The Advection of Mesoscale Atmospheric Vortices over Reykjavík

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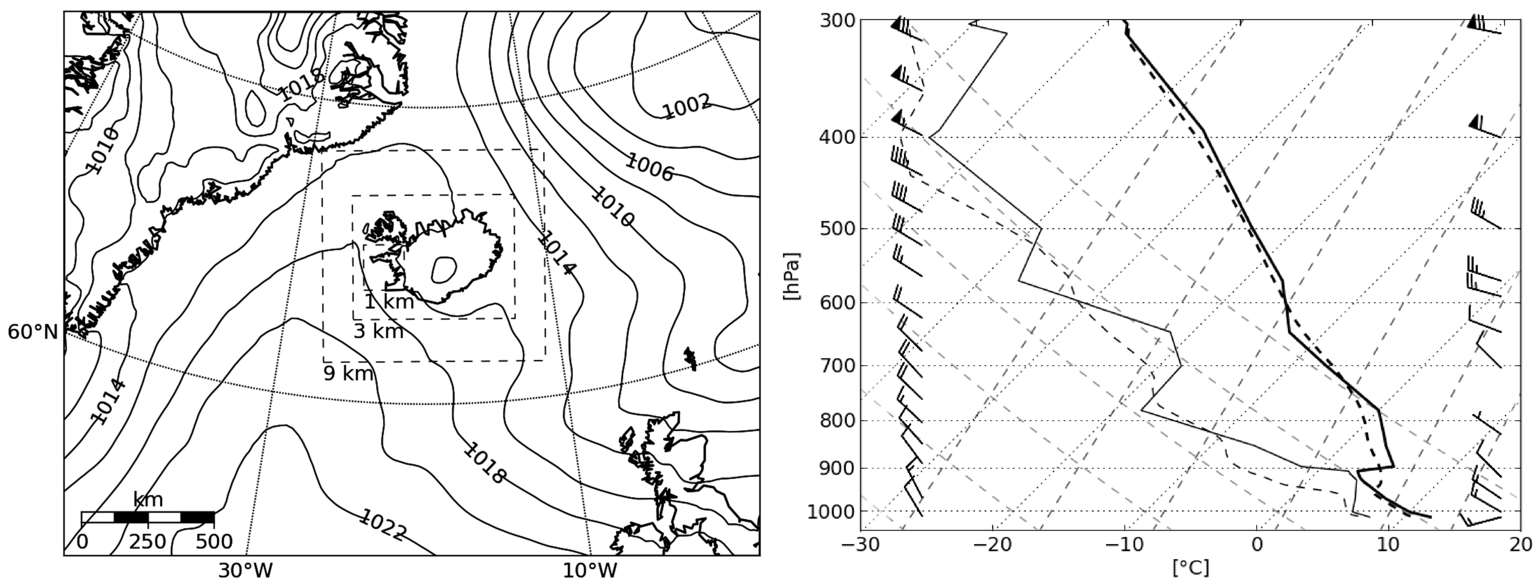
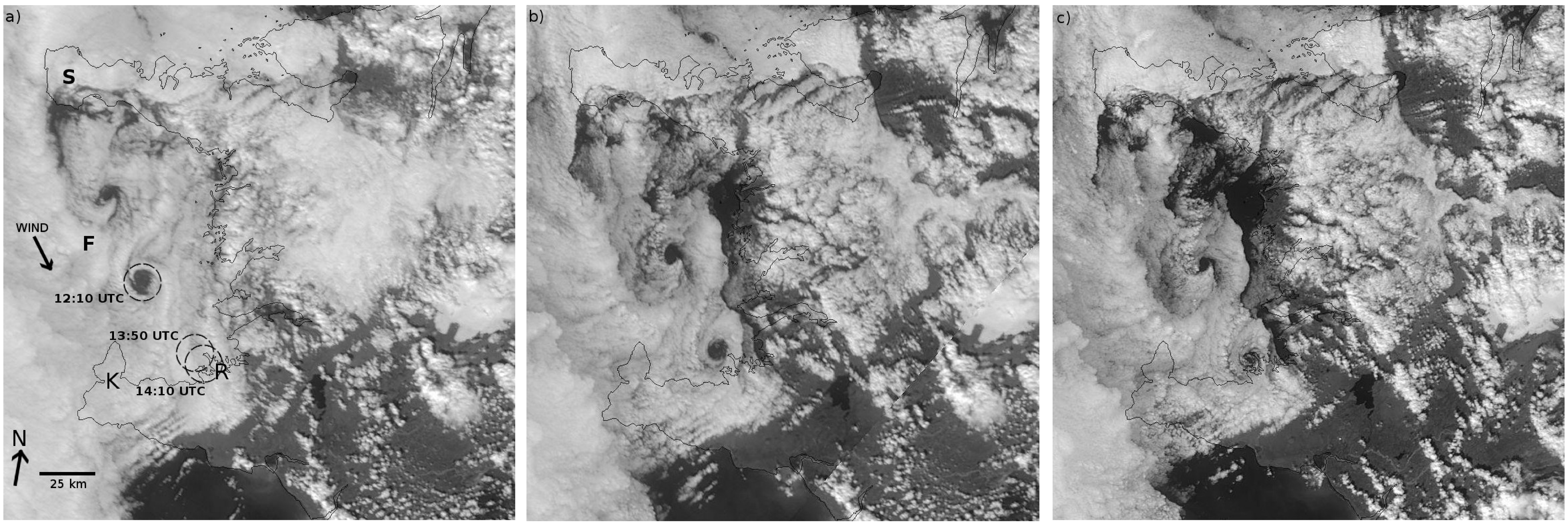
On 12 August 2009, a series of satellite images revealed asymmetric shedding of atmospheric vortices in the lee of Mt. Snæfellsjökull, and their passage a distance of 120km across Faxaflói Bay and over the city of Reykjavík in West Iceland. After landfall, the vortices were detected by a network of surface weather stations. These observations are presented and with the aid of a numerical simulation, they are discussed in view of existing theories of orographic wakes and vortex shedding. In general, the flow is in line with existing knowledge, but there is a remarkable absence of vortices with anticyclonic rotation. Atmospheric conditions for vortices of this kind are most often favorable in late winter and spring and they are a forecasting challenge.

