NOAA RESEARCH • ESRL • PHYSICAL SCIENCES DIVISION

Improving Forecasts for Wind Energy: WFIP and WFIP2

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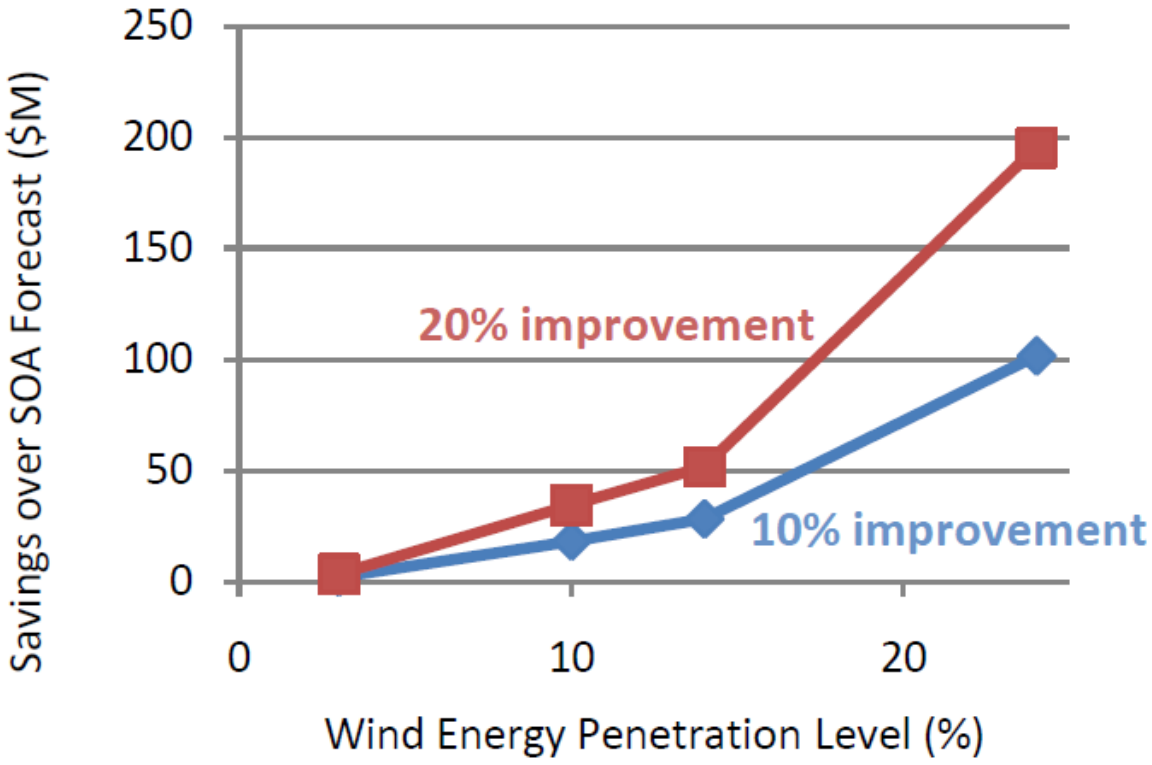
Outline

- Motivation: Why improving wind forecasts for wind energy is important
- Wind Forecast Improvement Project (WFIP)
  - Goals, Methods, Partners, Results
- WFIP2
  - Goals, Methods, Partners, Science Issues
- Summary

Is there economic value in improving wind forecasts?



