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Tropospheric ozone over Siberia in spring 2010: long-range transport of biomass burning and anthropogenic emissions, stratospheric intrusion and remote boundary layer influence

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Atmospheric pollution, including tropospheric ozone, has an adverse effect on humans and their environment. The Siberian air shed covers about 10% of Earth's land surface. Therefore, it can contribute significantly to the global tropospheric ozone budget due, in the region, to vast deposition losses on the boreal forest vegetation in the atmospheric surface layer on the one hand, and in-situ photochemical production from ozone precursors emitted by Siberian terrestrial ecosystems, and the influx of stratospheric ozone to the troposphere on the other hand. We have identified and characterized factors that influenced the tropospheric ozone budget over Siberia during spring 2010 by analyzing in-situ measurements of ozone, carbon dioxide, carbon monoxide, and methane mixing ratios collected by continuous analyzers during an intensive airborne measurement campaign of the YAK-AEROSIB Project, carried out between 15 and 18 April 2010. The observations, spanning over 3000 km and stretching from 800 to 6700 m above ground level, were analyzed using the Lagrangian model FLEXPART to simulate backward air mass transport. The analysis of trace gas variability and simulated origin of air masses origins showed that biomass burning and anthropogenic activity expectedly increased carbon monoxide and dioxide concentrations. Also, such plumes coming from east and west of West Siberian plain and from North-Eastern China were shown to increase ozone mixing ratio owing to photochemical processes taking place along the transport route. In the case of low ozone mixing ratios observed over a large area (800x200km) in the upper troposphere above 5500 m the air masses transported to the region under study were likely influenced by an Arctic ozone depletion event transported to lower latitudes and advected to the upper troposphere. The stratospheric source of ozone to the troposphere was observed directly in a well-defined stratospheric intrusion. Numerical simulations of this event suggest an input of 2.56 x 10^7 kg of ozone associated to a regional downward flux of 9.75 x 10^{10} molecules·cm^{-2}·s^{-1}.