# Application and verification of ECMWF products 2017

Latvian Environment, Geology and Meteorology Centre, L. Krumina

## 1. Summary of major highlights

The ECMWF products are used extensively in the operational work of LEGMC in fields of meteorology and hydrology. ECMWF model output data are integrated in forecaster workstation SmartMet, where analysis and editing of information is done, followed by generation of products for clients. For hydrological purposes, data is used in the hydrological model HBV and the hydrological simulation and forecasting system WSFS. Data is assembled and visualized in an internally used web portal. Furthermore, ECMWF website and ecCharts are used for general analysis, quick data overview and specific products. Yearly and quarterly verification results of ECMWF products for average air temperature, average wind speed and maximum wind gusts have been added. Additionally, direct comparison between ECMWF and HIRLAM verification results has been made for the visibility parameter.

## 2. Use and application of products

Include medium-range deterministic (HRES) and ensemble (ENS) forecasts, monthly forecast, seasonal forecast.

### 2.1 Post-processing of ECMWF model output

#### *2.1.1 Statistical adaptation*

At the beginning of winter, ECMWF data (mainly air temperature and precipitation) is used to predict the formation of ice cover in rivers, while in spring, forecasts are used to predict ice break-up, maximum levels and discharges of spring floods and the dynamics of the accession time.

#### *2.1.2 Physical adaptation*

ECMWF HRES and EPS data (daily average air temperature and sum of the precipitation) is used by the hydrological model to simulate river runoff for the next 10 days and twice a week LEGMC performs such simulation for the next 4 weeks.

#### *2.1.3 Derived fields*

Ensemble mean and probabilities of defined thresholds are calculated for a wide range of parameters (e.g. air temperature, maximum wind gusts, total precipitation, snow fall and snow depth, total cloud cover and cloud base height). Information is accessible to forecasters in their work stations for further editing of data and product generation for clients.

### 2.2 Use of ECMWF products

The ECMWF products are the basis for LEGMC medium-range forecasts for up to 14 days, and the only data source used for long range forecasts (up to 6 months ahead).

For operational purposes, ECMWF model data outputs from HRES, EPS and HRES-WAM are routinely provided to forecaster work station, where it is analysed together with observational data (ground observations, radio soundings, satellite pictures and radar data), climate data and other available models (for instance GFS) and edited for a period of up to 7 days. Maps, time series and vertical cross sections are used for a wide range of hydrometeorological parameters. Forecasters are not only provided with the single level (ground level) data – they also have access to pressure level and model level data. From these data sets, stability indexes, wind shear and other parameters are calculated. Visibility data has been added to operational data flow for testing purposes from June, 2016 and stored in the database and used for verification from November, 2016.

Together with HIRLAM and HARMONIE data (from FMI) ECMWF data is extensively used for short-range forecasts and warnings for both meteorological and hydrological phenomena. ENS is the only source of probabilities for our products. ECMWF Extreme forecast index and ENS clustering and plumes products are used from ECMWF web page and are partially available in our internal web portal.

For long-term forecasts, air temperature and precipitation ensemble means, anomalies and terciles are provided to forecasters together with climate data from LEGMC observational stations in the form of maps, graphs and tables.

## 3. Verification of products

Include medium-range HRES and ENS, monthly, seasonal forecasts. ECMWF does extensive verification of its products in the free atmosphere. However, verification of surface parameters is in general limited to using synoptic observations. More detailed verification of weather parameters by national Services is particularly valuable.

### 3.1 Objective verification

#### *3.1.1 Direct ECMWF model output (both HRES and ENS)*

Verification of ECMWF HRES model runs at 00 and 12 UTC is performed yearly and in quarters (January-March, April-June, July-September, October-December) for a time period of maximum 240 h (lead time). Verification methodology used for the continuous forecasts of average air temperature, average wind speed and maximum wind gusts consists of calculating mean error (ME), mean absolute error (MAE) and root mean square error (RMSE), while for the dichotomous forecasts of precipitation, false alarm ratio (FAR) and probability of detection (POD) methods were used.

Verification results are presented by parameters – average air temperature (Fig. 1), average wind speed (Fig. 2), maximum wind gusts (Fig. 3) and precipitation (FAR - Fig. 4; POD – Fig. 5).

A data point at the $i^{th}$ lead time hour represents all data between i-1 hour (included) and $i^{th}$ hour (not included).