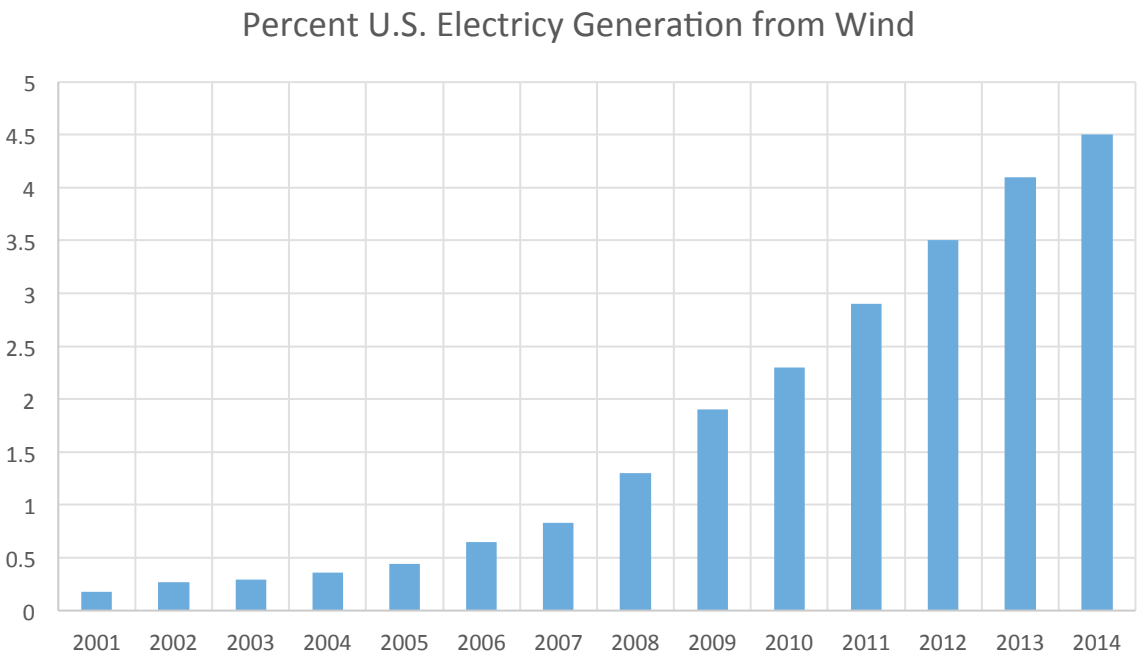
Results for WECC Western US grid area

NREL & GE study over western U.S. finds ~$200M annual savings from a 20% improvement in forecast skill for "next day" forecasts

Extrapolating for the entire U.S., the savings would be $975M/ year.

Lew et al, 2011

Historical and Future Wind Energy Generation



From U.S. DOE/Energy Information Administration

Future Wind Energy Production?

DOE/NREL REFS (2050):
82% non-fossil fuel
43% wind
Electricity Cost: 15.6¢ / kWh

NOAA NEWS (2030):
80% non-fossil fuel
42% wind
Electricity Cost: 10.7¢ / kWh

2014 average cost of electricity:
10.4¢ / kWh

Wind Forecast Improvement Project (WFIP)

DOE sponsored program with some NOAA funding

Can wind energy grid integration costs be decreased by improving short-term (0-6 h) wind energy forecasts by:

- Deploying a regional network of upper-air remote sensing observations
- Combining this network with proprietary industry provided tall-tower and wind turbine nacelle meteorological observations
- Assimilating this data into NWP models
- Improving NWP forecast systems

