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NATIONAL RENEWABLE ENERGY LABORATORY

Solar Uncertainty Management and Mitigation for Exceptional Reliability in Grid Operations (SUMMER-GO)

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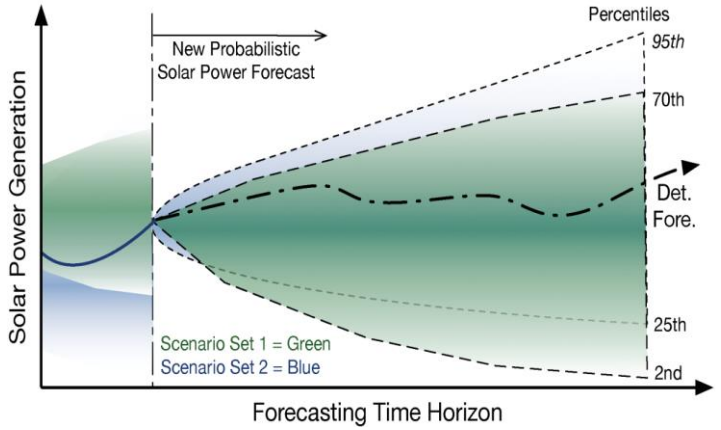
ESIG Meteorology & Market Design for Grid Services Workshop

SUMMER-GO

SUMMER-GO: Solar Uncertainty Management and Mitigation for Exceptional Reliability in Grid Operations

SUMMER-GO will bring probabilistic solar forecasts into ERCOT's real-time operation environment through automated reserve and dispatch tools that increase economic efficiency and improve system reliability.

- Develop accurate, calibrated, and sharp probabilistic solar power forecasts for both ***hourly*** and ***5-minute*** resolution
- Develop and validate risk-parity economic dispatch for ***5-minute dispatch period***
- Develop and validate adaptive reserves algorithm to ***reduce flexibility and regulation reserves*** and ***deploy in ERCOT'S iTest system***
- Produce situational awareness tool to present timely information for ***better decision making***



University of Colorado Boulder · RASEI Renewable and Sustainable Energy Institute · ercot · MAXAR Technologies · UT Dallas · Berkeley University of California

Why Use Probabilistic Forecasts?

	Pros	Cons
Point Forecast ("Deterministic")	• Simple, easy to understand	• Always wrong to some degree • Erodes operator confidence in the forecast
Probabilistic Forecast	• Demonstrates uncertainty in the forecast • Builds operator confidence in the forecast over time	• Not intuitive, takes some practice to understand

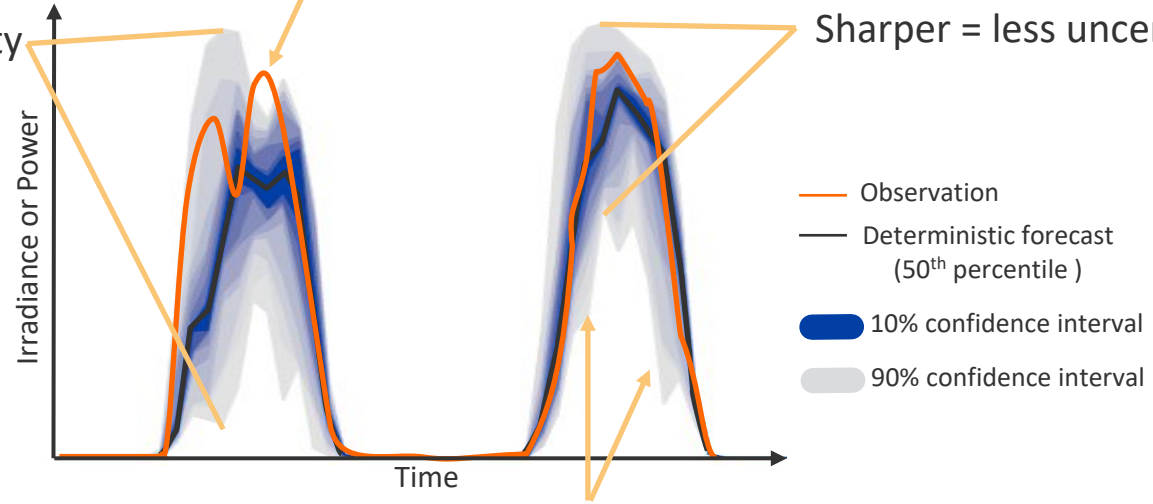
Calibration: Does 20th percentile get hit 20% of the time?

Sharpness: How concentrated are the confidence intervals?

Not sharp = high uncertainty

Observation exceeds 90% confidence bounds – this is still expected 10% of the time

Sharper = less uncertainty



Resolution: does the method generate case-dependent forecasts?

