P7.8 Surface marine wind from the NCEP/NCAR and NCEP/DOE-II reanalyses

Jörg Winterfeldt *, Ralf Weisse
Institute for Coastal Research, GKSS Research Center, Geesthacht, Germany

Abstract

The NCEP-NCAR Reanalysis and the newer NCEP-DOE Reanalysis II are intercompared concerning the forecast wind speed at 10 m height. Main focus of the comparison is the eastern North Atlantic and the North Sea. The results show a strong systematic bias between the forecast 10 m wind speed of both reanalyses. Comparison with marine in situ observations indicate a major inconsistency in the NCEP-DOE Reanalysis II reanalysis/forecast system and that the 10 m wind speed forecast of the NCEP-NCAR Reanalysis is closer to reality.

1. INTRODUCTION

The global reanalysis of atmospheric fields from National Centers of Environmental Prediction (NCEP) and National Center for Atmospheric Research (NCAR) involves the recovery of land surface, rawinsonde, pibal, aircraft, satellite, surface marine (ships, buoys, oil rigs, C-man platforms) and other data (Kalnay et al., 1996; Kistler et al., 2001). These data are quality controlled and assimilated with a data assimilation scheme that is kept unchanged over the reanalysis period to eliminate perceived climatic changes due to changes in the data assimilation scheme.

Briefly the reanalysis assimilation scheme works as follows: The 6h forecast started from the previous analysis serves as the first-guess field. In the spectral statistical interpolation (SSI) step, differences between the assimilated observations and the first guess-field are determined, which deliver the analysis correction. The analysis is updated with the analysis correction in the next step. The initial field for the next 6h forecast is determined from the analysis in the fourth step. Finally the forecast creates the guess for the next analysis step. The forecast model used is the T62/28-level NCEP global spectral model. The details of the model dynamics and physics are described in NOAA/NMC (1988), Kanamitsu (1989) and Kanamitsu et al. (1991)

The NCEP-NCAR Reanalysis (hereafter NRA_R1) is available from 1948 to present, the newer reanalysis from NCEP and the Department of Energy (DOE), the NCEP-DOE Reanalysis II (hereafter NRA_R2), is available from 1979 to present. The NRA_R2 provided upgrades to the forecast model (Kanamitsu et al., 2002). The implementation of the Hong-Pan planetary boundary layer non-local vertical diffusion scheme (Hong and Pang, 1996), a smoothed orography and different convective parameterizations may cause changes in the wind speed relative to NRA_R1. Both reanalyses are intercompared concerning the forecast wind speed at 10 m height. Main focus is the comparison with in-situ wind speed observations at 10 m height in the eastern North Atlantic and the North Sea.

2. METHOD

In-situ wind speed observations were available in 1998. They were, if necessary, converted to 10 m height using the COARE bulk flux algorithm in version 3.0b after Fairall et al. (2003). With the help of the NRA_R1 land sea mask the wind speed observations are classified as open ocean or coastal stations as depicted in Figure 1. For the comparison the 10 m wind speed forecasts of both the NRA_R1 and NRA_R2 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.

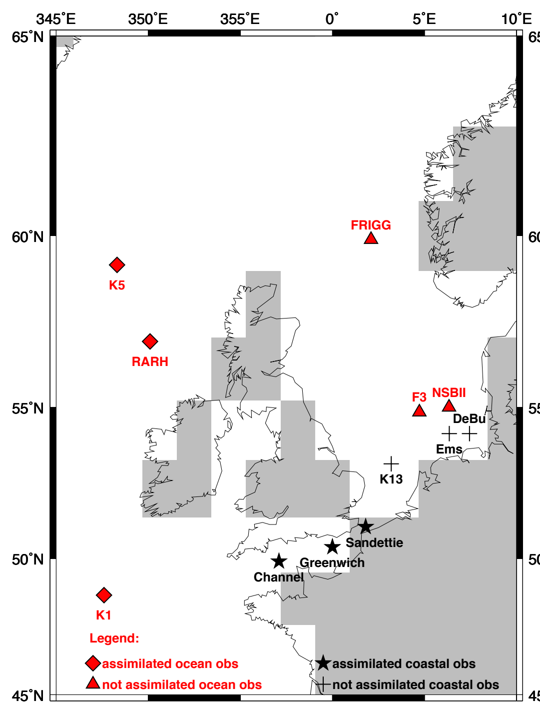

FIG. 1: Locations of wind speed observations (obs) over land sea mask of NRA_R1.

*Corresponding author address: Jörg Winterfeldt, GKSS, Institute for Coastal Research, Max-Planck-Straße 1, 21502 Geesthacht, Germany; e-mail: joerg.winterfeldt@gkss.de

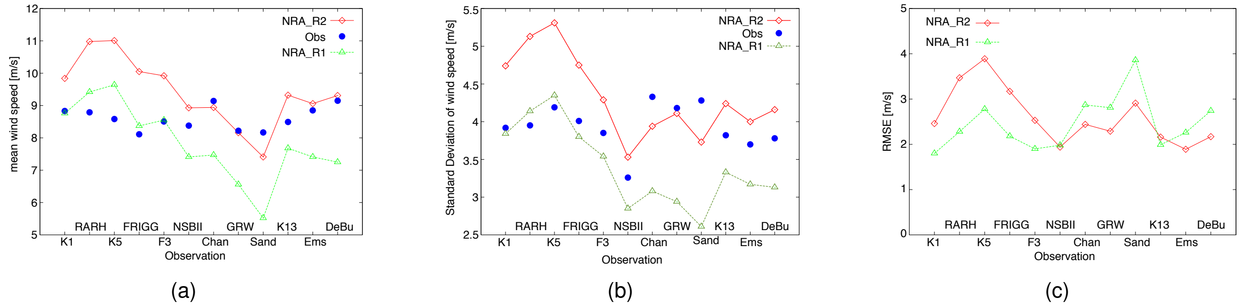

FIG. 2: Comparison of in-situ wind speed with 10 m wind speed forecasts of NRA_R1 and NRA_R2 in 1998: a) mean wind speed, b) its standard deviation and c) root-mean-square error.

