NORTHERLY WINDSTORMS IN ICELAND

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Abstract: The dynamics and frequency of northerly windstorms over Iceland in current and possible future climate are discussed. These storms are relatively frequent in Iceland in the spring and in the autumn and they are also frequent during periods when there is much sea ice in the waters to the east of Greenland. Unlike most of the southerly windstorms in Iceland and many windstorms in W-Europe, many of the northerly windstorms are characterized by a low level-jet and a reverse vertical windshear in the lower troposphere. The spring-time northerly windstorms coincide with the period of maximum extent of the sea-ice north of Iceland and the frequency of these windstorms is reduced dramatically in a simulation of future climate. The windstorms are discussed in relation to blocking of cold airmasses at the east coast of Greenland. A further study of the impact of the sea-ice and Greenland on meso- and synoptic scale strong winds and the wind climate is planned during the International Polar Year (IPY)

1. INTRODUCTION

Windstorms are frequent in Iceland (Einarsson, 1984), they are usually connected to the passage of synoptic scale disturbances over the area. However, the three-dimensional structure of the the storms is quite variable. Many storms are similar to the storms that occasionally ravage W-Europe (Munich Re, 2001), fast moving systems connected to upper level maxima of wind, but others are characterised by strong low-tropospheric temperature gradients with associated low-level jets (below 700 hPa) and a reverse wind shear above the jet. These latter systems tend to be slow moving or even stationary, as upper tropospheric winds are usually light. Such storms are consequently longer lasting than the ones more intimately linked to the polar jet stream. In this paper the climatology of the windstorms in Iceland is presented, the secular frequency of northerly windstorms is compared to the extension of the sea-ice east of Greenland and windstorms are counted in a simulation of future climate. The results are discussed in relation to blocking of low level air east of Greenland.

2. STORM IDENTIFICATION

Storms are identified and classified by various criteria (Jónsson, 2003). All synoptic observations made in Iceland are available online in the database of the Icelandic Meteorological Office (IMO) since 1949 to date. In the earliest part of the period about 140 observations were made per day, but during most of the period the number has hovered between 230 and 280 per day. A count was made of days when the wind speed at least 10% of the observations was greater than 17m/s (gale force winds). During the 56 year period such days were 1309, about 23 per year on the average. Resultant wind vectors were then calculated for the individual days and classified into 8 compass directions. These days are labelled as *type2* class storms. During the period before 1949 only a few observations are available online, but the archives of the IMO contain a list of days and stations where the estimated maximum 10-minute wind occurring during 24 hrs reach Beaufort force 9 or more (>20m/s), this is used for the identification of days when the wind at least 25% of the stations reached this limit. These days are given the label *type1* storms. During the post 1948 period their frequency is about 12 per year and have been also classified into compass directions, but in a subjective manner (by visual scanning of weather maps). By increasing the *type2* limit to 14% of observations exceeding 17m/s the frequency of the two types is similar during the 1991 to 2002 period, but during the early part of the common period one has to increase the limit still higher to get the frequency equal. The *type1* list extends back to 1912, but as the stations are few before 1925 and night-time observations are lacking before 1941 the confidence in the list decreases towards the past. As storm events usually last more than 3 hrs, but less than 24 hrs, the two types do not sample the data in the same manner. A short, widespread storm registers in both classes, or even in *type1* only, but a more local drawn-out storm registers preferably in *type2*. In the following, both types of storm days are aggregated into two direction classes, a northerly one, containing storms of the four directions, NW, N, NE and E and a southerly one, SE, S, SW, W.

3. CLIMATOLOGY OF THE WINDSTORMS

3.1. The seasonal cycle

Windstorms in Iceland show a marked seasonal cycle, being most common during the height of winter (late December to late February), as seen in fig 1. During most of the year the frequency of northerly storms exceeds the southerlies, the main exception being February. From mid-December to late January the frequency is similar. From mid-March onwards the northerlies clearly outnumber the southerlies. This is still clearer in figure 2, which shows the seasonal cycle of the relative frequency of the two direction classes. As the number of southerly storms is very low in late spring and a part of the early autumn the exact (high) values at this time of the year are clearly coincidental, however, the relative high frequency of the northerlies at these times of the year is not to be doubted.

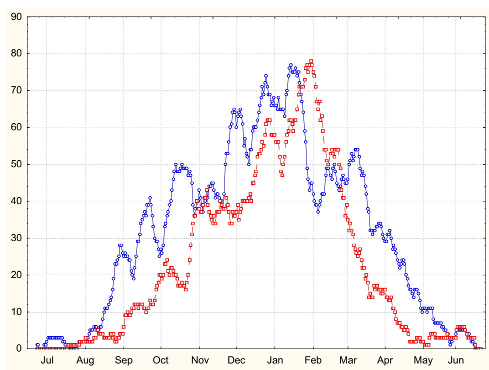

Figure 1. The seasonal cycle of windstorms (*type2*) in Iceland, northerly storms (blue) and southerly (red) as 15-day running sums of occurrences during the base period 1949 to 2004

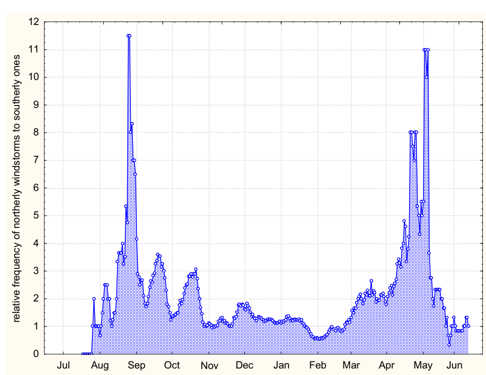

Figure 2. The relative frequency of northerly v. southerly windstorms in Iceland (based on the values shown in fig 1). Base period 1949 to 2004

The details of the seasonal variability of the storm frequency is related to intricate features of the general circulation in the Iceland/Greenland area as the polar vortex development and planetary waves interact with the topography of Greenland and the surface conditions over a larger area. This will be pursued at a later stage.

