National Aeronautics and Space Administration

Studies of Stratopause Structure, Evolution and Transport from Satellite Data and New Assimilation Products

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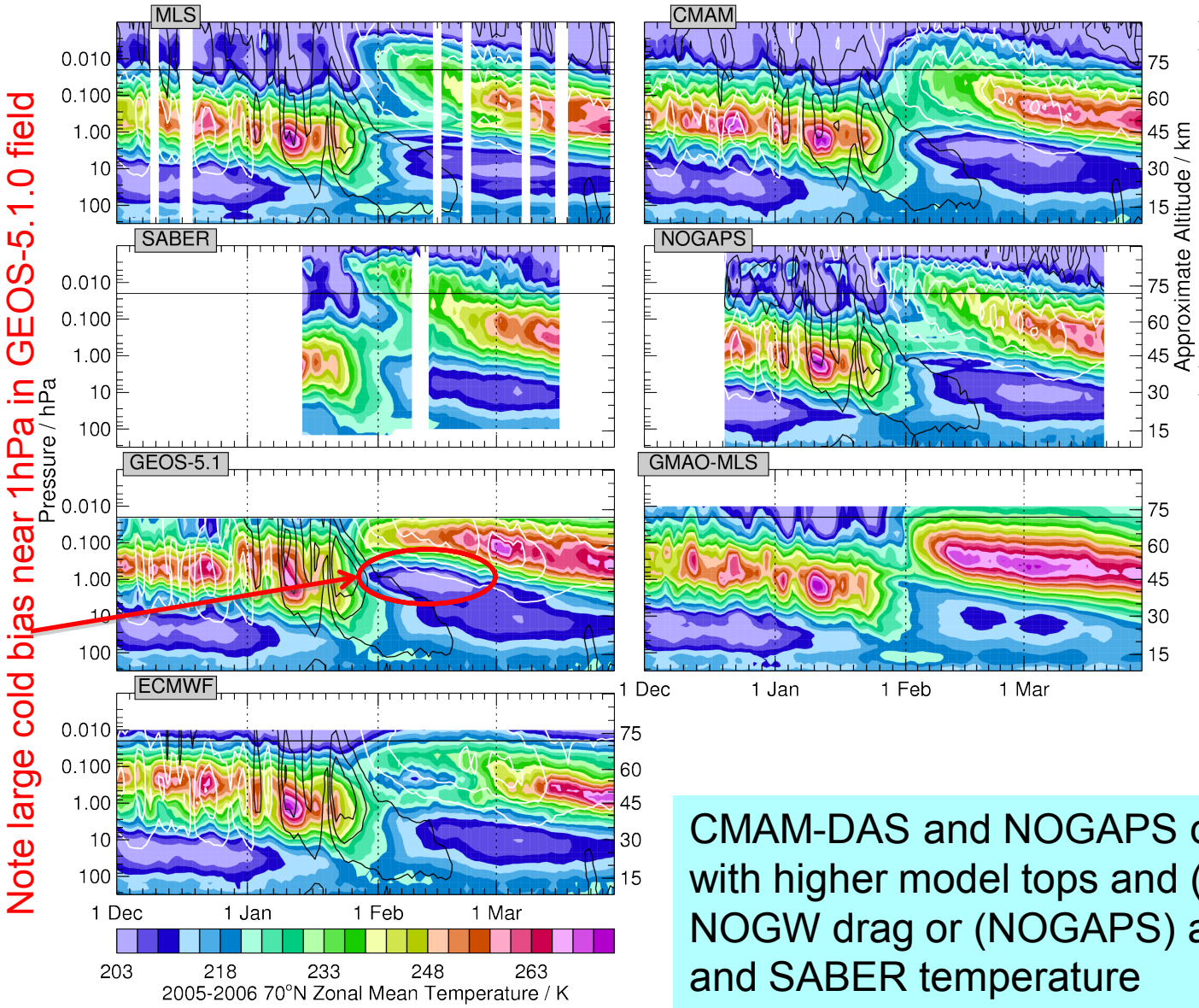
Datasets and Assimilation Products

