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Interactive comment on "The off-line Lagrangian particle model FLEXPART-NorESM/CAM (V1): model description and comparisons with the on-line NorESM transport scheme and with the reference FLEXPART model" *by* Massimo Cassiani et al.

Anonymous Referee #1

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The paper describes a modified version of the FLEXPART model, which is able to use input data from the NorESM/CAM model. For this purpose, the vertical velocity, dew point and 10m wind speed have to be determined in NorESM/CAM and the input routines from FLEXPART have been modified to be capable of reading the NETCDF output of NorESM/CAM. The latter modifications however, are not discussed in detail, but the corresponding code is freely available for download from the FLEXPART repository.

The modification of NorESM are minor, delivering the required additional diagnostic

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output; however, it is not obvious why the NorESM/CAM NETCDF data cannot be easily converted to GRIB format using classical data conversion tools (e.g. CDO). Nevertheless, the capabilities of this tool might prove useful, even though in my opinion most often FLEXPART will be driven by re-analysis data instead of using a chemistry-climate modelling system. Potential benefits which could be mentioned in the manuscript might be transport analysis for periods where no re-analysis data might be available, e.g. paleoclimate analysis and future climate projections.

Besides the technical development, the manuscript describes an evaluation of the new scheme, especially in comparison with the on-line transport of NorESM/CAM. The authors show that the re-calculation of the vertical velocity as needed by FLEXPART is realistic and that the two presented approaches yield similar results. On the considered scales, i.e. larger than 1° grid space, it is not surprising that the expression assuming hydrostatic balance is sufficient, as on these scales the hydrostatic approximation is highly realistic. A typical result from the comparison is that the lagrangian simulation results are far less dispersive compared to the Eulerian approach. However, this finding is well known and documented in the literature. In addition to the effect of the vertical velocity calculation the impact of the different convection schemes is analysed. This is in my opinion highly critical, even though not restricted to FLEXPART-NorESM, but to FLEXPART itself. The results show that for convectively dominated regions the impact of the selected convection parameterisation (based on different formulations of mass flux approaches) is substantial, as e.g. already discussed by Tost et al. (ACP, 2010). What is highly critical in my opinion is the application of a convection parameterisation on the output of a model which already includes a convection scheme. As the internal convection scheme of the driving model stabilises the atmosphere, the effect of the convection scheme is already included in the large-scale atmospheric state. The convective transport of tracers should therefore be determined from the convective massfluxes of the driving model, and not be re-calculated. Due to the application of the convection scheme in the driving model, CAPE, which is often used in the closure assumptions of the convection parameterisations (as also for the

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Emanuel scheme), is substantially depleted. Furthermore, large-scale clouds which are calculated after convection furhter stabilise the atmosphere. On the other hand radiative and advective for moisture and temperature processes tend to de-stabilise the atmosphere which can trigger new convection. As FLEXPART does not calculate moisture and temperature advection or radiation the convective massfluxes from FLEXPART will be mostly underestimate the actual convection. The application of the Emanuel scheme (which tends to produce stronger convection (personal experience), compared to other schemes) might nevertheless lead to stronger convection than the Zhang-McFarlance-Hack scheme combination. The convective outflow height is highly critical for the vertical transport of tracers, as the large-scale vertical velocities in the upper troposphere are very low compared to the convective velocities. Even more difficult might be an overshooting into the lowermost stratosphere, where otherwise transport times might be on the order of weeks to months compared to individual almost instantaneous convective events. Therefore, in my opinion the application of a traditional convection scheme under these conditions should be discussed in detail, as well as further emphasize should be placed on the comparison of tracer transport into the upper troposphere by convection in the lagrangian approach.

Overall, I think that the manuscript is solid, but does not provide interesting new findings or developments, but could work as a documentation for the new model combination. How often this configuration will be applied and therefore the overall value of this manuscript, is still to be shown.

Minor remarks: To what kind of grid are the tracers mapped from the FLEXPART/NorESM model? Is this the same as the on-line NorESM grid? In Fig.1 the smallest grid size appears to be smaller, which could also lead to the impression that the eulerian approach is more dispersive (which is nevertheless true!).

Are you really sure, that NorESM does not include a subgrid-scale orography parameterisation? I am not an expert with this model, but as far as I know several GCMs, e.g. ECHAM, use such a scheme to account for unresolved topographical effects for both

boundary layer as well as gravity wave parameterisations.

In Fig.7 the continents are not (well) visible. Furthermore, the longitude, latitude coordinates mix with the values in the graph. A better resolved color scale could solve the issue, since then the values in the plot could be omitted.

Do you have any idea, what causes the “clustering” in the density distribution (Fig.9), which appears to be stronger in FLEXPART/NorESM than in FLEXPART/ECMWF, and appears ot be already present in the initial distribution?

Is NorESM nudged to the observed/(re-)analysed meteorology for the footprint simulations? Or is the climatology so independent on the individual weather state, that no significant deviations from ERA-INTERIM and the climatology can be detected?

Page24, line 10: NoreESM → NorESM

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