#### *3.1.2 ECMWF model output compared to other NWP models*

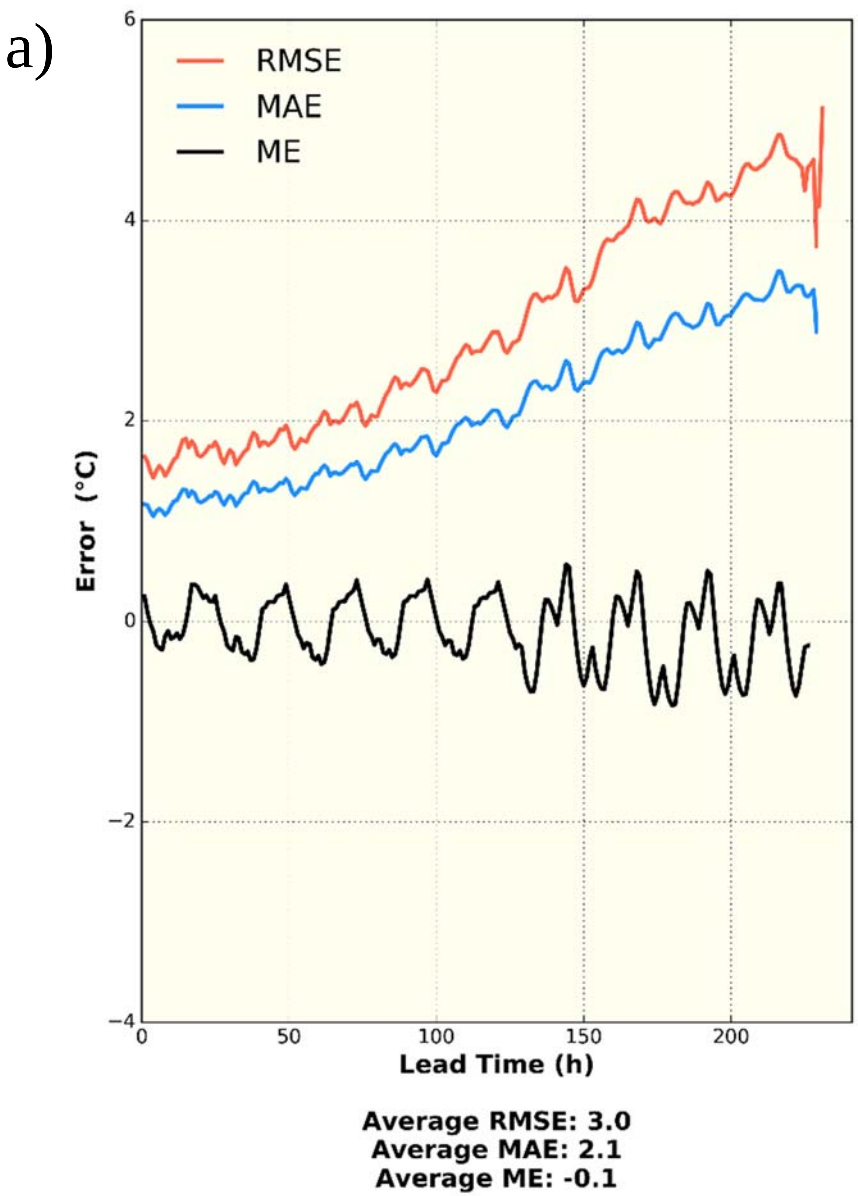
LEGMC has recently initiated forecast verification for the visibility parameter. This is done both temporally and spatially, in order to separate potential accuracy differences between inland and seaside meteorological stations. Data storage for such verification was only initiated from November 1st, 2016. Therefore, all results presented in this report are for data from the aforementioned date until July 1st, 2017.

To better understand the advantages of ECMWF relative to other NWPs, direct comparison of the ME, MAE and RMSE dynamics for ECMWF and HIRLAM models is presented in Fig. 6. Due to the lead time limitations of HIRLAM, a direct comparison can only be made for 44 hours. Furthermore, additional data from meteorological stations in Estonia and Sweden is added for visibility verification. This allows for a more detailed verification around the Gulf of Riga and the Baltic Sea.

In order to identify how the models perform for very low visibility conditions and to remove the influence of extremes in error values, two visibility thresholds were chosen – 2 km and 10 km. The data used for each threshold consists of data points where the forecasted visibility by both models and the observed visibility value are below the given threshold.

Similarly, these thresholds were also used for spatial verification (Fig. 7). Such approach allows to identify how models perform inland and near the sea. Only the RMSE comparison between both models is shown in this figure.

A data point at the $i^{th}$ lead time hour represents all data between i-1 hour (included) and $i^{th}$ hour (not included).



