2012 HIGHLIGHTS

SHC Task 46
Solar Resource Assessment and Forecasting

THE ISSUE

Knowledge of solar energy resources is critical when designing, building and operating successful solar water heating systems, concentrating solar power systems, and photovoltaic systems. However, due to their dependence on weather phenomena the energy output from these technologies can be highly variable, especially in situations where storage is not available to smooth out this variability. High penetrations of these technologies will then require utilities to be able to predict their availability to meet varying load demands. Solar resource and solar power forecasting is an important tool being made available to system operators to assist them in matching load fluctuations with the solar energy technologies available to them, thereby optimizing the value of these technologies in meeting clean energy goals.

OUR WORK

In a continuation of the work accomplished under the recent *Task 36: Solar Resource Knowledge Management*, participants representing research institutions and private consultancies from around the world, are engaged in *Task 46: Solar Resource Assessment and Forecasting* to produce information products and best practices on solar energy resources that will greatly assist policymakers as well as project developers in advancing renewable energy programs worldwide. Improving and benchmarking solar resource forecasting methodologies is one of the key efforts underway in this new Task, building on successes gained in Task 36.

One of the objectives of this work is to examine and compare various solar energy forecasting schemes over various time scales, such as over the next hour for load following, over the course of a day for overall grid reliability and balancing strategies, and 1-3 days ahead for system planning and maintenance. The scope of this Task is to "benchmark" various solar resource forecasting schemes with ground-based solar measurement data, and with actual PV system output.

PARTICIPATING COUNTRIES

Australia
Austria
Canada
Denmark
European Commission
France
Germany
Spain
Switzerland
United States

Task Date	**2011-2016**
Task Leader	**David Renné** **National Renewable Energy Laboratory (Emeritus), United States**
Email	**drenne@mac.com**
Website	**http://www.iea-shc.org/task36**

KEY RESULTS OF 2012

Observational and Numeric Modeling for Solar Forecasting

Work is underway in Task 46 to assess the suitability of various observational schemes and numerical modeling techniques to provide solar forecasts over time intervals from hour-ahead to 1-3-days ahead. For hour-ahead forecasts, critical to system operators attempting to effectively match varying loads with variable renewable energy technologies, application of Total Sky Imagers or all sky cameras appears promising. Images from these systems can be digitized in ways that predict cloud motions that allow system operators to evaluate how the solar resource will change over the next several minutes, up to as much as one hour. A new group that has joined Task 46 from France, the Laboratoire PIMENT at the Université Réunion on Réunion Island, is investigating how images collected from all-sky cameras can be used to predict short-term cloud motions, as shown in Figure 1.

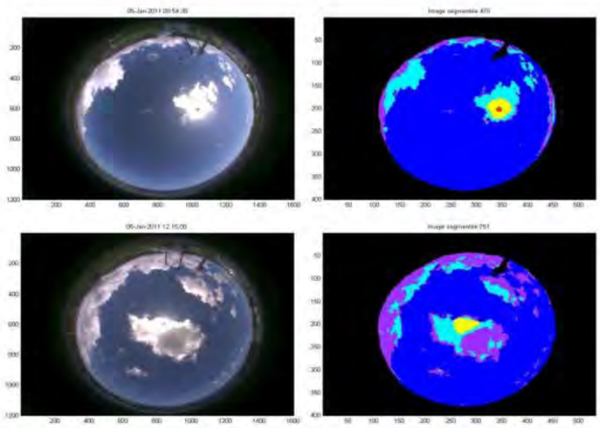

Figure 1. Examples of digitized clouds and clear sky segmentation (right) for two hemispheric sky images (left) obtained on Réunion Island.

Cloud Motion Vectors

Task 46 participants have investigated the reliability of forecasts derived from cloud motion vectors (CMVs), a method that projects forward into time the movement of clouds based on a time series of cloud images derived from satellite observations. This method, pioneered at the University of Oldenburg (Germany) over a decade ago, is now being applied by a number of Task 46 participants and is being tested throughout Europe and the U.S., and expanding to other regions as well. Task 46 participants have learned that this approach can provide more reliable forecasts than the more traditonal method of using numerical weather prediction (NWP) models for periods as much as 4 to 6 hours ahead. In Figure 2, for example, the comparison of cloud motion vector forecasts with those derived from NWPs is shown for various region sizes in Germany.

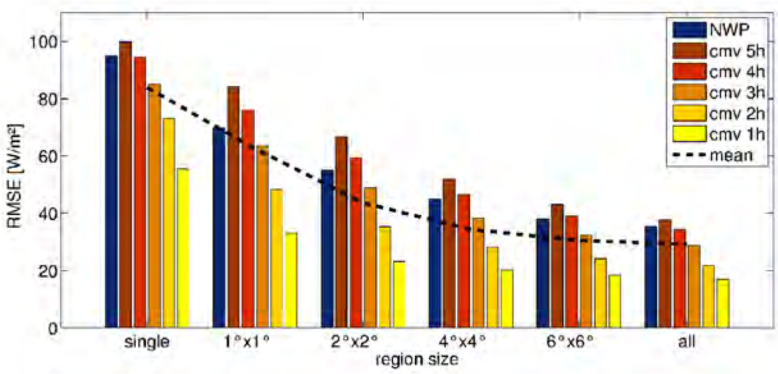

Figure 2. Evaluation of forecast accuracy in terms of RMSE compared to ground measurements for selected region sizes in Germany. NWP based forecasts as well as cloud motion vector (CMV) forecasts over different time horizons are displayed, showing that forecast reliability improves as the region size increases, and that NWP models begin to produce superior forecasts out beyond about 4-6 hours in the time horizon.

