Some recent results obtained with NASA's GEOS-4 DAS

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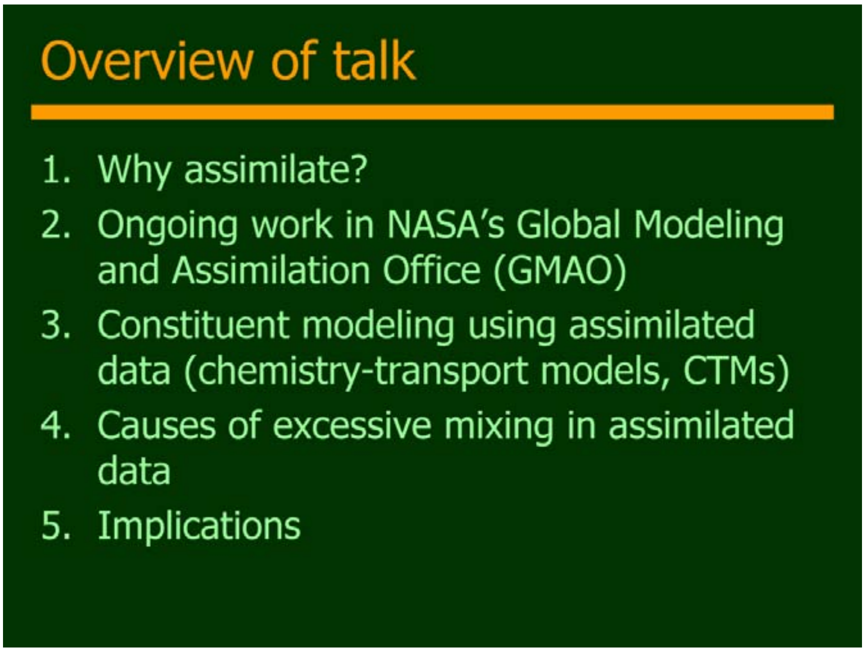
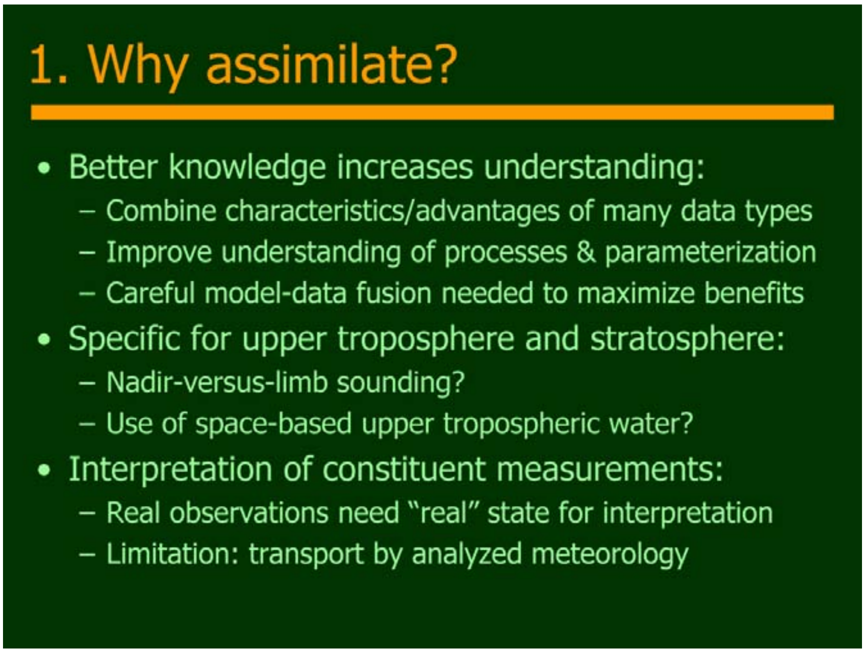




