Application and verification of ECMWF products in Austria

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1. Summary of major highlights

Medium range weather forecasts in Austria are primarily based on the ECMWF forecast. In the short range, ECMWF products are used in conjunction with those from ALADIN/ALARO and COSMO-EU. The Ensemble Prediction System (EPS) forecasts are used for operational uncertainty estimates in temperature and quantitative precipitation forecasts, while the EPS-median of temperature is used for point-forecast ranges exceeding 5 days.

Monthly and seasonal forecasts are becoming more and more interesting for public as well as for special customers mainly from the energy and tourism sector

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

A model output statistics system (AUSTROMOS II) is run operationally at ZAMG, using ECMWF forecast fields as input. This MOS covers a forecast rangce up to +5 days for ~110 Austrian stations, ~60 Central European stations outside Austria, and 37 predictands (Haiden and Hermann 2000). Three different types of predictors are used: (i) direct model output (DMO), (ii) derived quantities, such as relative vorticity or a baroclinicity index, (iii) previous observations. In the recent past, a new MOS system (A-UMOS) is under development, which will replace the Austromos system in the near future.

Additionally a PPM system based on ECMWF analyses is run on ZAMG.

A special Austrian Perfect Prog Model (APPM) based on ECMWF deterministic forecasts is used to improve point forecasts and areal quantitative forecasts of precipitation in Alpine watersheds (Seidl 2000) for hydrological applications. For precipitation, the PPM method was found superior to the MOS method, mostly because it does not use DMO precipitation which is sensitive to NWP model resolution changes. The operational APPM system provides 6-hourly areal precipitation forecasts for 34 catchment-type areas covering Austria and parts of Bavaria up to 4 days.

An area-dependent statistical combination of ALARO and ECMWF precipitation forecasts is made to provide high-resolution data as input for hydrological models up to 72 hours twice a day. This combination reduces the systematic errors of both models and is found superior as input for hydrological models.

A statistical calibration procedure is applied on 2-m temperature and 10-m wind speed forecasts of the ECMWF EPS in order to reduce systematic deviances of the first (ensemble mean) and second moment (ensemble spread). The method of non-homogeneous Gaussian regression (NGR, Gneiting et al. 2005) is used to derive calibrated PDFs of temperature and wind forecasts up to 10 days ahead.

2.1.2 Physical adaptation

A trajectory model (FLEXTRA) and a dispersion model (FLEXPART) are run operationally with ECMWF forecast fields as input (Pechinger et al. 2001). Forecasts are made up to +84 hrs for a domain extending from 90 deg W to 90 deg E, and 18 deg N to 90 deg N.

ECMWF precipitation forecasts are used as input for hydrological models for most of the main rivers in Austria. For the shorter forecast range ECMWF forecasts are combined

(see 2.1.1) while for forecasts longer than +72 hours DMO of the deterministic as well as the ensembles are used as input.

2.1.3 Derived fields

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output

Figures 1 to 4 show a verification of ECMWF-DMO for the station Linz while figures 5 to 8 show the scores for Vienna as a function of forecast range from +18 to +234 hours.

In the case of 2m temperature a height correction (0.65K/100m) has been applied. Wind direction was only verified for cases where the observation exceeded 2m/s. Verification for Linz shows a significant positive bias for relative humidity, a slight negative bias for wind speed, whereas 2m temperature is rather unbiased. Some small bias is found for temperature and wind speed for Vienna, a larger positive bias is obtained for relative humidity. Diurnal waves in forecast errors are found for most parameters with exception of wind direction. In general, errors do not show big differences compared to last years and show the good quality of the forecasts (ECMWF 1013; ECMWF 2012; ECMWF 2011; ECMWF 2010; ECMWF 2009; ECMWF 2008; ECMWF 2007).

Monthly 'Climagramms' for temperature and precipitation anomalies are computed as mean values for the austrian domain up to 6 months and made available on local intranet. Experiences show that although the forecasts vary for different runs, the sign of the predicted temperature anomaly at least sometimes corresponds to the observed sign.

Monthly forecasts for temperature, wind speed, precipitation and cloud cover are visualized for 6 different locations on the intranet. An objective verification is performed regularly. Generally the ensemble covers the observations, though the variations are not predicted in detail.

