14A.6 CASE STUDIES OF KATABATIC WIND IN COATS LAND, ANTARCTICA

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1. INTRODUCTION

The ice cap of Antarctica loses heat due to radiative cooling at the surface, which then cools the overlying atmospheric boundary layer. The resulting (dense) layer of cold air will accelerate down the slope in response to a down-slope buoyancy force. These katabatic winds play a key role in the Antarctic surface wind regime.

2. METHOD

The UKMO Unified Model (UM) version 6.1 has been used to simulate several case studies of katabatic wind situations in Coats Land, Antarctica. This region is located on the eastern shore of the Weddell Sea, and consists of the Brunt Ice Shelf and the adjoining continent to the south. Slopes are modest (5% at most), and katabatic winds are moderate (typically observed to be 7.5 m s^{-1} at the steepest part of the slope). Simulations of two case studies will be presented: from the 21-24 February 2002 (an Antarctic summer case) and 14 August 2003 (an Antarctic winter case). A large domain with a resolution of 12 km was run, followed by a one-way nested 4 km resolution domain (with 76 vertical levels) centred on Halley research station. This setup made it possible to compare the model results to measurements from four Automatic Weather Stations (AWS's) as well as from an autonomous Doppler sodar wind profiling system, providing rare remotely sounded ABL wind profiles on the slope near Halley.

3. CASE STUDY RESULTS

3.1 *Winter case: August 2003*

This case study focuses on the 14th of August 2003.The observed katabatic flow is clear but weak. It is cloudy over the Brunt Ice Shelf most of the time. A low-pressure area to the north influences the katabatic flow especially higher up the slope. This case study is also discussed in Renfrew and Anderson (2006).

The large-scale synoptic situation is well represented by the model. The main problem on the smaller scale is the cloud cover: the model shows clear skies over Halley for a large part of the run, while in reality it was mostly cloudy, and this is causing the surface temperatures at Halley to be largely underestimated by the model. The model shows little variation over time, which makes it hard to compare model output to the highly variable Doppler Sodar observations. In general, the model underestimates wind speeds at the surface while overestimating wind speeds higher up. The katabatic layer in the model appears too deep, though this is impossible to prove as the peak of the katabatic jet seems to fall in the observation gap between the AWS at 3 m and the lowest level of the Doppler Sodar at 30 m.

Figure 1 shows the wind speeds for a vertical cross-section along the slope. The model shows a shallow katabatic flow near the surface, with wind speeds of up to 6 m/s at the steepest part of the slope. Higher wind speeds are seen at the top of the slope, but these are upslope winds. Over time, the katabatic flow is blocked at the bottom of the slope, causing the flow to retreat upslope and overshoot at a height of a few hundred metres. This blocking is caused by the development of a pool of cold air at the bottom of the slope, a phenomenon also found in a modeling study by Renfrew (2004).

3.2 *Summer case: February 2002*

This case study spans four days: 21-24 February 2002. This is in the Antarctic summertime, when the diurnal cycle of solar radiation will influence the katabatic flow (see for example Parish et al. (1993) and Renfrew and Anderson (2006)). The background synoptic flow is weak during these four days, and hardly influences the katabatic flow (Renfrew and Anderson, 2006). The skies are mostly clear, so the diurnal signal is strong.

Figures 2 and 3 show the wind speed over height and time from the model and from Doppler Sodar observations. The discrepancy after midnight on the second day in figure 2 is caused by the fact that two model runs of 48 hr runtime each have been used. Both the model and the observations show a clear diurnal cycle.

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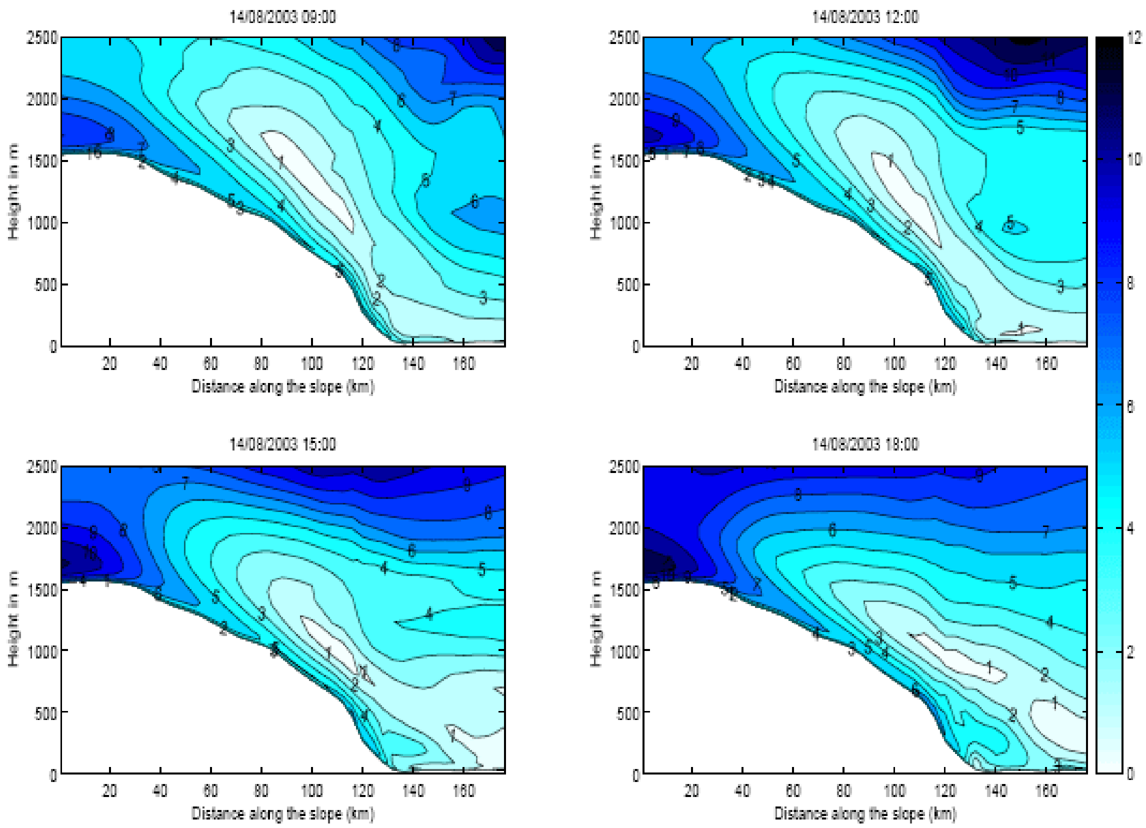