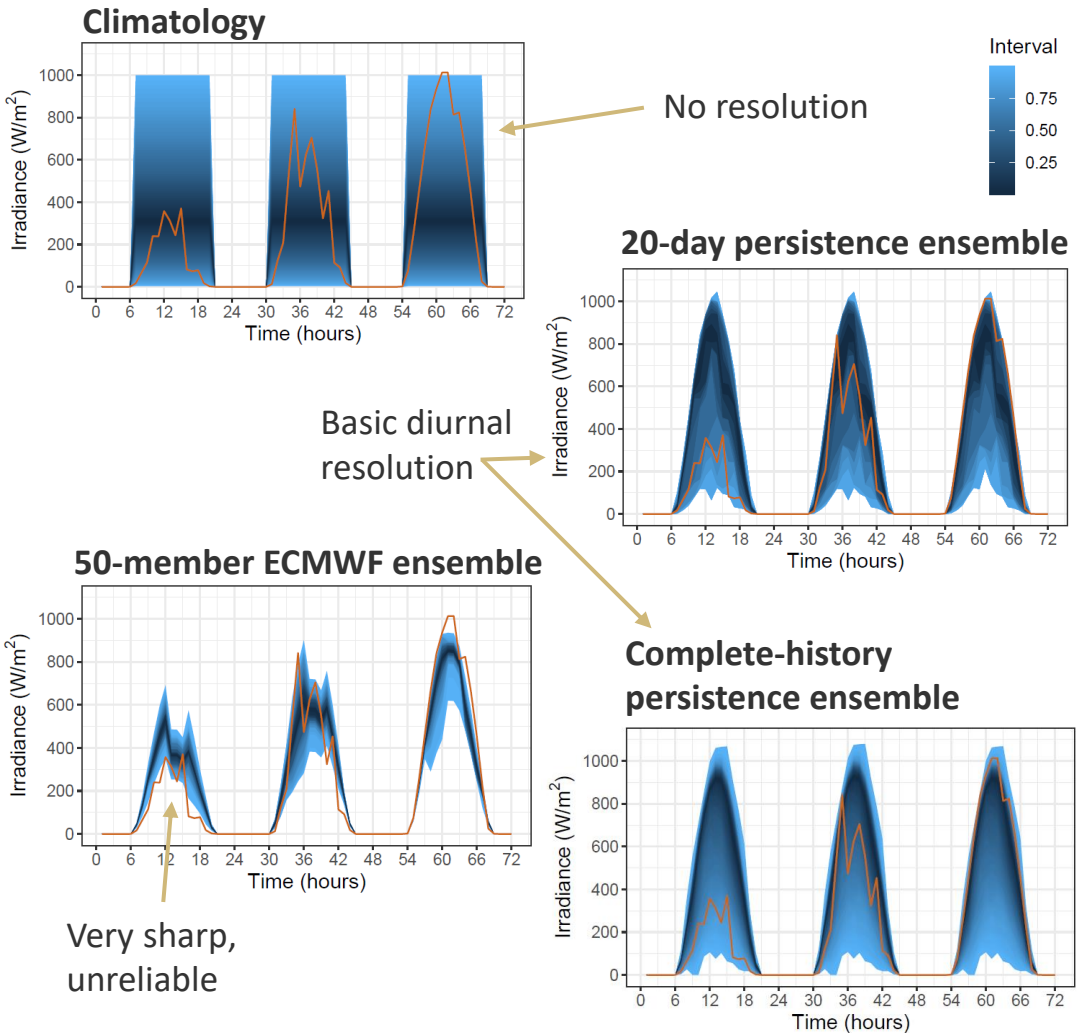
Research on Probabilistic Forecast Benchmarks

How do we properly assess improvement in probabilistic forecast methods?

What are the most common and/or useful probabilistic solar forecast benchmarks?

Illustrated characteristics and recommended implementations of benchmark probabilistic methods

- 5 methods implemented at hourly-resolution for day-ahead forecast
- 5 methods implemented at 5-minute resolution for hour-ahead forecast
- Code shared with Project Area 1 Team and open-sourced on Github
- SolarArbiter implemented persistence ensemble as a standard benchmark



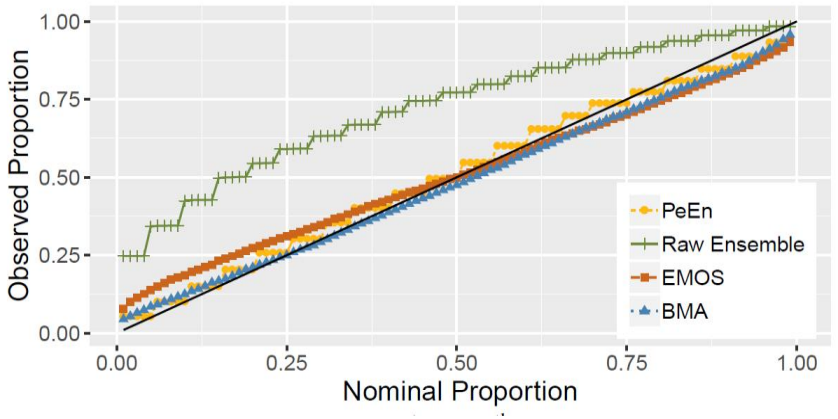
Advanced Probabilistic Forecast Methods

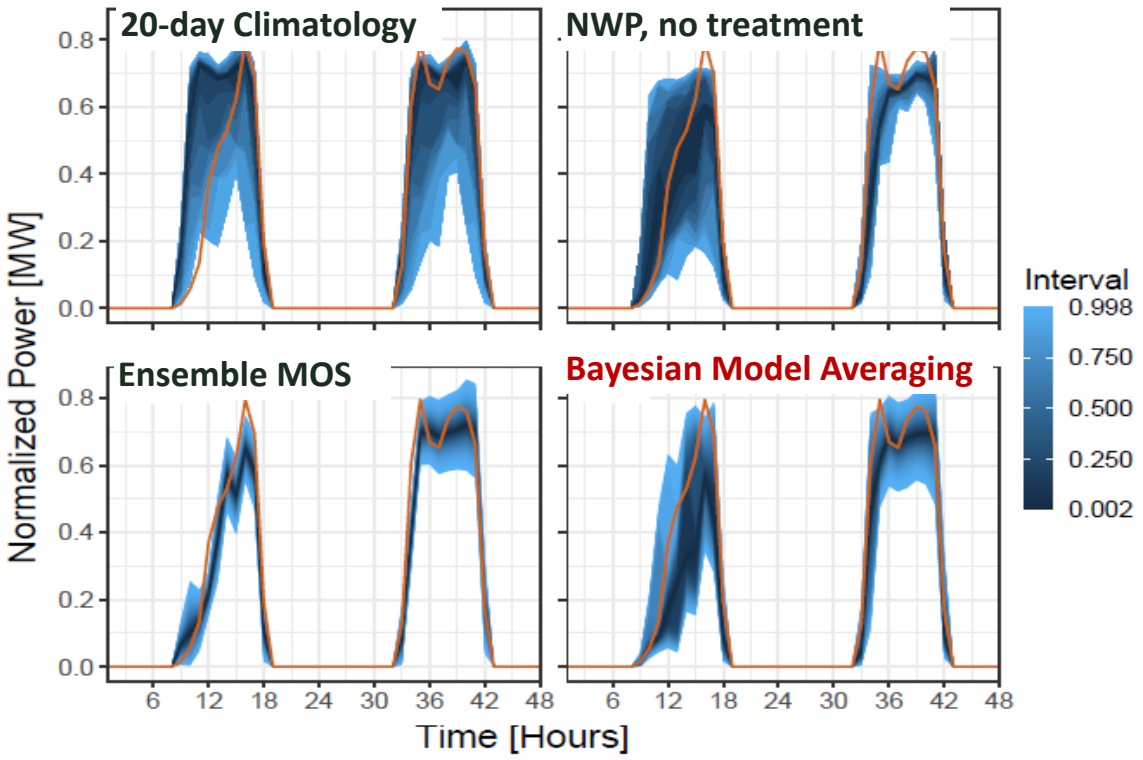
Developed new Bayesian model averaging (BMA) method to post-process NWP ensembles

