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DOWNSCALING OF ERA40 IN NORWAY

Idar Barstad,
Asgeir Sorteberg,
Frode Flatøy
Bjerknes Centre for Climate Research, University of Bergen, Norway
(email: Idar.Barstad[AT]bjerknes.uib.no)

Michel Déqué,
CNRM/GMGEC/EAC, Meteo-France, Toulouse, France

1. INTRODUCTION

The jubilated ERA40 reanalysis dataset (Uppala et al. 2005) has been widely used in the scientific community after it appeared.

The resolution of ERA40 (T159l60L) represents the large scale circulation patterns, however, smaller scales features such as precipitation and wind enhancement processes near terrain as well as sharp fronts over water, are not well resolved. In order to get a better representation of the intensities of such phenomena, further downscaling may be justified.

2. BACKGROUND

Downscaling of a global dataset might be done in several ways; most widely used is some sort of limited area model (LAM) approach where lateral boundaries of a LAM is fed continuously from global datasets. It turns out that the variability produced by the LAM depends on the domain size (Miguez-Macho et al., 2005) and for advective systems such as extra-tropical cyclones, proper resolution of the source region may be important. Spectral nudging (impose larger scales from global dataset on to the LAM solution) of the LAM may mitigate the variability problem, but to address the mentioned advection problem, a stretched grid approach might be in place.

In this study, we have made use of a global modelwith a grid similar to the one used for ERA40, and stretched it (contract grid points to the focus area on the expense of grid point at the opposite sphere) with a factor 3. The focus area has been set to (67N, 5W), see Fig. 1. Spectral nudging was applied so that waves from ERA40 longer than T42 were nudged on to the solution while shorter waves were set free to evolve. The dynamical core and the physical parameterization follow Arpege-climate V4.5.

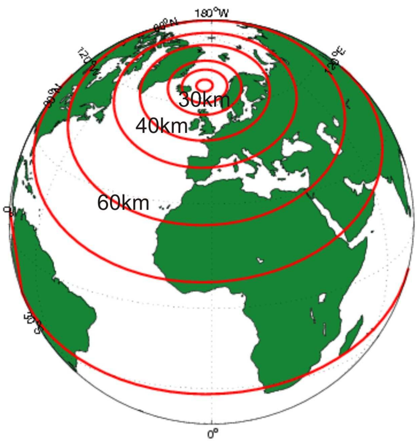

FIGURE 1: *Isolines of resolution for the stretched grid is indicated.*

3. THE RESULTS

The downscaling results were compared with precipitation (#357 stations), temperature (#98) and some coastal wind station (#10) in Norway. The comparison was done for a period of 30 years (1961-1990).

Precipitation

Fig. 2 shows the frequency distribution of daily precipitation for all precipitation stations. It indicates a clear improvement in reference to ERA40.

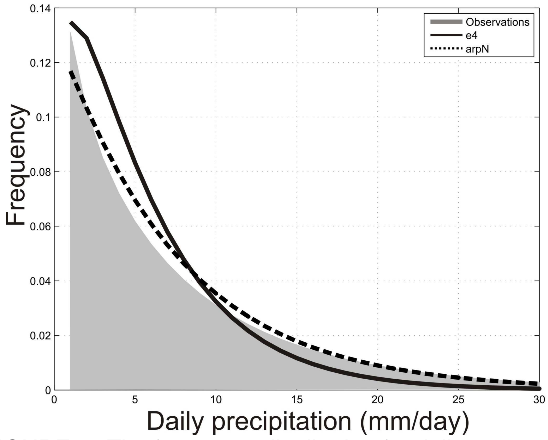

FIGURE 2: *The frequency distribution for daily precipitation (1961-1990). Gray is observations, solid line the ERA40 and dotted line the downscaling.*

Consistent with this picture are the percentiles shown in Table 1. Number of wet days (not shown) indicates a reduction from ERA40's 150% (overestimation) to 135% valid for the downscaling. Thus, the new simulation has similar deficiencies as other global models, however, the magnitude is reduced.

TABEL 1: *The relative error for model versus observations in % for different percentiles. Negative sign indicates underestimation by the downscaling (arpN) at given percentile. . "e4" refers to ERA40.*

Percentile (%)	Daily precipitation	
	e4	arpN
50	-53.1	-11.6
95	-45.3	-20.3
99	-51.4	-24.6
99.9	-58.4	-29.1

Fig.3 shows the downscaled distribution of daily precipitation at 50%tile level. This picture fits well with observed precipitation distributions, see Fig.4, but the downscaled intensities are still too small.

