Response to reviewer 5

We would like to thank Reviewer #5 for his/her thorough and useful comments. We have included in this response the original text (in italics) and our answers.

General statement: To answer this and the other reviews, we have considerably changed our figures to be more summarizing. This is in turn enables an easier side-by-side comparison of the various simulations, including the comparison of the two wet removal schemes. Regional aerosol optical depth and surface ozone diagnostics and discussions are also added. A better description of how CAM-chem relates to CAM4 and CESM is also included. Finally, a comparison of some meteorological fields is now in the paper.

The paper remains a bit too vague on the impact of different meteorological data set on the chemistry results, which is clearly one of the main points of the study since the authors present the results for the three different meteorological data sets. The differences between these data sets need to be pointed out more clearly in order to better understand the differences in the chemistry. The reader wants to know how do the off-line data sets (MERRA and GEOS-5) differ from the on-line meteorology and how big the differences are between the two of-line data sets. Referring to earlier papers on climate simulation with CAM (Lamarque et al. 2008, Lamarque and Solomon, 2010, Neale et al. 2011) in section 7 is not sufficient to answer these questions.

We have now included more quantitative diagnostics and easier to analyze figures to specifically address this comment.

It would beneficial to discuss the actual differences in temperature and humidity (perhaps a plot complementing Fig. 3.) Cloudiness and lightning activity might also be interesting to look at.

Such a section is included at the beginning of section 7.

Showing derived transport "diagnostics" such as Rn cross-sections would demonstrate the differences in the large-scale transport and convective activity.

But it would only show that they are different, not easily indicating which is right. So we focus our analysis on more widespread chemistry measurements instead.

Besides having a coarser vertical resolution, the off-line run applies a different wet deposition scheme (Neu et al., 2011), simulates stratospheric chemistry and is carried out for an earlier period (1991-2000) than the off-line runs. These additional differences should be better included in the discussion.

All this information is now in Table 6). We have tried to include this information whenever relevant.

An extended conclusion on the pros and cons of off-line vs. on-line meteorological

data, which refers to the literature and discusses also more technical aspects such computational cost, mass-conservation and artificial mixing etc., would improve the paper.

Computational cost is solely related to the number of levels and tracers (included in section 6). Conservation/artificial mixing has the same properties in all versions (same dynamical core), as is now mentioned in section 2.

Figures 3, 4, 5, 10 and 11 should be enhanced because it is very difficult to distinguish the individual lines and labels. Figure captions should refer to the labels and colours used in the graphs.

We have generated different and updated figures to clarify and enhance them.

Specific comments
Spell out CESM in title and consider changing it to "Description and evaluation of CAMChem:interactive : : :.)

We have kept the title but spelled out CESM.

P 2201, line 18: This is not clear. Other CTM also conserve tracer mass, the CAMChem advection does not completely conserve mass otherwise there would be no need for a family advection (see section 3.5).

Mass conservation can be ensured by many different techniques, but these do not ensure the additivity of tracers to be conserved (section 3.5). This is due to the difficulty of resolving sharp gradients and how mass conservation is ensured (filling negative values for example).

P 2201, l18: add reference for CMT

Reference added.

P 2202, l12: typical model resolution, top height, coordinate system etc. should be mentioned in this section.

This was done in Table 6. Coordinate system is hybrid (sigma-pressure); this is added.

P 2203, l1: delete "a"

Done.

P 2204, l2: What is the sign of the precipitation biases

We couldn't identify this statement. Ignored.

P 2205, l3: spell out LAI or delete

Spelled out.

P 2205, l15: clarify meaning of Xi

There was a typo that is now corrected.

P 2207, l5: The description of the "Neu" and "Horowitz" schemes should be complemented by a discussion on their impact on concentration fields. According to Neu et al. (2011) there is an impact on tropospheric ozone chemistry when using a improved approach for cloud overlap and scavenging in ice particles. It would be interesting to know if this can be confirmed with the presented CAM-chem simulations.

Such discussion is now included in section 7.2. A limited impact on ozone is found in our setup.

P 2207, l10 : Why is the scaled annual total a range and not one single number?

Interannual variability in cloud activity (text added).

Provide reference for the choice of value which is a below the most common value of 5 Tg/y.

This is already indicated: E2010.

Is the inter-annual variability of lightning activity accounted for?

