

WindLogics[®]



Solar Power Forecasting

Perspective and Understanding on Solar Power Forecasting

Utility-Scale PV Variability Workshop

October 7, 2009
Cedar Rapids, Iowa

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WindLogics, NextEra Energy Resources & FPL

- WindLogics founded in 1989 by supercomputer architects
- Assessment, forecasting, operations and integration of renewable energy
- Staff of 80, including a Ph.D.-level research center
- Became FPL Energy subsidiary (now NextEra) in 2006
- NextEra is largest wind and solar developer/owner in North America



The General Situation

- ▶ Clouds are the number one influence on a solar forecast
 - ▶ You can see coherent patterns of motion for “stable” clouds
 - ▶ Convective events (“unstable” clouds) will always be a challenge to predict, though like for wind, we can roughly predict the risk
 - ▶ Weather models have challenges with cloud forecasting
- ▶ There are excellent satellite-based cloud resources available to guide short term solar forecasts (no analogy for wind)
- ▶ Aerosols and haze also have a significant impact on energy production (but less so on ramps)

So what's the problem here...

- ▶ Very short term ramp & variability forecasting
 - ▶ Next thirty minutes
- ▶ Load following forecasting
 - ▶ Next five hours
- ▶ Day-ahead unit commitment forecasting
 - ▶ Next six hours to two days

Visual Solar Forecasting (next minutes)

Yankee
Environmental
Systems
Total Sky Imager
(TSI-880)



SRRL TSI-880 Total Sky Imager

NORTH

WEST

SOUTH

NORTH

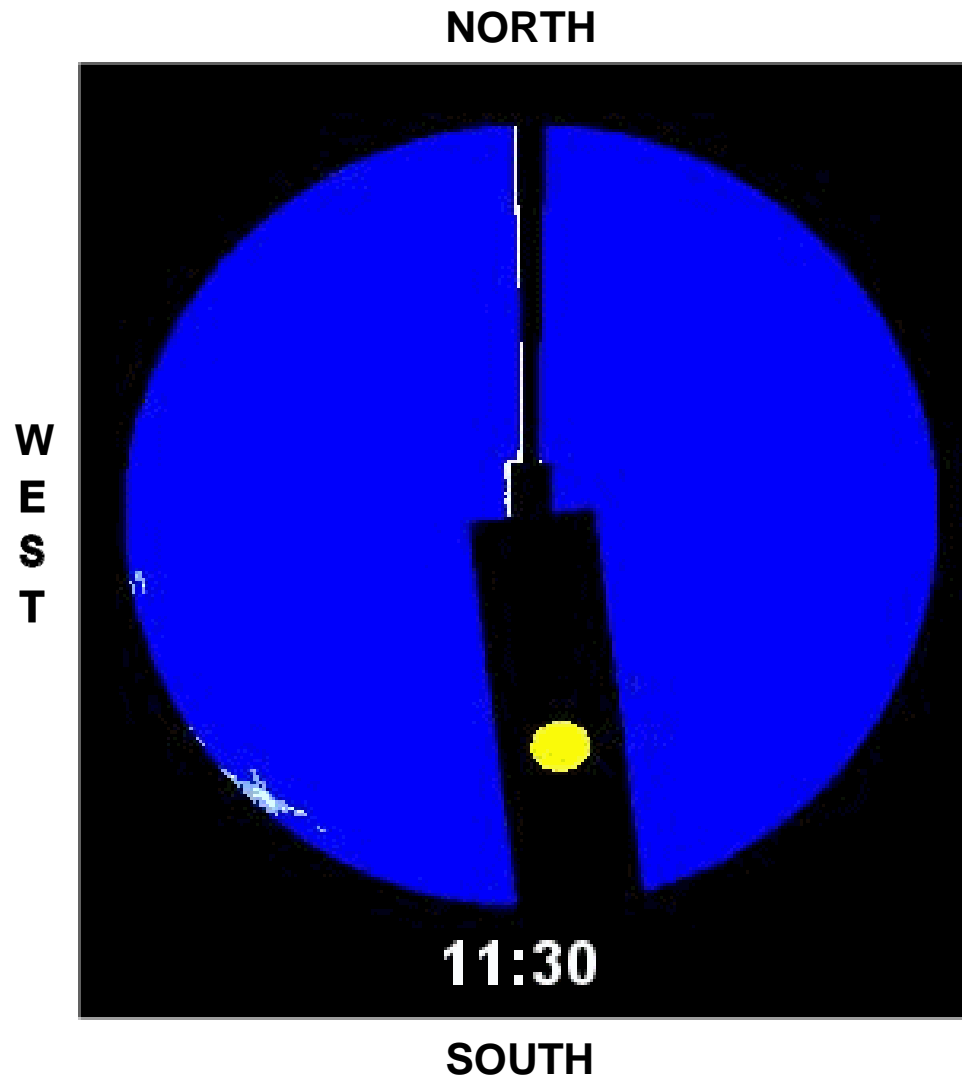
EAST

SOUTH

Prev 10-Min	Local Meridional Time 2009-10-03 12:50:00	Next 10-Min
Prev Hour	Solar Altitude 43.868°	Next Hour
Prev Day	Solar Zenith Angle 46.132°	Next Day
Prev Month	Solar Azimuth 201.129°	Next Month
	Opaque 19%	
	Thin 6%	
	Sunny No	

http://www.nrel.gov/midc/srri_bms

Sub-Hourly Solar Forecasting (next minutes)

