Atmospheric Gravity Waves in the Stratopause/Lower Mesosphere Region Using NASA AIM/ CIPS Observations

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(I) Abstract:

Atmospheric gravity waves are fluid waves generated when two media interact. Gravity becomes the restoring force, creating a wave pattern from the oscillations. Gravity waves (GWs) play a significant role in coupling the atmosphere, as they deposit momentum energy from their origin in the lower atmosphere to the middle and upper atmosphere [*Holton*, 1982, 1983]. The new release of the Rayleigh Albedo Anomaly (RAA) product from the CIPS instrument provides unprecedented high resolution data at the 50-55 km level which can be used to identify GW activity. By combining this new high resolution stratospheric data set with the already available AIRS GW products, GWs can be studied from their origin to the upper atmosphere.

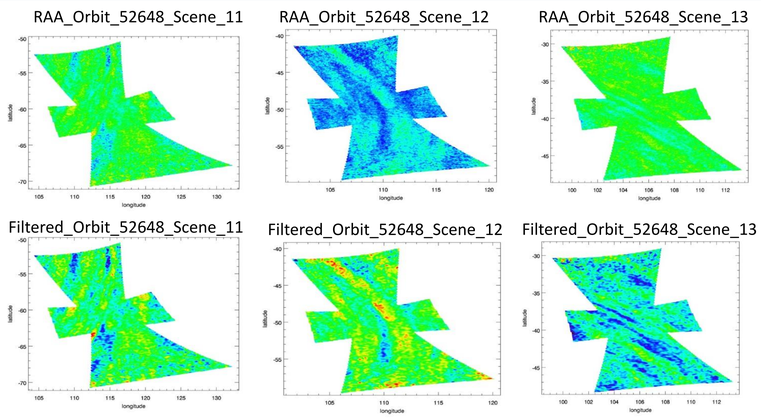
(II) AIM Overview:

The AIM satellite is a polar orbiting satellite designed to measure the composition of the mesosphere by studying the thermal, dynamical, and chemical composition of polar mesospheric clouds (PMCs). The science objective studied in this project focuses on gravity waves and their importance to climatology and long term atmospheric effects.

(III) CIPS RAA Dataset:

The CIPS instrument on the AIM satellite measures the Rayleigh Albedo Anomaly (RAA) which provides high resolution GW data at 50 – 55km by looking at variations in the Rayleigh albedo measurements. The instrument has an average effective spatial resolution varying from 7.5 km x 7.5 km(along the orbit track and across the orbit track respectively). Images are collected every 43 seconds, providing a direct view of Rayleigh scattering phase functions. Wavelengths 15-600 km can be measured by oscillations from the mean measurements of Rayleigh albedo. [*Randall et al*, 2017] - http://lasp.colorado.edu/aim/download-data-raa.php

(IV) Individual CIPS Images:



$RAA = 100(R_n - R_{base}) / R_{base}$
R_{base} = Baseline Albedo
R_n = Rayleigh Scattering Phase Function

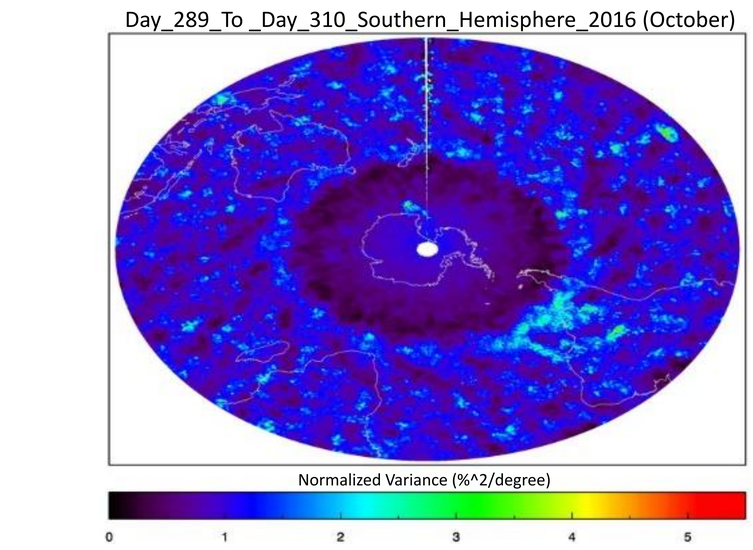
(V) CIPS FFT Filter:

An FFT filter was applied to the original CIPS images, reducing the noise and leaving the highest values of the signal. Each filtered scene is placed into 0.5 x 0.5 degree bin and the variance is calculated through the corresponding data to identify fluctuations in the values. Higher values of variance indicates larger deviations from the mean indicating changing values within the bins which correspond to waves. These images are located southwest of Australia, their binned variances can be seen in section IX