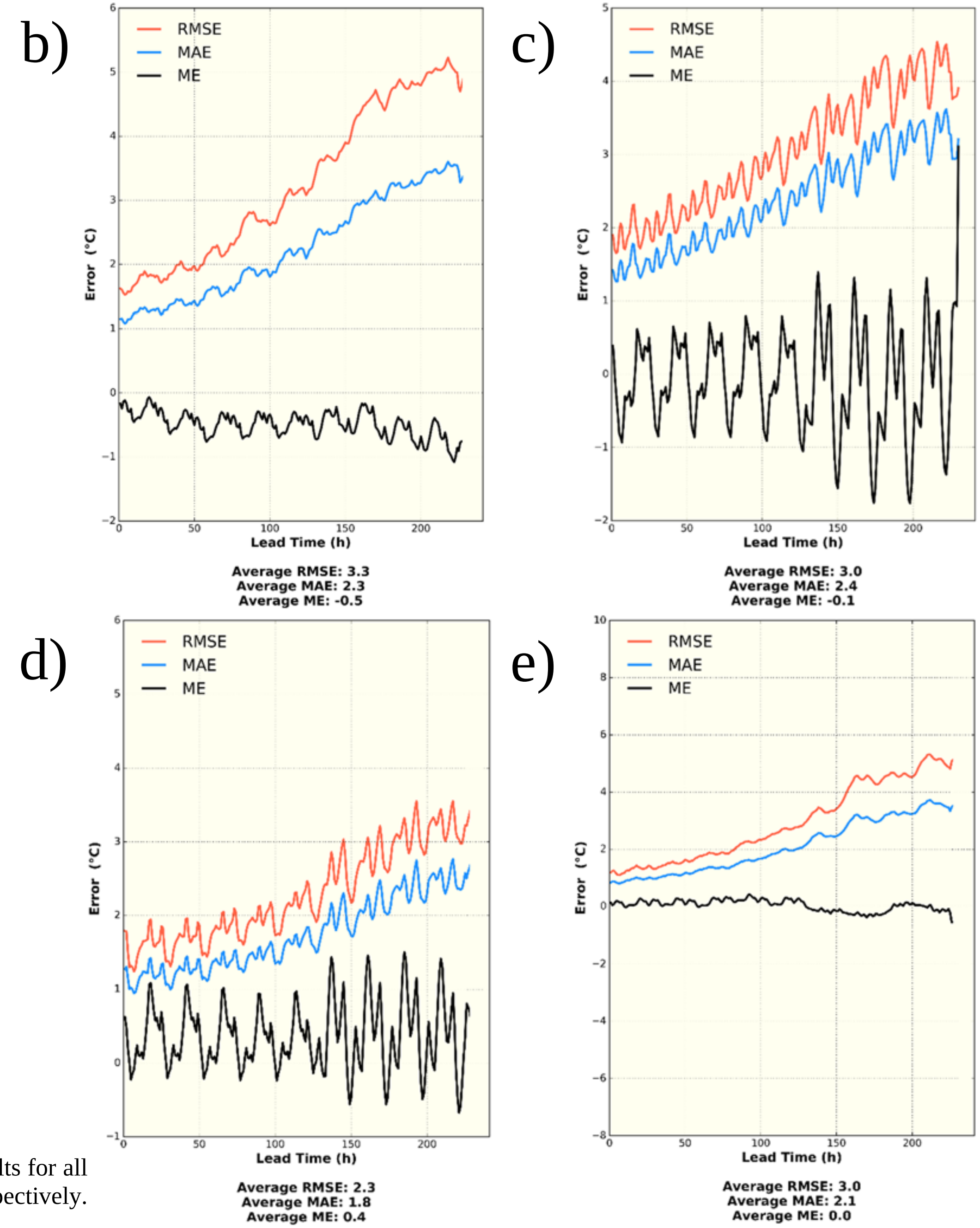
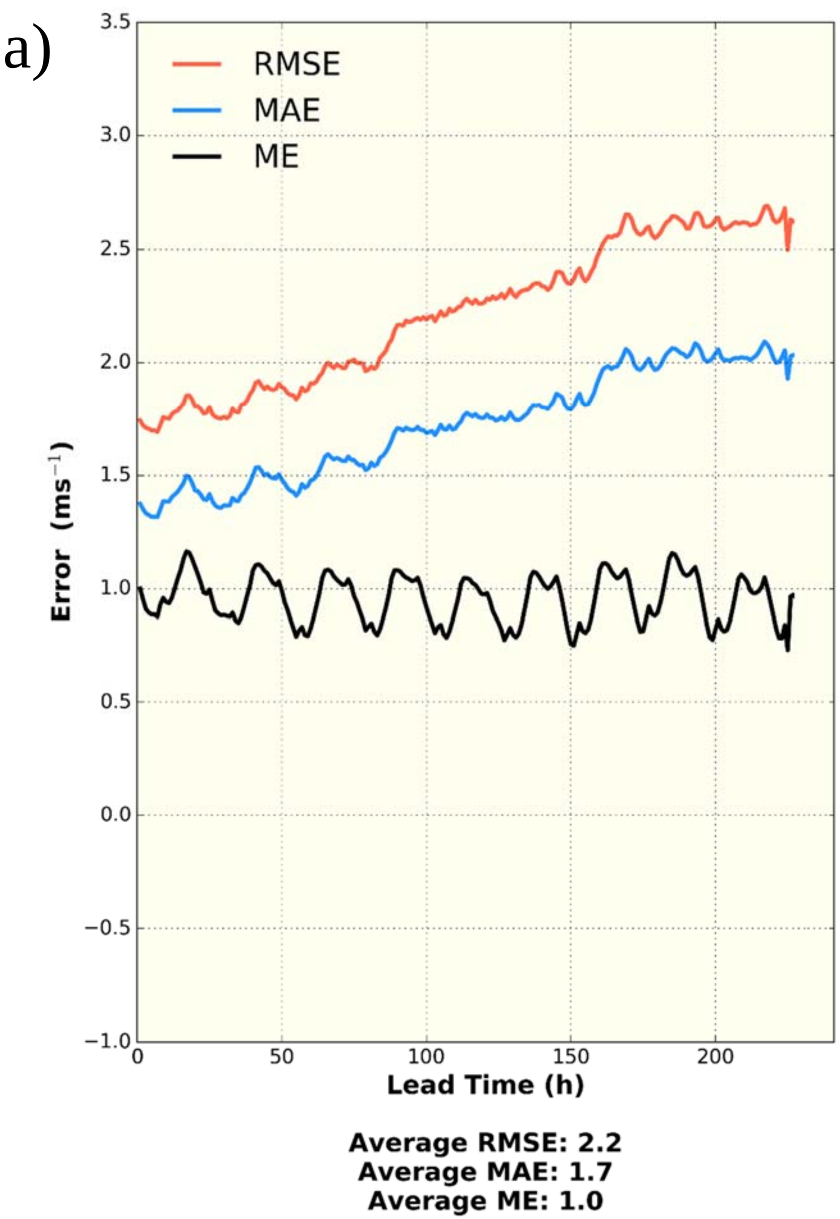