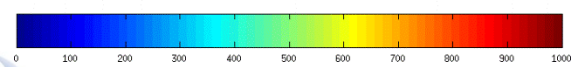
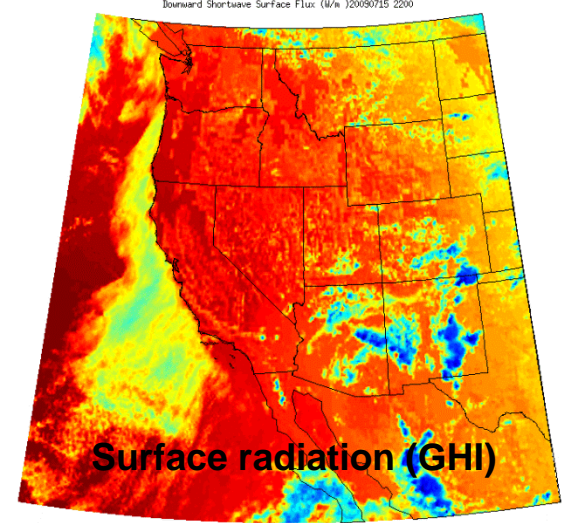
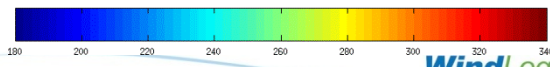
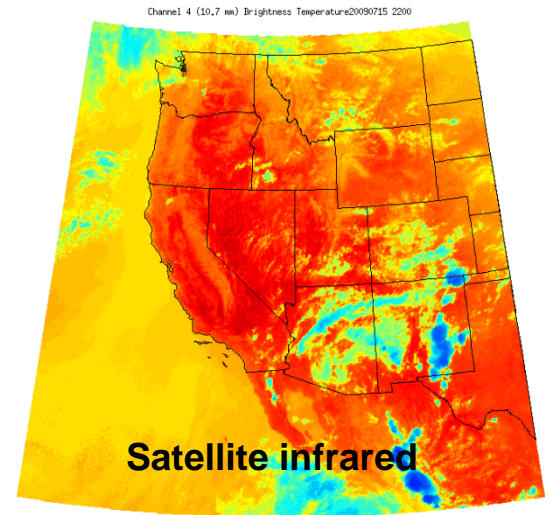
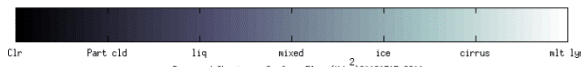
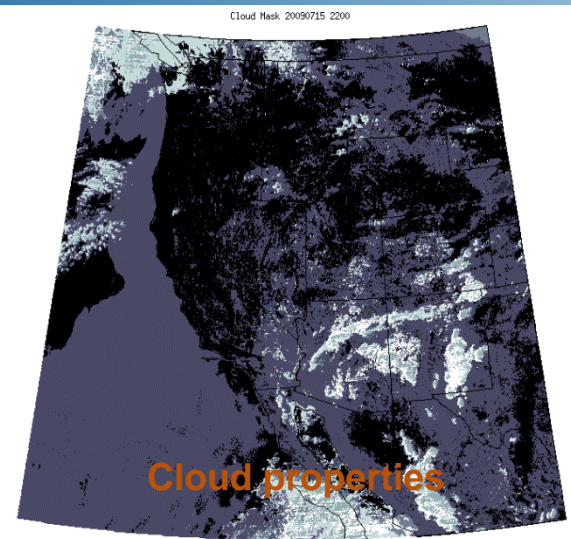
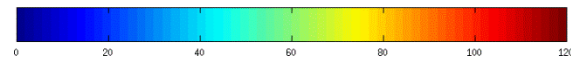
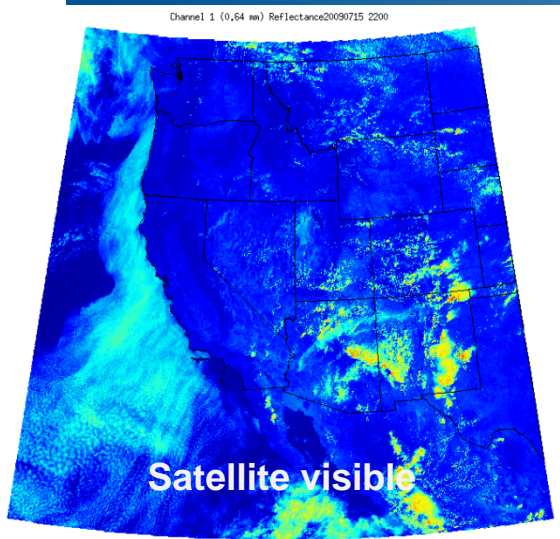


- Digitized cloud mask
- Short term forecasting
- Cloud tracking capable
- Operational assessment

Satellite-based Solar Forecasting (next hours)

July 15, 2009

Satellite imagery, retrieved clouds and surface radiation from GOES West from NOAA's GOES Surface and Insolation Products (GSIP) Algorithm



