



AESO Forecasting Pilot Project Workshop

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Wind Power Production Forecasting in Alberta: AWST's Thoughts and Recommendations

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- Mapping
- Energy Assessment
- Project Engineering
- Performance Evaluation
- Forecasting

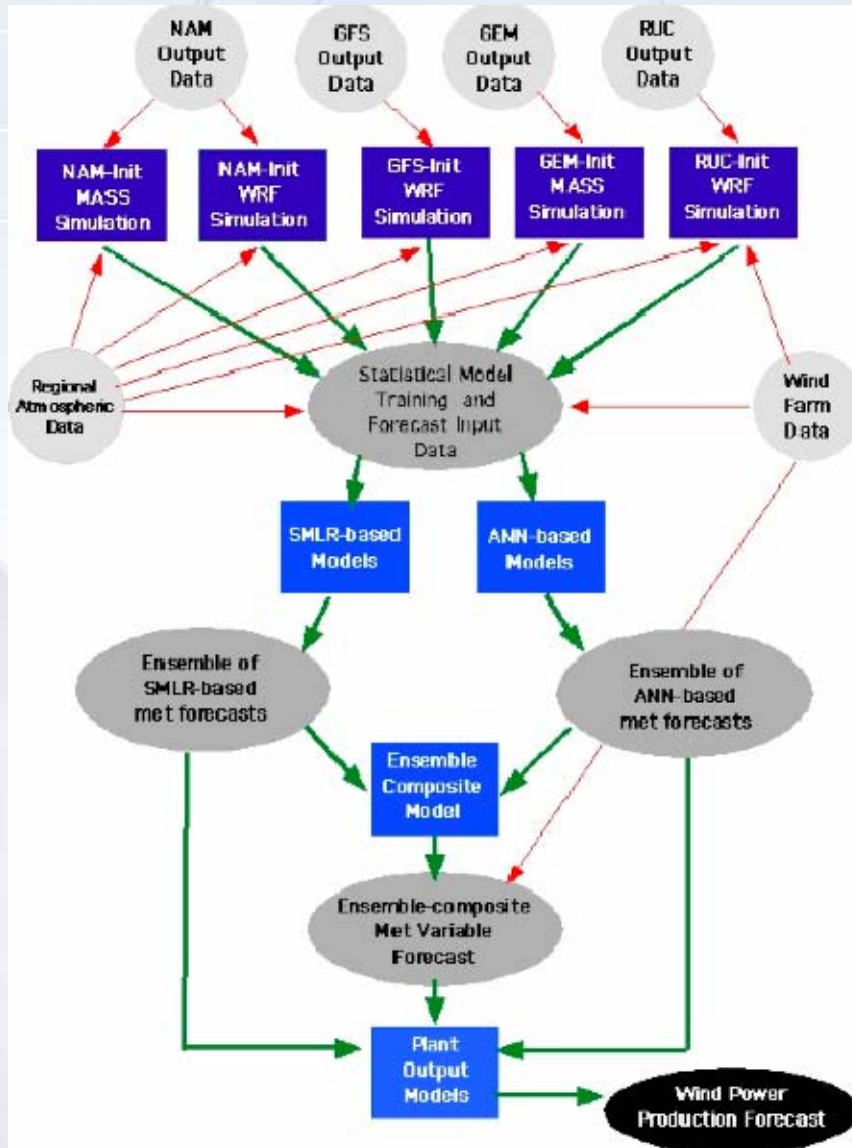


- **Mapping and Project Development**
 - Utilizes AWST's resource assessment tools: MesoMap and SiteWind
 - Constructed regional wind maps for over 25 countries and 50 states and regions
 - Been involved in over 15,000 MW of project development
- **Forecasting**
 - Based on AWST's multi-model forecast system: eWind
 - Currently contracted to provide forecasts for over 7,500 MW
 - Selected as forecast provider to several major grid operators: CAISO, ERCOT, NYISO etc.
- **European Applications through Meteosim Truewind partnership**
 - Headquarters in Barcelona, Spain

Overview

- How AWST Produced Forecasts
- Lessons Learned (or Reinforced)
- AWST's Recommendations
- Next Steps in Alberta
- Next Steps in the Industry

