# STATISTICS OF FORECAST ERRORS AND OROGRAPHY

Þórður Arason[1] and Haraldur Ólafsson[2]

[1] Veðurstofa Íslands – Icelandic Meteorological Office, Bustadavegi 9, IS-150 Reykjavík, Iceland
[2] University of Iceland, Icelandic Meteorological Office and Institute for Meteorological Research, Bustadavegi 9, IS-150 Reykjavík, Iceland
*arason@vedur.is*

**Abstract:** We have compared differences between radiosonde observations in SW-Iceland and 48 hour forecast by a numerical weather prediction model over a period of five years (2000-2004). Temperature and height of the pressure levels of 925, 850 and 500 hPa were compared in search for systematic errors. In the overall mean, the predictions have little error and very limited bias. There are however slight seasonal variations and indications of situations where the model does relatively poorly. At 500 hPa there is a cold bias in the forecasts in late winter, but no such bias in the autumn and early winter. At the lowest level there is a tendency of a cyclonic bias in the forecasted wind direction in northeasterly winds and in westerly flow, there is a warm bias in the forecasts. Both of these systematic low-level errors are attributed to non-resolved orography; the bias in the wind direction is most likely due to an underestimation of the deviation of the flow by the mountains and the warm bias appears to be associated with an underestimation of the accumulation of low level cold air upstream of Iceland.

***Keywords*** *– Weather prediction model, Radiosonde observations, Orography, Iceland, Forecast errors*

## 1. INTRODUCTION

In order to assess the accuracy of a numerical weather prediction model and get an insight into the physics behind possible forecast errors we have compared 48 hour forecasts to radiosonde data. Furthermore, we have focused on the instances where there seems to be systematic deviations between the model and data.

## 2. DATA

For this study we used radiosonde observations from Keflavík Airport in Iceland, WMO station number 04018, at 63°58.1'N, 22°36.9'W, elevation 38 m a.s.l. The radiosonde data at 00h and 12h UTC from the five year period 2000-2004 were used. The temperature, humidity, wind speed, wind direction and geopotential height at the 925, 850, and 500 hPa pressure levels were extracted from our data base. These were compared to the corresponding 48 hour prediction at 64°N, 23°W of the French numerical weather prediction model, Arpège (Courtier et al., 1991).

The time period of the study represents 1827 days, 3654 observation times at three pressure levels, a total of 10962 records. For this study we omitted records where data were missing or something appeared faulty with any of the parameters, and ended up using 9461 pressure level instances; 86% of the possible.

Fig. 1 compares the wind speeds of the model to the observed. Although there seems to be on average good correspondence there are both too high and too low forecasted wind speeds. Fig. 2 shows wind roses for both the observed and model data for the three pressure levels, and Fig. 3 shows in addition wind roses for the stormiest observed data, where the wind speeds exceed 30 m/s at 500 hPa and 20 m/s at 850 and 925 hPa. Fig. 4 shows differences between the observed and forecast temperatures versus observed wind direction, and in Fig. 5 we have calculated average values in 10° wind direction bins along with standard deviations. It is noteworthy that in general there is no apparent bias in the difference between the forecast and observations.

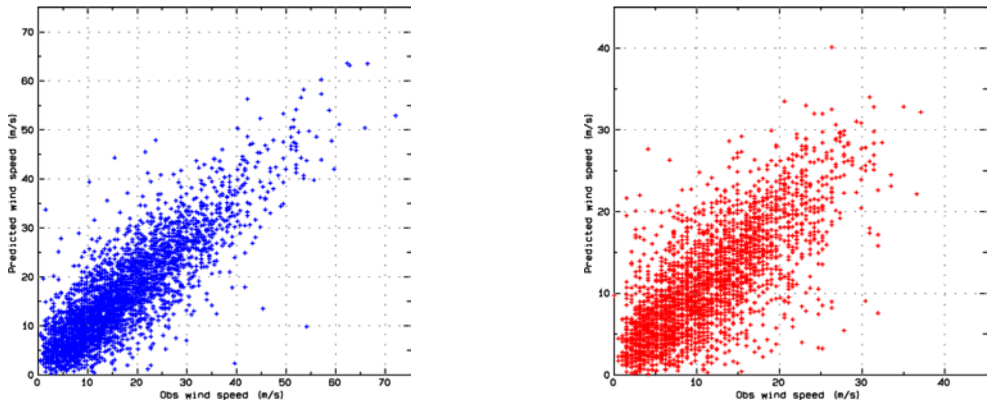


**Figure 1.** Comparison of observed and model wind speeds (m/s) at the 500 hPa (left) and 925 hPa (right) pressure levels

