The impact of assimilating data from a remotely piloted aircraft on simulations of weak-wind orographic flow

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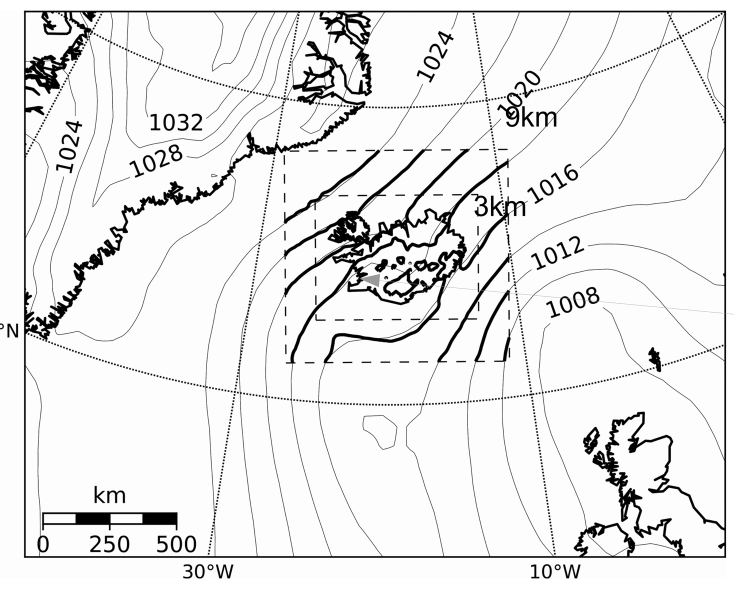
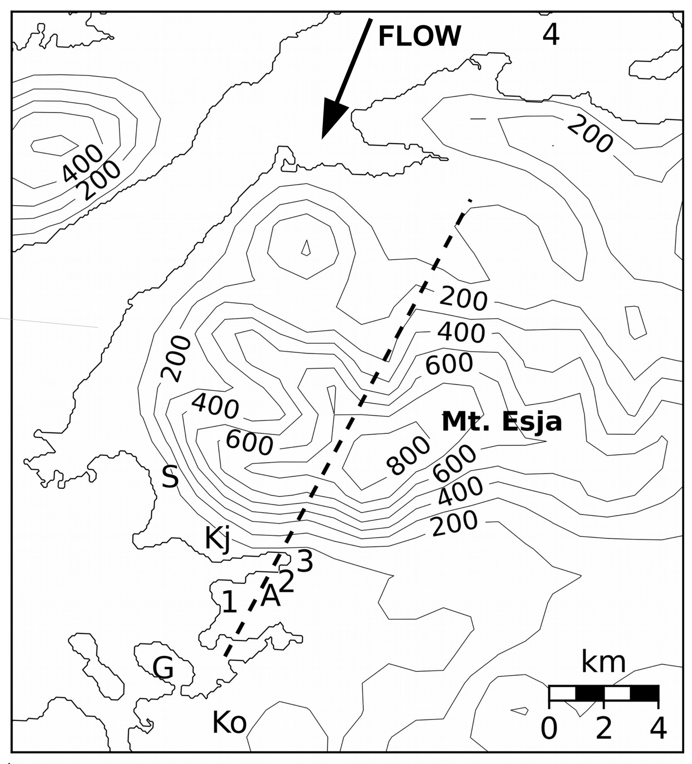
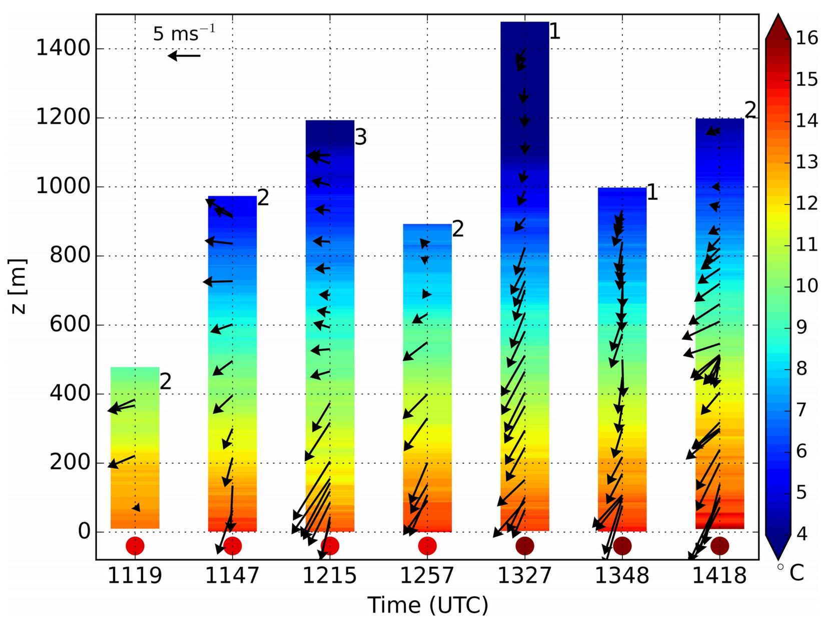
Orographic winds near a 900 m high mountain in Southwest-Iceland are explored using unique observations made aloft with a small remotely piloted aircraft, as well as with traditional observations and high-resolution atmospheric simulations (9, 3 and 1 km resolution). There was an inversion well above mountain top level at about 2 km with weak winds below. Observed winds in the lee of the mountain were indicative of flow locally enhanced by wave activity aloft. Winds descended along the lee slope with a prevailing direction away from the mountain. They were relatively strong and gusty at the surface close to the mountain, with a maximum at low levels which weakened and became more diffuse a short distance further downstream. The winds weakened further aloft, with a minimum on average near mountain top level. This situation is reproduced in a high-resolution atmospheric simulation (ALL), forced with atmospheric analysis as well as the observed lee side profiles of wind and temperature below 1.4 km. Without the additional observations (NO), the model fails to reproduce the winds aloft as well as at the surface in a region in the lee of the mountain. A sensitivity simulation (KEF) indicates that this poor performance is a result of the poorly captured strength and sharpness of the inversion aloft. The study illustrates, firstly, that even at very low wind speed, in a close to neutral low-level flow, gravity waves may still be a dominating feature of the flow. Secondly, the study presents an example of the usefulness of lee-side atmospheric profiles, retrieved by simple model aircraft, for improving numerical simulations and short-term weather forecasting in the vicinity of mountains.