3.1.2 ECMWF model output compared to other NWP models

Comparisons between models (including MOS) show that ECMWF forecast quality is less good for wind speed and direction if compared with high-resolution model ALARO. The statistical model (ECMWF-MOS) gives the most significant improvement for temperature and short range cloudiness DMO forecasts.

3.1.3 Post-processed products

MOS forecasts are verified together with ECMWF-DMO, ALARO and human forecasts. Weekly graphs are available for forecasters via intranet.

3.1.4 End products delivered to users

3.2 Subjective verification

3.2.1 Subjective scores

3.2.2 Synoptic studies

4. References to relevant publications

ECMWF, 2006: Verification of ECMWF products in member states and co-operating states,141 p .

ECMWF, 2007: http://www.ecmwf.int/products/greenbook/2007/GB_2007_Austria.pdf

ECMWF, 2008: http://www.ecmwf.int/products/greenbook/2008/GB_2008_Austria.pdf

ECMWF, 2009: http://www.ecmwf.int/products/greenbook/2009/GB_2009_Austria.pdf

ECMWF, 2010: http://www.ecmwf.int/products/greenbook/2010/pdf/Austria_GB_2010.pdf

ECMWF, 2011: http://www.ecmwf.int/products/greenbook/2011/pdf/Austria_GB_2011_AB.pdf

ECMWF, 2012: http://www.ecmwf.int/products/greenbook/2012/pdf/AustriaAB12.pdf

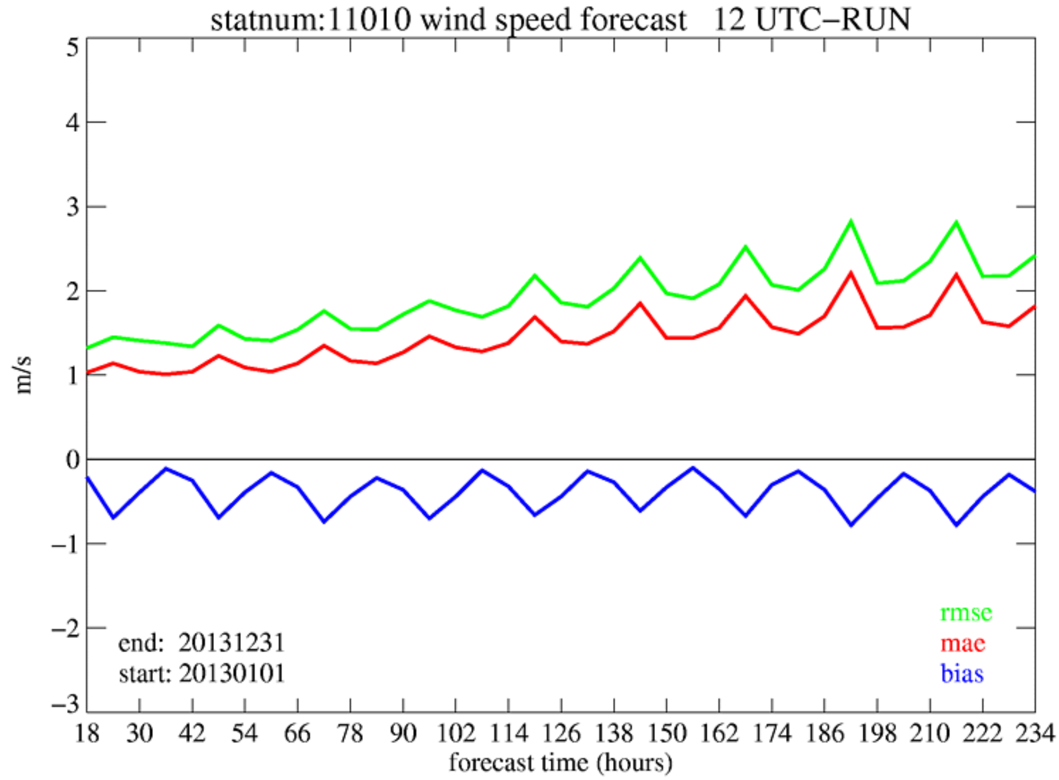
ECMWF, 2013: http://old.ecmwf.int/products/greenbook/2013/pdf/AustriaAB13.pdf

Gneiting, **T.**, **A. E. Raftery**, **A. H. Westveld**, and **T. Goldman**, 2005: Calibrated probabilistic forecasting using ensemble model output statistics and minimum CRPS estimation. *Mon. Wea. Rev.*, **133**, 1098-1118.