Dr. Istvan Laszlo
NOAA/NESDIS/STAR
Dr. Andrew Heidinger
UW/CIMSS/NOAA
 NOAA


Courtesy of
Dr. Manajit Sengupta



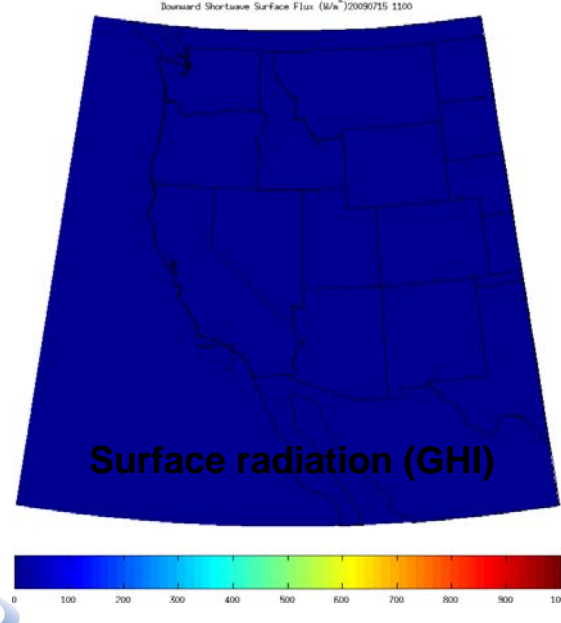
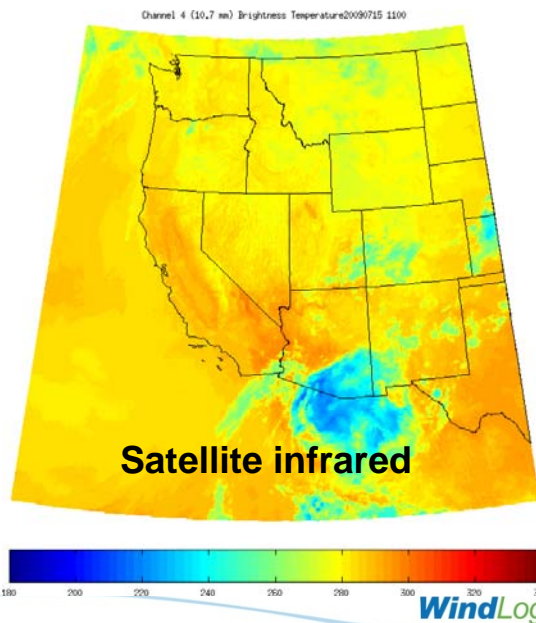
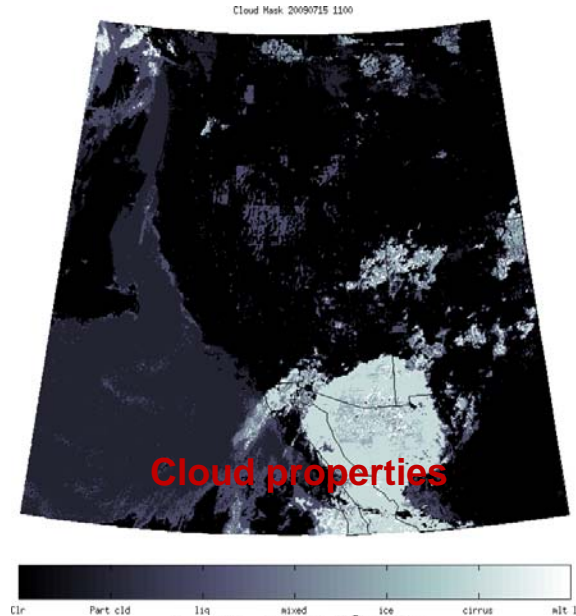
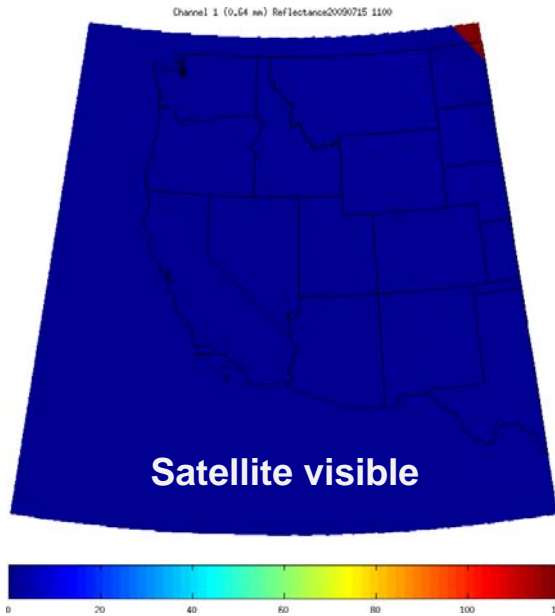
Satellite-based Solar Forecasting (next hours)

