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Identifying Forecast Bust Events in recent years over European Region

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Overview

This study is a part of the project that will investigate the mechanisms behind forecast busts. These are poor forecasts, which occur because of unresolved uncertainties in the numerical weather prediction model. Despite of huge progress in the models (Fig 1), the influence of mesoscale convective processes over the upper-tropospheric atmospheric flows can contribute to what is known as a forecast bust.

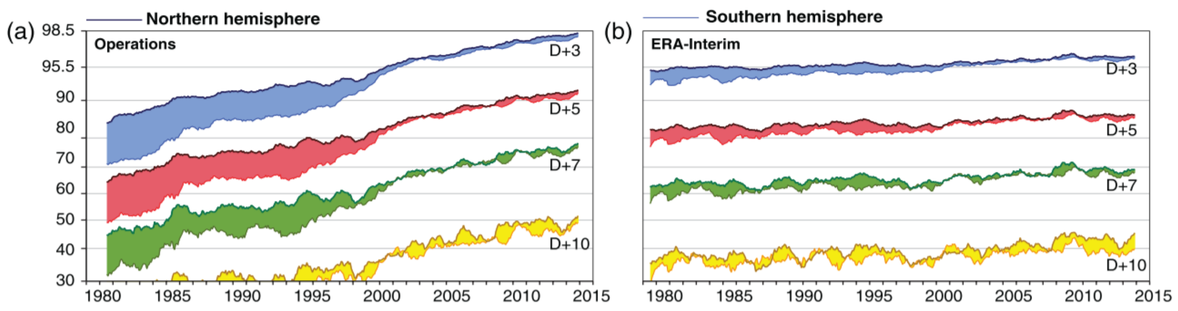

Fig. 1 12 month running mean of 500 hPa geopotential height (Z500) anomaly correlation coefficient (ACC) over the extratropical Northern and Southern Hemispheres for (a) the operational ECMWF and (b) the ERA-Interim. (Lillo & Parsons, 2017)

Defining 'Forecast Busts'

One way of defining forecast busts is defined in terms of errors in the prediction of the height of the 500-hPa pressure surface, when the day-6 high resolution (HRES) forecast of European Z500 has a root-mean-square error (RMSE) greater than 60 m and an anomaly correlation coefficient (ACC) less than 40% (Rodwell et al., 2013, Fig 2). ACC and RMSE are defined as:

$$ACC = \frac{\sum_{i=1}^{N}(Z500_f - Z500_c)(Z500_a - Z500_c)}{\sqrt{\sum_{i=1}^{N}(Z500_f - Z500_c)^2}\sqrt{\sum_{i=1}^{N}(Z500_a - Z500_c)^2}};$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Z500_f - Z500_a)^2}$$

Where, $Z500_f$, $Z500_a$ and $Z500_c$ are the forecasted (6-day), analysed (0 day) and climatological 500-hPa geopotential heights, and N is the total number of grid points.

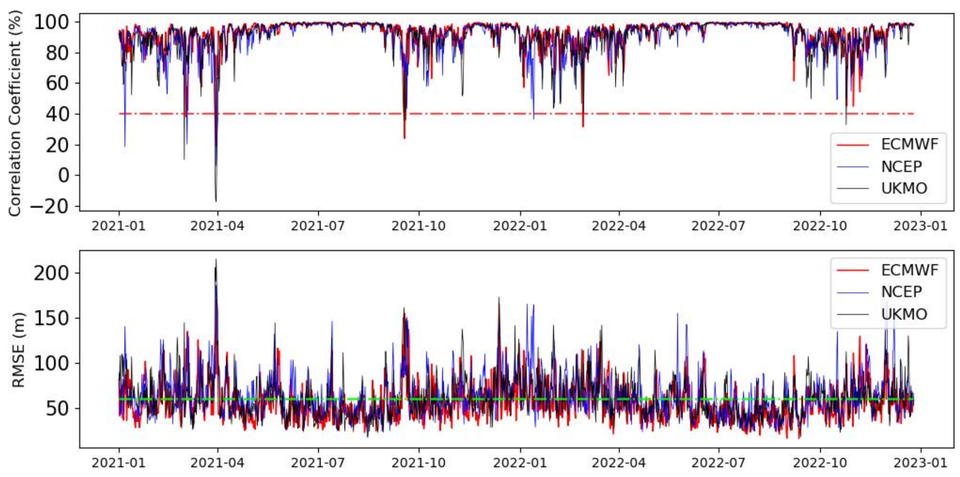

Fig. 2 Time series of (a) RMSE and (b) ACC for 500 hPa geopotential height for 2021- 2022 including the bust case of 30th March 2021, 1200 UTC. The scores are calculated for 6-day forecasts over Europe (35°N–75°N, 12.5°W–42.5°E). ERA5 climatology from 1989-2022 is used to calculate the ACC.

A Forecast Bust Case

The bust case presented here (Fig 3) is from March 2016. The mean values for HRES over the two-month period were 86% for ACC and 72m for RMSE, but for the HRES forecast from 7th March at 0000 UTC the scores were -20% for ACC and 214 m for RMSE.

