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IONOSPHERIC STUDIES USING MWA AND LOFAR OBSERVATIONS

María J. Rioja * (1,2,3), Richard Dodson(1), Thomas Franzen(4) and George Heald(2)
(1) ICRAR, University of Western Australia, Perth Australia
(2) CSIRO Astronomy and Space Science, 26 Dick Perry Avenue, Kensington WA 6151, Australia
(3) Observatorio Astronómico Nacional (IGN), Alfonso XII, 3 y 5, 28014 Madrid, Spain
(4) ICRAR, Curtin University, Perth Australia

Extended Abstract

The next generation of low frequency radio interferometers are designed to have high sensitivities and wide fields of view. However, to achieve the ambitious goals of the SKA and the pathfinders requires, in addition, a precise calibration of all the sources of error. The ionospheric propagation effects dominate at low frequency; therefore this is the most crucial challenge in calibration. Ionospheric effects are characterized by spatial (i.e. direction dependent) and temporal fluctuations of the phase observables, which degrade the image quality and ultimately will limit the science achievable by the SKA. Therefore an empirical characterization and understanding of the ionospheric diffraction and refraction properties is fundamental to developing optimum strategies to eliminate their effects.

We present an approach that measures the ionospheric phase screen above the array, along multiple directions across the field of view, independently and in parallel. This is achieved by selecting out the sky signal from each line of sight to be solved for, by suppressing the contributions from all other directions. We demonstrate the method using both MWA and LOFAR observations.

We find that the most common distribution of the ionospheric phase screens across the MWA can be approximated as a planar surface, which is the lowest order of ionospheric spatial structure and results in a position shift in the image domain. However higher order structures (i.e. curvatures) can be found at the lower frequencies and in bad weather conditions. Such a screen results in a de-focusing of the array, and therefore cannot be corrected in the image domain. Our method corrects for the phase errors in the visibility domain, allowing for more robust imaging solutions; Figure 1 shows the improvement in the image astrometry for an hour observations at the MWA, after we have applied our corrections in the visibility domain.

We discuss the implications of these findings for the baseline lengths and sensitivity planned for SKA-Low.

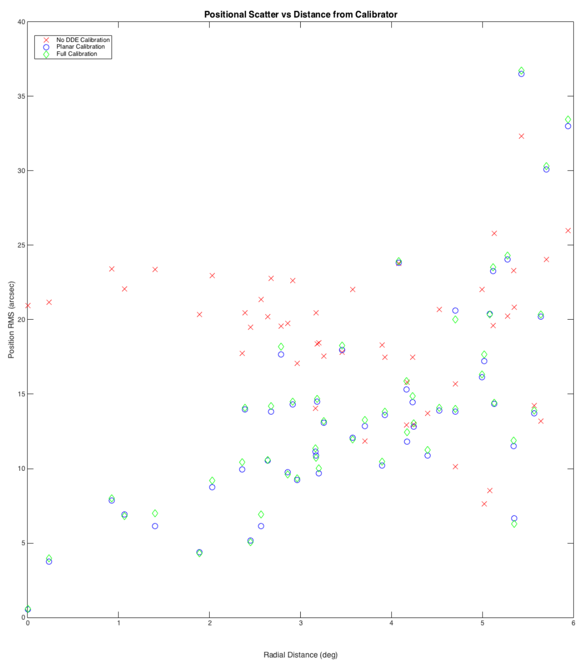

Figure 1: Image astrometric stability across seven two-minute snapshots, spanning an hour, for the strongest sources in the field around calibrator 0213-312, from MWA at 150MHz in good weather conditions and plotted as a function of radial distance. In red crosses we plot the results after default calibration, without additional directional dependent corrections. The RMS astrometric variation between snapshots is ~20 arcseconds across the 6 degree field. Applying our directional dependent phase solutions derived from 0213-312 (in green circles) reduces the astrometric variation to ~10 arcseconds over the inner ~3 deg. After this point the stability reverts to the original levels. Also plotted (in blue circles) are the astrometric variations using a planar fit to the phase screen, which slightly improves the results by reducing the number of fitted parameters.