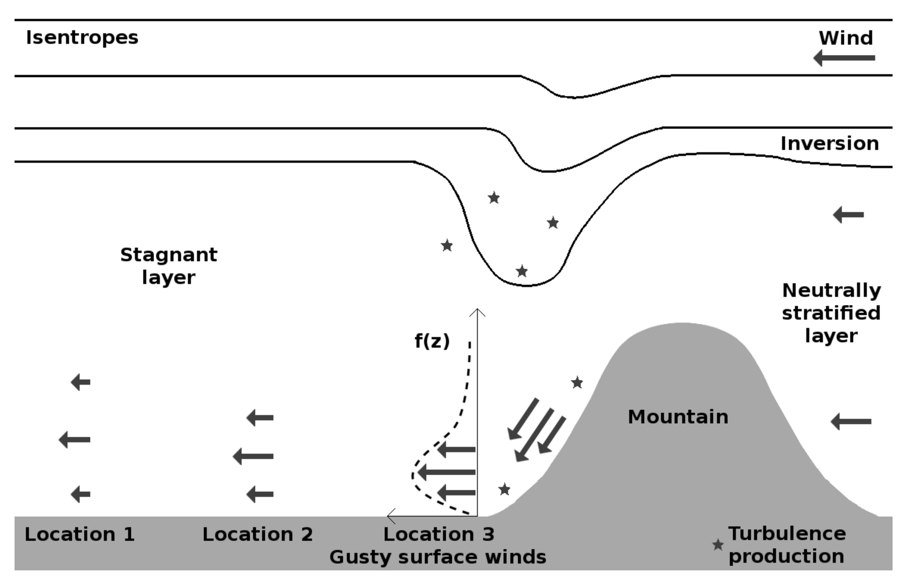


Left: Mean sea level pressure [hPa] at 1200 UTC on 15 July 2009 (ECMWF analysis: thin lines, simulated: bold). Above: Model topography at 1 km resolution (100 m contours). Shown are locations of RPAS flights (1, 2, 3), pseudo temperature sounding (4), cross-section (dashed line), and stations (Ke, R, G, Ko,A, Kj, S)