Yes, see above.

P 2208, l18: Give exact number for UV limit of photolysis rate simulation.

Information added.

P 2208, l20: Is the prognostic ozone below 40 km used in the photolysis scheme?

Yes. This is mentioned in section 2.

P 2210, l18-25: This amount of detail might be too much, consider shortening paragraph.

This is actually quite important information for users so that we believe it needs to be explicitly stated.

P 2210, l28: Give more background on the technical aspects of the MERRA and GEOS-5 data such as original resolution, assimilated observations or model versions.

We have included some additional information and are referring the reader to the recently published paper by Rienecker et al. (2011)

P 2211, l15-20: Since the impact of chemical solvers is not discussed, this paragraph could be omitted.

This is important information for potential users who will want to modify the chemistry.

P2213, l3: Why only 26 levels. How do the 26 level relate to the 56 levels.

26 levels is the standard CAM4 configuration. An additional figure shows the vertical configurations.

P2213, l8: Please motivate the choice of the simulation period.

Post-Pinatubo. Information added.

P2214, l3-6: This amount of technical detail could be shortened.

Again, we believe that this is important information for potential users.

P2214, l24: correct typo "Not"

Done.

P2215, l3-5: These reference prove the validity of the CAM result but do not help to explain the differences between the off and on-line data sets used in this study.

Comparison of some climate variables is included.

P 2215, l23: Vertical resolution might be one reasons but meteorological fields may also differ between on-line and off-line. Further, the on-line run uses a stratospheric chemistry which may lead to biases independent of the dynamical features. Chemical aspects (OH) may also play a role.

It is indeed difficult to pinpoint exactly the source of error. We have rephrased that statement.

P2216, l10: Why is MERRA more prone to more stratospheric mixing than GEOS-5.

Possibly because of the different assimilation system and different assimilated data. This is mentioned in the description of MERRA vs GEOS5.

P2216, l25:. Dry deposition might be also important for biases in surface ozone.

True. Although it is the same scheme for all versions (but could be responding to different climates).

P2217, l6: The on-line flux of 410 Tg/a is at the very low end of published values. How

can the low on-line flux be reconciled with the finding of a positive tropospheric ozone bias of the on-line run (p2215 line 23) , which was attributed to problems in strat-trop exchange. Likewise - the good agreement in ozone life time.

The discussion was rewritten in light of the Taylor diagram analysis.

P2217, l18:. It would be interesting to see how "unrealistic" the on-line run actually is.

The sentence was rephrased.

P2218, l25: It is not clear from section 2 that CAM and MOZART-4 use the same PBL parameterisations apart from convection.

They do. In both cases it is the Holtslag and Boville parameterization.

If PBL ventilation plays a role diffusion scheme and vertical layer depth may be further candidates to explain the differences. Again, dry deposition could be different.

All these are indeed good suggestions and testing them is beyond the scope of this paper. We have however included a reference to the paper by Lin that discusses those various topics.

P 2219, l13: Please also mention the CO overestimation in the NH subtropics. This could be a problem in emissions or convective transport.

This is done. The largest overestimation is for Mt Kenya, a high-altitude site.

P 2221, l1: Figures 11 and 12 are not discussed. The differences between HALOE and ACE seemed to be very large. Please explain .

We have actually removed these figures as they were not central to our discussion.

P2221, l18: Please add "surface" before aerosol

Done

P2222, l7: Also consider the relatively coarse horizontal resolution (ca. 200 km) of the model. Peak concentrations are not likely to be captured.

Good point. Statement included.

P2222, l23:"performs equally well" – this is a very general statement. Please point also to the differences.

This section was rewritten.

P2222, l27: "separate" i.e. different chemical mechanism have not been discussed in

the paper. In the on-line run a stratospheric chemistry scheme was added.

True. We are now using "various"

P 2241, caption Table 4: Please clarify units, T, k, r and

Done.

P 2258, caption Fig.3: Please mention averaging period, make labels more readable, mention colours in caption text.

Figure 3 is moved to the supplement and replaced by the Taylor diagrams and bias maps. Averaging period is in the caption.

P 2261, caption Fig 4: mention ozone in caption.

It is mentioned as the Y-axis label. Figure is moved to supplement.

P 2272, capture Fig 9a : should not refer to 9a, change figure order

Done