MOUNTAIN METEOROLOGY AND THE INTERNATIONAL POLAR YEAR

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Abstract: The polar regions provide a unique framework for mountain flows. At high latitudes, the atmosphere is very often strongly stably stratified, there is relatively low surface roughness over ice-covered mountains and changes in surface forcing (and mountain height) in a new and different climate have an impact on the orographic flows that may be stronger than elsewhere. Here, examples are given of some orographic flow patterns at high latitudes that merit to be investigated. Some of these flows will be an object of research during the International Polar Year (IPY).

Keywords: *arctic, Antarctic, polar, meteorology, mountain, IPY*

1. INTRODUCTION

In 1879, the Second Meteorological Congress approved the concept of an International Polar Year (IPY), which was held in 1822-1883. A second International Polar Year, initiated by the International Meteorological Organization took place in 1932-1933. Building on the experiences from these events, an International Geophysical Year (IGY) was announced 1957-1958. Thousands of scientists from a large number of countries participated in projects of the IGY, contributing to its respectable status in the history of geophysical research. Now, the international community will again give special attention and status to the polar regions. The period from March 2007 to March 2009 has been defined as an International Polar Year. This current polar year is co-sponsored by the World Meteorological Organization (WMO) which has decided the theme for the year 2007 to be “Polar meteorology: understanding global impacts”.

The polar regions and the IPY offer many challenges for mountain meteorology. Low-level airmasses are typically stably stratified, sometimes extremely stable, leading to strong response of the atmosphere to even small mountains. Ice caps have typically much smaller surface roughness than mountain ranges like the Alps or the Pyrenees, but surface roughness can indeed be destructive to flow perturbations like gravity waves. On the large scale, there are indications that orographic perturbations in the arctic may lead to downstream developments and have a hemispheric impact on the weather patterns. From a forecasting perspective, it is of a particular interest to explore the atmospheric conditions when a small change in the atmosphere may lead to a relatively large change in its response to the ororgaphic forcing. This is in fact one of the objectives of the international THORPEX programme.

On the climatic time scale, forecast models tend to diverge more in the polar regions than elsewhere. In these regions, there are potentially strong feedbacks in the earth system. Snow cover reduction changes the albedo and a change in the sea ice extent changes both the albedo and the fluxes of heat and momentum between the atmosphere and the ocean. Little is known about how these changes may affect the long term impact of the high latitude mountains on the atmospheric circulation.

In the remainder of this paper, examples are given of orographic flows in arctic regions. Some of these flows, such as the Greenland jets are the primary object of IPY projects (e.g. the Greenland Flow Distortion Experiment), while others are an integrated part of projects with a wider meteorological or climatological scope.

2. MOUNTAIN FLOWS IN THE POLAR REGIONS

The Greenland ice cap is possibly the greatest flow barrier in the polar regions. The southernmost tip of Greenland reaches into the N-Atlantic Storm track and very strong winds are frequent in both westerly and easterly flow. The westerly jet has to some extent been investigated and related to circulation in the ocean, but fig.1 (left) shows an example of an easterly jet which has not yet gained similar attention. There is a regular speed-up along the mountains at the east coast of Greenland a maximum wind speed is reached close to Cape Farewell (the southernmost tip). The QuikSCAT observations indicate surface winds of more than

35 m/s, a value not far from the values observed in similar winds during the Greenland Flow Distortion Experiment in February and March 2007.

