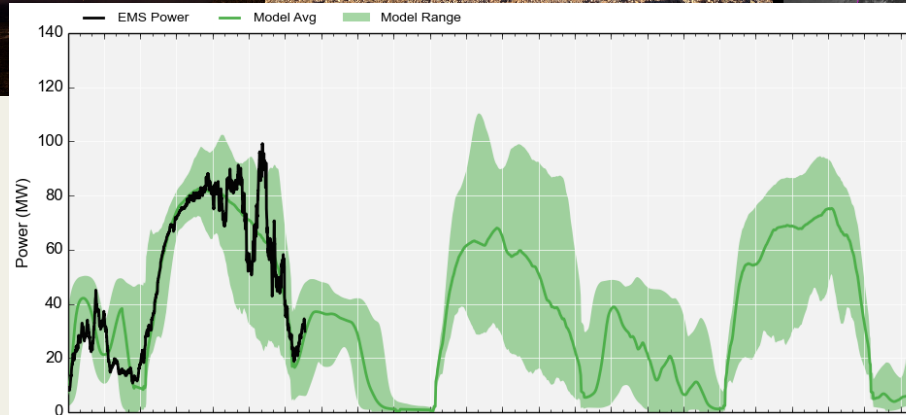
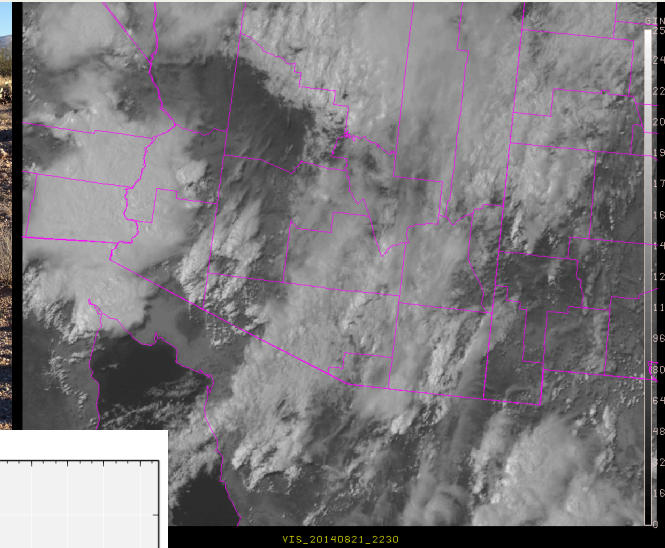


U. Arizona Renewable Power Forecasting



Charles Miles, Creative Commons



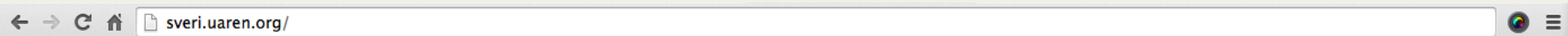
Will Holmgren

DOE EERE Postdoctoral Fellow
UA Department of Atmospheric
Sciences

Alex Cronin, Associate Professor, Physics
Antonio Lorenzo, Grad Student, Opt. Sci.
Eric Betterton, Dept. Head, Atmo. Sci.
Mike Leuthold, Meteorologist, Atmo. Sci.
Chang Ki Kim, Post doc, Atmo. Sci.
Ardeth Barnhart, Director, UA-REN
Rey Granillo, Developer, UA-REN



sveri.uaren.org



About

- About SVERI and UA REN
- How to use this website
- Glossary

Date Selection

Select the date range:

Start: 2014-06-08

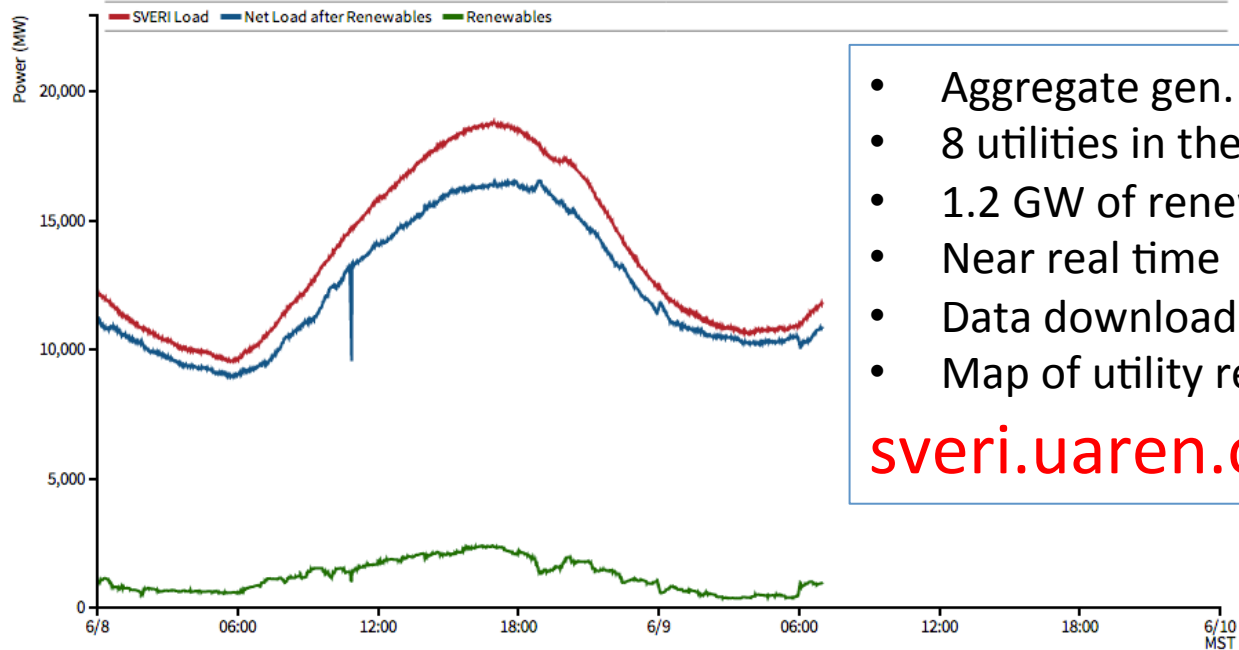
End: 2014-06-10

Graphs

- Generation and Load
- Renewables and Load
- Variable Energy Resources (VERs) and Load
- Generation by Fuel Type
- Renewables by Type
- Dispatchable vs. Variable Renewables
- Solar
- Wind
- Rooftop Solar

Maps

Renewables and Load



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

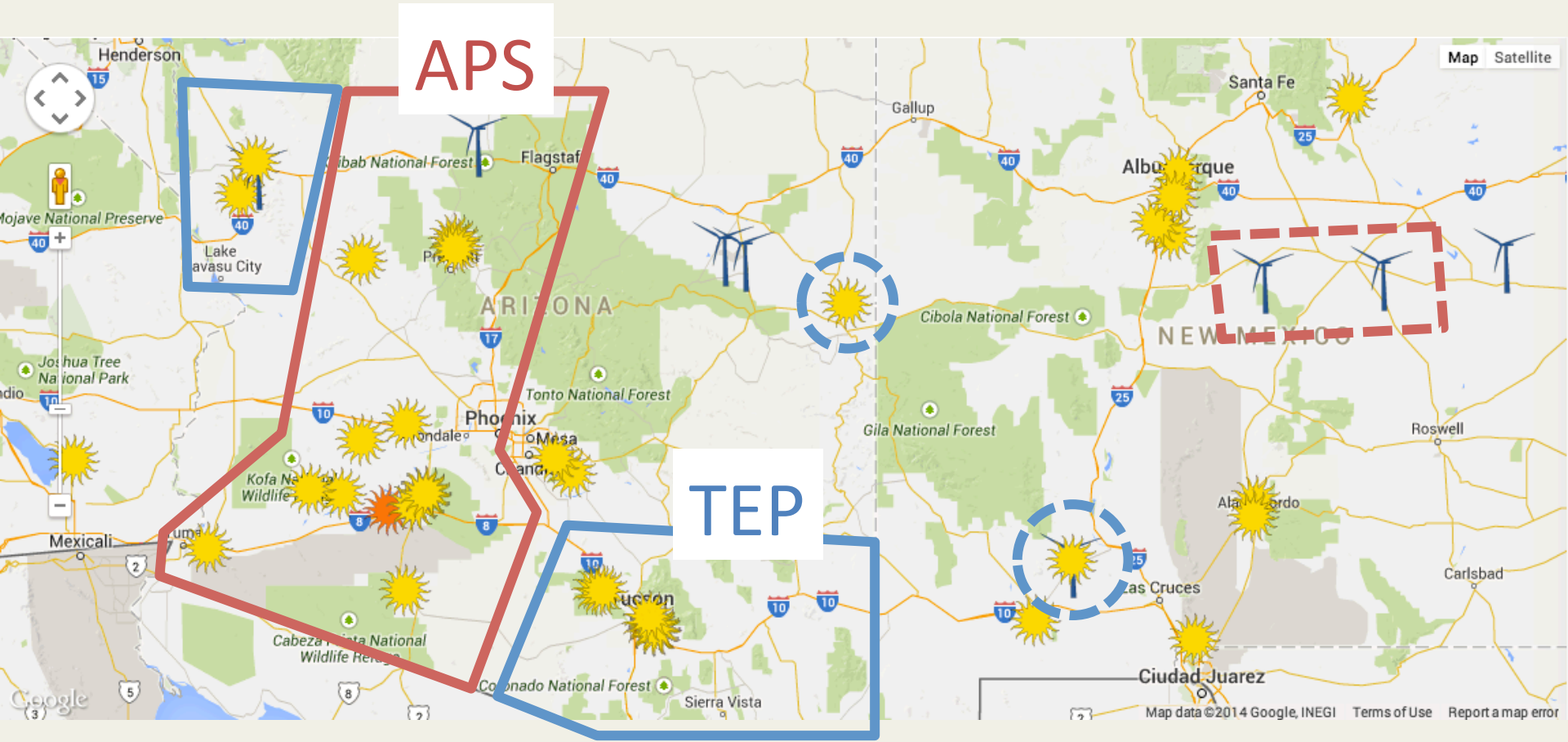
sveri.uaren.org

The Renewables and Load graph shows the total SVERI Load, the total SVERI renewable generation, and the Net Load after Renewables. The Net Load after Renewables is the load that must be met using conventional resources such as coal, gas, and nuclear or by importing energy from other regions of the Western Interconnection. Net Load after Renewables is calculated by subtracting the total renewable generation from the total load.

Tip: hover your pointer over one of the lines on the graph to get its value at that point in time.

