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Presented at: ESIG 2025 Forecasting & Markets Workshop

A New Approach for Grid-Wide Wind Measurement with Embedded Optical Fibers

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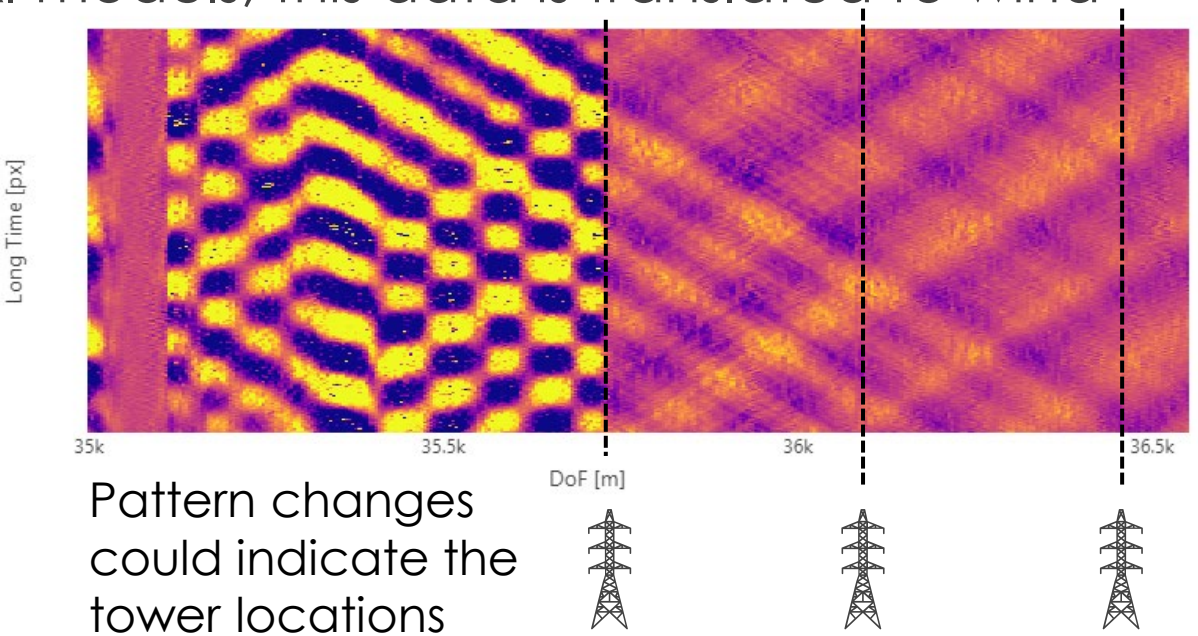
Using the Grid to Monitor itself

OPGW

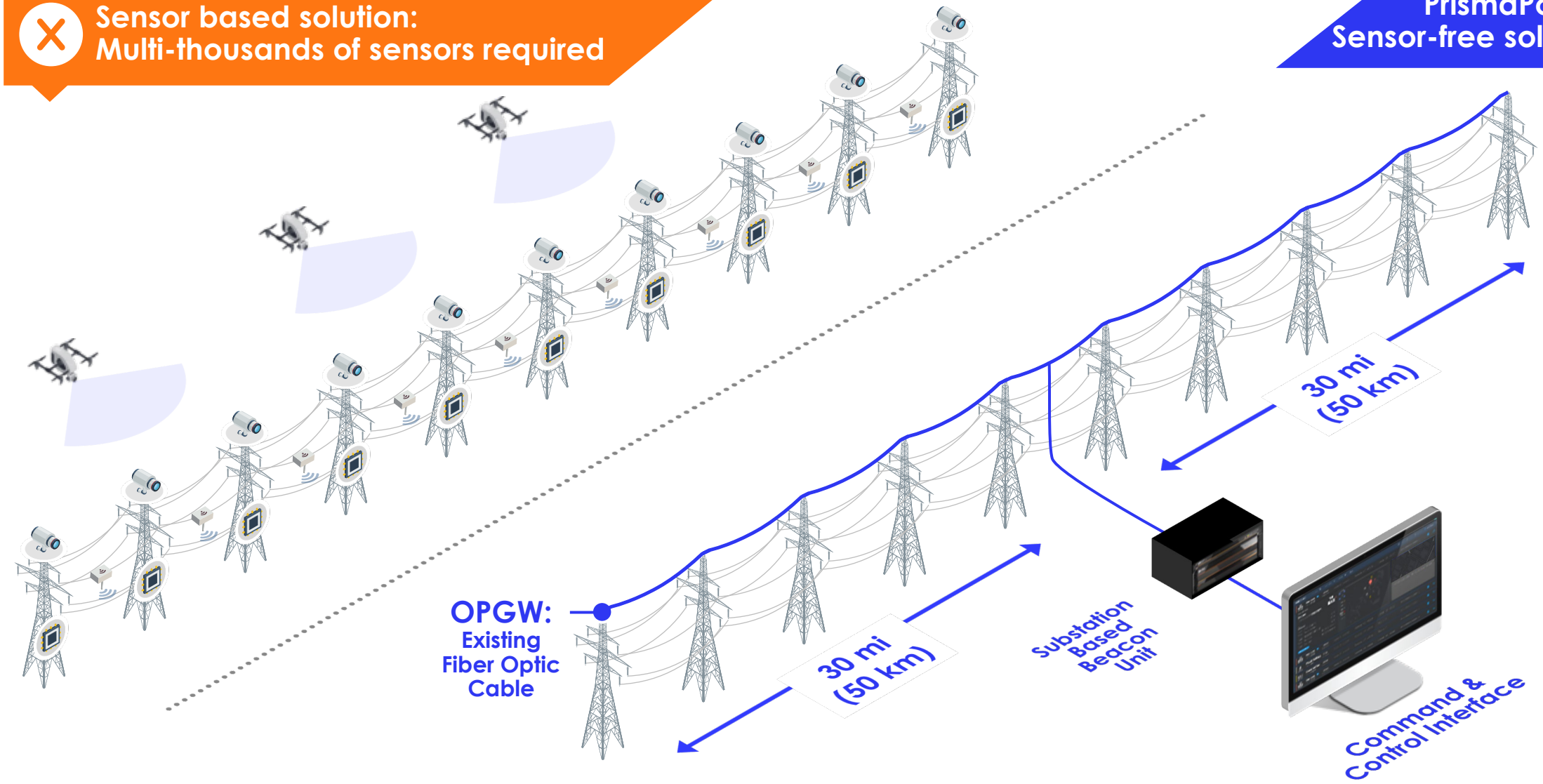
- Optical Ground Wire (OPGW) runs on top of transmission
- Utilizing optical fiber sensing we monitor everything
- The image below shows raw data
  - The colors depict the vibration frequencies of the wire
- Using AI models, this data is translated to wind metrics