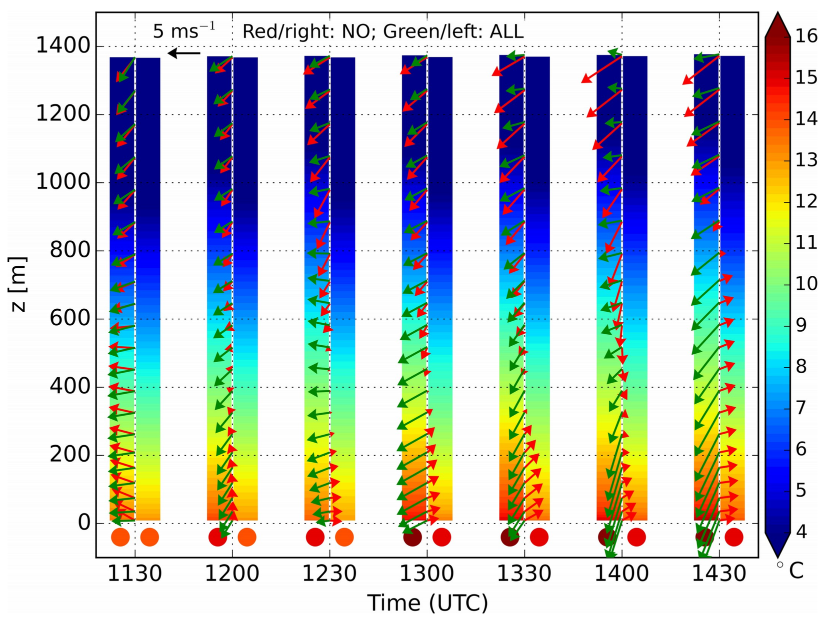
Ref: H. Ágústsson, H. Ólafsson, M. O. Jonassen, Ó. Rögnvaldsson, 2014: The impact of assimilating data from a remotely piloted aircraft on simulations of the atmosphere. Tellus A, 66, 25421