July 15, 2009

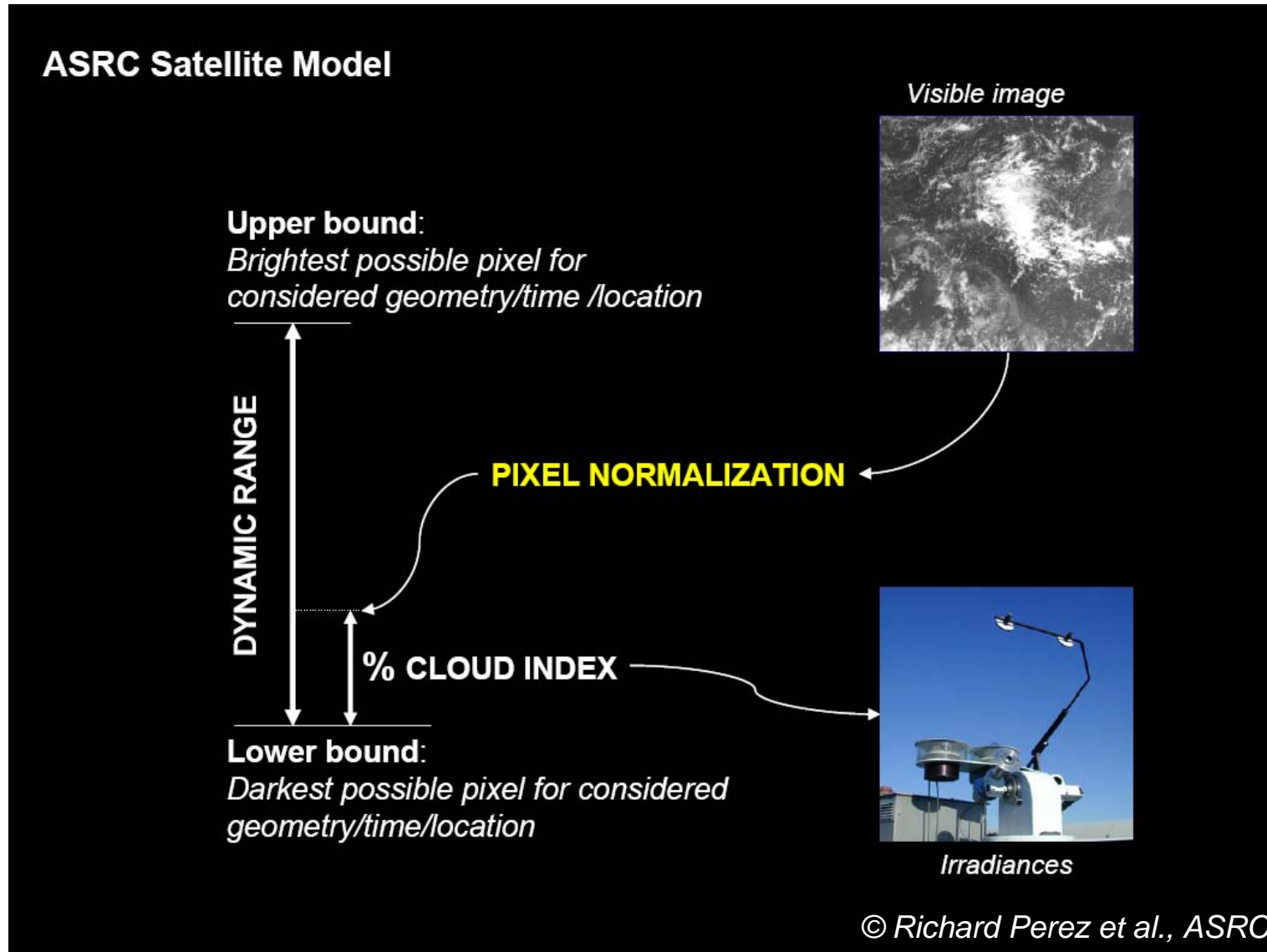
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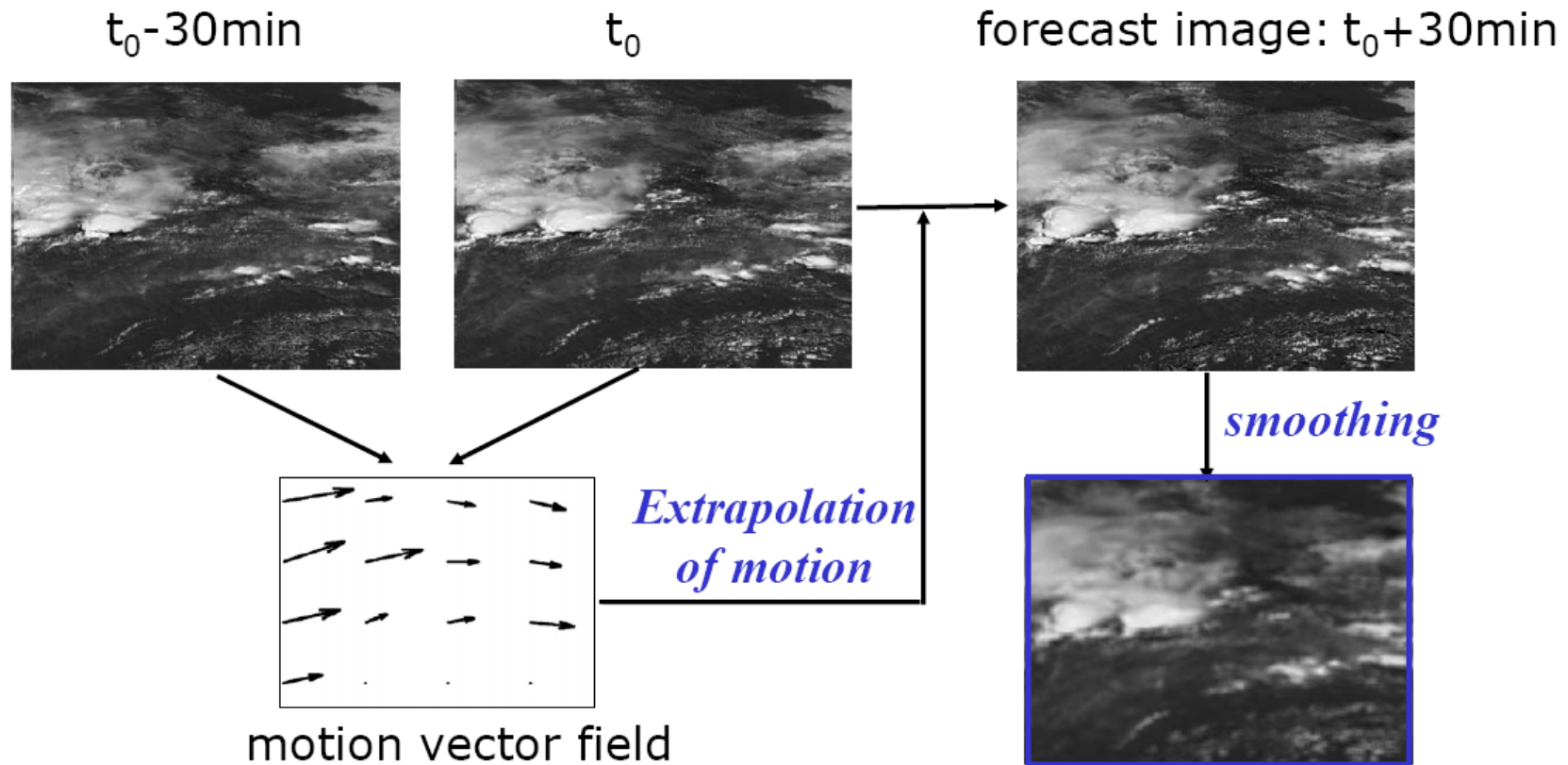


Satellite-based Solar Forecasting (next hours)



Motion Vector Analysis of Cloud Fields

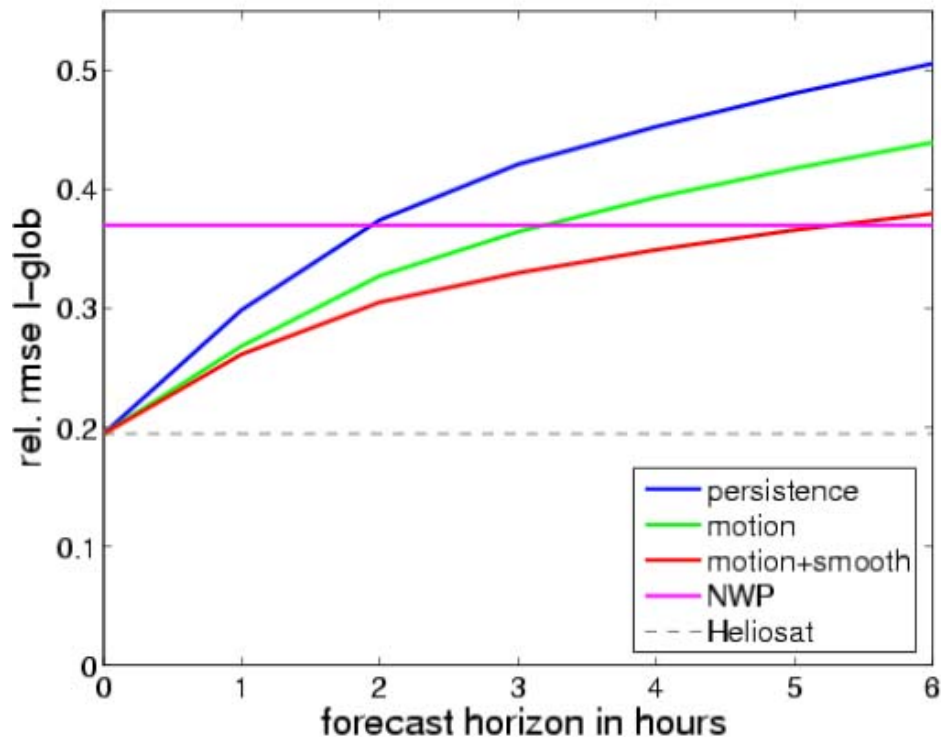
A Satellite-based Cloud Forecasting Example



