

More accurate support structure loads and lifetime reassessments by using site specific directional turbulence intensity

Jorge Garza¹, Rémi Gandoin¹, Jens Lycke Wind¹, Christian Berg Mørch¹

¹C2Wind, Denmark

- **In principle**, wave and wind inputs to Integrated Load Analysis (ILA) are directionally dependent and can be modelled as such. More complex dependencies may exist tied to site-specific physical drivers such as atmospheric stability and sea-state composition (ie. wind-sea & swell).
- **In practice**, due to a wide variety of challenges related to data limitations, simulation volume, certifiability, and existing tools and methods, not all interdependencies are accounted for in ILA, requiring conservative choices.
- **In particular for ambient- and wind farm turbulence**, the typical approach is to use omni- or directional ambient TI to calculate *omnidirectional* effective **wind farm turbulence (WFT)**, which is in turn used as envelope in ILA.

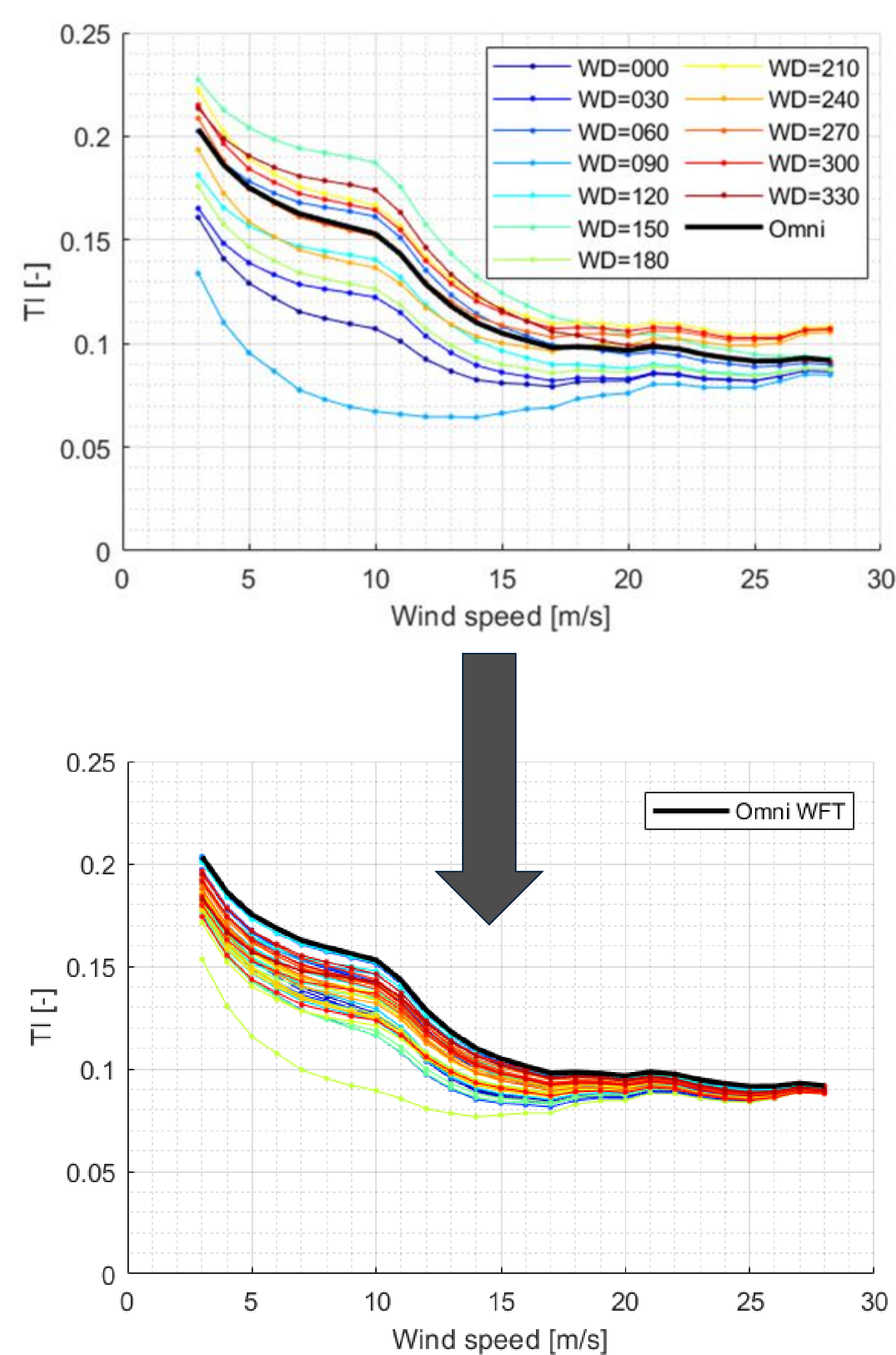


Figure 1: Illustration of how omni- or directional ambient turbulence typically results in directional WFT for use in ILA.

