Intercomparison of horizontal wind speed components from NCEP/NCAR-Reanalysis and NCEP-DOE Reanalysis II.

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Hindcasts with reanalysis driven Regional Climate Models (RCMs) are a common tool to assess weather statistics (i.e. climate) and recent changes and trends. The capability of the two state-of-the-art RCMs REMO in two configurations (with and without spectral nudging applied) and CLM (with spectral nudging applied) to add value for surface marine wind fields in comparison to the reanalysis wind speed forcing is assessed by the comparison with wind speed observations in the eastern North Atlantic. For the locations of the in-situ observations and for details on the added value assessment please refer to the extended abstract on "Assessment of value added for surface marine wind fields obtained from two reanalysis driven Regional Climate Models (RCM)."

The added value is assessed with in-situ marine wind speed data at 10 m height in 1998. The observed 10 m wind speed is compared with the diagnostic 10 m wind speed of the RCMs and the forecast 10 m wind speed of the reanalysis, which is used as best guess for the 10 m wind speed of the reanalysis forcing because both the NCEP/NCAR (hereafter:NRA_R1) and NCEP/DOE II (NRA_R2) reanalyses do not deliver reanalysed 10 m wind speed. The SN-REMO, STD-REMO and CLM hindcasts were forced by the NRA_R2 in 1998. Consequently the forecast 10 m wind speed of the NRA_R2 should be used in the added value assessment. Unfortunately the NRA_R2 10 m wind speed forecast represents a rather unplausible data set with limited agreement with in-situ wind speed, as will be demonstrated in the following.

For the comparison of the in-situ wind speed with both NRA_R1 and NRA_R2 10 m wind speed forecasts, the latter are bilinearly interpolated onto the locations of the in-situ measurements. In addition, both the NRA_R1 and NRA_R2 forecasts were time interpolated linearly to the one hour resolution given by the observations. The results of the comparison are displayed in Figure 1.

