Planetary Wave Type Oscillations seen in ionospheric Total Electron Content

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Summary:
Planetary waves (PW) are responsible for a large part of the middle atmosphere dynamics. They are supposed to impact the thermosphere-ionosphere system, too. The aim of the CAWSES project CPW-TEC is to find evidence for a measurable influence of PW on the Total Electron Content (TEC) of the ionosphere.

Objectives:
The ionosphere is used as an indicator for thermospheric dynamics and density variations. Empirical PW analyses on ionospheric and stratospheric data as well as related modeling studies are used to trace the vertical propagation of PW energy.

Tools and data base:

Ionosphere:
Ray path geometry for the trans-ionospheric satellite signals. This shows the derivation of the vertical total electron content (TECv) from the slant TEC (TECs) (Jakowski, 1996).

Stratosphere:
Global fields of assimilation data (UK Met Office, NCEP/NCAR) are used for PW analyses in stratospheric heights.

Modeling:
MUAM global circulation model from the ground to the thermosphere to investigate wave propagation, and interaction with tides.

MUAM is able to enlighten upward PW penetration.

Correlation of stratospheric PW and ionospheric PWTO:
The comparison between the wavelet amplitude spectra of the westward propagating waves with wavenumber 1 in the zonal wind at 1hPa (UKMO, upper panel) and the DTEC (lower panel) show a similar appearance in time and scale of the middle atmospheric and ionospheric waves.

Zonal mean variations are mainly driven by the solar influence

The mean spectra of the propagating PWTO found in the differential TEC during 2002-2006 display a dominance of the westward-propagating waves with wavenumber 1. The strongest amplitudes occur during winter (upper left panel), while their activity is low during summer (lower left panel).

The comparison of the periods found in DTEC during 2002-2006 with periodicities observed in solar and geomagnetic indices reveals a certain coherency especially during summer.

Conclusion:
The variability of solar flux as well as ionospheric and geomagnetic storms were found to be the main drivers of PWTO in the middle atmosphere. The dominance of the solar influence makes it difficult to extract the probable influence of middle atmosphere PW in the ionosphere. Nevertheless, the signatures of the propagating PWTO reveal a behavior like the middle atmosphere PW. A coherency between the propagating middle atmosphere PW and ionospheric PWTO is a reasonable hypothesis, but could not yet be explained by modeling studies.

Further investigation of the mechanisms transporting the PW energy into the ionosphere is necessary. A possible mechanism to produce PWTO in the ionosphere is the modulation of gravity waves, tides, and shorter-period PW by longer-period PW. These fast waves may be able to penetrate into the thermosphere.

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Diagram:

Modeling using MUAM:
Modeling results indicate a possible upward penetration of the ultra-fast Kelvin and Rossby-gravity waves into the ionosphere at low latitudes, but could not explain the PWTO found at high latitudes.

Geopotential height amplitudes of the Normal mode (NM) and ultra fast (UF) Kelvin waves.

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