Use of satellite observations in wind and solar forecasting and in offshore wind resource assessments

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Feb. 3, 2014

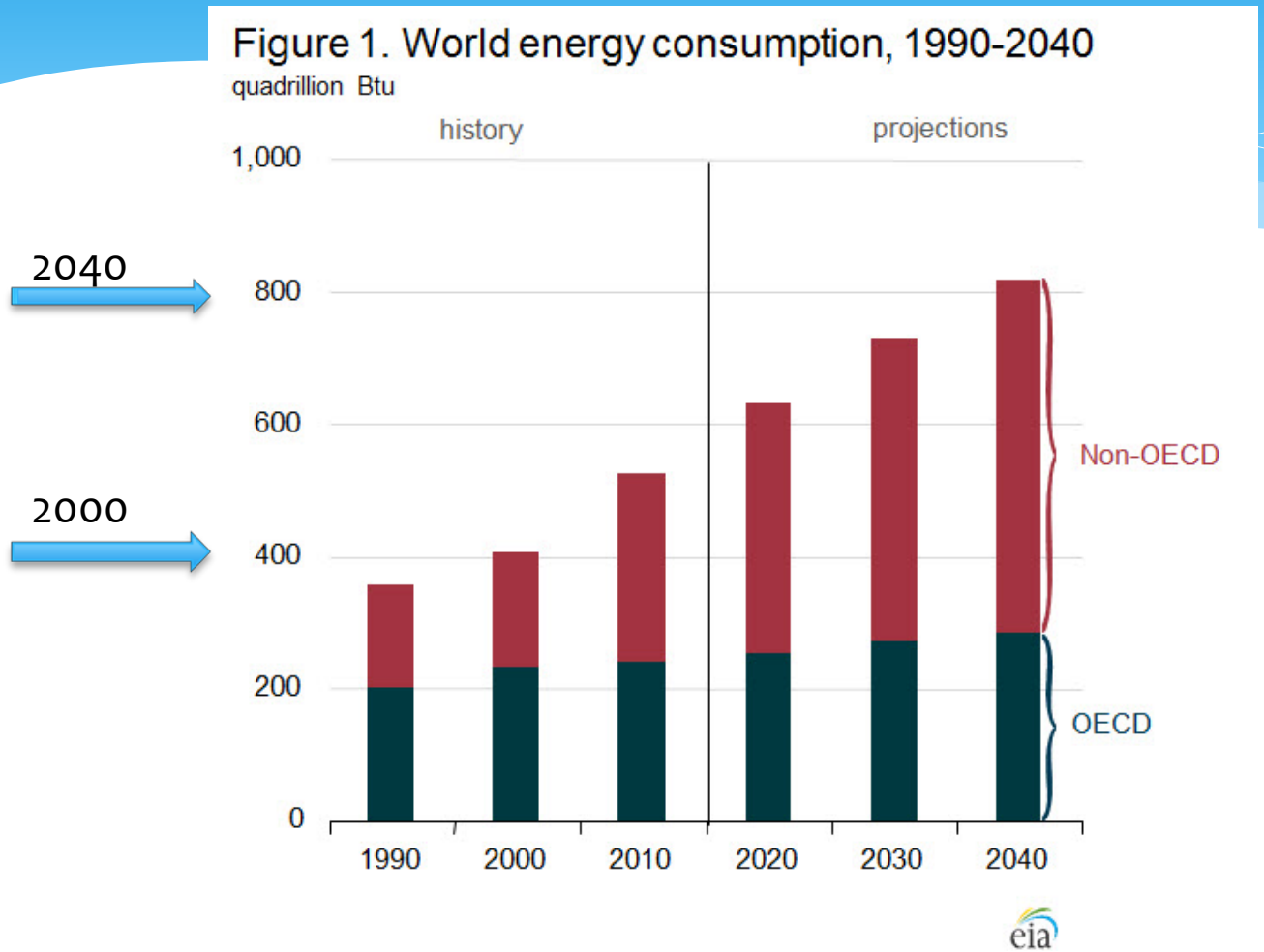
Outline

1. Societal benefit area – Energy
2. Solar Forecasting Improvement Project
   * Rapid Refresh and High Resolution Rapid Refresh Models
   * Advanced GOES products
3. RFORE
4. Future SAR data set for wind speed climatology

Acknowledgements and thanks to colleagues
at ESRL, Stan Benjamin, Joe Olson, Eric James, Jim Wilczak, Laura Bianco, Irina Djalalova, Bob Banta, Yelena Pichugina;
at NCEP, Jacob Carley; and at NESDIS, Andy Heidinger and Christine Molling.

