Geophysical Research Abstracts, Vol. 7, 01256, 2005
SRef-ID: 1607-7962/gra/EGU05-A-01256

Precipitation and cloud coverage tendencies in the upper Danube catchment with respect to global warming

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Precipitation is a principal governing component of the water balance, but its space-time structure is too complex to be sufficiently monitored by the traditional surface network, especially in a region with complex topography, like the Upper Danube water catchment. Tendencies of precipitation have already been analysed by Mika and Bálint (2000) for the 1973-1998 period of monotonous warming in the Northern Hemisphere. The aim of the study is to extend these computations by five further years (1999-2003) for the same 76 stations, representing 6 countries of the region, and to validate the obtained patterns of precipitation tendencies by additional computations on parallel development of cloudiness, quantified in two different ways, circulation changes. First step of the study is to estimate regression of local precipitation to the hemispherical mean temperature, by using the method of instrumental variables for the extended 1974–2003 period. As the second step, the validation, parallel changes of cloudiness above the same area are analysed on a three times larger sample, i.e. 219 observing stations. Results derived by this kind cloud quantification are also tested including for the satellite based outgoing long-wave radiation (OLR) at the top of the atmosphere, considered as another indicator of cloud coverage. This feature of OLR is based on recent empirical investigations and former model studies (Rimóczi-Paal et al., 1998), as well. The obtained regression coefficients are further divided by 2, in order to estimate the changes of local precipitation and cloudiness assuming 0.5 K increasing of hemispherical mean temperature. The results show temporal and spatial differences, i.e. regions with both increasing and decreasing tendencies, as well. Precipitation changes mainly continue to increase in the Alpine region, and the gradual

decreasing remained valid to the east from this region, especially in the winter half-year. The Eastern Carpathians exhibit decreasing tendencies in both half-years. The order of magnitude of the precipitation changes is several tens of percents in the most sensitive regions. These tendencies are generally confirmed by the changes of independent cloudiness indicators, mostly in the warm period of the year. Visual cloudiness represents somewhat stronger changes than OLR, considered with reverse sign, of course. In the summer time cloudiness decreases almost in the whole investigated area, even in most of the Alpine regions. Slight differences between precipitation vs. cloudiness patterns indicate the emerging role of the precipitable water content in a vertical air column, which is generally increasing with the warming, independently from the cloud coverage tendencies. This latter condition of precipitation, in turn, is governed by macro- and mezo-scale circulation. Analysing sea-level pressure tendencies, we could establish, that the negative precipitation tendencies are in coincidence with the observed more anticyclonic feature of the pressure patterns, quantified from grid-point data of sea-level pressure. Summer patterns of the precipitation, however, are in less equivocal connection to the macro-scale patterns, which indicates high importance of macro-scale patterns, including independent tendencies of precipitable water and vertical stability.