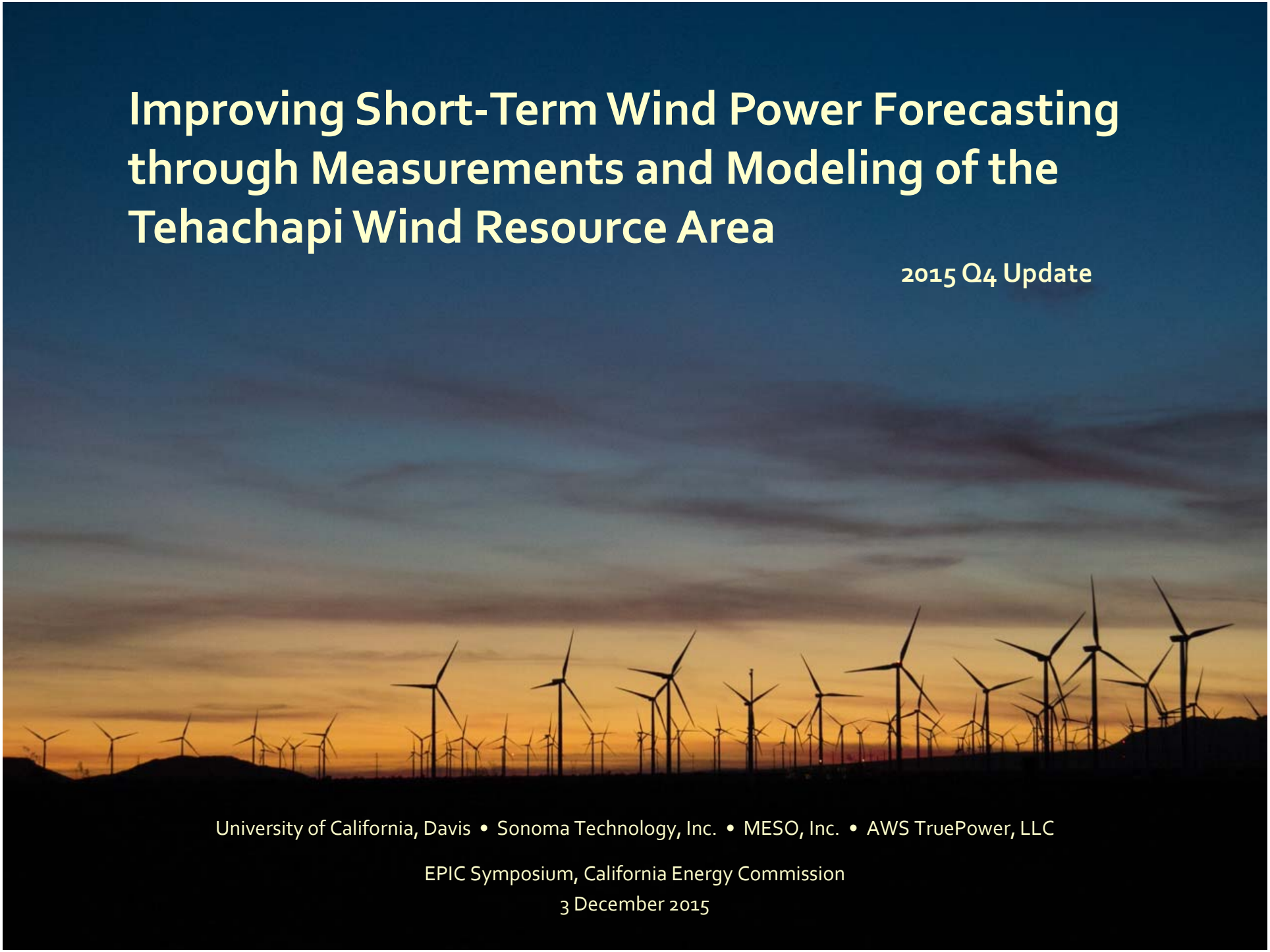
Improving Short-Term Wind Power Forecasting through Measurements and Modeling of the Tehachapi Wind Resource Area

