NEW URBAN PLANNING TOOL ALLOWING IMPROVED PREDICTION OF URBAN AIR POLLUTION LEVELS USING RAY-TRACING DEVELOPED AT LUND UNIVERSITY

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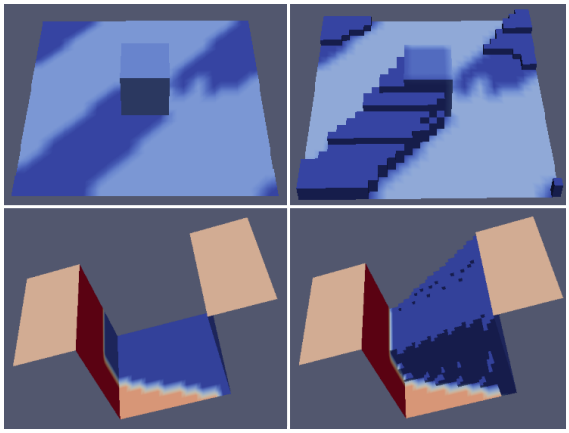
A master's thesis study at Lund university has developed a new model for calculating shadows in CFD simulations

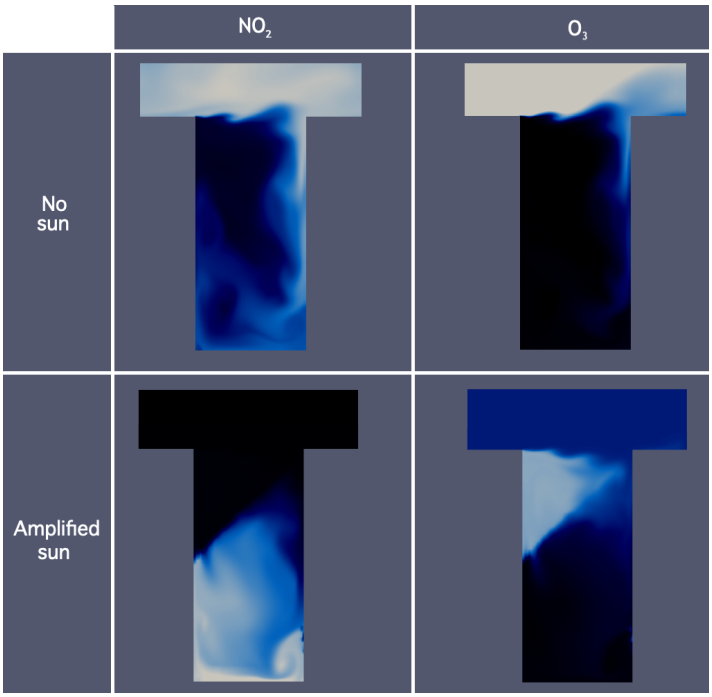
A master's thesis studying nitrate oxide levels in city air has been conducted at Lund University. It was performed using OpenFOAM, an open source simulation program used for dynamic computation of fluid flow in custom environments. A new solar module was developed for the thesis, allowing for the automatic calculation of shaded areas in a domain, assisting in simulating photo-dependent chemical processes in non-flat geometries, such as city environments. It utilizes a ray-tracing algorithm and is compatible with parallel processing.



Demonstration of the new solar model. Shadows can now be represented in three dimensions.

NO_x in city air is the primary cause of pollution-related illnesses worldwide

NO and NO_2, referred together as NO_x, are two compounds long known to have a significant negative impact on the respiratory health of urban populations worldwide. They are found in the air of most cities, most commonly created from high temperature processes, like car engine combustion or processes found in heavy industry. The Stockholm Environment Institute found an estimated 38 000 premature deaths worldwide were caused by NOx emissions in 2015, predicting the same number increasing to 186 000 in 2040. Tools like these will help urban planners to estimate how different architectures and city configurations might affect NO_x levels in the atmosphere, and subsequently what configurations will minimize health risks from pollutant exposure for local inhabitants.



Relative NO2 and O3 levels using two different solar models. The No sun simulation has no sun active, while the Amplified sun simulation has the shadow solar model active, with photolytic effects amplified for clearer viewing.

The study found that solar irradiation has a mostly local impact of NO levels

While NO_2 is mostly non-reactive in the atmosphere, it is broken down into NO and O when affected by sunlight of a low enough wavelength, in a process known as photolysis. For this reason, solar irradiation becomes an important metric in simulations involving these chemicals and their interactions. In this study, the concentration levels of NO, NO_2 and O_3 were measured using different solar models for comparison, including one with no sun, one with a uniform sun and one with sun only in non-shaded areas. It was found that for the model including shadows, the areas in the shade had similar pollution levels to the equivalent areas of the simulation with no photolysis at all. This suggests that the effects of photolysis are mostly local, and that for studies where all points of measurement have similar levels of solar exposure, a simple uniform solar model can be used. The total differences in pollutant concentration were also found to be relatively small compared to concentration differences caused by reaction with Ozone.

Original thesis

"Implementing spatial variance in the photolytic breakdown of NO_2 in urban street canyons"
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