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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

# Towards a convection permitting reanalysis for the European CORDEX domain

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*The main goal of any reanalysis project is to provide the best possible state of the system in question. For this, state of the art models are combined with current data assimilation (DA) techniques. Since both models and DA methodologies are constantly improving as well as the increasing availability of computing resources the quality the re-analyses improves as well. For this study the Atmospheric model ICON run at a resolution of 3km is combined with a DA system based on the Localized Ensemble Transform Kalman Filter (LETKF). Even though computing resources are much more plentiful today, still some compromises have to be made to run a multi-decade reanalysis at this scale. Preliminary results are presented showing great potential.*

### Advantages of a convection permitting reanalysis

In contrast to other continental-scale reanalyses, which are usually not at resolutions allowing for convection permitting settings, this reanalysis offer a number of improvements:

- Better representation of precipitation, especially for very high rain rates[3]
- Improved wind gusts for convective events
- More realistic drainage networks especially in regions with complex terrain
- More realistic snow depth distribution in mountainous regions

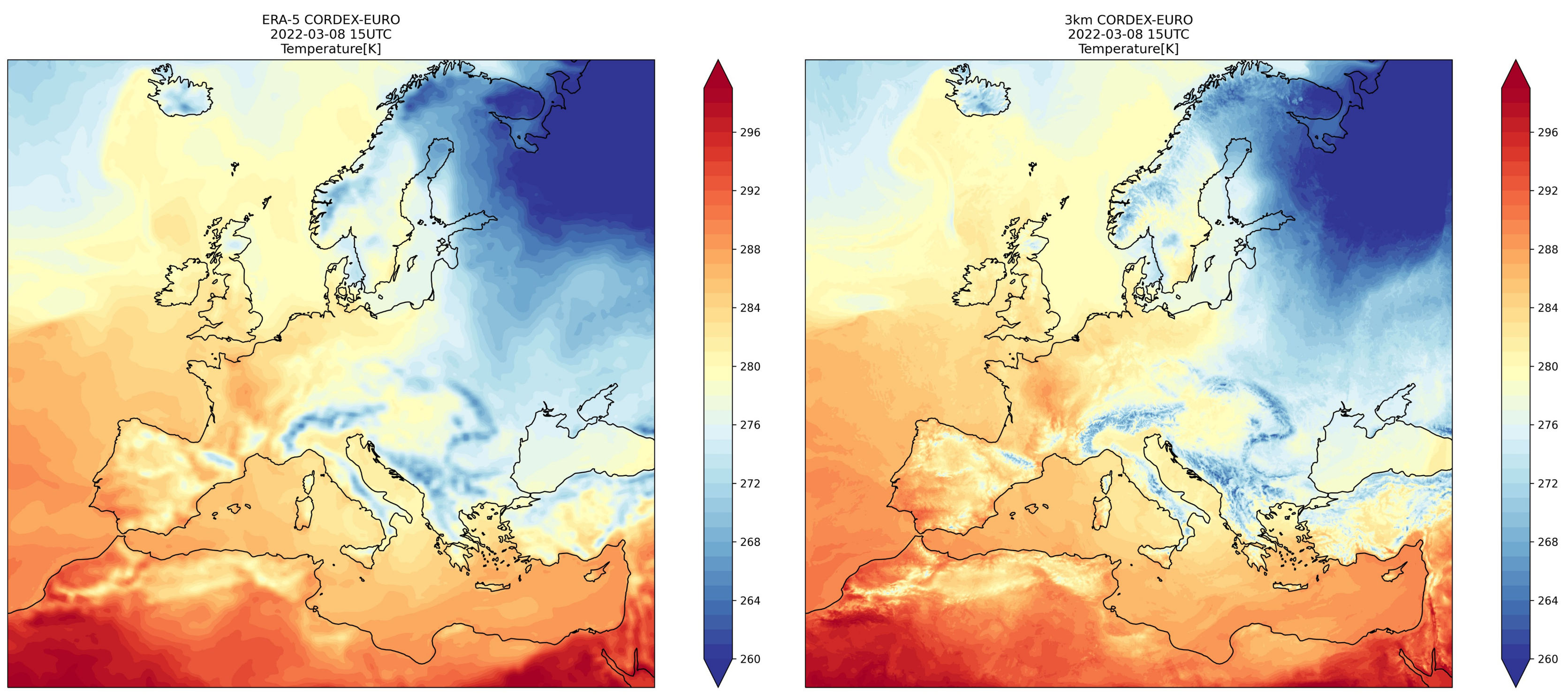


**Figure 1**: Left: Near-surface temperature of ERA-5 forcing data
Right: Near-surface temperature of the 3km simulation

### The ICON model and European CORDEX domain

For this reanalysis project the ICON (Icosahedral Nonhydrostatic) model is used. ICON is designed to run over a large range of resolutions, starting at 160km for coarse global simulations down to several 100 meters for limited areas. As the name suggests, ICON uses an irregular icosahedral grid and includes non-hydrostatic dynamics for the dynamical core[1]. Based on the chosen resolution, different parameterizations for processes below the grid scale are used.