BMA regularly outperforms ensemble MOS

- Better Continuous Ranked Probability Scores (proper probabilistic metric)
- Better tail behavior
- Ensemble MOS's single parametric distribution can fail to capture disagreements in the ensemble

Ensemble model output statistics (MOS) uses normal kernel based on a weighted sum of members and ensemble variance



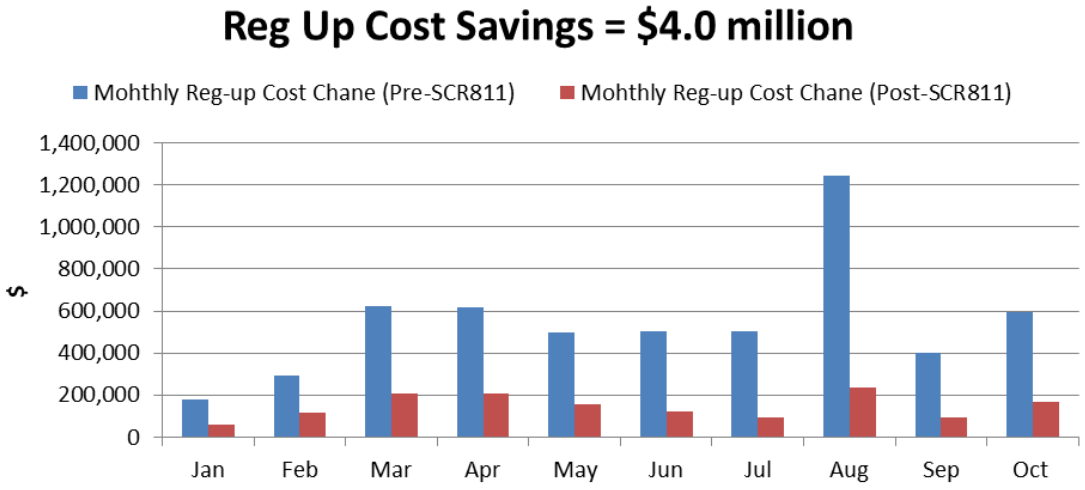


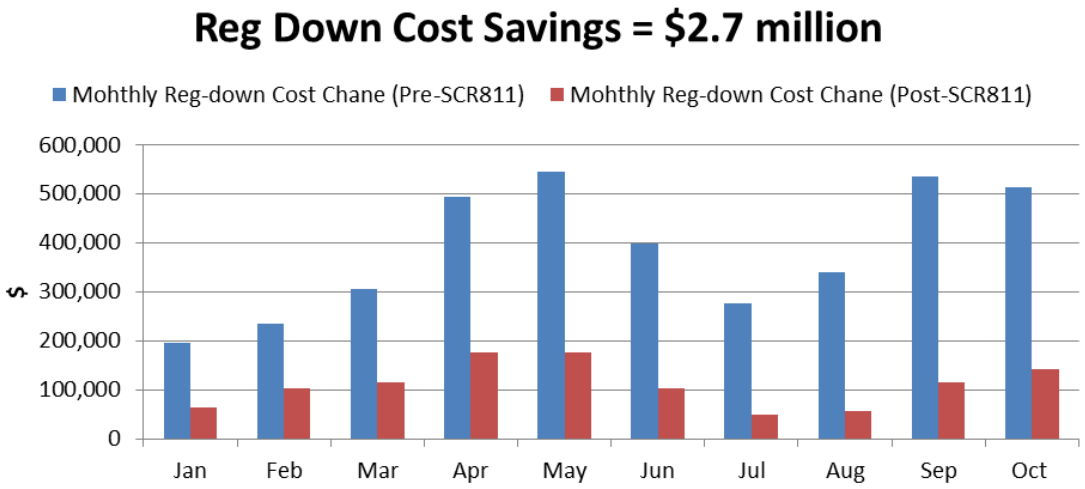
Advances to ERCOT's Operational Solar Forecasts

Temporal Resolution

- *Previously:* Hourly resolution
- *Now:* 5-minute resolution for first 2 hours, then hourly

- Currently testing in iTest system
- Will be operational on May 27nd
- ERCOT estimates $6-7 million savings from using new forecast in regulation reserve calculations





