High-resolution simulations of mountain weather improved with observations from small unmanned aircraft

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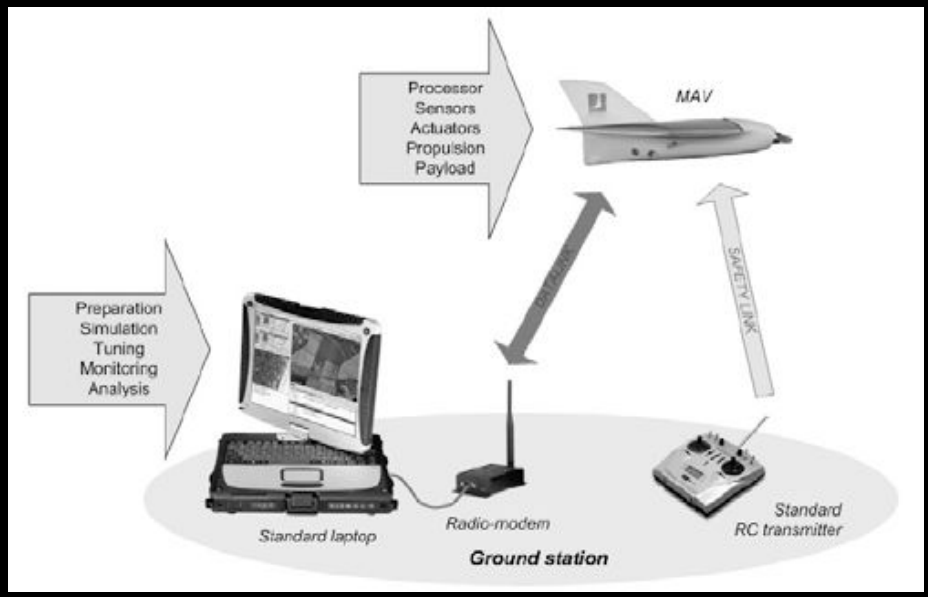
Video footage from national TV news
SumoFrett.avi

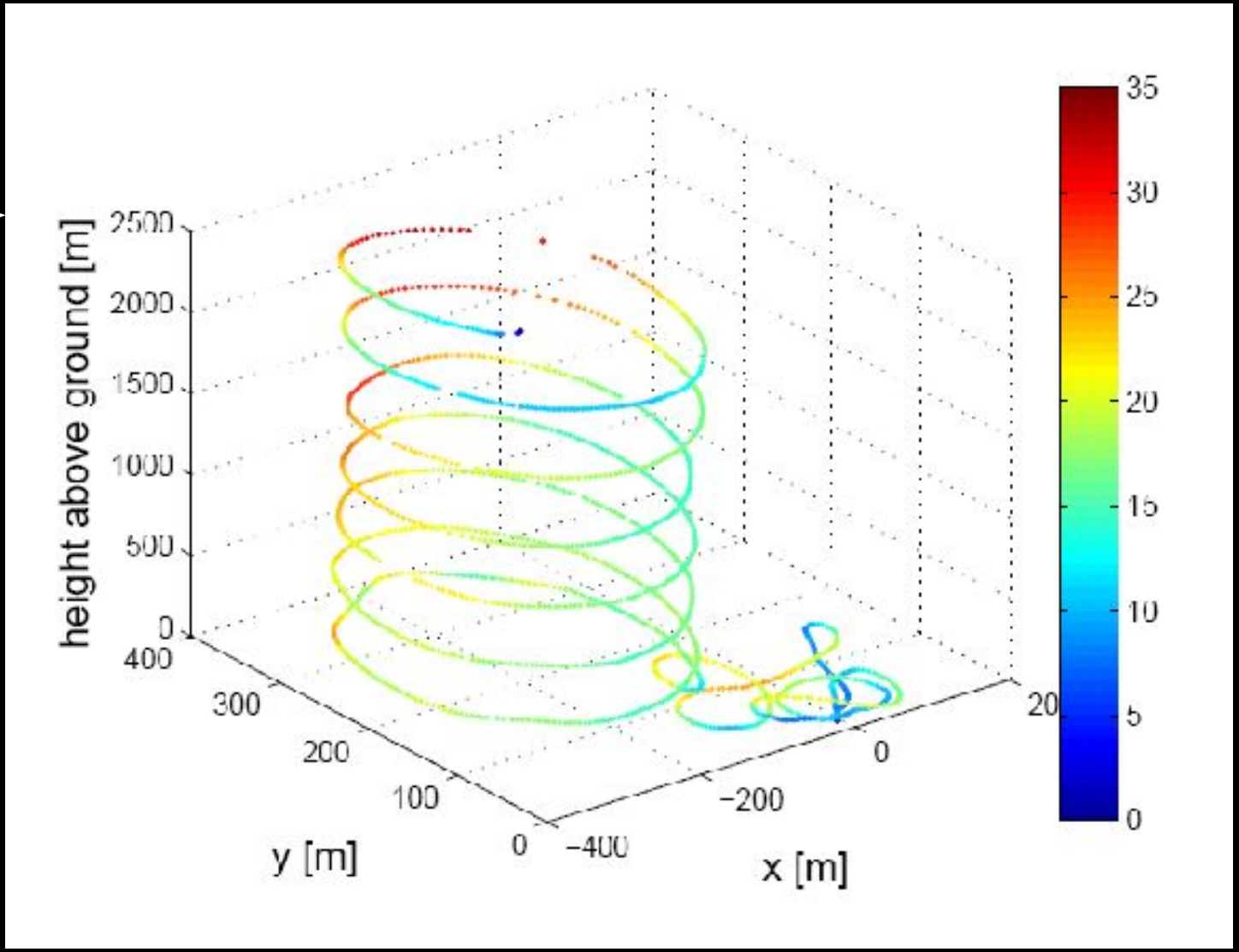
The observations

- Approx. 10 days of with the SUMO (Small Unmanned Meteorological Observer) in Southwest-Iceland in 2009.
- In addition, surface based observations were available at a high temporal and spatial resolution.



The SUMO observes winds, temperature, humidity, pressure

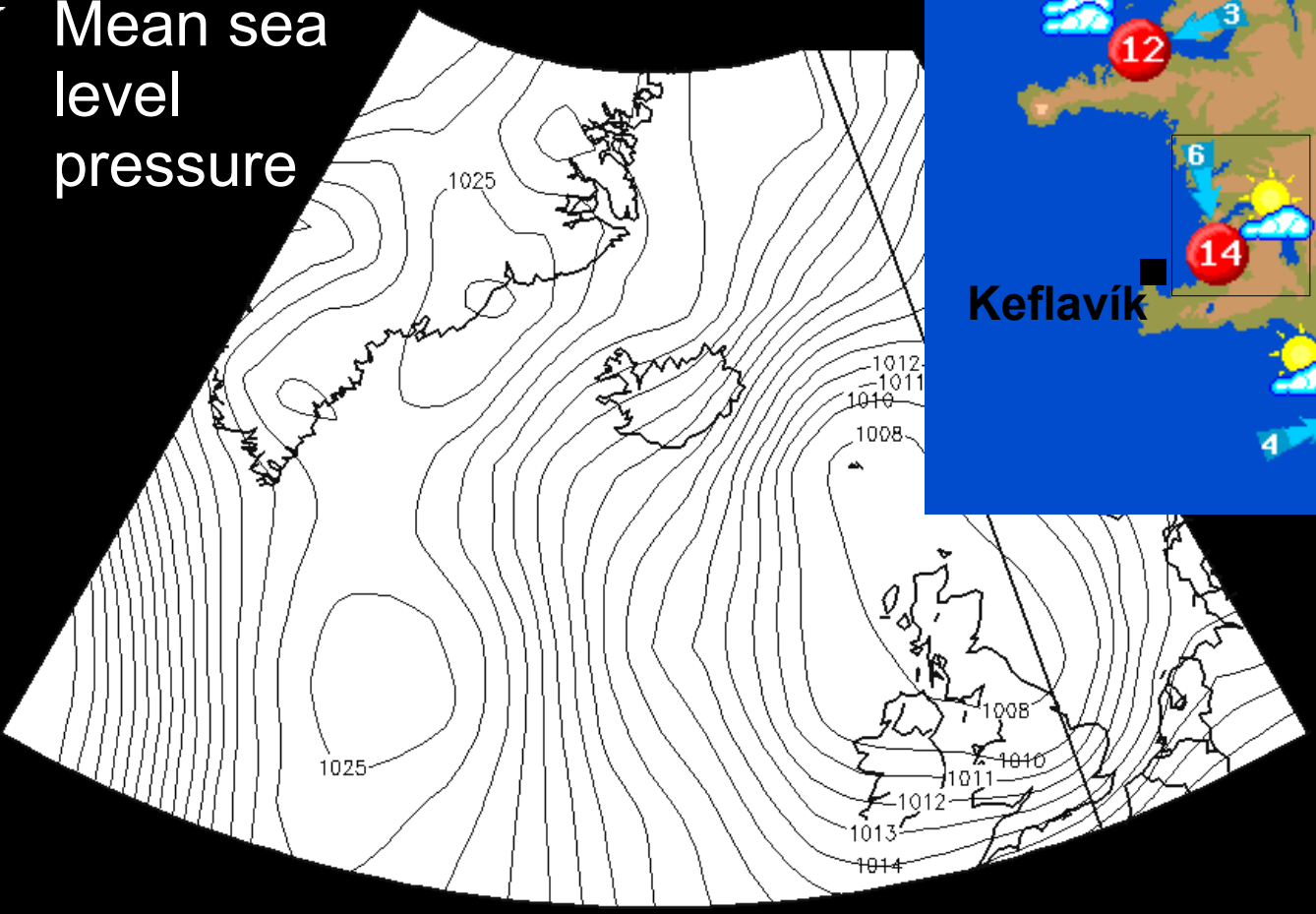
Up to ca. 3 km.

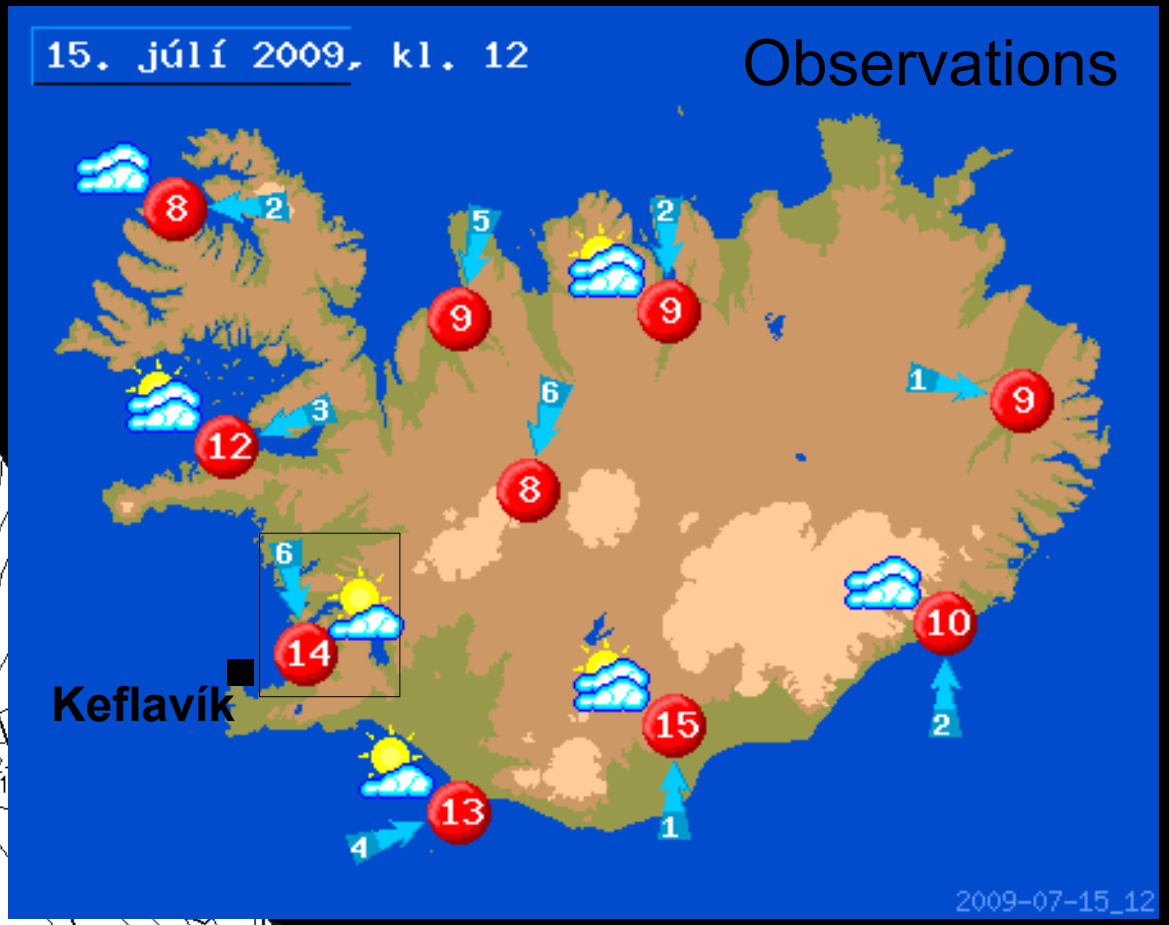


The weather on 15 July 2009 at 12 UTC

Weak winds with a north-easterly background flow.