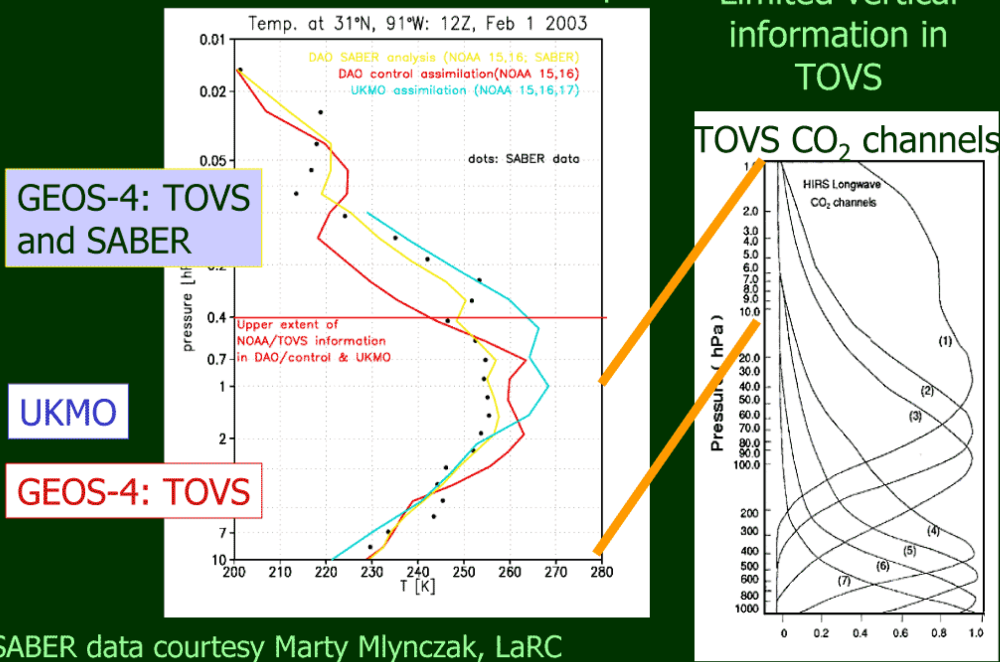
2. Assimilation in GMAO

- Meteorological DAS: GEOS-4
  - FVGCM (Lin-Rood dynamics, CCM3 physics)
  - PSAS (observation-space analyses)
  - Nadir-sounders (TOVS)
  - Cloud-track winds, scatterometers, TPW, ...
  - Impact of SABER data (TOVS info content)
- Ozone DAS: off-line with chemistry
  - TOMS, SBUV – standard data input
  - Impact of MIPAS data
- Some thoughts about water

Assimilation of SABER limb-sounder temperatures

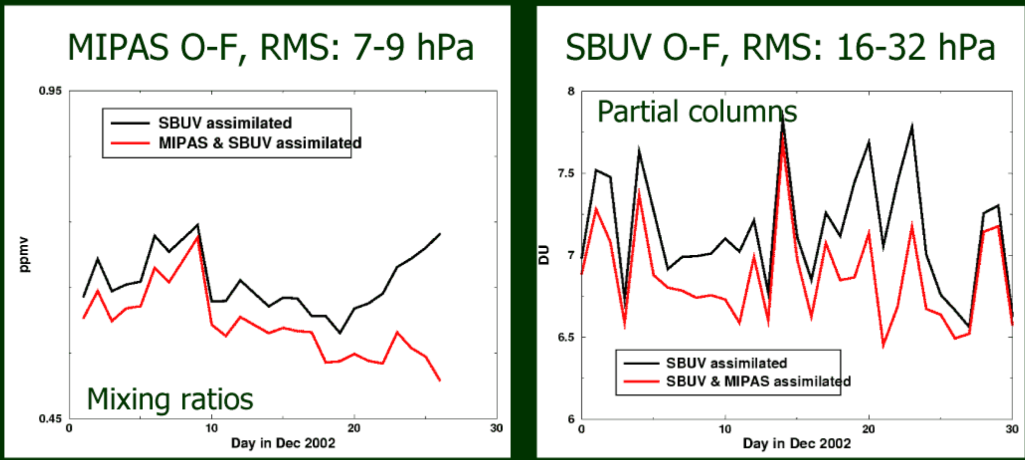
Limb sounders can have substantial impact

Limited vertical information in TOVS



SABER data courtesy Marty Mlynczak, LaRC
da Silva et al., work in progress

MIPAS O_3 assimilation: O-F statistics (Dec. 2002)

