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Trends in surface radiation and cloud radiative effect over Switzerland in the past 15 years

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We analyzed 15 years of high quality observations of surface down-welling short-wave and long-wave radiation from four Swiss sites. Results from two lowland stations show that the net cloud radiative effect has decreased due to a weakening of the short-wave and long-wave cloud radiative effect, respectively. These results are consistent with the observed positive trend in the all-sky short-wave radiation and the decrease in the all-sky long-wave radiation.

The radiation data used in this study were taken from pyranometer and pyrgeometer measurements of the Alpine Surface Radiation Budget (ASRB) and the Swiss Alpine Climate Radiation Monitoring network (SACRaM). The cloud radiative effect was derived from the observations and the corresponding cloud-free short-wave and long-wave calculations. The cloud-free short-wave irradiance was determined using radiative transfer calculations in dependency on the solar zenith angle, the aerosol load and the water content of the atmosphere. For the long-wave cloud radiative effect, a cloud-free model which parameterizes the cloud-free long-wave radiation as a function of humidity and screen-level temperature was used. Furthermore, the temperature lapse rate, which is a crucial parameter in determining the cloud-free long-wave radiation, was also considered in the model by inferring it from pyrgeometer measurements.

On the other hand, the analysis of the radiation data from the two mountainous sites yielded reverse trends with respect to those from the plane: The all-sky short-wave radiation has decreased, whereas the all-sky long-wave radiation increased. The net cloud radiative effect also tends to increase. However, we observe larger uncertainties in these calculations and hence, these trends are not conclusive. The larger uncertainties are caused by substantial discrepancies in the respective cloud-free models, particularly in the short-wave. We explain these larger uncertainties in the short-wave model by the highly reflective environment due to the snow cover. We propose to use observations of the snow depth as a proxy in order to correct these discrepancies. Furthermore, we will discuss and compare the results with trends calculated from other data sources, such as the cloudiness reported by human observers, sunshine duration data and data from the ERA-40 reanalysis project.