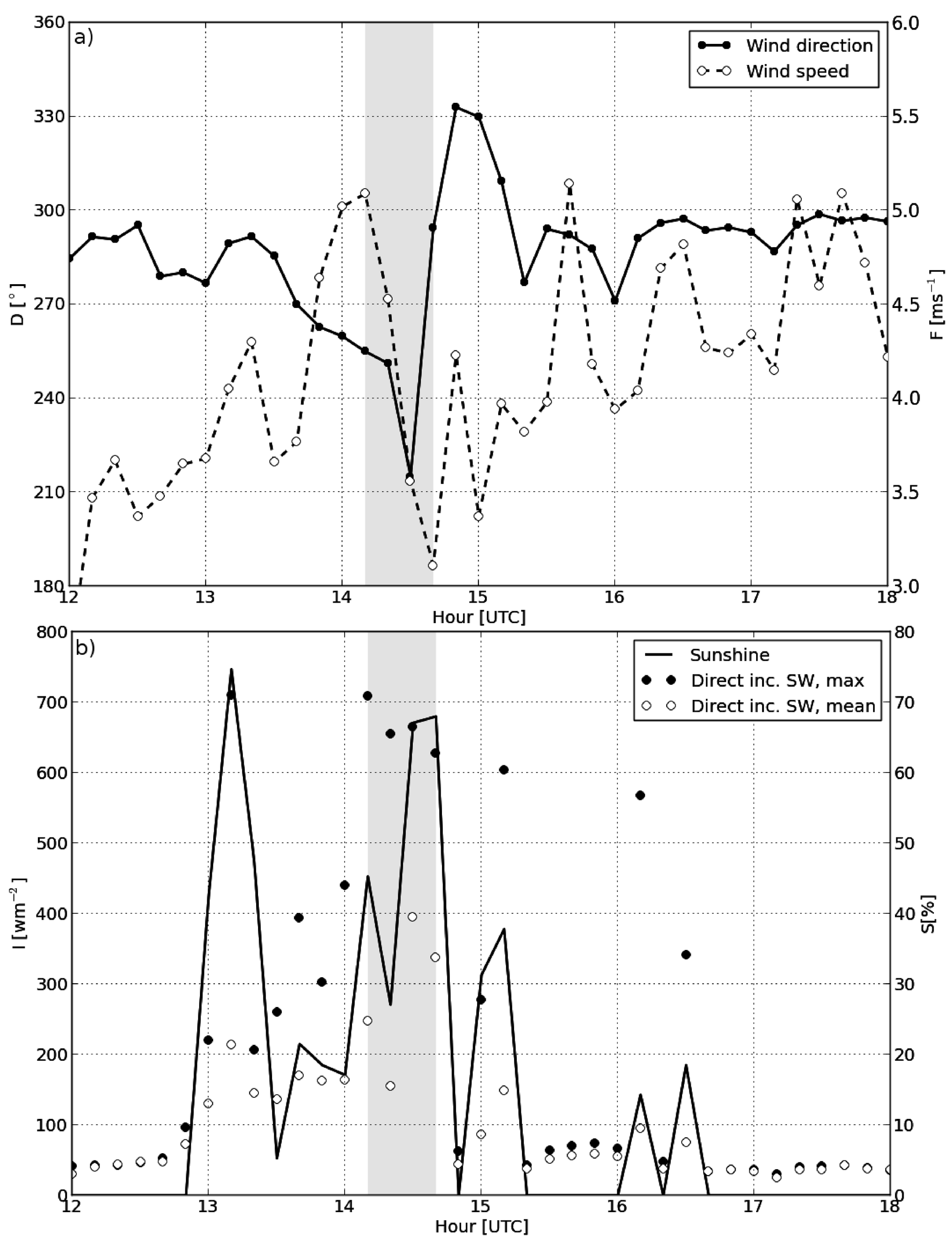
Reference: H. Ágústsson and H. Ólafsson, 2014: The Advection of Mesoscale Atmospheric Vortices over Reykjavík, Mon. Wea. Rev., 142 (10), 3549-3559.