How AWST Forecasts were Produced



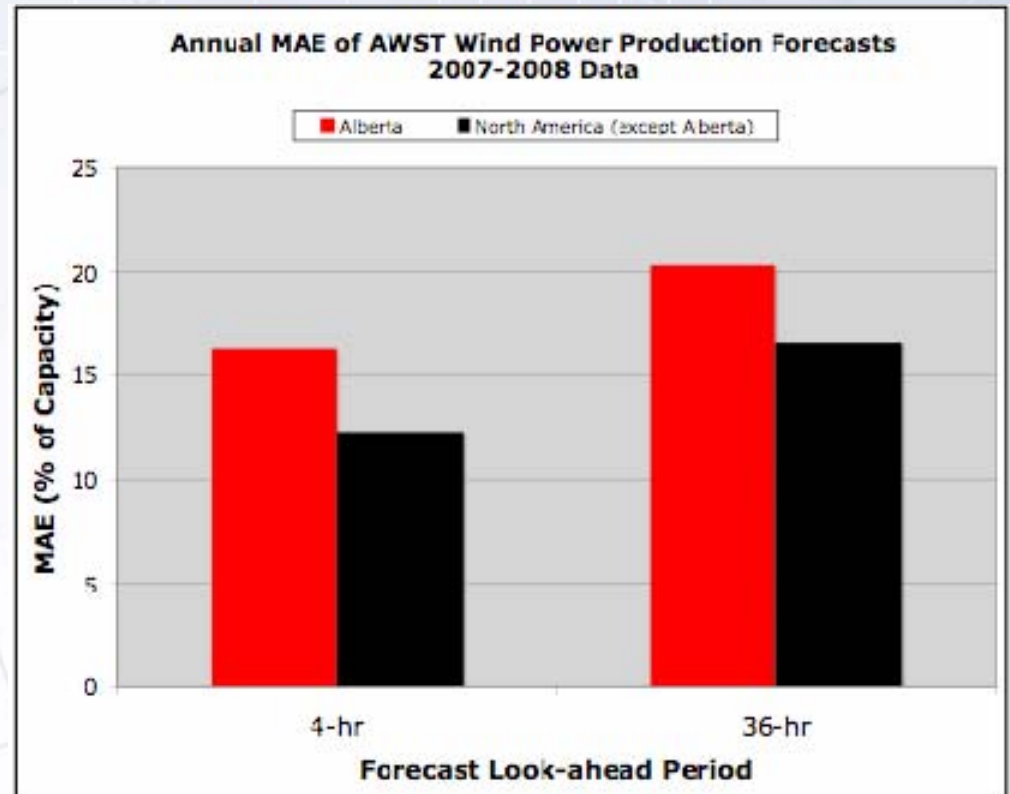
- Based on an ensemble of forecasts from a set of physics-based and statistical models
- Optimization algorithm weights each forecast according to its recent performance

A Few of the Lessons Learned or Reinforced

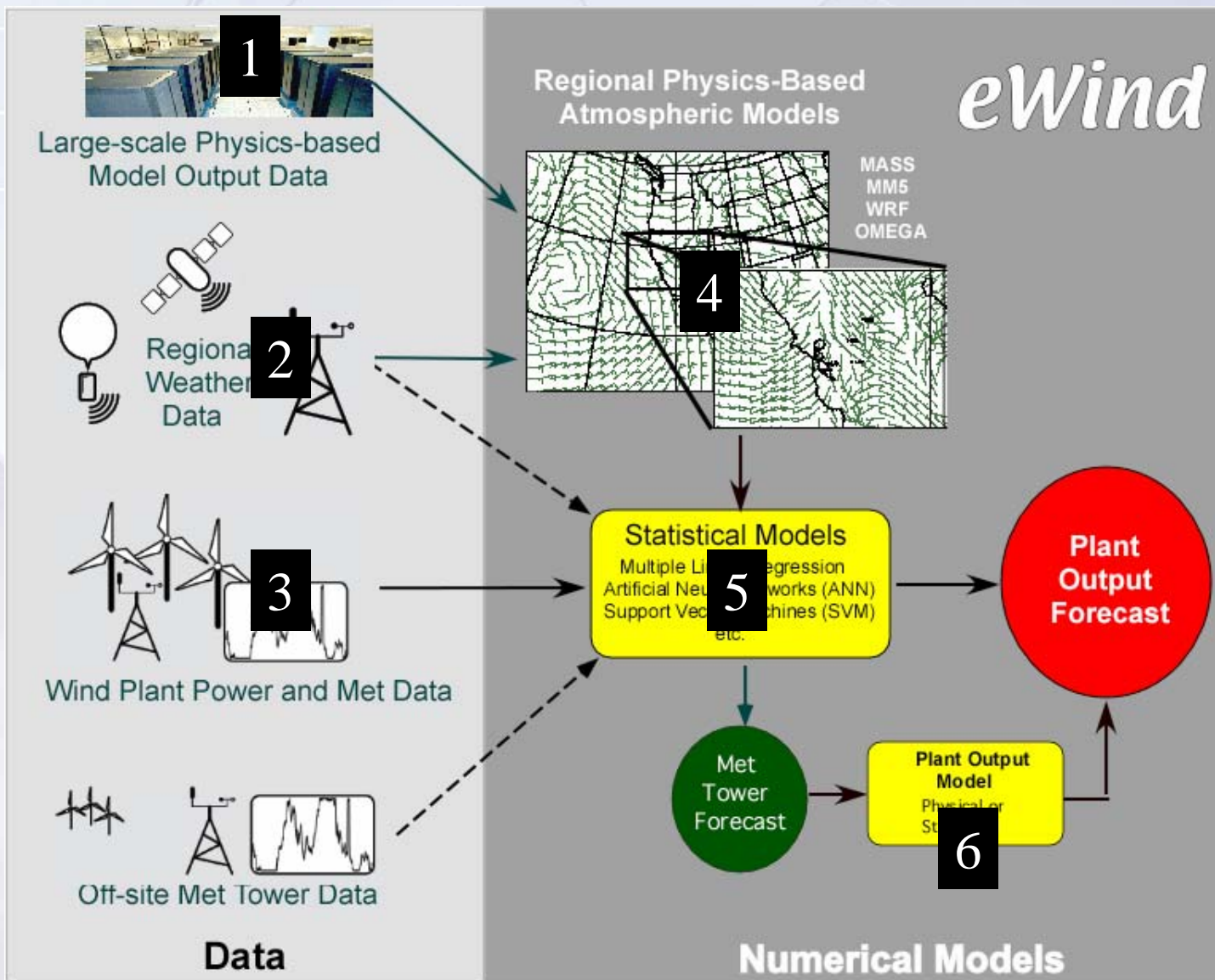
- The forecasting of wind power production is typically more difficult in Alberta than in many other places in North America,
- Contributions of data types and forecast system components differ by look-ahead time
- Quality and representativeness of **Wind Generation Facility (WGF)** data can significantly impact forecast performance
- Knowledge of the characteristics of Alberta-specific wind regimes can improve forecasts
- There is much information about ramp events hiding in NWP forecasts

