SnT 2021
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Methods to Assess the Value of High Input Resolution in Atmospheric Transport Models

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P4.1-593

POSTER

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The support of this work by CTBTO, under funding from European Union Council Decisions VII, is gratefully acknowledged

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ABSTRACT

The question of whether the increased cost of implementing higher input resolutions in atmospheric transport models is difficult to address, and any answer is typically qualified with an “it depends.” Attempts to study the effects of high resolution are frequently performed with a small set of case studies, making it difficult to generalise the findings to other cases that may vary in a number of attributes.

Our group has developed a methodology to run hundreds to thousands of paired ATM simulations in which only the resolution is varied, evaluating metrics such as plume arrival time and concentration, and then looking for “signatures” over many simulations that may reveal significant differences due to resolution alone. We suggest that if there are general improvements due to higher resolution, they must exhibit such signatures, and once they are detected they are further scrutinised. The methods have been used to explore FLEXPART simulations driven by 0.5 vs 1.0 degree ECMWF and GFS inputs every 36 hours over periods of eight to twelve months.

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INTRODUCTION

- We want to understand if, in general, increasing the spatial (or temporal) resolution of a model will result in significant improvements
- Exploration of simulations against real world data is difficult, limited in scope, and typically gives us “it depends” answers within a narrow set of parameters amidst a field of a large number of degrees of freedom, making it impossible to reach general conclusions
- We hypothesise that IF a change in resolution provides significant improvements, then a comparison of hundreds to thousands of paired (low-res vs high-res) simulations should reveal a “signal” of consistent and significant differences worthy of deeper exploration. If this is not the case, then it might be that we are wasting our time looking for resolution-based improvements in a general sense

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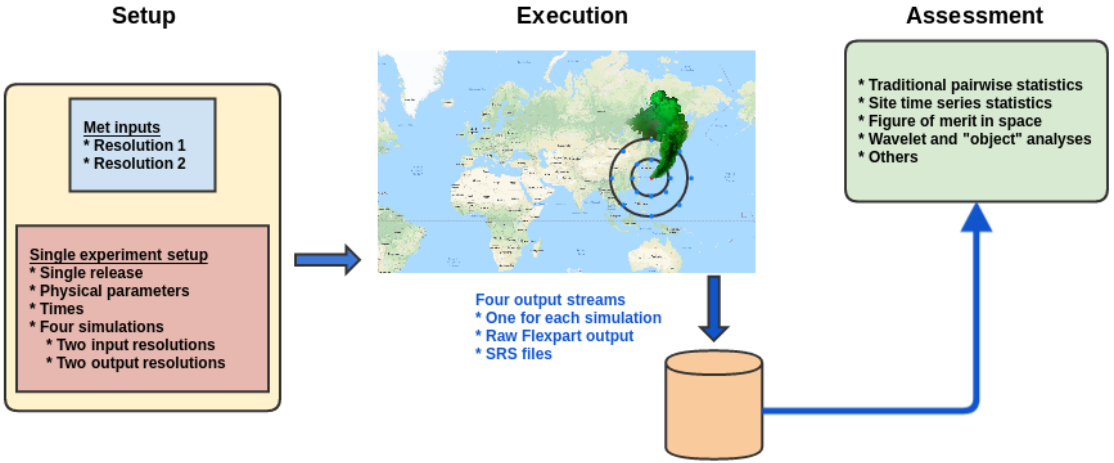
INTRODUCTION

- Our work consists of
  - building and using a Python-based software environment (Resolution Testing Thang - RTT) that will run one FLEXPART simulation against another, varying ONLY the spatial resolution, leaving everything else constant, archiving all outputs
  - post-processing tools to evaluate output metrics - typically in scatterplots - to look for significant biases that result from resolution differences



