Solar Controlled Quality

Worldwide precision for your solar site

0 Introduction

0.1 Company

meteoblue is a Swiss specialist company producing high precision weather data for the entire world, using observation data, high-resolution Numerical Weather Predictions (NWP) and specialised data output methods adapted to the needs of different user groups.
meteoblue produces weather data since 2007, and produces the largest daily available data volume of any private EU weather service. The available weather archives cover 30 years in maximum detail which is important for any verification purposes. Quality verification results are shown on:
https://content.meteoblue.com/en/verified-quality/verification.
Based on these simulations, meteoblue produces solar radiation forecast and data validation services.

0.2 Distribution

meteoblue offers products, services and project resources to clients worldwide.
For representation in certain countries or market segments, meteoblue works with selected distributors, who represent, sell and service meteoblue products, services and /or project resources.
meteoblue offers data feeds specifically designed for the needs of solar power generators, electricity traders, grid or building management. More information is provided in these documents:
>>meteoblue_Solar_Technical_Specification_EN.pdf<<
>>meteoblue_Solar-forecast_Pricing+Ordering_EN.pdf<<
>>meteoblue_Solar-history_Pricing+Ordering _EN.pdf<<

1 Validation principles

1.1 Global horizontal irradiation (GHI)

The global horizontal irradiation is the most important parameter for all meteoblue solar products. The quality of meteoblue radiation forecast is critical for all solar forecast and history data. Systematic errors are corrected by statistical post processing methods, that are used for all meteoblue services. To prove the high quality of meteoblue radiation forecasts and their worldwide consistency, we validated meteoblue NMM and NEMS models in several extensive studies published at scientific conferences in 2013, 2014, 2015, 2016 and 2017. More recent research showed, that satellite derived radiation data brings substantial improvements to optimize historic time series, intraday and day-ahead forecast. Since 2017 meteoblue automatically implements a weighted average of multiple models to reach the best quality level, as shown in chapter 2.

1.2 Radiation measurements

Radiation measurements are much more challenging than measurements of other weather parameters, such as temperature. Whilst there are more than 10'000 stations with temperature measurements in Europe alone, radiation measurements are only sparsely available and often affected by considerable errors. The *Baseline Surface Radiation Network* (BSRN) is the most reliable data source, and does not include many stations, because of the high level of quality control required. Therefore, meteoblue aimed at including radiation measurements from different data sources into this validation and developed quality controlling (QC) routines to ensure only high quality data would be used for model validation purposes.

1.3 Stations

The radiation data of about 150 stations were included in the QC process, but only 120 passed the QC successfully, with the rating: "Good Quality". An overview of the 120 stations is given in Figure 1.1.

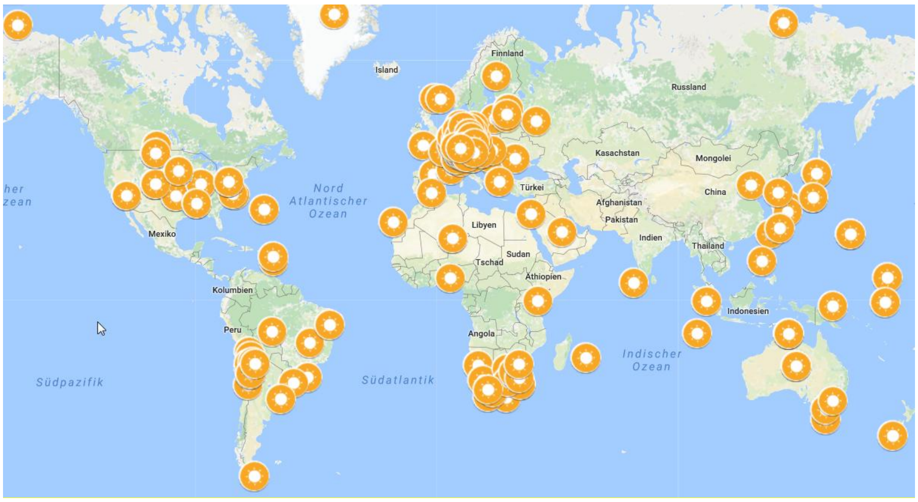

Figure 1.1 Overview of the 120 stations with radiation measurements constantly validated by meteoblue.