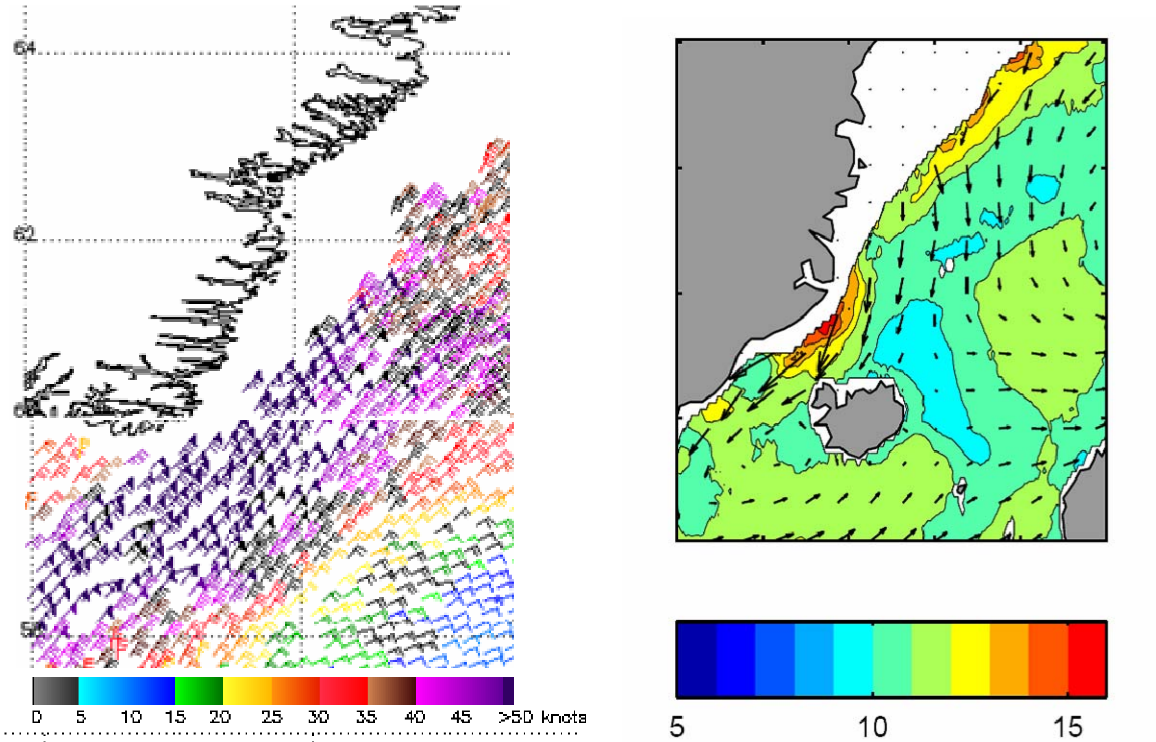

Figure 1: QuikSCAT surface winds (NOAA/NESDIS). Left: winds (kt) on 26 February 2007. Right: mean wind speed (m/s) in December 1999-2006. (Courtesy of E. W. Kolstad)

Further north, there is another location of strong north-easterly winds which we choose to call the Cape Tobin jet (fig.1, right). The Cape Tobin jet is more persistent than the Cape Farewell jets, and it is probably one of windiest places in the N-Hemisphere. The Cape Tobin jet is poorly represented in coarse resolution analysis.

Figure 2 (left) shows a satellite image of a cyclone in the lee of S-Greenland. This location is a preferred place for cyclones which can be influenced by the topography of Greenland in different ways. This is a nice example of a quasi-stationary cyclone which continues to deepen although the main low-level baroclinic part of the system has moved far away towards Iceland. The cyclone is being fed by upper level vorticity coming from Greenland. Techniques that predict where improved observations are likely to improve the weather forecast do indicate that the conditions in the arctic are often important for the weather in the more densely populated mid-latitude areas. Figure 2 (right) shows an example of such a sensitivity area prediction where improved observations in an area centered close to the Cape Tobin jet in East-Greenland are expected to improve a 48 h forecast for the UK and other countries at the North Sea.

There are many challenges for mountain weather research at smaller scales. Figure 3 shows the surface winds in southerly flow over Hofsjökull glacier in Central Iceland. The glacier has a relatively smooth surface and reaches about 1000 meters above its surroundings. The numerical simulation shows a gravity wave-like speed-up over the downstream slope (greater than 25 m/s), while upstream the wind speed is much weaker (less than 10m/s), although the flow is not blocked. Flow over Hofsjökull will be studied during the FLOHOF project later in 2007. FLOHOF may be the last project of its kind during an IPY, since Hofsjökull glacier is predicted to disappear in a future climate. Very strong orographic winds are generated when the cold and extremely stable air over Northern Scandinavia is advected towards the mountains at the coast of the Barents Sea (fig.4). Forecasting such winds is indeed a challenge which must be met with ever increasing resolution of the forecast models, but there is indeed a strong need for improvements of the models at the scales of about 1 km and below. Figure 5 (right) shows a gap wind in Sptizbergen, reminiscent of the gap winds in N-Norway in fig.4. A last example of an important orographic impact on the atmosphere is from SE-Iceland (fig.5, right), showing precipitation over the mountains being more than 10 times as much than in the lowlands upstream. Water in the mountains is an important energy resource in many arctic regions and accurate short-term forecasts of precipitation as well as prediction of changes in the precipitation climate at fine scales are important. In spite of significant efforts in recent years, such forecasts are still some distance ahead and they pose indeed a challenge to the scientific community.

