P2.25 SUMMER-TIME THERMAL WINDS OVER ICELAND: IMPACT OF TOPOGRAPHY

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1. INTRODUCTION

Knowledge of mesoscale thermal circulations such as sea breezes, valley (upslope) winds and katabatic flows are important for several reasons. Such flows can be important for local transport of airmasses, pollution studies and fine-scale weather forecasting of not only winds, but also of temperature and even precipitation. During the summer, and even in winter, thermal circulations may in some places dominate the climatology of winds. These winds are not resolved by climate models, not even at their finest resolutions. The evolution of thermally driven local circulations in a future climate is therefore quite unclear. Here, thermally driven winds are investigated numerically with an idealized set-up of the atmosphere over Iceland. Apart from the observational study by Jónsson (2002), this is, to the knowledge of the authors, the first systematic investigation of summer-time thermally driven flows over Iceland.

2. THE NUMERICAL SIMULATIONS

In this study, the atmospheric flow is simulated during a sunny day in June over Iceland. The simulations start up at rest and the flow is allowed to develop as a consequence of horizontal temperature gradients. The simulations shown here are carried out with the numerical model MM5 (Grell et al., 2004) with a horizontal resolution of 3 km for all of Iceland and the surrounding waters. Two sensitivity studies are made, one with flat Iceland and one with no sea.

3. RESULTS

3.1 *The Surface Flow*

Figure 1 shows the 2 m temperature field over Iceland at 18 UTC. The air over the sea remains cool as well as the air over the glaciers (yellow areas), while at low levels over land, the temperatures are typically 16 to 20°C. Maximum temperatures in this range are typical in regions away from the coast on a bright summer day. In Fig. 2 (12 UTC), the sea breeze has set in at the coast and at the same time about equally strong upslope winds can be detected over gentle slopes. At 18 UTC (Fig. 3), the sea breeze has merged with the upslope winds and they can no longer be identified as two separate features. Figure 3 also shows katabatic winds above the slopes of the glaciers, particularly the largest one (Vatnajökull). There is a considerable speed-up of the flow where it passes in gaps between mountain ranges and this is where the maximum wind speed is reached.

3.2 *The Peninsula Effect*

In the surface flows, there is a speed-up on the right hand side of peninsulas (standing on the peninsulas and facing Iceland). This speed-up is advected away from the peninsula in the evening (not shown).

3.3 *The Flow Aloft*

Figures 4 and 5 show the flow at 1000 m above the ground at 18 and 24 UTC. At 18 UTC, there is a pronounced return current and at 24 UTC the return current has developed into an anticyclonic wind blowing roughly along the coast of Iceland. The wind at 24 UTC is much closer to being geostophic than the surface winds in Figures 2 and 3 and the return current in Fig. 4.

3.4 *Flat Iceland*

Figure 6 shows the surface flow at 18 UTC, but with no mountains in Iceland. As expected, the flow field is more uniform than if the topography is present. The difference field (Fig. 7) reveals 3 prominent features which can be considered to be the contribution of topography to the thermal flows. Firstly, there is a band of upslope winds above the gentle slopes. Secondly, there is a clear topographic enhancement in gaps between mountains (in fjords). Thirdly, the previously mentioned peninsula effect is enhanced by the topography.

3.5 *No Sea*

Figure 8 shows the surface flow when no sea is present. In this case, there is of course no sea breeze, but the upslope winds are stronger and extend further into the highlands than if the sea (breeze) is present.

3.6 *Convergence*

Figure 9 shows the vertical velocities at 500 m. There are bands of strong updrafts at several locations, such as where the thermal winds from the North coast meet the thermal winds from the West coast or the katabatic flows eminating from the glaciers. The satellite image (Fig. 10) indicates that the convergence bands may indeed reflect reality.

4. DISCUSSION

The present simulations indicate that the upslope/valley effect may be as important as the sea breeze over Iceland in the summer. This is somewhat contradictory to what is commonly considered. Apparently, the sea breeze has a hampering effect on the upslope winds. This needs to be studied further with for instance a more idealized set-up.

The channeling effect of the topograpy gives quite strong breezes in limited areas. Observations are in general not available at the locations of the maximum surface winds, but it would certainly be of interest to verify the simulations at these locations.

