MODELLED LONG TERM TRENDS OF SURFACE OZONE OVER SOUTH AFRICA

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1. INTRODUCTION

Currently little is understood about the potential local response of air quality to anthropogenically induced changes in the regional climate of southern Africa. Such changes are likely to influence the future transport and chemistry of air pollutants over the region. Previous monitoring campaigns have described local trends of surface and profile ozone (e.g. Thompson et al, 2007); however results are spatially limited and temporally sparse.

The modelling of surface ozone within a large timescale seeks to provide a spatially comprehensive view of trends while also creating a baseline for comparisons with future projections of air quality through the forcing of air quality models with modelled predicted long term meteorology. Previous research within CSIR Climate Studies, Modelling and Environmental Health (CSM&EH) group has enabled the photochemical air quality model CAMx to be forced with fields from the CCAM atmospheric model, which is also capable of simulating forecasted meteorological conditions at the climate change time scale. The use of forecasted climate change data to drive CAMx is the final objective in a larger research initiative that aims to understand the influence future projected changes in climate will have on air quality. The research presented in this poster discusses the model simulations used to derive the baseline from which comparisons with future simulations will be made.

For this baseline trend study, the period 1989-2009 was chosen since necessary ancillary input for CAMx, such as total column ozone and background air quality data, is readily available for this time. Additionally, for CCAM to provide CAMx with realistic meteorological fields, representative real world initial and boundary conditions were required. This came in the form of the NCEP Reanalysis dataset. To date years 1997, 2000, 2003, 2006 and 2009 have been simulated by the CCAMCAMx system, and are presented here as an analysis of trends.

2. METHODOLOGY

A description of development and initial results for the CCAMCAMx system are fully presented in Naidoo and Engelbrecht, 2010. An important improvement to the previous system is the inclusion of vertically disaggregated rainfall. This is achieved by distributing surface rainfall into each model level (per volume) up until cloud base is reached.

The emissions inventory, developed previously (CSIR, 2009), covers the entire CAMx model domain at a 12km resolution, and includes the pollutant species: SO2, NOx, CO, NMVOC, NH3 and PM. The original intent for the emissions inventory was to understand ozone formation over the Highveld area, particularly with respect to emissions from power generation and the synthetic petrochemical industry. Therefore more emphasis on detail was applied to the NOx and NMVOC species from those sources within the Highveld area. The inventory was designed to represent year 2006. Sources included in the inventory are:

- Residential – Emissions from domestic fuel burning
- Transportation – Emissions from road vehicles, diesel trains and airport ground vehicles
- Large Industry – Emissions from Sasol, Eskom and coastal refineries
- Small Industry – Emissions from smaller more disperse industry
- Biogenic – Emissions from vegetation and soil

Since the main aim of the larger research initiative is to understand the influence future projected changes in climate will have on air quality, the emissions inventory remains unchanged for all simulation years, thus leaving meteorology as the main variable. Initial and boundary conditions for CAMx are based on data from the Cape Point GAW station. The column ozone/haze/albedo data, necessary to derive photolysis rates, are sourced from the the TOMS and now OMI instruments.

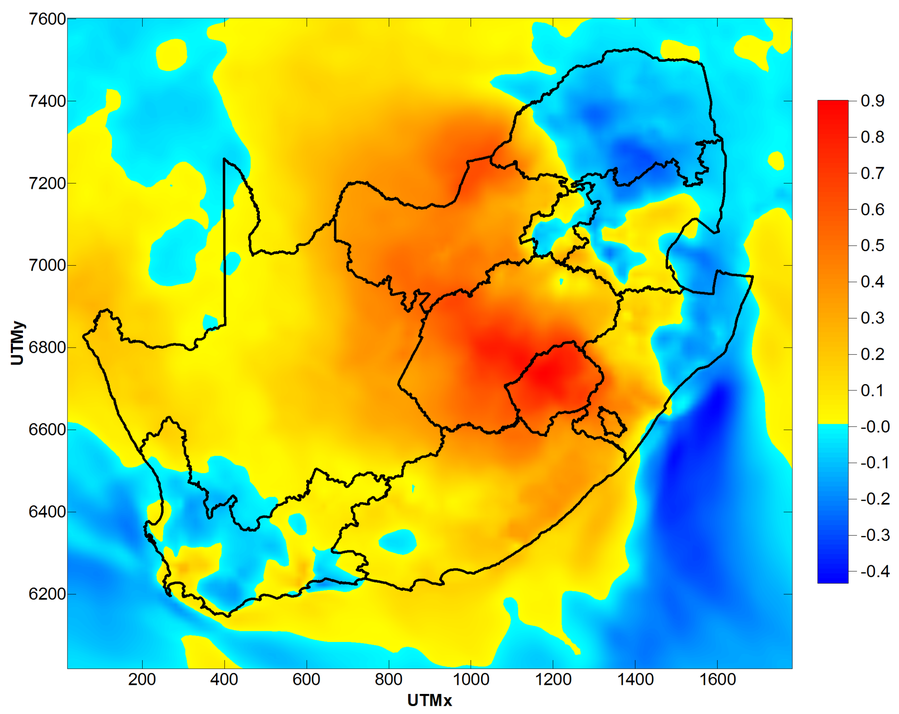

Figure 1: Averaged inter-annual trend of surface ozone (ppb)

