

An Operational Solar Forecast Model For PV Fleet Simulation

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Agenda

- Historical and forecast platform
- Blended forecast approach
- Application in electric grid operation



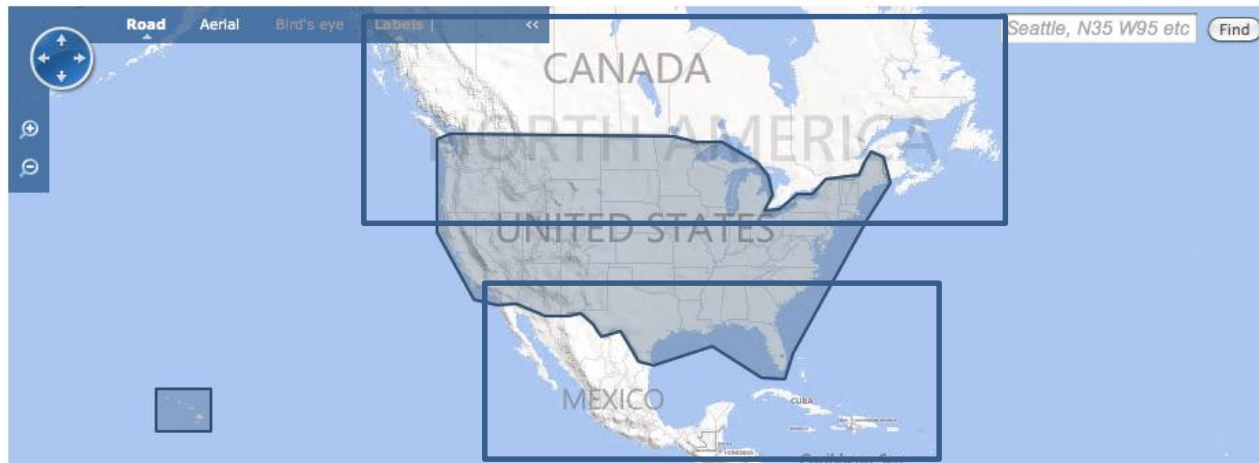
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FORECAST

Zoom in to select location(s)

You are logged in as public | [Change Login](#)



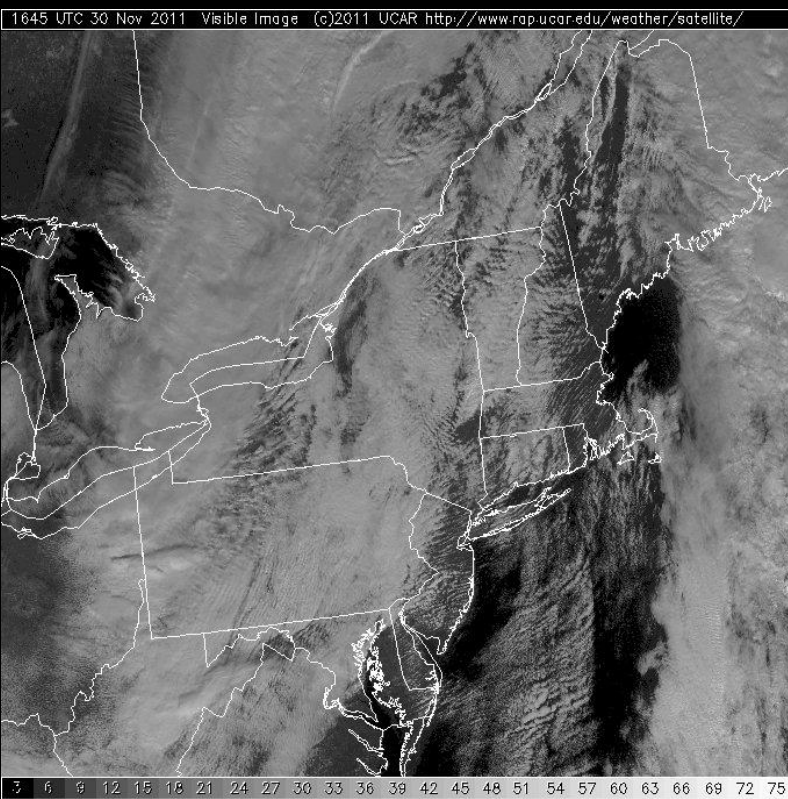
CLIMATOLOGY

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FORECAST

1998

→ 6 days ahead



SATELLITE REMOTE SENSING MODEL

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1998

→ **6 days ahead**

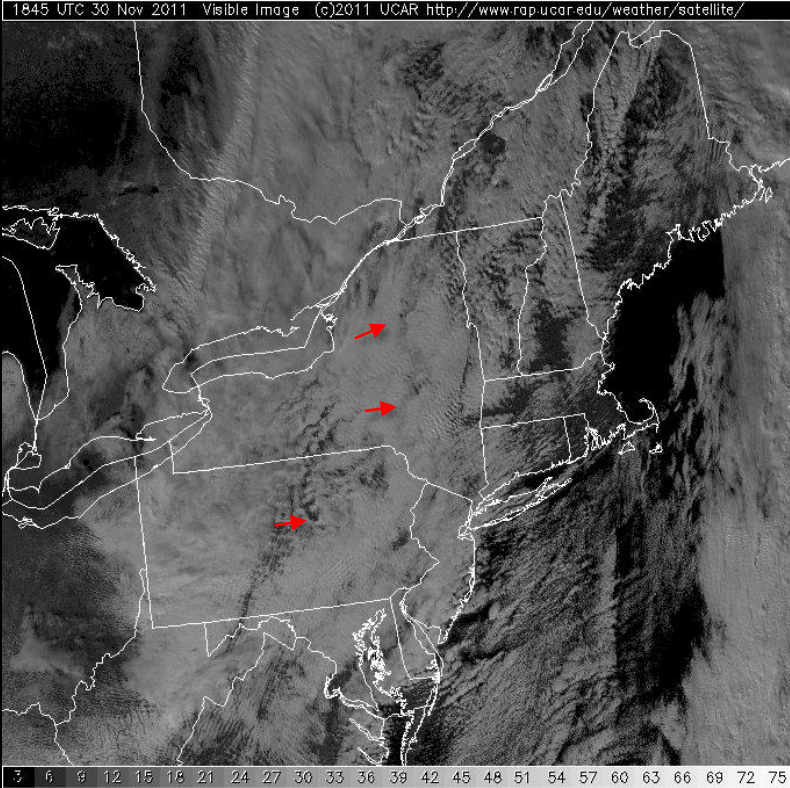


CLIMATOLOGY

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FORECAST

Original Model



Cloud speed calculated individually for each image pixel, by minimizing pixel-surrounding scene difference between two consecutive images.

Cloud speed is applied to generate future image

With high resolution images, model can be applied to generate 1-minute resolution data forecasts

The procedure can also be applied to generate 1 minute historical data

CLOUD MOTION

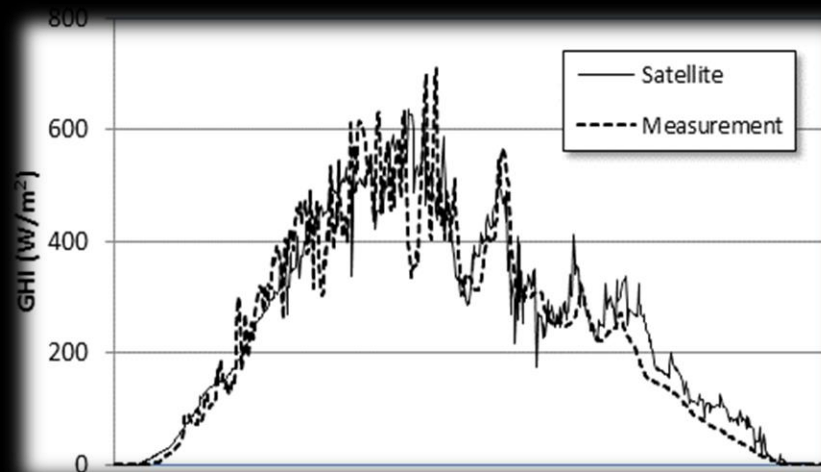
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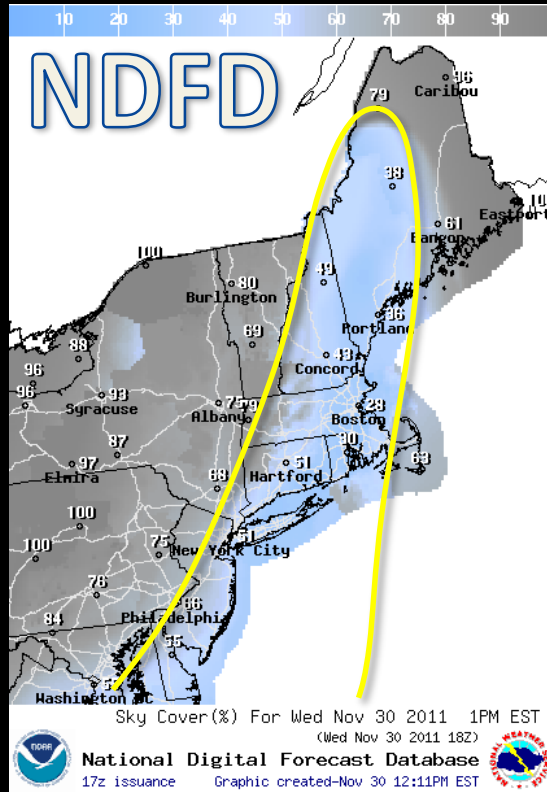
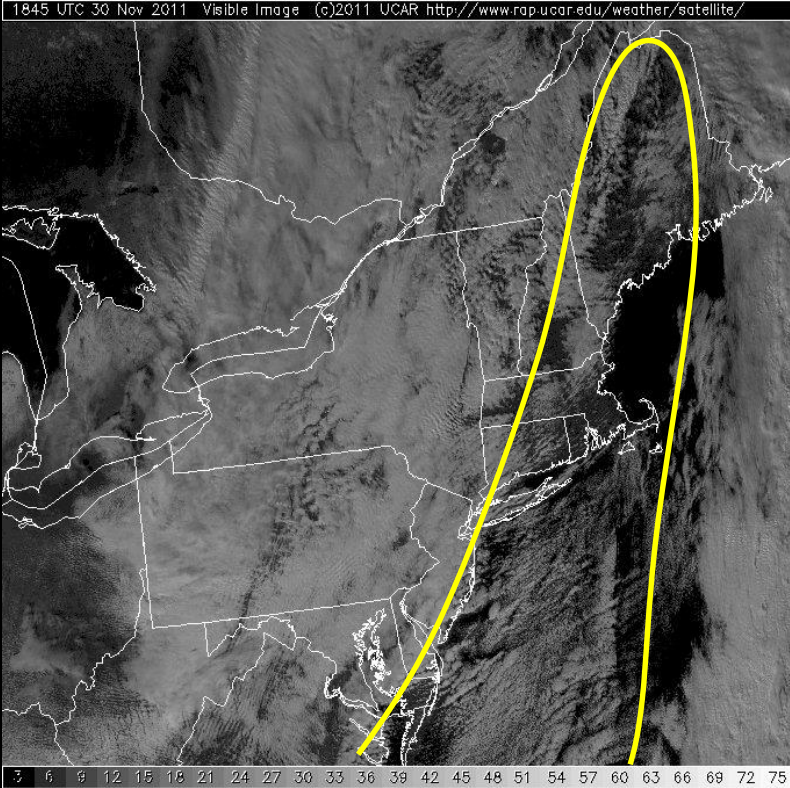
NOW

