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Wind gusts and local gust forecast for Icelandic Roads

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ABSTRACT

At present the development of gust forecasts is underway at the Icelandic Road Administration. The goal of the project is to analyse dangerous wind locations, especially by steep mountains and to increase the public service. By forecasting gusts the public will get better information of local winds at specific locations, and a forecast for the next few hours for the places where dangerous katabatic winds are common during certain meteorological conditions. Over 60 places of strong wind gusts are investigated. Wind measurements are available for more than 10 years for some of these locations. The wind data compared with winds higher aloft, mainly at the 850 hPa level are the base to a probabilistic gust model (30 m/s) for 9 locations.

Keywords: Wind gusts, downslope wind, gust forecast,

1 INTRODUCTION

Strong wind gusts close to steep mountains are a threat to the safety of travellers on the Icelandic National Roads. Numerous events of strong wind gusts blowing vehicles off roads, and the collateral damage is considerable. Injuries have occurred in these events, as well as fatalities. The maximum wind gusts can easily exceed 50 m/s during these events. The Icelandic Road Administration has operated roadside anemometers in a few of these places for 10 til 15 years. Measured wind gusts (1 sec) along with average winds velocity are displayed on backlit billboards at some distance before travellers reach these locations. A map of 60 known places where vehicles have been blown off roads has been produced. Data series from the weather stations have been analysed and the occurrences of wind gusts (fg > 30 m/s) have been correlated with wind direction, wind velocity and temperature gradient at the 925 hPa and 850 hPa pressure levels via ECMWF ERA -Interim [1]. Based on this analysis a statistical model for the likelihood of wind gusts in 9 different locations in 1 hour time steps has been produced. Section 2 shows a wind gust map of Iceland, but in Section 3 the meteorological reasons for wind gusts in Iceland as well as the methods used to forecast the magnitude of wind gusts are discussed.

Figure 1. Backlit billboard for two nearby locations. Wind gusts are shown in red for measurements at least 15 m/s. Photo: Morgunblaðið/Júlíus Sigurjónsson

Figure 2. An example of collateral damage due to a violent wind gust in month of May. Photo: Morgunblaðið/Jón Sigurðsson.

2 WIND GUST MAP

A map depicting places where wind gusts by mountains have threatened travellers has been produced. Most often these locations are a short stretch of road, from under 100 m to 2 to 3 km. One example of a stretch of road 13 km long can be found in the Snæfellsnes peninsula. In the making of this map wind measurements, as well as the experience and description of the Icelandic Road Administration's experienced staff were used. In these locations the surface coating of the roads is known to become loose and even blow off in the most violent events. This map is by no means exhaustive and less travelled roads have been left out. Along with the map a short description of each location has been produced, indicating in which wind direction and during which meteorological conditions extreme wind events are likely to produce dangerous wind gusts.

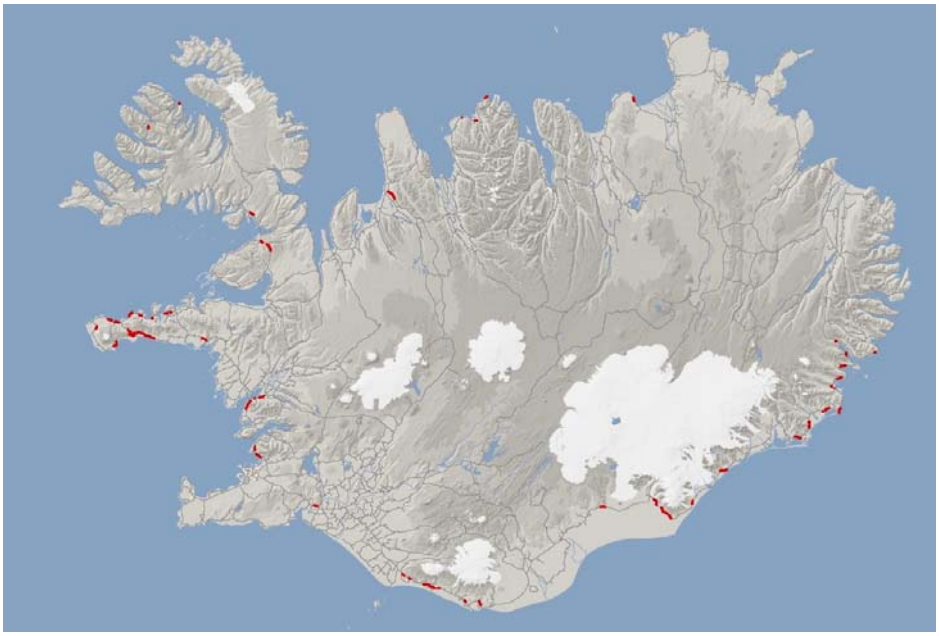

Figure 3. 67 locations on the frequently travelled national roads where strong wind gusts are common. Roads in these locations are usually near steep mountains.

