



Distributed Solar Electricity Smoothing to the Grid

Tom Hoff, February 29, 2012



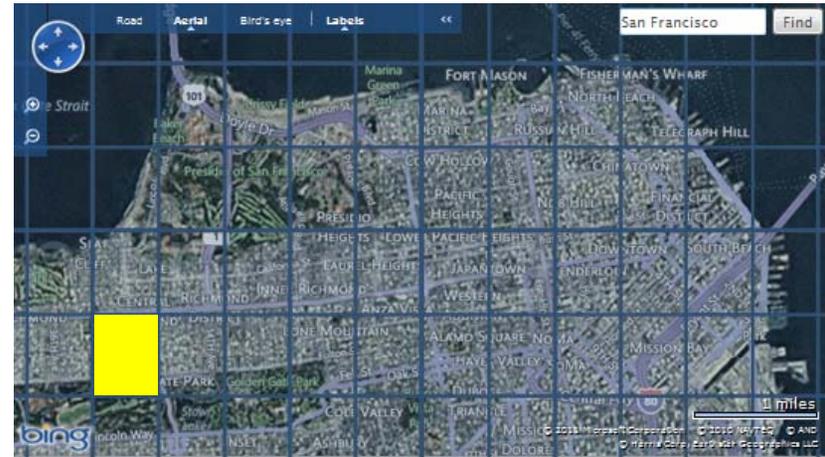
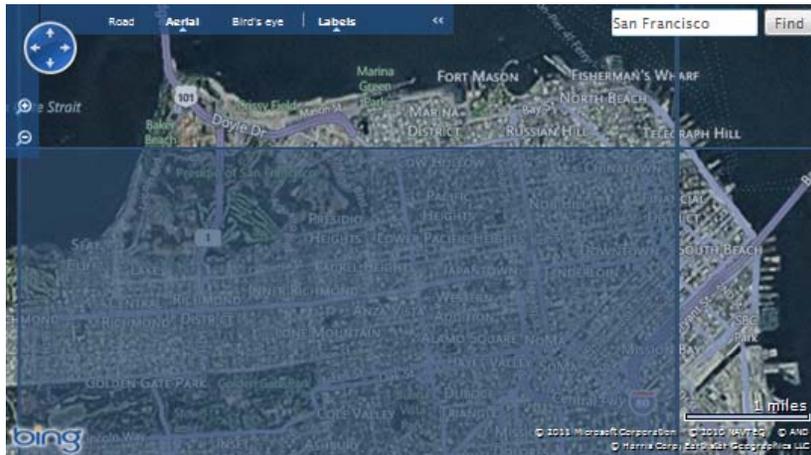
California ISO
Shaping a Renewed Future



Clean Power Research®



CSI R&D Phase I Grant



Example: San Francisco, CA



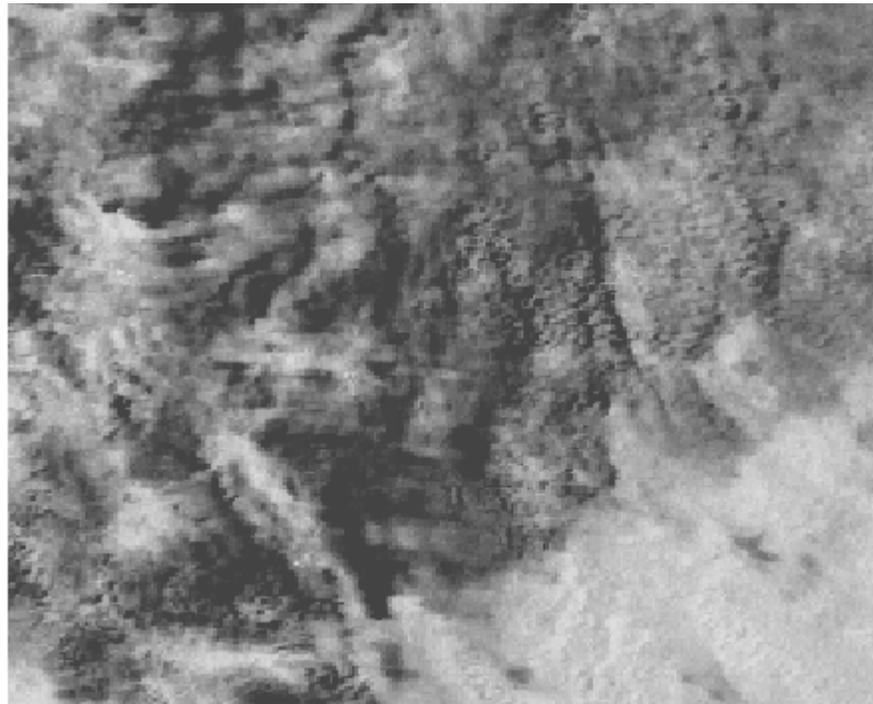
CEC PIER Grant



- *Goal: Validate existing research and tools in partnership with the California ISO, and to integrate the methodologies into the California ISO planning process in order to address existing and future variability from PV generation*
- *Acknowledgements*
 - Funding support from the CEC PIER program
 - Data and direction support provided by Jim Blatchford and others at California ISO