HOURS AHEAD

DAYS AHEAD

Original Model





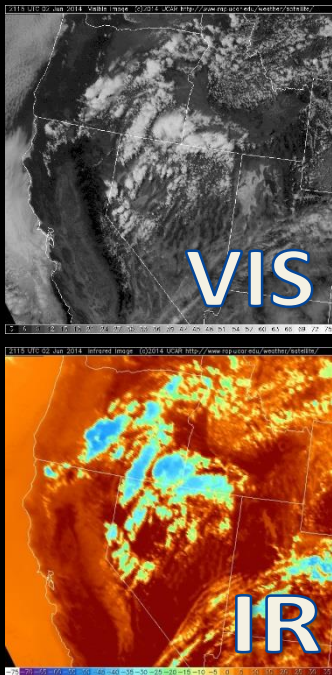
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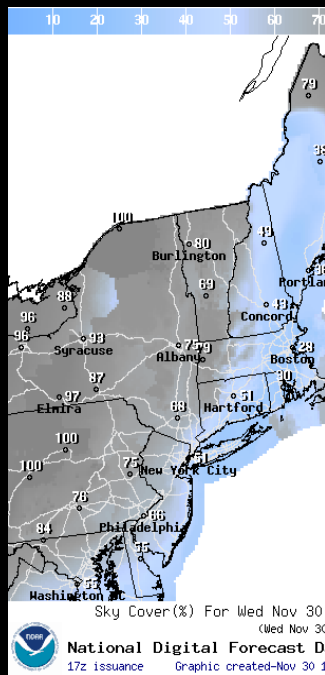
HOURS AHEAD

DAYS AHEAD

Original Model



Cloud motion



NDFD

Operational NWP models

GLOBAL SCALE MODELS

- NCEP GFS
- ECMWF

CONTINENTAL SCALE MODELS

- NAM

HIGH RESOLUTION ASSIMILATION MODELS

- RAP
- HRRR

CLIMATOLOGY

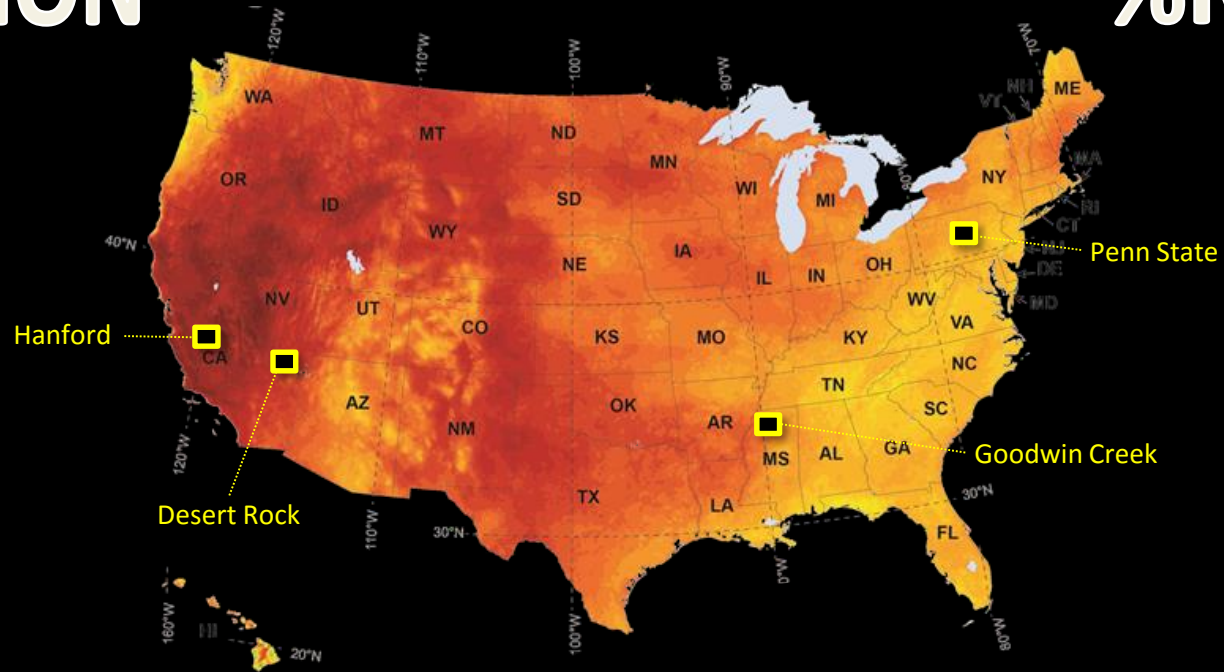
NOW

FORECAST

**NEW Model
OPTIMUM MIX**

VALIDATION

%RMSE



CLIMATOLOGY

NOW

FORECAST

NEW Model

%RMSE



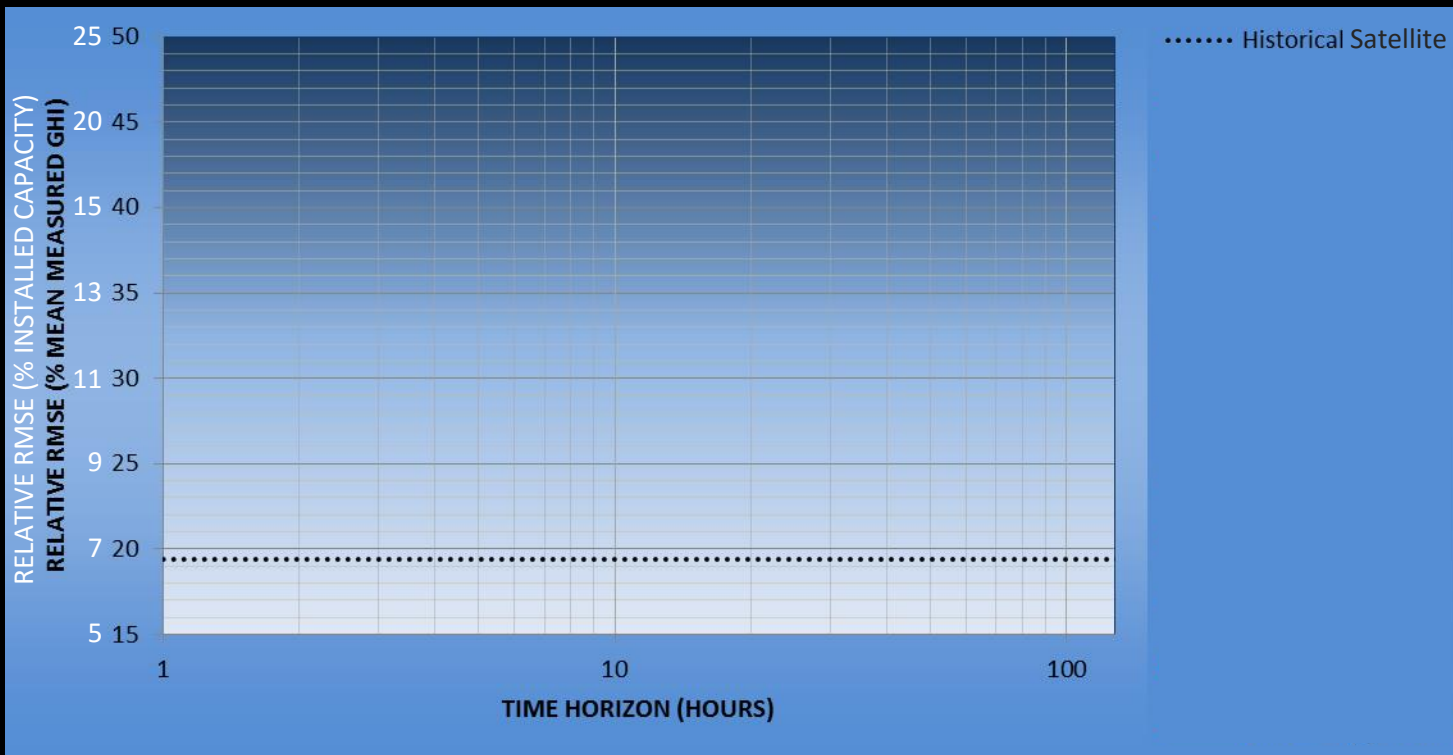
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FORECAST

