Initial Measurements of Mesospheric Gravity Waves over McMurdo, Antarctica

Jonathan R Pugmire, Utah State University
Michael J Taylor, Utah State University
Yucheng Zhao, Utah State University
P Dominique Pautet, Utah State University

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Introduction

The ANtarctic Gravity Wave Instrument Network (ANGWIN) is an NSF sponsored international program designed to develop and utilize a network of gravity wave observatories using existing and new instrumentation operated at several established research stations around the continent. The primary goal is to better understand and quantify large-scale gravity wave climatology and their effects on the upper atmosphere over Antarctica. ANGWIN currently comprises research measurements from five nations (U.S., U.K., Australia, Japan, and Brazil) at seven international stations (see map). Utah State University's Atmospheric Imaging Lab operates all-sky infrared and CCD imagers and an Advanced Mesospheric Temperature Mapper (AMTM) imager at several research stations (Davis, Halley, Rothera, McMurdo, and South Pole). In this poster we present new measurements of short-period mesospheric gravity waves imaged from McMurdo Station (77°S, 166°E) on Ross Island. This camera has operated alongside the University of Colorado Fe Lidar during the past two winter seasons (March-September 2012, 2013). Here we present image results from the first year.

IR Imaging

Digital (CCD) imaging systems are regularly used to study gravity wave events in the Mesosphere and Lower Thermosphere (MLT) region (~80-100 km) using well-defined nighttime airglow emission layers (e.g. Taylor, et al., 1997). However, moonlight and other sources of light pollution (e.g. aurora, street lights, etc.) can significantly limit the use of CCD imagers which are sensitive to light in the visible and near-infrared spectral range (< 1 µm). Therefore we use new infrared imaging systems to help mitigate these problems and to enable more detailed studies at high latitudes. As part of ANGWIN program all-sky observations of the OH airglow in the (2.6-2.4 µm) band were made from McMurdo using an infrared (0.9-1.7 µm) cooled InGaAs camera.

The OH airglow emissions extend from approximately 0.4-4 µm. The infrared emissions as shown in blue in the above figure are much stronger in the infrared region (>1 µm) are used by InGaAs cameras and enable high-quality short-exposure (a few seconds) imaging of gravity waves under auroral observing conditions. For example the infrared OH (3.1) band at 1.55 µm is ~70 times brighter than the OH (6.2) band which is a prominent component of subsonic OH emission used for CCD measurements. Another major advantage of IR OH imaging is that the scattered moonlight spectrum is much weaker in the IR as shown in the right-hand figure.

Data Reduction Method

Raw images (a) were calibrated using the IR star field. The stars were then removed (b) and an average image known as a flat-field was created of the entire night and subtracted from the data images (c). The images were then unwrapped and mapped onto a 350 x 320 km geographic grid as shown in figure (d).

McMurdo Station (77° S)

All-sky image data were recorded every 10 s with a XX s exposure at McMurdo Station enabling detailed measurements of individual gravity wave events in the infrared OH emission region (~2.67 km). During the 2012 observing season (March-September, 365 nighttime hours) at McMurdo over 300 short period (< 1 hr) gravity wave events were observed. Gravity waves were analyzed using well developed Fourier analysis techniques to determine direction of propagation, horizontal wavelength, and observed horizontal phase speed. The gravity wave characteristics observed at McMurdo (blue) are contrasted with 3 years of wave measurements (1100 wave events) from other sites around the continent: Rothera station (67° S) in red, and Halley Station (76° S) in green.

Summary and Future Work

We have analyzed one year of data from date to date from McMurdo Station, Antarctica. The results are the following:

- A large number (300+) of short-period gravity waves observed over McMurdo, Antarctica enabling the climatology to be investigated.
- Similar magnitude horizontal wave characteristics (wavelength, phase speed) observed annually at each site although McMurdo does exhibit a large spread of phase speeds.
- The sources of the events observed from McMurdo are probably associated with strong weather systems outside Antarctica (over the Weddell and Ross Seas), with another source perhaps being the polar vortex.
- Dominant poleward wave propagation observed at Halley Station with strong year to year consistency. The source of the waves may be similar to those observed at McMurdo, from convection in the South Atlantic. Evidence for a rotation of the direction of propagation during the winter season (Nielsen, et al., 2009, 2012).
- Dominant westward wave propagation observed at Rothera Station with strong intra-annual consistency and no variation during the winter season shows signatures of mountain waves being created off of the Antarctic Peninsula.
- New measurements have recently been initiated from the South Pole Station and in combination with other ANGWIN sites will be used to investigate pan-Antarctic anisotropy and wave parameters.
- Ongoing analysis of McMurdo data from 2013 and soon to be available 2014 data will further clarify the anisometries in the wave propagation at this key site for understanding the climatology of gravity waves observed at McMurdo.

References


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