3.2. Secular variabilty of the relative frequency of northerly and southerly storms

During the 20th century there have been some marked variations in the relative frequency of northerly and southerly storms in Iceland. Both *type1* and *type2* classifications show qualitatively similar variations on the decadal scale, both they also show a coherance with the E-Greenland April ice index of Vinje (2001), see fig. 3. The ice-index and the temperature in Iceland are negatively correlated, but it is particularly interesting that the maximum seen in both the ice-index and the northerly storm frequency in the early 1940s is much less evident or absent in the Icelandic temperature record (Hanna et al., 2004). Even though the ice area reached a similar magnitude during this episode and during the maximum of late 1960s, the ice reaching the coast of Iceland was much less in the first period than the later one. The influence of the ice seems in other words to reach much further than to the ice covered area only.

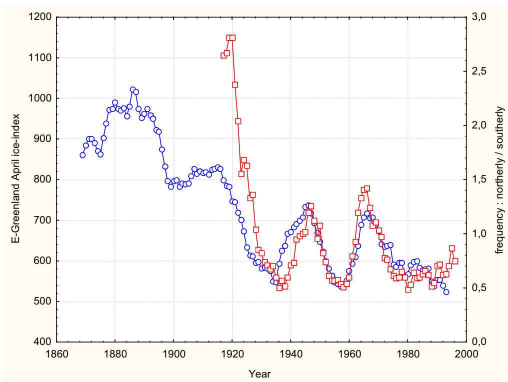

Figure 3. The East-Greenland ice-index (11-yr running means – blue) and the relative frequency of northerly versus southerly storms in Iceland (11-yr running means – red). Note the caveats regarding the early part of the storm frequency in the text.

4. STORM DYNAMICS

A closer inspection of the storms reveals that the low-level jet event population is largely composed of storms with damaging winds from a northerly and north-easterly direction, while the south-westerly storms are generally more closely linked with the upper tropospheric jet (W-European type). The northerly storms are consequently to a larger extent based on a low level west-east temperature gradient. Intuitively, one may suspect that the orography of Greenland may be important for the generation of the northerly storms through blocking at Greenland's east coast and a diversion of the cold airmasses to the south towards W-Iceland. One case of a northerly spring-time storm has been simulated without the topography of Greenland. The absence of Greenland resulted in a weaker west-east low-level temperature gradient east of Greenland and substantially weaker northerly winds over Iceland (not shown).

5. FUTURE CLIMATE

As the northerly windstorms appear to be linked to low-level temperature gradient and to the sea-ice off the east coast of Greenland it may be of particular interest to investigate how the climate prediction models predict these storms in a future climate scenario. For this purpose, we have investigated the frequency of northerly windstorms in simulations downscaling global simulations of the Hadley Centre (scenario B2). The downscaling is carried out by the Norwegian Meteorological Institute (met.no), using the HIRHAM model and is a part of the PRUDENCE project (www.prudence.dmi.dk). Figure 4 reveals a dramatic drop in the frequency of spring-time northerly windstorms and some reduction of in the number of northerly windstorms in the autumn.

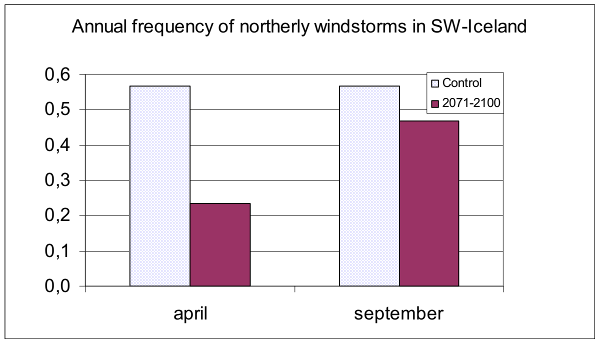

Figure 4. Annual frequency of northerly windstorms in april and September in SW-Iceland in a simulations of current and future climate (HIRHAM based on BC from HAD-B2)

6. DISCUSSION

There are strong indications that the northerly windstorms are closely linked to an orographic blocking of dense low level air at the east coast of Greenland, north of ca. 69°N. A positive interaction can be expected between the sea-ice and Greenland. The more sea-ice there is, the colder is the low-level airmass and blocking is favoured. Blocking prevents advection of warm air from the southeast and contributes thereby to maintaining the sea-ice. The high-frequency of northerly windstorms during periods of much sea-ice is presumably linked with the sea-ice contributing to the low-level west-east temperature gradient associated with most of the windstorms. The role of the blocking of Greenland is to reinforce the temperature gradient and bring it to the south by the outflow from the blocking at Cape Tobin (Scoresbysund). The rapid drop in the frequency of the spring-time northerly windstorms in a future climate scenario (which has very little sea-ice) supports this and also lends credibility to the climate simulation.

7. FURTHER WORK

Cases of northerly windstorms in the region of Iceland and E-Greenland will be simulated and the sensitivity of the windstorms to the topography of Greenland and to the extension of the sea-ice will be explored. The morphology and dynamics of the windstorms will be studied in current climate and in scenarios of a future climate. This will be carried out in the context of the International Polar Year (IPY).

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