Geophysical Research Abstracts
Vol. 14, EGU2012-13511, 2012
EGU General Assembly 2012

Use of the Hualien, Taiwan, dynasonde for surveillance of HF environmental radio and positioning of transmitting stations

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Since 2010, a 2nd generation NOAA HF radars, also referred as dynasonde, has been built at Hualien (23.89 N, 121.55 E), Taiwan. The Hualien dynasonde has a new design of ionospheric radar of fully digitizing the complex signal records and using multiple parallel receiver channels for simultaneous measurements of signals from multiple spaced receiving antennas. The Hualien dynasonde utilizes interferometric sounding pulse patterns and a receiving antenna array (including eight receivers connected to different spaced dipole antennas) to receive not only ionospherical echoes but also environmental radio signals. We have applied the Hermite normal form method to solve the phase-measurement aliasing and least squares problem and improve measurements of radio angles of arrival (AOA). The further ray-tracing experiments can be used for the study of radio wave propagation in the ionosphere. In this study we present a numerical and step by step ray-tracing method on a phenomenological ionospheric electron density model, the TaiWan Ionospheric Model (TWIM), which is constructed from the FormoSat3 / Constellation Observing System for Meteorology, Ionosphere and Climate (FS3/COSMIC) ionospheric radio occultation data and global ionosonde foF2 data. The three-dimensional TWIM consists of vertically-fitted α-Chapman-type layers, with distinct F2, F1, E, and D layers, for which the layer parameters such as peak density, peak density height, and scale height are represented by surface spherical harmonics. This way the continuity of Ne and its derivatives is maintained. The methodology is successfully applied to a practical HF transmitter for oblique incidence ray tracing. Then, the AOA data will be used for backward ray tracing in the TWIM model and be used to determine ground-based transmitting station position.