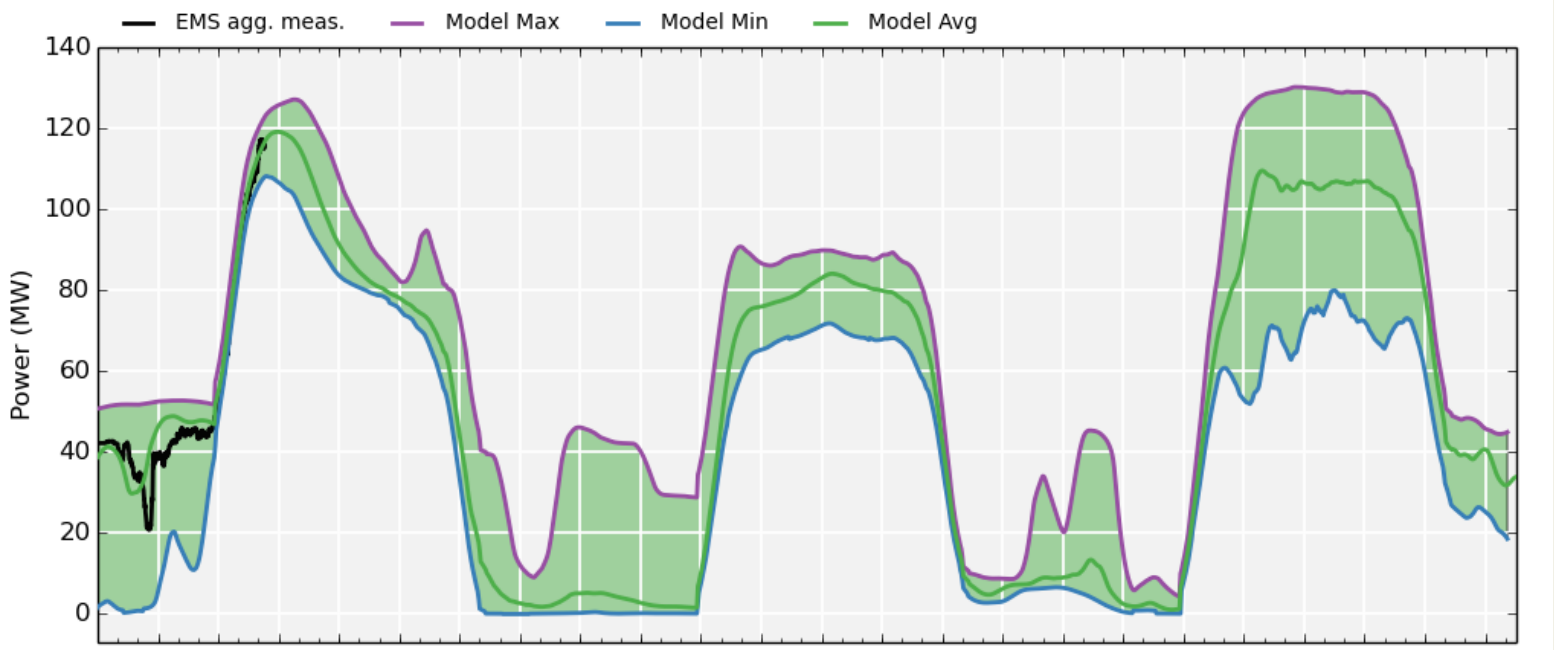
Real-Time Renewable Power Forecasting



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ARIZONA®

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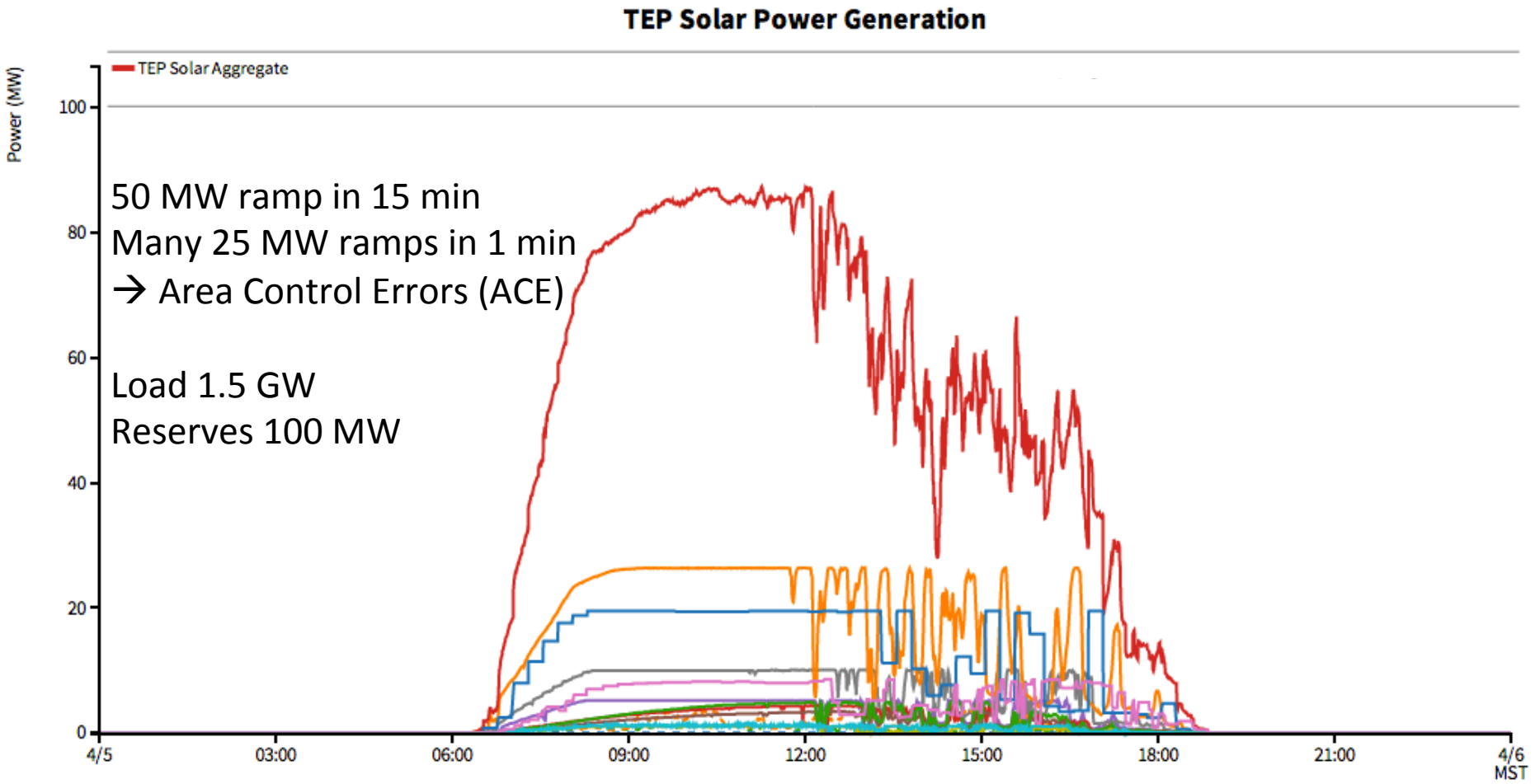
Ardeth Barnhart, Director, UA-REN
Rey Granillo, Developer, UA-REN

The Problem:
TEP's Solar Power Variability



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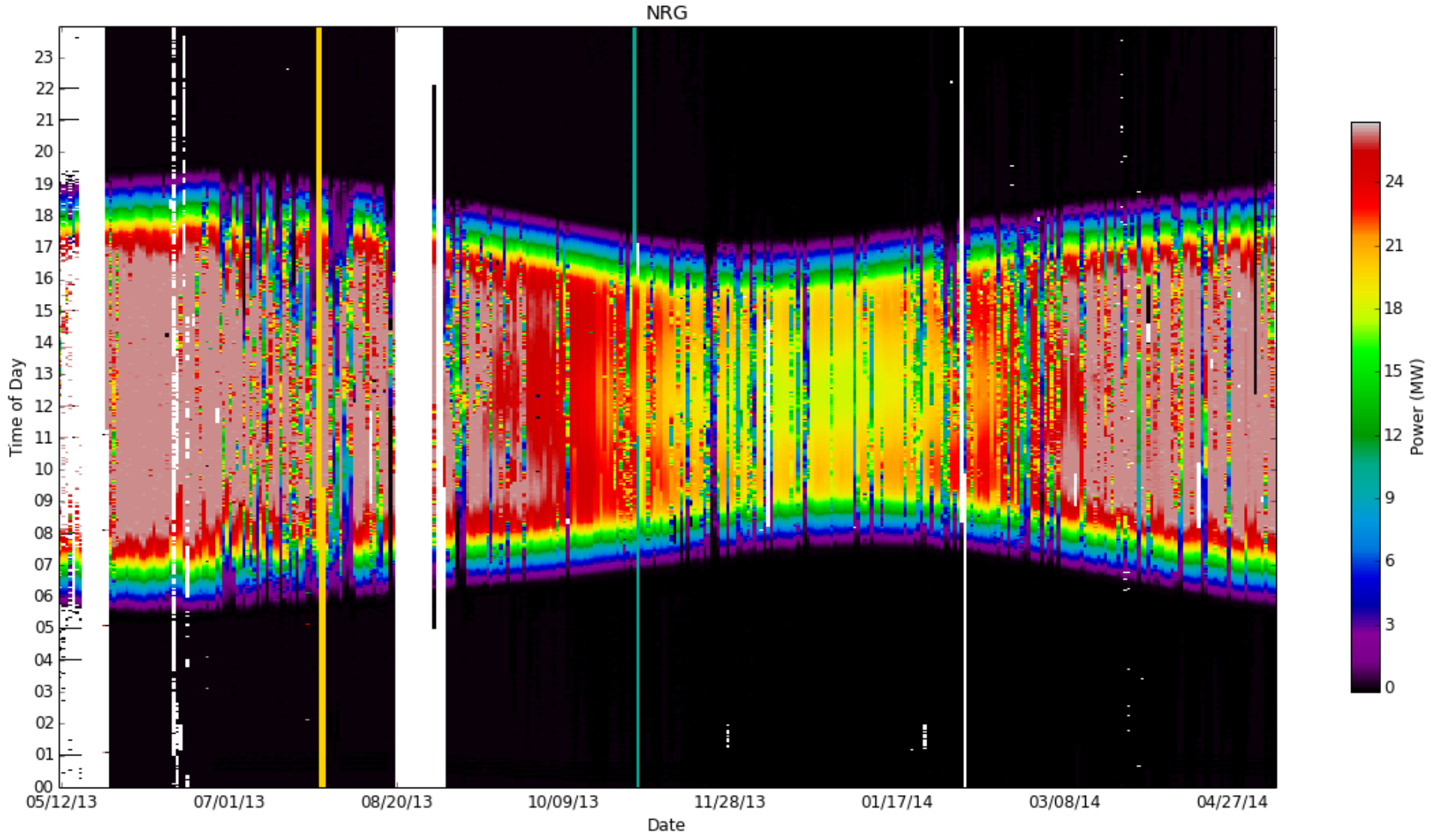