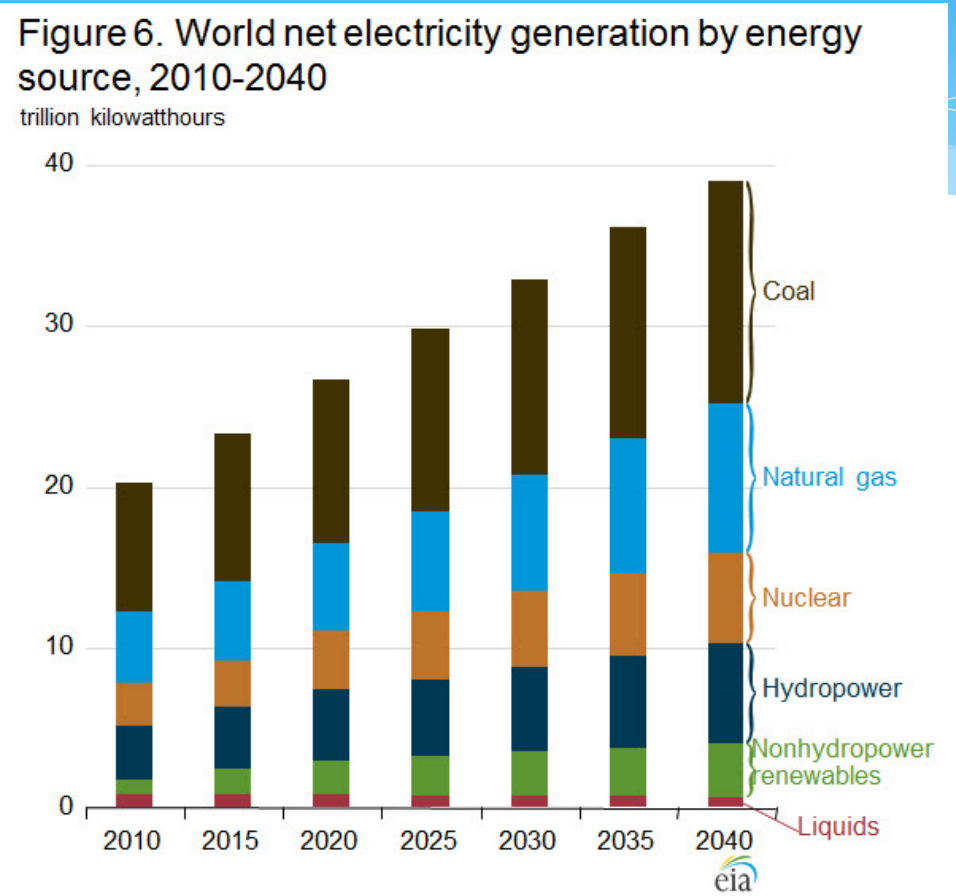
* 1. Societal benefit area – Energy

Global energy consumption forecast to grow by 56 percent between 2010 and 2040



U.S. Energy Information Administration: International Energy Outlook 2013
http://www.eia.gov/forecasts/ieo/

Renewable energy is projected to grow faster than all other sources globally



Renewable energy sources are the fastest growing sources of electricity generation in the *IEO2013* Reference case, at 2.8 percent per year from 2010 to 2040.
U.S. EIA: International Energy Outlook 2013 (http://www.eia.gov/forecasts/ieo/)