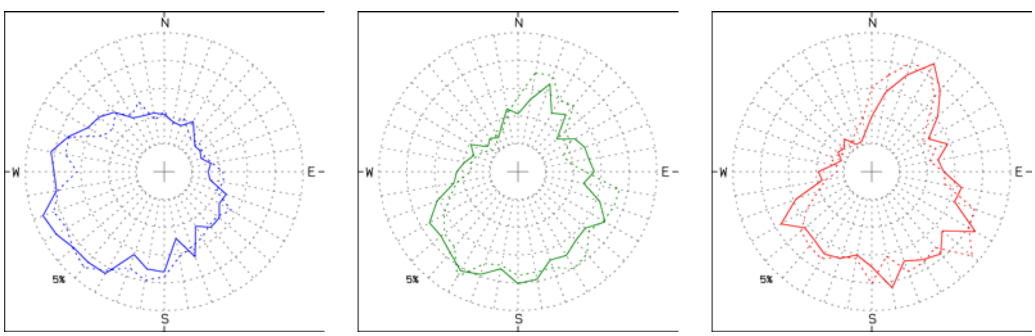


**Figure 2.** Wind roses for the observed wind directions (solid) and forecast wind directions (dashed) for the three pressure levels (blue: 500 hPa, green: 850 hPa, red: 925 hPa)

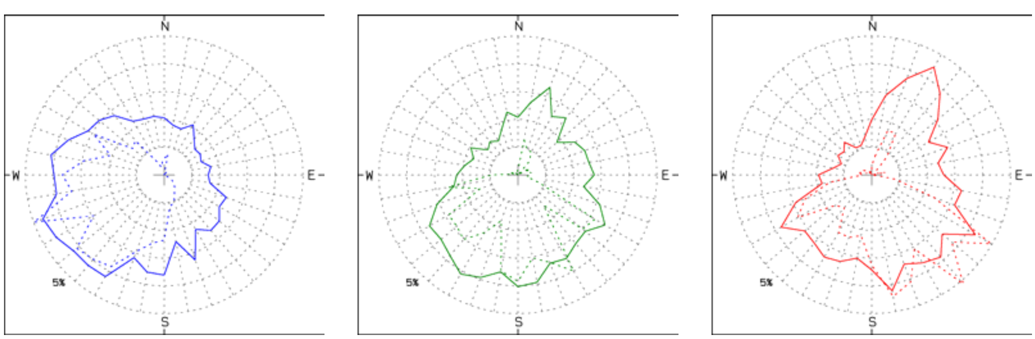


**Figure 3.** Wind roses for the observed wind directions (solid) and observed wind directions for about 10% of the stormiest data (f>30 m/s at 500 hPa, and f>20 m/s at 850 hPa and 925 hPa). The stormy data has been scaled up by a factor of 5 for comparison purposes

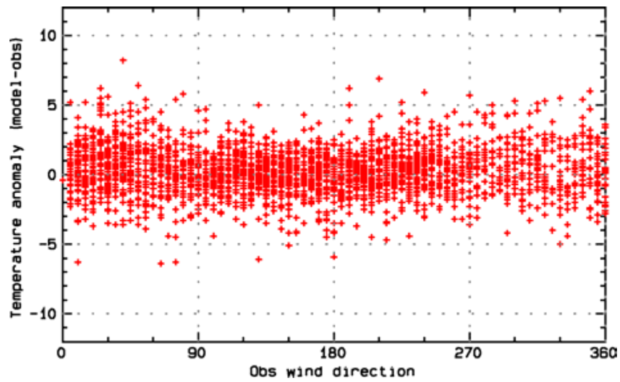


**Figure 4.** Temperature anomaly (K) at the 925 hPa pressure level versus obs wind direction in degrees

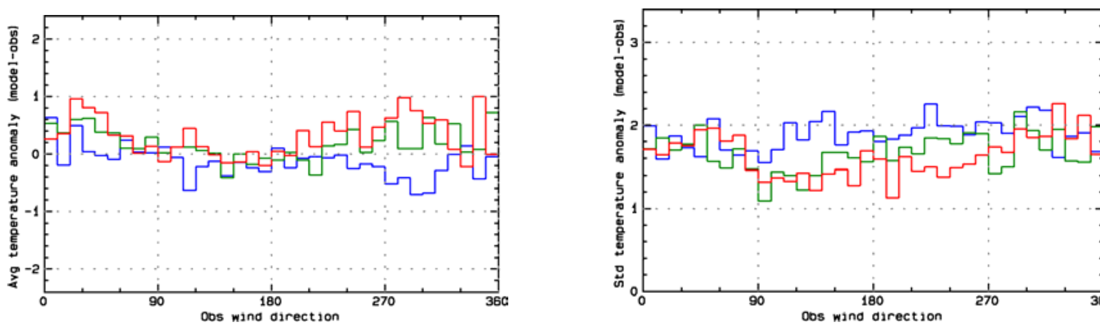


**Figure 5.** (a) Average temperature anomaly (K) for the three pressure levels (blue: 500, green: 850, and red: 925 hPa) versus observed wind direction. (b) Standard deviation of the temperature anomaly (K) for the same pressure levels.

