Seminar: Group GW

Overview: Gravity waves in the upper mesosphere / lower thermosphere (UMLT)

Background

With the help of ground-based infrared spectrometers as they are operated within the Network for the Detection of Mesospheric Change (https:\\ndmc.dlr.de), the temperature of the UMLT can be measured every 10 – 15 s during (at least nearly) cloudless nights. This is achieved through the observation of a self-luminescent layer, the hydroxyl airglow, which is centered around 86 – 87 km height. The full-width at half maximum of the layer accounts for ca. 7 – 8 km.

The temperature at this height is determined by large and small-scale dynamical processes, so by the residual circulation and planetary waves as well as gravity waves and infrasound. Those are at least in parts generated by airflow over mountainous regions. The analysis of temperature time series allows conclusions to be drawn about the temporal variations of the aforementioned processes.

In the Alpine region, a number of identical infrared spectrometers, so called GRIPS (Ground based Infrared P-branch Spectrometer), is operated by DLR together with scientific cooperation partners. The fields of view of three GRIPS systems (GRIPS 6, GRIPS 7 and GRIPS 16) formed an equilateral triangle for about one and a half years and allowed the derivation of additional spatial information about gravity waves.

Research Questions

1. How does the yearly course of temperature in the UMLT look like and why?
2. Investigate GRIPS time series of two different night! Can you identify periods, which are typical for gravity waves? What can you say about the horizontal wavelength (please use the fact that the fields of view of the instruments formed an equilateral triangle)?
3. How can gravity waves be measured in the UMLT?

Database

Time series of the same night recorded by the three GRIPS instruments mentioned above are provided.

Methods

The three time-series are analyzed by "eye" and additionally by a Fast Fourier Transform. This analysis provides information about the periods and phases of the processes, which dominate the temperature during the respective night.

Topics for Presentations

- Gravity waves
- Airglow instruments

Group 2: Instruction for literature research for the presentations

Presentation 1: Gravity waves

1. What are they, why do they exist and what are their characteristic parameters?
2. Under which circumstances can the propagate vertically and why are they important?

Literature Presentation 1:

Andrews, D. G. (2000): An introduction to atmospheric physics. Cambridge University Press, 3. edition, Chapter "Further atmospheric fluid dynamics: Gravity waves"

Fritts, D. C., Alexander, M. J. (2003): Gravity wave dynamics and effects in the middle atmosphere. In: Reviews of geophysics, 41(1), https://doi.org/10.1029/2001RG000106

Nappo, C. J. (2013). An introduction to atmospheric gravity waves. Academic press. (Chapter 7.1-7.3 and 7.5)

Wüst S. (2022). Gravity waves. In: Bittner, M. (Editor). Science at the Environmental Research Station Schneefernerhaus / Zugspitze.

Presentation 2: Airglow instruments

1. How does the infrared spectrometer GRIPS work and what information does it deliver?
2. How does the instrument FAIM work and what information does it deliver?

Literature Presentation 2:

Schmidt, C., Höppner, K., Bittner, M. (2013): A ground-based spectrometer equipped with an InGaAs array for routine observations of OH(3-1) rotational temperatures in the mesopause region. In: Journal of Atmospheric and Solar-Terrestrial Physics, 102, 125-139, https://doi.org/10.1016/j.jastp.2013.05.001

Sedlak, R., Hannawald, P., Schmidt, C., Wüst, S., Bittner, M. (2016): High resolution observations of small scale gravity waves and turbulence features in the OH airglow layer. In: Atmospheric Measurement Techniques, 9, 5955-5963, https://doi.org/10.5194/amt-9-5955-2016

Hannawald, P., Schmidt, C., Wüst, S., Bittner, M. (2016): A fast SWIR imager for observations of transient features in OH airglow. In: Atmospheric Measurement Techniques, 9, 1461-1472, https://doi.org/10.5194/amt-9-1461-2016

Wüst, S., Bittner, M., Yee, J.-H., Mlynczak, M. G., Russell III, J. M. (2020): Variability of the Brunt-Väisälä frequency at the OH-airglow layer height at low and mid latitudes. In: Atmospheric Measurement Techniques, 13, 6067–6093, https://doi.org/10.5194/amt-13-6067-2020