1.4 Quality indicators

To analyze radiation forecast of different data sources, common error values have been calculated with algorithms developed and acknowledged by the scientific community and by the solar energy service providers (http://www.mesor.net/docs/MESoR_Benchmarking_of_radiation_products.pdf). For all stations at least a full year of data has been analyzed in hourly time resolution. The following error values have been calculated:

- BIAS: Mean Biased Error – indicates systematic errors
- rBIAS: relative Mean Biased Error – Bias in percent
- RMSE: Root Mean Squared Error
- rRMSE: relative Root Mean Squared Error – RMSE in percent

- MAE: Mean Absolute Error
- rMAE: relative Mean Absolute Error – MAE in percent
- stddev: Standard Deviation
- rstddev: relative Standard Deviation – stddev in percent

In the following we use only rMAE and rBIAS as to allow the easy comparison of different graphics.

1.5 Causes for errors

There are different causes for differences between radiation measurements and model simulations. Firstly, a model is a simplified version of the reality and does not receive a perfect reality picture for the calculations. These errors are already introduced at the initialization of the model and increase with the forecast range.

Secondly, a weather model is composed by grid cells with a certain spatial resolution. Hence, the forecast data describe the mean radiation over a defined area with the size of the grid cell, in contrast to a measurement that represent a certain point. Higher variability within a grid cell results in bigger deviations between measurement and model. This is of major importance especially in complex terrain.

Thirdly, there may be problems in appropriately calibrating a model to the exact parameter expression in every location.

Fourthly, there is a possibility of incorrect measurements. High quality radiation measurements require expensive equipment, thorough calibration and regular maintenance. Such errors can (and have been proven to) be substantial, especially when coming from unknown or not controlled data sources.

Quality issues of observation data are even more substantial for measurements of power output from solar generators. Beside the described issues soiling and shading problem often appears. Thoroughly quality controlling is inevitable for a valid evaluation of data quality.

2 Product quality

2.1 Summary

Hourly mean absolute errors differ between below 10% for subtropical areas and 25% for temperate climates. With satellite observations error for nowcasting or monitoring products are reduced for the actual day (intraday forecast).

The intelligent multi model approach implemented in 2017 reduced errors by more than one third on individual locations.

With additional techniques (e.g. MOS), errors might be further reduced. These effects have to, however, be assessed for each specific location (e.g. with QC- and Validation Reports).

2.2 Radiation simulation accuracy

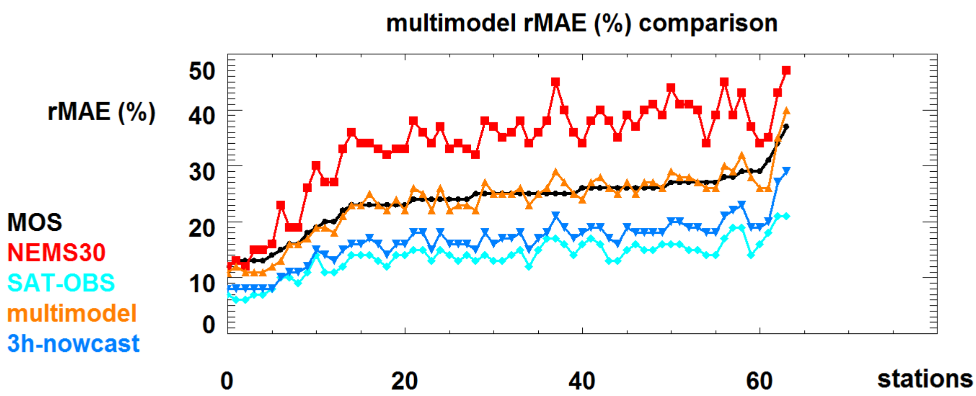

Figure 2.1: Hourly mean absolute errors (rMAE) of meteoblue day-ahead (MOS, NEMS30 & multimodel) and intraday (SAT-OBS & 3h-nowcast) radiation data from 2015 validated on 65 stations.

To provide the highest precision meteoblue combines weather and radiation data from many different sources. Beside more than 25 different weather models, meteoblue is using satellite derived radiation observations to calibrate forecast and history data and for nowcasting (intraday forecasting) and monitoring. As shown in Figure 2.1 the error values of different sources, respectively their quality levels vary especially for different time horizons. The standard quality level of meteoblue forecast (day ahead) and history data is the multi-model simulation. This is a major improvement, compared to before 2017, when the NEMS30 model was used. For monitoring and nowcasting higher quality can be achieved, when accessing the data of the actual day. Even though the statistical optimization with MOS technology shows hardly improvements, when comparing the absolute errors (Figure 2.1), it might still be useful for certain sites as the systematic errors are often reduced (see Figure 2.2).

