Evaluation of the capability of ECHAM5/MESSy in the tropical tropopause layer: comparison with aircraft data

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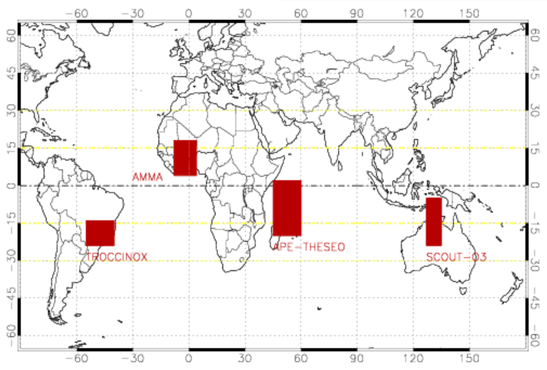
Introduction

The objective of this study is to evaluate the capability of the ECHAM5/MESSy CCM to reproduce the structure of the TTL water vapour and chemical species in the Tropical Tropopause Layer (TTL). We have analyzed the in-situ **O3, N2O, H2O, and CO2 measurements** obtained on board the research aircraft Geophysica during four tropical campaigns: APE-THESEO, TROCCINOX, SCOUT-O3, and AMMA. The aim is to show that local observations from in-situ campaigns can be representative of the **average vertical structure of the TTL @ regional scale** and can be compared to CCMs as ECHAM5/MESSy.

The measurement campaigns



APE-THESEO
15 Feb - 15 Mar 1999, Seychelles.
TROCCINOX
Jan - Feb 2005, Brazil
SCOUT-O3
Nov - Dec 2005, Australia
AMMA
31 Jul - 18 Aug 2006, West Africa

Fig.1. Geographic location and times of the four measurement campaigns

ECHAM5/MESSy simulation

- horizontal resolution of **T42 (2.8°x2.8°)**
- **90** vertical layers from the ground to the mesopause (0.01 hPa) with vertical resolution of approximately 500 m in the TTL
- **forced by climatological SSTs** (no dynamical nudging)
- **realistic chemistry**
- **QBO** spontaneously generated

Simulation time: from April 1998 to April 2001.
Model data have been sub-sampled according to the times of the campaigns and observation sites. Data are taken every 24 hours.