1 year field program 2011-2012

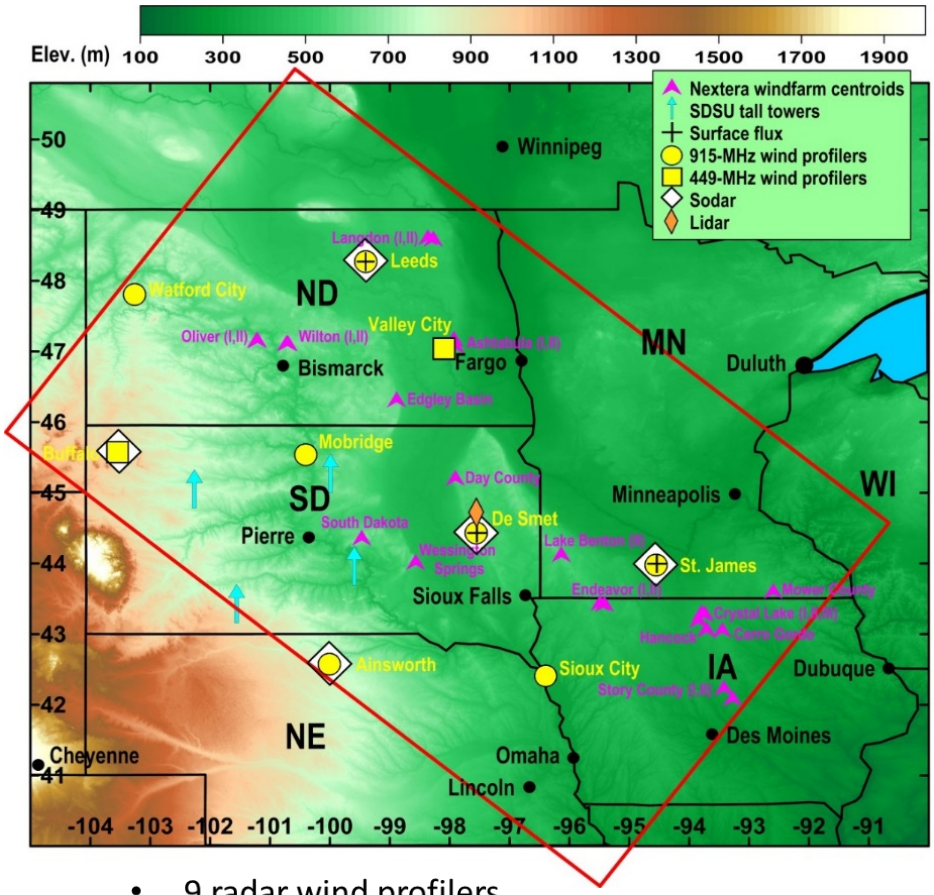
Partners
DOE labs
Wind Logics Inc
- MISO
- SDSU

AWS Truepower
- ERCOT
- Meso, Inc.
- OU, TTU, NCSU
- ICF International

NOAA/ESRL/GSD, ARL

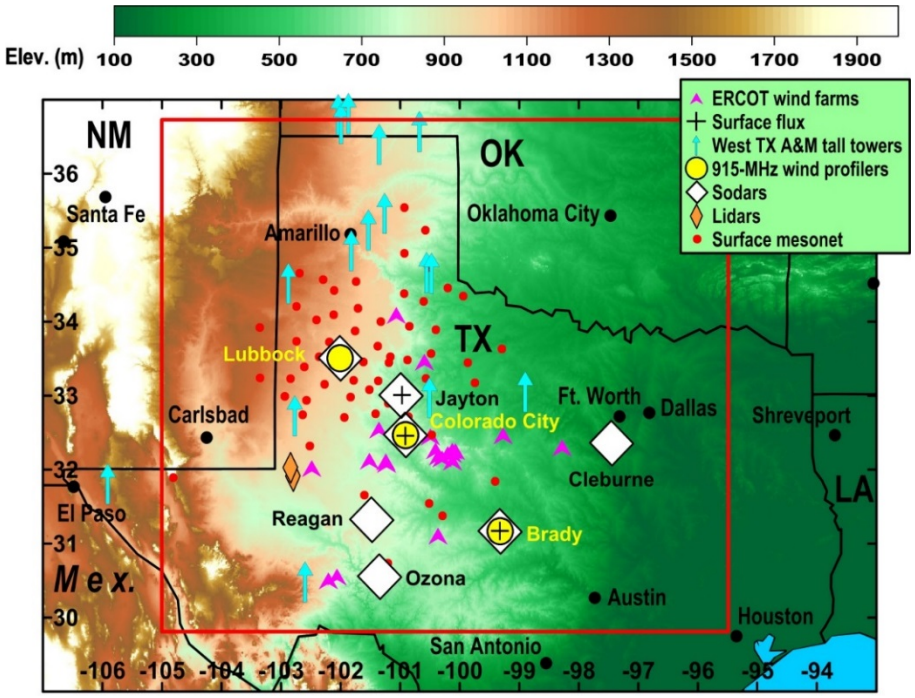
(Wilczak et al., 2015 BAMS)