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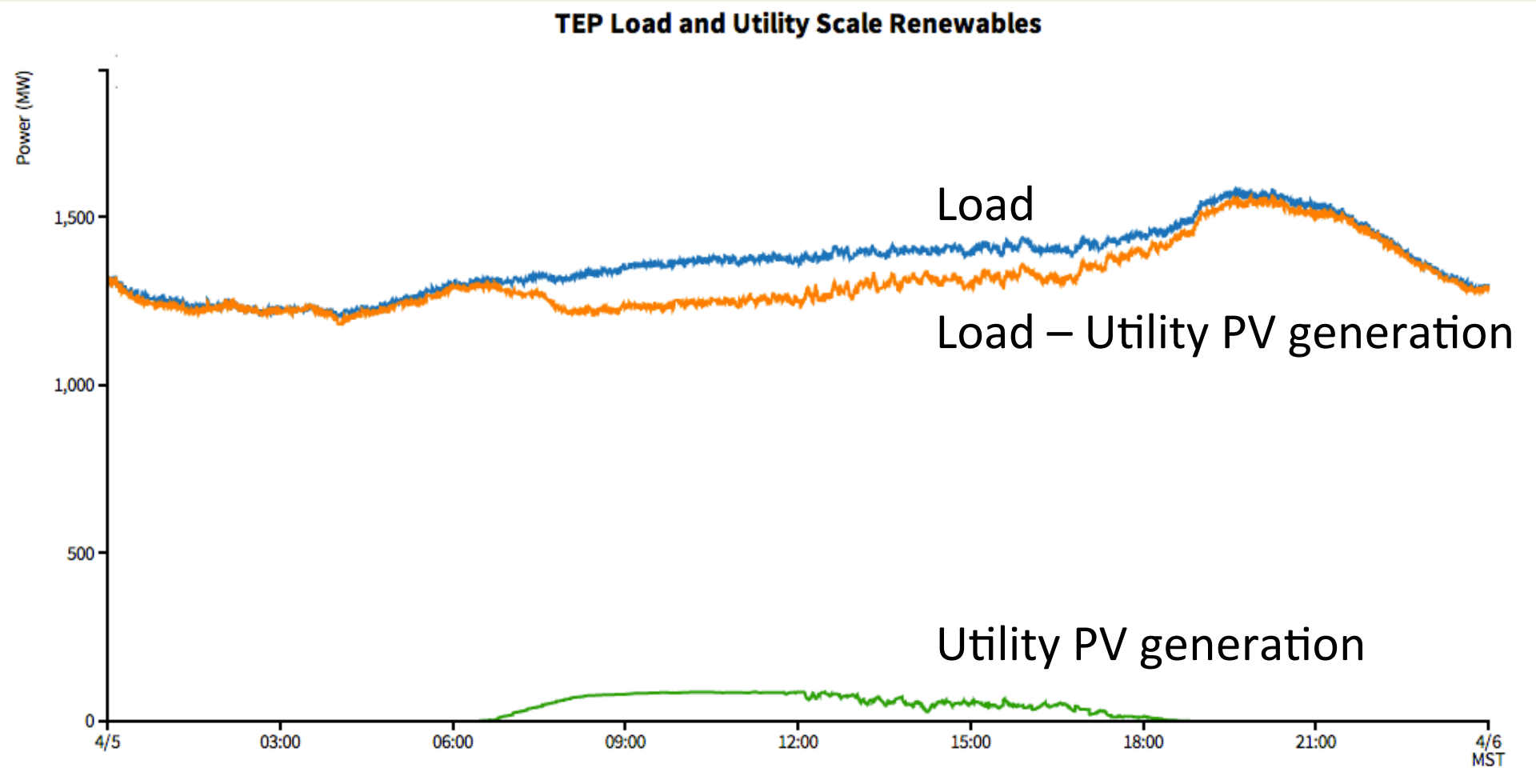

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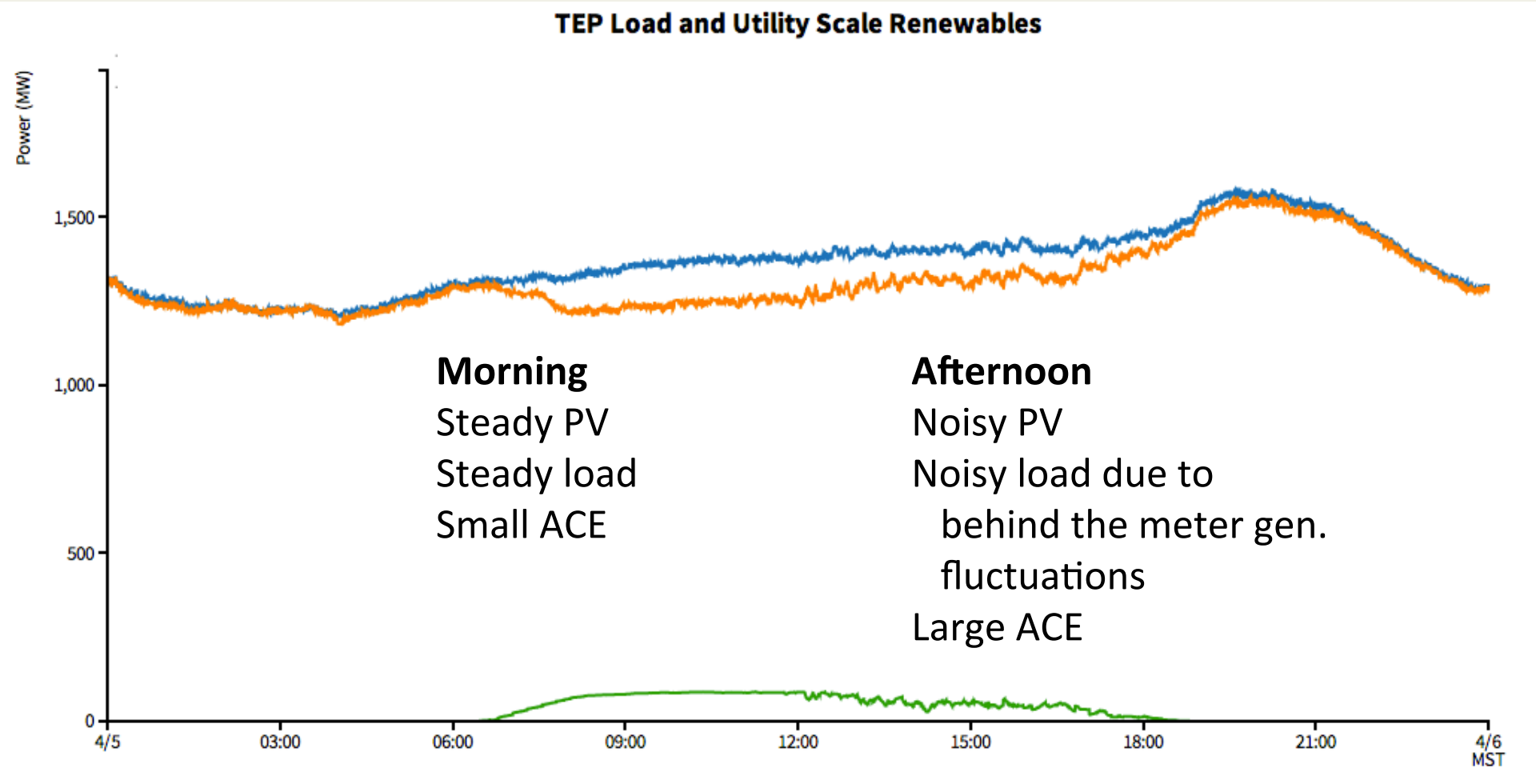

