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Atmospheric Chemistry and Physics 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.

A. Aghedo et al.

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We thank the anonymous Referee #1 for the useful comments. Our response are provided immediately after each of the referee comments (in bold).

More specific comments:

1) In order to be useful to more than the people directly involved with ECHAM5 the following is needed.

1.1) Where is the top of the model and what is the configuration of the vertical levels? This is essential information for the reader to evaluate the performance of the model.

The mid-point pressure of the top of the model (i.e. the uppermost level) is 10hPa. ECHAM5 uses a hybrid coordinate system that calculates the pressure, P at a given location and time, t from the relation: $P(x, y, z, t) = A(z) + B(z).aps(x, y, t)$; where, x is longitude, y is latitude, z is the level, and aps is the atmospheric surface pressure. The mid-point interface values of the pressure quantity A in the 31-level models are 1000, 3000, 5000, 7000, 8988.07, 10898.34, 12625.97, 14083.88, 15212.78, 15977.91, 16365.81, 16381.31, 16044.61, 15388.43, 14455.39, 13295.41, 11963.26, 10516.32, 9012.31, 7507.28, 6053.63, 4698.32, 3481.14, 2433.19, 1575.35, 917.02, 454.89, 171.85, 36.03, 0, 0 (all in Pa). The unit-less quantity B varies from 0 to 1. Note that the first level (i.e. $z = 1$) is the topmost pressure level in ECHAM5. The topmost 3 (in L19) or 4 (in L31) levels are pure pressure coordinates, because $B = 0$.

1.2) Please explicitly state the mechanisms of sub-scale mixing in the model. What sort of diffusion is used in the spectral dynamics? What sort of filters? What are the diffusive characteristics of the tracer advection algorithm? Since the formulation of subscale mixing strongly influences, perhaps dominates, the transport on these space and time scales, the reader needs to know this.

The aim of this paper is not to characterize individual mixing and transport which are parameterized within the model, but to understand how trace species are transported from one hemisphere to another, and how such transport are influenced by model different model configuration (i.e. resolution, tracer lifetime and the prescribed meteorology). We are certain the large spatial coverage (whole hemispheres) and time scales (15 days, 150, 1500 days) of our artificial tracers permit us to achieve this aim. We would streamline the model description, following anonymous referee 2 technical comment 18, since this the focus of the paper is not on clouds. The trace constituents are not subject to horizontal diffusion within the model, however surface emissions and other trace constituents undergo vertical diffusion, which are obtained from the bulk transfer relationships involving the difference of the respective model variable (wind components, potential temperature, humidity) between the surface and the low-

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est model level (about 30 m above ground), the wind velocity at that level, and the transfer coefficients. The transfer coefficients are obtained from Monin–Obukhov similarity theory (full details can be found in Roeckner et al, 2003). This explanation would be included in Section 2.1 of the revised manuscript.

1.3) As I understand the experiment, all of the experiments are on-line versus off-line. This is true even for the ECMWF experiment. The data is used as a forcing, and there is a characteristic time scale of this relaxation. This relaxation is a dissipative process, and it strongly influences the transport on large spatial and temporal scales. We need to know the value of this parameter.

All the experiments are on-line including the experiment whose meteorology is relaxed towards ERA40 data. The ECMWF forecast data are available on a 6-hourly time step. The characteristic time scale of this relaxation is held fixed and does not change across the simulations, and it is set to 3 hours. These information are now included in the manuscript.

2) The experiment design is solid to investigate model performance. However, for scientific investigation of transport processes it is not adequate. The design mixes the influence on the resolution of dynamical features and the influence of resolution on parameterized and numerical dissipative processes. Further, the tracers are placed without consideration of natural dynamical barriers: e.g. the tropopause, the subtropical jet stream, etc. There could be significant change in the results if, say, the tropopause tracer was placed 1 grid box higher or lower. Similarly, if north was defined as north of the subtropical jet stream. Again, the experiment design is robust for characterizing model performance, but attribution of cross equatorial transport to behavior of the ITCZ is not convincing. The same comment is relevant with attribution of differences to the QBO in the ECMWF experiments. There are other substantive differences, including perhaps the interactions of planetary waves with the upper boundary.

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The experiments are designed to reveal the sensitivity of transported tracers to mere changes in model configuration, and not for full investigation of individual transport processes. As already stated in the manuscript, similar experimental setup has been used in the literature before (see Bowman and Carrie, 2001). We would remove the tropopause tracers in our discussion because of the discrepancies that may occur between their injection height and the actual atmospheric tropopause. Based on this and Kenneth Bowman comments, we would recalculate the inter-hemispheric transport time using only the “northern” and “southern” tracers, that is, we would drop the assumption that the ITCZ is at the equator. It is without any doubt that there are major differences in the transport of the tracers when the ECMWF reanalysis data were used, and the seasonal variability of the stratT tracer shows the quasi-biennial oscillation.

3) I need more description of, for example in Figure 2, than the curves have different values. I have little intuitive link to R and M, your variables, and it would help me to use terms of magnitude, larger and smaller, and what it means in terms of transport, for example, faster and slower.

Our resolution comparison index, R provides the relation between the source region independent global-mass of a tracer, $m(t)$ in any resolution to the global-mass of the same tracer in T63L31 resolution, $m(t, T63L31)$. R is therefore 1.0 for all tracers in the T63L31 resolution (of course on an annual average). The source region independent tracer global-mass is $m(t) = M(t)/M(t = 0)$, where $M(t)$ is the tracer global-mass, and $M(t = 0)$, is the global-mass of the tracer at the beginning of the simulation. In order to preserve the seasonality of the tracers, we divide their monthly-mean global-mass with their respective T63L31 4-year-mean global-mass. We have now included this clarification and further equation within the text that relates R directly to M. We have also provide this further clarification in Figure 2 caption. The significant of R to the transport of tracer is provided in Sect. 3.

4) I disagree with your statement that the impact of horizontal resolution is limited to the experiments with surface sources. Note the role of high resolution in

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the stratT experiment. There is also something interesting in the surfT experiments. These figures have more richness than described.

The influence of horizontal resolution is now discussed for both surface and stratosphere tracers.

5) Are not the interhemispheric transport times in this model very fast? That would seem to be consequential to the model performance in general. This perhaps demands more discussion.

The too low inter-hemispheric transport time we calculated was due to the assumption that the ITCZ located at the equator acts as transport barrier, which is not true in reality, since the location of the ITCZ shifts with respect to the season. We have now re-computed the inter-hemispheric transport time using only transport from one extra-tropical region to another (i.e. surfN to S regions and surfS to N regions, according to comment 2 of referee K. Bowman). This resulted in a 4-year mean IHT ranging from about 17 months in the T21L1K9 resolution, to 12 months in the T106L31 resolution.

6) In general, more mention of the ability of the model to stimulate transport mechanisms would be nice. For example, does the Madden Julian Oscillation change with resolution?

This would be beyond the scope and aim of this paper. However, our discussion and conclusion has now been extended to provide additional suggestions, especially concerning the use of ECHAM5 model with chemical species simulation.

Page 146 lead to led.

Done

There are oddnesses which I think are due to software translation of embedded characters. What is citepsimbur81 ?

This has been corrected.

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

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