Simulation of current and future surface ozone concentrations over the South African Waterberg region

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CSIR NRE Climate Studies, Modelling and Environmental Health

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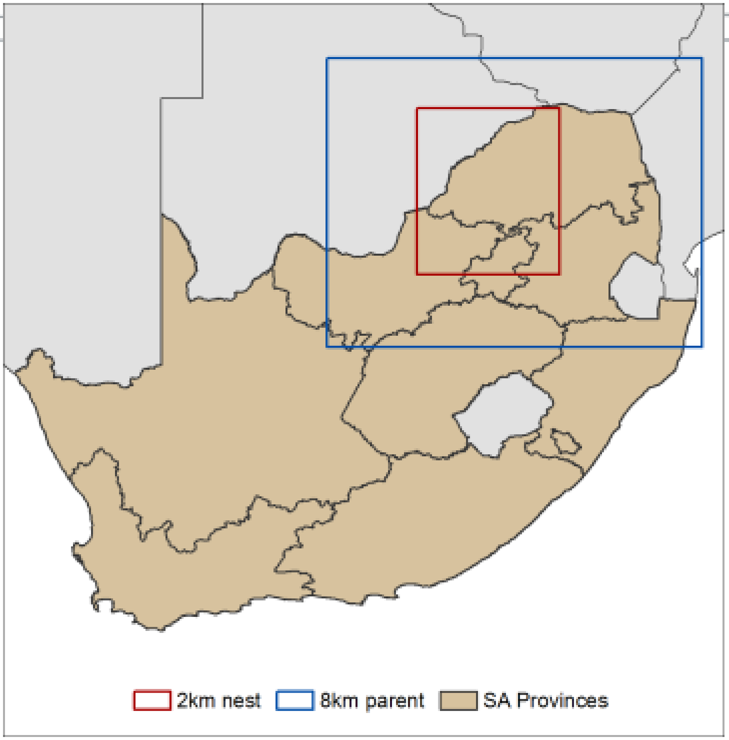
Conclusions

- Background
  - Waterberg region = rapid development (Coal + platinum)
  - Power stations: Matimba (4GW) **+ Medupi (4.8GW)**
  - Previous AQ monitoring shows relatively low O_3 , only one station next to Matimba
  - Newer monitoring shows higher concentrations at three stations (still close to Matimba)
  - Other research[1] shows potential for regional impact and even higher O_3
  - Look at current O_3 and **assess the future impacts a changing climate will have on O_3** formation in the region, along time-scales that show significant climate change. EI remains static.
- Findings
  - "Current" 2013 simulated reasonably well. Impact of Matimba further afield; primarily to the south.
  - Better spatial coverage shows O_3 may be an issue in Waterberg; particularly during convective conditions. JHB may have bigger problems!
  - CAMx projections based on 2091 vs 2013 only (3 x 10 year slices still running)
  - For now it seems surface inversions more important than temperature re. O_3 changes
  - Differences in Waterberg and JHB region re. inversions
  - Waterberg more convective, moving NOx away from surface, increasing O_3.
  - JHB more inversions, retaining NOx and decreasing O_3.

Methods

- CAMx AQM forced with CCAM G/RCM
  - CAMx: 2 way feedback, no SA, no PiG, WESELY89 drydep, PPM advection and EBI chemistry solvers. Carbon Bond 2005. OMI driven initial photolysis rates. MOZART4 IC/BC.
  - CCAM (Conformal Cubic Atmospheric Model – ~~PCOM ocean model~~ – CABLE land-surface): CCSM GCM downscaling. 50km → 8km → 1km.
- Emissions (2013)
  - Industry: Able to get Eskom (power utility) emissions very easily. Sasol from previous work. Others extremely difficult to get. Round-about route through Eskom/friends gets us sources from only one province (lots of QA/QC) needed.
  - On-road vehicles: Hybrid methodology using magesterial district fuel sales for top-down and roads agency count data for bottom-up. COPERT emission factors (speed varying). 7 classes (included freight).



