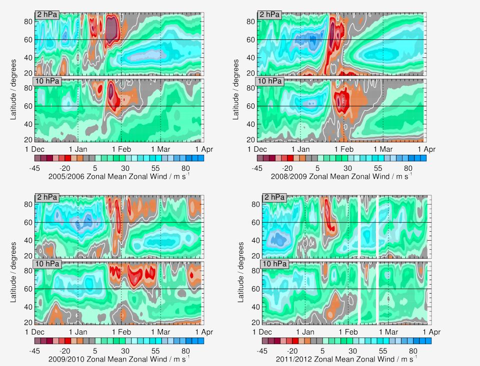
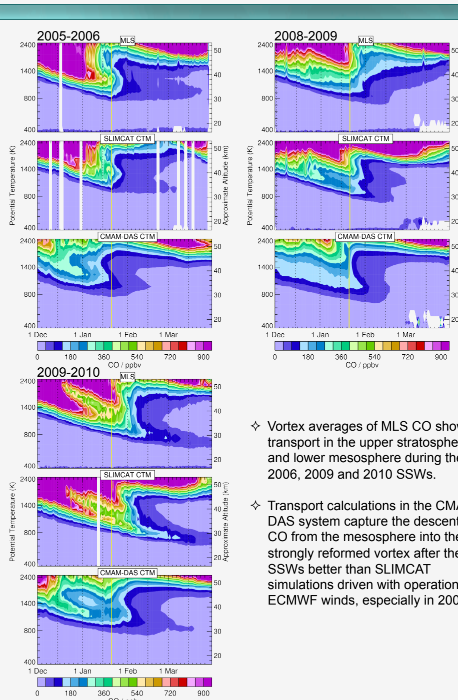
Stratospheric Sudden Warming Signatures in Satellite Data and Data Assimilation Systems: Stratopause Evolution and Transport

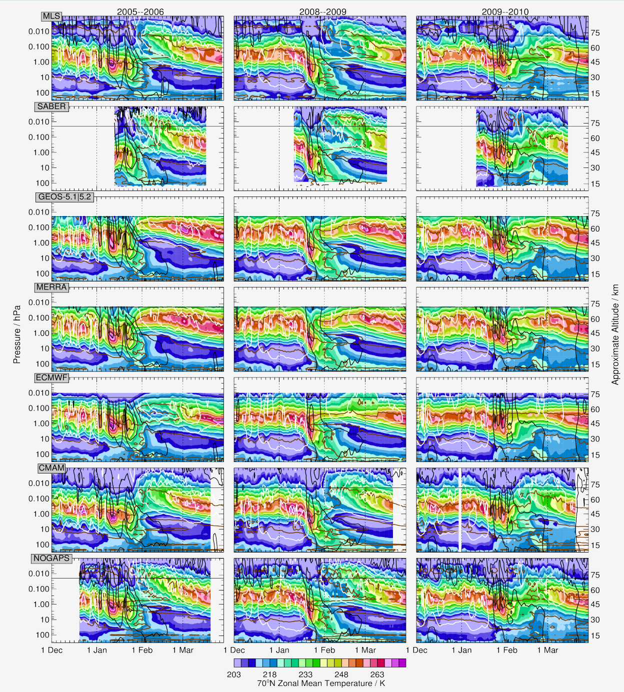
Gloria L. Manney[1**,2], Ken Minschwaner[2], Saroja Polavarapu[3] Shuzhan Ren[3], Karl W Hoppel[4], Fabrizio Sassi[4], Michael J. Schwartz[1], William H. Daffer[1], Kirstin Krüger[5], Steven Pawson[6]
[1]Jet Propulsion Laboratory, California Institute of Technology; [2]New Mexico Institute of Mining and Technology; [3]Environment Canada; [4]Naval Research Laboratory; [5]IFM-GEOMAR; [6]NASA Goddard Space Flight Center
**Now at NorthWest Research Associates