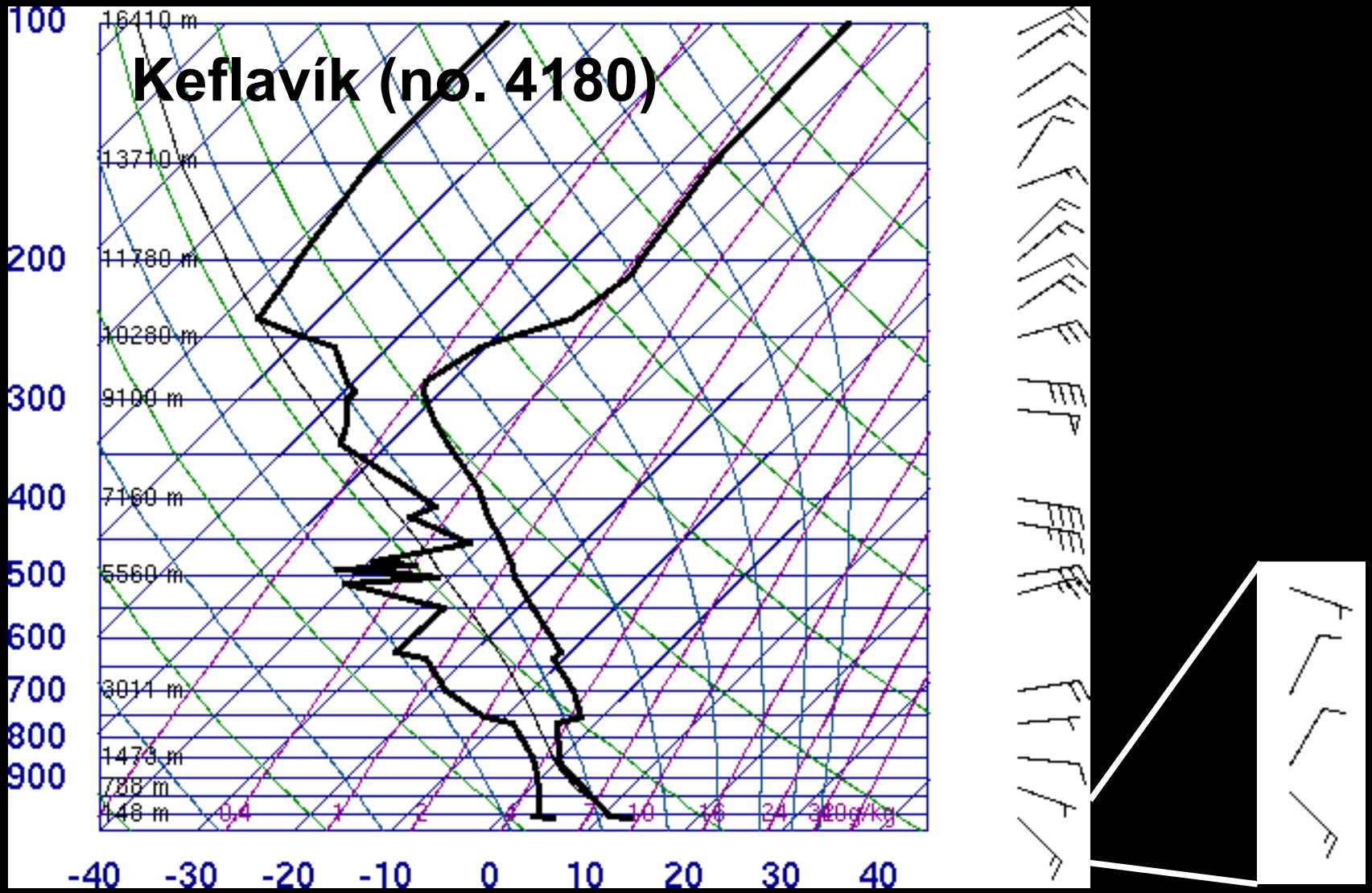
Mean sea level pressure



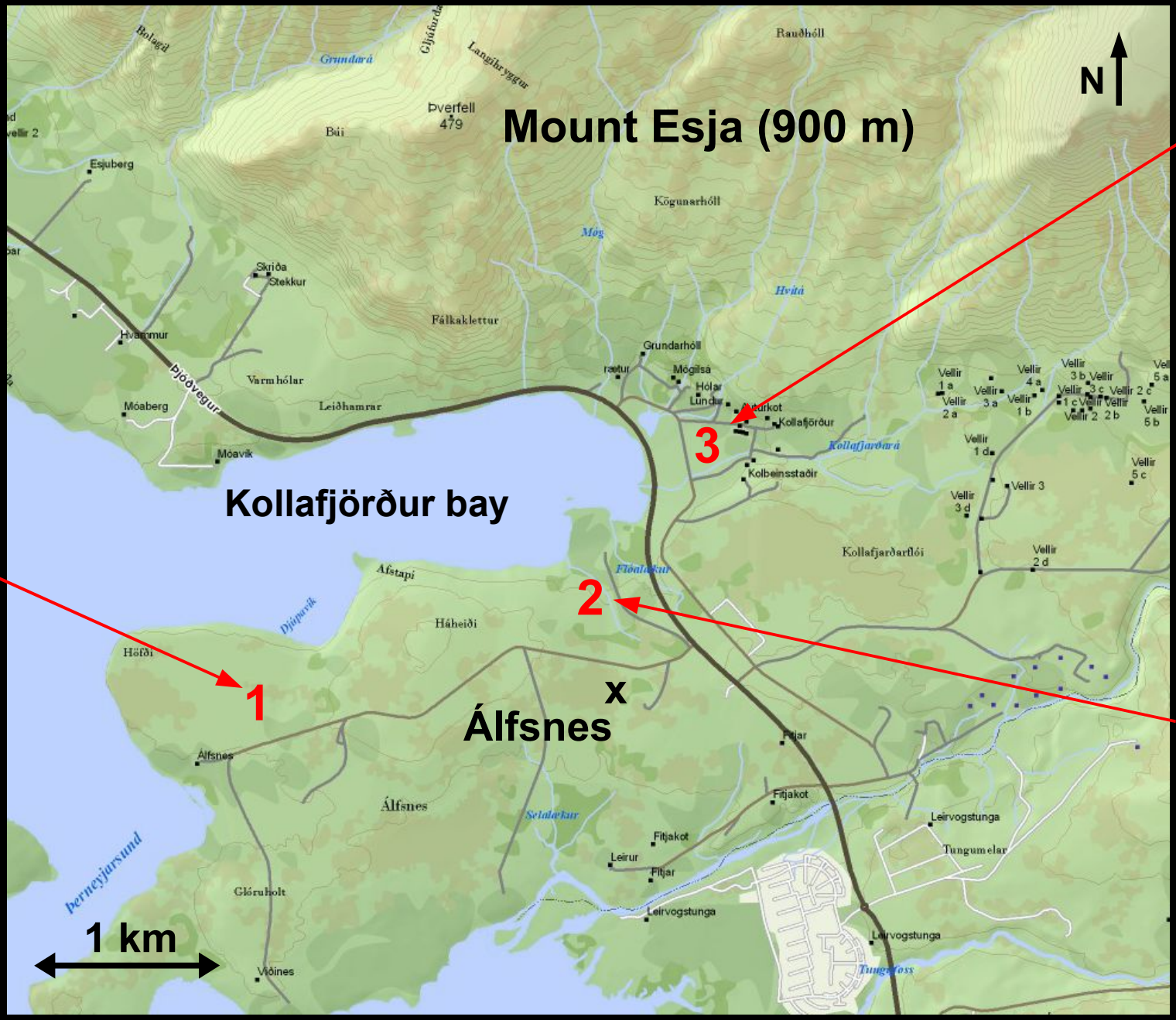


The weather on 15 July 2009 at 12 UTC

Weak easterly winds in the lower troposphere.



