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Impacts of intercontinental ozone transport on Northern Hemisphere yields of six major crop types.

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Tropospheric ozone concentrations have increased steadily since pre-industrial times, driven by in-situ production from anthropogenic emissions of nitrogen oxides (NO_x) and organic compounds. Ozone in the troposphere is a global air pollution problem, and has harmful effects on human health and vegetation. Transport of ozone and its precursors between continents has been shown to contribute to surface ozone concentrations in many developed and developing regions of the northern hemisphere. Enhanced surface ozone concentrations are known to be harmful to vegetation and may significantly reduce crop growth and yields in many regions. We have used the TOMCAT global atmospheric chemistry model to quantify intercontinental contributions to crop ozone exposure and yield reduction in the Northern Hemisphere. We apply the use of 3 metrics (AOT40/M7/M12) to assess the impacts of NO_x emissions from each of the Northern Hemisphere's three major industrialised regions (North America, Europe and South East Asia) on global and regional exposure of 6 major agricultural crop types to harmful ozone concentrations, and the resultant yield losses during the 2005 growing season. The AOT40 metric relates vegetation damage to exceedence of a 40ppbv threshold concentration, while M7 & M12 (Mx) are based on mean surface ozone concentrations. Using the 3 metrics, model calculations show that for 4 of the major crops considered (wheat, rice, cotton and potato) 90% reductions in SE Asian anthropogenic NO_x emissions tend to produce the greatest reduction in crop yield losses (45.1% to 94.9%) on a global scale with the same cuts to N American emissions resulting in the greatest global impact on crop yield reductions for maize and soybean (55.9% to 85.5%). N American NO_x emissions tend to produce the largest transboundary impact, resulting in European yield loss reductions of between 32.9% and 41.1% with the AOT40 threshold metric and 9.3% to 17.8% with the mean ozone Mx metric, when a 90% cut is applied to NO_x emissions from the N American receptor region. European NO_x emissions tend to produce a greater local impact on crops rather than a transboundary impact, due to inefficiency of export of ozone and its precursors from the European domain. We find that due to the threshold nature of the AOT40 index, inferred non-local contributions to ozone-induced yield loss have a strong dependence on local ozone concentrations. Mx-derived non-local contributions also have a small dependence on local ozone concentrations, due to the non-linear dependence of yield loss on mean ozone. The results demonstrate that local air quality and emission control strategies over each of the regions have the potential to partly alleviate non-local ozone-induced yield loss, in addition to effectively mitigating local ozone-induced yield losses for six major crop types.