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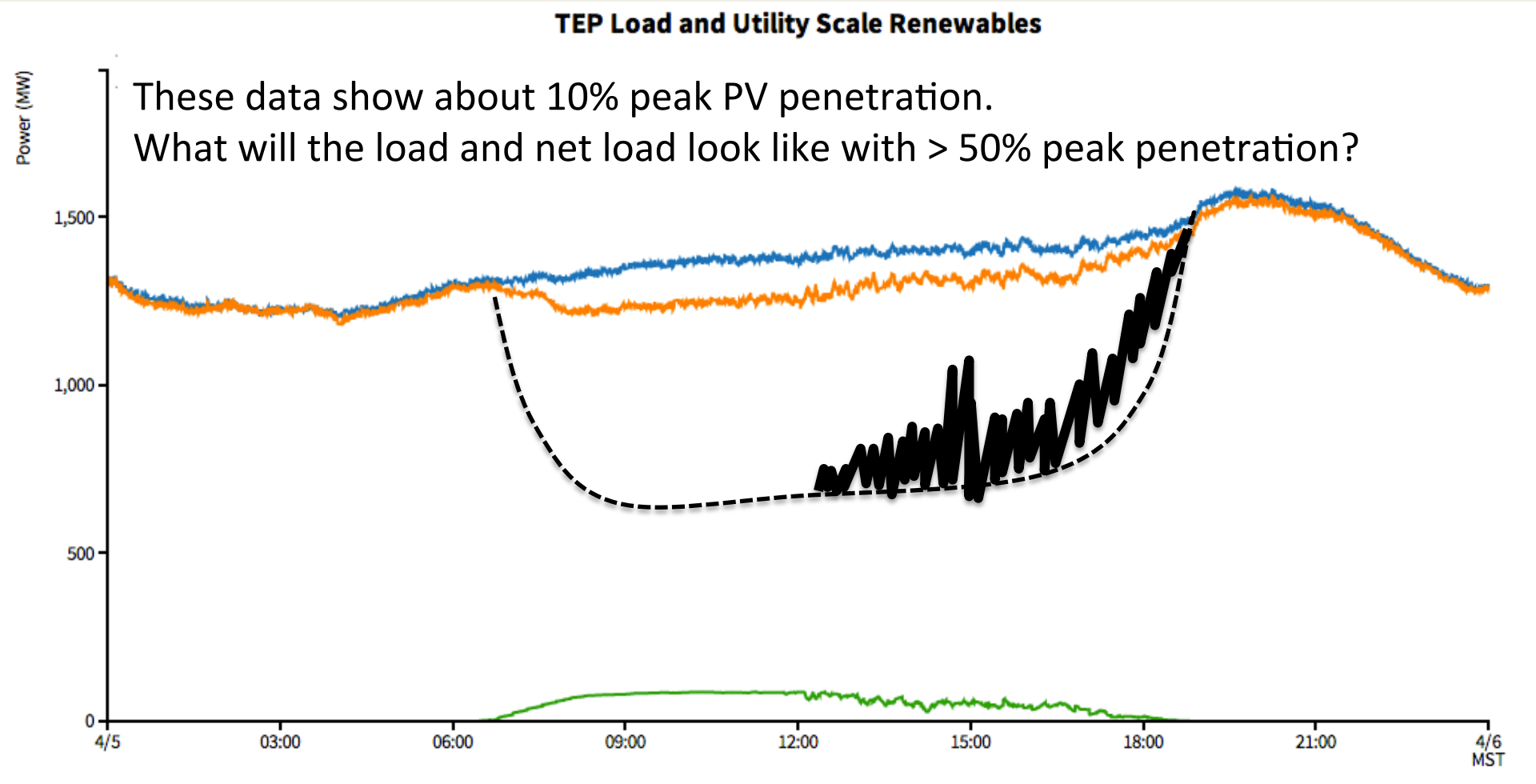


A Solution:
UA + TEP developing renewables forecasts

How can forecasts help utilities keep energy costs low and maintain grid reliability?

- Improve energy market trading strategies
- Schedule more efficient generators (e.g. combined cycle vs. combustion turbine)
- Reduce costs associated with generator starts
- Defer maintenance associated with excessive generator set point seeking
- Optimize the use of battery storage

UA is providing TEP with forecasts as we speak!

Different forecasting methods work better at different time scales.