2015 Q4 Update



University of California, Davis • Sonoma Technology, Inc. • MESO, Inc. • AWS TruePower, LLC

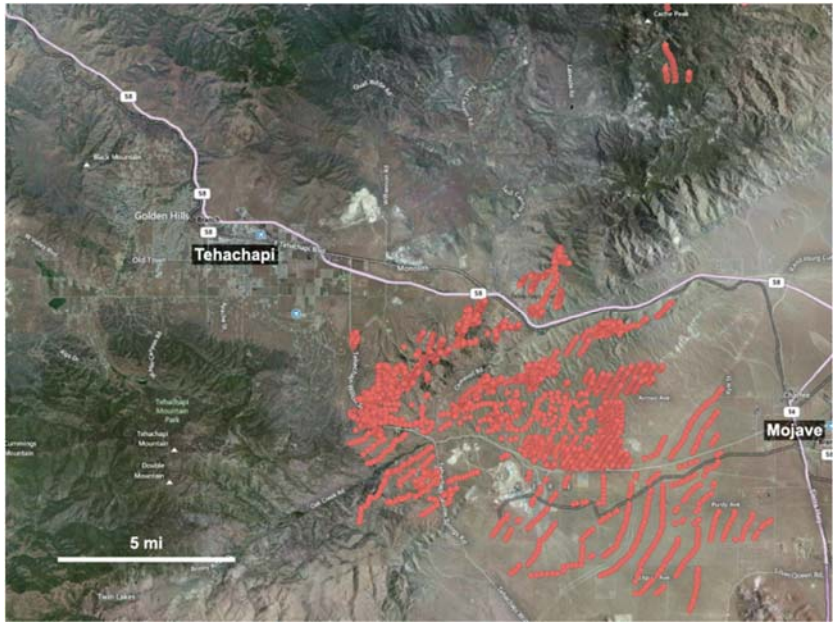
EPIC Symposium, California Energy Commission
3 December 2015

Agenda

- Project overview
- Goals
- Task Breakdown and Status Updates
  - Field measurement campaign (Task 3)
  - Wind ramp forecast system improvements (Tasks 2, 5, 6)
  - Numerical weather modeling improvements (Task 4)
- Future directions