Next: [Variable Energy Resources \(VERs\) and Load](#)

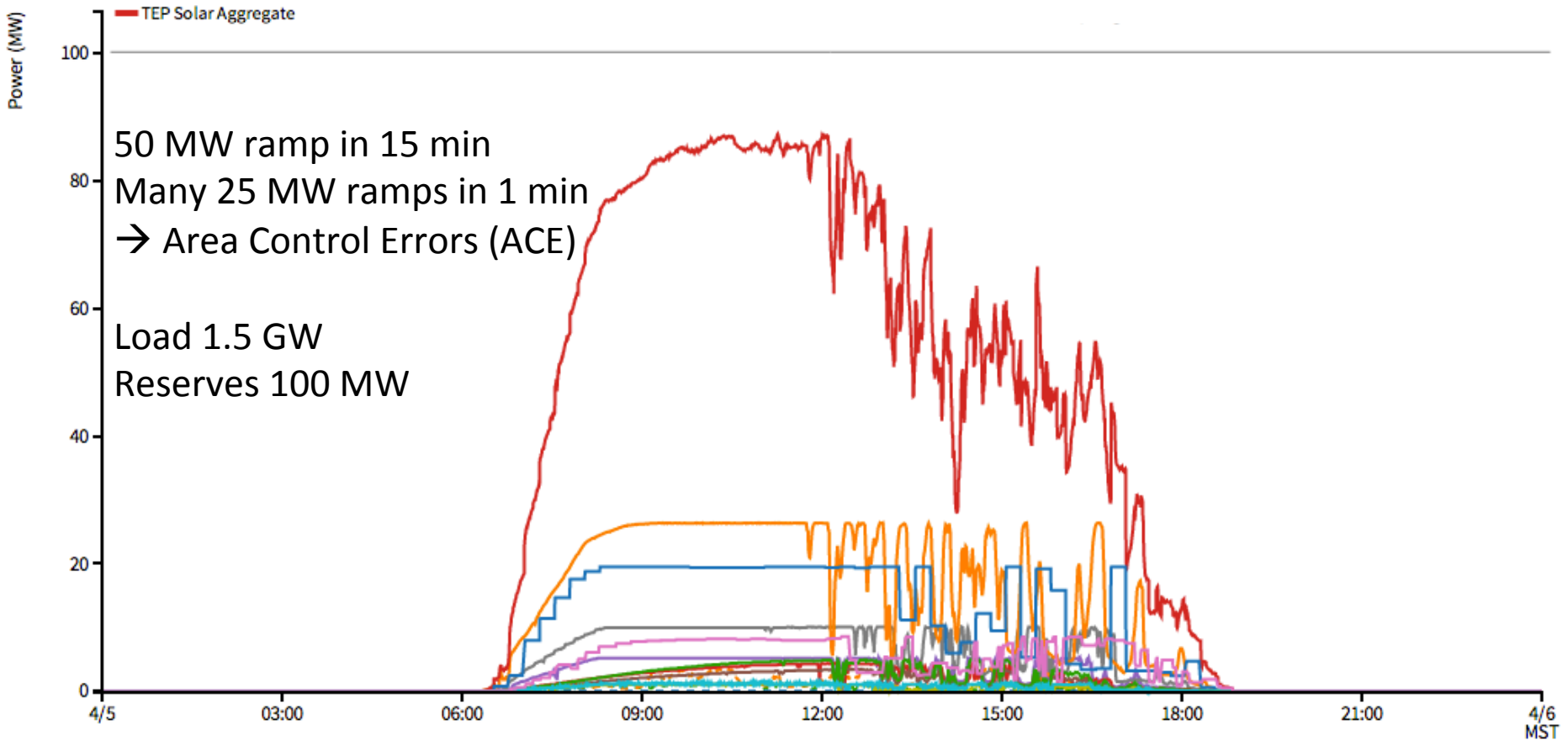
SVERI renewables



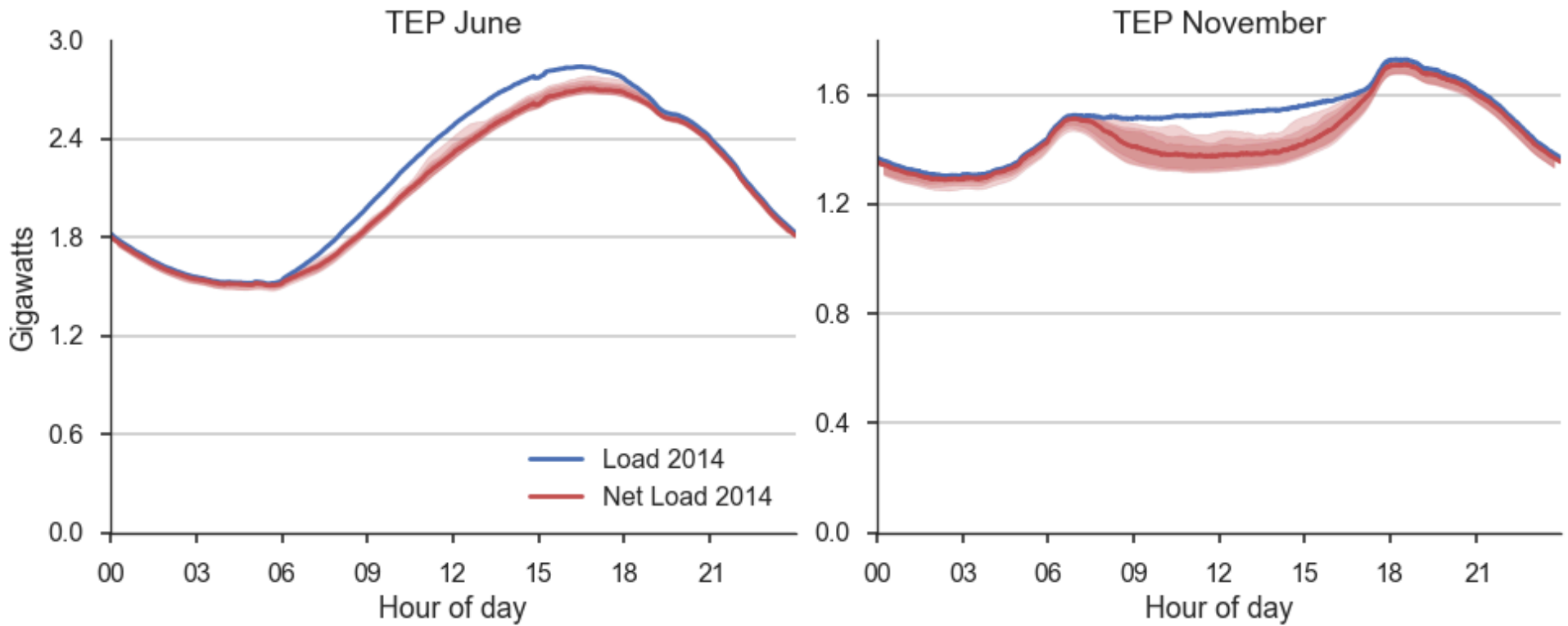
from sveri.uaren.org

TEP's Solar Power Variability

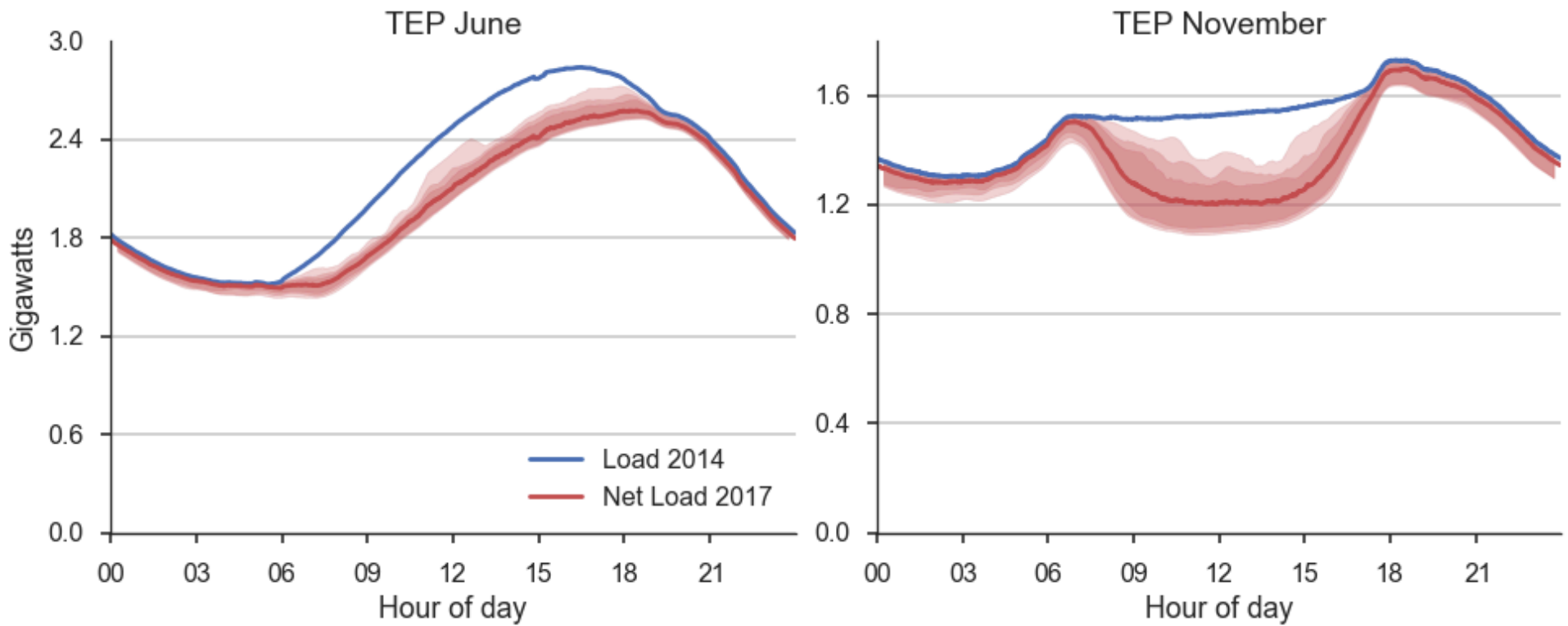
TEP Solar Power Generation