U.S. energy consumption and electricity generation projections

Figure 7. Delivered energy consumption by sector, 1980-2040

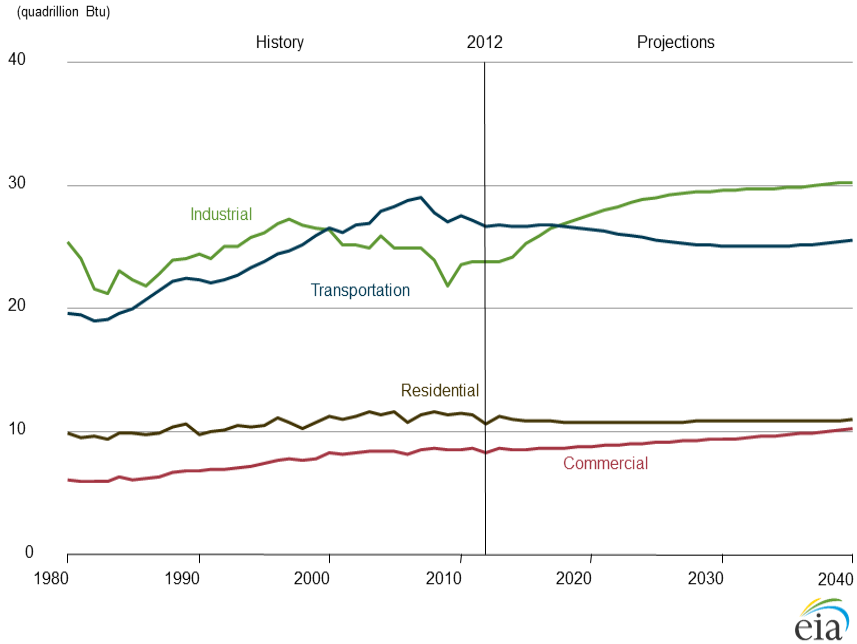
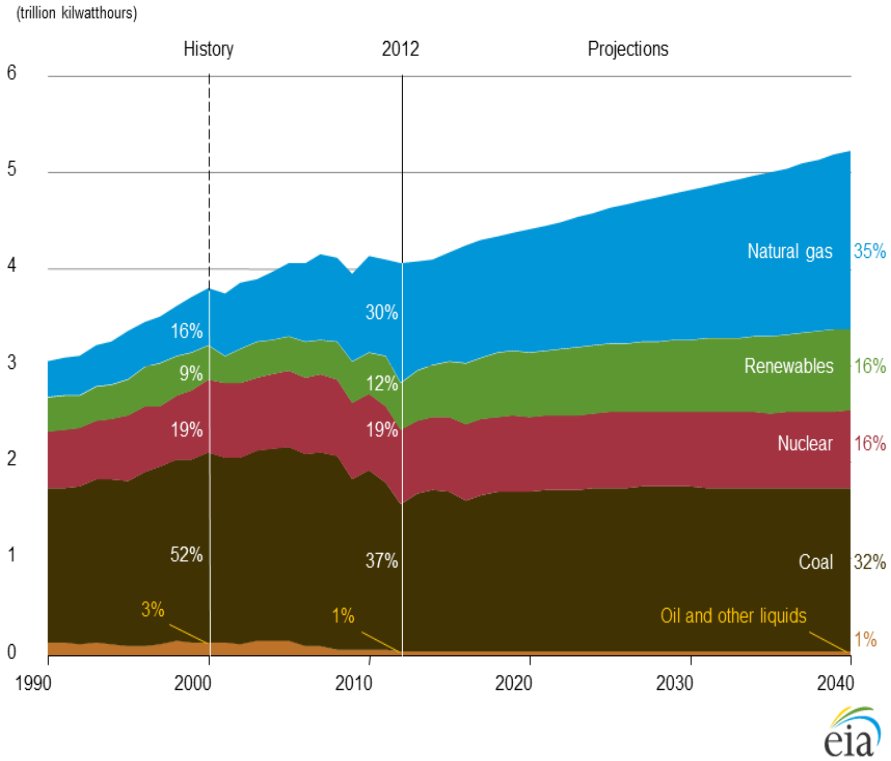
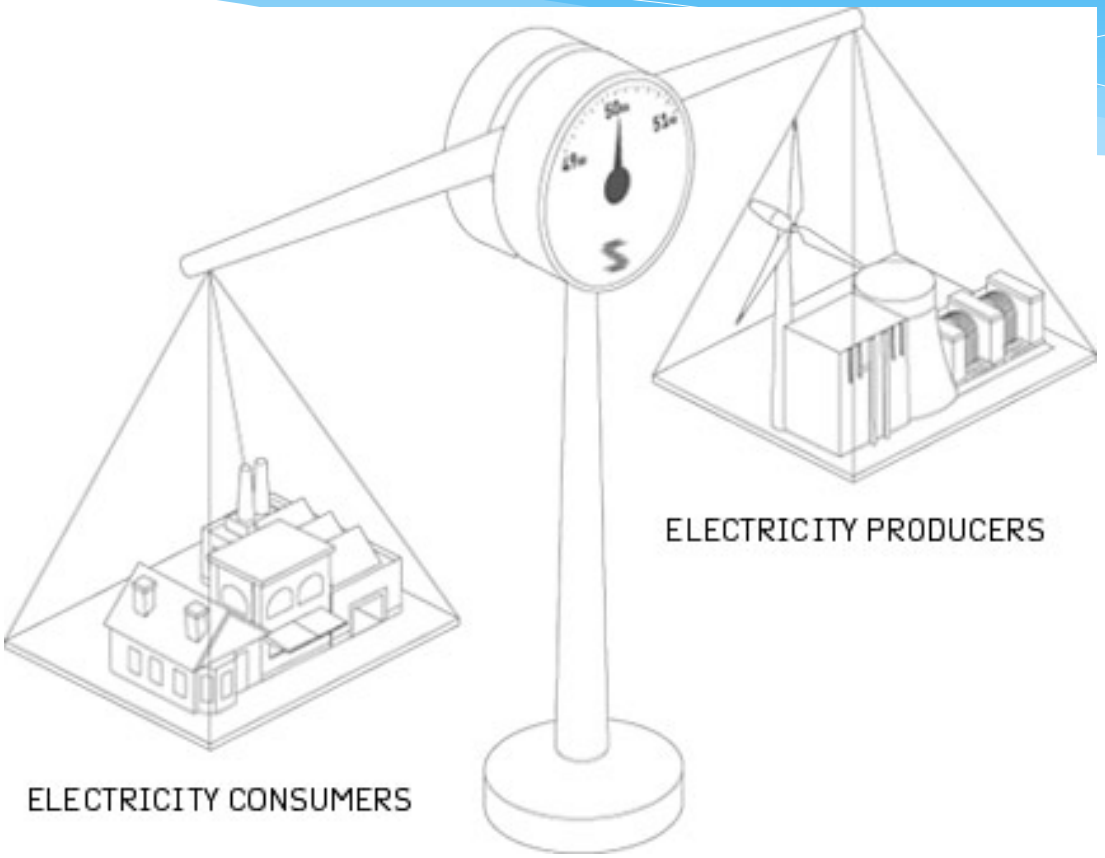