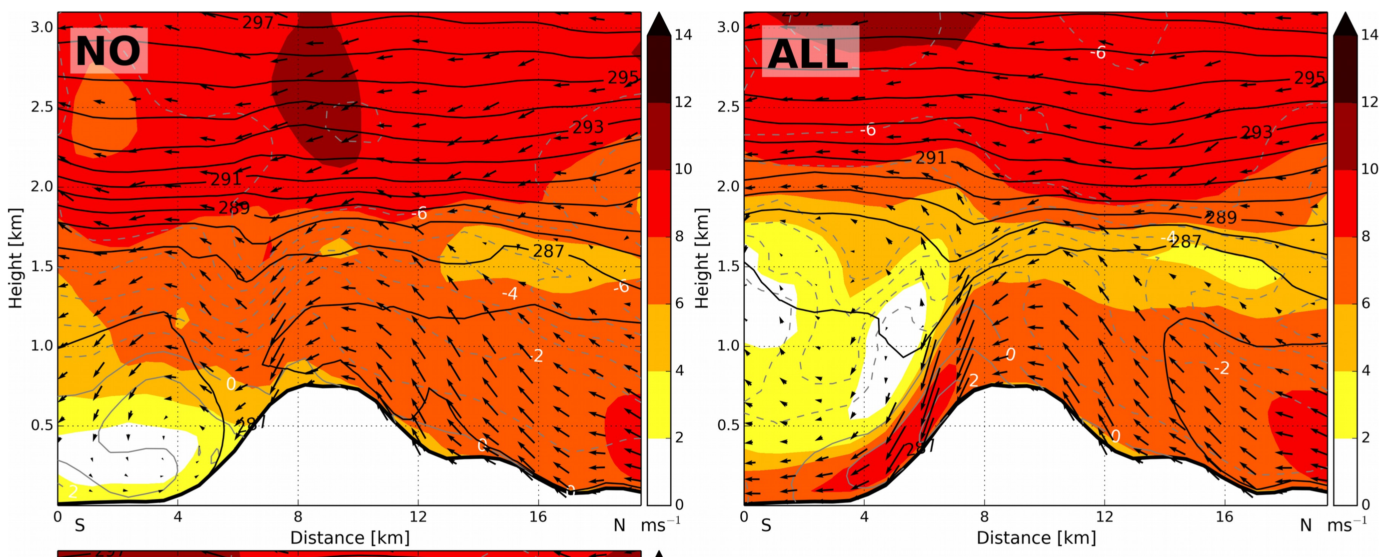


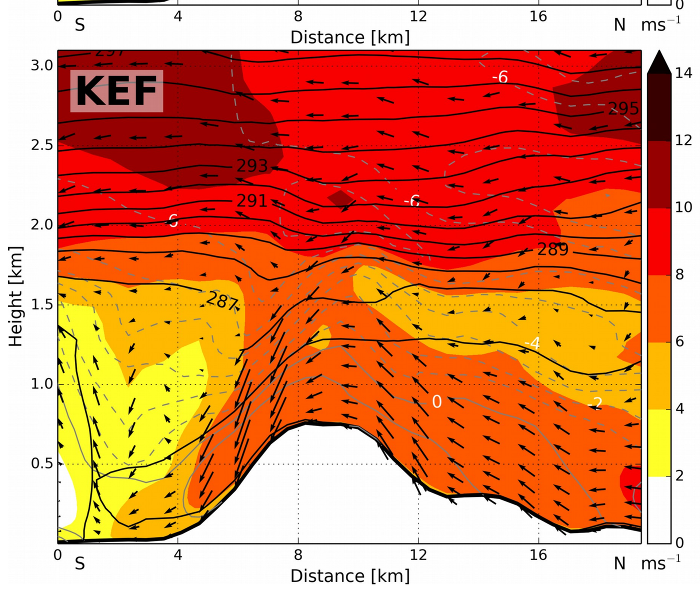
Observed and simulated vertical profiles of winds and temperature (bars), as well as 2-m temperature (dots) on 15 July 2009. Observed profiles (left) are from the descending part of the RPAS flights (locations indicated at top of bars and in map), with 2-m temperature from Álfsnes (A) station. Simulated surface temperature and profiles (right) are from the control (NO, red arrows/right column) and nudged (ALL, green arrows/left column) 1 km domains, at/above the Álfsnes (A) station



Right: A schematic summary depicting the presumed gravity wave activity aloft and the lee-side accelerated flow, as well as observed wind profiles in lee of the mountain.