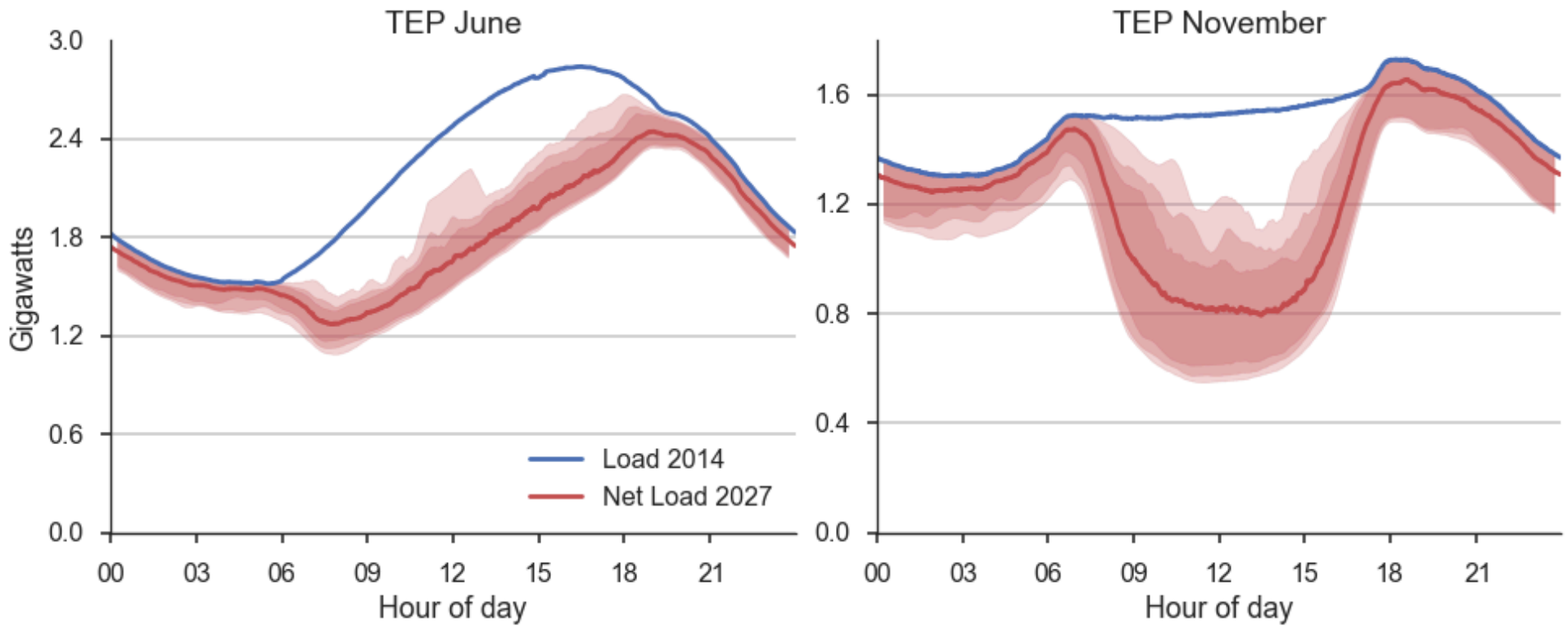
TEP 2014 Net Load Range



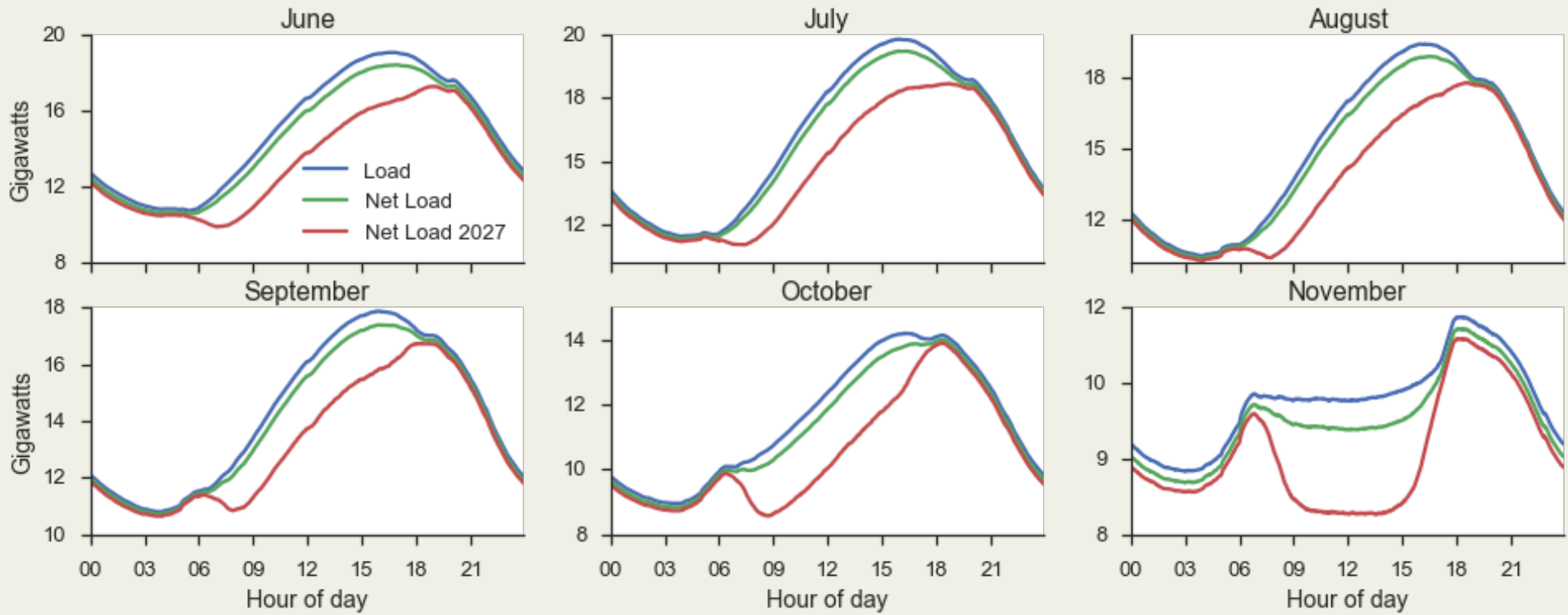
TEP 2017 Net Load Range



TEP 2027 Net Load Range



SVERI Net Load



SVERI solar variability

100% 95% 90%

June 2014

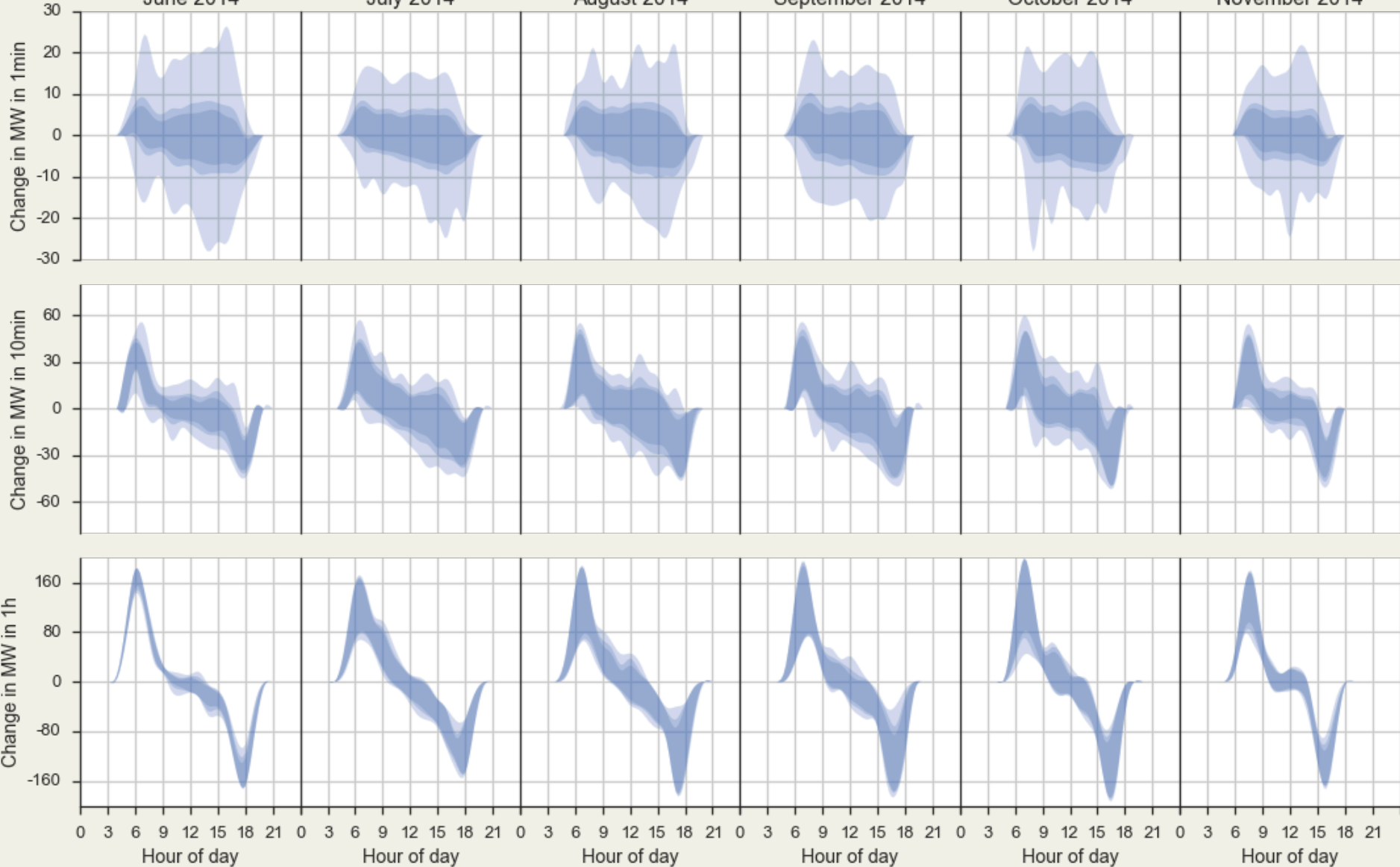
