Possible Mesosphere-Thermosphere-Ionosphere Coupling through the Modulation of Gravity Waves by Planetary Waves

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Introduction

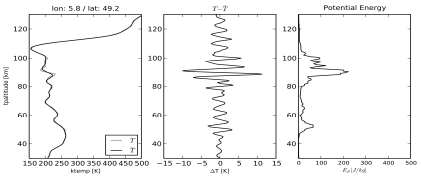
A possible connection of stratospheric planetary waves (PW) and ionospheric PW type oscillations (PWTO) at midlatitudes can only happen indirectly through processes such as the modulation of gravity waves (GW) by PW.

To investigate this possible coupling, information about GW are retrieved from SABER temperature profiles (30-130 km) by calculating the potential energy (Ep).

For the period of time from 2002-06 to 2008-08 proxies of stationary and traveling PW were calculated to obtain a general picture of PW, modulation of GW by PW, activity of ionospheric TID modulations and PWTO.

Data and Analysis Method

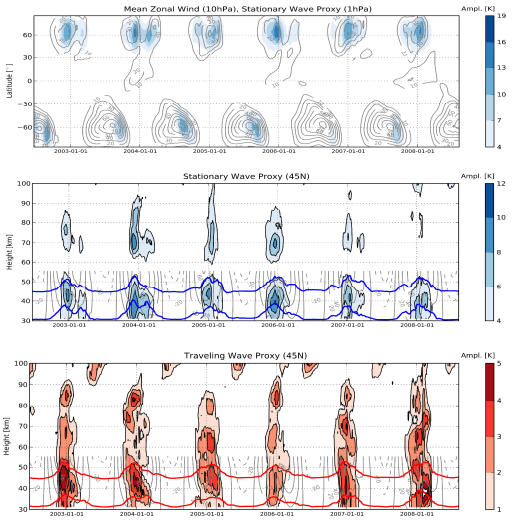
- Data: Latitude/Time: 45°N / 2002-2008
- Met Office reanalyses, SABER (L2A) temperature profiles, GPS-derived TEC-maps, European TID analyses from GPS TEC
- PW/PWTO analysis: Proxies of stationary and traveling PW



- Potential energy E_p as GW proxy, derived from SABER temperature profiles (30-130km)

Planetary Waves (Proxies)

1. define time windows of 48 days each , 3rd order polynomial detrending within the window
2. temporal standard deviation of parameter A: $\sigma_t(A)$ at each gridpoint
3. zonal mean $m_x(A)$ at each time
4. time series A-$m_x(A)$ at each grid point excludes vacillations
5. $m_x(\sigma_t(A\text{-}m_x(A))$ is a proxy for **traveling waves**
6. use zonal standard deviation of time mean $\sigma_x(m_t(A))$ as a proxy for **stationary waves**



Top panel: Mean wind (isolines) and proxy of stationary waves (color code); MetOffice
Middle panel: Proxy of stationary waves (isolines and blue lines), background wind (contours); MetO, SABER
Bottom panel: Proxy of traveling waves MetO, SABER

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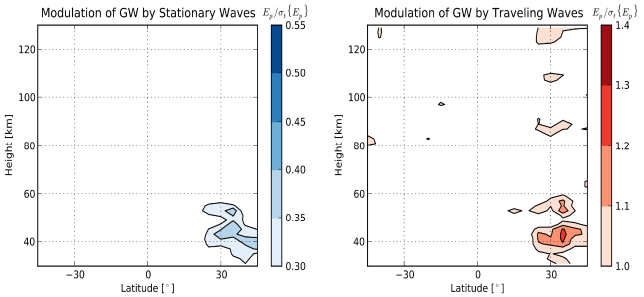
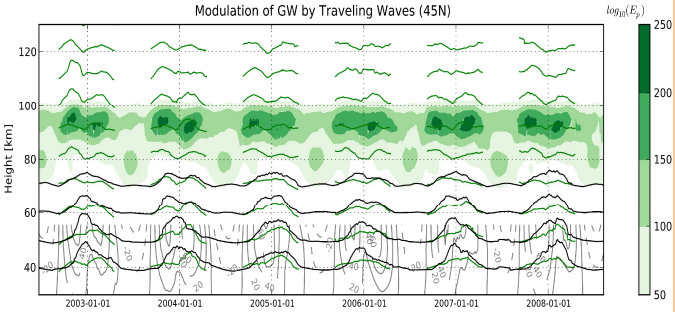
Modulation of GW by PW

Height-Latitude Section of GW Modulation (Dec-Jan 03/04)



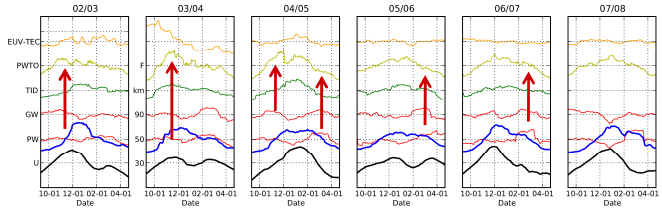
Modulation of GW by stationary waves (left)
Modulation of GW by traveling waves (right)



Background zonal winds (light gray isolines), GW potential energy (green color coding), proxy of traveling PW (solid black lines), modulation of GW by traveling waves (green lines)

Possible connection between PW and PWTO

Part of PWTO variability may be owing to solar variability at time scales of PW.



Zonal wind at 30km (black), traveling PW proxy at 40km (blue), GW traveling waves modulation proxy at 50 and 90km (red), TID modulation over Europe (green), traveling PWTO modulation proxy (yellow), and solar EUV-flux modulation (orange). Arrows denote joint maxima of GW modulation and PWTO.

EUV-TEC is an index that describes ionospheric primary ionisation. It is based on satellite EUV measurements.

Conclusions

Using proxies of stationary and traveling PW for analysing global stratospheric and ionospheric datasets we obtain a simplified picture of the seasonal variability of PW and PWTO as well as similarities between them.

The results indicate possible connections between PW and PWTO during winter. The same method applied to the potential energy of GW derived from temperature profiles (SABER/TIMED) reveals the modulation of GW by PW, which is considered as one of the potential processes, how signatures of PW can penetrate the lower thermosphere.

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