Fig. 1 Verification results for average air temperature. Plot a) shows verification results for all data from 2016, while plots b), c), d), e) correspond to quarters 1, 2, 3, and 4 respectively.



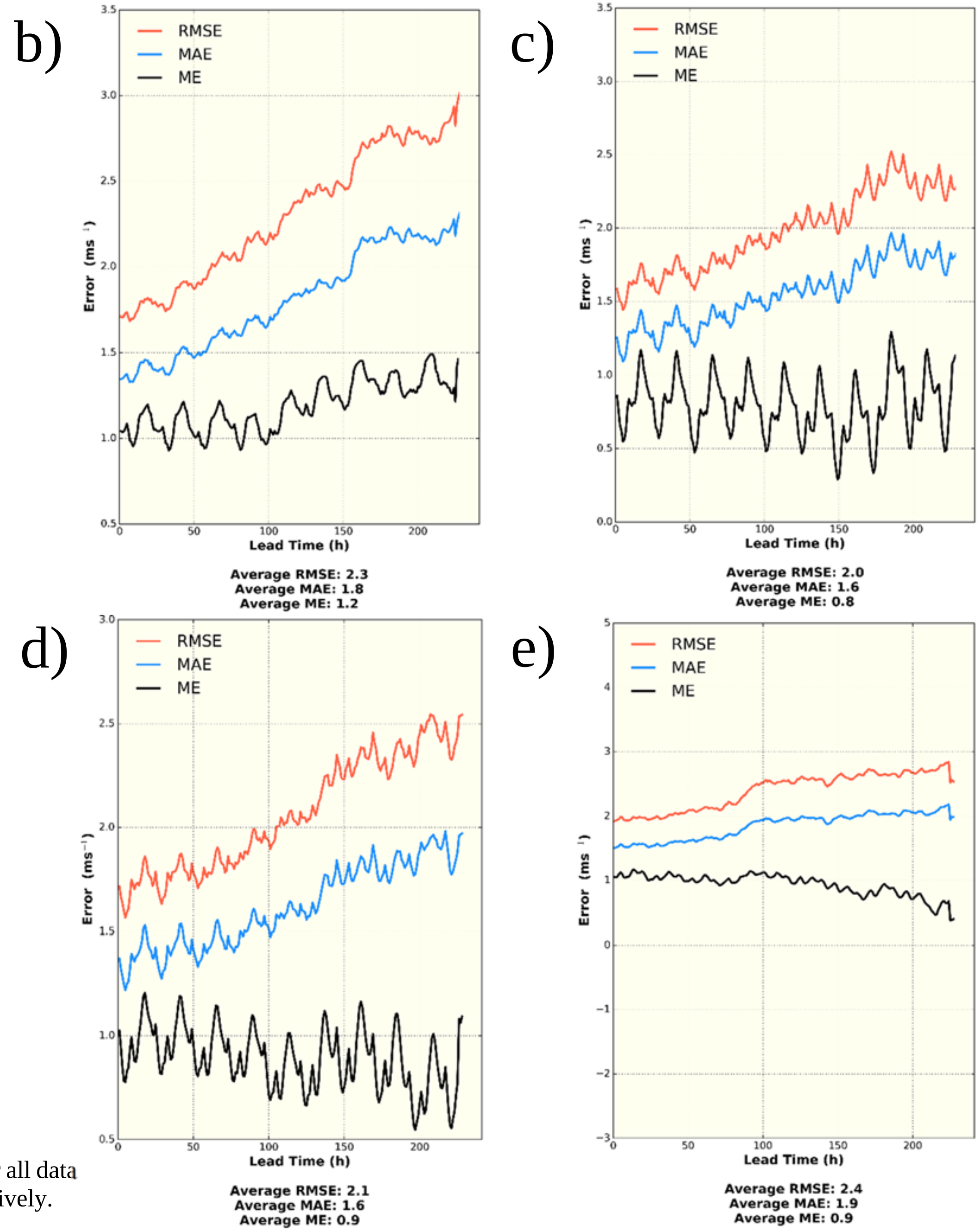




Fig. 2 Verification results for average wind speed. Plot a) shows verification results for all data from 2016, while plots b), c), d), e) correspond to quarters 1, 2, 3, and 4 respectively.