July 2014

August 2014

September 2014

October 2014

November 2014



SVERI wind variability

100% 95% 90%

June 2014

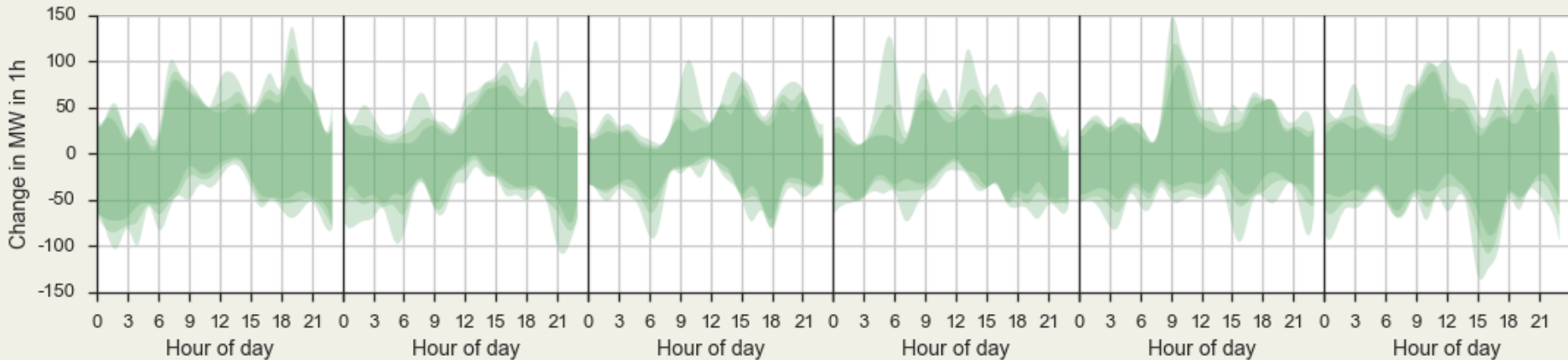
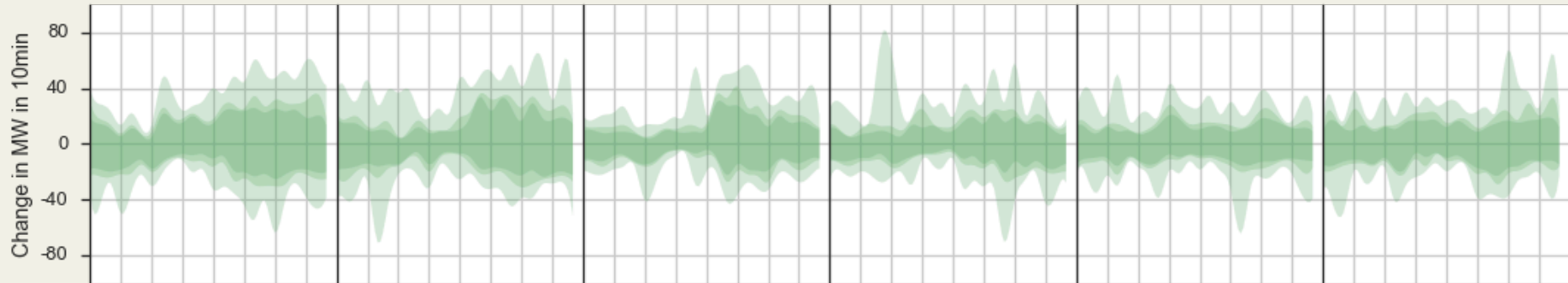
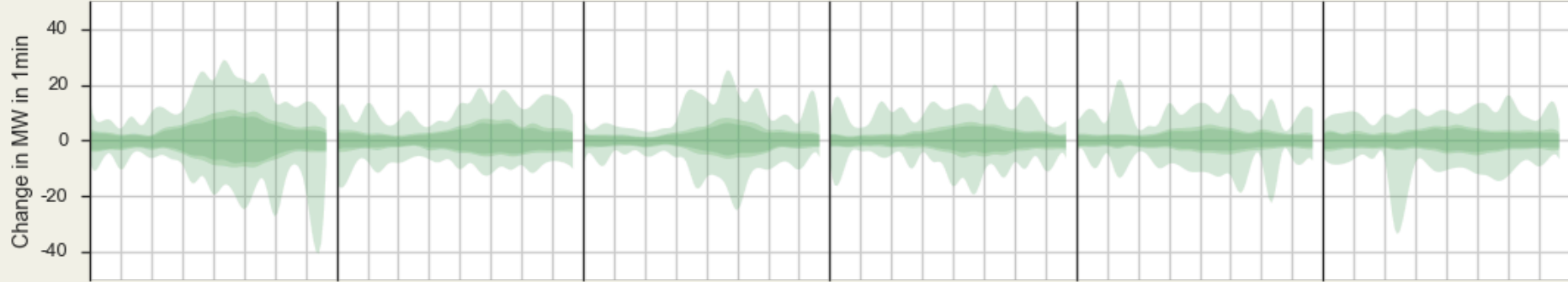
July 2014

