The relationship of gravity wave and planetary wave activity in the mesopause – first investigations in the course of the VAO-project VoCaS-ALP

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Gravity Waves

Significant influence on large-scale circulations in the atmosphere

small-scale phenomena
• hard to observe
• poorly represented in climate models

Has the activity of gravity waves changed? If so, how and why?
Gravity wave activity of the previous decades?

Problem: long historical data sets have **too coarse resolution** for investigating gravity waves.

Dispersion relation

\[ m^2 \sim \frac{1}{(c - u)^2} \]

\( m \): vertical wavenumber
\( c \): horizontal phase speed

Gravity wave propagation dependent of **background wind** \( u \), which is modulated by planetary waves.

Activity of **planetary waves** can be calculated for the past few decades.

**Goal:** find mathematical expression for relationship between activity of **gravity waves** and **planetary waves**
Wind Filtering (Winter)

\[ m^2 \sim \frac{1}{(c-u)^2} \]
Wind Filtering (Summer)

\[ m^2 \sim \frac{1}{(c-u)^2} \]
Influence of Planetary Waves

Higher planetary wave activity:
- lower activity of fast gravity waves
- higher activity of slower gravity waves

OH* airglow ~ 87 km
VAO Stations

OPN: Oberpfaffenhofen
UFS: Schneefernerhaus
OHP: Haute-Provence
ABA: Abastumani
ALR: Alomar
SBO: Sonnblick
OTL: Otlica
How do gravity waves look in GRIPS data?

UFS Schneeefernerhaus, 21/22 Jan 2016
How do planetary waves look in GRIPS data?

- Sonnblick Observatorium
- Observatoire de Haute-Provence

Temperature / K

Feb 2018
Gravity Wave Potential Energy Density (PED)

\[ E_{pot} = \frac{1}{2} \frac{g^2}{N^2} \langle \dot{T}^2 \rangle \]

- \( g \): acceleration of gravity
- \( N \): Brunt-Väisälä frequency

see Wüst et al. (2016)

Long-periodic (> 60 min)
Short-periodic (< 60 min)
UFS: ERA zonal winds and gravity wave PED

Vertical Profile of Zonal Wind at 47.25° N, 11.25 °E (Close to UFS)

Height [km]


long-periodic PED derived from GRIPS 8, UFS

Zonal wind speed [m/s]

Eastward

Westward

- 50

0

50

100
UFS: Pearson Correlation between long-periodic potential energy density and zonal mean wind

Pearson Correlation Coefficient

65.6 km
35.7 km
21.4 km
10.9 km
4.5 km
0.9 km
VAO stations: Pearson Correlation between long-periodic potential energy density and zonal mean wind

Pearson Correlation Coefficient

- 0.9 km
- 4.5 km
- 10.9 km
- 21.4 km
- 35.7 km
- 65.6 km

Pearson Correlation Coefficient
VAO stations: Pearson Correlation between long-periodic potential energy density and zonal mean wind

Positive correlation in the stratosphere
  \(\rightarrow\) wind filtering, GW generation by wind shear

No correlation in the tropopause
  \(\rightarrow\) no contribution of tropospheric jet to wind filtering

Correlation in the boundary layer strongly dependent on location
OPN DPE vs. DAI (Planetary Wave Activity)
Influence of Planetary Waves

modulation of wind field

Higher planetary wave activity:

- lower activity of fast gravity waves
- higher activity of slower gravity waves

fast westward

fast eastward

$u, c$
Summary

Goal: find mathematical expression for relationship between activity of gravity waves and planetary waves

Anticorrelation of gravity wave and planetary wave activity as a basis

Gravity wave activity correlated with zonal mean wind in stratosphere and boundary layer

No contribution of tropospheric jet to wind filtering of gravity waves
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