Project Details

ROSES ID: NRA-NNH04ZSS001N
Selection Year: 2005
Program Element: Focused Science Topic

Topic: To quantify the response of thermospheric density and composition to solar and high latitude forcing.

Project Title:
Heating and mixing of thermospheric constituents in small scale aurora

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Summary:
The mechanisms for ion outflow from the auroral ionosphere into the magnetosphere are one of the fundamental open problems of space physics. It is widely accepted that this process is a multi-step process. In a first step ionospheric and thermospheric mechanisms provide an upwelling of oxygen and other heavy ions to higher than usual altitudes. These ions then constitute the seed population for active acceleration mechanisms such as localized electric fields or inertial forces. Both of these steps are currently not understood. Here it is proposed to study and quantify possible mechanisms which cause the ion upwelling. Similarly, observational evidence for unusually strong vertical neutral winds in the vicinity of aurora is plentiful. This wind contributes to thermospheric mixing and compositional changes. Wind velocities significantly exceed expectation, and modeling efforts to explain the structure and speed of vertical wind or the resulting compositional changes lack satisfactory conclusion. This problem fits well into the LWS focused science topic (T3.b) to quantify the response of thermospheric density and composition to solar and high latitude forcing. With this proposal we will investigate the coupled plasma and neutral dynamics in aurora to explain the generation, structure, and dynamics of vertical neutral wind and ion upwelling. Observations have shown strong upwelling of ionospheric ions, strong and localized vertical neutral winds, and changes to the atomic to neutral mixing ratio in aurora. Rather than considering each of these phenomena separately, we will look at the complete picture in a systematic manner. Structured aurora leads to Joule heating in the lower ionosphere. This in turn drives neutral vertical wind. Auroral precipitation and field aligned currents cause electron heating, electron pressure gradients, and upwelling of ions through the resulting ambipolar electric field. Vertical neutral wind interacts with the plasma dynamics by ion drag and allows, or even forces, upwelling of ions. At the same time the neutral mixing ratio is transported upwards, causing atomic oxygen depletion in the aurora. We will use a 3-D three fluid code to simulate the ionospheric and thermospheric processes in aurora. This simulation code is well developed and runs with up to 1000x1000x1000 grid points on a parallel computer. We have used this code to study small-scale auroral processes in the past. We will conduct case studies using observations to specify the input and boundary conditions, and predict observable parameters. We will run the simulation in a parameter study where we look at individual processes separately and in combination. We will develop diagnostic tools for the simulation that allow us to produce parameters with the same spatial and temporal resolution as the instruments that are used for these observations. The results will clarify how different ionospheric conditions and different drivers impact the vertical motion of heavy ions. This is the source population for additional acceleration at higher altitudes. The upwelling and this additional acceleration together determine the ion-outflow from the ionosphere. In addition, the results will shed light on the neutral dynamics and composition changes in the auroral ionosphere. Theses changes are not well understood and are important for many dynamical and chemical processes in the upper atmosphere.

Publication References:

Summary: no summary

Reference: Holmes, J. M.; Conde, M.; Deehr, C.; Lummerzheim, D.; (2005), Morphology of evening sector aurorae in ?557.7-nm Doppler temperatures, Geophysical Research Letters, Volume 32, Issue 2, CiteID L02103, doi: 10.1029/2004GL021553