# The Benefit of Computational Fluid Dynamics Data in Dynamic Line Rating Calculations

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## BACKGROUND

- Typical static line rating values for transmission lines use constant values for temperature and wind in calculations for the IEEE738 standard. Some ratings are adjusted seasonally or with daily ambient temperature adjustments, but usually these ratings are overly conservative in static rating values.
- Using dynamic line ratings (DLR) for transmission lines provides the potential to increase ampacity without additional infrastructure cost.

## OBJECTIVE

- The objective of this research is to show the increase that DLR can have over typical static rating assumptions using actual weather data.
- The weather data collected is coupled with computational fluid dynamics (CFD) results so that the wind fields are corrected from weather data to every span along a transmission line.
- The area of study is a complex region of terrain, Hell’s Canyon along the Idaho-Oregon border which consists of mountain peaks up to 2300m above the height of the Snake River.

## METHODS

CFD

- The CFD code WindSim was used for the simulations. The area was divided into two sections of 55 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.

GLASS

- The general line ampacity state solver (GLASS) tool was developed by INL for processing the weather data together with CFD wind fields.
- GLASS parses all of the weather data and runs it through local wind direction shifts and speed changes from the CFD wind field to determine the ampacity at every transmission line span with IEEE738 standard calculations.

## RESULTS

- The line considered a substitute for the actual conductor. With parallel wind flow, and conservative constant wind speed and temperature assumptions reflecting IEEE738 standards, the static rating on the line is 600A.
- Figure 1 shows the terrain of interest, and the transmission line path and Figure 2 shows the local wind fields calculated with the CFD simulation results for the north and south wind sectors for the two domains. The white color highlights low wind speeds due to the terrain. CFD captures these low wind speeds that may go unnoticed in other methodologies.
- Figure 3 shows the collected weather data for the region. The red line shows the azimuth of the weather station, and the turquoise shade shows the range of the transmission line midpoints.

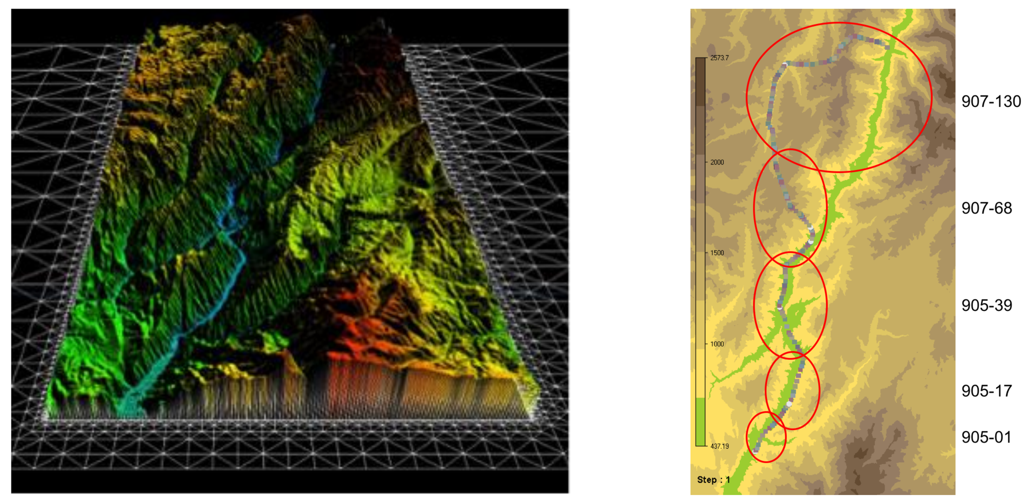


*Figure 1. 3D Terrain Layout for Hells Canyon, and path of the transmission line with weather station locations and line section numbers.*

- The line considered is divided into 5 sections to calculate the dynamic line rating. Figure 4 shows the total percentage of time that the DLR is calculated to be over the static rating. The head room on the line is above the static line rating nearly 99% of the time.
- This plot shows for data calculated directly at the weather stations, and data that is processed through the GLASS code to utilize CFD results for differing wind speeds along a line.
- Table 1 shows the difference in average ampacity over static; without accounting for slow wind speeds from the CFD results the additional head room can be over predicted.
- Using the CFD results the locations of the limiting midpoints can be found, this is plotted in the histogram in Figure 4. These locations for limiting spans may prove useful for placement of other line rating sensors.
- Figure 5 shows close-ups of the terrain of the limiting spans, which occur here next to ridges blocking wind from the N-S or E-W direction.