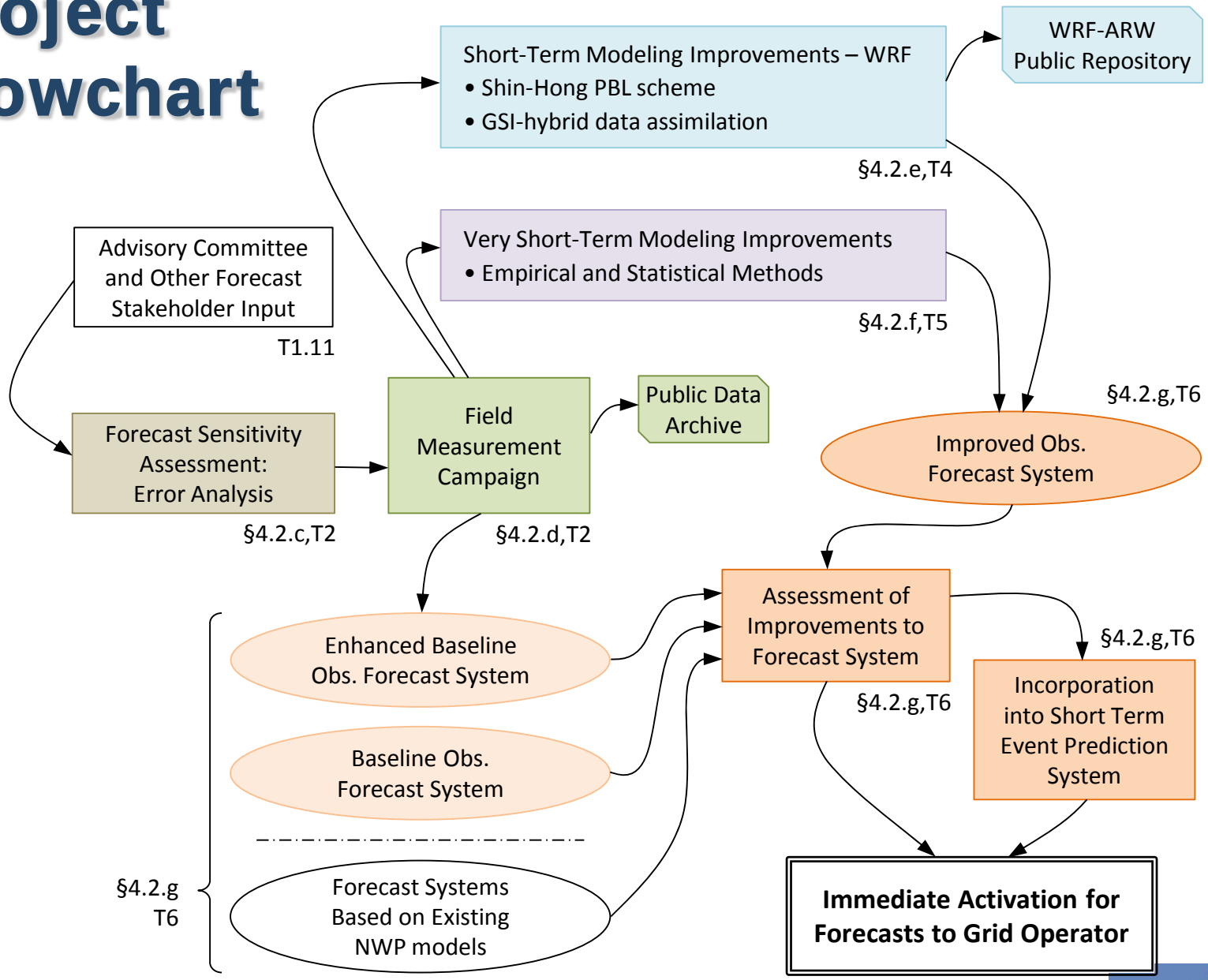
Project Overview

Coordinated field measurement campaign and computational modeling improvements to improve 0-15 hour forecasts of wind power ramps in the Tehachapi Wind Resource Area (TWRA)



- Tehachapi Wind Resource Area
  - California's largest wind resource area, both in existing capacity and potential
  - More than 3.1 GW installed capacity
  - Additional 2.3 GW in CAISO interconnection queue
  - More than 8 GW potential (CEC IAP, 2007)
  - Very complex terrain and meteorology
- Wind power ramp forecasting
  - Wind and solar forecasting identified as substantially beneficial by virtually all integration studies including CA IAP and NREL WWSIS
  - Wind and solar power ramp forecasting identified by CAISO as #1 task for renewables integration