Figure 13. Electricity generation by fuel, 1990-2040

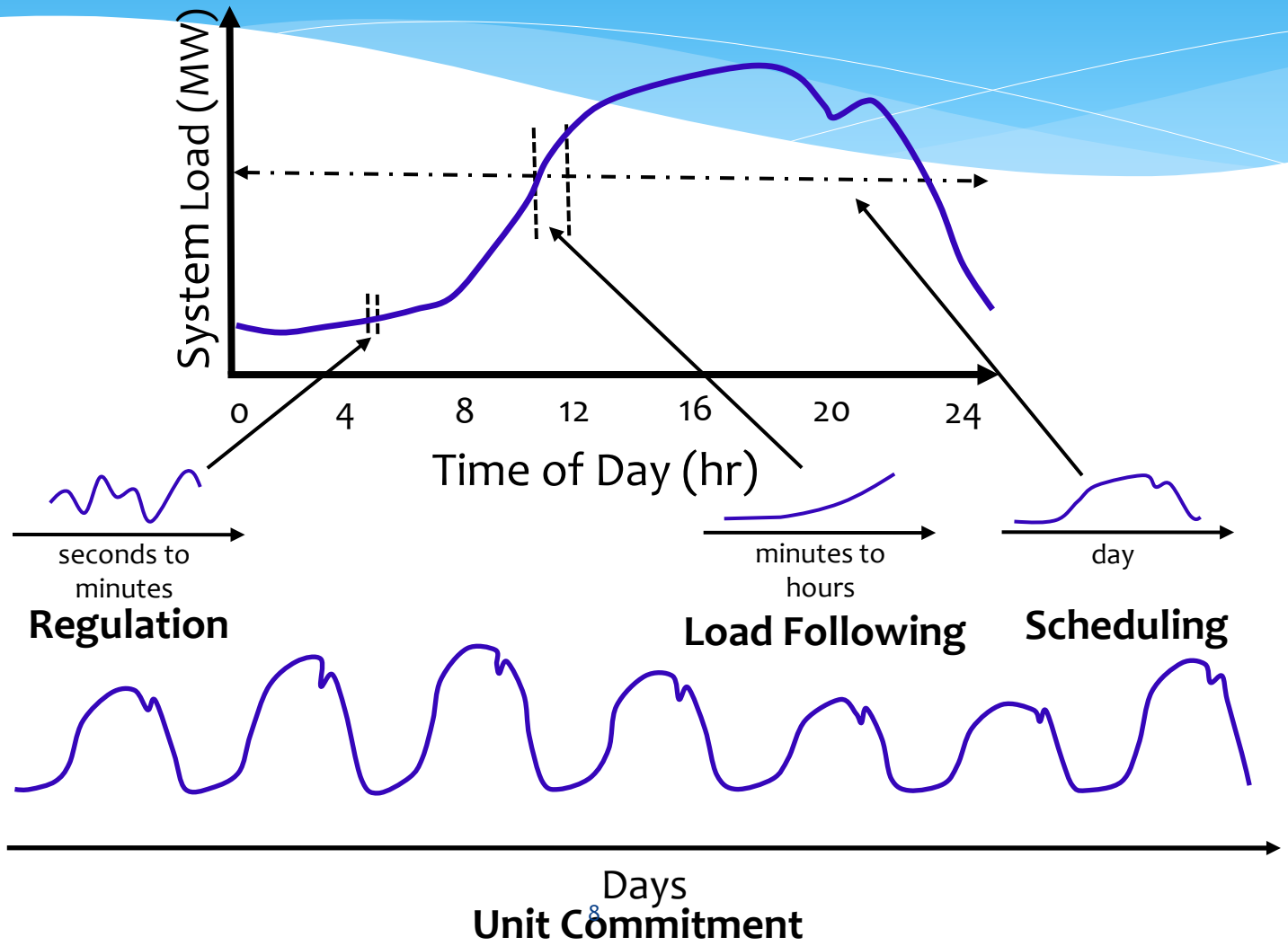


Electric grid operators must constantly balance supply and demand



Better weather forecasts – across a range of time scales - are needed to integrated wind and solar power, reduce unnecessary fossil reserves, and run the power grid most efficiently.

Power System Operations Timescales



* Solar Forecast Improvement Project

Solar Forecast Improvement Project

* We will collaborate with both FOA awardees (NCAR and IBM) on all three topics, but most of NOAA's contributions will be in #2 (improved irradiance forecast):
  1. Metrics
  2. Solar forecasting
  3. Incorporation of improved forecast into utility and ISO ops

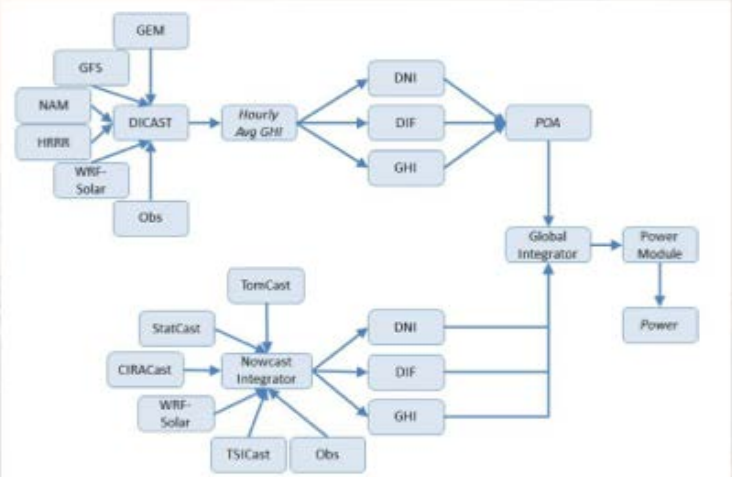
* We will do this by:
  1. Improving irradiance forecast from RAP and HRRR
  2. Providing verification of model output using SURFRAD and ISIS observations
  3. Improved satellite products

SunShot
U.S. Department of Energy

Acknowledgement and thanks to DOE Solar Program for funding this research.