Sensor Network

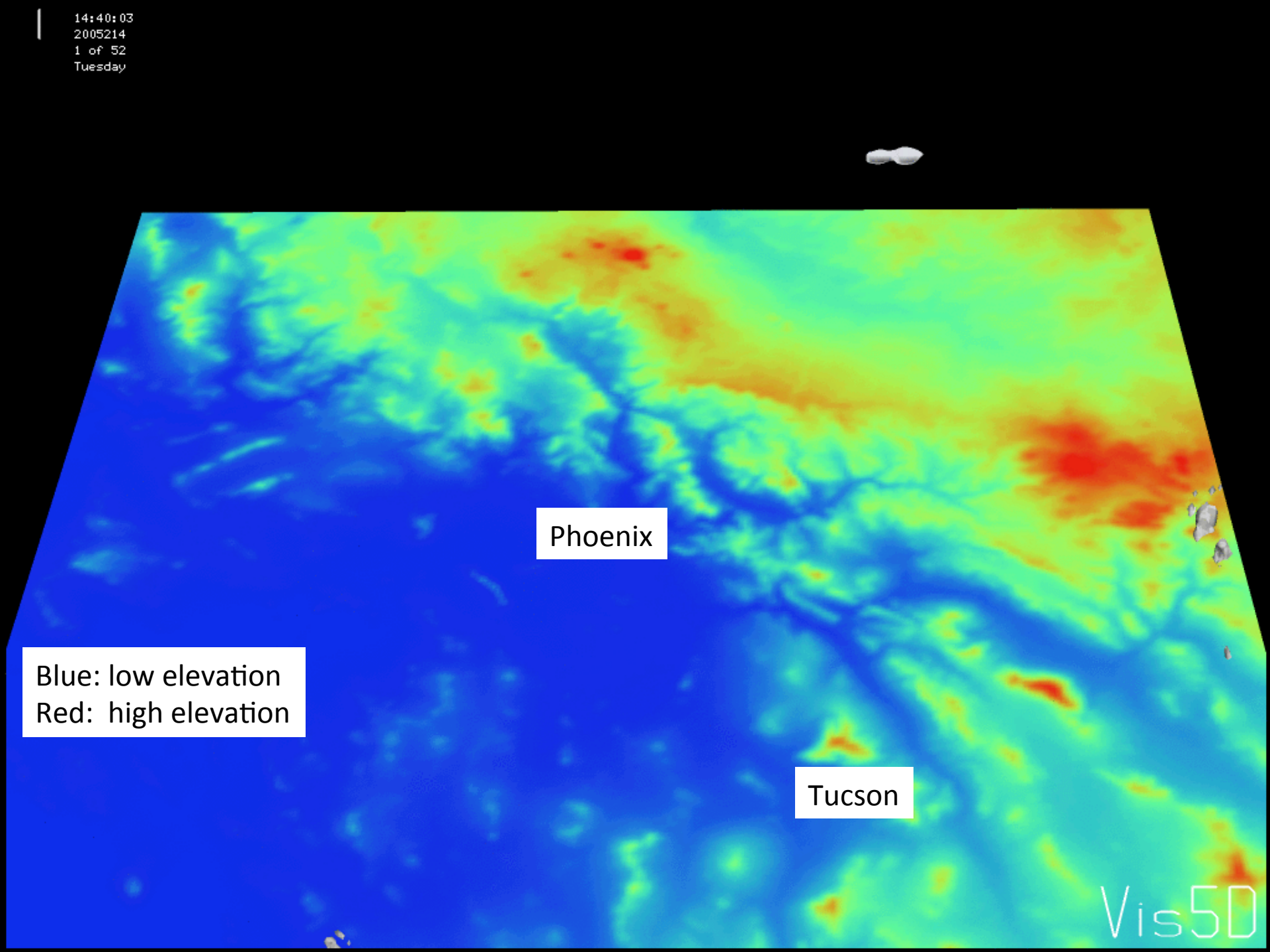
Satellite Imagery

Numerical Weather Models

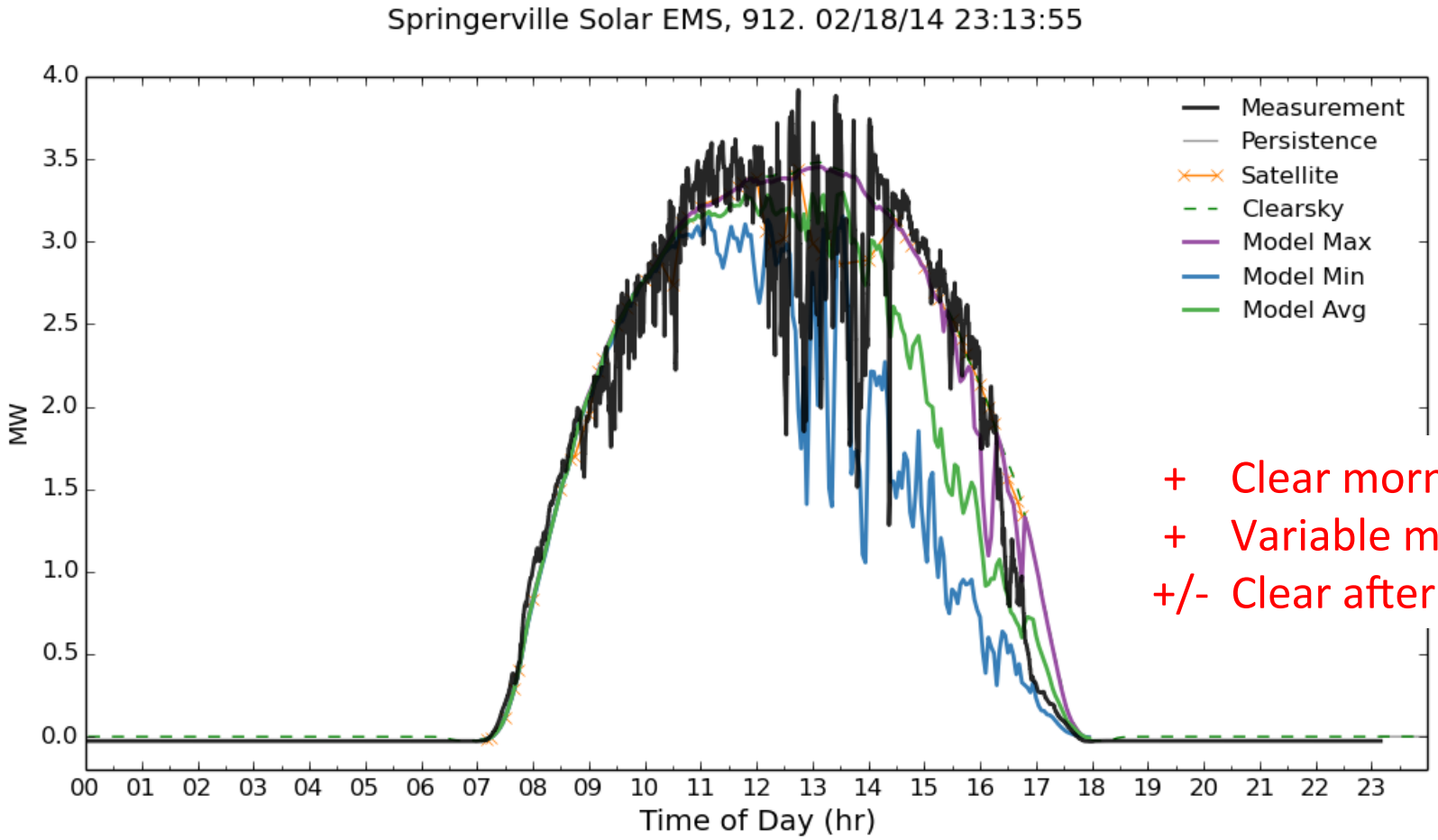
Climate Models

Numerical Weather Prediction at UA

- Local/regional knowledge of weather is extremely important
- State of the art model modified to better represent the unique characteristics of southwestern U.S. weather
  - Mountains + moisture + heating = monsoon storms
  - Unreliable initialization data from Mexico
  - Extreme planetary boundary layer heights
  - Rapidly changing land/surface characteristics
- Five model runs per day, out to 72 hours in advance
- 1.8 km resolution, 3 minute outputs of:
  - GHI, DNI, 10 m wind, 80 m wind, temp


14:40:03
2005214
1 of 52
Tuesday
Phoenix
Blue: low elevation
Red: high elevation
Tucson
Vis5D