Assumes Steady-State Cloud Field

Satellite-based Solar Forecasting

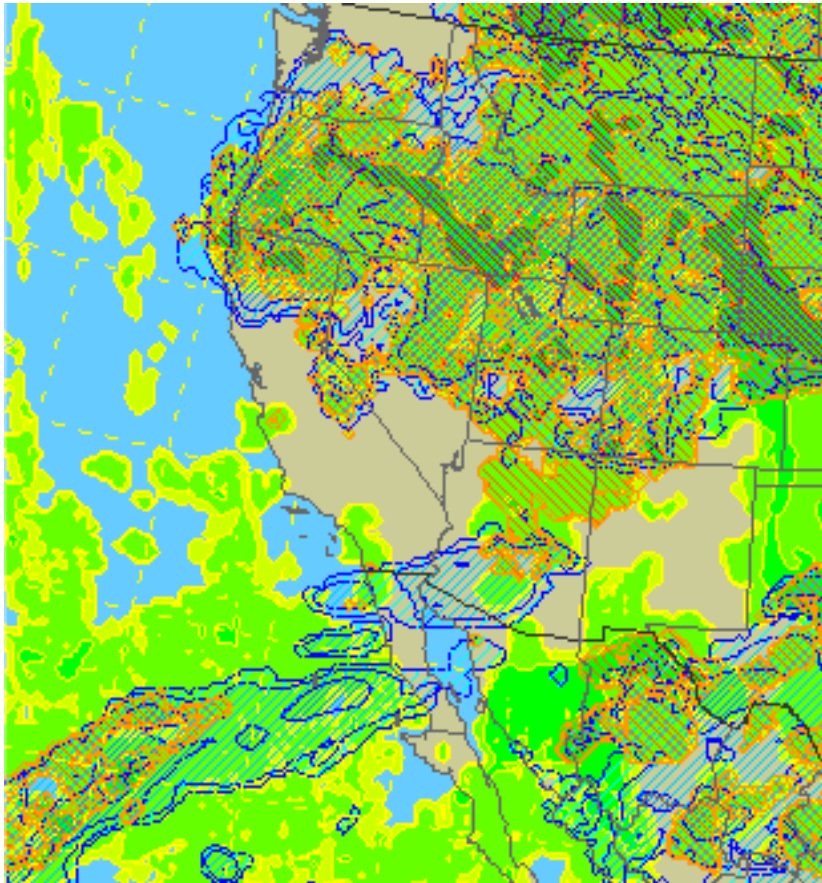
Comparison of satellite-based forecasts and forecasts based on Numerical Weather Prediction (NWP) models



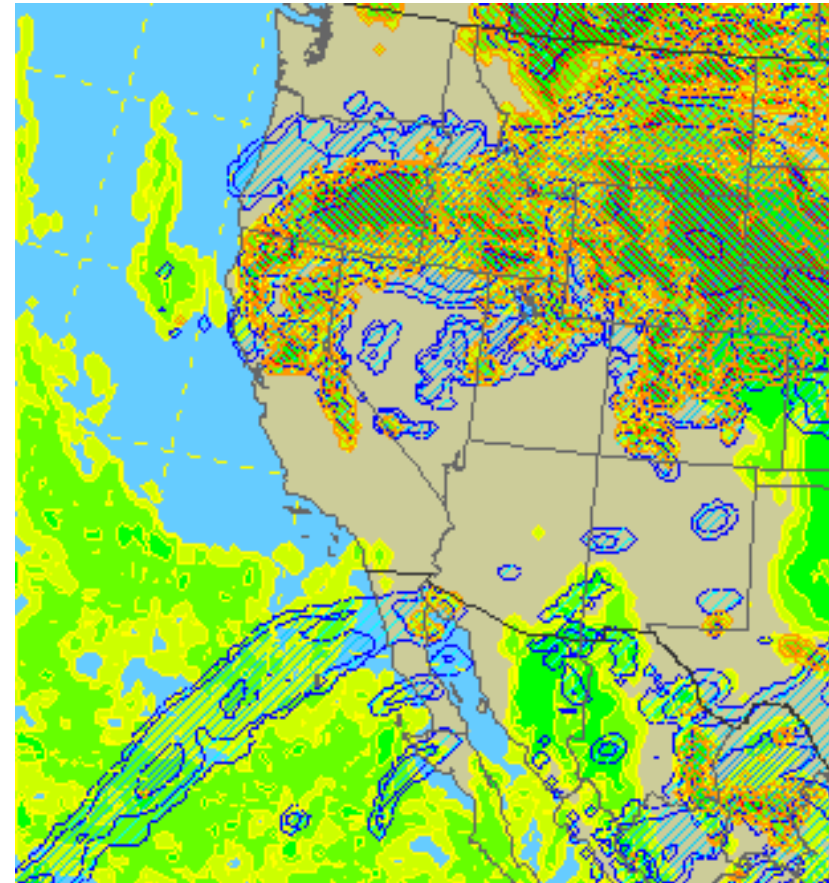
- ▶ Up to 5 hours: forecast based on satellite images
- ▶ more than 5 hours: NWP based forecast

NWP Solar Forecasting

RUC2 Model (Analysis)



RUC2 Model (6-Hour Forecast)



Water ($T > 0^{\circ}\text{C}$)

