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Atmospheric
Chemistry
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Discussions

Interactive comment on "Sensitivity of tracer transport to model resolution, forcing data and tracer lifetime in the general circulation model ECHAM5" *by* A. Aghedo et al.

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[12pt]article

General comments

This paper evaluates the effects of model resolution on transport in a global atmospheric model by using idealized tracers with simple source functions. It presents some interesting results, but could be improved, as discussed below.

Suggestions, questions, and comments

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1. Section 3: The discussion in this section could be improved and clarified. If I understand the experimental design correctly, within a given tracer source region, the tracer concentration is held constant. Presumably this is done by providing a source that restores the tracer concentration to a constant value at each time step after the tracer is depleted by transport out of the region. (Does the tracer within the source region also decay with a timescale of τ?) Once outside the source region, the tracer decays at a fixed rate independent of location. Therefore, only S affects the global amount of tracer, not the distribution of the tracer within the atmosphere. (Once some of the tracer leaves the source region, there is the possibility that some of it will be transported back into the source region. Is S, therefore, the *net* transport of tracer out of the source region?) The normalized transport s is estimated from a multi-year integration such that the time derivative of m can be neglected. Can't the normalized tracer transport s be estimated directly from the source required to maintain the tracer concentration in the source region?

   Because the tracer decays uniformly everywhere, these experiments only measure the transport out of each source region, not transport elsewhere in the atmosphere after the tracer leaves the source region.

2. Section 5: The authors calculate the interhemispheric transport time by dividing the atmosphere into two halves at the equator. They state 'This may be physically interpreted to represent the inter-tropical convergence zone (ITCZ) at the equator, which acts as a major resistance to air mass exchange between the Northern and Southern Hemispheres.'

   This conceptual view of the ITCZ as a transport barrier might be true in an idealized world, but it is not the case for Earth's atmosphere. If there were no seasonal cycle, and if the tropical circulation consisted only of the two Hadley cells, then there would be *no* transport across the equator. In the real atmosphere, however, the ITCZ undergoes rather large north-south excursion during year in response to the solar forcing. This produces rather efficient mixing within the tropics, as was shown by Bowman and Cohen (*JAS*, 1997).

In addition, the tropical transport circulation is not steady and zonally-symmetric. There are substantial zonal variations in the wind field across a range of space and time scales. As a result, air that enters the ITCZ at low levels from one hemisphere exits at high levels more or less equally in the northern and southern directions, resulting in transport 'across' the ITCZ. (See Figs. 5 and 7 in Bowman and Carrie (*JAS*, 2002).

It is permissible, of course, to define the control volume for transport calculations in any way you wish; but I don't believe that it that the equator is a useful dividing surface, precisely because of the rapid transport across the equator at certain times of year (e.g., p. 148, l. 8-18). The global scale 'mixing barriers' in the troposphere are in the subtropics, where they divide the atmosphere into three parts (northern hemisphere, tropics, and southern hemisphere). Those three regions are relatively well mixed internally (the tropics by the Hadley circulation, the extratropics by midlatitude eddies), while exchange between the regions is comparatively slow. I think the authors' choice of control volumes is largely responsible for the rapid interhemispheric exchange rate that they find. A more useful quantity is probably the transport from the extratropics of one hemisphere through tropics to the extratropics of the other hemisphere.

3. The authors basic result that transport rates increase as model resolution increases is an interesting one. *A priori* I would have guessed the opposite because lower resolution models tend to be more 'diffusive', due to both explicit diffusion and numerical errors. Do the authors have any suggestions for why the higher resolution models have higher transport rates? Are they resolving a wider spectrum of motion? Are the large-scale components of the flow, which should be responsible for most of the large-scale transport, more vigorous in the high-resolution simulations? I do not think that the authors necessarily need to

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answer these questions in this paper, but it would be worthwhile to think about how to design numerical experiments to address them.

Minor comments

1. p. 140, l. 5: The subject and verb in item (3) do not agree.
2. p. 140, l. 22: Malformed citation? (citepsimbur81)
3. p. 141, l. 25: What is ‘strang splitting’?
4. p. 144, l. 4: Instead of ‘quasi steady state’ do you mean ‘statistically steady seasonal cycle’?
5. p. 144, l. 12: Instead of ‘the order of the curves’, do you mean the ‘the average values of R’?
6. p. 144, l. 14-15: Add at the end of the sentence, ‘, which means that transport from the source regions is larger in the L31 runs.’
7. p. 145, l. 3-4: This should not be surprising since the inner tropics have a strong semi-annual forcing caused by the twice-yearly passage of the sun across the equator.
8. p. 145, l. 6: ‘... values of $R_{i,r}$ which are ...’
9. p. 146, l. 2: ‘Constraining the model with ERA40 data generally leads ...’
10. p. 146, l. 21-22: Don’t you mean that ‘models with fewer vertical levels show *smaller* vertical transport’?
11. p. 147, l. 19: Should this be ‘The transport rate of any tracer ...’?

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12. p. 147, l. 19-25: The transport rate ϕ does not depend on the tracer source or lifetime does it? It will be true that $\phi_{12} = \phi_{21} = \phi$ as long as there is no net transport of mass from one hemisphere to the other, which is true to a good approximation. (That is, the surface pressure integrated over one hemisphere is nearly constant.)

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 137, 2008.

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