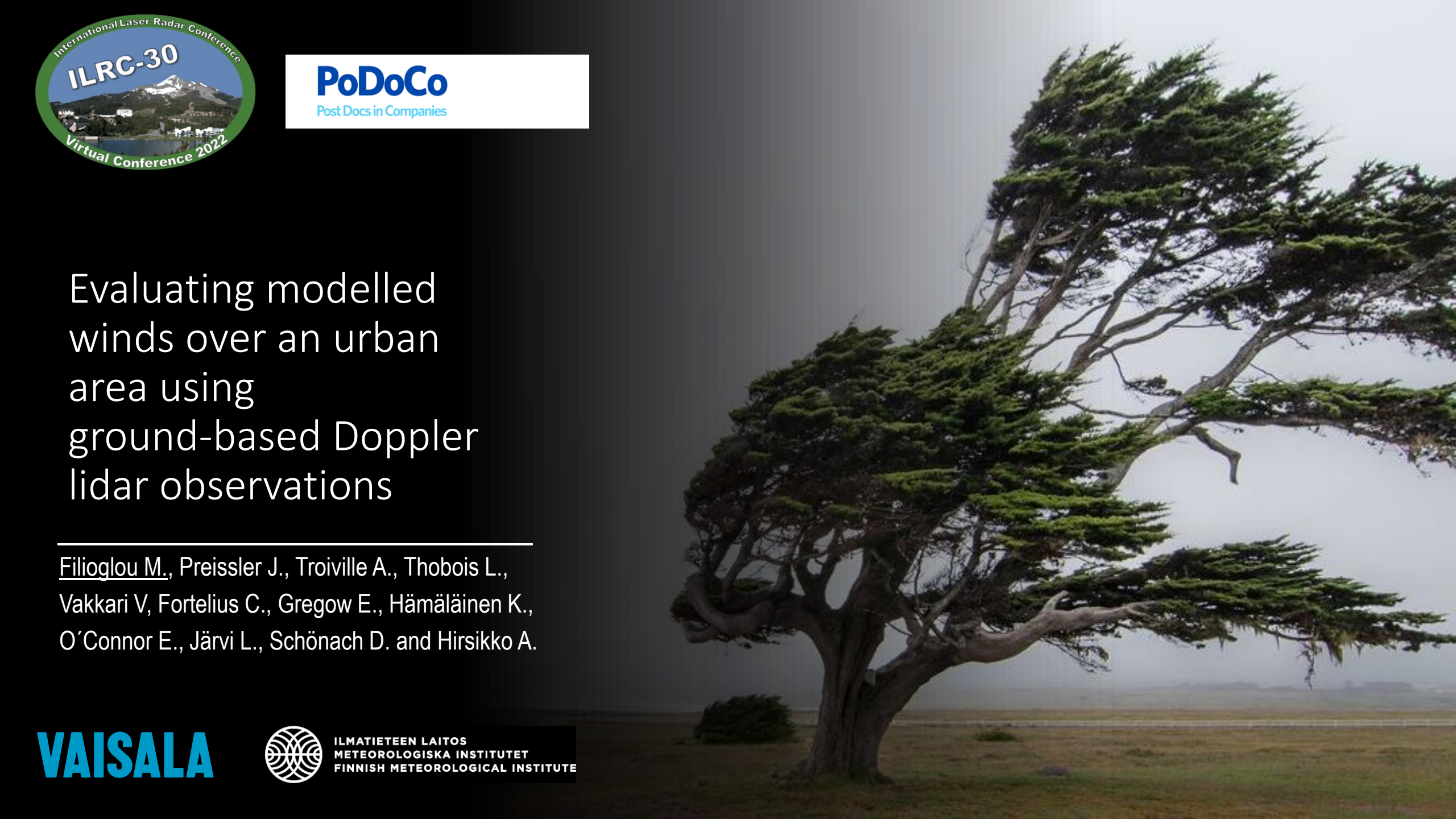


Evaluating modelled winds over an urban area using ground-based Doppler lidar observations