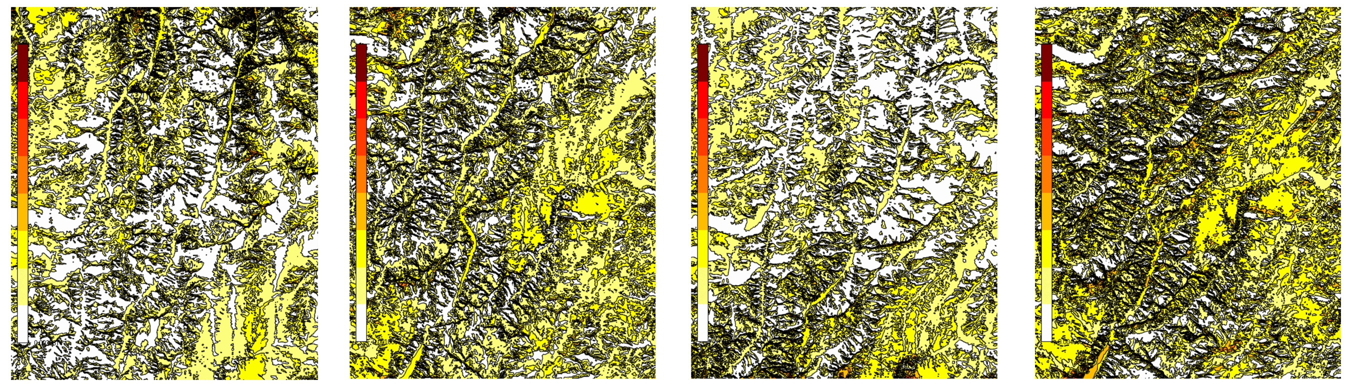

*Figure 2. Wind speeds for Hells Canyon for north and south wind direction at 10m above ground level.*

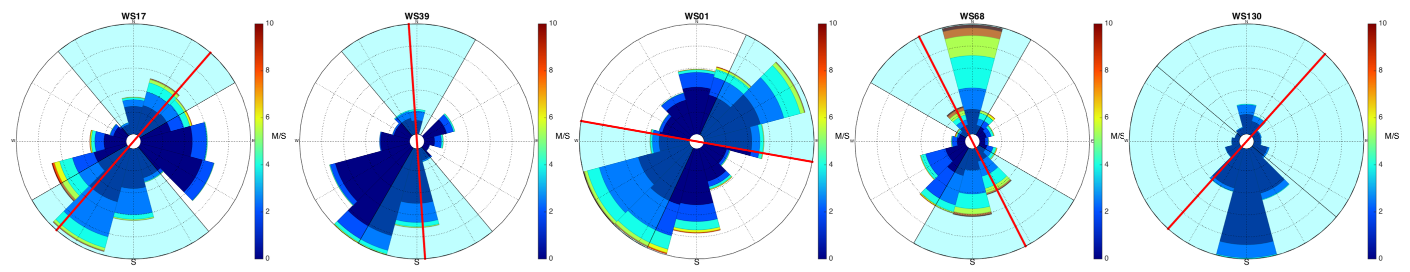

*Figure 3. Wind roses for 1 year of collected data for the five weather stations.*