Cloud Motion Vector Approach

16:29



Each image is composed of 90,000 1 km x 1 km tiles

Source: Perez

Quantify Accuracy Using Measured Data

- *Irradiance and simulated PV output*
- *Multiple time intervals*
 - *Long (year, month, day)*
 - *Medium (1 hour, ½ hour)*
 - *Short (minute, seconds)*
- *Individual locations and fleets*
- *Historical and forecasted*

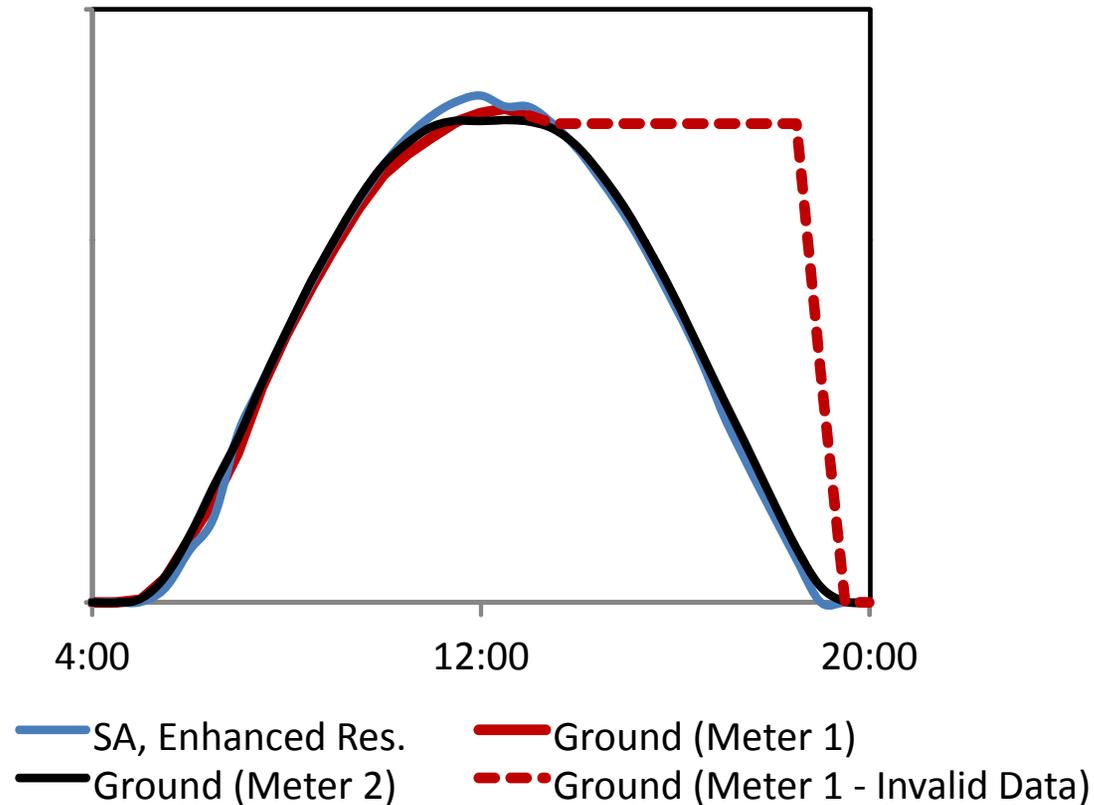


Approach

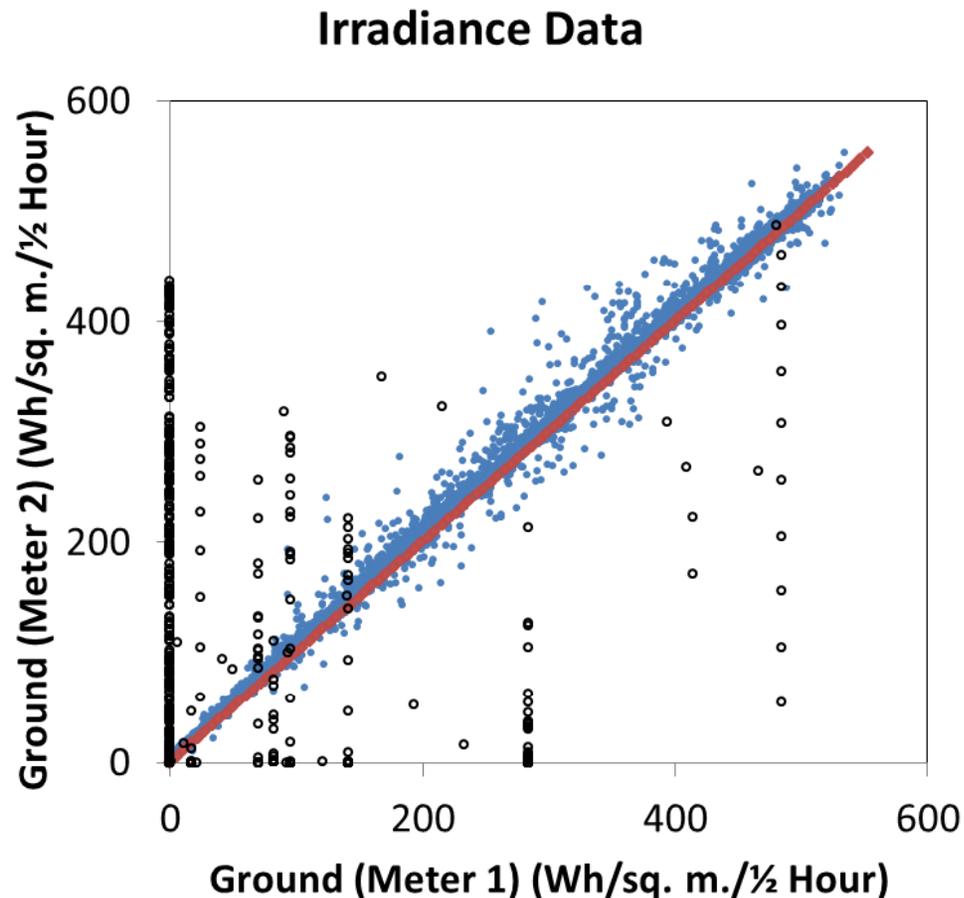
