Connecting Earth to Space: NASA Heliophysics Provides Data on how Space Weather Impacts Earth's Environment

Using NASA Van Allen Probes mission data, researchers have connected plasma waves in Earth's magnetosphere that cause pulsating auroras with ozone destruction in the mesosphere. This research provides the space science community with valuable information on how space weather can impact Earth's atmosphere.

Image of aurora taken October 2015.
Credit: NASA

Using both ground-based and satellite observations, researchers from Finland and Japan studied energetic electron precipitation associated with pulsating auroras observed over Europe on November 17, 2012. The researchers connected bursts of chorus waves, which are a specific kind of plasma wave, with electron precipitation at energies of 1-10s of keV into the ionosphere. At high latitudes, this precipitation can cause ionization in the mesosphere and lower thermosphere ultimately leading to mesospheric ozone destruction.

This study, published in the *Geophysical Research Letters* last year, provides an analysis of the quantitative effects of one event using data from NASA's Van Allen Probes, the European Incoherent Scatter Scientific Association VHF radar in Norway, the Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA) in Finland and a detailed ion and neutron chemistry model.

Their research shows how aurora cause enhanced ionization of air molecules due to the precipitation of high-energy electrons into the atmosphere. The ions that are created by this process can undergo a series of chemical reactions ultimately leading to an enhancement of odd hydrogen. Odd hydrogen (HOx) is a term that lumps H, OH, and HO_2 into one species due to the rapid interconversions between them. The HOx processes destroy ozone catalytically. In a catalytic cycle, a HOx molecule is left unchanged after destroying an ozone molecule and is ready to begin another cycle. Through this process, one HOx molecule can participate in the destruction of a large number of ozone molecules. This destruction continues until the HOx molecule is removed by other chemical reactions.

During the 2012 event, the precipitating electrons were energetic enough to penetrate below the altitude of 70 km. Using the model, the team finds that at an altitude of 75 km, a 14% depletion of odd oxygen, which is the concentration of oxygen and ozone combined, is observed. However, the largest relative change in odd oxygen is not seen immediately after the precipitation begins, but only after the odd hydrogen cycles increase.

The Van Allen Probes mission isn't the only NASA Heliophysics mission collecting data on this frontier region between Earth's atmosphere and near-Earth space. NASA's TIMED and THEMIS missions provide data on the chemistry and dynamics of Earth's upper atmosphere and aurora. Scientists use the solar wind data from the ACE spacecraft to forecast geomagnetic storms at Earth. The next-to-launch NASA Heliophysics mission, the Ionospheric Connection Explorer, will study the ionosphere, a dynamic boundary region where Earth's atmosphere interacts with near-Earth space.

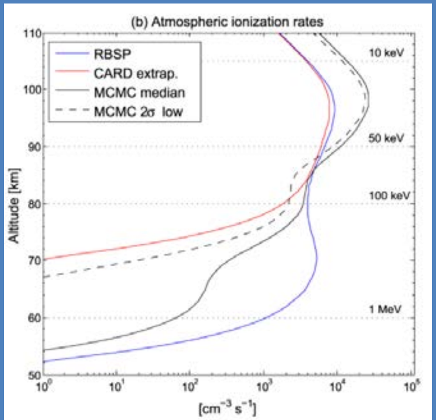

Figure caption: Atmospheric ionization rates using four different energy spectra: Van Allen data (blue line), model data using the CARD method up to 1 meV (red data), and two versions of the model data using the MCMC . The horizontal dotted lines indicate the altitudes of maximum ionization due to 10, 100, and 1000 keV electrons..
Credit: Turunen, et al