Utilizing A Highly Resolved Forecasting Model Coupled with Computational Fluid Dynamics for Dynamic Line Rating Predictions

A.W. Abboud[1], J.P. Gentle[1], T.R. McJunkin[1], B. Bhattari[1], B.A. Fehringer[1], K.R. Fenton[2], M.A. Petty[2], M.W. Wandishin[3], M.C. Marquis[4], C. Meissner[5], P. Anderson[6], S. Woods[6].

1 Idaho National Laboratory, Idaho Falls, ID
2 Cooperative Institute for Research in the Atmosphere, Boulder, CO
3 Cooperative Institute for Research in the Environmental Sciences, Boulder, CO
4 National Oceanic And Atmospheric Administration/Oceanics and Atmospheric Research/Earth System Research Laboratory/Global System Division, Boulder, CO
5 WindSim AS, Tonsberg, Norway
6 Idaho Power Company, Boise, ID

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BACKGROUND

- Using dynamic line ratings (DLR) for transmission lines provides the potential to increase ampacity over static assumptions without additional infrastructure cost.
- Coupling high-resolution forecasting models with Computational Fluid Dynamics (CFD) has the potential to allow for calculated DLR to be forecasted in advance to give utilities better knowledge of constraints in planning and market response

OBJECTIVE

- The objective of the research is to couple a model for forecasting with local CFD modelling of wind fields in the Boise bench region of Idaho.
- These forecasted wind fields and ambient temperatures can then be used in the IEEE738 Standards to calculate the DLR ampacity for future times so that the future value is actionable for utility companies.

METHODS

CFD

- The CFD code WindSim was used for the CFD simulations that were run. The area was divided into four sections of 85 million cells each with 30 meter spatial resolution. The CFD simulations solve the standard *k*-ε RANS model for turbulent kinetic energy and dissipation rate.

HRRR

- The HRRR model developed by NOAA creates forecast data out to 18 hours in advance with 15 minute temporal resolution and 3 km spatial resolution. The data from HRRR can be mapped from the mesoscale coordinates to the local midpoint spans using the CFD results.

RESULTS

Figure 1 shows the terrain and roughness layer (tree/buildings/shrubs/etc.) of southwest Idaho that is modeled.

The CFD simulation results for the incoming N-S and E-W wind vectors are shown in Figure 2. Local terrain effects speeds up and slow downs of the wind speed depending on the incoming direction.

Figure 3 shows a map of the HRRR forecast grid points (blue) and the locations of the physical weather stations (red) that collected weather observations at two length scales.

The data from the HRRR model is collected for one year, the wind roses for 3 HRRR model points are shown on the left side in Figure 4. Example transfers are shown from the HRRR model point to different midpoint spans using the wind fields from the CFD model. This transferred data gives updated wind speeds to use at the transmission line locations for the ampacity rating.