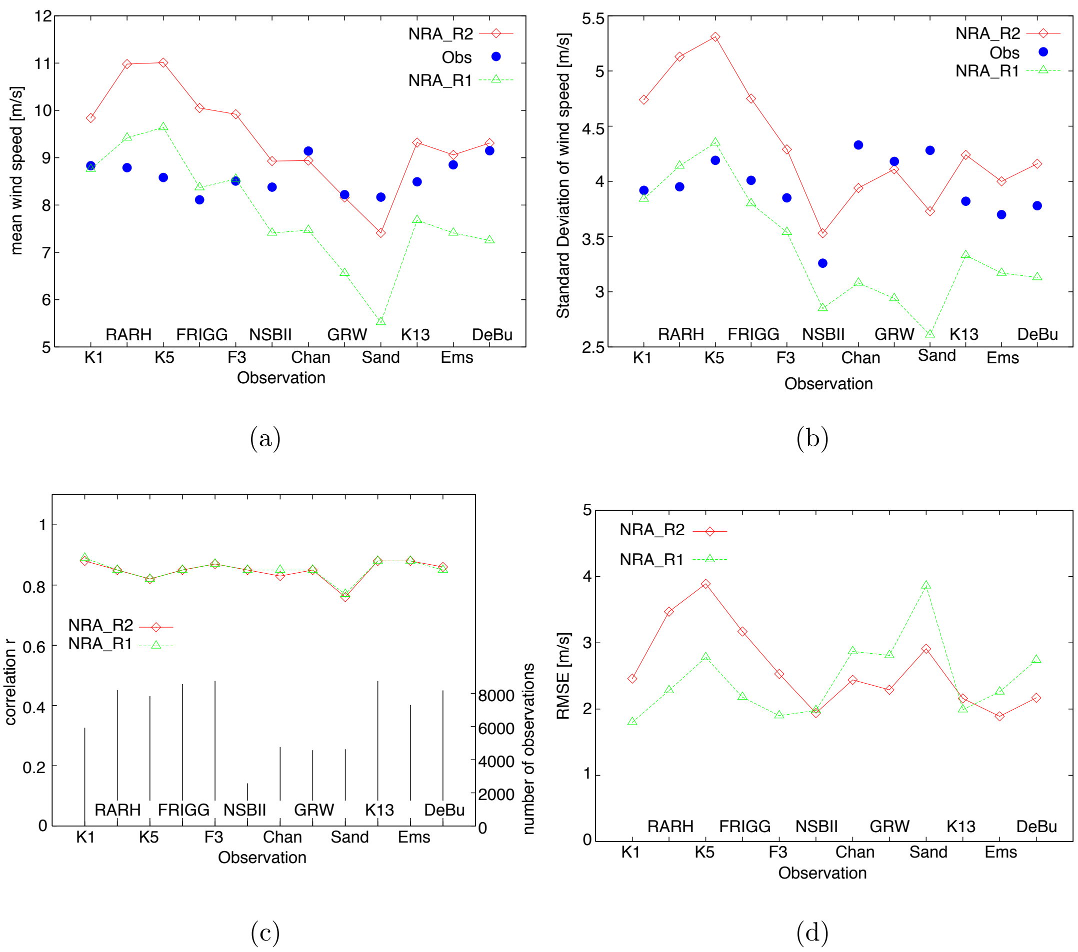
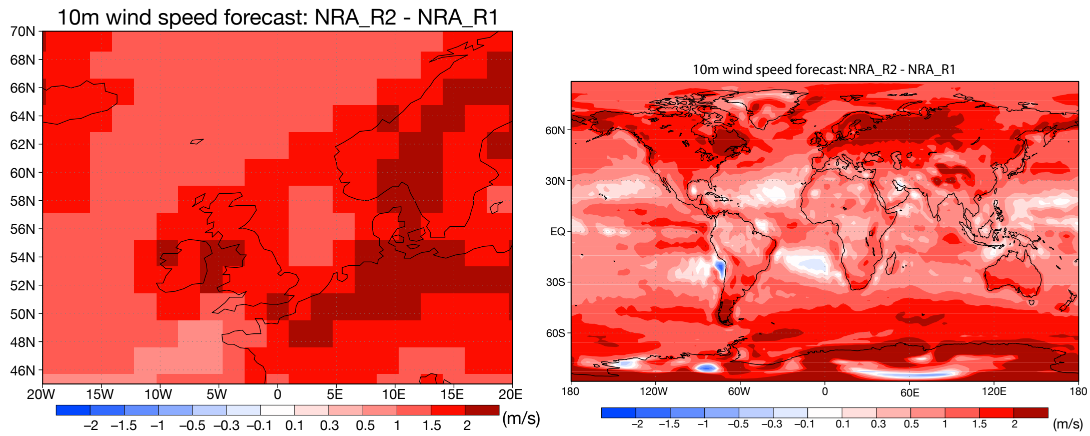


Figure 1: *Comparison of in-situ wind speed with 10 m wind speed forecasts of NRA_R1 and NRA_R2 in 1998: a) mean wind speed, b) its standard deviation, c) number of observations and correlation r, d) root-mean-square error.*

In general a large positive bias between the NRA_R2 and the NRA_R1 in the order of 2 m s^{-1} can be inferred (see also Figure 2(a)). Far offshore at K1, RARH, K5, FRIGG and F3 the NRA_R1 agrees better with observed mean wind speed while the NRA_R2 overestimates 10 m wind speed by up to 2 m s^{-1} (3 m s^{-1} at K5 due to both NRA_R2 large bias and too low wind speed measurements at K5). Closer to the coast and, especially within the English Channel, the NRA_R2 shows a much better agreement with the observations.