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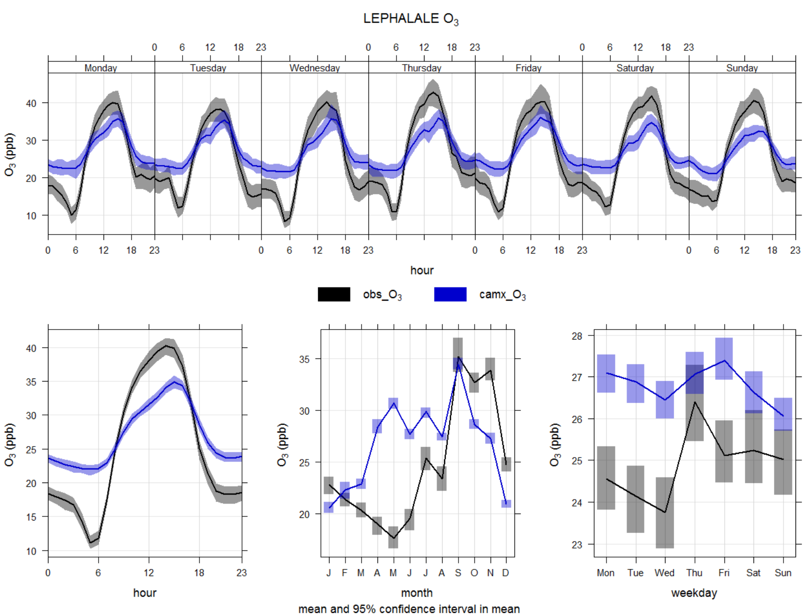
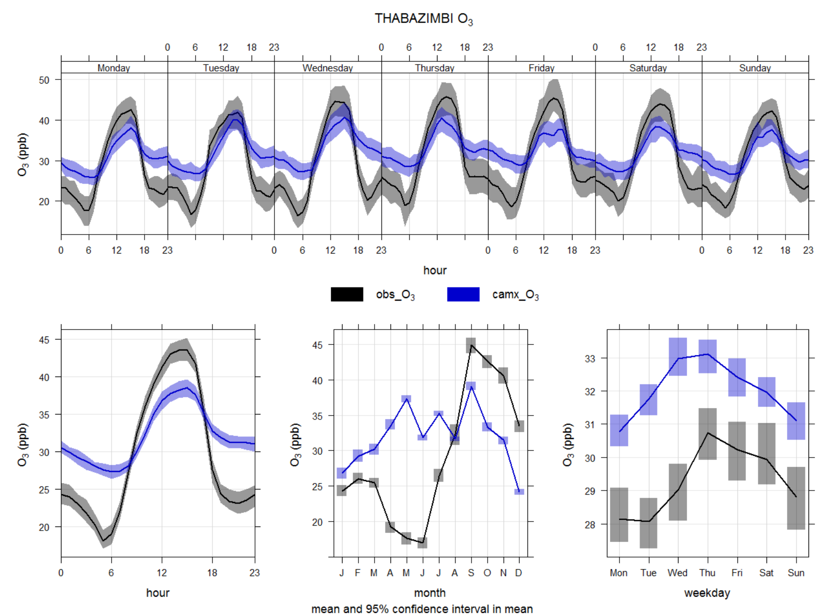
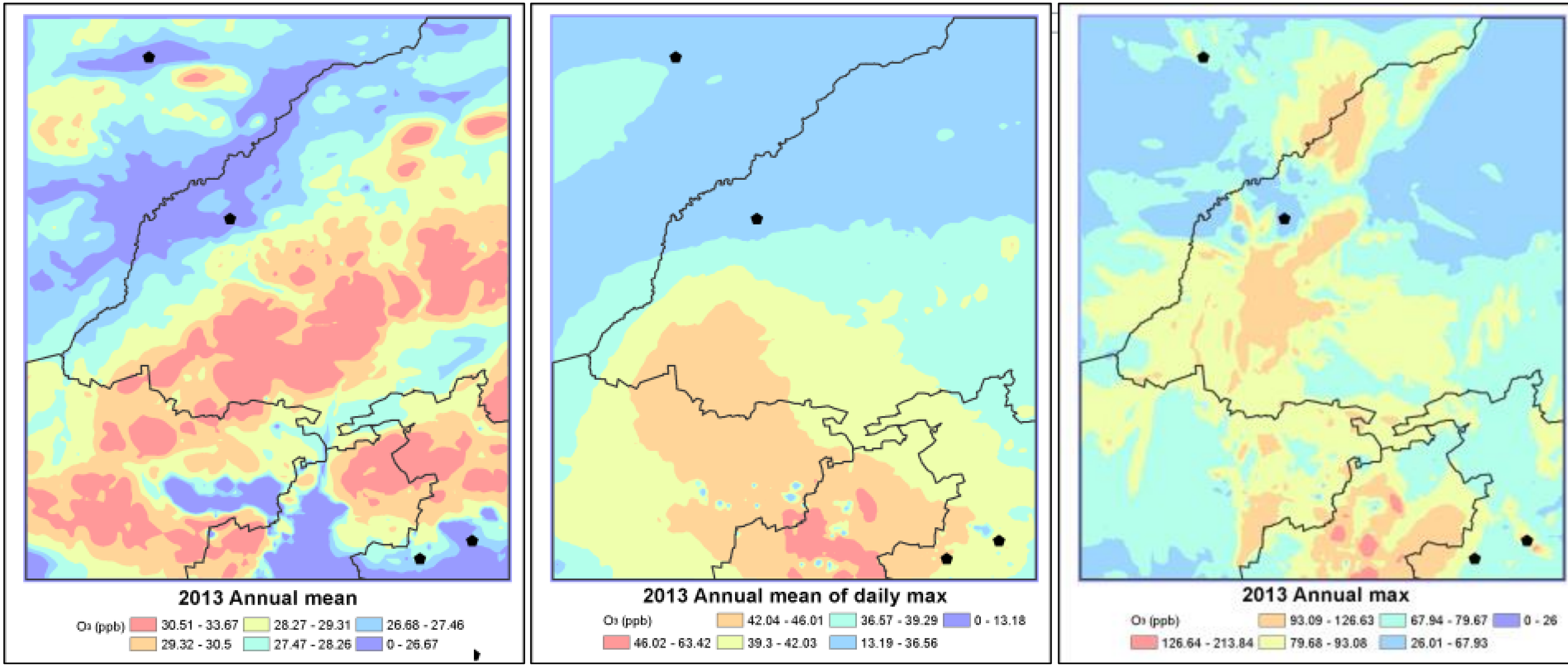
Methods