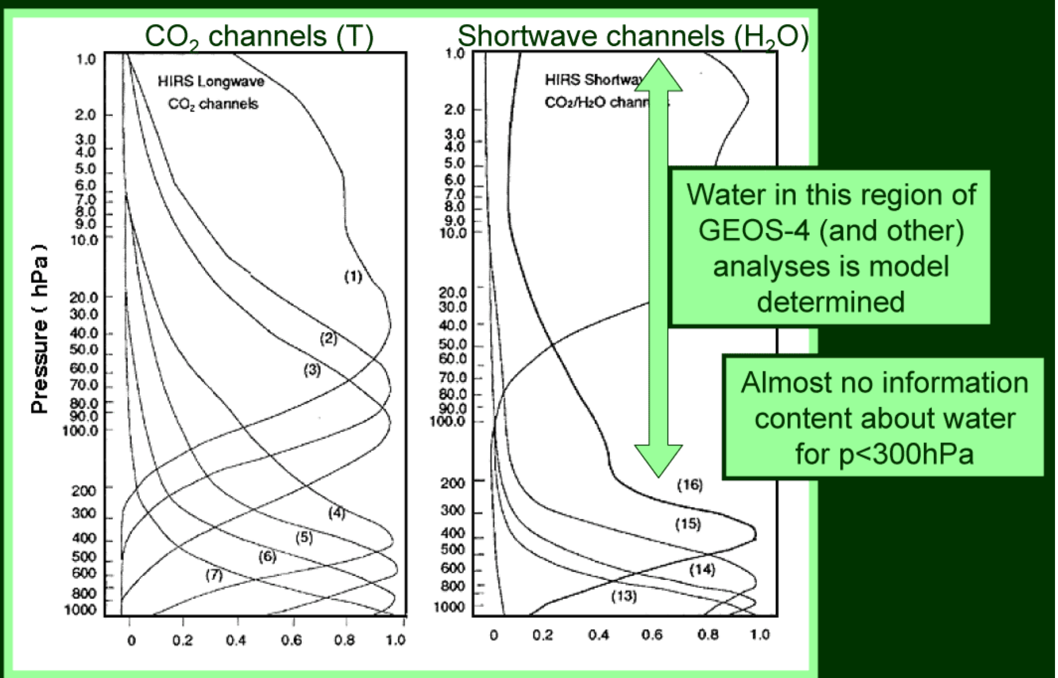


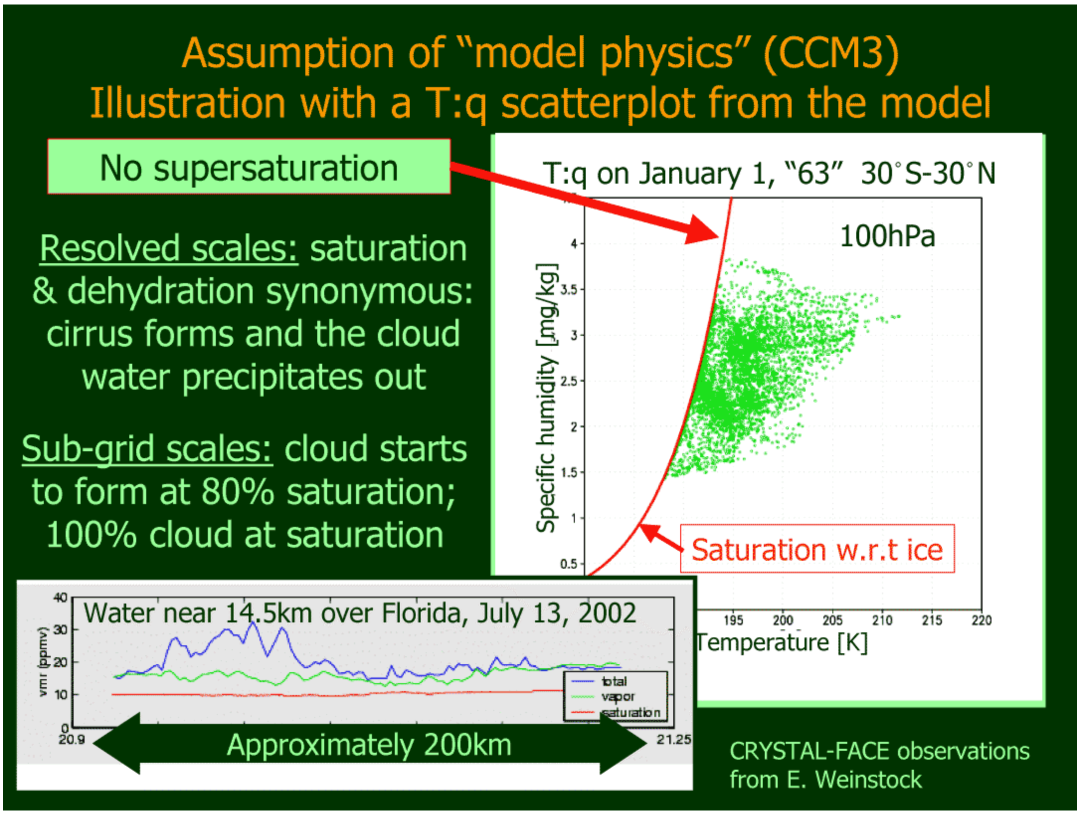
Global O-F RMS values for MIPAS & SBUV both improve (decrease) when MIPAS data are assimilated

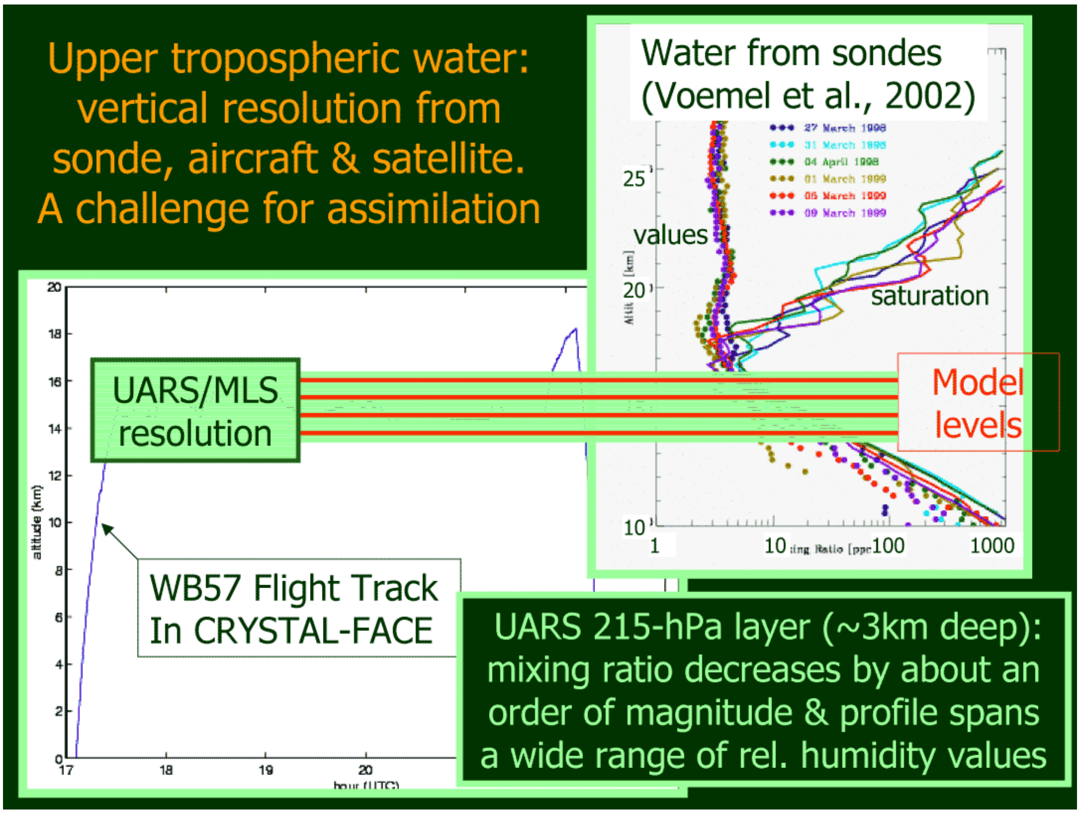
Chi^2 statistics indicate that the reported MIPAS standard deviations may be too small