The latter represents a highly unplausible result, because both forecasts calculate wind speed over approximately 200x200 km wide grid boxes and can therefore hardly resolve the topography within the English Channel. At each grid box within the English Channel some kind of smoothed topography, averaged over the water and adjacent land surfaces, is used in both forecasts. As a result the surface roughness will be higher and consequently the forecast wind speed within the English Channel should be lower than that measured by the English Channel lightships Chan, GRW and Sand. While this is the case for the NRA_R1, the NRA_R2 gives mean wind speeds comparable to the in-situ data. Similarly,



(a) (b)

Figure 2: *Bias between the 10 m forecast wind speed of the NRA_R2 and NRA_R1 in the eastern North Atlantic and the North Sea (left) and globally (right) in 1998 .*

where topographic features, averaged over a forecast grid cell, are relatively homogeneous (such as for open waters) near-surface wind speed is expected to show less variance and in-turn a better agreement between in-situ and forecast wind speed might be expected. While again this is the case for the NRA_R1, it is not for the NRA_R2. While representing an average over 200x200 km with an integration time step of 20 min, the NRA_R2 forecast gives wind speed variabilities higher than observed for 9 of 12 cases, which is highly unplausible. The RMSE

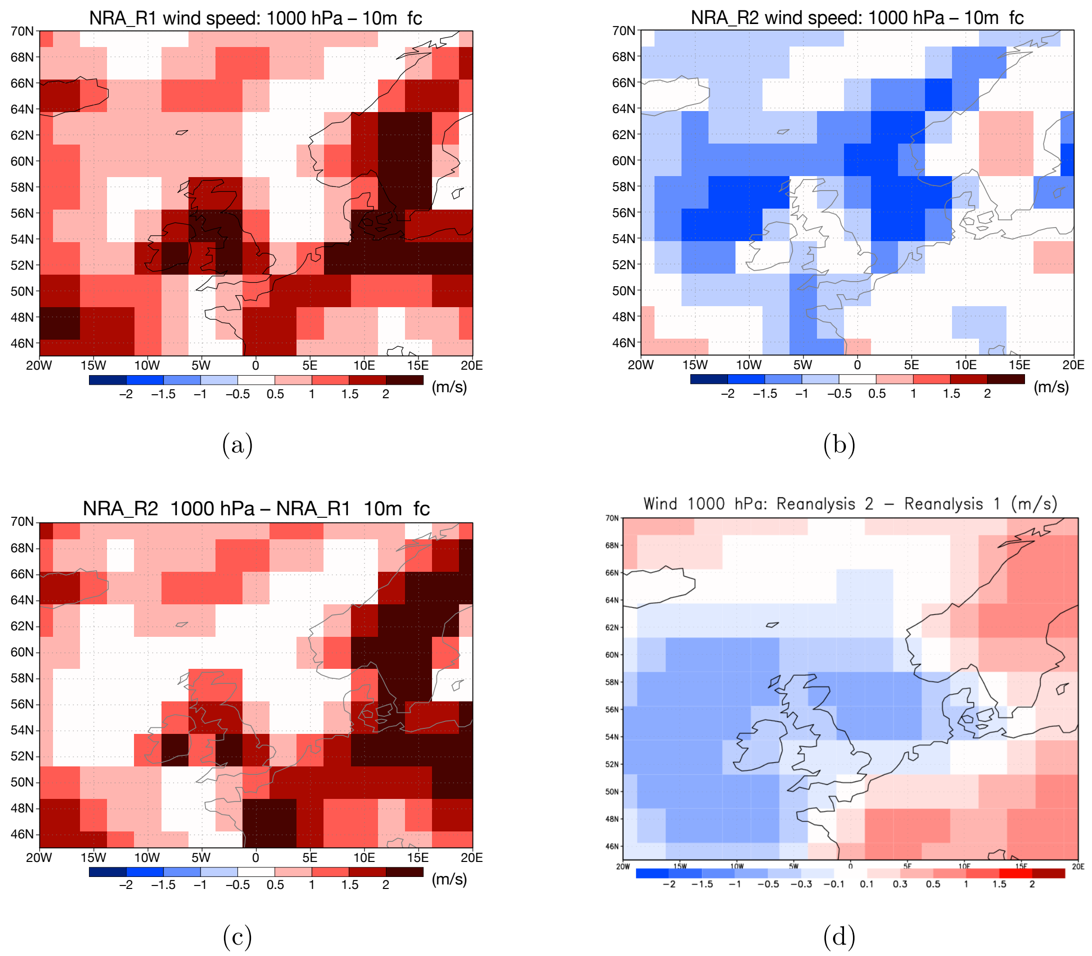


Figure 3: *Comparison of the reanalysed 1000 hPa and forecast (fc) 10 m wind speed of both reanalyses in 1998: a) NRA_R1: 1000 hPa - 10 m fc, b) NRA_R2: 1000 hPa - 10 m fc, c) NRA_R2 1000 hPa - NRA_R1 10 m fc, d) 1000 hPa: NRA_R2 - NRA_R1.*

of the NRA_R2 10 m forecast again shows its counterintuitive behaviour, since it gives lower RMSE values near coastlines it cannot resolve and higher RMSE for areas far offshore.

As depicted in Figure 2(b), the strong bias between the NRA_R2 and NRA_R1 10 m wind speed forecasts is not constrained to the Northeast Atlantic. With the exception of the subtropical latitudes around 30° and some patches in the Antarctic, the NRA_R2 shows too high 10 m wind speed as compared to the NRA_R1. This positive bias peaks to 1.5 m s^{-1} and above in and around the

Antarctic and on the Eurasian and North American land masses.

