Monthly Climatology of Thermospheric Neutral Winds Obtained from COSMIC Radio Occultation Measurements

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ABSTRACT

Radio Occultation (RO) data from the six Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) satellites provide an invaluable source of information about the ionosphere/thermosphere system. A new method has been developed to use these data to estimate the monthly climatology of the zonal and meridional components of the thermospheric neutral wind at low and middle latitudes. The method is based on using a Kalman filter technique. First, the climatology of the magnetic meridional wind is obtained by assimilating seasonal maps of F region ionosphere peak parameters (NmF2 and hmF2), obtained from COSMIC radio occultation data, into the Global Assimilation of Ionospheric Measurements Full Physics (GAIM-FP) model. GAIM-FP provides the 3-D electron density throughout the ionosphere, together with the magnetic meridional wind. Next, the global zonal and meridional wind components are estimated using a newly developed Thermospheric Wind Assimilation Model (TWAM). TWAM combines the magnetic meridional wind data obtained from the assimilation of the COSMIC RO data into GAIM-FP with a physics-based 3-D thermospheric neutral wind model using an implicit Kalman filter technique. Ionospheric drag and ion diffusion velocities, needed for the wind calculation, are also taken from GAIM-FP. We present an overview of the method of our wind estimation from COSMIC RO observations and compare individual horizontal wind components to their corresponding empirical model values and to measurements made by interferometers.

Key words: COSMIC Radio Occultation, Ionosphere, Thermosphere, Neutral Wind, Data Assimilation.

Basic Approach:
In our approach, the estimation of the zonal and meridional components of the thermospheric winds is based on COSMIC radio occultation data and requires two separate steps (see Figure 1). In the first step COSMIC monthly mean NmF2 and hmF2 maps are assimilated into the GAIM-

FP model [1] to specify the low- and mid-latitude electron density distribution as well as the monthly magnetic meridional wind climatology. In the second step the GAIM-FP magnetic meridional wind data (together with the use of the 3-D electron density and ion diffusion velocity also obtained from GAIM-FP) are assimilate into a new physics-based Thermospheric Wind Assimilation Model (TWAM) [2, 3]. The output of TWAM are the estimated geographic zonal and meridional components of the thermospheric wind. TWAM combines the magnetic meridional wind data from GAIM-FP with a physics-based 3-D thermospheric neutral wind model using an implicit Kalman filter technique. The use of a physics-based wind model together with a data assimilation technique in TWAM helps to minimize the model errors in a dynamically consistent way. The estimated winds should be understood as climatological values given the average nature of the assimilated GAIM-FP magnetic meridional wind data, which themselves are derived using average ionospheric data from COSMIC.

An example of the low- and mid-latitude magnetic meridional winds at 250 km altitude derived from the COSMIC radio occultation data is shown in Figure 2. Values are shown for January, March, May, July, September and November conditions and correspond to 1300 UT. Positive values indicate northward flow. The obtained wind pattern agrees well with its established characteristics, i.e., the wind is equatorward during the night and poleward during the day. The wind speed is up to about 150 m/s and the flow is predominantly from the summer to the winter hemisphere during the solstices and more symmetric about the geographic equator during the equinox.

Summary:

We will present an overview of our thermospheric wind estimation based on COSMIC radio occultation data. The estimated wind represents monthly climatology and includes the meridional and zonal wind components. The estimated wind is found to be in good agreement with independent observations obtained by Fabry-Perot Interferometers (FPI) at Millstone Hill, Arecibo, and Arequipa spanning the latitude range from equatorial to mid-latitudes.

