Equatorial Transport as diagnosed from Nitrous Oxide Variability

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Scientific Issues

- Time evolution of long-lived and tropospheric-origin nitrous oxide (N_2O) in the equatorial UTLS and stratosphere is examined by combining satellite measurements and 3D CTM results.

- Particular attention is given in the Equatorial UTLS over different regions (Western Pacific vs. Africa) where Troposphere-to-Stratosphere Transport might be more intense e.g. over Africa during the March-May 2002-2004 season (*Ricaud et al.,* ACP, 2007).

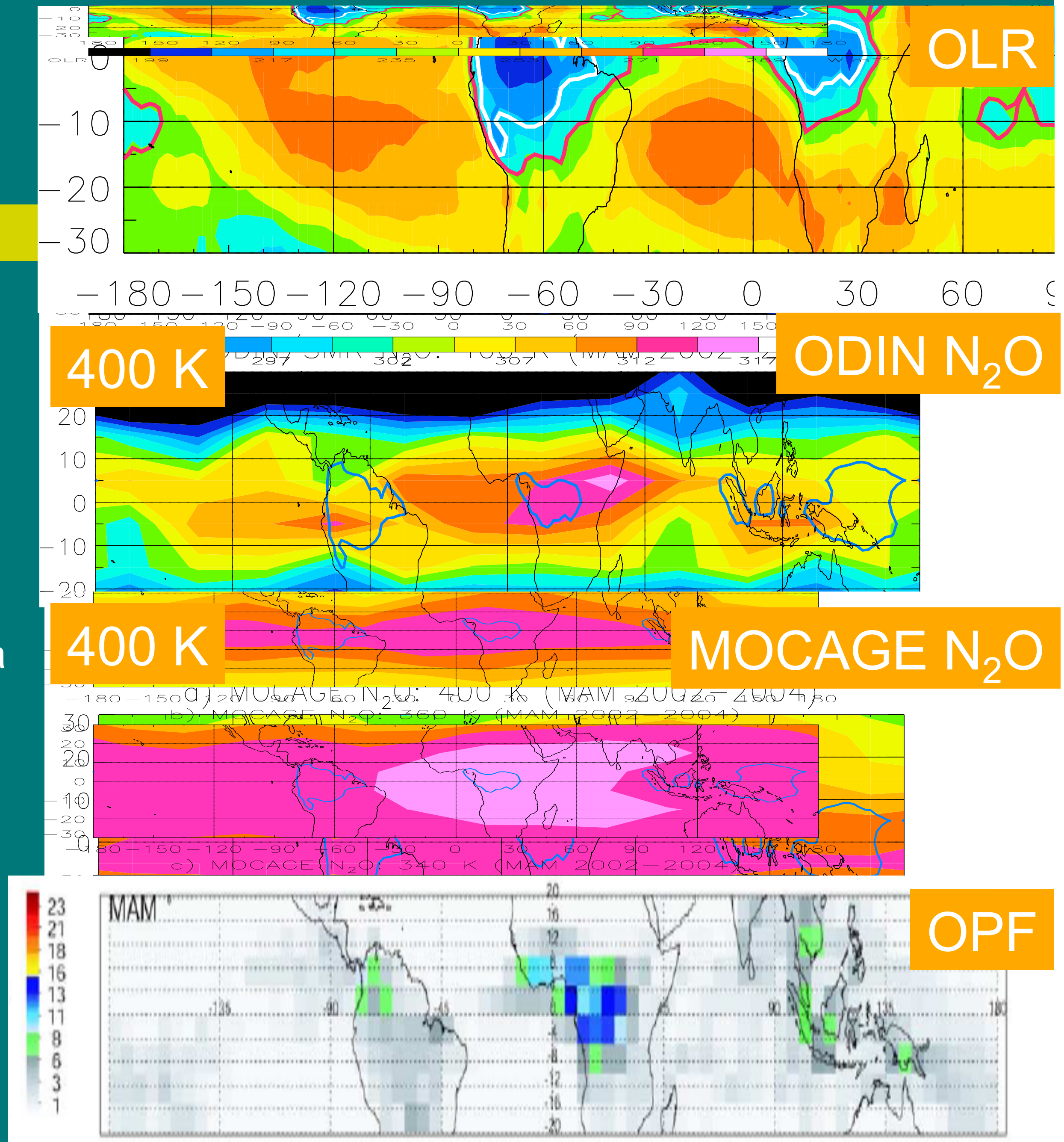
- Seasonal variations are now considered in the present study.
  - 400, 450, 500, 550 K
  - 10°S-10°N (and 20°S-20°N)
  - Western Pacific (120°E-210°E) and Africa (30°W-60°E)

