A Model Output Statistics system to forecast the 2 m temperature at the “Wettermast Hamburg“ site

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Introduction

The **Model Output Statistics (MOS)** approach is used to develop a not yet existing **2 m temperature (T2m) forecasting system** for the **“Wettermast Hamburg”** site. The following science question was investigated:

“Can the MOS system be restricted without an increased error and what can MOS reveal about the model errors?”

Wettermast Hamburg

The "Wettermast Hamburg" site. Measurements of the lower tower (right) are used.

The **“Wettermast Hamburg”** is a measurement site located **in the south-east of Hamburg**. It is operated by the Meteorological Institute of the University Hamburg. The data is collected automatically **since 1995**. The temperature and the wind are measured with up to 20 Hz from 2 m to 280 m.

Model – GEFS

The **legacy "Global Ensemble Forecast System"** delivers a long and stable time series of data between 2012 and 2015. **The control run of the GEFS was used** as deterministic model run to develop the equations with the traditional MOS method. **Only the 0 UTC run** was used to get interpretable results for every lead time. The spatial resolution of the model is 1 degree with 42 height levels and the temporal resolution is 6 hours.

Data

Model data at the nearest grid point to the “Wettermast Hamburg“ (54° N and 10° E) was used.

- Training: (01.03.2012 – 28.02.2014)
- Evaluation: (01.03.2014 – 28.02.2015)
- Data missing in the archives:
  radiation and fluxes
- Too much missing data, therefore not used:
  total precipitation, CAPE and CIN

The equations were developed for lead times between 0 and 96 hours with a time step of 6 hours. Only the model data within the corresponding time step is used.

Statistical methods

- Linear regression
- Stepwise selection
- Bayesian Information Criterion
- Warm-cold splitting
- Five-fold cross-validation

Decomposed errors in the first 24 hours

Direct model output

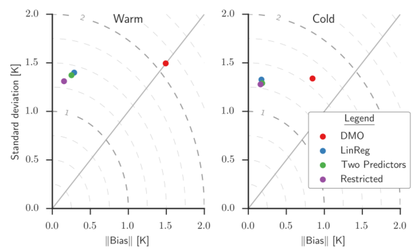
- Large bias, about the same magnitude as the standard deviation error.
- Seasonal behaviour.

Up to two predictors

- Additional error decrease by second predictor is small.

Restricted MOS

- Smallest errors in both seasons.
- Hardly any differences between the seasons.



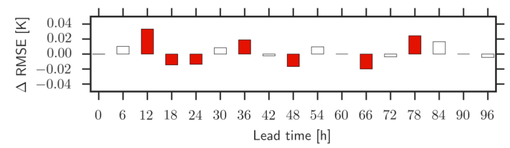
The standard deviation error as function of the absolute bias for the first 24 hours lead time in the evaluation period. The dashed lines symbolize the RMSE . For different equation complexity, the errors are shown as coloured point (DMO: Direct model output, LinReg: MOS with the modelled T2m as predictor; Two predictors: MOS with an additional second predictor, Restricted: The restricted MOS)

MOS was restricted without an increased error

The MOS system was restricted to get physical meaningful and interpretable results:

- The first predictor was fixed to model's T2m
- The selection of the second predictor was limited to 10 variables, which have a meaningful connection to T2m
- The number of predictors was limited to 6 out of 78 variables

In comparison to the non-restricted method, **the error was not changed significantly** for the evaluation period.



The differences between restricted MOS and MOS without restriction in the RMSE as function of the lead time for the evaluation period. The red bars symbolize high stiatistical significance, while the white bars have no significance.

MOS can reveal possible sources of the model error

The second predictor is selected, because it has the biggest correlation with the model error. As a consequence an analysis of **this predictor in combination with meteorological knowledge can reveal possible sources of the model error**.

In the following table are the most selected second predictors for the specific day time shown. Below the predictors are the possible model error sources, which lead to the selection of the predictor:

Warm Season (01.04 – 30.09)

00 UTC + 06 UTC: 850 hPa temperature

- Problems of vertical temperature interpolation
- Importance of air masses for the stability

12 UTC + 18 UTC: 500 hPa Geopotential

- Influence of troughs and ridges through missed showers and thunderstorms

Cold Season (01.04 – 30.09)

00 UTC + 06 UTC: 10 m wind speed

- Problems with the boundary layer mixing

12 UTC + 18 UTC: 1000 hPa / Surface temperature

- Problems of vertical temperature interpolation

Conclusion

A linear MOS system was successfully implemented to forecast the 2 m temperature at the „Wettermast Hamburg“ site. It was shown that with **meaningful restrictions** the system can be stabilized in terms of overfitting **without a significant change in the error**. With the second preditor was identified that the **model error of the legacy GEFS** could be arosed by:

- **Problems with the vertical temperature interpolation**
- Influences of throughs with showers
- **Problems with stability and boundary layer mixing**

Literature

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Observation

Model