ERA-CLIM2: Global 20th century reanalysis (WP1)

General Assembly – Patrick Laloyaux – 16 January 2017

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SEVENTH FRAMEWORK PROGRAMME

ECMWF
EUROPEAN CENTRE FOR MEDIUM RANGE WEATHER FORECASTS

MERCATOR OCEAN
OCEAN FORECASTERS

LSCE

- Summary of the status of WP1
- Scientific results from CERA-20C reanalysis
- Work planned for the rest of the project

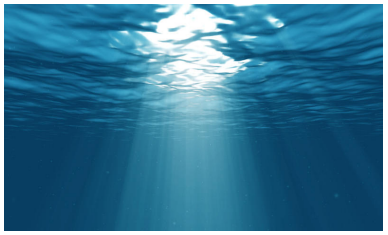
Summary of the Description of Work

Produce global reanalyses to reconstruct the past climate/wheater of the earth system


Atmosphere


Land


Wave


Ocean


Sea ice

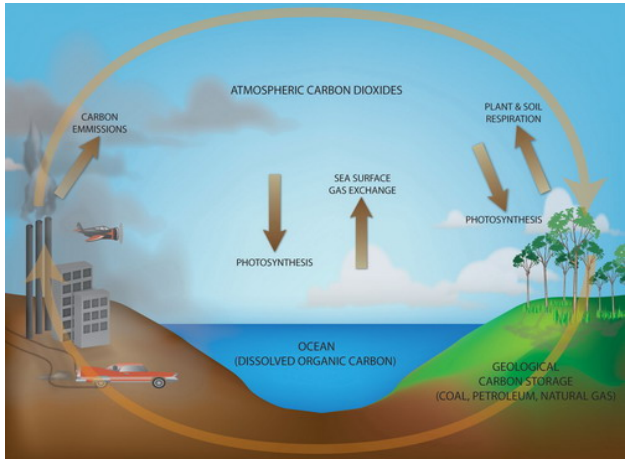
CERA-20C: A coupled reanalysis of the 20th century (1901-2010)

- based on conventional surface and subsurface observations
- deliver long timeseries of Essential Climate Variables (ECVs)

CERA-SAT: A coupled reanalysis at higher resolution (2008-2016)

- based on conventional and satellite observations
- evaluate the impact of a higher resolution on the coupled processes

Produce associated reanalyses to reconstruct the evolution of the carbon fluxes



CERA-20C/Carbon: land & ocean carbon reanalyses

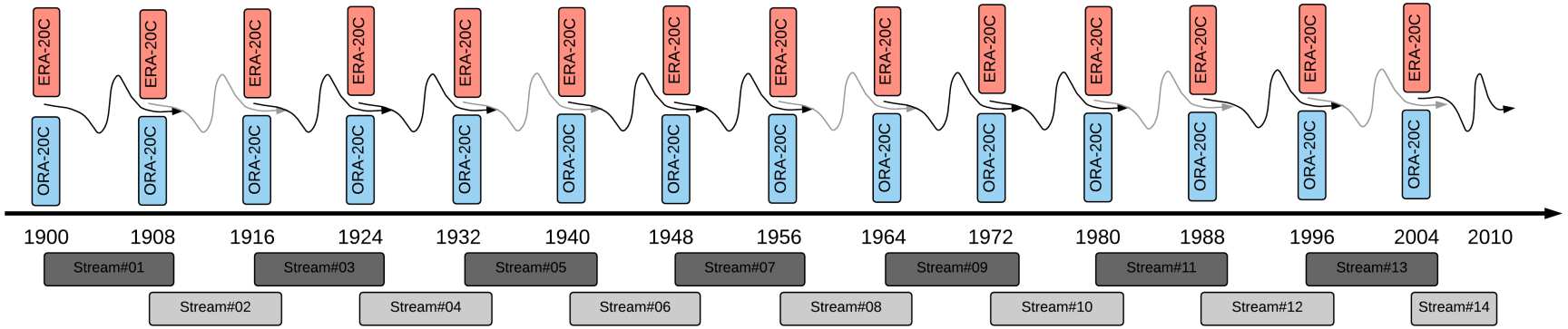
- based on forcings from atmospheric/ocean reanalyses
- estimate carbon flux anomalies over the 20th century

CERA-SAT/Carbon: two land carbon reanalyses

- produced online by the CTESSEL land model
- produced offline by the ORCHIDEE land model

CERA-20C: A coupled reanalysis of the 20th century

Production of CERA-20C is completed (D1.1)



- period 1900-2010 divided in 14 streams of 10 years
- all the streams run in parallel
- initial conditions from uncoupled climate reanalyses (ERA-20C and ORA-20C)
- 2-year overlap to ensure consistency in the final product

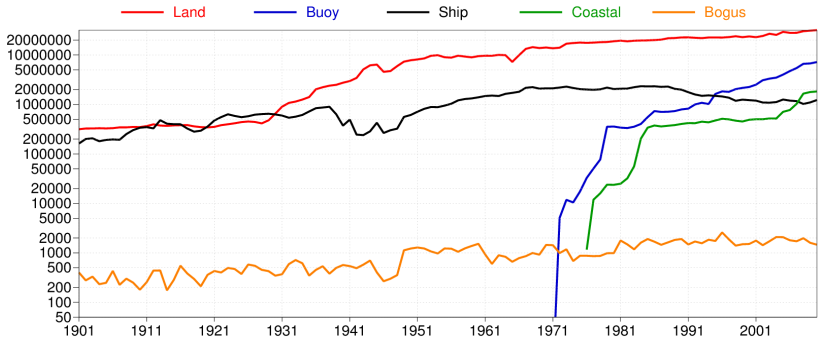
Computation footprint

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.)
optimised production suite with dedicated HPC support

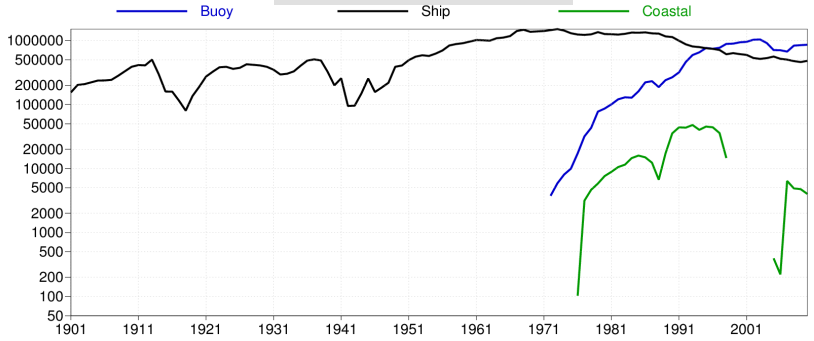
The first coupled climate reanalysis of the 20th century openly available

CERA-20C: A coupled reanalysis of the 20th century

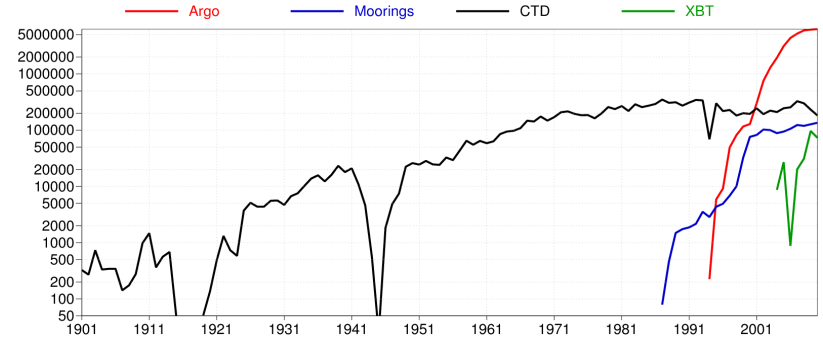
Surface pressure



Marine wind



Temperature & salinity



Sea surface temperature analysis HadISST2 reconstructed from past observations

Reanalysis dataset

1400 Tb of atmospheric data
200 Tb of ocean data
dedicated data service (WP5)

CERA-20C/Carbon: Associated reanalyses of the carbon fluxes

A first carbon reanalysis for the ocean has been produced (D1.2)

- Ocean carbon reanalysis based on PISCES and forced by ERA-20C is completed
  assessment of the sea-air CO2 flux shows promising results when compared to observations, better assessment of the interannual variability is required
- Ocean carbon reanalysis forced by CERA-20C scheduled for 2017

