Project Details

ROSES ID: NNH05ZDA001N
Selection Year: 2006
Program Element: Focused Science Topic

Topic: Determine the effects of changes in the atmospheric abundance of greenhouse gases on the temperature and dynamics of the upper atmosphere

Project Title:
A Data Analysis and Modeling Study of Secular Change in Thermospheric Density

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Summary:
We propose a data analysis and modeling study of long-term changes that have occurred in the upper atmosphere over the recent several decades. Interest in these trends has been stimulated by the classical modeling study of Roble and Dickinson (1989), who predicted a dramatic response to a hypothetical future increase of greenhouse gases: the upper atmosphere is expected to cool down by tens of degrees in response to the standard doubled-CO2 scenario. The search for signs of global change in upper-atmospheric and ionospheric historical data records has been inconclusive. While some parameters clearly reveal long-term trends in general agreement with the model predictions, other estimates have produced inconsistent and even contradictory results due, in part, to the scarcity of sufficiently long uniform observational records. Our ability to detect trends is also confounded by the enormous variability of the upper atmosphere driven primarily by solar and geomagnetic activity on various temporal and spatial scales.

The "greenhouse cooling" is expected to result in a substantial thermospheric density decline that depends on the level of solar activity. Existing analyses of neutral density trends based on satellite drag data over the last 2 to 3 decades have provided perhaps the most robust evidence of global change in the upper atmosphere to date. These results inherently provide a global view and qualitatively agree with each other and with theoretical model predictions. More work is required to improve our confidence in the trend estimates, to delineate the contributions of solar activity and other parameters, to better understand the physical mechanisms, and to quantify their contributions to the observed changes.

The science goal of this project is to advance our understanding of the mechanisms driving the long-term global changes in the upper atmosphere and the near-Earth space environment. Our approach is unique in that it synergistically combines two key components: (1) we will extend, in time and altitude coverage and in number of observations per year, our comprehensive analysis of the global satellite-drag database to delineate the contributions of solar activity and other sources of natural variation, and to detect anthropogenic and possible natural long-term trends; (2) we will use an updated global upper-atmospheric numerical model to study the natural and anthropogenic variability using the records of greenhouse gas concentrations and solar activity over the same period of time. A direct comparison of the results of theoretical modeling with the analysis of accurately determined trends in the upper atmosphere will be carried out for the first time. This will provide insights into the key physical mechanisms and their possible interactions and feedbacks, and will facilitate the attribution of the observed trends. A clearer understanding of the thermospheric "greenhouse cooling" will lead to development of meaningful long-term forecasting capabilities.

This work is immediately relevant to the science goals of the NASA Living With a Star program and, in particular, to its Targeted Research science topic T3e. The ability to understand and predict the long-term density variability in the near-Earth space environment is also of enormous practical significance to any spacecraft operators, including the NASA's programs and missions.

Publication References:

Summary: no summary

Reference: Lastovicka, J., R. A. Akmaev, G. Beig, J. Bremer, J. T. Emmert (2006), Global change in the upper atmosphere, Science, 314, 1253-1254.

Summary: no summary

Reference: Lastovicka, J., R. A. Akmaev, G. Beig, J. Bremer, J. T. Emmert, Ch. Jacobi, M. J. Jarvis, G. E. Nedoluha, Yu. I. Portnyagin, Th. Ulich (2008), Emerging pattern of global change in the upper atmosphere, Ann. Geophys., in press.

Summary: no summary

Reference: Akmaev, R. A.; Fomichev, V. I.; Zhu, X.; (2006), Impact of middle-atmospheric composition changes on greenhouse cooling in the upper atmosphere, Journal of Atmospheric and Solar-Terrestrial Physics, Volume 68, Issue 17, p. 1879-1889, doi: 10.1016/j.jastp.2006.03.008