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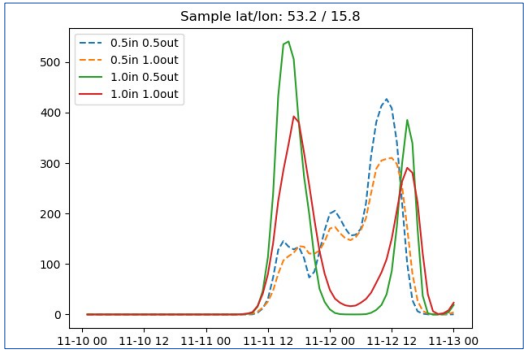
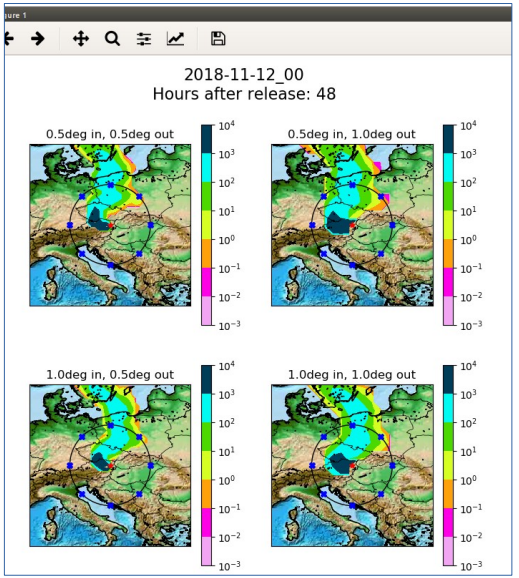
METHODS

- Use of RTT to run paired FLEXPART experiments in batch mode over 8-12 months of archived ECMWF and NCEP data, spaced 36-hours apart
- Each experiment
  - Four FLEXPART simulations - 0.5 and 1.0 deg input / 0.5 and 1.0 deg output
  - 240 hours in length
  - Releases at five sites within different climate and terrain regimes
  - Archived output





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METHODS

- Post processing
  - Through all of the archived output, extract concentration time series at selected points around each release
  - Scatterplots to compare key metrics - plume arrival time, time integrated concentration, peak concentration, etc.


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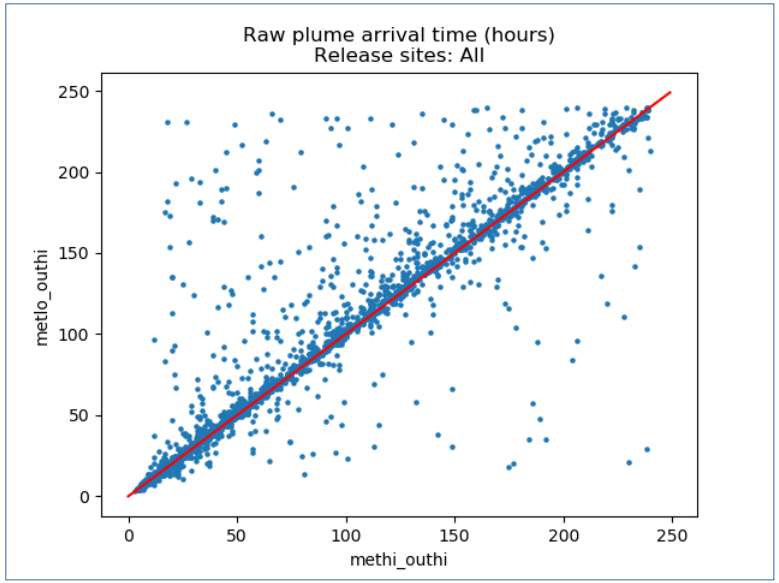

