Assimilation of stratospheric chemistry observations into the operational NWP model GEM

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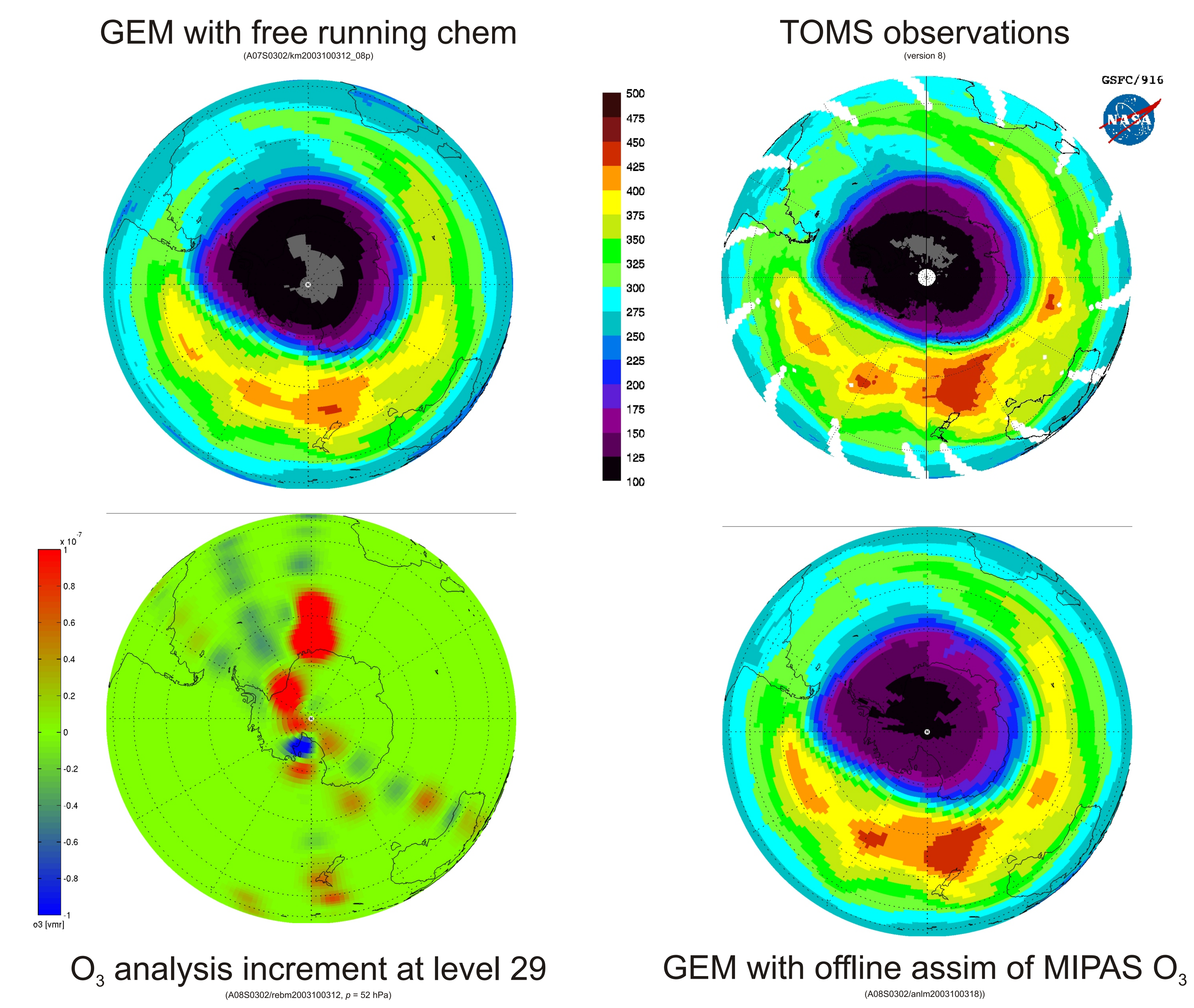
Abstract

The operational Numerical Weather Prediction (NWP) model GEM now includes the stratosphere (lid at 0.1 hPa, 80 -p levels) and the stratospheric chemistry module developed for BASCOE. This module can impact the dynamics through ozone and water vapor radiative effects.
The 3D-VAR module has been extended to allow incremental assimilation of chemistry observations. This is (one of?) the first operational system to assimilate chemistry and dynamics in a fully coupled way.
Here we assimilate MIPAS O_3 and CH_4 observations during Fall 2003 with dynamical fields overwritten every 6h from an offline assimilation of meteorology.
The results are compared with previous experiments where no assimilation is performed, or where dynamics only is assimilated (free-running chemistry). We validate with observations from TOMS (fig.1), MIPAS and two other assimilation systems (BASCOE and ECMWF, fig. 2).
The final experiment, with simultaneous assimilation of dynamics and all MIPAS chemistry observations, remains to be done.

Fig. 1. Ozone column (D.U.) above South Pole on 2003/10/03



Validation against MIPAS

(2003/09/01-04 is *before* ozone hole)

Temperature
Assimilation of TOVS radiances corrects well the warm bias of GEM model (grey) in strato. Analyses have +/- same quality as ECMWF (pink). Problem: bias "zig-zags" with altitude. Note: MIPAS temperatures are *not* assimilated yet.

