Project Details

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Program Element: Focused Science Topic

Topic: Long Term Variability and Predictability of the Sun-Climate System

Project Title:
Solar Driven Upper Atmosphere Climatology Under the Influence of the Secular Change of Earth s Magnetic Field and Anthropogenic Forcing

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Summary:
The Earth s upper atmosphere is governed by solar inputs via complicated chemical and physical processes. Variations in solar radiation and geomagnetic activity are coupled with Earth s internal processes to shape the upper atmosphere climate and its variability. These processes include, in particular, the increasing anthropogenic greenhouse gas concentrations that impact the upper atmosphere thermal structure and the secular changes of the Earth s magnetic field that is expected to regulate ion-neutral coupling and the redistribution of energy and momentum both locally and globally. These processes are especially important on time scales from the 27-day solar rotation, season to solar cycle and beyond. However, the physical processes by which anthropogenic forcing and secular magnetic field change affect the solar-driven upper atmospheric climate, and the quantitative extent of these effects, have not been adequately studied and fully understood. It is not clear how much the changing greenhouse gas concentrations and the magnetic field impact the solar-driven upper atmospheric climate, and very importantly, how they impact the way that solar energy input governs the upper atmosphere climate Here we propose to study how solar and magnetic activity determine the upper atmospheric climatology in the presence of the changing greenhouse gas concentrations and magnetic field. Specifically, we propose to undertake following studies:
1) How is the solar driven upper atmospheric climate modulated by the secular change of Earth s magnetic field, regionally and globally?
2) How is the solar driven upper atmospheric climate modulated by the increasing anthropogenic greenhouse gas concentrations?
3) How do solar activity, and the secular changes of the Earth s magnetic field and greenhouse gas concentrations contribute to upper atmosphere climate separately and collectively?
4) How deep do the atmospheric climate effects of solar-terrestrial magnetic forcing penetrate to the mesosphere?
Diagnostic analysis of model simulations and model-data comparison will be performed to address these questions and obtain new insight into solar driven upper atmosphere climate and its change. The model used is the Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension (WACCM-X), which treats the Earth s atmosphere as an integrated system. WACCM-X can simulate upper atmospheric energetics and dynamics driven by solar and magnetic activity, taking into account anthropogenic greenhouse forcing and magnetic field change. We will analyze long-term space and ground-based data in this work. These data include: thermosphere composition from TIMED/GUVI, mesosphere temperature from TIMED/SABER, ionospheric peak density from ionosondes, plasma density and temperature from incoherent scatter radars. Data uncertainty will be assessed and analyzed. Model-data comparisons and ensemble model runs will be performed to assess and characterize model uncertainty.

This proposed work is highly supportive of the LWS Program goal by providing an understanding of the solar-climate system with realistic Earth s internal forcing. It is directly relevant to the 2020 LWS FST #4 Long Term Variability and Predictability of the Sun-Climate System . The proposed study also addresses science goals of the Heliophysics Decadal Survey, such as to Determine the dynamics and coupling of Earth s magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs .

Our project will characterizes the upper atmospheric climate determined by solar and geomagnetic activity and gain new insight into the dynamics and chemical processes through which the anthropogenic forcing and magnetic field secular change affect this climate. The data collected, model simulations and diagnostic analysis results will be made available to other team members. We will also run the model for team-identified events as part of the team efforts.

Publication References:

no references