August 2014

September 2014

October 2014

November 2014

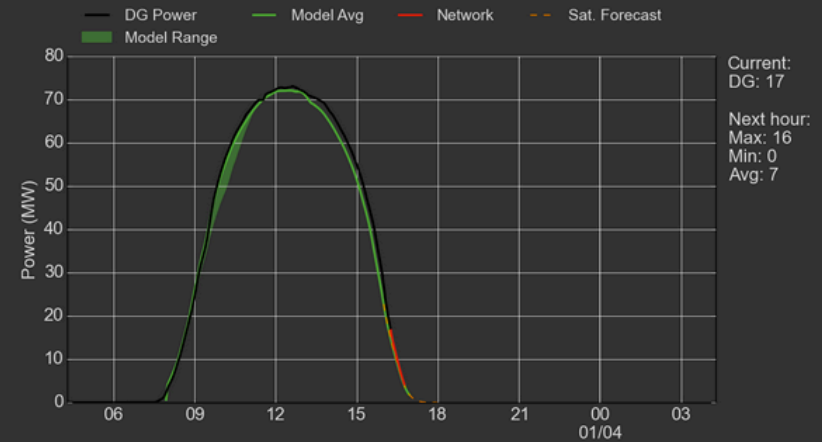


UA Forecasting Website for TEP + APS

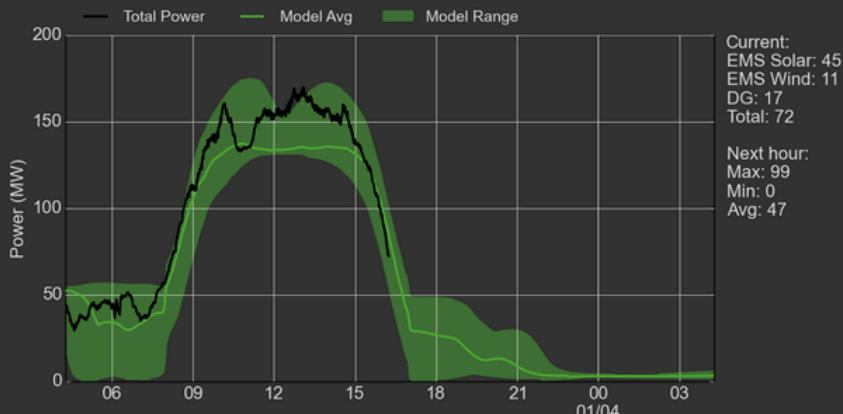
EMS aggregate 01/03/15 16:17:05



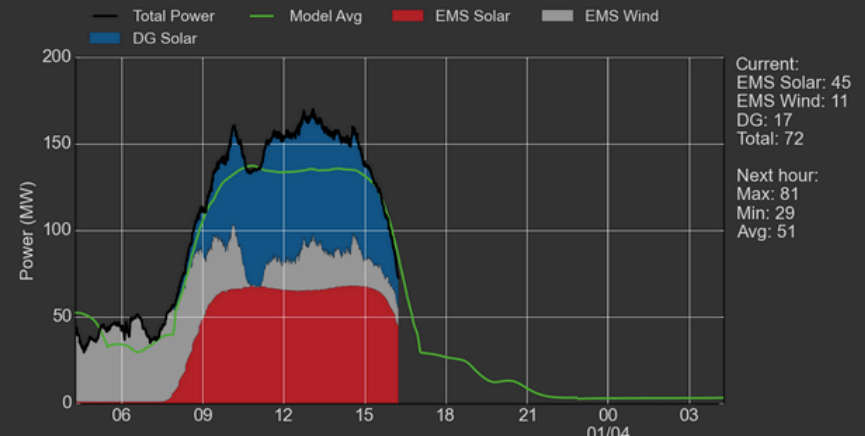
DG aggregate 01/03/15 16:17:10



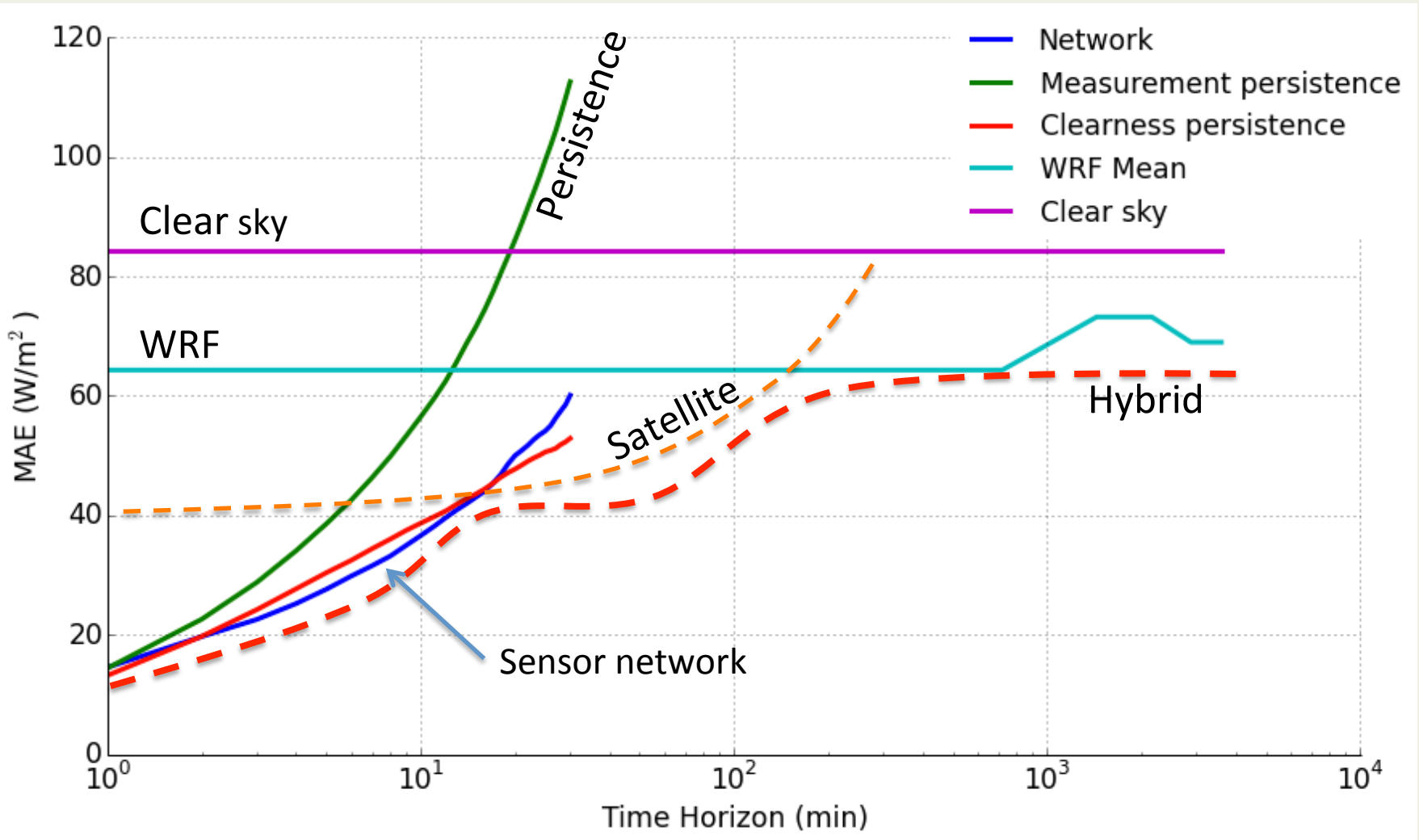
Total aggregate 01/03/15 16:17:15



Total aggregate 01/03/15 16:17:14



UA forecasting methods



Numerical Weather Prediction at UA



Christopher Marks, Creative Commons

- Model highlights
 - 5.4 km outer domain, 1.8 km inner domain
 - Initialized on the 6Z and 12Z GFS and NAM
 - Most days include 12 RAP initialization (esp. in summer)
- Local challenges include:
 - Mountains + moisture + heating = monsoon storms
 - Unreliable initialization data from Mexico
 - Extreme planetary boundary layer heights
 - Rapidly changing land/surface characteristics
- 1.8 km resolution, 3 minute outputs of:
 - GHI, DNI, 10 m wind, 80 m wind, temp

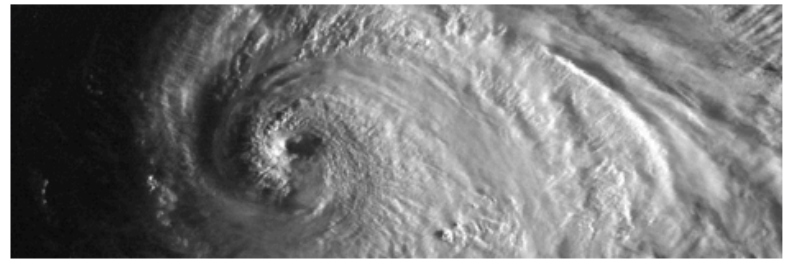
WRF configuration details:

- RRTMG
- Morrison 2 mom. or SBUYLIN
- Bougeault-Lacarre or ACM2
- Noah LSM



UA WRF forecasts available at
atmo.arizona.edu

Contact me for access to raw data



- HOME
- WEATHER
- PEOPLE
- RESEARCH
- STUDENTS
- COURSES
- NEWS & EVENTS
- RELATED SITES
- SUPPORT ATMO

Arizona Regional WRF Model Data

Model Derived Forecasts

[SE AZ Forecast](#) [Phx Area Forecast](#) [AM Optical Depth](#)

Model Discussion

During the monsoon season and for significant weather events, a model discussion may be available.

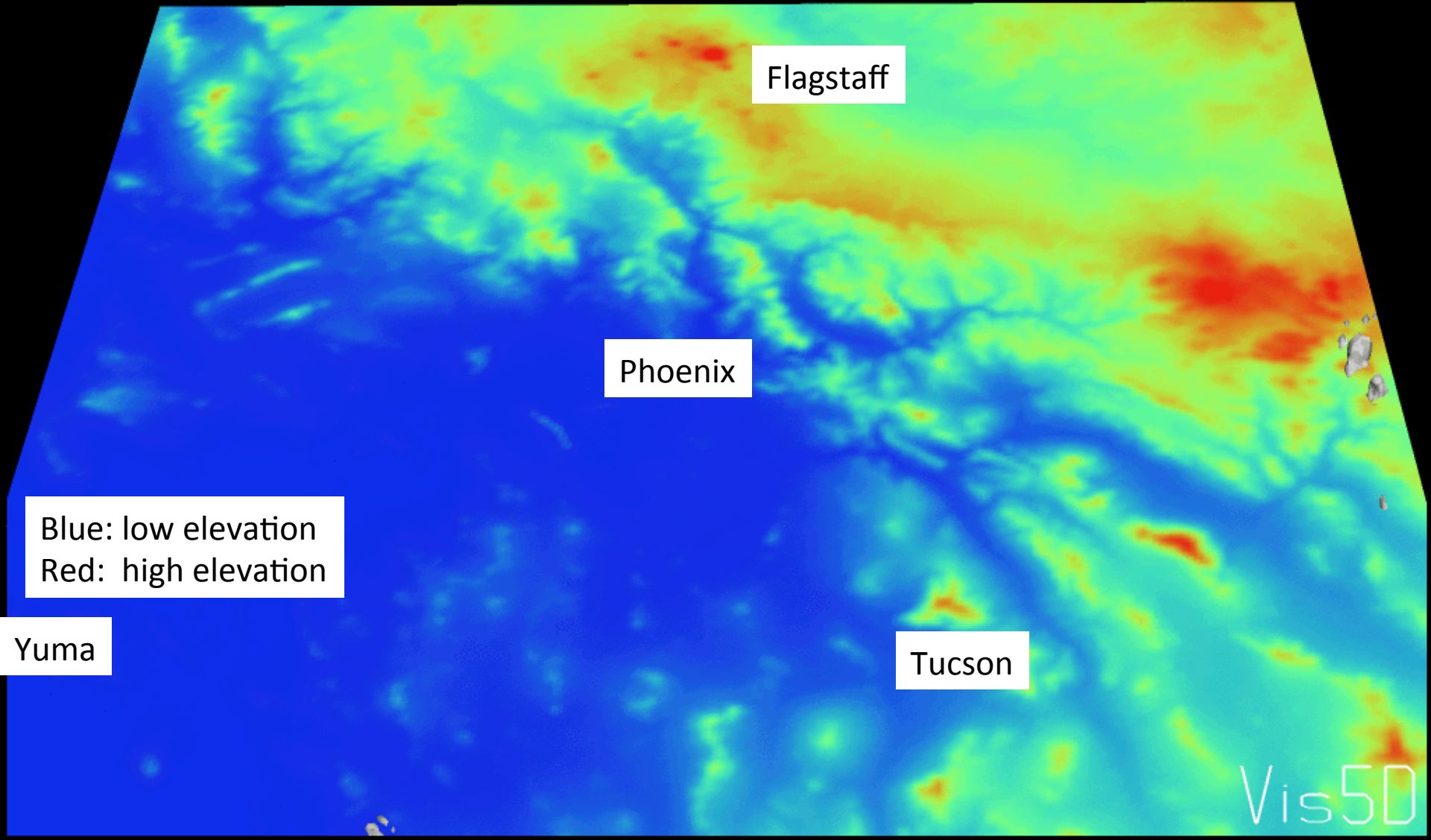
[Current Discussion](#) [Previous Discussion](#)

Model Products

	06z AZ WRF-GFS	06z AZ WRF-NAM	12z AZ WRF-NAM	12z AZ WRF-GFS	12z AZ WRF-RUC
Domain-Level Products					
Composite RADAR	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km
Precipitation	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km
Accumulated Precipitation	1.8kmz 5.4kmz	1.8kmz 5.4kmz	1.8kmz 5.4kmz	1.8kmz 5.4kmz	1.8kmz 5.4kmz
Accumulated Snow	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km
Snow Cover	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km	1.8km 5.4km
2m Temp	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz
10m Wind	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz	1.8km 5.4km 1.8kmz 5.4kmz
Precipitable					

- [Current Weather](#)
- [Campus Weather Conditions](#)
- [Campus Weather Plots \(English Units\)](#)
- [Daily, Weekly & Monthly Plots](#)
- [Solar Observatory Data \(opens new tab or window\)](#)
- [Satellite Imagery](#)
- [RADAR](#)
- [Lightning Plots \(arizona.edu only\)](#)
- [Maps and Plots](#)
- [Arizona Regional WRF Model Data](#)
- [Idaho Regional WRF Model Data](#)
- [GPS Precipitable Water](#)
- [Cloud movies](#)
- [Full Day Cloud Camera Movie](#)
- [Last 90 mins. Movie](#)
- [Yesterday's Movie](#)
- ["Best Of" ATMO Cloud Movies](#)

