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Passive Tracer Modelling at Super-Resolution with WRF-ARW to Assess Mass-Balance Schemes

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Editor Comments in Grey (24 June 2023)

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(Sepehr Fathi, 4 July 2023)

Author Responses to Editor Comments Submitted on 24 Jun 2023:

Public justification (visible to the public if the article is accepted and published):

I ask revision of abstract. Abstract consists of two paragraphs. First paragraph is lengthy with sentences to emphasize the super-resolution modeling and second one summarizes this study with relatively short information. Please concise the sentences for the important aspects of this study and put more relevant information on the summary.

Abstract was revised as follows:

"Super-resolution atmospheric modelling can be used to interpret and optimize environmental observations during top-down emission rate retrieval campaigns (e.g., aircraft-based) by providing complementary data that closely correspond to real-world atmospheric pollution transport and dispersion conditions. For this work, super-resolution model simulations with Large-Eddy-Simulation sub-grid scale parameterization were developed and implemented using WRF-ARW (Weather Research and Forecasting - Advanced Research WRF). We demonstrate a series of best practices for improved (realistic) modelling of atmospheric pollutant dispersion at super-resolutions. These include careful considerations for grid quality over complex terrain, sub-grid turbulence parameterization at the scale of large eddies and ensuring local and global tracer mass-conservation. The study objective was to resolve small dynamical processes inclusive of spatio-temporal scales of high-speed (e.g., 100 m/s) airborne measurements. This was achieved by downscaling of reanalysis data from 31.25 km to 50 m through multi-domain model nesting in the horizontal and grid-refining in the vertical. Further, WRF dynamical-solver source code was modified to simulate the release of passive-tracers within the finest resolution domain. Different meteorological case studies and several tracer source emission scenarios were considered. Model-generated fields were evaluated against observational data (surface monitoring network and aircraft campaign data) and also in terms of tracer mass-conservation. Results indicated agreement between modelled and observed values within 5 °C for temperature, 1-25% for relative humidity, and 1-2 standard deviations for wind fields. Model performance in terms of (global and local) tracer mass conservation was within 2% to 5% of model input emissions. We found that to ensure mass conservation within the modelling domain, tracers should be released on a regular resolution grid (vertical and horizontal). Further, using our super-resolution modelling products, we investigated emission rate estimations based on flux calculation and mass-balancing. Our results indicate that retrievals under weak advection conditions (horizontal wind speeds < 5 m/s) are not reliable due to weak correlation between the source emission rate and the downwind tracer mass flux. In this work we demonstrate the development of accurate super-resolution model simulations useful for planning/interpreting/optimizing top-down retrievals, and discuss favourable conditions (e.g., meteorological) for reliable mass-balance emission rate estimations."