Solar forecasting with Weather Models

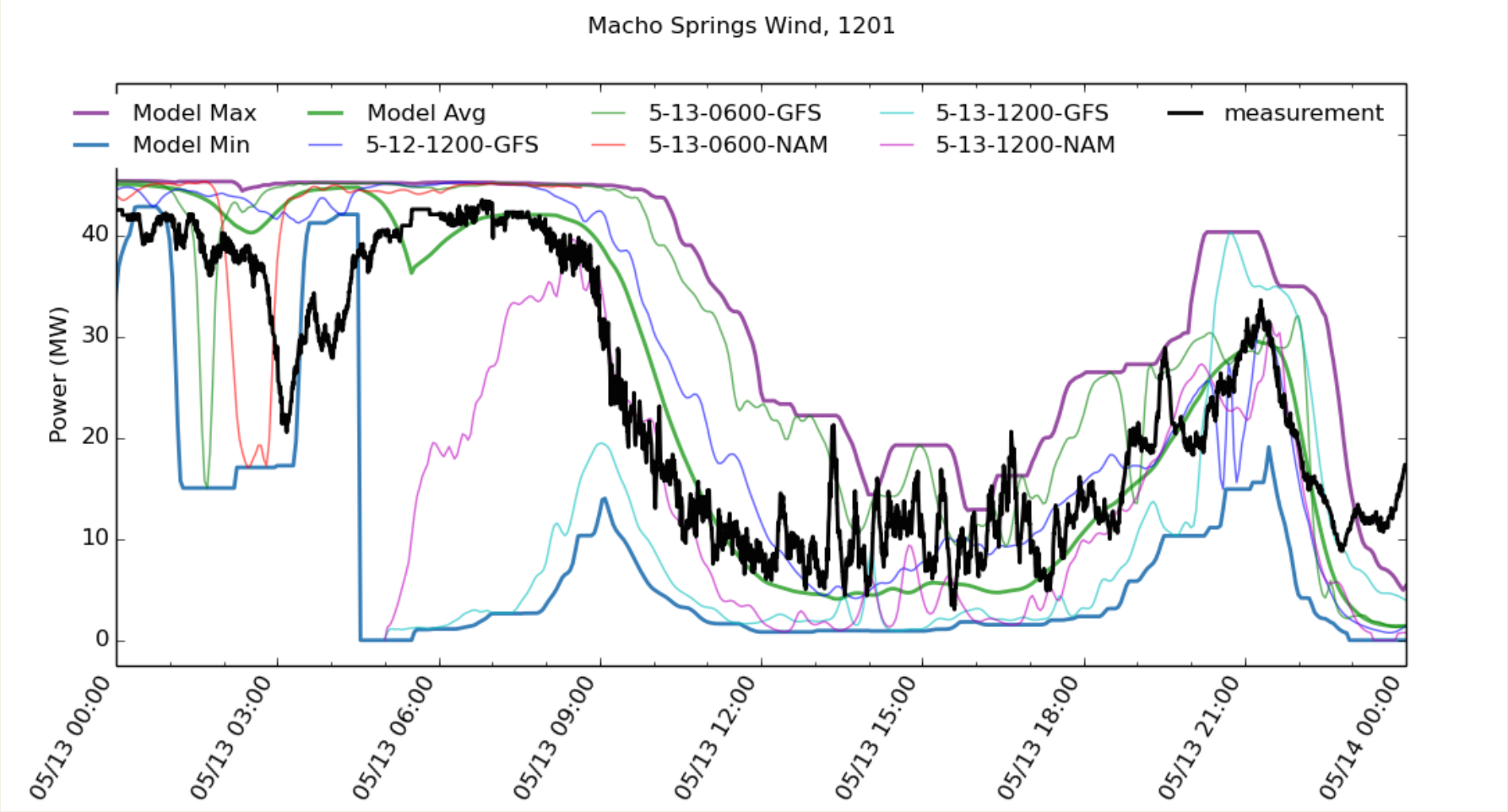


\+ Clear morning

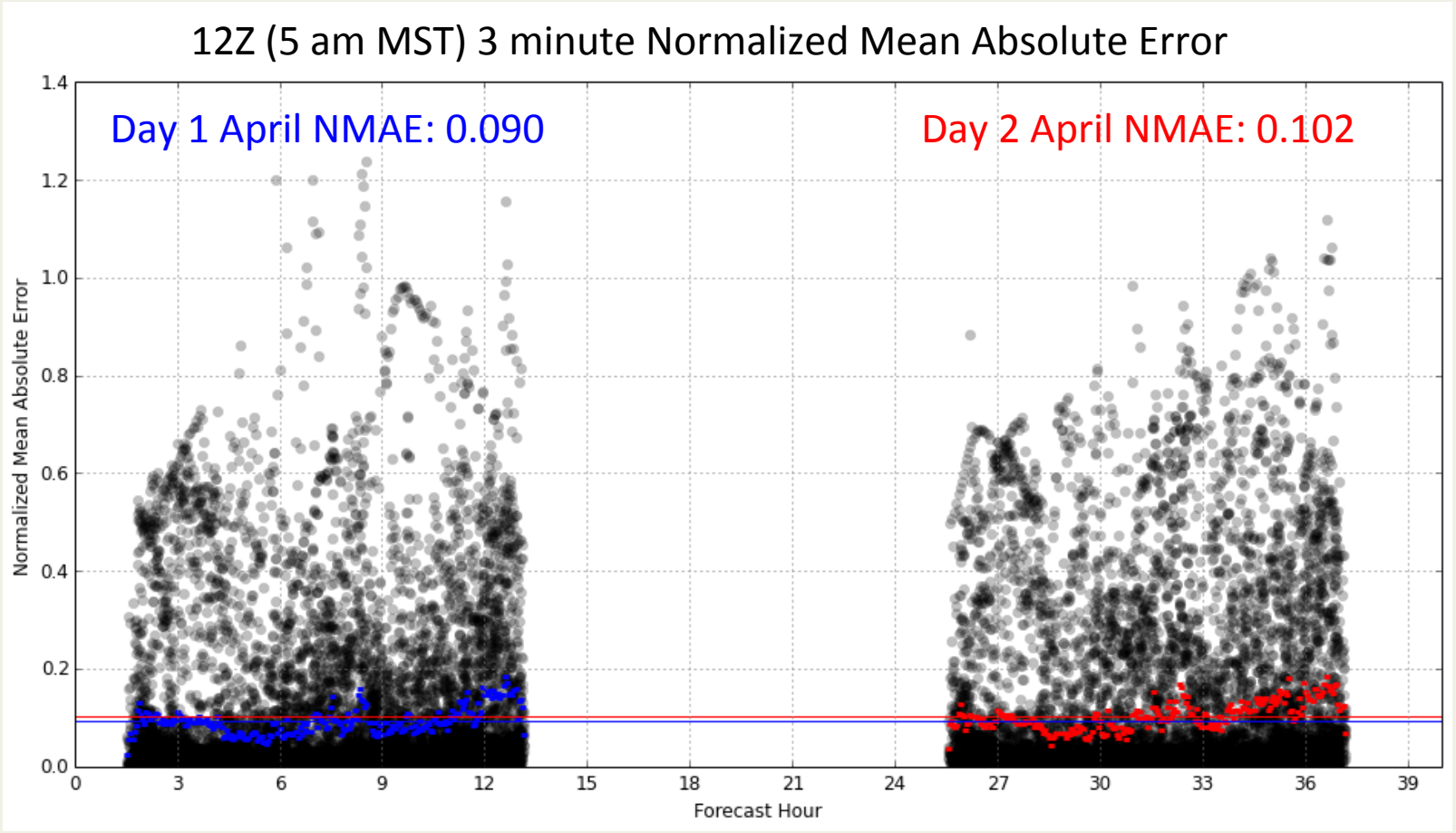
\+ Variable mid-day

+/- Clear afternoon

Wind forecasting with Weather Models



Weather model error stats



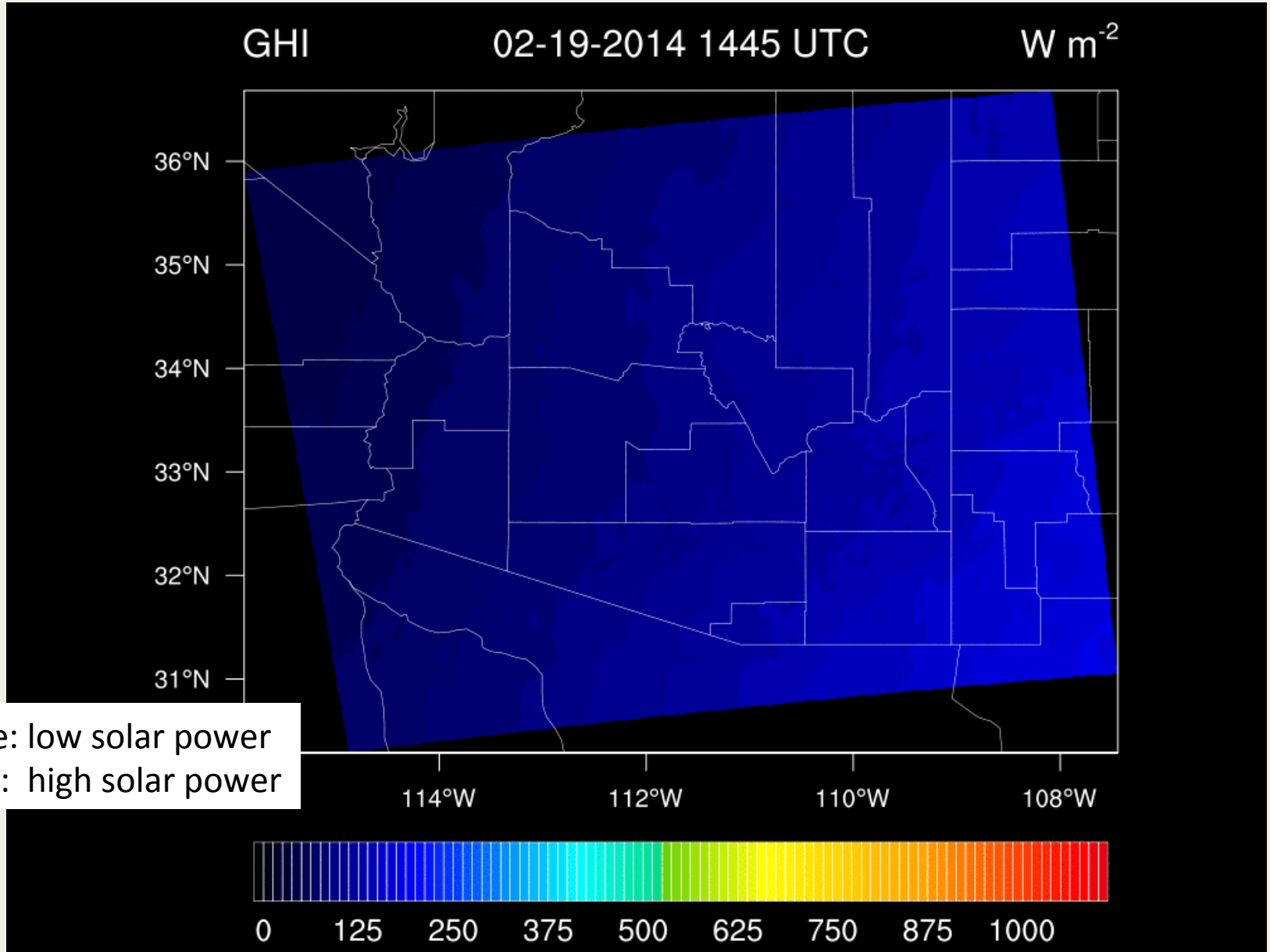
NMAE

Forecast time

Clear sky NMAE: 0.125

See paper for statistics by weather model type and time

Satellite Derived Solar Irradiance

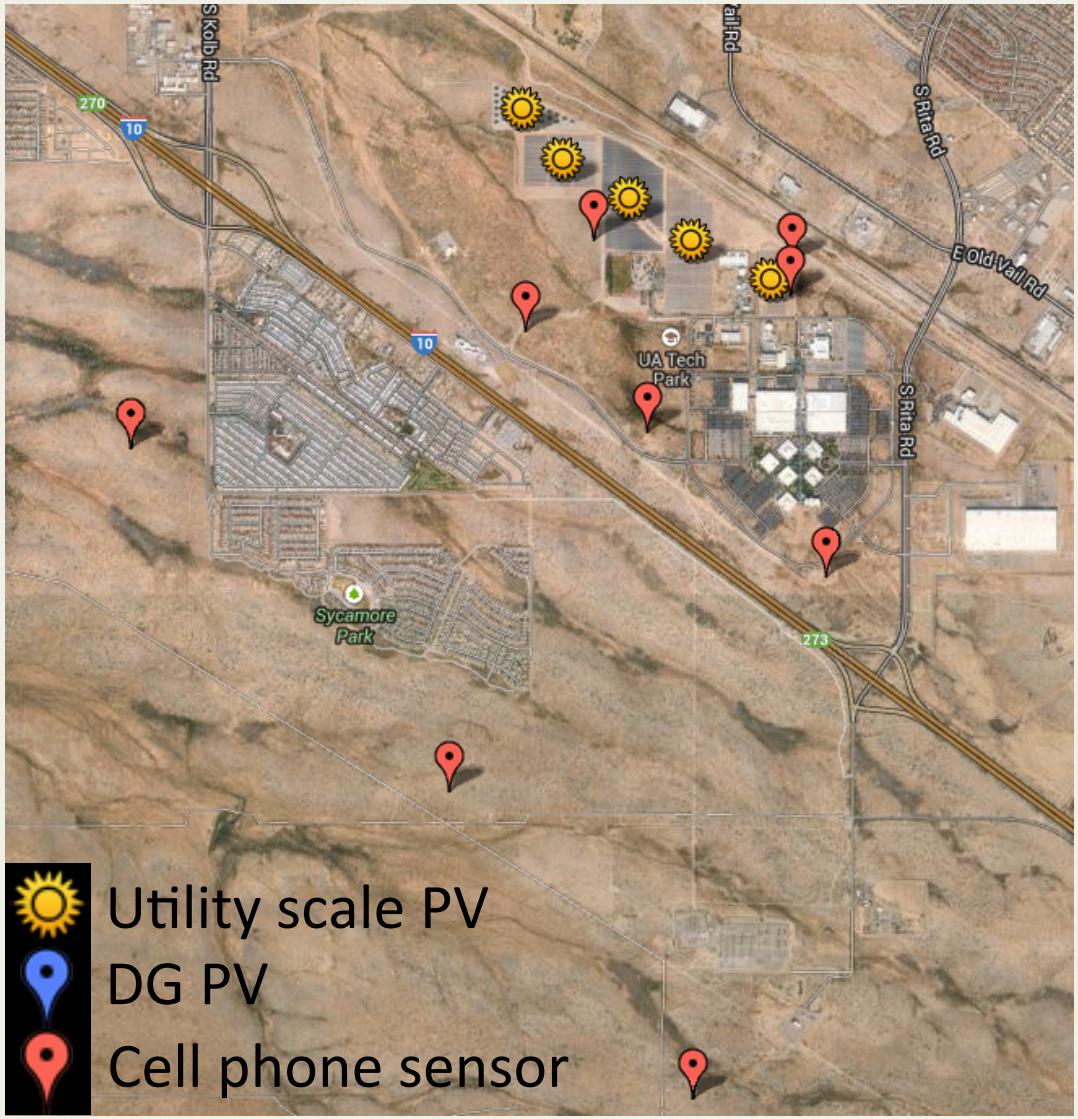


Blue: low solar power
Red: high solar power