NCAR's Approach in Solar Forecasting Project

Solar Forecasting System



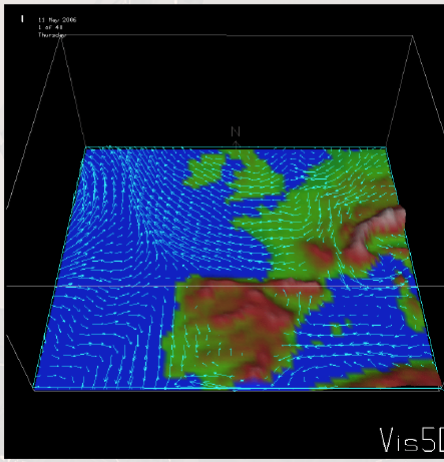
To forecast clouds, aerosols, scattering, one must assimilate data and blend across scales.

WRF-Solar

Weather Research & Forecasting Model

Solar version with improved:

- Satellite data assimilation
- Cloud physics parameterization
- Convective parameterization
- Clear-sky aerosol estimation
- Radiative transfer modeling
- Collaborate with NOAA to make relevant for operations



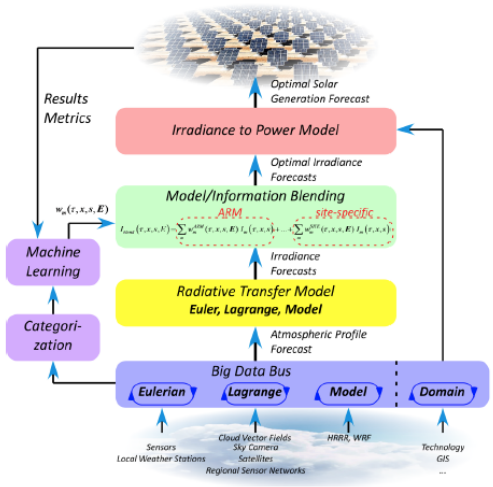
Slides courtesy of Sue Haupt, NCAR.

8:30 AM-10:00 AM: Wednesday, Feb. 5
Room C204 (**9:45 a.m.**) *Development of Clear sky models for solar energy using machine learning* - G. Cervone, J. Lin, T. C. McCandless, and **S. Haupt** (Joint between the **12th Conf. on Artificial and Computational Intelligence and its Applications to the Environmental Sciences**; and the Fifth Conference on Weather, Climate, and the New Energy Economy)

1:30-3:00 P.M. : Thursday, Feb. 6
Room C114 (1:45 p.m.) Advances in Predicting Solar Power for Utilities[11] - Sue Ellen Haupt
Host: Fifth Conference on Weather, Climate, and the New Energy Economy

IBM's Approach to Solar Forecasting Project

Watt-sun - Overview



***Watt-sun* is a general and scalable technology platform for improved solar forecasting by**

- using big-data information processing technologies;
- applying Watson machine learning approaches to blend outputs from multiple models and to enhance system intelligence, adaptability and scalability

System includes:

- Big Data Bus
- Radiative Transfer Model
- Model / Information Blending
- Irradiance to Power Model
- Machine / Learning and Categorization

- **System provides a *platform* to optimally leverage current and future forecasting capabilities and models.**
- **Adapts to different metrics and applications**