Supercooled

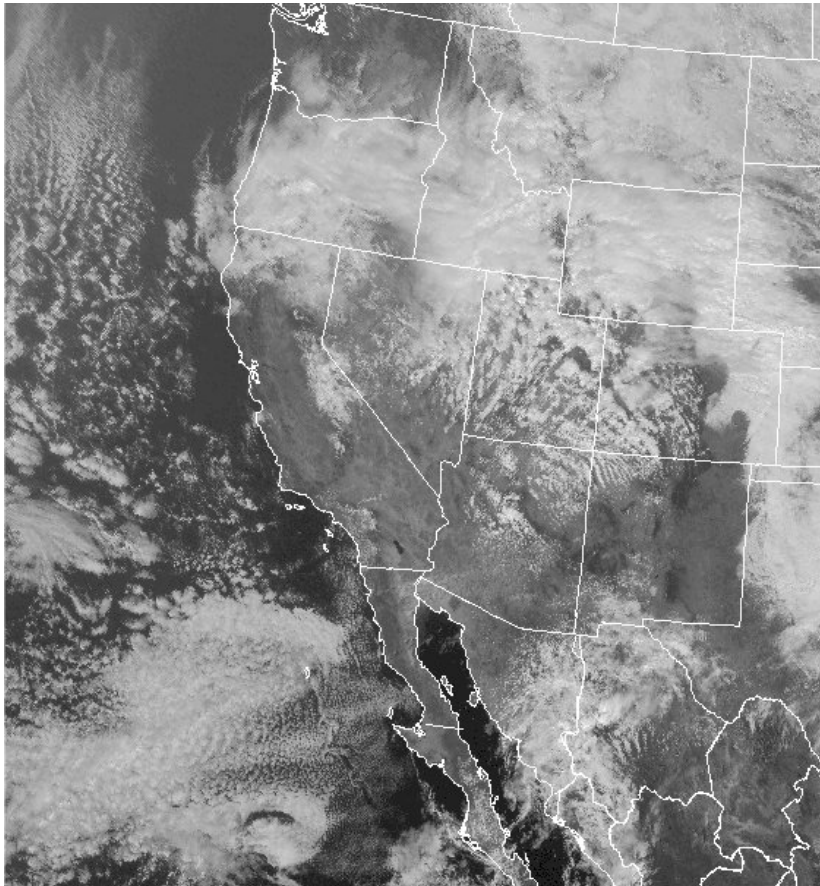
Ice & Snow

Integrated Liquid and Frozen Hydrometeors (all levels)

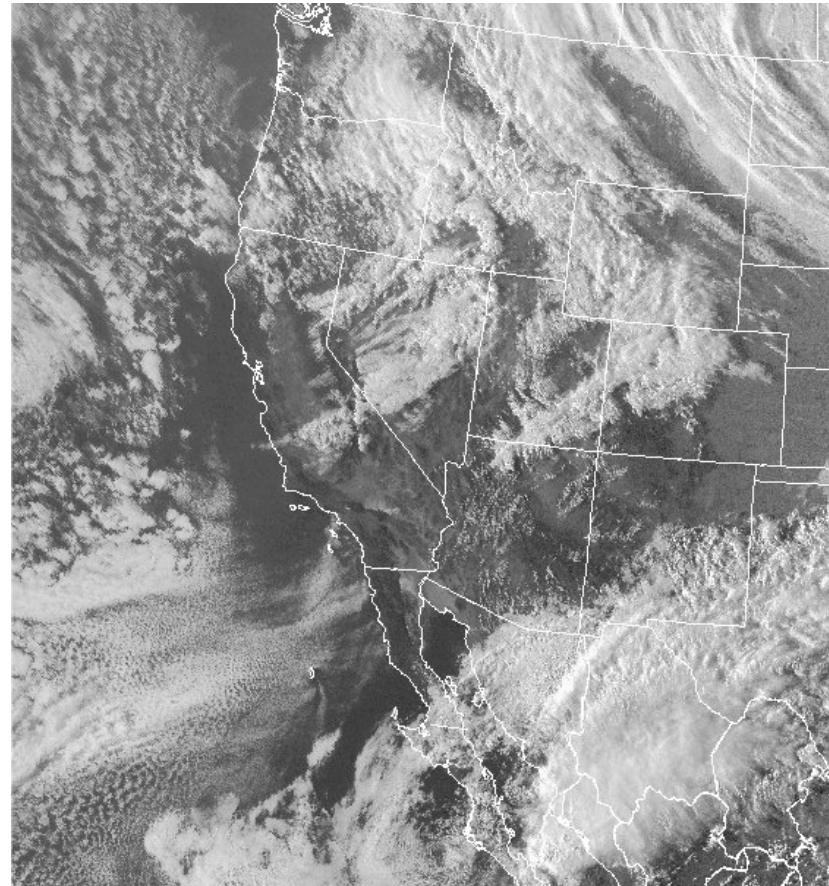
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NWP Solar Forecasting

Visible Satellite (Analysis)

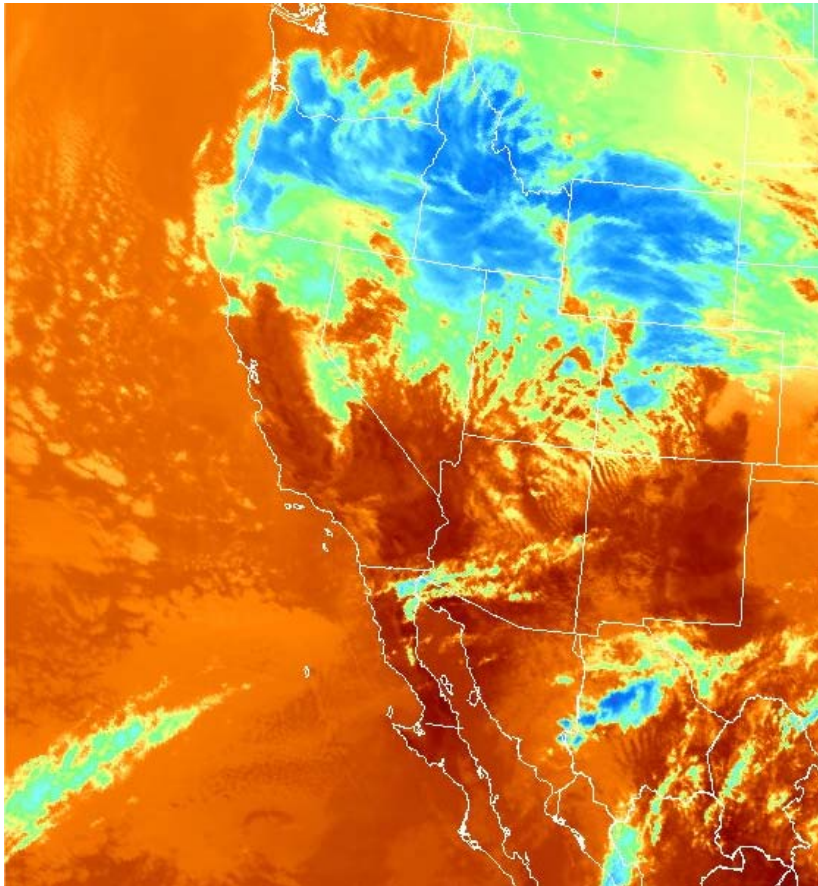


Visible Satellite (6-Hour Forecast)

