

Interactive comment on “Constraining tropospheric mixing timescales using airborne observations and numerical models” by P. Good et al.

P. Good et al.

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The authors would first like to thank the referee for taking the time to study our manuscript, and offer some useful comments which will lead to a greatly improved paper.

Responses to '1) General comments' _____

1. Clarifying text added: 'That is, it was found that if CO was treated as a passive tracer, this did not affect the mix-down timescales derived, since the slow CO photochemistry does not have much influence at small spatial scales. The results presented correspond to full photochemical calculations.'

2. Statistical tests were not used in the main body of the text, because it was felt

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that a) within the sensitivity allowed by model errors and variability between flights, the results could easily be derived by inspection and b) inspection of the plots is important, since this is a new technique, even if a statistical test is applied later. In the revised manuscript, plots of KS test P-values are presented and discussed for the five similar flights of Aug 16,17,22a,22c,24. For Aug 3 and 8, the extra precision offered by the KS test is not appropriate, since both results are treated with some caution.

3. The mixdown timescale is indeed affected by the resolution of the initial data, and the effect was actually estimated in the final paragraph of the text - namely an increase of about 3 days per e-folding increase in grid dimension. In response to referee comments, a section on 'Sensitivity to the mixing spatial scale' has been added to the revised manuscript, including tests with initial data of degraded resolution.

4. Regarding conceptual differences from the timescales hybrid Lagrangian-Eulerian models, a new section will be included - 'Applicability to mixed Eulerian-Lagrangian models', describing additional tests conceptually closer to hybrid models. These were applied to the five flights where recent convection was not suggested. These tests are less flexible than the main method - meaningful results are obtained for only three of the five flights, the others are influenced by convection in the TOMCAT model affecting some results from longer trajectories. However, for the three suitable flights, the results are very similar to those derived with the original method, differing by no more than 1 day. The effect of grid size is important but not large, and is discussed above. The problem of spatial/temporal dependence will be emphasised in the text, but is always relevant when comparing 3d models with such measurement campaigns. The method gives an idea of mixing timescales for a particular region; it is a method which may be applied to other campaigns to get wider coverage. The referee mentions a variation of almost an order of magnitude in timescales. This is due to two flights where convection is implicated - for Aug 3 this is supported by independent data; the timescales for the other five flights are much more similar.

Responses to '2) Specific comments' _____

'1. p.1214, l.22-28': Text added: 'These numbers refer to a mixing spatial scale of 2.8 degrees, defined here by the resolution of the Eulerian grid from which tracer fields were interpolated to initialise the Lagrangian model.'

Responses to '3) Technical comments' _____

'1.-'4.' corrected

'5. p.1219, l.24-28' Text added: 'That is, for long-lived tracers, the relative magnitude of features of different spatial scales is largely controlled by advection. Therefore, the ratio between the magnitudes of features of different spatial scales is expected to be more reliably modelled than the absolute magnitude of a given feature.'

'6. p.1223, l. 4-5' Text changed to: 'This suggests that the TOMCAT fields used to initialise these trajectories were reasonable. That is, although a direct comparison between TOMCAT and observations at the actual measurement points shows TOMCAT performing less well than usual, when TOMCAT was used to initialise the above short trajectories, the results were much more satisfactory.'

Comments 7.-9.: Text changed to: 'test how much this assumption can be relaxed for the five similar flights (16, 17, 22a, 22c and 24 August) if a slightly larger upper bound of 11 days is chosen for the mix-down timescale. The question addressed is, if an upper bound of 11 days is accepted as valid for these flights, how large could the errors in TOMCAT CO be?'

'10'-'11' corrected

'12. p.1226, l.24': Text changed to: ...'the results reported in this work are the timescales over which the identities of features start to be lost, and not the time for a feature to vanish completely.'

'13'-'14' corrected.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 1213, 2003.