- Emissions (2013)
  - Domestic fuel use: Top-down methodology using national estimate of residential fuel usage based on the annual published DOE energy balance data. Often correlate with IEA data (except wood use!). Census 2011 to disaggregate to SAL and then SPOT building count for further refinements. Mix of local and EPA (AP-42) emission factors.
  - Biomass burning: NCAR FINN[2]. Does under-estimate[3] (at least for CO_2). Fire Radiative Power product may be better however for air quality need high spatial and temporal resolution.
  - Biogenic VOC: Simulated with MEGAN (driven by CCAM fields). PFT based internal emission factors. MODIS LAI (v6) and MODIS PFT (re-classed to CLM).
  - Agricultural NH_3: ECLIPSEv5[4]. Livestock manure (housing, storage, application on land, grazing) and mineral nitrogen fertilizer application. Coarse resolution but required for sulfate (power stations).





Results – 2013



- Annual mean: Higher on south side of mountain range and north of PTA-JHB (titration)
- Annual mean daily max: Removing evening concentrations reveals better detail. Downwind Matimba plume and JHB. Spots of titration around industry.
- Annual max: High max of >200ppb is simulated. According to measurements up to ~180ppb is possible in JHB while in Waterberg >100ppb is possible (however stations near power stations).

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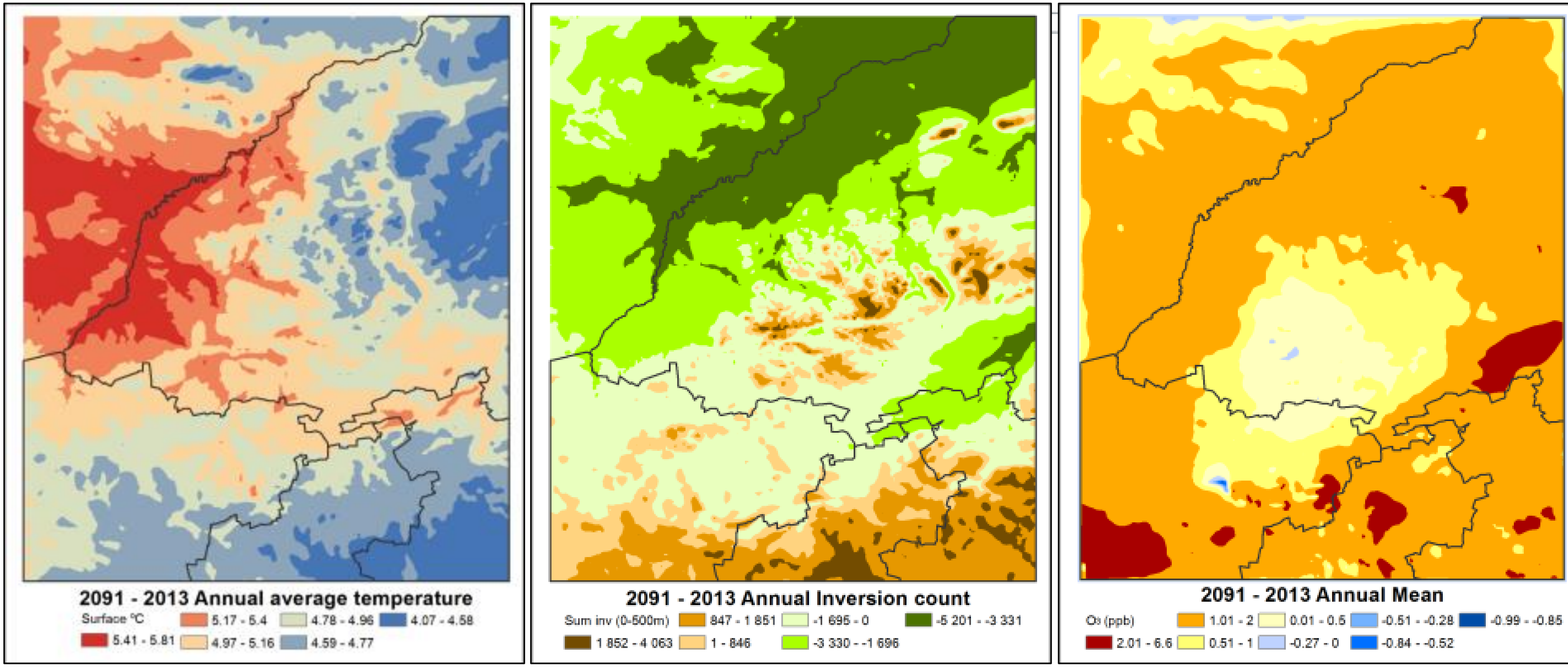
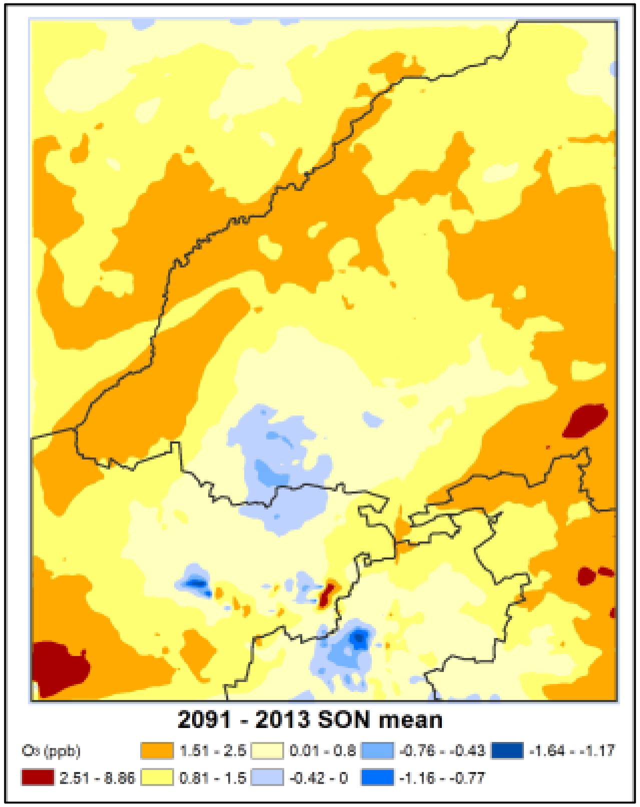
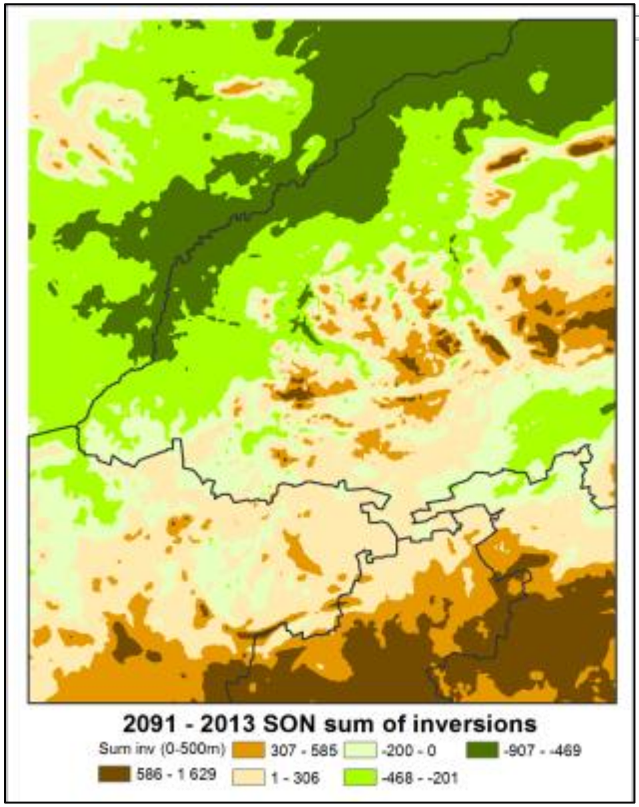
Results – Projected vs 2013 (Annual)

