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Tomographic Inversion of the 135.6 nm Emission: The Importance of Radiation Transport in the Nighttime and Terminator Regions

The 135.6 nm emission of atomic oxygen has become a workhorse for satellite remote sensing of the nighttime ionosphere. Previous work on interpreting the 135.6 nm emission carried out at the Naval Research Laboratory (NRL) and more recent research carried out elsewhere have confirmed the importance of properly modeling the Mutual Neutralization and Radiative Recombination contributions to the volume emission rate and emphasized the importance of modeling and interpreting the transfer and transport of the radiation. Properly modeling the radiation transfer is important for converting the line-of-sight brightnesses into volume emission rates using tomographic inversion techniques.

Because the 135.6 nm emission undergoes multiple resonant scattering by atomic oxygen in the thermosphere that entraps the photons in the lower thermosphere, radiation transport is important for determining where the photons were originally created. Recently, we have developed and published a new inversion approach called Volume Emission Rate Tomography, which handles the radiation transfer as part of the tomography process. The VERT approach was validated using satellite-based 91.1 nm measurements, which were used to infer the electron densities that were shown to be in good agreement with coincident incoherent scatter radar measurements.

We apply the VERT technique to the 135.6 nm measurements made by the Special Sensor Ultraviolet Limb Imager (SSULI) instruments aboard the Defense Meteorological Satellite Program satellites made during ALTAIR overflights in 2010 and 2014. We determine the electron density distribution including the effects of transfer of the radiation from its point of origin to the observer, the redistribution of the photons by multiple resonant scattering (radiation transport), and the Mutual Neutralization Radiative Recombination contributions to the volume emission rate. The electron density distribution is then validated against the ALTAIR measurements.

We first test the inversion technique against the ALTAIR measurements in 2010, which assesses the technique during nighttime conditions when it should perform most accurately. As the 2014 measurements were made when the terminator was above the northern portion of the ALTAIR field-of-view, we also assess the accuracy of the 1-D plane-parallel, radiation transfer calculations and their effect on the retrieved densities when resonant scattering of dayside emissions into the terminator and nightside is more problematic.