Chapter 5

Outlook

Although ozone pollution is a major problem in Europe, there is currently no legally binding limit value for ozone. The EU Directive 2008/50/EG sets a target value for human health requiring the mean eight hourly ozone concentration not to exceed 120 μg m^{-3} (= 60 ppbv) on more than 25 calendar days per year. The same EU Directive also sets an AOT40 target value for the exposure of vegetation to ozone of less than 18,000 μg m^{-3} $\cdot$ h. AOT40 is the sum of the differences between the mean hourly ozone values above 80 μg m^{-3} (= 40 ppbv) and the value of 80 μg m^{-3} between 8 am and 8 pm from May to July.

The EU has laws regulating the emissions of ozone precursors (NO_x and VOC). While these laws have reduced the emissions of both NO_x and VOC over Europe, the target value for ozone is regularly exceeded throughout Europe. The non-linear relationship between ozone, NO_x and VOC as well as intercontinental transport of ozone and its precursors impact the response of ozone pollution despite reductions in precursor emissions. The European Environmental Agency (EEA) recommends further mitigation efforts on the local, regional and global scales to reduce ambient ozone levels.

Setting a legally binding limit value for ambient ozone over Europe should inspire mitigation strategies at the local and regional scales in a bid to meet this limit. Meeting a limit value requires assessing different mitigation approaches and here AQ modelling will be a vital tool in determining the efficacy of a mitigation strategy for reducing ambient ozone. Thus research aiming to improve model performance would also aid in increasing the confidence of AQ predictions from models, an asset for judging different mitigation strategies.

The detailed process studies performed as part of this work were designed

to ultimately improve model performance increasing the confidence of the predictions of AQ models for mitigation strategies. A number of recommendations to the AQ modelling community are listed based on these studies. AQ modelling groups should use up-to-date chemical mechanisms to incorporate the findings and recommendations from the chemical kinetics community as well as updated representations of emitted VOC and their secondary degradation. This is undoubtably more work for a modelling group as further work such as testing the model with a new chemical mechanism and translating emissions into the new chemical species would need to be performed. However as shown in the first study, updated versions of the same chemical mechanism produced more similar amounts of ozone to the near-explicit MCM v3.2 chemical mechanism. Thus using an updated chemical mechanism should increase the confidence of the modelled ozone production from the degradation of emitted VOCs.

As the lumped-intermediate chemical mechanism produced the most similar amounts of ozone to the MCM v3.2, the approach of using a highly detailed chemical mechanism and lumping the degradation products appears promising for developing future chemical mechanisms. This approach did not break down the emitted VOC into smaller degradation products as fast as the lumped-molecule and lumped-structure chemical mechanisms, which was the main cause for the lower ozone production using these chemical mechanisms compared to the MCM v3.2. Lumped-intermediate chemical mechanisms include more chemical species than lumped-molecule and lumped-structure chemical mechanisms making their use less appealling from a computational efficiency perspective. However gains in computational speed with modern computing centres might reduce this concern and facilitate the use of more complex chemical mechanisms as part of 3D models.

One feature of future mitigation strategies could be to substitute the emissions of a more-reactive NMVOC with a less-reactive NMVOC thus changing the NMVOC speciation profile from emission sectors. Such mitigation strategies require updating emission inventories and assessing how the change in speciation could influence ambient ozone levels. The results of the second study indicate that ozone production close to emission sources would be reduced using such mitigation strategies but ozone production downwind may increase.

A warmer climate is predicted in the future as a result of climate change and this may affect ozone production chemistry in future emission scenarios. The influence of meteorological variables on ozone production is extremely important with the third study demonstrating an increase in ozone production with temperature. A deeper understanding of the effects of meteorology on ozone production is required

to ensure that mitigation strategies are robust enough to still reduce ambient ozone in the future.

The increase of ozone with temperature was determined by the faster oxidation of the emitted NMVOC further emphasising the importance of adequately representing both the speciation and initial degradation of emitted NMVOC. The ozone-temperature relationship was sensitive to atmospheric mixing with less atmospheric mixing allowing the secondary degradation of NMVOC to proceed further than situations with enhanced atmospheric mixing. This highlights the importance of representing the secondary degradation of NMVOC by the chemical mechanism used by an AQ model.

The results from the detailed process studies performed in this work were all performed using a box model and further work using 3-D models is required to verify how additional processes, such as regional transport, also influence ozone production under these conditions. The use of a box model was ideal for the scope of the studies of this thesis allowing a deeper insight into the chemical processes requiring a sharper focus than when using more realistic 3-D models. The recommendations of this thesis along with testing the sensitivity of ozone production within 3-D models would aid in constructing effective mitigation strategies that would meet the EU regulations for ozone pollution.