**Figure 2**: Left: Representation of the icosahedral grid of ICON (from the ICON tutorial)
Right: Flowchart of the model structure of ICON (from the ICON tutorial)

1. Zängl, G., D. Reinert, P. Ripodas, and M. Baldauf, 2015: The ICON (ICOsahedral Non-hydrostatic) modelling framework of DWD and MPI-M: Description of the non-hydrostatic dynamical core. Q. J. R. Meteorol. Soc., 141, 563–579
2. https://cordex.org/domains/cordex-region-euro-cordex/
3. Isotta, F., Vogel, R., & Frei, C. (2015). Evaluation of European regional reanalyses and downscalings for precipitation in the Alpine region. Meteorologische Zeitschrift, 24, 15-37. doi:10.1127/metz/2014/0584
4. Brian R. Hunt, Eric J. Kostelich, Istvan Szunyogh, 2007: Efficient data assimilation for spatiotemporal chaos: A local ensemble transform Kalman filter, Physica D: Nonlinear Phenomena, https://doi.org/10.1016/j.physd.2006.11.008.

### The data assimilation system

The DA system used for this reanalysis is based on the LETKF approach[4]. Due to computational constraints, only 10 members are possible.

### The EURO-CORDEX domain

This reanalysis is based on the European CODEX domain[2]. ICON is run at a horizontal resolution of 3km and 75 vertical layers extending up to 30km in height. This would be the first reanalysis at the continental scale at this resolution.

ICON runs for a local area need boundary conditions (BC). These are taken from the ERA5 reanalysis, interpolated to the ICON grid.

### Preliminary results for March 2022

Comparison between two setups, the reference being the closest possible to an operational NWP setup and the chosen reanalysis (REA) setup:

Reference: ICON BC, conventional OBS Central Europe, MODE-S, 1h DA interval
REA: ERA5 BC, conventional OBS entire domain, no MODE-S, 3h DA interval