The simulations reveal an unknown effect of mountainous peninsulas on the sea breeze. We choose to call this the peninsula effect. The peninsula effect may be explained by a geostrophic component of the flow along the peninsula being added to the sea breeze generated by the mainland. The advection of the peninsula speed-up in the evening is associated with advection of warm air from the peninsula over the coastal sea on the speed-up side of the peninsula.

The simulated convergence and updrafts in the vicinity of the glaciers raise questions on the climatology of sumertime precipitation, which may to a substantial extent be convective in these regions. A future retreat of the glaciers may lead to a shift in the location of the convergence zones and consequently to important changes in the precipitation climatology.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Grell, G. A., Dudhia, J. and Stauffer, D. R.: 1995, A Description of the Fifth Generation PennState/NCAR Mesoscale Model (MM5), Technical Report NCAR/TN-398+STR, National center for atmospheric research. Available at http://www.mmm.ucar.edu/mm5/doc1.html (May 2004).

Jónsson, T., 2002. Frumstæð athugun á dægursveiflu vindhraða og vindáttar í júnímánuði. Tech Rep. no 18, Icelandic Meteorological Office (In Icelandic), 12 pp.

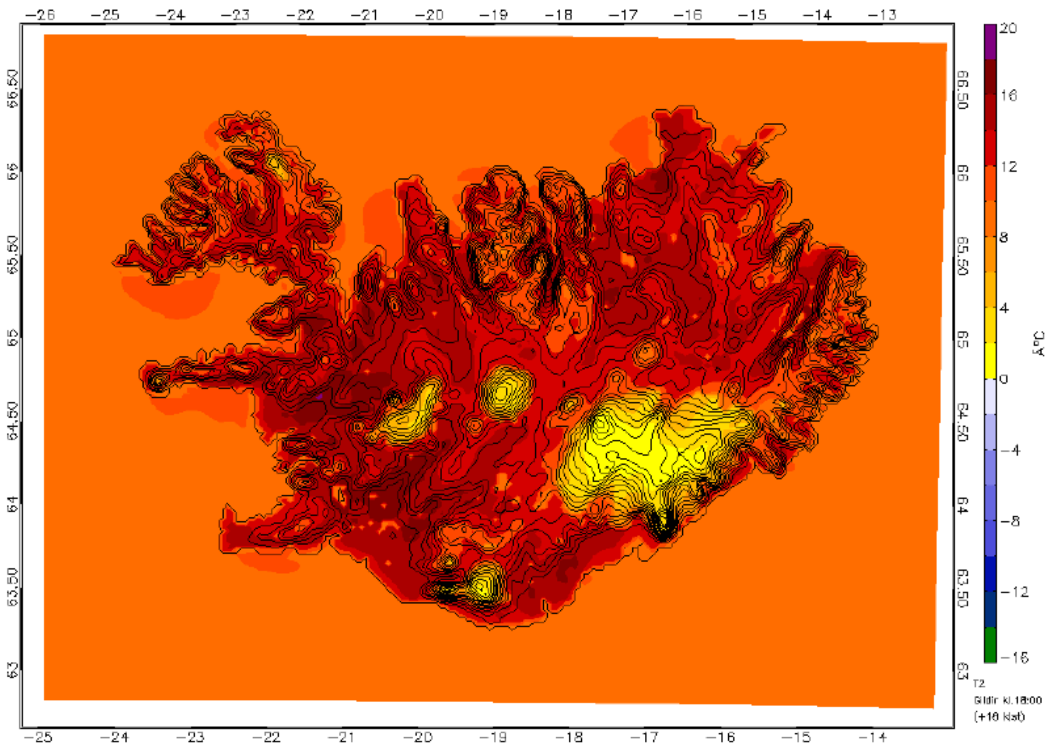

Figure 1. Two metre temperature over Iceland in an idealized simulation of a clear day in June at 18.00 UTC.