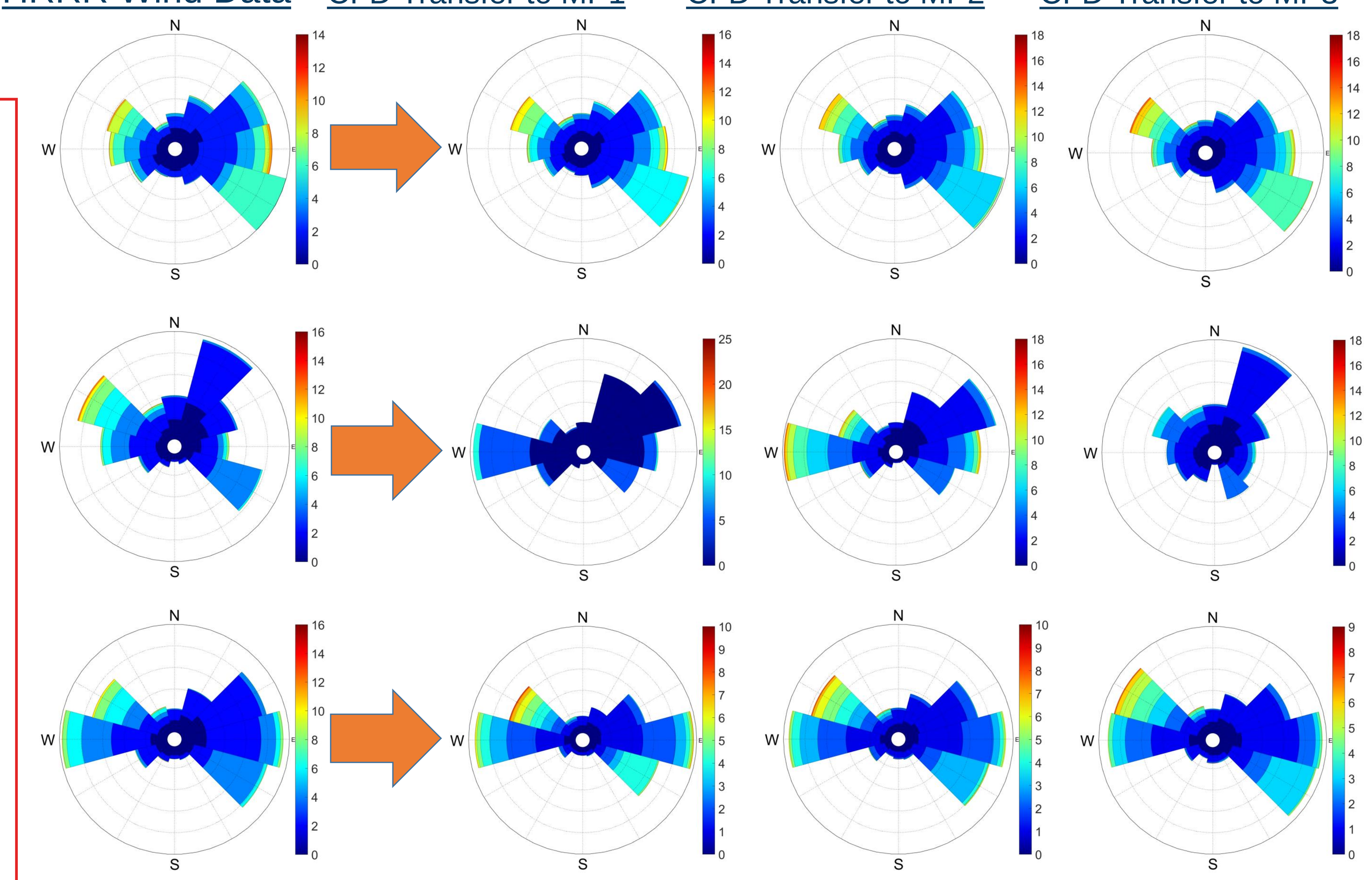

Figure 4. HRRR data from 3 model points processed through CFD lookup tables to create new transferred climatologies at 3 different midpoint spans.