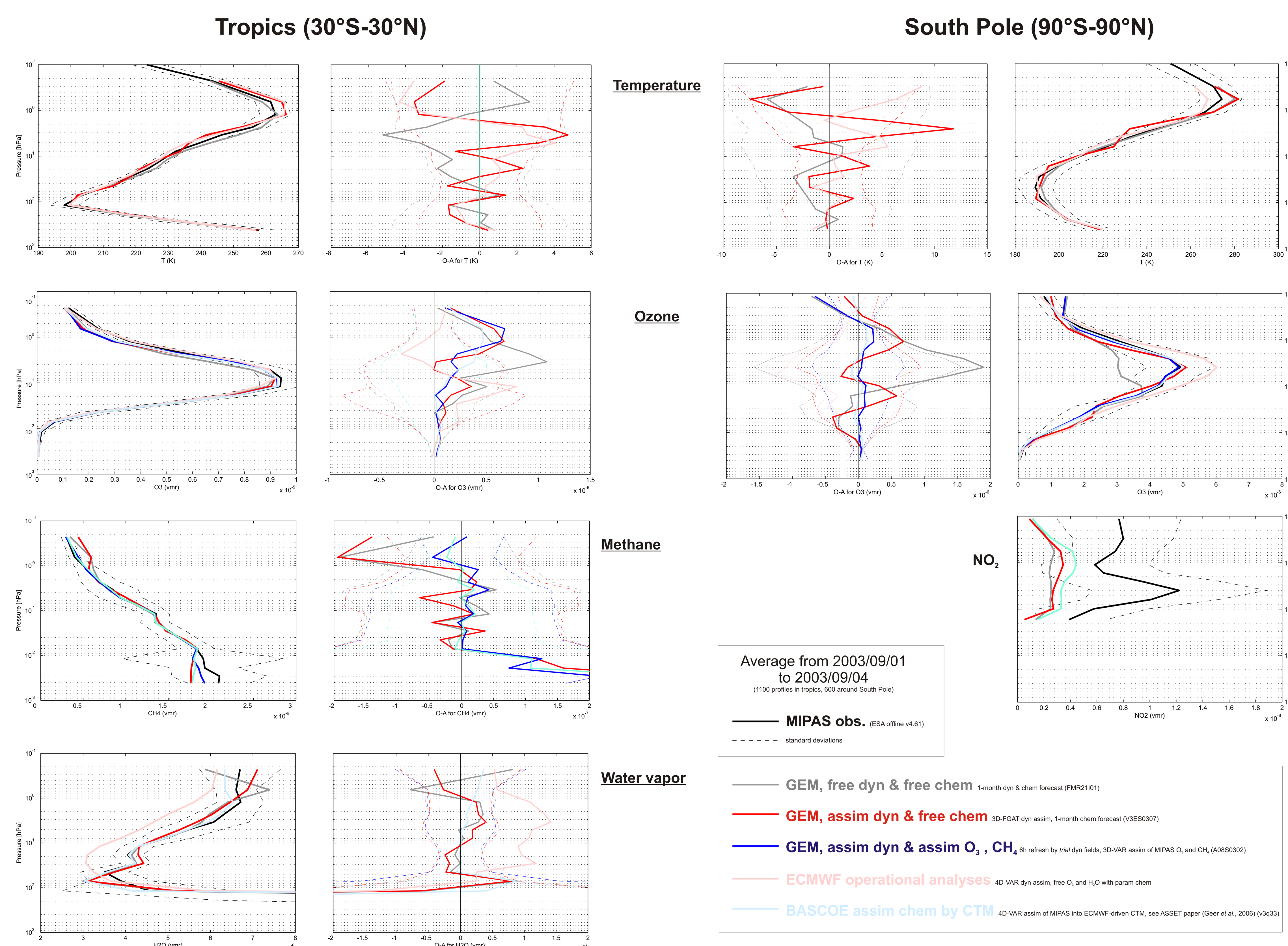
Ozone
Results very similar to BASCOE analyses (cyan): model has less ozone than MIPAS ESA (patly due to obs, *cf* ASSET), assim corrects this below 10hPa but not above. Tropics: the "wiggles" issue (see below) can be seen in red stdev. South Pole: excellent match.

Methane
Assim corrects well the bias, we get results similar to BASCOE

Water vapor
Model performs quite well below 1hPa, assim should be easy.

NO_2 above South Pole
Downdraft in polar night vortex => very high NO_2 in strato due to NO productions specific to MLT. These are not modelled => model severely underestimates NO_2 (QC in BASCOE

Fig. 2. Averaged vertical profiles: comparison of MIPAS with GEM, BASCOE and ECMWF



Standing issues

Horizontal oscillation of ozone ("wiggles") in tropical lower strato
See fig.3. Wiggles are present when advection is driven by assimilated wind fields, but disappear when advection is driven by *trial fields* (6h forecasts) from an offline assimilation of dynamics. Wiggles contribute to "zig-zags" in vertical profiles of bias with MIPAS (fig. 2). Modifying *T* stdev (in *B*) and/or removing p_0-*T* balance operator in tropics could solve this issue (ask Y.R.).

Horizontal length of correlations in B and vortex edge
See fig.1. Horizontal correlations in *B* have a circular shape with default length = 600 km. When the observation is close to the polar vortex, the analysis increment runs over the edge and injects ozone into the vortex. This is why a free-running simulation delivers better (more) ozone depletion than the MIPAS analysis.

Fig. 3. Zonally averaged ozone on 2003/09/04