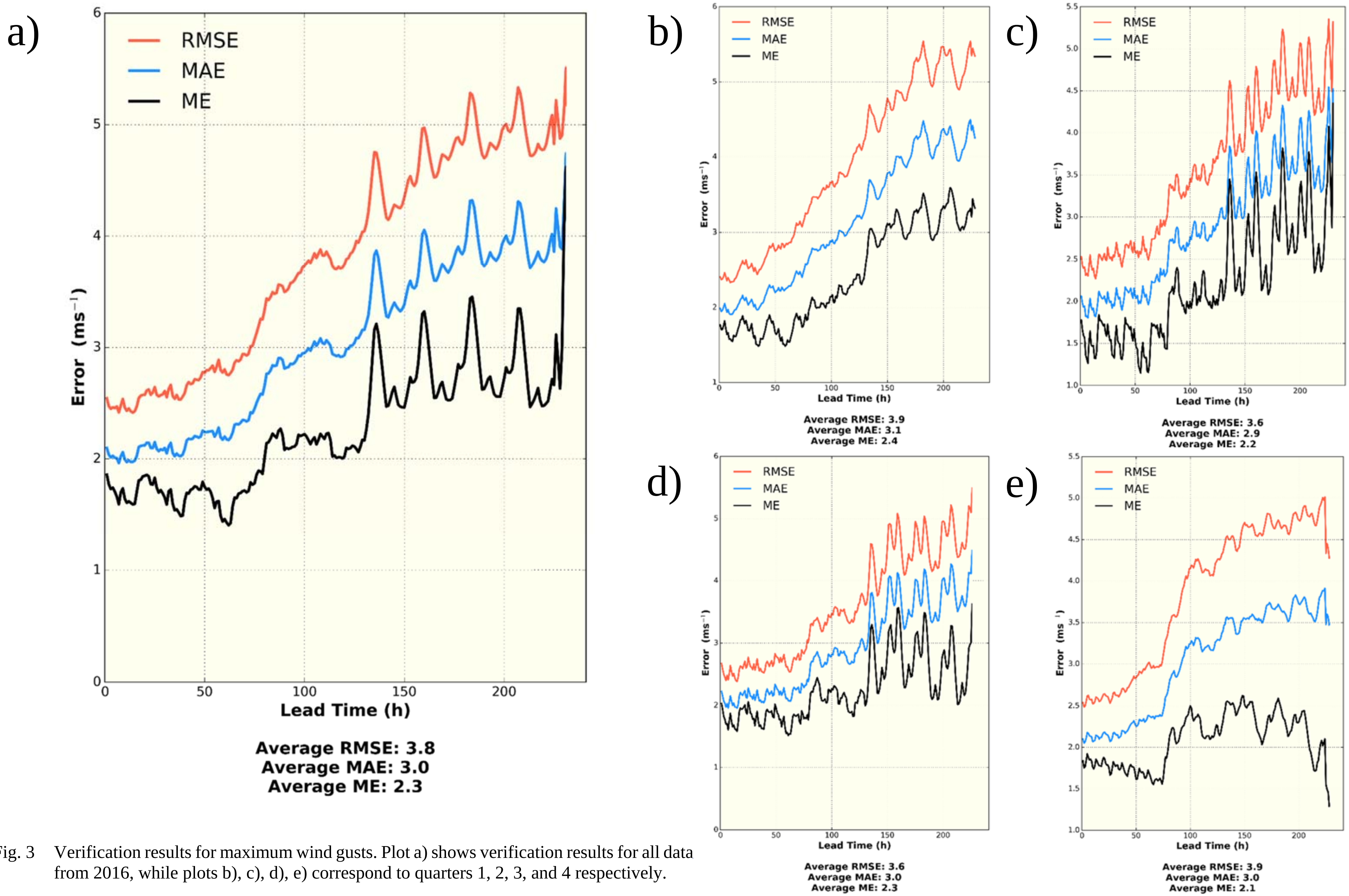



Fig. 3 Verification results for maximum wind gusts. Plot a) shows verification results for all data from 2016, while plots b), c), d), e) correspond to quarters 1, 2, 3, and 4 respectively.

