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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

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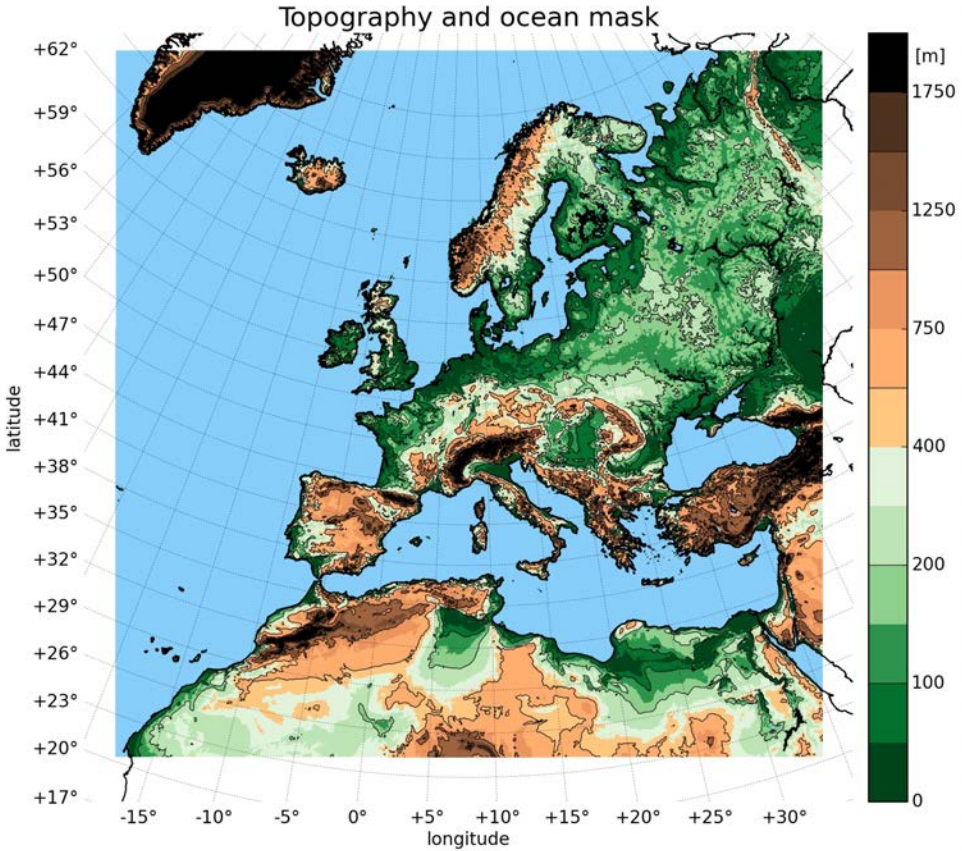