Figure 1 A vertical cross-section showing wind speeds along the slope near Halley Research Station, for the 14th of August 09:00, 12:00, 15:00 and 18:00.

The core of the katabatic jet is probably again located in the observation gap between the AWS at 3 m and the lowest Doppler level at 30 m. The model shows the core of the katabatic jet at a height of 60-70 m. The katabatic winds are strongest between about 20:00 and 08:00.

4. CONCLUSIONS

The model performs reasonably well for both case studies. The model is also able to capture the diurnal variation of the katabatic winds in the Antarctic Summer case study. The model shows a too deep katabatic layer in both case studies and tends to underestimate wind speeds at the surface and lowest layers of the atmosphere.

5. REFERENCES

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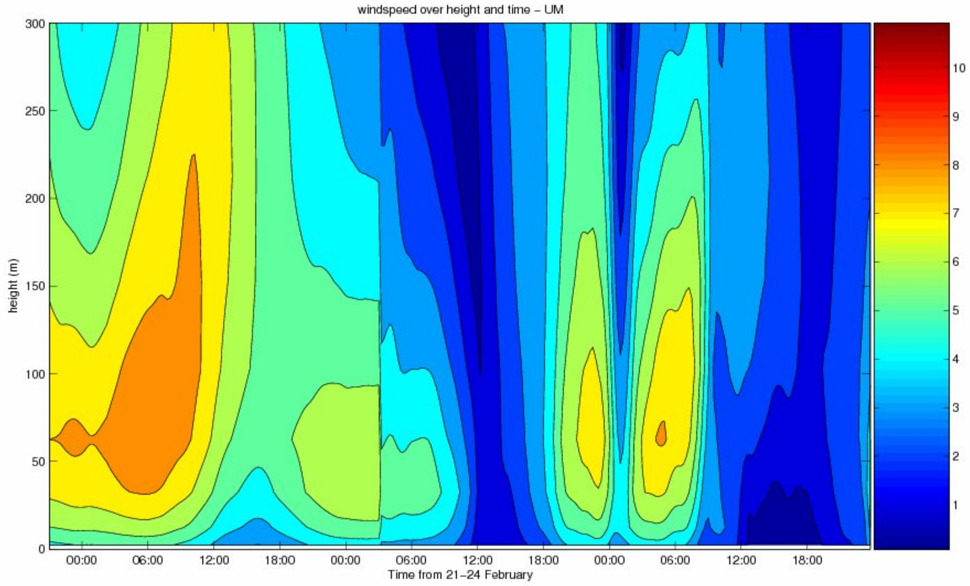

Figure 2 Wind speed over height and time from the model (15 minute averages every 15 minutes), for 21-24 February 2002.

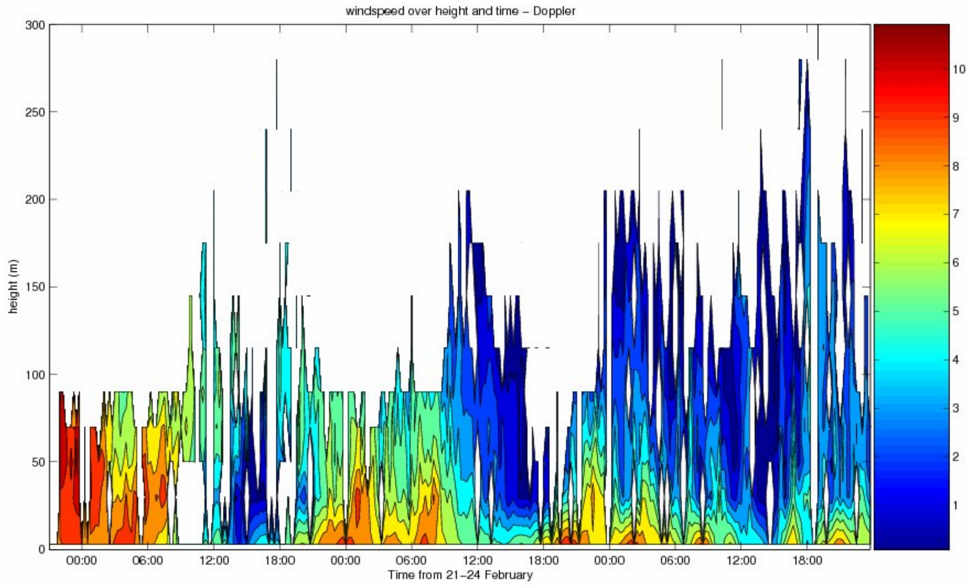

Figure 3 Wind speed over height and time from the Doppler Sodar (15 minute averages every 15 minutes), for 21-24 February 2002. The lowest level is provided by the AWS at the same location. Note that the AWS observations are taken at a height of 3 m, while the lowest Doppler level is at 30 m. This causes the gradients in the lowest levels.