Project Flowchart

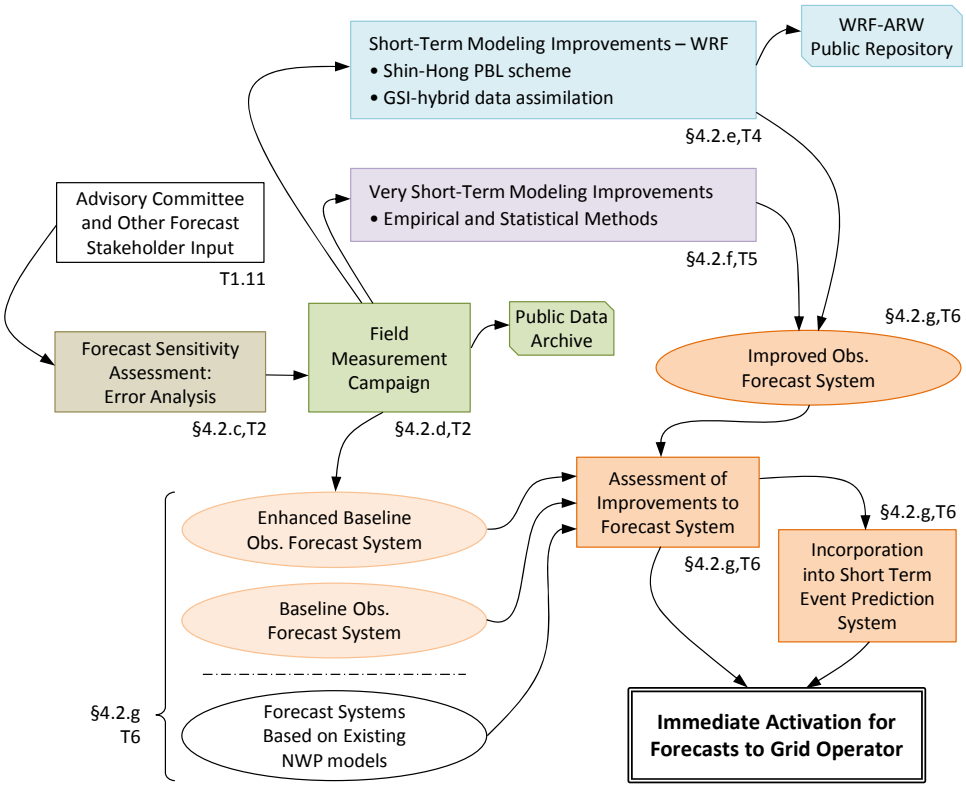


Project Goals

- By the project's conclusion, have an improved wind power forecast system for the TWRA, ready for incorporation by CAISO into grid operations
  - Validated improvements in prediction of short-term (1-3 hour duration, 0-15 hours ahead forecast horizon) and very short-term (< 1 hour duration, 0-3 hours ahead forecast horizon) events
  - Adaptable to other regions, control areas
- To the greater wind power and meteorological research communities:
  - A one-year long, advanced meteorological dataset of the TWRA
  - Improvements to WRF that target scales most critical to wind power
- Improved forecasting will:
  - Reduce the cost of integrating wind power
  - Improve grid reliability
  - Reduce emissions, both by facilitating more wind power development and lessening the amount of fossil-fueled of generating reserves needed by the grid operator