Wargan et al., work in progress

Information content of TOVS: water



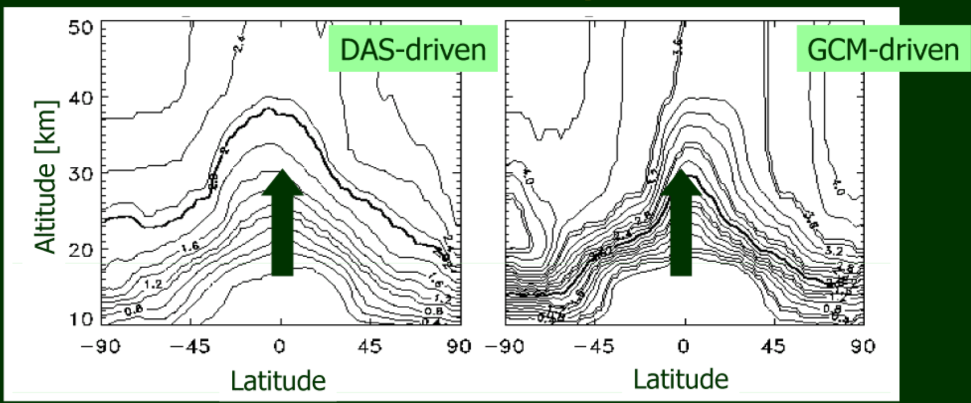

Assumption of "model physics" (CCM3)
Illustration with a T:q scatterplot from the model
No supersaturation
Resolved scales: saturation & dehydration synonymous: cirrus forms and the cloud water precipitates out
Sub-grid scales: cloud starts to form at 80% saturation; 100% cloud at saturation
T:q on January 1, "63" 30°S-30°N
100hPa
Specific humidity [mg/kg]
Saturation w.r.t ice
Temperature [K]
Water near 14.5km over Florida, July 13, 2002
vmr (ppmv)
total
vapor
saturation
Approximately 200km
CRYSTAL-FACE observations from E. Weinstock


Upper tropospheric water: vertical resolution from sonde, aircraft & satellite. A challenge for assimilation
Water from sondes (Voemel et al., 2002)
27 March 1998
31 March 1998
04 April 1998
01 March 1999
06 March 1999
09 March 1999
values
saturation
Model levels
UARS/MLS resolution
WB57 Flight Track In CRYSTAL-FACE
altitude (km)
UARS 215-hPa layer (~3km deep): mixing ratio decreases by about an order of magnitude & profile spans a wide range of rel. humidity values

3. Assimilation-driven CTMs

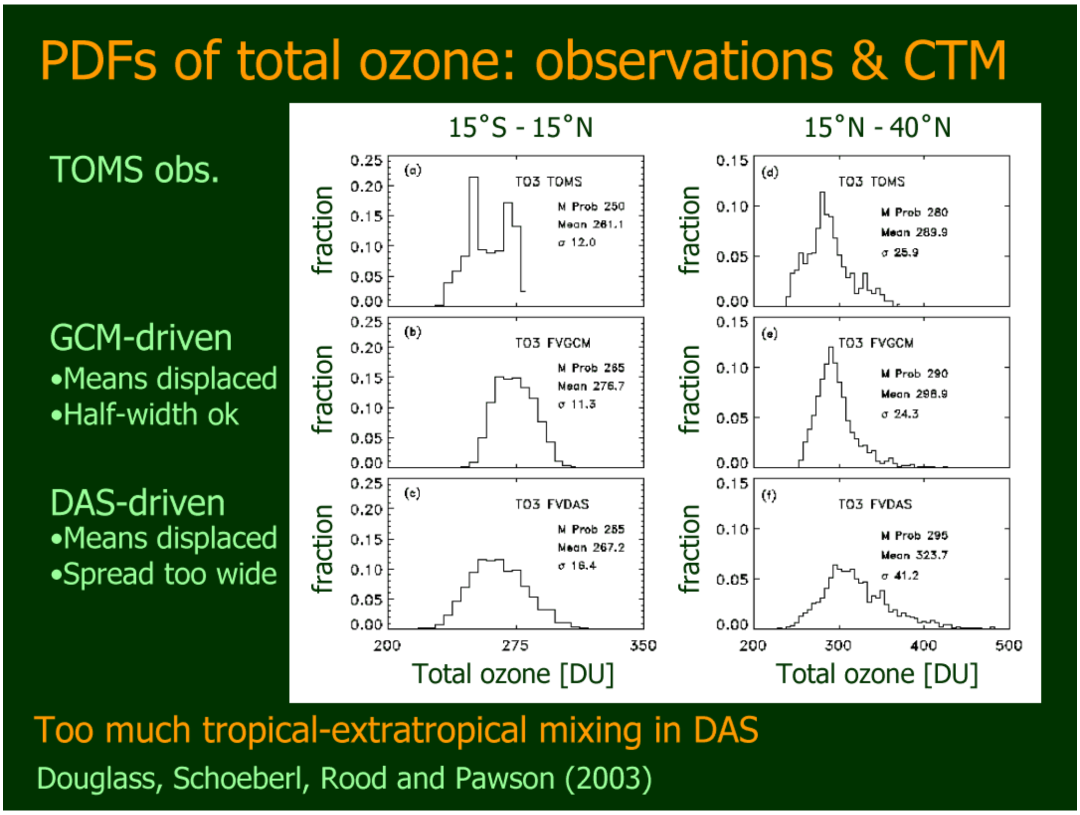
- About a decade of experience using CTMs driven by successive versions of GEOS-DAS
- Lin-Rood code provides highly accurate representation of large-scale transport
- Improvements in meteorological assimilations have benefits for CTMs
- What is the "limit" of success?
- GCM-driven transport may offer insight, given the high quality of present simulations