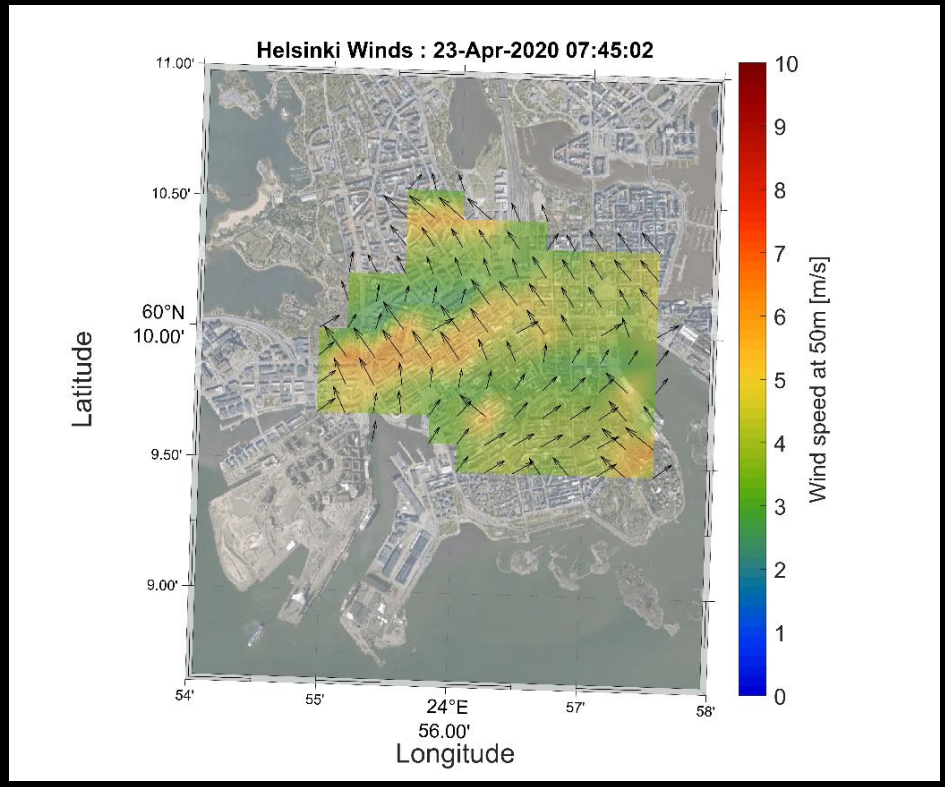
Filioglou M., Preissler J., Troiville A., Thobois L., Vakkari V, Fortelius C., Gregow E., Hämäläinen K., O´Connor E., Järvi L., Schönach D. and Hirsikko A.

Motivation

Wind energy, air quality, meteorology, aviation and many other applications depend on accurate and regular information of the 3D wind field, ie. wind speed and direction at specific locations, over an area of interest or in a volume.

Therefore, there is the need to first measure the wind and further validate the models upon which many applications depend on.

This gets more complicated within a city domain where the morphology changes from neighbourhood to neighbourhood altering the wind flow.



Example case of 2D wind speed and direction as captured from the WindCube Doppler lidar over the city centre of Helsinki, Finland on 23rd of April 2020.

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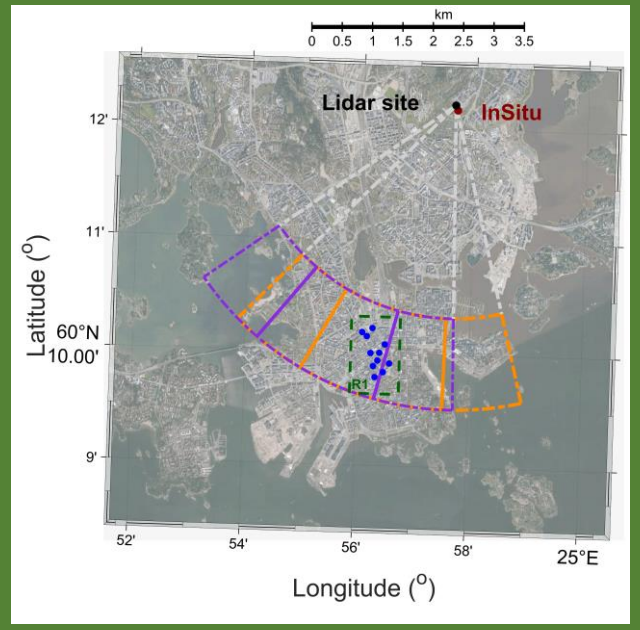
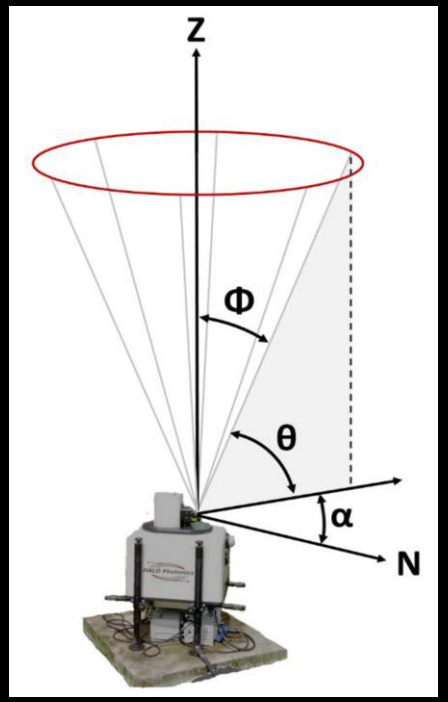
Area of study



