Effects of vertically propagating mountain waves during a strong wind event over the Ross Ice Shelf, Antarctica

Sheeba Nettukandy Chenoli[1,2,3,*], John Turner[4] and Azizan Abu Samah[1,2,3]

[1]Department of Geography, Faculty of Arts and Social Sciences, University of Malaya, Kuala Lumpur, Malaysia
[2]National Antarctic Research Centre, Institute of Graduate Studies, University of Malaya, Kuala Lumpur, Malaysia
[3]Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur, Malaysia
[4]British Antarctic Survey, Cambridge, United Kingdom

Weather forecasting in the Antarctic presents many challenges, with strong wind events (SWEs) often disrupting air and field operations. Here, we study the mechanisms responsible for a SWE (maximum wind speed 22 ms^{-1}) that occurred at the McMurdo/Scott Base region on the Ross Ice Shelf (Antarctica) over 12–13 October 2003. The study is based on *in situ* observations, satellite imagery and output from the Antarctic mesoscale prediction system (AMPS) model. The event occurred during the passage of a complex low pressure system that increased the pressure gradient between the northwest Ross Ice Shelf and the continental high, initiating a strong southerly flow. AMPS simulations as well as upper air sounding profiles from McMurdo station showed the involvement of large amplitude vertically propagating mountain waves over the area. The amplification of mountain waves by the self-induced critical level reflected all the energy back towards the surface to generate high downslope winds.

Keywords: Katabatic wind, mesoscale model, mountain wave, strong wind events.

Introduction

THE wind field over Antarctica has been studied for almost a century and the dynamics of the airflow over the continent are well understood. From the recent literature, it is evident that the Antarctic strong wind events (SWEs) are forced by diabatic cooling of surface air and the pressure gradient force generated by the synoptic influence of cyclones in the coastal margin and due to topography[1–3].

The present study aims to examine the occurrence, nature and dynamical environments of SWE over the northwest Ross Ice Shelf, Antarctica and the mechanisms responsible for its development. We define SWEs as events with a wind speed greater than Beaufort scale 6 and above, which is more than 22 knots or 11.3 ms^{-1} for a duration >6 h (refs 3, 4).

Data and methods

A major part of this study is based on observational analysis from AWS and mesoscale output. The data consists of surface observations from automatic weather stations (AWS), surface and upper-air radiosonde data from McMurdo Station, and moderate resolution imaging spectroradiometer (MODIS) satellite imagery. The European Centre for Medium-Range Weather Forecasts (ECMWF), ERA interim reanalysis[5] data were also used to supplement the *in situ* data to obtain a detailed insight into the synoptic background. We utilized the data from the Malaysian Antarctic Research Program (MARP) AWS1 (77.908°S, 167.058°E) and AWS2 (77.898°S, 167.098°E) (hereafter referred to as WF-AWS1 and WF-AWS2 respectively). Radiosonde data from McMurdo were used to assess the upper air meteorological conditions during the SWEs (ftp://amrc.ssec.wisc.edu/pub/mcmurdo/radiosonde/).

Numerical weather model output from the AMPS archive was also used to study certain salient features of SWEs at McMurdo/Scott Base region. The AMPS Polar MM5 covers five polar stereographic domains. Domains 2 (30 km resolution), 3 (10 km resolution) and 5 (3.3 km resolution) are used in this analysis.

An overview of the development of a SWE and the synoptic situation

Our selected SWE was caused by the passage of a sub-synoptic scale low pressure system that formed on the Rose Ice Shelf from a pre-existing trough extending from another synoptic low pressure over the Ross Sea. When the low pressure system approached the station (Figure 1), it strengthened the pressure gradient between the northwestern ice shelf and the continental high.

The track of the low pressure system (L1) that gave rise to the SWE is shown in Figure 2. It was determined

*For correspondence. (e-mail: sheeba@um.edu.my)