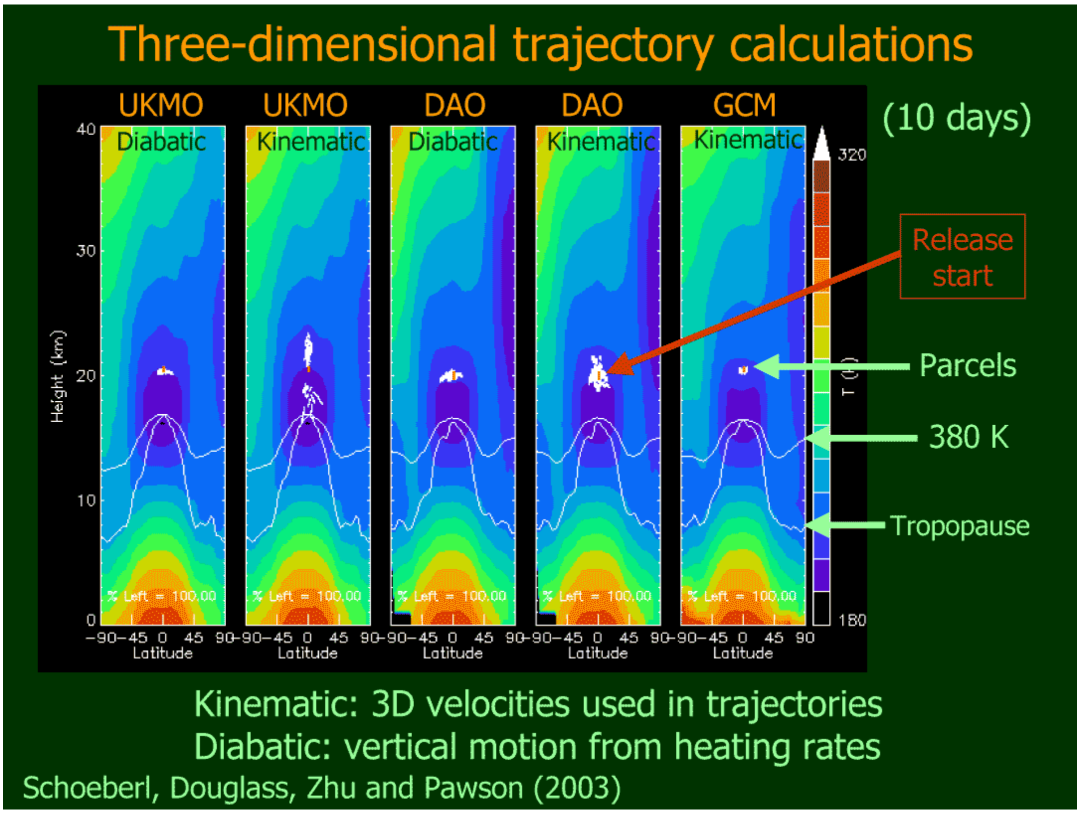
"Age of Air:" long-lived tracer with surface source, weak decay



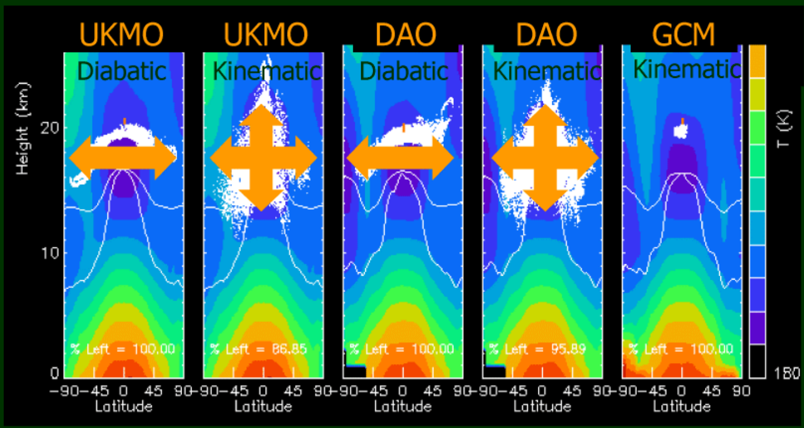
- Determined "off line" using DAS- or GCM-driven winds
- Tropical ascent and weak meridional mixing lead to "bulge"
- Subtropical barrier much stronger in GCM than in DAS
- GCM values in better agreement with observations

Douglass, Schoeberl, Rood and Pawson (2003)