- Recent satellite data provide the first comprehensive coverage of the upper stratosphere/lower mesosphere (USLM). We use here:
  - SABER v1.07 temperatures from 100hPa through the mesosphere
  - Aura MLS temperatures and trace gases from 316 to 0.001hPa
  - ACE-FTS trace gases from upper troposphere to ~90km
- Operational assimilation products (tops at 0.01hPa):
  - GEOS-5.1.0 (through 15 Sep 2008) and GEOS-5.2.0: Garcia & Boville non-orographic gravity wave (NOGW) drag (non-conservative implementation)
  - ECMWF T799/L91 operational: Rayleigh friction in lieu of NOGW drag parameterization
- Research assimilation products:
  - CMAM-DAS: Top ~0.0006hPa, Scinocca (JAS, 2003) NOGW drag
  - NOGAPS-ALPHA (NRL), top ~0.0005hPa, Garcia et al (2007) NOGW (conservative implementation), assimilating MLS and SABER T and O_3
  - GMAO Model (like GEOS-5.2.0, coarser horizontal resolution) assimilating MLS T

Stratopause Evolution During the 2006 Major SSW

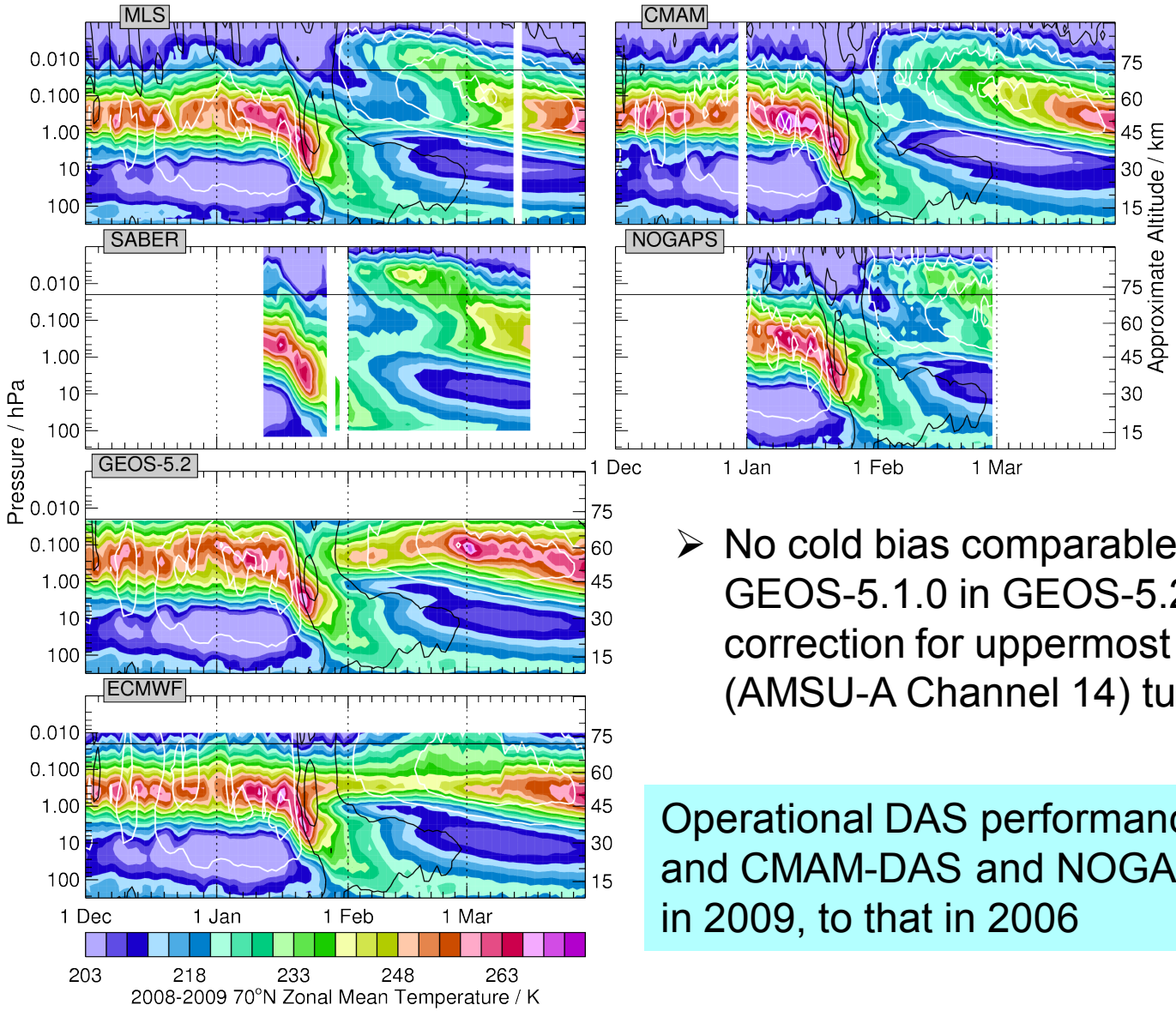


Note large cold bias near 1hPa in GEOS-5.1.0 field

- Operational DAS represent the stratopause region poorly after 2006 SSW (Manney et al, JGR, 2008)
- Assimilation of MLS T in a GEOS-5.2.0-like system improves USLM before, but not after the SSW (likely issues with model top, GWs)

CMAM-DAS and NOGAPS do much better, with higher model tops and (CMAM) better NOGW drag or (NOGAPS) assimilating MLS and SABER temperature

