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Winter Climatology of Short-Period Polar Mesospheric Gravity Waves Observed Over Poker Flat Research Range, Alaska (65° N, 147° W)

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Introduction

Momentum deposition by short-period (<1 hr) gravity waves is known to play a major role in the global circulation in the mesosphere and lower thermosphere (MLT) region ~60−100 km (e.g. Fritts and Alexander, 2003). Observations of these waves over the Arctic Region are few and their impact on the Arctic MLT region is of high interest, but has yet to be determined. The Mesospheric Airglow Imaging and Dynamics (MAID) project was initiated in January 2011 to investigate short-period gravity wave dynamics over central Alaska. MAID is a collaborative project between Utah Valley University (UVU) (Principal Investigators: Negale and Nielsen), Utah State University (USU), and the University of Alaska, Fairbanks (UAF). The main goals of this project are to:

- Establish a long-term climatology of short-period gravity waves observed in the Arctic MLT region.

- Determine dominant source regions and potential sources of the observed waves.

- Investigate the impact of large-scale waves (tides and planetary waves) on the short-period wave field.

- Perform quantitative comparison between Arctic and Antarctic winter-time dynamics.

In this poster, we focus on quantifying the climatology of short-period gravity waves during two winter seasons (2011-2012) over central Alaska.

Critical Level Filtering

To investigate the eastward wave motion at PFRR we consider the effects of critical level filtering. Critical level filtering occurs when the intrinsic wave speed is less than or equal to the background wind in the direction of the wave. Most gravity waves are assumed to be tropospheric in origin and propagate up into the MLT region. If the intrinsic phase speed of the wave matches, or is less than, the wind speed in the direction of the wave, the wave will not be able to propagate up into the MLT region (Taylor et al., 1993). There were no observed gravity waves in the MAID imager data, indicating that they were not affected by critical level filtering.

PFRR 2011-2012 Results

Figure 3 summarizes the results of the image analysis in standard histogram plots of the geolocation of the gravity waves, latitude, longitude, and monthly averaged geophysical wave parameters.

Figure 1: Raw OI image containing wave structures. (b) Unwrapped rotated image with region of interest. (c) Unwrapped rotated image showing rotated peak corresponding to the observed wave event. Optical measurements of gravity waves in the Arctic MLT region are difficult to obtain due to limited observing conditions and the frequent presence of aurora which can overwhelm the faint gravity wave mesospheric structures as seen in Figure 1a. The MAID imager runs continuously during the winter months, and has yielded 1249 hours of data with 600 hours of clear sky and 279 hours of good wave events. Figure 2 summarizes the monthly distributions of our observations for 2011 and 2012.

The background star field was used to calibrate raw images. After calibration, the stars were removed and the image was transformed to uniformly spaced geographic coordinates (commonly known as unwarping), and mapped onto a 500 x 500 km geographic grid as shown in Figure 1b. Images obtained sequentially in time were used in the unambiguous 3-dimensional analysis (Coble et al., 1998; Gardner et al., 1996), which give the horizontal wave parameters as shown in Figure 1c.

PFRR 2011-2012 Results

Figure 3: Histogram plots showing combined 2011 and 2012 wavelet distributions of the observed wave parameters.

In this section we compare our results from PFRR (69°N) with other recent and ongoing high-latitude measurements of short-period gravity waves in the Arctic at: Resolute Bay (74°N) (Suzuki et al., 2006), Swavbard (78°N) (Dyrland et al., 2012), and ALOMAR (69°N). The relative locations of these high-latitude sites are indicated in Figure 5. Figure 6 illustrates the similarity of the wave characteristics, which are also similar to short-period events measured at mid- and low-latitude, indicating their global nature.

Figure 7 shows the comparisons of the observed wave directionality of the five high-latitude sites. The reported measurements at the comparison sites are all dominated by westward motion. In stark contrast, PFRR shows clear eastward propagation.

Summary so far...

- The reported westward wave propagation is attributed to critical level filtering of the upward propagating gravity waves by the background wind.

- Importantly, the PFRR eastward propagating waves exhibited relatively high phase speeds suggesting they were not restricted by the critical level filtering.

- Future work: Further investigation of these high speed events, their potential sources, and collaborative measurements with the Poker Flat Incoherent Scatter Radar to study their penetration into the lower thermosphere.

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