NEW Model

%RMSE



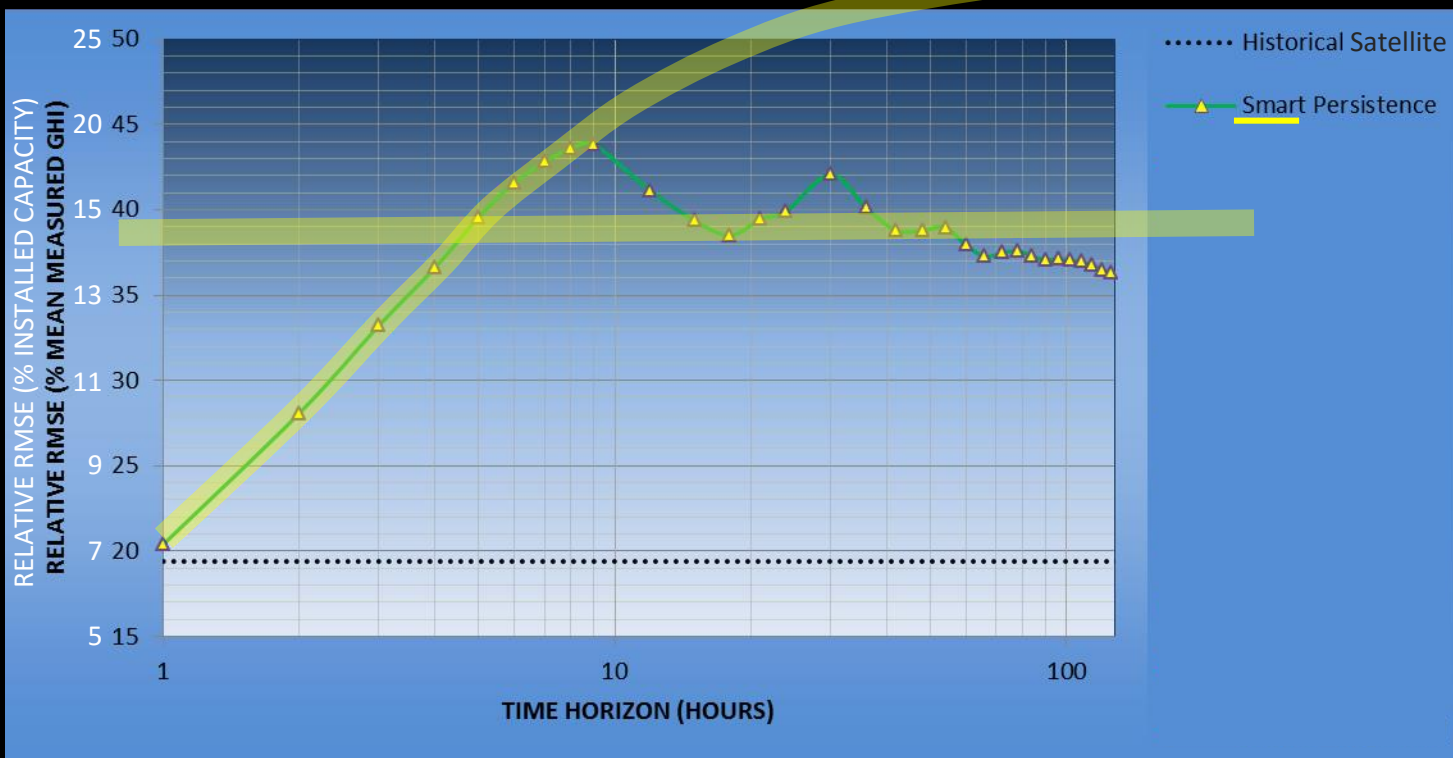
CLIMATOLOGY

NOW

FORECAST

NEW Model

%RMSE



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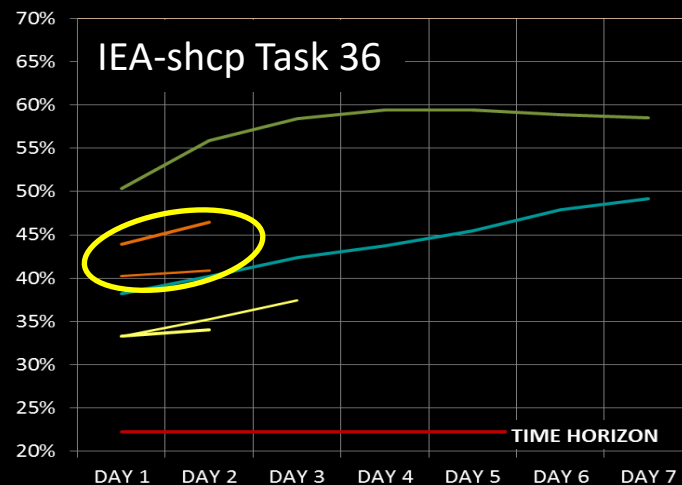


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FORECAST

NEW Model



RMSE USA

- Reference Satellite model
- OZ Persistence
- OZ GEM
- OZ ECMWF
- 12Z NDFD
- 12Z WRF-ASRC
- OZ WRF-MOS

%RMSE



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FORECAST

NEW Model

%RMSE



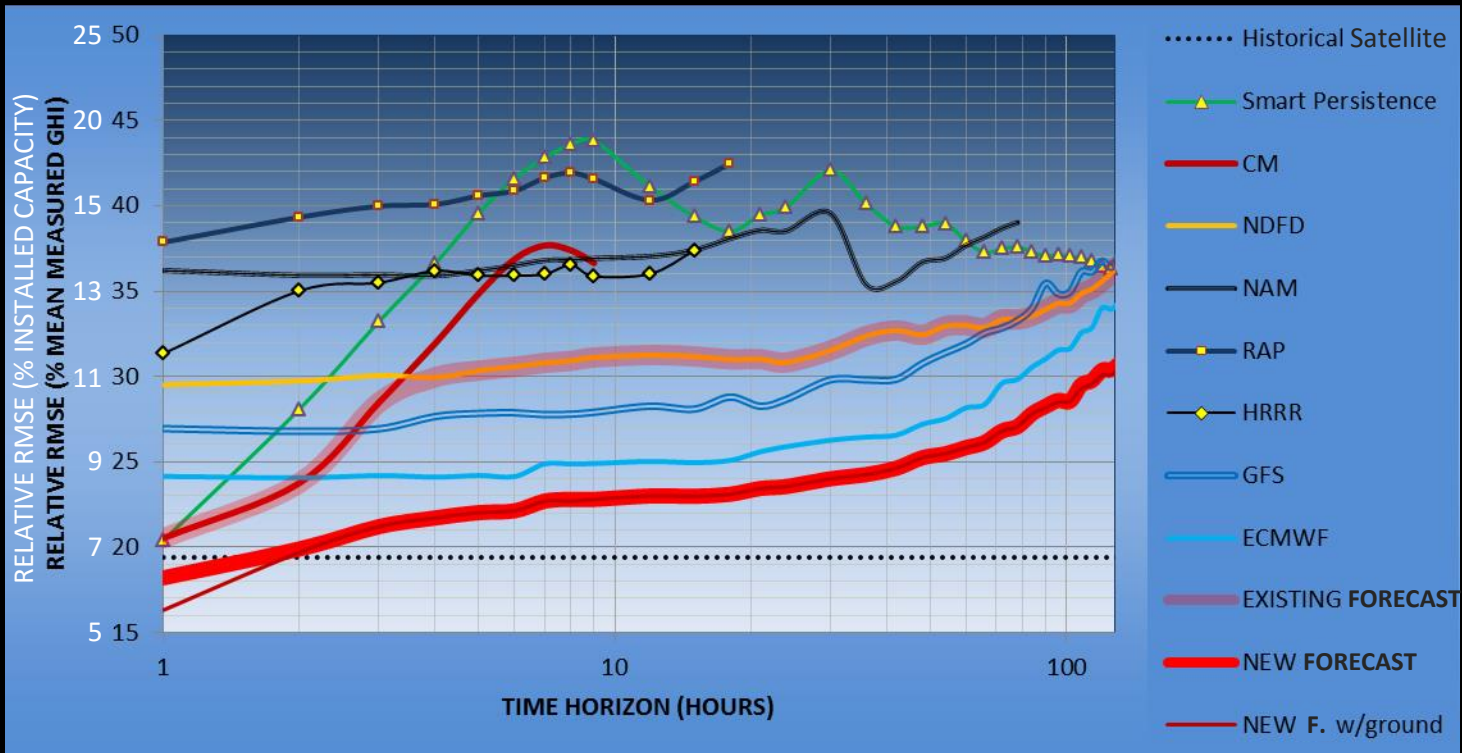
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NEW Model

