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MESOSPHERIC GRAVITY WAVES OBSERVED AT FERRAZ STATION (62° S) DURING 2010-2011

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Abstract: The upper atmosphere above the Sub-Antarctic Islands and Drake Passage is abundant in gravity waves from the troposphere up to the mesosphere. Satellite data and ground based instruments have demonstrated this high gravity wave activity in these regions. Since 2010 an all sky airglow imager has observed gravity waves through the OH NIR airglow emission (~87 km height) over Comandante Ferraz Antarctic Station (62° S) on King George Island. A new-generation meteor radar was installed on that site in 2010 and has been operated simultaneously with an OH airglow imager. The data set of airglow images from 2010 and 2011 is under analyses, and the results from 2010 showed similar characteristics for the waves reported in a campaign carried out in 2007. This work will present the observational results for the gravity waves observed in 2010 and 2011 above King George Island. These results are composed by the observational statistics for 2010 and 2011, and the observed wave parameters and the preferable propagation directions for the events observed during 2010.

Keywords: airglow, atmospheric gravity waves, wave characteristics

Introduction

The dynamics of the polar mesosphere and lower thermosphere (MLT) are dominated by waves with periods ranging from a few minutes to months (Hibbins *et al.*, 2007). Gravity waves are now recognized to play an important role in the general circulation of the middle atmosphere. Forcing by gravity waves causes reversals of the zonal mean jets and drives a mean meridional transport circulation that leads to a latitudinal temperature gradient opposite to that which would be expected in the absence of wave forcing (Fritts & Alexander, 2003). Espy *et al.* (2004) reported seasonal variations in the gravity wave momentum flux over Halley Station, Antarctica (75.6° S and 26.6° W). They used data from a sodium airglow imager and an Imaging Doppler Interferometer (IDI) radar for wind measurements. The authors showed a significant day-to-day variability in the momentum flux, with a strong westward momentum flux that turned eastward around the equinox. Nielsen *et al.* (2006) used an all-sky imager at Halley Station to show the first bore event observed at high latitudes. Bageston *et al.* (2009) presented the first airglow observations at Ferraz Station (62.1° S and 58.4° W) based on a full winter data set. They showed the wave parameters distribution and preferable propagation directions for the waves identified during the austral winter of 2007. Climatology of gravity waves above Halley Station was reported by Nielsen *et al.* (2009), using airglow data of two consecutive austral winters (2000 and 2001) and including local hourly winds and intrinsic wave parameters. This paper present results for two consecutive austral winters above Ferraz Station (62.1° S, 58.4° W), including example of wave events, statistics of the observations and the observed wave characteristics.

Materials and Methods

The data used in this work includes all-sky airglow images, from which it is possible to identify small and medium-scale waves in the upper mesosphere. The observed airglow emission is the hydroxyl in the near infrared spectrum (OH NIR, 715–930 nm), with emission peak around 87 km high. Small-scale gravity waves can be identified in Figure 1 in original all-sky images obtained in May 2010 and August 2011. The images are aligned N-S (top-bottom) and E-W (left-right) and boxes were drawn in order to identify an arbitrary region of wave activity since we can see wave activity over a large area in the images.

The methodology used to analyze airglow images and obtain the wave parameters was revised by Wrasse *et al.* (2007). They describe the main steps of the imaging pre-processing and spectral analysis used to obtain the wave parameters. The first stage is to align the top of the images with the geographic north, followed by the stars filtering from images in order to eliminate the spectral contamination at the high frequencies (Maekawa, 2000). The third step consists in mapping the image into the geographic coordinates, i.e, the images are corrected (unwarped) for the lens function calibration. The last stage of the imaging pre-processing is the application of a second order Butterworth filter (Bageston *et al.*, 2011). Previous to the wave analysis (spectral analysis), it is necessary to select one gravity wave event easily identified in a set of airglow images. Then, it is necessary to animate the images in order to recognize and select the interested region of the image where the event is appearing clearly. The last step in the wave analysis is the application of the bidimensional Fast Fourier Transform (FFT-2D) in the selected region which contains the wave event (Wrasse *et al.*, 2007; Bageston, 2010).

Results

The results already obtained are the observation statistics for 2010 and 2011, and observed wave parameters for the waves identified in 2010. The statistical results revealed that among 81 observed nights in 2010 we could identify wave events in 31 nights with a total of 74 wave events, while in 2011 we had observations during 123 nights and in 52 of them it was possible to identify 149 wave events. The difference in the observational statistics between the two years is mainly due to the time required for the installation of the meteor radar and the time spend for the installation of the airglow camera in 2010. Furthermore, the all-sky airglow camera started operating automatically only in May of 2010, while in 2011 the beginning of systematic observations was in March. We should emphasize that we had several technical problems in the automatic mode of data acquisition, causing a lower number of useful nights than would be expected considering the length of the austral winter and its long nights.