Advances to ERCOT's Operational Solar Forecasts

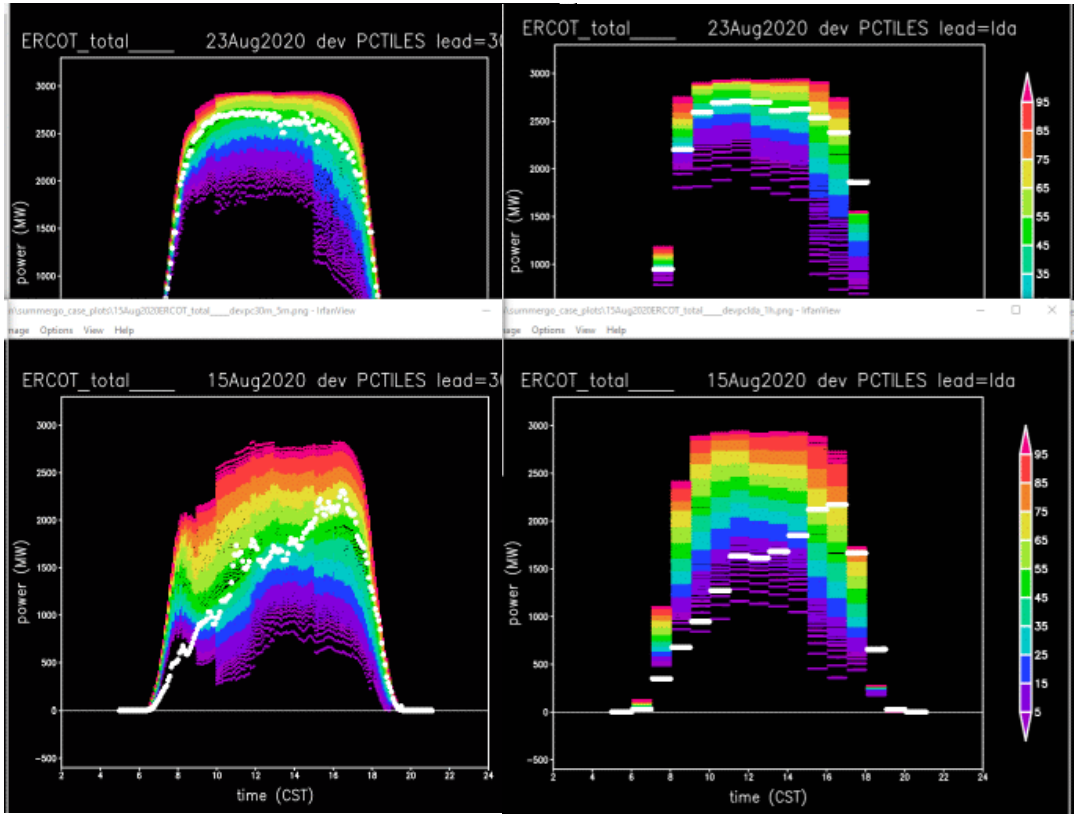
Probabilistic Format

- *Previously*: Point forecast (50th) and 20th percentile
- *Now:* All 99 percentiles available
- Maxar already providing operationally based on much larger NWP ensemble
- Upgrade to ERCOT's EMS to ingest new format expected end of year/early next

5-minute resolution, rolling 30-minute ahead ***Hourly resolution, Day ahead***

Sunny

Cloudy



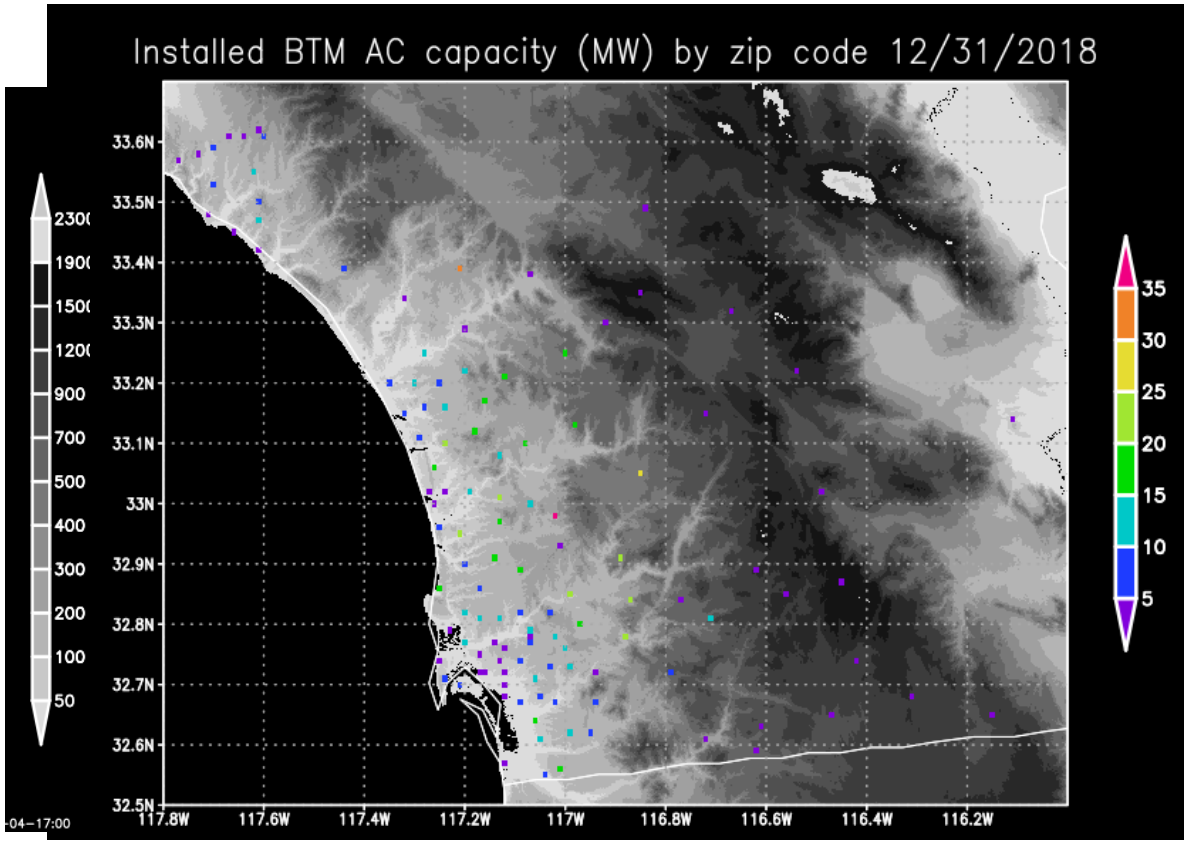
Behind-the-Meter Forecast Case Study

Conducting case study of probabilistic behind-the-meter (BTM) solar power forecasting for San Diego Gas and Electric (SDG&E) service territory

