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Meteorology and air pollution in an alpine Valley during two strikingly different winter periods

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During winter essentially, Alpine valleys are frequently prone to enhanced air pollution inducing serious impairments of human health and of sustainable development in these regions. This is mainly due to particular topographic and meteorological effects, which are investigated within this study. The focus of this contribution is based on comparison of consistent data collected during two winters with strikingly different characteristics. The measurements were performed in context of specific campaigns covering the full winter periods 2005/06 and 2007/08 and a cross section in the lower Inn valley (Austria). Notably, the concentrations of air pollutant species matters and the meteorological parameters were measured at the same places employing almost identical instrumentation during both periods.

Meteorological analysis is mainly based on data from routine synoptic stations and automatic weather stations located at different elevations in a cross section of the valley, which is supported by mixing-height data derived from SODAR and ceilometers operated at the valley bottom. Air pollution analysis consider NO, NO2 and PM10 and is based on data from routine monitoring stations, a passive sampler network and differential optical absorption spectrometer (DOAS) yielding quasi-continuous information about the small scale gradients of the nitrogen compounds. Partly these measurements are strongly influenced by a nearby motorway.

The analysis shows that both winter periods differed significant from the climatology. In 2005/06 there was a long-lasting snow cover and the meteorological regime was characterized by outstandingly low air temperatures (-1.5°C compared to the long-term average) in response to persistent high-pressure periods during the central winter months. Mixing processes were inhibited due to the inherent inversion conditions and low-lying mixing heights which both support high concentrations of the investigated air pollutants.

In contrast to the first winter, the temperatures during the investigation period 2007/08 were significantly above the long-term means (+1.8°C) and there were only few days with a snow deck. Measured air pollution was significantly lower than in 2005/06. Climatological analysis is supported by employing specific weather type classification schemes.

In depth analysis considers comparative investigation of the vertical temperature-gradients at both sides of the valley and their impact on the air quality. The indicated cross-valley asymmetries may be related to different snow cover and slope wind developments. Further analysis focuses on the developments of mixing layer height and their effect on air pollutant concentrations measured at the valley bottom. Finally some small scale effects in the vicinity of a motorway will be addressed in which context the emission scenarios during the two winters are considered as well.