Data Sets

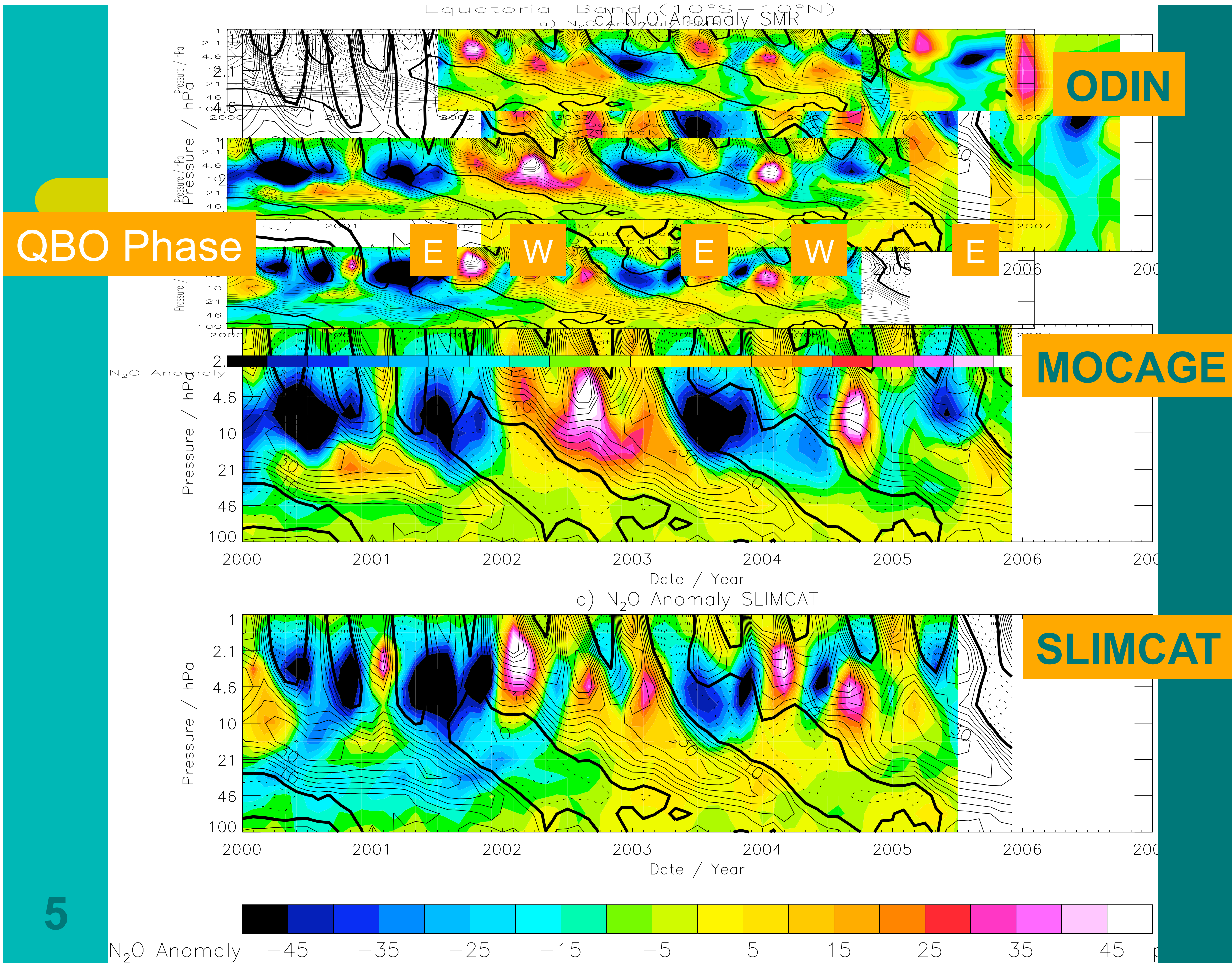
- N_2O Measurements
  - SMR instrument on the ODIN platform
    - 2001-2005 in V222 (ETHER data base)
    - 100-1 hPa
- 3D off-line CTMs
  - SLIMCAT
    - Univ. Leeds, UK
    - 1977-2005 (→ 2000-2005)
    - 7.5°x7.5°, 24 levels from the surface to about 60 km
    - Detailed stratospheric chemistry
    - Vertical advection from diabatic heating rates
    - ECMWF : 1977-2001 (ERA 40) and after (operational analysis)
  - MOCAGE
    - Météo-France, Toulouse, France
    - 2000-2005
    - 5.6°x5.6°; 60 layers from the surface to about 0.07 hPa
    - Detailed tropospheric and stratospheric chemistry
    - Vertical velocities calculated from the ECMWF forcing analyses

MAM season

- At 400 K, all measured gases (N_2O, CH_4 and CO) show significant longitudinal variations, not captured by the model (Ricaud et al., ACP, 2007).
- The maximum amounts are primarily located over Africa in MAM 2002-2004.
- The suggestion is of strong overshooting over land convective regions, particularly Africa, very consistent with the TRMM maximum overshooting features over the same region during the same season.