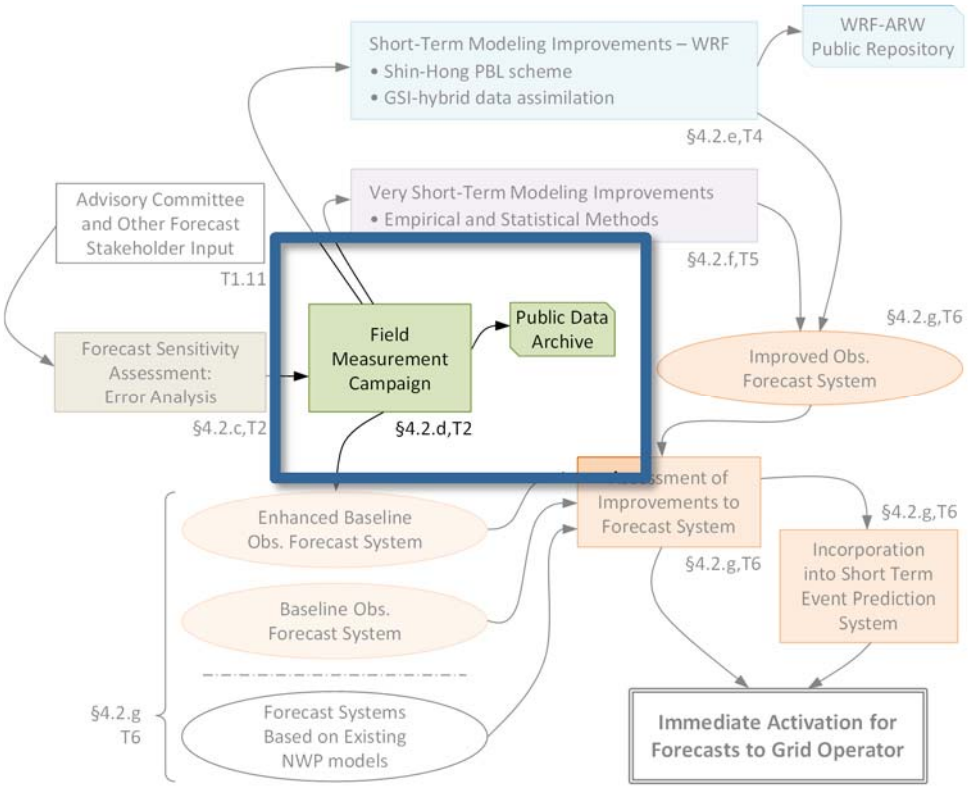
Project Management

- Prime recipient / project manager: University of California, Davis
  - Lead: Dr. C.P. "Case" van Dam
  - Henry Shiu
  - Rob Kamisky
- Period of performance:
  - May 2015 – July 2017

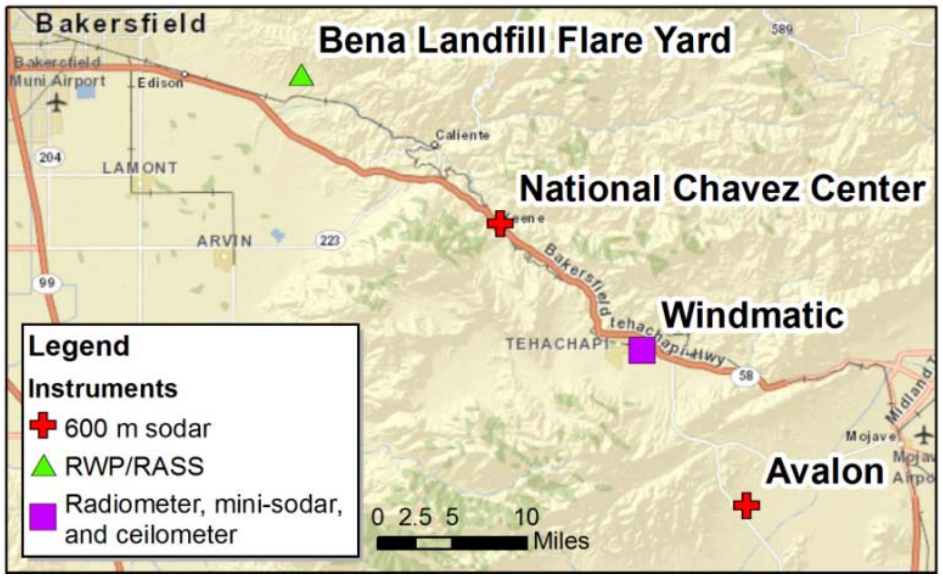


Field Measurement Campaign

- Sonoma Technology, Inc. (STI)
  - Lead: Clinton MacDonald
- Builds upon existing CEC WindSense project
- Deploy and operate an advanced met sensor network in TWRA
  - Input for forecast systems
  - Data for calibration/verification of computational improvements
- Status
  - All instruments installed and operating
  - Some sites under negotiation, but this is an ongoing process