Stratopause Evolution During the 2009 Major SSW

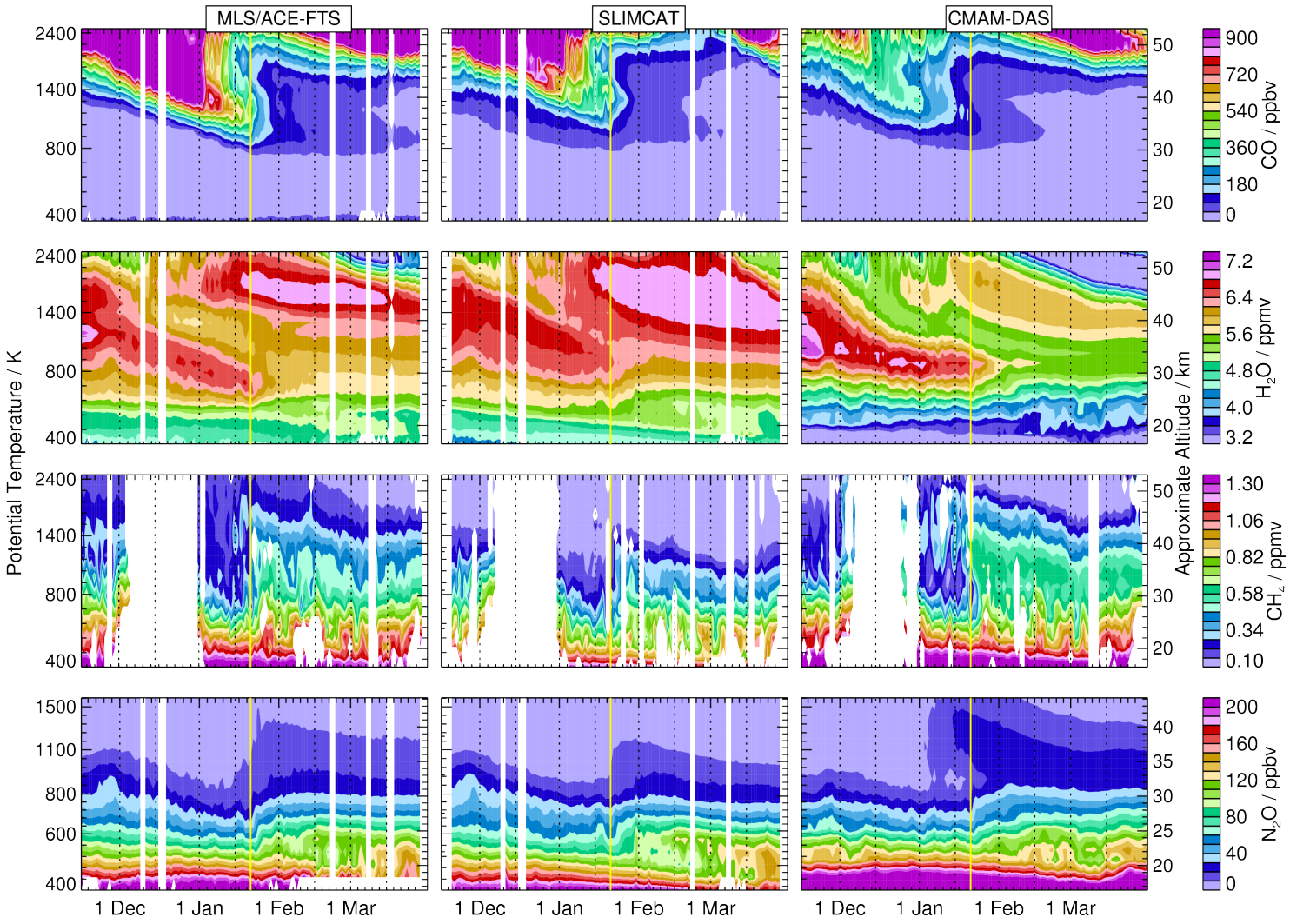


- An even stronger, longer-lasting SSW occurred in Jan 2009, this time a vortex split event (Manney et al, GRL, 2009)

- No cold bias comparable to that in GEOS-5.1.0 in GEOS-5.2.0: Bias correction for uppermost satellite channel (AMSU-A Channel 14) turned off

Operational DAS performance similarly poor, and CMAM-DAS and NOGAPS similarly better in 2009, to that in 2006