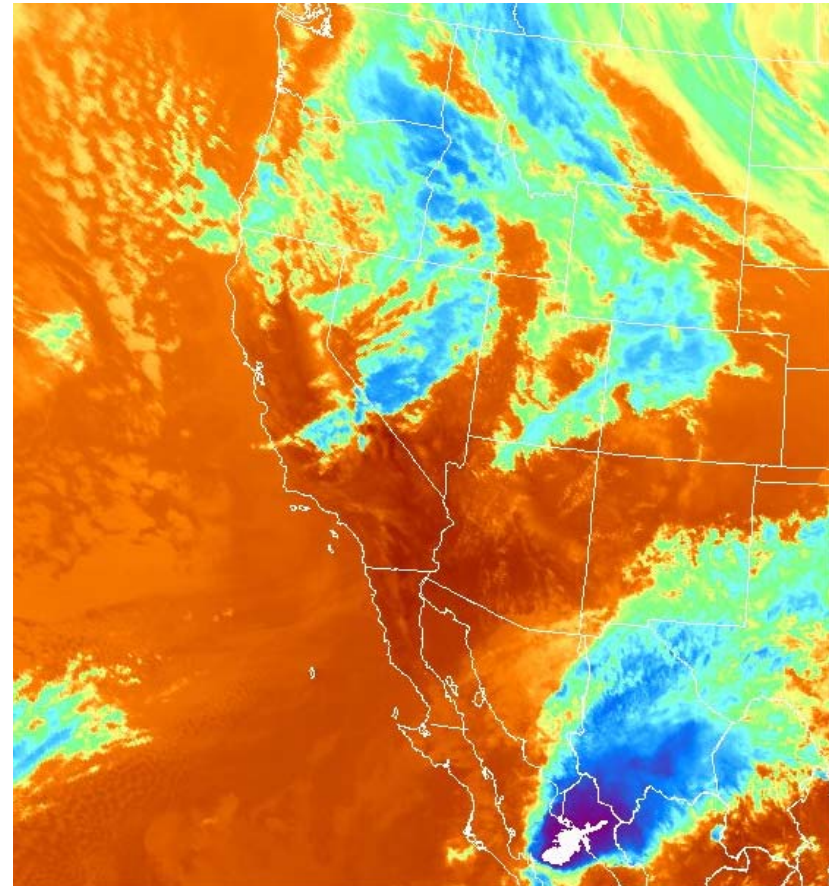


NWP Solar Forecasting

Infrared Satellite (Analysis)

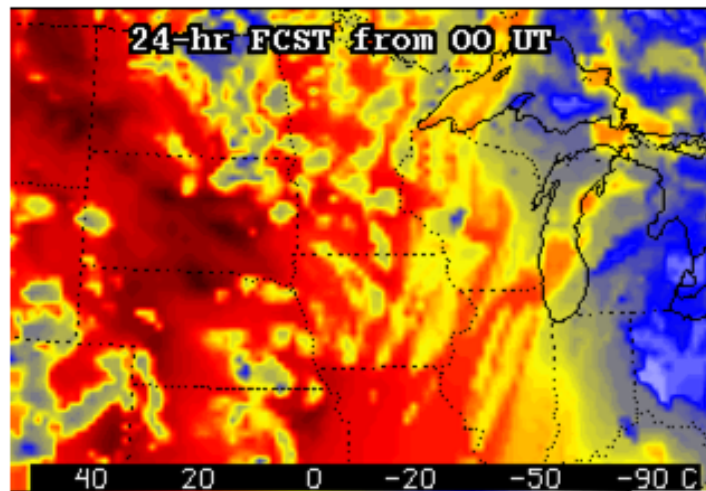
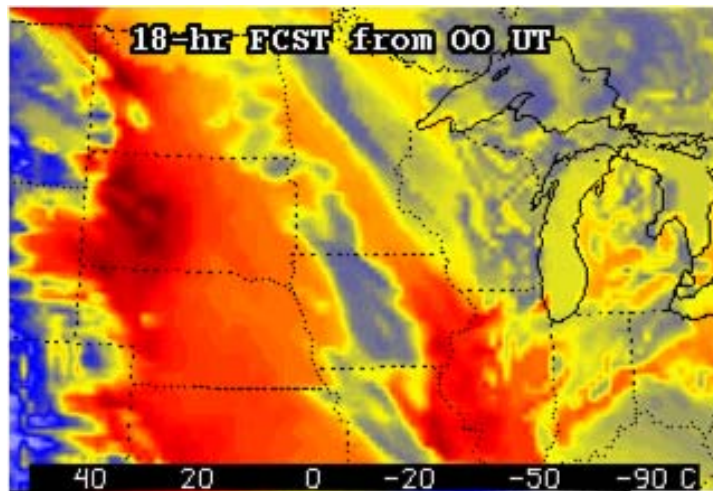


Infrared Satellite (6-Hour Forecast)