AWST Forecast Performance Alberta vs North America

- 2007-08 MAE for Alberta sites was about 20% to 30% higher than NA averages
- Why?
 - Less forecaster familiarity with Alberta wind regimes
 - Frequent occurrence of difficult to forecast wind regimes
 - Less than optimal quality of WGF met and operational data

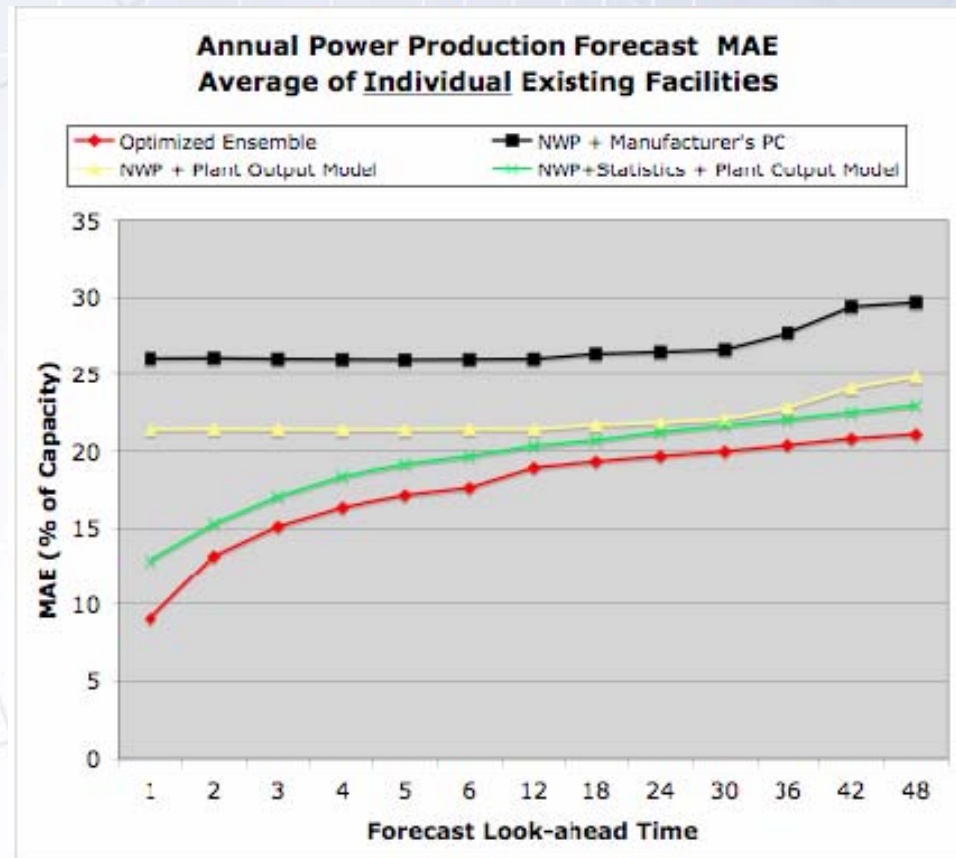


What are the sources of error?