Time of flights on 15 July 2009

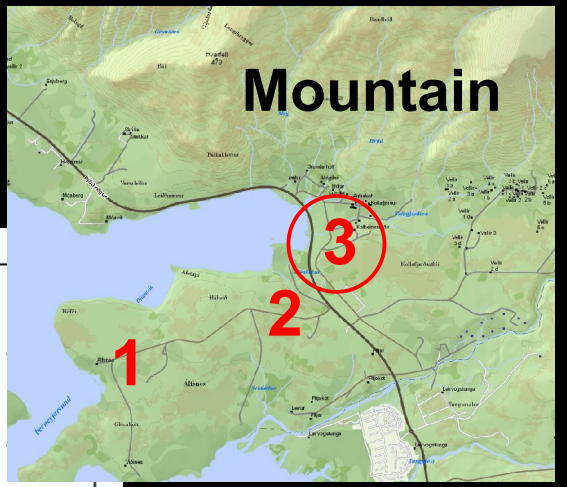


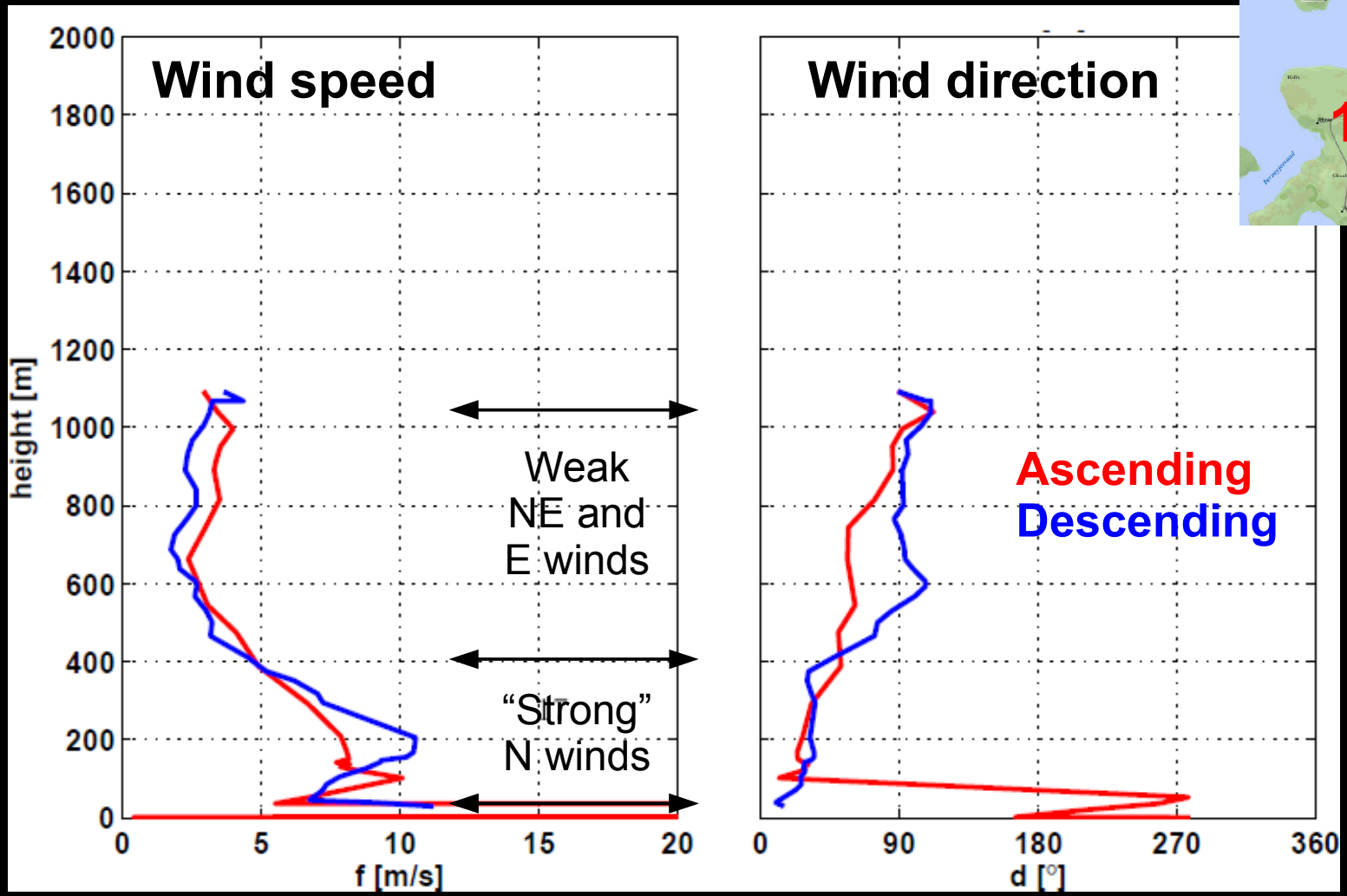
Photos from location 2

Observations on 15 July 2009

Location 3 at 12:15 UTC

Gusty surface winds

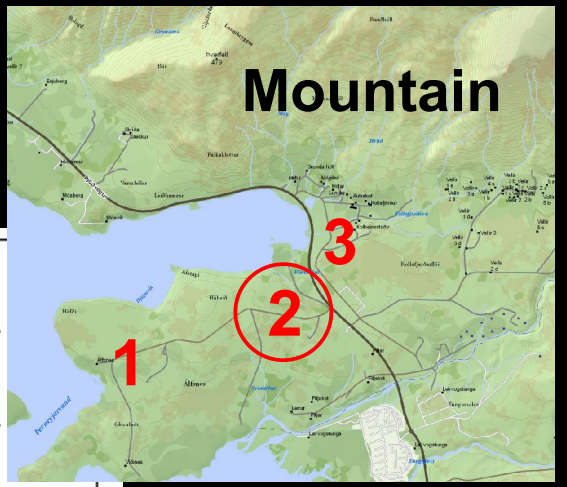


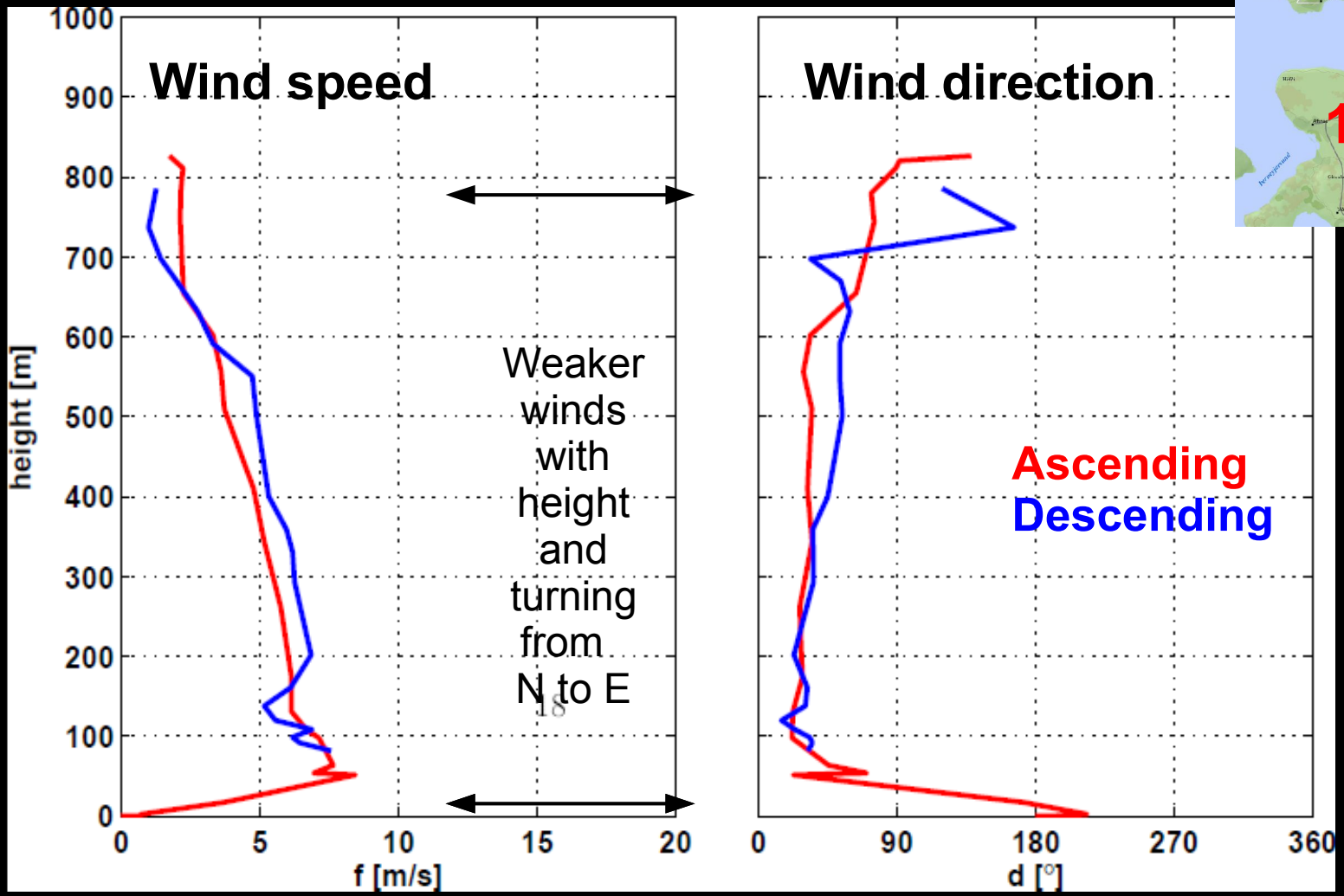


Observations on 15 July 2009

Location 2 at 12:57 UTC

Gusty northerly surface winds

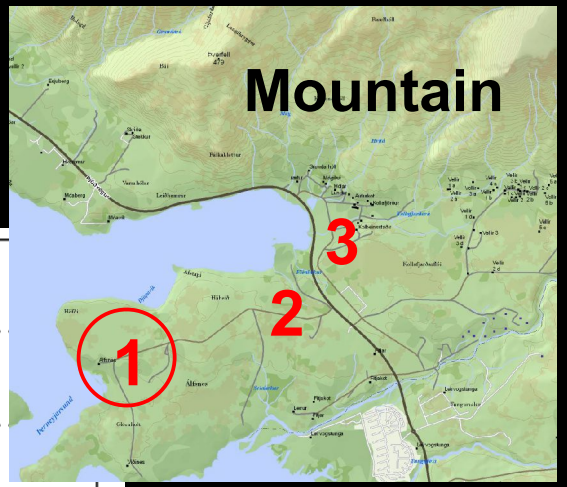


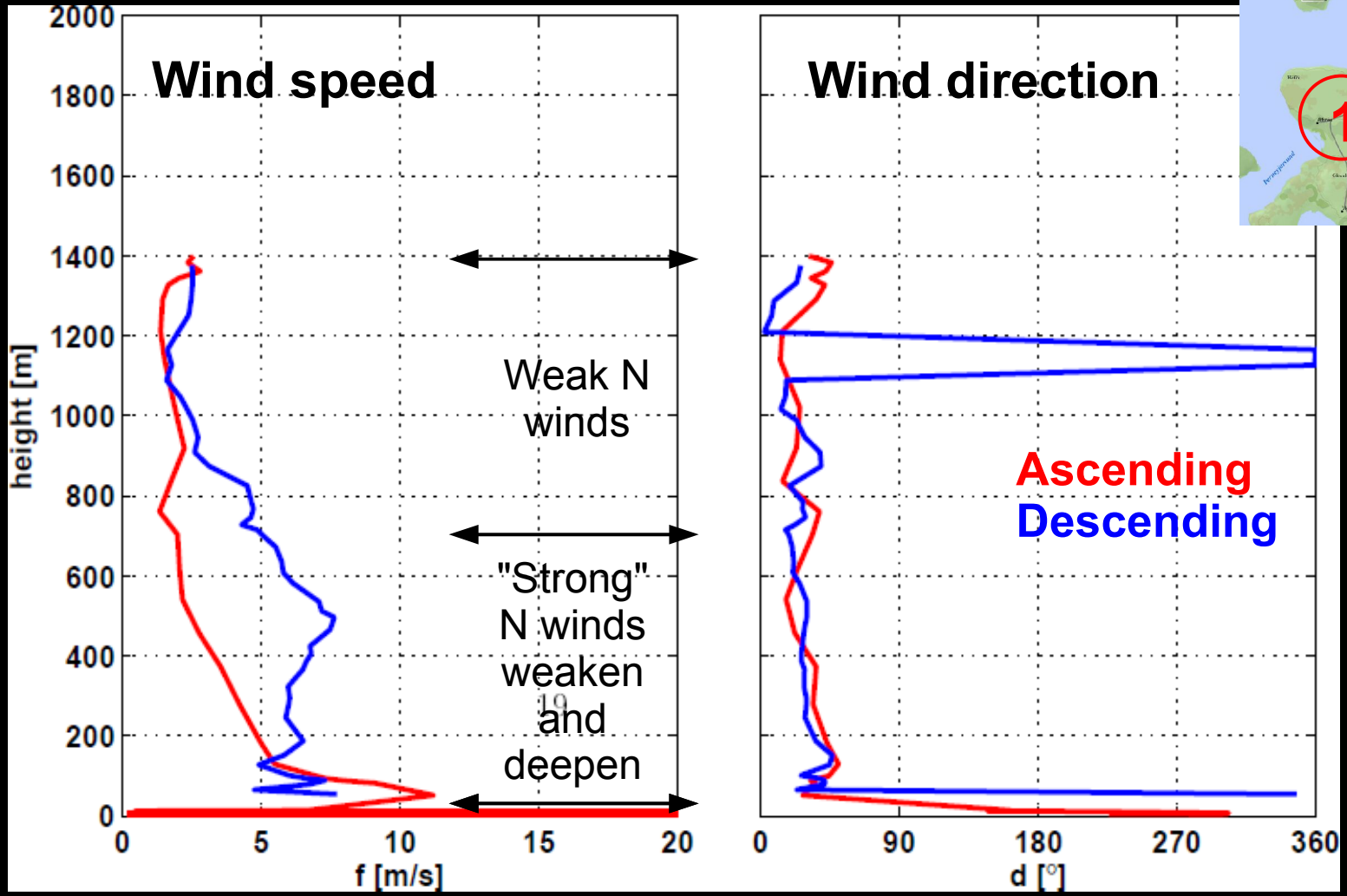


Observations on 15 July 2009

Location 1 at 13:27 UTC

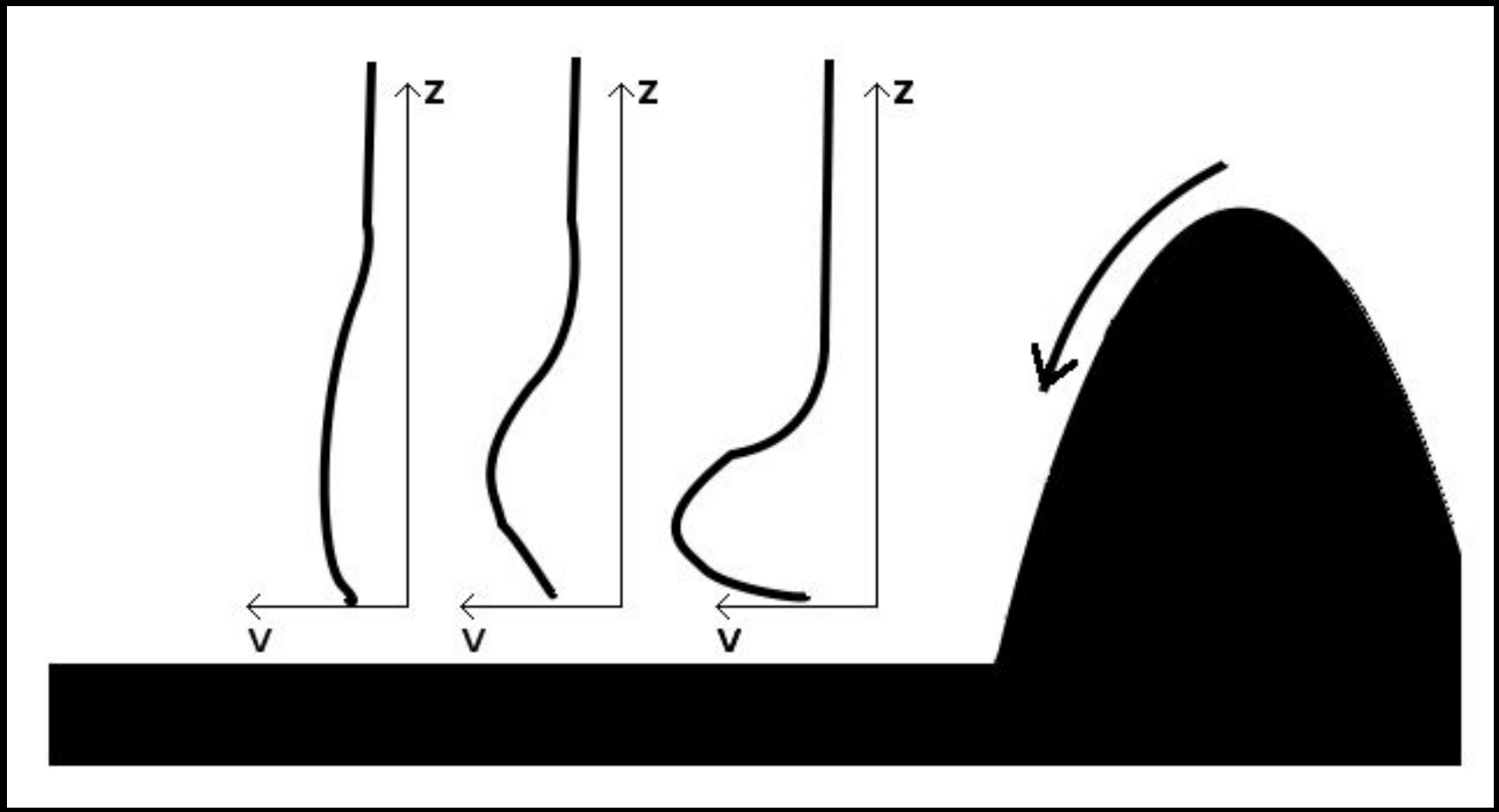
Northerly surface winds



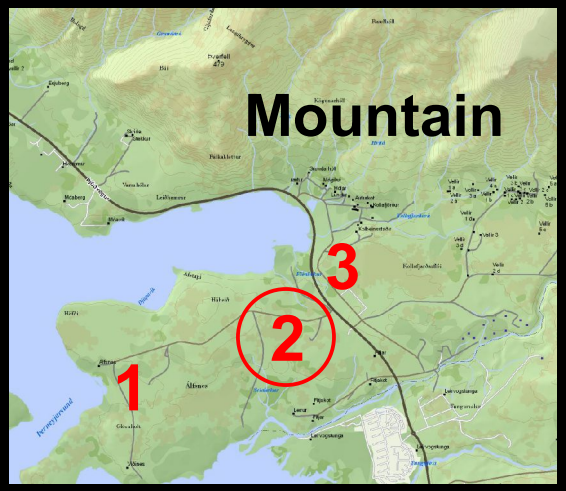