3 DOWNSLOPE WINDSTORMS

Strong, localized windstorms immediately downstream of mountains have been investigated by numerous authors. Favourable large-scale flow condition for generation of downslope windstorms include elements such as strong low-level winds and strong static stability at low levels [2]. Several gust prediction systems have been devised, some which use statistical methods while others are based on a physical model of the formation of gusts. One such method, which is based on the parameterization of turbulence and atmospheric stability in numerical models is the method of Brasseur [3]. Some simulations of atmospheric flow in complex terrain have been calculated in Iceland. The results are consistent with other studies on the use of the gust prediction method. The mean surface winds are correctly captured, but the gust prediction are generally underestimating the gusts during severe downslope windstorms [4]. Although there is clear evidence of progression of small scale WRF-models, more precise parameterization of the turbulent kinetic energy (TKE) is of primary importance for creations of wind gusts.

In this research project the focus has mainly been on three sets of conditions where mountains break wind into smaller rotors. 1) Mountain blockage, where mountains break a low level jet streams into smaller eddies or rotors. A steep incline or mountain cliffs cause the jet stream to become plugged. The force (strength) of the jet stream, along with the stability of the atmosphere are the deciding factors in how much of the wind energy is transformed into turbulent kinetic energy on the lee side of the mountain. 2) Corner wind, where acceleration of wind happens alongside a steep mountain side and resistance breaks wind into smaller rotors. 3) Breaking of gravity waves. Intense downdrafts due to breaking gravity waves on the lee side of mountains is much more difficult to simulate, that applies both to the methods, statistical and dynamical as well as the force of the wind gust.

4 DEVELOPING A WIND GUST MODEL

A wind gust model has been developed for 9 locations, and in all locations wind data is available. While developing the model, measurements were used and compared to wind direction, wind velocity and temperature in the 925 hPa and 850 hPa pressure fields from the ERA -Interim reanalysis from ECMWF. Results showed that correlation between measurements and the meteorological parameters in the two pressure fields was poor, and not acceptable for a model. The ERA -Interim resolution is not good enough for small scale phenomena such as a local wind gust. Instead demo models were run for 6 locations for the time interval November 2010 to June 2011 with data from the High resolution weather prediction model from Reiknistofa í Veðurfræði (IMR). Spatial resolution is 3 km and temporal resolution 1 hr. The demo model was adjusted after comparison to the measurements. In some of the locations wind gusts are only products of two variables, wind direction and wind velocity at the 850 hPa field, but in other locations the atmospheric stability, i.e. temperature gradient between the 925 hPa and 850 hPa is also important. 3 of the 9 locations are still in development, data is being collected but a final product is scheduled to be launched in the summer of 2012. The wind gust model is a stepwise probability model issued each 6 hours for a 36 hour forecasting period.

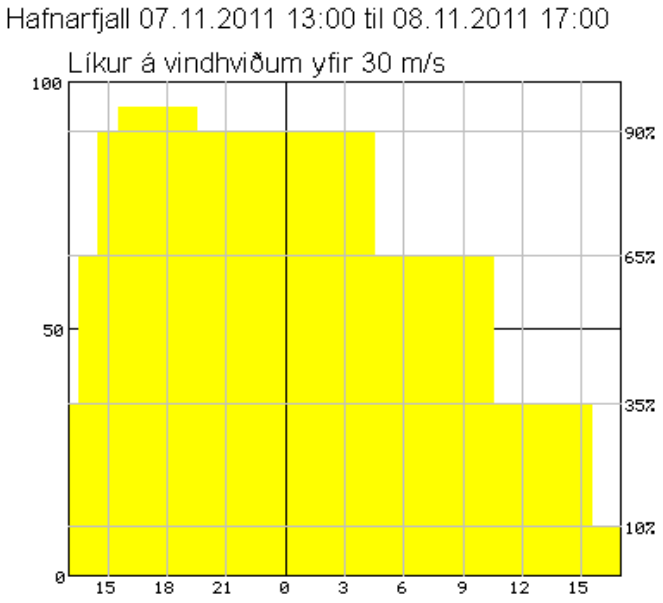

Figure 4. An example of a wind gust forecast for wind gusts > 30 m/s or higher for the meteorological station Hafnarfjall. This forecast is run on the 06 UTC analysis and published at 11 UTC on 07. Nov. 2011

5 RESULTS

The wind gust model is in it's first year of operation for 6 locations. After a full year a process of verification will commence as probability forecast using verification methodology based on Relative Operating Characteristics (ROC). Adjustment of the models is a possibility after the first operating year, if verification reveals a significant bias. Icelandic Road Administration also intends to publish the model on it's website in the fall of 2012. Other means of publishing are being considered. The wind gust model is developed to increase the flow of information to public as well as increase the safety of those who travel in strong winds events on the main roads in Iceland.

6 REFERENCES

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