CubeSat-based ground-to-space bistatic radar experiment: Radio Aurora Explorer

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Radio Aurora Explorer (RAX) is a CubeSat-based ground-to-space UHF radar experiment funded by the new NSF Small Satellite Program. The satellite is scheduled for launch in December 2009 into a polar orbit at 650 km altitude. The primary science objective of the RAX mission is to understand the microphysics of auroral plasma instabilities that lead to meter-scale plasma turbulence in the form of field-aligned irregularities (FAI) of electron density in the altitude range of 80-400 km.

Because the magnetic field lines in the polar regions are nearly vertical it is difficult to probe FAI with ground-based coherent scatter radars. The geometry is such that a coherent scatter radar's beamwidth is either too large to resolve the structures in altitude or that refraction causes source location ambiguity. The narrow beam incoherent scatter radars (ISR) are positioned not to see the coherent scatter, which escapes into space. Moreover, orbiting spacecraft cannot descent into the dense upper atmosphere to probe the turbulent structures. Therefore, the new ground-to-space bistatic radar geometry is a unique configuration that enables exploration of the turbulent ionospheric structures not accessible from the ground or space alone.

The FAI will be illuminated by an ISR, that is Poker Flat Incoherent Scatter Radar (PFISR) for first experiments, and the scattered radiation will form a hallow cone-shaped radio aurora into space. The satellite radar receiver will record the amplitude and phase of the scattered signals as the satellite passes through the radio aurora. Irregularity locations will be determined using the time delay between PFISR transmissions and the satellite receptions through GPS-based clock synchronization. The payload does not require excessive attitude control and determination and it is not sensitive to the satellite electrostatic environment.

The mission will measure for the first time, with extremely high-angular resolution, the 3-D k-spectrum of 0.5-1 m scale irregularities. The 3-D k-spectrum will be constructed not in one pass, but through regularly scheduled experiments throughout the lifetime of the mission. In particular, the mission will determine irregularity intensities as a function altitude and magnetic aspect angle. In addition, the incoherently scattered signals going back to the ISR from the same volume of plasma will be used to estimate the convection electric field, plasma density, and temperatures, effectively simultaneously.

This paper presents an overview of this nanosat radar experiment, including the radar equation and the radar ambiguity function for multiple bistatic scattering geometries.