Left: Mean sea level pressure (hPa) in the ECMWF analysis at 1200 UTC 12 Aug 2009. Also shown are the locations of the numerical domains, with the extent of the innermost domain similar to that of the satellite images. Right:Skew T–logp diagram from the Keflavík upper-air station in southwest Iceland at 1200 UTC 12 Aug 2009. Shown are observed temperature and dewpoint (solid lines), and wind (left) as well as simulated at 1-km resolution (dashed lines, barbs to the right).



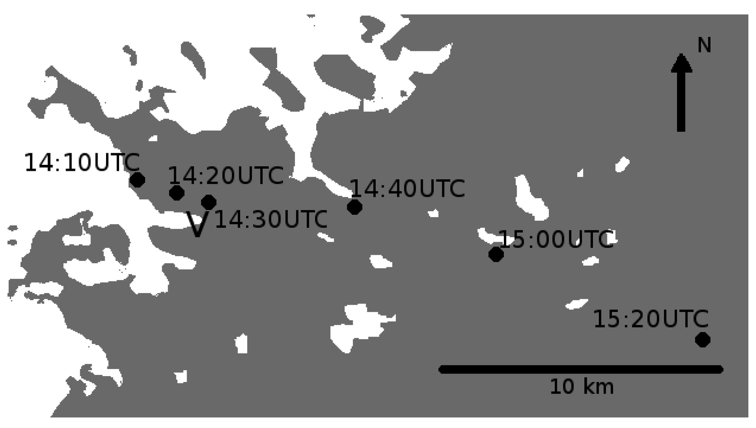
Moderate Resolution Imaging Spectroradiometer (MODIS) images (visible light, 250-m resolution) from the Terra and Aqua satellites showing a part of West Iceland at (a) 1210, (b) 1350, and (c) 1410UTC 12 Aug 2009. Also shown in (a) are the coastline, the locations of Mt. Snæfellsjökull (S),Reykjavík (R),Keflavík (K), the Faxaflói bay (F), the direction of the large-scale flow, as well as the location of the first vortex in the three satellite images.



Observations of (a) 10-m wind speed F and direction D and (b) incoming solar radiationl and sunshine S at VI (Fig. 5). The time of the vortex above the station is depicted by the shaded region.

