MEETING

Mesospheric Ice Clouds as Indicators of Upper Atmosphere Climate Change

Workshop on Modeling Polar Mesospheric Cloud Trends; Boulder, Colorado, 10–11 December 2009

PAGE 183

The 20-year-old speculation that high-altitude summertime ice clouds (polar mesospheric, or noctilucent, clouds, here denoted MC) are affected by anthropogenic activities has recently received support from a 30-year time series of solar backscatter ultraviolet (SBUV) satellite measurements. SBUV data reveal a significant trend in bright MC properties. However, the robustness of the trend, extracted from interannual, local time, and solar cycle variability, and its underlying causes remains debatable.

General circulation models that simulate MC have finally reached the sophistication to address this question. Two modeling groups have reported simulating trends in MC optical properties, which closely match the SBUV data. The models are (1) Leibniz Institute Middle Atmosphere/Ice (LIMA/Ice) and (2) Whole Atmosphere Community Climate Model–Polar Mesospheric Clouds (WACCM-PMC). Both simulations agree well with satellite data in the Northern Hemisphere (NH). Trends of Southern Hemisphere MC are apparently masked by large interannual variability.

To understand how two different simulations could produce such remarkable agreement, MC scientists recently attended an informal workshop at the Laboratory for Atmospheric and Space Physics, in Colorado.

Changes in the mesosphere result from a host of long-term forcings, including changes in greenhouse gases (GHG). The WACCM group reported that simulations covering the period from 1953 to 2003 and altitude range 0–140 kilometers indicate a negligibly small (<0.4 K per decade) cooling in the MC domain (the high-latitude summertime mesopause region, 80–90 kilometers). A simulated 10–15% per decade increase of water vapor results in part from oxidation of rising concentrations of methane. This study (with no ice modeling) points toward water vapor as the possible driving force for MC trends. Use of the same long-term forcing in WACCM-PMC (with an ice parameterization) showed excellent agreement with SBUV trends in the NH polar region.

To investigate the stratospheric influences on the NH clouds, LIMA/Ice simulates millions of ice particle trajectories governed by winds that are forced at the lower boundary (~40 kilometers) by a meteorological database, updated every 6 hours over the period from 1961 to 2008. GHG concentrations were held constant. The LIMA/Ice group reported that a small mesospheric cooling rate (~1 K per decade) was found to be due partly to atmospheric contraction owing to stratospheric cooling. Yet even this model simulated the observed trend in MC, despite the lack of any explicit methane or carbon dioxide trends in the mesosphere.

Subsequent discussion considered unmodeled influences (e.g., space shuttle injections of water and detailed nucleation schemes). None was considered to be of major importance for MC trends. Interhemispheric coupling is implicit in both models, but its influence has not been separately isolated.

The WACCM group noted that although their model predicts realistic upper stratospheric cooling (~1 K per decade), it is difficult to segregate the various influences in a free-running model. Future work will include sensitivity calculations in which the various forcings are held constant. The LIMA/Ice modeling group plans realistic optical calculations, coupling between chemistry and dynamics, and the addition of GHG increases. Progress should be forthcoming before the next meeting of the International Association of Geomagnetism and Aeronomy (IAGA)/International Commission on the Middle Atmosphere (ICMA)/Climate and Weather of the Sun-Earth System (CAWSES) Workshop on Long-Term Changes and Trends in the Atmosphere, to be held in Boulder, Colo., 15–18 June 2010.

—GARY THOMAS, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder; E-mail: thomas@lasp.colorado.edu; DAN MARSH, Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, Colo.; and F.-J. LÜBKEN, Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany