox"/> Forecast albedo                                  |
| <input type="checkbox"/> Forecast logarithm of surface roughness for heat | <input type="checkbox"/> Forecast surface roughness                       |
| <input type="checkbox"/> High cloud cover                                 | <input type="checkbox"/> Ice temperature layer 1                          |
| <input type="checkbox"/> Ice temperature layer 2                          | <input type="checkbox"/> Ice temperature layer 3                          |
| <input type="checkbox"/> Ice temperature layer 4                          | <input type="checkbox"/> Instantaneous eastward turbulent surface stress  |
| <input type="checkbox"/> Instantaneous moisture flux                      | <input type="checkbox"/> Instantaneous northward turbulent surface stress |
| <input type="checkbox"/> Instantaneous surface sensible heat flux         | <input type="checkbox"/> Lake bottom temperature                          |
| <input type="checkbox"/> Lake cover                                       | <input checked="" type="checkbox"/> Lake depth                            |
| <input type="checkbox"/> Lake ice depth                                   | <input type="checkbox"/> Lake ice temperature                             |
| <input type="checkbox"/> Lake mix-layer depth                             | <input type="checkbox"/> Lake mix-layer temperature                       |
| <input type="checkbox"/> Lake shape factor                                | <input type="checkbox"/> Lake total layer temperature                     |
| <input type="checkbox"/> Leaf area index, high vegetation                 | <input type="checkbox"/> Leaf area index, low vegetation                  |
| <input type="checkbox"/> Low cloud cover                                  | <input type="checkbox"/> Mean sea level pressure                          |
| <input type="checkbox"/> Medium cloud cover                               | <input type="checkbox"/> Near IR albedo for diffuse radiation             |

# CERA-20C goes public for 1901–2010

Instantaneous surface sensible heat flux

Lake cover

Lake ice depth

Lake mix-layer depth

Lake shape factor

Leaf area index, high vegetation

Low cloud cover

Medium cloud cover

Near IR albedo for direct radiation

Neutral wind at 10 m v-component

Sea-ice cover

Skin temperature

Snow density

Soil temperature level 1

Soil temperature level 3

Surface pressure

Total cloud cover

Total column liquid water

Total column rain water

Total column water

UV visible albedo for diffuse radiation

Volumetric soil water layer 1

Volumetric soil water layer 3

Lake bottom temperature

Lake depth

Lake ice temperature

Lake mix-layer temperature

Lake total layer temperature

Leaf area index, low vegetation

Mean sea level pressure

Near IR albedo for diffuse radiation

Neutral wind at 10 m u-component

Sea surface temperature

Skin reservoir content

Snow albedo

Snow depth

Soil temperature level 2

Soil temperature level 4

Temperature of snow layer

Total column ice water

Total column ozone

Total column snow water

Total column water vapour

UV visible albedo for direct radiation

Volumetric soil water layer 2

Volumetric soil water layer 4

[Select All](#) or [Clear](#)

## Work planned for the rest of the project

Monthly means available (M36)

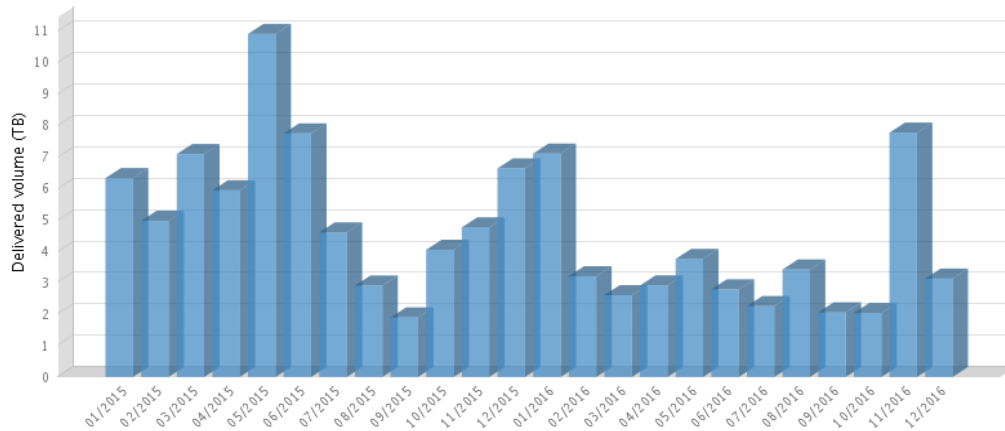
Daily Analysis, Ensemble means/stddev (M37)

Daily Forecast, Observation Feedback, Ocean (M39-M42)

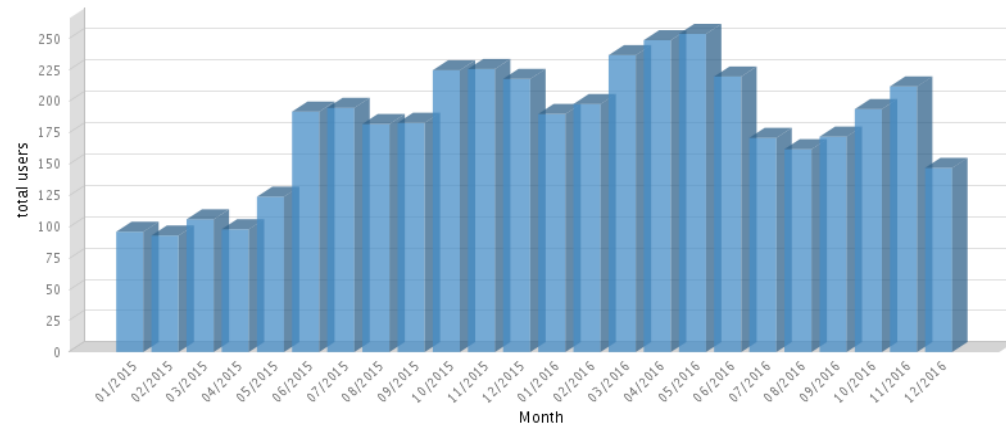
# Data services usage (D5.3)

- Measure service usage and performance
- Set up the users support
- Experience gained from ERA-20C released on 1 October 2014

Delivered Volume in TB



total users



**Work planned for the rest of the project**

Statistics expected M42-48, once all datasets under D5.2 are available