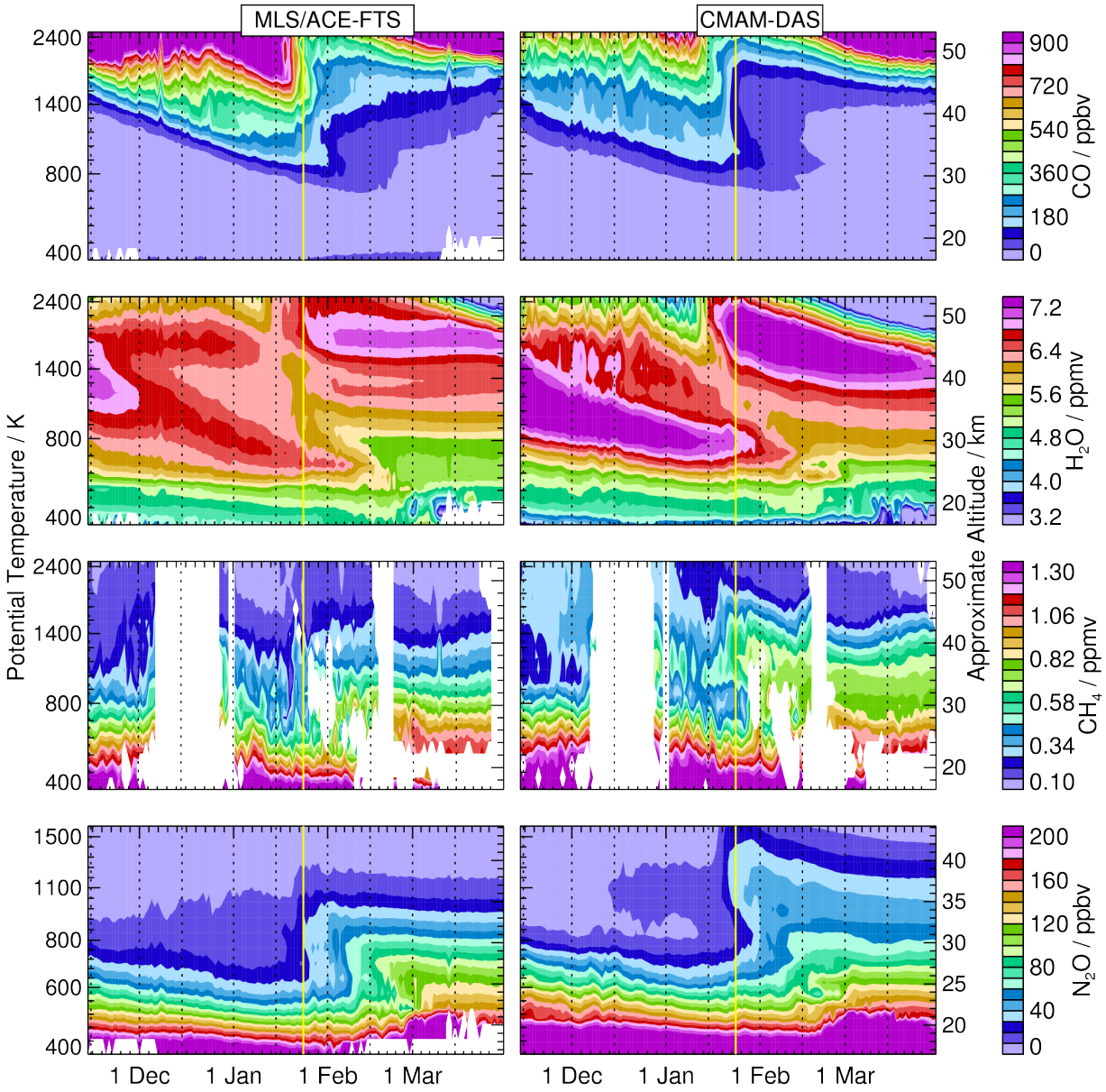
Transport During the 2006 SSW



- SLIMCAT driven with ECMWF winds & diabatic heating
- CMAM online transport (H_2O range 3-5 ppmv)

Biases in ECMWF temperatures lead to inaccurate transport in USLM; CMAM USLM transport much better

