Satellite Observations and Chemistry Climate Models – A Meandering Path Towards Better Predictions

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Knowledge of the chemical and dynamical processes that control the stratospheric ozone layer has grown rapidly since the 1970s, when ideas that depletion of the ozone layer due to human activity were put forth. The concept of ozone depletion due to anthropogenic chlorine increase is simple; quantification of the effect is much more difficult. The future of stratospheric ozone is complicated because ozone is expected to increase for two reasons: the slow decrease in anthropogenic chlorine due to the Montreal Protocol and its amendments and stratospheric cooling caused by increases in carbon dioxide and other greenhouse gases. Prediction of future ozone levels requires three-dimensional models that represent physical, photochemical and radiative processes, i.e., chemistry climate models (CCMs).

While laboratory kinetic and photochemical data are necessary inputs for a CCM, atmospheric measurements are needed both to reveal physical and chemical processes and for comparison with simulations to test the conceptual model that CCMs represent. Global measurements are available from various satellites including but not limited to the LIMS and TOMS instruments on Nimbus 7 (1979 – 1993), and various instruments on the Upper Atmosphere Research Satellite (1991 – 2005), Envisat (2002 – ongoing), Sci-Sat (2003 – ongoing) and Aura (2004 – ongoing). Every successful satellite instrument requires a physical concept for the measurement, knowledge of physical chemical properties of the molecules to be measured, and stellar engineering to design an instrument that will survive launch and operate for years with no opportunity for repair but providing enough information that trend information can be separated from any instrument change.

The on-going challenge is to use observations to decrease uncertainty in prediction. This talk will focus on two applications. The first considers transport diagnostics and implications for prediction of the eventual demise of the Antarctic ozone hole. The second focuses on the upper stratosphere, where ozone is predicted to increase both due to chlorine decrease and due to temperature decrease expected as a result of increased concentrations of CO_2 and other greenhouse gases. Both applications show how diagnostics developed from global observations are being used to explain why the ozone response varies among CCM predictions for stratospheric ozone in the 21st century.