Mesoscale variations in the wind and air temperature during a cold-air outbreak over the Gulf of Finland

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Quantitative information on mesoscale variations in the wind field profile in the lowest 150 m are needed for wind energy applications. In a coastal region, the mesoscale wind field is affected by thermal and roughness differences between the sea and land. During a cold-air outbreak over a warm sea, the mesoscale wind field differs a lot from that during a similar large-scale flow under neutral boundary-layer stratification, and a low-level jet is often generated. c

In this paper, wind field simulations are presented applying the Fifth-Generation Mesoscale Model (MM5) over a 10-day period of a cold-air outbreak from east over the Gulf of Finland from 15 to 25 January 2006. The motivation was to better understand the applicability of MM5 in reproducing strong wind events, which are important for the economy of wind power production.

The period was characterized by a stable stratification over land surface, very large turbulent surface fluxes and shallow convection over the open sea, and large horizontal wind and temperature gradients, perpendicular to an easterly synoptic-scale flow along the Gulf of Finland. Over the sea, the air temperatures were some 8 K higher than over the land 20 km from the coast. The model results indicated a low-level jet (LLJ) at the height of 150 m over the Finnish coast. Baroclinicity was supposed to be the main mechanism for the generation of the LLJ.

The performance of MM5 was investigated using different lower-boundary conditions (sea ice and sea surface temperature) and with different resolution of meteorological input from ECMWF. The model results were validated using surface weather station observations from coastal, archipelago and lighthouse stations, high-resolution observations from Helsinki Mesoscale Tetbed, as well as rawinsonde sounding, satellite, and radar data.