The impact of resolution on the $O_x$-HO$_x$-NO$_x$ chemistry of ship plumes

C.L. Charlton-Perez (1), M.J. Evans (1), J.H. Marsham (1), and J.G. Esler (2)
(1) School of Earth And Environment, University of Leeds, Leeds, UK, (2) Department of Mathematics, University College London, London, UK

Ship emissions constitute a significant fraction of total anthropogenic emissions of NO$_x$. However, their inclusion in global atmospheric chemistry transport model causes these models to calculate unrealistically high concentrations of $O_3$ and NO$_x$ in the marine boundary layer. It has been suggested that the coarse resolution of such models coupled to the non-linear nature of the model chemistry leads to this overestimate however this has not been systematically investigate.

In order to investigate this hypothesis a high resolution chemical transport model of the marine boundary layer based on winds from a LEM which can be systematically degraded to lower and lower resolution.

Our simulations show that the OH concentration, NO$_x$ lifetime and ozone production efficiency of the model change by 8%, 32% and 31% respectively between the highest and lowest resolution 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 due to ship NO$_x$ by approximately 15%, 55% and 59% respectively. Thus, the failure of CTMs to simulate ship plumes efficiently is likely due to the combined impact of coarse resolution and non-linear $O_x$-HO$_x$-NO$_x$ chemistry. These results are significant for the assessment and forecasting of the climate impact of ship NO$_x$ and indicate that at current global model resolutions ship plume emissions in CTMs, need to be suitably parameterized.