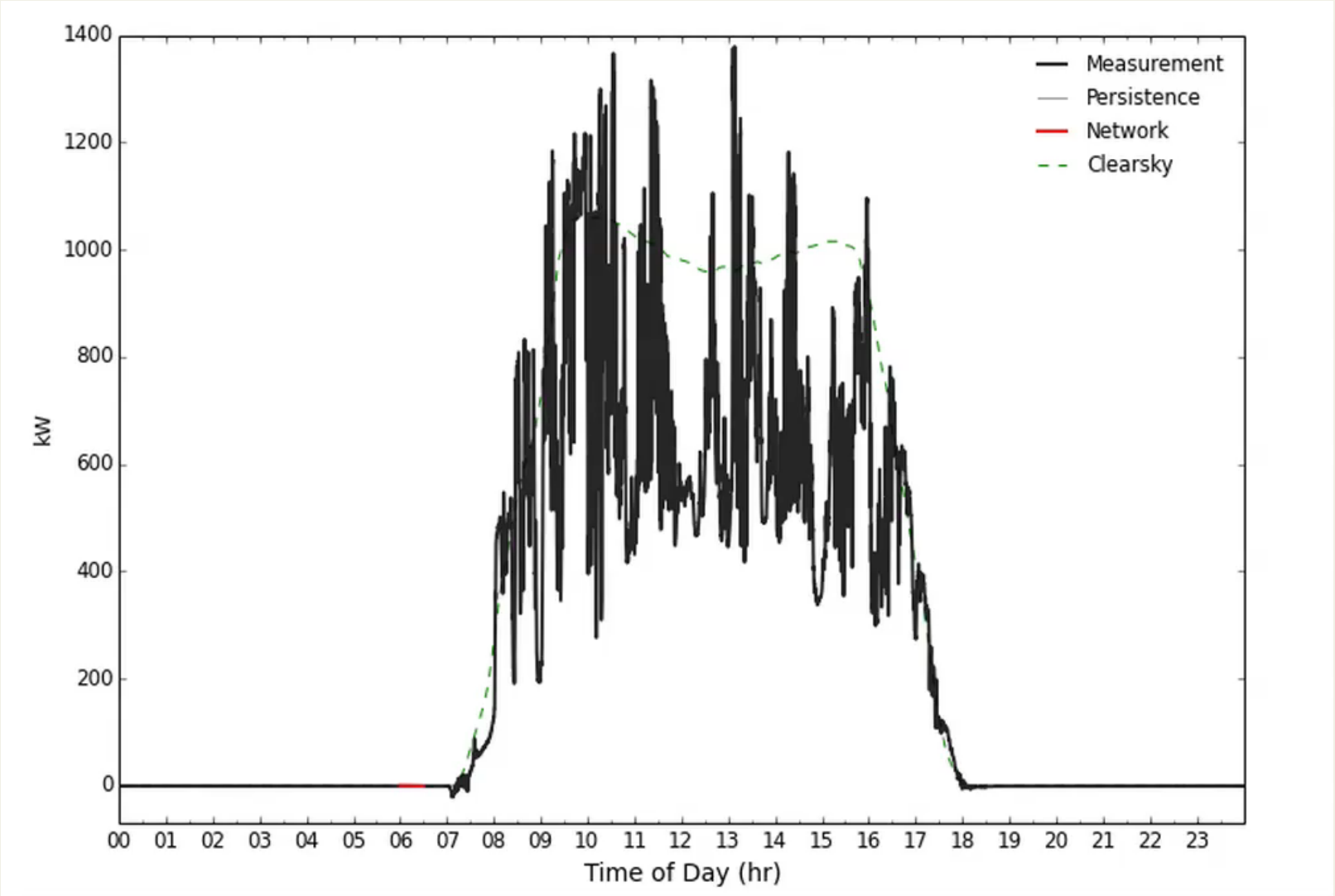
PV Cloud Detection Network

UA Science and Technology Park
20 MW of Solar PV

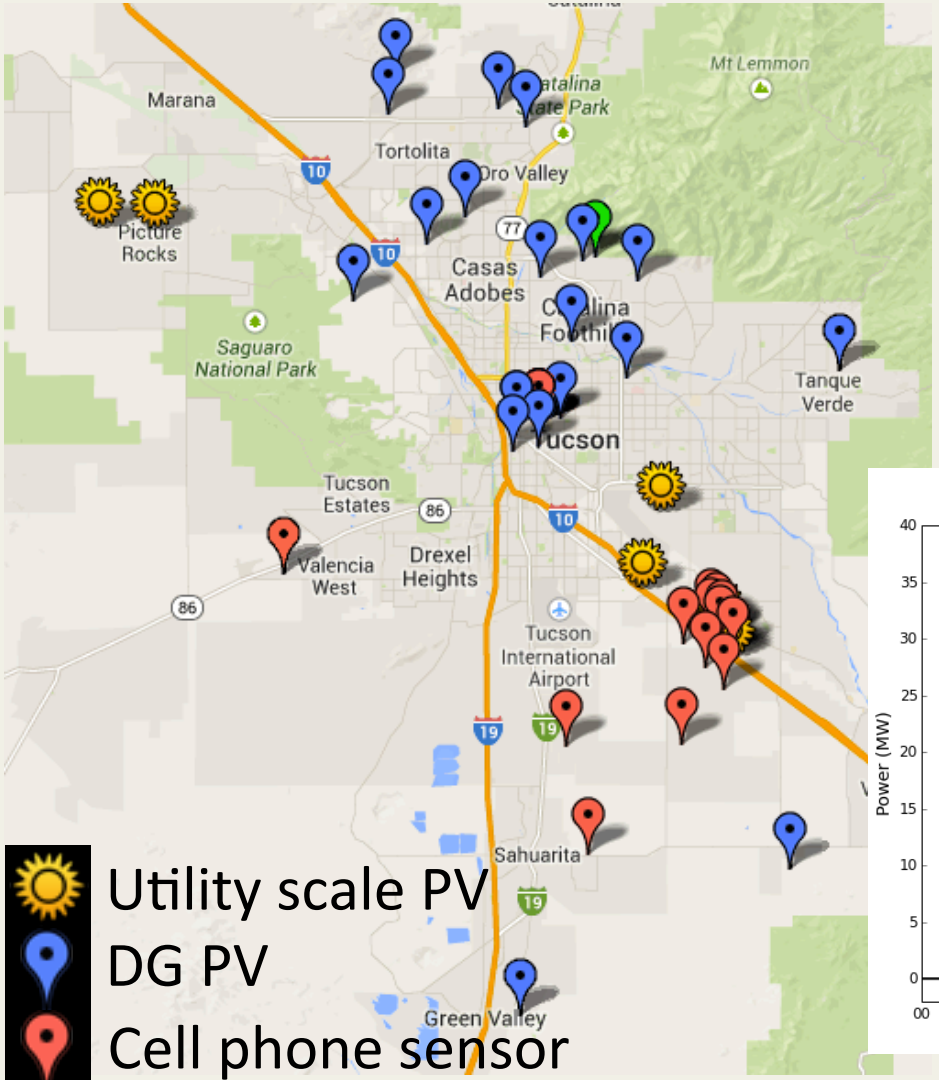
Network of irradiance sensors provides 30 minute ahead warnings of clouds



Network Forecast



Behind the Meter Visibility and Forecasting

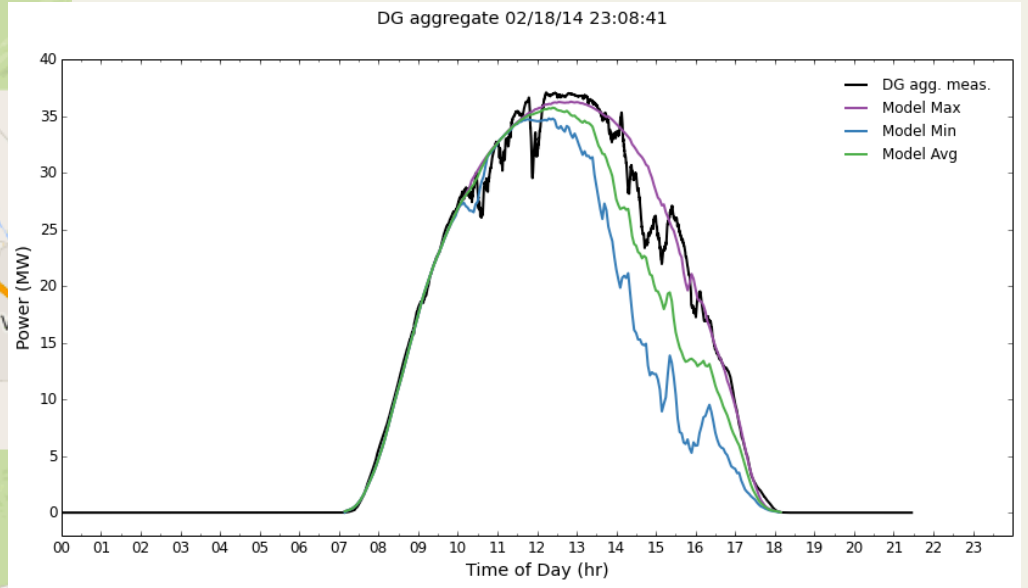


Utility scale PV

DG PV

Cell phone sensor

Partnered with Technicians for Sustainability to obtain access to real-time data feeds of residential PV systems