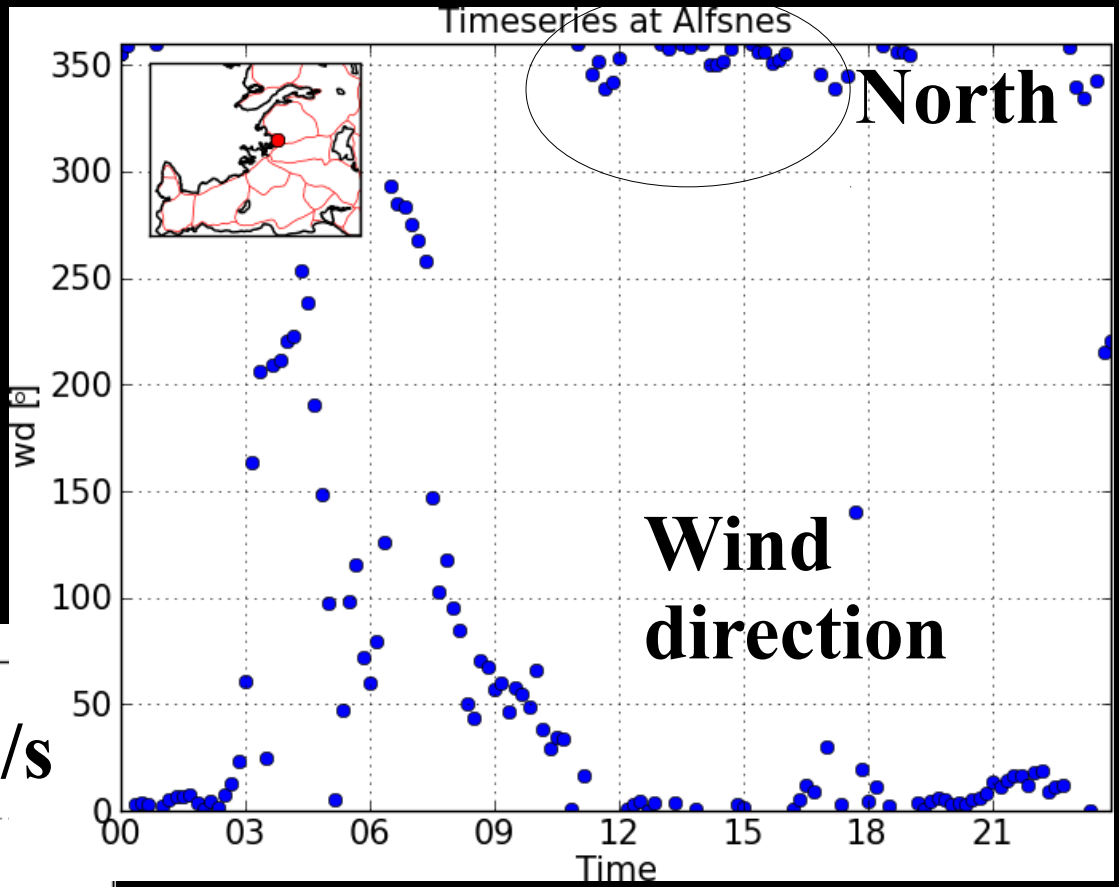
Schematics of observed winds

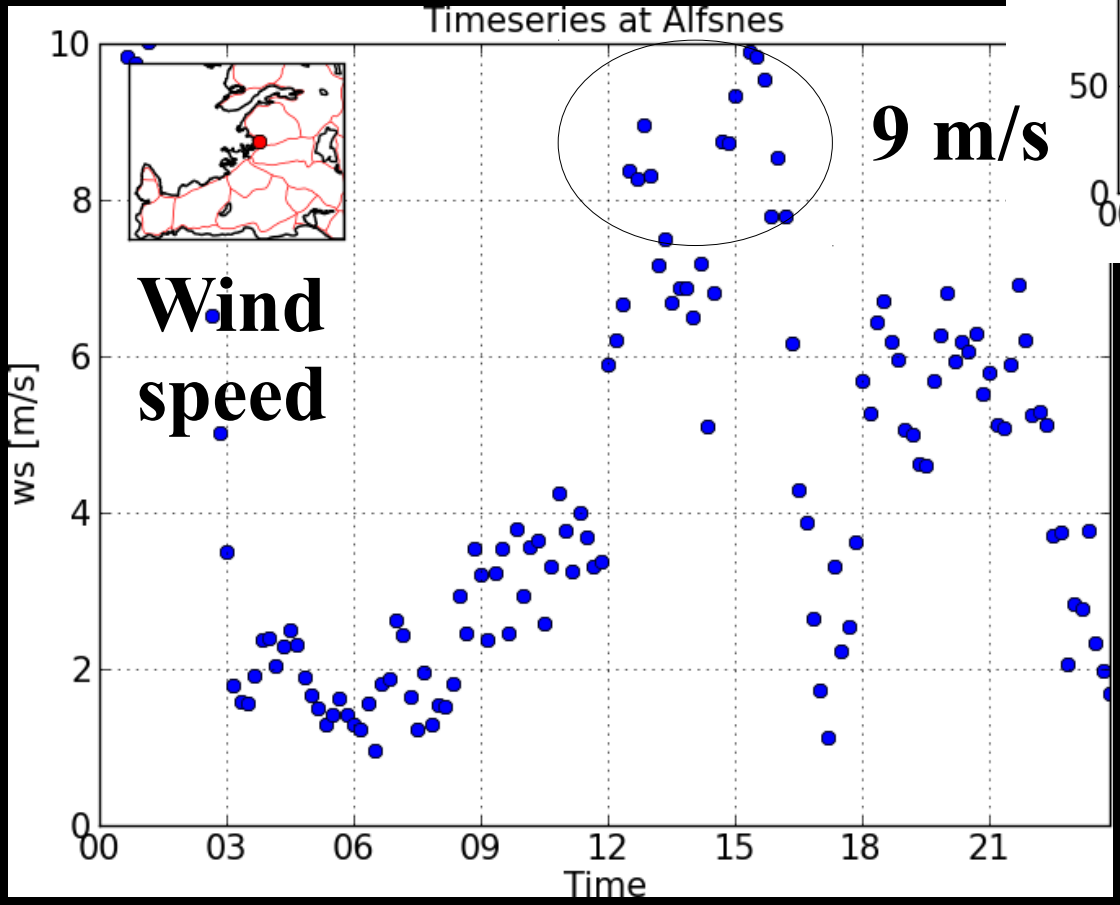
Gravity wave activity is presumably accelerating winds down the leeside slopes of Mt. Esja with a maximum in wind speed near the surface close to Mt. Esja. The wind maximum weakens and thickens further away from Mt. Esja.



Surface obs. of winds





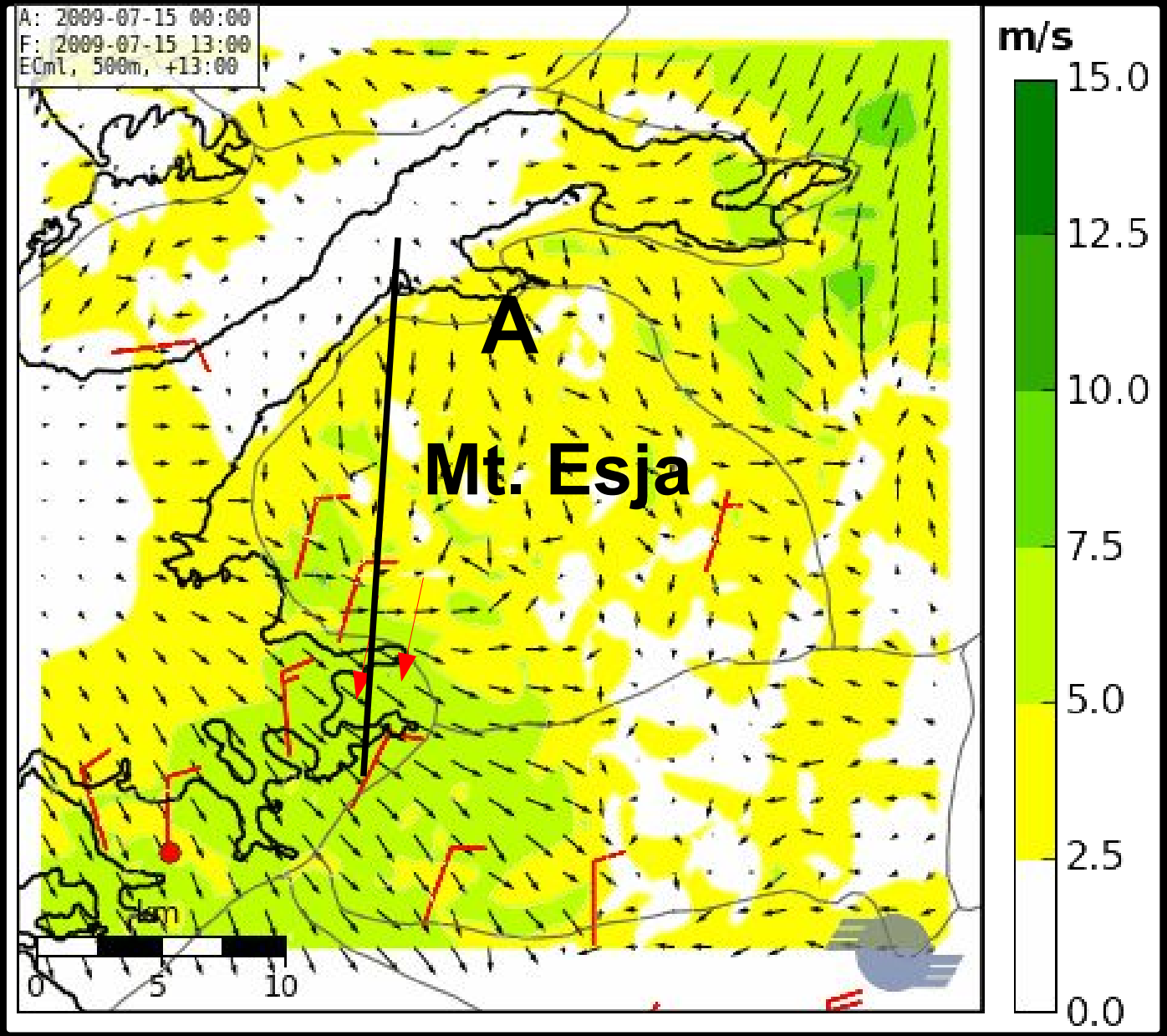


Pure westerly winds NOT observed in the afternoon!

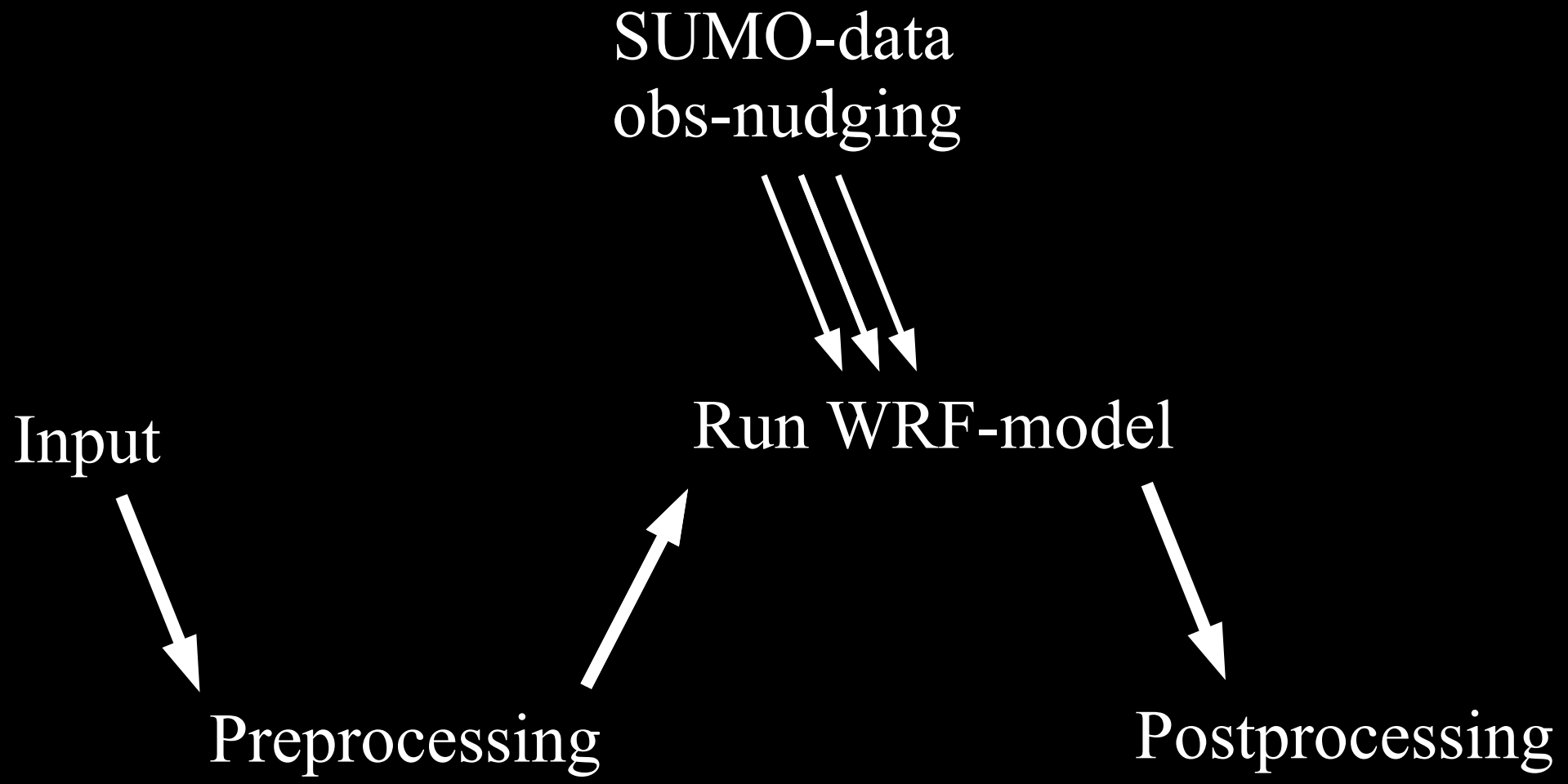
Simulated and observed surface winds on 15 July 2009 at 13 UTC

WRF at a resolution of 500 m forced with ECMWF-data on model levels.