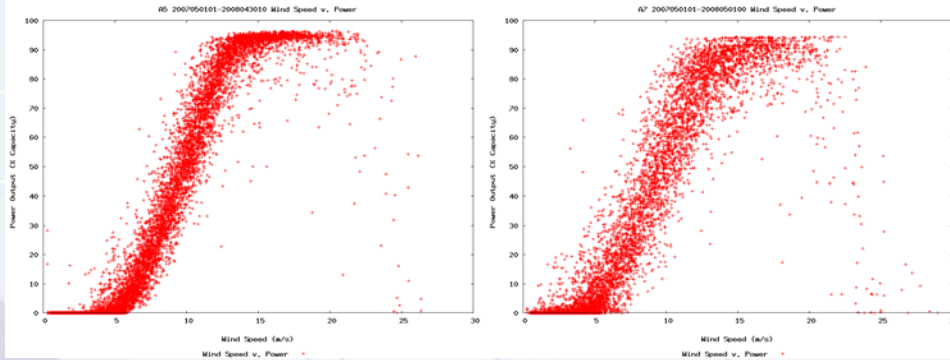
Impact of Forecast System Components on Forecast Performance

- NWP supplies most of the skill after about 6 hrs
- Onsite data is crucial for first 6 hrs
- Plant output model based on WGF data outperforms “manufacturer’s power curve approach
- Statistical adjustments of NWP (MOS) and “optimized ensembles” add modest improvements to NWP skill after 6 hrs



Can NWP be improved for 1-6 hr range? RUC?