Pattern changes could indicate the tower locations

Sensor based solution: Multi-thousands of sensors required

PrismaPower: Sensor-free solution



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The PrismaPower™ Suite

PrismaCapacity

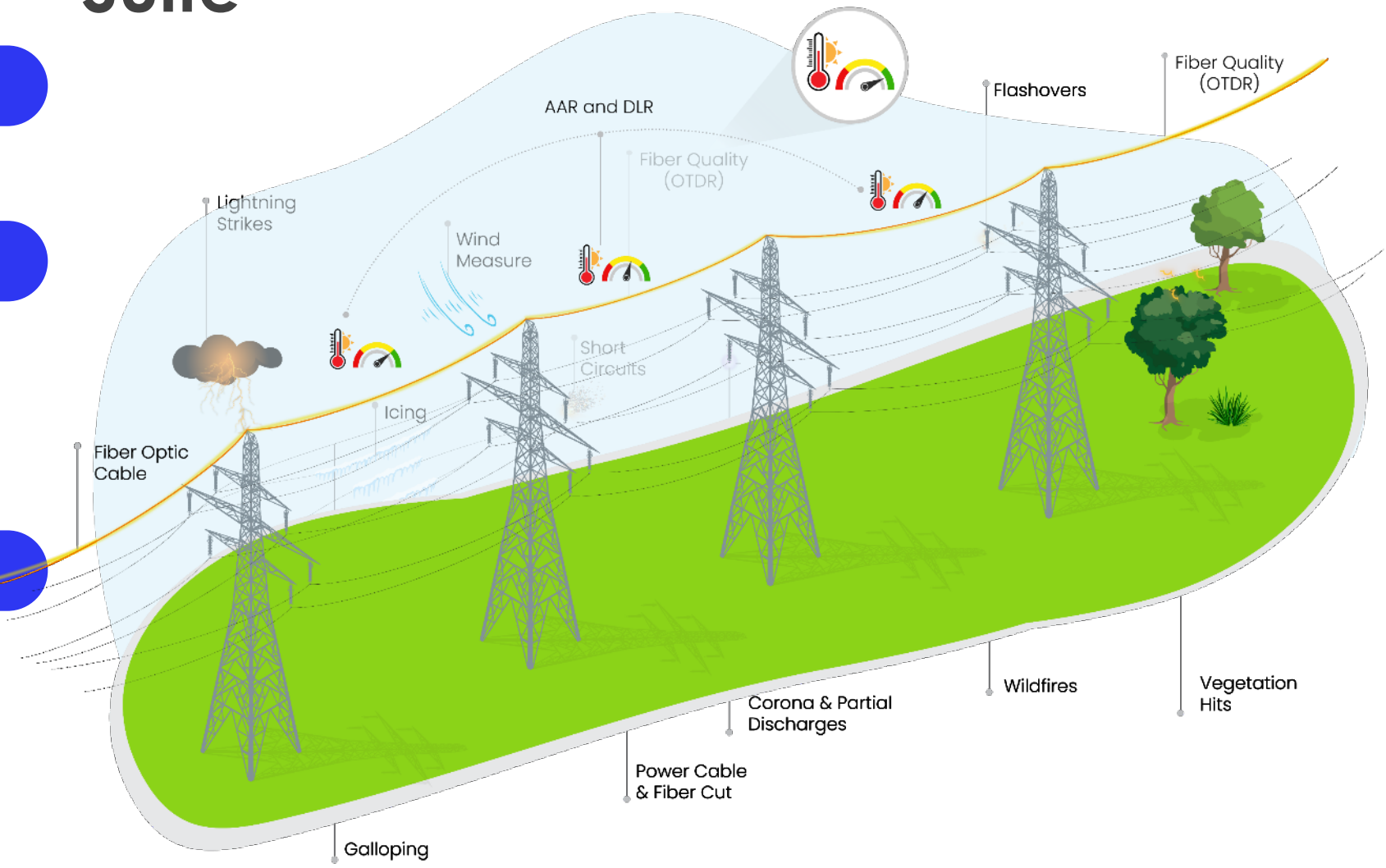
- Dynamic Line Rating (DLR)
- Ambient Adjusted Rating (AAR)

PrismaClimate

- Galloping
- Wire tension
- Extreme winds
- Icing
- Lightning strike
- Wildfires

PrismaCircuit

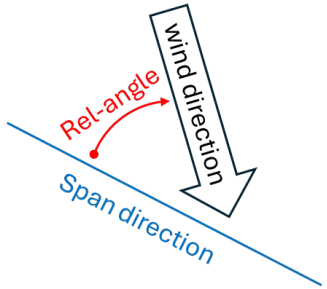
- Short circuits
- Flashovers
- Partial discharge & Corona
- Fiber cut
- Fiber quality (OTDR)
- Vandalism
- Tower climbing
- Vegetation hits