In 1998, the mean sea level pressure in the investigated area is similar to the 1013 hPa given for the U.S. Standard Atmosphere after NASA(1976)(not shown). Thus, in agreement with the standard atmosphere, the 1000 hPa level is expected to be in average at a height of around 100 m. Consequently, according to the vertical wind speed profile in the surface layer, the wind speed at 1000 hPa is in average higher than that at 10 m height. For 1998, the differences of the annual averages of the reanalysed 1000 hPa and forecast 10 m wind speed are depicted in Figure 3. While the NRA_R1 shows higher wind speeds on the 1000 hPa level (Figure 3(a)), the NRA_R2 forecast wind speed in 10 m height even exceeds the reanalysed wind speed at the 1000 hPa level (Figure 3(b)), indicating a major inconsistency in the NRA_R2 reanalysis/forecast system, as far as near-surface wind speed is concerned.

Both reanalyses show similar wind speed patterns at 1000 hPa, which is not surprising given that both reanalyses assimilate similar marine near-surface wind speed observations. In detail, the differences are much smaller than the differences between the 10 m wind speed forecasts and have the opposite sign (Figure 3(d)). These findings indicate on the one hand, that the NRA_R2 10 m wind speed forecast is not representative for the near-surface wind field of the NRA_R2 reanalysis. On the other hand, a problem within the Hong-Pan planetary boundary layer non-local vertical diffusion scheme (Hong and Pang, 1996) implemented in the NRA_R2 forecast model is indicated. Additionally, the strong bias may be attributed at least in part to the different convective parameterizations leading to more intense storms in the NRA_R2 (W. Ebisuzaki (Climate Prediction Center, NCEP), pers. comment). The effects are also visible in the wind speed frequency distributions (Fig 4). While the bias between both forecasts is similar at all stations, the bias between the NRA_R2 forecasts and in-situ wind speed is strongest for open ocean areas (4(a)). The latter bias is lowered in coastal areas by the increasing influence of the surrounding land mass on the forecast wind speed, leading to apparently well matched wind speed frequency distributions in the German Bight at the light ships Ems and Debu and especially in the English

Channel at Chan (Figures 4(b)-4(d)).