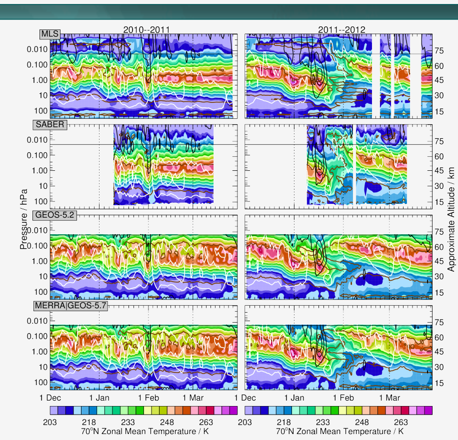
- ✧ Prolonged major stratospheric sudden warmings (SSWs) in 2006, 2009 and 2010 dramatically disrupted the Arctic winter circulation throughout the stratosphere and mesosphere; effects have been noted from underground into the thermosphere.
- ✧ A "minor" SSW in 2012 had just as profound an effect on the mesospheric and upper stratospheric circulation.



- ✧ Vortex averages of MLS CO show transport in the upper stratosphere and lower mesosphere during the 2006, 2009 and 2010 SSWs.
- ✧ Transport calculations in the CMAM-DAS system capture the descent of CO from the mesosphere into the strongly reformed vortex after the SSWs better than SLIMCAT simulations driven with operational ECMWF winds, especially in 2006.

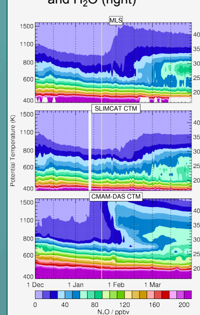


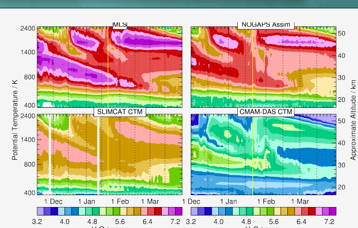
- ✧ 70N zonal mean temperature (colors), winds (black, easterly, and white, westerly, contours), and static stability (brown contours) are shown during the 2006, 2009 and 2010 SSWs.
- ✧ The breakdown of the stratopause and its reformation near 75–80km during these extreme events are seen in MLS (top row) and SABER (second row) data.
- ✧ The operational analyses (GEOS-5/MERRA, ECMWF Operational, rows 3–5) cannot capture the high-altitude reformation of the stratopause.
- ✧ CMAM-DAS (with a higher model top and more sophisticated gravity wave parameterization, but similar data sources) shows improved performance.
- ✧ NOGAPS-ALPHA (which not only has a higher model top, but also assimilates MLS and SABER temperatures) agrees closely with MLS and SABER.



- ✧ 70N zonal mean temperatures in 2010–2011 shown an example comparison in a cold, quiescent Arctic winter; GEOS-5 (and ECMWF, not shown) perform better than in the disturbed winters, but still show biases with respect to MLS and SABER in stratopause altitude and temperature.
- ✧ Similar deficiencies to those in 2006, 2009 and 2010 are seen during the breakdown and reformation of the stratopause during the 2012 minor SSW.

2009–2010 Vortex Averaged N_2O (below) and H_2O (right)





- ✧ In the lower stratosphere, SLIMCAT with ECMWF winds shows evidence of too little mixing, but CMAM-DAS evidence of too much.
- ✧ While both simulations show serious biases in the magnitude of H_2O mixing ratios, the general patterns of transport are captured; CMAM-DA more faithfully represents the descent into the stratospheric vortex after the SSW.

- ✧ Operational meteorological analyses cannot capture the high-altitude reformation of the stratopause after strong SSWs, and show biases in stratopause altitude and temperature.
- ✧ Low model tops and crude gravity wave parameterizations are important factors leading to these deficiencies.
- ✧ Recent satellite datasets provide comprehensive temperature information through the mesosphere for assimilation, and for validation of data assimilation products.
- ✧ See also France et al. poster, this meeting.