Comparison of the mean vertical profiles

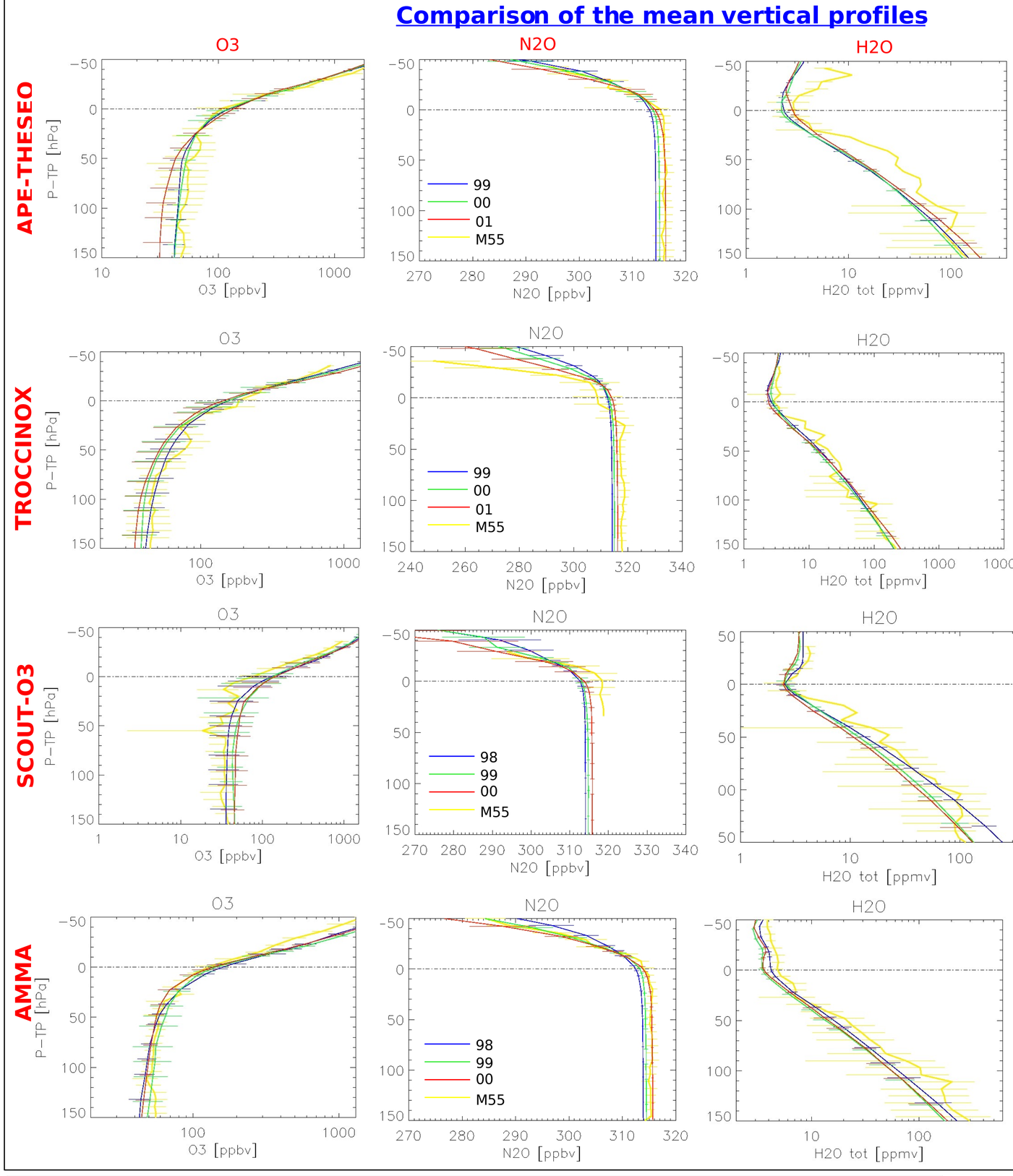


Fig.2. Comparison between the observed vertical profiles of O3, N2O, H2O, and CO2 (yellow line) and the modelled vertical profiles for the three years of model (blue, green, red lines).

H2O-O3 correlation in the UTLS

The morphology of the tracer-tracer scatter plots in the tropical UT/LS allows to infer information about the transport mechanisms that occur across the tropopause and the role of mixing and local processes.

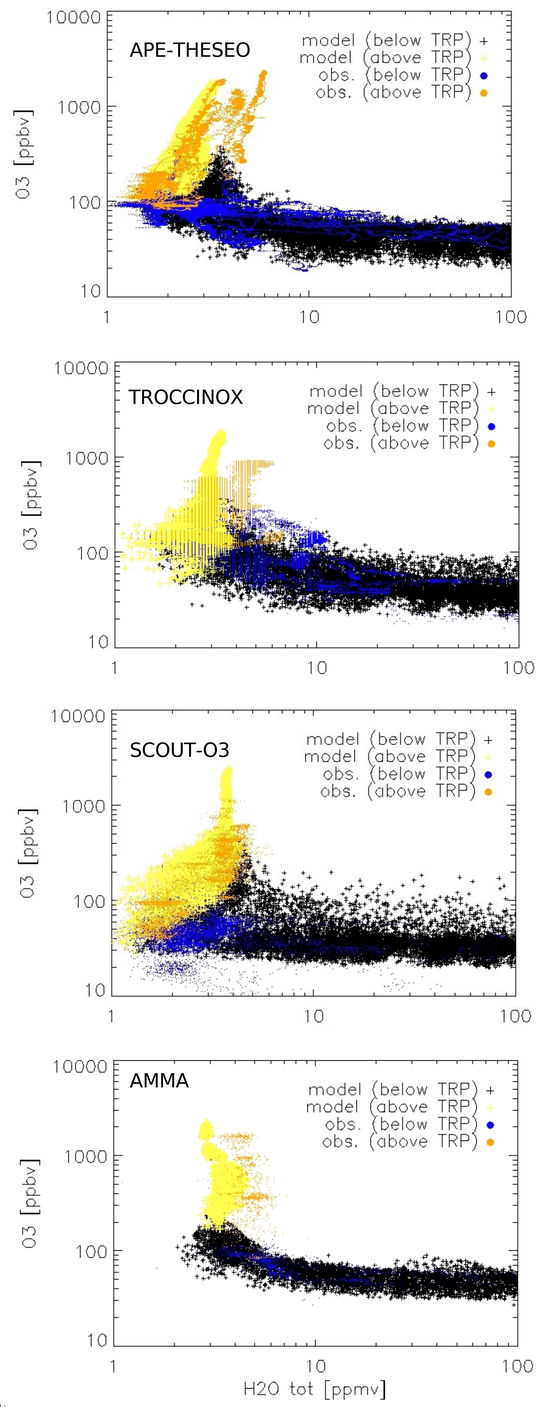


Fig. 3. H2O-O3 scatter plots for the four campaigns and the model data.

