

## ***Interactive comment on “The Lagrangian particle dispersion model FLEXPART-WRF version 3.0” by J. Brioude et al.***

**J. Brioude et al.**

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The authors would like to thank the reviewers for their time and effort in reviewing our manuscript. We answer each comment below. Beside correcting the text, the major change in the paper is the addition of a figure that represents the vertical distribution of particles using the different PBL scheme available in the model in the case of a convective PBL.

### **Bug report**

Besides the review itself, we fixed some bugs in FLEXPART-WRF v3.0. A bug was found related to the sign of the sensible heat flux read from WRF which subsequently made FLEXPART-WRF underestimate the turbulence in a convective PBL in the Hanna

C1467

scheme, and overestimate it in stable conditions. This bug doesn't affect FLEXPART-ECMWF.

The main effect is on trajectories from an isolated source within the first couple of hours of transport when the tracer is diluted vertically in the PBL. The average absolute difference in the forward test case provided with the manual is 8-10% for concentrations within the 0-100m layer, and less than 3% for the layer between 100-1000 m for transport times less than 2 hours. The differences are lower for longer transport times.

No significant differences were found in the FLEXPART-WRF runs made for the studies published by Brioude and Angevine. An extensive test for a surface point source in complex terrain in California gives an average absolute difference of 4%. For large source areas, the differences are smaller.

It should be noted that this bug does not affect PILT (the old version of FLEXPART-WRF) if SURF\_OPTION=0 is used, because in this case, the sensible heat flux was calculated by a parameterization in FLEXPART instead of being read directly from WRF.

Minor fixes were also applied to the skewed PBL scheme (CBL), to the PBL schemes that use TKE, and the netcdf FLEXPART-WRF output format when a nested domain is used.

Because of those changes in the code, the revised version is now called version 3.1

### **Reviewer 1:**

**My only major comment would be that it would have been nice to see some evaluations / comparisons of trajectories from the new model with the previous version of FLEXPART-WRF, and possibly even FLEXPART itself. However I understand if the authors feel that this is beyond the scope of the current paper.**

Differences in results obtained by FLEXPART-WRF and FLEXPART-ECMWF or NCEP GFS would be due mainly to differences between the meteorological realizations in

C1468

WRF and in the global models instead of differences between the two FLEXPART versions. The difference between FLEXPART-WRF and PILT (the old public version of FLEXPART-WRF), beside the development of parallelisation, different domain output projection and random number generator is mostly related to bug fixes. The differences arising from using different vertical wind has already been treated in Brioude et al. (2012). Therefore we do not think it would give additional information to compare FLEXPART-WRF to PILT in this manuscript and is probably beyond the scope of this paper. It would be interesting to provide a more detailed evaluation of the various FLEXPART versions for instance against tracer experiments but this is beyond the scope of this paper.

**Minor comments: The discussion of CPU time was a bit confusing for the uninitiated: maybe clarify that CPU time is a function of number of particles, and that the number of particles necessary for a simulation is a function of the spatial and temporal resolution required and the number of sources? Note also that some runs are limited by the time to read the meteorological fields from disk.**

We agree that this section was a little bit confusing. We have modified the way the benchmark values are presented.

**3630: WRF uses eta levels, not sigma levels. I believe this should be corrected throughout the manuscript?**

We used the word “sigma” to be consistent with the GMD paper of Brioude et al., 2012. To avoid any confusion, we state that “eta” is used in the WRF manual instead of the word “sigma”.

**Technical details:**

**3618-9: shouldn't it be “grid-cell” instead of “grid-point”?**

We have removed the word grid-point

**3618-13: of \*the\* simulated meteorological fields**

C1469

Fixed

**3618-17: with \*the\* horizontal winds**

We do not think there is a need of a “the” here.

**3631-15: the last term is truly zero rather than negligible in the model isn't it?**

The last term is not zero because the height of a pressure-based sigma level can change with time.

