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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Can statistics of turbulent tracer dispersion be inferred from camera observations of SO_2 in the ultraviolet?" *by* Arve Kylling et al.

Anonymous Referee #1

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This paper models an elevated, continuous release of SO2 gas in a channel flow using large-eddy simulation (LES). It uses a radiative transfer model to model what an ultraviolet camera would see and compare that with line-of-sight integrated SO2 directly from the LES. Several statistics are compared such a plume dispersion, both relative and absolute, and it is shown that the statistics of those does not change. There are no comparison with real measurements data of any kind.

Generally speaking, the LES with the setup that the authors have chosen is not adequate to simulate plume dispersion. The grid resolution is around 1 m in all three directions and it is well known that only eddies of the size of almost ten grid cells are

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well resolved. The authors use the plume from it is released until 200 meters downstream for their investigation. Even 125 m downstream from the source the plume is not larger than ten times the grid resolution which means that the plume is not dispersing due to turbulence but rather because of the sub-grid-scale parametrisation of the LES, which I assume it more like molecular diffusion (The authors do not describe that process in detail). This means that most of the plume does not look like real dispersion but appears much smoother. It is therefore dubious to replace experimental measurements with LES in this case. They simulate and store 100 snapshots of the plume evolution.

Then the authors go to radiative transfer calculations with the sun as the light source. It is rather surprising that the calculations use circular boundary conditions such that when one photon leaves the domain on one side it appears again on the opposite side. The refer to energy conservation for this, but I simply don't understand the reasoning behind. It appears unphysical and gives rise to various artefacts such as ghost plumes that have to be removed. They analyse only one (!) out of the 100 snapshots which I think is a very little number for getting good statistics.

The plume statistics analysis is a bit messy. There is an equivalence between the x and z position in space and the two pixel coordinates in the camera. This might be a good approximation but it is confusing that the same symbols are used for the different physical quantities. The mean plume height is a mean of plume heights at all downstream positions. Usually, in a boundary layer the mean plume height is a function of downstream position x since the plume may rise if it is released close to the surface. As a consequence of choosing the average plume height over all x values is that the absolute dispersion sigma_z is a mix of ordinary absolut dispersion (which is relative to the mean height at a specific downstream position x) and the general plume rise. The definition of meandering dispersion suffers some of the same inconveniences. The poor reason for those somewhat awkward definitions is that the authors have an ensemble of one which prevents making ensemble means as is usually done.

Jumping to fractal dimensions, the authors fail to describe exactly what the do, and one could ask how relevant fractal dimensions are given the poor resolution of the LES. Often fractal dimensions are used to describe the interface between the plume and the surrounding air, but here it is unclear what N(epsilon) really is. There is no supporting figure to let the reader know.

The lack of realism of the LES of the plume is also displayed in figure 4 where the relative dispersion is shown. The slope of the red curves in this double logarithmic plot around 1/2 indicating pure molecular-like dispersion (if it is sigma_zr which is plotted) . It is confusing that the authors talk about slope between 0.01 and 0.0217 while I get something from the plot around 1/2. Theoretically, the slope in this range should be close to 3/2 as also mentioned in the Dinger et al paper which they refer to.

To summarize, it looks like the work does not spend enough computational resources on doing a realistic dispersion simulation and, secondly, doing analysis of all their snapshots to get proper statistics.

“Turbulence is one of the unresolved problems of physics” it is written at several occasions. It is not very clear that this work brings us much further.

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