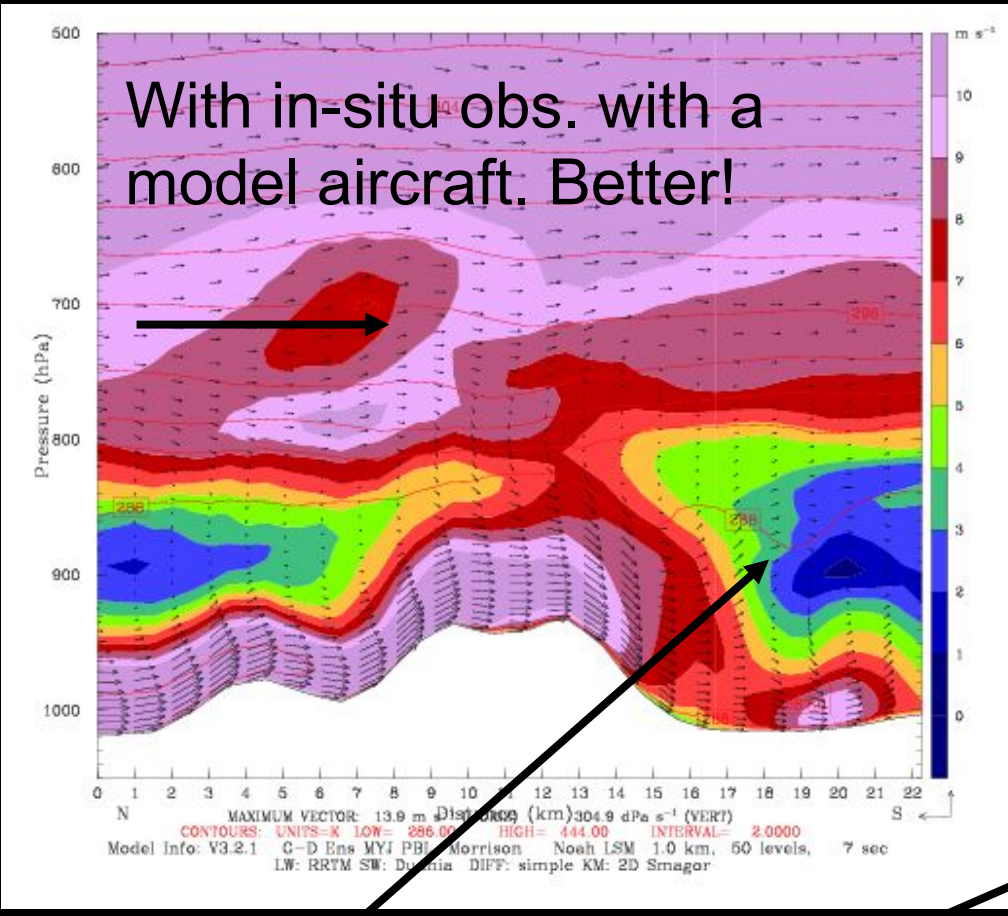
Observed surface winds in red

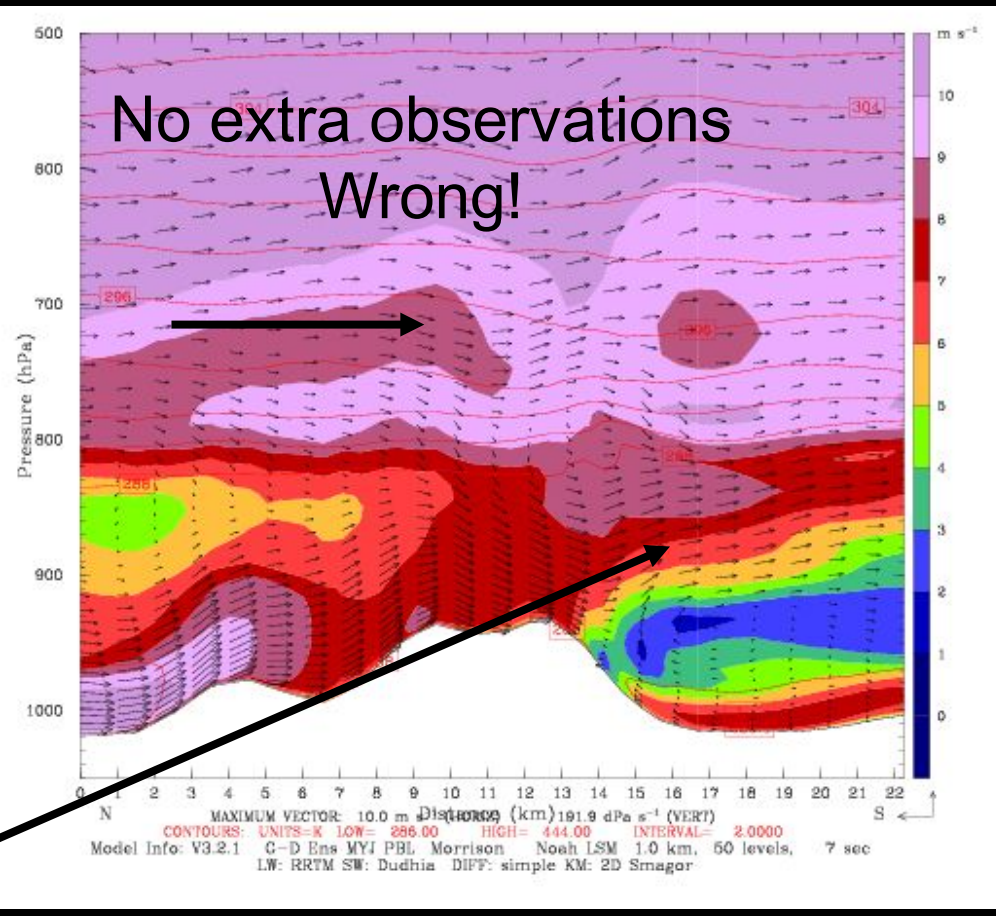


The SUMO-data is incorporated into the WRF-simulation, via obs-nudging



Simulated flow in section across mountain



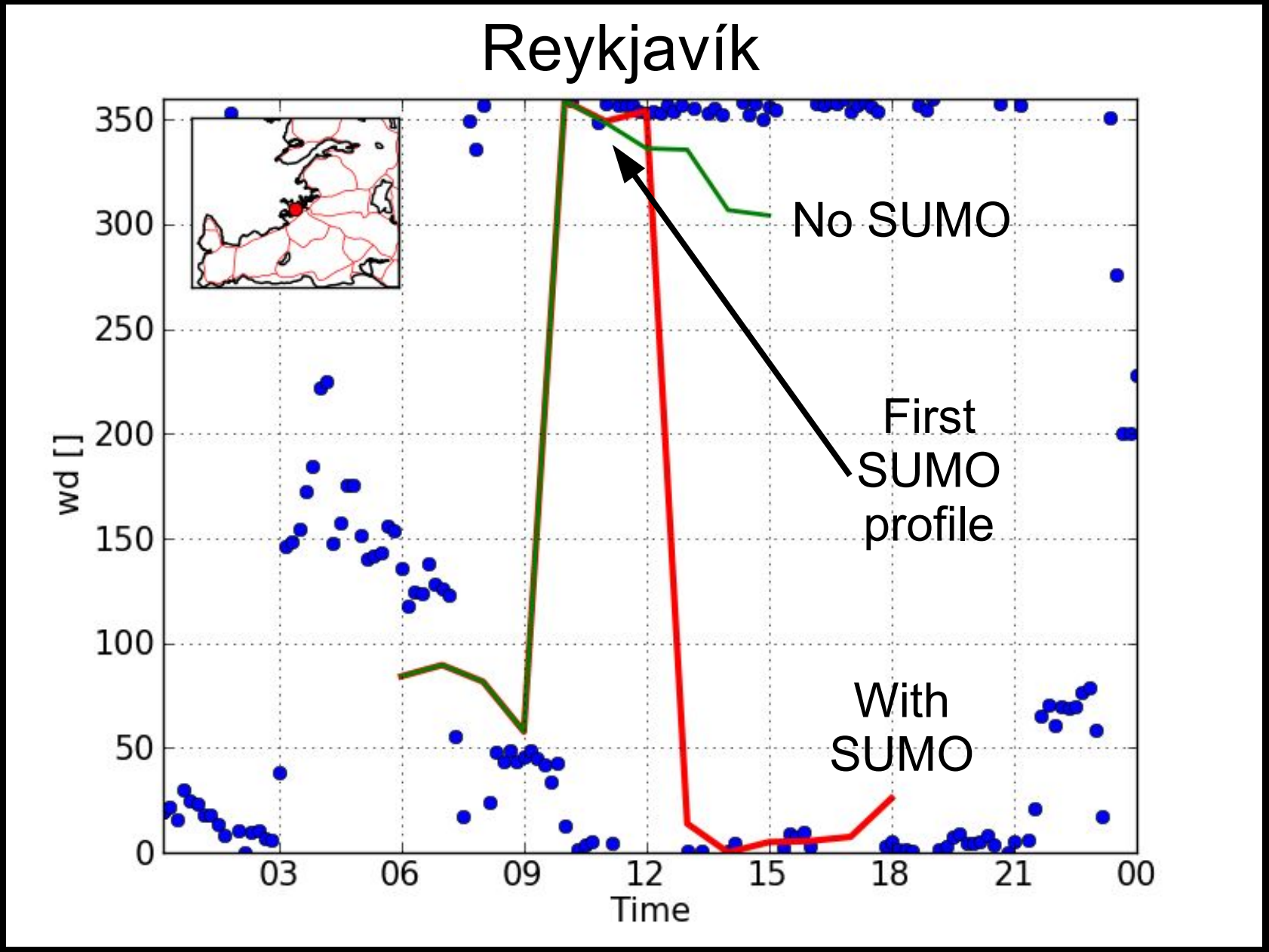


A major difference in flow pattern extending far above mountain top level

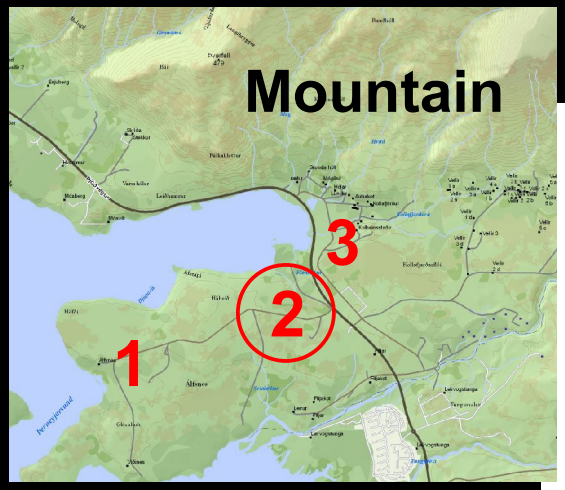
23 km

Wind speed, ranging from 0 to 12 m/s

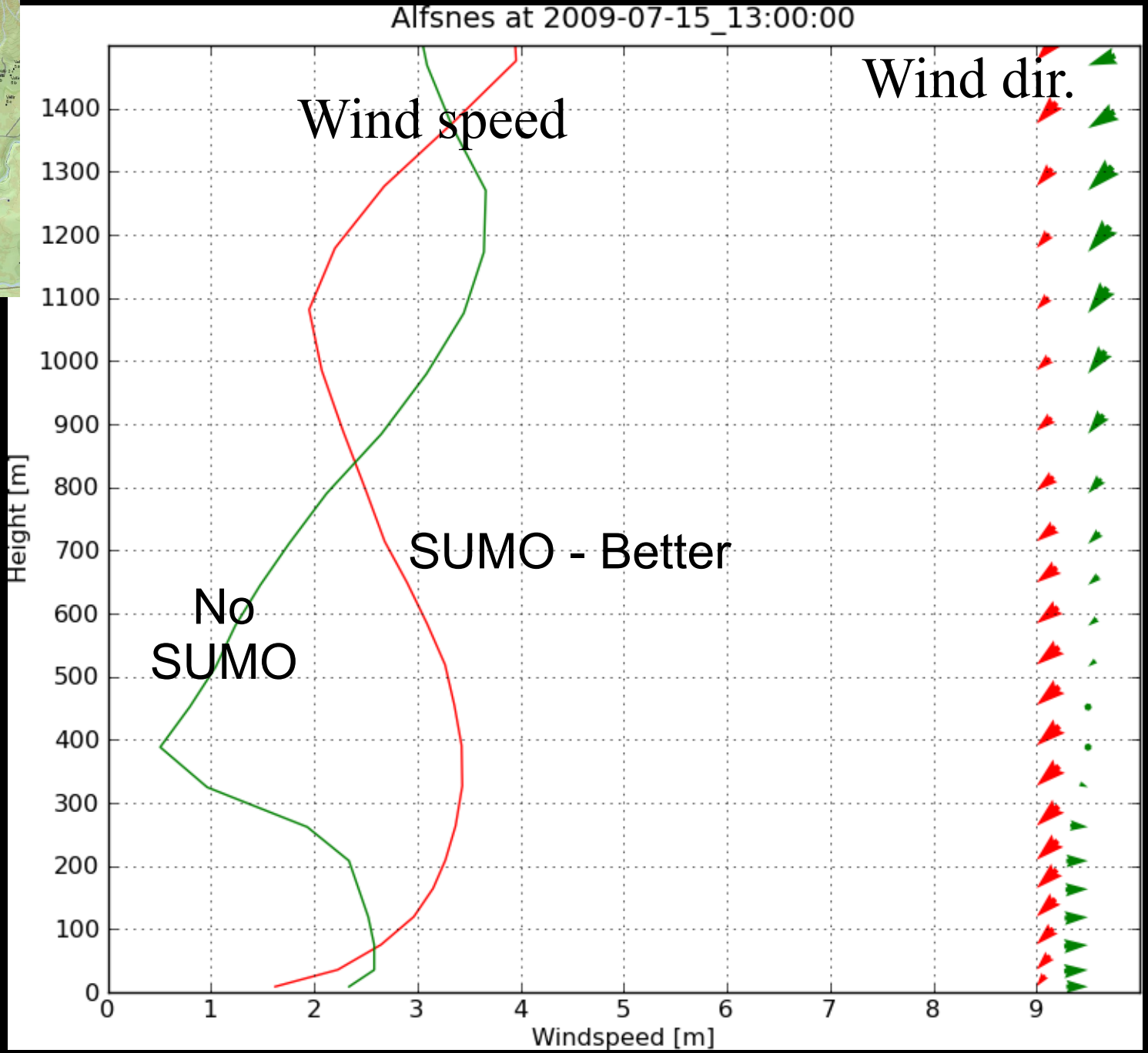
Simulated and observed wind direction



Simulated wind profile

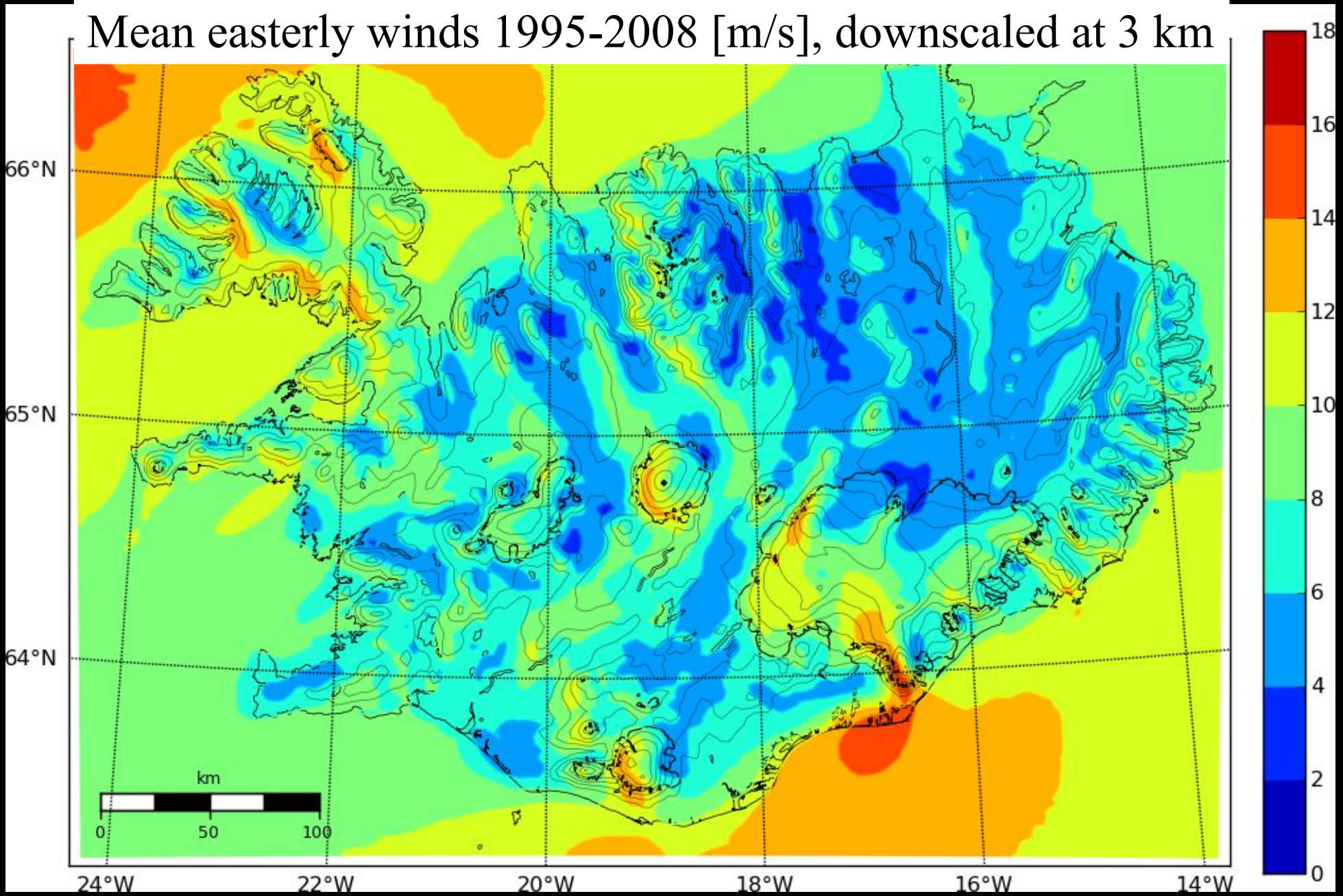


Height [m]



One forecasting perspective
Wind mills in complex terrain

Gravity waves are important for the wind climate!