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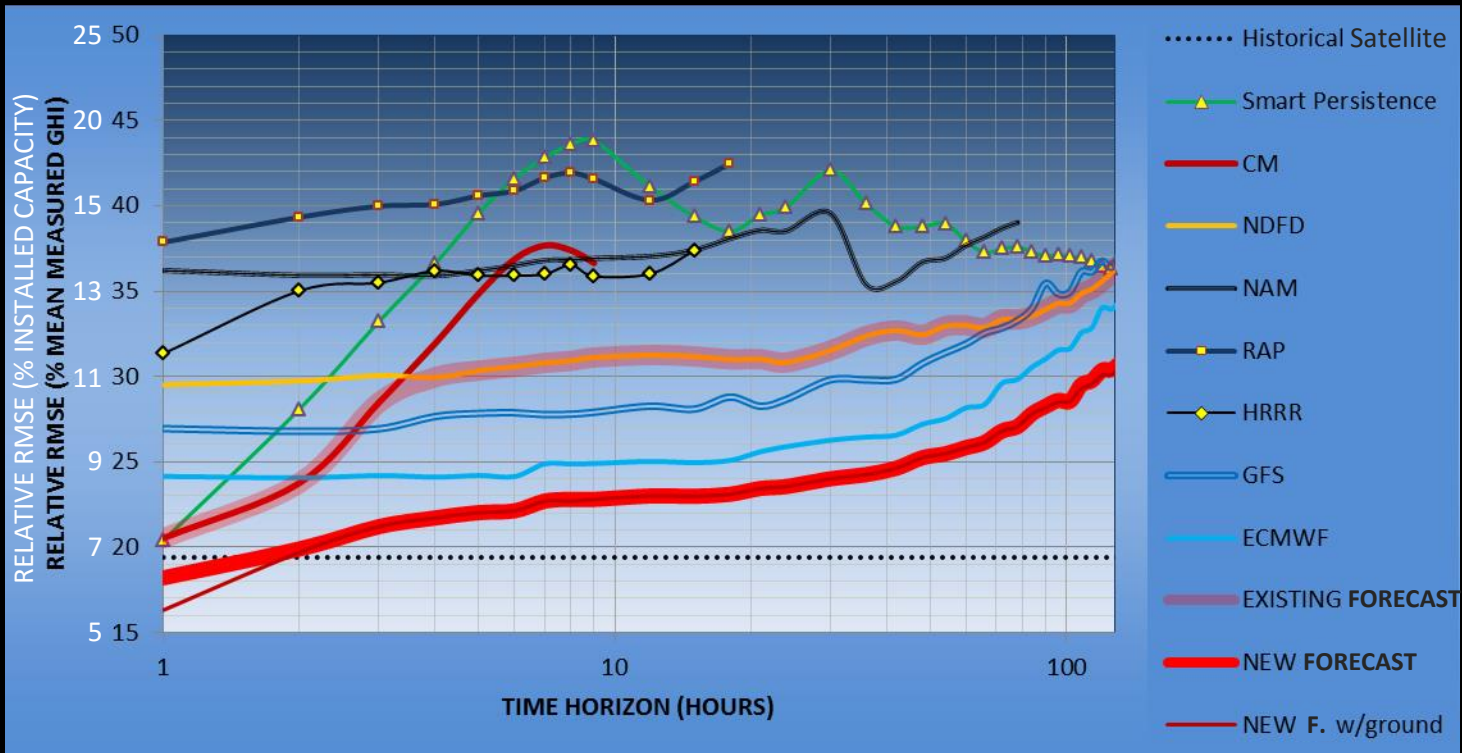
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NEW Model

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CLIMATOLOGY

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NEW Model

IEA HIT/MISS METRIC

After SMUD's TJ Vargas et al.