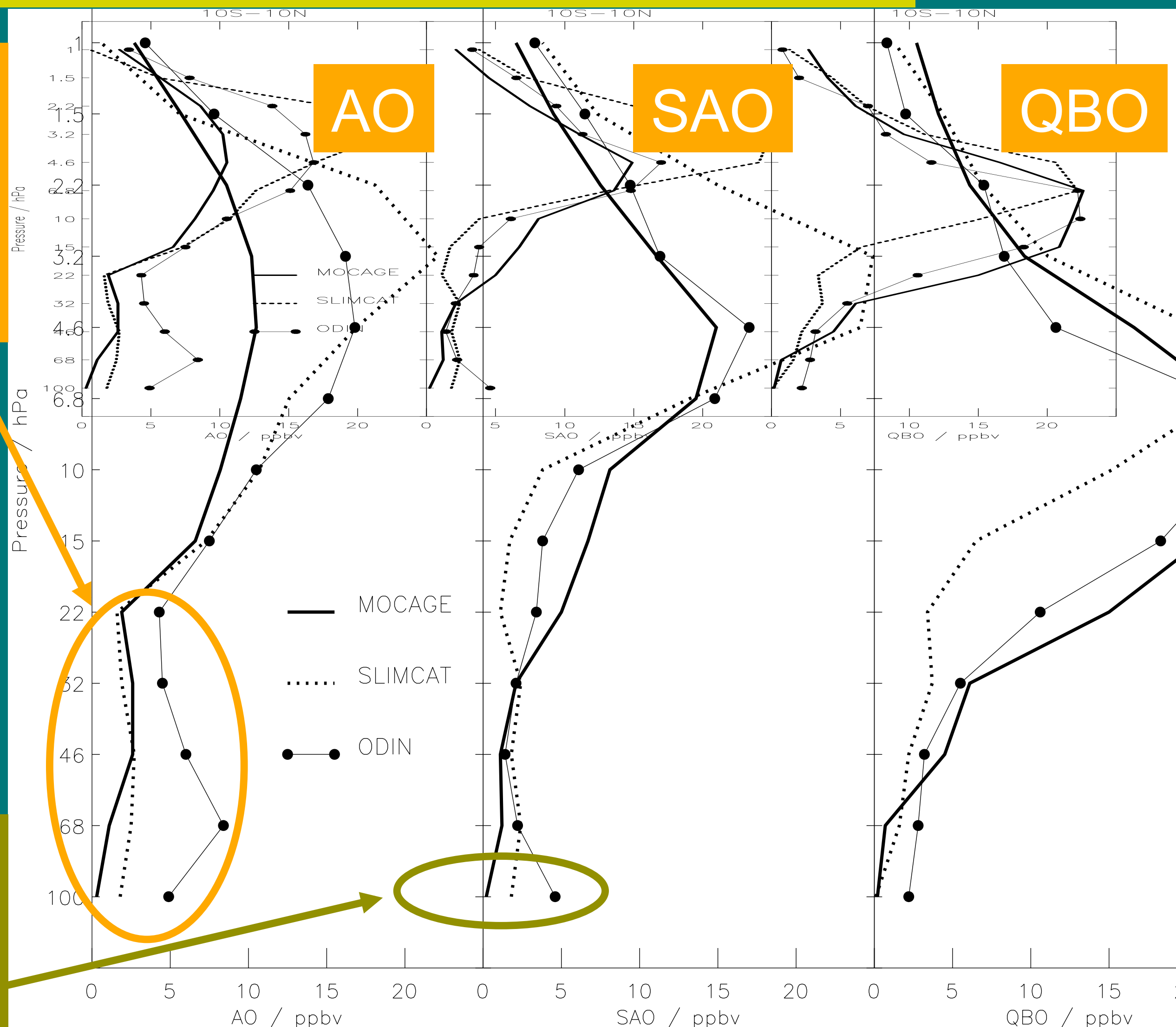
Overshooting Probability Function (*Liu and Zipfser*, JGR, 2005)



