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Can we explain the trends in European ozone levels?

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In Europe emissions of ozone precursors (NOx, CO and non methane hydrocarbons) have been substantially reduced over the last 10 - 15 years. As a result surface ozone levels are changing. Reliable surface ozone measurements are available since the late 1980's at a number of sites. There are large inter-annual variations in ozone levels making it difficult to identify significant trends over the same period. However, both model and measurements agree that there has been an increase in winter surface ozone as a result of less titration by NO2, and that there has been a decrease in high ozone episodes. For ozone sites sampling background and/or free tropospheric air, measured ozone has in general increased significantly at all seasons. At Central European surface sites there are mixed or virtually no trend at all. The substantial trends observed at many European background sites are presently not adequately reproduced by global or regional photochemistry models, and the origin of this increase in European background ozone is unclear. Emissions of ozone ozone precursors are mainly increasing in East Asia. To reach Europe ozone of Asian origin must be lifted into and advected in the free troposphere. A careful analysis of ozone sonde measurements by several authors indicates no trend in free tropospheric ozone since the mid. 1980's. This conclusion is to some extent contradicted by measurements at mountain tops and by routine aircraft measurements, but unfortunately the timespan of these measurement series are to short (of the order of 10 years) to draw firm conclusions about ozone trends.

In order to explain the European trends in ozone since 1990 the EMEP regional photochemistry model has been run for the the years 1990 and 1995 - 2002. The EMEP model is a regional model centered over Europe but the model domain also includes most of the North Atlantic and the polar region. For ozone climatological data are used as initial and lateral boundary concentrations. Model results are compared to measurements over this timespan of 12 years. Possible causes for the measured trends

(or lack of trends) in European surface ozone have been investigated using model sensitivity runs perturbing emissions (including emissions from international shipping) and lateral boundary concentrations. For most seasons the measured changes in European surface ozone can only be reproduced by the model when applying a trend in the lateral boundary concentrations of ozone (based on measurements from the Atlantic sector) in the lower troposphere. As already noted above such an increase is not supported by ozone sonde measurements, but is to some extent supported by measurements at mountains and routine aircraft measurements. Thus it appears that the the effects of the substantial reductions in European ozone precursors is compensated by an increase in background ozone. Without such reductions present European ozone levels would most likely have been even higher.