WGF Data Issues



WGF #1

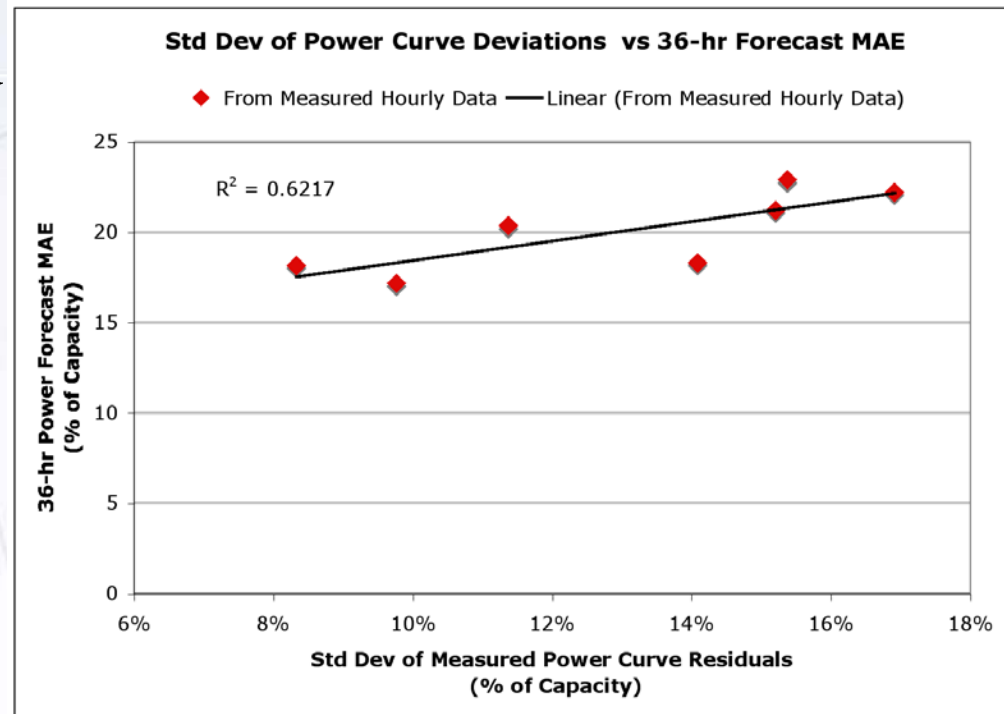
WGF #7

Site	Std Dev
1	8.3%
2	9.8%
3	11.4%
4	14.1%
5	15.2%
6	15.4%
7	16.9%

Group	WGF No.	Comments
Lowest scatter	WGFs 1 & 2	The met tower is at same elevation as turbines and is relatively centered on the prevailing upstream side. Close to an ideal placement for a met tower.
Moderately low scatter	WGF # 3	The met tower is at a lower elevation than many turbines by about 20 m
Moderately high scatter	WGFs # 4, 5 & 6	Lots of terrain elevation variation within two of these farms. At farm #5 the met tower is at the low point on a ridge about 60 m below the high point. At farm #4, the met tower is about 60 m below and several km away from any turbine. At Farm #6 there is only about 20-40 m elevation variation and the met tower is in the middle but the tower is close to the water, which most likely reduces its representativeness.
Highest scatter	WGF # 7	Prevailing 250 wind direction has many turbines sheltered by a 200 m ridge, but the met tower is not sheltered. Secondary prevailing direction around 290 for which almost everything is sheltered by the ridge but the met tower is less sheltered. Turbines elevation ranges from about that of the met tower to 60 m higher.

Impact of WGF Data Quality on Forecast Performance

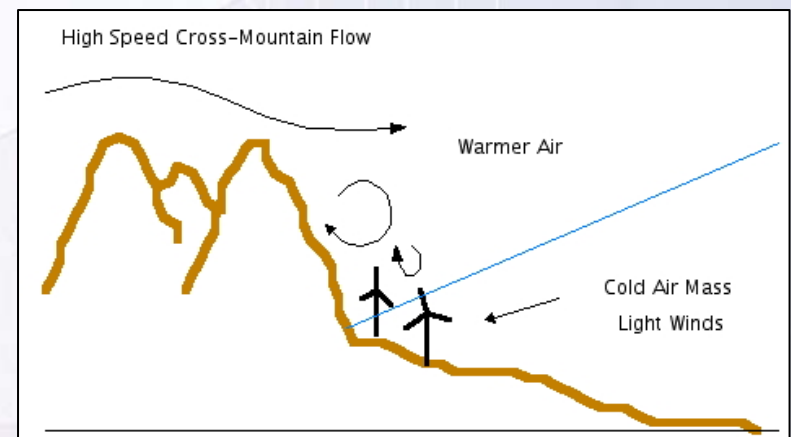
- Scatter in the power-wind relationship is strongly correlated with day-ahead forecast MAE
- 62% of MAE variance among the 7 existing WGFs is examined by the data scatter parameter



Lesson Learned (Reinforced): Quality and representativeness of WGF data has a significant impact on forecast performance

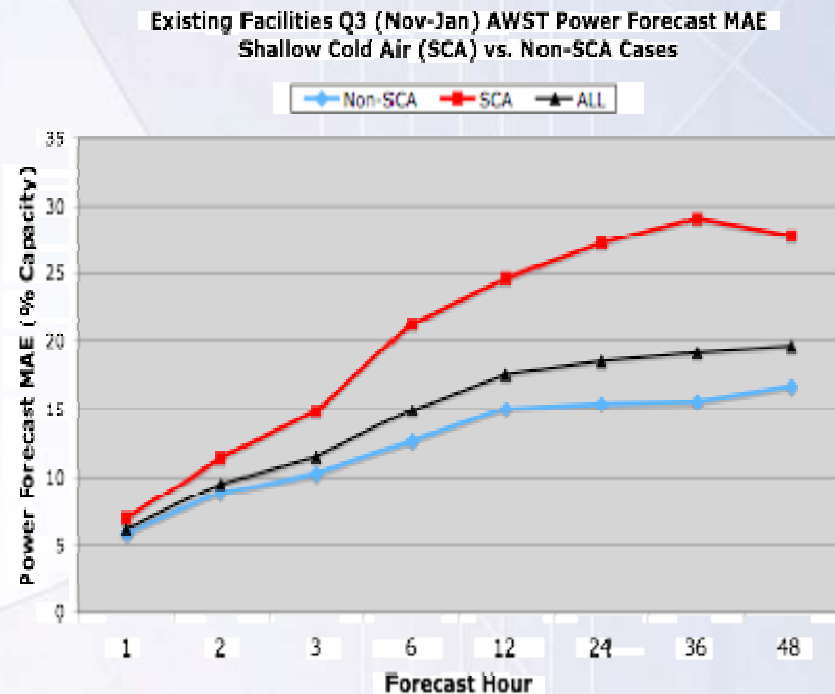
A Path to Improved Forecasts: Understanding Alberta's Wind Regimes

- Wind regimes were identified and analyzed for Q3
- Most prominent regimes
 - Cross-mountain flow with mixing to E & below mts
 - Shallow cold air (SCA)
 - Cold air surge
 - Nocturnal cooling
- SCA is more difficult to forecast than other regimes
 - Very sensitive to stability
 - Difficult to initialize in NWP
 - Turbulence models important



