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Source: Varotsos, K.V., Giannakopoulos, C. and Tombrou. M. (2013) Assessment of the Impacts of Climate Change on European Ozone Levels. *Water, Air, & Soil Pollution.* 224:1596 Doi: 10.1007/s11270-013-1596-z.

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1. In addition, a simpler statistical model was developed to examine the potential impact of increasing future temperatures due to climate change on ozone exceedances (days with daily maximum 8 h average ≥ 60 ppb) for Europe. See: Varotsos, K. V., M. Tombrou, and C. Giannakopoulos (2013), Statistical estimations of the number of future ozone exceedances due to climate change in Europe, *Journal of Geophysical Research: Atmospheres*. 118, doi:10.1002/jgrd.50451.

European Commission

Science for Environment Policy

Ozone levels will vary across Europe under future climate change

Climate change affects air pollution at a regional and local scale. A recent study has reassessed the latest findings and suggests that climate change will increase ozone concentrations by about 3 parts per billion (ppb) in central and western Europe in the year 2050 if emissions from human activities remain at present-day levels. However, if emissions increase, ozone concentrations could increase by 16 ppb for much of Europe.

Ground-level ozone pollution is a serious problem that affects the health of people and plants. It is usually formed during hot summer months in the lower atmosphere (troposphere) by chemical reactions between the ozone precursors carbon monoxide, nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. NO_x and VOCs are emitted by human activities, such as burning fossil fuels and fertiliser use in agriculture. Some VOCs, such as isoprene, are also emitted from natural sources, including trees, other vegetation and wildfires.

Previous studies have shown that ozone formation is closely linked to temperature, and a warmer climate in the future could exacerbate the problem. Partly-funded by the European Union Social Fund, this study investigated the effects of climate change on ozone pollution in Europe.

The researchers modelled the complex interactions between the climate and atmospheric chemistry under four possible scenarios: 1.) present-day (year 2000) climate and emissions of ozone precursors from human activities and natural sources; 2.) present-day emissions and a future climate (year 2050); 3.) present-day climate and future emissions; and 4.) future climate and future emissions. Future climate conditions in 2050 were taken from the Intergovernmental Panel on Climate Change IPCC A1B scenario, which assumes a global average temperature rise of 2.8°C. Future emissions were calculated using projections from the IPCC A1B scenario[1].

Results suggest that ozone concentrations will increase by less than 3 ppb in central and western Europe under 2050's climate, assuming emissions stay the same as they were in 2000, i.e. the second scenario considered. These increases are mainly caused by higher isoprene emissions from vegetation, as a result of increased temperatures.

Under this same scenario, the model suggested that ozone levels will fall in the rest of Europe, with maximum concentrations of about 2.5 ppb in Italy and Greece as a result of increased water vapour over the sea and faster wind speeds. In northern Europe, less snow cover will increase the rate of dry deposition of ozone and, together with less radiation from the sun, is expected to reduce daily maximum ozone concentrations in 2050.

If emissions increase according to projections for 2050, ozone levels increase by around 16 ppb in continental Europe and the south-west and south-east Mediterranean in 2050 (i.e. under the fourth scenario considered). This increase is a result of higher isoprene and NO_x emissions with the added impact of rising temperatures under climate change, described as the 'climate penalty'. This suggests that stronger emission controls are needed to achieve air quality goals. Also in this scenario, ozone concentrations fall by up to 2 ppb in France, Switzerland and northern Italy owing to lower NO_x levels and higher isoprene emissions.

Furthermore, although increased NO_x emissions in 2050 raise ozone concentrations in south-east Europe, this increase is limited to about 2 ppb owing to more water vapour in the atmosphere and higher wind speeds. This study has extended the analysis of future ozone levels, not just from potential climate change impacts, but also by considering the influence of future emissions of ozone precursors from human and natural sources.