See poster by Marius O. Jonassen et al.

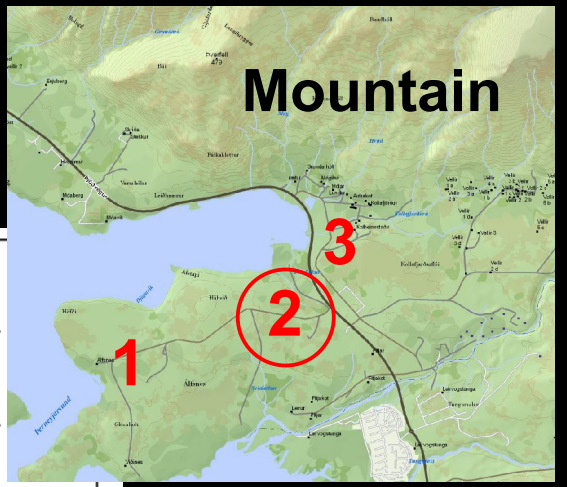
Main conclusions

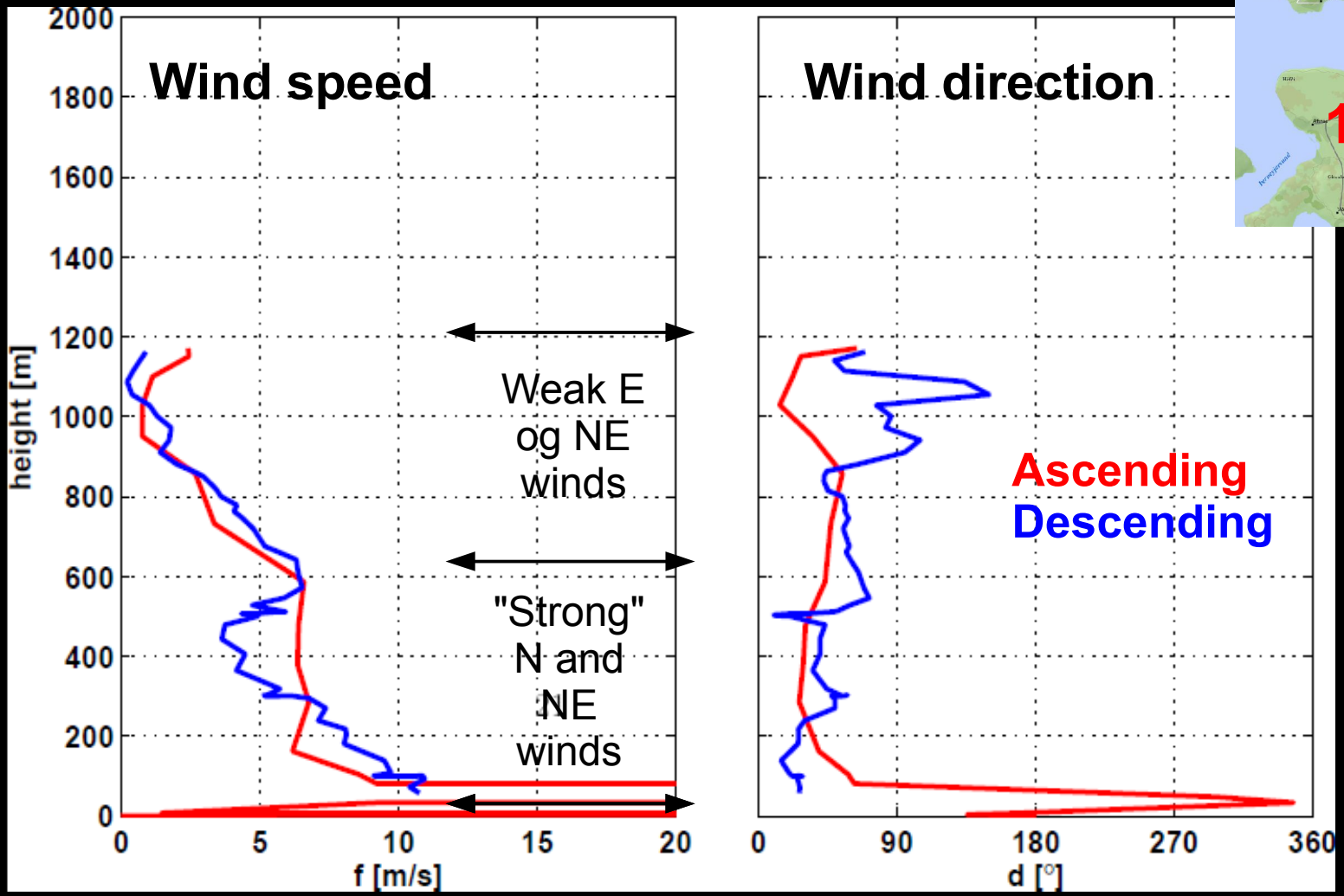
- We improve high-resolution atmospheric simulations using unique observations from aloft.
- The observations reveal unexpected winds in the boundary layer and lower troposphere.
- Indications of accelerated lee-side flow in spite of weak mountain top and boundary layer winds.
- Input of realtime in-situ SUMO-observations into operational WRF-simulations is under way.
- Further work includes:
  - Investigate the dynamics of the flow,
  - Increase resolution of grid, use 3D turbulence calc.,
  - More field experiments with the SUMO.

Observations on 15 July 2009

Location 2 at 14:18 UTC

Gusty northerly surface winds

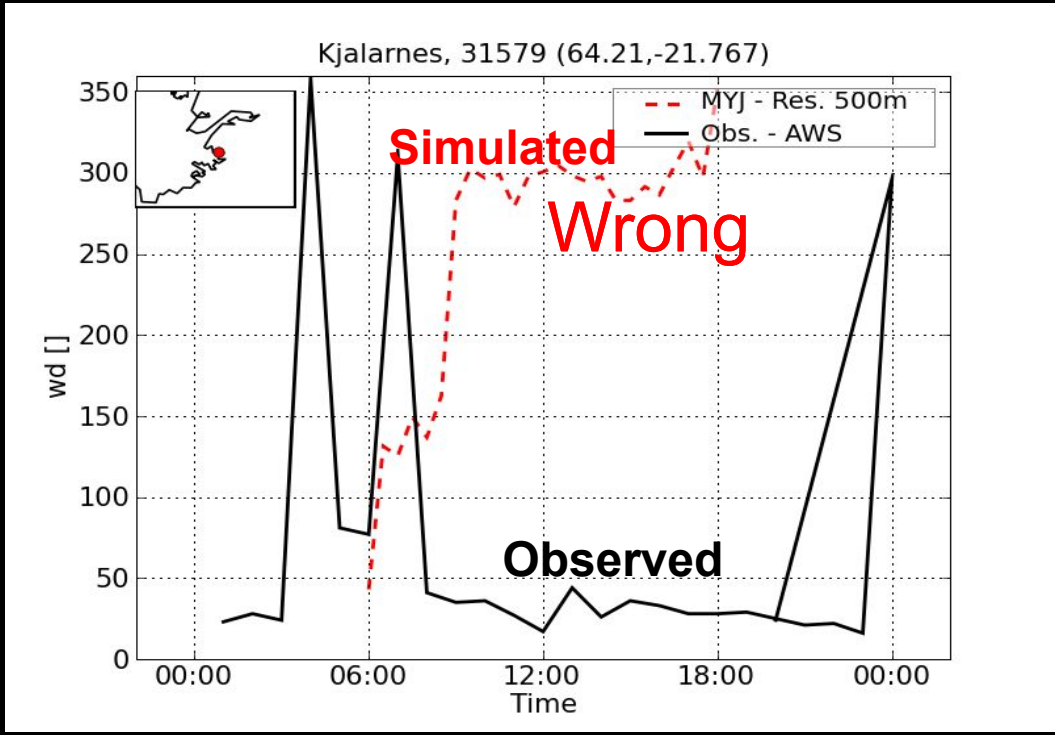




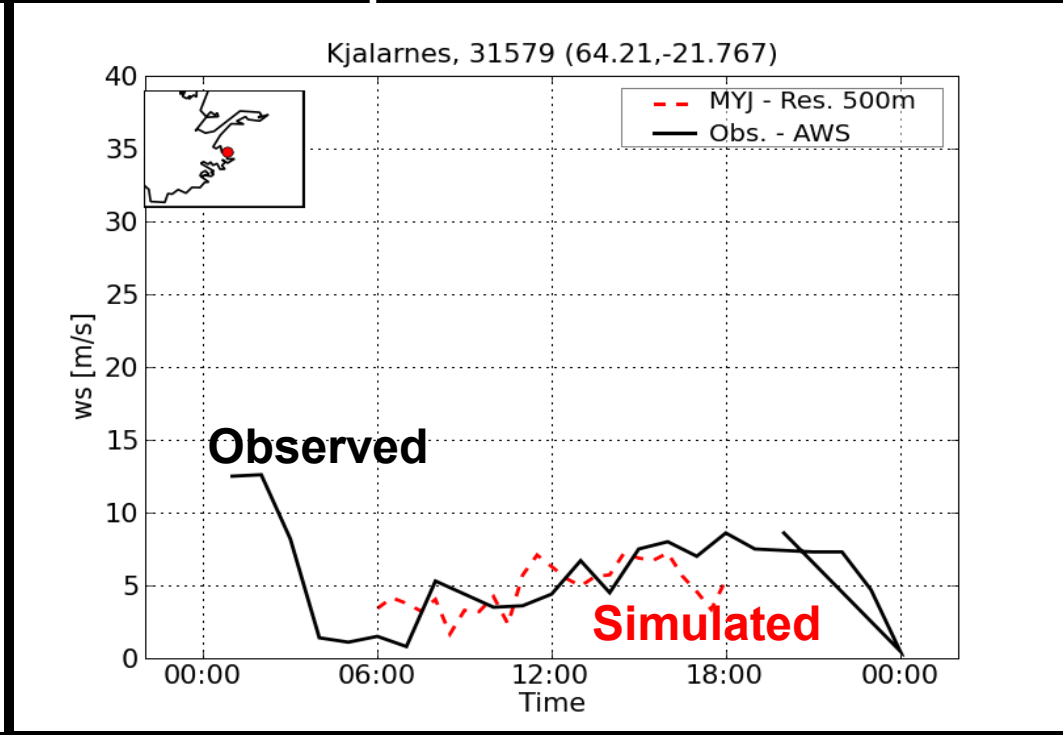
Simulated and observed surface winds at Kjalarnes, south of and near Esja

Non-zero surface friction

Wind direction



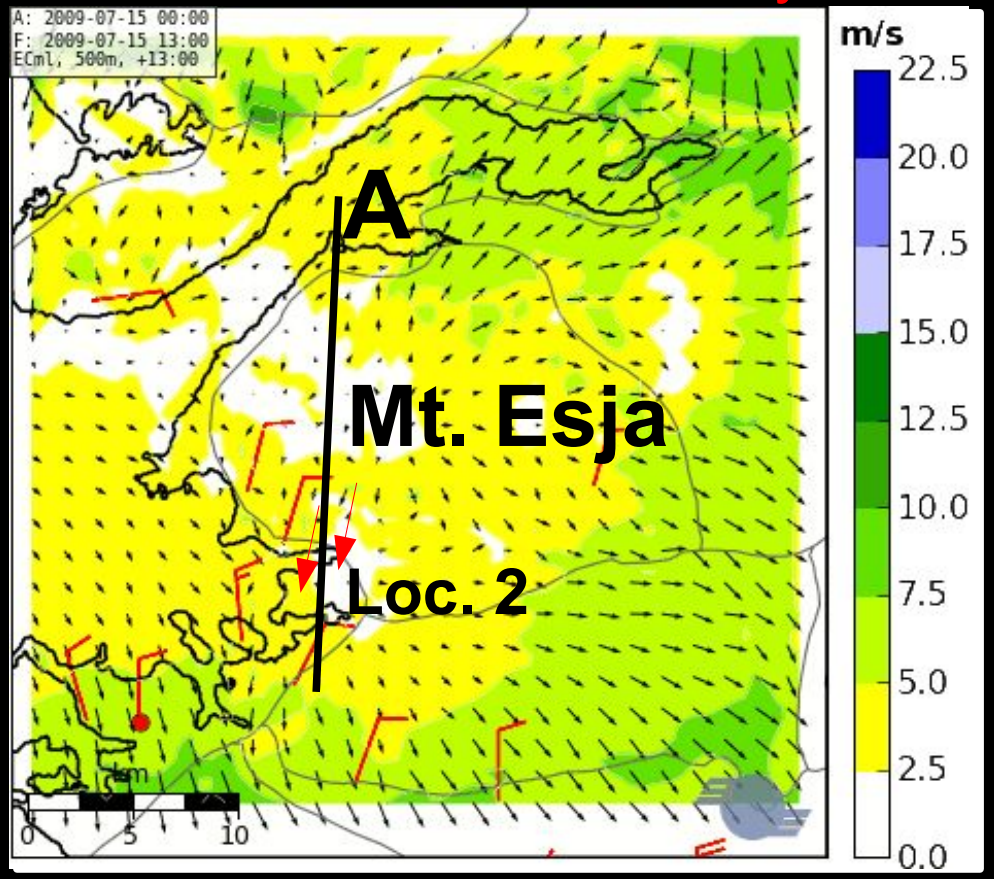
Wind speed



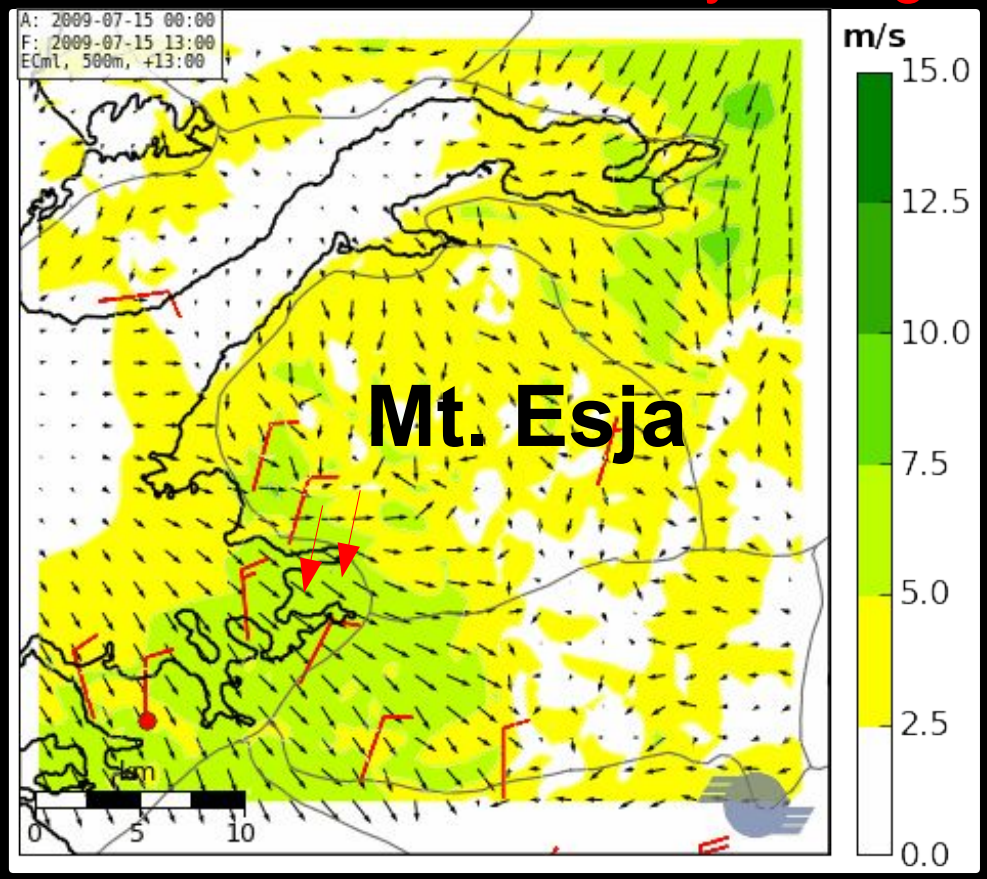
Simulated and observed surface winds on 15 July 2009 at 13 UTC

WRF at a resolution of 500 m forced with ECMWF-data on model levels.