Equatorial Band (10°S–10°N)
a) N2O Anomaly SMR
ODIN
QBO Phase
E
W
E
W
E
MOCAGE
c) N2O Anomaly SLIMCAT
SLIMCAT
Pressure / hPa
1
2.1
4.6
10
21
46
100
2000
2001
2002
2003
2004
2005
2006
Date / Year
N2O Anomaly
−45
−35
−25
−15
−5
5
15
25
35
45

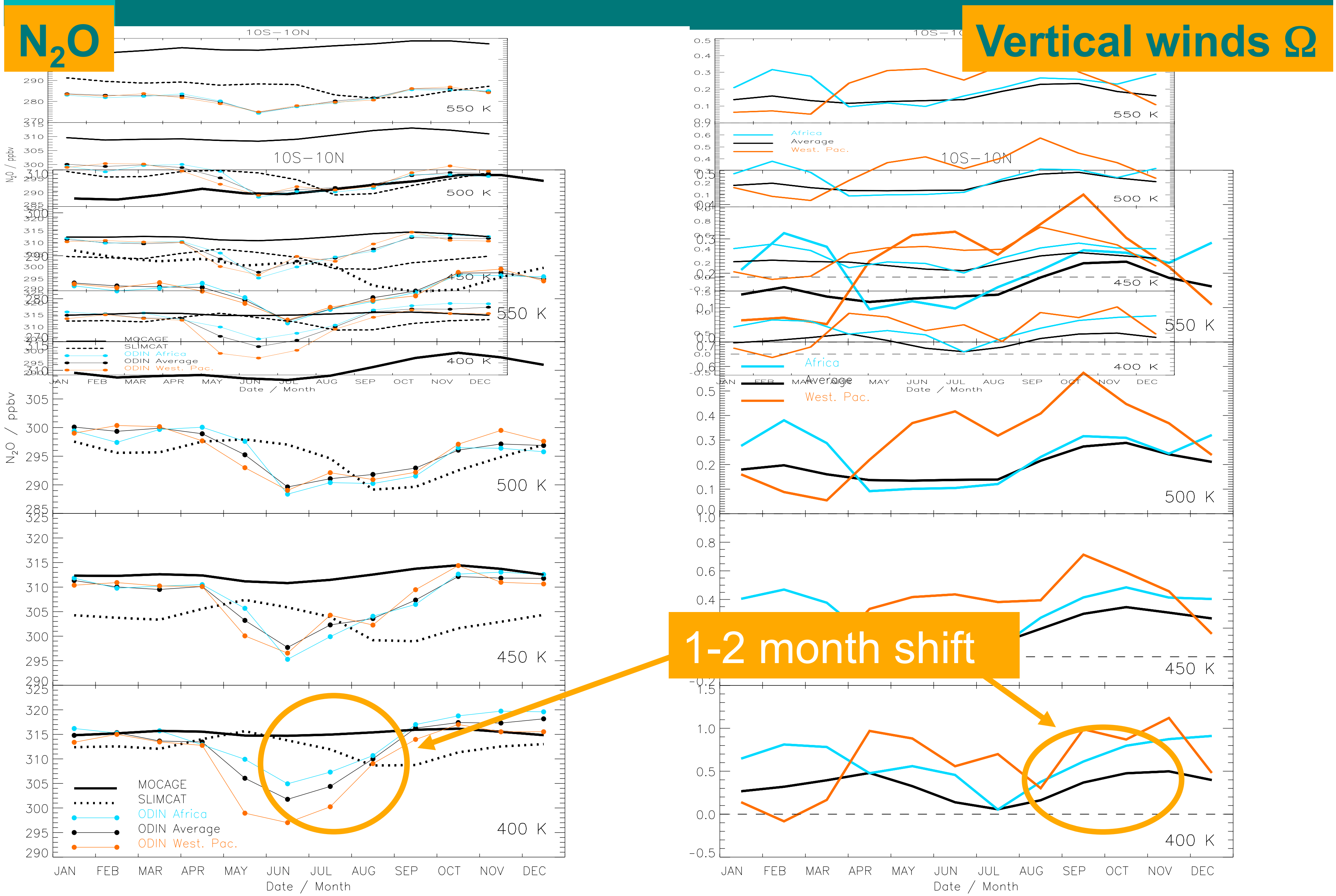
AO, SAO and QBO

Model underestimation of the AO in the UTLS



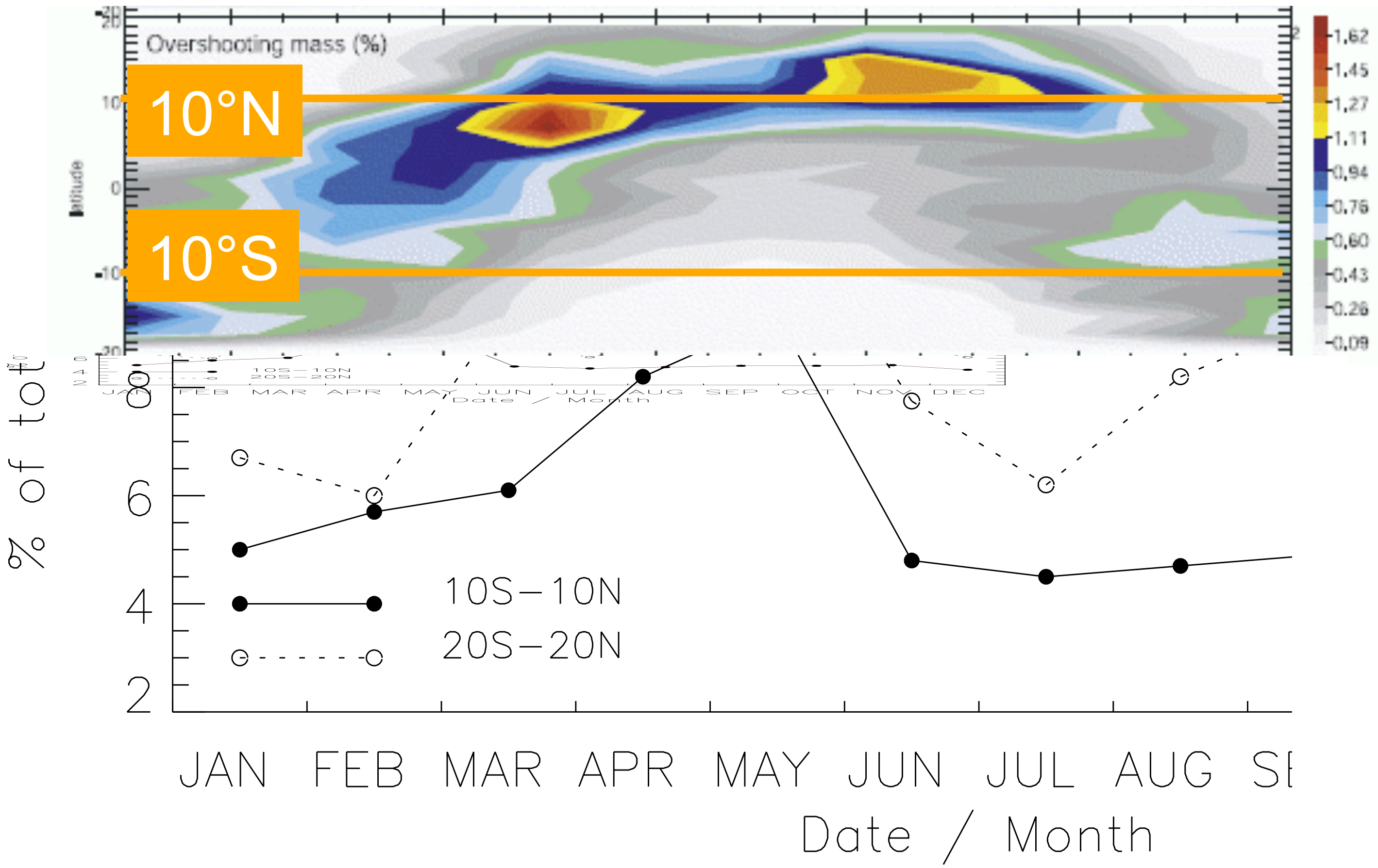
