



Hawai'i Natural Energy Institute Research Highlights

Grid Integration

Solar Power Forecasting

OBJECTIVE AND SIGNIFICANCE: This project's objective was to develop advanced forecasting systems, including new methods and technologies, to predict solar photovoltaic (PV) power generation from minutes to days ahead. Knowledge of upcoming PV power production allows grid operators and grid management systems to proactively address the inherent variability of solar power. These systems also provide visibility and situational awareness for distributed behind-the-meter solar systems, helping to minimize the impact of reliability issues and disruptive events and manage the cost of grid operations, as the levels of PV interconnected to the electric grid increase.

BACKGROUND: Power output from PV systems is directly related to the power of the sunlight striking the panel, measured as irradiance. Irradiance variability at the top of the atmosphere (TOA) is driven by sun-earth geometry and fluctuations in solar output. As solar radiation passes through the atmosphere it is attenuated through a complex series of reflections, absorptions, and re-emissions due to interactions with clouds, fog, and haze, as well as other particulates, such as dust, ash, and smog. Ground-level irradiance varies erratically across a range of time-scales.

PROJECT STATUS/RESULTS: HNEI has developed a multi-scale, probabilistic solar forecasting system that monitors current regional irradiance conditions in near real-time and predicts upcoming irradiance conditions and resulting PV power production, from minutes up to 4-days ahead. This system is fully automated, generating predictions without human intervention.

Probabilistic irradiance predictions are generated using ensemble methods that combine individual, overlapping forecasts from three components. Minute-ahead (MA) forecasts, from 1 to 30 minutes ahead, are provided by the Affordable High-Resolution Irradiance Prediction System (AHRIPS), a novel solar forecasting instrument developed by HNEI. Hour-ahead (HA) forecasts, from 10 minutes to 6 hours ahead, are derived from geostationary satellite images, which provide consistent monitoring of regional atmospheric conditions (sample nowcast shown in Figure 1). Day-ahead (DA) forecasts, longer than 6 hours ahead, are generated using a

specific configuration and augmentation of the Weather Research and Forecasting (WRF) system designed for solar energy applications.

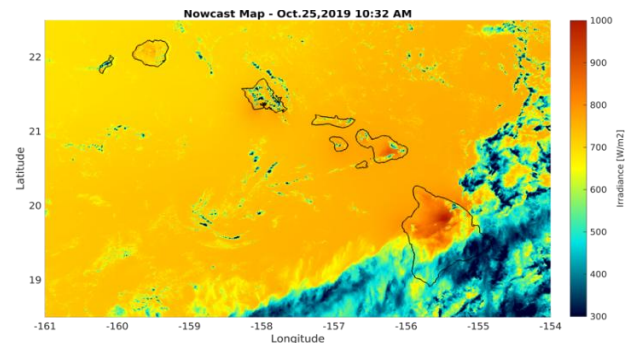


Figure 1. Sample irradiance nowcast map derived from GOES-17 imagery.

The system generated operational forecasts for a Hawaiian Island domain that includes all of the main islands of the Hawaiian archipelago. Multiple probabilistic irradiance and PV power forecasts were produced using ensembles composed of 4-day ahead WRF forecasts, generated nightly, and 6-hour ahead GOES forecasts, generated from the latest satellite images every 5-10 minutes.

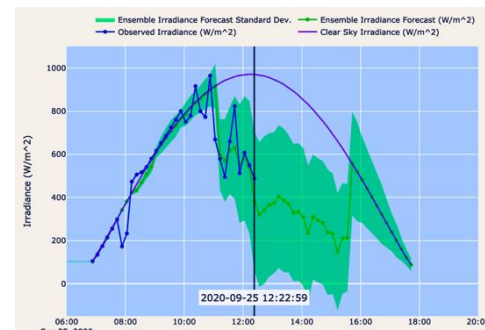


Figure 2. Sample output from the forecasting system.

In April 2021, a patent for the system was approved by the U.S. Patent & Trademark Office: Matthews, Dax Kristopher. 2021. Ground-based sky imaging and irradiance prediction system. U.S. Patent 10989839, filed August 29, 2018, and issued April 27, 2021.

These achievements mark the successful conclusion of the project.

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Contact: Dax Matthews

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