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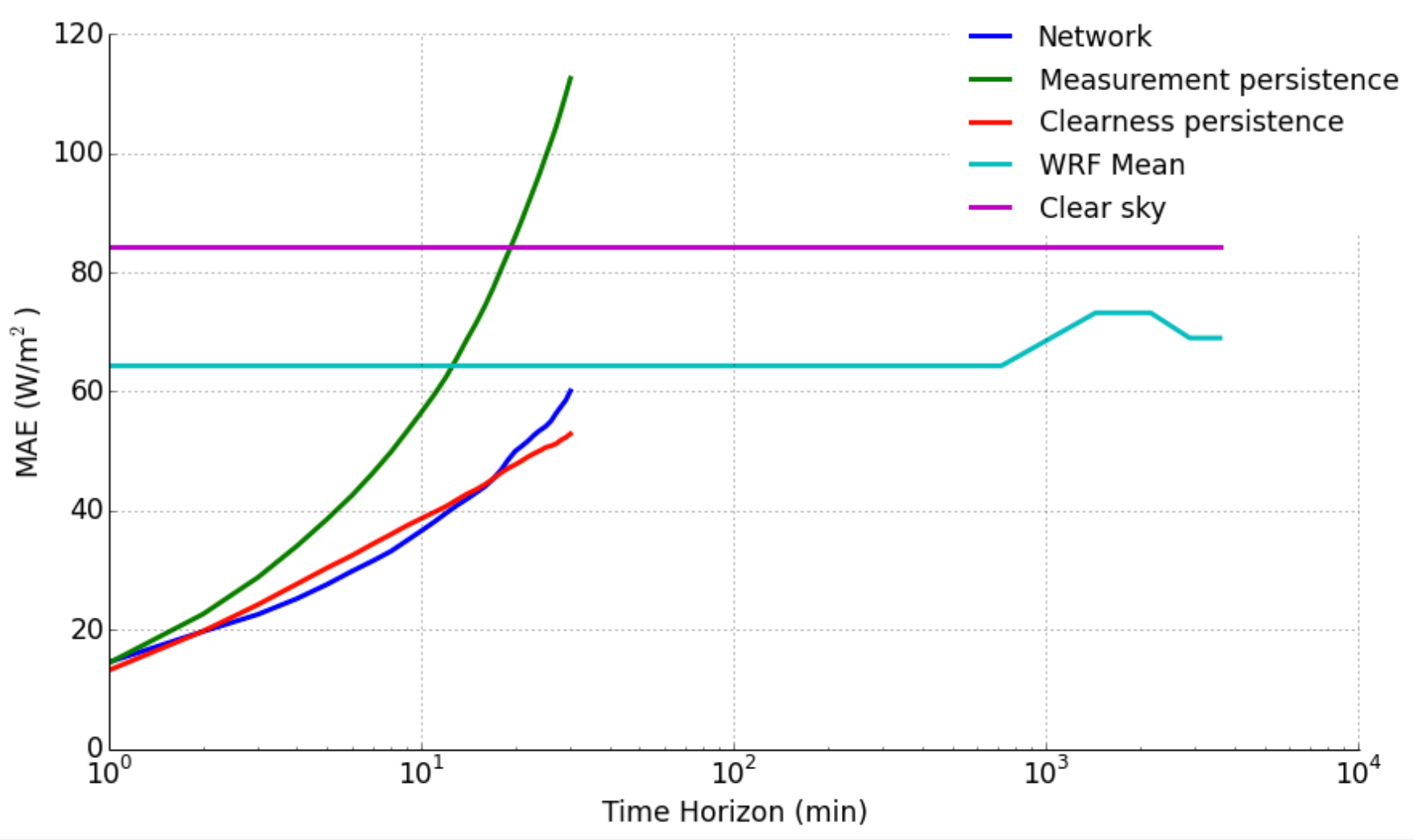
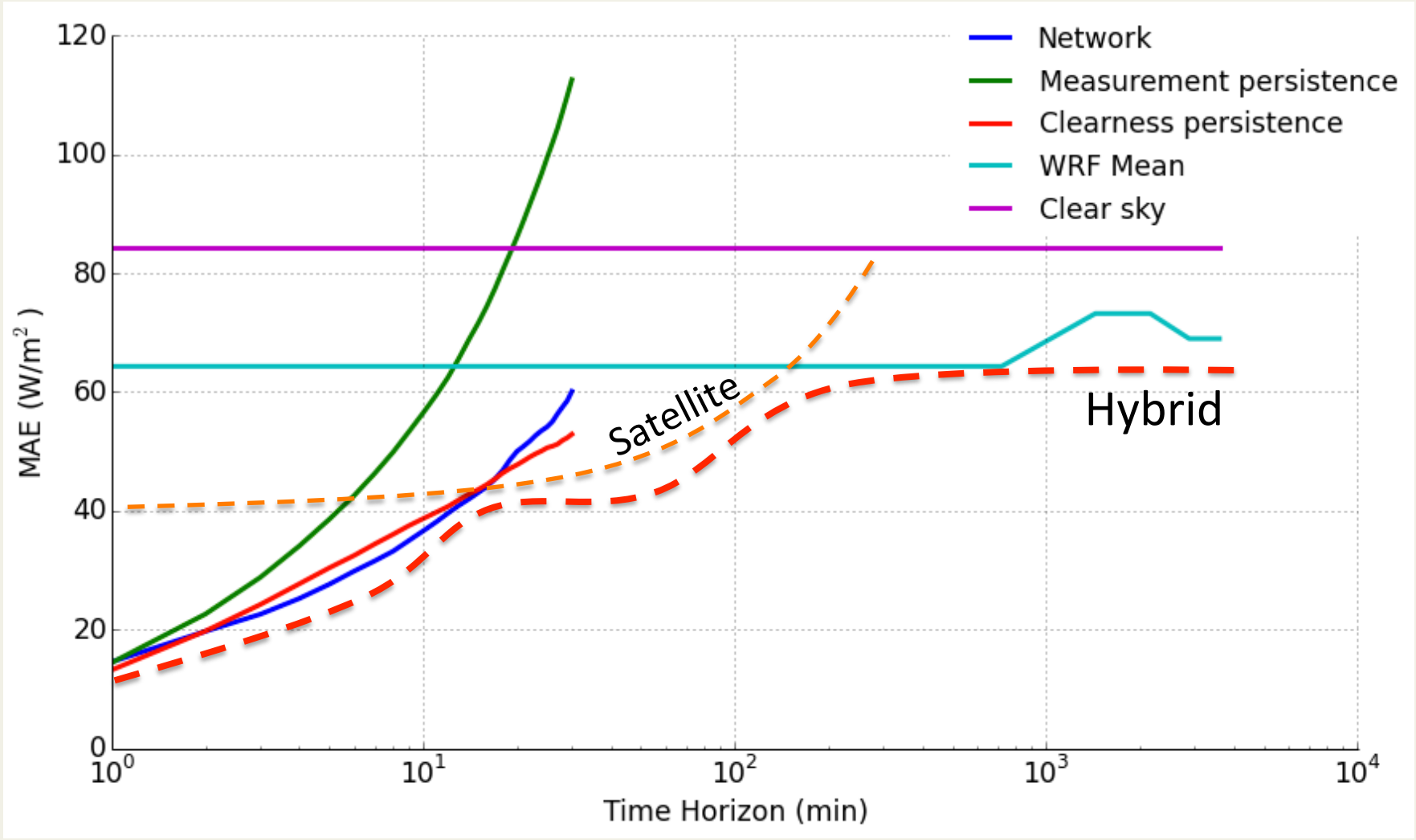


Next steps: Satellite, Hybrid



Forecasting Website for TEP

THE UNIVERSITY OF ARIZONA®

Forecasts for TEP EMS sites, irradiance sensors, and rooftop PV

Home page

About

Feedback

Maps

Full dataset
Tucson
Tucson animated
UA-STP
google map

Aggregate plots

EMS Aggregate
EMS Solar Aggregate
EMS Wind Aggregate
DG Aggregate
Total Aggregate