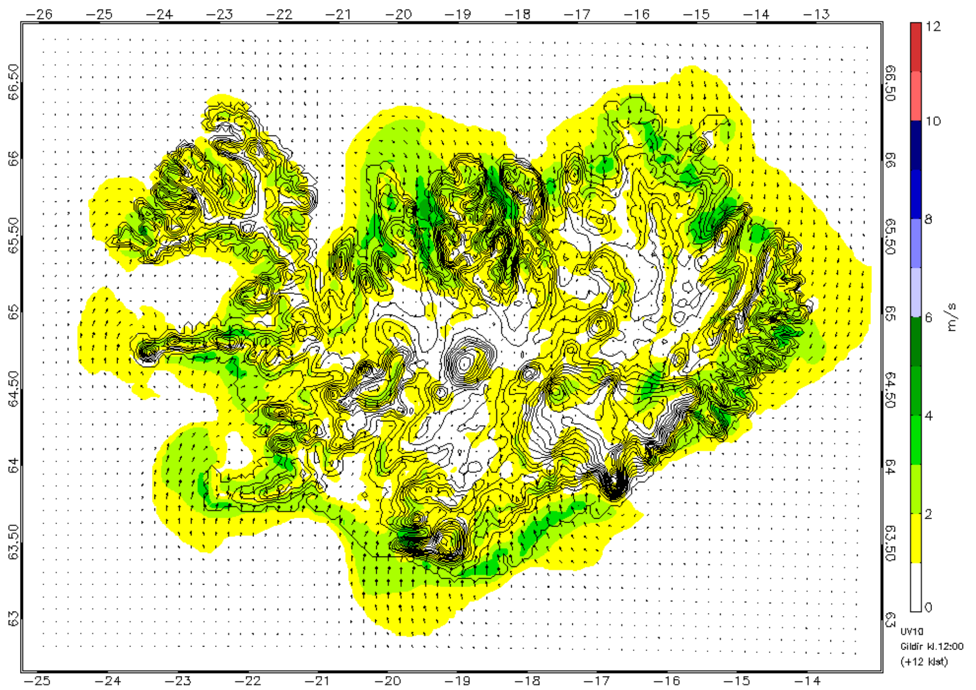

Figure 2. Surface winds in an idealized simulation of a clear day in June at 12.00 UTC.

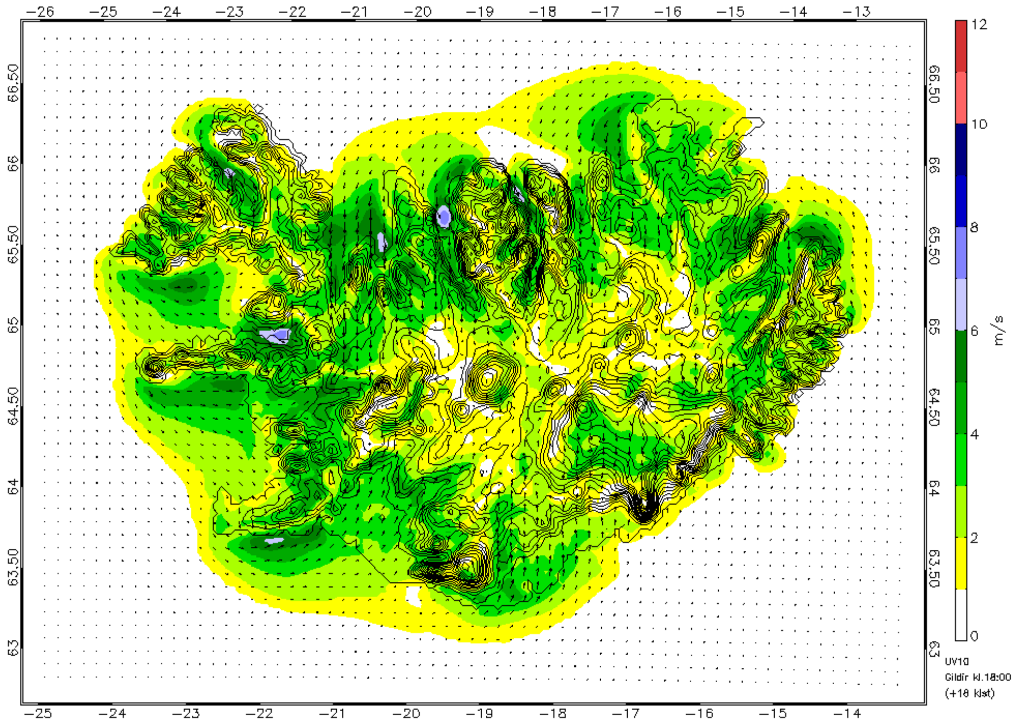

Figure 3. Surface wind speed over Iceland in an idealized simulation of a clear day in June at 18.00 UTC.