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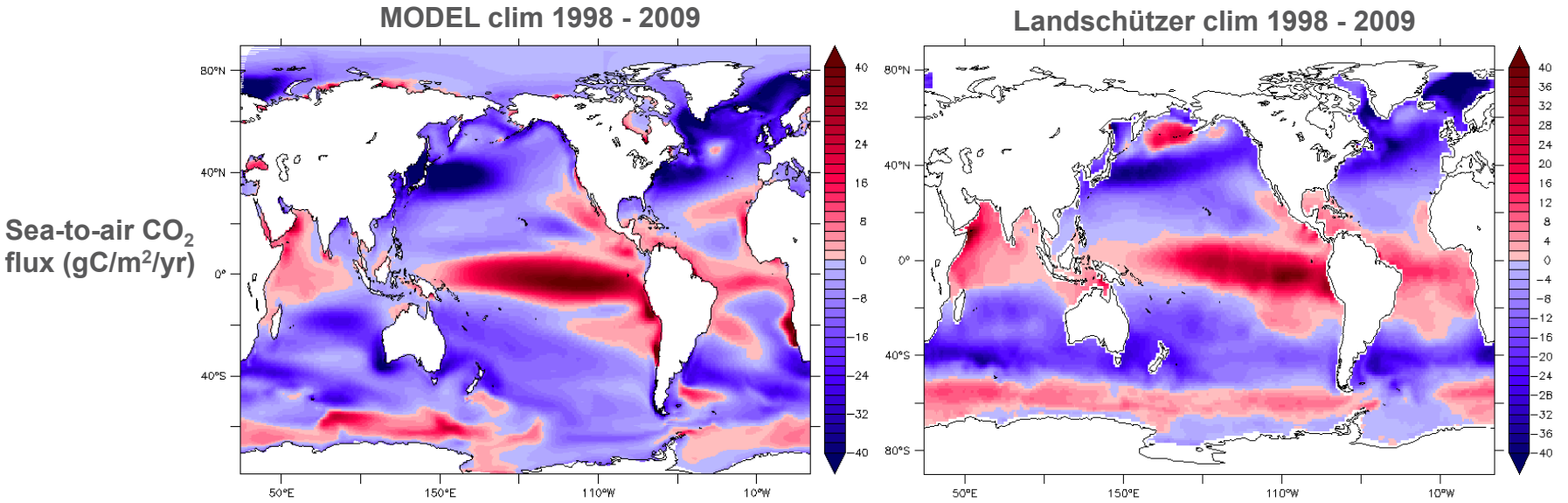


Good agreement in large scale structures

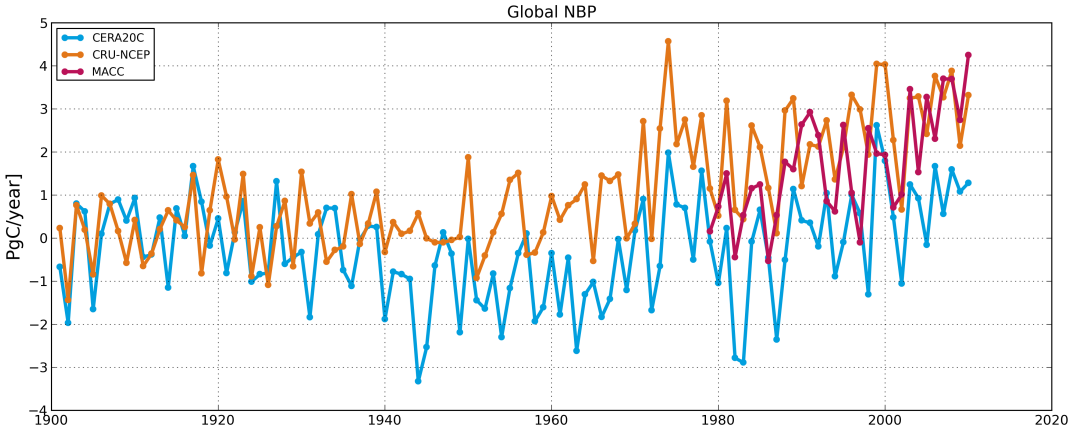
CERA-20C/Carbon: Associated reanalyses of the carbon fluxes

A first carbon reanalysis for the land has been produced (D1.2)

- Land carbon reanalysis based on ORCHIDEE and forced by CERA-20C is completed
- Consolidation of the ORCHIDEE model for land carbon reanalyses
- Land carbon reanalysis based on the consolidated ORCHIDEE, forced by CERA-20C scheduled for 2017

LSCE

Global Net Carbon fluxes

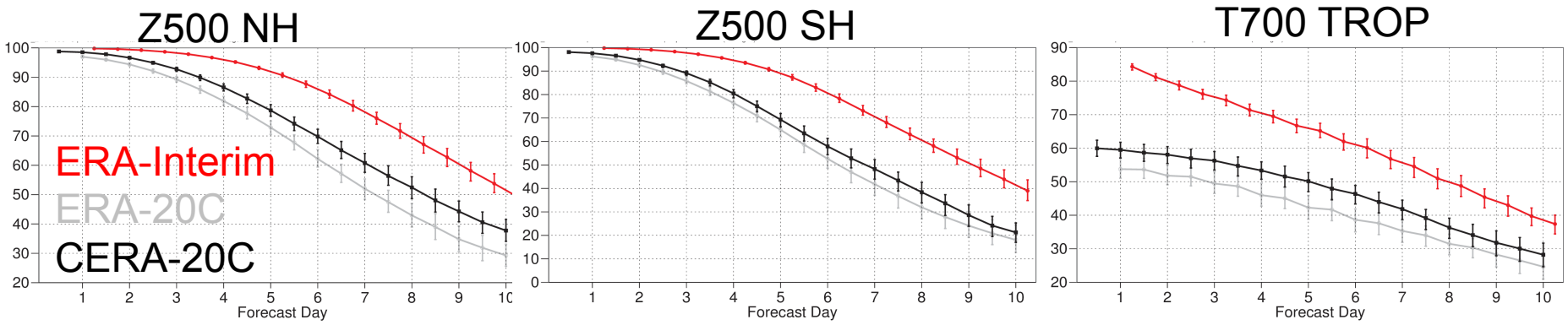


ORCHIDEE forced by CERA-20C
ORCHIDEE forced by CRU-NCEP
MACC2 atm. CO2 inversion

- Summary of the status of WP1
- Scientific results from CERA-20C reanalysis
- Work planned for the rest of the project

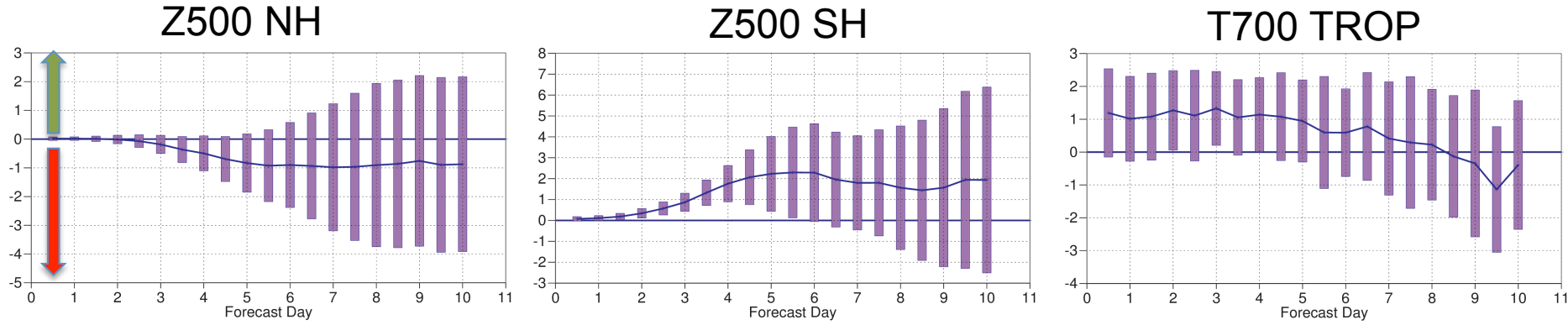
Comparison between different climate reanalyses

Anomaly correlation coefficient (1st March 2010 to 1st June 2010) using the ECMWF operational analysis as reference



→ Forecast skill improved in CERA-20C compared to ERA-20C (IFS model, error specification, ocean coupling)

Impact of ocean coupling in CERA-20C (1st March 2010 to 1st June 2010)