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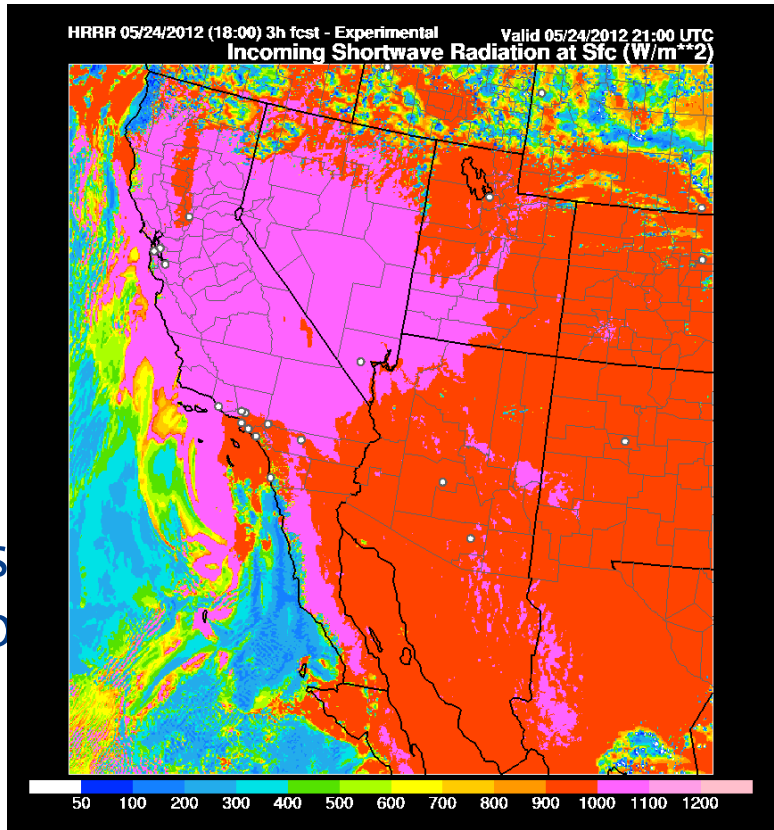
8:30 AM-10:00 AM: Wed., Feb. 5
Room C204 (**8:45 a.m.**) A mulit-scale solar energy forecast platform based on machine-learned adaptive combination of expert systems - S. Lu et al.
(Joint between the **12th Conf. on Artificial and Computational Intelligence and its Applications to the Environmental Sciences**; and the Fifth Conference on Weather, Climate, and the New Energy Economy)

Slide courtesy of Hendrik Hamann, IBM

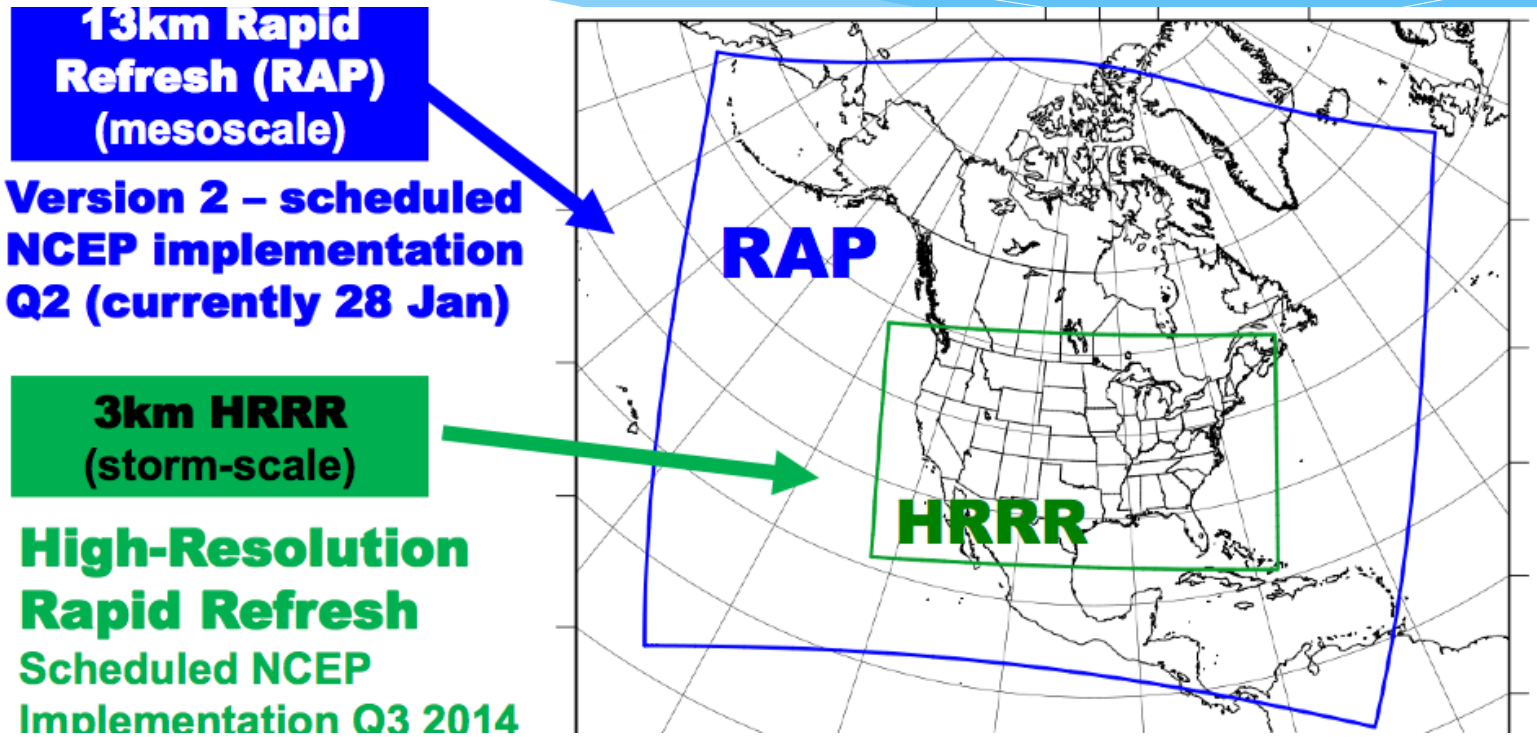
8:30 AM-10:00 AM: Thurs., Feb. 6
Room C114 (**8:45 a.m.**) Improvements in short-term solar energy forecasting.
S.Bermudez, **S. Lu**, M. A. Schappert, T. G. van Kessel, and H. F. Hamann
(Fifth Conference on Weather, Climate, and the New Energy Economy)