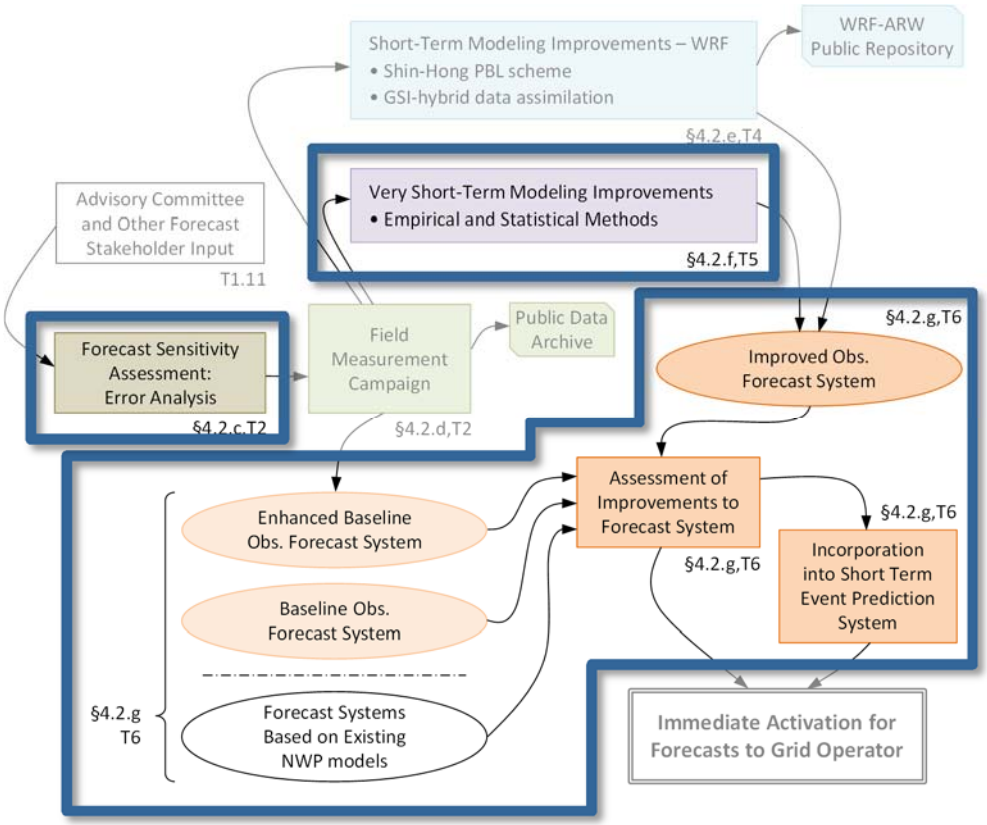
Sensor Network: Instruments and Sites



Instrument	Parameter(s)	Measurement Height(s) Above Ground Level (m)	Vertical Resolution (m)
Mini-sodar: ASC 4000	Wind speed, direction	~20 to 200	10
Sodar: ASC 2000	Wind speed, direction	~80 to 600	25
Sodar: ASC 2000	Wind speed, direction	~80 to 600	25
Microwave Radiometer: Radiometrics MP-3000A	Temperature, humidity, and liquid water	~10 to 10,000	50 at <500 100 at 500-2000 250 at >2000
Radar Wind Profiler: Vaisala LAP 3000	Wind speed, direction	~120 to 3500	60 to 100
RASS: Vaisala LAP 3000	Virtual temperature	~120 to 1500	60
Ceilometer: Vaisala	Boundary layer and cloud base height	~2 to 10,000	5