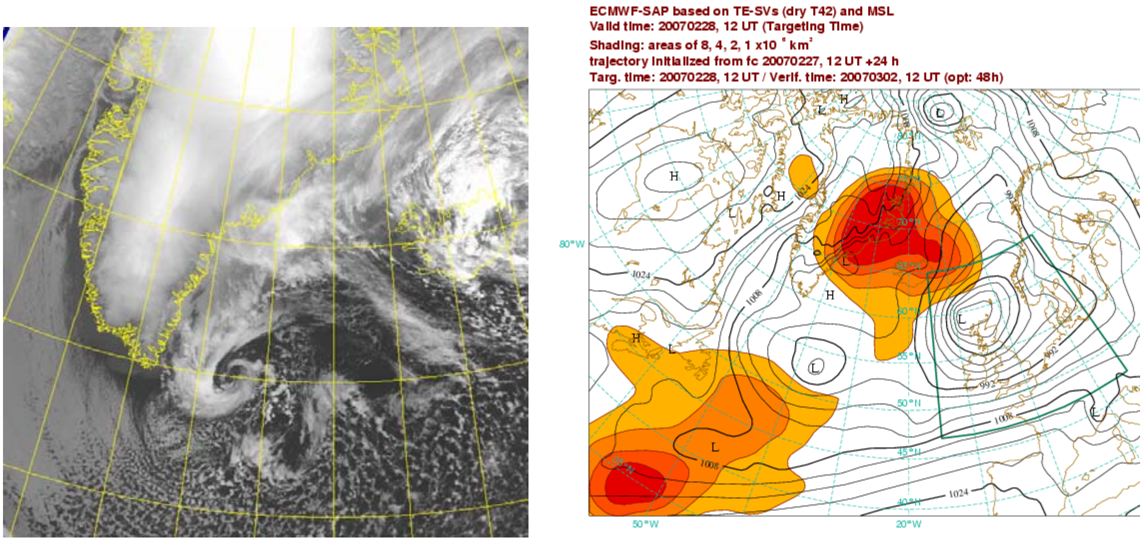

Figure 2: An IR satellite image from 3 March 2007. From NOAA / Dundee Satellite Receiving Station. Right: A sensitivity area prediction from the ECMWF.

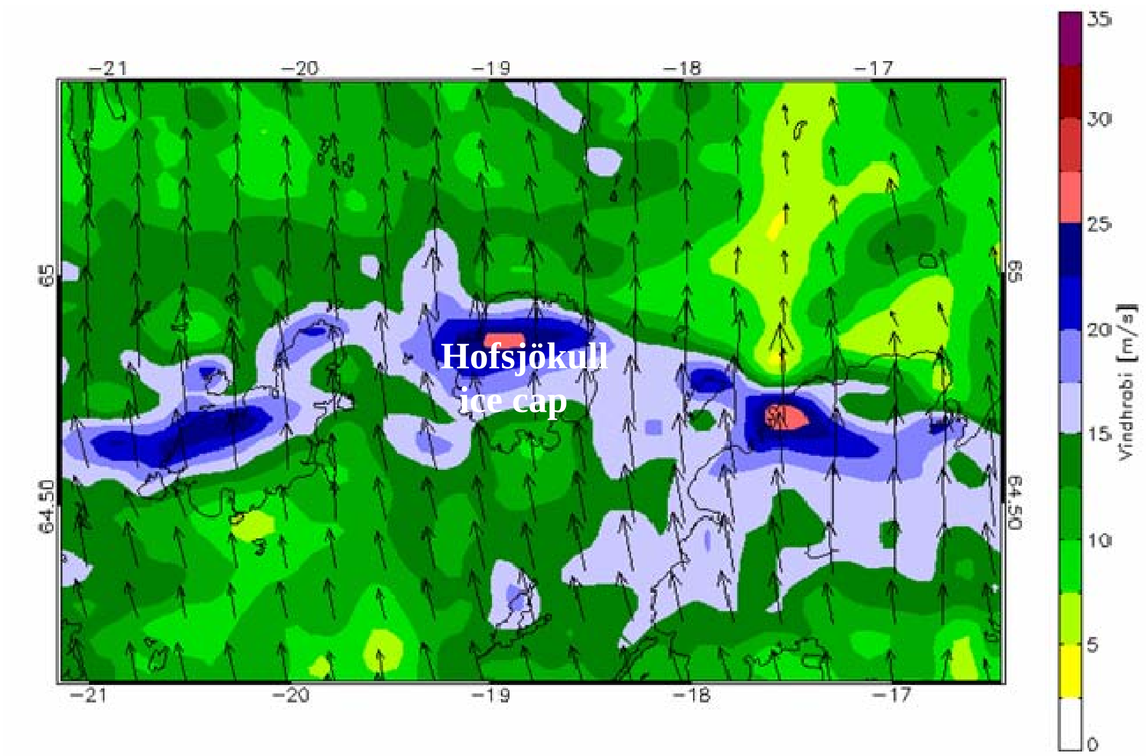

Figure 3: Forecasted surface wind speed (m/s) over Central Iceland on 24 March 2007. From the MM5/ECMWF based forecasting system HRAS (http://www.belgingur.is)