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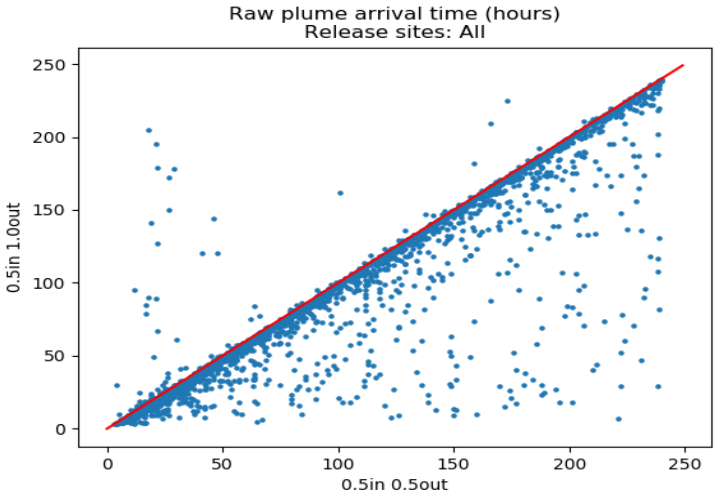
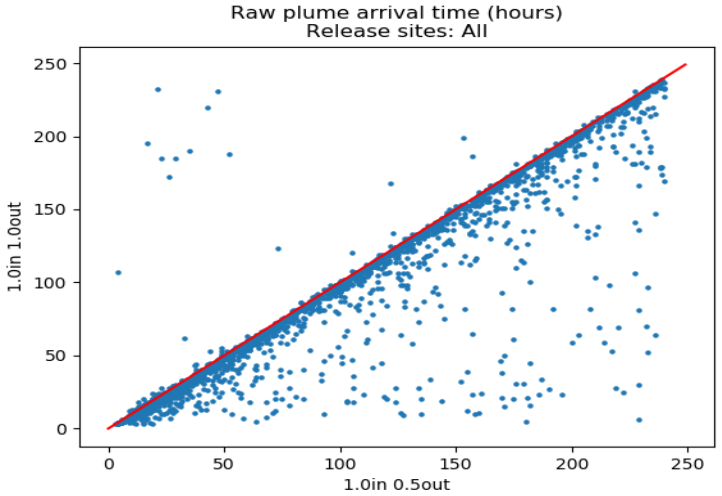
RESULTS

1 DOF. Variation of OUTGRID resolution with input resolution held constant (not the focus of this study, but useful to see).





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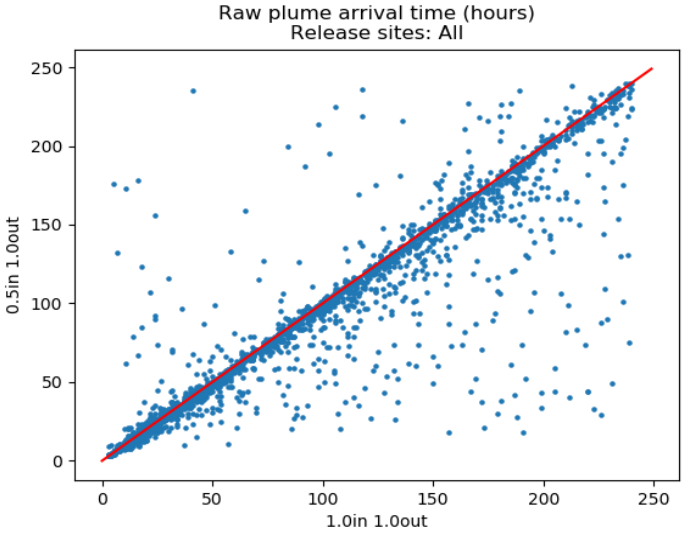
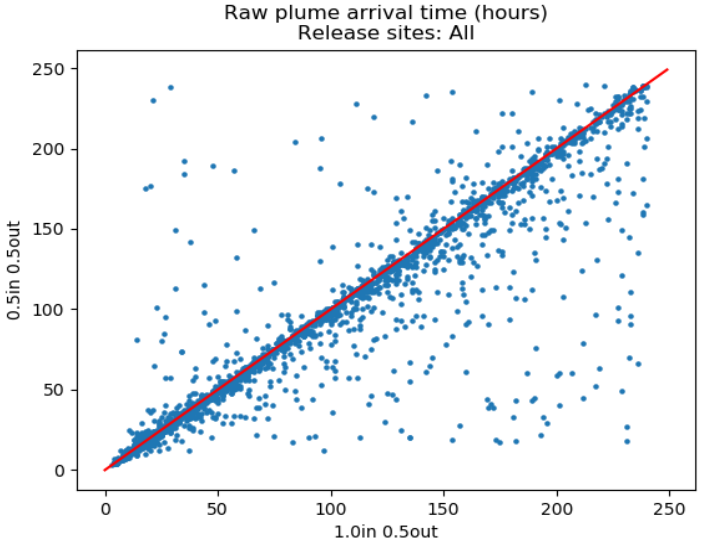
RESULTS