- Obtain ½ hour GHI data for 2011 for 6 locations
 - Ground data from two separate sensors from California ISO
 - SolarAnywhere Enhanced Resolution data
 - SolarAnywhere Standard Resolution data (1 hour data)
- Evaluate every data point for data quality
- Calculate Mean Absolute Error relative to energy (***not capacity***)
- Extend results to fleets



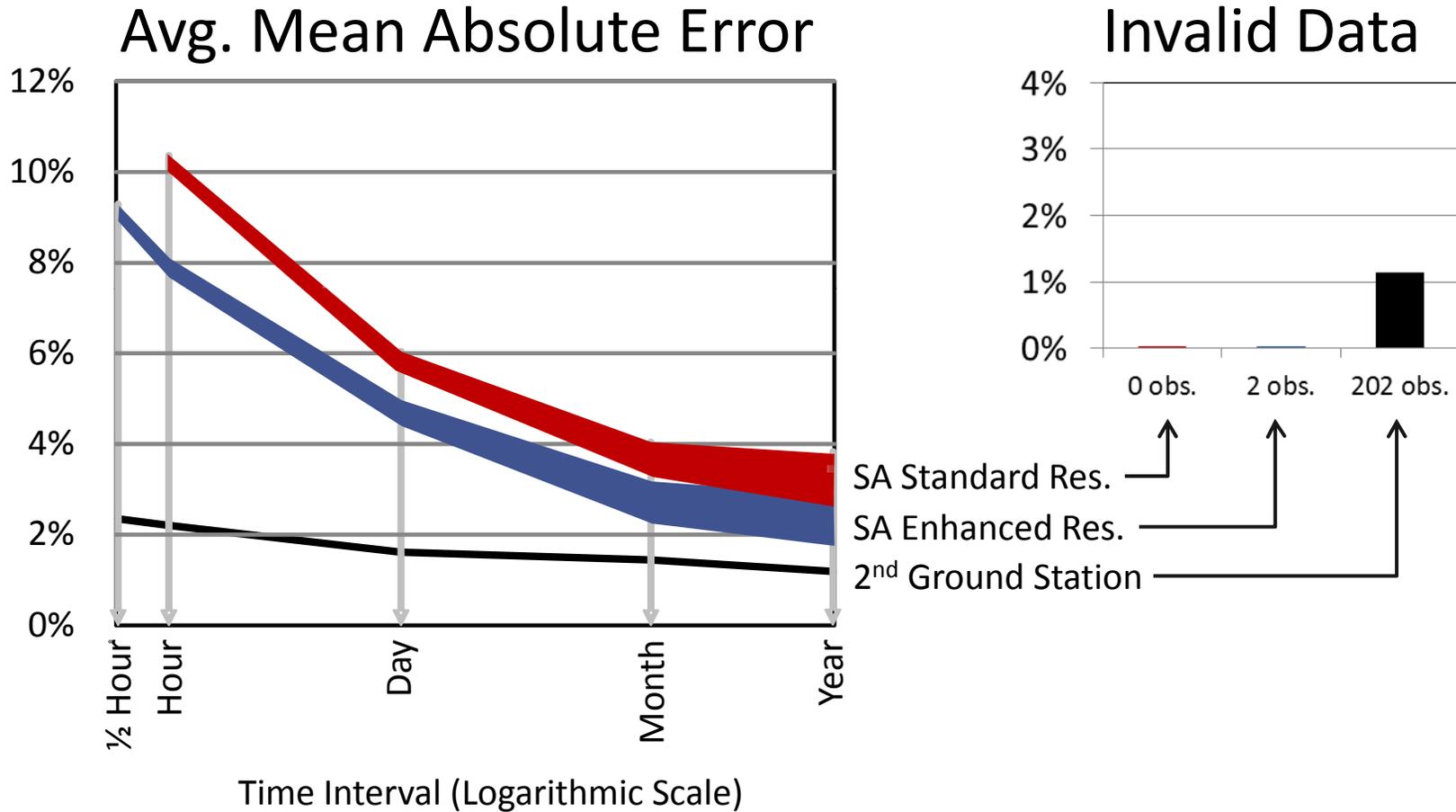
Example of Invalid Ground Sensor Data (Site A, June 22, 2011)



