TEMPORAL OSCILLATIONS IN DOWNSLOPE WINDSTORMS

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1. INTRODUCTION

One of the characteristics of downslope windstorms is gustiness. Windgusts in downslope windstorms are often more than twice as strong as the mean wind speed. In fact, mean gustfactors of more than 1.7 are common up to several km downstream of mountains (Ágústsson and Ólafsson 2004).

In between gusts, there may be periods with relatively weak winds. The physics behind the gustiness of downslope windstorms is not well understood and until recently the only way to predict the gusts has been by statistical methods.

During a few recent downslope windstorms in Iceland, observations of wind have been made every one second, permitting an analysis of the characteristics of the temporal oscillations of the wind speed. In this short paper, two such windstorms are analyzed and one of these windstorms is simulated with the numerical model MM5 (Grell et al. 1995). The numerical simulation employs boundaries from the ECMWF and is run with a horizontal resolution of 1 km and in 40 vertical levels. The turbulence is parameterized with the ETA scheme.

2. THE 13–14 JANUARY 2005 WINDSTORM

The temporal evolution of the wind speed at Skrauthólar, SW-Iceland during a downslope windstorm on 13–14 January 2005 is given in Fig. 1.

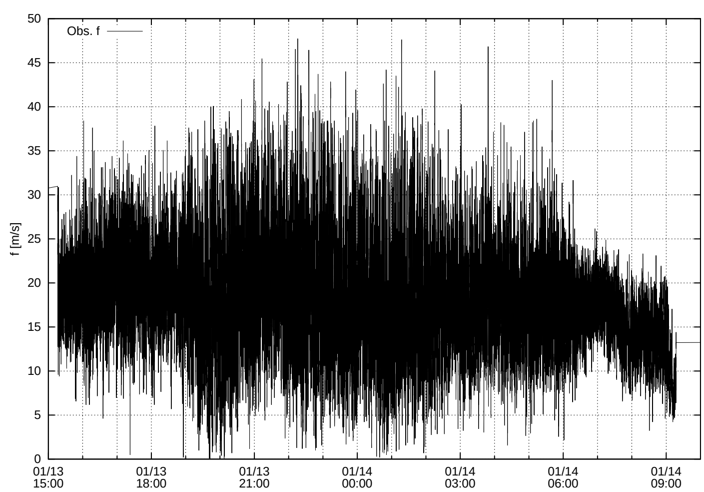

Figure 1. Temporal evolution of the wind speed at Skrauthólar, SW-Iceland on 13–14 January 2005.

A Fourier analysis of the temporal oscillations during the most gusty part of the windstorm and a more calm part of the windstorm is given in Figs. 2 and 3.

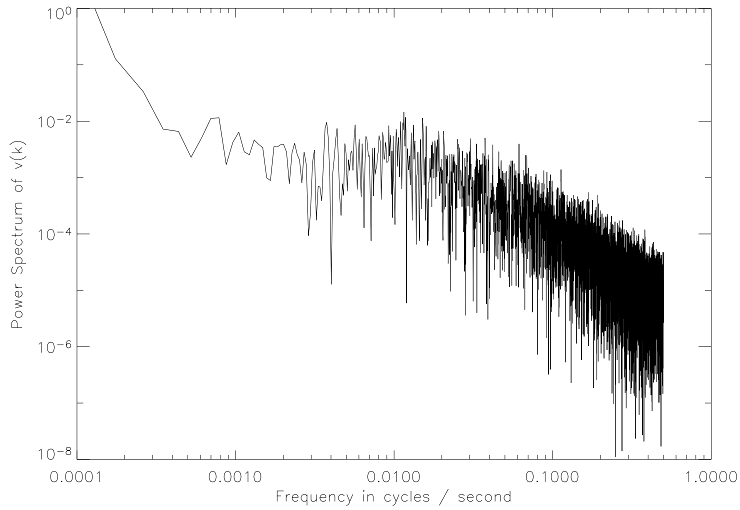

Figure 2. The energy spectrum of the wind during a calm period in the windstorm in Fig. 1.