Northern Study Area (NSA)
Wind Logics/MISO



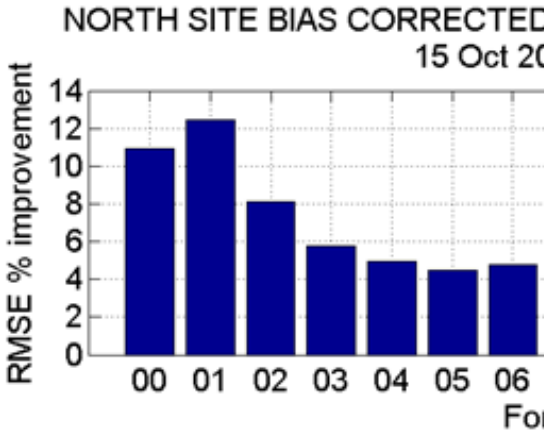
- 9 radar wind profilers
- 5 sodars
- 135 tall towers
- ~400 nacelle anemometers

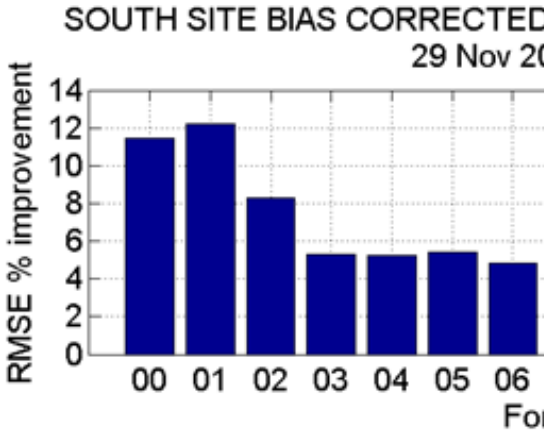
Southern Study Area (SSA)
AWS Truepower/ERCOT