Animation available at:
<http://forecasting.uaren.org>



Blue: low elevation
Red: high elevation

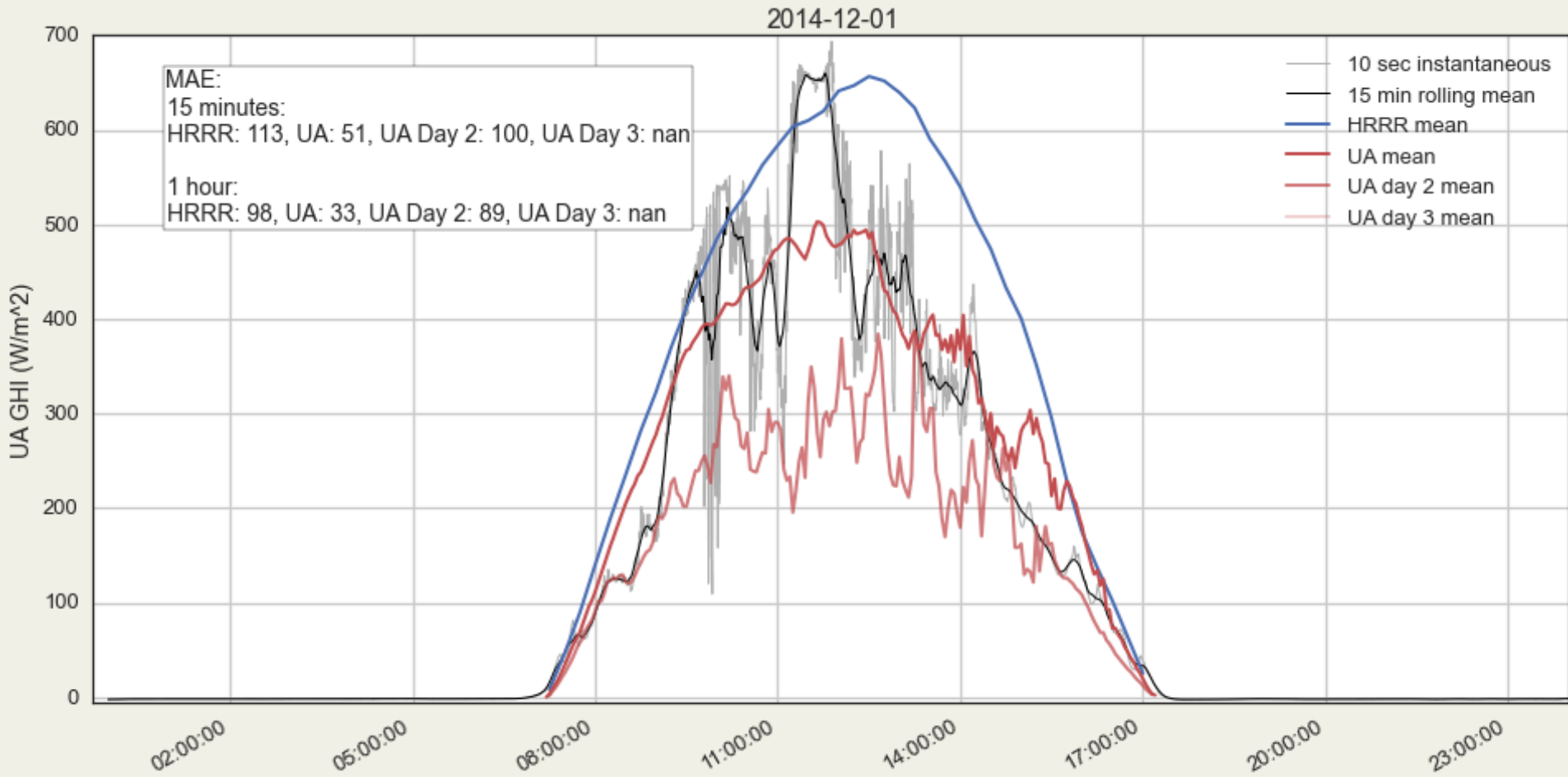
Yuma

Phoenix

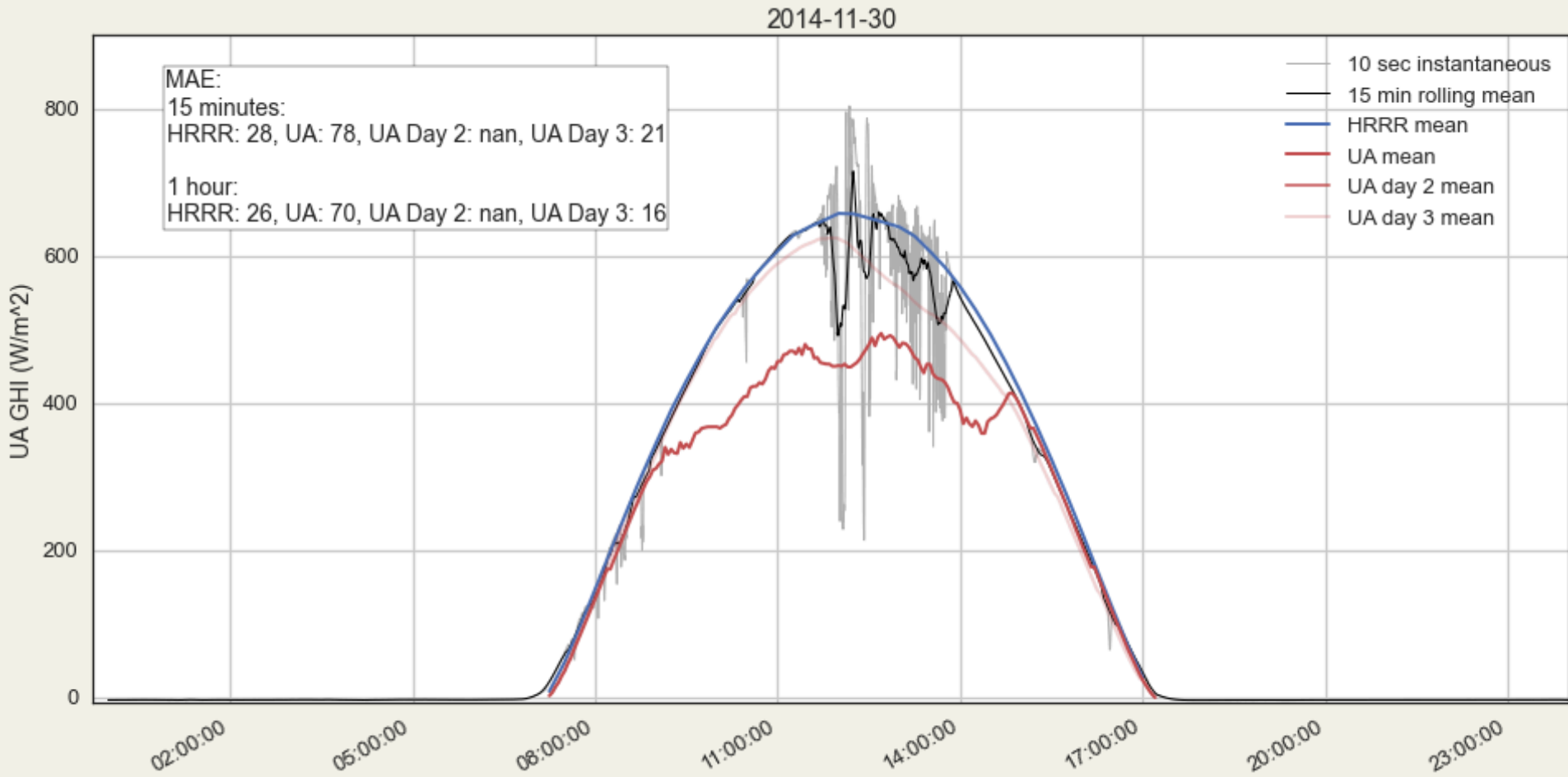
Flagstaff

Tucson

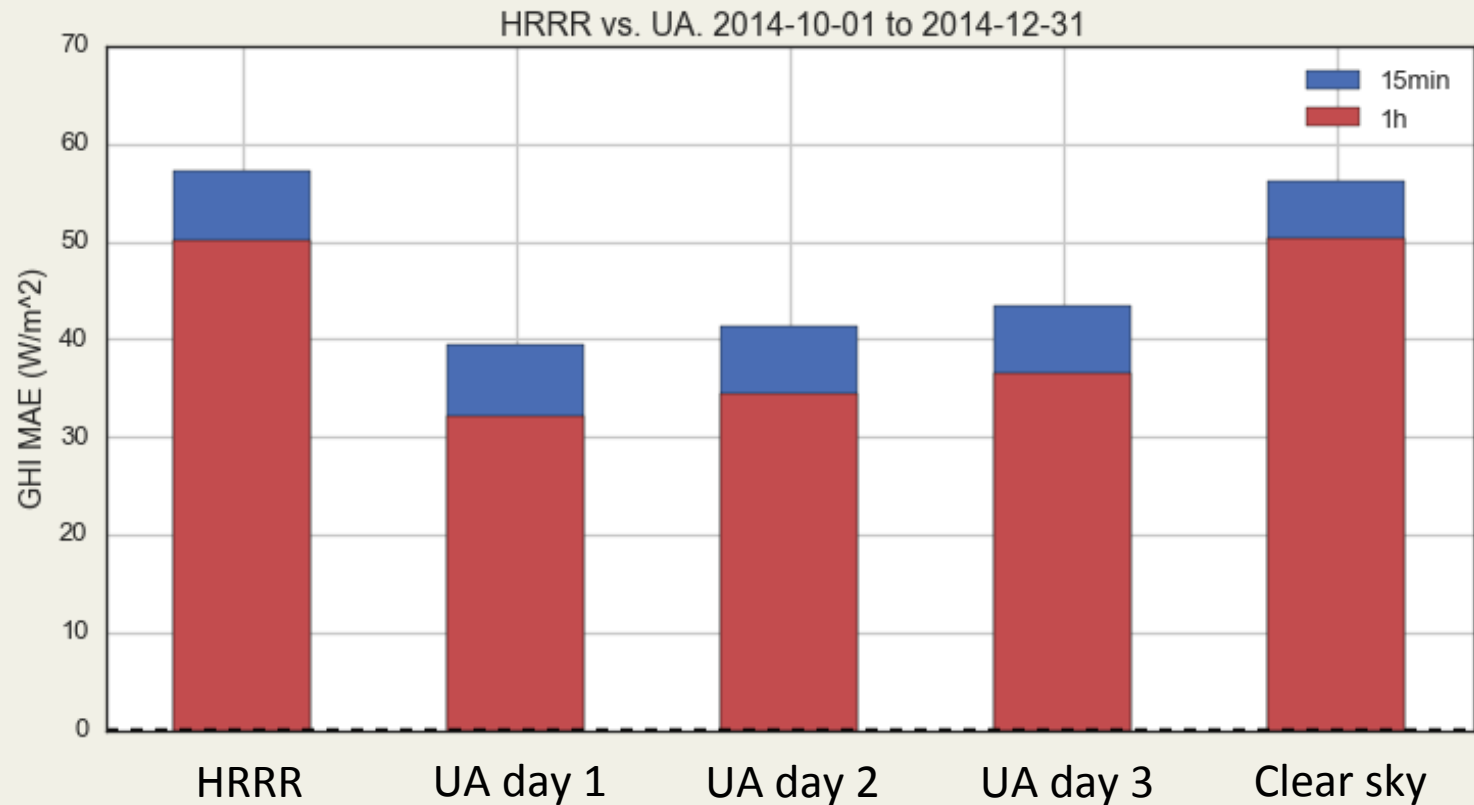
UA vs. HRRR Tucson GHI



UA vs. HRRR Tucson GHI



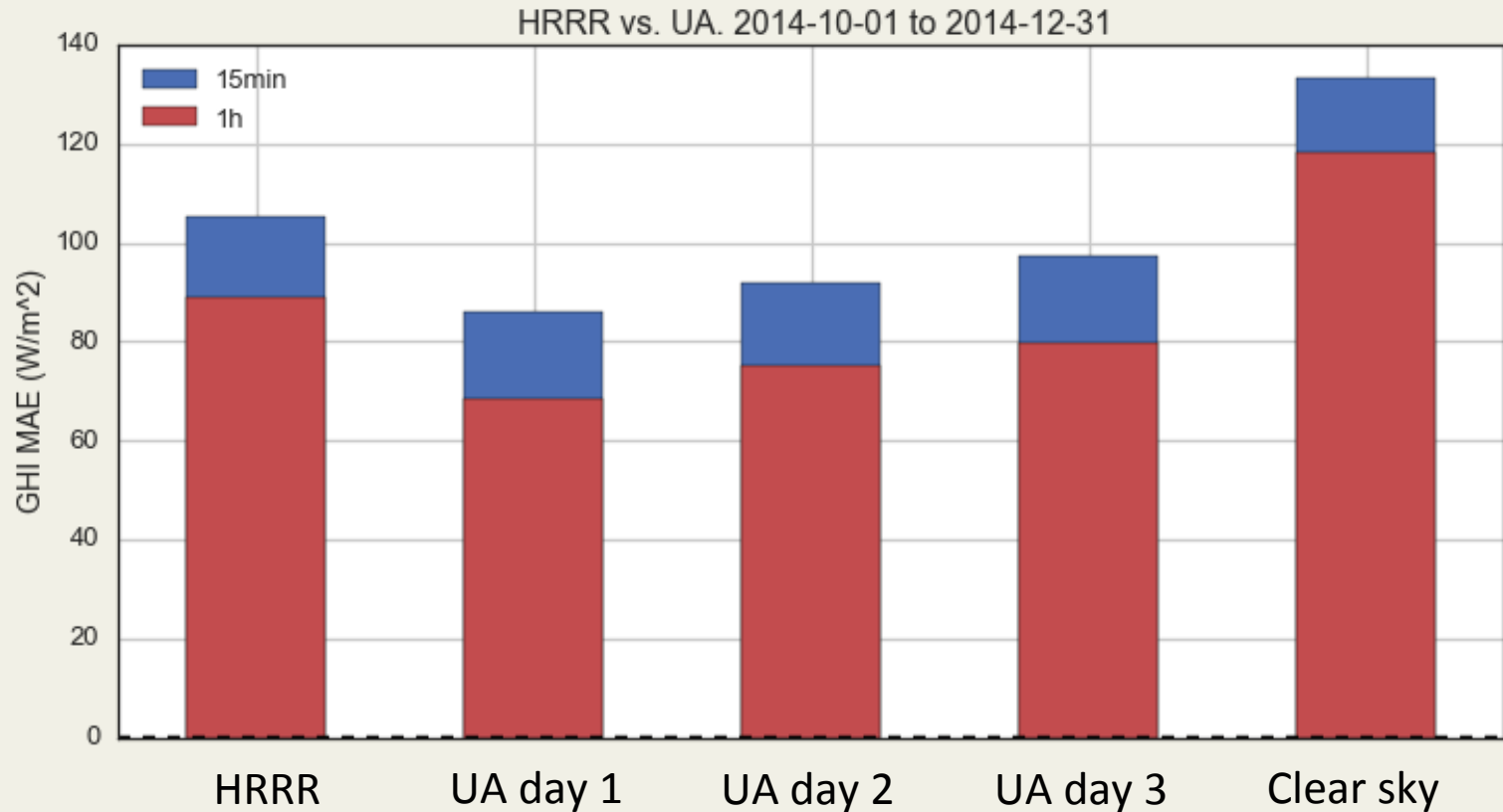
UA vs. NCEP HRRR Tucson GHI



Not a fair comparison because NCEP HRRR does not use the correct eqn. of time