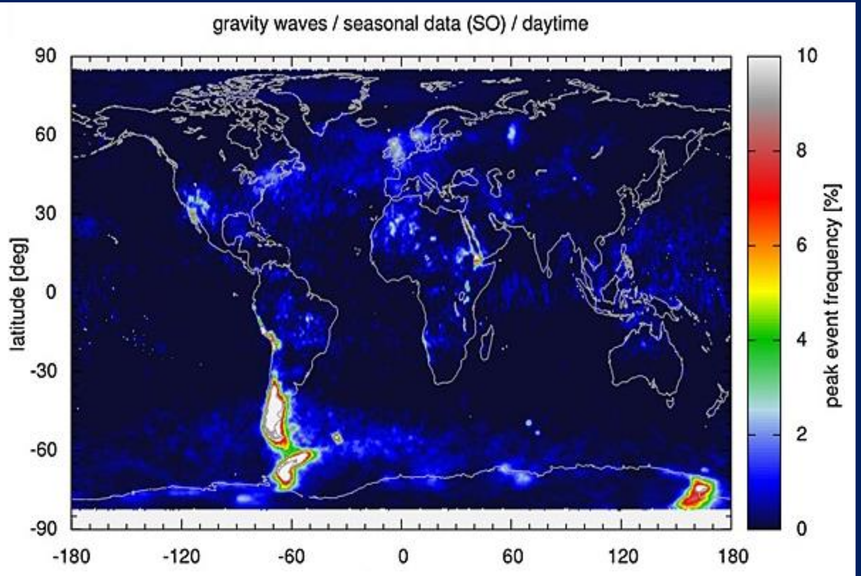
(VI) AIRS Dataset:

Data from the Atmospheric Infrared Sounder (AIRS) instrument on the NASA Aqua satellite will be used to obtain measurements of GW activity in the upper troposphere and lower stratosphere (UTLS). AIRS is a cross-track scanning infrared spectrometer which uses a cross track scan mirror to direct infrared energy from the Earth onto the instrument. The instrument measures the incoming infrared radiance in over 2143 different channels giving it exceptionally high spectral resolution. It scans roughly 800 km on either side of the ground track. Local brightness temperature values are sensitive to GW perturbations, particularly in the 4.3 micrometer CO_2 band. [*Hoffman and Alexander*, 2010]

(VII) 21 Day Variance CIPS Image:

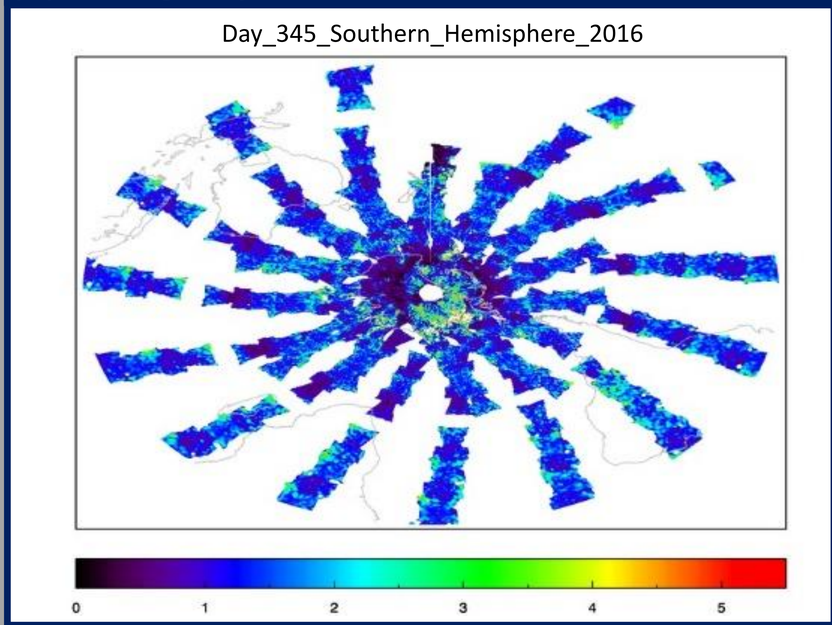


(VIII) September – October AIRS Gravity Wave Frequency:



[*Hoffman et al,* 2016]

(IX) CIPS Single Day Binned Variance:



(X) CIPS Single Day Highlights:

- Scattering from PMCs at 83 km interferes with the RAA retrieval and causes the high variance scene near the pole in the figure above
- Gravity wave activity southwest of Australia (seen in the individual CIPS images section) and East of the Andes are highlighted by increased variance in the images
- Regions of image overlap produce high variance when binned due to increased uncertainty

(XI) CIPS AIRS Wave Frequency Comparisons:

- CIPS has active regions east of the Andes in South America and off the coast of Antarctica similarly to AIRS.
- CIPS also captures several smaller “hot spots” near New Guinea and in the central Pacific corresponding to island GWs
- AIRS does appear to have more activity at its corresponding hotspots corresponding to a lower altitude and thus more frequent GW activity
- Variance can be used to indicate wave frequency and presence

(XII) Conclusions:

- The FFT filter properly increases the wave signatures in the CIPS dataset Variance indicates regions of gravity wave activity on a scene by scene and monthly basis.
- This work indicates a connection between active gravity wave regions near the tropopause and stratopause over a long scale timeline suggesting a connection between the two.

References

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