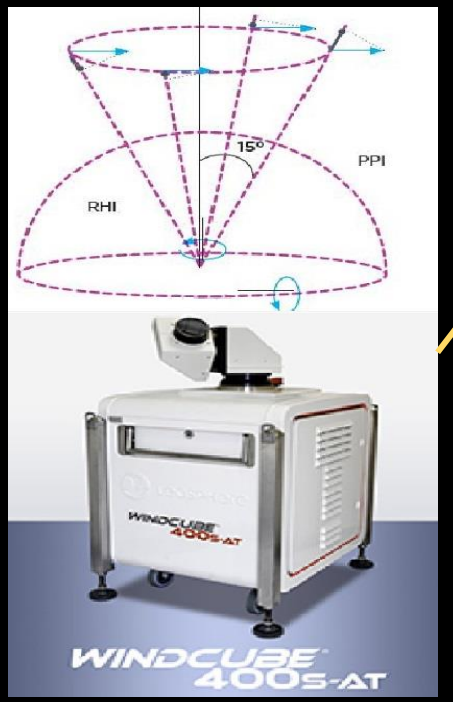
- Wind information from 2 models (LAPS and MEPS)* were evaluated using 2 Doppler lidar instruments in the urban environment of Helsinki city in Finland.

Instrumentation

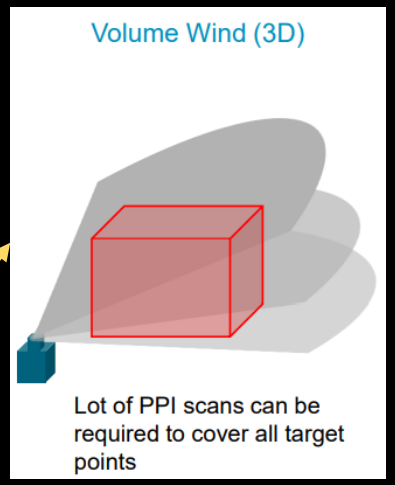
HALO lidar
provided profiles of the horizontal wind above the lidar site



WindCube 400s lidar
provided 3D wind in the scanned area. (Coloured area)



The reconstruction of 3D wind is based on the Volume Velocity Processing



* More information: https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/met.2052