- Chose California because BTM penetration in Texas within “noise” of net load

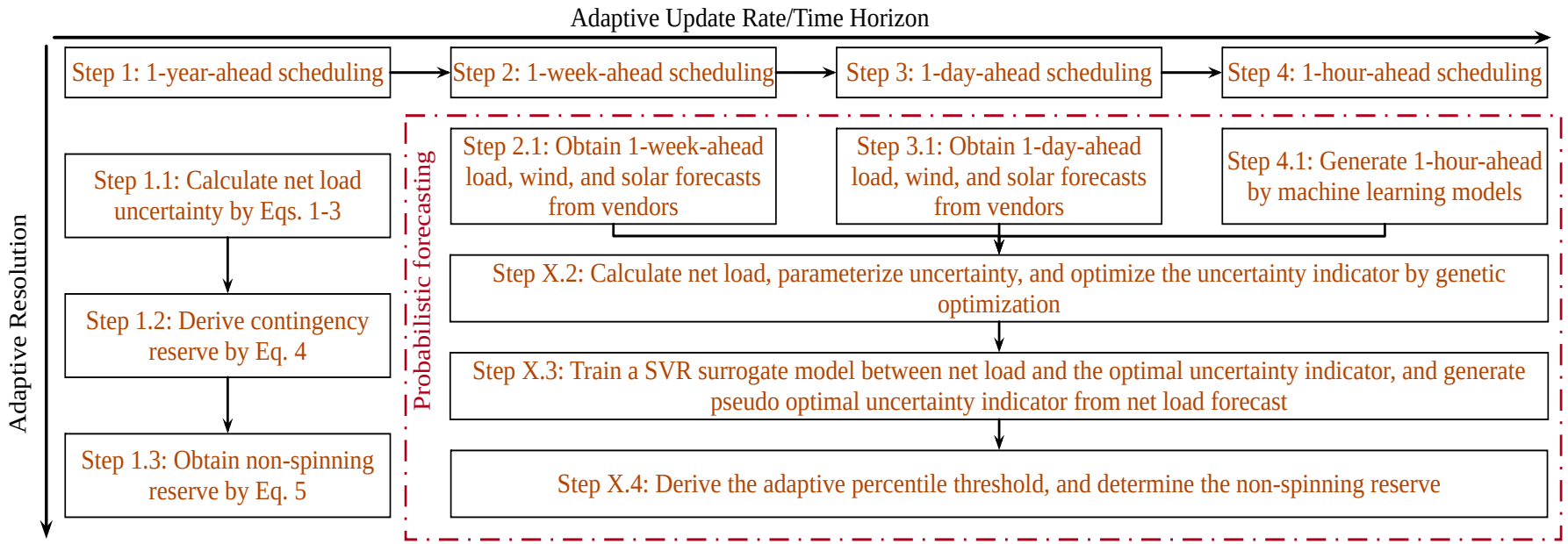
Zip-code scale bottom-up approach:

- 15-min zip-code average sampled power for 2-year period from Genscape
- California net-meter interconnected list is used to determine daily specifications by zip code
- Generating zip-code average power forecasts by translating Maxar weather forecasts through PVWatts



Forecast Applications: Non-Spinning Reserves

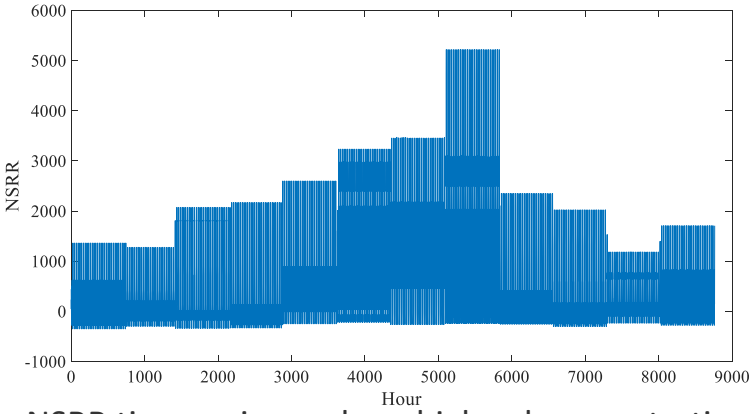
Use probabilistic forecasts to improve scheduling of non-spinning reserve requirements (NSRR) from year-ahead to hour-ahead



Overall framework of the developed method for NSRR estimation

- ✓ Follow ERCOT NSRR estimation procedure
- ✓ Take forecasting error into account
- ✓ Add four-step flexibility