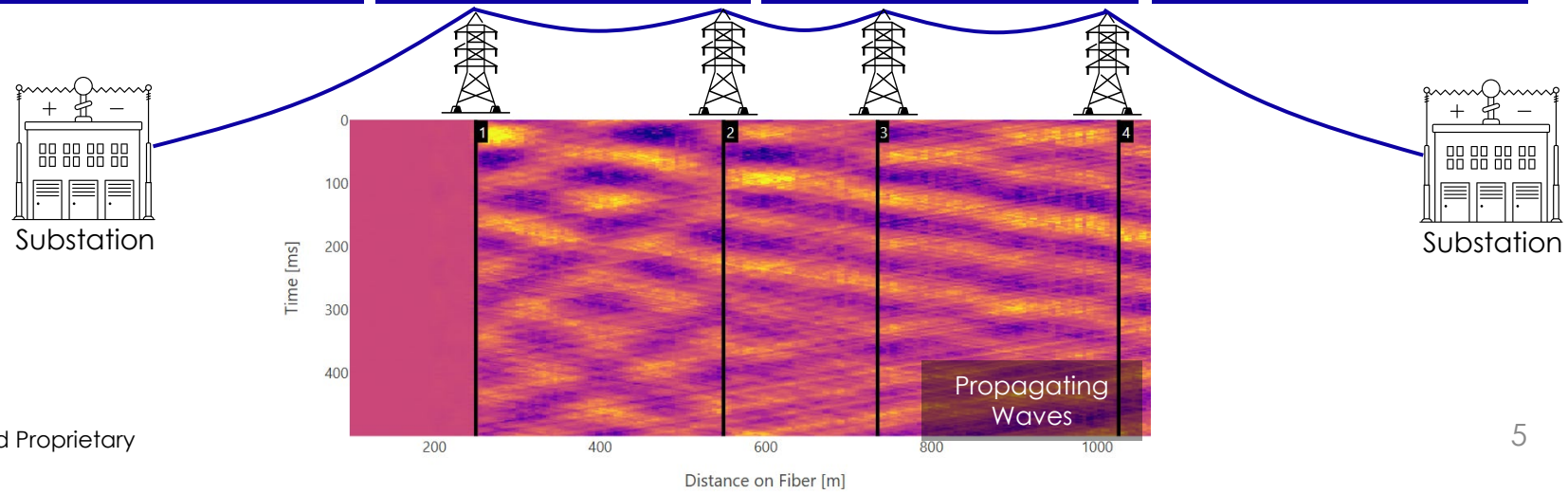


From Optical Fiber to Wind Metrics

Fiber Signal	Feature Extraction	Span localization	AI Model	Effective Wind	Continuous Measurement
The **fiber signal of the entire line** is recorded and digitized	Per span, **spectral features** of wind-induced vibrations **are extracted** from the signal	Signal cleaning and noise reduction. Data is **split into spans**	A **machine learning model** is used to infer the **Wind Speed** and **Attack Angle** (0 - 90 deg)	Calculating the **Effective Wind for DLR**	**Each span acts as a wind sensor, continuously** estimating local wind conditions

Wind Attack Angle
- The angle between the wind direction and the orientation of the power line
- Used directly in the DLR model
- Can be derived from wind direction

