Thermosphere/Ionosphere Response to the Recent Solar Minimum

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During this protracted solar minimum period of 2007-2009, the upper atmosphere and ionosphere were cooler, lower in density, and consequently lower in altitude, than usual. The question is whether the terrestrial response to this solar minimum was significantly different from previous solar minima, and if so, how different. Measurements from the SEM instrument on SOHO spacecraft, from the SEE instrument on the TIMED satellite, and from measurements by suborbital rocket flights, indicate that solar EUV and X-ray irradiance levels were lower than they were during the previous solar minimum. However, secular change due to increased levels of carbon dioxide and other greenhouse gases, which increase tropospheric temperature but have the inverse effect of cooling the upper atmosphere, also plays a role. In order to understand the causes of these changes, and to quantify the interplay of the solar cycle with the evolution of upper atmosphere climate, we present a combination of data analysis and global numerical simulation. Thermospheric density data from atmospheric drag on satellites, ionospheric measurements by the COSMIC mission, and cooling rate observations by TIMED/SABER, are compared to model simulations by the NCAR Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM). Solar ultraviolet irradiance observations, solar wind and geomagnetic data, and measurements of anthropogenic greenhouse gases, provide the external forcing of the model. The response to the recent solar minimum is compared to previous solar minima, and to model simulations. We find compelling evidence that the thermosphere was cooler during 2008 than any other year for which measurements exist (back to about 1970), and that the primary reason for this is the unusually low levels of solar extreme-ultraviolet and soft X-ray irradiance.