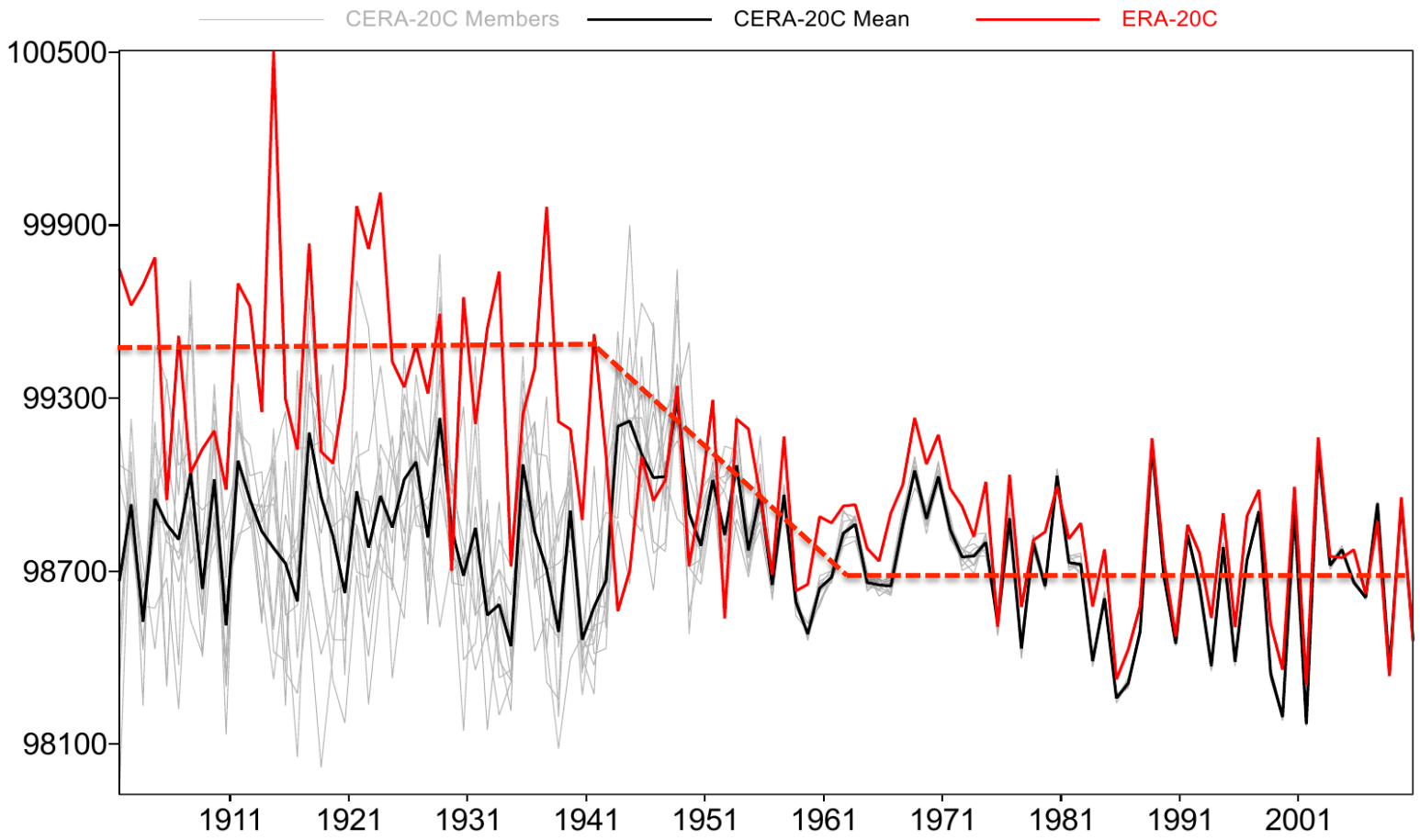


→ Impact of ocean coupling on the analysis is positive over Tropics

Mean sea level pressure analysis

Mean sea level pressure analysis in ERA-20C (red) and CERA-20C (black) over Antartica (60°S-90°S) for the SON season.

→ spurious trend in ERA-20C, 8hPa higher before the 40'

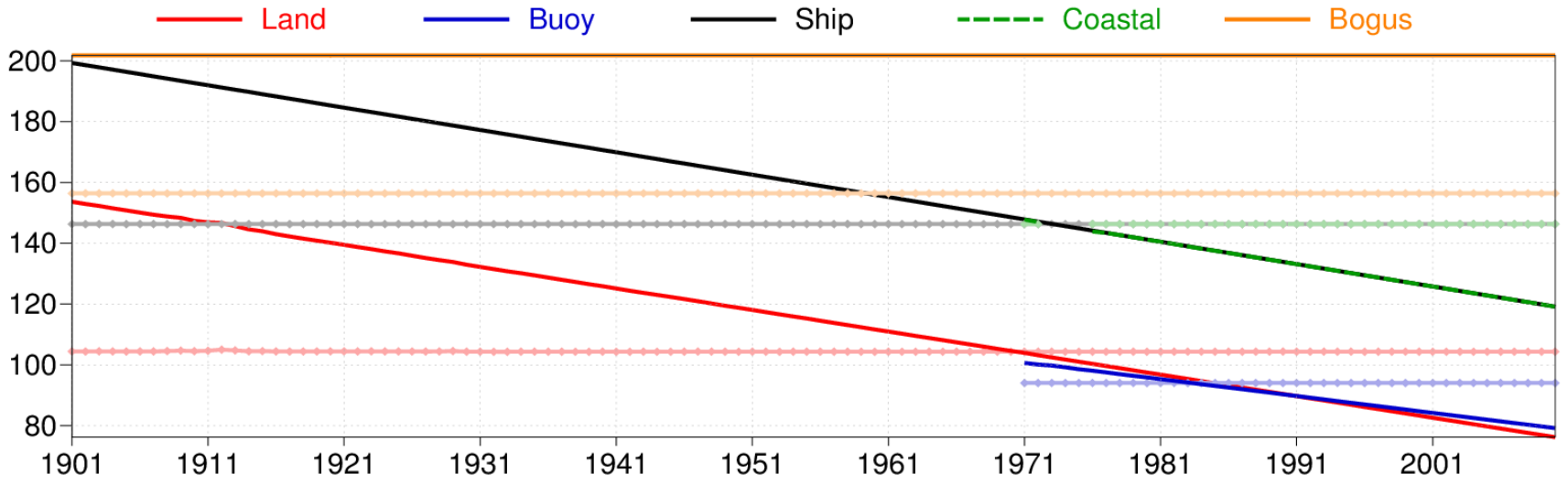


Observation error specification

Observation error specification has been reviewed

- ERA-20C: from operations, inflated by a factor of two and kept constant
- CERA-20C: from the Desroziers' diagnostic on ERA-20C feedback information, time-varying.

Observation error for mean sea level pressure for different platforms in ERA-20C (light colours) and CERA-20C (dark colours)



In CERA-20C, observation errors should be more realistic:

→ Larger at the beginning of the century

→ Smaller at the end of the century

P. Poli et al., ERA-20C Deterministic, ERA Report Series, 48, 2015.

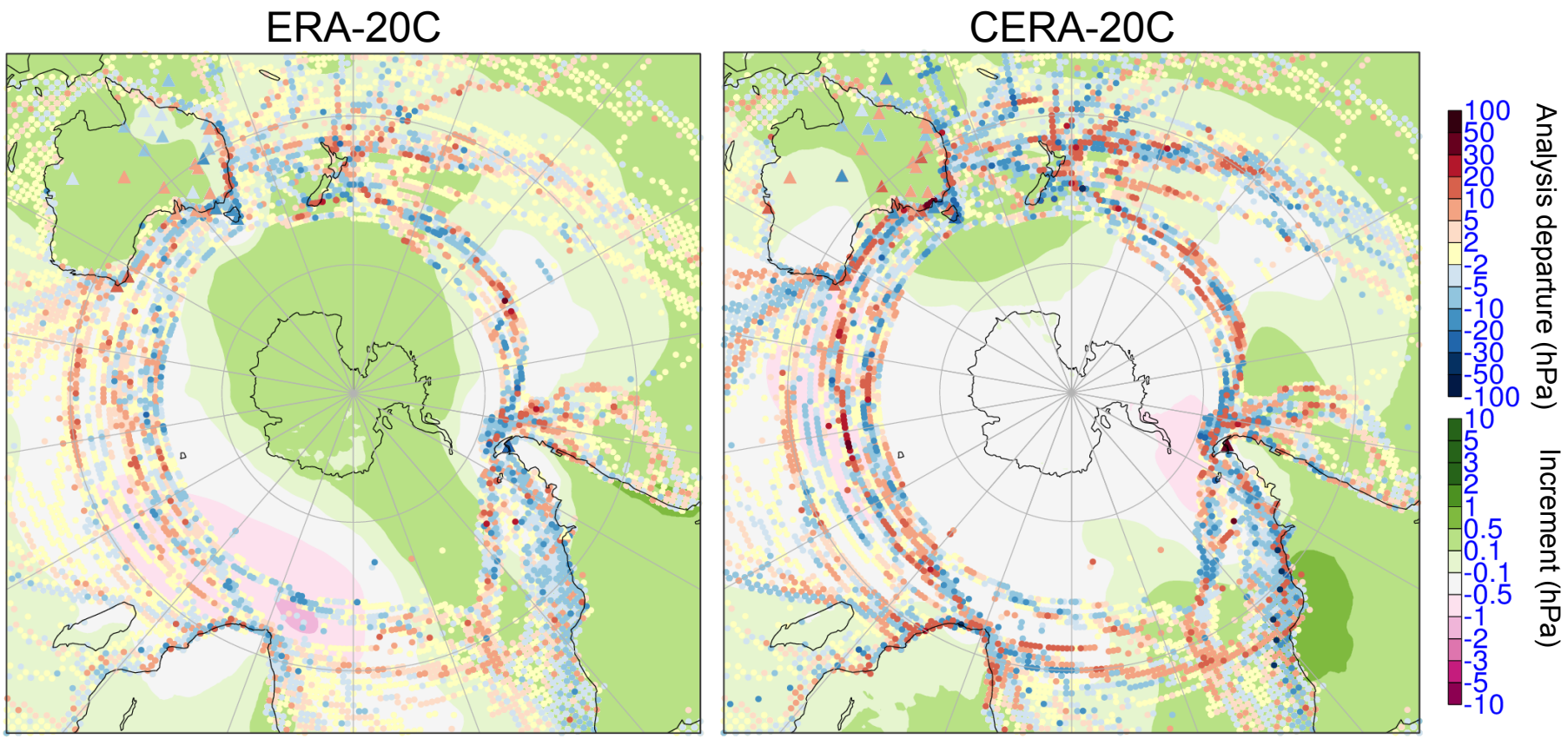
Assimilation in Antarctica before 1940

Assimilation in the Southern Hemisphere before 1940 is a challenge:

→ No SYNOP station in the Antarctic circle, only very few ships in summer

→ Increment in the Antarctic circle highly sensitive to observation and background error

MSLP increment in 1924 (shading). Analysis departure for pressure observations (dots)



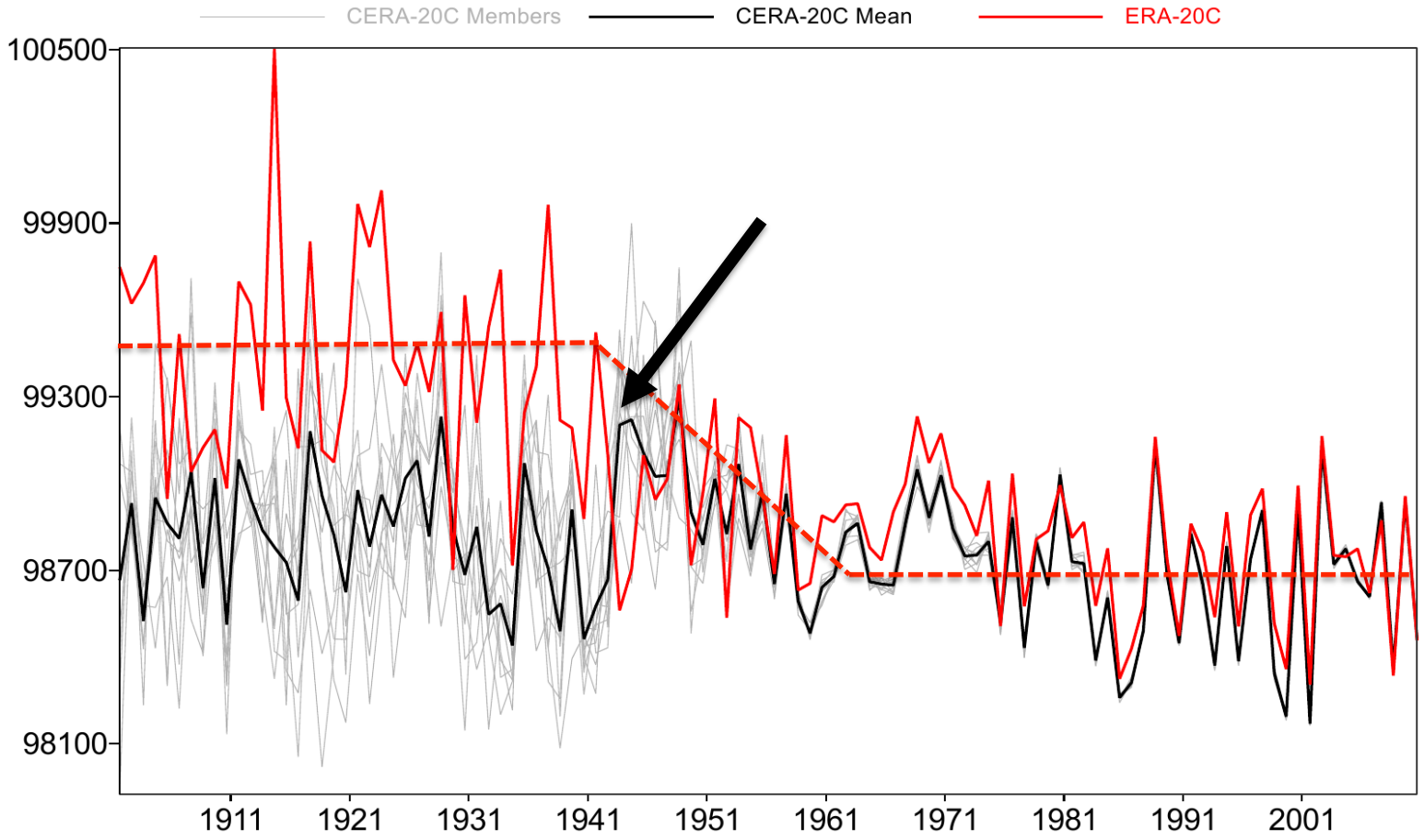
→ Much smaller increment in the Antarctic circle in CERA-20C thanks to the reviewed observation errors

Mean sea level pressure analysis (copy of first slide)

Mean sea level pressure analysis in ERA-20C (red) and CERA-20C (black) over Antartica (60°S-90°S) for the SON season.

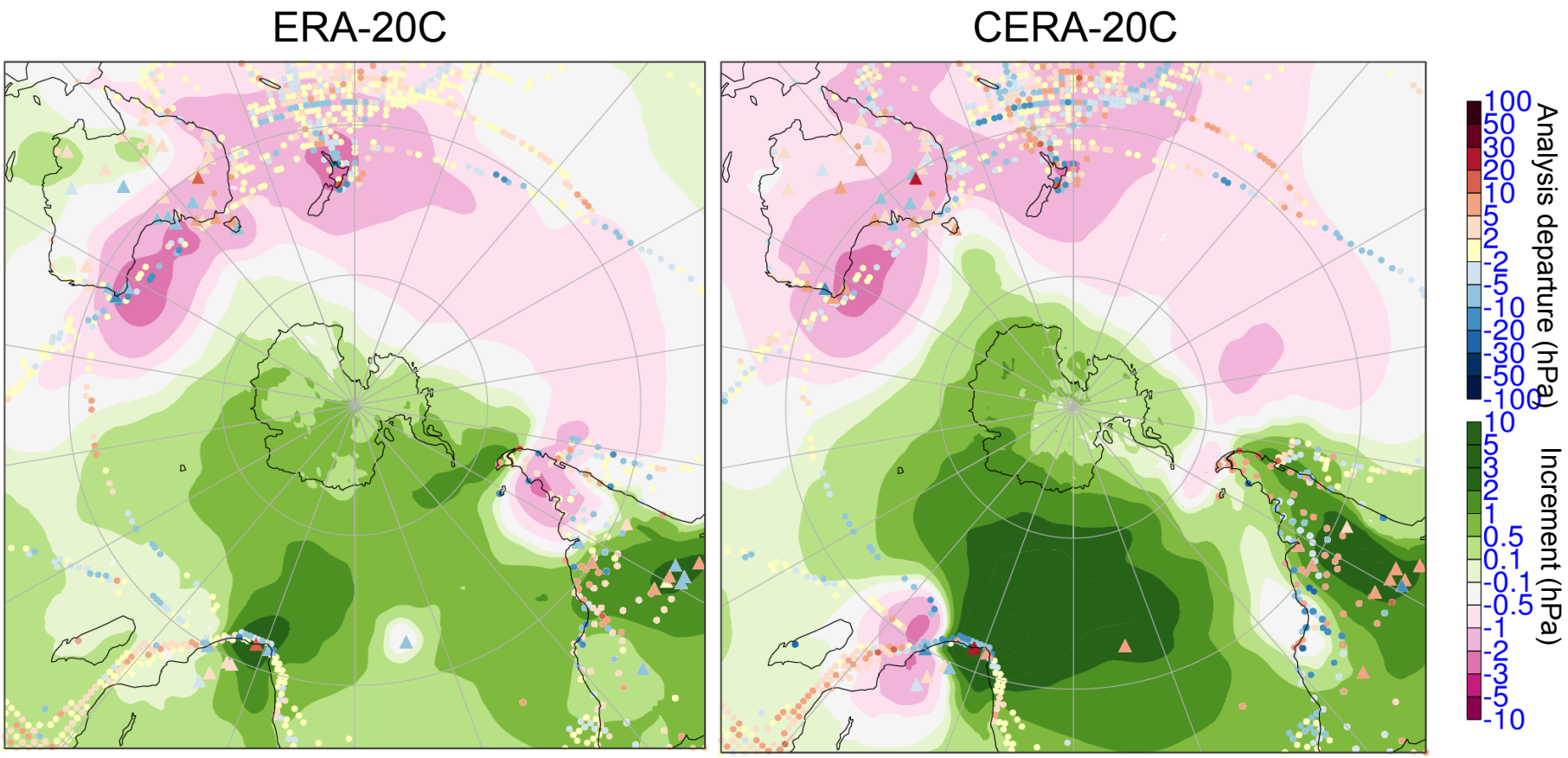
→ spurious trend in ERA-20C, 8hPa higher before the 40'