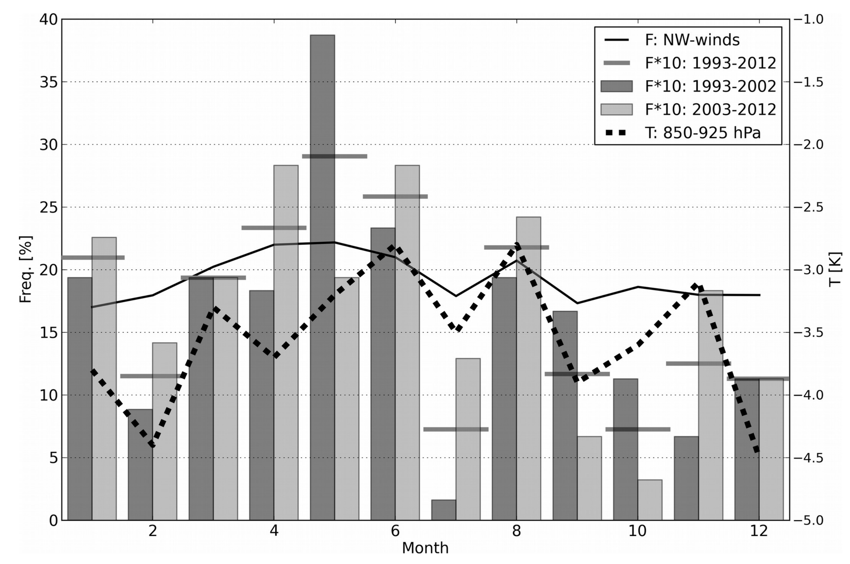
TABLE 1. Fundamental morphological and dynamical parameters of the flow: N is the Brunt–Väisälä frequency; U is the wind speed; h is mountain height; L is a characteristic length scale and the diameter of the mountain; a is the along-stream distance between vortices; CD is surface drag; Z_i is the height of the inversion; T_e is the period of vortex shedding; h_c is a critical mountain height for internal wave breaking; b is the cross-flow distance between vortices; Fr is the Froude number and Fr (div) and Fr (sw) are the Froude numbers based on the dividing streamline and shallow water, respectively; St is the Strouhal number; Ro is the Rossby number; and Re is the Reynolds number.

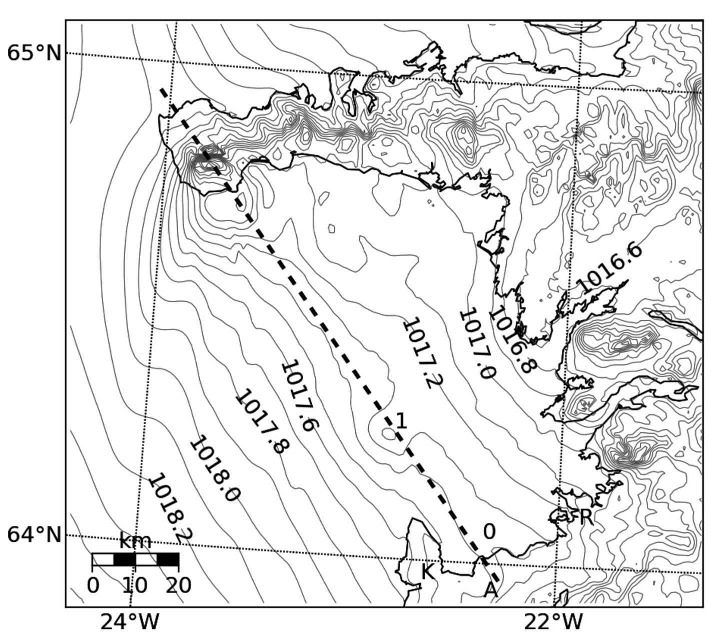
N	U	h	L	a	CD	Z_i	T_e	h_c	h/Z_i	h/d	a/h	h/L	h/h_c	Nh/U (Fr)	Fr (div)	Fr (sw)	St	Ro	Re
$0.009\,s^{-1}$	$5\,m\,s^{-1}$	1400 m	10 km	30 km	0.001	1000 m	2 h	600 m	1.4	0	∞	0.14	2.3	2.5 (0.4)	0.05	0.2	0.3	4	100