• Limitations:

- Can we really get TI(WS, WD)? Can we trust it? Certify it?
 - See poster PO401
- Why do we use only omni WFT?
 - IEC 61400-1, Annex E.

• Challenges:

- Some sites have complex interdependencies, for example nearshore sites, strong stability dependence, tight & asymmetric layouts, directionally sensitive jackets.

• Why is WFT important?

- Particularly relevant for jackets, which are typically fatigue-driven and more sensitive to directional loads in their design.

• Refined approach #1

- $f(WS, WD), TI(WS, WD), \alpha(WD)$
- Directional WFT in ILA
- 720 simulations in ILA
- *Test case*: OWF in the Irish Sea, >40 WTGs, ~15MW type, jacket foundations

• Refined approach #2

- $f(WS, WD, z/L), TI(WS, WD, z/L), \alpha(WD, z/L)$
- Directional WFT in ILA
- 3 x 720 simulations in ILA
- *Test case*: Nearshore OWF in the Irish Sea, >40 WTGs, ~15MW type, jacket foundations

Results

- In Case #1, the use of **directional WFT**, all other things being equal, results in a **15% reduction in fatigue loads**.
- For Case #2, using directional- rather than omnidirectional WFT **reduces fatigue loads by up to 6%**.
- In both cases, the **wind direction driving interface loads can change** when using directional WFT.
- Directional WFT consistently yields lower interface loads, and using stability allows for more accurate physics relevant for complex sites.
- Highly relevant for fatigue-driven and directionally sensitive structures such as jackets.
- Getting more accurate loads can be vital in lifetime reassessments.