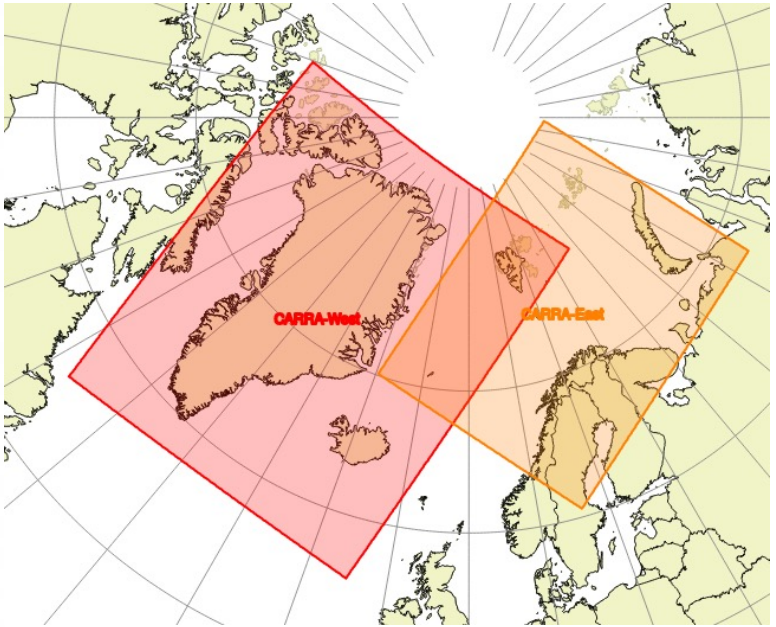

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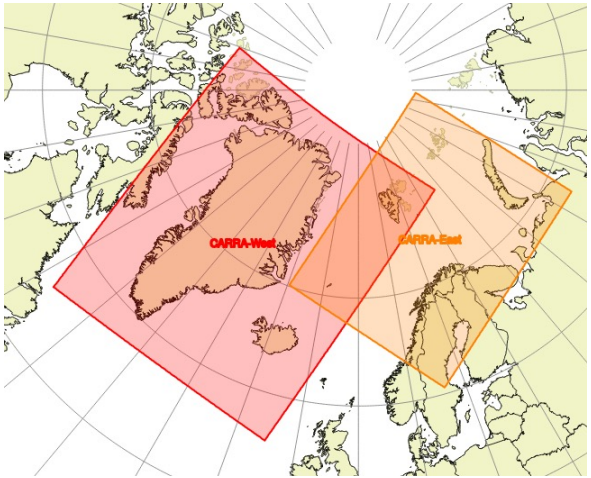
Copernicus Regional Reanalysis for the Arctic region (CARRA)

- 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)

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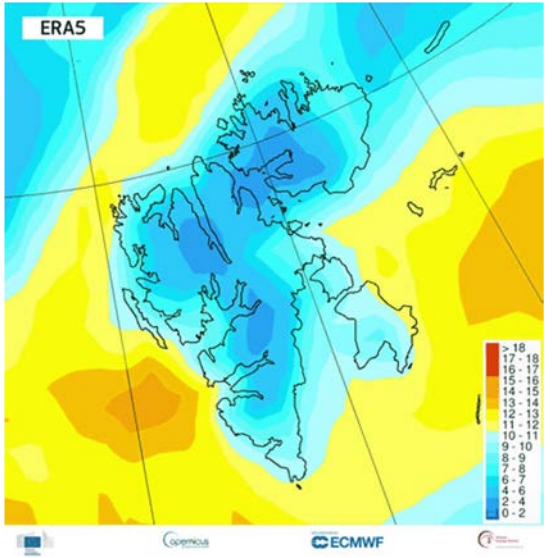
Copernicus Regional Reanalysis for the Arctic region (CARRA)

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

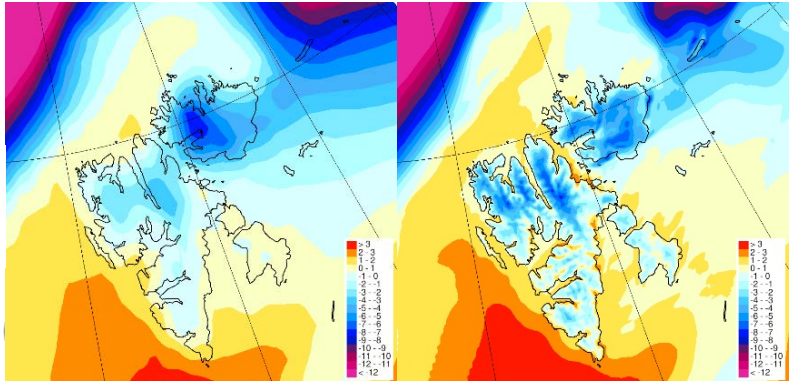
https://cds.climate.copernicus.eu/#!/search?text=CARRA

- 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



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Regional reanalysis for Europe