Improved solar irradiance forecast from RAP and HRRR

* Testing and improvement of HRRR system, which will provide detailed cloud (3-d hydrometeor) forecasts for use in irradiance forecasting.
* Testing and improvement of Rapid Refresh (RAP), which will provide initial and boundary conditions for the HRRR and serve as the data assimilation engine.
* Evaluation of real-time RAP-chem and HRRR-chem runs and assimilation cycles to provide real-time aerosol forecasts to complement HRRR GHI/DHI/DNI forecasts.



RAP and HRRR NWP Models



The RAP contributes to initialize the 3km High-Resolution Rapid Refresh (HRRR), providing a background for a 1-h assimilation cycle with 15-min radar and 3-km GSI before the HRRR is initialized.

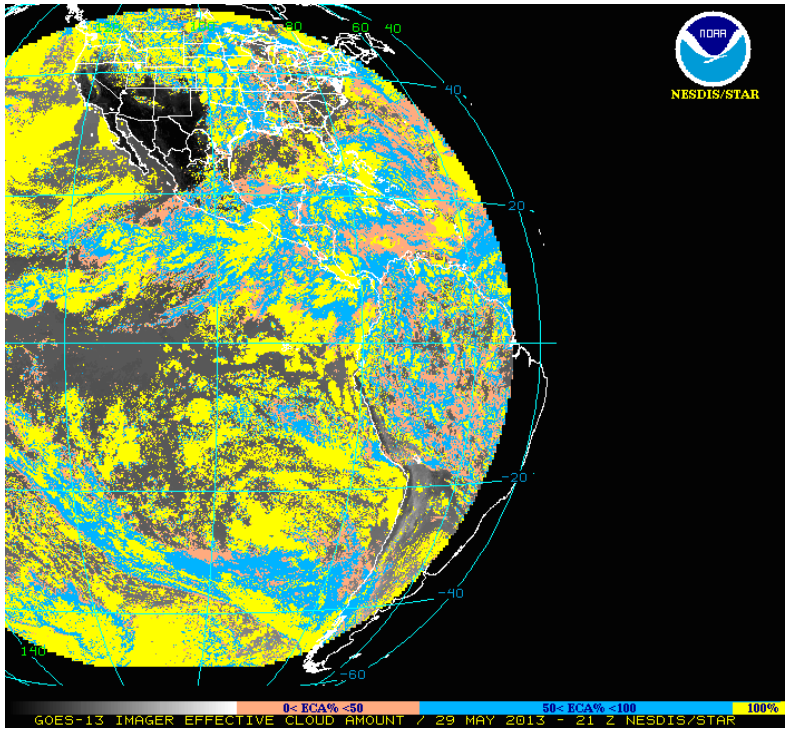
Rapid Refresh
Hourly Update with Observations

Hourly Observations	RAP 2013 N. Amer
Rawinsonde (T,V,RH)	120
Profiler – NOAA Network (V)	21
Profiler – 915 MHz (V, Tv)	25
Radar – VAD (V)	125
Radar reflectivity - CONUS	1km
Lightning (proxy reflectivity)	**NLDN, GLD360**
Aircraft (V,T)	2-15K
Aircraft - WVSS (RH)	0-800
Surface/METAR (T,Td,V,ps,cloud, vis, wx)	2200- 2500
Buoys/ships (V, ps)	200-400
GOES AMVs (V)	2000- 4000
AMSU/HIRS/MHS radiances	Used
GOES cloud-top press/temp	13km
GPS – Precipitable water	260
WindSat scatterometer	2-10K

Satellites

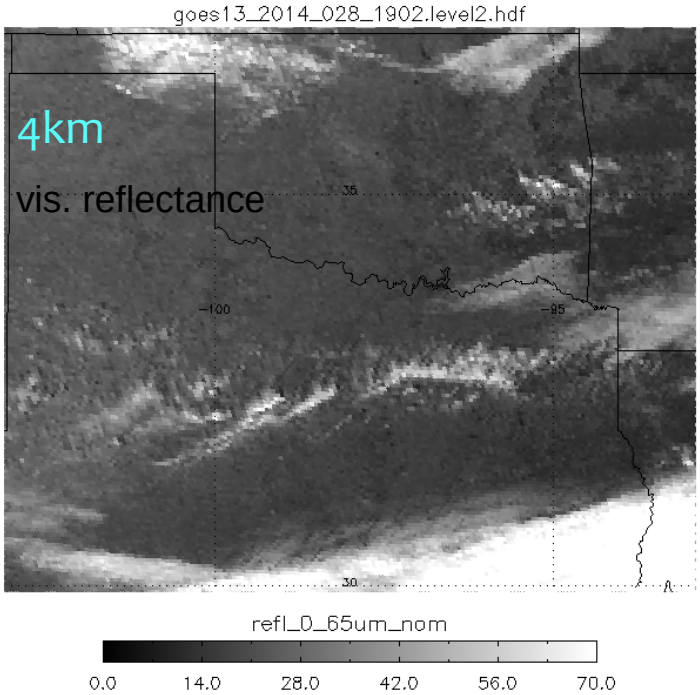
Enhanced GOES Products

* NOAA algorithms will be generated at higher spatial and temporal resolution to support this call. Processing will be done at a NOAA CI (CIMSS, Madison WI).
* NESDIS will provide a stream of real-time products from the NOAA GOES Imagers.
* These products will differ from the operational products in that they will be at the full spatial and temporal resolution of the sensor (**15 minutes and 1 km**).