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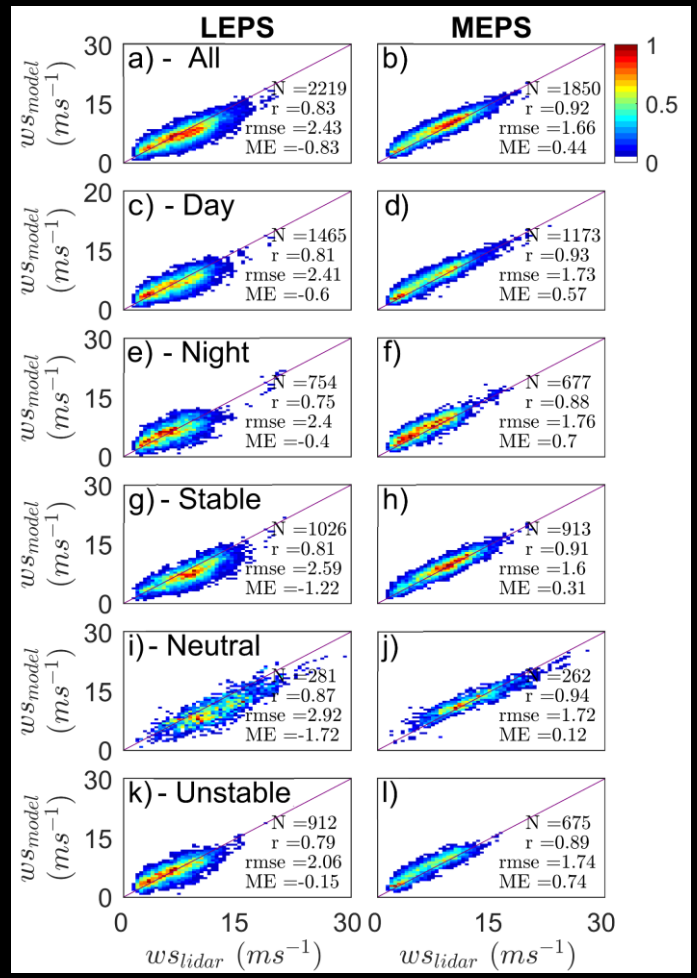
Results - Verification of wind profiles

LEPS

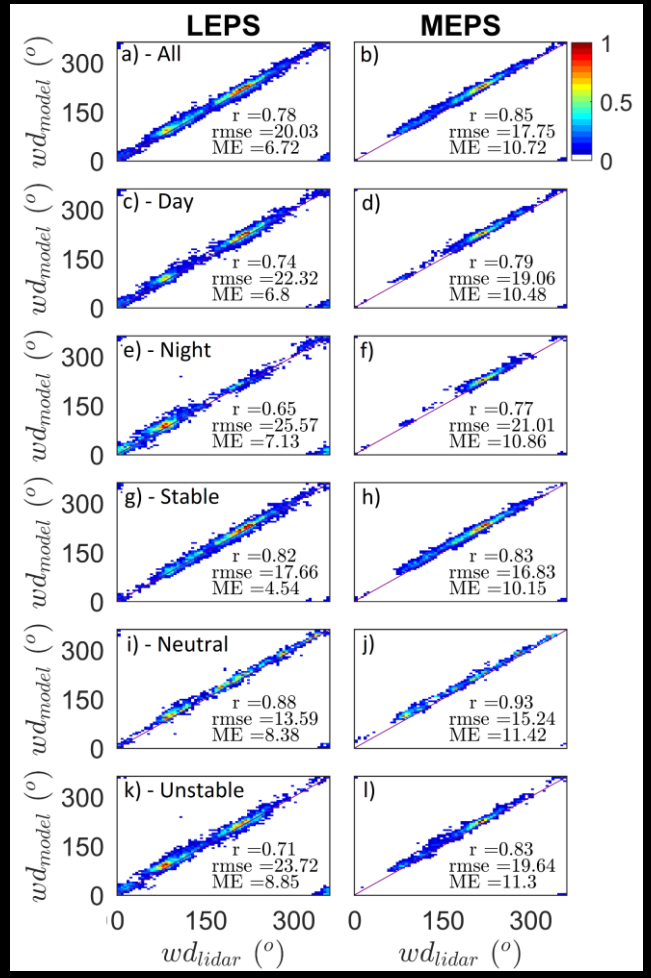
- Negatively biased
- overall mean bias error in wind speed is -0.83±2.28 m s^{-1}
- Unstable conditions are the least challenging
- 7 ±19◦ difference in the wind direction

MEPS

- Positively biased
- overall mean bias error in wind speed is 0.44±1.60 m s^{-1}
- neutral and stable conditions are the least challenging
- 11 ±14◦ difference in the wind direction



