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Real-Time Global Ionospheric Weather Monitoring by GIRO and IGS

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ABSTRACT

Real-time 3D specification of the Earth's ionosphere is a challenging task, given the dilemma of data availability in real-time. In foreseeable future, space-borne sensors will continue to be scarce and late in delivering data to the ground for their timely analysis. To date, rapid monitoring of the ionospheric dynamics relies on assimilation of data streams from the ground-based networks of observatories. Two major contributors to the task are (1) GNSS receiver network providing total ionospheric content (TEC) of plasma in the ionosphere and plasmasphere/polar cap up to ~20,000 km of the GNSS spacecraft altitude and (2) network of high frequency (HF) ionosondes monitoring plasma distribution in the sub-peak ionosphere. In particular, IGS real-time service (RTS) with 200 contributing GNSS receivers (http://www.igs.org/) and Global Ionospheric Radio Observatory (GIRO, http://giro.uml.edu) with its 50 contributing ionosondes are both capable of sub-minute latency in data acquisition and delivery to a central node for immediate assimilation. The ultra-rapid TEC specification recently became possible at IGS RTS, featuring 15 minute cadence and 15 minute latency; in 2013, the IRI-based Real-Time Assimilative Modeling (IRTAM) project began publishing global maps of the peak density NmF2 and height hmF2 in the ionosphere with a 15 minute cadence and a 7 minute delay from the real time. Two data resources are complementary in their capability to bring an intuitive, immediate insight in the ionospheric weather. The IRTAM portal at http://ulcar.uml.edu/IRTAM publishes deviation maps of the real-time peak density and height vs their empirical climatology to reflect unusual sub-peak plasma production, loss, horizontal transport, and vertical restructuring. High spatial

resolution of the TEC maps allows to fill the IRTAM gaps in GIRO coverage and sense plasma variability above the peak. In combination of TEC and NmF2, the plasma slab thickness τ is computed to provide approximate knowledge of the altitude distribution; efforts are underway to assimilate the F2 layer bottomside half-thickness, B0, and then obtain the half-thickness of the plasma above the peak. For illustration, we present timelines of the global ionospheric specification using IGS and GIRO cooperative monitoring during one of the most remarkable event in the latest solar cycle, the substorm of March 17, 2015. Practical questions of building and interpreting real-time weather maps of TEC, NmF2, hmF2, τ and B0 are discussed.

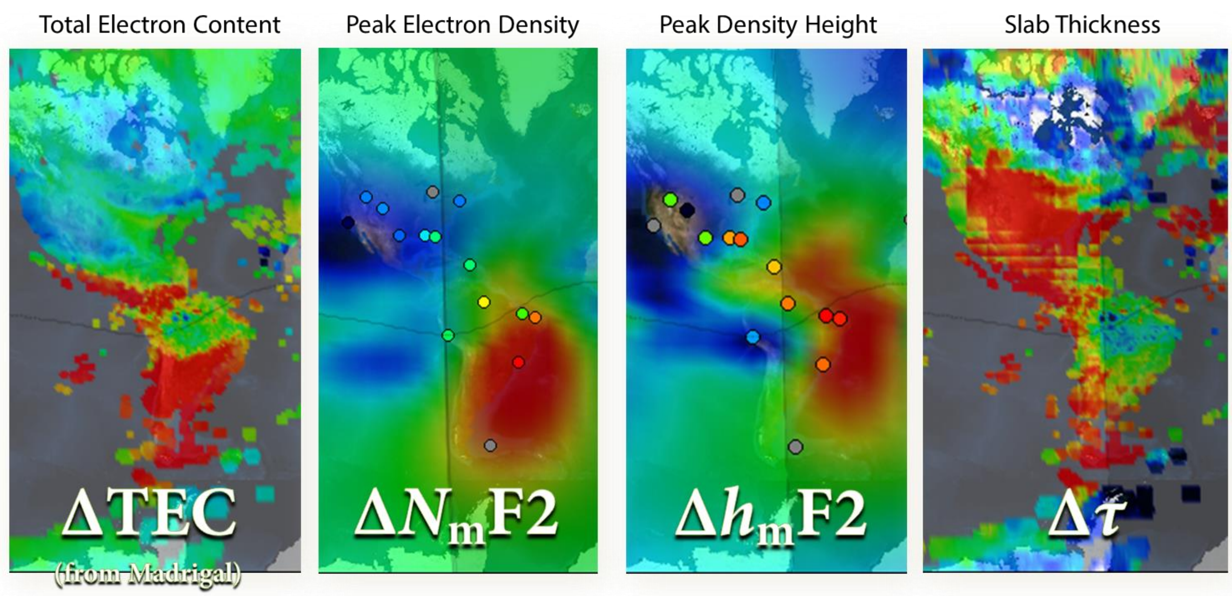

Figure 1. TEC, peak density, peak density height and slab thickness deviations from expected behaviour during quiet time, acquired by cooperation between IGS and GIRO

Key words: International Reference Ionosphere (IRI), Global Ionospheric Radio Observatory (GIRO), International GNSS Service (IGS), Total Electron Content (TEC), slab thickness