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A Comparison of GPS-derived TEC and foF2 over Japan

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The total electron content (TEC) is an important parameters in the study of the ionospheric properties. As a dispersive medium to Global Positioning System (GPS), the ionosphere causes group delay to the radio wave propagation from GPS satellites to ground-based receivers. Since the

satellites are in an orbit at an altitude of about 20,200 km, the long ray path through the tenuous hydrogen-based plasma of the plasmasphere also contributes to the group delay. The GPS-derived TEC involves electron in the plasmasphere. Comparison of GPS-derived TEC and foF2 has both theoretical and

practical meanings. It will help us to understand the coupling process between the ionosphere and the plasmasphere, and enable us to gain an insight into characteristics of the plasmaphere during ionospheric disturbed conditions. In practical, it will help to develop a better model for

single-frequency GPS receiver in navigation uses, and hence higher accuracy of the positional estimate.

This study tries to look for the characteristic pattern of the coupling

process between the ionosphere and the plasmasphere with comparison of GPS-derived TEC and foF2. The GPS data was downloaded from GPS Earth Observation Network (GEONET) of Geographical Survey Institute, Japan. About 200 stations are used in the study, which have precise code pseudoranges (P1 and P2) at both frequencies. The differenced pseudoranges, P2-P1, and the differenced phases, L1-L2, are used to obtain slant path

TECsl between the satellite and receiver. In order to estimate absolute vertical TEC from TECsl, the ionosphere over Japan is assumed to be a thin screen at a height of 400 km and partitioned into 32 meshes that are 2o in

longitude by 2o in latitude. For those slant path TECsl that go through the same mesh, their vertical TECs are assumed to be identical. Then with 28 satellites and 200 receivers, using observations with 15 minutes

interval, the absolute TECs at different meshes for one day are derived by

solving a set of equations with about 2,600 unknowns by about 35,000 equations with least squares fitting technique, and the biases intrinsic to satellites and receivers are estimated at the same time.

With the procedure described above, TECs are obtained over Japan for both ionospheric quiet and disturbed days. Then TEC comparisons are made with foF2 observations at several ionosonde stations distributed from Okinawa (27o N) to Wakkanai (45o N).

For ionospheric quiet times, it is found that the ratio of TEC to the square of foF2 increases by 20% for about 2 hours around the sunset, and decreases by 20% for about 2 hours around the sunrise. The ratio is constant for other times. It implies that after the sunset, the ionization ceases in the ionosphere, the hydrogen plasma in the plasmasphere return to lower altitudes, where charge exchange forms an oxygen plasma that maintain the nighttime F region. It takes about 2 hours to reach the equilibrium state. On the other hand, after sunrise, the solar-produced oxygen plasma in the ionosphere begins to refill the plasmasphere by moving upward along the

magnetic field lines. Charge exchange of the oxygen ions with neutral hydrogen gives a hydrogen-dominated plasma above 1000 km. It also takes about 2 hours for the refilling process reaching the equilibrium state.

The behavior of the ionospheric storms over Japan will also be discussed by

comparison of TEC with foF2.