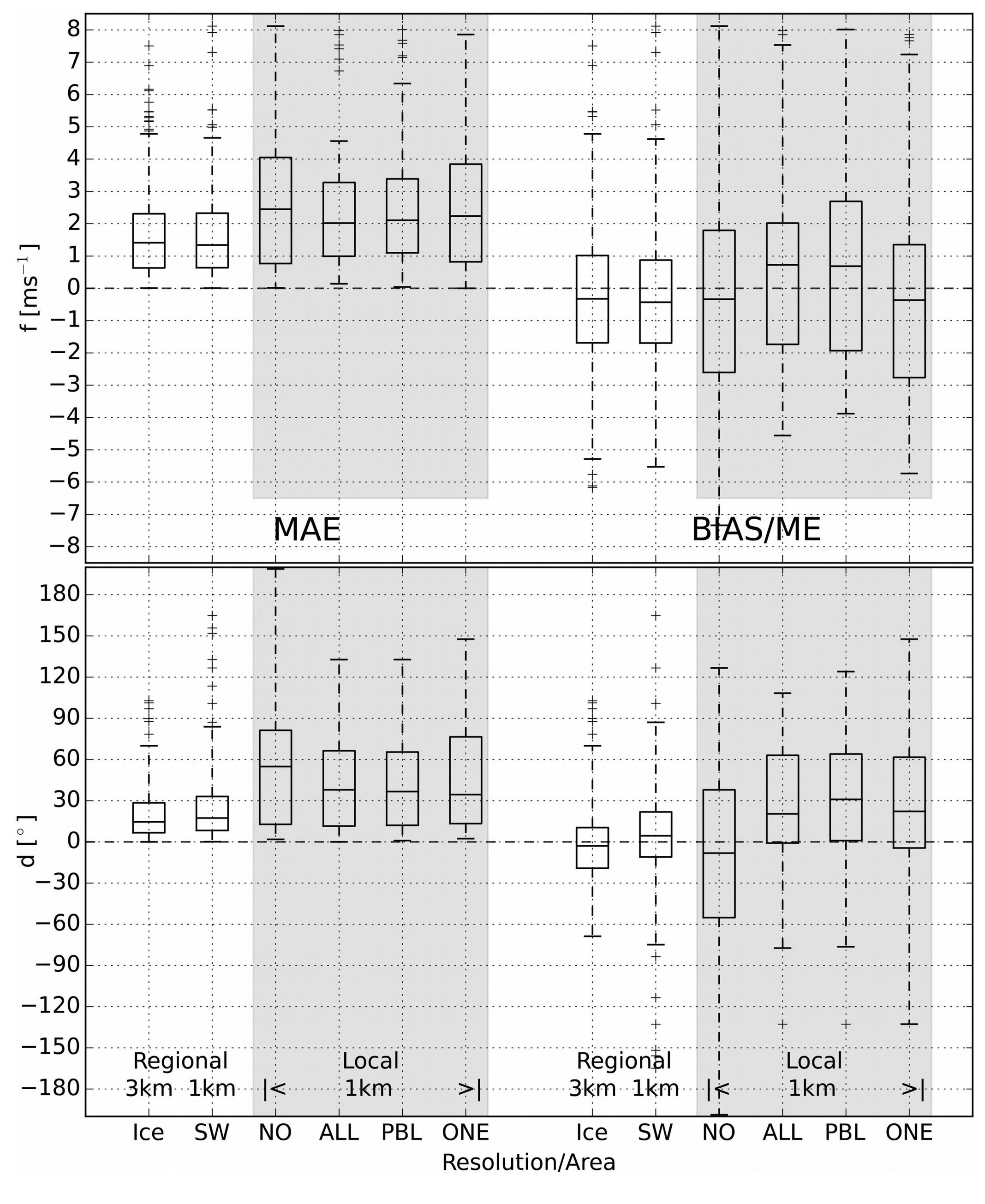




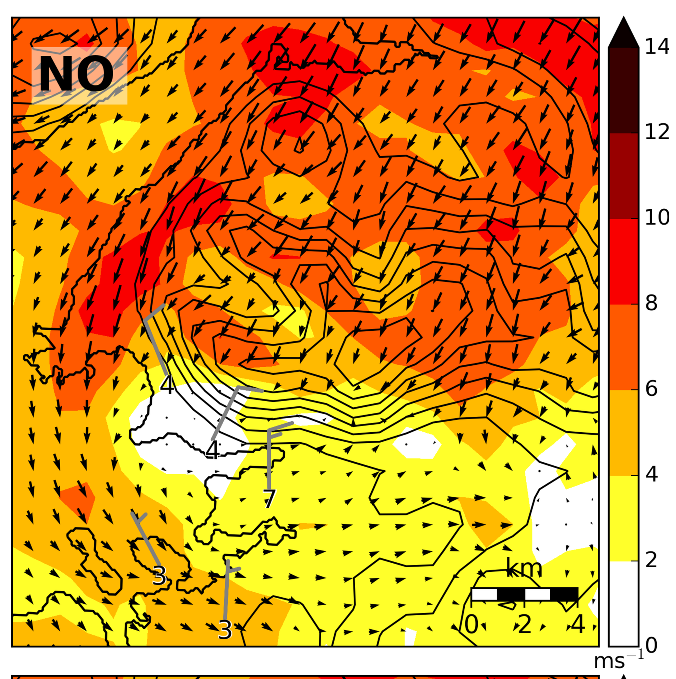


Wind speed [m/s], wind vectors in the plane (vertical wind scaled by 10) and isentropes [K] at 1 km resolution in the control (NO, upper left), nudged (ALL,above) and sensitivity (KEF, left) simulations in a section across Mt. Esja, at 1400 UTC on 15 July 2009. Also shown is orography, as well as grey lines indicating, respectively, flow out of (solid) and into (dashed) the section with a 1m/s interval.