Non-negligible measured SAO at 100 hPa

Variations of N_2O vs. Vertical Winds



Overshootings

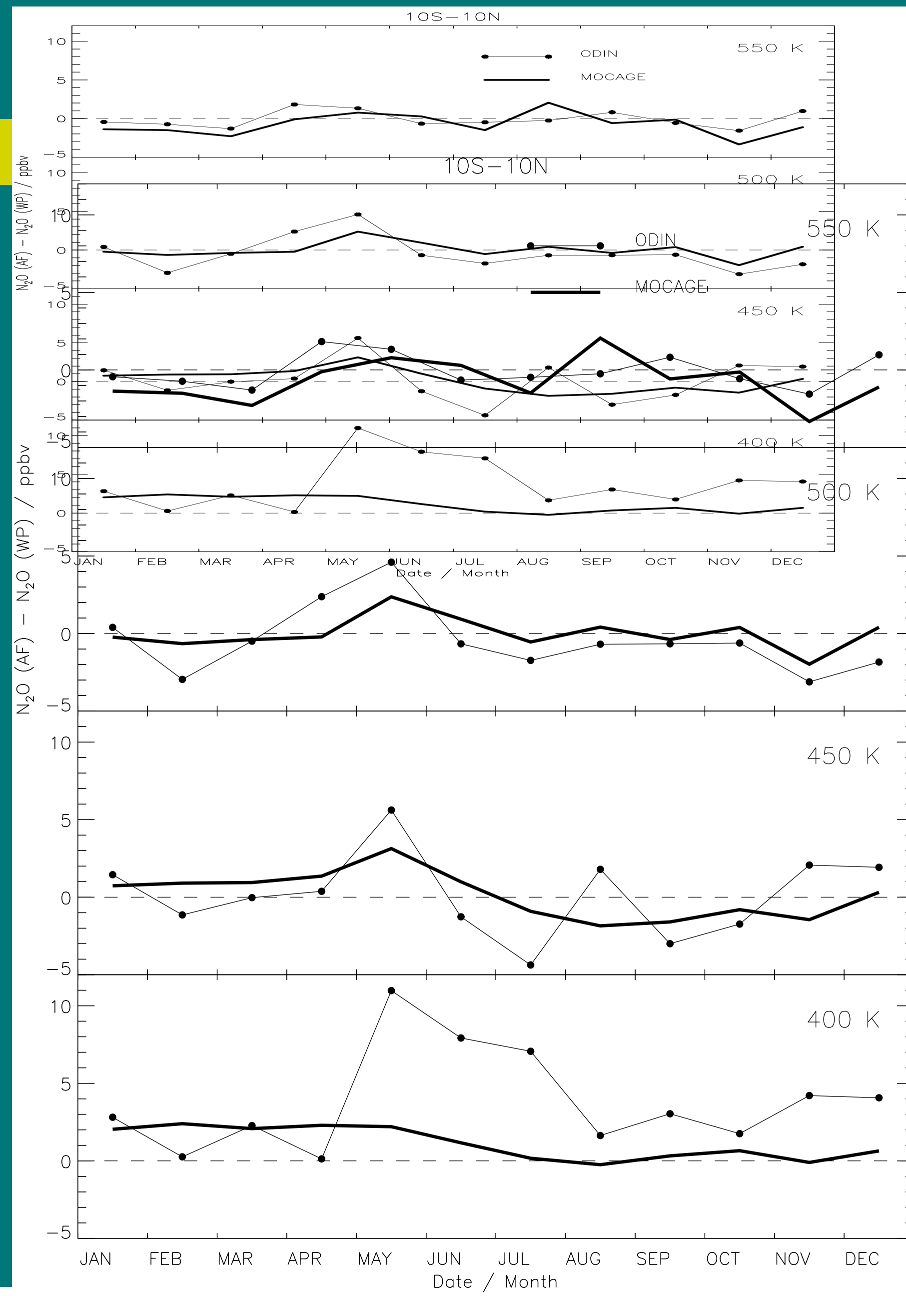
Contribution of overshootings above 14 km (Liu and Zipser, JGR, 2005.)