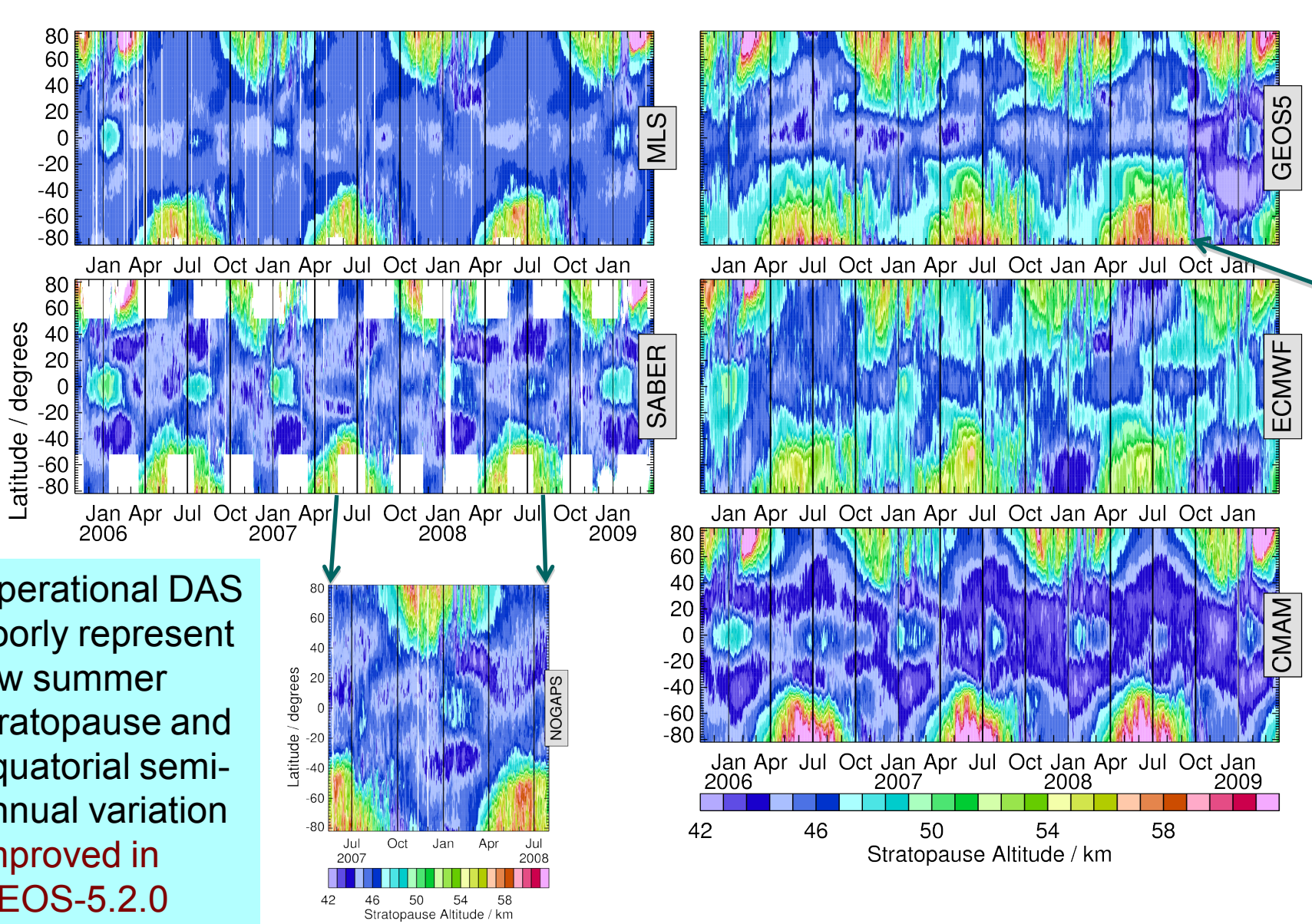
Transport During the 2009 SSW



- SLIMCAT run in progress for 2009
- CMAM performance similar to that in 2006

CMAM transport is accurate in the USLM and lower stratosphere; possibly too much mixing at ~30-40km; demonstrates accurate diabatic descent (hence temperature)