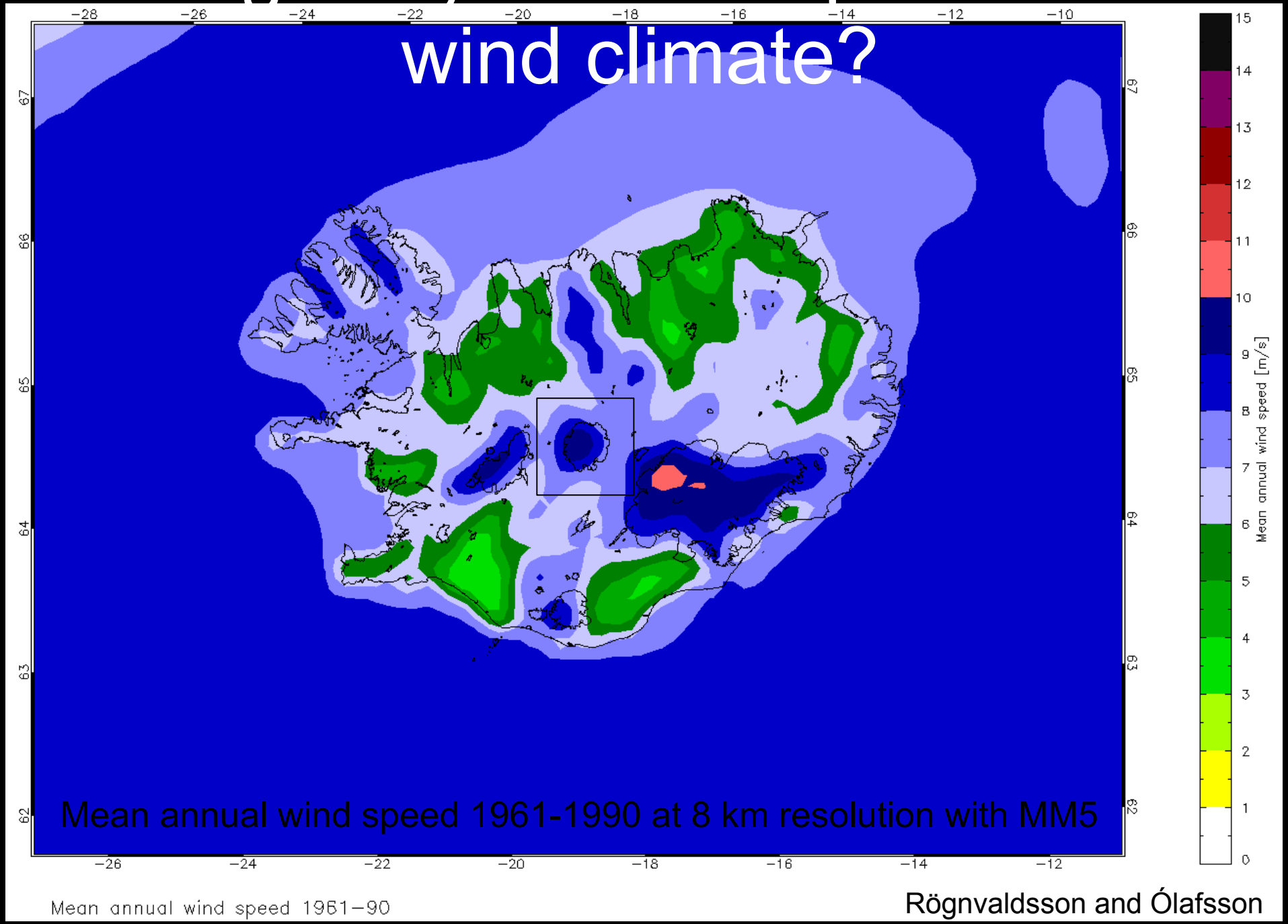
No surface friction – Mostly correct



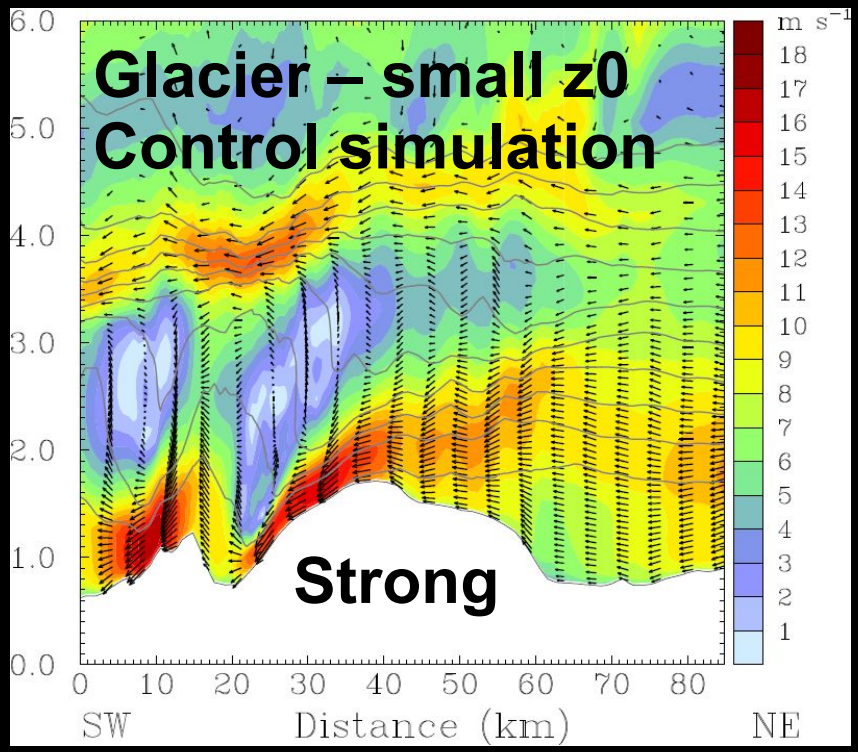
Surface friction – Mostly wrong

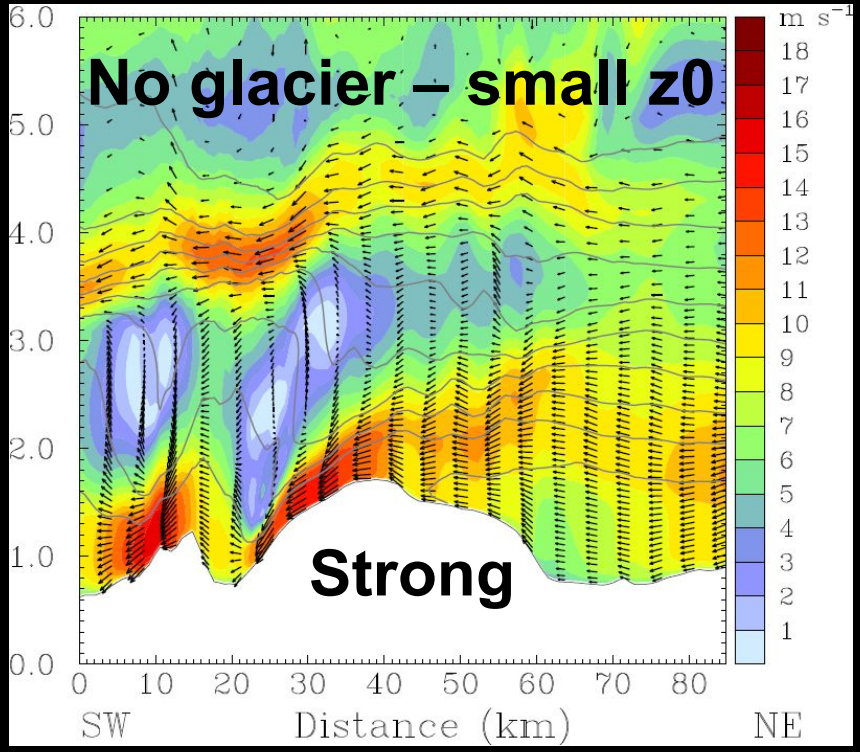


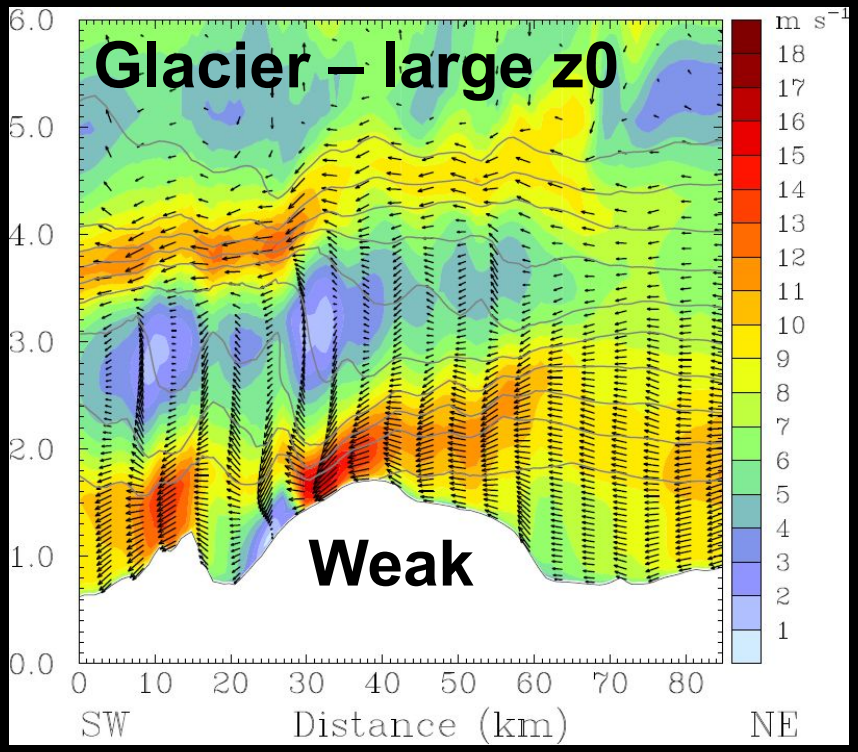
Are the gravity waves important for the wind climate?

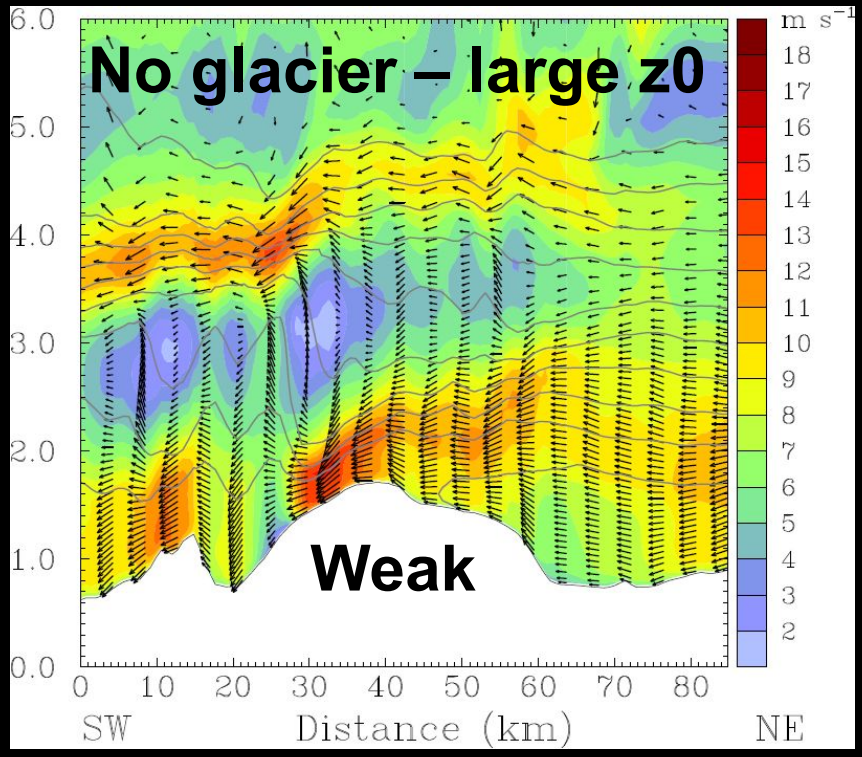


Examples from an Icelandic glacier
Wind and isentropes in section across mt.