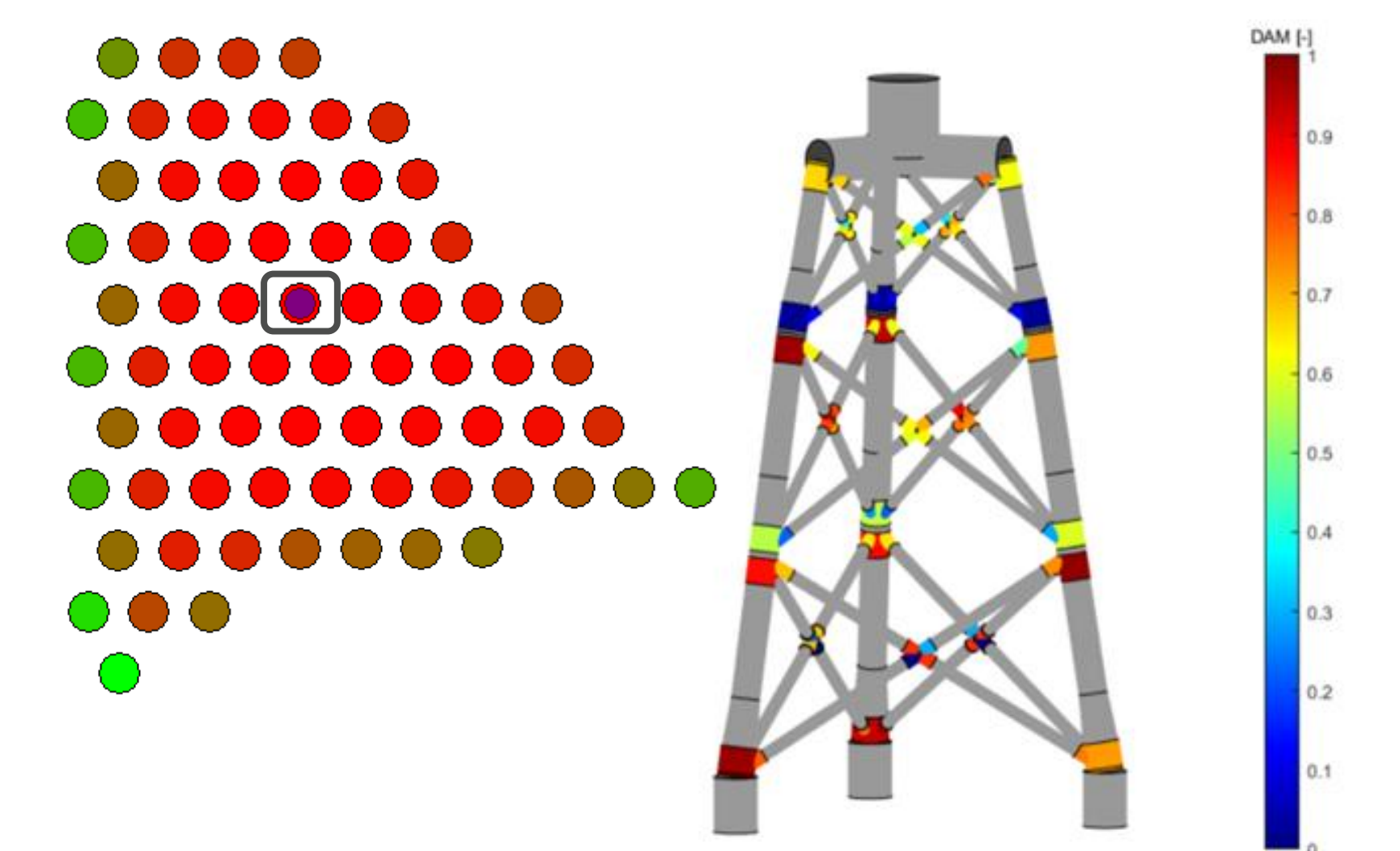


Figure 2: Example of most exposed WTG driving WFT envelope, along with stress concentration points on a jacket.

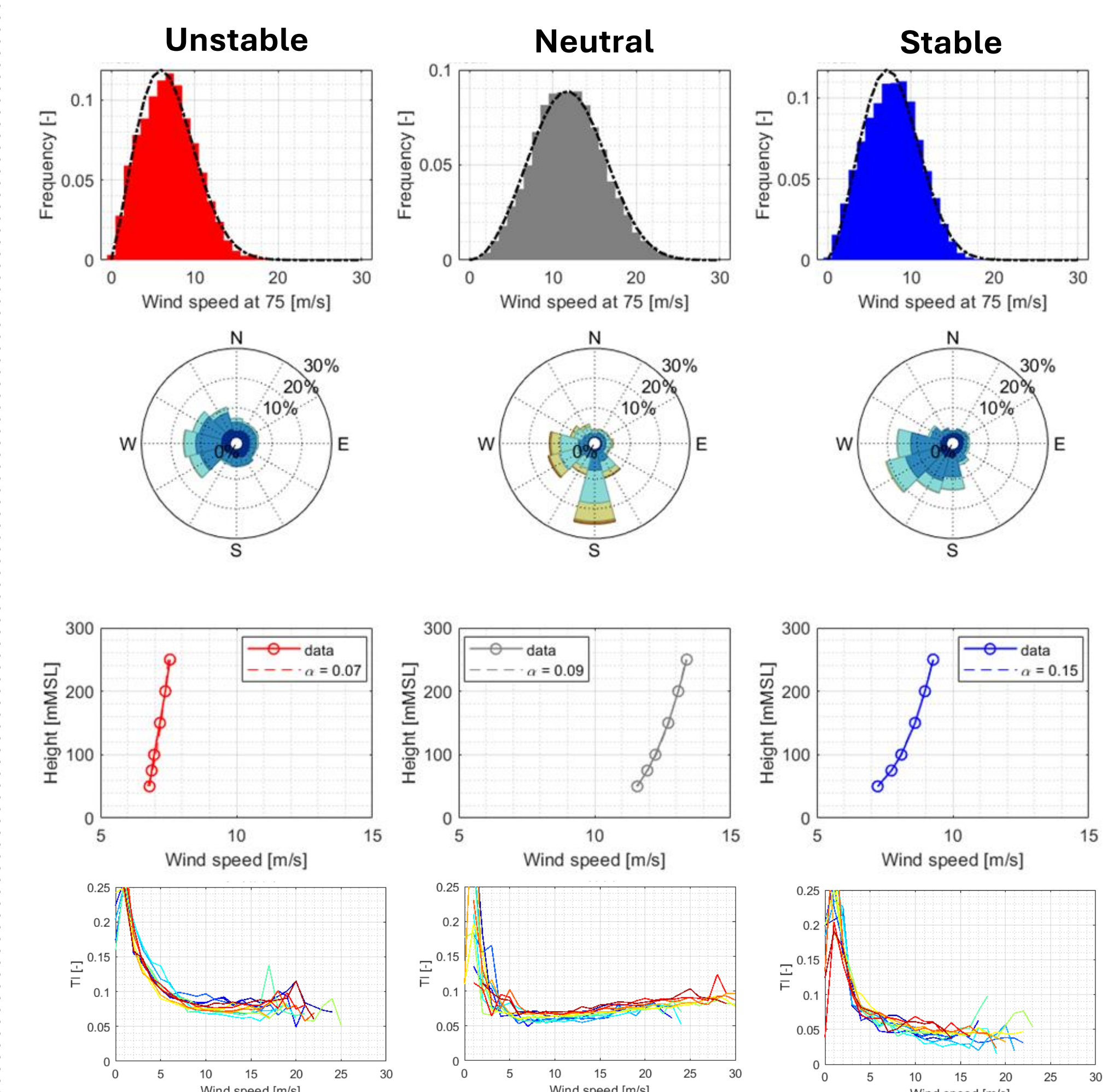


Figure 3: Example of stability-dependent inputs: wind speed- (top row) and direction (second row) distributions, wind shear (third row) and directional ambient turbulence intensity 90% quantile (bottom).

