

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2022-76

Anonymous Referee #1

Referee comment on "Downscaling atmospheric chemistry simulations with physically consistent deep learning" by Andrew Geiss et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-76-RC1>, 2022

Review of "Downscaling atmospheric chemistry simulations with physically consistent deep learning"

Geiss et al. produce an interesting use case of upsampling/downscaling CNNs for the purpose of producing higher resolution chemistry simulation coarse forecasts from process models. I think the main interest, and perhaps the novelty, is in their adaption of widely used CNNs to ensure that to high resolution output is physically realistic and consistent. I am not aware of this being done before, so I think this is of interest to the community and therefore GMD.

Overall, I thought the message of the paper was clear and tells a compelling story as to how these upsampling methods can be useful. I particularly liked how the introduction contains all the relevant details though I think some terminology could use more explanation (comments about this are later in the review). I have no major concerns about this manuscript, and any minor comments and thoughts are included below. Thank you for a nice and interesting paper!

Major comments

Section 1.1 and 3.1: I think the introduction of the technical language could be improved a bit. GMD will have readers who don't understand what CNNs are or why we'd want to use one for image processing. I think perhaps a couple of plain text sentences about CNNs and why they're useful would benefit this section. There's also language used without introduction such as 3-layer, vanishing gradients, convolutional kernels, and deeper CNNs, that could be explained more. I don't disagree at all with what you've written, I just think the audience (GMD) and the manuscript will benefit from a little more explanation.

Minor comments

L23: It'd be worth clarifying that you mean small 'spatial' lengthscales as small temporal lengthscales are equally important.

L92: It's not immediately apparent to me why being able to train a CNN on log-normally distributed data is a result of your work. Wouldn't a standard approach be to scale your data before training?

L160: What's a spatial chip?

L174&177: There are numerous other loss functions that will account for the issue of the loss dominating for large concentrations (negative log likelihoods, normalised loss etc)

L201: Unit for this value 4×10^6 would be useful?

L203: Neither a ReLU nor an ELU will enforce non-negative outputs. I believe this sentence to be incorrect and it should be updated.

L271: What was the motivation for using MAE to evaluate. I personally would have thought MSE alongside so evaluation of fractional errors to be more informative.

L275: This could be a limitation in my understanding, but I thought SSIM values are between 0 and 1, not -1 and 1.

Table1: What's the intuition behind CO and it's fairly similar performance (for LOG-SSIM, but not MAE) across the downscaling methods?

Figure 2 and others: Representing ship tracks only really shows that the CNN learns that these are stationary features right. If we moved this ship track elsewhere, I'd imagine the CNN wouldn't upscale that well. Is this right?

Figure 6: About the 'ringing artifacts'. Should we be concerned that the interpolation methods (particularly the CNN) are producing upsampled output that contains these

harmonic artifacts?

Sec5: What's the additional computational cost of using VSR methods as opposed to SISR?

Typographical comments

L114 (and throughout): I don't think chemicals should be in LaTeX math mode. If using LaTeX, try using the chemformula package and `\ch{}` command.

L159: Mention explicitly that SLP is sea level pressure?

L415: As far as I can tell, GCM hasn't been introduced.

Other thoughts

L111: I really appreciated the forethought in scaling to a fairly standard (non-square model resolution)

Sec3.4: I think this is all very sensible and a nice solution to the conservation problem

I really appreciated the availability of the code and the video supplement. I thought these were useful additions.