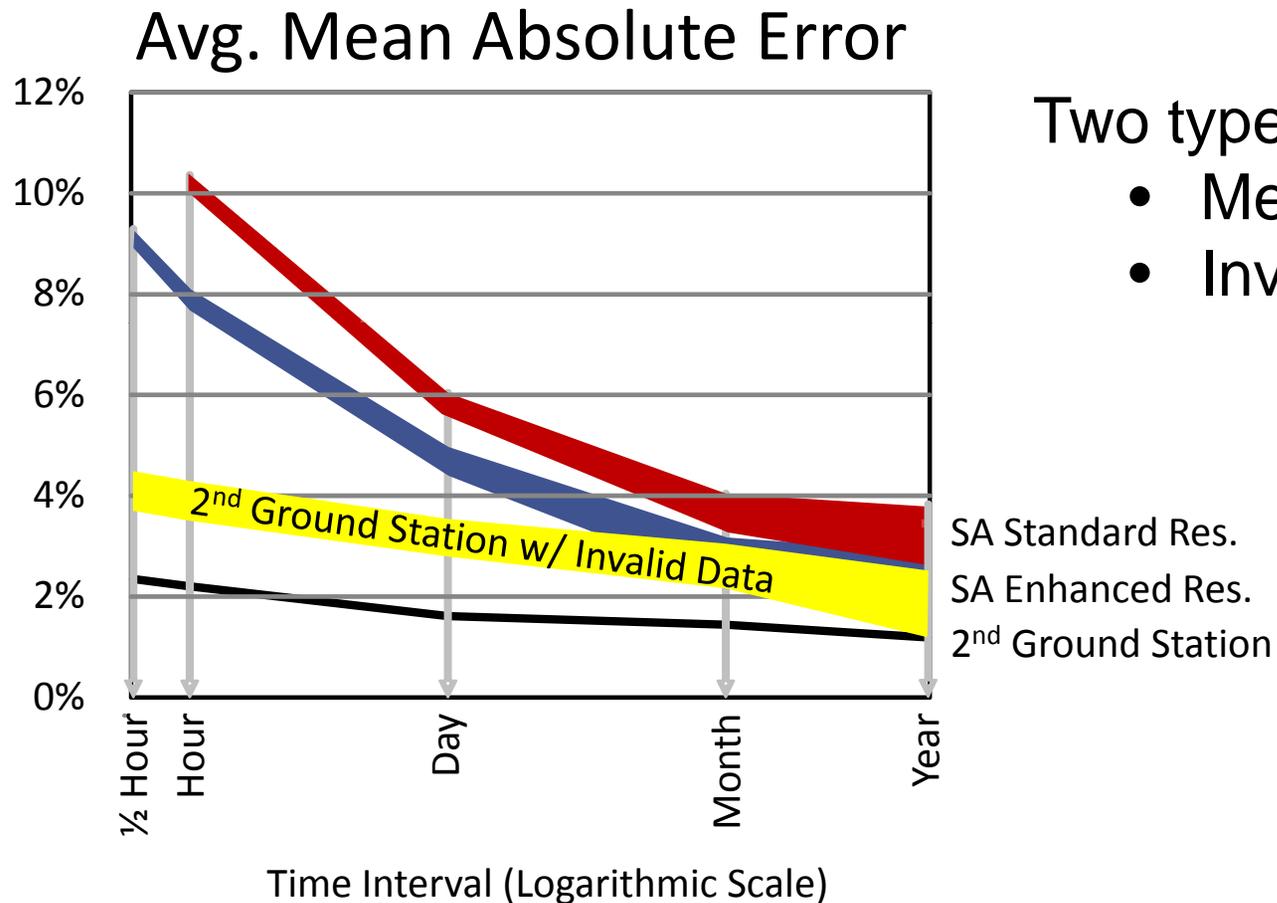
Screen Invalid Data Using 2nd Ground Sensor and SA Enhanced Resolution (Site A)



Summary: Average of 4 Individual Locations



Effect of Data Quality Issues?

