NWP Wind Forecasting Benchmarks

Forecasting Session 3: IEA Wind Task 36 Joint Session
ESIG 2020 Meteorology and Market Design Online Workshop
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WP1: Global Coordination in Forecast Model Improvement

- **Subtasks:**
  - Subtask 1.1: Compile list of available wind data sets, especially from near the hub height of modern turbines (>100m a.g.l.).
  - Subtask 1.2: Annual reports documenting and announcing field measurement programs and availability of data. Ensure usable data description.
  - Subtask 1.3: Verify and Validate the improvements through one or more common data sets to test model results upon and discuss at IEA Task meetings
  - Subtask 1.4: Work closely together with the international modeling centers to include energy forecast metrics in NWP model upgrades.

- **Deliverables**
  - D 1.1: Annual summary of major field studies supportive of wind forecast improvement; list of available data
  - D 1.2: Common benchmark for V&V: definition, release and analysis of results as a paper
  - D 1.3: Report on future issues for research in wind power prediction
Second Wind Forecast Improvement Project (WFIP2)

Maps by Billy Roberts, NREL

Columbia River Gorge

Mt. Hood (3429 m)

Mt. Adams (3743 m)
Improving Wind Energy Forecasting Through Numerical Weather Prediction Model Development

Operational numerical weather prediction models are being developed to improve wind energy forecasts by leveraging a multi-disciplinary dataset from the Second Wind Forecast Improvement Project field campaign in the U.S. Northeast.

Numerical weather prediction (NWP) models provide the foundation for forecasting a wide range of meteorological phenomena, from tropical cyclones to gale forces. The development of many operational NWP models has traditionally been motivated, in large part, by improvements in forecasting high-impact weather events and extension, near-shore, “strategic” weather, while comparatively little effort has been devoted to improving forecasts of wind speed and wind direction. This is particularly true for wind turbines, where wind energy harvested in wind energy communities results in 6% and 4% of the electricity production of the United States and the world, respectively, and the rate of growth since 2001 is 17% and 21%, respectively. Wind energy is expected to become a large component of the electrical generation portfolio for the United States and the world as a whole (DOE, 2005). The U.S. Wind Energy Roadmap (2010) projects, for instance, that by 2030, the U.S. Wind Vision of the Department of Energy (DOE) study has mapped out target scenarios for wind energy to provide 35% of the United States’ electricity demands by 2034 (Department of Energy, 2015). However, forecasts of wind speed and wind direction are critical to the overall efficiency and performance of these systems. In this end, the strategic aim of NWP model development must broaden to include the goal of improved forecasting of rate-layers winds.
WFIP2 Verification and Validation (V&V)

- WFIP2 V&V Goals
  - Provide tools, methods, and guidance to enable repeatable, metrics-based assessment of WRF and HRRR for analysis and forecasting of mesoscale weather phenomena that are important for wind energy in the Columbia River Gorge and CONUS.

- Verification
  - Verification is concerned with checking the mechanics of the software code rather than checking that the model’s physics are correct.

- Validation
  - Validation is determining the degree to which the model represents the real world for a particular application.
WFIP2 Approach to V&V

WFIP 2 Weather Taxonomy

- Gap Flows
- Cold Pool Mix-Outs
- Mountain Waves
- Orographic Waves
- Marine Push/Thermal Troughs

Key variables and metrics:
- 80 m wind speed
- wind power
- Bulk rotor layer statistics (RMSE, bias, MAE, % improvement)
- wind ramp metric

Common case study data set to test validation code

EVS validation tool and data base

Experiment to Model Analysis Table (EMAT):
- What, where, when?
- What are the dominant physics?
- How do we see this in measurements?
- What are the metrics we should use?

Event Log

Case Study Report Template

Workshops to compare validation results and test EVS tool

PI Interviews

Regular V&V meetings to discuss and coordinate results

Model Testing Framework
Plans for IEA Wind Task 36 Benchmark

• Experience from WFIP2
  – Tested a case study
    • Provided a time series with hourly time stamps
    • Everyone used their own scripts to calculate RMSE and bias
    • Provided results
  – Outcome: Different results
    • Different results due to wrong interpretations of time stamp
    • Different averaging techniques in horizontal and vertical
  – Motivation for Task 36

• Work for Task 36
  – Focus is on methodology
  – Select case study from WFIP2
    • Data are freely available
    • Observations already available
  – Reproducible by participants
    • WRF model
    • Benchmark output provided
      – Control and experimental (improved) runs
      – Observations provided
    • Validation framework provided
Case Selection

- **Mountain Gravity Waves**
  - WFIP2 cases analyzed
  - Challenging due to multiple time and spatial scales

- **Team to Provide**
  - WRF setup files/output
  - Observations
  - Defined 24-hr period
  - Documentation

- **Task 36 Engagement**
  - Concept discussion
  - Case reproduction/extension
Dissemination

- A2e Data Archive and Portal
  - WRF setup files/output
  - Observations
- Validation Framework
  - Bulk rotor layer statistics (RMSE, bias, MAE), NOAA wind ramp metric
- Framework Communication
  - Via GitHub
  - Jupyter notebook
  - R code as second option
- Documentation
  - Report/journal article
  - Perhaps recommended practice
- Invitation to collaborate
  - To provide feedback
  - To extend cases