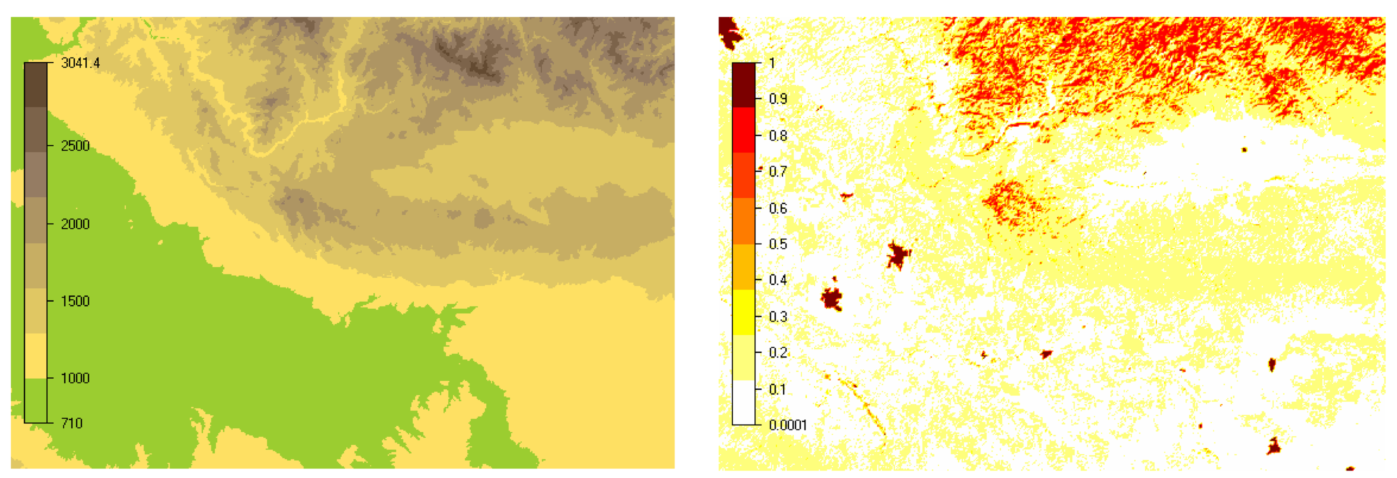

Figure 1. The Terrain elevation and roughness map for southwest Idaho.

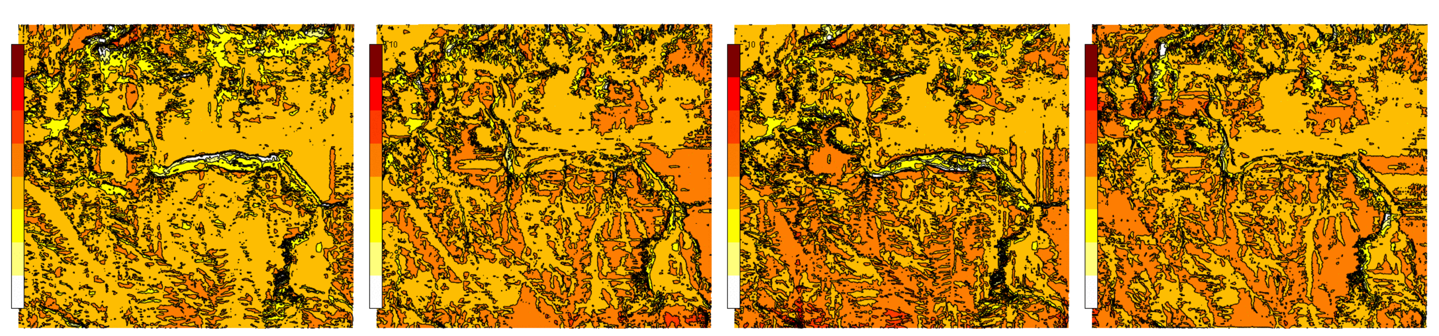

Figure 2. CFD results of the wind speeds for 4 incoming wind sectors – North/South/East/West.

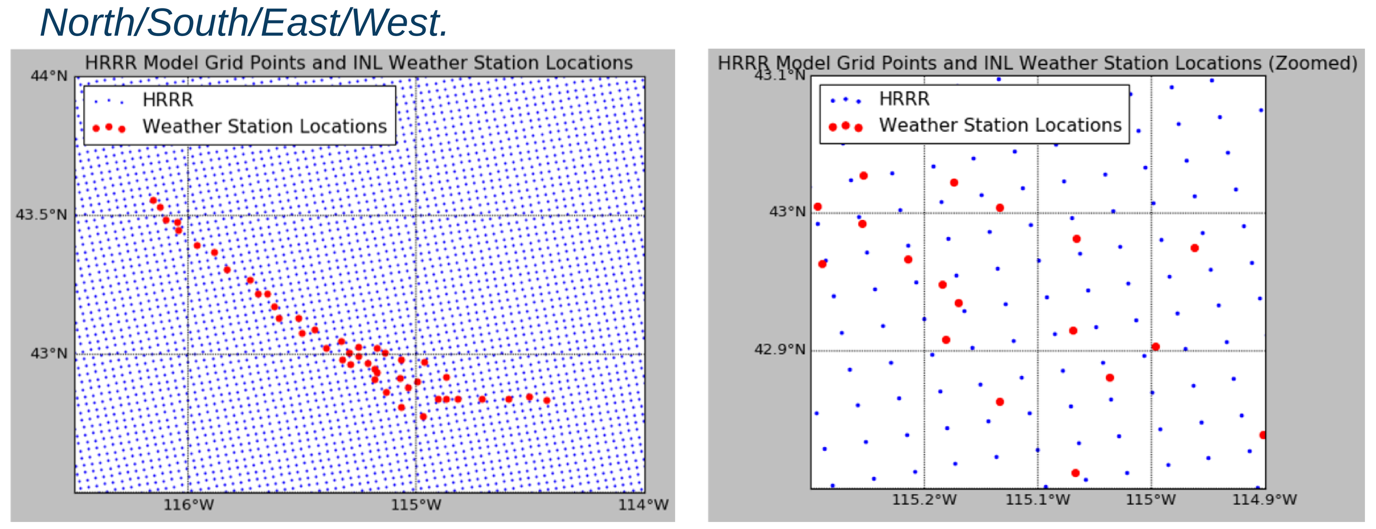

Figure 3. HRRR Map of mesoscale locations compared to physical weather station locations for the entire region, and a close up to show discrete points.