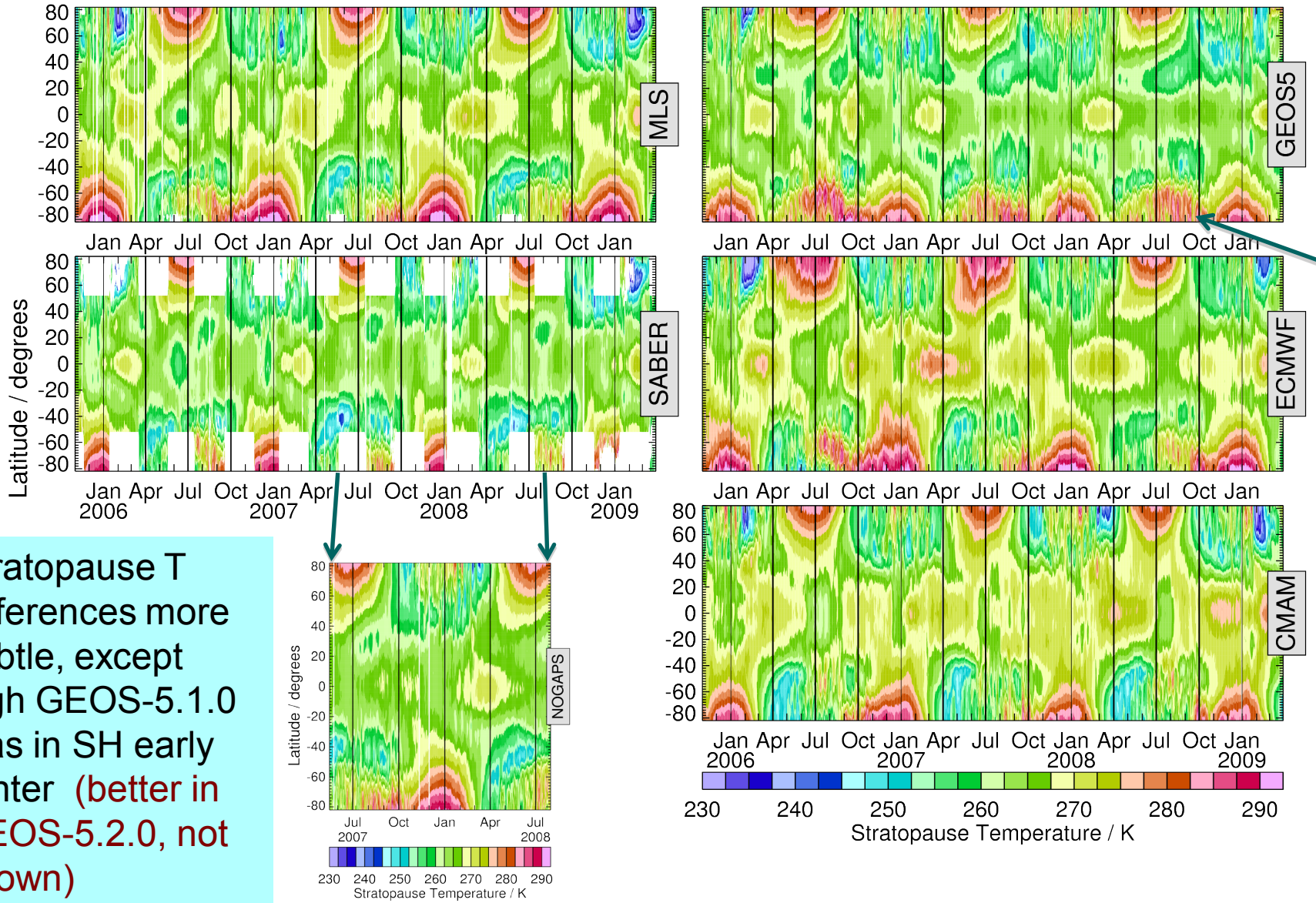
Global/Interannual Stratopause Evolution - Altitude



Operational DAS poorly represent low summer stratopause and equatorial semi-annual variation

Improved in GEOS-5.2.0

Global/Interannual Stratopause Evolution - Temperature



Stratopause T differences more subtle, except high GEOS-5.1.0 bias in SH early winter (better in GEOS-5.2.0, not shown)

Summary/Continuing Work

- Recent satellite datasets (Aura MLS, SABER, ACE-FTS,…) provide the first global multi-annual coverage of the upper stratosphere and mesosphere
- Analyses of these datasets have elucidated the details of stratopause evolution and transport during prolonged major stratospheric sudden warmings in 2006 and 2009
- Operational assimilation products extending into the mesosphere poorly represent stratopause evolution, largely because of too low model tops and crude non-orographic GW schemes
- New assimilation products show improvements in stratopause representation, through a combination of higher model tops, more sophisticated GW schemes, and/or assimilation of MLS and/or SABER temperatures
- Using satellite data to assess the performance of assimilation systems can assist in improving model performance in the USLM
- Satellite data and new assimilation products are being used to study the climatology and variability of the stratopause