So, we subtracted 15 minutes from HRRR time for approximate correction for these months
First HRRR point also discarded

Oct-Dec average of the daily average of 15 minute or 1 hour MAEs

UA vs. NCEP HRRR Tucson GHI



Limit analysis to large (MAE > 60) errors.

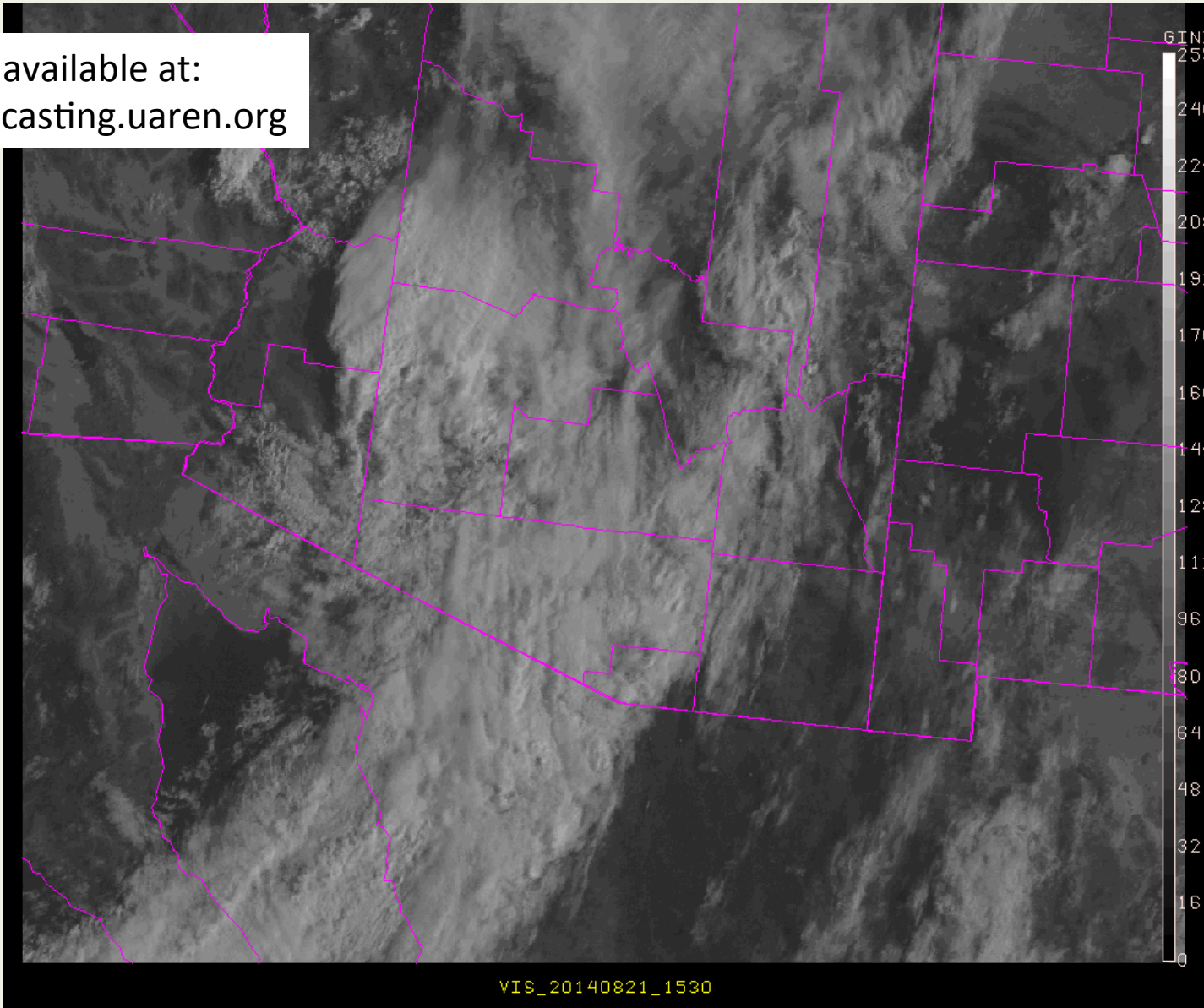
Eliminates clear days.

Helps HRRR, relatively, since it is much worse than UA on clear days.