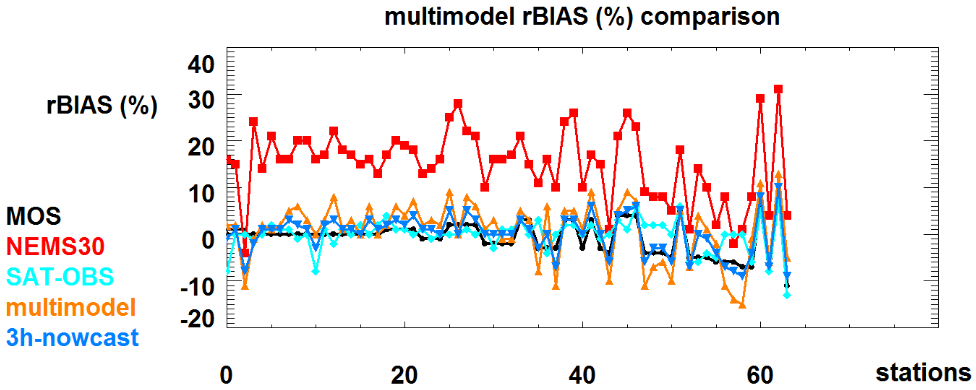

Figure 2.2: Hourly mean biased errors (rBIAS) of meteoblue day-ahead (MOS, NEMS30 & multimodel) and intraday (SAT-OBS & 3h-nowcast) radiation data from 2015 validated on 65 stations.

2.3 Regional accuracy

The error values differ not only for different time horizons but also for different regions, following a simple formula: Less clouds lead to lower errors. Thus arid region might have an rMAE of below 10 %, while inner tropical or temperate climates have error of up to 25%. Figure 2.3 shows the quality levels of different data sources and time horizons within different regions: Lower forecast errors can be expected in South Africa and Brazil, while the errors in the French Caribbean are slightly higher. The temperate climate in Central Europe shows errors of about 25 %.

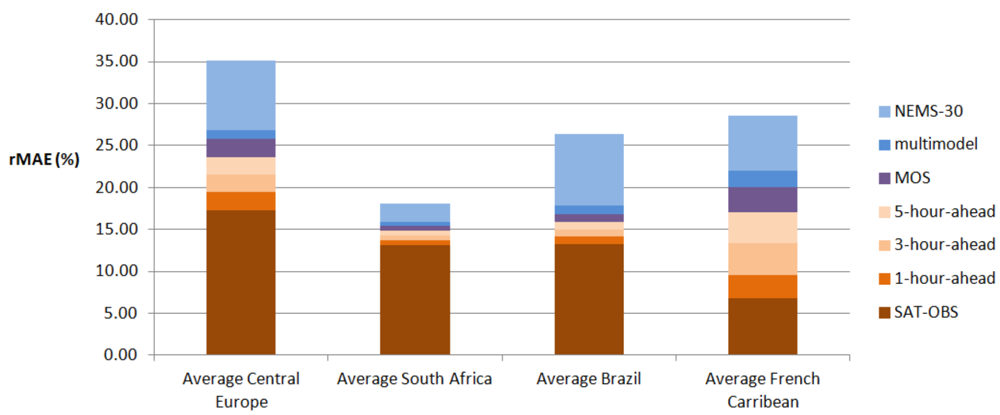

Figure 2.3: Hourly mean absolute errors (rMAE) of meteoblue day-ahead (MOS, NEMS30 & multimodel) and intraday (SAT-OBS & hour-ahead) radiation data averaged for all stations in a specific region.

2.4 PV reference yield simulations

The simulation of PV systems is highly determined by solar radiation. When reference yield simulations are carefully calibrated, the accuracy of these is within the range of the accuracy of radiation simulations. When the PV system is thoroughly configured, the performance of PV yield simulations is expected to be more precisely as the radiation simulation, as the systematic errors (BIAS) are largely eliminated. Higher errors have their causes in local shading, system deterioration or malfunction. Wrong temporal allocation of measurements may also lead to substantially higher errors. The expected precision of the standard forecast and simulations for sites in temperate zones, such as Central Europe, is expected between 15 and 30% rMAE on an hourly basis for day ahead forecast, depending on location and year. For locations with higher radiation intensity in subtropical areas, errors of below 15% can be achieved. Direct Normal Radiation (DNI) usually shows slightly higher error values.