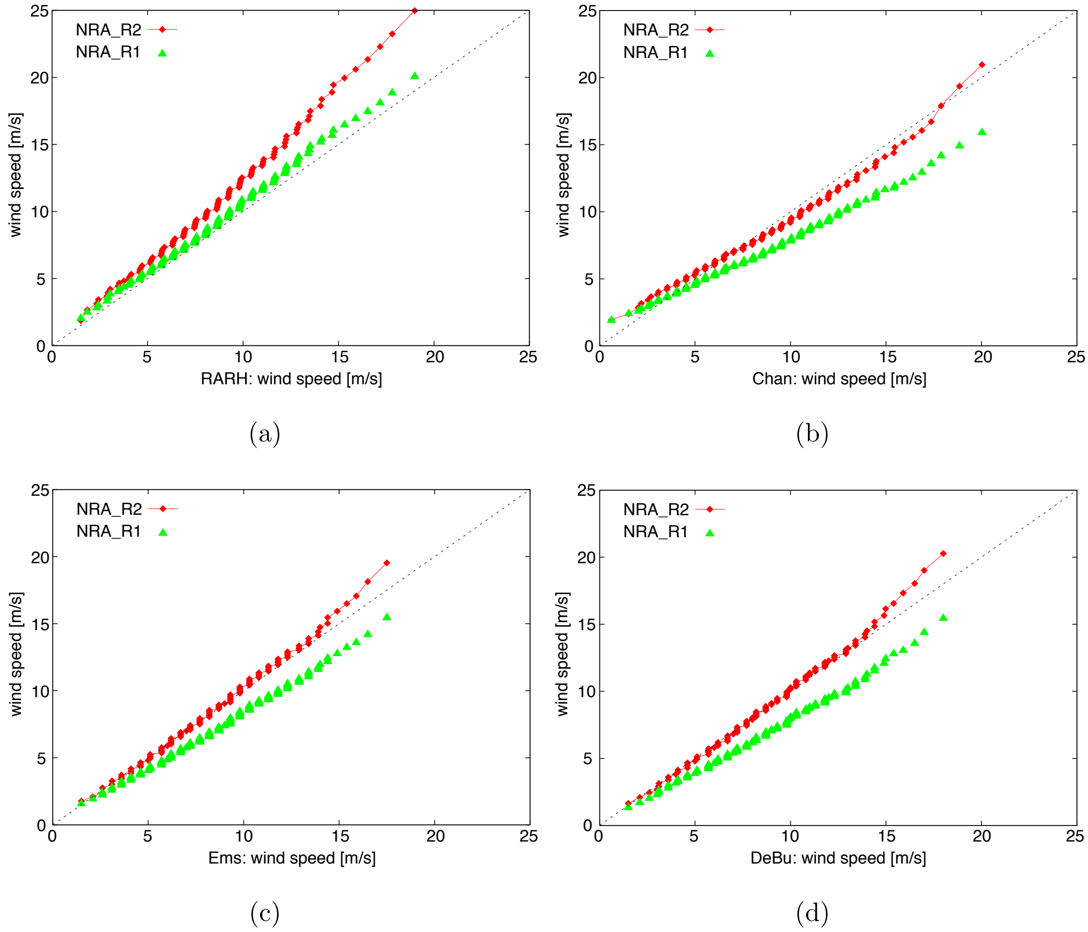


Figure 4: *Comparison of percentile-percentile distributions of 10 m wind speed from NRA_R1 and NRA_R2 forecasts and in-situ data at a) RARH, b) Chan, c) Ems and d) DeBu.*

Because of the plausibility arguments discussed, the NRA_R2 10 m forecast is not considered as an appropriate product to assess the added value of RCM hindcasts. However, the difference between the NRA_R2 1000 hPa wind speed and the 10 m wind speed forecast of the NRA_R1 shows a similar spatial pattern as the difference between the NRA_R1 1000 hPa and its forecast wind speed (Figures 3(c) and 3(a)). It is therefore suggested to use the NRA_R1 10 m wind speed forecast as best guess for the 10 m wind speed within the NRA_R2 reanalysis. Still, this approach is suboptimal and the added value assessment should be redone, when in-situ data is available for periods prior to 1997, when the SN-REMO and STD-REMO hindcasts are forced with the NRA_R1.

Literature:

NASA (1976). U.S. Standard Atmosphere. NOAA, NASA and USAF.

Hong, S.-Y. and Pang, H.-L. (1996). Nonlocal boundary layer vertical diffusion in a medium-range forecast model. Monthly Weather Review, **124**, 2322-2339.