Regional reanalysis experience in Europe - the Copernicus perspective

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Why regional reanalysis (in C3S)?

Additional (local) observations
- Local surface observations and slightly different treatment of satellite data where possible

Better description of surface characteristics
- Sea surface temperature or sea ice concentration or glacier albedo or snow cover for the Arctic
- Additionally, orography and soil information and vegetation on 1 km resolution for Europe

Special regional models with higher horizontal resolution
- 2.5 km for the Arctic; 5.5 km for Europe (ERA5: 31 km)
- The wind field is adapted better to the local orography
- Generally better description of temperature and wind patterns or extreme events, for example
C3S regional reanalyses: domains
Copernicus Regional Reanalysis for the Arctic region (CARRA)

- Two subdomains over the European Arctic
- Model: HARMONIE-ALADIN
- 2.5 km horizontal resolution; non-hydrostatic version
- ERA5 lateral boundary conditions
- Improved physiographic datasets used
- Additional local observations assimilated

(details at https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-carra-model-levels?tab=doc)
Copernicus Regional Reanalysis for the Arctic region (CARRA)

• Dataset for the period September 1990 - June 2021 published in the C3S Climate Data Store (CDS)

https://cds.climate.copernicus.eu/#!/search?text=CARRA

• CDS catalogue entries: single (including soil), pressure, height and model levels (see, for example, web article: https://climate.copernicus.eu/c3s-zooms-arctic-climate)

• Data available: hourly - analysis every 3h; forecasts at hourly resolution

2m temperature near: ERA5, far: CARRA
Copernicus European Regional Reanalysis (CERRA) - consists of 3 datasets spanning September 1984 - June 2021

- CERRA (5.5 km horizontal resolution) – analyses every 3h, hourly forecasts
- CERRA-EDA (11km horizontal resolution): 10-member EDA – analyses every 6h, hourly forecasts
- CERRA-Land (5.5km horizontal resolution): 3h analyses & forecasts; daily precipitation analysis

To be published in 2022
Regional reanalysis for Europe (CERRA and UERRA)

CERRA
Models: HARMONIE-ALADIN (atmosphere); MESCAN - SURFEX (land)
  •  boundary conditions from ERA5;
  •  additional local surface observations (e.g. Greenland, Finland, etc) assimilated
  •  24h total precipitation assimilated;
  •  use of 1km map of Soil Organic Carbon areas → potentially improved soil temperature profiles in regions with permafrost (in CERRA-Land)

UERRA-HARMONIE
  •  previous-generation regional reanalyses for Europe (mostly produced in a EU FP7 project)
  •  available in the CDS (1961-2019, 6-hourly, 11km and 5.5km land product)
Case study: storm Gudrun, southern Sweden, January 2005

10m wind speed at the peak of the storm at 18 UTC 08 January 2005

More realistic features related to topography and land-sea mask:
- Higher wind speed over lakes, e.g. lakes Vättern and Bolmen - better in CERRA
- Lower and more realistic wind speed over the Bornholm island (circle) in CERRA.
Case study: storm Gudrun, southern Sweden, January 2005

For many Swedish stations CERRA has a better fit to 10-m wind speed obs than ERA5.

Hanö - Sweden
Snow depth in the Alpine region

The regional reanalysis products CERRA-Land and MESCAN-SURFEX outperform ERA5-Land, which in general overestimates the snow depth (SAFRAN is a dataset that can be considered as a close to the truth).
Plans for Copernicus 2 (2021-2027)

- Near-real-time updates of the current European and Arctic regional reanalyses - 2-3 months behind real time
  - Next generation pan-Arctic regional reanalysis
    - new models configuration; new domain; ERA5 boundary conditions
    - period: at least 1991-2025
  - Support action for (European) reanalysis downscaling activities
  - Extension back in time
What did C3S ‘learn’ in this context?

**Evaluation**

- For users: to select from number of products, to accept reanalysis over observations (e.g. verification of climate predictions)
- For producers/funders: to decide prioritization of effort
- Evaluation by providers: important; evaluation by users: also available


Is the methodology currently used for reanalysis evaluation suited for such objectives?
What did the producers ‘learn’ in this context?

On system development, testing, implementation
• ‘Improvements’ were attributed to the use of new data
• Deviations from NWP model configurations are costly and take time – here, they were used sparingly
• Modification of QC set up, to minimize rejections of observations of extreme events
• The HPC resources required for testing should not be underestimated

On preparation of input data sets:
• preparation of new observations as inputs is not trivial, but these data can have uses beyond the production of reanalysis – they may be worth sharing more widely
• need to plan for the real-time component (e.g. data collection close to real time)

On production:
• HPC requirements in production mode (e.g. risk of bottlenecks)
• Improve observation usage statistics – used as a monitoring tool (e.g. include long time series of number of observations going into the system).

Evolution of the system for use in reanalysis will also benefit the operational NWP suites
Key messages

- The use case rests primarily on the high spatial resolution
- The costs are significant

- Evaluation is key
Thank you for your attention