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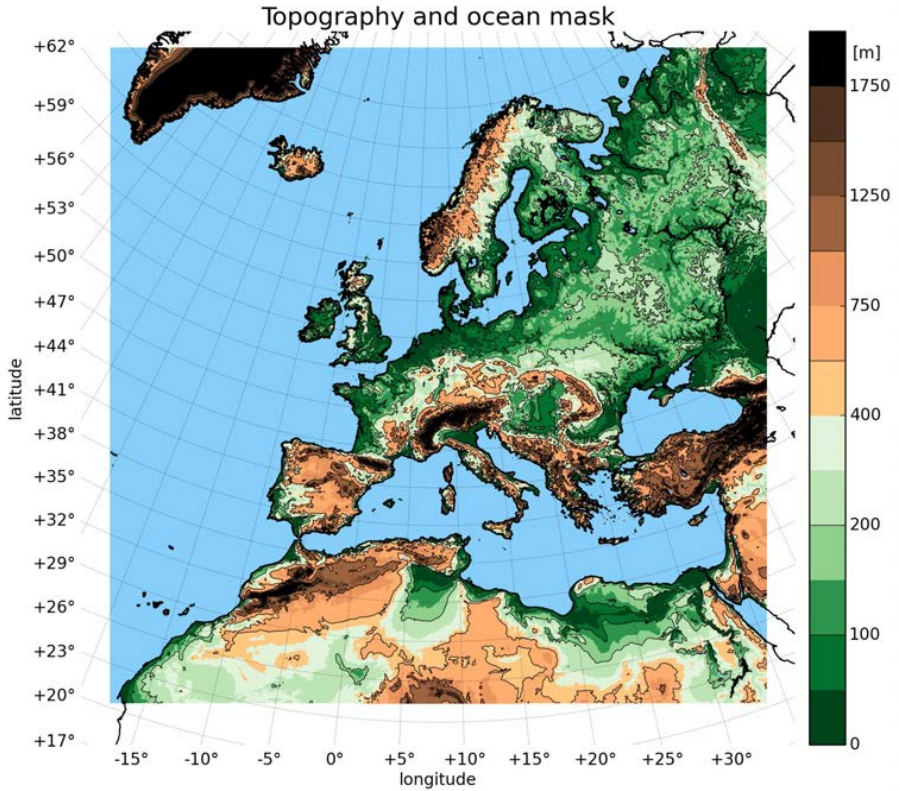
Copernicus European Regional Reanalysis (**CERRA**) - consists of 3 datasets spanning September 1984 - June 2021

- 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



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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

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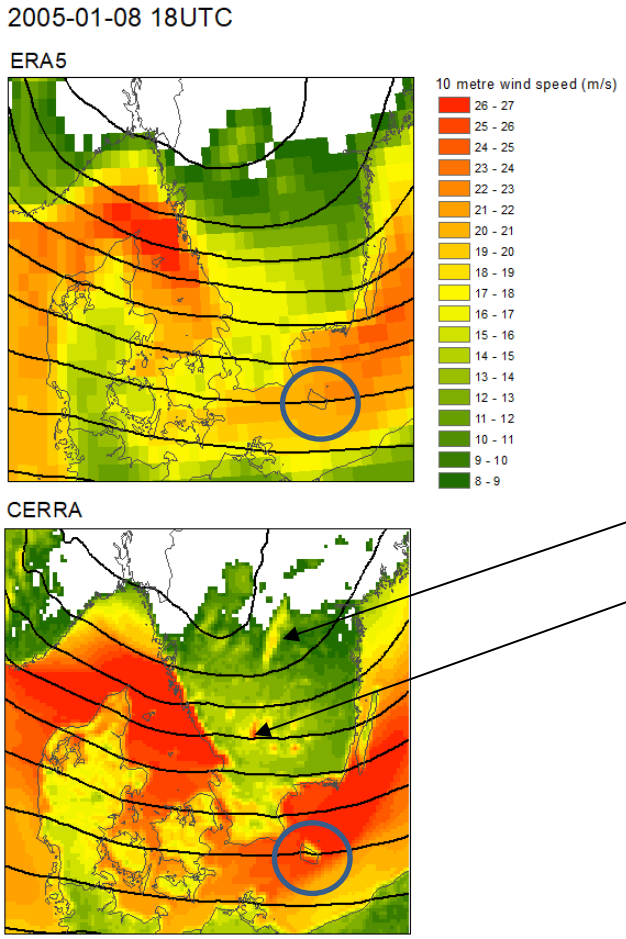
ERA5

CERRA



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.

