Review for "Simulating the variations of carbon dioxide in the global atmosphere on the hexagonal grid of DYNAMICO coupled with the LMDZ6 model"

General comments

This paper presents a comparison of global CO_2 atmospheric transport using two different configurations of the LMDZ general circulation model. The difference between the two configurations is that one uses the hexagonal grid of the DYNAMICO core (ICO) and another uses the longitude-latitude grid (REG). The main conclusion of the paper is that the ICO configuration achieves a similar accuracy as REG while reducing the computation cost by about 20%.

My main concerns of this paper are:

- Submitted as "Development and technical paper", this paper does not contain model development nor any substantial description of the model used in the comparison except for the references provided. In general, the model description in this paper lacks the necessary details.

- Comparisons of the two model configurations (REG and ICO) are needed to make this paper valid. At the coarse resolution of $2.5° \times 1.25°$, there is no clear advantage of using ICO over REG. Similar global CO_2 atmospheric transport model simulation at higher horizontal resolution can be found at [1, 2, 3].

I could not figure out whether the integration of the Dynamico core to LMDZ for tracer transport is implemented in this paper or in the previous study by [4]? In Line 47, it states that "We build on the dynamical core Dynamico (Dubos et al., 2015), which has recently been integrated into LMDZ", yet between Sections 2.1.1 and 2.1.2, it appears that the REG has the older dynamical core. If the implementation of Dynamico core to LMDZ for CO_2 transport is done in this paper, a detailed description is needed. If it is done in [4], what is the scientific contribution of this paper in terms of model development?

Given the above concerns, I think this paper needs substantial revision before it can be considered for publication at GMD.

Specific comments

-Line 22-23. Given the fact that both the ICO and REG simulations used in this study have a horizontal resolution of about $2.5° \times 1.25°$, I do not see how the study "emphasize the importance of .... high-resolution innovative grids...".

-Lines 43-45. The authors state that model simulations using regular longitude-latitude grids have resolution clustering problems which leads to computing bottlenecks caused by significant data communication. "In this paper, we are addressing this specific issue...", however in Lines 249-250, "This speedup is comparable to the reduced number of cells in ICO. For our spatial resolution, it seems that other differences such as the absence of a polar filter for ICO did not significantly improve the computational speed." My understanding is that the current simulation comparison at the coarse resolution of $2.5° \times 1.25°$ does not prove the ICO configuration has a substantial

advantage over the REG except for the reduced number of cells (about 20%). A comparison at higher horizontal resolutions is needed to support the main points of this paper.

-Line 46: "Such a solution has been explored by few models so far,..." This statement is not up-to-date: Unstructured grids have been used for simulating global atmospheric CO_2 transport in several studies, such as [2, 3]

-Line 55: "Coupling it to the LMDZ GCM also represents the first step towards the use of Dynamico for inverse modeling". I guess you meant inverse modeling of CO_2. Please specify.

-Lines 68-72. As CO_2 is modeled as a tracer, the chemical processes in INCA are not applied. Please state this explicitly.

-Line 90. Please specify "our resolution"

-Line 94. "ICOLMDZORINCA". The acronym is used here without being previously defined.

-Line 99. Please clarify whether the atmospheric dynamics used for CO_2 transport described in this study is hydrostatic or non-hydrostatic. It is not clear the way it is presented here.

-Lines 105-107. The two sentences appear to be contradictory: the first states that the transport equations do not use any information from the momentum equations, while the second states that the kinematics handle the transport of mass, potential temperatures, and tracers using the mass fluxes computed by the dynamics.

-Line 107. Since both the REG and ICO use the same atmospheric model LMDZ (with different dynamical cores), this sentence is a bit confusing. Do you mean "dost not differ from vertical transport from the REG configuration"? See line 113.

-Line 124-125. Judging from this sentence, it appears that CO_2 fluxes are prescribed (using CAMS). However, in line 68, it states that "tracers, such as CO_2, are modeled by INCA". Please clarify the seemingly contradictory statements.

-Line 126-127. Remaud (2018) tested the impacts of two different versions of LMDZ physics on CO_2 atmospheric transports and these tests all used the latitude-longitude grid. I do not understand how the authors reached the conclusion of "we consider that this imprint hardly affects our conclusions" as the ICO simulation used a hexogonal grid.

-Line 128. What are the "boundary files"? Please explain.

-Lines 149-151. It is not clear to me how "This selection accounts for the usual failure of ..".

-Line 382. The causes that both ICO and REG configurations provide inadequate modeling of synoptic variability most likely also include the horizontal resolution used in the simulations.

-Lines 392-393. This sentence is quite confusing. Probably it can be better phrased.

-Line 398-399. It is not clear to me what you meant by the "damping the induced increase of the code time-to-solution". Please clarify.

Technical comments

-Line 40: "e.g., the kilometric resolution of the current space-born...". Do you mean the computational cost of model simulation at kilometer resolution?

-Line 113: Is this one-sentence paragraph intentional?

References

References

[1] Anna Agusti-Panareda, Michail Diamantakis, Sebastien Massart, Frederic Chevallier, Joaquin Munoz-Sabater, Jerome Barre, Roger Curcoll, Richard Engelen, Bavo Langerock, Rachel M. Law, Zoe Loh, Josep Anton Morgui, Mark Parrington, Vincent-Henri Pench, Michel Ramonet, Coleen Roehl, Alex T. Vermeulen, Thorsten Warneke, and Debra Wunch. Modelling CO_2 weather - why horizontal resolution matters. *Atmospheric Chemistry and Physics*, 19(11):7347–7376, JUN 4 2019.

[2] Andrew E Schuh, Martin Otte, Thomas Lauvaux, and Tomohiro Oda. Far-field biogenic and anthropogenic emissions as a dominant source of variability in local urban carbon budgets: A global high-resolution model study with implications for satellite remote sensing. *Remote Sensing of Environment*, 262:112473, 2021.

[3] Tao. Zheng, S. Feng, K. J. Davis, S. Pal, and J.A. Morguí. Development and evaluation of co_2 transport in mpas-a v6.3. *Geoscientific Model Development*, 14(5):3037–3066, 2021.

[4] Frédéric Hourdin, Catherine Rio, Jean-Yves Grandpeix, Jean-Baptiste Madeleine, Frédérique Cheruy, Nicolas Rochetin, Arnaud Jam, Ionela Musat, Abderrahmane Idelkadi, Laurent Fairhead, et al. Lmdz6a: The atmospheric component of the ipsl climate model with improved and better tuned physics. *Journal of Advances in Modeling Earth Systems*, 12(7):e2019MS001892, 2020.