Ionospheric Measurements from the VLA Low-frequency Sky Survey

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Abstract

The VLA Low-frequency Sky Survey (VLSS[1]) is a nearly complete 74 MHz (4-meter wavelength) survey of the entire sky visible to the Very Large Array (VLA) telescope near Socorro, New Mexico, USA. Astronomical imaging at such a low frequency at the survey resolution of $80''$ (4×10^{-4} rad) has only recently become practical with the development of a new series of algorithms for removing ionospheric distortions. Ionospheric distortions have traditionally hampered long-wavelength astronomy because of the need to track and mitigate ionospheric density fluctuations at the milliTECu level. Calibrating the ionosphere for the more than 500 hours of survey observations produced a set of ionospheric measurements large enough for meaningful statistics to be derived. Specifically, we have measured the median differential refraction of pairs of celestial emitters as a function of their angular separation. This measurement probes variations in the gradient of the total electron content (TEC) to $\sim 10^{-3}$TECu/km accuracy over spatial scales of under 10km to over 100km. We analyze how median differential refraction changes depending on time of day and elevation above the horizon. We find that elevation effects are large, but primarily geometric and predictable. We find a strong dependence on time of day, with up to three times greater median differential refraction during the day than at night. Daytime increases in median differential refraction appear to affect the larger angular scales to a relatively greater degree indicating that they are caused by disturbances on larger spatial scales. Implications for the next generation of low-frequency telescopes such as the Long Wavelength Array (LWA), Low Frequency Array (LOFAR) and the Murchison Widefield Array (MWA) will be discussed.

[1] `html://lwa.nrl.navy.mil/VLSS`