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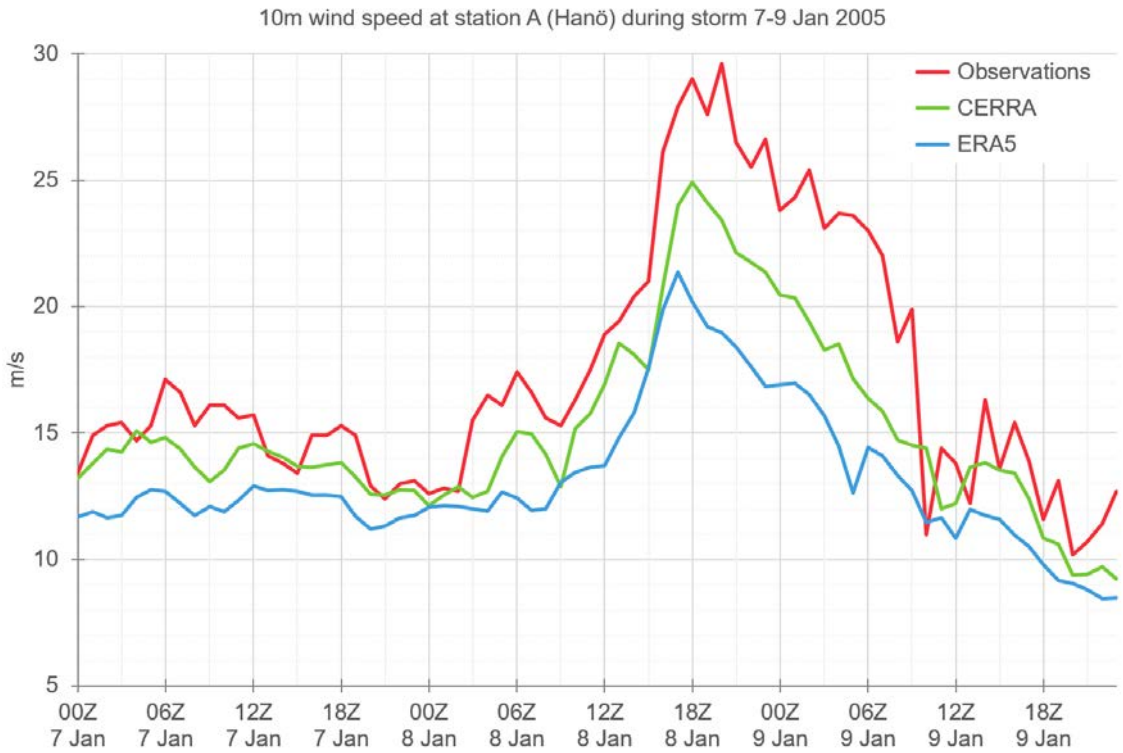
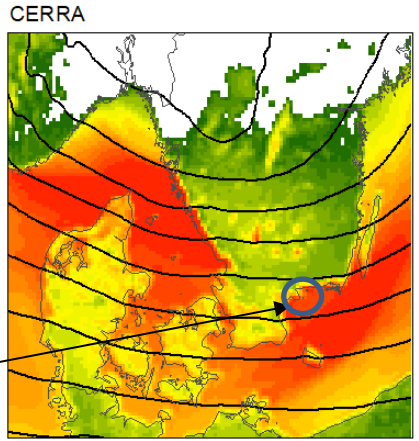
Case study: storm Gudrun, southern Sweden, January 2005



