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The impact of resolution on ship plume simulations with NO_x chemistry

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Abstract. A high resolution chemical transport model of the marine boundary layer is designed in order to investigate the detailed chemical evolution of a ship plume in a tropical location. To estimate systematic errors due to finite model resolution, otherwise identical simulations are run at a range of model resolutions. Notably, to obtain comparable plumes in the different simulations, it is found necessary to use an advection scheme consistent with the Large Eddy Model representation of sub-grid winds for those simulations with degraded resolution. Our simulations show that OH concentration, NO_x lifetime and ozone production efficiency of the model change by 8%, 32% and 31% respectively between the highest (200 m×200 m×40 m) and lowest resolution (9600 m×9600 m×1920 m) simulations. Interpolating to the resolution of a typical global composition transport model (CTM, 5°×5°), suggests that a CTM overestimates OH, NO_x lifetime and ozone production efficiency by approximately 15%, 55% and 59% respectively. For the first time, by explicitly degrading the model spatial resolution we show that there is a significant reduction in model skill in accurately simulating the aforementioned quantities due to the coarse resolution of these CTMs and the non-linear nature of atmospheric chemistry. These results are significant for the assessment and forecasting of the climate impact of ship NO_x and indicate that for realistic representation of ship plume emissions in CTMs, some suitable parametrisation is necessary at current global model resolutions.

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