**3630-14: Do you mean: Therefore, no \*separate\* preprocessing of the WRF output is needed: : : or: simple preprocessing is done internally: : :**

We meant that no external preprocessing of the WRF files was needed. If the interpolation is done internally, we do not think we can qualify it as a preprocessing. We have changed the word separate to “separate external”.

**3632-23: in \*the\* case of : : :**

corrected

**3635-6: advise \*using\***

corrected

**3635-20: inconsistent use of UK/US spelling: neighbor or neighbour**

We use in the revised version neighbor throughout the text.

**3635-20: nearest neighbor – this part was a bit confusing – don't you mean interpolation to particle positions, or interpolation when using different grids for WRF and for FLEXPART-WRF?**

Sorry about that. We meant the particle position, not the grid cells. It has been corrected in the revised version.

**3636-25: why not just state the minimum rainfall rate**

C1470

We have modified the wording.

**3637-8: first not firstly**

Corrected.

**3643-2: Brioude not Briouden**

Corrected.

**Fig 1: the terminology of regular vs. irregular grids is meaningful in terms of the FLEXPART code but is a bit confusing here. I would recommend latitude/longitude grids vs. WRF grids, or something like that.**

We agree. We have modified the caption accordingly.

**Table 2: The caption labels could be expanded to make the information clearer**

We have modified the caption. We also talk about “openmp thread” instead of “thread”, and “trajectory calculations” “interpolation calculations” to make the term “speed up factor” more meaningful.

**Reviewer 2:**

**Major comments:**

**- It would be helpful to have at least one inter-comparison between FLEXPART-ECMWF/GFS and FLEXPART-WRF included in the paper, potentially including a comparison with the prior version of FLEXPART-WRF.**

The results of a comparison between FLEXPART-ECMWF and FLEXPART-WRF would be driven mainly by the differences between ECMWF and WRF. Furthermore, such differences will depend on the location and the meteorological phenomenon that is simulated. A single case will not give any statistically meaningful information. Notice also that even using different meteorological input data from ECMWF (e.g., operational, ERA-15, ERA-40, ERA-Interim) will give different results, although the FLEXPART ver-

C1471

sion in this case would be exactly the same. The only way to judge differences between the different versions would be to run a large suite of tracer experiments (probably for experiments ranging in scale more suitable for WRF to the longer-range tracer experiments more suitable for ECMWF or GFS data), compare all versions against measurement data, and perform detailed statistical evaluations. However, this is clearly beyond the scope of the present paper. A comparison between the old version and the new version of FLEXPART-WRF can be done. However, the differences will mostly come from bug fixes. The previous version of FLEXPART-WRF, PILT, was a beta version and was never considered as a completed model. We do not think that such a comparison would provide meaningful information.

**- P3622 L15 and section 2.5 – the impact of using different PBL and turbulence output from WRF in FLEXPART could be expanded. As it stands, the options to use boundary layer and turbulence output from WRF have been implemented, but they are not recommended for use. While this may be for future scientific studies, it would be helpful to have a figure to demonstrate the differences between these options, for example for emissions from a point source in the boundary layer. It would also be helpful to compare this with FLEXPART-ECMWF/GFS.**

We added a figure (see attached figure) in the manuscript that describes the differences in vertical transport between the different schemes for a convective PBL. The reviewer will clearly notice the difference between the Hanna's scheme and the schemes that use TKE. There is no reason to compare to FLEXPART-ECMWF, which uses the same Hanna's scheme. Therefore, for the same meteorological parameters, the scheme produces the same result.

**- Table 2 in its current format is unclear. Please clarify what portions are for OPENMP vs MPI, or both. Does the “number of threads” heading apply to the entire column, or is the bottom half of the table not for threads, but for nodes instead?**

C1472

Following your comment and Referee 1, we have modified this table to make it clearer.

**- Both the text and references should be checked carefully for English and typos. For example, in the first reference CALNEX should be capitalized. The authors should check the document for these types of errors that occur frequently when using LaTeX.**

Thank you for pointing this out. We have taken care of the reference in the revised version.