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



Hanö - Sweden

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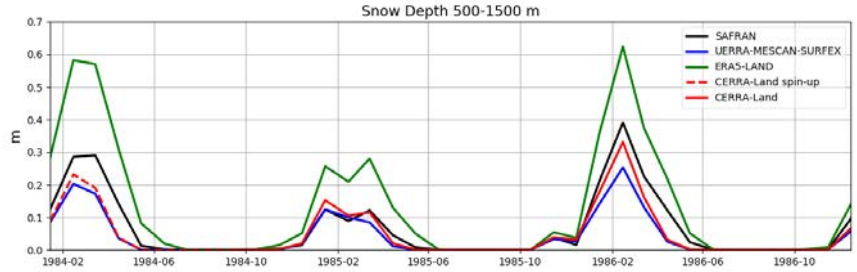
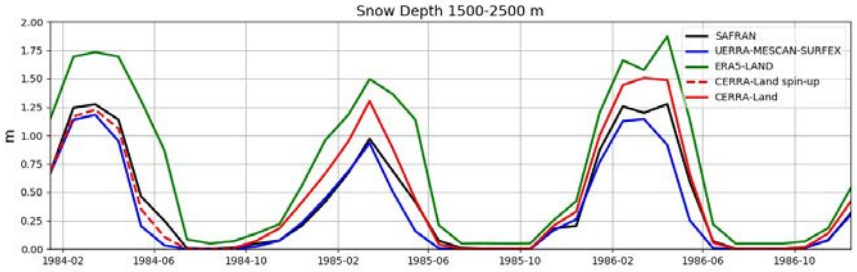
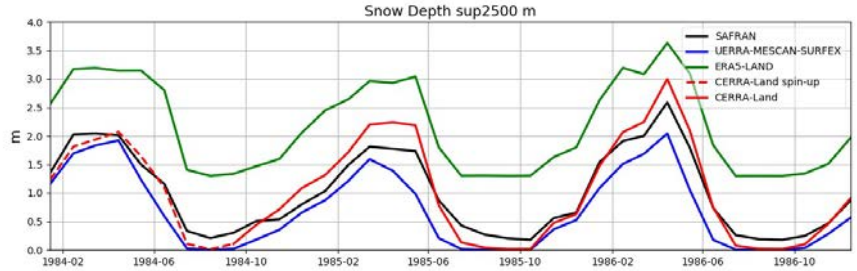
Snow depth in the Alpine region







The regional reanalysis products CERRA-Land and MESCAN-SURFEX outperform ERA5-Land, which in general overestimates the snow depth (SAFRAN is data can be considered as a dataset close to the truth)

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Plans for Copernicus 2 (2021-2027)

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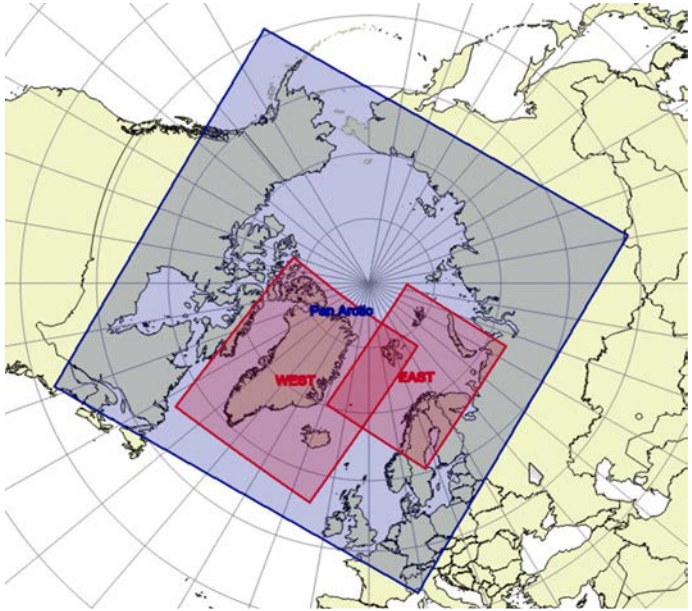
- Near-real-time updates of the current **European** and **Arctic** regional reanalyses - 2-3 months behind real time
- Next generation **pan-Arctic** regional reanalysis
  - new models configuration; new domain; ERA5 boundary conditions
  - period: at least 1991- 2025
- Support action for (**European**)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



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What did C3S 'learn' in this context?

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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

KøltzowM., SchybergH., StøylenE., & YangX. (2022). Value of the Copernicus Arctic Regional Reanalysis (CARRA) in representing near-surface temperature and wind speed in the north-east European Arctic. Polar Research, 41. https://doi.org/10.33265/polar.v41.8002

⇨ Is the methodology currently used for reanalysis evaluation suited for such objectives?

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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

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Key messages

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

- Evaluation is key

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Thank you for your attention

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