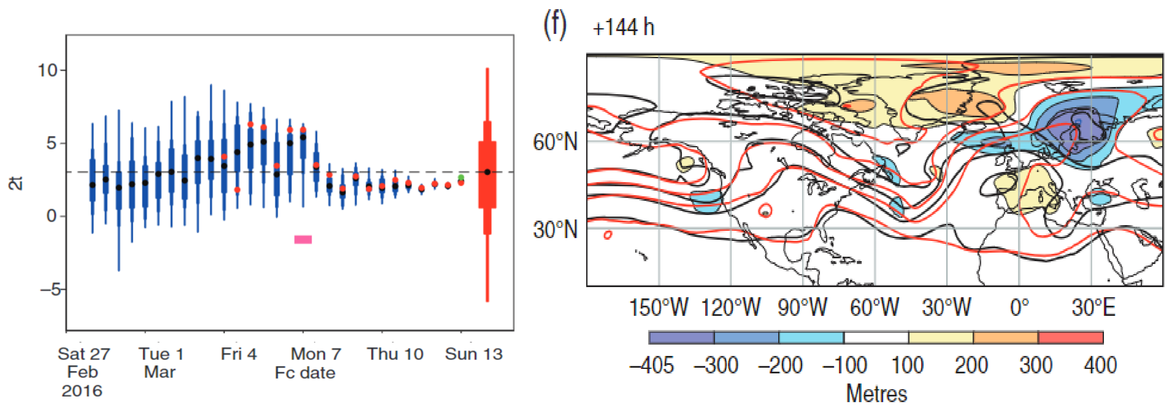

Fig. 3 Bust case on 7th March showing (a) daily mean 2m temperature valid on 13th March over Germany, for the analysis (green dot), ensemble median (black dot) and probability distribution (blue box-and-whisker) and the HRES forecast (red dot) and (b) shows a map of Z500 for the HRES forecast (black line), analysis (red line) and forecast error (shaded). (Magnusson, 2017)

Forecast Bust

To investigate the relative model performances based on the forecast busts, bust event metrics have been defined (Fig 4). The parameters will quantitatively characterize each model through its bust statistics. An example is shown in the table below (Table 1), where the bust metrics are computed for the ACC time series in Fig 2.

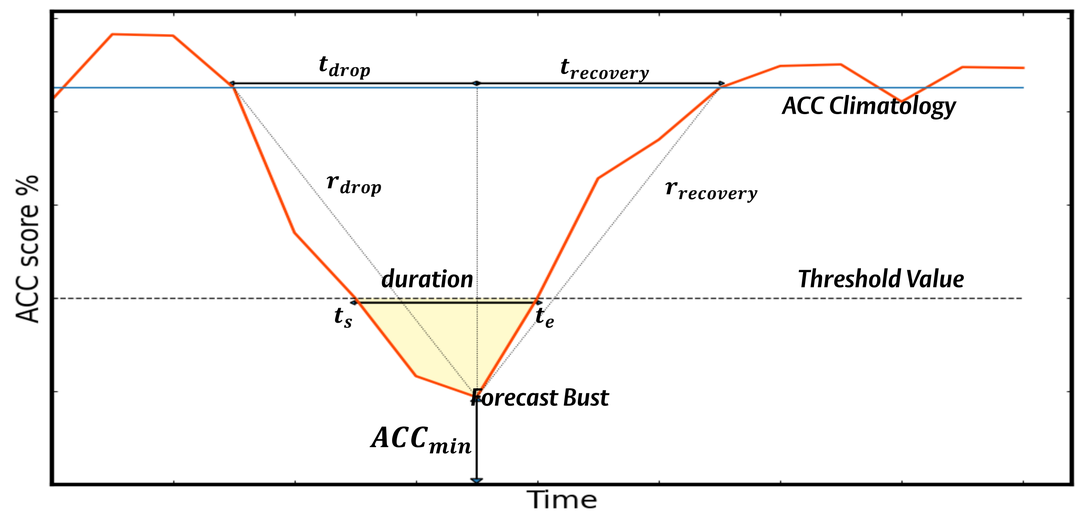

Fig. 4 Schematic of metrics used to define a forecast bust event. The figure shows the duration of a bust event which is defined by the time ACC remains below the threshold value, minimum ACC values during a bust event, start and end time of an event. Rate of drop and rate of recovery are calculated with reference to the ACC climatology, time taken by the ACC to drop to the minimum and the time taken by the ACC to rise back to the climatology.

Statistics	ECMWF	UKMO	NCEP
Number of Events	5	6	3
Average Duration (hrs)	17	18	24
Average ACC % (minimum)	28	23	12
Average rate of drop (%/12h)	52	55	68
Average rate of recovery (%/12h)	56	54	63

Table. 1 Forecast Bust metric comparison for 3 models (ECMWF, UKMO and NCEP) for the ACC time series for year 2021 – 2022.

Questions to be addressed in this study

- What is the current annual rate of forecast bust events for different forecast models?
- If there is a progress in reducing the frequency of busts in the recent years, then how does different forecast models compare with each other?
- After there is a recovery from a bust event, do the effects carry further into subsequent days? If yes, then how far?
- What marks an end of a forecast bust event? How much time is required to differentiate between two consecutive forecast bust events?

Summary

Forecast Busts over Europe are defined in terms of errors in 6-day forecast of Z500 height, through RMS (>60m) and ACC (<40%). Different models have different bust characteristics, which can be quantitatively summarised using the bust metrics. The models can be compared based on the number of busts encountered by it, relative average duration of each bust, peak minimum ACC achieved during a bust and the ACC drop rate & recovery rate. Every forecast bust can be attributed to a precursor environmental conditions and different models respond differently to such conditions due to difference in characteristics for same bust event.

References

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