Dynamic Non-Spinning Reserve Results



NSRR time series under a high solar penetration

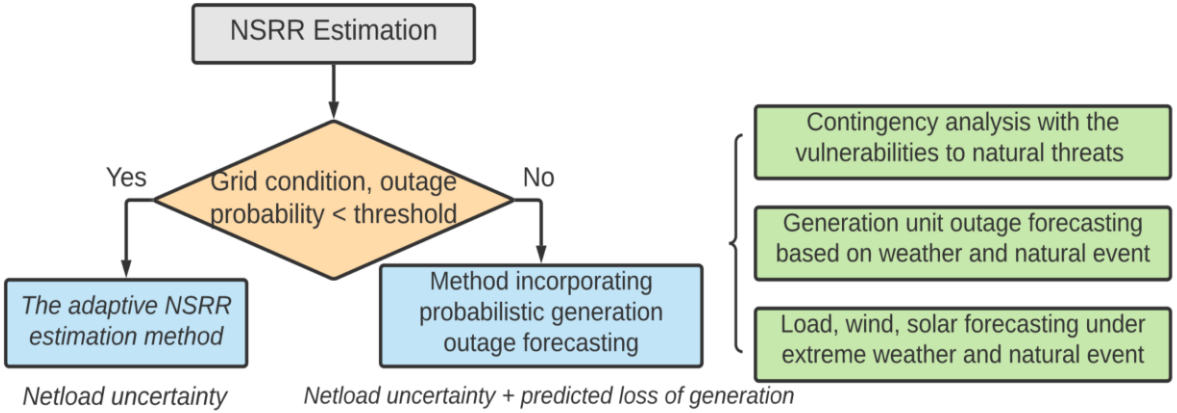
Hourly average NSRR [MW]

Method	Note	Hourly average
ERCOT	The current ERCOT method	2353.87
1HA	Hourly updated reserve under low solar	1414.75
1HAHS	Hourly updated reserve under high solar	539.82

- The hourly NSRR is reduced by **39.89%** and **77.07%** based on 1 hour-ahead forecasts under low and high solar penetration, respectively, compared to 1-year-ahead scheduling
- Negative values mean no NSRR is required during these time periods
  - Negative values replaced with 0 in post-processing

Current Work: Dynamic Reserves under Extremes

Extending previous work inspired by extreme conditions in Texas in Feb. 2021

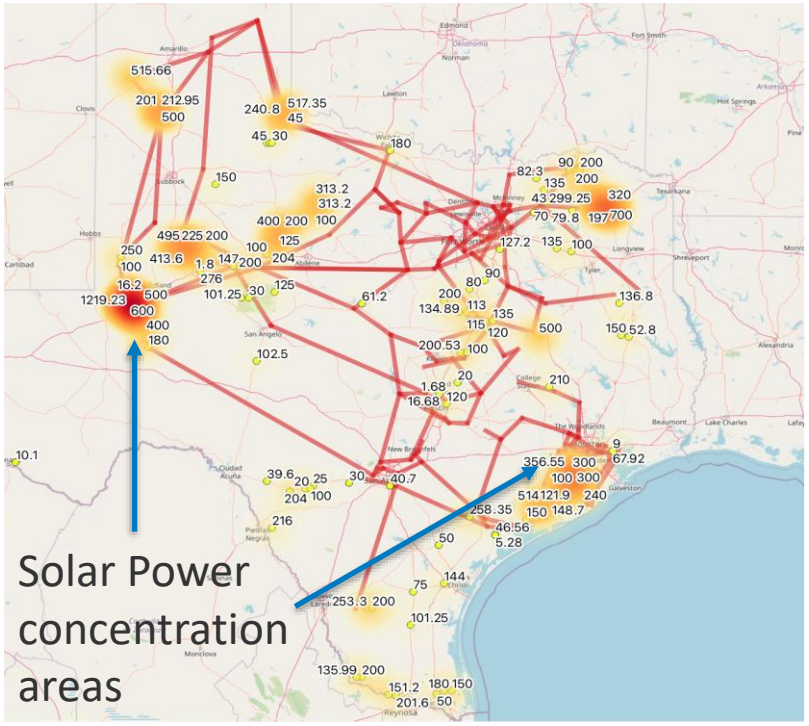


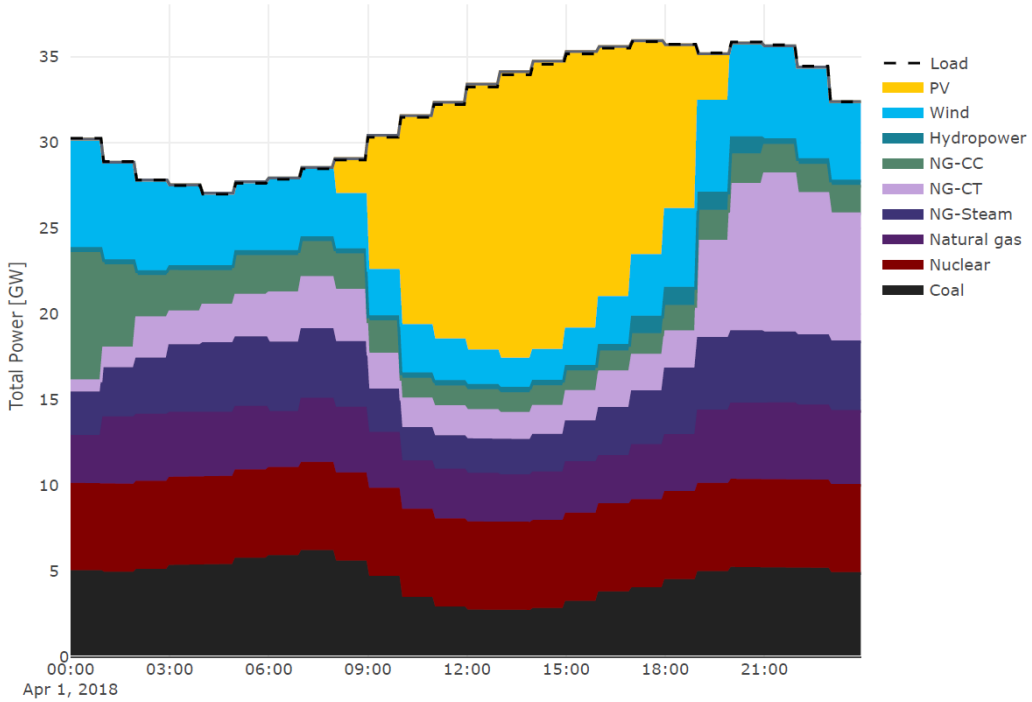
Under extreme conditions

- **Vulnerabilities**: Determine the factors that are most discriminatory between minor and major power outage events.
- **Outages**: Identify generators with high probability of failure.
- **Forecasting**: Accurate load/wind/solar forecasting is needed for reliable system operations.

