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Gravity Wave Detection Methodology Using Dynasonde Data

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The importance of gravity waves to ionospheric and thermospheric dynamics is a well known fact. While the phenomena is being studied by a variety of methods, actual measurements are rather sparse and include only certain parameters of the gravity wave field. We propose an analysis methodology based on VIPIR/Dynasonde system measurements processed with the NeXtYZ inversion algorithm. By simultaneously determining the plasma density and plasma density gradients within the station's field of view, we can infer both the temporal and spatial characteristics of gravity waves. This is done over a wide range of ionospheric altitudes, starting where the plasma frequency exceeds the minimum frequency used by the sounder, typically 1.8 MHz, and below the altitude of the F2 layer peak, the hmF2. The stations' ability to operate continuously also allows us to obtain extremely long time series. The raw electron density is processed using an automated detrending procedure to extract perturbations due to gravity waves. The resulting time series show Traveling Ionospheric Disturbances (TID's) clearly caused by gravity wave propagation. The corresponding perturbations are visible in the plasma gradient and tilt data without the need of any detrending. We can then observe the predominant wave activity and its characteristic frequencies by using very large time series and Fourier Analysis. A complimentary approach is to track changes in wave activity over shorter time scales using a sliding window approach. We complete the characterization of TID's by calculating the wavevector components. This is performed in the spectral domain, giving us the wavelength and direction of propagation for each mode independent of all others. To support our claim that the observed TID's are caused by gravity waves, we observe the wavelength to frequency correspondence and compare it to the theoretical dispersion relation. All the methods described above operate autonomously and have been tested to be very robust when confronted with different data sets. Finally, we implemented a ionosphere-to-thermosphere transfer function to obtain the original gravity wave amplitude from the determined TID amplitude. This is done both in a simplified manner, considering a basic coupling mechanism and in a more complex way, taking into account chemistry via a numerical thermospheric model.