The observed characteristics for the waves identified in 2010 above Ferraz Station are presented in Figure 2. The horizontal wavelength, observed period and phase speed are in panels (a), (b) and (c), respectively. The intrinsic wave parameters will be estimated later, together with the results

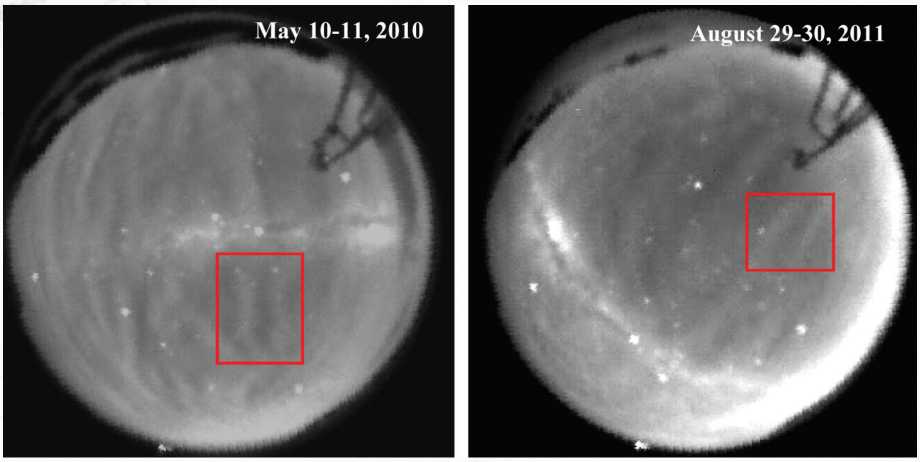

Figure 1. Examples of airglow images where it's possible to identify gravity wave activities.

of 2011 (now under analysis). The horizontal wavelengths were distributed from 10 to 60 km, with a maximum occurrence between 20 and 40 km. The observed periods were distributed from 5 up to 60 minutes, with a maximum occurrence between 5 and 15 minutes. The observed phase speed has a distribution that extends from 0 to higher than 70 m/s, and the majority of the waves had velocities between 10 and 40 m/s. The results presented in Figure 2 are very similar to the observations reported previously for Antarctic latitudes (Bageston *et al.*, 2009; Nielsen *et al.*, 2009), with slight differences in the phase speed distribution and basically the same characteristics regarding the horizontal wavelength and observed period.

Figure 3 shows the preferable propagation directions for the waves identified in 2010, and it is possible to identify anisotropy, with most of the waves propagating to the northwest. Also, a significant number of wave events are seen propagating to the south and southwest. The results on the propagation direction of gravity waves are mainly related with the location of the gravity wave sources and also to the winds filtering processes below the airglow emission layer.

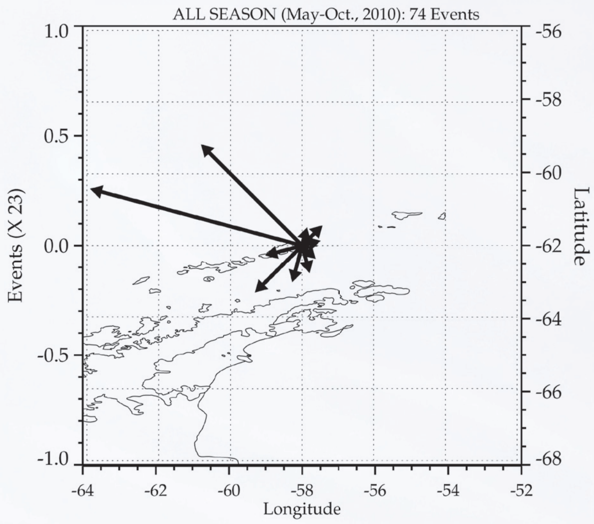

Figure 3. Propagation directions for the waves observed at Ferraz Station in 2010. It is possible to identify an anisotropy to the northwest.

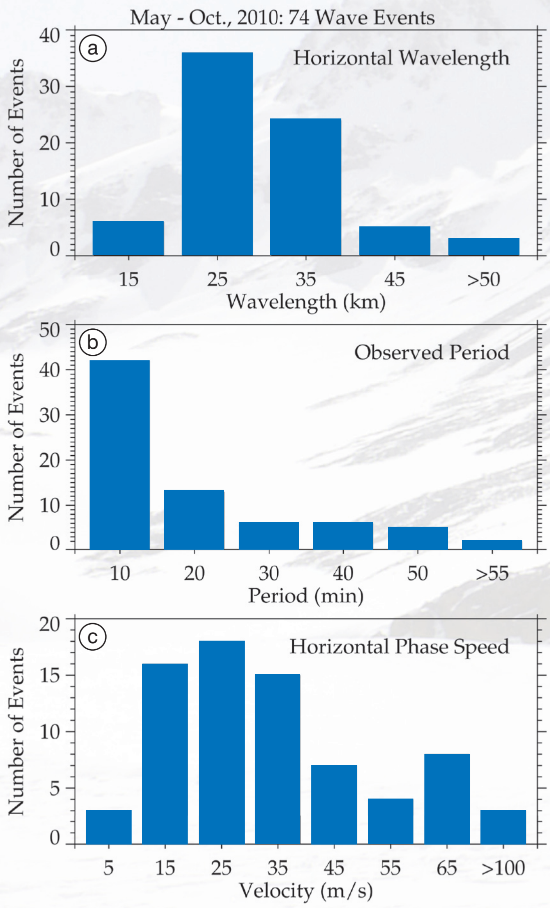

Figure 2. Histogram plots for 74 gravity wave events characterized above Ferraz Station in 2010. The panels show the distribution of (A) horizontal wavelength, (B) observed period and (C) observed phase speed.

Discussion and Conclusion

The present work showed the statistics and characteristics of the gravity waves observed at Comandante Ferraz Antarctic Station (62.1° S and 58.4° W) during the austral winters of 2010 and 2011. We presented the wave characteristics and propagation directions for the waves identified in 2010. These results are similar to previous observations in Ferraz Station and in other sites around the Antarctic continent.

The characteristics of the waves identified during 2011 are currently being analyzed, and the intrinsic wave parameters will be obtained for the full data set by using local mesospheric winds as obtained by a meteor radar. Future investigations will focus on gravity wave sources in the lower atmosphere through the reverse ray tracing model, which makes use of the observed wave parameters, mesospheric winds obtained by meteor radar and models, temperatures derived from satellite and reanalysis data, and meteorological satellite images.

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