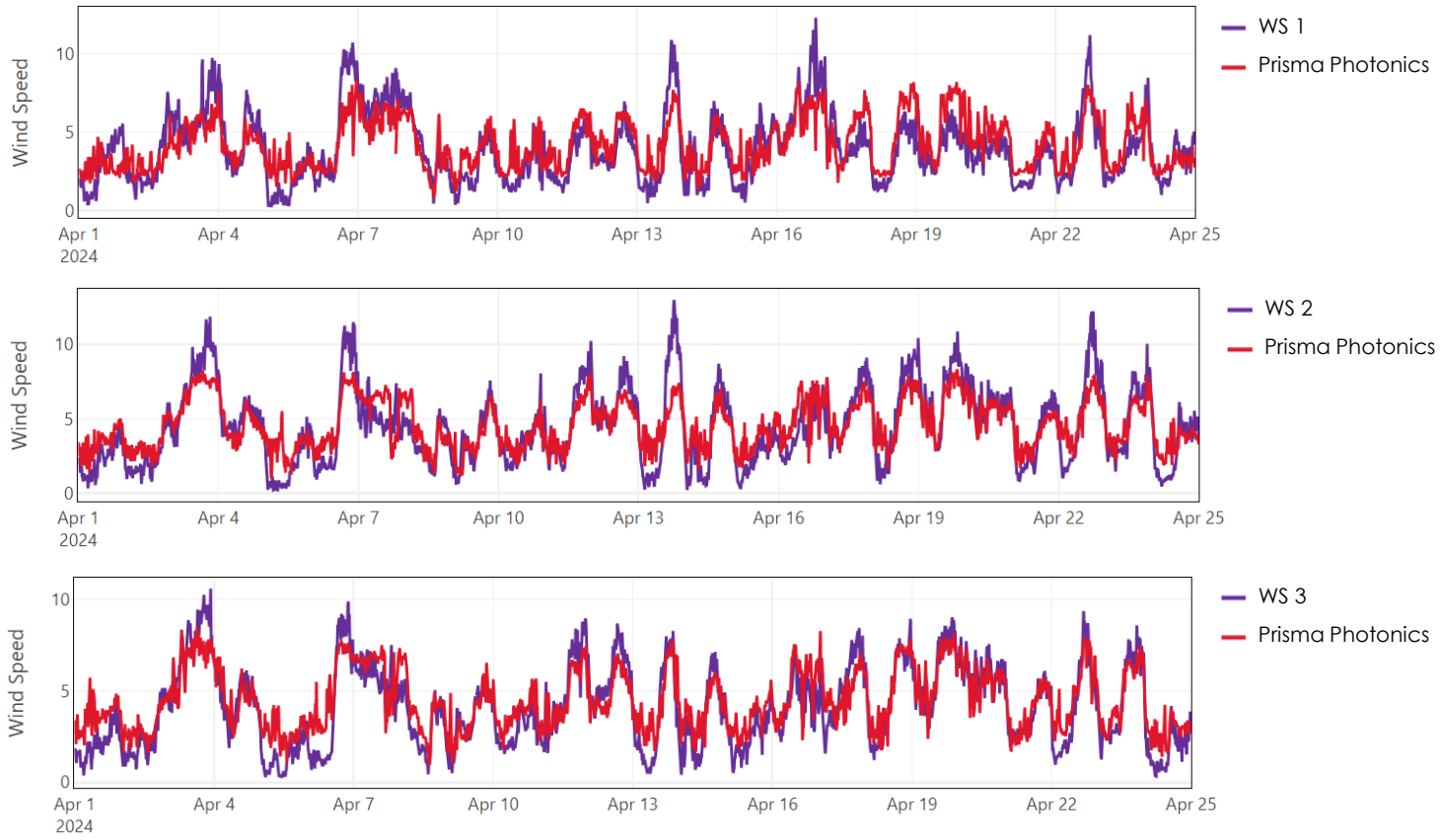


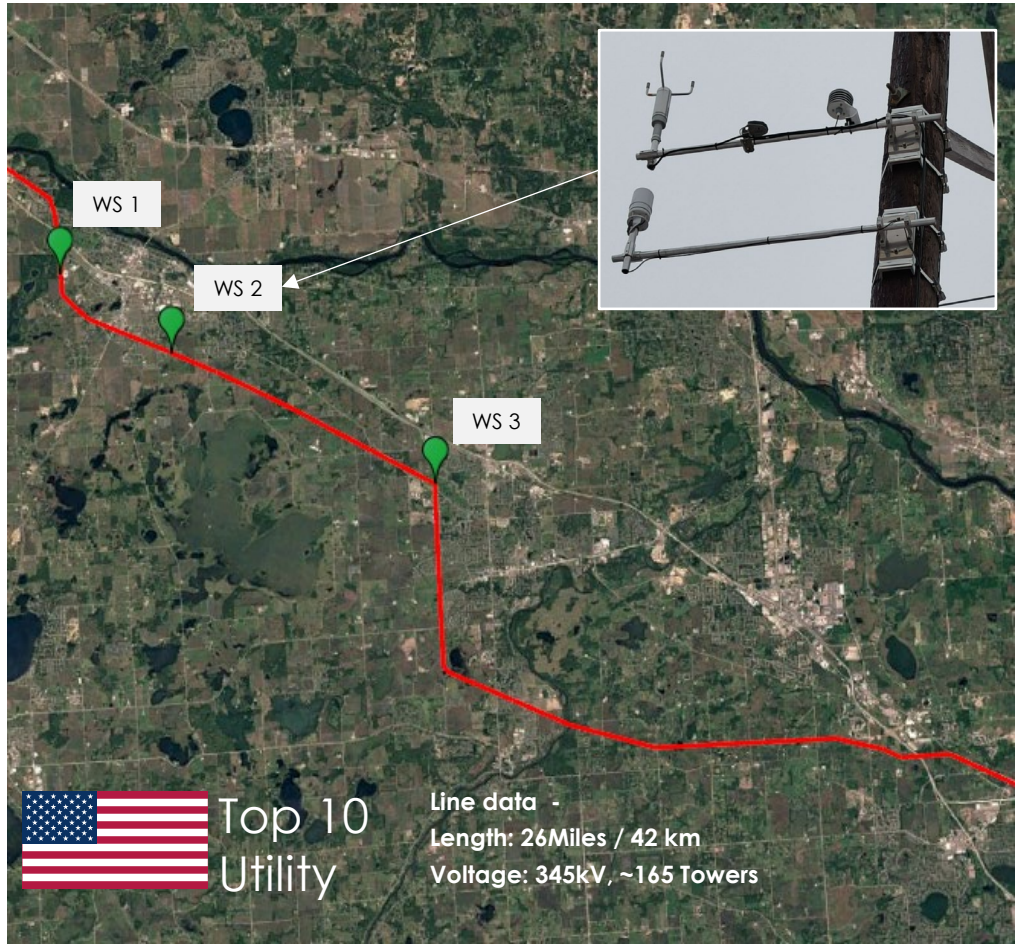


Validating Accuracy

Measuring wind accurately on every span

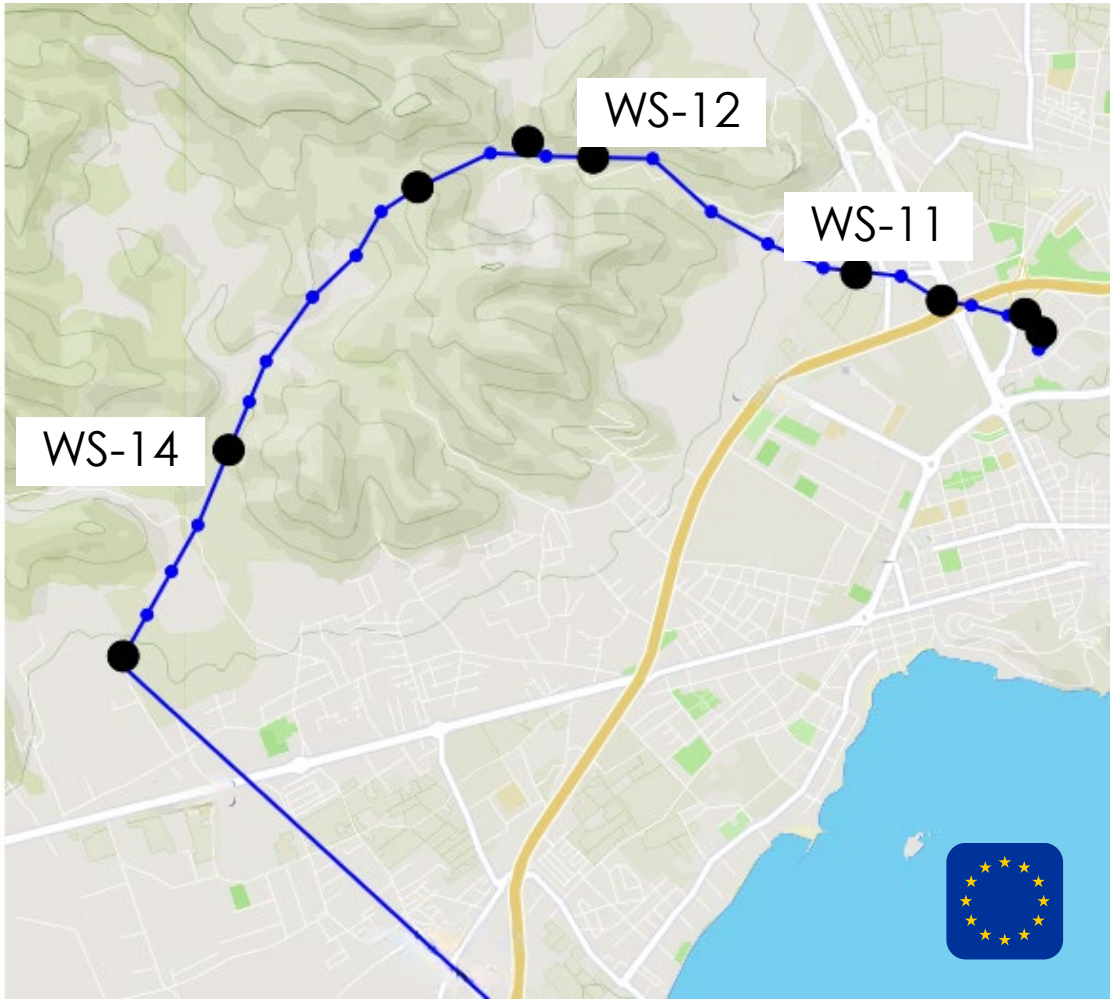
Compared to anemometers in different places along a 26mi line, there is a strong correlation with fiber-based wind readings





European TSO, Coastline to Mountain

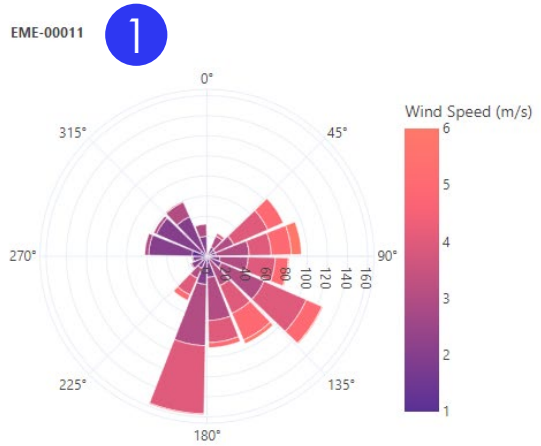
- PrismaPower™ deployment in European TSO
- Out of 20 miles, 5 miles are equipped with wind stations crossing coastal areas and into a hill range with deep valleys
- TSO installed multiple wind stations on specific towers to validate PrismaPower
