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Intra-Annual Comparison of Mesospheric Gravity Waves Over Halley and Rothera Stations, Antarctica

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Introduction

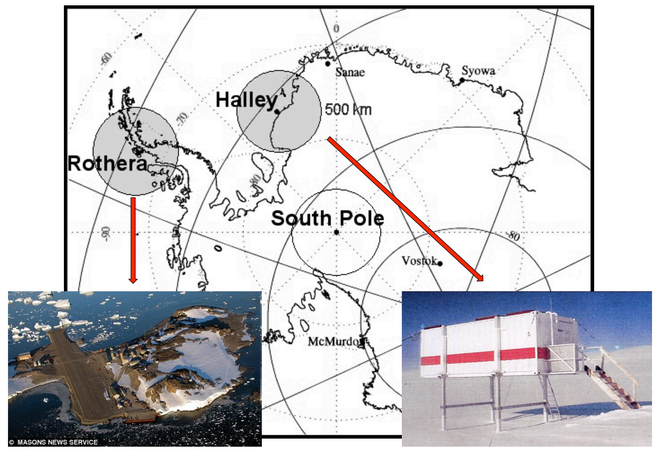
As part of a collaborative program between British Antarctic Survey and Utah State University, an all-sky CCD airglow imager has been operated at either Halley Station (76° S, 27° W) on the Brunt Ice Shelf, or Rothera Station (68°S, 68°W), situated on the Antarctic Peninsula since 2000. This study comprised the first detailed winter seasonal investigation of short-period mesospheric gravity waves at high-Antarctic latitudes. The primary goals were to:

•Determine the climatology of short period (<1 hour) gravity waves at high Antarctic latitudes.

•Compare high-latitude gravity wave morphology and dynamics.

•Investigate the nature of the observed gravity waves (vertically propagating or ducted).

To date, a total of six austral winter seasons have been analyzed (2000-2006) enabling a novel investigation of inter-annual variability in wave occurrence and properties. In this study we have analyzed the spatial and temporal properties of extensive wave events observed in the NIR OH emission (altitude ~87 km) obtained during this extended period. We present example wave data and seasonal summaries of their properties at both observing sites focusing on wave anisotropy and the strong year to year consistency.



Ariel view of Rothera Station

Camera Hut at Halley

Instrumentation and Data Analysis

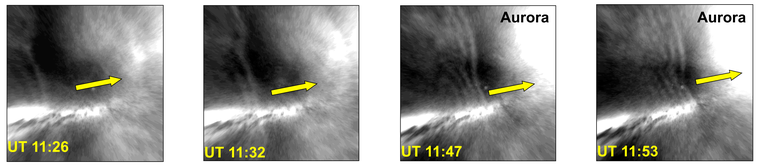
The same all-sky (180°) CCD imager was used for the measurements at Halley and Rothera alternating between sites every two-three years.

Images of several nightglow emissions were recorded. For this study we have used NIR OH emission bands (~710-950 nm, altitude ~87 km) image data recorded every 120 s with a 15 s exposure.

Gravity waves were analyzed using well developed Fourier analysis techniques and movies to determine direction of propagation, horizontal wavelength, observed horizontal phase speed, and observation period.

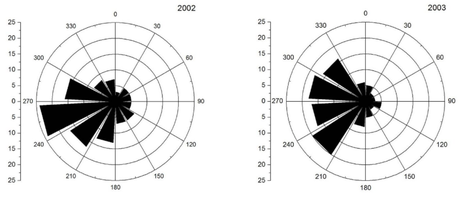
CCD Camera System

Rothera Station (67° S)



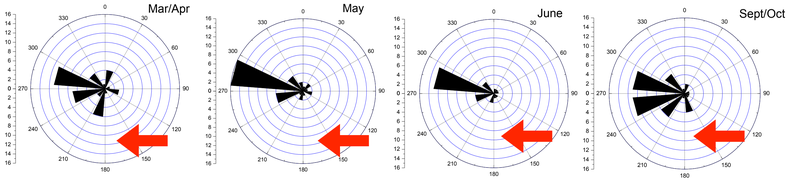
Instrument operated at Rothera Station from March to September in 2002, 2003, and 2004. Sequence of images showing a bore like event observed on June 25, 2004 with horizontal wavelength (λ) 34±1 km, phase speed 108±9 m/s and observed period 5.2 min.

Distributions of Wave Parameters During the 2006 Winter Season



Polar Plots Showing Distribution of Wave Headings: 2002-2004

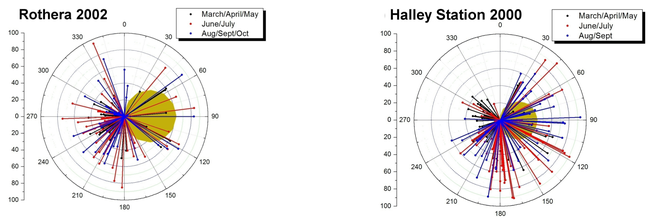
Note the strong and consistent westward wave motions observed during each year from Rothera.



