Characteristics of Abnormal Wind Profiles at a Coastal Site

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Abstract

Phenomena such as internal boundary layers and low-level jets can cause short-term fluctuations resulting in the vertical wind profile deviating from its expected logarithmic shape. Analysis of the vertical wind profile at an on-land coastal site reveals that deviations in the form of 1 or 2 local maxima, or a completely reversed and monotonically decreasing profile is present in close to half of the analyzed profiles. Inflections are generally found to be progressively more common at higher elevations regardless of the direction of incoming wind. Local maxima have been found to occur at lower wind speeds, and in unstable atmospheric conditions.

Site description

The studied Skipheia site is at an on-land coastal location in Mid-Norway. The incoming wind is divided into 3 directional sectors; onshore incoming, offshore incoming, or a mixed-fetch direction.

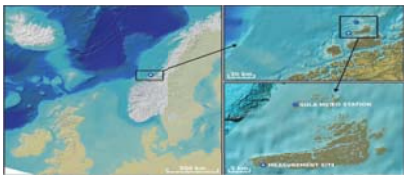

Fig 1. Skipheia location

Profile identification

The vertical wind profile is categorized as abnormal if it exhibits local maxima. With 6 wind measurement heights (10m, 16m, 25m, 40m, 70m, 100m) this results in the 4 possibilities shown below.

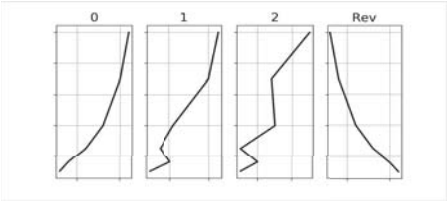

Fig 2. Profile categorization

Results

Wind speed and stability analysis

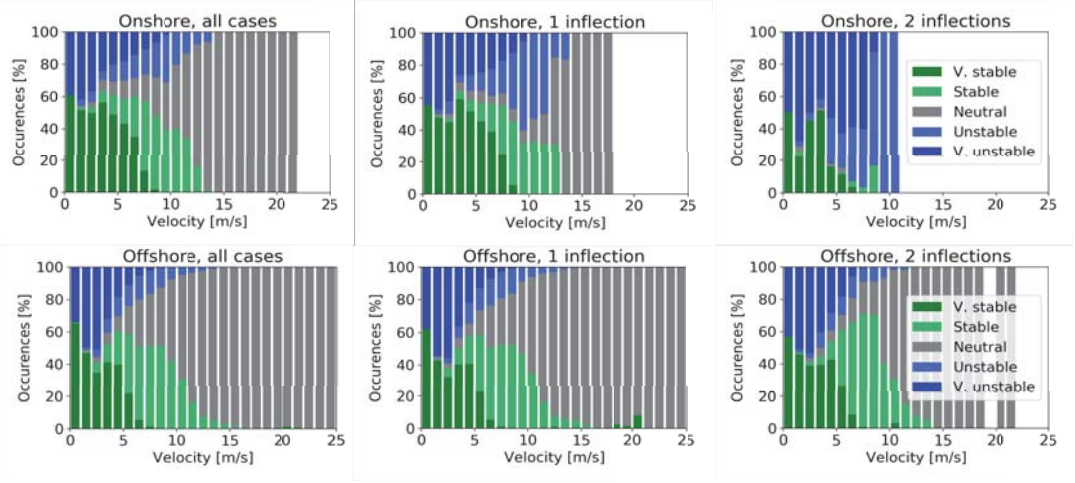

Fig 3. Stability analysis results

Abnormal profiles occurrences

Inflections	0	1	2	Rev
All directions	55.33%	38.71%	5.18%	0.78%
Onshore sector	64.19%	31.61%	2.88%	1.32%
Offshore sector	54.10%	39.74%	5.83%	0.33%

Tab 1. Inflected wind profiles

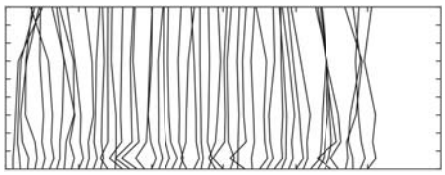

Fig 4. Abnormal profiles found in dataset

Inflection height

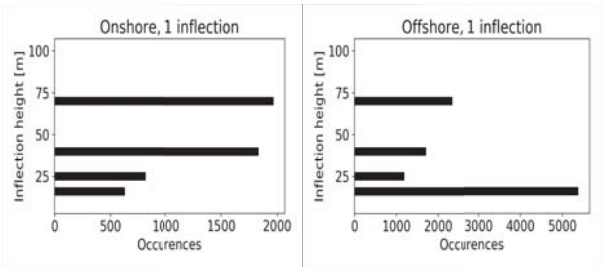

Fig 5. Height distribution of 1-inflection case

Results summary

- Offshore incoming profiles more likely to exhibit local maxima
- Inflections occur more often in unstable atmospheric conditions, offshore also in stable conditions
- Inflections occur at lower mean wind speeds compared to site average
- Duration decreases with number of inflections
- IBL-formation in offshore sector, inflection height matches fetch
- If disregarding this IBL, inflections are progressively more common at higher elevations
- Cause could be low-level jet or departure from surface layer both onshore & offshore

Conclusion

- Significant portion of both offshore and onshore profiles have one or more local maxima
- The local maxima could prove a challenge for future wind power estimation and fatigue calculations
- Likely a result of several phenonema such as internal boundary layers, low level jets and sea-land breezes.
- Coherence with very unstable atmospheric conditions could aid in predicting these abnormal profiles

References (selected)

[1] Kettle A J 2014, *Journal of Wind Engineering and Industrial Aerodynamics* **134** 149-162
[2] Nunalee C G and Basu S 2014 W*ind Energy* **17** 1199-1216

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