Haiden, **T.**, and **G. Hermann**, 2000: Experiences with the Austrian MOS system. Preprints, 1st SRNWP Workshop on Statistical Adaptation, Vienna, 10-11.

Pechinger, **U.**, **M. Langer**, **K. Baumann**, and **E. Petz**, 2001: The Austrian Emergency Response Modelling System TAMOS. *Phys. Chem. Earth*, **B26**, 99-103.

Seidl, **H.**, 2000: An operational PPM for areal precipitation predictands transformed into Gaussian variables. Preprints, 1st SRNWP Workshop on Statistical Adaptation, Vienna, 2-5.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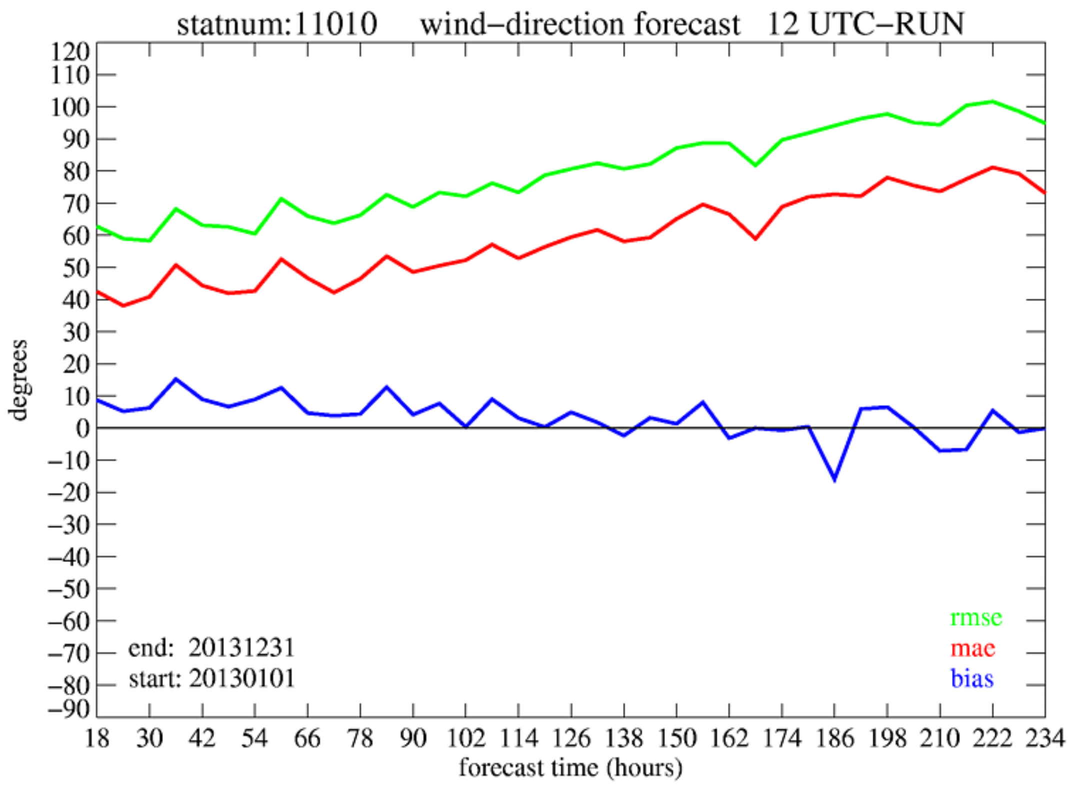
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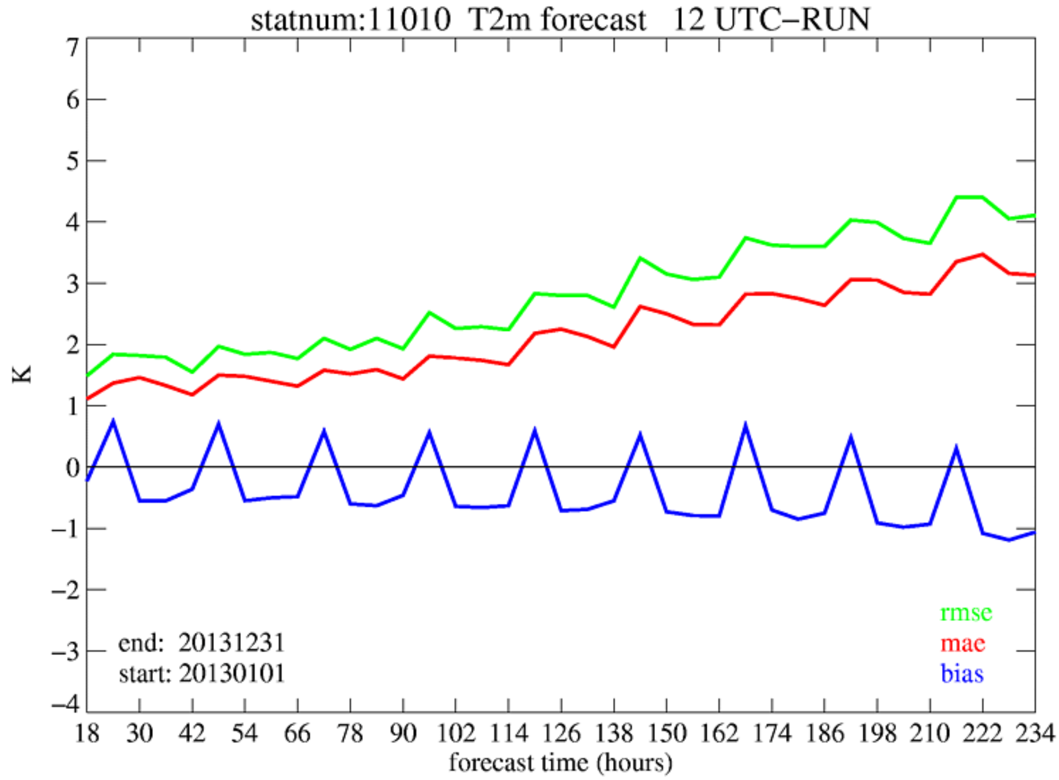
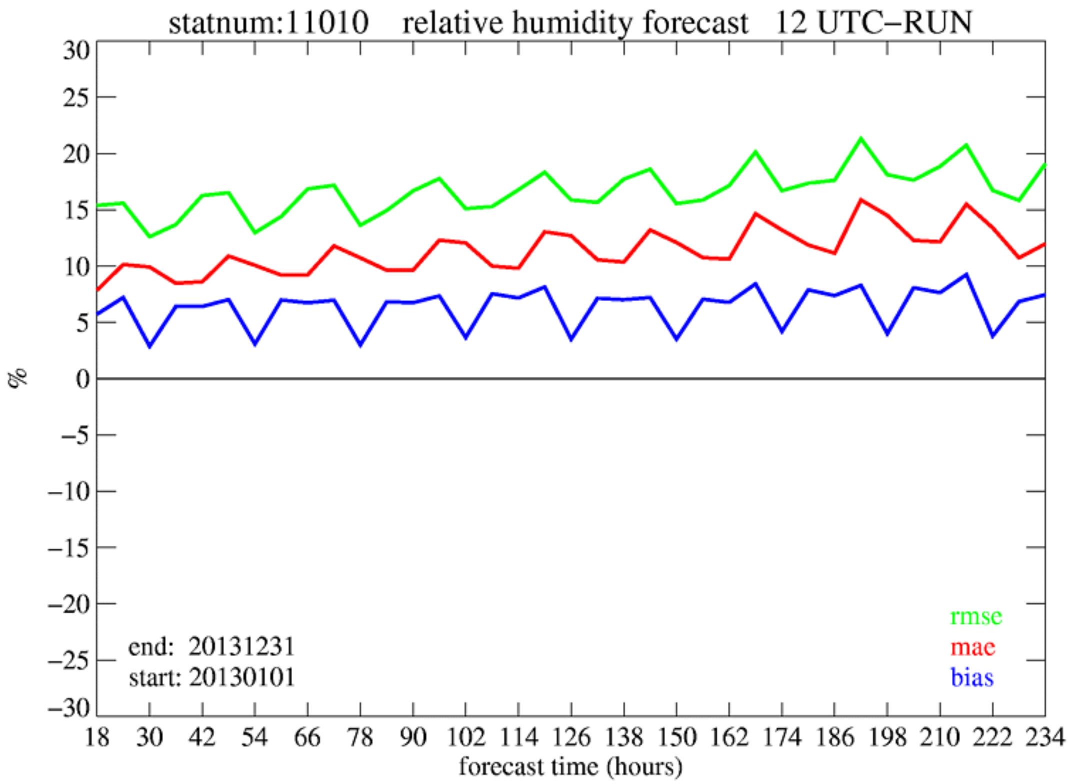
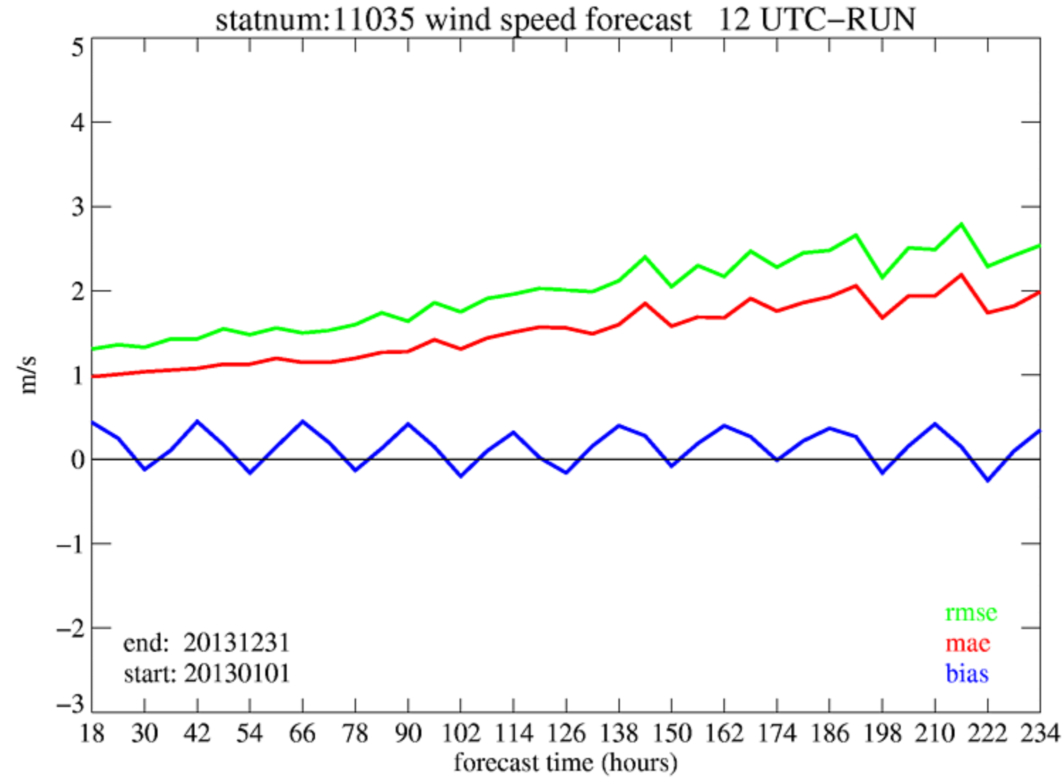