  - These are marked as WS (Weather Station)
  - WS-11 location is near the coastline
  - WS-12 location is in a valley in the hills
  - WS-14 location is in a valley

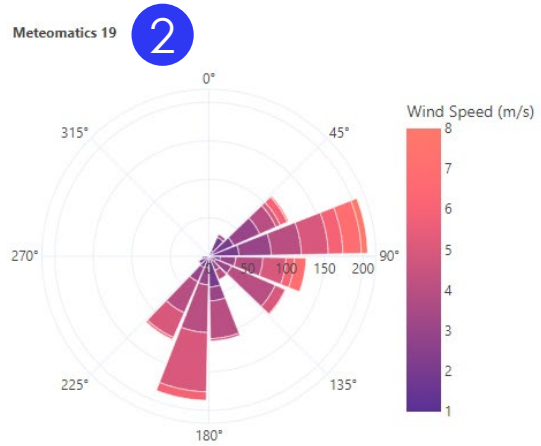


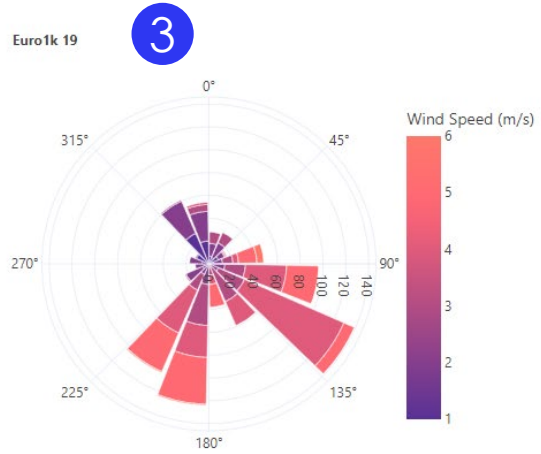
WS-11 – Coastline Oriented

Weather data from Coastline area, over several months:

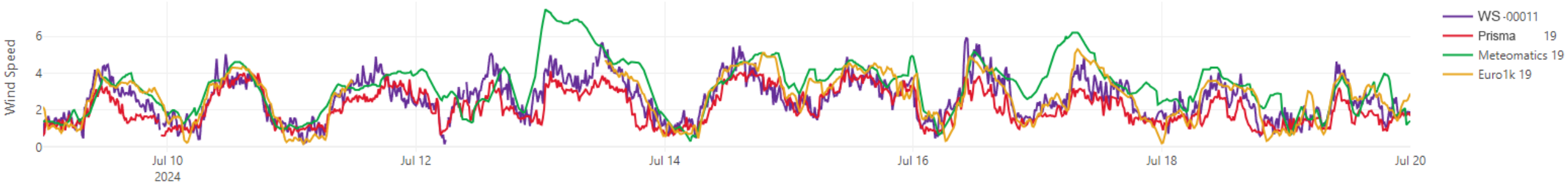
- **Wind direction** of tower-mounted WS11 ❶ is the ground truth
- Regular weather model ❷ is not perfect
- High resolution model ❸ is more similar to the ground truth
- Looking at **Wind speed**, Fiber-based readings are similar to local station ❶ and ❸