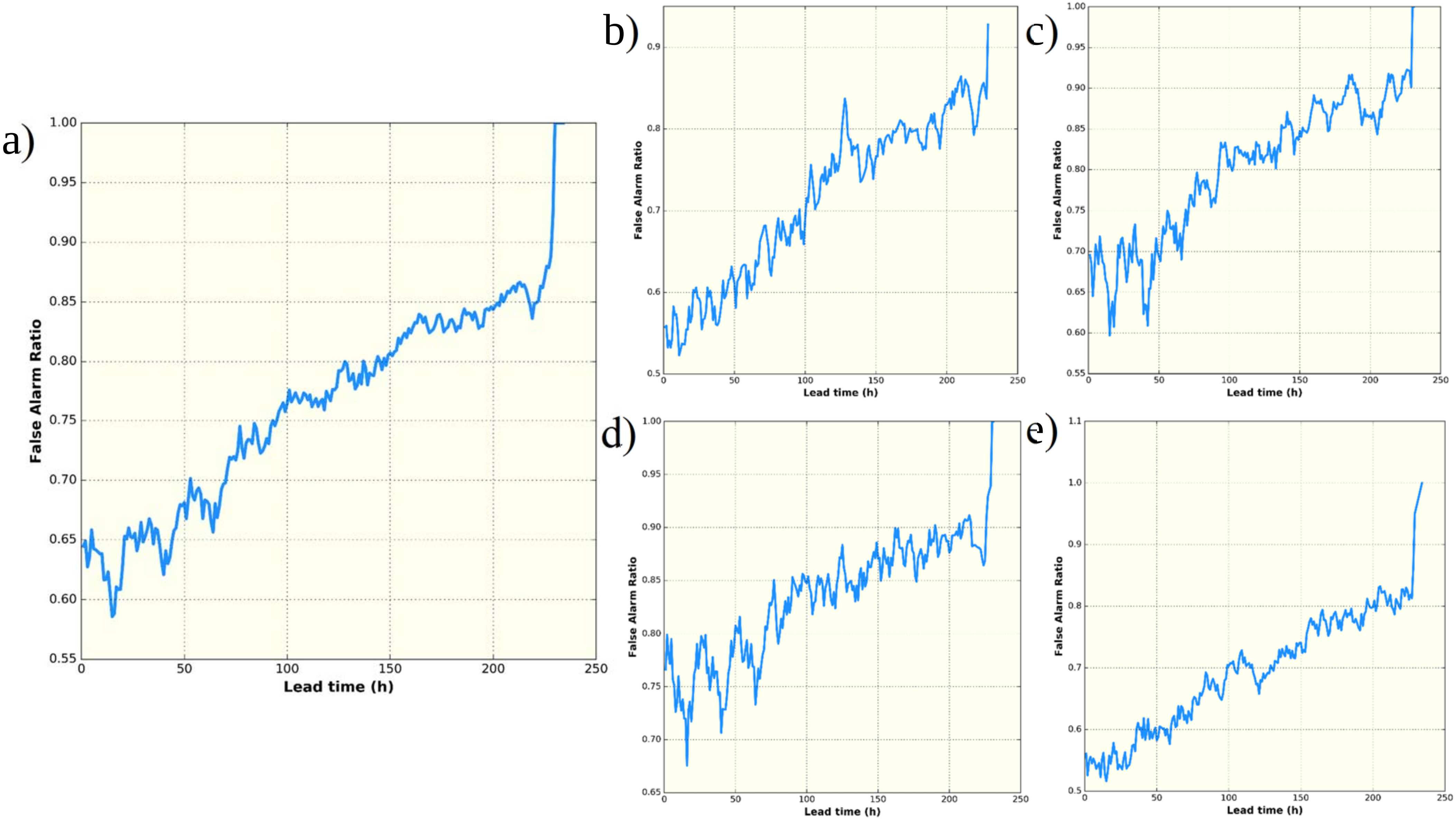



Fig. 4 Verification results for precipitation (FAR). Plot a) shows verification results for all data from 2016, while plots b), c), d), e) correspond to quarters 1, 2, 3, and 4 respectively.