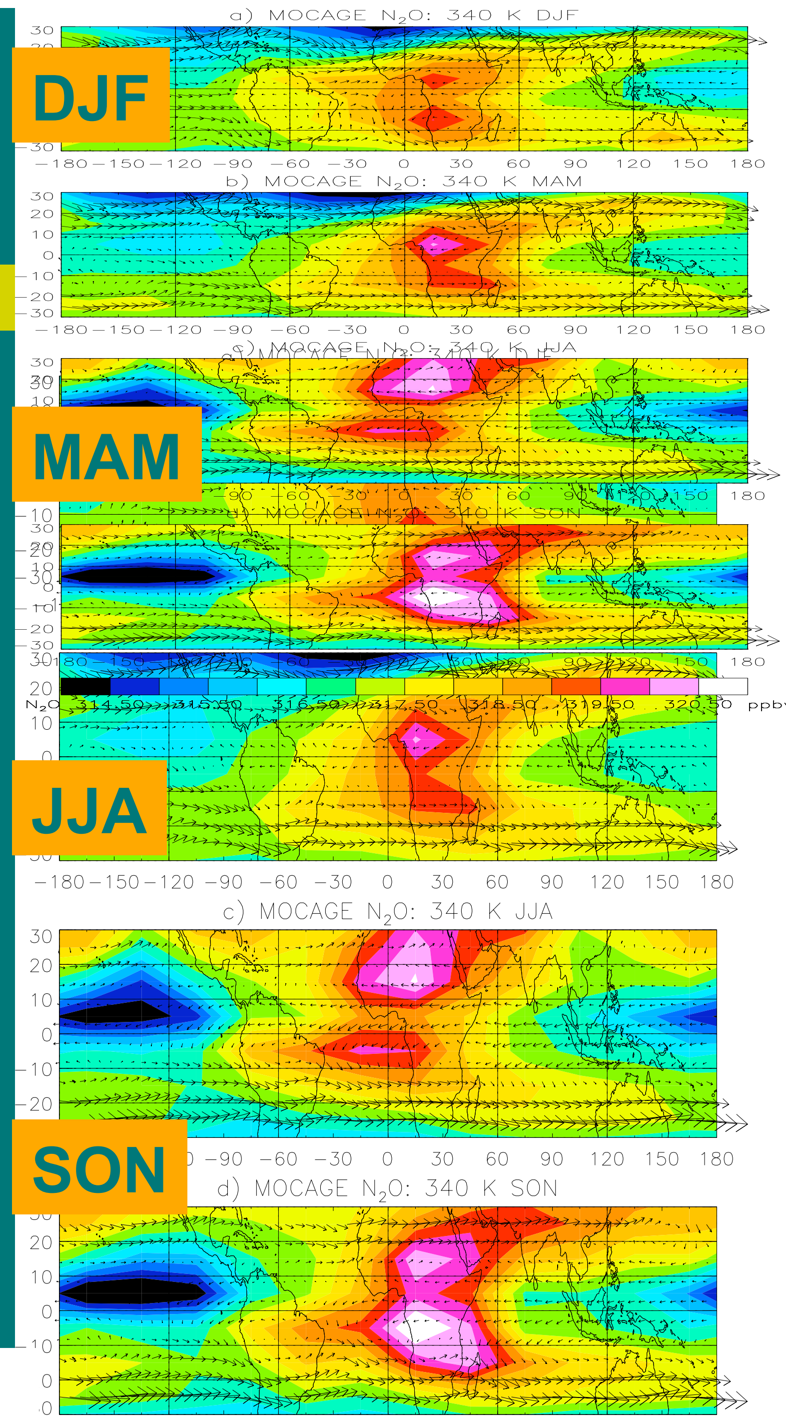
Adapted from Liu and Zipser (2005)

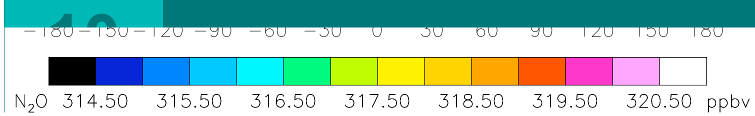
Difference between N_2O (Africa) and N_2O (Western Pacific)

- Longitudinal gradients in N_2O vanishes above 500 K whatever the month considered
- At and below 500 K, a maximum in N_2O is observed over Africa peaking in:
  - May-July at 400 K
  - May at 450 and 500 K
- Overshooting Probability Function restricted to 10°S-10°N adapted from Liu and Zipser (2005) also peaks in May
- This strongly suggests that small-scale vertical processes over Africa in May can directly impact on the global-scale distribution of long-lived species in the LS