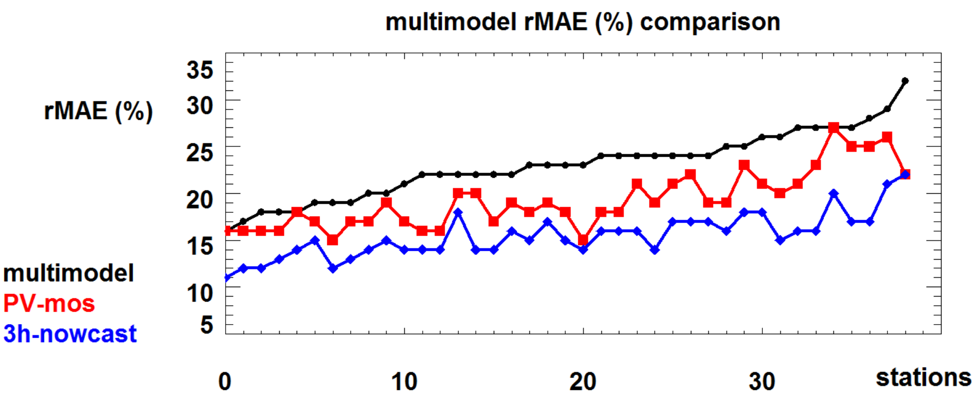

Figure 2.4: Hourly mean absolute errors (rMAE) of meteoblue day-ahead (multimodel & PV-mos) and intraday (3h-nowcast) PV yield forecast validated on 38 PV systems in Central Europe.

The accuracy of PV reference yield simulations can be compared to radiation simulation accuracy. Likewise for daily and monthly sums, reduced errors values can be observed. Higher differences are a strong indication for inaccurate system specifications or malfunction of the PV system.

2.5 Nowcasting simulations

To optimize the quality of intraday forecast of the next 5 hours based nowcasting methods are implemented in all meteoblue products. For solar forecast it is based on real time radiation observations derived from satellite images and cloud trajectories. Nowcasting data is usually updated in real time every 15 minutes depending on the availability of the satellite. For the first 3 hours the forecast error is reduced by 5 % to 50 % (see Figure 2.5). For past hours the quality of satellite observations is achieved, which are applicable for monitoring of solar generators.

Real time matching with satellite observation increases accuracy of Hour-Ahead Forecasts by up to 50 %. The errors decline with forecast horizon, thus nowcast is only applied for the next 5 hours. The satellite observation is available for past hours and an excellent reference for real time monitoring.

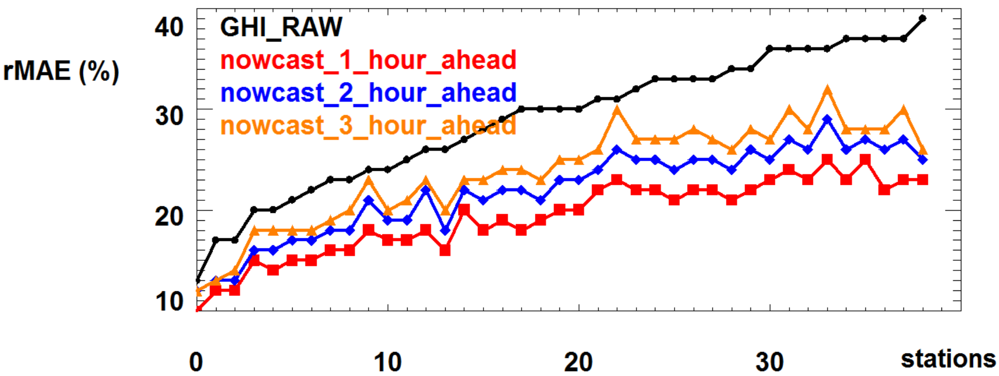

Figure 2.5: Hourly mean absolute errors (rMAE) of meteoblue day-ahead (GHI_RAW) and intraday (nowcast_1-2-3_hour_ahead,) radiation data from 2015 validated on 38 stations.