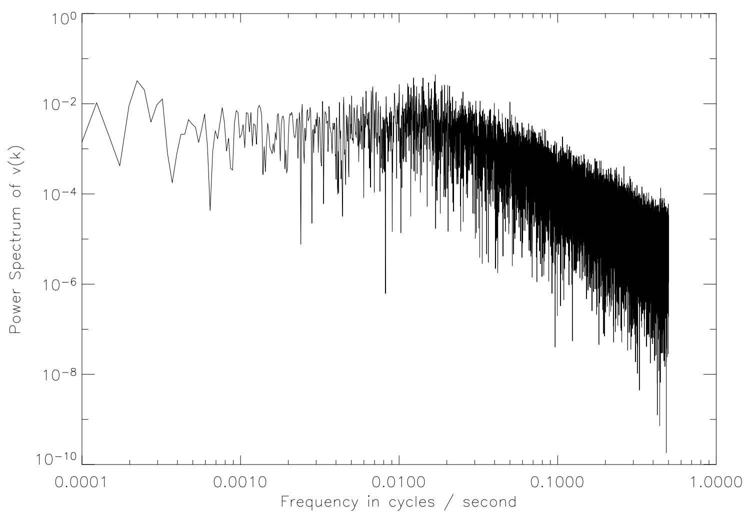

Figure 3. The energy spectrum of the wind during a gusty period in the windstorm in Fig. 1.

During the windstorm, the wind speed oscillates between 0 and 47 m/s. The energy spectrum in Figs. 2 and 3 shows a quite steady increase from the most rapid oscillations of a few seconds to oscillations of 1–2 minutes. For periods of longer duration the energy remains quite constant. At periods of approximately 10 seconds, the calm part of of the windstorm (Fig. 2) has more variability (energy) than the gustier part of the windstorm. For periods of 1–2 minutes and longer, the gusty part of the windstorm features on the other hand more energy than the calm part.

3. THE 2 FEBRUARY 2005 WINDSTORM

Figure 4 shows the temporal evolution of the wind speed during a downslope windstorm at Grundarfjörður, W-Iceland. An analysis of the temporal oscillations of a calm part of the windstorm and of the gustiest part of the windstorm is given in Figs. 5 and 6.

As in the 13–14 January case, there is relatively more energy associated with the most rapid oscillations during the calm part of the windstorm than during the gusty part. For oscillations of 1–2 minutes and up to 12–15 minutes there is on the other hand more energy in the oscillations in the gusty part of the windstorm.

Figure 7 shows a similar analysis of the output from a numerical simulation with the MM5 model. The model

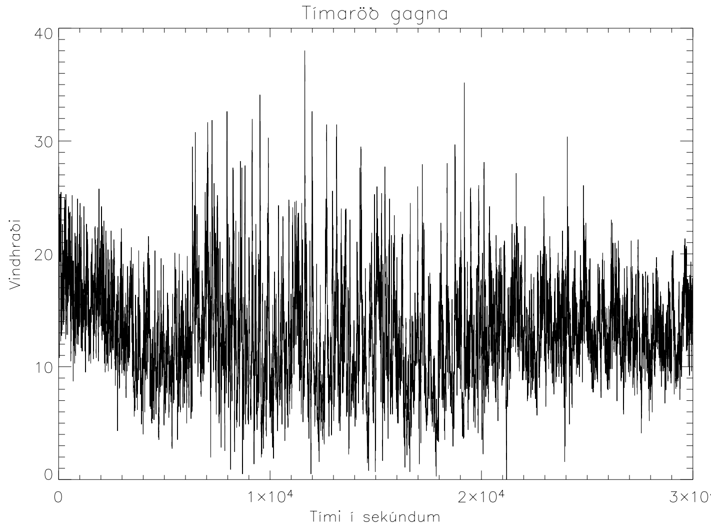

Figure 4. Temporal evolution of the wind speed at Grundarfjörður, W-Iceland on 2 February 2005.

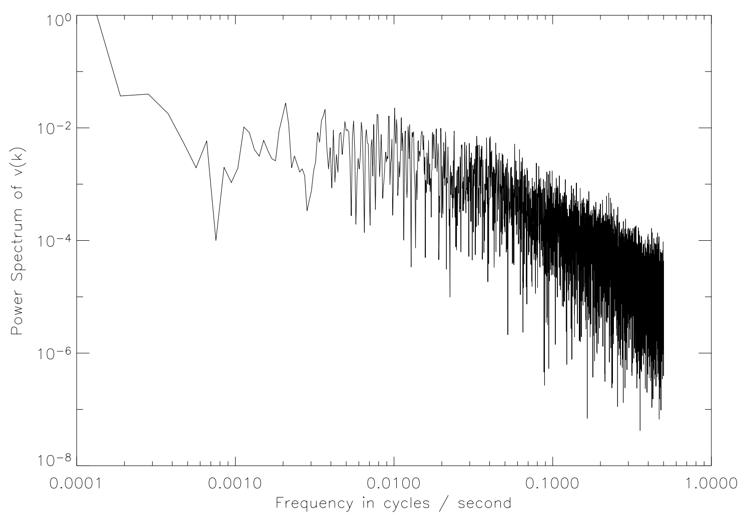

Figure 5. The energy spectrum of the wind during a calm period in the windstorm in Fig. 4.

does not reproduce the observed variability, neither at high-frequency (10 sec.), nor at lower frequencies (1 minute and more).