PDFs of total ozone: observations & CTM
TOMS obs.
GCM-driven
•Means displaced
•Half-width ok
DAS-driven
•Means displaced
•Spread too wide
15°S - 15°N
15°N - 40°N
fraction
TO3 TOMS
M Prob 250
Mean 261.1
σ 12.0
TO3 FVGCM
M Prob 265
Mean 276.7
σ 11.3
TO3 FVDAS
M Prob 255
Mean 267.2
σ 16.4
TO3 TOMS
M Prob 280
Mean 289.9
σ 25.9
TO3 FVGCM
M Prob 290
Mean 298.9
σ 24.3
TO3 FVDAS
M Prob 295
Mean 323.7
σ 41.2
Total ozone [DU]
Too much tropical-extratropical mixing in DAS
Douglass, Schoeberl, Rood and Pawson (2003)


Three-dimensional trajectory calculations
UKMO Diabatic
UKMO Kinematic
DAO Diabatic
DAO Kinematic
GCM Kinematic
(10 days)
Release start
Parcels
380 K
Tropopause
Height (km)
Latitude
% Left = 100.00
T (K)
Kinematic: 3D velocities used in trajectories
Diabatic: vertical motion from heating rates
Schoeberl, Douglass, Zhu and Pawson (2003)

Three-dimensional trajectory calculations



(50 days)

Kinematic: considerable vertical and horizontal dispersion
Diabatic: vertical dispersion reduced (smooth heating rates)

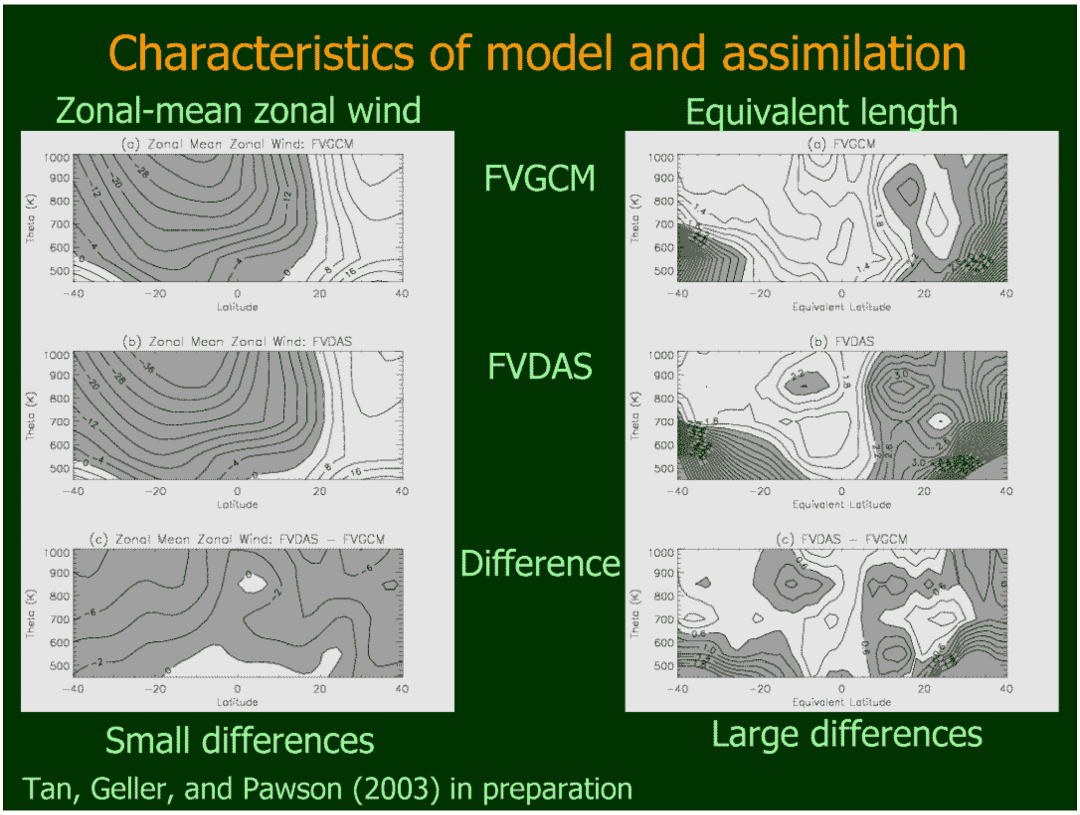
GCM shows very little dispersion, regardless of method used
Assimilated fields are excessively dispersive