Figures 1-4 Mean error (bias), mean absolute error (MAE) and RMSE of ECMWF point forecasts of 10m wind speed and direction, 2m temperature and 2m relative humidity as a function of forecast range for station LINZ in the period Jan-Dec 2013.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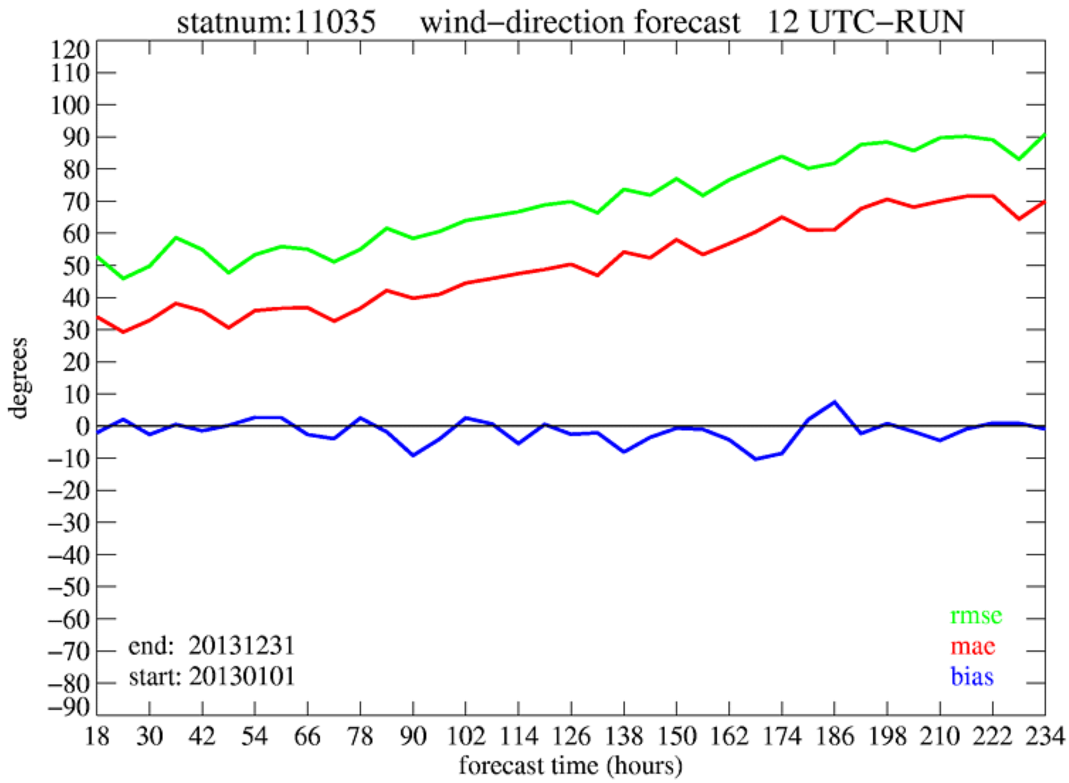
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forecast time (hours)