This study has been further extended to determine whether combining NWP models, such as those produced by the European Center for Mid-Range Weather Forecasting (ECMWF) with a regional model operated by the German Weather Service, can improve forecast reliability over the cloud motion vector approach in the 0-6 hour time frame. In Figure 3 it can be seen that the “combination” model results show significant improvements over use of just the ECMWF forecast, particularly over a large region. The combination ("combi") method can actually provide improvements compared with the cloud motion vector method, both at single sites and over large regions. Again, Figure 3 shows that the cloud motion vector approach is most suitable only out to about a 4-hour time horizon. The Figure also shows that using persistence as a forecasting method, whereby the current observations are projected into the future, is not as reliable as either the cloud motion vector or the combi forecasting schemes, especially at a single site.

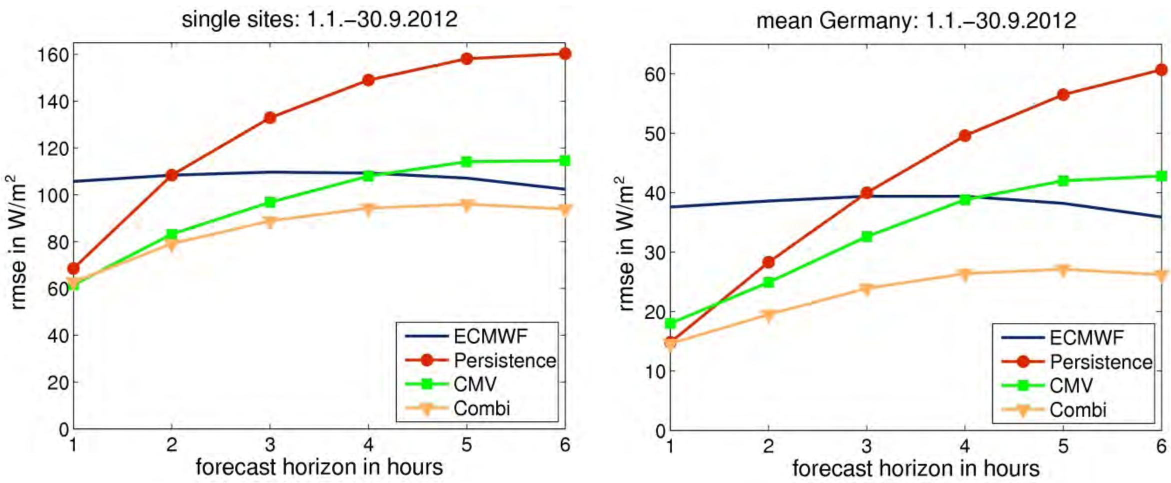

Figure 3. RMSE of ECMWF based, cloud motion vector (CMV), and combined forecasts in comparison to persistence as a function of the forecast horizon. Left: single sites, right: German mean.

In another study, Meteotest (Switzerland) developed a short term forecasting method that combines cloud and radiation fields from Meteosat satellite images with wind fields from the numerical weather prediction (NWP) model known as the weather research and forecasting (WRF) model. An evaluation for lowland, alpine and high-alpine stations in Switzerland for July and August 2012 revealed a superior performance of the satellite-based forecasting scheme to WRF forecasts up to 6 hours ahead, as shown in Figure 4. Forecast uncertainties are larger in alpine and high-alpine areas.

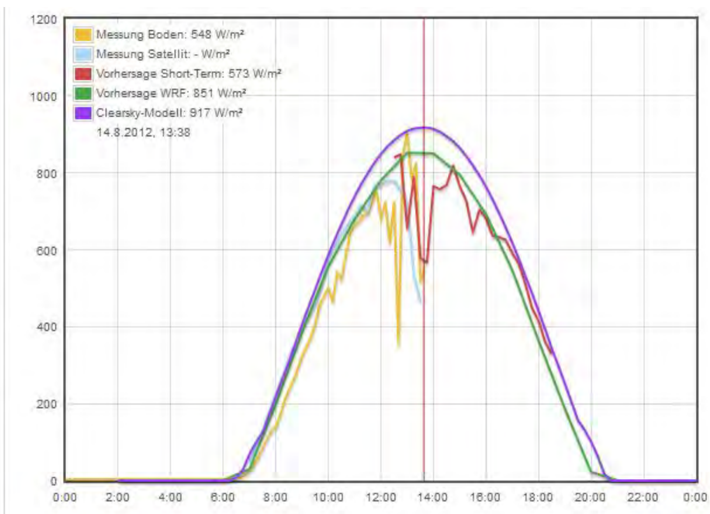

Figure 4. Comparison of forecasted and measured irradiances (14 August 2012) for Muehleberg Stockeren. (yellow; measured; light blue: satellite-derived, Red: new short term forecast, green: WRF, pink; clear sky).