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Quantification of the interactive effects of ozone pollution on health and ecosystems

For the first time, researchers have quantified the link between heat waves, the removal of ozone from the atmosphere by vegetation, ground-level ozone concentrations and its impact on human health and ecosystems. They found that high ozone levels, enhanced by effectively 'turning-off' the loss of ozone to the vegetated surface, could have caused around 460 extra deaths during a UK heat wave in 2006. In contrast, the heat wave protected ecosystems from ozone damage as plants absorbed less ozone from the atmosphere.

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This study is free to view at: www.atmos-chem-phys-discuss.net/12/27847/2012/acpd-12-27847-2012.html

Contact: l.emberson@york.ac.uk

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Elevated atmospheric concentrations of ozone have been associated with high death rates during heat waves, as the pollutant worsens respiratory and cardiovascular conditions. The concentration of ozone is influenced by its deposition from the atmosphere to the ground surface, which is controlled by the amount of ozone taken up by vegetation. This largely depends on the plants' stomata, which allow the exchange of gases between the atmosphere and the vegetated surface and accounts for 40-60% of ozone uptake by an ecosystem. However, drought can 'switch-off' the ozone sink by causing the stomata to close, which reduces water loss and prevents ozone uptake.

The results of this study demonstrate the importance of accounting for the deposition of ozone, driven by vegetation uptake, for modelling ozone concentrations and their effects on human health. As heat waves and drought are predicted to become more common under climate change, the results could help policymakers manage ozone precursor emissions more accurately to reduce the effects on human populations and ecosystem services.

To quantify the effects of vegetation sink strength on ozone levels during heat waves, the researchers used a model to simulate three scenarios for ozone deposition, using the conditions of a 2006 heat wave in the UK as a reference point: (1.) actual conditions of ozone deposition in 2006 (the 'reference' scenario) (2.) a 'no stress' scenario with conditions that assume a perfect vegetation sink for ozone deposition (stomata are open and taking ozone from the atmosphere); and (3.) a 'stress' scenario with conditions that reduce the vegetation sink to a minimum (where stomata are closed and ozone uptake is limited). They also estimated the number of additional premature deaths in two ways: firstly, using a threshold ozone concentration of 35 parts per billion (ppb) before harmful effects occurred, and secondly, without this threshold.

During the heat wave, average daily atmospheric ozone concentrations were 8 ppb higher for the 'stress' scenario, when plants were taking little ozone from the atmosphere, than in the 'no stress' scenario. This is compared to just a 2.5 ppb difference during the rest of the year.

This had a noticeable effect on the number of deaths that would be attributable to ozone. Without a threshold for harm, and compared to the 'reference' scenario, the 'no stress' scenario showed 410 fewer premature deaths due to ozone; the 'stress' scenario estimated an additional 95 premature deaths, with the greatest differences occurring in urban areas. Using the 35 ppb threshold, the number of deaths were roughly similar, as they were reduced by 370 for 'no stress' scenario and increased by 90 for the 'stress scenario'.

However, the heat wave and drought reduced the ozone risk to vegetation. The smallest risk of ozone damage occurred under the 'stress' and 'reference' scenarios, as hot dry conditions caused plants to close their stomata, reducing the flux of ozone through the stomata and limiting the damage it could cause. The findings highlighted the importance of including information on soil moisture levels when modelling ozone deposition, as this was a significant driver of the pattern of risk to both human health and ecosystems.