3. RESULTS

CAMx hourly surface ozone output was compared to data from monitoring stations to assess system performance. Year 2006 was chosen due to data availability and the fact that the emissions inventory was designed for simulations of 2006. Table 1 shows comparison statistics using each of four Eskom run monitoring stations with data available for this study. The Camden station shows best data completeness. Standard deviation for observed data is comparable across stations, while similar can be said of the CAMx output. However CAMx does not capture as much variability, which is expected due to the relatively coarse model cell size (12kmx12km) when compared to a point on the ground. The average bias shows that CAMx under-estimates ozone at all stations; a possible indication of an incomplete emissions inventory. Correlations also show low similarity between observed and simulated. However it should be noted this may be due to a time misalignment with emissions and model time. Indeed shifting simulated output two hours ahead improves correlation.

Comparison with observed data not withstanding, this study aims to show change and the response of surface ozone levels to a changing climate. Discrete ozone concentrations are then not as relevant as trends between time periods, which show increase or decrease. Figure 1 shows the average inter-annual trend over the modelled years. Trend is considered to be the linear slope between annual averages, and this is averaged for the entire modelled period (i.e. trend of annual average between 1997-2000; 2000-2003; 2003-2006; 2006-2009). In Figure 1, highest average inter-annual change is 0.9ppb/year seen over central region of South Africa. It should be noted that this is based on annual averages, and so represents more accurately the long term large scale transport of ozone over the model domain. Figure 2 shows the Spring trend, calculated similar to Figure 1, but with only Spring months (September, October, November). Inter-annual Spring trends show lower increase and a general decrease over the country. Maximum increases of 0.6ppb/year are seen particularly around the coastal refineries in Durban and Cape Town. Minor dispersed increases are also seen over the Gauteng region.

4. CONCLUSION

The mechanisms of these changes are still to be investigated and an analysis of the changing meteorology will reveal much more (particularly over a longer timescale and with more complete inter-annual model output); noting that the emissions inventory remains static, leaving meteorology as the major driver. However, while this study will be able to show various photochemical responses to a changing climate, it is still limited by the lack of biomass burning in the emissions inventory; a further possibility to decreases seen in the Limpopo province.

Table 1: Comparison of CAMx hourly surface ozone with monitored data

	Data %	Stdev Obs	Stdev CAMx	Av Bias	Correl
Camden	86	16.15	9.07	-7.03	0.27
Elandsfontein	42	13.33	8.74	-15.28	0.19
Kendal 2	67	16.27	8.63	-9.34	0.08
Verkykop	70	10.97	9.59	-5.35	0.01

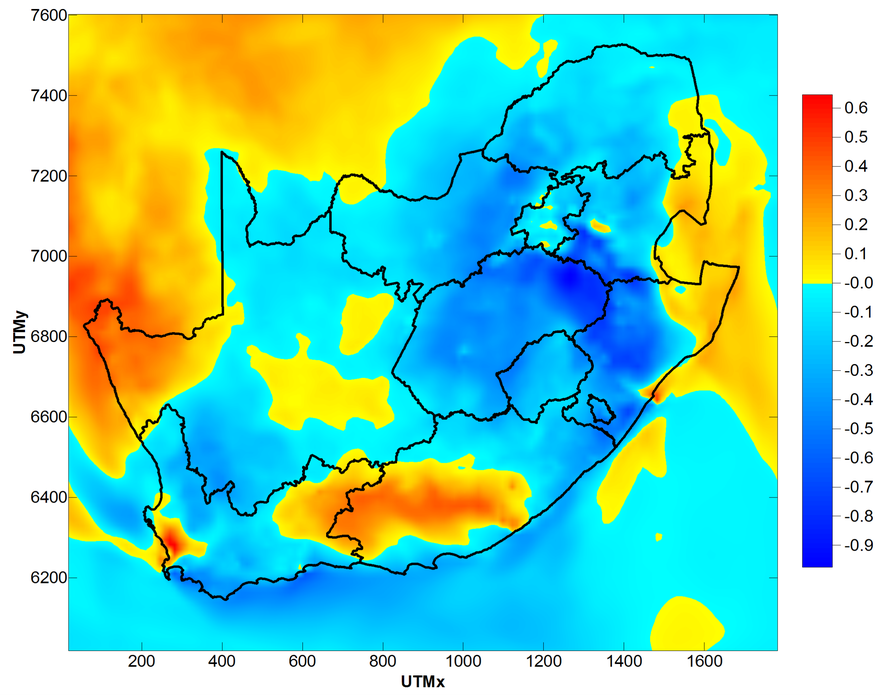

Figure 2: Averaged inter-annual Spring (SON) trend of surface ozone (ppb)

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