3. Results

The results of the comparison are displayed in Figure 2.

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 3(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, 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 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 3(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.

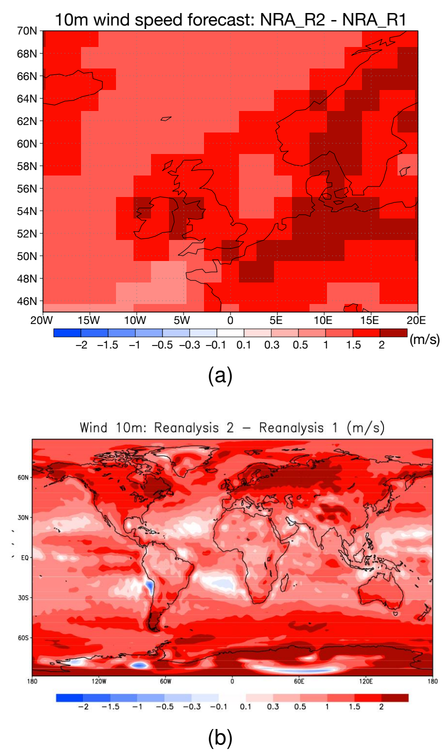

FIG. 3: Bias between the 10 m forecast wind speed of the NRA_R2 and NRA_R1 in the eastern North Atlantic and the North Sea (left) and globally (right) in 1998 .

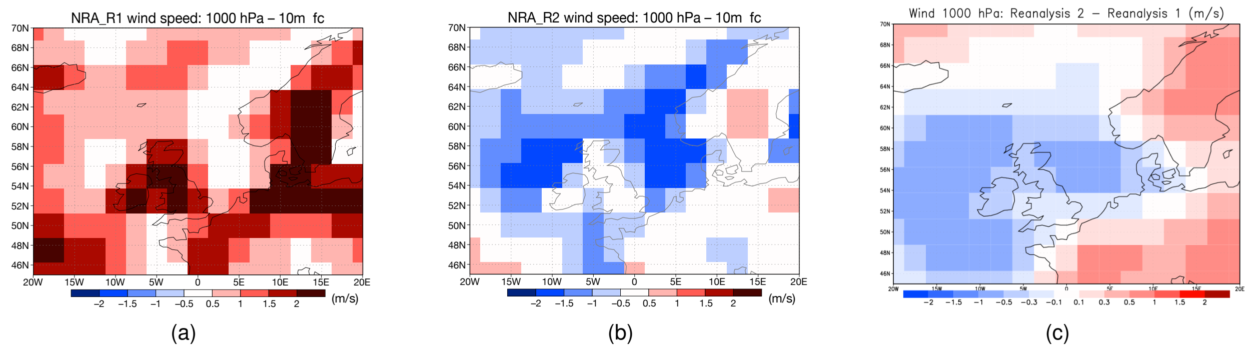

FIG. 4: Comparison of the reanalysed 1000 hPa and forecast (fc) 10 m wind speed of both reanalyses in 1998: a) NRA_R1: 1000 hPa - 10 m fc, b) NRA_R2: 1000 hPa - 10 m fc, c) 1000 hPa: NRA_R2 - NRA_R1.

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 4. While the NRA_R1 shows higher wind speeds on the 1000 hPa level (Figure 4(a)), the NRA_R2 forecast wind speed in 10 m height even exceeds the reanalysed wind speed at the 1000 hPa level (Figure 4(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 4(c)). 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 in Figure 5. 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 as depicted in Figure 5(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 and especially in the English Channel as illustrated in Figures 5(b) and 5(c).

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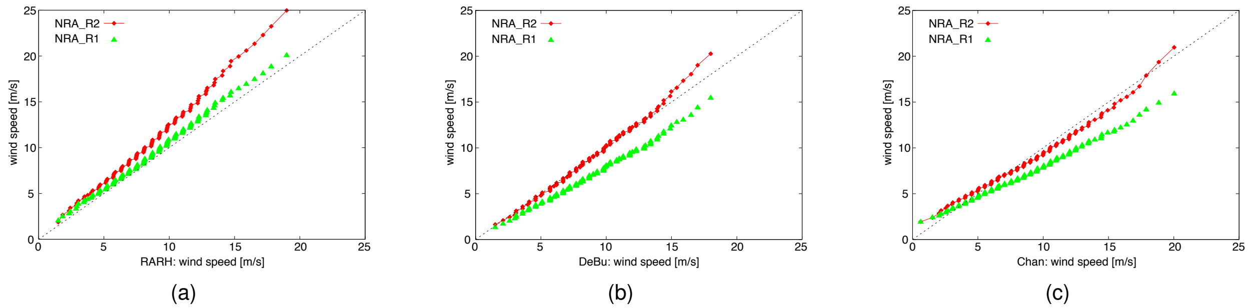

FIG. 5: Comparison of percentile-percentile distributions of 10 m wind speed from NRA_R1 and NRA_R2 forecasts (y-axis) and in-situ data (x-axis) at a) the buoy RARH as an open ocean station and b) the light ships DeBu and c) Channel as coastal stations.

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