



Is high resolution a good thing?

Will higher spatial and temporal resolution in an Atmospheric Transport Model (ATM) like Flexpart (FP) provide "sufficient benefit" to warrant the increased cost? The answer is - it depends.

There are many degrees of freedom (DOF) to consider, and many subjective interpretations of "sufficient benefit," making it difficult to answer the question generally and objectively. For example, in the following graphic, how do we make the case that increased resolution is or isn't beneficial, and can we generalise that case?



In this work, we reduce the number of DOFs by addressing the question, will higher spatial and temporal ATM resolution provide "better" results than lower resolution and, if so, how much better?

Unfortunately, even this question presents an overwhelming number of DOFs, so we have reduced the number of DOFs even more by asking the question, given two ATM simulations that differ only in the resolution of their meteorological input and/or gridded output, can we detect a significant difference in the model results? And, if so, is this detectable difference consistently present in hundreds to thousands of such pairwise comparisons?

We suggest that only by finding such "signatures," can we justify the next step of determining whether such signatures suggest any kind of benefit in using higher resolution. And, if we can't even find consistent signatures, it may be that we're wasting our time trying to assess benefits of higher resolution.

Hence, we are pursuing the hypothesis that *if higher* resolution leads to better ATM results, then repeated, controlled experiments of ATM simulations with only two DOFs will consistently produce signals that indicate significant difference in the model output. If no such consistent signals exist, then we assume that, at least within the metrics we're looking at, no benefit and/or degradation in model results exists between two different resolutions.

In order to create the hundreds to thousands of FP experiments, we have created a framework that facilitates the relatively painless launching of individual experiments, each with four simulations that vary only in the resolution of the meteorology input grid and/or the resolution of the FP output grid. From there, we can launch a series of these experiments, each under different meteorological conditions (an attempt at controlled random sampling of scenarios), storing all of the outputs in a logical directory hierarchy for analysis and any postprocessing.

The execution of a single experiment is set up to produce a stream of four model results that come from varying two resolutions of input meteorology grids and FP output grids (see figure to left).

The postprocessing of the results is fully decoupled from the simulations, giving us a great deal of flexibility in how we choose to analyse the numerous outputs. The first component of the system simply provides the framework for generating results of numerous experiments, and the second component provides tools for postprocessing and analysing.

The current postprocessing tools place one or more abstract rings of equidistant "receptors" around the release point, and then monitor the model concentrations at each of the sampling receptors.



In just a single experiment we find compelling evidence of interesting differences arising from the use of different input and output resolutions. The overriding question then becomes, *if we use this same model setup for hundreds* or even thousands of experiments, each driven by different meteorology (the "random" influence, so to speak), will these – or other – signatures appear on a consistent basis? And, if we run other experiments with different model configurations, will those signatures continue to appear?

Scientific evaluation of the benefits of increase in resolution for IDC's ATM tools and launching interface

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Methods





Next steps - analysis

To date, we have the software tools to run large numbers of experiments, each consisting of paired (or fourwise) simulations where only the resolution is different, and each experiment is driven by different meteorology. To some degree, we consider the different meteorologies as randomly varying inputs to otherwise controlled simulations.

An initial proof of concept of the experiment driver was performed with five backwards experiments with start times 18 hours apart, separated by a total of 72 hours. After generation and archival of the model outputs, the postprocessing tools were used to create - for each experiment - graphical representations of the differences in plumes and concentration envelopes.





The short time period for this test did not facilitate the varying input meteorologies that we would hope for over longer periods, but it is apparent that, at times, there are compelling differences associated with different input and output resolutions. It is not our intent at this early stage to derive hypotheses from such sparse data.

The important next step is to run several groups of experiments. A single group of experiments will consist of perhaps hundreds to thousands of experiments each with the same model configuration used for fourwise varying resolution simulations. It is important to run several of these groups of experiments to account for variation in topography and climate.

The end goal is to generate huge amounts of data and then search it for signals that may indicate that simulations at one resolution have significant and fairly consistent differences from simulations at another resolution. The great challenge, then, is to derive analytical methods that will reveal such signals if they exist. Approaches for consideration include comparison of normalised concentration envelopes (e.g. arrival times, peak times, amount of variability), spatial analysis of plume features, and more advanced methods.



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