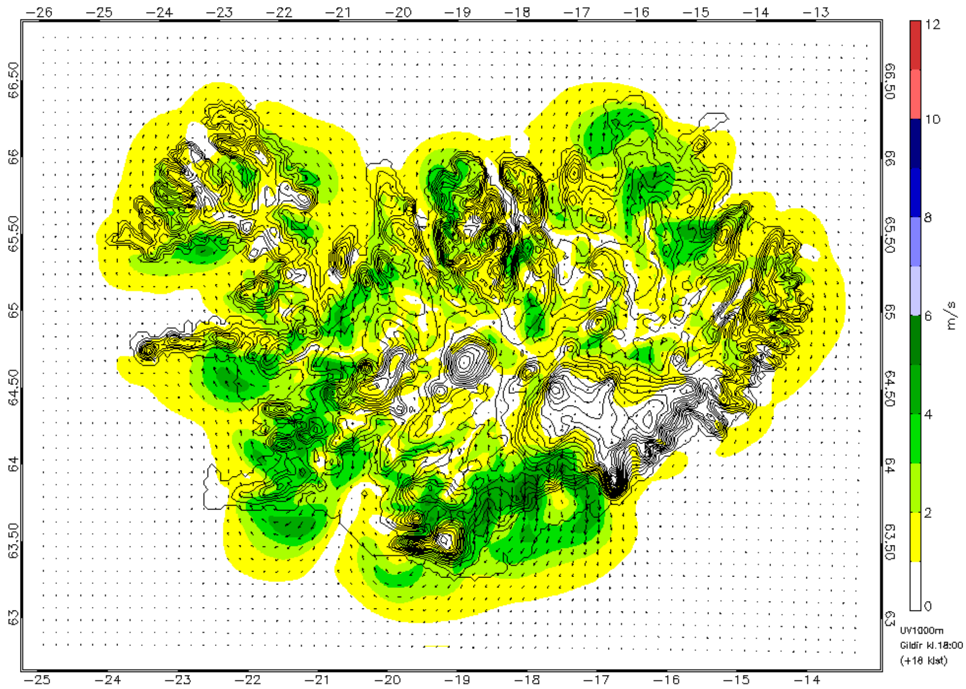

Figure 4. Wind speed at 1000 m above the ground in an idealized simulation of a clear day in June at 18.00 UTC.

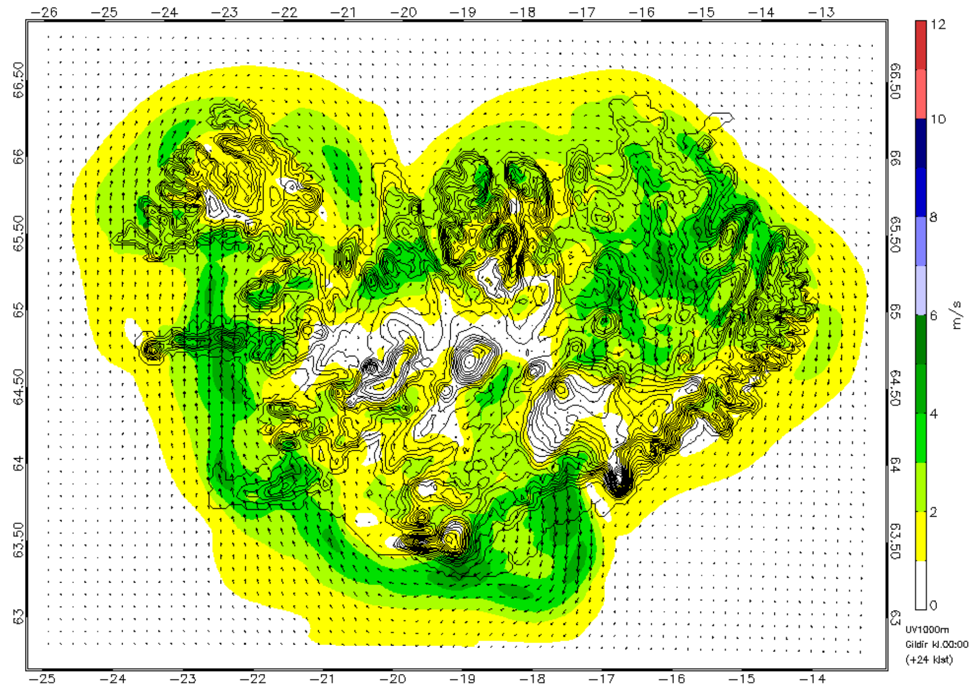

Figure 5. Wind speed at 1000 m above the ground in an idealized simulation of a clear day in June at 24.00 UTC.