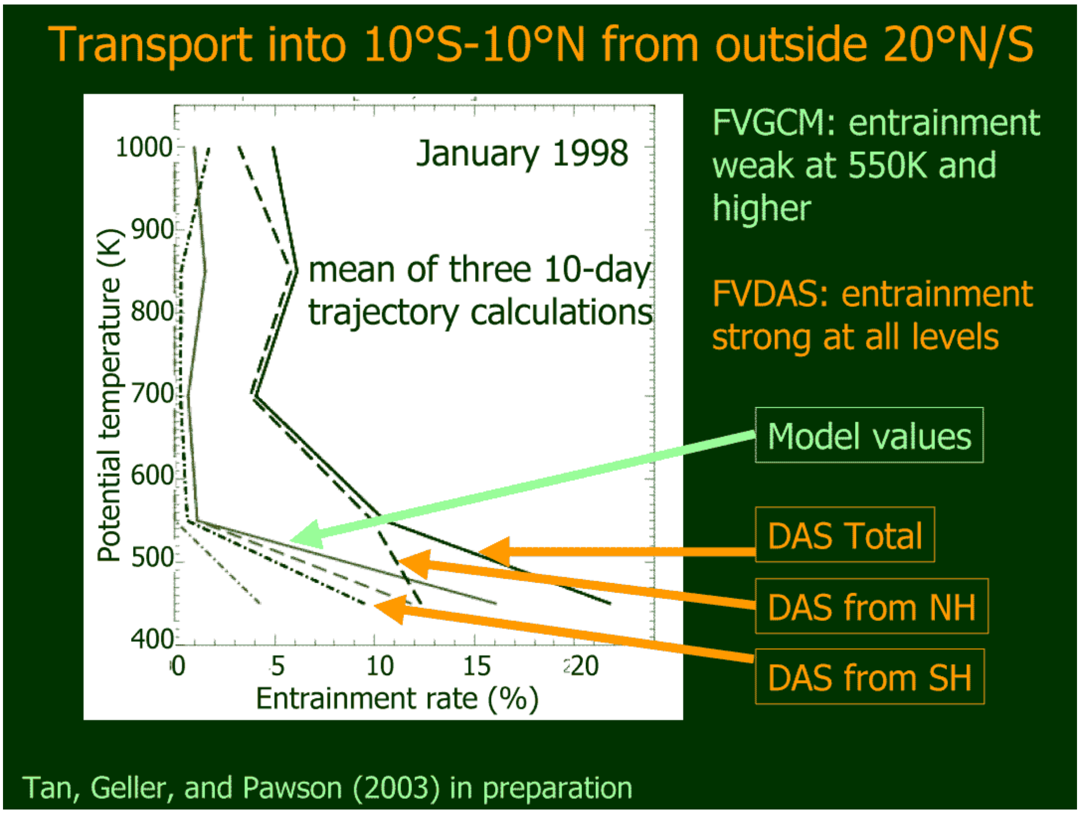
Schoeberl, Douglass, Zhu and Pawson (2003)