Operational Simulations with High Solar Penetrations

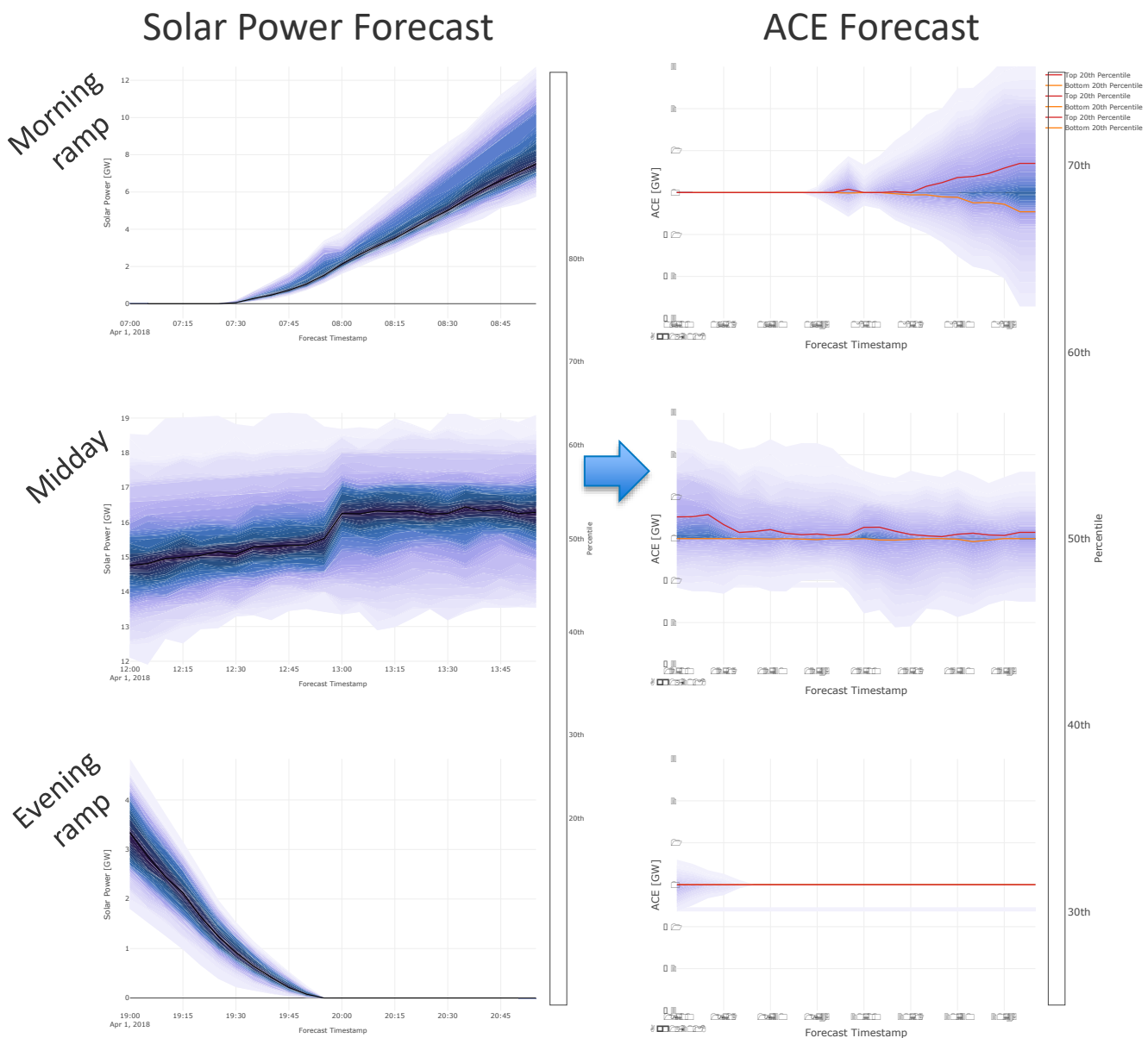
- Developed very high solar penetration model system based on ACTIVSg2000 synthetic system of Texas
- Added 110 new solar plants (20 GW) of solar power based on ERCOT's Interconnection Queue
- Instantaneous solar penetrations up to 45%
- Testing day-ahead and real-time operational algorithms using probabilistic forecasts of system-total solar power





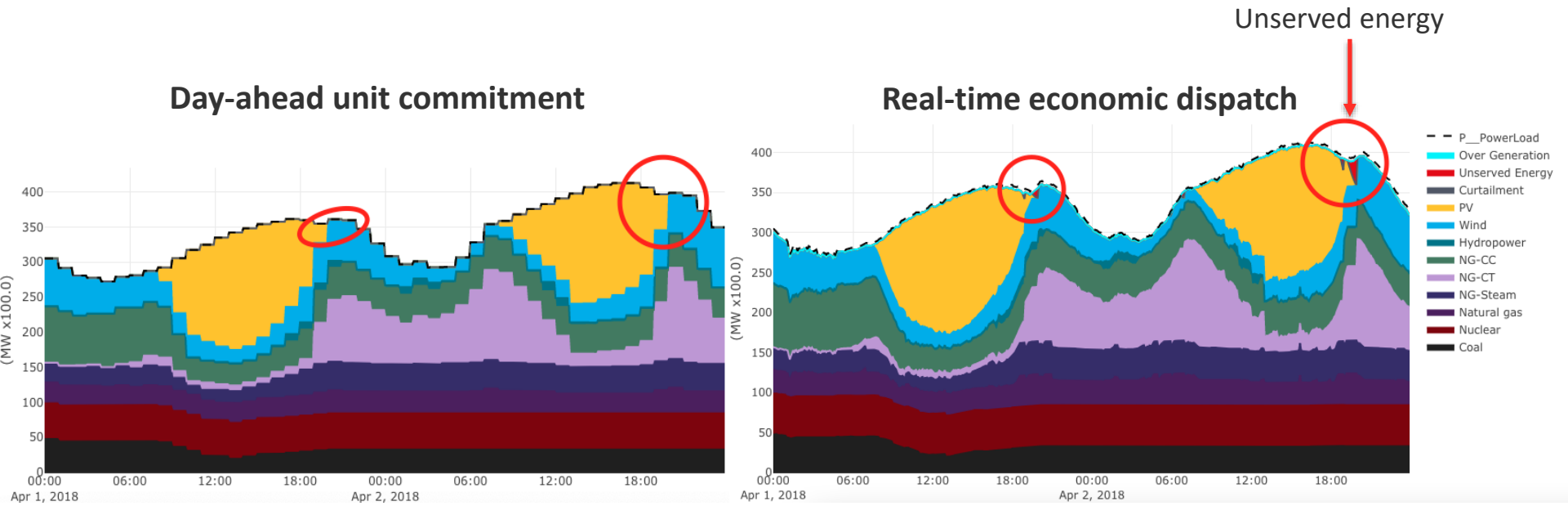
Mapping Probabilistic Forecasts into System Operation Forecasts

