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Umwelt, Verkehr, Energie und Kommunikation UVEK

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IEA SHC TASK 36: SOLAR RESOURCE KNOWLEDGE MANAGEMENT

GLOBAL RADIATION AND PV PRODUCTION FORECAST

Annual Report 2008

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Project- / Contract Number	101498 / 151784
Duration of the Project (from – to)	July 2005 – June 2010
Date	12.12.2008

ABSTRACT

In the framework of IEA Solar Heating and Cooling (SHC) task 36 Meteotest investigates mainly the possibilities and quality of global radiation forecast. In the third year the validation of the global radiation forecast of Meteotest's new operational WRF model was started. For three sites in the USA the model was compared to measurements and to 2 other models (ECMWF, NDFD). The uncertainty of WRF model was somewhat higher than ECMWF and NDFD and highly dependent on the region. The uncertainty lies between 18-50% for hourly values. The breakeven of persistence is reached after 2-4 hours. In autumn a detailed benchmark for Alpine region has been started. The results will be available in summer 2009.

The solar radiation forecast has been coupled with the PV yield control tool spyce. Like this the PV production for the next two days is available for sites in Europe.

Introduction

In the framework of IEA Solar Heating and Cooling (SHC) task 36 "Solar Resource Knowledge Management" [1] Meteotest investigates mainly the possibilities and quality of global radiation forecast.

The task 36 is divided into 3 main subtasks:

a) Standard qualification for solar resource products (includes benchmarking of different radiation estimation models based on satellite measurements).

b) Common structure for archiving and accessing solar resource products (includes prototype of online tool for accessing data).

c) Improved techniques for solar resource characterization and forecast; improve satellite retrieval methods for solar radiation products; conduct climatological analysis of solar resources.

The aim in the radiation forecast subtask is to define the quality of the existing models and to enhance the quality. A further aim is also to check the quality of forecasted PV production data. Main partners in this subtask are University Oldenburg and New York State University at Albany.

Additionally Meteotest did some work within part c), where a new turbidity climatology was made.

Work done and first results

RADIATION FORECAST

Models and data

In 2008 a benchmark of three forecast models (ECMWF, NDFD and GFS/WRF) (Tab. 1) was made for three sites within the USA (Tab. 2) [2].

Table 1: Team members and their used model.

Team	Output parameter used	Resolution	Model
New York State Univ. Albany, ASRC, USA	Cloud cover statistical model for GHI 3 h time resolution	9 km	NDFD [3]
Univ. Oldenburg EHF, Germany	Direct model output GHI (3 h time resolution enhanced to 1 h resolution)	25 km	ECMWF [4]
Meteotest, Switzerland	Direct model output GHI 1 h time resolution	11 km	GFS/ WRF [5]

The NDFD data were based on a combination of GFS model, local area models and local human input (regional weather offices within USA).

For GFS/WRF the global radiation of the nearest grid point based on Dudhia radiation code was used. The GFS data (1°) were upscaled with two nestings at 33 and 11 km.

At present we focus our attention on the global irradiance component with forecast ranges of up to up to 60 hours.

The data has been compared to three sites of BSRN/SURFRAD network (Tab. 2).

Table 2: Sites used for benchmarking.

Site	Latitude	Longitude	Altitude
Desert Rock NV	36.63°N	116.02°W	1007 m
Boulder CO	40.13°N	105.24°W	1689 m
Goodwin Creek MS	34.25°N	89.87°W	98 m

Desert Rock is an example for desert climate. Boulder is at the eastern edge of the Rocky Mountains. It's in-between the mountainous climate and the climate of the Great Plains. Goodwin Creek in the Mississippi basin shows a more moderate and humid climate.

The period of comparison is April – September 2007.

Results

The mean bias errors (mbe) are generally small (Tab. 3). Only GFS/WRF model shows higher values at Boulder and Goodwin Creek (overestimation of global radiation).

Table 3: mean bias errors of one day forecast

Site	NDFD [W/m^2] ([%])	ECMWF [W/m^2] ([%])	GFS/WRF [W/m^2] ([%])
Desert Rock NV	10 (2)	15 (3)	13 (2)
Boulder CO	12 (3)	43 (11)	85 (19)
Goodwin Creek MS	-17 (-4)	24 (6)	82 (18)

As the main uncertainty measure the root mean squared error (rmse) is used. The rmse varies strongly from site to site. The forecast at Boulder show clearly the highest and Desert Rock the smallest uncertainties (Tab. 4 and Fig. 1) .The uncertainty grows only slightly from day to day.

Table 4: rmse of one day forecast

Site	NDFD [W/m^2] ([%])	ECMWF [W/m^2] ([%])	GFS/WRF [W/m^2] ([%])
Desert Rock NV	96 (18)	87 (18)	105 (18)
Boulder CO	167 (41)	162 (40)	223 (50)
Goodwin Creek MS	149 (36)	136 (32)	190 (41)

The large share of sunny hours at Desert Rock facilitates the forecast. For Boulder, lying at the border of two different climate regimes, forecasting is much more difficult. An enhancement of the spatial resolution to 2-5 km could enhance the quality at this site. ECMWF shows the best results, followed by NDFD. GFS/WRF model shows approximately 25% higher uncertainties mainly at Boulder and Goodwin Creek MS.