4. DISCUSSION

The data presented here indicates that the character of the temporal oscillations of the windspeed is different during the climax of the windstorm than during more calm periods. When the windstorms are at their maximum there is relatively large variability at periods from 1–2 minutes and upward. A possible reason for this may be related to oscillations in the gravity waves that generate the downslope windstorm at the surface, but this is hard to verify. In order to establish more knowledge about how the temporal variability of the wind relates to local topographic conditions and to elements of the atmospheric flow, data from more windstorms is needed and will be collected.

The poor performance of the numerical model is not unexpected for the high-frequency oscillations (less than a minute). As the physical reason for the oscillations with longer periods is unclear, it is difficult to indicate whether the numerical model should be able to reproduce this feature. There is nothing inhibiting oscillations related to buildup and breakdown of mountain waves to be reproduced in a numerical model, but the associated

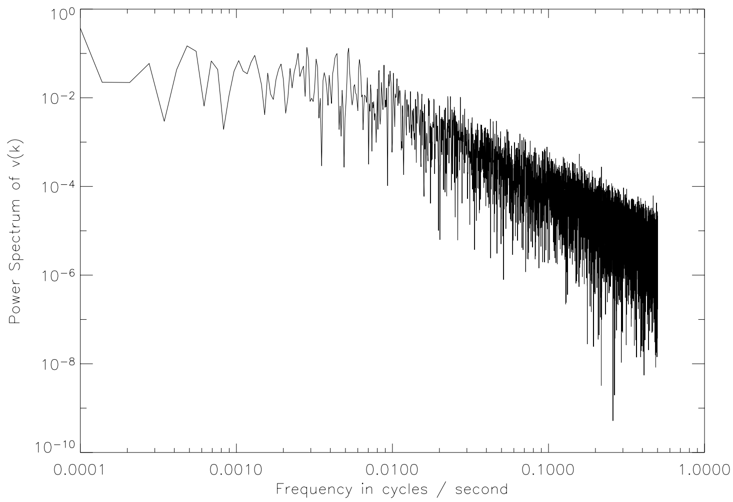

Figure 6. The energy spectrum of the wind during a gusty period in the windstorm in Fig. 4.

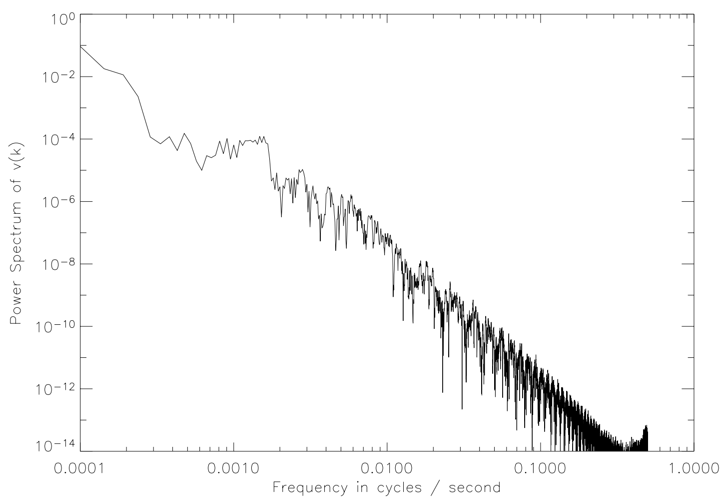

Figure 7. The energy spectrum of the wind as simulated with the MM5 during the windstorm in Fig. 4.

wind speed oscillations and generation of turbulence is inevitably dependent upon the turbulence parameterization and the diffusion in the model.

5. CONCLUSIONS

Observational data indicates that during the gustiest part of downslope windstorms, there is relatively large variability on the time scale of 1–2 minutes and upwards. The observed variability is not reproduced in a numerical simulation, not even at periods of several minutes. A method to reproduce this variability needs to be developed.

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