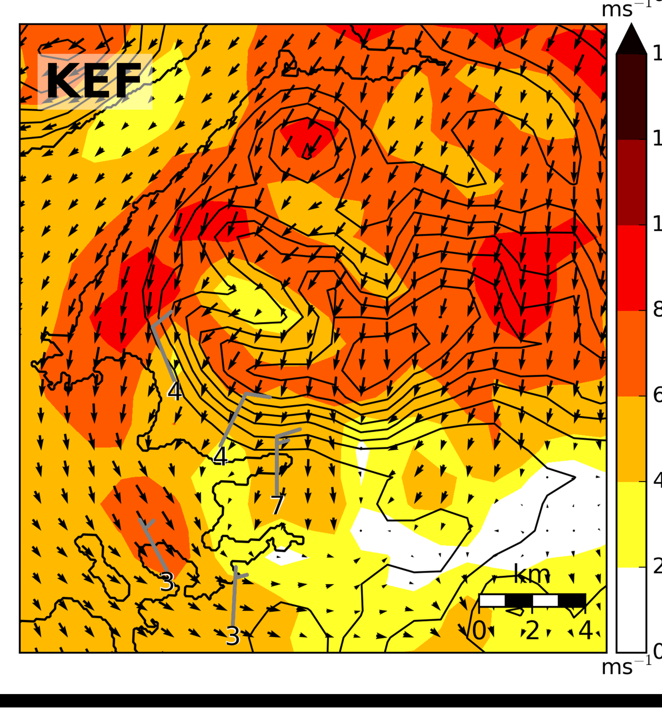
- **NO - Control simulation, not nudged**
- **ALL - Nudged simulation using all profiles**
- **ONE - Nudged simulation using 1 profile**
- **PBL - Nudged simulation excluding temperature observations in the PBL**
- **KEF - Sensitivity simulation testing importance of inversion strength and height**

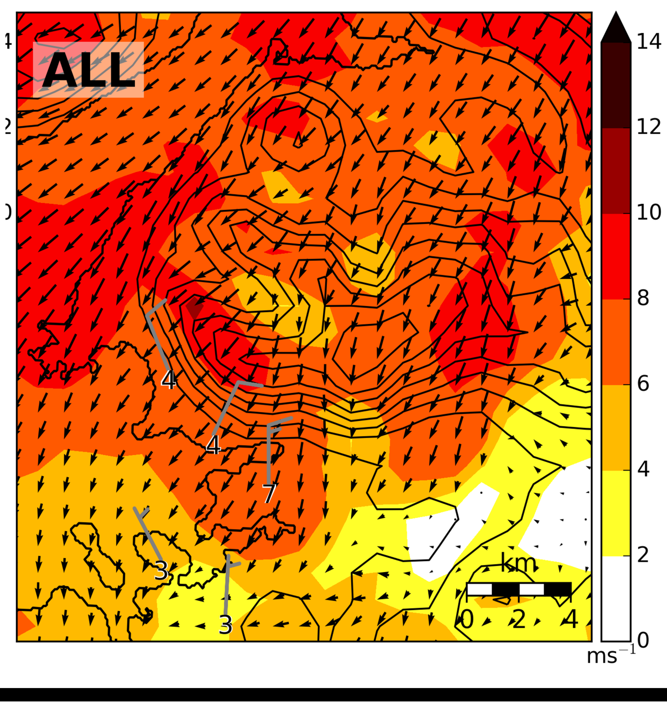


Right: Mean absolute error (MAE) and mean error (BIAS/ME) for simulated wind speed (above) and direction (below). The regional flow in Iceland (Ice, 3 km) and Southwest-Iceland (SW, 1 km) is presented based on the control (NO) simulation. The local flow in the main region of interest is presented for five stations (S, Kj, A, G and Ko as in map) and the nudged NO, ALL, PBL and ONE 1 km simulations (shaded region). The median is given by the horizontal line inside the box which covers the 25% and 75% quartiles, while whiskers show the range of the data, excluding outliers.

