Investigating Ionospheric Lightning Returns Using the Long Wavelength Array

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In this study we use the Long Wavelength Array (LWA) to study High Frequency (HF) signals produced by lightning and reflected off of the ionosphere to study bottom-side ionospheric structures. The LWA is a interferometer radio telescope situated in central New Mexico that can observe between 3 and 88 MHz. It consists of two stations that each contain 256 dipoles arranged in a 110 by 100 meter ellipse which can be combined into a single dish using aperture synthesis interferometery. The stations are 70 km apart, providing good angular resolution even at these low frequencies. The LWA can sample two tunings of 10.8 MHz each, giving maximum time resolution of 46ns. We use this instrument to record signals produced by Lightning near the station. Lightning produces broad band HF emission from 3 to 3000 MHz as it ionizes the air in what is known as the step leader breakdown process. Each step, a 100 meter long arc of air ionized by the extreme voltage of the lightning, produces a powerful broadband signal which propagates in all directions, which the LWA can caputre. For frequencies below the ionospheric plasma frequency, the signal is also reflected back to the ground, and can also be sampled by the LWA. This allows us to create density ionograms from this natural transmitter in the same way that an ionosonde does with radar techniques. The advantage that lightning has over traditional ionosonde technology is the frequency of transmission, up to several times per second, and lightning is not restricted by transmission bands since it is a natural phenomena. Additionally, the lightning transmits from many locations in a short amount of time, greatly increasing the spatial information of the ionosphere overhead. We have developed a pipeline for this process, able to produce hundreds of ionograms an hour as well as techniques for isolating the position of the lightning, enabling accurate spatial information processing. We use this information to explore very short time and dense spatial scale structures within the ionosphere using this natural transmitter.