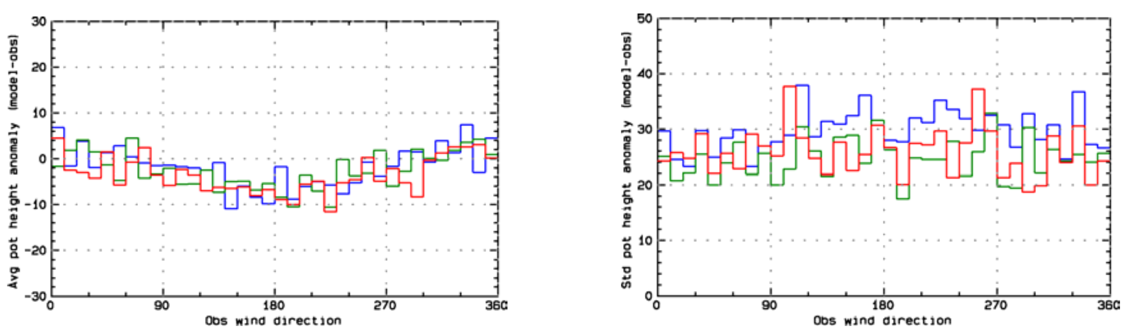


**Figure 6.** (a) Average geopotential height anomaly (m) for the three pessure levels (blue: 500, green: 850, and red: 925 hPa) versus observed wind direction. (b) Standard deviation of the geopotential height anomaly for the same pressure levels.

Fig. 6 shows average and standard deviation of differences of geopotential height of the model and the observed at the three pressure levels. Generally there is no bias, although the observations appear relatively higher in Southerly winds.

Fig. 7 shows the observed wind speed versus wind direction anomaly, where significant wind speed anomalies are identified with red and yellow dots. We note that most of the time when wind speeds were high there was not a significant deviation in the wind directions, and also that most of the time when there is a large deviation in wind direction then the wind speed is very low.

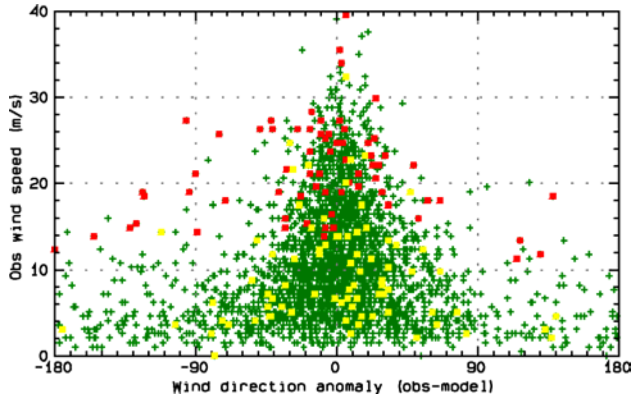


**Figure 7.** Observed wind speed (m/s) versus the wind direction anomaly in degrees (obs-model), for all the data at the 850 hPa pressure level. The red dots show data where the observed wind speed was more than 10 m/s faster than the predicted wind speed, and the yellow where the observed wind speed was more than 10 m/s slower than predicted.

## 3. DISCUSSION

At least two systematic errors appear to be a direct result of the mountains not being adequately resolved. The warm bias in the temperature prediction at 925 hPa during westerly winds occurs mainly in very stable airmasses and weak winds. The flow at the southwest coast of Iceland is blocked by the mountains and since the height and the steepness of the mountains is underestimated by the model, the magnitude of the blocking can also be expected to be underestimated by our model. The blocking can hamper descent of warmer air from above and it may also lead to some piling up of the cold air in the lowest layers. An underestimation of these effects leads to a warm bias in the predictions.

The low level northerly winds tend to be more northeasterly in reality than in the forecasts. This is explained by the model systematically underestimating the deviation of the flow by the mountains in SW-Iceland.

## 4. CONCLUSIONS

Five years of 48 hour operational forecasts for Iceland made by the numerical weather prediction model Arpège show very good skill in temperature, wind and geopotential height. Rather small systematic errors can however be detected. Some of the errors can be attributed to subgrid orography, i.e. underestimation of low level blocking in stable southwesterly flow and underestimation of the flow deviation by the mountains in SW-Iceland in northeasterly flow. Although small, these systematic errors should be considered in the interpretation of the numerical forecasts.

***Acknowledgements:*** *The authors are grateful for the access to numerical predictions of the Arpège model of Météo-France.*

## REFERENCES

Courtier, P., C. Freydier, J.-F. Geleyn, F. Rabier, and M. Rochas, 1991: The Arpège project at Météo-France, *ECMWF Seminar Proceedings*, September 9-13 1991, Vol. 2, European Centre for Medium-Range Weather Forecasts, Reading UK, 193-232.