6-23-2015

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Horizontal phase speed distribution of gravity waves observed in mesospheric temperature maps

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ABSTRACT

The goal of the current work is to develop a method suitable for analyzing the horizontal phase speeds of atmospheric gravity waves from an extensive amount of gravity wave data obtained by the USV Advanced Mesospheric Temperature Mapper (AMTM) from Logan, Utah and South Pole, Antarctica. AMTM is a novel infrared digital imaging system that measures selected emission lines in the mesospheric OH (3,1) band to create intensity and temperature maps of the mesosphere. This analysis builds on the recent work by Matsuda et al., (2014) using all based remote sensing temperature measurements in the atmosphere without material transport (Hines, 1960).

Image Pre-Processing

- AMTM provides high spectral sensitivity and high resolution temperature, but the image format is not immediately suitable for standard 2-D spectral analysis technique.

- To investigate the features of gravity waves motions, Matsuda et al. developed a new statistical method using all-sky intensity data to analyze the horizontal parameter of gravity waves for extensive amount of images with a much broader range of data-collecting times. In our analyses we applied this technique to process spectra from temperature maps with 120° field of view obtained from Logan, UT and South Pole, Antarctica.

- The only interested range of wavelengths (5-100 km) and periods (8-60 min) are selected and converted to average power spectrum to get horizontal distribution of gravity-waves phase-speed (~150 m/s). The following image shows the horizontal phase speed all over the night on May 30, 2013 for ~ 11 h.

Gravity Waves Analyses

- Gravity waves are known to be important drivers of mesospheric fluctuations throughout atmosphere (Hines, 1969). They couple momentum and energy upward from their source into middle and upper atmosphere without material transport (Fritts and Alexander, 2003). Energy is transported by group velocity \( v_g / \Omega \) which is perpendicular to \( \Omega \) and only high frequency, long vertical wavelength components penetrate to the highest altitudes (Mowbray and Rarity, 1967). However, due to wave growth in upper atmosphere, large amplitude waves can break and influence mean circulation (Nappo, 2013). The most important wavelengths involved in this transfer are from 5 and 100 km.

Results

- To investigate the features of gravity waves motions, Matsuda et al. developed a new statistical method using all-sky intensity data to analyze the horizontal parameter of gravity waves for extensive amount of images with a much broader range of data-collecting times. In our analyses we applied this technique to process spectra from temperature maps with 120° field of view obtained from Logan, UT and South Pole, Antarctica.

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Conclusion and future work

- We have analyzed AMTM temperature data from Logan, UT and South Pole, Antarctica in order to investigate phase-speed distribution of mesospheric gravity waves.

- Applying Matsuda et al. method, we have obtained the spectra corresponding to the gravity waves propagating over Logan, UT. The results were compared to intensity data and later to conventional event analysis in which the phase fronts are traced manually. This task was done when we were developing our IDL program to check the accuracy of the work.

- Existing result shows two main directions of propagations during the night of May 31, 2013, due to two small-scale gravity waves (5-10 km) traveling in different directions. Applying this method to big number of temperature maps from different sites can improve our understanding about gravity waves dynamics in middle and upper atmosphere region (global model).

- The limit for the current work is the program runs for clear-sky and aurora-free images. And we have used simple dispersion relation with no background wind given in Nappo, 2012 in order to 3-D FFT spectra to phase-speed.

- The future work will be to investigate the seasonal directionality of gravity waves propagation over a mid-latitude site (Logan) and an high-latitude site (South Pole).

- The energy transported by the gravity waves can also be assessed by this method and compared between the different sites/latitudes.

References


Acknowledgments and Contact info

I would like to acknowledge the support of Keith Taylor Fellowship for funding summer 2015 which supported me towards my research project. The Advanced Mesospheric Temperature Mapper was designed under the Air Force DURIP grant F49622-02-D-0286 and operated, through the NSF Grant No. 1042227, for the instrument located in Logan, and the OPP Grant Nos. 0542164 and 1143587, for the instrument running at the South Pole Station.

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