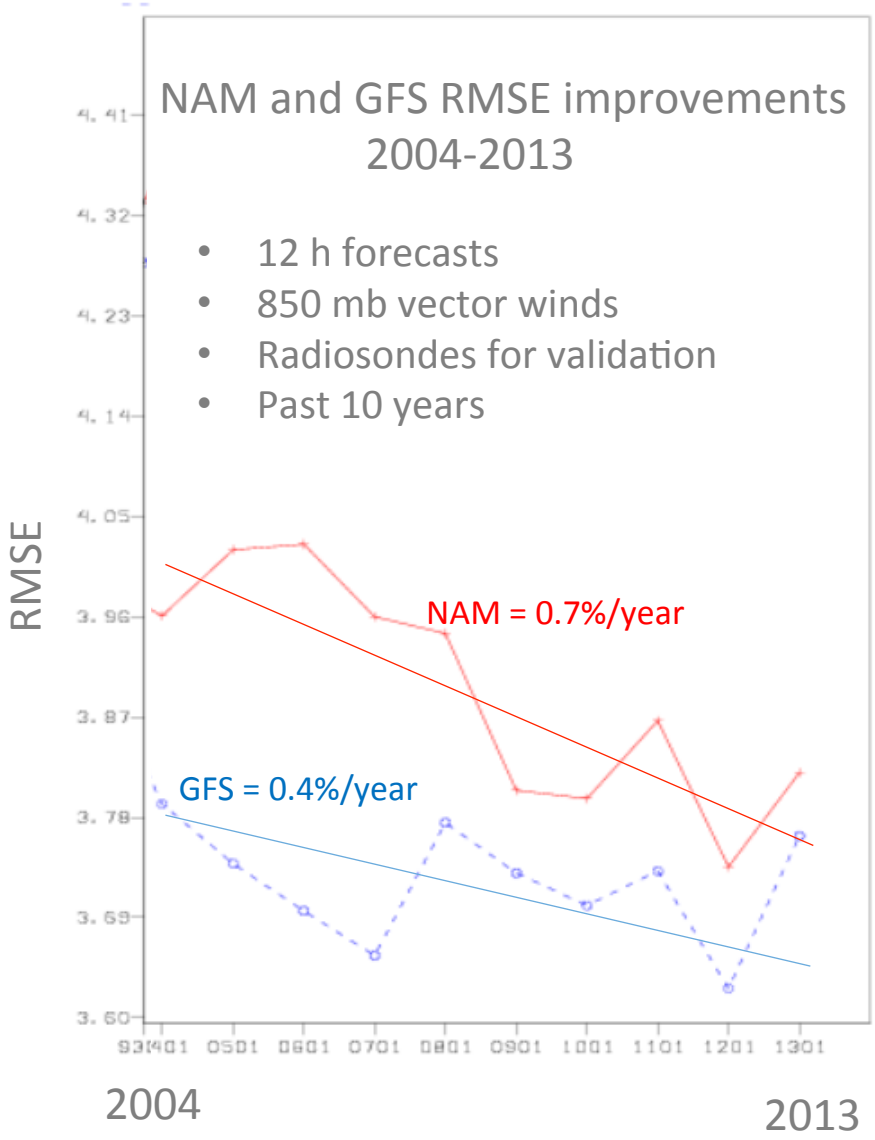


- 3 radar wind profilers
- 7 sodars
- 50 towers
- 62 surface met

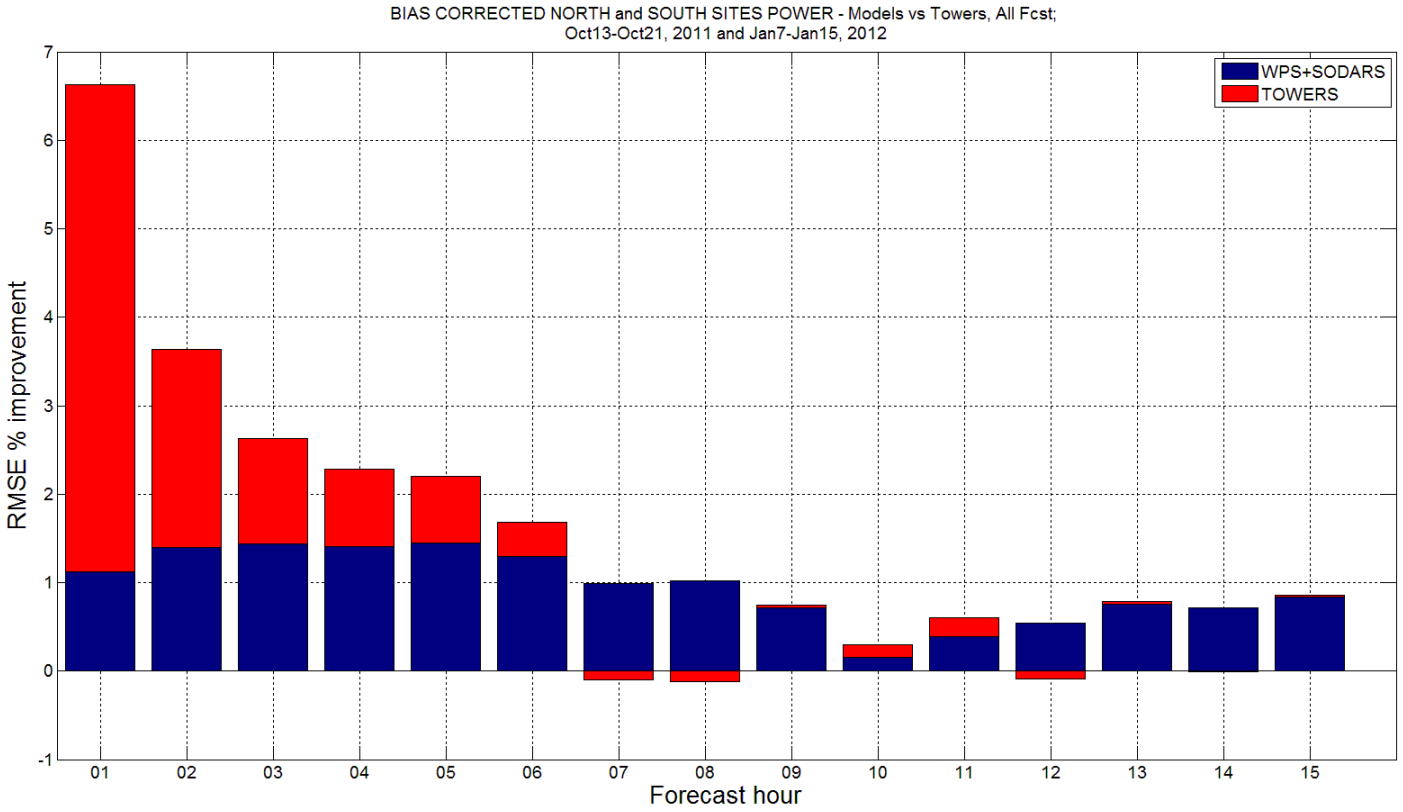
Industry tall tower locations not shown


NORTH SITE BIAS CORRECTED
15 Oct 20
RMSE % improvement
14
12
10
8
6
4
2
0
00 01 02 03 04 05 06
For


SOUTH SITE BIAS CORRECTED
29 Nov 20
RMSE % improvement
14
12
10
8
6
4
2
0
00 01 02 03 04 05 06
For


NAM and GFS RMSE improvements
2004-2013
• 12 h forecasts
• 850 mb vector winds
• Radiosondes for validation
• Past 10 years
RMSE
4.41
4.32
4.23
4.14
4.05
3.96
3.87
3.78
3.69
3.60
NAM = 0.7%/year
GFS = 0.4%/year
2004
2013