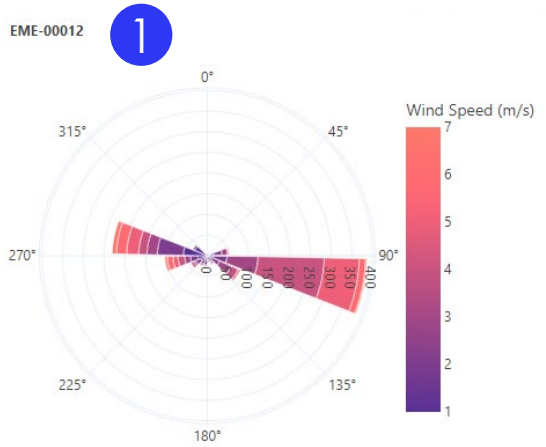
Comparing wind direction:
1. Local Wind station WS11
2. Regular Weather model
3. Hi-Res weather model

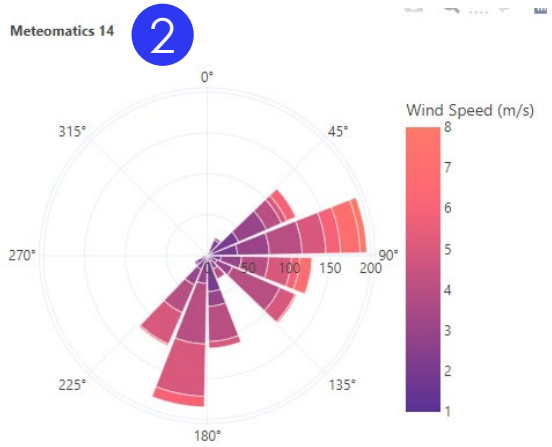


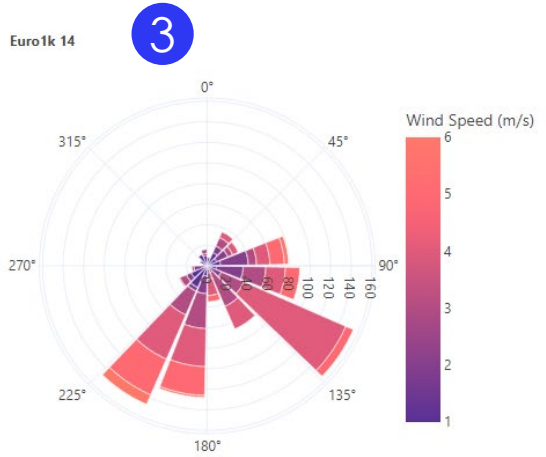
WS-12 – Valley Oriented Wind

Readings were taken over several months in a **valley** oriented east–west.:

- Wind direction of WS12 ❶ West-East along the valley – Ground truth
- Both models ❷ and ❸ are not local enough and **miss that altogether!**
- Looking at Wind speed, Fiber-based readings are similar to local station ❶ and ❸







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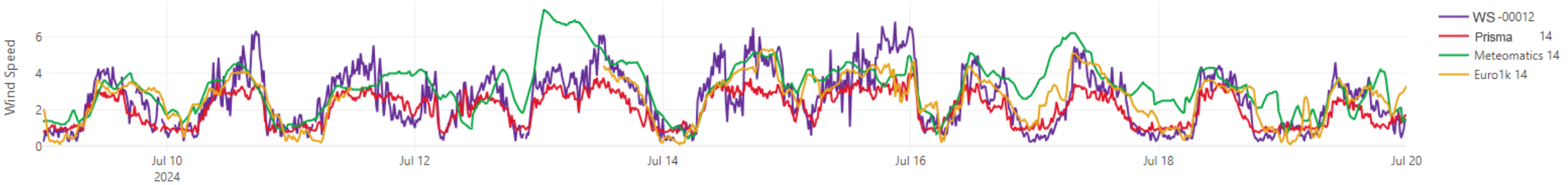
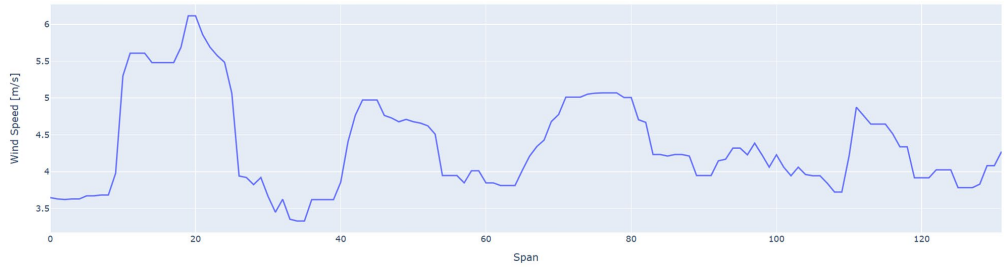


Fiber Sensing Wind tested – Speed and Angle

- Effective wind measurement in a PrismaPower in the U.S.
- Fiber based wind measurement on every span – 1 hour snapshot