→ Peak in the CERA-20C analysis in 1943



Assimilation in Antarctica in 1943

MSLP increment in 1943 (shading). Analysis departure for pressure observations(dots)

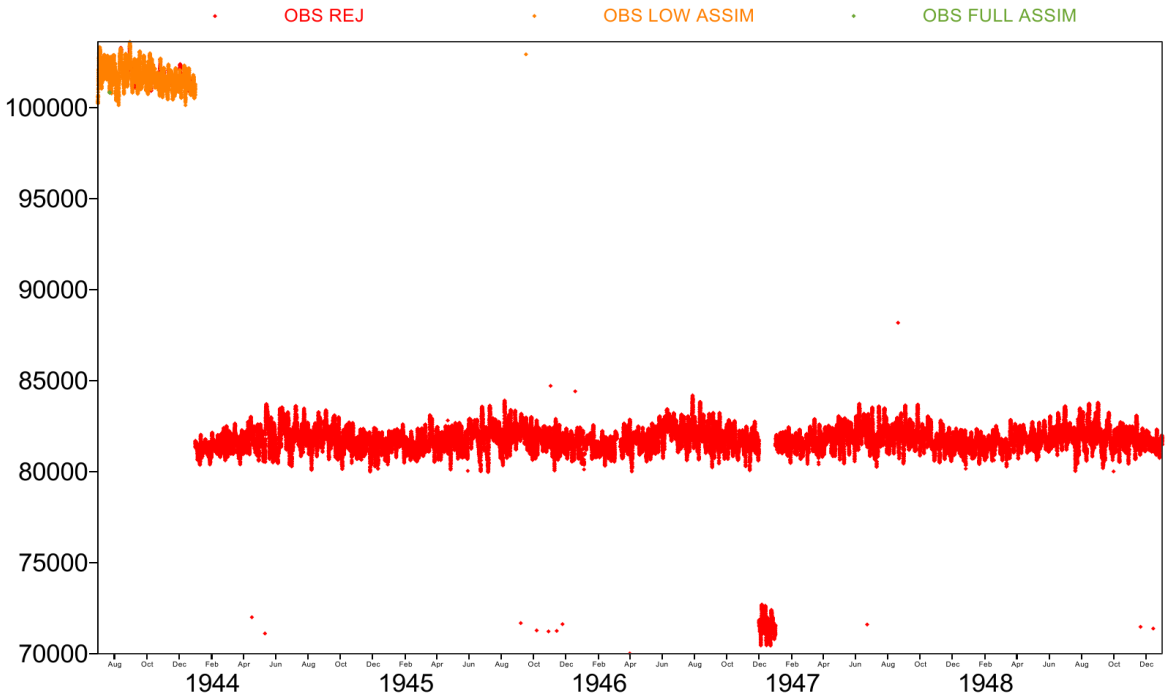


- In 1943, first SYNOP weather stations in Southern Africa.
- Large increment due to one SYNOP station (00287480)
- No ships at higher latitude to provide observations and reduce the increment spread

Study of SYNOP station 00287480

SYNOP station 00287480 appears in July 1943
Position: 33.97°S 22.42°E with elevation: 220 m

Measurements from 00287480: rejected by first-guess check (red), small weight from VarQC (orange)



→ In 1943: positive bias, possibly because MSLP observations are assimilated as SP observations (metadata issue)
→ In 1944 onwards: completely wrong measurements

Uncertainty and confidence in reanalysis datasets

Uncertainty workshop of the FP7/H2020 Copernicus Climate Change projects hosted by the European Commission in Brussels.

- increase convergence on how to define, assess, and communicate uncertainties and data quality
- emphasize that uncertainty is part of the scientific result, not a limitation

Visit NOAA in Boulder

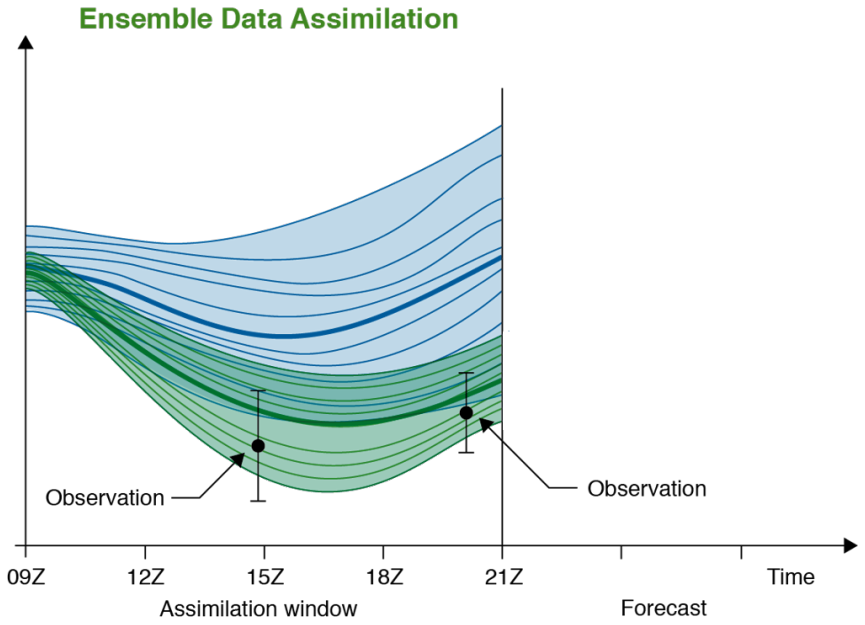
- exchange experience on uncertainties from 20CR and CERA-20C (Gil Compo and Laura Slivinski)
- development of a new metric to estimate the confidence we can have in the data

Ensemble of Data Assimilation (EDA)

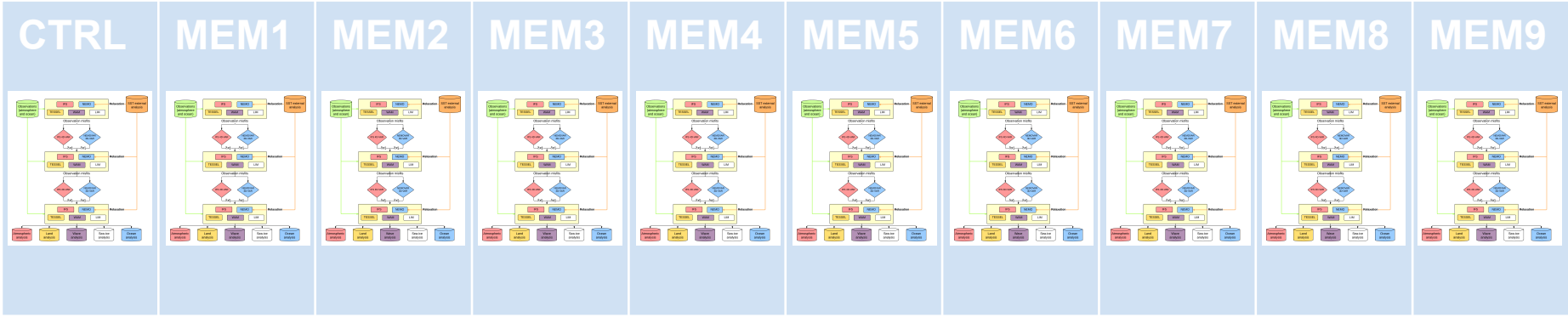
EDA system introduces perturbations for

- observations
- sea surface temperature
- stochastic physics

"An ensemble of perturbed first-guesses is transformed in an ensemble of analysis by running the assimilation system on each member"