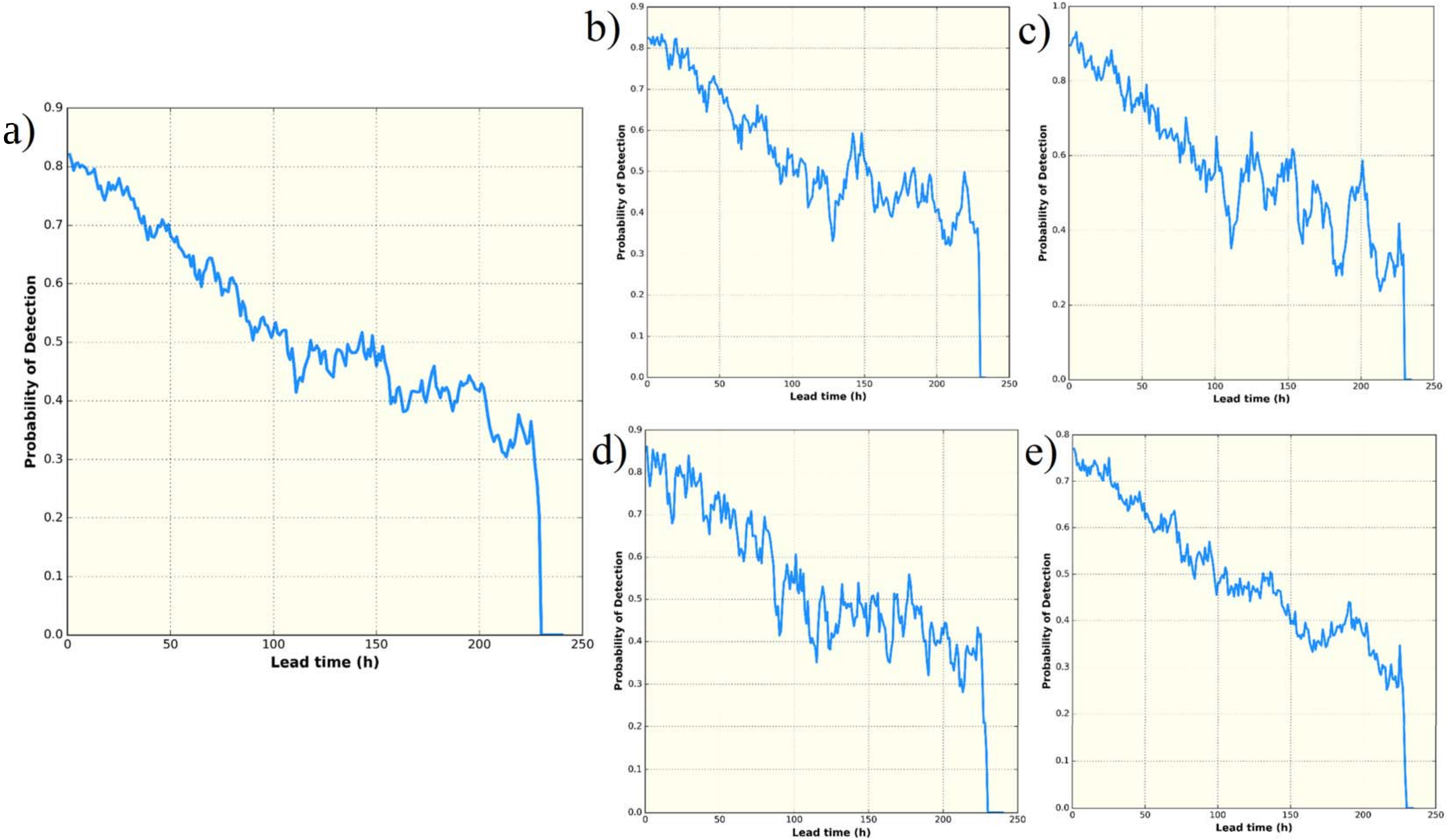



Fig. 5 Verification results for precipitation (POD). Plot a) shows verification results for all data from 2016, while plots b), c), d), e) correspond to quarters 1, 2, 3, and 4 respectively.