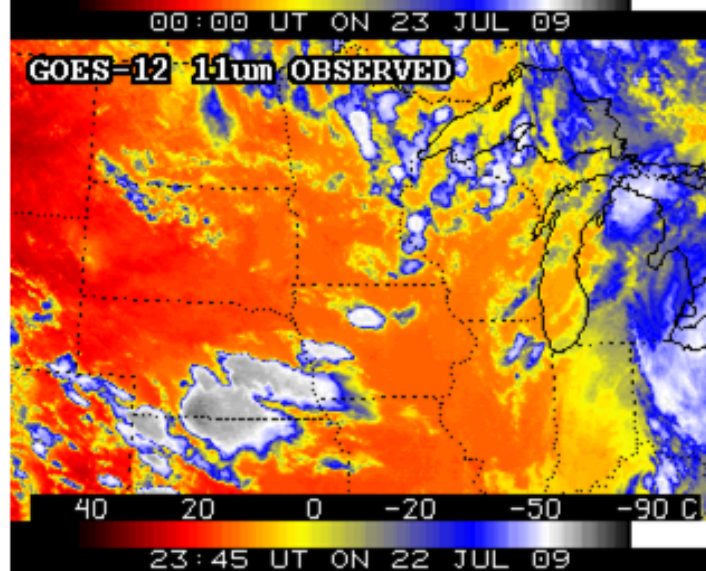
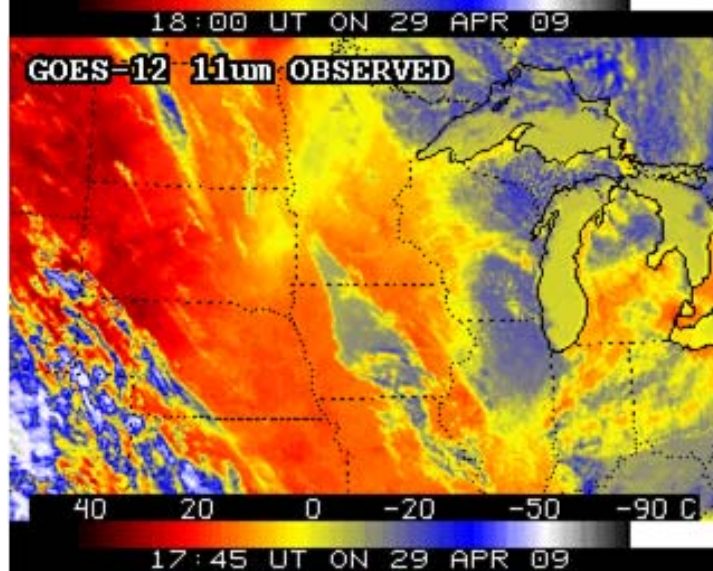


NWP Solar Forecasting – Convective Challenges

NCEP Model (GFS) Forecast Examples (a convective example on left)



Predicted
Satellite
Irradiance
(11 μ m)



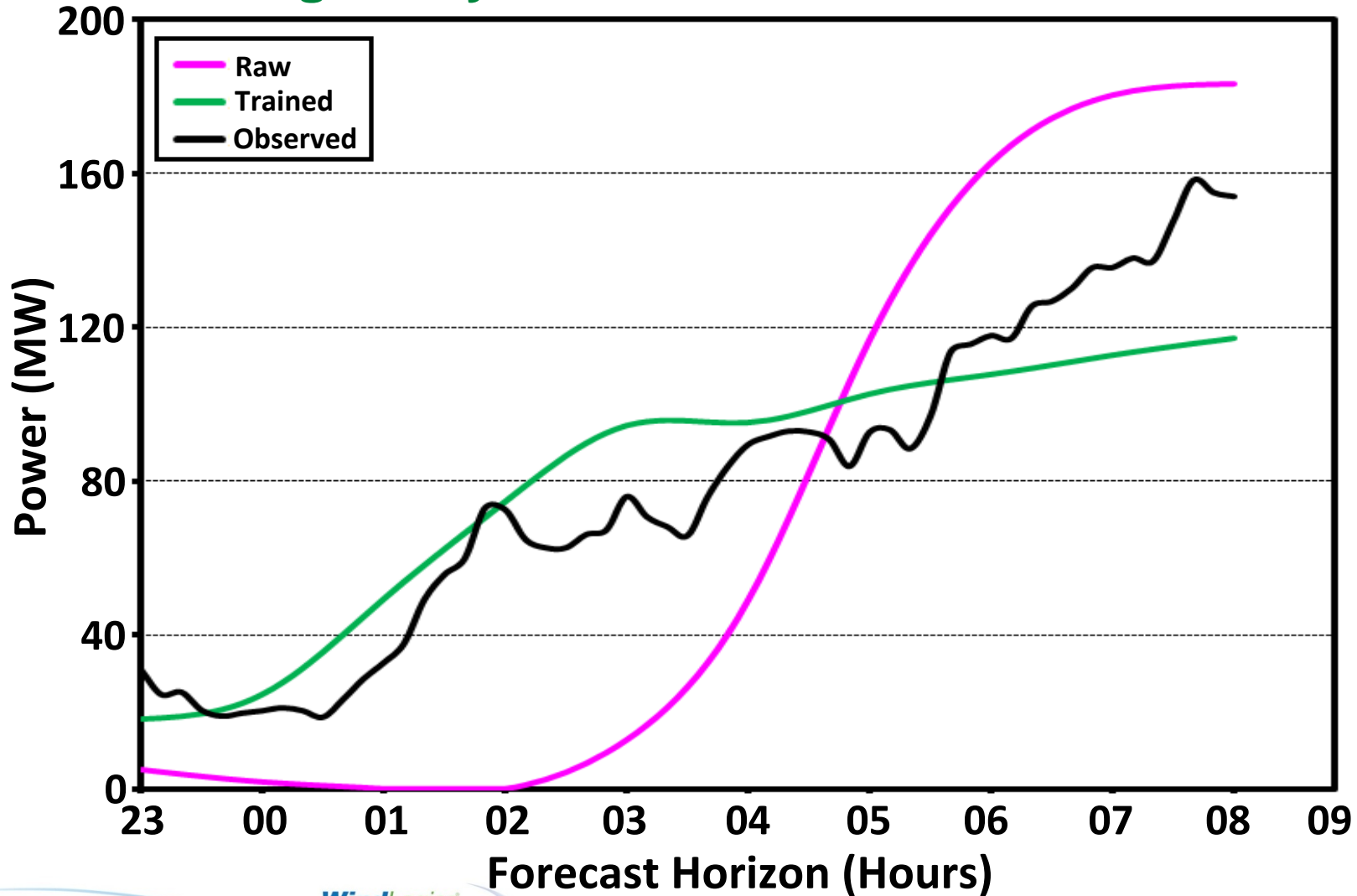
Observed
Satellite
Irradiance
(11 μ m)

Courtesy of



Motivation for Forecast Training

Correcting for Systematic Biases with Model Training



Conclusions

- ▶ Solar forecasting & integration build on the industry's wind integration experience
- ▶ While accurate forecasting is challenging, solar has some characteristics that make it easier than wind forecasting
- ▶ Although still in development, we can expect to see a variety of good solar forecasting models and services
- ▶ In the control room, we should look work toward a unified view of both wind and solar integration
- ▶ Because NERC and others have already started work on variable generation issues, and because solar is already being included in this work, solar is on a fast path

Near Future

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**Florida Power & Light DeSoto Project (25 MW PV)
in Central Florida - Commissioning Fall 2009**