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Understanding patterns of variability in tropospheric ozone over Europe and eastern Asia in 2005-2009 using TES observations and the TM5 chemistry transport model

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Tropospheric ozone is an important greenhouse gas and a global air pollutant. Because of its oxidizing power, it is harmful to the tissues of many living organisms. Ozone in the troposphere is produced by photo-chemical oxidation of precursors including volatile organic compounds (VOC's) and CO in the presence of NO_x. These precursors may originate from anthropogenic emissions, but may also be naturally produced by vegetation, animals, bacteria and fungi. Intrusions of stratospheric ozone into the higher troposphere also contribute to the ozone abundance in the troposphere.

The interpretation of tropospheric ozone observations remains a challenging task due to complex varying spatio-temporal emissions of ozone precursors with different lifetimes (from minutes to hours, days and weeks), stratospheric intrusion, and the effect of long-range transport of precursors and ozone driven by meteorological variables. In some areas the combination of favourable photochemical regimes and specific meteorological conditions may enhance the local tropospheric ozone productions.

Thanks to their extensive spatial coverage and frequent overpasses, spaceborne sensors are excellent tools to map spatio-temporal patterns of tropospheric ozone. However, evaluating trends in tropospheric ozone concentrations over Europe (e.g. Mediterranean maxima) and China requires the use of advanced chemical transport models (CTM) for understanding and attributing the different sources to the observations.

The objective of this study was to evaluate time series of tropospheric ozone observed from space by TES (Tropospheric Emission Spectrometer onboard NASA's EOS-Aura satellite) with the TM5 CTM using five years (2005-2009) of observations and simulations. From dedicated TM5 model runs, the spatio-temporal TES trends of tropospheric ozone are analysed aiming at understanding the different sources and mechanisms involved.

First comparison of tropospheric ozone concentration from TES v4 observations and TM5 runs at the global scale returned r values of 0.97 for the lower troposphere (LT, surface - 500 hPa) and 0.98 for the higher troposphere (UT, < 500 hPa). At the 464 hPa level, on average, the percentage difference in ozone concentrations between TES and TM5 is 15% which is in line with earlier reported comparisons between TES v2 and sonde data.

Generally, at the global scale, the TES-TM5 overestimations at the 468 hPa level were located at higher latitudes, whereas underestimations were observed at lower latitudes. In January the absolute differences in ozone concentration between TES and TM5 at the 464 hPa level are smaller compared to July. At the regional scale at 464 hPa, TES v4 time series (2005-2010) show an increasing trend of ozone concentrations in eastern Asia (NE China) in addition to reported increasing concentrations of NO_x with higher differences between TES and TM5 in July compared to January. For Europe, no clear-cut trends in time series of ozone concentrations were observed.

For better understanding the increases and/or decreases in tropospheric ozone in some parts of the world different TM5 model runs with varying anthropogenic emissions will be run in future research.