EVALUATION OF IONOSPHERIC CORRECTION METHODS FOR THE EUROPEAN VLBI NETWORK

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The Earth\'s ionosphere introduces delays (group delay, delay rate, etc.), Faraday rotation, and refraction effects to radio waves propagating through this medium. These effects are geographically, directionally, and temporally variable as long-term climatology, diurnal cycles, and short-term space weather modify the electron content of the Earth\'s ionosphere. With antenna locations widely distributed around the globe, determining ionospheric corrections for long-baseline interferometric observations of astronomical sources at long wavelengths presents a significant challenge. The behavior of the ionosphere over each antenna is essentially independent, so the delays are different for each antenna. Observations are necessarily made at all times of the day and night, sunrise and sunset, and in order to achieve maximum baseline separations sources are routinely observed at very low elevations. Left uncorrected, ionospheric effects reduce the coherence of interferometric observations and introduce distortions in images.

The European VLBI Network (EVN) is a particularly sensitive instrument for low-frequency radio observations. Weak source strengths, steep or unknown spectral indices, and limited receiver capabilities normally preclude the use of multi-frequency observations (for example, S/X-band observations) to remove the effects of the ionosphere for astronomical observations. The greatest number of EVN observations are made in L-band, and phase referencing techniques are employed to observe sources which are too faint to have fringes detected directly. Correcting for the variable delays introduced by the ionosphere in order to increase the coherence time is crucial for detecting weak emission and enabling self-calibration for modestly-weak sources to improve image quality.

As part of the Advanced Long Baseline User Software (ALBUS) project funded by the EU through the RadioNet consortium, we are evaluating and implementing several algorithms to apply different ionospheric correction methods to very long baseline (VLBI) data. We are focusing on methods to predict the effective total electron content (TEC) along the observed slant paths for each VLBI antenna. The TEC values will in turn, be used to predict the path delays for individual frequency channels. These predictive methods will include estimates based on dual-frequency GPS measurements of the ionospheric delay from GPS receiver stations co-located with VLBI antennas as well as nearby GPS station measurements (from networks such as EUREF). We will also exercise empirical and semi-empirical ionospheric models such as the International Reference Ionosphere (IRI) model and the Parameterized Ionospheric Model (PIM). Two-dimensional global ionospheric electron content models, such as the global TEC files produced by CODE, ESOC, JPL, and so on (the IONEX files currently used for ionospheric corrections in the AIPS task TECOR) and three-dimensional models such as Fusion Numerics\' numerical ionospheric forecasting system will also be included for analysis. Furthermore, local GPS station measurements will be combined with the global models to attempt to resolve small-scale structure in the ionosphere.

We plan comparison tests for the predicted slant TEC values from these various data sources for actual EVN observations. The amount of coherence gain provided by the different correction methods will be evaluated for for different observing times, elevations, and phase referencing configurations.