end: 20131231
start: 20130101
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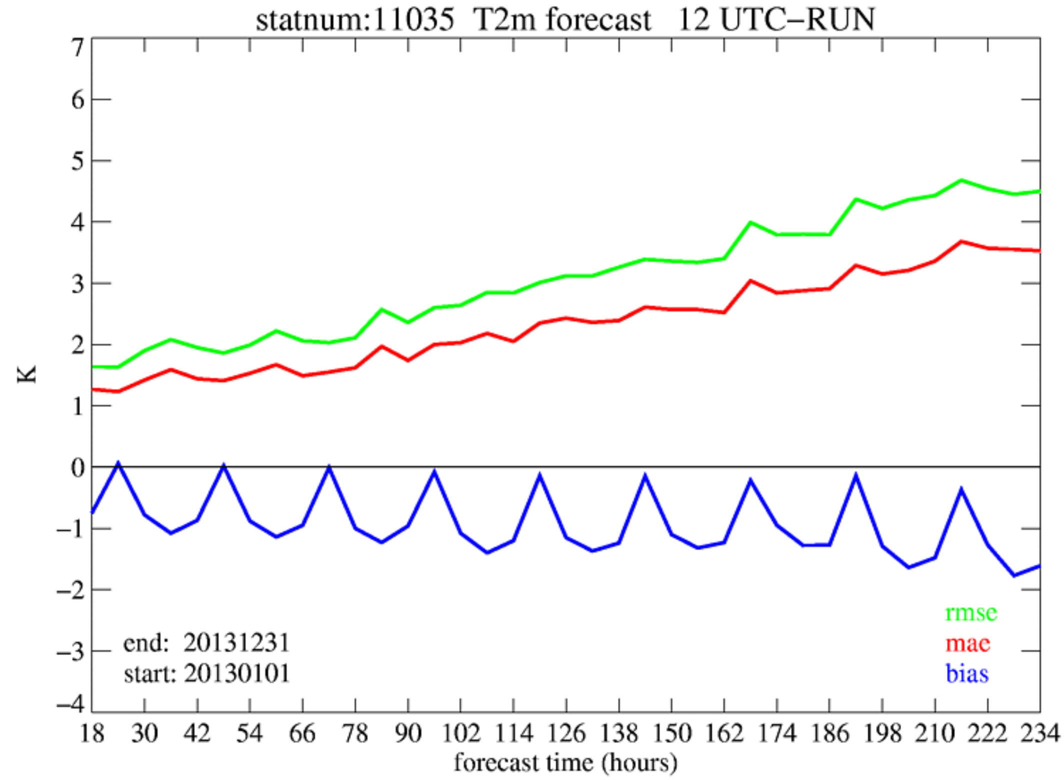
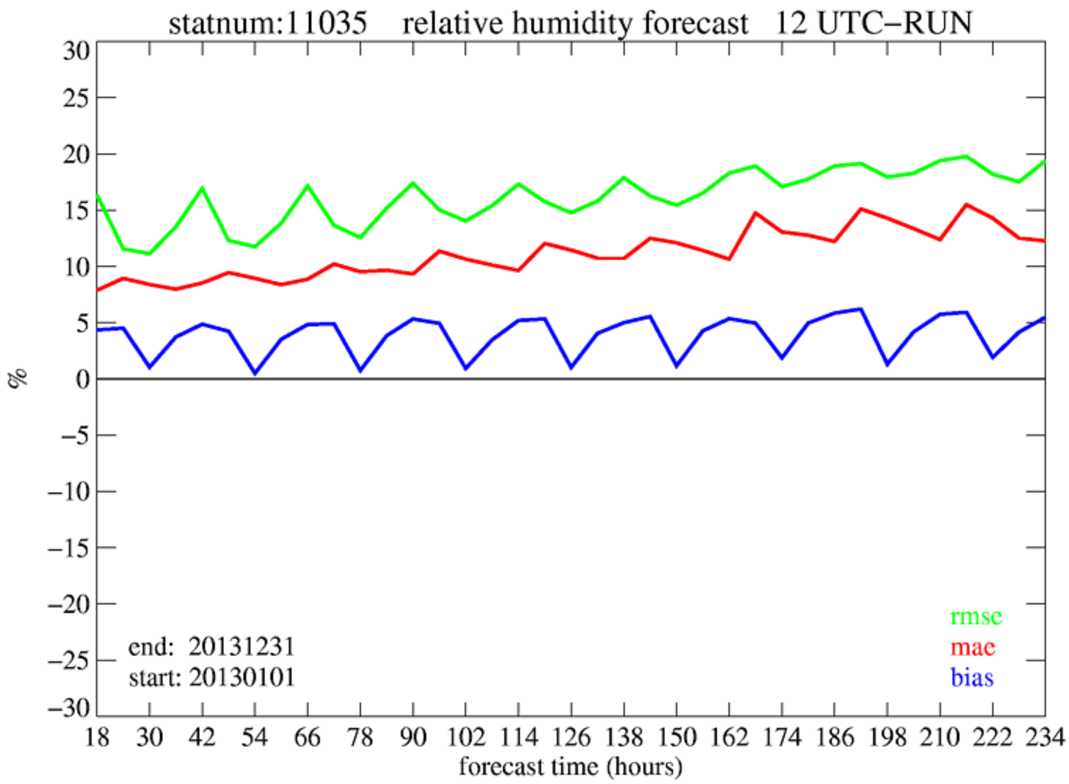
mae
bias





Figures 5-8 Mean error (bias), mean absolute error (MAE) and RMSE of ECMWF point forecasts of 10m wind speed and direction, 2m temperature and 2m relative humidity as a function of forecast range for station VIENNA in the period Jan-Dec 2013.