Long-term space climate monitoring

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Growing evidence shows that the upper atmosphere is experiencing appreciable cooling over the last several decades. This is connected to the increase in greenhouse gas concentration since the start of the industrial age, which drives global warming near the Earth's surface, but causes global cooling in the middle and upper atmosphere. Long-term changes in the solar-terrestrial environment arise also from the secular change in Earth's magnetic field. Both changes in the strength and orientation of the geomagnetic field are important drivers of long-term change in the upper atmosphere, especially in regions where the magnetic equator and magnetic poles have shifted their position. Note that long-term changes in the atmosphere addressed here are changes on a time scale longer than a solar cycle; changes across different solar cycles are important long-term aspects too.

Consequences of some long-term changes driven by forcing from above and below could appear subtle over short time scales but the accumulated effect can be significant in the long term. For example, incoherent scatter radar observations at Millstone Hill and elsewhere suggested that ion temperature has decreased by 100 K at high altitudes of the ionosphere since the space age. Potential risks of space debris to survive in orbitals harmful to spacecraft and humans in space become larger due to global cooling and the associated drop in upper atmosphere air density, as this reduces the drag on space debris, increasing its lifetime..

The scientific community needs to maintain and develop the important capability to monitor space climate over the long-term. Such monitoring is relatively easier to achieve using ground-based observational systems, complimentary to mission-based in-situ space observations. These systems are characterized by a clear separation between temporal and spatial ambiguity as well as consistency and stability of observing conditions and maintenance.

A list of a few important techniques that can enable atmospheric long-term monitoring include magnetometers, ionosondes, incoherent scatter radars, Fabry-Perot Interferometers, All-sky imagers, SuperDARN HF radars, and Lidars. These ground-based observations will benefit the science and application communities for understanding and predicting short-term space weather, but long-term investments in this area are vital for the sustainability of global civilization. Government long-term commitments to support fundamental upper atmosphere measurements are essential.