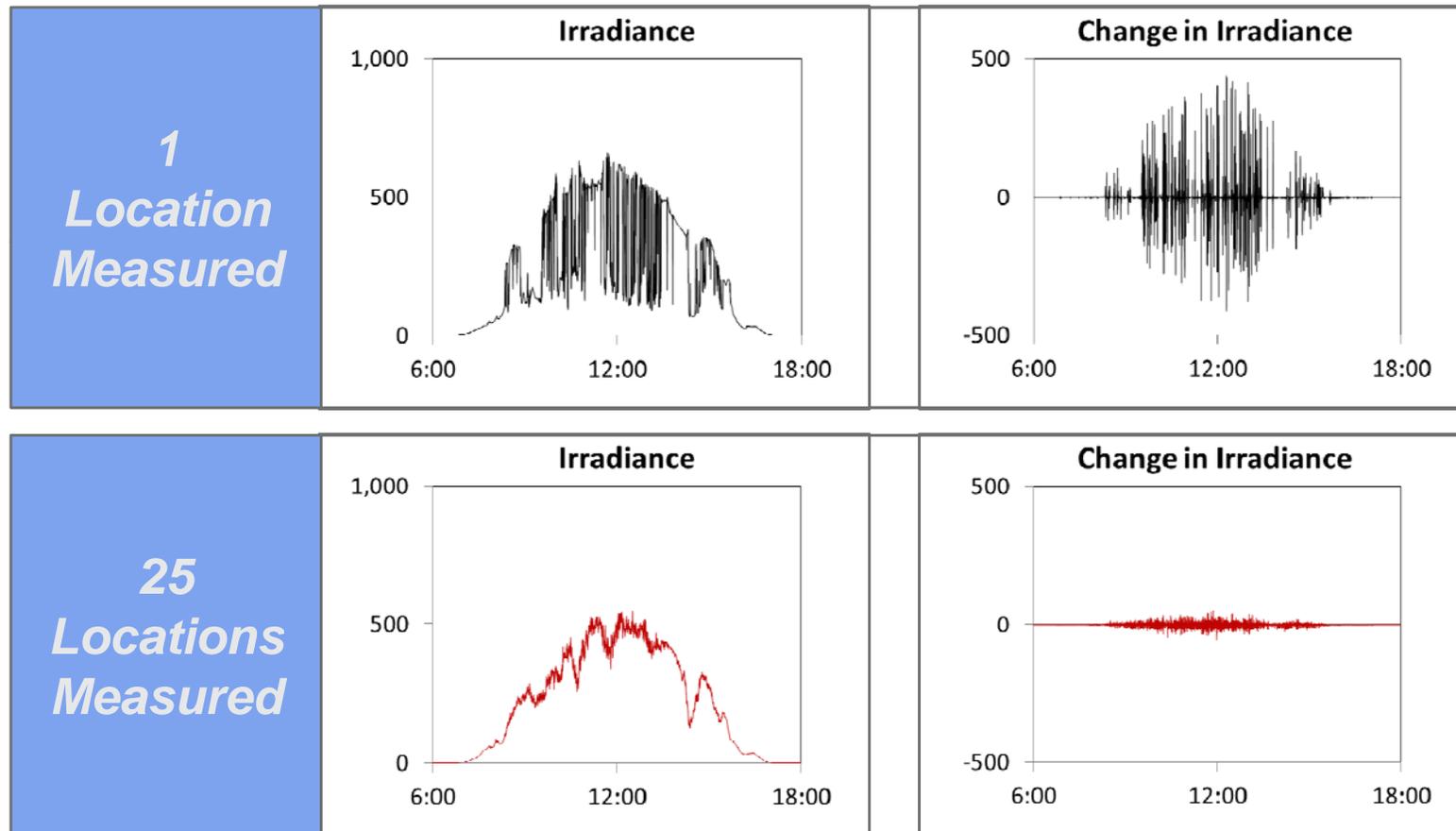


Evaluate the fleet, not individual systems



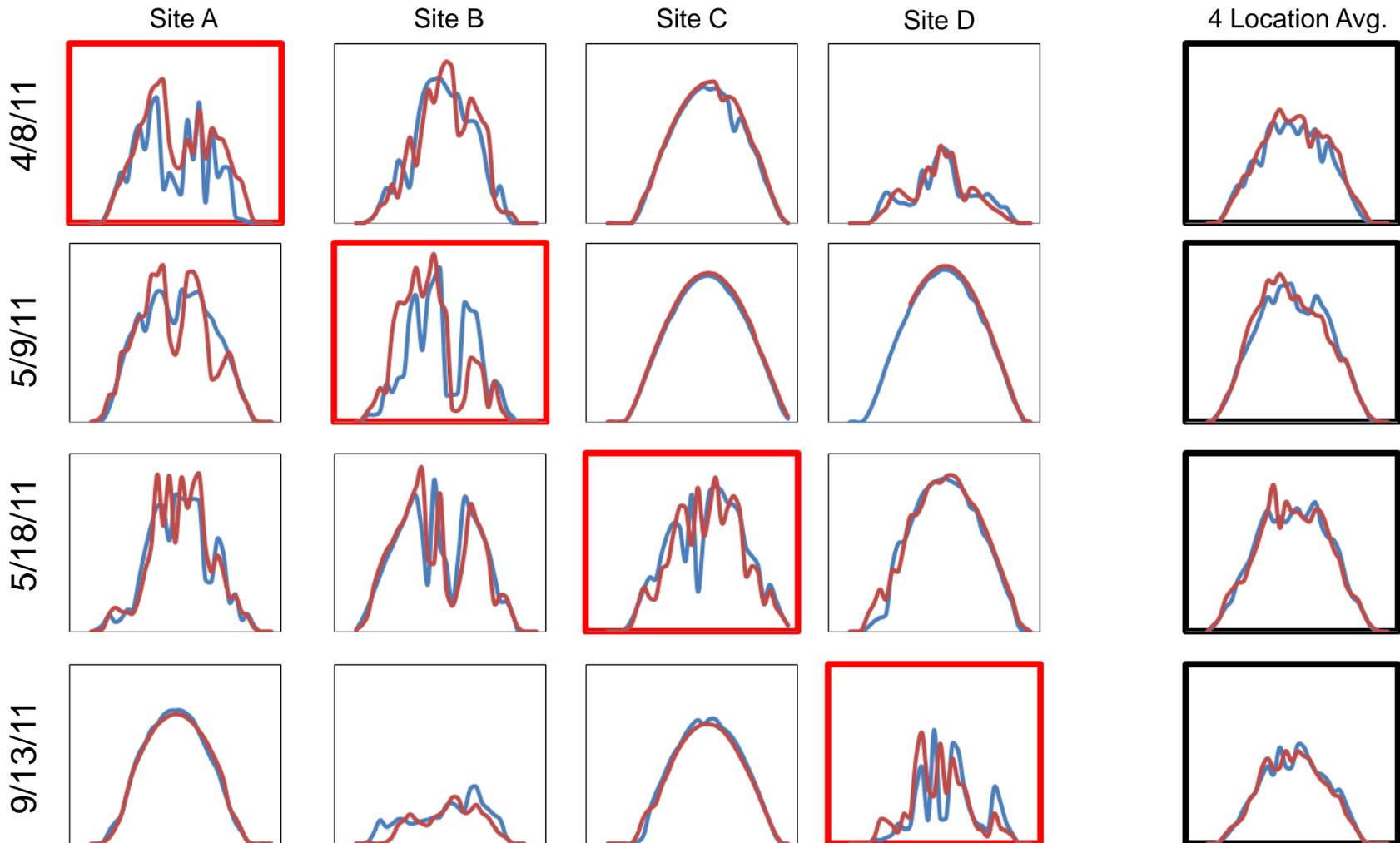
Output Variability Reduces with Geographic Diversity