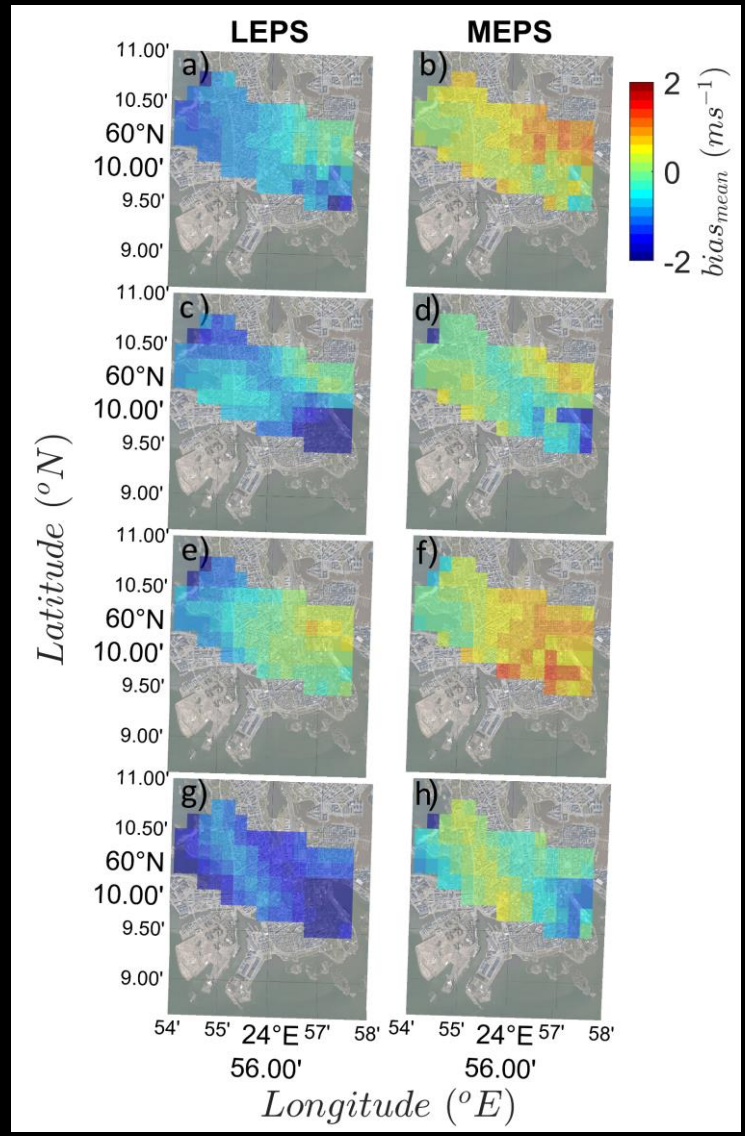
Frequency plots of horizontal wind speed between the HALO Doppler lidar and the models. Pixel width for wind speed is 0.5 m s^{-1}.



Frequency plots of wind direction between the HALO Doppler lidar and the models. Pixel width for wind direction is 5°.

Results - Spatial differences

- Interesting wind flow features brought up by the finer 200 x 200 m WINDCUBE Doppler lidar observations compared to the coarser model spatial resolution (especially for SE or NW wind directions).
- The interesting channeling effects of the wind flow were not captured by any of the two models used in this study.
- The upper end of the disagreement between models and observations is 3–9 m s^{-1} , depending on the location.



Mean horizontal bias between models and WindCube Doppler lidar observations at 60 m above ground level for each wind sector: (a–b) NE (0°–90°), (c–d) SE (90°–180°), (e–f) SW (180°–270°) and (g–h) NW (270°–0°).

Summary

- The selected models exhibit different strengths and weaknesses depending on the atmospheric conditions but no significant diurnal variation in performance was observed.

- The spatial evaluation showed that specific wind directions (NW and SE in this instance) created an interesting channeling effect of the wind flow that was not captured by any of the models.

- Any differences between the models and the observations were attributed to the representation of the PBL together with the coarser vertical and spatial model resolution .

- The full evaluation/discussion can be found here:

Filioglou, M., Preissler, J., Troiville, A., Thobois, L., Vakkari, V., Auvinen, M., Fortelius, C., Gregow, E., Hämäläinen, K., Hellsten, A., Järvi, L., O'Connor, E., Schönach, D., & Hirsikko, A. (2022). Evaluating modelled winds over an urban area using ground-based Doppler lidar observations. *Meteorological Applications*, 29(2), e2052. https://doi.org/10.1002/met.2052

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