- Map probabilistic solar forecasts to probabilistic forecasts of corrective actions
  - E.g., reserve deployment
- Enhances operator's situational awareness about future system states
- Could prompt preventive actions, like reserve substitution or curtailment

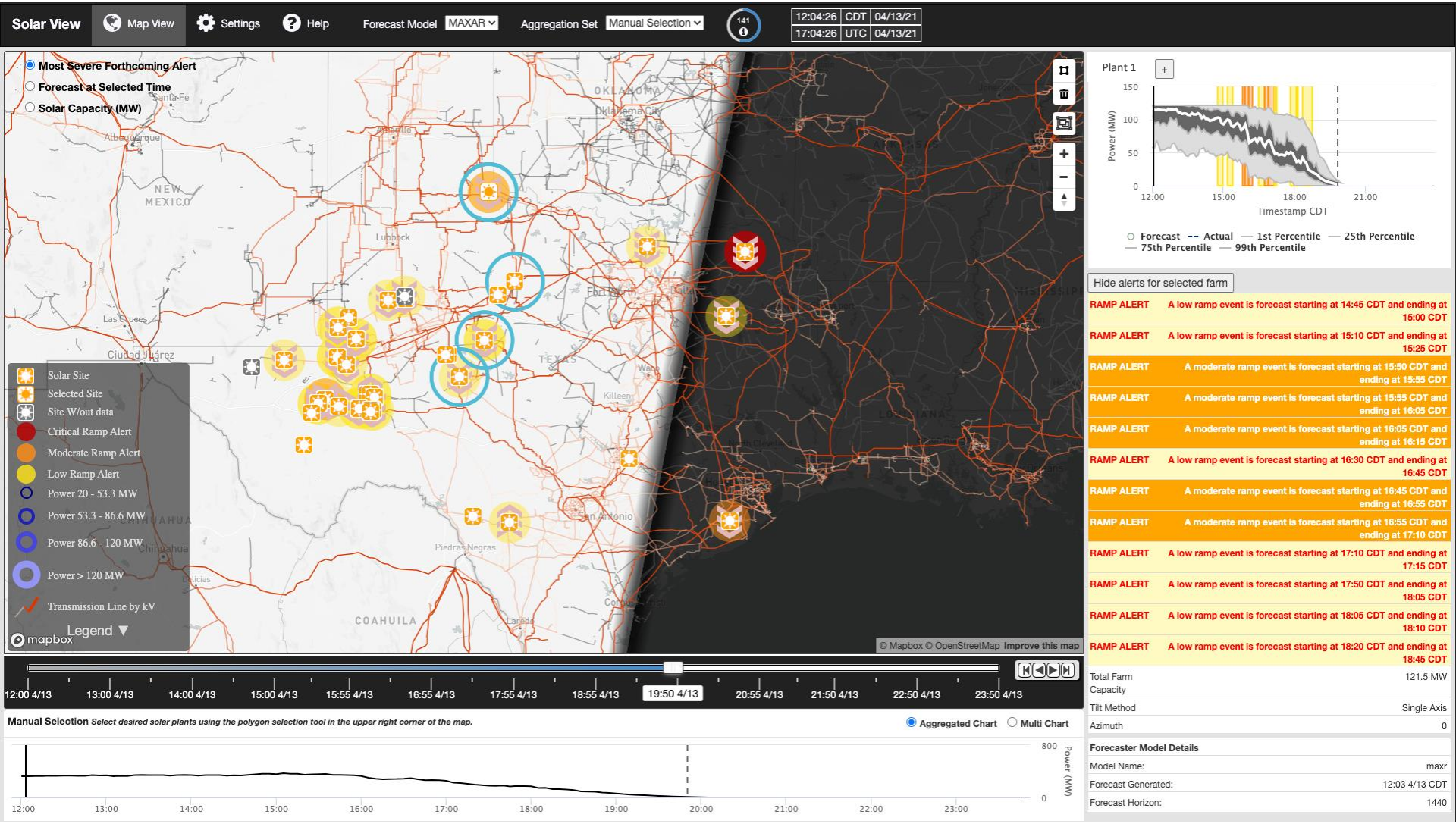


Current Work: Unit Commitment with Solar Ramps

- Focusing on risks relevant to day-ahead decision making: Ramping capacity for steep diurnal solar ramps
- Hourly resolution day-ahead unit commitment can result in insufficient intra-hourly ramping capacity
- Using probabilistic solar forecast scenarios to model the risk of needing to take future recourse actions at the hour-ahead timescale



SolarView Visualization Tool



Thank You

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