10 second irradiance data from 4 x 4 km grid in Napa on Nov. 21, 2010



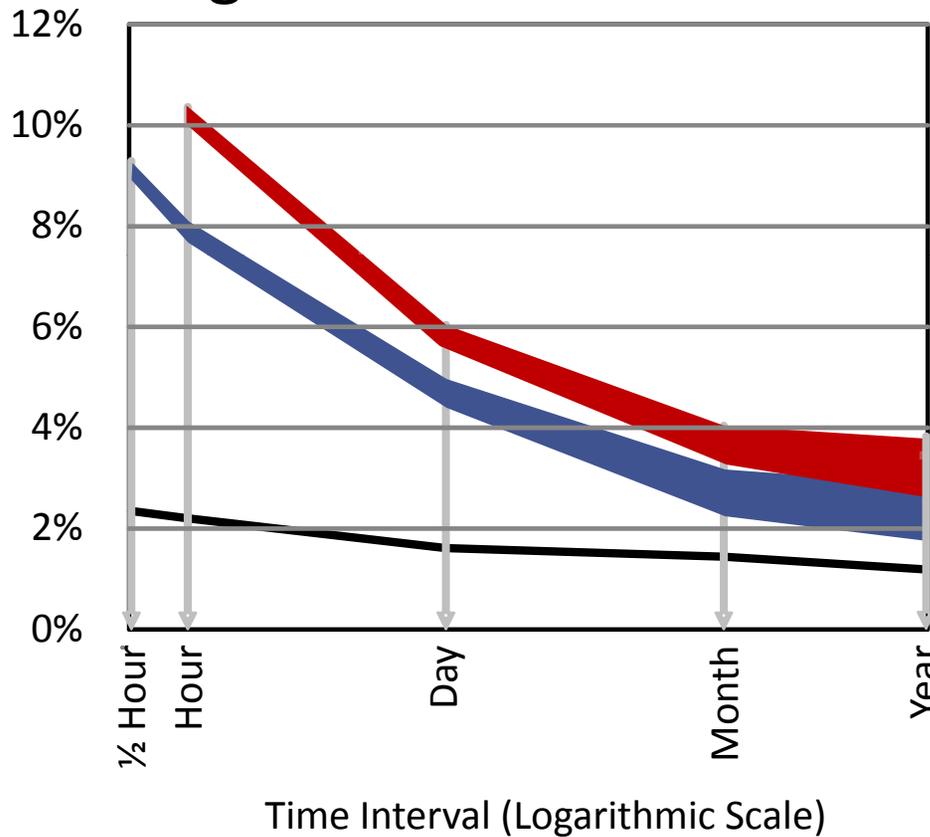
Days with Highest Half-Hour Errors

— SA, Enhanced Res.
— Ground (Meter 1)