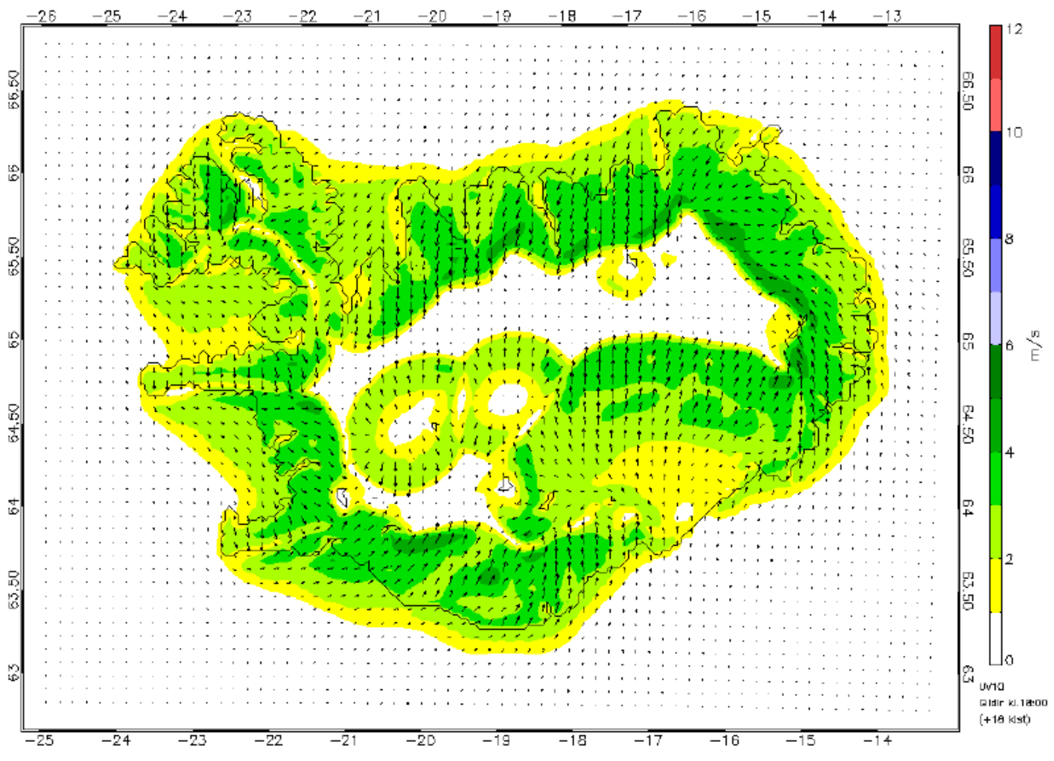

Figure 6. Surface wind speed in an idealized simulation of flow over flat Iceland on a clear day in June at 18.00 UTC.

