Supplement of Geosci. Model Dev., 16, 3997–4016, 2023
https://doi.org/10.5194/gmd-16-3997-2023-supplement

Geoscientific Model Development
Open Access
EGU

Supplement of

Segmentation of XCO_2 images with deep learning: application to synthetic plumes from cities and power plants

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We report here a study suggested by a referee. The referee proposed investigating whether the model is biased towards the shape of the plume. In the results, it was found that most plume smoke shapes are long-tailed, and when the smoke does not spread and gathers in the middle, the segmentation results are not as good as those from long-tailed shapes. There has been a bias towards the plume shape. It seems necessary to analyse whether the result of having a higher NWBCE score was influenced by the shape of the plume.

In line with this proposal, we investigate whether plumes that stack in the middle are less well reconstructed than long-tailed plumes. For this study, we calculate for each plume a quantity called "ratio centre mass". This quantity is the sum of the plume concentrations in the centre of the image divided by the sum of all plume concentrations. The dimensions of the images span from 0 to 160 in both the x and y directions. The center of the images is defined as the pixels located within the range of [40:120, 40:120]. We can then group the plumes into four categories according to their "ratio centre mass" and plot the kernel densities (histograms) of the nwbce of these four categories in Fig. S1. The best reconstructed plumes are those with a medium

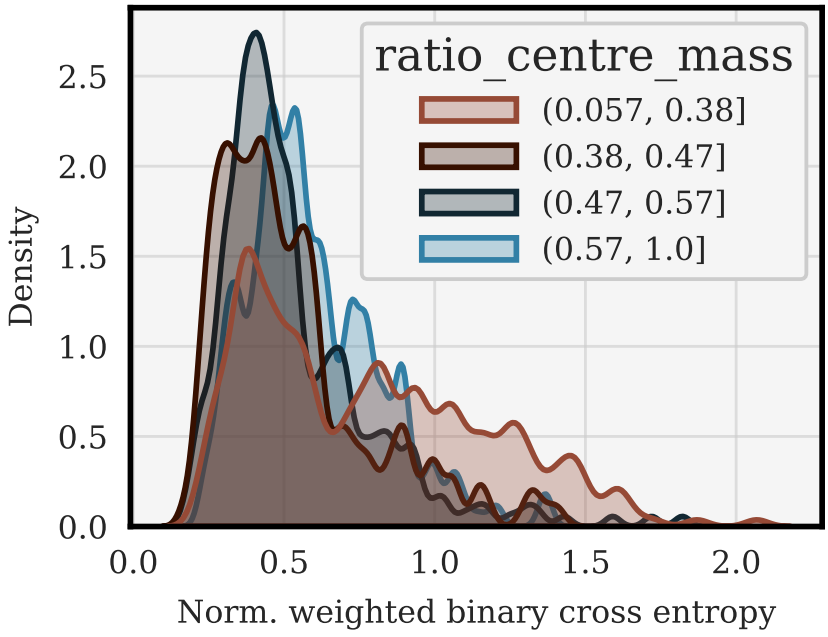

Figure S1. Histograms of the NWBCE image scores over all test images of Lippendorf. The plumes are classified in four equivalent clusters according to the ratio centre mass.

"ratio centre mass". Furthermore:

- low "ratio centre mass" plumes is the category with the worst NWBCE. A large plume spread (due to a strong wind) is correlated with a smaller amplitude (as the plume is spread). It is therefore reasonable to observe that a large spread (i.e. low "ratio centre mass") is correlated with lower model performance;
- plumes with high "ratio centre mass" (e.g. plumes that stack in the middle) also have a significant NWBCE.

This second fact seems in line with the bias hypothesis, but the first fact shows that other phenomenons (e.g. the amplitude of the plume) have a higher influence on the performance of the model. Since optimal results are obtained for intermediate ratios, we can assume that the competence of the model is a compromise between amplitude and a plume-like shape. For a more complete analysis, it would be necessary to create much more specific categories of plumes according to their shape.