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Surface ozone at the Caucasian site Kislovodsk High Mountain Station and the Swiss Alpine site Jungfraujoch: data analysis and trends (1990–2006)

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Abstract. Long-term ozone measurements of two background mountain sites, namely the Kislovodsk High Mountain Station in Caucasus, Russia (KHMS, 43.70° N, 42.70° E, 2070 m a.s.l.) and the Jungfraujoch in Switzerland (JFJ, 46.55° N, 7.98° E, 3580 m a.s.l.) are compared. Despite of more than 1.5 km altitude difference ozone mixing ratios are comparable at JFJ an KHMS in the beginning of measurements (1990–1993) while the annually averaged levels at JFJ are around 15 ppb higher than the ones at KHMS for the most recent years (1997–2006). The seasonal cycle of the surface ozone mixing ratios is characterized by a double spring-summer maximum at both sites with a spring one being more pronounced for the air masses with the longest contact with the upper free troposphere and stratosphere. Ozone mixing ratio increased at JFJ but decreased at KHMS for the period 1990–2006. Trends are more pronounced for the 1990s (+0.73±0.20 ppb/year at JFJ and −0.91±0.17 ppb/year at KHMS for the period 1991–2001) in comparison with the later years (+0.04±0.21 ppb/year at JFJ and −0.37±0.14 ppb/year at KHMS for the period 1997–2006). Trends show a distinct seasonality, which is different for the different periods. To investigate possible reasons for this remarkable trends difference 3-D trajectories using LAGRANTO trajectory model are used. Effects of horizontal and vertical transport on ozone trends are considered. No substantial systematic changes in the transport patterns were detected which could lead to strong changes in the trend magnitude between 1991–2001 and 1997–2006. The geographical position of the sites relative to the main topographic features and emission sources as well as distance from the coast are interpreted to be among the main reasons for the opposite surface ozone trends. During the 90s the JFJ trend reflects increase of the ozone in the upper free troposphere/lower stratosphere, while KHMS is not sensitive to this change or even showing the opposite tendency. The analysis provided evidence for a stronger influence of processes in the lower troposphere, in particular the dramatic emission decrease in the earlier 1990s in former USSR and emissions regulations in Western Europe on the surface ozone trend at KHMS.

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