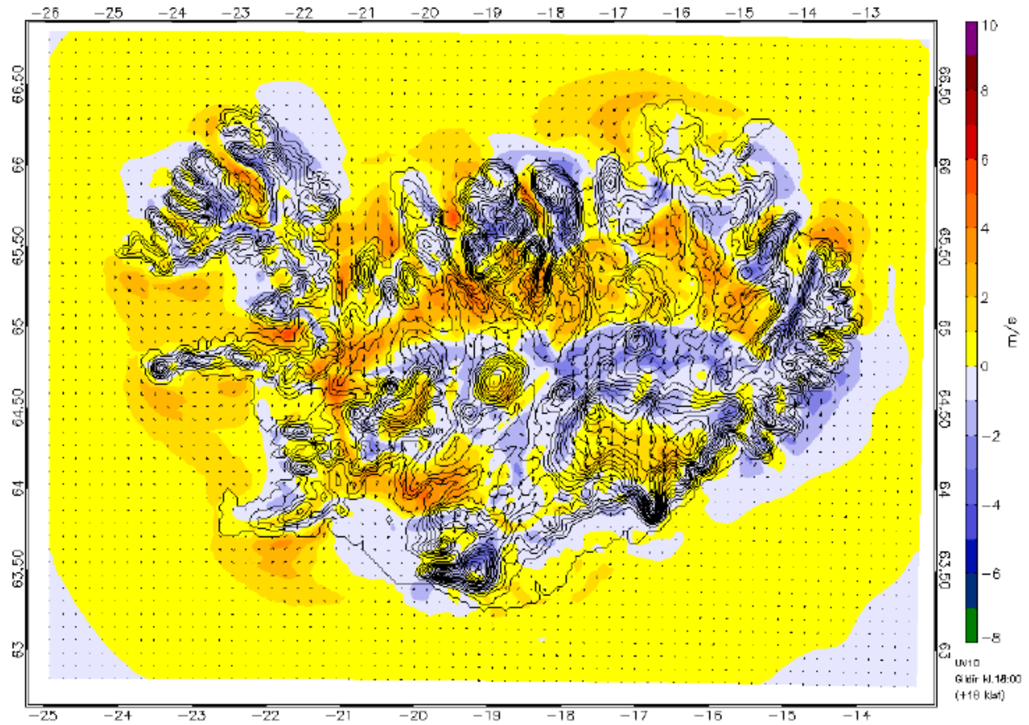

Figure 7. Surface wind speed in a control simulation (Fig. 2) minus surface wind speed in a simulation with flat Iceland (Fig. 6).

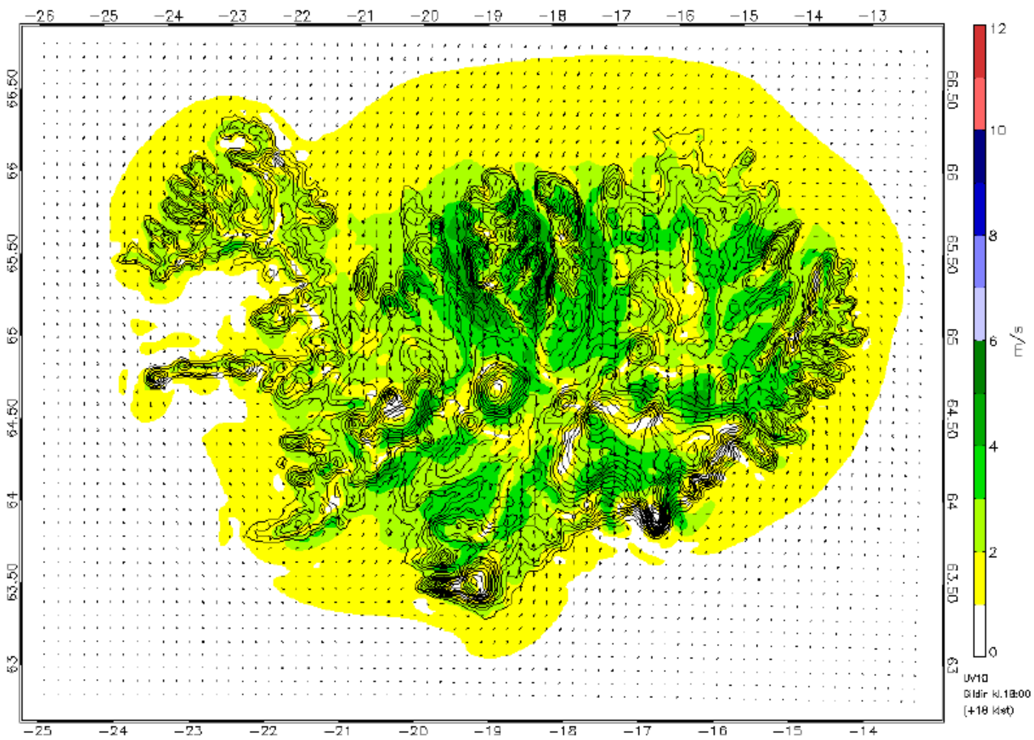

Figure 8. Surface wind speed in an idealized simulation of flow over Iceland with no surrounding sea on a clear day in June at 18.00 UTC.