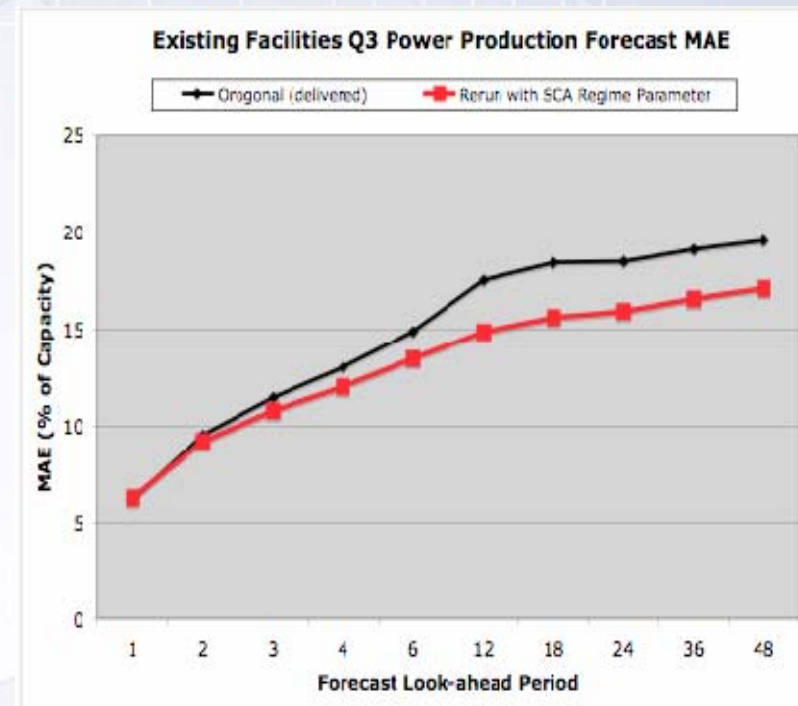
Forecast Performance in the SCA regime

- SCA regimes influenced 25.7% of the hours in Q3
- 4-hr ahead MAE was 68.7% higher for SCA hours than for non-SCA hours
- 36-hr ahead MAE was 86.8% higher for SCA hours than for non-SCA hours



Improved Forecasts with Knowledge of SCA Regime Characteristics

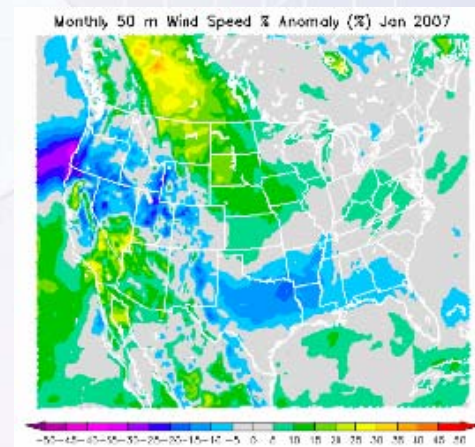
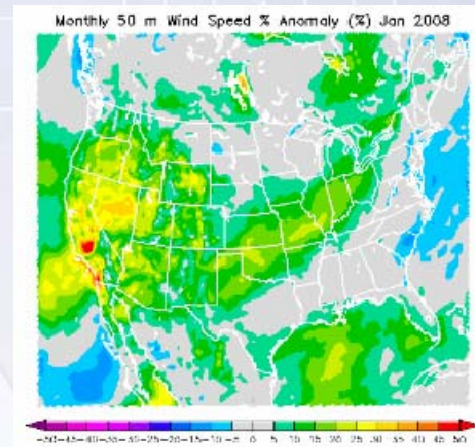
- A parameter was developed to distinguish SCA from non-SCA regimes in NWP forecasts
- Reran forecasts for Q3 of project with the new parameter
- Result: 15% to 20% reduction in overall Q3 MAE for hours 12-48



Lesson Learned: Knowledge of the characteristics and NWP model error patterns in key regimes can improve forecasts