CLOUDY

Cloudy forecast
Clear conditions

CLIMATOLOGY

NOW

FORECAST

NEW Model

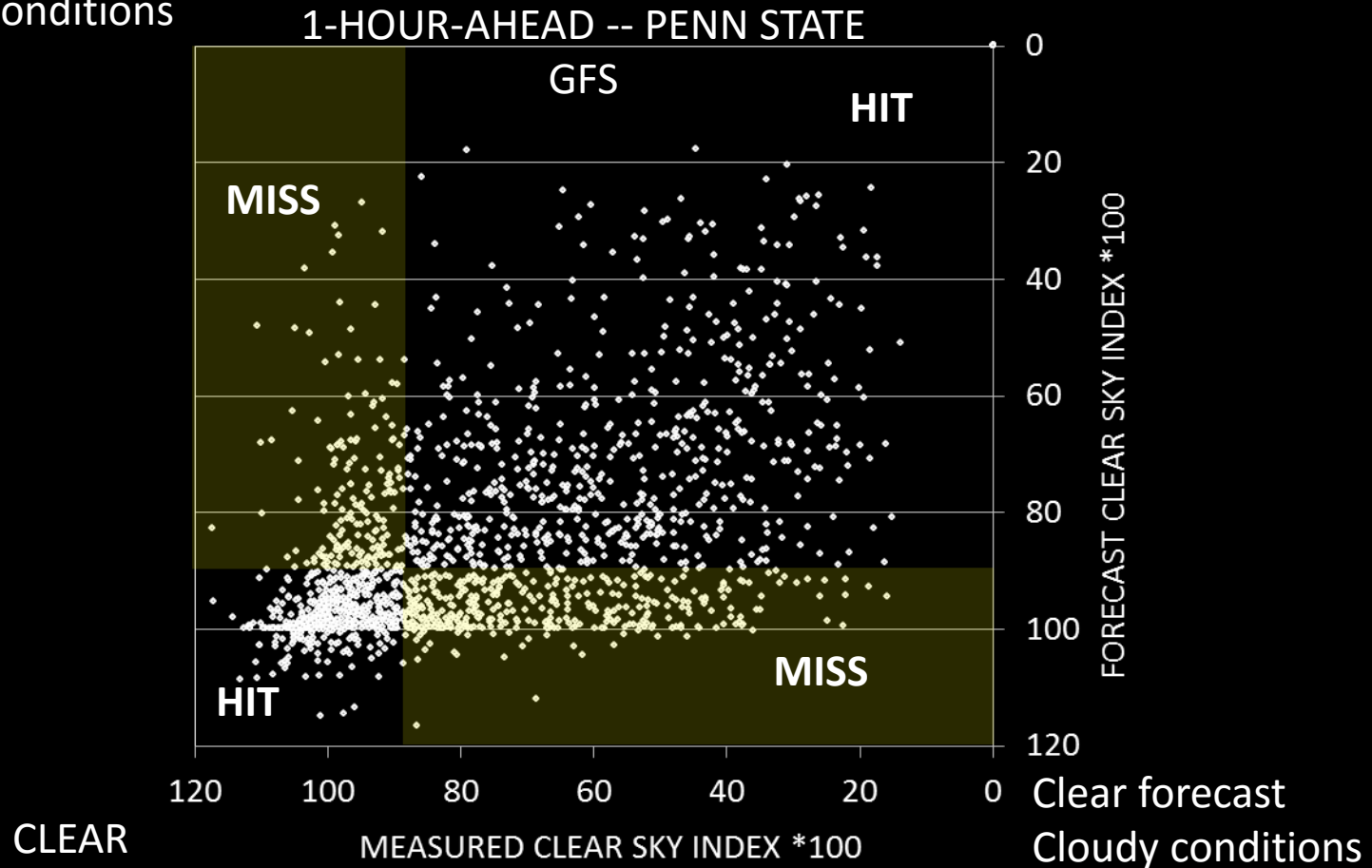
CLEAR

Clear forecast
Cloudy conditions

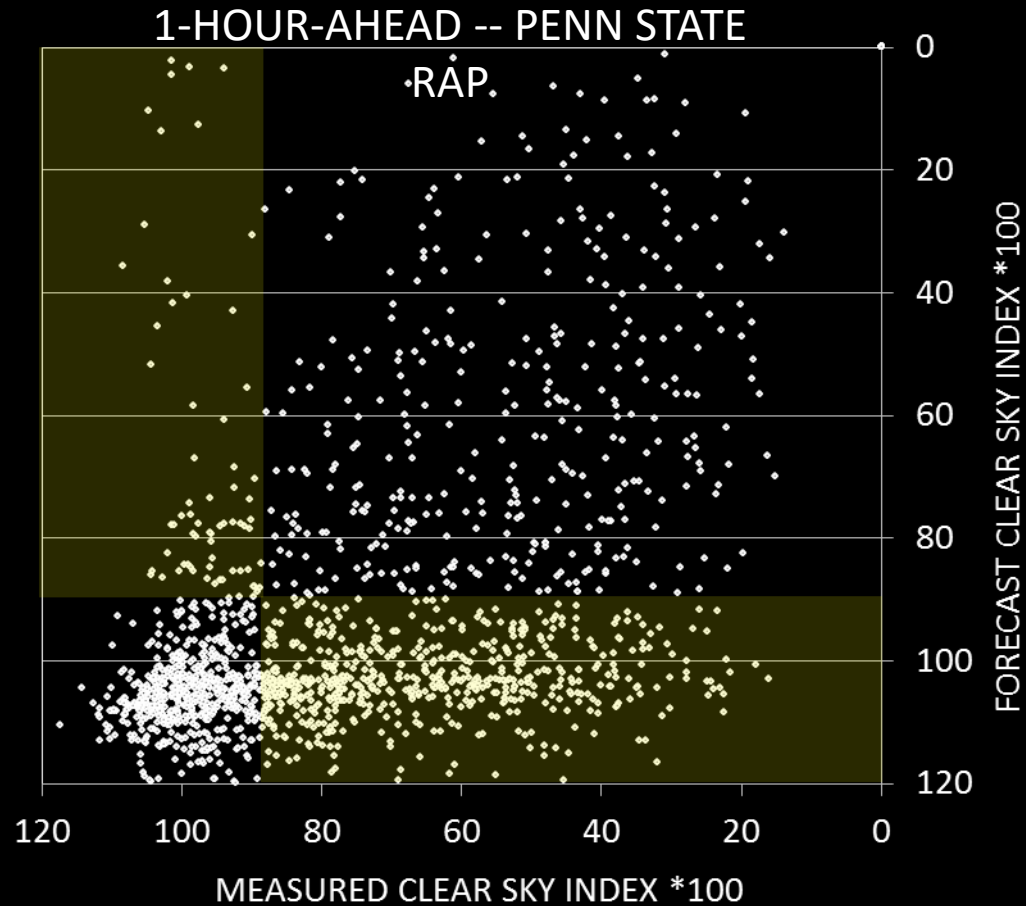
IEA HIT/MISS METRIC

Cloudy forecast
Clear conditions

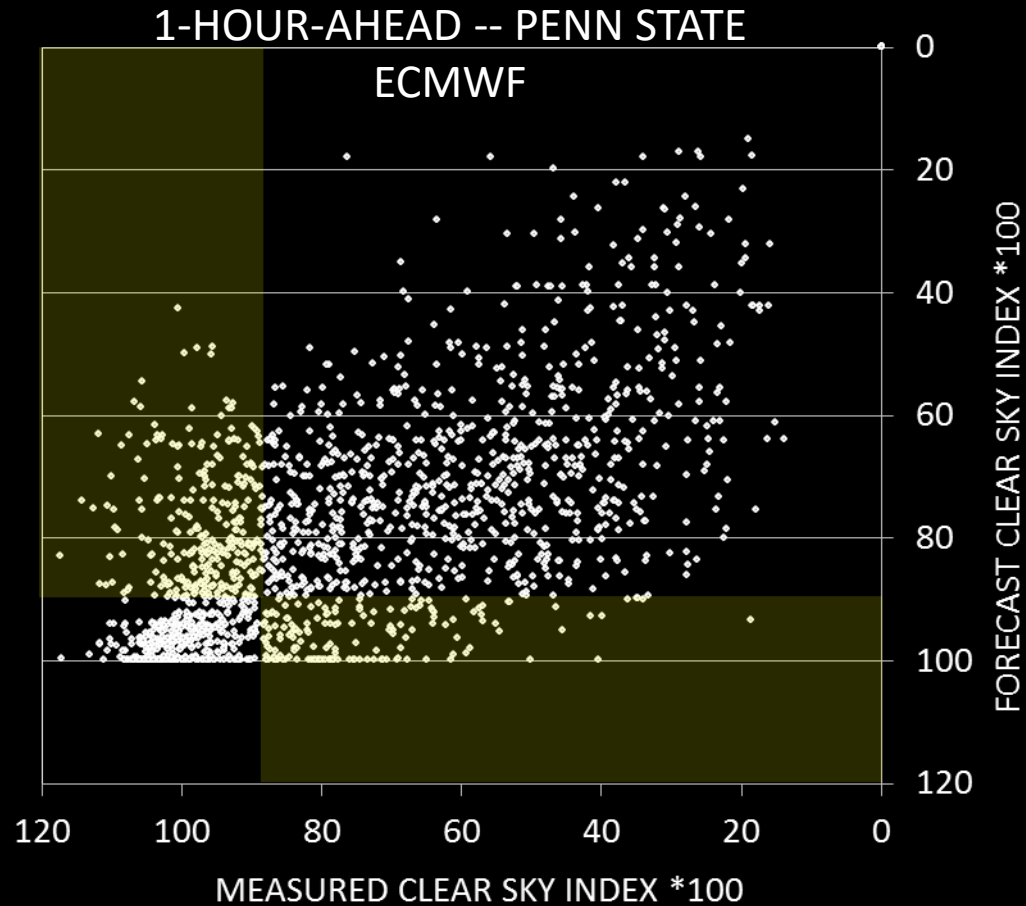
CLOUDY



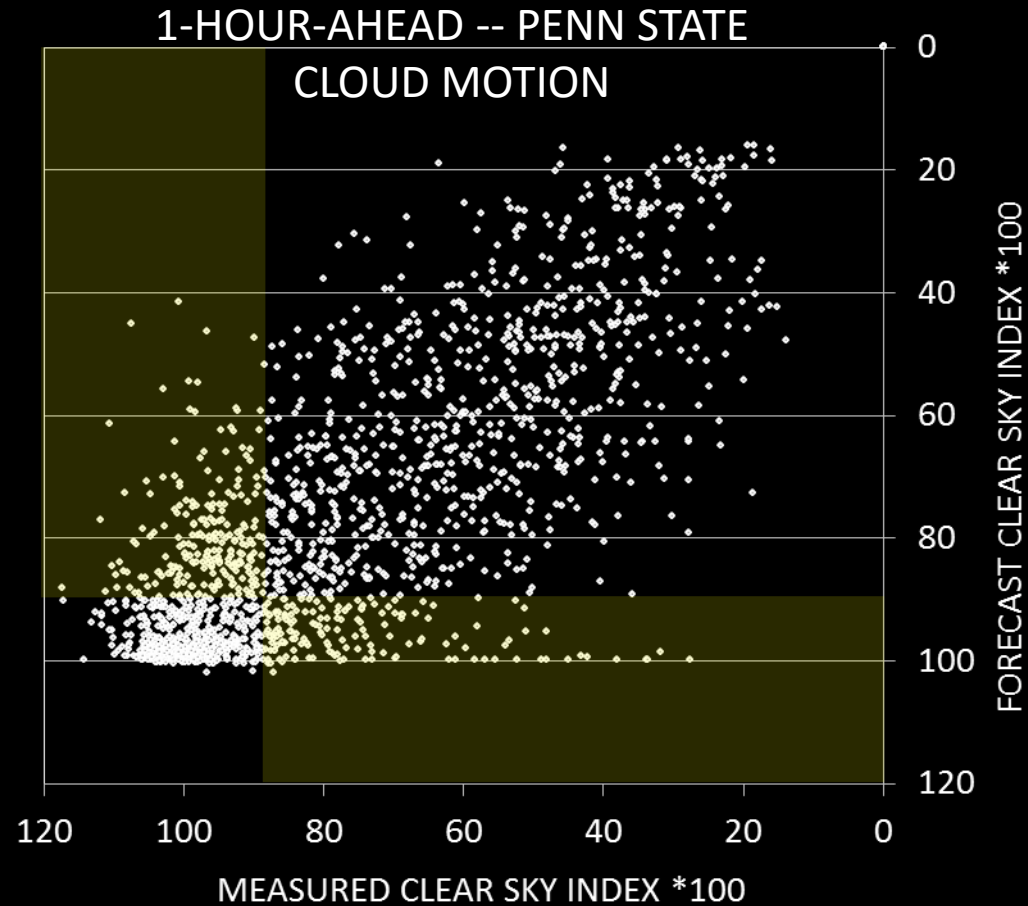
IEA HIT/MISS METRIC



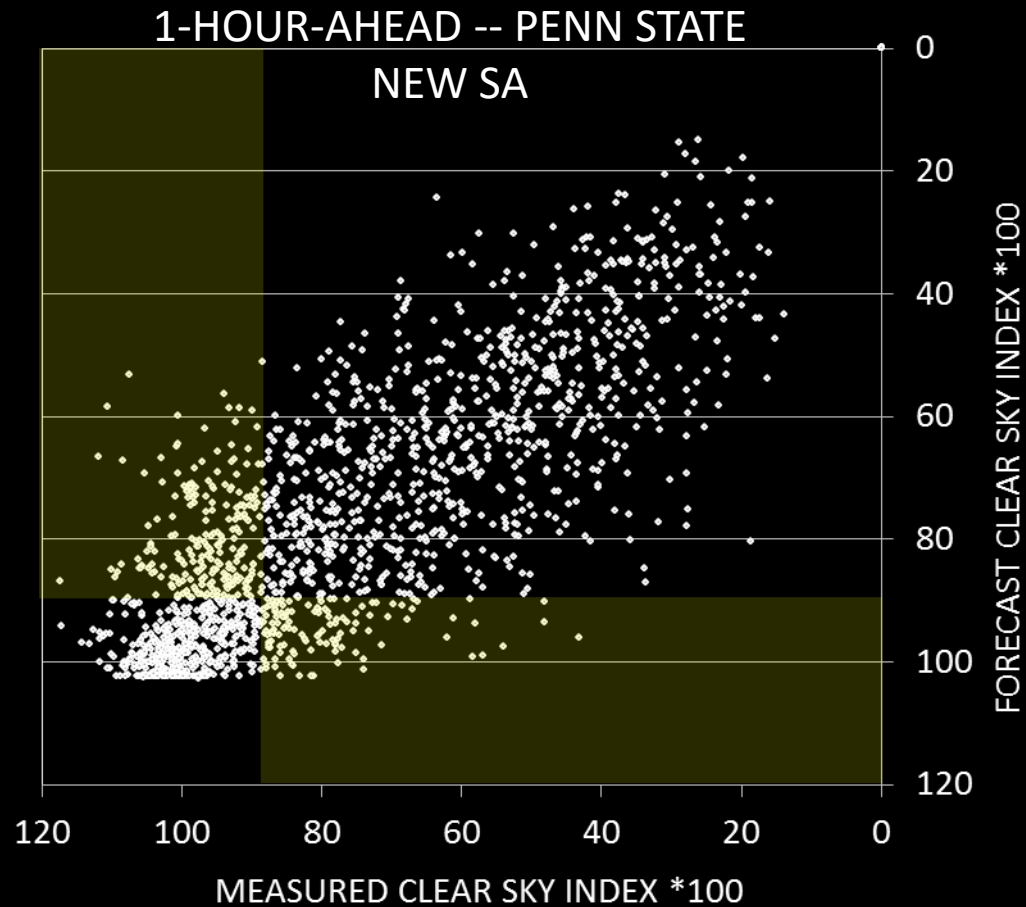
