Feature
Ozone in southern Africa

Ozone is one of the most important pollutants in South Africa. During 2014, all of the monitoring sites in the Vaal Triangle and Highveld priority areas were out of compliance with the National Ambient Air Quality Standards for ozone in terms of the number of reported exceedances. In South Africa, the focus of concern relating to ambient ozone has largely been in relation to human health, however, it has long been known that high levels of ambient ozone have a large detrimental effect on agricultural productivity. Recently, a number of articles have been published regarding the impact of ozone on agriculture and two of these are highlighted below.

Research Brief

Reduction of India's crop yield due to ozone

A recent study by Ghude et al (2014), published in *Geophysical Research Letters*, utilized the WRF-Chem model to estimate the ozone concentrations to the district scale at a resolution of 0.5° over India. They used the MOZART-4 chemistry scheme linked to the Goddard Chemistry aerosol Radiation and Transport aerosol scheme to simulate the ozone production. The emission inventories applied included the INTEX-B inventory for CO, SO_2, non-methane hydrocarbons, PM_{10}, $PM_{2.5}$, BC and organic carbon. Fire emissions were obtained from the FINNv1 inventory from the National Centre for Atmospheric Research (NCAR) and biogenic emissions from the MEGAN (Model of Emissions of Gases and Aerosols from Nature) model. Due to the high variability in the NO_x emission inventories for the region, the O_3 concentrations were simulated utilizing 6 differing NO_x inventories as an ensemble average. The NO_x inventories utilized included INTEX-B, EDGARv4.1, REAS, MACCity, SAFAR-India and Top-Down NO_x.

From the simulated ozone concentrations from each of the crop production seasons that were assessed, the ozone induced crop loss was calculated utilizing the AOT40 exposure metric for wheat, soybean, cotton and rice. The estimated losses in crop production as a result of the impact of ozone amounted to 5.3% (±3.1%) for cotton, 2.7% (±1.9%) for soybean, 2.1% (±0.9%) of rice and 5.0% (±1.2%) for wheat. The economic value of the loss is expected to amount to 1.29 (±0.47) billion US$ per year. The loss of wheat and rice alone is estimated to be enough to feed 94 million poor people in India. The authors ended the paper by stating that there is little known about the combined impacts of air pollution and climate change on agricultural production and suggested further research.

Research Brief

Threat to future global food security from climate change and ozone air pollution

A recent paper published by Tai et al. (2014) in *Nature Climate Change* examined the impact of both ozone pollution and climate change on agricultural production and food security at a global level. In this study, the authors utilized the Community Earth System Model (CESM) to simulate present day (2000) and future (2050) hourly temperature and ozone concentrations under two representative concentration pathways (RCP) as in the IPCC AR5 report. For this study, the two RCPs were:

- RPC4.5 - this is an intermediate pathway where pollution control measures are implemented world-wide and there is a global reduction in surface ozone, and
- RCP8.5 - which is an energy intensive pathway with increases in surface ozone occurring world-wide except for the USA and Japan.

The simulated results were used to develop metrics for temperature and ozone impact on the production of wheat, rice, maize and soybean. The metrics used for the temperature impact include, Growing Degree Days (GDD) and Killing Degree Days (KDD) which represent the number of days with a temperature conducive for crop growth and the number of days with a temperature high enough to result in the death of crops. The metrics used to assess the impact of ozone included AOT40, SUM06, W126 and M7 or M12, which are metrics that are used to describe the physiological impact of ozone on crop growth.

In terms of the temperature, strong and spatially varying responses to GDD and KDD were observed for all of the crops. Since ozone concentration is highly correlated with the temperature and it is possible that damage to crops at high temperatures is a result of ozone rather than temperature, a correction was applied for the ozone-temperature co-variation. It was found that on average ozone accounted for 24% of the KDD effect of wheat, 44% for rice, 9.8% of maize and 46% of soybean.

Under the RCP8.5 scenario, greater surface ozone concentrations led to substantial crop losses reducing total global crop production by 3.6%, however, in the RCP4.5 scenario reductions in surface ozone concentrations resulted in substantial gains to crop productivity in many regions, with an overall increase in food production of 3.1% compared to the 2001 scenario.

In comparison to the impacts of ozone, the two scenarios show a similar temperature impact on agricultural production of an 11% decrease. It is shown that the control of ozone, as in the RCP4.5 scenario, has the potential to offset some of the damage to agricultural production caused by increased temperatures (total crop losses reduced from 11% to 9%), while under the higher ozone scenario, agricultural crop loss is compounded to a combined 15% loss.

These changes in crop production are expected to have an important impact on the rates of undernourishment around the world. The authors suggest that due to the public health co-benefits of ozone control, the regulation of ozone may prove to be a practical strategy to help secure food production. The authors highlight the need for greater collaboration between farmers, air quality managers and agricultural policymakers to achieve the coordinated goals of improved public health and food security.

References

Ghude, S.D. et al., 2014. Reductions in India's crop yeild due to ozone. Geophysical Research Letters, 41, pp.5685–5691.

Tai, A.P.K., Martin, M.V. & Heald, C.L., 2014. Threat to future global food security from climate change and ozone air pollution. Nature Climate Change, (July), pp.2–6.