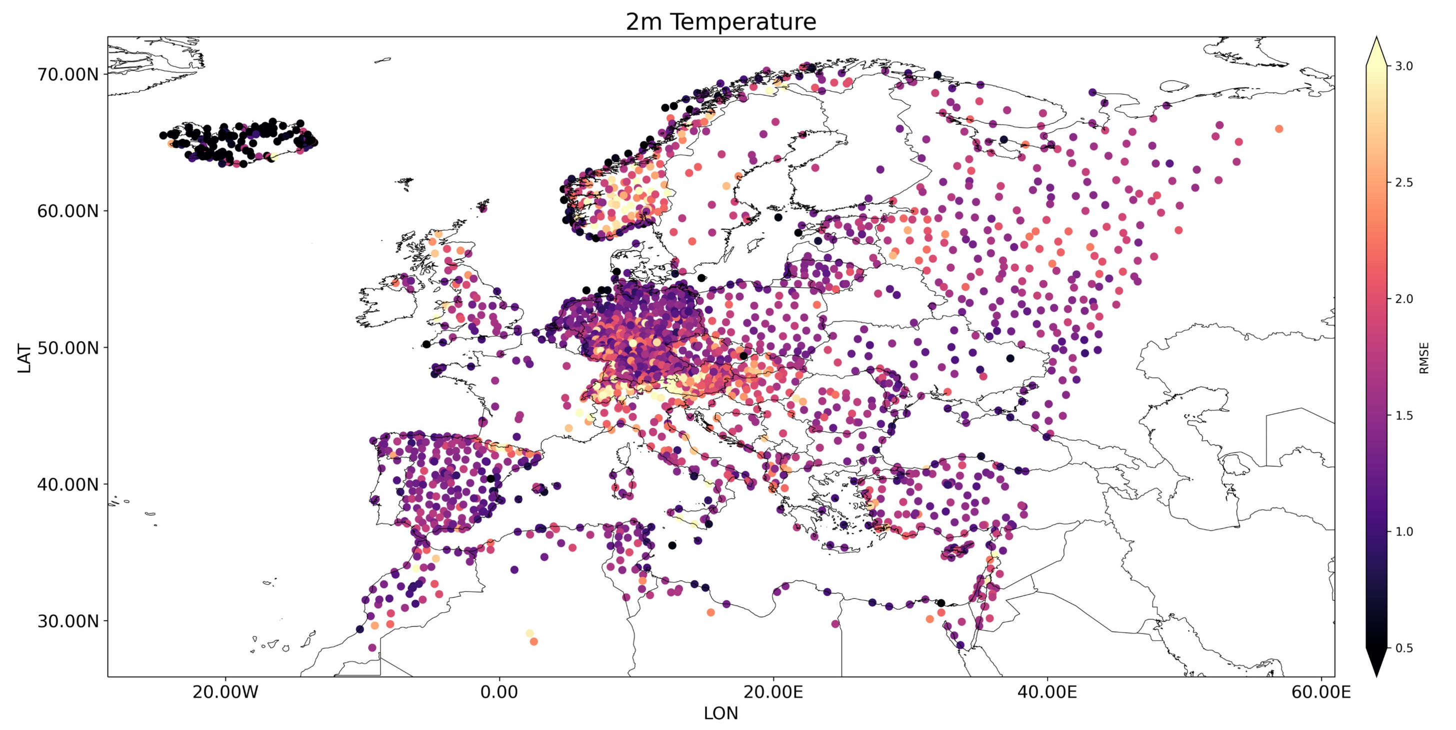


**Figure 3**: Scatter plot of 2m Temperature RMSE showing all observation locations for REA

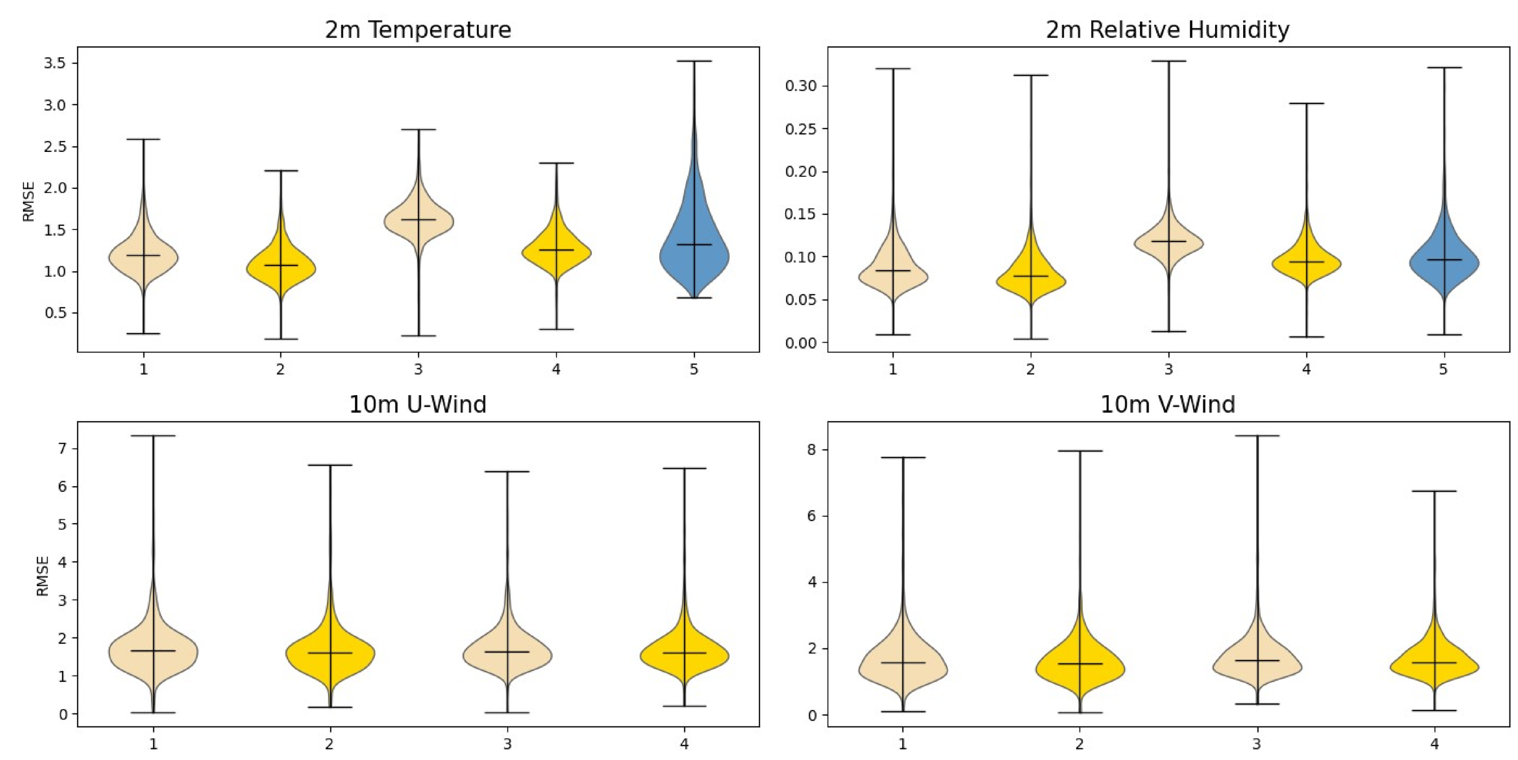


**Figure 4**: Comparison of RMSE distribution for different observables for 1: reference first guess 2: reference analysis 3: REA first guess 4: REA analysis 5: ERA5

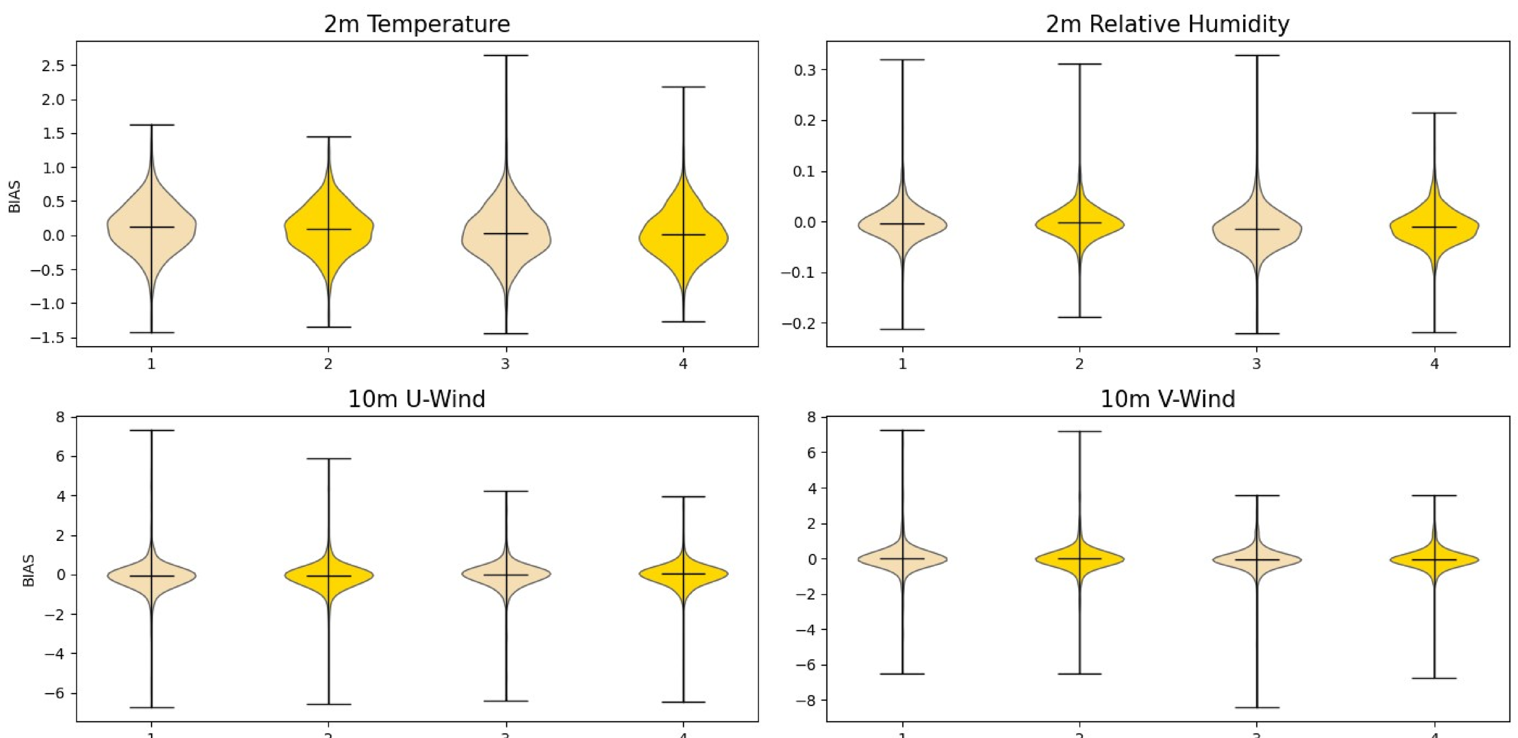


**Figure 5**: As figure 4 but showing the distribution of BIAS instead.

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