CERA implements a 10-member EDA system

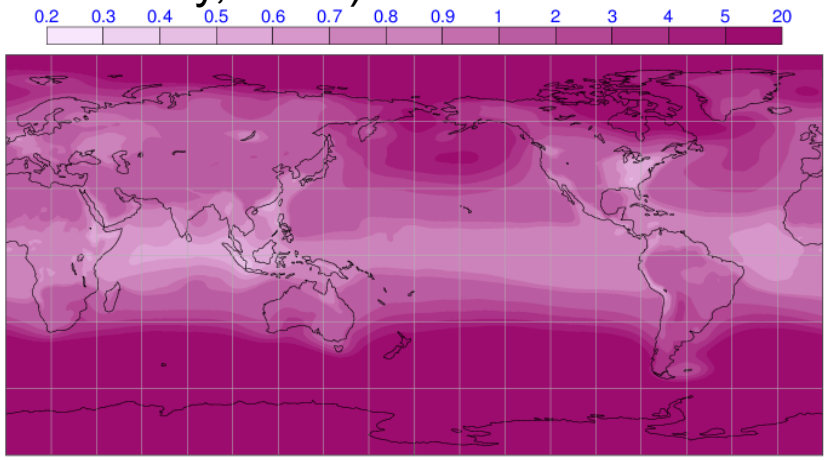


→ hybrid method for the background error in atmosphere, not yet in ocean (WP2)

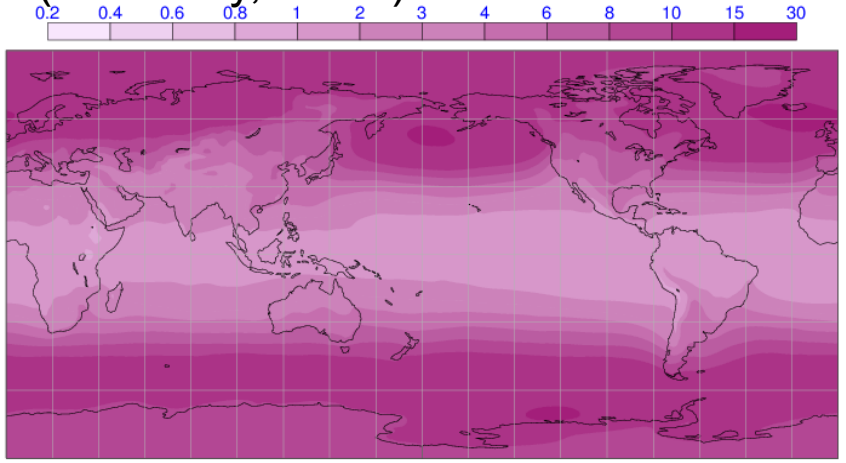
→ 10 different realisations providing a measure on uncertainties

Winter 1915-1918 (climatology 1981-2010)

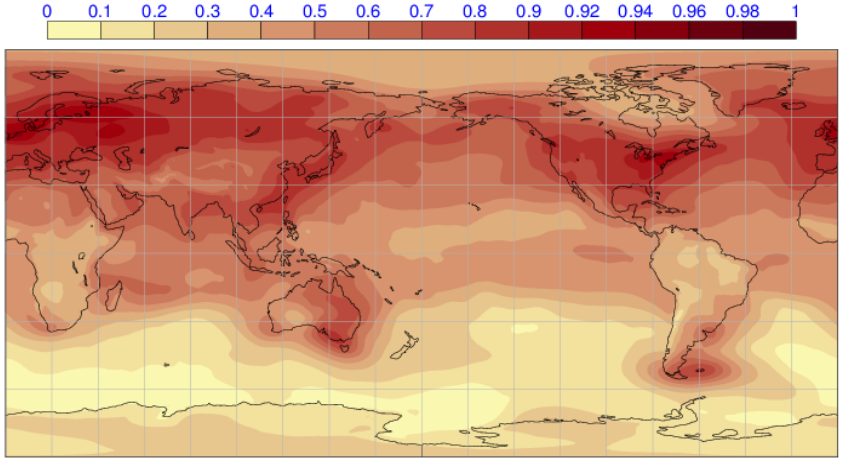
Standard deviation of ensemble analysis (uncertainty, σens)



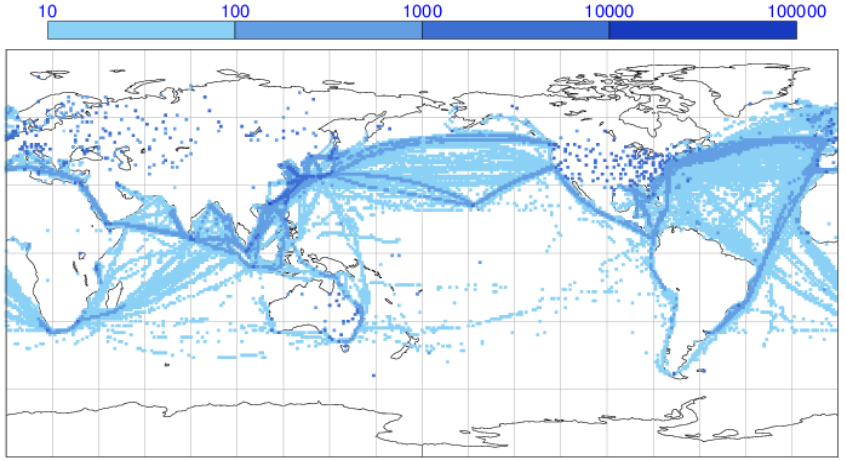
Standard deviation of climatology (variability, σclim)



Data confidence 1-(σens/ σclim)



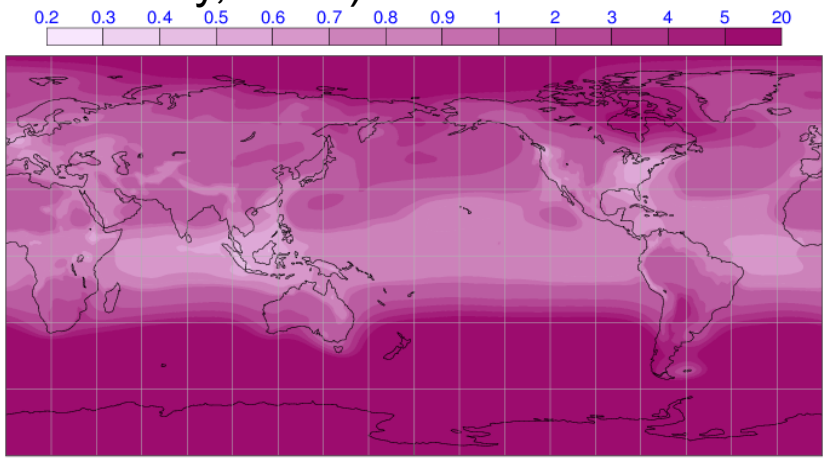
Number of observations



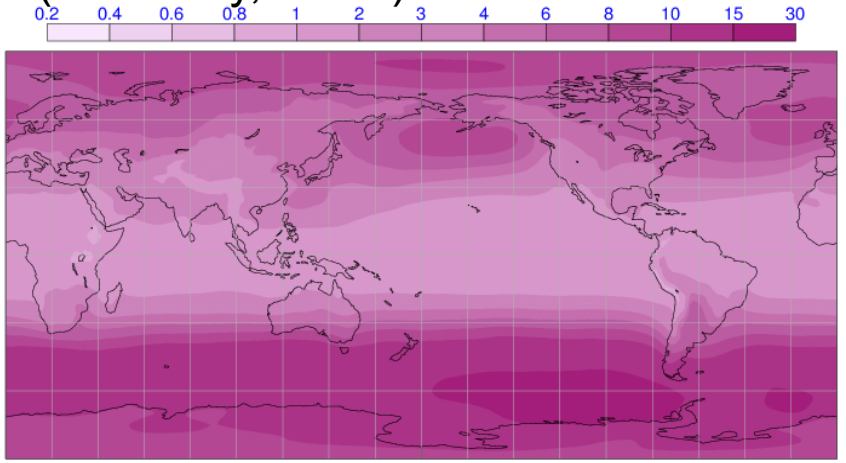
- uncertainty depends on weather variability and observation density
- data confidence (analysis better than climatology) depends only on observations