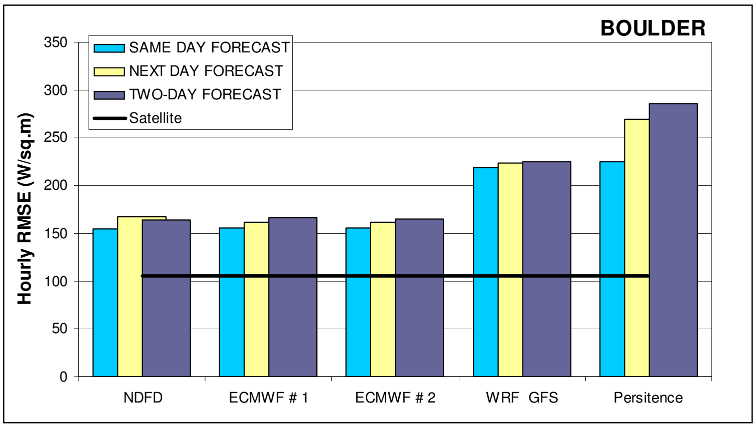

Figure 1: Uncertainty of radiation forecast models at Boulder CO.

The breakeven of persistence (clearness index is kept constant) is reached after 2-4 hours. The breakeven is dependent on the uncertainty. For ECMWF and NDFD this value is reached at 2 hours for GFS/WRF at 3 hours.

Conclusions

ECMWF Version 2 performs best overall (3-hourly model with physical model interpolation). The uncertainty of NDFD is not much greater and not bad for a 3-hourly cloud cover model. GFS/WRF is not as good as other two models. It could be improved with a better radiation model and a statistical post processing eliminating the bias, which is planned for the future.

The persistence breakeven is for all models lower than 3 hours.

PV PRODUCTION FORECAST

Spyce forecast is the implementation of radiation forecast in the PV yield control system Spyce (www.spyce.ch). The standard service of Spyce calculates the PV production of the previous day by using measured global radiation (at ground or by satellites) and simulating the PV production. The simulated values are then compared to measured. If they differ statistically users are informed.

As an additional and new service forecasted radiation is used as input and the power production of the two following days is calculated (Fig. 2). Within the algorithmic chain also direct normal irradiance and tracked radiation (single axis tracking) as well as uncertainty of the parameters is calculated and delivered to the user. Further software options are included in the service like the possibility to define losses due to string or tracking malfunctions [6].

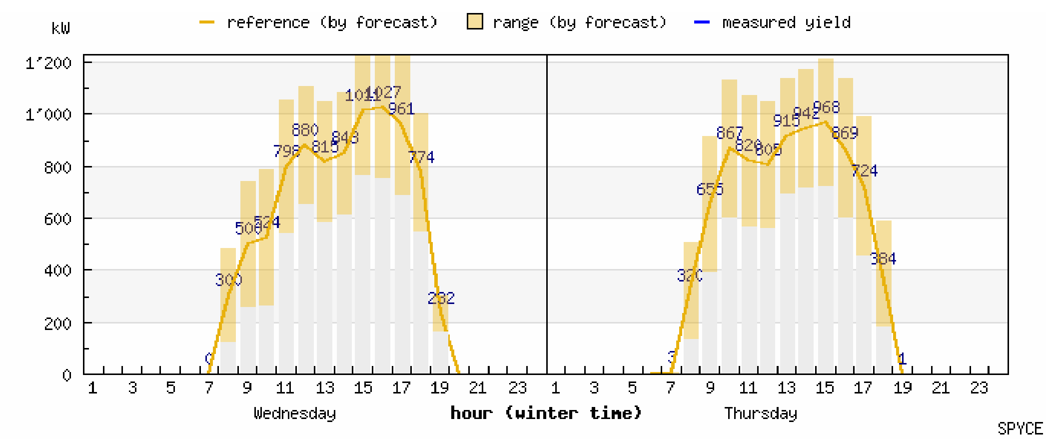

Figure 2: Example of forecasted PV production of two days with uncertainty band.

National / international cooperation

The work was done in the framework of IEA Solar Heating and Cooling task 36. From Switzerland there is also University of Geneva part of the task team.

Outlook

The validation of the solar radiation forecast will be carried on. The calculation of radiation forecast for the alpine region with the WRF model at 5 km has been started. The calculation for the period July 2007 – June 2008 will take 4 months. The benchmark for alpine region will be finalised in spring 2009. Other models from other expert teams including Ciemat (Spain), University of Jaen (Spain), Meteocontrol (Germany), and Blueskywetter (Austria) will be benchmarked as well.

The work within the IEA task will continue until 2010.

References

[1] Homepage of IEA Solar Heating and Cooling task 36:
http://re.jrc.cec.eu.int/iea-shc-task36/index.htm

[2] J. Remund, R. Perez and E.Lorenz, Comparison of solar radiation forecasts for the USA. Proceedings of the 23rd European Photovoltaic Solar Energy Conference, Valencia, 1 – 5 September 2008, WIP-Renewable Energies.

[3] National digital forecast database (NDFD) of NOAA (http://www.weather.gov/ndfd/).

[4] Global model of the European Centre for Medium-Range Weather Forecasts (ECMWF, http://www.ecmwf.int).

[5] Weather research and forecasting (WRF) model (http://www.wrf-model.org) with 1° input of Global Forecast System (GFS) model.

[6] J. Remund, C. Schilter, S. Dierer, S. Stettler and P. Toggweiler, Operational forecast of PV production. Proceedings of the 23rd European Photovoltaic Solar Energy Conference, Valencia, 1 – 5 September 2008, WIP-Renewable Energies.