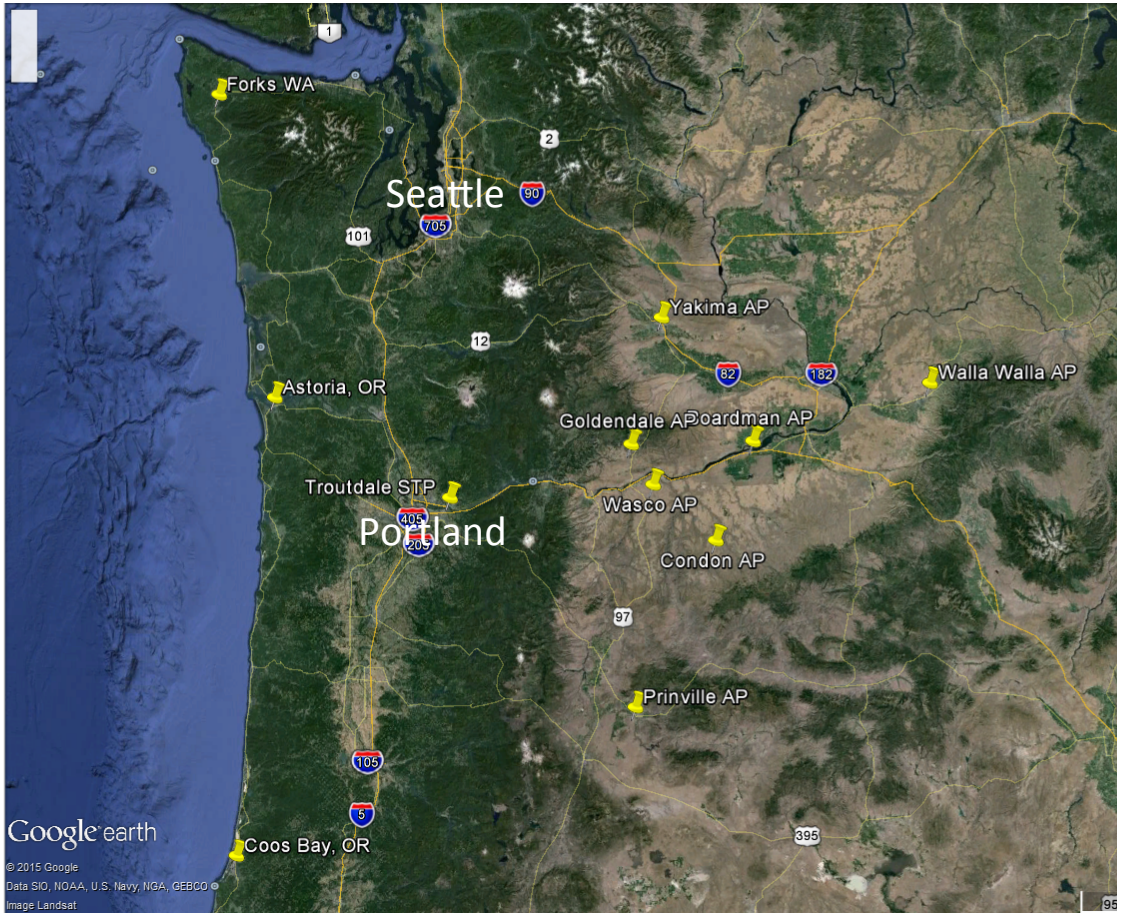
New Observation Impact



WFIP 2

- Goal: Improve NWP model forecast skill for turbine-height winds in regions with complex terrain
- Approach:
  - Collect new meteorological observations, especially within the atmospheric boundary layer
  - Observe and understand relevant atmospheric processes
  - Develop and test new model parameterization schemes
  - Transfer improved models to NOAA/NWS operations

WFIP 2: Area, Partners, Models, Instrumentation



- Area: Columbia Gorge & Eastern WA and OR
- Partners: DOE Labs (PNNL, ANL, LLNL), NOAA/ESRL/ GSD & CSD, NOAA/ARL, Vaisala (NCAR, Universities), Bonneville Power Administration
- Models: RAP, HRRR, NAM

- Observations
- 11 wind profiling radars (7 PSD)
- 17 sodars
- 5 wind profiling lidars
- 4 scanning lidars
- 4 radiometers (2 PSD)
- 28 sonic anemometers
- 10 microbarographs (all PSD)

WFIP 2

WFIP 2

WFIP 2

- Science Issues
  - 3D turbulence parameterization
  - Improved PGF with Immersed Boundary Method
  - Gap flow
  - Mountain waves
  - Mountain wakes
  - Mix-out of stable cold pool

Summary and Conclusions

- The future U.S. electrical grid system will contain significant generation from weather dependent sources (wind and solar, plus hydro)
- Providing forecasts to support this generation will likely become a critical mission for NOAA
- Improved forecasts make for a more economical and reliable energy system
- NOAA science in partner with DOE and the private sector can help speed the development of carbon-free energy generation
- Through WFIP, proprietary industry tall tower and turbine nacelle anemometer observations are now routinely available to NOAA for data assimilation and model evaluation.

Stakeholders

- Departments of Energy, Interior
- Wind plant owner/operators (e.g. Florida Power and Light, Iberdrola)
- Utilities (e.g. Pacific Gas & Electric, Xcel Energy)
- Grid transmission operators (e.g. Cal ISO, ERCOT)
- Private forecasting companies (e.g. AWS Truepower, WindLogics, Vaisala)
- NOAA/National Weather Service