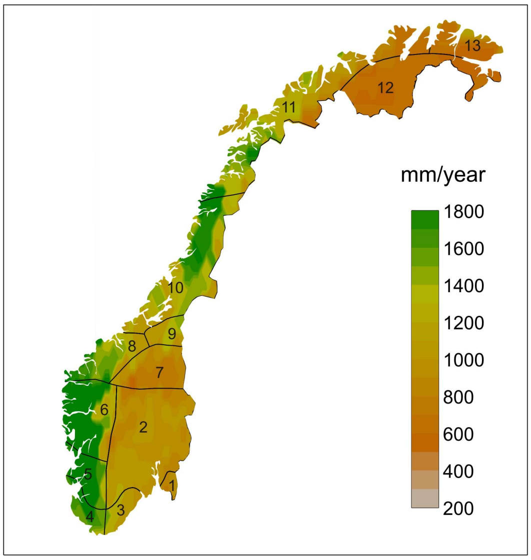

FIGURE 3: *Results from the downscaling. Geographical distribution of 50%tile daily precipitation. Precipitation regions are indicated.*

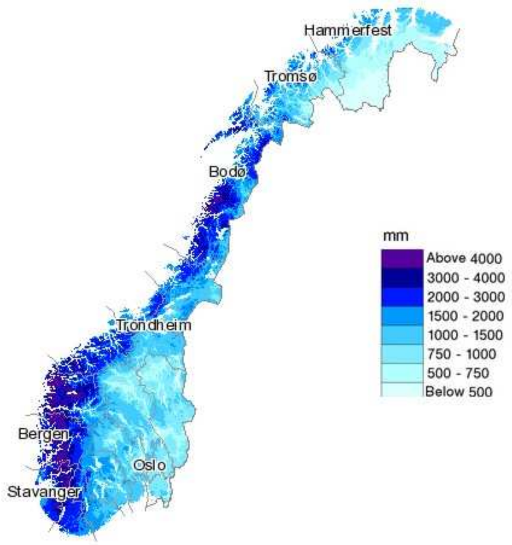

FIGURE 4: *Observed averaged annual precipitation (1961-1990) (from www.senorge.no). Main cities are indicated.*

Temperature

Comparison of daily 2m temperature (adjusted for height difference using a lapse rate of 6K/km), also indicate an improvement. The bias is improved by about a degree in most regions for most seasons. The reduction of RMSE indicates an improved synchronic match. The winter season is an exception. However at the coastal regions, the match is good even during winter. The reason is probably that coastal regions do not get really cold in winter, and that the model handles such situations better than cold inland cases.

Wind

The inland wind stations do not represent scales resolved by the downscaling as they typically are highly influenced by local (non-resolved) circulations. For our comparison, we have limited our data to a few coastal stations that is believed to have a larger influence of scaled resolved. The stations are located evenly along the coast. The improvement in wind speed comes typically for the wind speed range from 5-15m/s. Fig.5 shows an example from a light house on the south tip of Norway. We clearly see that the wind speed is improved in the intermediate regime.

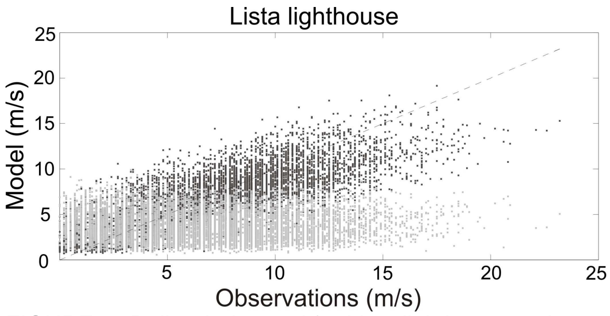

FIGURE 5: *Daily wind speed for Lista lighthouse at the south tip of Norway. Dark dots indicate downscaling simulation and light color refers to ERA40.*

Fig.6 shows the distribution of winds for the coastal stations. Bias and RMSE for the distribution indicate (not shown) that the downscaling has a weak overestimation of wind speed, while ERA40 has a larger underestimation. The numbers of RMSE reflects first of all that stronger winds are given more weight than weaker winds.

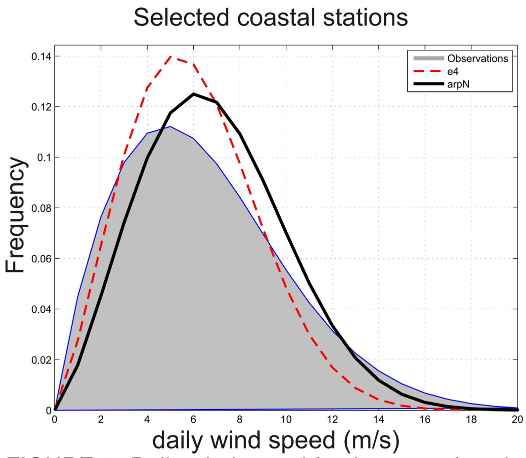

FIGURE 6: *Daily wind speed for the coastal stations. Gray refers to observations, broken line to ERA40 and solid line to downscaling.*

3. CONCLUSIONS

A novel approach applied to downscale the ERA40 data set has been applied. The method is based on a stretched global model with long waves from ERA40 nudged on to the simulation. By comparison of precipitation, temperature and wind data from all over Norway, the downscaled results showed that the new simulation provided a more accurate description of the atmospheric state. The downscaled data reproduced more of smaller scales and thus larger intensities in wind and precipitation resulted. The bias in the temperature has been reduced, but the bias for cold inland sites during winter had merely a small improvement. The approach taken has proven useful and produced a new and improved dataset for the Atlantic region of the Arctic area.

(a version of this manuscript is submitted to J Climate)

4. REFERENCES

Uppala SM et al. (2005): The ERA-40 re-analysis. Quart. J. R. Meteorol. Soc., 131, 2961-3012. doi:10.1256/qj.04.176

Miguez-Macho G Stenchikov G Robock A (2005) Regional climate simulations over North America: Interaction of local processes with improved large-scale flow. J Climate 18:1227-1246.