Summary: Average of 4 Individual Locations

Average of Mean Absolute Error

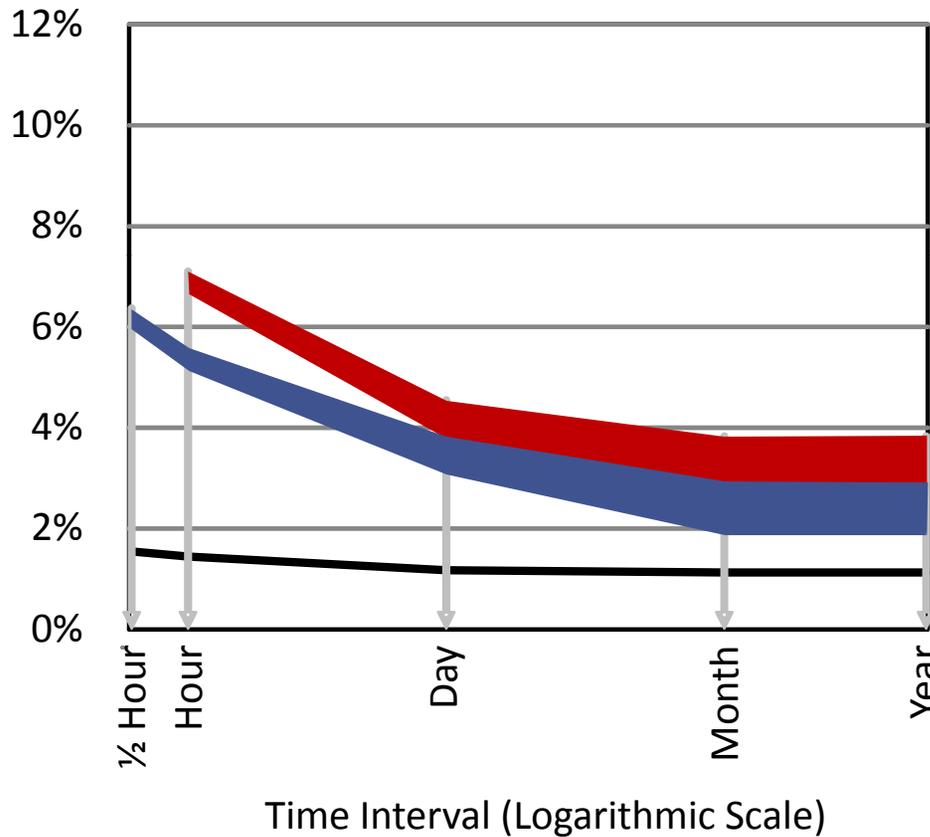


Invalid Data



Geographic Diversity Reduces Prediction Error

Mean Absolute Error of 4-Location Average



Invalid Data



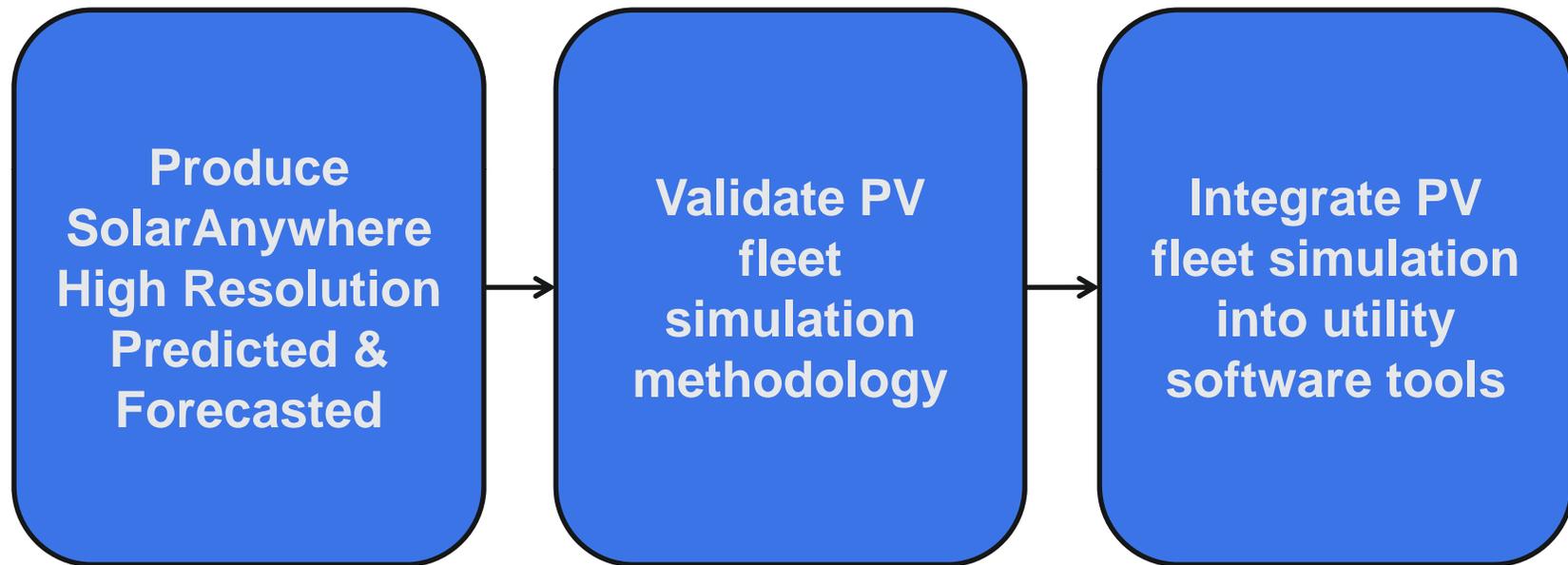
SA Standard Res. → 1 obs.
 SA Enhanced Res. → 8 obs.
 2nd Ground Station → 668 obs.