Another Regime Issue: Representativeness of Training Sample

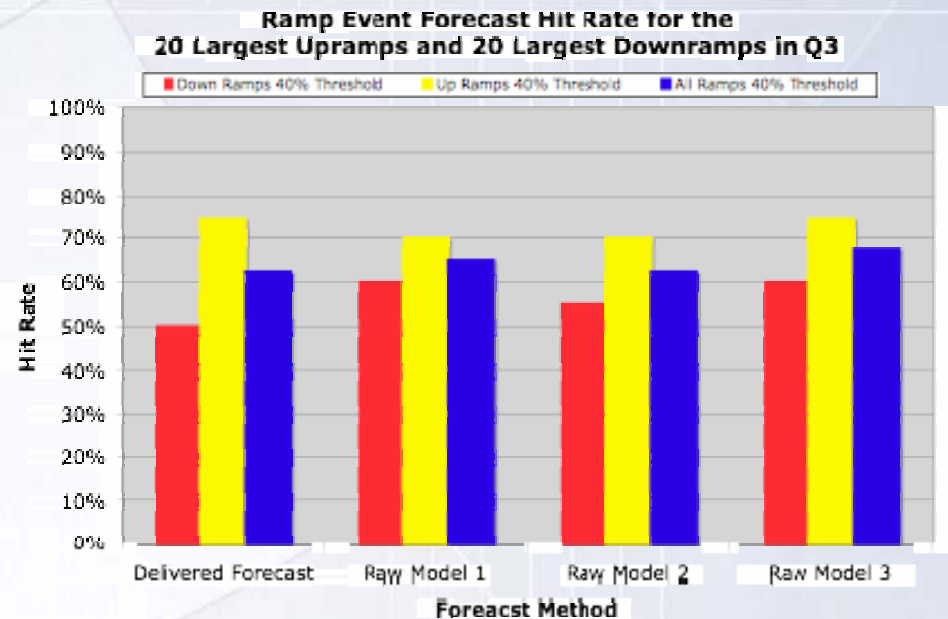
- ~ 1 year (Jan 06 - Apr 07) of “training data” was available at the start of the project
- Weather regimes in Dec 06 and Jan 07 were anomalous:
 - much less cold air
 - stronger cross mountain flow
- Therefore: impact of SCA regime was less significant in training sample



% deviation of 80 m wind speed
from 10-year mean

Ramp Forecasting: The Story Behind the Story

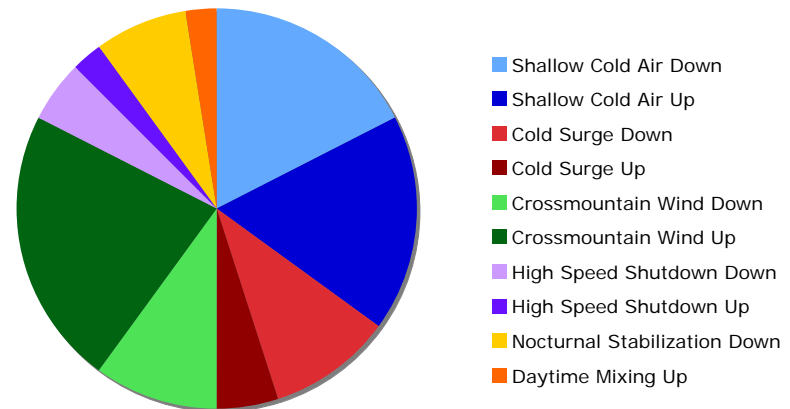
- ORTECH's analysis indicated little skill in forecasting of significant 1-hr ramps
 - Based on 80% to 120% of amplitude "hit" criteria
- Analysis of 40 largest Q3 ramp events indicates that this is due to a significant low bias in ramp amplitude in the forecasts
- If one accounts for the low amplitude bias there is actually a signal of most ramp events in the forecast



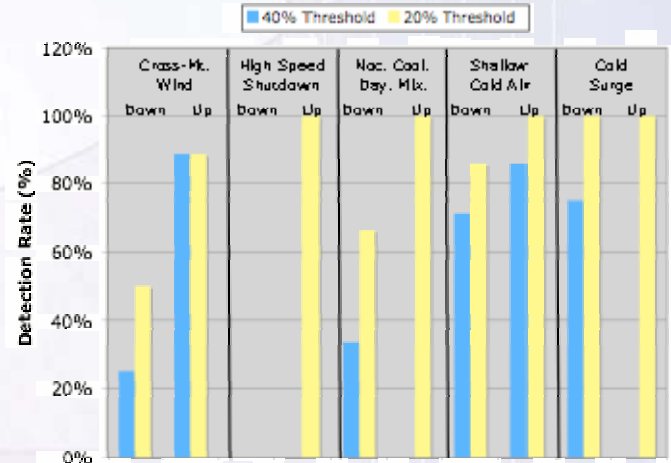
Ramp Predictability

- Large ramps are caused by a variety of atmospheric processes
- Some processes and the associated large ramp events have a much higher detection rate (I.e are more “forecastable”)

Composition of Q3 Ramp Events (40 total)