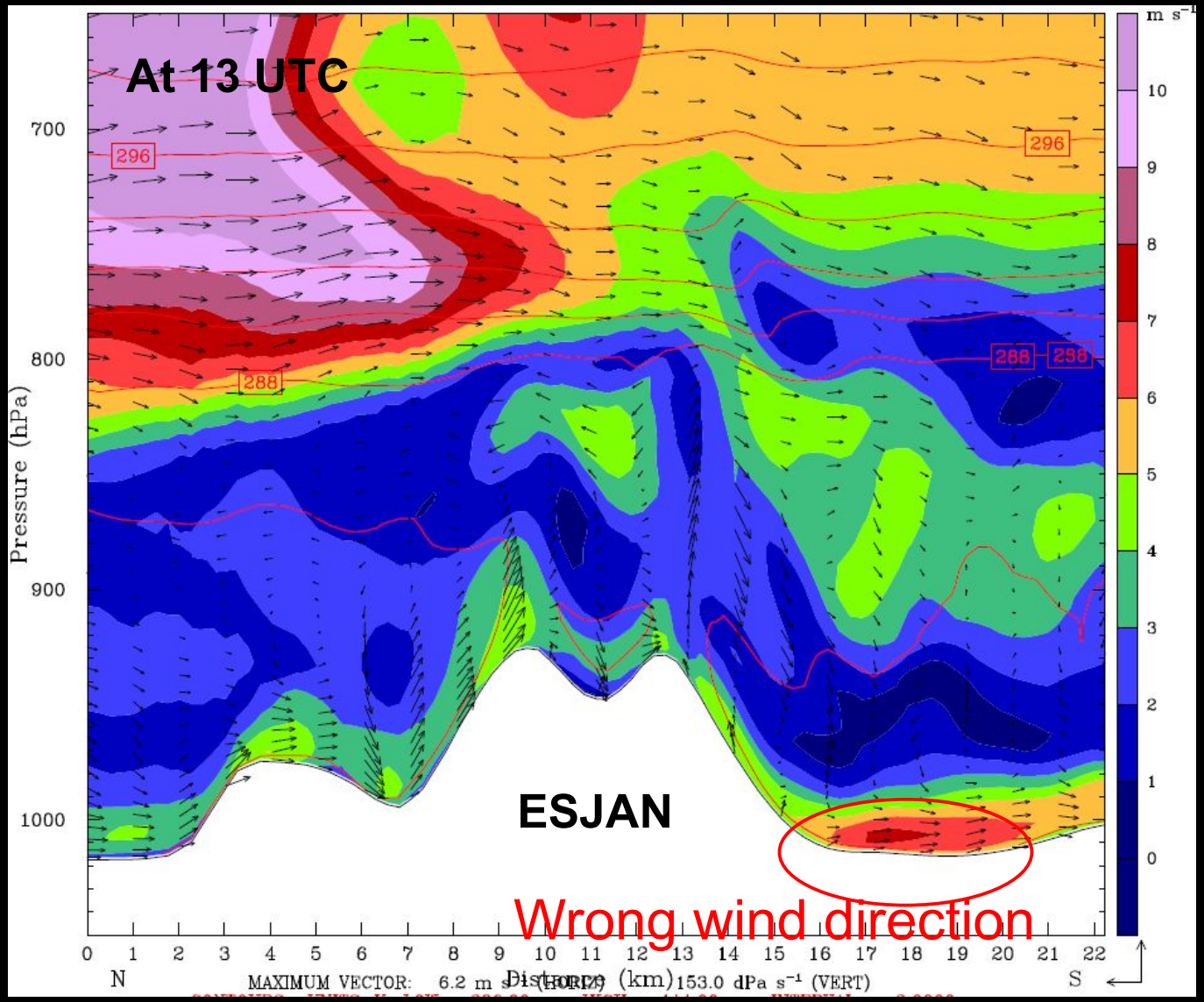






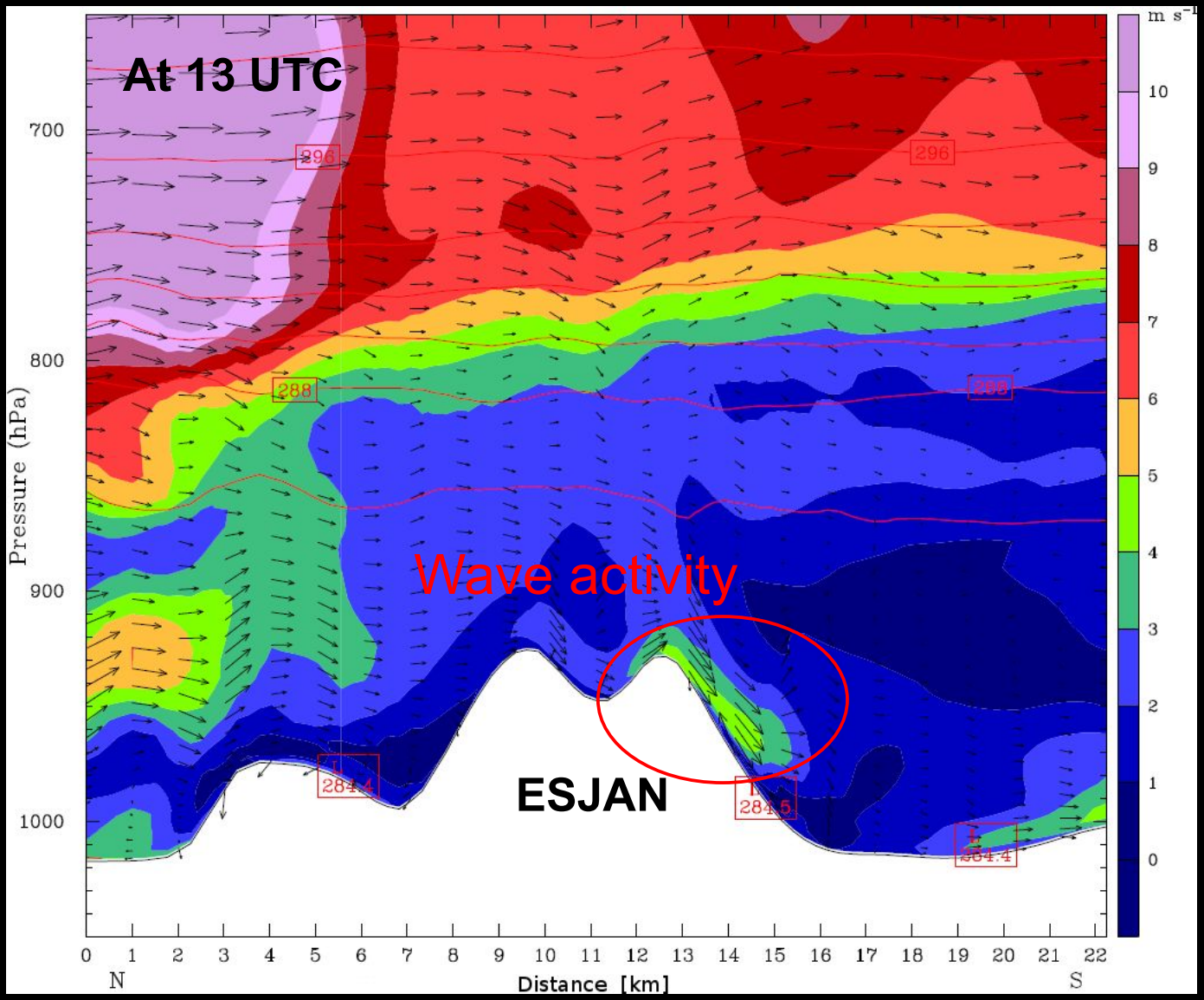
Simulated wind and isentropes in section A across Mt. Esja

Non-zero surface friction



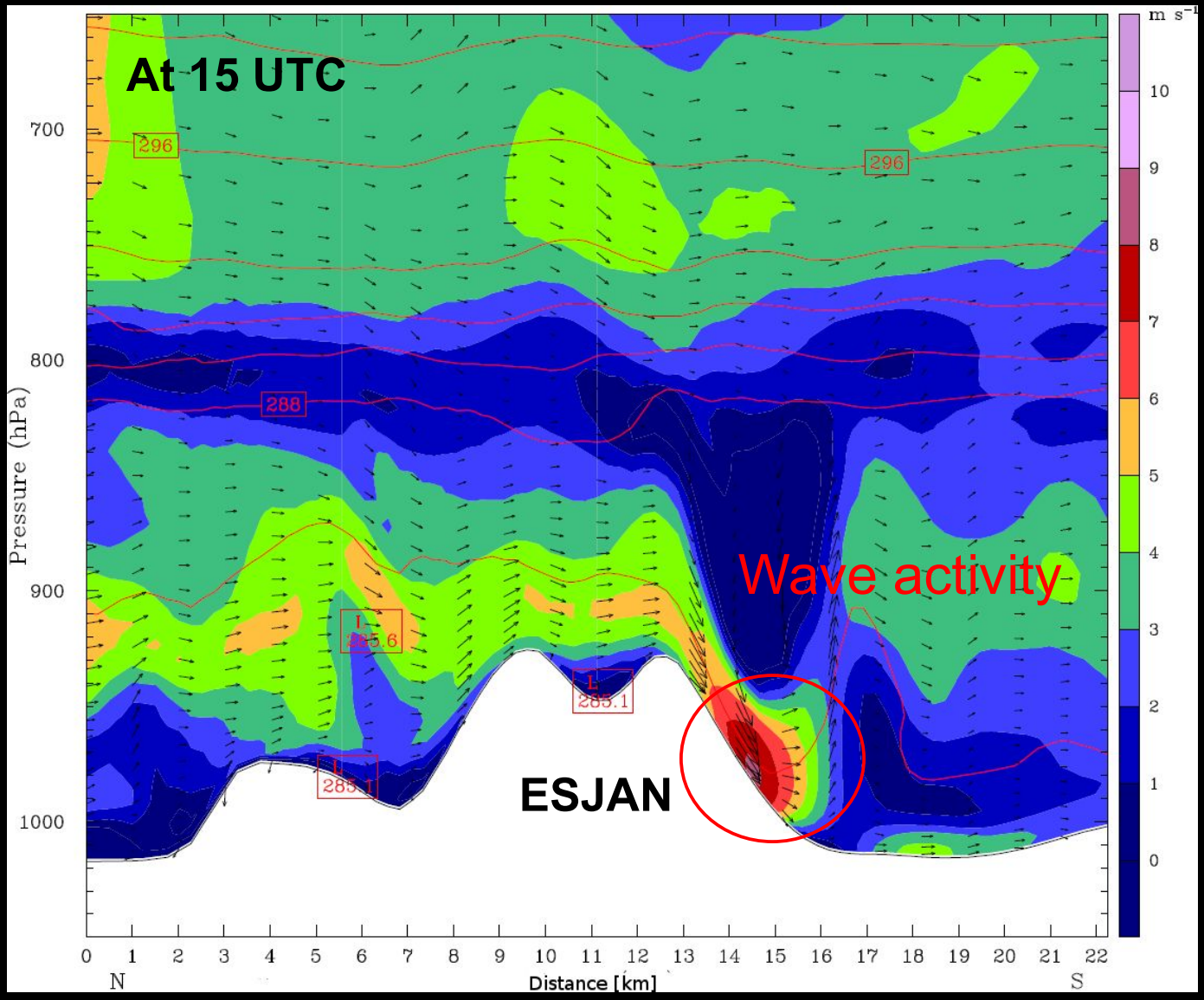
Simulated wind and isentropes in section A across Mt. Esja

Zero surface friction

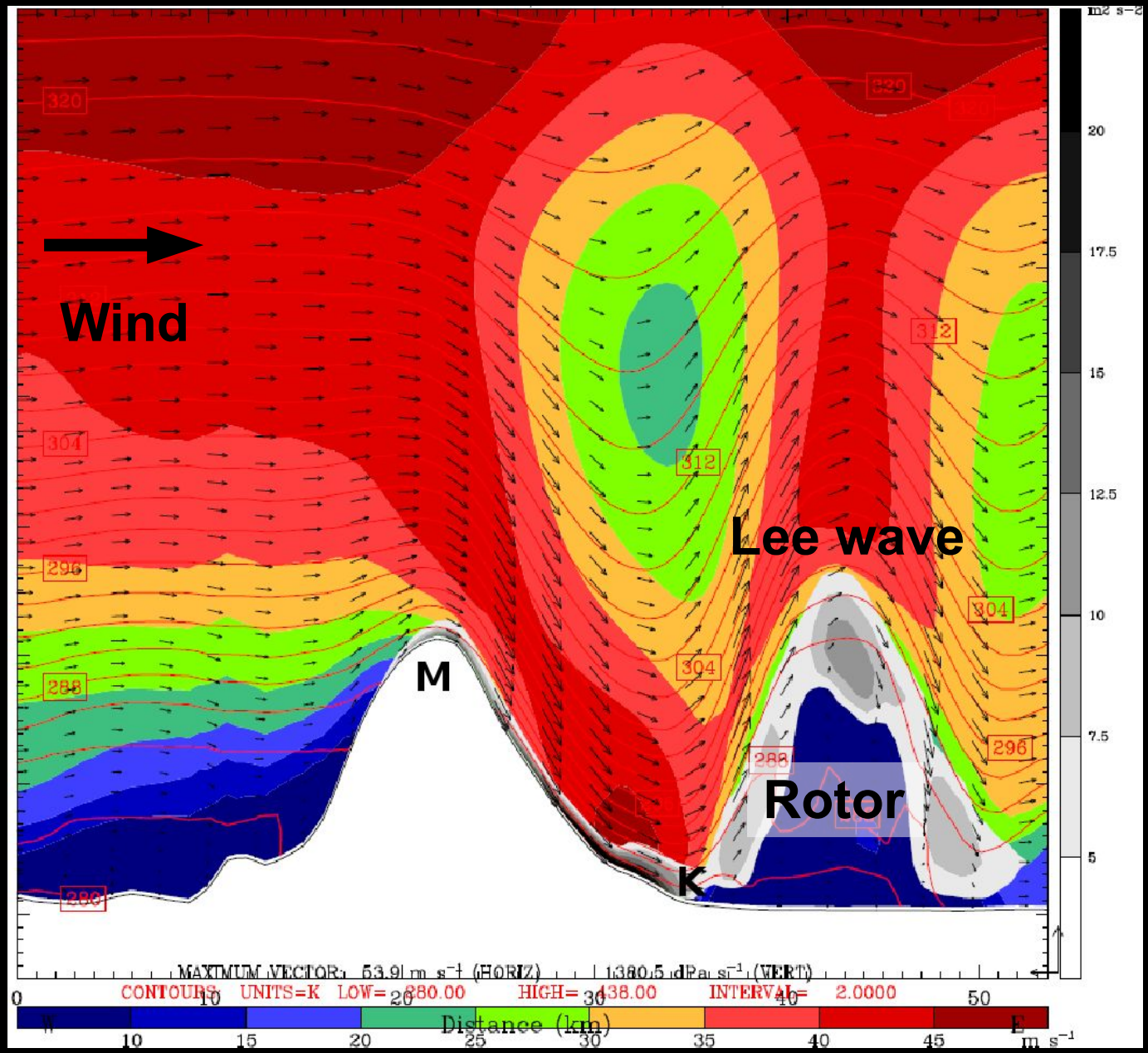


Simulated wind and isentropes in section A across Mt. Esja

Zero surface friction



Forecasting perspective – Windstorms



Ágústsson and Ólafsson, 2009