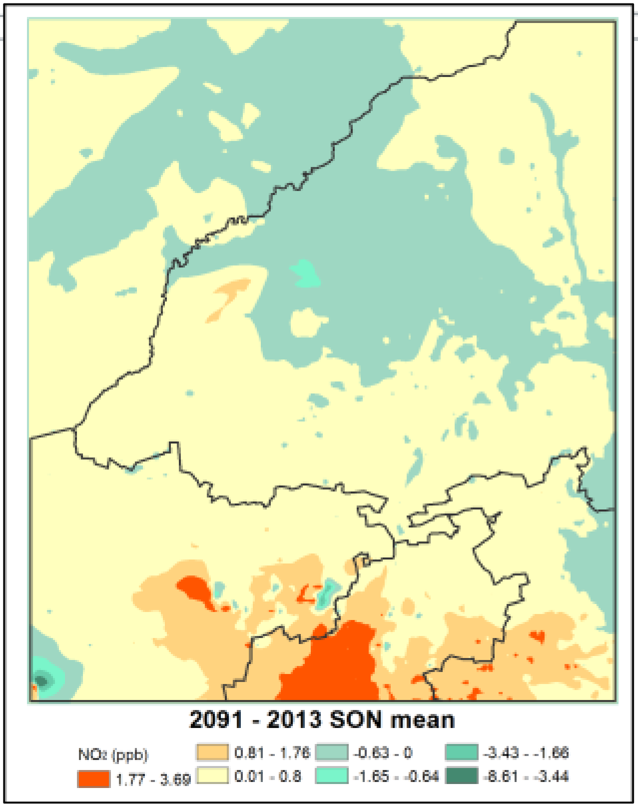


- General temperature increase; up to 5.8ºC are projected (RCP8.5).
- These areas show decrease in near surface inversions.
- However not for southern part of domain; this is due to projected increased frequency of high pressure currently common during Winter/Spring
- In terms of ozone there are generally increases. Up to 6.6ppb is possible. Some areas with low increase or decrease in inversions lead to increase in O_3
- Surface inversion → higher NO from surface sources → lead to titration

Results – Projected vs 2013 (SON)







- Pattern seen more clearly in peak o_3 season (SON)
- Increase in O_3 around areas of inversion decrease
- Decrease in O_3 around areas of inversion increase and surface NOx source
- NOx (showing NO_2) shows increase in areas of surface NOx sources and inversion increase

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