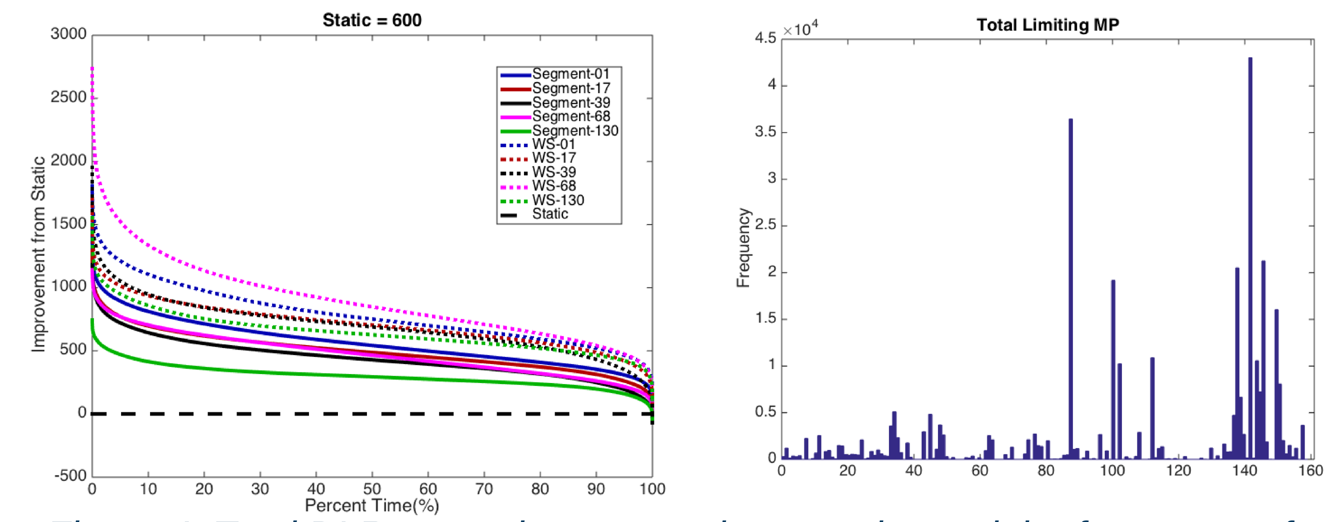


*Figure 4. Total DLR ampacity over static ampacity, and the frequency of the limiting midpoints.*

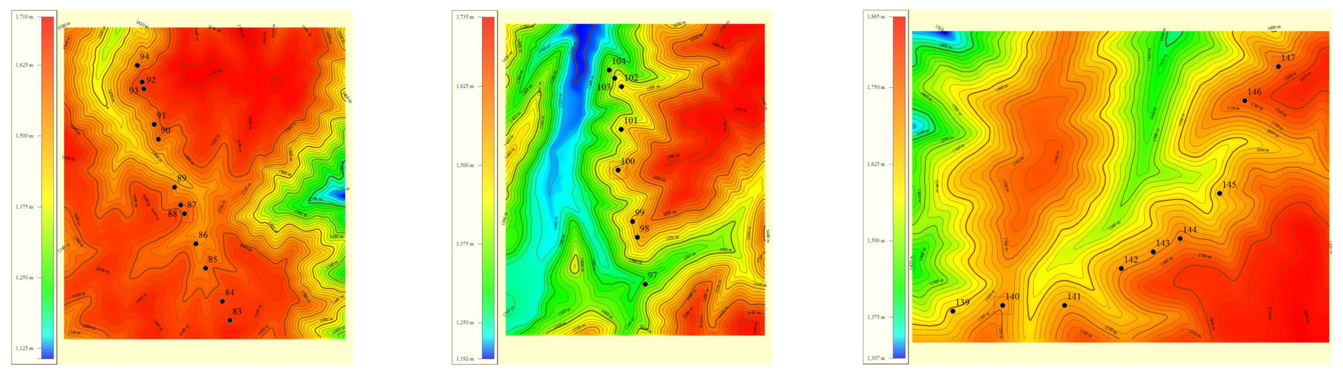

*Figure 5. Close-ups of the terrain for regions which are shown to be limiting in the GLASS ampacity calculation*

*Table 1. DLR ampacity over static ratings predicted with weather station data, and with CFD corrected wind fields. The actual weather data is used in these calculations, but on a substitute conductor.*

| Line Section # | Ampacity over static at weather station | Ampacity over static with CFD/GLASS correction |
|---|---|---|
| 01 | 778 | 557 |
| 17 | 701 | 492 |
| 39 | 683 | 434 |
| 68 | 889 | 470 |
| 130 | 638 | 297 |

## CONCLUSIONS

- DLR utilizing real-time collected weather data can provide a benefit in the additional head room for the ampacity of a transmission line. CFD results help weather conditions be more realistically captured over a line instead of at a single location
- Due to the complex terrain in the Hell’s Canyon region, the resolved wind fields that can be collected from CFD simulation results become more important as transmission lines below high mountain peaks may experience significant wind speed changes and direction shifts relative to the weather stations.
- The effects of the terrain impacts on the wind fields with CFD model is not limited to the methodology used here to couple with weather stations, and could be useful with other sensors..
- Using wind fields from CFD simulations, the locations of the limiting midpoint spans can be identified from local wind speeds. These identified locations can be utilized in other DLR solutions allowing for improved placement of sensors.

## ACKNOWLEDGEMENTS

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## CONTACT INFORMATION

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