Conclusions

- Satellite-based irradiance data have essentially no invalid data; ground sensors have 1 percent invalid data
- SA Enhanced Resolution has annual error comparable to ground sensors and twice the hourly error when invalid data is included
- Accuracy improves (predictably) due to benefit of geographic dispersion



CSI R&D Phase 3 Grant





Thank you

Questions?

Contact Tom Hoff

tomhoff@cleanpower.com

cleanpower.com

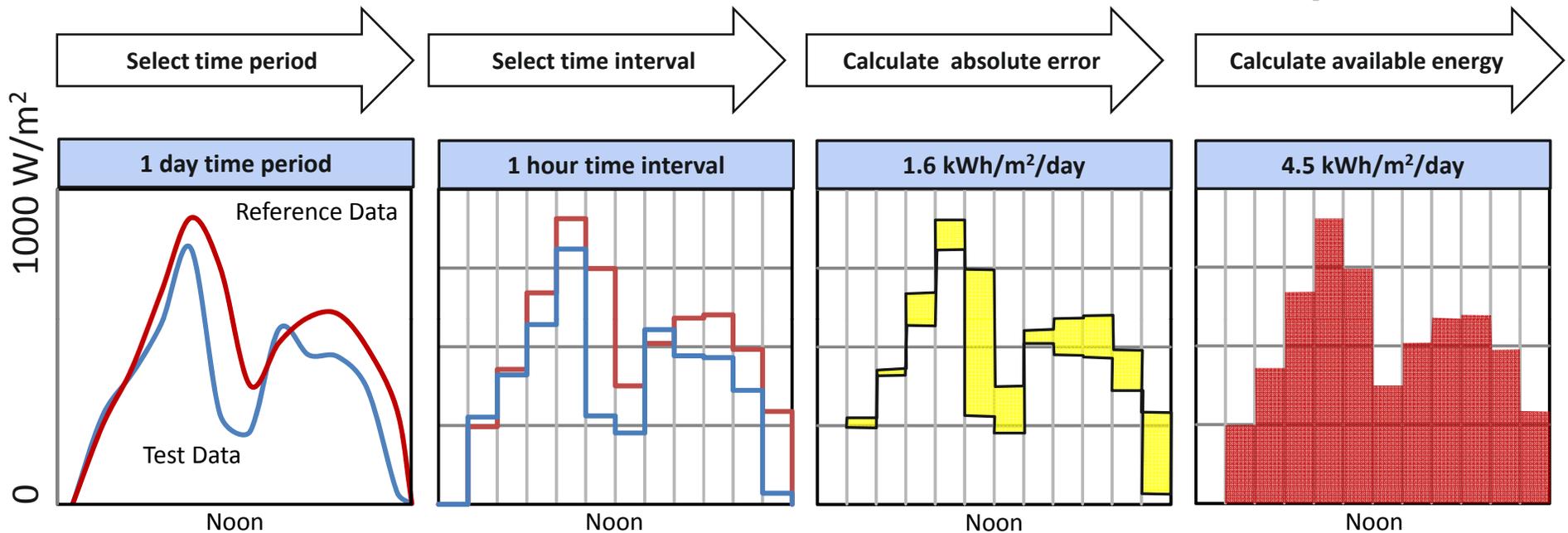


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Appendices

Mean Absolute Error Calculation Example



Result: MAE relative to energy = **36%** ($1.6/4.5$)

Note: MAE relative to daytime capacity = **14%** ($1.6/12$)

MAE relative to daily capacity = **7%** ($1.6/24$)