Figure 5 shows an example data set for the forecasted ampacity calculated with DLR compared to the static ampacity. The HRRR forecasted data can be considered form 1-17 hours in the future, allowing utilization for the short term and day ahead market forecasts in blocks of time.

The data for the ampacity for an entire year of calculations using the HRRR model data is shown in Figure 6, this is compared to the seasonally adjusted value for the static ampacity.

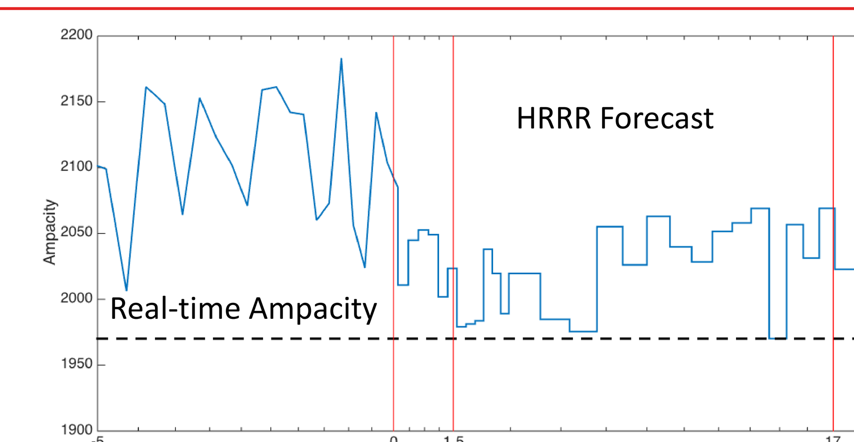

Figure 5. Example of utilizing forecasted data for predictions of ampacity in an 18 hour window.

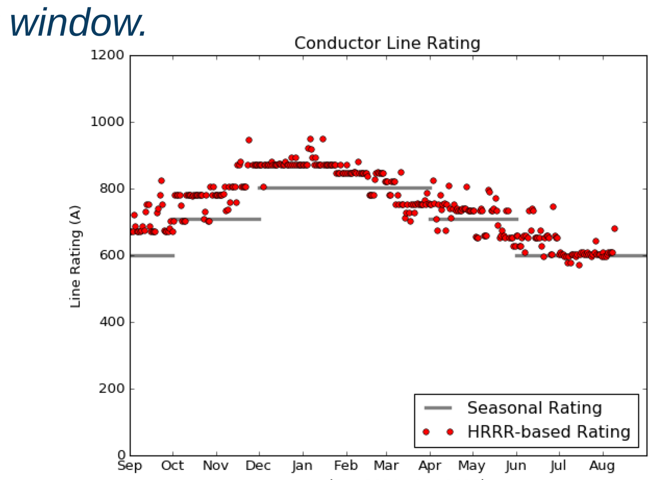

Figure 6. Ampacity calculated with HRRR forecasts over seasonal static ampacity for a year-long span.

CONCLUSIONS

- Using the HRRR model for DLR ratings can be calculated up to 17 hours in advance. With very conservative assumptions, these ratings are shown to be an improvement over the static assumptions made on the transmission line.
- When the HRRR model is upgraded later this year, the forecasted time provided can be increased to up to 36 hours in advance. This update to the HRRR should not have any impact on the methodology of these calculations.
- Eventually this HRRR model forecast can be coupled with the GLASS code to provide future forecast ampacity along thousands of transmission midpoint spans simultaneously.

ACKNOWLEDGEMENTS

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CONTACT INFORMATION

Alexander.Abboud@inl.gov, Jake.Gentle@inl.gov, Catherine.Meissner@windsim.com, Ken.Fenton@noaa.gov, Melissa.A.Petty@noaa.gov