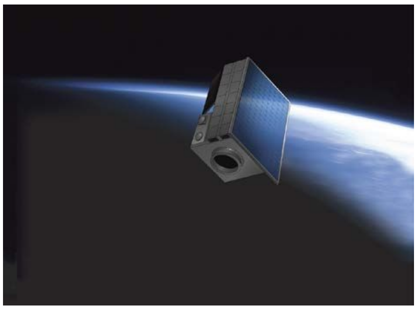
Master's thesis project in Global Environmental Measurements and Modelling

Atmospheric waves observed from space



The Swedish MATS satellite

A packet of gravity waves observed from the ground

What are atmospheric gravity waves?

Internal gravity waves naturally occur in both the ocean and the atmosphere. The name is given because gravity and the buoyancy force are paired as a restoring force acting on an air parcel, just like the action of a spring. These waves can be generated in the lower atmosphere, and, through transporting momentum from the ground upwards, influence wind speeds and the thermal structure of the upper atmosphere. However, there are large uncertainties in the global distribution of atmospheric waves and hence it will affect the accuracy of the weather and climate prediction.

What is the project about?

Sweden will launch the MATS satellite in 2019 to characterise wave activity on a global scale. As a part of preparatory work before the launch, we need to have a feeling for what we might see from MATS and how to interpret the wave information once we have the measurement data. The goal of the thesis project is to extend a monochromatic wave model to investigate propagation and spectra of wave packets in 3D. The simulated results can then be compared to measurements by current satellites. It is a perfect project for students who want to get into the middle atmospheric dynamics and earth observation. Furthermore, you will be involved in an ongoing Swedish space mission, with closely ties to the national and international research institutions.

Requirements:

Basic programming skills and a broad interest in atmospheric dynamics. Good linear algebra or fluid dynamic background are preferable.

Interested? Excited? Please contact us!!

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Thesis project plan

Research questions:

1. What kind of waves can survive in the mesosphere?
2. How does the background wind affect the wave pattern?
3. How does the wave transport energy?
4. What information can we get from MATS?

Primary goals:

- Extent the 3D monochromatic wave model to a <u>wave packet</u> model, to use in the simulation of airglow measurements from the MATS satellite
- Understand the propagation of atmospheric waves in the mesosphere
- Have a simple GW model at Chalmers/SU to use for analysis
- Provide updated knowledge on the field of GW research

Possible extensions:

- How to get quasi-momentum-flux from MATS
- Compare OSIRIS imager data (1D)
- Evanescent wave, wave reflection, ray theory
- Wave breaking, Kelvin Helmholtz instability
- Secondary waves

Main literature:

- An Introduction to Atmospheric Gravity Waves (Nappo 2012)
- Internal Gravity Waves (Sutherland 2010)
- Gravity Wave Dynamics and Effects in the Middle Atmosphere (Fritts 2003)
- Gravity wave propagation through a vertically and horizontally inhomogeneous background wind (Heale 2015)
- On the Interpretation of Gravity Wave Measurements by Ground-Based Lidars (Dörnbrack et. al 2017)

Suggested schedule:

According to the background and working pace of the student, time spent on each task might be adjusted. Follow up meetings will be arranged each week. Milestones are only defined for the first phase to begin with. The student should be involved in the planning of the second phase.

1. Literature study -- go through the wave theory and terminologies. Write some words down about GW in the atmosphere for the introduction part to the report. (1 week)

What are internal gravity waves? What are the phase velocities and the group velocities? What is the dispersion relation? Intrinsic frequency and doppler-shifted frequency? Stratified fluid? Statically stable atmosphere? Brunt-Väisälä frequency? Why gravity wave are important to study?

2. Implement 1D temperature perturbation from dispersion relation (Nappo 2012 chapter 2) (1 week)

3. Implement eq. 14 in Dörnbrack 2017 for temperature perturbations and reproduce figure 5 and 6 (1 week)

4. Extend to 3D with wind profiles (2 weeks)

5. Where is the critical level? Any reflection level? Reproduce Heale 2015 figures (1 week)

6. Implement density perturbations and calculate quasi-momentum-flux (1 - 2 weeks)

7. Write up report for phase 1 and give a seminar in the division (2 weeks)

8. Choose one of the extensions listed above or propose own idea and make a plan for the coming weeks (10 weeks)