Temperature, water vapour and CO2 variability

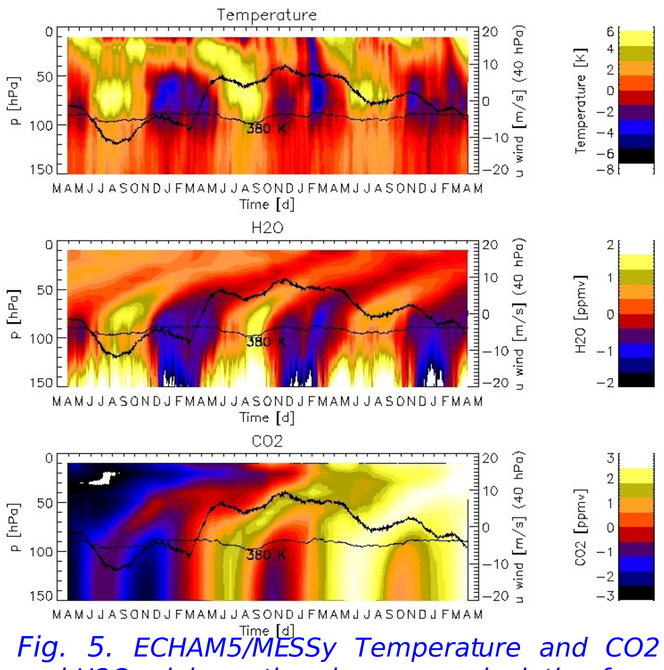


Fig. 5 shows the ECHAM5/MESSy time-height sections of temperature (in Kelvin), water vapour and carbon dioxide mixing ratios (in ppbv) shown as a deviation from the time mean profile averaged between 15°S and 15°N. Each panel of Fig. 5 also shows the isentropic surface at θ=380 K (which marks the tropical tropopause level) and the zonal mean zonal wind at 40 hPa (in ms^{-1}), useful to correlate the variability among the different campaigns with the quasi-biennial oscillation of the zonal wind (QBO). It should be noticed that the three-years temporal series of the model contains a full cycle of QBO > 0.

Fig. 5. ECHAM5/MESSy Temperature and CO2 and H2O mixing ratios shown as a deviation from the time-mean profile, between 15 °S and 15 °N.

In addition, the statistical properties of the tracer-tracer field can also be analyzed by means of tracer-tracer probability density functions (PDFs). An example is supplied in Fig. 4. (preliminary analysis)

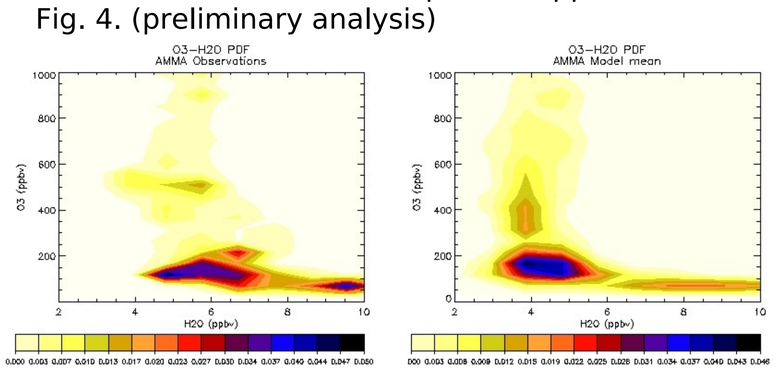


Fig. 4. Bivariate PDFs of the H2-O3 correlation AMMA observations (left) and the model (right).

The H2O-O3 correlation is “L” shaped in the tropical UT/LS region. However, Fig. 3 shows that a significant fraction of data lie outside the region of the tropospheric and stratospheric branch. Moreover, there are noticeable differences among the four campaigns regarding the transition between the troposphere and the stratosphere.

Conclusions

- ECHAM5/MESSy is able to reproduce the structure of the TTL
- Observations, besides the local effects and the flight planning dedicated to specific aims are representative of an average structure of the TTL @ regional scale
- CO2 and H2O variability among the campaigns can be explained in terms of long stratospheric transport (tape recorder effect)

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