1 DOF. Variation of input resolution with OUTGRID resolution held constant.





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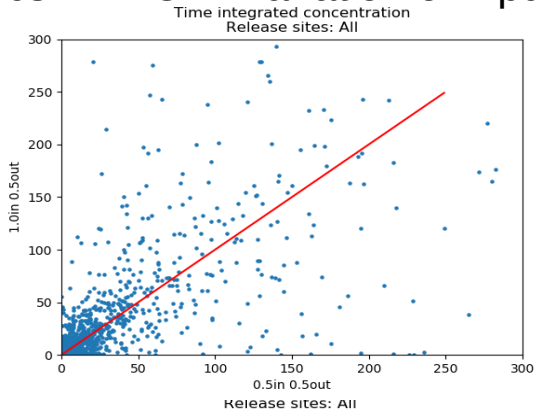
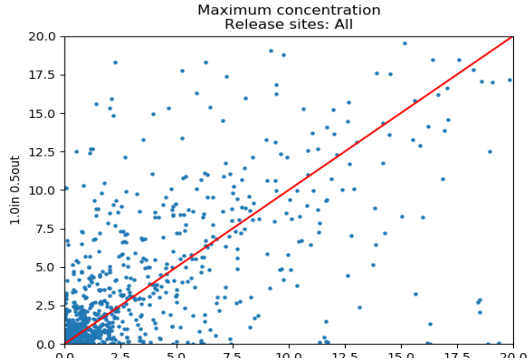
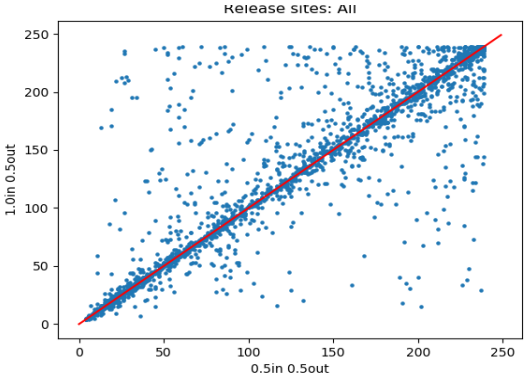
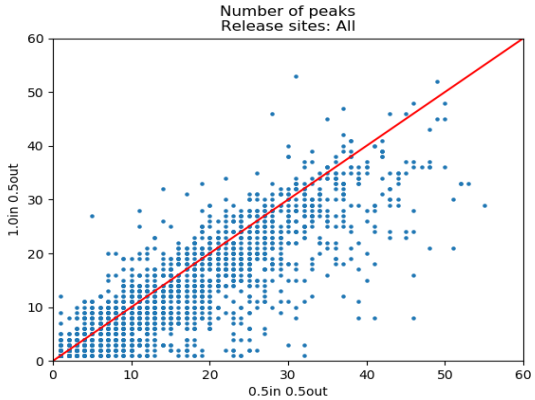
RESULTS

Other metrics. 1 DOF. Variation of input resolution with OUTGRID resolution held constant.









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CONCLUSIONS

- Exploring question of whether “higher resolution improves results” by first looking for signs that higher resolution produces significant and consistent differences in certain metrics with respect to lower resolution
- Software created for batching huge numbers of paired simulations and assessing behaviours with respect to specified metrics, varying a small number of DOFs
- The first, preliminary application of this method suggests areas where significant differences occur, worthy of more targeted investigation to determine if these result in significant improvements
- This approach, and software, can be used for numerous comparisons where we want to vary a single parameter and explore its effect