TEP EMS data

csv files

Irradiance sensors

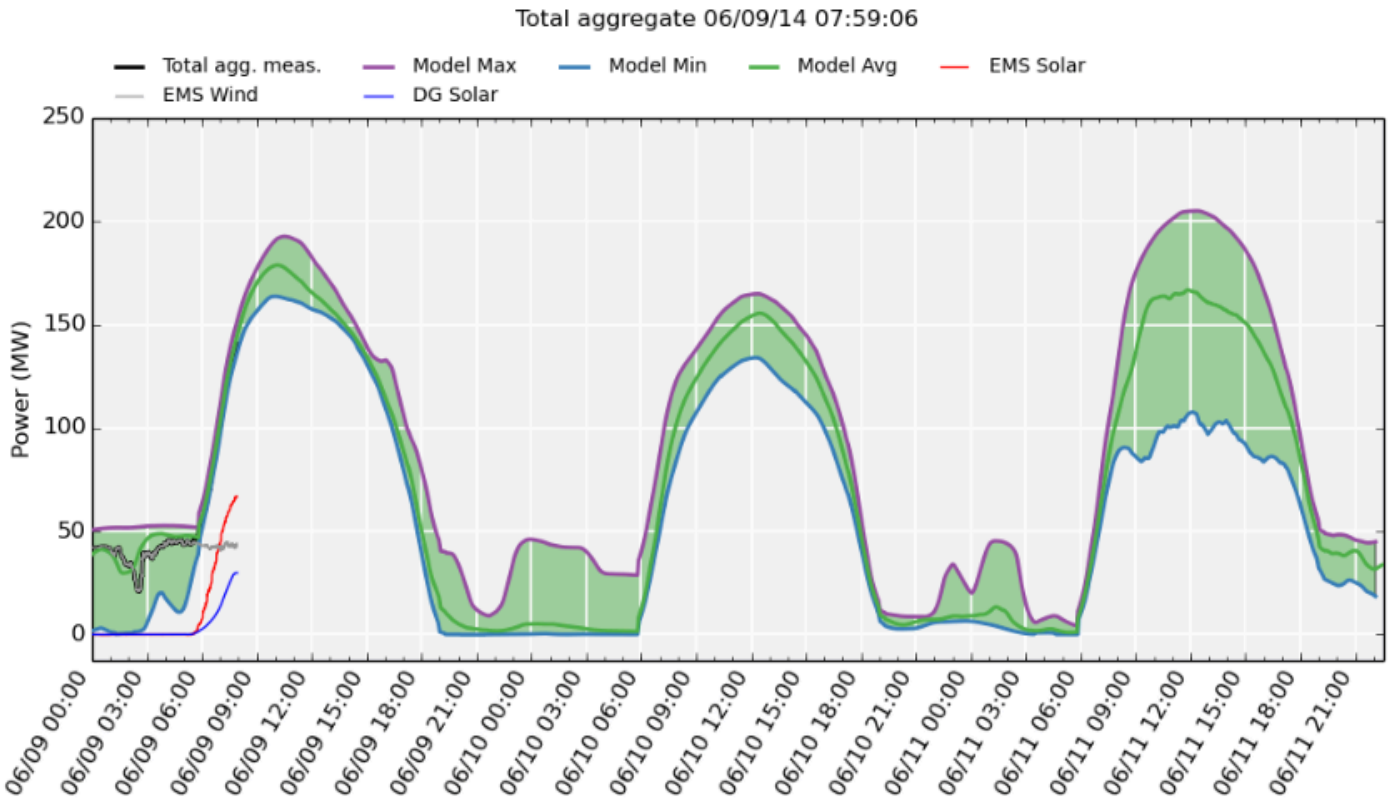
kW rooftop PV

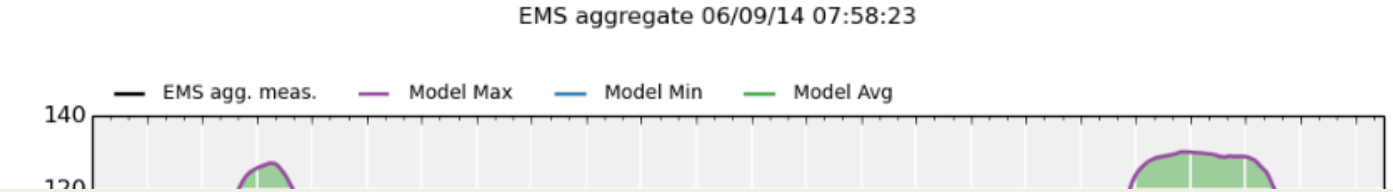
Environmental data

Other resources

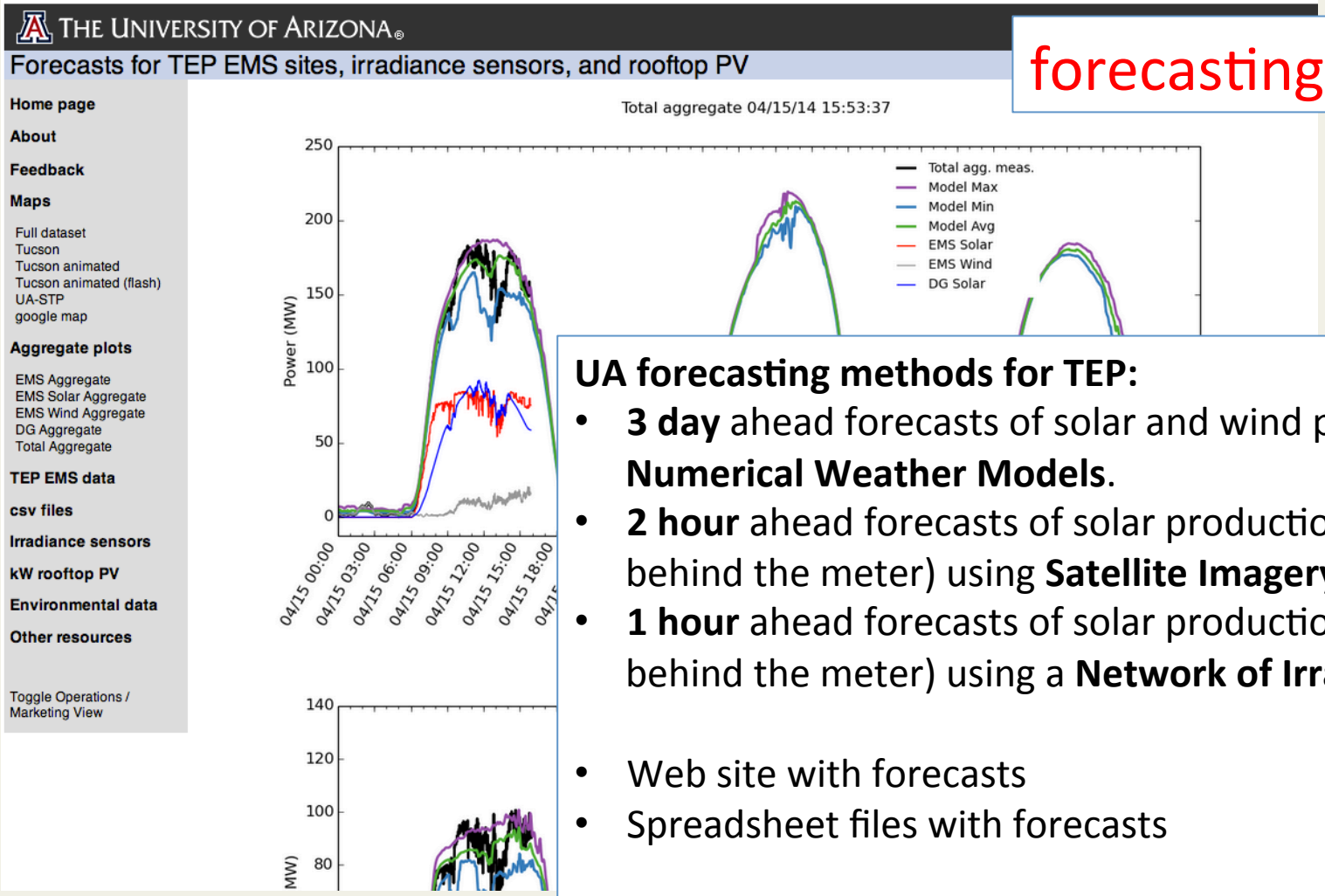
Toggle Operations / Marketing View

Current view: marketing





UA + TEP developing renewables forecasts



forecasting.uaren.org

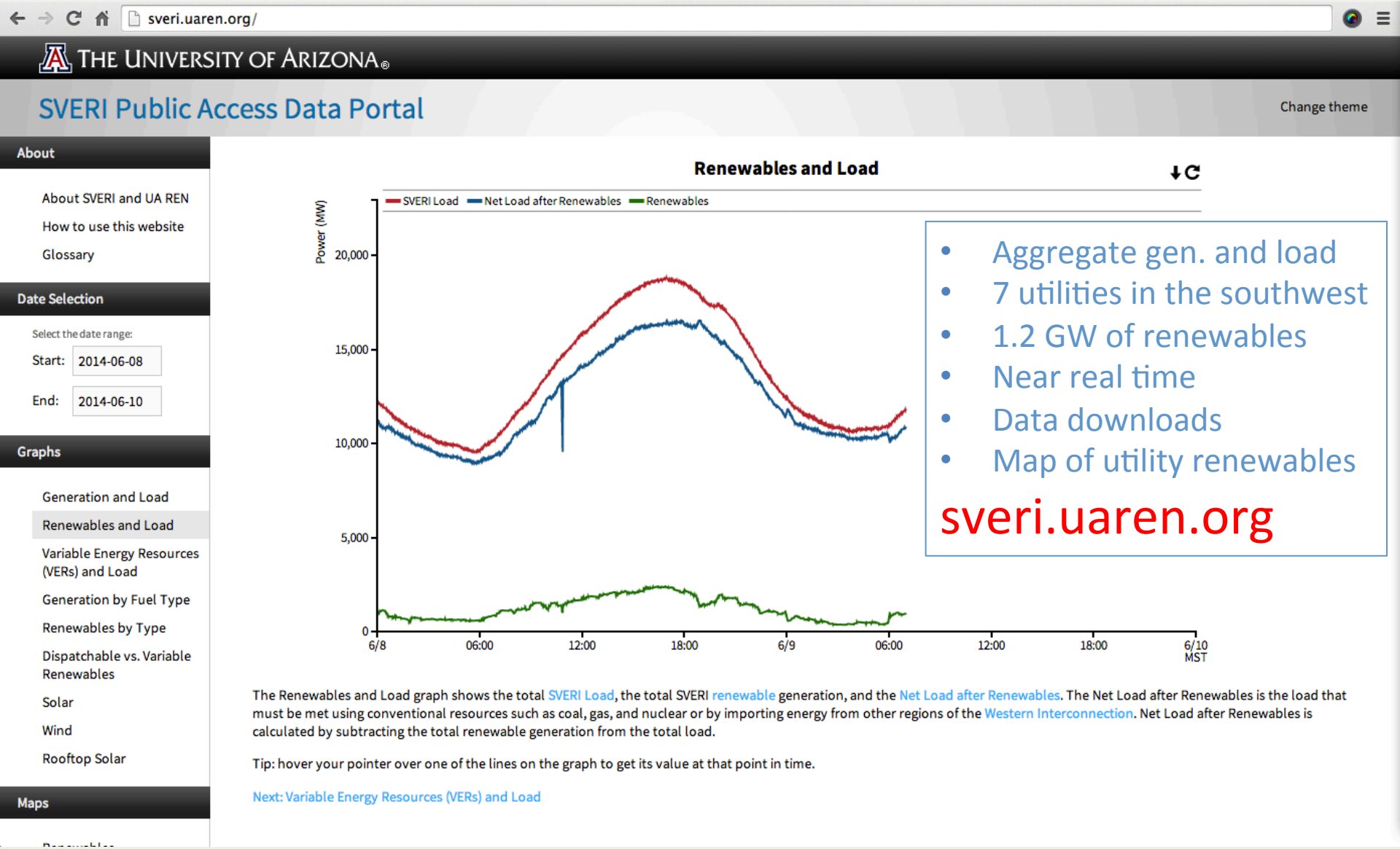
UA forecasting methods for TEP:

- **3 day** ahead forecasts of solar and wind production using **Numerical Weather Models**.
- **2 hour** ahead forecasts of solar production (utility and behind the meter) using **Satellite Imagery** (preliminary).
- **1 hour** ahead forecasts of solar production (utility and behind the meter) using a **Network of Irradiance Sensors**.

- Web site with forecasts
- Spreadsheet files with forecasts

Working with SVERI utilities APS, SRP, PNM, IID, EPE, IPC to explore forecasting in their service territories

SVERI Website



- Aggregate gen. and load
- 7 utilities in the southwest
- 1.2 GW of renewables
- Near real time
- Data downloads
- Map of utility renewables

sveri.uaren.org