Summer 1915-1918 (climatology 1981-2010)

Standard deviation of ensemble analysis (uncertainty, σens)



Standard deviation of climatology (variability, σclim)



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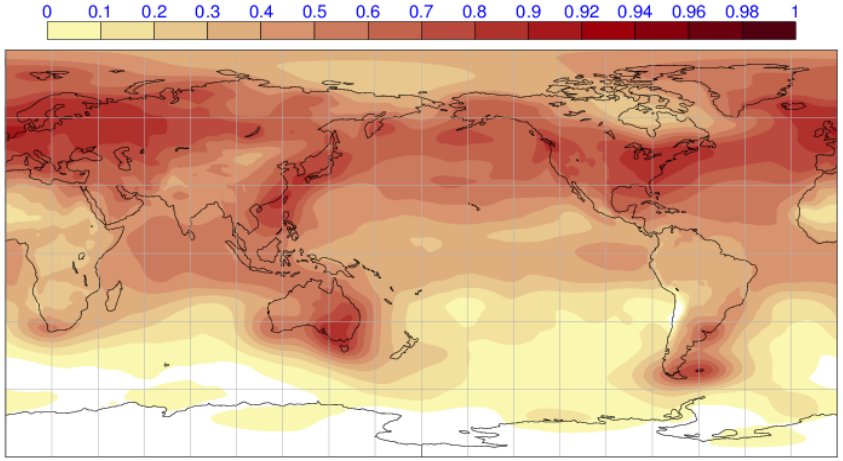

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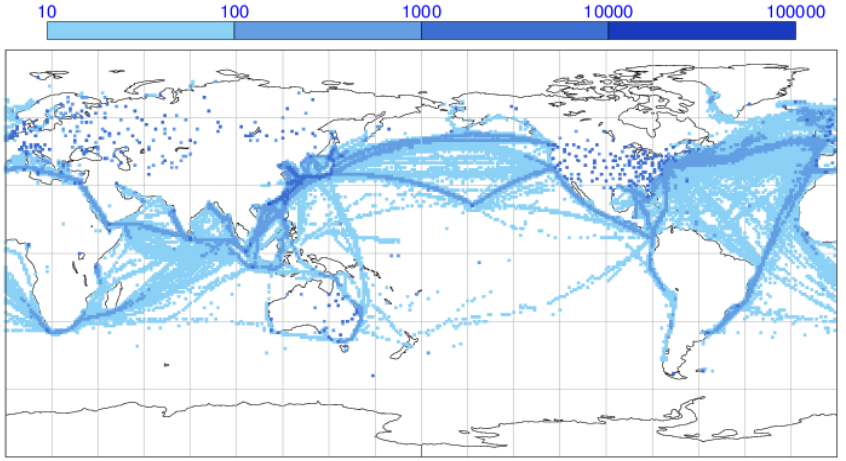

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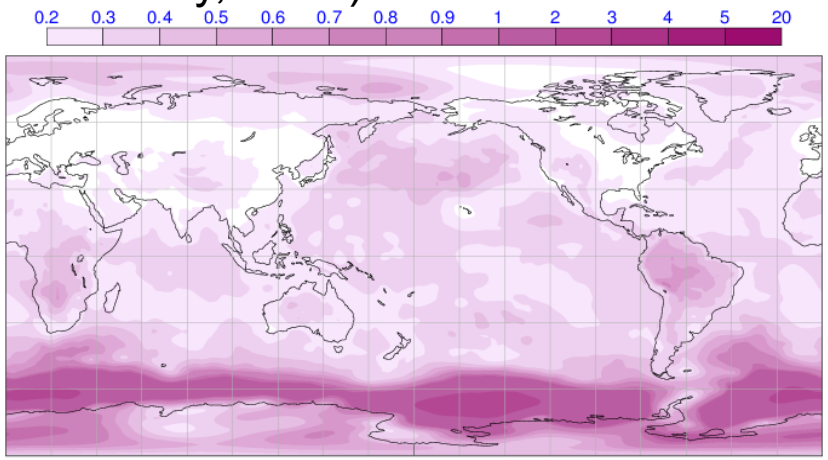
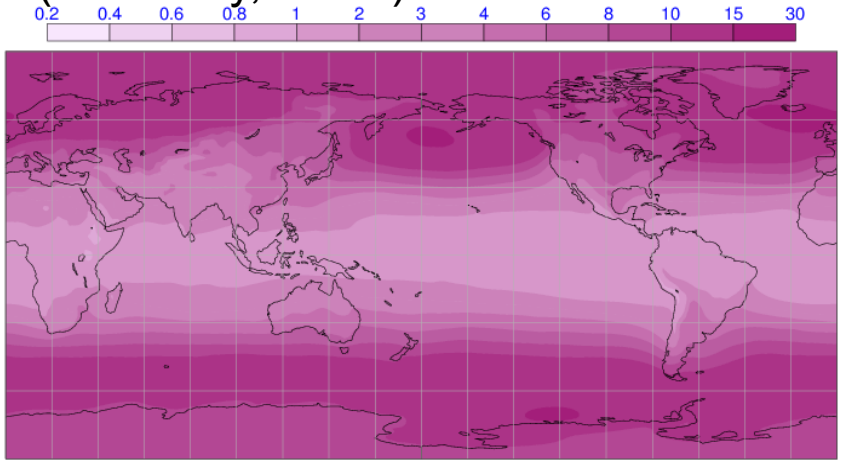
Winter 2005-2008 (climatology 1981-2010)

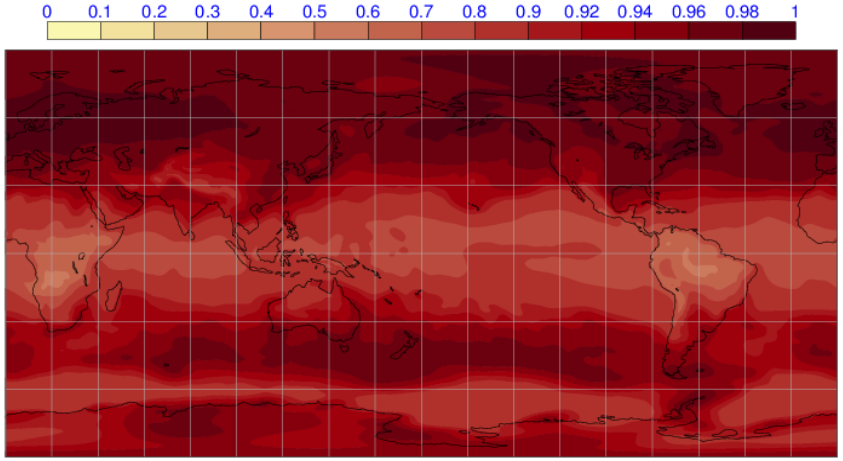
Standard deviation of ensemble analysis (uncertainty, σens)



Standard deviation of climatology (variability, σclim)



Data confidence 1-(σens/ σclim)



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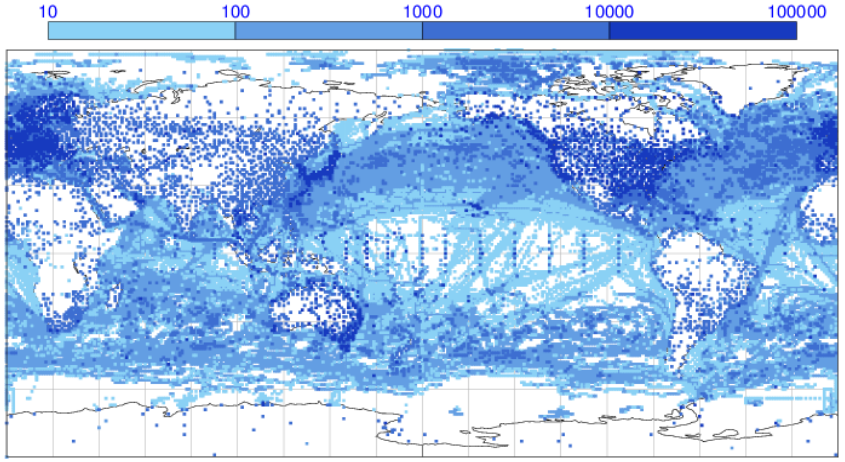