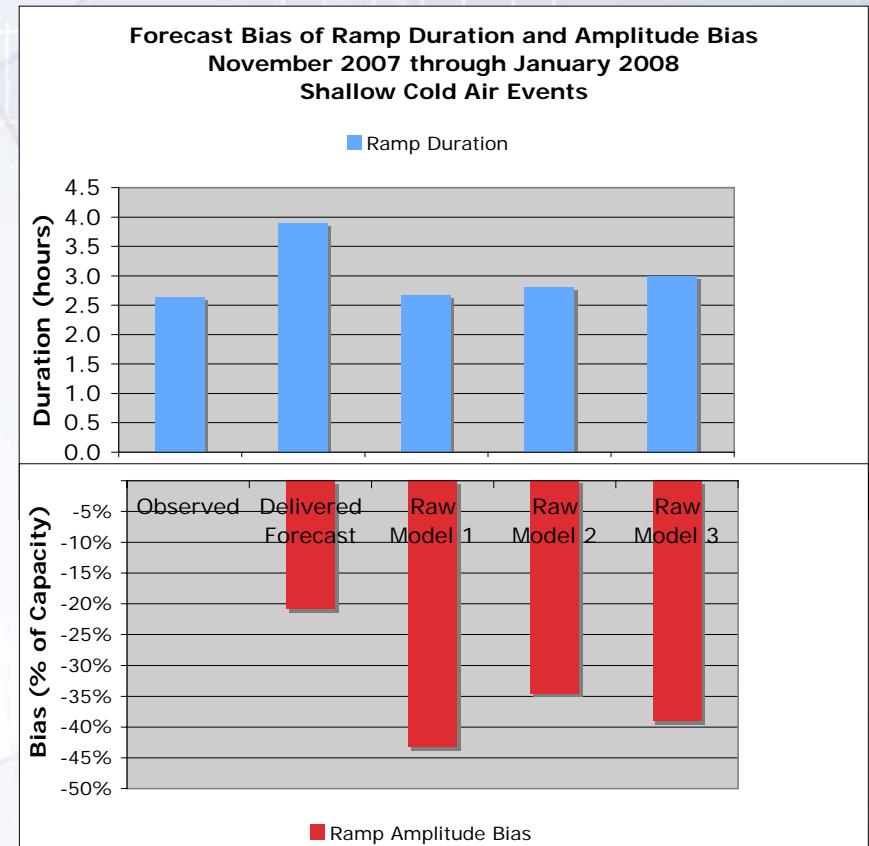


Q3 Ramp Forecast Detection Rate by Event Type and Threshold



Ramp Forecasts: Impact of the Wrong Optimization

- Q3 analysis indicates:
 - Raw NWP model forecasts have approximately the correct duration but a low amplitude bias
 - RMSE-optimized forecast (i.e. the delivered forecast) has a lower amplitude bias but a high duration bias



Lesson learned: NWP forecasts have a lot of hidden information about ramp events that could be exploited in a ramp forecast system

A map of Canada with the province of Alberta highlighted in red. The map shows the outlines of the provinces and territories, with the oceans in light blue and land in light grey. The title 'AWST's Recommendations for Alberta' is centered over the map.

AWST's Recommendations for Alberta

- Forecasting Program Design
- Next Steps in Alberta
- Next Steps in the Wind Industry

AWST's Recommendations



- Centralized Forecast System
 - Most likely a lower cost per WGF (economies of scale)
 - Probably can use individual WGF data for benefit of other WGFs and system-wide forecasts
 - More uniform forecast quality
- Multiple (at least 2) forecast providers
 - Mini-ensemble
 - Redundancy (backup)
 - Competition accelerates innovation
- Establish data standards for WGFs
- Clearly define forecast objectives
 - Performance parameter(s) to be minimized?
 - Event-oriented forecasts (ramps etc.)?
 - Situational awareness?
- Establish a mechanism for provider-user interaction
- Include Alberta-specific R&D in forecasting program

Next Steps in Alberta

- Establish forecasting objectives
 - Understand how AESO and MP are sensitive to forecast error
 - Types of products needed to address needs
- Upgrade quality of data from WGFs
 - Availability information is very important
 - Representative met tower siting
 - Multiple level wind and temperature measurements
 - Robust communication of data in near real-time
 - Operational and met data by turbine if possible
- Develop an off-site real-time meteorological database
 - Establish access to existing public/private networks (e.g. RWIS)
 - Consider future deployment of strategic remote sensing sites
- Establish an Alberta-oriented forecasting R&D Program

Next Steps in the Industry



- Establish Forums for Communication
 - Facilitate provider-user interaction
 - Facilitate researcher-provider-user interaction
- Establish Forecast Performance Benchmarks
- Improve Data quality from WGFs
 - Establish data quality/representativeness standards for WGFs
 - Establish data format and communication standards
- Advocate for New Measurement System Technology
 - Lobby for space-based sensors most relevant to wind forecasting
 - Space-based LIDAR (3-D wind measurements over large volumes)
 - Facilitate deployment of new ground-based remote sensing
 - Low-cost, low power “cell-tower” mounted Doppler radars
- Support Wind Forecasting R&D