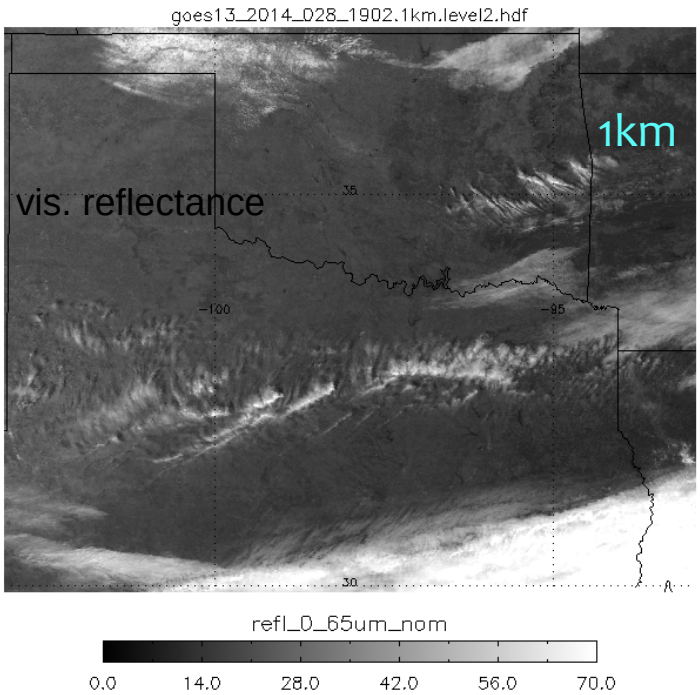


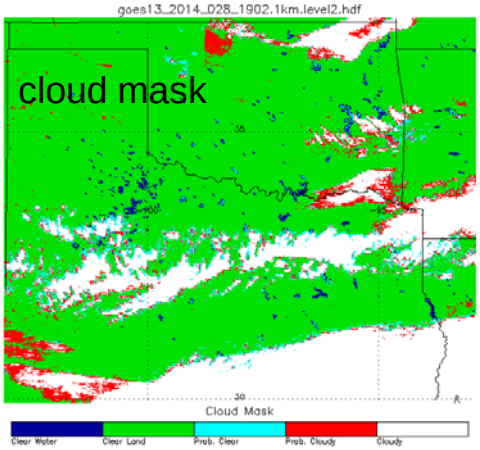
Resolution increased from Standard 4km to 1km

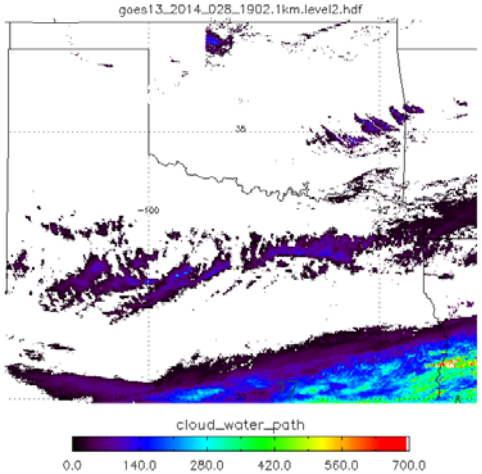
Slide courtesy Christine Molling, UW/CIMSS and Andy Heidinger, NOAA/STAR

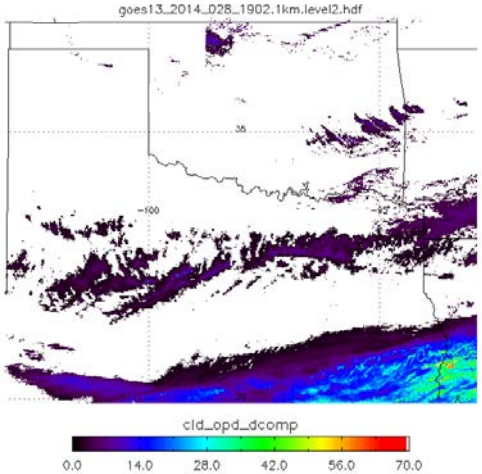


Cloud products and related data are computed from GOES-WEST and EAST at the visible (1km nominal) resolution, every ~15min over CONUS. Pixel level files available via ftp.









1km

Thank you.

11:00 AM-12:00 PM: Thursday, 6 February 2014
Session 11
Wind Forecast Improvement Project (WFIP)
Location: Room C114 (The Georgia World Congress Center)
Host: **Fifth Conference on Weather, Climate, and the New Energy Economy**