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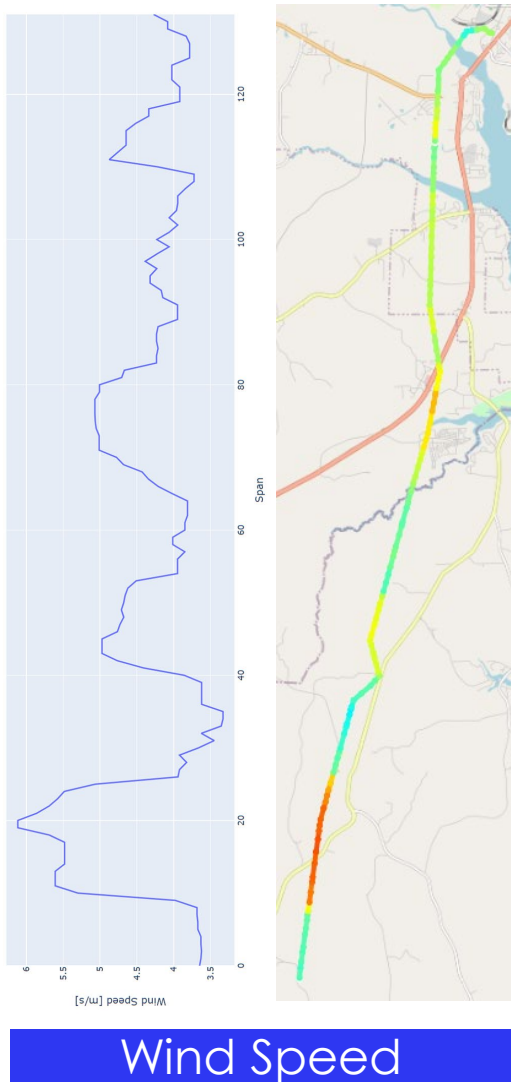
- The variance over short distances is impressive

Strong Weak



Wind Speed

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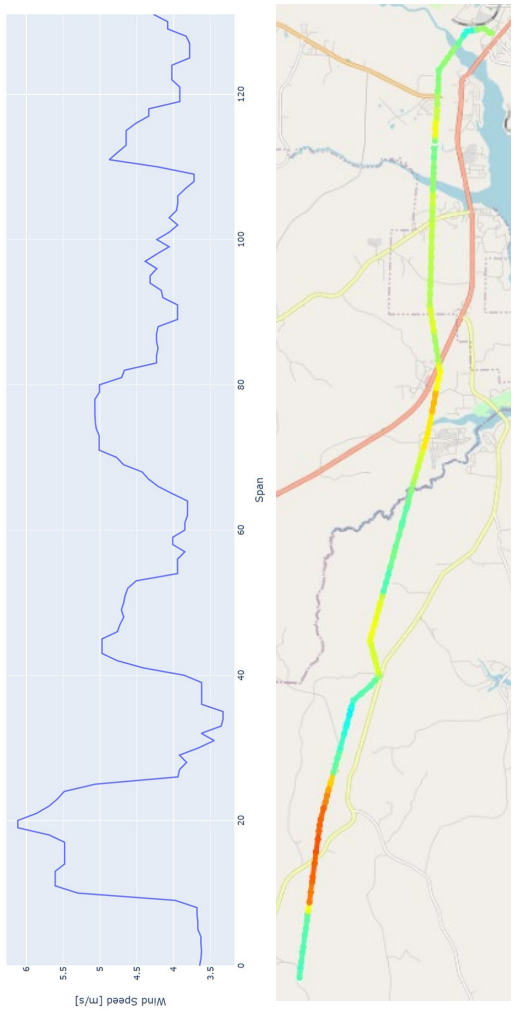
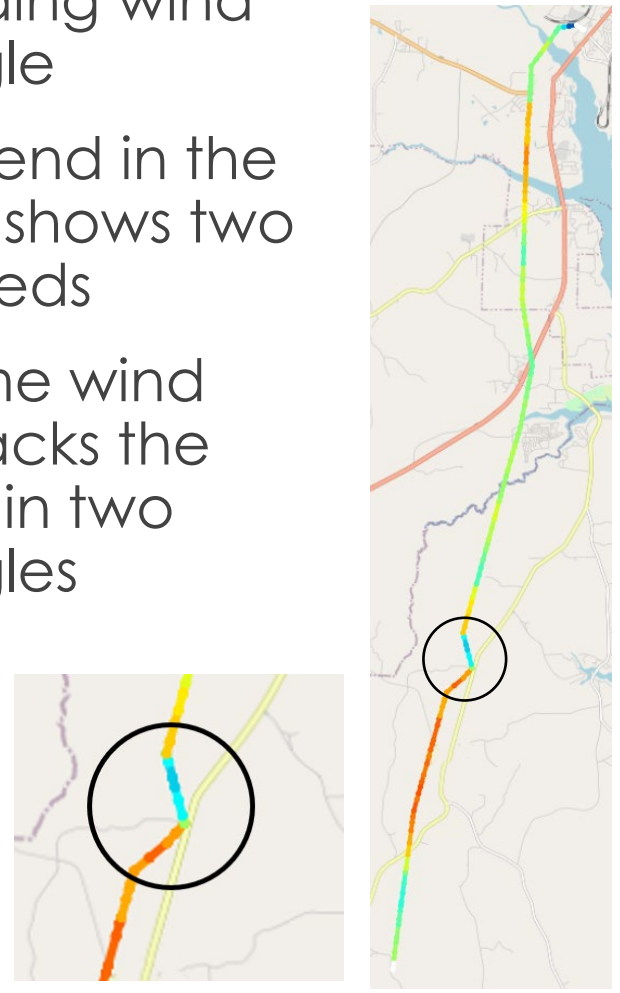