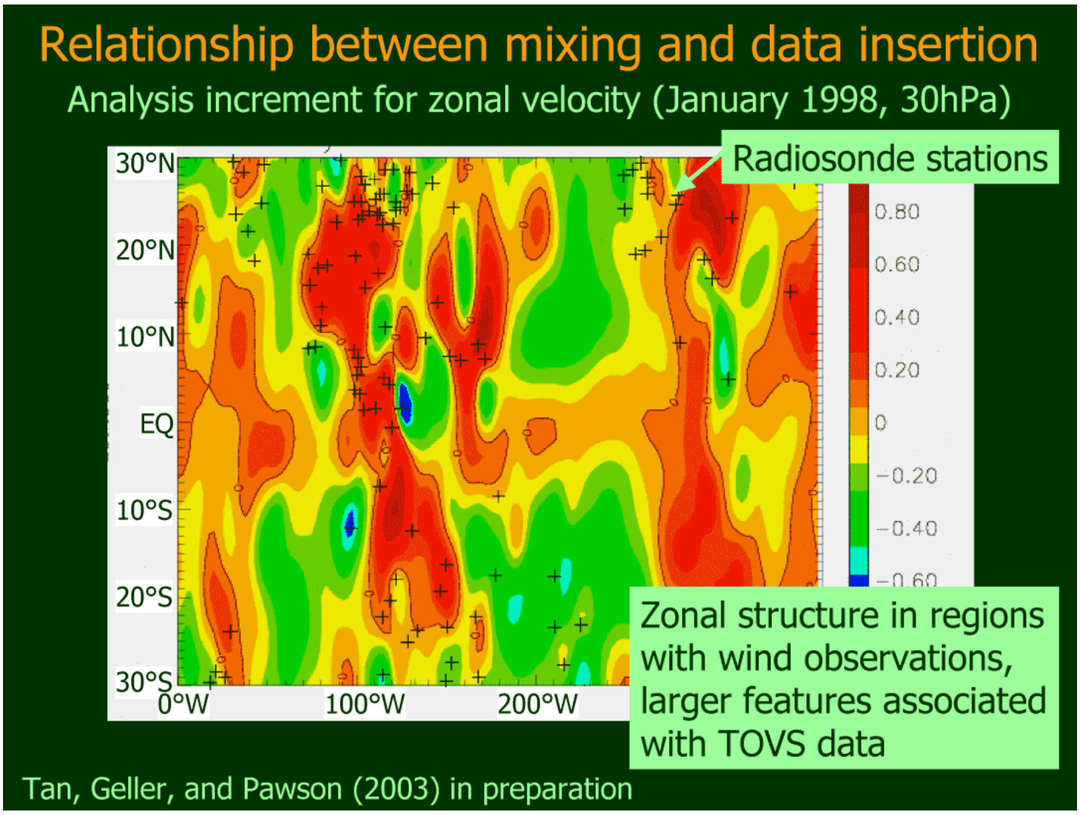
4. Causes of Excess Mixing

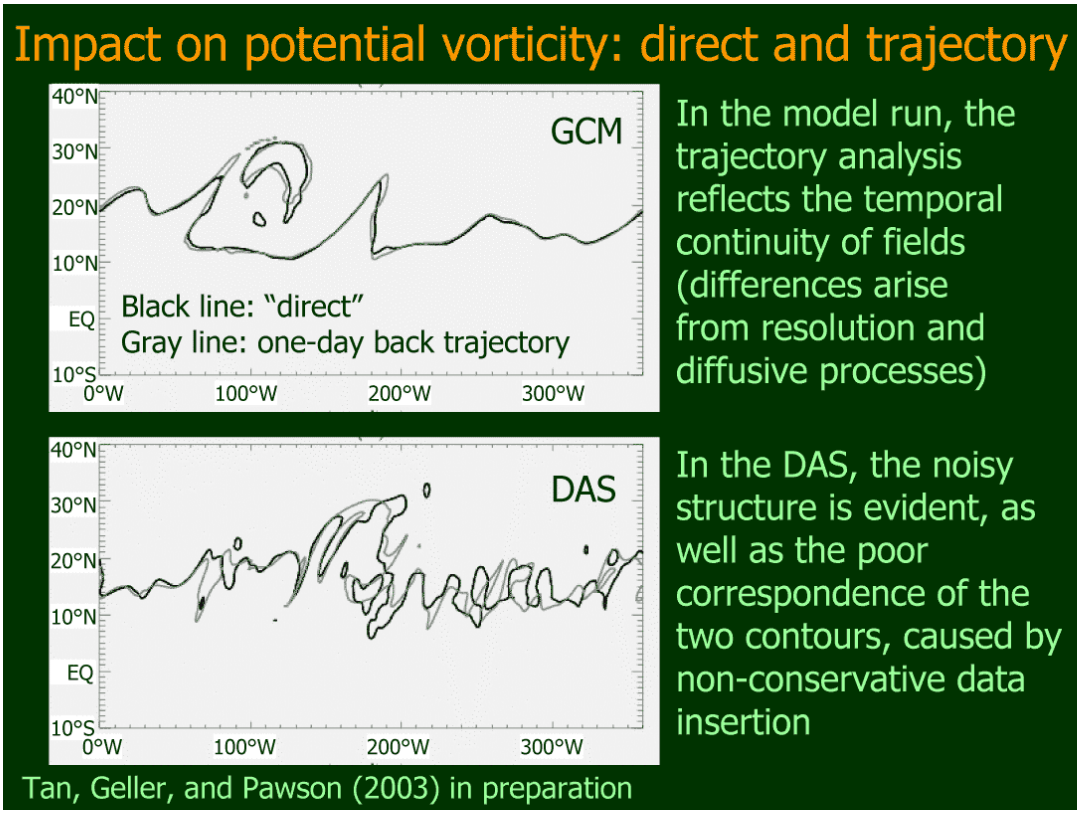
An attempt to quantify the links between data insertion and superfluous subtropical mixing using FVGCM and FVDAS

- January 1998: six-week model run and DAS
- Additional data-withholding experiments
- Trajectory calculations
- Equivalent length and "entrainment" into Tropics give quantitative measures of mixing


Characteristics of model and assimilation
Zonal-mean zonal wind
Equivalent length
(a) Zonal Mean Zonal Wind: FVGCM
(b) Zonal Mean Zonal Wind: FVDAS
(c) Zonal Mean Zonal Wind: FVDAS – FVGCM
(a) FVGCM
(b) FVDAS
(c) FVDAS – FVGCM
Theta (K)
Latitude
Equivalent Latitude
FVGCM
FVDAS
Difference
Small differences
Large differences
Tan, Geller, and Pawson (2003) in preparation


Transport into 10°S-10°N from outside 20°N/S
January 1998
mean of three 10-day trajectory calculations
Potential temperature (K)
Entrainment rate (%)
FVGCM: entrainment weak at 550K and higher
FVDAS: entrainment strong at all levels
Model values
DAS Total
DAS from NH
DAS from SH
Tan, Geller, and Pawson (2003) in preparation


Relationship between mixing and data insertion
Analysis increment for zonal velocity (January 1998, 30hPa)
Radiosonde stations
30°N
20°N
10°N
EQ
10°S
20°S
30°S
0°W
100°W
200°W
0.80
0.60
0.40
0.20
0
−0.20
−0.40
−0.60
Zonal structure in regions with wind observations, larger features associated with TOVS data
Tan, Geller, and Pawson (2003) in preparation


Impact on potential vorticity: direct and trajectory
GCM
40°N
30°N
20°N
10°N
EQ
10°S
0°W
100°W
200°W
300°W
Black line: "direct"
Gray line: one-day back trajectory
In the model run, the trajectory analysis reflects the temporal continuity of fields (differences arise from resolution and diffusive processes)
DAS
40°N
30°N
20°N
10°N
EQ
10°S
0°W
100°W
200°W
300°W
In the DAS, the noisy structure is evident, as well as the poor correspondence of the two contours, caused by non-conservative data insertion
Tan, Geller, and Pawson (2003) in preparation

5. Summary

- Limb-sounding temperature data (SABER) can be effectively combined with TOVS data
- Inclusion of MIPAS ozone, alongside SBUV, improves performance of ozone system
- Need good information about upper tropospheric water and clouds for improving models
- CTM studies using assimilated meteorology reveal excessive cross-barrier transport
- Local assimilation leads to noise and excessive transport near the sub-tropical barrier

Drawing Information From:

- A.R. Douglass, M.R. Schoeberl, R.B. Rood, S. Pawson: *Evaluation of transport in the lower tropical stratosphere in a global chemistry and transport model*. J. Geophys. Res., in press (2003).
- M.R. Schoeberl, A.R. Douglass, Z. Zhu, S. Pawson: *A Comparison of the lower stratospheric age-spectra derived from a general circulation model and two data assimilation systems*. J. Geophys. Res.,**108**, DOI 10.1029/2002jd002652 (2003).
- W. Tan, M.A. Geller, S. Pawson: *A Case Study of Excessive Subtropical Transport in the Stratosphere of a Data Assimilation System*, J. Geophys. Res., almost submitted (2003).