Month by Month Variability In Wave Propagation Headings 2004

For each month the dominate wave propagation direction was westward. The same results were obtained during the 2002 and 2003 winter seasons.

Data Comparison



These plots illustrate different dominant directions from Rothera and Halley. The vectors show individual wave velocities while the shaded yellow area depicts expected regions of wave blocking due to background winds (Nielsen, 2006).

Results and Summary

❖We have analyzed six years of data to date from Halley and Rothera Stations, Antarctica. The results are the following:

❖A large number (1100+) of short-period gravity waves observed over Antarctica enabling the climatology to be investigated.

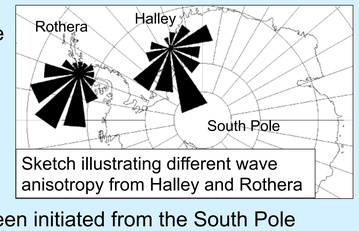
❖Similar magnitude horizontal wave characteristics (wavelength, speed and observed period) observed annually at each site.

❖Dominant poleward wave propagation observed at Halley Station with strong year to year consistency. Evidence for a rotation of the direction of propagation during the winter season.

❖Dominant westward wave propagation observed at Rothera Station with strong intra-annual consistency and no variation during the winter season.

❖The near absence of equatorward propagating waves from both sites indicates that high-latitude auroral sources are not dominate in our data.

❖Strong source regions for waves have been identified by satellites in the vicinity of the Antarctic Peninsula and may account for the observed dominant westward propagation observed over Rothera. However, the sources of the wave events observed from Halley are probably associated with strong weather systems over the South Atlantic Ocean.



Sketch illustrating different wave anisotropy from Halley and Rothera

❖New measurements have recently been initiated from the South Pole Station to investigate wave properties deep within the Antarctic continent.

References

Nielsen, K., Climatology and Case Studies of Mesospheric Gravity Waves Observed At High Latitudes, Ph.D. Dissertation, Utah State University, 2006.

Nielsen, K., Taylor, M.J., Hibbins R.E., and Jarvis, M.J., Climatology of short-period mesospheric gravity waves over Halley, Antarctica (76 S, 27 W), Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 71, June 2009

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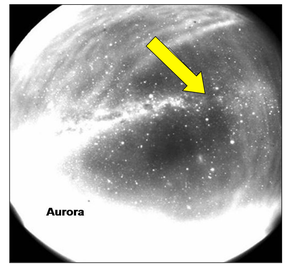
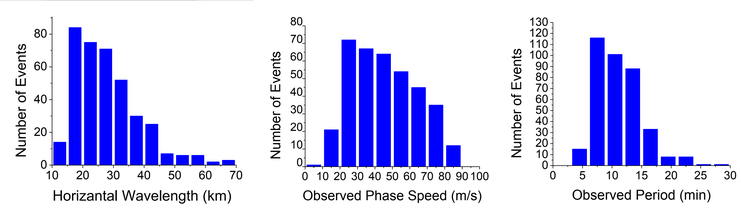
Halley Station (76° S)

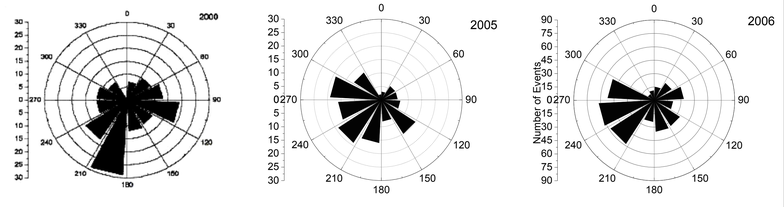


The CCD camera was installed initially at Halley Station and operated successfully from March to September in 2000 and 2001. Following measurements in Rothera it returned to Halley for further observations in 2005 and 2006.

This image shows a short-period gravity wave imaged over Halley in the OH emission on June 6, 2000. The arrow indicates the direction of wave motion. Also evident in the image is auroral activity (lower part of image).

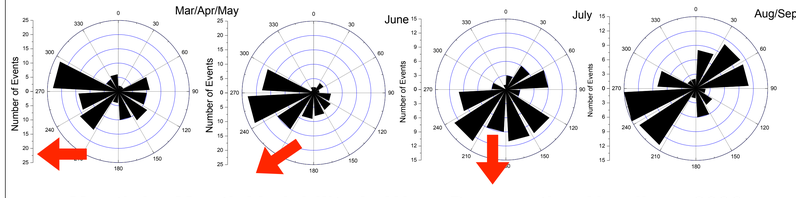


Distributions of Wave Parameters During the 2005 Winter Season



Polar Plots Showing Distribution of Wave Headings: 2000, 2005, 2006

Note the strong and consistent poleward wave motions observed during each year from Halley.



Month by Month Variability In Wave Propagation Headings 2006

A clear rotation from ~west during fall to dominant poleward during the mid-winter and then eastward during spring can be seen at Halley Station during the 2006 observation season.