Geosci. Model Dev. Discuss., 8, C1943–C1948, 2015
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Geoscientific Model Development Discussions

# *Interactive comment on* "Adjoint of the Global Eulerian–Lagrangian Coupled Atmospheric transport model (A-GELCA v1.0): development and validation" *by* D. A. Belikov et al.

**Anonymous Referee #2**

Received and published: 8 September 2015

Overview:

The manuscript "Adjoint of the Global Eulerian–Lagrangian Coupled Atmospheric transport model (A-GELCA v1.0): development and validation" by Belikov et al. describes the construction of a new coupled adjoint model based on GELCA, which is a coupled forward transport model based on the NIES Eulerian transport model and the Lagrangian transport model, FLEXPART. The methodology described in this manuscript provides an interesting development upon existing adjoint models, and may be used in future to supply high-resolution adjoint sensitivities at relatively low computational cost. The authors describe the applications of the model, before describing its development and providing examples of the adjoint model's accuracy in comparison



with the forward model. Finally, a real-world example of use of the adjoint model is described.

Overall the manuscript is fairly clearly written, although there are a large number of technical corrections necessary before publication. Some of the descriptive sections are quite brief and lacking in necessary detail. The figures and tables are generally clear and well chosen. Although the performance of the forward coupled model compared with the Eulerian model is investigated to some extent, my biggest concern with the manuscript is that only a handful of sites are included in this analysis, all of which are in relatively close proximity to each other, in a region where surface fluxes are uncertain. However, from this limited perspective, the coupling does appear to improve the model performance. The adjoint model is shown satisfactorily to be accurate in comparison with the forward model, which is the most important aspect of the manuscript.

I recommend publication after these revisions have been carried out.

Comments:

5985.11: define 3-D for first use

5985.20: Can you provide a more recent reference than Bovensmann et al., (1999) for this statement?

2986.2-4: Rephrase: "Generally, there are the Eulerian and the Lagrangian method of modelling the atmospheric constituents transport"

5986.16: Rephrase the sentence beginning "The adjoint of the transport model. . ." as it is unclear.

5986.24: The accompanying references to this sentence seem out of place here, as they relate to inverse modelling of CO and NOx, rather than the longer-lived species discussed in the rest of the manuscript.

5987.3: You should mention recent work that has made use of nested grids together with inverse modelling methods in order to obtain high-resolution inverse results, such as Hooghiemstra et al., (2012).

5988.19: Have you investigated the effect of changing the number of particles used in the Lagrangian model (both in terms of information content and computational time)? Perhaps you should mention how you settled on 1000 particles.

5989.3: You should clarify what it means to have a coupling at the time boundary in the global domain, rather than at the spatial boundaries. I felt that this was unclear, and should be clearly explained in a development manuscript such as this one.

5989.25: You say that the model performs well in comparison with measurements, but you should further clarify this statement. Can you quantify the performance? Are there any major discrepancies in the model performance in (e.g.) interhemispheric exchange time or vertical mixing?

5992.6: H is, by definition, already linear if it is a matrix.

5993.27-29: I do not think that this statement is supported by the values provided in Table 3. The high-resolution Eulerian model variously outperforms and is outperformed by the low-resolution coupled model at different sites. You should either remove or add qualifications to this line.

5994.10: Although you have mentioned this in the text, I'm bothered by the fact that you have assessed the model performance at only a few sites in one region of the globe. There exist a number of observational datasets available for comparisons to model data, such as those provided by the Global Monitoring Division of the National Oceanic and Atmospheric Administration. Can you examine the coupled model performance in tropical regions, for example?

5996.12: This explanation of the model set-up for the accuracy test is a little unclear and should go into more detail. What do you mean by "perturbed by 1ppm per grid



cell"?

5996.15: The sentence is unclear and needs rephrasing. How exactly are you saving CPU time here?

5997.17: This section needs more explanation. What simulations did you carry out here, exactly? What were your initial conditions for the adjoint model runs?

6013-14: Keep the same order of cases from left to right when printing R, M and S in the plots (i.e. red-cs1, blue-cs2, green-cs3, not green, blue, red).

Figures 4 – 7: It might be interesting to see panels showing the differences between the different results when using the different versions of the model, as it can be difficult to discern these differences by eye. Also, in Figure 5, are the left-hand and right-hand panels the same results, but aggregated onto different grids? I can see the logic of this, but it feels a little unnecessary to me to have both grids displayed. I'd consider showing only the results on the native model grid, as Figure 6 shows the combined results on the 2.5 degree grid anyway.

Technical corrections: Overall, the manuscript requires a thorough proofreading in order to make sure that there are no further technical corrections necessary. I have included all of the mistakes that I found. 5984.7: tangent -> tangent linear

5984.11: As results -> As a result

5984.17: shown -> shows that

5984.20: demonstrates the high accuracy -> demonstrates high accuracy

5985.18: a density of observational network -> the densityof the observational network

5985.21: CO2 observation are not existing -> CO2 observations do not exist

5986.13: If tracer is a chemically inert -> if a tracer is chemically inert

5986.15: is running -> is run

5986.28: speeds -> speeds up

5987.10: To utilize of the strongest sides of both methods -> In order to exploit the advantages of both methods

5988.10: This may change in the font of the final manuscript, but the capital "I" and lower-case "l" appear identical in this equation. Maybe consider changing notation?

5989.12: The model's employs -> The model employs

5989.16: we follows -> we follow

5989.22: ration -> ratio

5989.25: intercomparisons -> comparisons

5990.2: FLEXPART similar to other LPDMs consider... -> FLEXPART, like other LPDMs, considers...

5990.4: sink and sources -> sinks and sources

5990.5: running -> tracking? following?

5990.6: no comma necessary here

5990.11: Gaussian grid T106 -> Gaussian T106 grid

5990.12: and in 6h time steps -> and 6-hourly time steps.

5991.2: 3-dimensional -> 3D

5991.6: driving -> driven

5991.8: "The" current version

5991.10: Remove extra 'of'

5991.13: parameter estimation method used in different reanalysis dataset the use... -> parameter estimation methods used in different reanalysis datasets, the use



5994.21: a construction of continuous adjoint -> construction of a continuous adjoint

5995.13: remoted -> remote (or distanced?)

5995.20: inpute -> input

5997.2: did not seriously changed -> did not significantly change

5997.8: the M in the denominator should be M' (i.e. tangent linear)

6000.12: Performed in the paper analyses showed, that GELCA -> Analyses in this paper showed that GELCA...

6000.14: Decreasing of the Eulerian model resolution are not able to significantly distort... -> Decreasing the Eulerian model resolution does not significantly distort...

6001.3: variation -> variational

6014: As Fig 2 -> As Fig 1

6015: Siberian observations towers -> Siberian observation towers

REFERENCES:

Hooghiemstra, P. B., M. C. Krol, T. T. van Leeuwen, G. R. van der Werf, P. C. Novelli, M. N. Deeter, I. Aben, and T. Röckmann (2012), Interannual variability of carbon monoxide emission estimates over South America from 2006 to 2010, J. Geophys. Res., 117, D15308, doi:10.1029/2012JD017758.

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Interactive comment on Geosci. Model Dev. Discuss., 8, 5983, 2015.