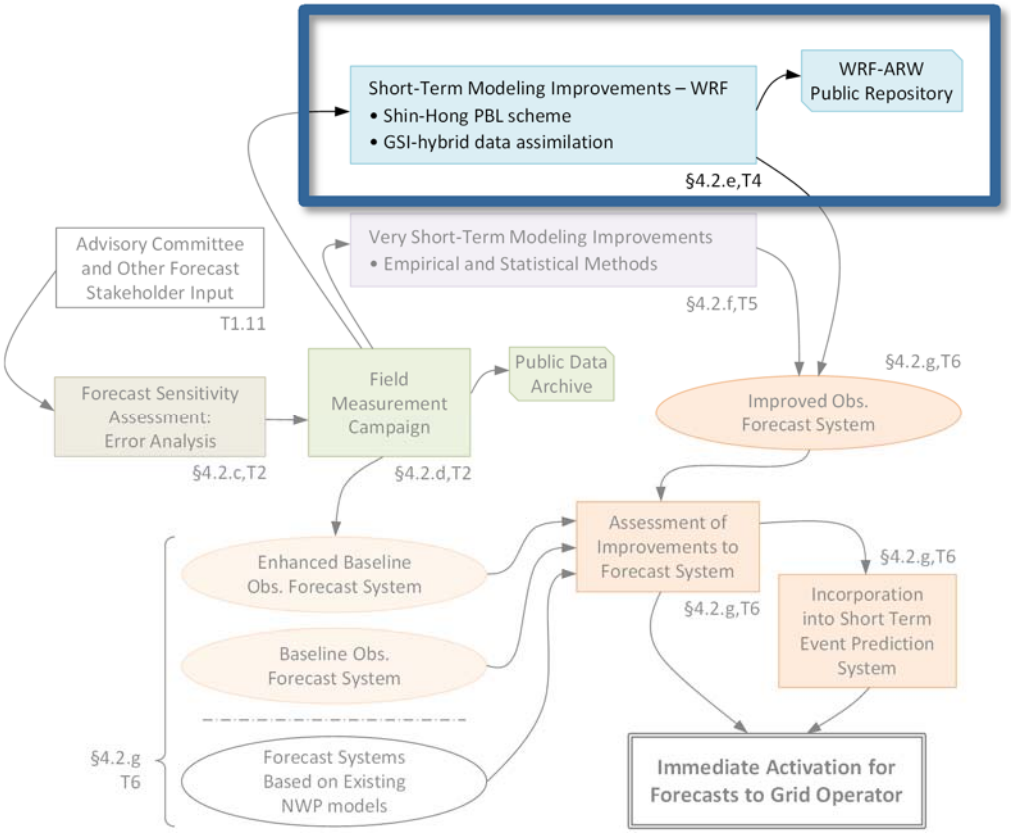
Improved Wind Ramp Forecast System

- MESO, Inc. and AWS Truepower, LLC
  - Lead: Dr. John Zack
  - Joseph Lefevre
- Assess forecast sensitivities
  - A study of 30 cases to determine sensitivity of the numerical weather model to configuration
  - Status: Complete
- Apply statistical methods to forecast very short-term events (< 1 hour) at horizons of 0-3 hours
- Integrate improvements; operate and evaluate forecast systems
  - Status: BOFS operational. Establishing inputs from field measurement campaign for EBOFS.



Short-Term Modeling Improvements

- University of California, Davis: Department of Land, Air, and Water Resources
  - Lead: Dr. Shu-Hua Chen
  - Chih-Ying "David" Chen
- Improve physics modeling in numerical weather prediction models
- Targets longer duration events (1-3 hours) at horizons of 0-15 hours ahead
- Status
  - Completed integration of high resolution land cover data
  - Assessing GSI-hybrid data assimilation and Shin-Hong planetary boundary layer scheme with site data from the field measurement campaign



Status Summary

- A lot of work is underway!
  - Sensor network is installed and operational.
  - Forecast sensitivity assessment is complete.
  - Baseline Observational Forecast System (BOFS) is running.
  - Enhanced Baseline Observational Forecast System (EBOFS) will be running shortly.
  - Schemes/methods for improving numerical weather modeling are being assessed with actual site data.
- Recently presented at 2015 Wind Integration Workshop, Brussels, Belgium.

Future Research Directions

- Expand sensor network
- Additional modeling improvements, both in WRF (flow physics) and very short-term empirical methods
- Extend coordinated measurements/modeling approach to include solar
- Expand to other renewable resource areas and control areas

- We are currently negotiating a new funding award that will allow us to do some of the above

Other Project Partners

- California Independent System Operator (CAISO)
- Southern California Edison (SCE)
- National Center for Atmospheric Research (NCAR)
- Korea Institute of Atmospheric Prediction Systems (KIAPS)
- National Central University, Taiwan
- Lawrence Livermore National Laboratory (LLNL)
- EDF Renewable Energy

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