Coupled land-atmosphere data assimilation developments in support of the next generation of Earth system reanalyses and seasonal prediction systems: The CopERnIcus Climate Change Service Evolution (CERISE) project

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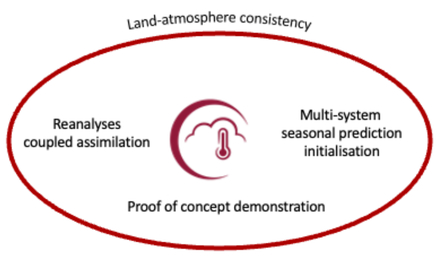
Objectives

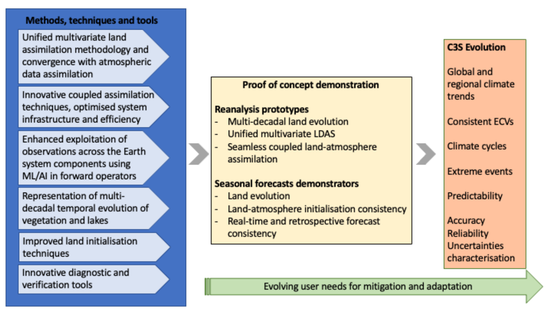
Evolution of the C3S reanalysis and seasonal prediction systems with a focus on land

- Development of land-atmosphere coupled data assimilation (DA) to improve the climate consistency of the next generations of C3S Earth system reanalyses,
- Enhancement of the quality of user-relevant seasonal forecast information by improving forecast skill and process understanding over land,



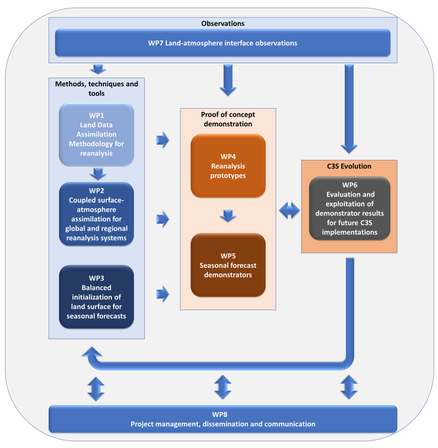
- Demonstration of the proof of concept by delivering global and regional reanalysis prototype datasets and seasonal forecast demonstrator datasets showing the feasibility and the added value of the integration in the existing core service.

Concept: support the C3S evolution through future integration in the core Service



CERISE will take the C3S tools beyond the state-of-the-art in the areas of land and coupled land-atmosphere DA methodologies, exploitation of surface sensitive observations using AI-based observation operators, and land initialisation, for the benefit of the consistency of C3S reanalysis and seasonal forecast products across the Earth system components.

Workplan and consortium



Consortium: includes key partners involved in C3S operational reanalysis and seasonal prediction development and production.
Twelve partners from nine European countries (Denmark, France, Germany, Italy, Norway, Portugal, Spain, Sweden, and the United Kingdom).

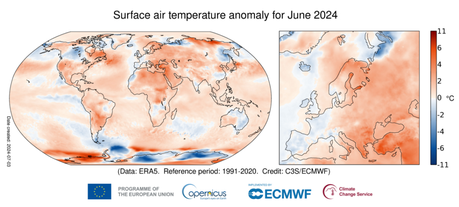
ECMWF, Met Norway, SMHI, Météo-France, DWD, CMCC, BSC, UK Met Office, DMI, Estellus, IPMA, NILU.

Four-year project: 2023-2026

C3S Climate Reanalyses and Seasonal Prediction

Climate reanalyses

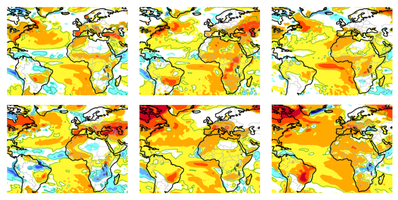
⇒ Maps without gaps of Essential Climate Variables (ECVs), globally (ERA5, ERA5-Land), and Copernicus Arctic and European ReAnalyses, CARRA1 and CERRA.



Surface air temperature anomaly from the C3S ERA5 global reanalysis, for June 2024 relative to the June average for the period 1991-2020. Data source: ERA5. Credit: Copernicus Climate Change Service/ECMWF Climate Bulletin.