IEA HIT/MISS METRIC



IEA HIT/MISS METRIC

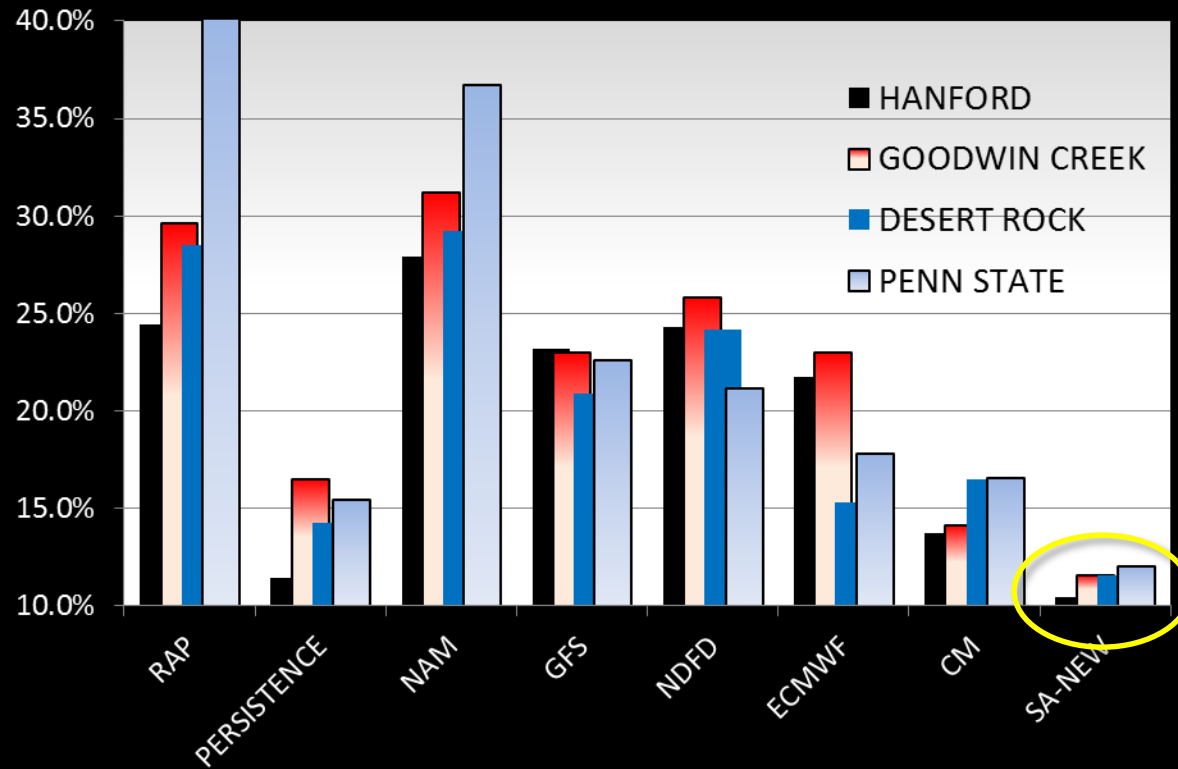


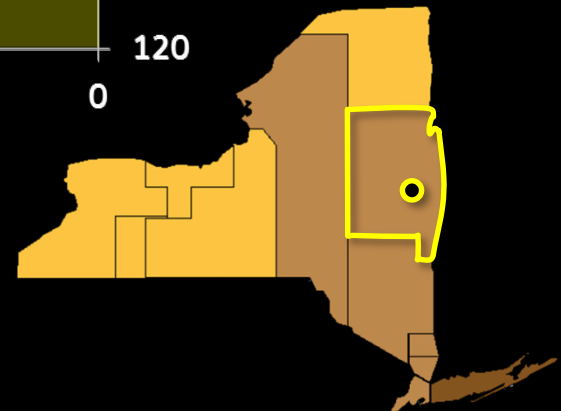
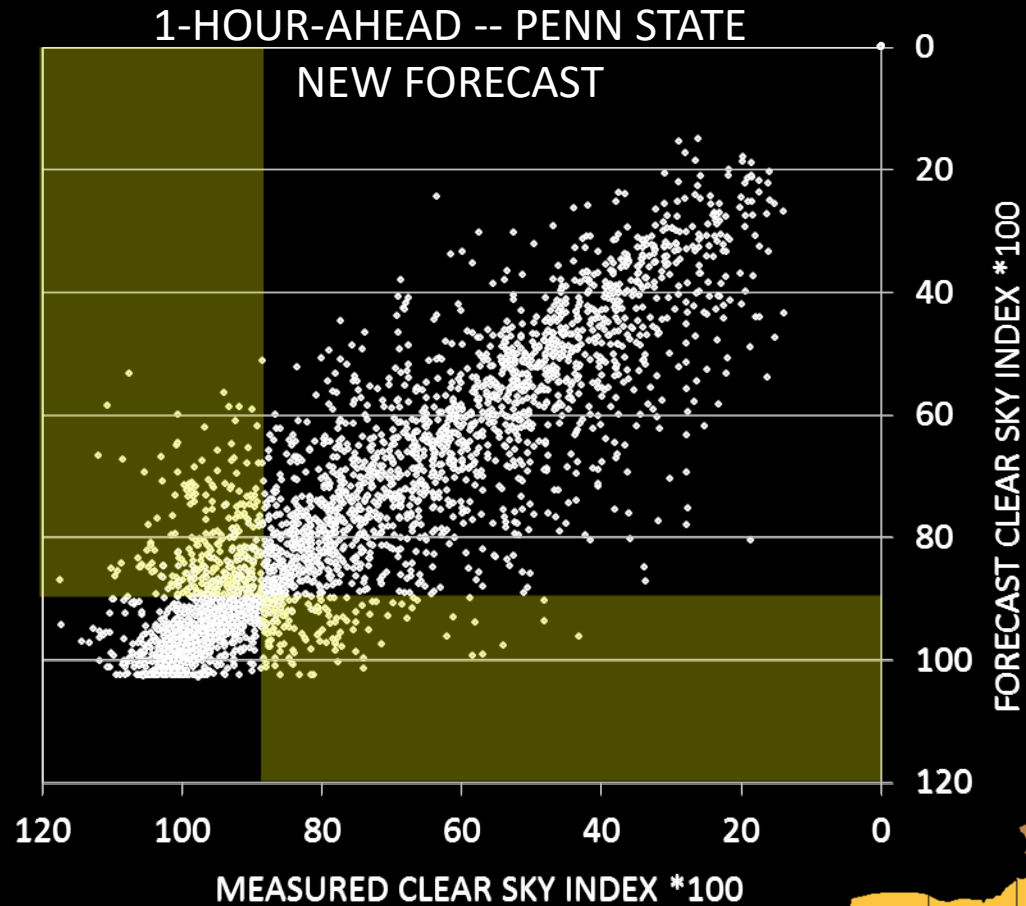
IEA HIT/MISS METRIC



IEA HIT/MISS METRIC

% MISSED FORECASTS -- 1 HOUR AHEAD

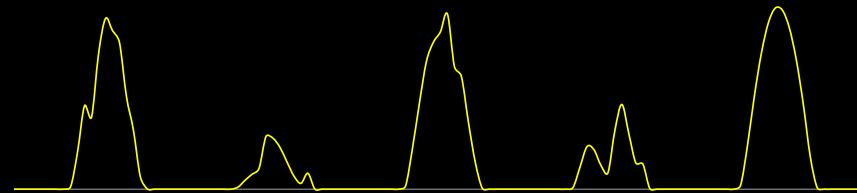




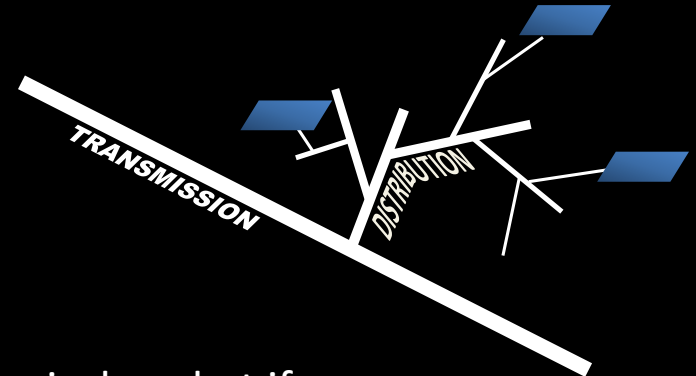
APPLICATION: PV FLEET MANAGEMENT

PV FLEET DATA:

Individual system size, orientation, location, specs, shading



PV SIMULATIONS



Historical: what if
Forecast: Operational

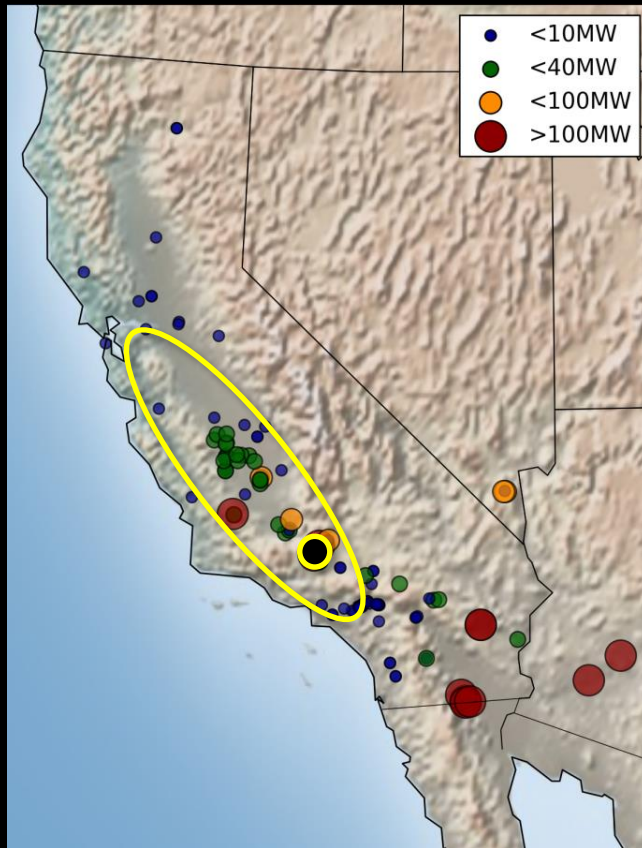
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APPLICATION: PV FLEET MANAGEMENT

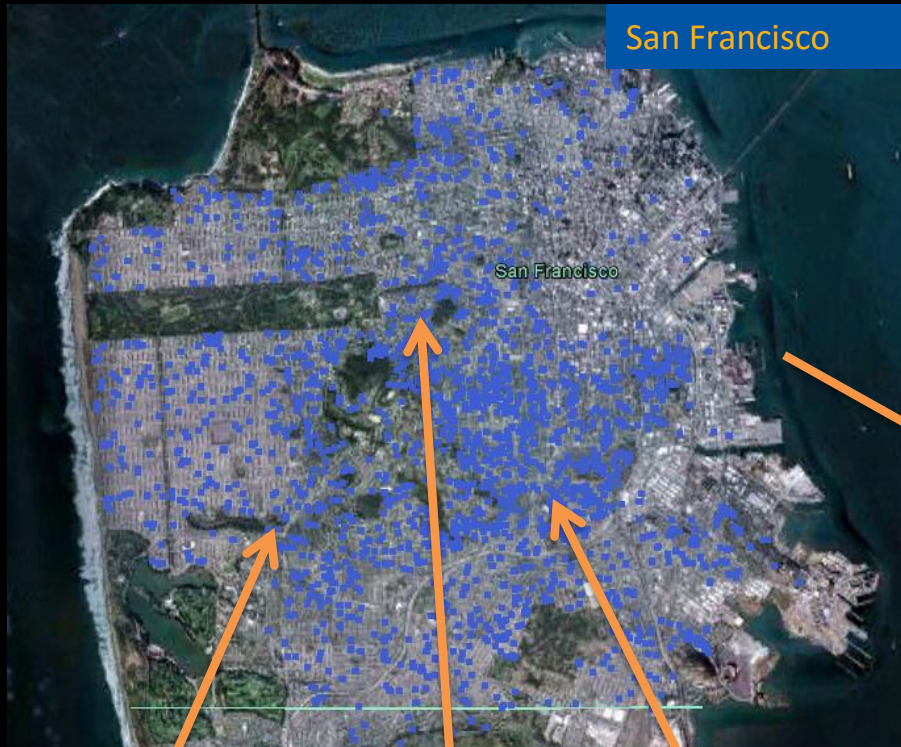
Centralized PV Plants



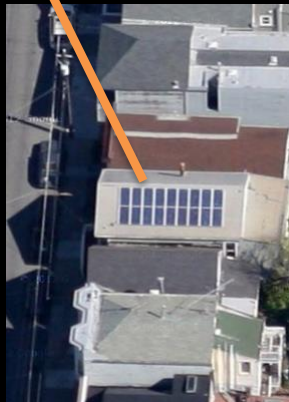
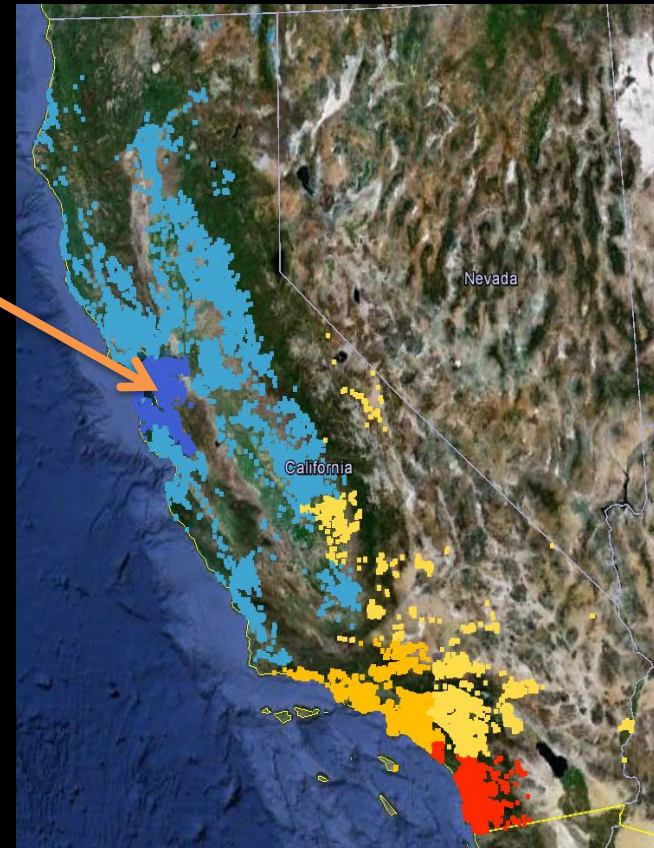
Distributed PV