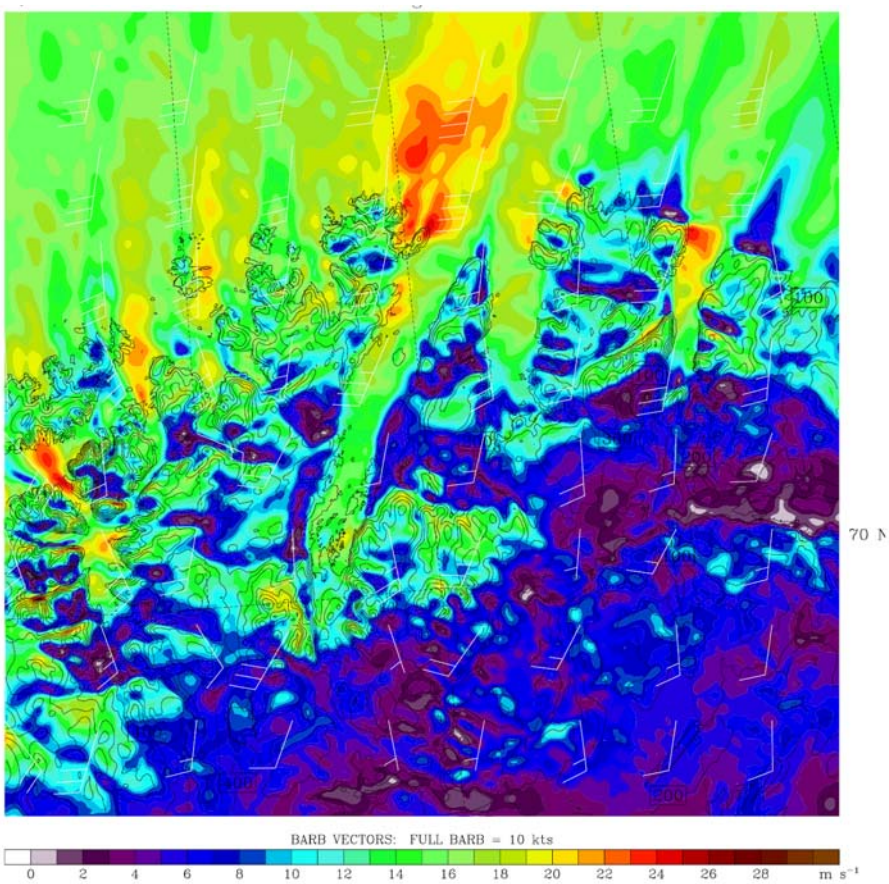

Figure 4: Simulated surface wind speed (m/s) over N-Norway on 19 January 2006. There are 30 km between wind barbs (Courtesy of E. M. Samuelsen).

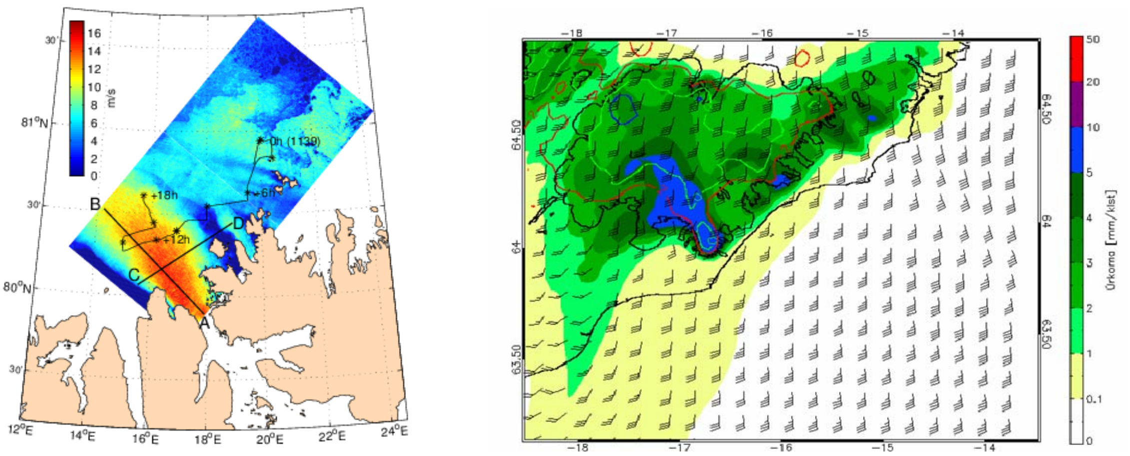

Figure 5: Left: Observed surface wind speed in Spitzbergen on 14 Aug. 1996 (SAR) (Courtesy of A. D. Sandvik). Right: Forecasted precipitation over SE-Iceland on 23 March 2007 (mm/h) from the MM5/ECMWF based forecasting system HRAS (http://www.belgingur.is).

3. CONCLUDING REMARKS

The polar regions provide a multitude of challenges and opportunities for research on the impact of orography on the atmosphere at a variety of scales in time and in space. The International Polar Year will hopefully be a trigger for research in mountain meteorology at high latitudes, not only during the IPY, but in years to come.