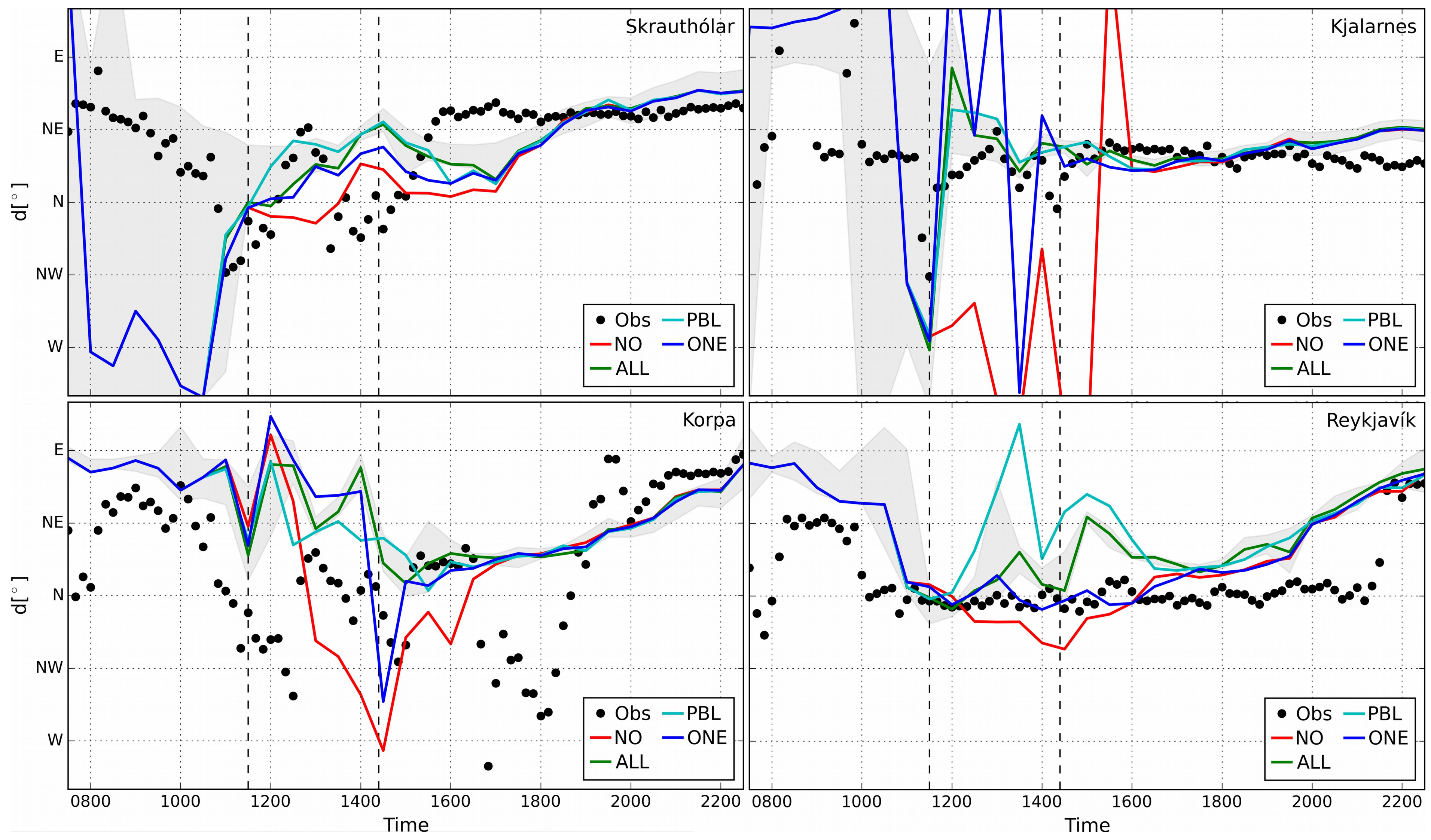


Simulated 10-m wind speed [m/s] and wind vectors at a horizontal resolution of 1 km in the control (NO,left), nud-ged (ALL, below) and sensitivity (KEF, lower left) simulations, as well as observed 10-m winds at automatic weather stations (numbers and barbs, 2.5 m/s each half barb), at 1400 UTC on 15 July 2009. Terrain contours with 100 m interval.





Below: Observed and simulated 10-m wind direction at four automatic weather stations on 15 July 2009. Simulated values are from the 1 km horizontal domain for the control run (NO) and nudged runs. The spread of the simulated values (ALL) in a 3x3 km2 area centred on the station location is bounded within the grey envelope. The dashed, vertical, lines indicate the time interval with available RPAS observations.



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