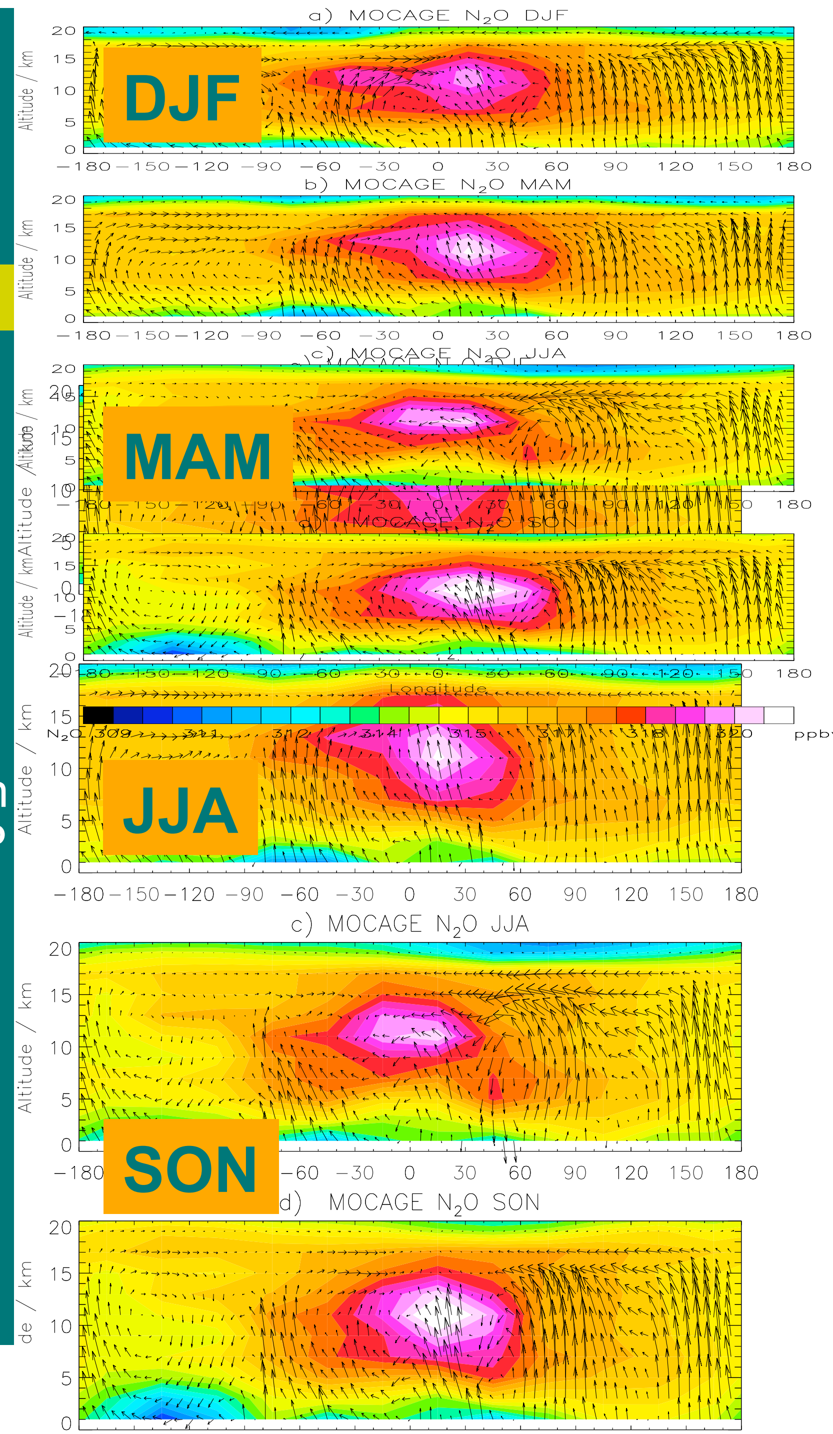
Tropospheric distribution of N_2O from MOCAGE @ 340 K

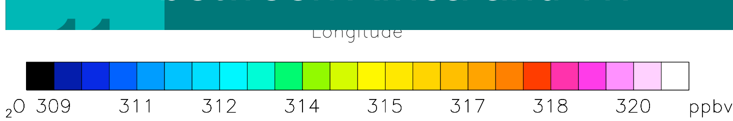




Vertical distribution of N_2O from MOCAGE (0-20 km)

- Africa appears to be a Convergence Zone all over the year
- Onset of the Monsoon Seasons (DJF & MAM)
  - Weak horizontal in-mixing & strong vertical uplift (+ overshootings)
  - Marked horizontal inhomogeneity in the LS N_2O between Africa and WP
- During the Monsoon Seasons (JJA & SON)
  - Strong horizontal in-mixing and weak vertical uplift (- overshootings)
  - No marked horizontal inhomogeneity in the LS N_2O between Africa and WP





Conclusions

- From the middle to the upper stratosphere, both the QBO and the SAO signals are fully consistent within all the measured and modelled data sets. In the lower stratosphere, the measured AO signal is more intense than the modeled AO outputs, and the measured SAO is non negligible at 400 K.

- In the LS, at 400 K, the measured N_2O SAO and AO are shifted by 1-2 months compared to the SAO and AO of the vertical winds. N_2O amounts over Africa are measured to be more intense than over Western Pacific in May-July (consistent with *Ricaud et al. (*2007) that concentrated in MAM).

- The measured seasonal variation of the difference between N_2O (Africa) and N_2O (Western Pacific) peaks in May consistently with the seasonal variation of the contribution of overshootings (Liu and Zipser, JGR, 2005).

- Africa appears to be a Convergence Zone all over the year that impacts long-lived species in the LS mainly during the onset of the Monsoon Seasons (DJF & MAM): weak horizontal in-mixing & strong vertical uplift (+ overshootings).

- This study strongly suggests that small-scale vertical processes over Africa around May can directly impact on the global-scale distribution of long-lived species in the LS.