Wind Speed

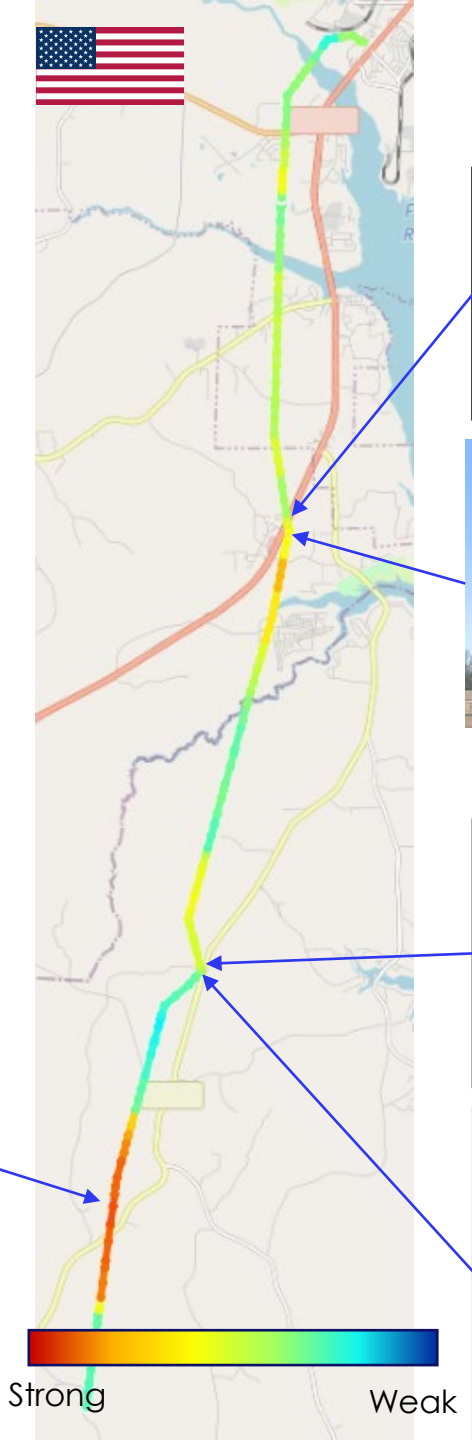
- Adding wind angle
- A bend in the line shows two speeds
- Same wind attacks the line in two angles

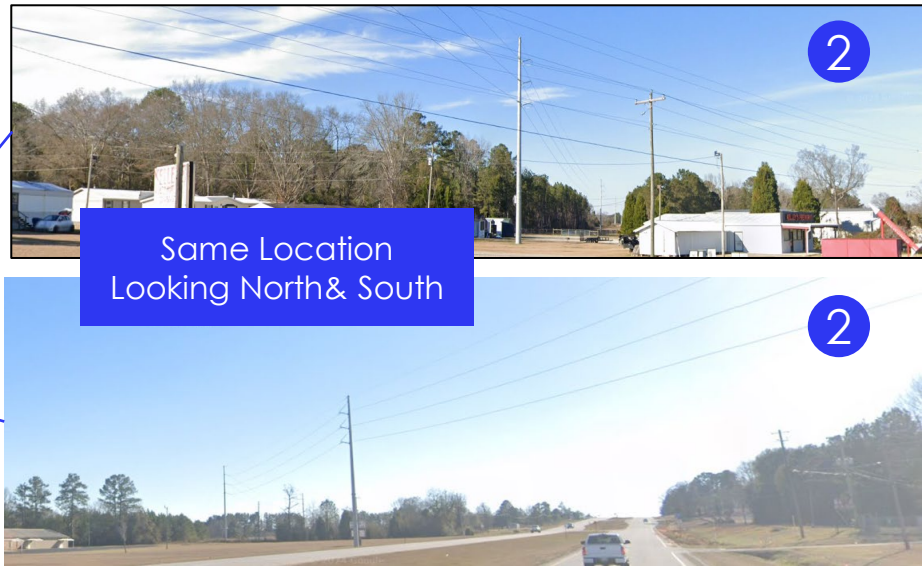


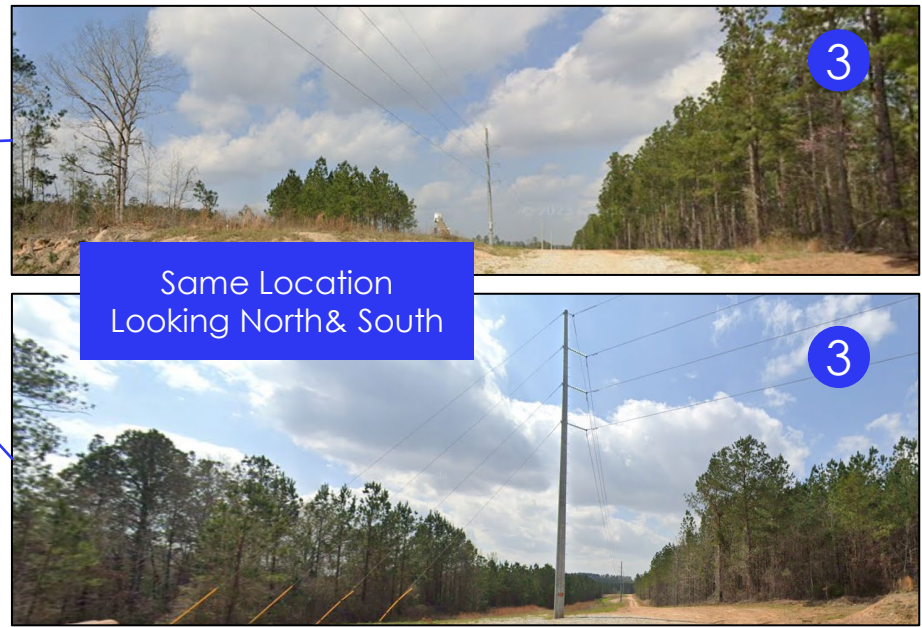
Wind Angle

Land Cover & Impacts

1. Open land with minimal tree coverage allows for strong wind speeds
2. Open land on one side of the line and tress on the other – allows for irregular winds
3. Trees on either side of line plus in a valley – allows partial blocking of the wind







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The Longest-Range Wind Monitor

- Wind varies span by span — only localized data delivers true accuracy
- With fiber sensing, the grid monitors itself
- Feeding real-time, local wind data into DLR models enables safe and reliable ratings

Questions, please?

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THANK YOU

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