**Minor comments:**

**- P 3620, first sentence – the references are not appropriate for this statement, especially since the following statements regarding NILU, INTE, and ARSC do not include similar references.**

Those references were used as a validation of the model. We have added a sentence to make the use of those references more useful.

**- Page 3620, last sentence of first paragraph: the “full palette” should be changed to something like the “full suite”**

We have replaced the word palette with suite, as recommended by the reviewer, although we do not really see a difference in meaning.

**- P3620 L20, This paragraph is strangely placed as the conclusion to the introduction.**

We agree. We have moved this paragraph before the previous one.

**- P3621 L18, add a statement that explicitly says the user should be confident in the WRF forecast by for example testing/comparing the forecast to observational data to be more confident in the FLEXPART-WRF results.**

We have added: “We recommend that WRF simulations should be evaluated with me-

C1473

teorological observations to have confidence in using FLEXPART-WRF.

**- P3635 L21, is it the implementation or the scheme itself that is too simplified?**

The scheme itself is too simplified, leading to unrealistic patterns. We have changed the wording accordingly.

**- P3636 L3, replace “aspect” with “issue”**

fixed

**- P3636 L9, replace “a better implemented” with “and implemented a better”**

fixed

**- P3636 L11, it would make more sense to say “new scheme” instead of “new implementation” here**

fixed

**- P3636 L15, what does “somewhat differently” mean in this context? A more clear statement should be used.**

We removed “somewhat” in the revised version

**- P3637 L14, Use a more complete thought for this first sentence, for example: Three choices are given to the user for model output.**

We have changed the sentence to “Three choices of format are given to the user as FLEXPART-WRF model output”

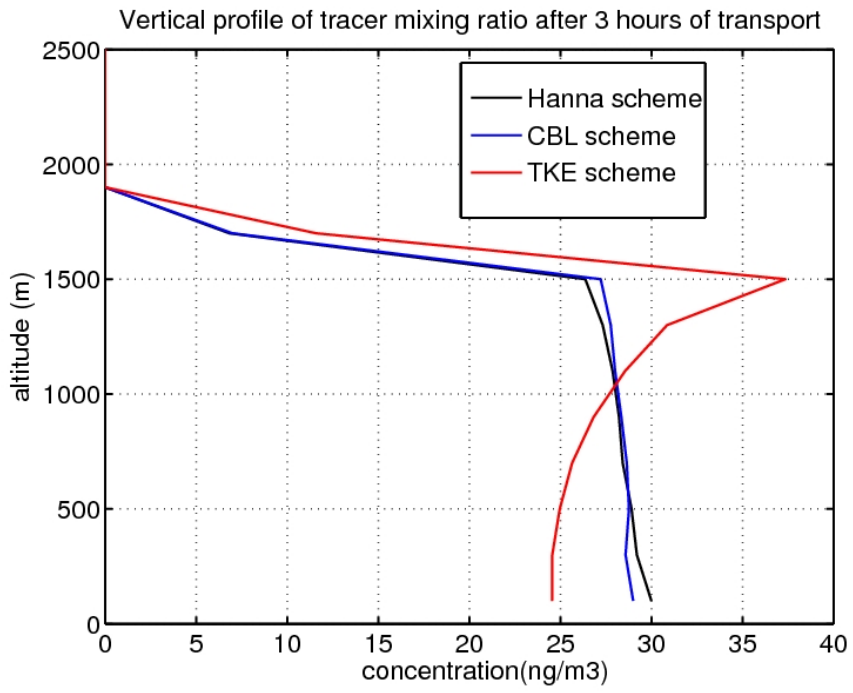
**- P3642 L2: replace “some of them would include” with a more clear statement, for example: “Some future developments and investigations could include”**

We changed the sentence to “Future developments would include”.

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Interactive comment on Geosci. Model Dev. Discuss., 6, 3615, 2013.

C1474



**Fig. 1.** Vertical profile of mixing ratio of a point source emitted at the surface in a convective PBL after 3 hours of transport. Vertical profiles from each available PBL scheme in FLEXPART-WRFv3.1 are shown