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

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Accurate wind forecasts covering urban areas is essential for predicting the heat island effect (UHI), air pollution, energy demand and safety of drone-related operations. Yet, forecasting the wind in an urban environment can be challenging due to the complexity of the city morphology and the highly complex wind field. Doppler lidars (Light Detection And Ranging) provide a unique opportunity for wind forecast verification as they can provide both the vertical profile of the horizontal wind and the spatial variation in the horizontal domain at high resolution. In this study, the performance of one Numerical Weather Prediction (NWP) model and one analysis system have been analyzed by comparing the modelled winds against Doppler lidar observations under various atmospheric conditions and from season to season, in the coastal and urban environment of Helsinki, Finland. The long-term mean vertical profile of the modelled horizontal wind shows good agreement with observations; neutral and stable conditions are the least challenging for the NWP model. Unstable conditions are the least challenging for the analysis system while slightly better performance is observed during daytime compared to nighttime. The overall mean bias error in wind speed is -0.83±2.28 m s^{-1} for the analysis system and 0.44±1.60 m s^{-1} for the NWP model. The corresponding wind direction mean difference between the models and the observations is 7 ±19◦ and 11 ±14◦ for the analysis system and NWP. Regarding the spatial agreement, both the NWP model and analysis system show differences in their spatially averaged bias when investigating different wind directions.