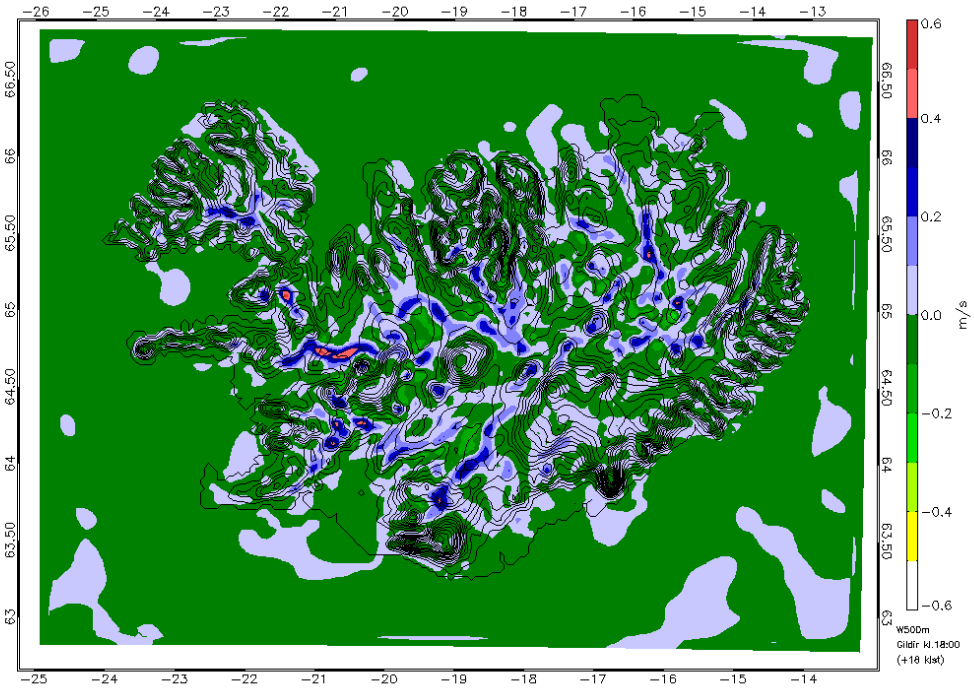

Figure 9. Vertical velociy at 500 m height in an idealized simulation of the atmosphere over Iceland on a clear day in June at 18.00 UTC.

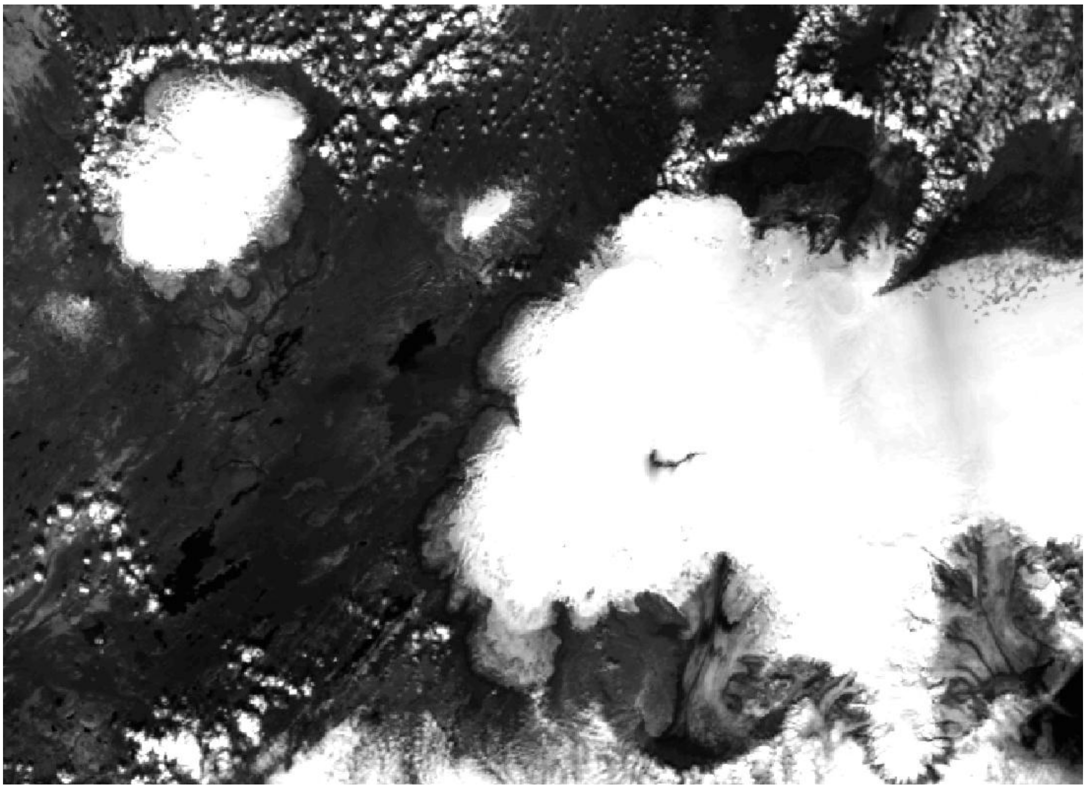

Figure 10. Satellite image (visible light) on a clear summer day with convection.