UA day 3 still outperforming NCEP HRRR

Satellite Imagery

Animation available at:
<http://forecasting.uaren.org>



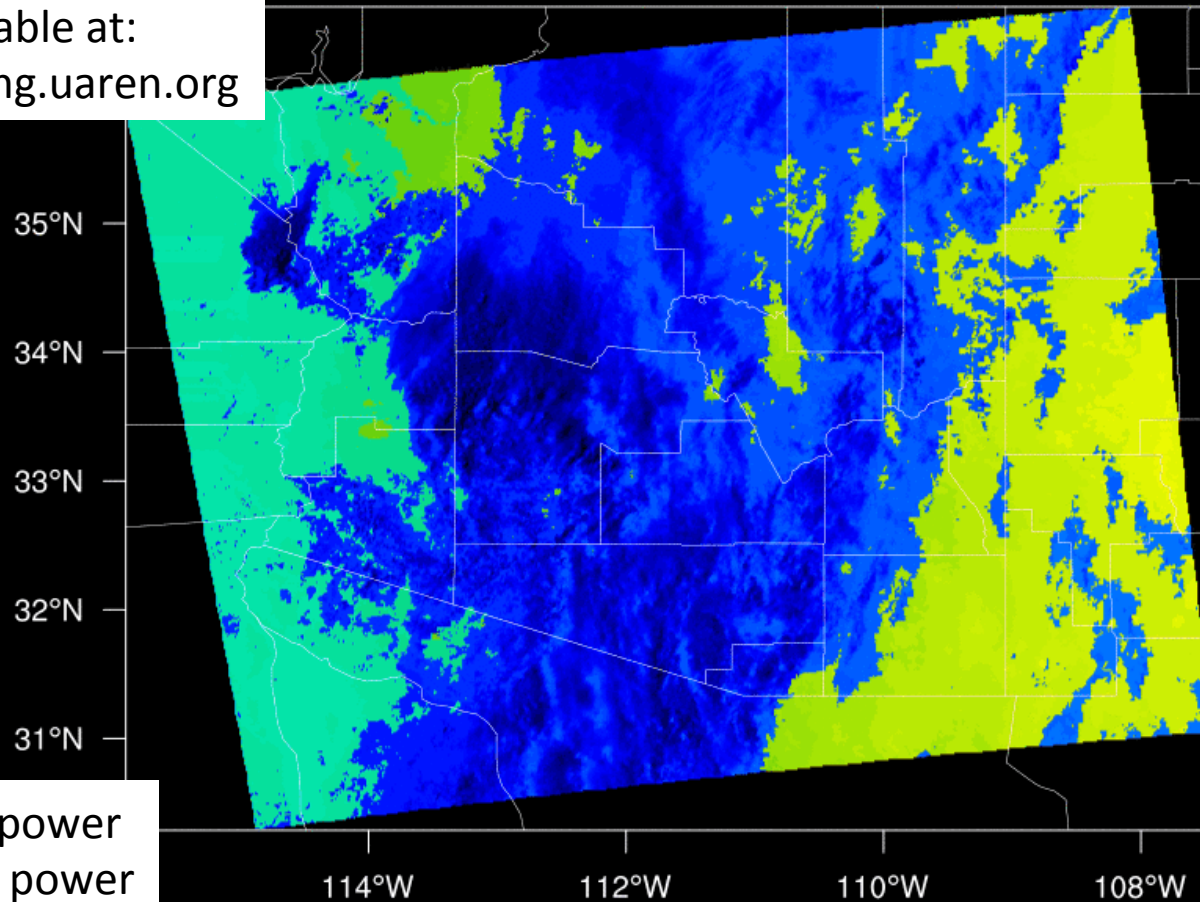
Satellite Derived Solar Irradiance

GHI

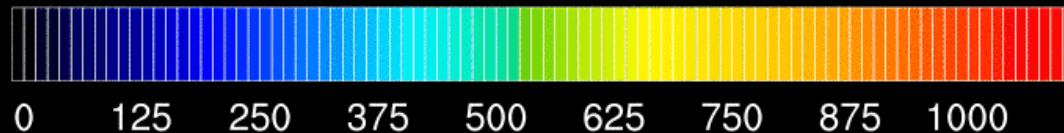
08-21-2014 1545 UTC

$W m^{-2}$

Animation available at:
<http://forecasting.uaren.org>



Blue: low solar power
Red: high solar power

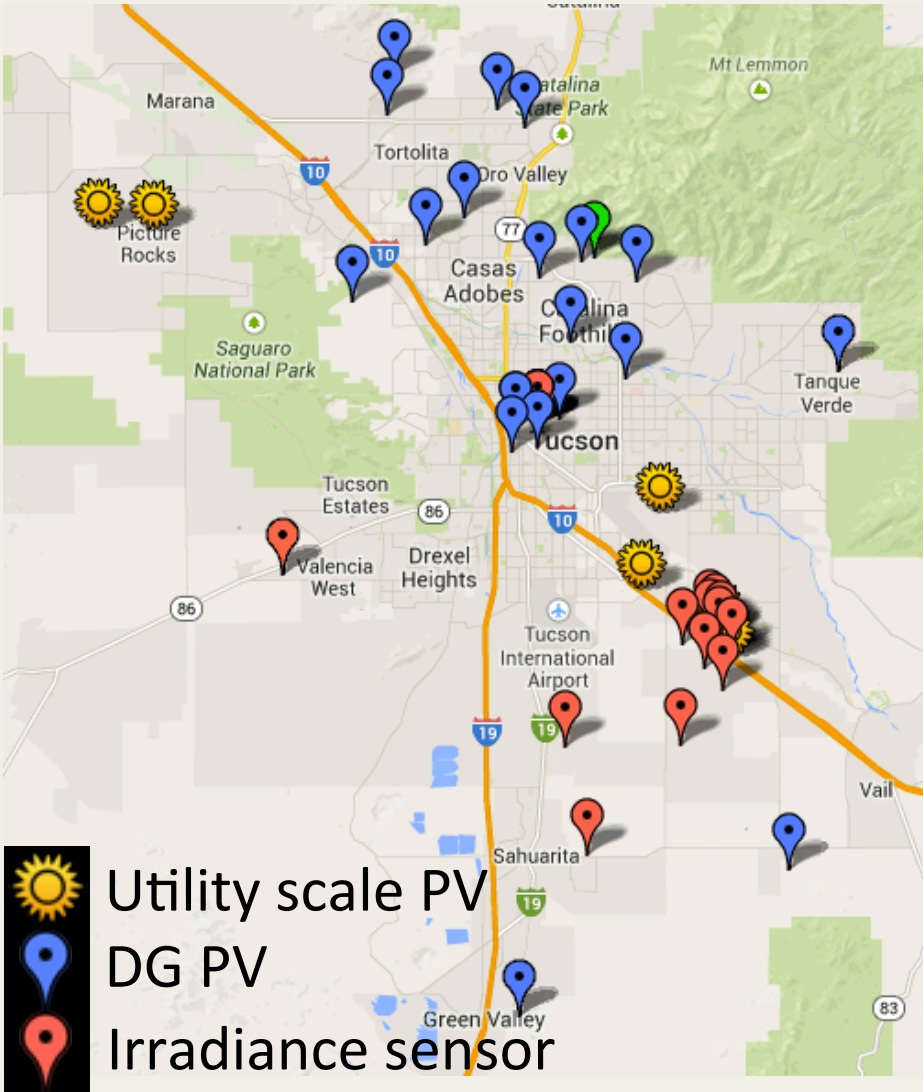


Sensor network forecasting

Partnered with local PV installer Technicians for Sustainability to obtain access to real-time (5 min latency) data feeds of residential PV systems.

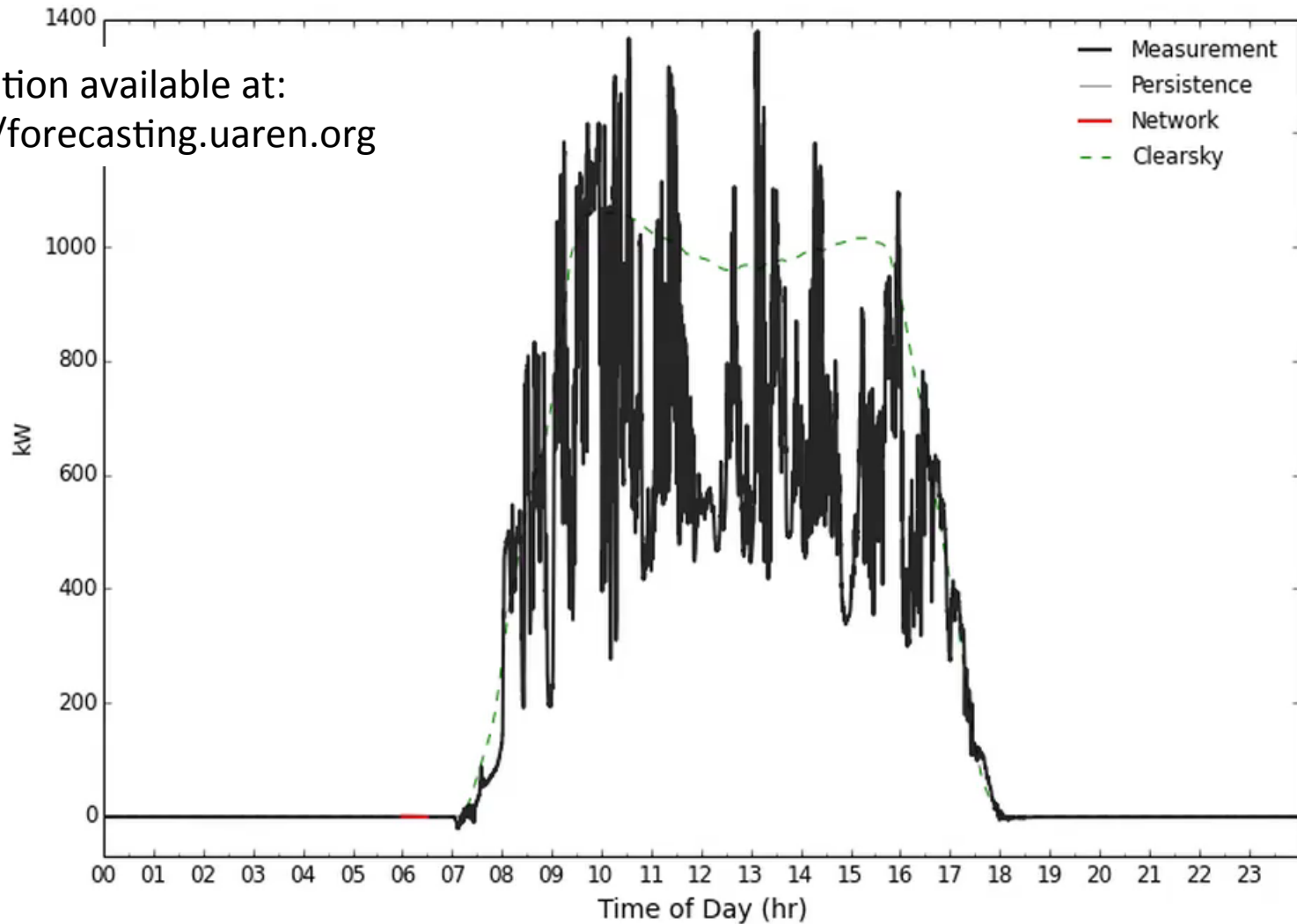
Homebuilt irradiance sensors will cell modems (see A. Lorenzo, AMS 2015).

Network of rooftop solar data and irradiance sensors provides most accurate 30 minute forecasts.



Network Forecast

Animation available at:
<http://forecasting.uaren.org>



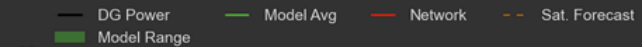
UA Renewable Power Forecasting

EMS aggregate 01/03/15 16:17:05



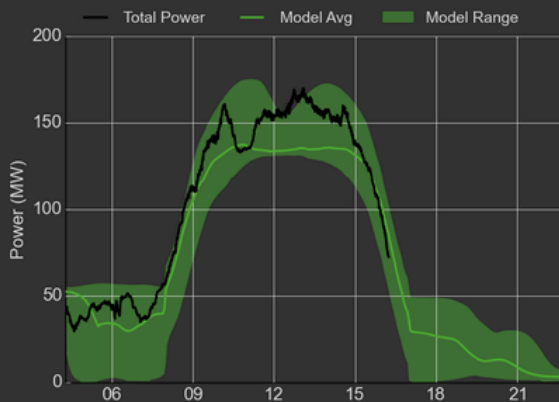
Current:
EMS Solar: 45

DG aggregate 01/03/15 16:17:10



Current:
DG: 17

Total aggregate 01/03/15 16:17:15



UA forecasting for TEP and APS:

- **3 day** forecasts of solar and wind production using **WRF**. (operational)
- **2 hour** forecasts of solar production (utility and behind the meter) using **GOES**. (development)
- **1 hour** forecasts of solar production (utility and behind the meter) using a **Network of Irradiance Sensors**. (operational on sub-domain)

UA forecasting for Idaho Power Company:

- 1-10 day WRF wind forecasts
- Also collaborating with NCAR, IPC on cloud seeding (hydro)

UA forecasting for SVERI

- Outer domain 6Z runs for every utility scale site

Thanks to our funding agencies

Major support from



DOE EERE
Postdoctoral
Fellowship

Additional support from

The SVERI utilities



Arizona Department of
Environmental Quality

U of A