APPLICATION: PV FLEET MANAGEMENT



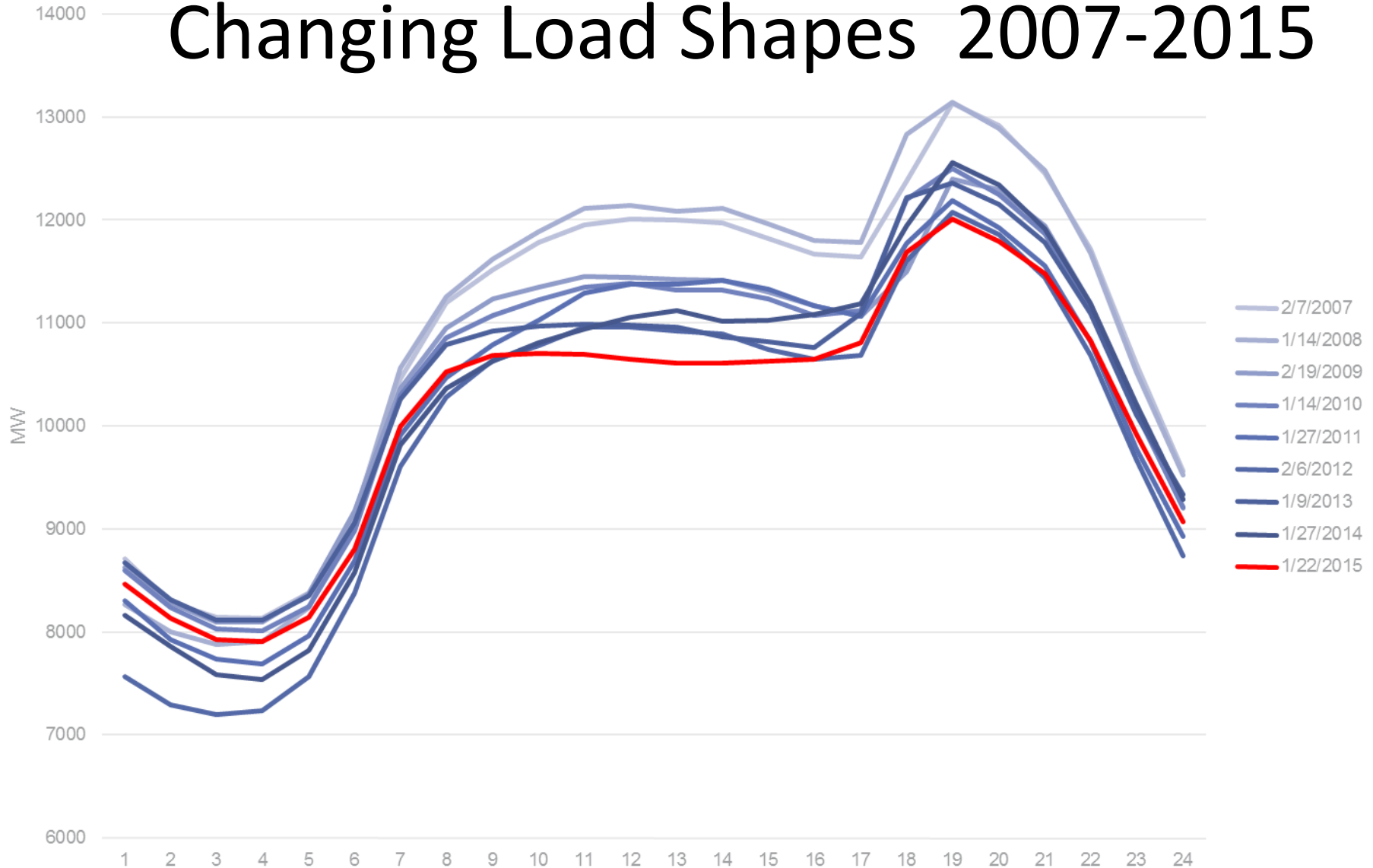
Distributed PV



Detailed Individual PV system specs (location, modules, inverter, layout, etc. details)

- PG&E Bay Area
- PG&E Non Bay Area
- SCE Coastal
- SCE Inland
- SDG&E

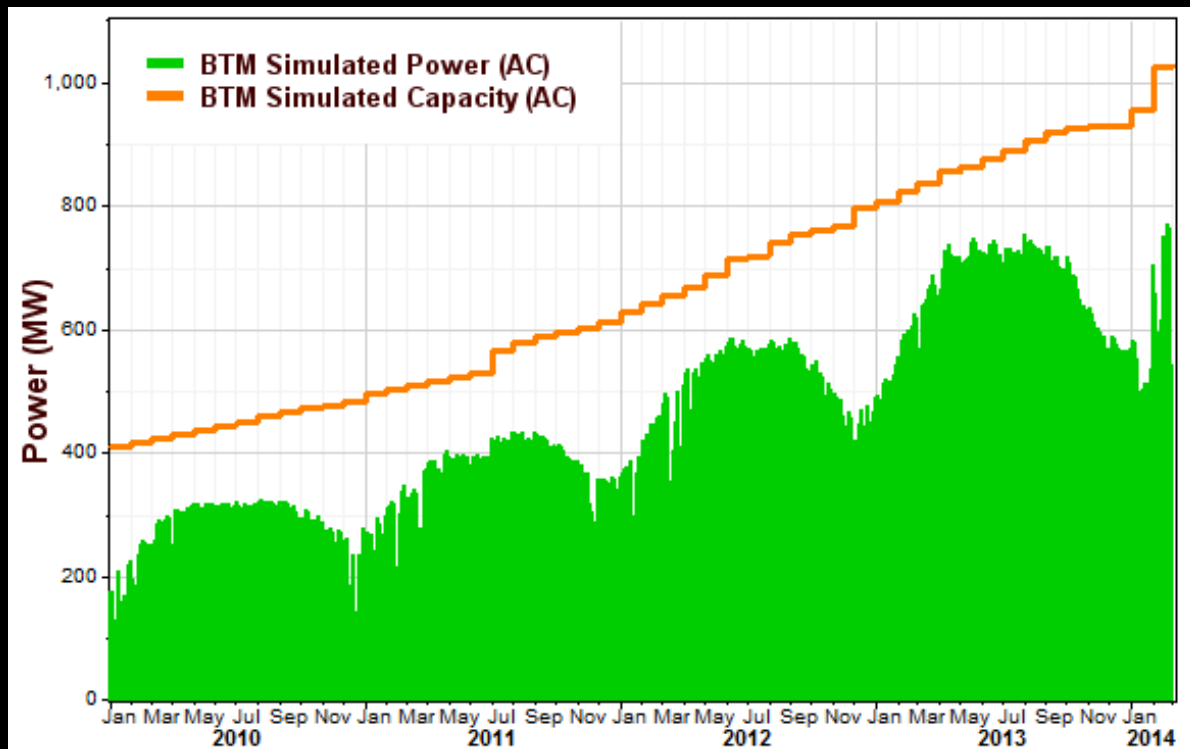
Changing Load Shapes 2007-2015



Data courtesy of the CAISO

Validation in Load Forecasting Models

- Itron and CAISO evaluated SolarAnywhere PV fleet historical production as training input into CAISO's Automated Load Forecast System (ALFS)
- Regions modeled from Jan 2010 through Feb 2014



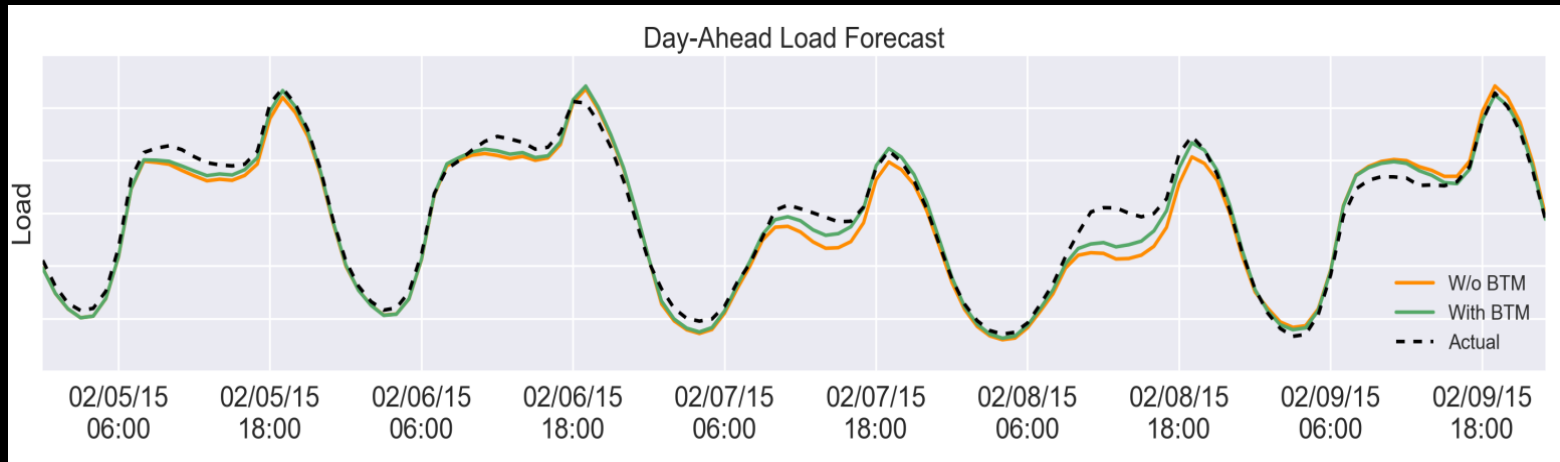
Preliminary Results (Historical Load Training)

| Hour of Day Ahead Forecast | 9 am | | 12 pm | | 3 pm | |
|------------------------------------|-------|-------|-------|--------------|-------|--------------|
| CPR BTM Dataset? | No | Yes | No | Yes | No | Yes |
| Load Forecast Error (MW) | 122.3 | 121.7 | 136.7 | 130.1 | 149.3 | 142.7 |
| Load Forecast Error (%) | 1.11% | 1.10% | 1.18% | 1.12% | 1.27% | 1.21% |
| BTM Coefficient | - | -0.21 | - | -0.92 | - | -0.94 |
| T-test (significant if < -1.64) | - | -1.8 | - | -10.1 | - | -8.9 |

- A BTM coefficient of -1 is the ideal result (i.e., for every predicted MW of BTM generation, one MW of load is shed)
- BTM production datasets offer a statistically significant improvement for mid-day and late-afternoon load forecasting
 - results lie quite close to the theoretical value of -1
- BTM production datasets offer a smaller impact for morning load forecasting
 - Believed to result from higher morning load variability

Data courtesy of Itron, CAISO

Preliminary Results (Load Forecasting)



- Historical training used as the base for inputting operational forecasting to the ALFS
- BTM forecasts significant improvement for mid-day and late-afternoon load forecasting
 - 9-months of results, up to 18% improvement on accuracy (at 2 PM DA prediction)

Data courtesy of Itron, CAISO

Preliminary Results (Load Forecasting)

| Minutes Ahead | % Forecasts Improved |
|---------------|----------------------|
| 15 | 2.90% |
| 30 | 15.70% |
| 45 | 2.90% |
| 60 | 27.10% |
| 90 | 32.90% |
| 120 | 41.40% |
| 180 | 41.40% |
| 240 | 55.70% |
| 300 | 77.10% |
| 360 | 82.90% |

Data courtesy of Itron, CAISO

Conclusions

- Irradiance forecasts can be optimized for the North American climate
- Application to grid operation is needed
- Historical training vital to the neural net load forecast model
- PV fleet forecasts generate improved load forecasts for day-ahead and 2-6 hour ahead horizons



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Thank You



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