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Interactive comment on "Development of a grid-independent GEOS-chem chemical transport model as an atmospheric chemistry module for Earth System Models" *by* M. S. Long et al.

Anonymous Referee #2

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In this study, Long and co-authors report on a technical redesign of the GEOS-Chem code that enables it to be used as an atmospheric chemistry module in Earth System Models (ESMs) based on the Earth System Modelling Framework (ESMF). The new GEOS-Chem version is capable of using any atmospheric grid, which allows it to be operated either as a stand-alone chemical transport model (CTM) or as an ESM module. The new code has been implemented into the NASA GEOS-5 ESM. Results on the scalability and computational performance of the coupled system are presented.

The technical developments presented in this paper are a promising first step towards

a more complete integration of GEOS-Chem into the GEOS-5 ESM. The technical aspects of the redesign and the results of the performance testing are generally well described.

Specific comments:

1. The authors claim that the new GEOS-Chem code can serve as an atmospheric chemistry module for Earth System Models (plural). In practice, this will be limited to those ESMs that make use of the ESMF interface. The authors should indicate which ESMs besides GEOS-5 actually use ESMF, and if there are concrete plans for integrating GEOS-Chem in other ESMs.

2. The splitting in a transport operator and a local or chemical operator, indicated in Equations (2) and (3) in Section 2, is inconsistent with the actual implementation, described in Section 3. According to Section 2, wet deposition is described by the chemical operator in GEOS-Chem. According to Section 3, however, cloud processing and in-cloud scavenging of chemical tracers are described as part of GEOS-5 native moist physics. Please make sure that the theoretical description given in Section 2 is consistent with the actual implementation, and adapt the equations accordingly.

3. According to Section 2, the transport operator describes advection, convection, and boundary layer mixing. I assume that sedimentation of large particles is also described by the transport operator. Please mention this in the text, or clarify why it is not.

4. Please add a statement on the mass-conserving character of the semi-lagrangian advection scheme used in GEOS-5, and explain why and for which tracers this is important.

5. The HEMCO emission module is presented as a general tool to describe emissions in CTMs and ESMs. Please indicate how widespread its use is. Is it used in other models besides GEOS-Chem?

6. Page 7515, line 19: The scaling efficiency using 192 cores is close to 0.7. On a

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scale from 0 to 1, I wouldn't call that "close to unity".

7. Page 7517, line 2: Quantitative comparison of the GEOS-5/GEOS-Chem and CTM systems does not necessarily require using the same meteorological data in both. Quantitative comparison of the climatological behavior of both systems could also be of interest, e.g. to study to role of climate biases in the GEOS-5 ESM.

8. Last sentence of the summary: "Although the inclusion of detailed atmospheric chemistry in an ESM is a major computational expense, it becomes relatively more efficient as the number of cores increases due to its consistent scalability." Since the chemical tracers are transported within the GEOS-5 general circulation model, the inclusion of GEOS-Chem will affect the scaling efficiency of the dynamics. The reduced scalability of the dynamics could therefore also be related to the addition of chemical tracers, in which case the concluding sentence would not hold. Please clarify this issue.

Technical corrections:

1. In the title, please change "GEOS-chem" to "GEOS-Chem".

2. On page 7511, line 13, please add a space between "ESMF_" and "macro".

Interactive comment on Geosci. Model Dev. Discuss., 7, 7505, 2014.