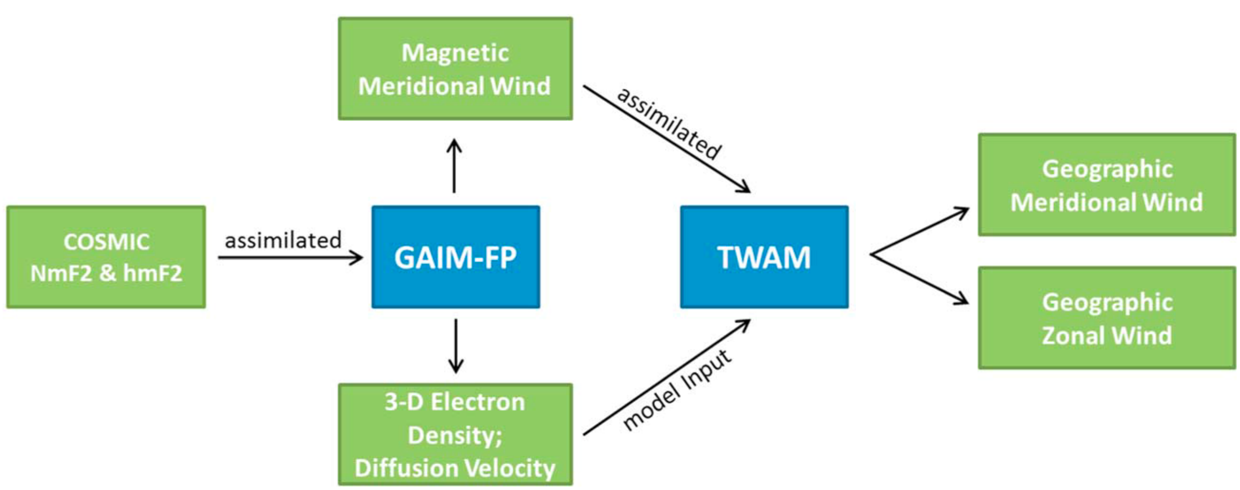

Figure 1. Schematic view of TWAM horizontal wind component estimation [3].

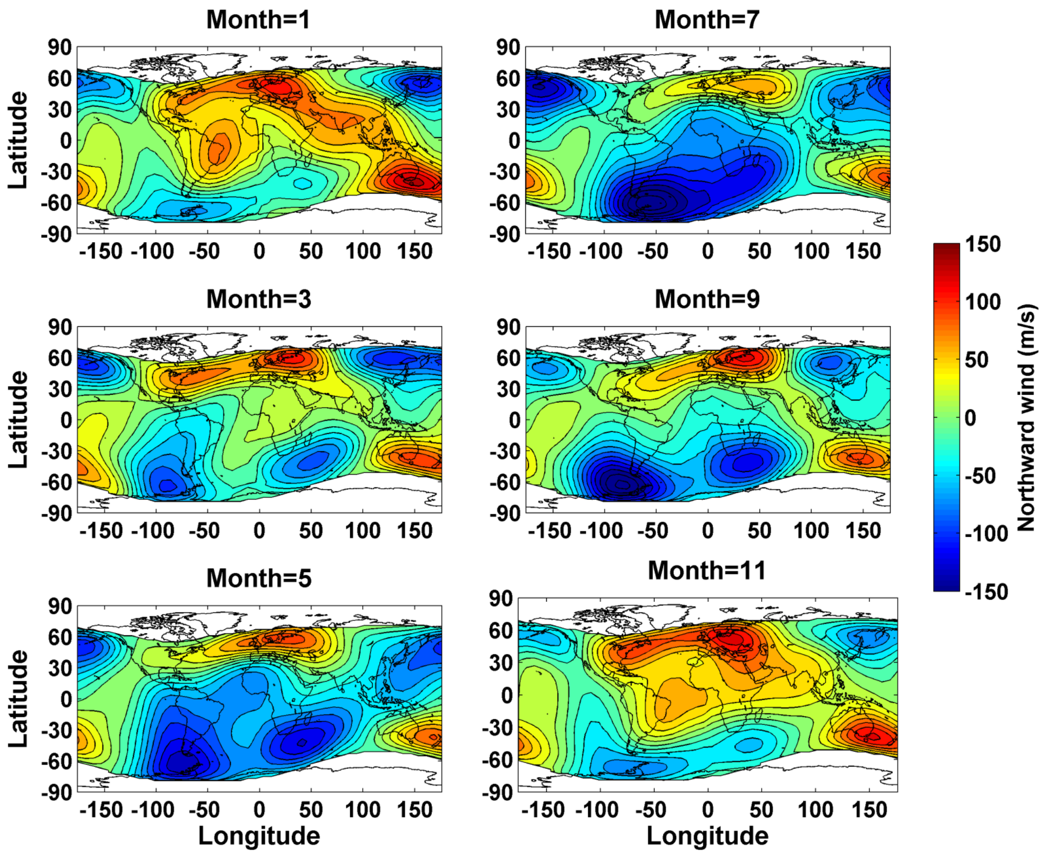

Figure 2. Low- and mid-latitude magnetic meridional winds at 250 km altitude derived from COSMIC radio occultation data. Values are shown for January, March, May, July, September and November conditions and correspond to 1300 UT. Positive values indicate northward flow.

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