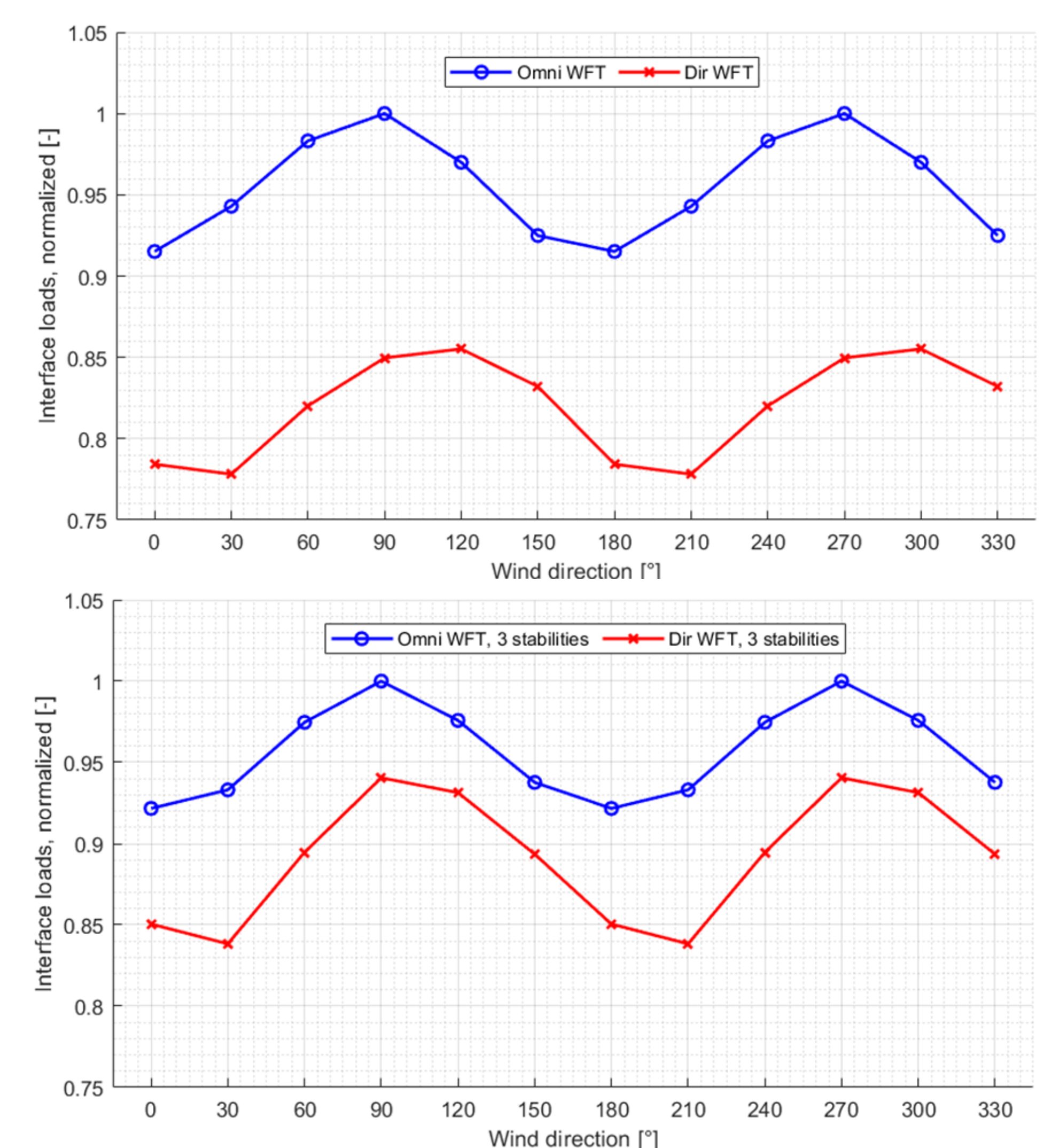


Figure 4: Normalized interface loads for test cases #1 (top) and #2 (bottom) as a function of wind direction, with omnidirectional (blue) and directional (red) WFT.

Meet us at

Watch this presentation

Download the poster