Seasonal prediction

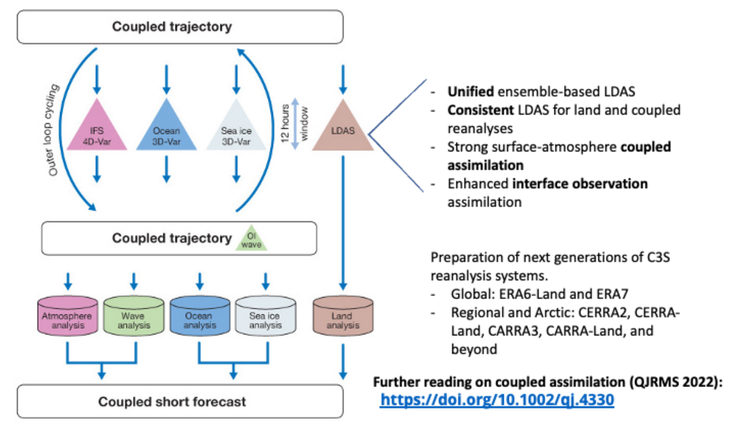
⇒ Multi-system ensemble approach to forecast the evolution of large-scale modes of climate variability for approximately six months.



Surface air temperature ensemble mean anomaly for June 2021 for forecasts from 1st May, from six different models in the C3S seasonal forecast multi-system, showing substantial variation between forecasts in many regions where land surface initial conditions play a crucial role.

Near surface conditions over land of critical interest to the C3S users.

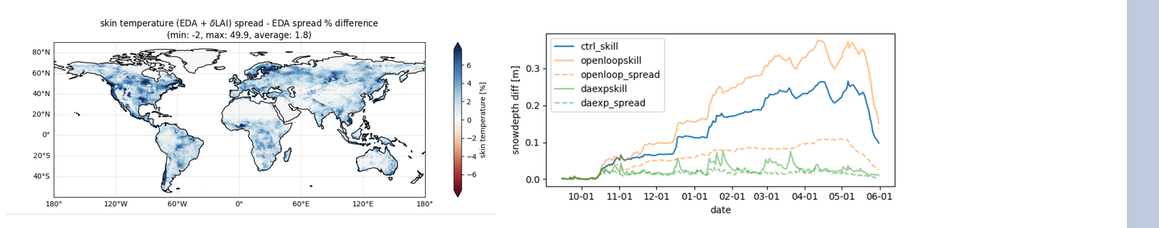
Coupled land-atmosphere data assimilation



⇒ Herbert et al. 2024 poster EMS2024-530

Unified ensemble-based land data assimilation (DA)

- Unified approach towards multivariate land DA (Herbert et al. QJRMS 2024 https://rmets.onlinelibrary.wiley.com/doi/10.1002/qj.4808) and EMS2024-525
- Land surface parameter perturbations (SPP) to improve surface ensemble spread in the Integrated Forecasting System (Figure below, left)
- Ensemble land DA development in HARMONIE-AROME (Figure, right)
- Machine learning to enhance ensemble approaches and satellite observations operators

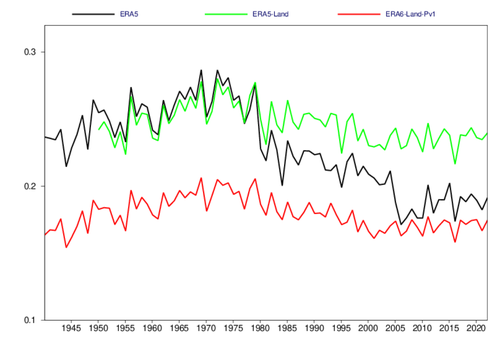


Left: Normalised increase in skin temperature Ensemble DA spread in the IFS (full annual cycle period) when using SPP for Leaf Area Index and vegetation fraction, compared to current spread obtain with no land surface perturbation. Right: Snow depth (m) ensemble spread (dashed lines) and errors (solid lines) from September 2021 to June 2022 in HARMONIE-AROME, for control (blue), open loop (orange), and ensemble land data assimilation experiment (green) in HARMONIE-AROME.

Increased ensemble spread and improved spread-skill in the global (IFS) and regional (HARMONIE-AROME) reanalysis systems. (Blyverket et al. 2023, D1.1 Preliminary assessment of ensemble perturbation methods for the land-surface assimilation systems https://www.cerise-project.eu/deliverables).

Reanalysis prototypes

- CERISE design, develop, produce and deliver a set of global and regional scale reanalysis prototypes for future C3S service provision.
- Focus on improved consistency and long-term trends of land-atmosphere ECVs through progressive integration of the unified land data assimilation developments conducted in the project.



Timeseries of snow depth (m) for February over the northern hemisphere from 1939 to 2022 for ERA5 (black), ERA5-Land (green) and ERA6-Land-Pv1 (red). ERA6-Land-Pv1 improves on the known positive snow bias for ERA5 and ERA5-Land and also does not show the artificial drop for ERA5 around 1980 and 2004.

CERISE includes prototypes for land and coupled reanalyses, and for the global and regional domains. The Figure illustrates results from the first CERISE global land reanalysis prototype ERA6-Land-Pv1

Acknowledgement

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