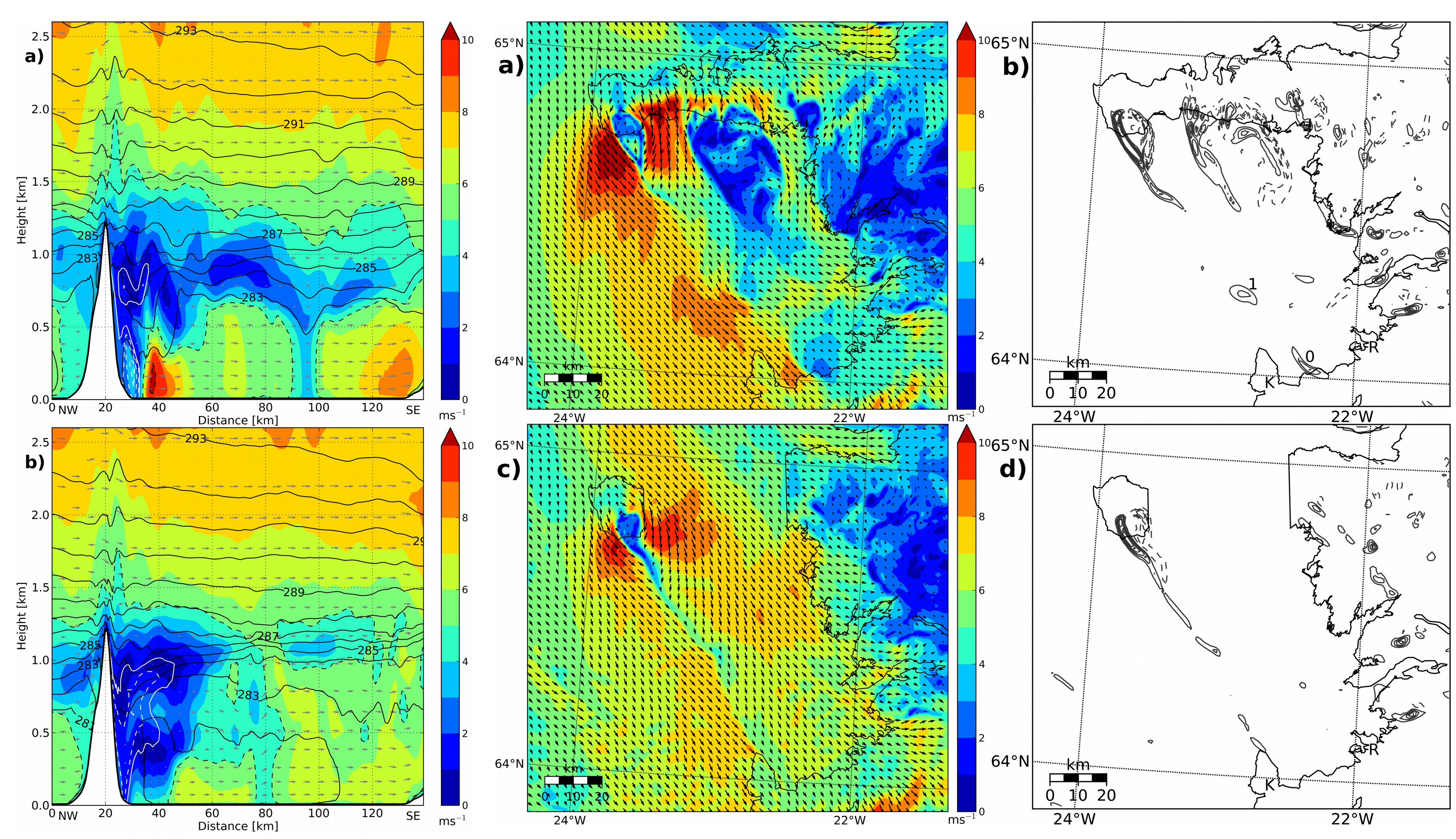
Map of the Reykjavík region depicting the timing of the passage of the vortex aloft as deduced from changes in wind speed and direction at 10m observed at automatic weather stations. The station at VI is marked with V.

Seasonal variability of the following parameters: frequency of winds fromthe northwest quadrant at 850 hPa (solid line), mean temperature difference between 850 and 925 hPa (T at 850 hPa minus T at 925 hPa: high value means strong mean static stability) in K (dotted line) and frequency of flow [%of time x10] from the northwest quadrant at 850 hPa featuring an inversion between 925 and 850 hPa (columns and short solid horizontal lines). Based on radiosoundings at 0000 and 1200 UTC at Keflavik Airport (WMO 04018) 1993–2012.





Simulated surface pressure (hPa) at 1-km resolution at 1200 UTC 12 Aug 2009. Also marked are the locations of Reykjavík (R), vortices 0 and 1, as well as the cross section in Fig. 10 across Mt. Snæfellsjökull and Faxaflói bay (dashed line).



LEFT: (a) Wind speed (m s21), wind vectors, turbulence kinetic energy (J kg21), and isentropes (K) in section A across Faxaflói Bay, simulated at 1km at 1200 UTC 12 Aug 2009. Also shown is orography, dashed line at 4m/s, stagnant flow with a white line (0m/s), and reversed flow with white dashed lines at 1m/s int. (b) As in (a), but with no mountains on the Snæfellsnes peninsula, east of Mt. Snæfellsjökull. **CENTRE AND RIGHT:** Simulated winds (m/s) with intervals of 1 m/s and vertical vorticity (s-1) with intervals of 100 s-1 at a model level close to 35m above the ground (a),(b) with true topography and (c),(d) with no mountains in the Snæfellsnes peninsula east of Mt. Snæfellsjökull.Negative vorticity is indicated with dashed isolines. The zero isoline is omitted.

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