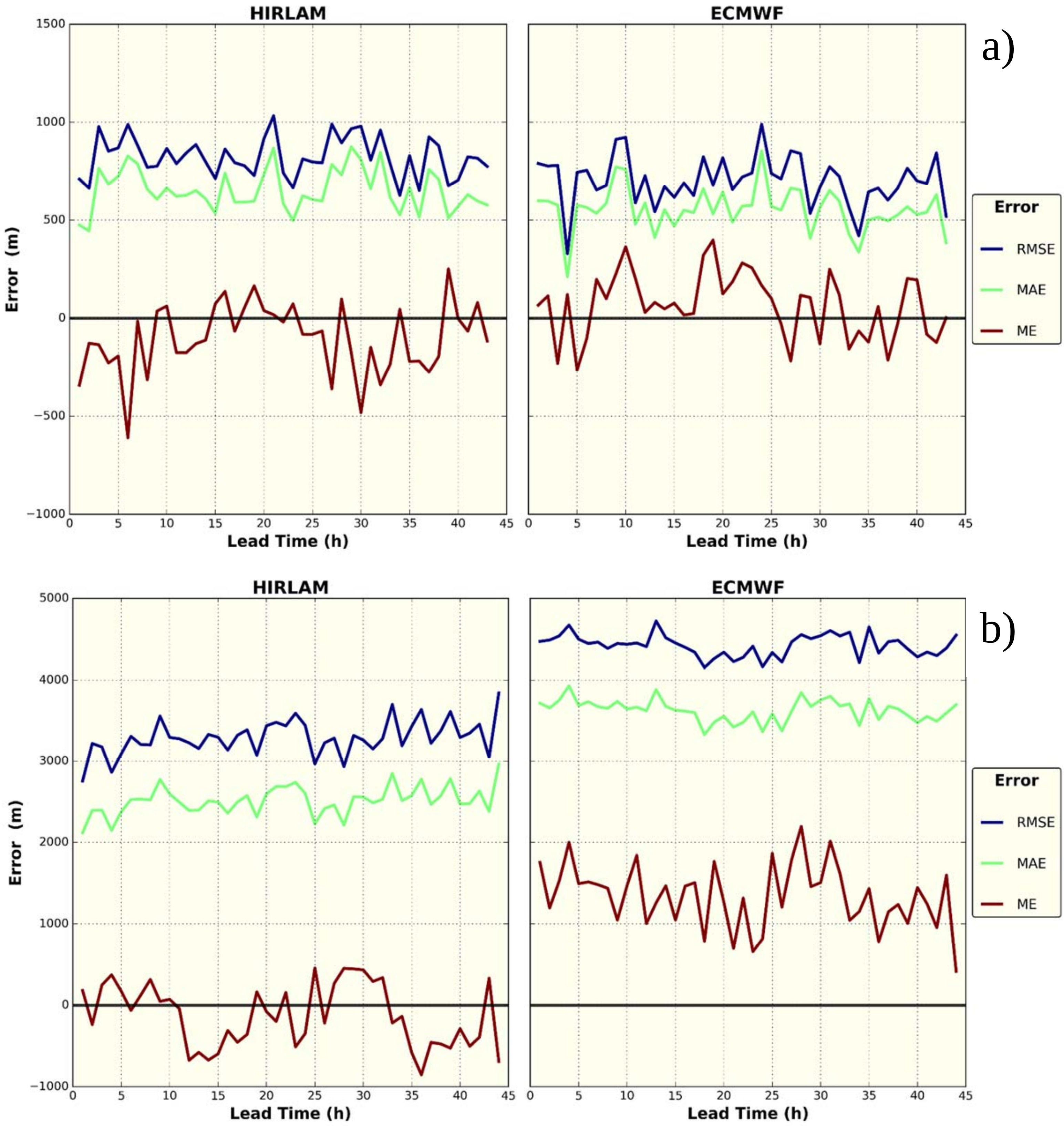



Fig. 6 Temporal verification results for visibility. Plot a) shows verification results for all model and observational data below 2 km visibility, while plot b) shows verification results for all model and observational data below 10 km visibility.

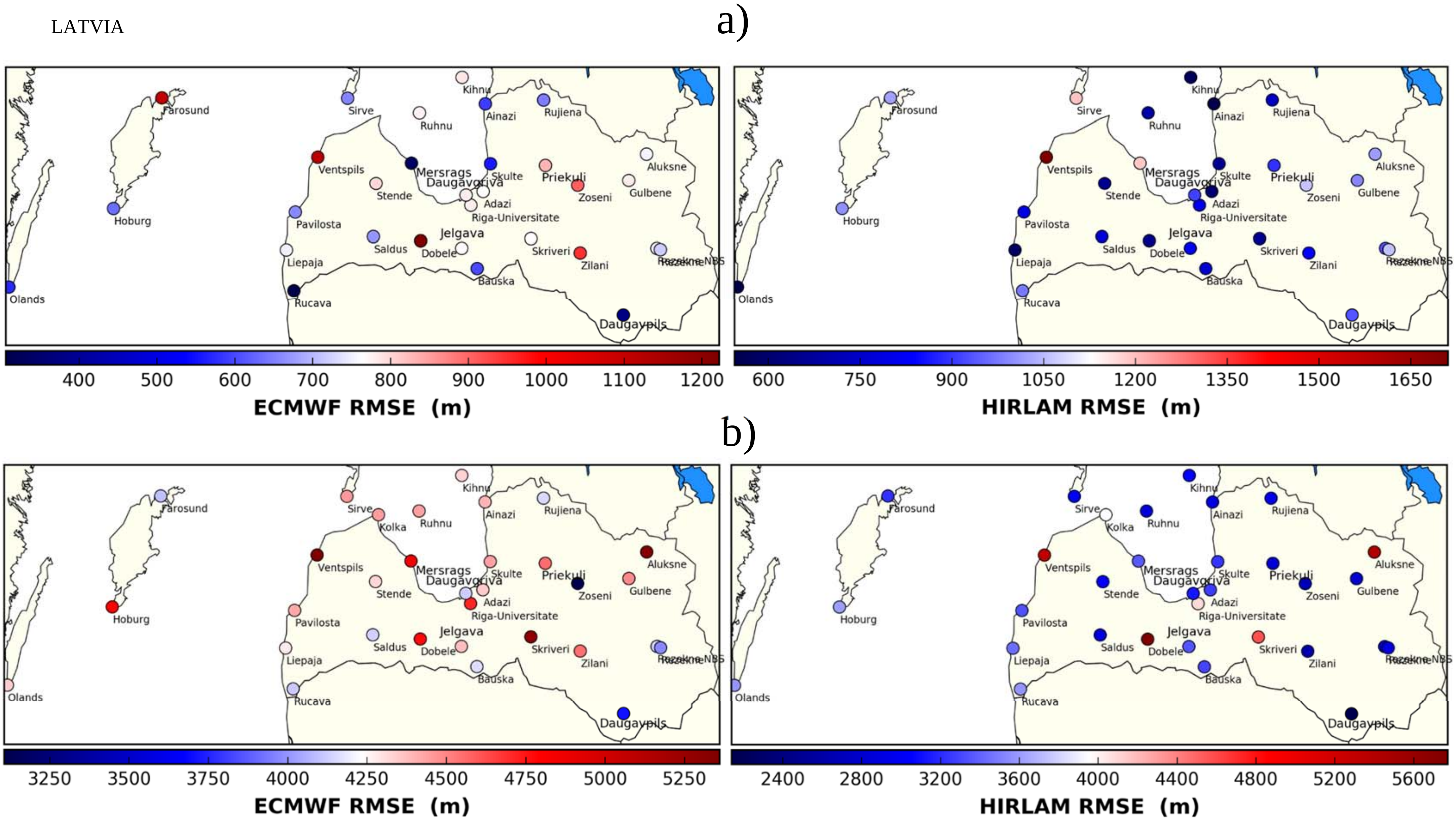



Fig. 7 Spatial verification results for visibility. Plot a) shows verification results for all model and observational data below 2 km visibility, while plot b) shows verification results for all model and observational data below 10 km visibility.