



EGUsphere, referee comment RC2  
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## **Comment on egusphere-2022-441**

Anonymous Referee #2

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Referee comment on "Improving trajectory calculations by FLEXPART 10.4+ using single-image super-resolution" by Rüdiger Brecht et al., EGU Sphere,  
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### General

The manuscript entitled "" by Brecht and co-workers presents a very interesting and relevant study on using machine learning to interpolate (down-scale) meteorological wind data as taken from three-dimensional meteorological models in order to use them in advection calculation (semi-Lagrangian and Lagrangian). They apply their approach to global dataset (ERA5) and show that the ML approach is more successful in restoring the original, higher-resolution data than a simple linear-interpolation. Furthermore, they indicate similar improvements when ML interpolation is used in trajectory calculations in comparison to linear interpolation. The presented approach is a first step in the development of improved interpolations for Lagrangian models and semi-Lagrangian advection schemes. As the authors state, additional improvements can be expected when interpolation in time and onto particle positions could be incorporated. As such the study is highly relevant and should be published in GMD. The applied methods are sound, the manuscript is well written, the results presented in a concise and clear manner. Hence, I only have one 'major' comment and few minor suggestions.

### Major comment

Construction of the degraded data: On line 85 it is described that the lower resolution data was obtained from sub-sampling the original ERA5 data. I am a bit surprised by this approach, since it does not necessarily reflect the representation in a coarser-resolution model, where the state variables in a larger grid cell should still represent the average in this grid cell and not a sub-sample. Could you please comment on the choice of this degradation strategy.

One direct result of the approach could be the large differences across frontal systems as indicated for the linear interpolation of coarse vs reference data. Likely, these differences would be smaller when average would have been used for degrading.

## Minor comments

L40: Higher-order interpolation. It would be interesting to see how higher-order interpolation schemes would compete with the ML approach. Did you give this any try?

L65ff: Largely repeating the same points and references as in introduction. Consider removing/shortening it here or in intro.

L83: I would rather call this a 'vertical model layer' than a 'horizontal layer'.

L87: How much does the exclusive treatment of the horizontal wind components impact the flow's mass budget (continuity)? It is mentioned later (conclusions) that all interpolation methods suffer from potentially breaking conservation laws and that physics-based ML could improve things. Maybe it can already be mentioned here. Why was the vertical wind not included in this study? Are there any fundamental differences that make it impossible to directly train the model for vertical wind?

L115: Original levels are counted from the model top in IFS. So 0 to 50 would be the upper part of the atmosphere. What is the rationale for cutting at level 50? What is the approximate pressure at this level? Does this separate into troposphere vs stratosphere?

Related to training two models for two vertical layers. How about training different models land and ocean as these give fundamentally different lower boundary conditions. How much does the performance increase in the ML method differ for land and ocean areas? How much for boundary layer (where turbulence is part of FLEXPART's transport description) vs free troposphere?

L131: Are  $\mu_x$  and  $\mu_y$  scalars representing the overall image mean? If yes, I don't quite understand the use of the 11 x 11 Gaussian filter. Furthermore, I think it would be good to argue if and why SSIM should be a useful metric for comparing wind components as opposed to images. I suppose wind components will have a very different pdf from that of images (color channels)?

L132f: What is the motivation for  $K_1$  and  $K_2$ ? Why not simply mention  $C_1=1E-4$  and  $C_2=9E-4$ ?

L177: There is an exception to this observation! For SSIM linear interpolation in  $u$  seems to perform slightly better than model4.

L186, Fig.5: How would the same figure look like for the relative error? Are these large error associated with large wind speeds?

L191: It is mentioned elsewhere that FLEXPART was not run on the same compute architecture as the ML model. How comparable are the times given here? Consider adding CPU/GPU specs.

Fig 6: Figure caption wrong? I assume these are similar differences as in Fig. 3

Fig 7: Why do we not see the checkerboard pattern (as mentioned in the caption to Figure 4) here?

L234ff: Other downscaling approaches ingest additional high-resolution predictor variables (like topography or land cover) that have a direct impact on near-surface flow and spatial variability. Could such predictors be integrated into the present method as well?

Technical issues

Citation style: Seems to be wrong. Authors are given outside braces most of the time.

Equation 1: Consider using the same x, y notation as in equation 2.

L188: Additional figures in git repository? Shouldn't they rather be made available as part of a supplemental document/dataset? As git repository is not a permanent link/location, I would suggest to put figures elsewhere.