

## ***Interactive comment on “Assessing stratospheric transport in the CMAM30 simulations using ACE-FTS measurements” by Felicia Kolonjari et al.***

**Anonymous Referee #1**

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The authors compare free-running and nudged simulations using the CMAM middle-atmosphere model to ACE-FTS measurements of long-lived tracers (

The analysis is generally well grounded and based on established analysis techniques, such as tracer-tracer correlation plots. Generally my impression is that the paper takes in a lot of information, making this a fairly dense read. For the future, I recommend to the lead author to break up such works into into smaller, separately publishable pieces. I don't think it would be adequate to recommend this course of action for the present paper as this is only a matter of presentation. The captions of some figures could be more detailed; for examples see below. In the comparison of models versus satellite measurements, a more thorough discussion of the effect of measurement uncertainty on tracer-tracer plots would be desirable. For example, the density plots of  $N_2O$  versus

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CFC-11 and CFC-12 (figures 13a and c), in the case of the satellite, are probably affected by measurement noise giving the JPDFs a fuzzy appearance. Such noise is absent in the model, making for a skewed comparison. Possibly averaging kernels of the ACE-FTS measurements could be used to define random noise to be added to the model data, making them more comparable to the measurements. If this is not practical, at least some text to this effect would be good to have.

Similarly, the discussion of differences in stratosphere-troposphere intrusions / extrusions mentions that resolution might factor into this comparison. At least for the detection of such structures in the data, this can be accounted for by removing small scales from the satellite data using a low-pass filter. Then the two datasets are nominally at the same resolution. This would however not address that the simulation of cut-off systems is fundamentally sensitive to numerical diffusivity in the model, causing reduced incidences of such systems.

Regarding the differences in age-of-air between the free-running and nudged version of the model, my impression is that this is partly caused by mass non-conservation in the nudging fields, whereby artificial divergence caused by relaxation towards reanalyses causes noise in the vertical motion fields. The effect of this might be increased numerical diffusion and a reduced age. Since CMAM is based in a spectral dynamical core, one could consider, in separate experiments, to only nudge divergence or only vorticity, to try to control this behaviour.

On the whole, the above amounts to a recommendation to publish after a minor revision. Minor comments:

P3L3: This sentence reads a little awkwardly – modelling and observations are independent activities. How about “The BDC is well characterized in models but remains poorly constraint in obs” or so?

P7L10: It’s certainly possible to rescale the fields to construct approximations for the other tracers. But this requires further assumptions.

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P7L20: Worth mentioning / discussing Meinshausen et al., Geosci. Model Dev., 2017 here. They have constructed boundary conditions for CMIP6 simulations that follow very similar ideas.

P8L6: It remains a little unclear to me how you can have systematic differences between the LBCs used to constrain the simulations and the long-term observations, when the obs were used to construct the LBCs.

P8L27ff: Perhaps not drag but noise in the vertical motion. The  $\omega$  fields in the nudged and free-running model might show some differences.

P14L10: Perhaps insert “annual-mean” and some time information here (which period does the average represent?) Likewise in the caption, here and elsewhere.

P20L3: Here’s where the above comment on model resolution applies. The key difference is not that the two fields are at different resolutions (that could be easily fixed) but that the finite resolution of the model leads to differences in the formation and lifetimes of the cut-off systems.

P34: More detail in the caption please. Which species, which network, which measurement principle, why are there these systematic differences when the measurements had been used in constructing the LBC for the model?

P46: Here’s where I think measurement uncertainties make this a skewed comparison. The model output would ideally be folded with the averaging kernels and a-priori assumptions used in the retrievals of the ACE-FTS measurements before comparison with those measurements.

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