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PERUN/Reanalys – the high resolution reanalysis for central Europe driven by ERA5

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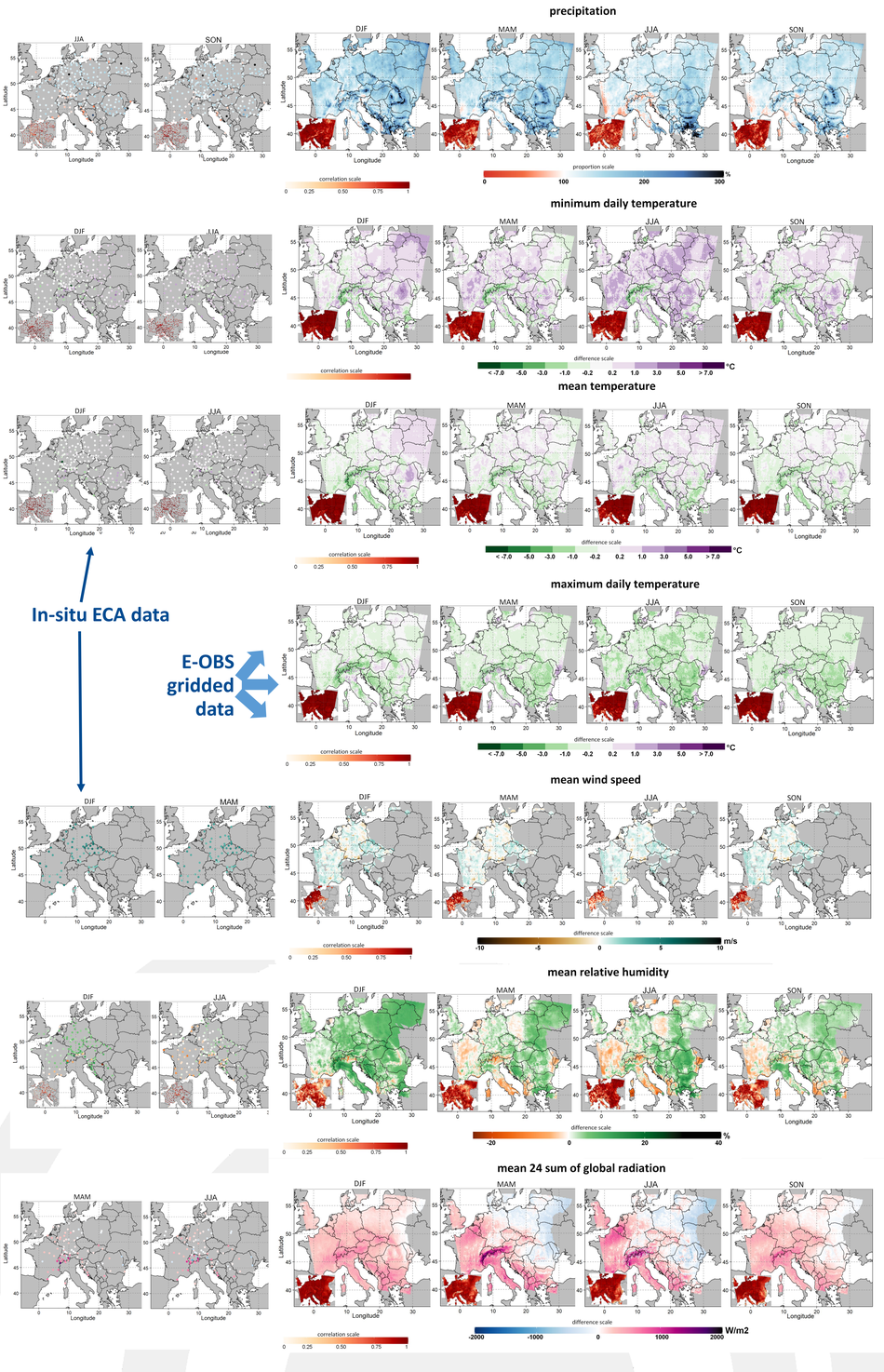
PERUN Reanalysis (PERRea)

PERRea is a product based on the ALADIN system with horizontal resolution 2.3 km, which shares its model code with the global NWP systems ARPEGE. The convection-permitting scale unable a smooth transition between the resolved and unresolved origin of precipitation. The ALADIN dynamical core includes coupling to the global model, time and advection schemes and a nonhydrostatic equation system. The horizontal diffusion scheme correctly reflects the nature of turbulent dissipation. The convection parametrization uses among others the vertical geometry of clouds and the sedimentation of precipitation is based on statistical approach. The radiation scheme garrantees high accuracy in both shortwave and longwave spectra thanks to a full cloud–radiation interaction at each model grid point and time step.
The model main purpose is the computation of future climate conditions in Central Europe. However precise description of model errors is necessary for the correct scenario interpretation. The PERRea, the model run driven by ERA5 and assimilating observed data, has the potential to highlight the model advantages and weakness as well.
Comparison of seasonal means or sums of individual climate parameters (bias and correlations) between reanalysis and reference datasets are displayed to show the model skills.

