Interactive comment on "A 4D-Var inversion system based on the icosahedral grid model (NICAM-TM 4D-Var v1.0): 1. Off-line forward and adjoint transport models" *by* Yosuke Niwa et al.

A. Babenhauserheide (Referee)

arne.babenhauserheide@kit.edu

Received and published: 9 January 2017

Solid and relevant manuscript

The manuscript describes the implementation of the offline forward and adjoint transport for the NICAM-TM 4D-Var system with two different approaches: A linear forward mode with an exact adjoint and a non-linear forward mode with flux limiter using an approximate adjoint.

The manuscript is well writen, relevant and well-suited for GMD. The validation methods are well-chosen and the tradeoffs in both modes are explained.

As a minor revision I would suggest adding a comparison between the magnitude of the error introduced by data-thinning and the error introduced by using the approximated adjoint (with the non-linear forward equations) on page 10, subsection 3.4 (validation of the adjoint model) to complement the estimate in the companion paper (Niwa et al., 2016). By eye Figure 6 seems to show deviations with a magnitudes up to 10%.

Improving the reproducibility would require providing the source code of the described model versions (offline and online) and the required data which is not yet common practice for weather models and would likely face institutional hurdles.

Line-notes:

- page 2 line 13: Chevallier et al. (2010) used 21 years of data but note that at this scale "modeling and representativeness errors exceed the measurement errors

by an order of magnitude", therefore the reference does not support the argument. Babenhauserheide et al. (2015) show that a 10 to 15 weeks assimilation window suffices to represent remote fluxes, i.e. in the antarctic (sorry for the self-reference here).

- page 2 line 14: resulting **in** at least . . .

- page 2 line 15: of making **the** computation . . .

- page 2 line 28: loses → **losses**

- page 3 line 34: This avoids the pole problem **inherent in latitude-longitude grids** and . . .

- page 3 line 34: simulations. **Therefore** ← seems not to follow from the previous sentence. Maybe **The** instead?

- page 4 line 11: "240km . . . comparable or finer than previous inversion studies" ← CarbonTracker CTE2016-FT used in the Global Carbon Budget 2016 (Le Quéré et al., 2016) uses 1x1 degree resolution over Europe and North America[1], which is approximately 100x100km resolution.

- page 5 line 20: can be easily shown → can **easily be shown**

- page 6 line 16: second approach **a** continuous

- page 6 line 19: is no longer inexact → **exact**

- page 6 line 23: detail derivation → **a detailed** derivation . . .

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[1]As reported in the ICOS project (https://www.icos-cp.eu/), see https://www.icos-cp.eu/sites/default/files/2016-09/ICOS%20SC2016%20-%2027%20SEP%202016%20-%20Plenary%20Session%202%20-%20Ingrid%20van%20der%20Laan-Luijkx.pdf

- page 6 line 30: to readily make **create** the adjoint model, but it sometimes makes **this carries the risk of making** the model . . .

- page 12 line 13: coefficient, while → coefficient **and**

References

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