Exploring the Ionosphere with Radio Telescopes and Lightning Strikes

Joseph Malins[1], Kenneth Obenberger[2], and Gregory B. Taylor[1]

[1] University of New Mexico, Department of Physics and Astronomy, Albuquerque, NM

[2] Air Force Research Laboratory, Kirtland Air Force Base, NM

We discuss a novel technique for replicating the output of a modern digisonde by observing the high frequency (HF; 3-30MHz) emission from lightning with the Long Wavelength Array Sevilleta (LWA-SV) radio telescope. Modern techniques for specifying the ionosphere include the use of digital ionosondes, or digisondes, which both transmit and receive sweep soundings in the HF band. For vertical soundings, the frequency dependent group delay of the returned signal is determined by the electron density as function of altitude. Therefore, measurements of the frequency dependent group delay (aka an ionogram) can be converted to an electron density profile. Our team replicates this process of observing the broad band emission from lightning using the LWA-SV radio telescope, which is located in central New Mexico. The LWA-SV consists of 256 dual-polarization dipoles with sensitivity ranging from 3 to 88 MHz and time resolution of 100 ns. We use this station to observe the powerful broadband radio bursts from the stepped leader breakdown that precedes lightning strikes. For nearby lightning we observe both the direct line of sight and the delayed ionospheric reflection. By comparing the time of arrival of the direct line of sight to that of the ionospheric reflection, we can calibrate the group delay as a function of frequency. We can then use this group delay to reconstruct the electron density profile of the bottomside ionosphere in the same manner as a digisonde. This novel technique allows for a greater range of directions to probe the ionosphere at much shorter time scales than with a digisonde, thus opening new avenues for exploration of the ionosphere without the need of a transmitter.