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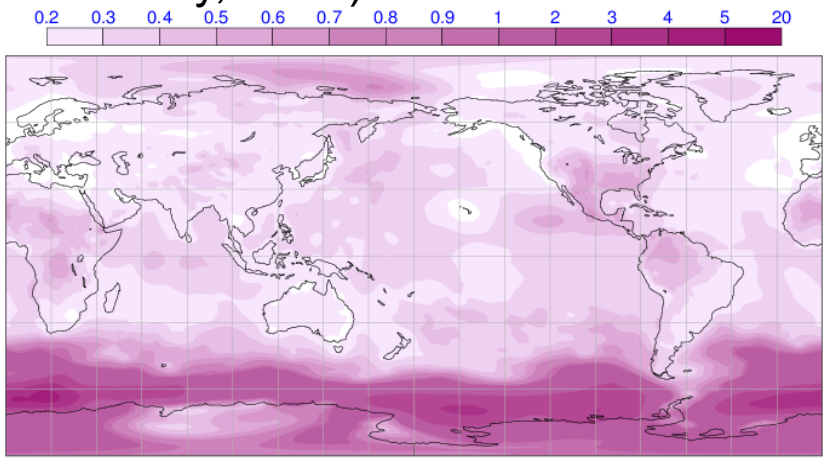
Summer 2005-2008 (climatology 1981-2010)

Standard deviation of ensemble analysis (uncertainty, σens)



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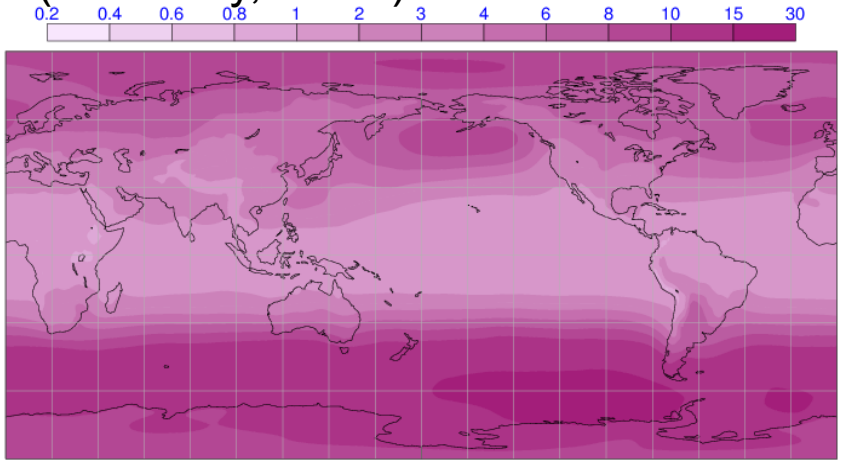
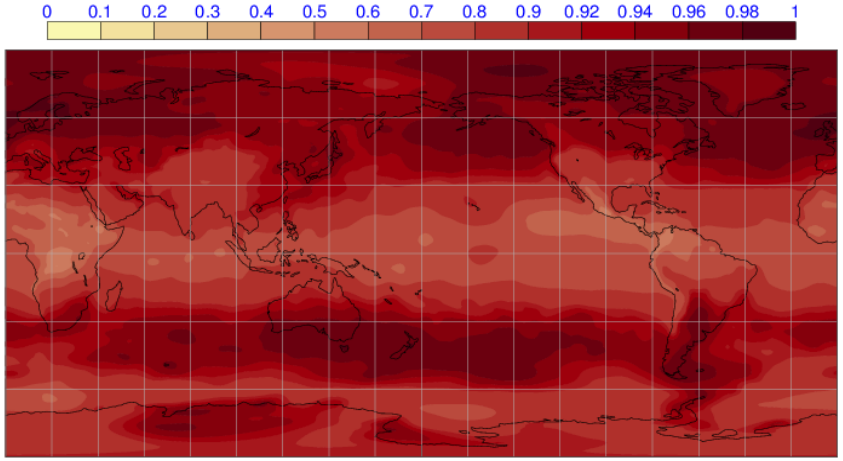


Data confidence 1-(σens/ σclim)



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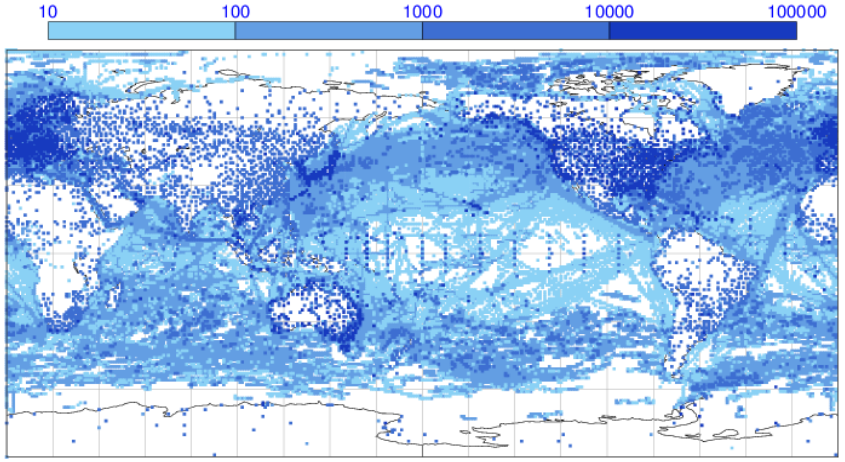

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CERA-20C and CERA-SAT

CERA-20C (D1.1)

- CERA-20C dissemination is ongoing (WP5)
- CERA-20C paper to be submitted soon in QJRMS

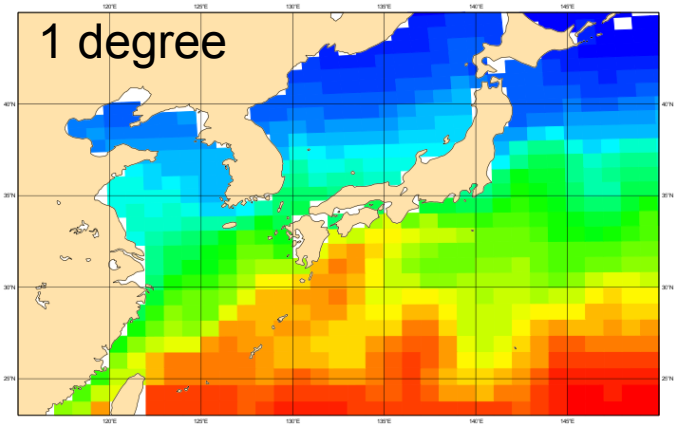
Production of CERA-SAT is ongoing (D1.3)

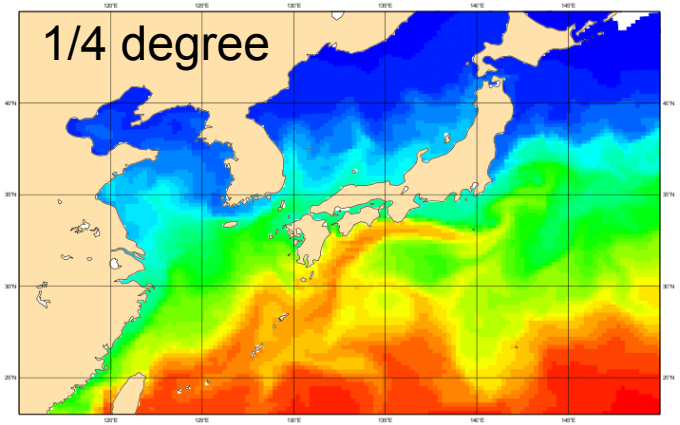
Resolution upgrade:

- atmosphere from 110km to 65km
- ocean from 1 degree (42 levels) to ¼ degree (75 levels)

Satellite assimilation:

- improve the coupled assimilation system to ingest satellite measurements (SLA)
- activation of the land, wave and sea-ice assimilation systems





Ocean and land carbon reanalysis

Ocean carbon reanalysis

- Ocean carbon reanalysis forced by CERA-20C (D1.2)

Land carbon reanalysis

- Land carbon reanalysis based on the consolidated ORCHIDEE forced by CERA-20C (D1.2)
- Land carbon reanalysis based on the consolidated ORCHIDEE forced by CERA-SAT (D1.4)

Coordination

Coordination with WP2

Develop a roadmap for the possible integration of the developments made for the SST assimilation and the ensemble strategy. Other developments?

Coordination with WP4

Provide early access to CERA-20C data.