Maps

Display differences/rates of seasonal means/sums and correlations between PERRea and reference datasets (E-OBS in the central column and in-situ data in the left column) for individual climate elements and seasons. A rate of model to observed precipitation in % (100% Is the best agreement) and a difference in °C, m/s², % resp. W/m² for temperature, wind speed, relative humidity resp. global radiation is indicated by color; stations indicated by circles show the position od stations. The correlations maps for individual elements and seasons are situated in left bottom corner of corresponding bias map.



Data and methods

The PERRea domain covers central Europe and surrounding continental Europe, the output fields are available each hour. E-OBS represent the basic dataset for validation however the comparison of reanalysis with station data and ERA5 (the driving reanalysis of PERRea) are shown for selected seasons and elements too.

- PERUN Reanalysis regional Reanalysis, resolution 2,3 x 2,3 km^2
- E-OBS v23.0 (gridded station daily data over Europe) in 0.1° space resolution
- PERRea was recomputed to the E-OBS resolution using Bilinear interpolation
- Daily station data from ECA&D dataset, nonblended, stations with less than 10% missing data
- Missing in-situ data are excluded from seasonal sums in PERUN Reanalysis, means are computer if at least 70 % observations is available
- the nearest PERRea grid-point was used for comparison with station data
- period 1990 – 1999
- seasonal means or sums (climatological seasons DJF, MAM, JJA, SON)
- elements: precipitation, mean, maximum, minimum temperature, wind speed, relative humidity, global radiation (downward solar radiation at the surface)

Results

PERRea generally overestimates mean seasonal precipitation, particularly in southeastern Europe and mountain regions. Correlations are the lowest in summer. The comparison with stations confirms general overestimation. The PERRea simulates the sesonal precipitation better than other regioanl reanalysis in terithory of the Czechia (Bliznak et al., 2022).

Mean daily minimum temperature is overestimated over whole domain with exception of Italy, the Alps and southeastern Europe. Bias up to +5 °C obtains in JJA although the correlations are high in all seasons. Agreement between PERRea and in-situ data is better with the highest overestimation in JJA again.

Mean daily temperature is generally the best simulated with only slight underestimation in southern Europe, particularly in Italy, and overestimation in northeastern Europe. The largest bias occurs in the Alps in winter (underestimation up to -6 °C), while correlations indicate some difficulties in France during summer. Comparison with in-situ data confirms the results with exception of mountains with not so high underestimation.

Mean daily maximum temperature is underestimated with the magnitude between -3 to -5 °C in large areas in JJA and in souteastern Europe in MAM and SON. Comparison with in-situ data is not available.

Mean daily wind speed is generally overestimated, particularly in the region of the Czechia. The overestimation is even higher comparing PERRea with statin data. This may affect maximum and minimum temperature, both. The correlations are weak in JJA and SON.

Mean daily relative humidity shows large overeatimation in winter and spring in eastern Europe and in winter in central and southern Europe too. It may contribute to a minimum temperature overestimation in DJF. Correlations are generally low in comparison with other elements. Comparison of PERRea with in-situ data confirms this statements.

Mean daily sums of global radiation are generally overestimated, particularly in mountins and Southern Europe, but in JJA in western Europe too. In situ measurements confirms the highest overestimation in mountain regions. However it does not effect the maximum temperature, that is generally underestimated in PERRea

Conclusions

- New regional reanalysis can simulate well precipitation sums and mean temperature, additionally, the low bias was found in western and central Europe in selected seasons for individual elements
- Daily maximum/minimum temperature is generally under/overestimated up to ±3 °C but in some regions even more than ±5 °C
- The large bias at selected stations indicate problems with the measured data or the large difference in a station and the nearest grid-point altitude rather than the model failure
- Daily temperature (particularly maximum) is related rather to precipitation and wind speed than to solar downword radiation or relative humidity
- Lower bias of PERRea against in-situ data in comparison with E-OBS in the case of precipitation and mean temperature indicates that smoothed station data may not be the suitable refference database at least in regions with complex terrain

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References
Bliznak et al., 2022: Assessment of the capability of modern reanalyses to simulate precipitation in warm months using adjusted radar precipitation. Journal of Hydrology: Regional Studies, 42,101121, https://doi.org/10.1016/j.ejrh.2022.101121.