Trend analysis of cloud-free downwelling long-wave radiation from four Swiss Sites gives evidence of changes in the cirrus cloud cover over Switzerland

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Down-welling long-wave radiation (DLR) emitted by the Earth's atmosphere towards the surface is a key component in the surface energy budget and is directly related to the greenhouse effect: Simulations with General Circulation Models (GCMs) suggest that DLR will experience the largest changes of all of the Earth's radiation and energy balance components when the concentration of greenhouse gases in the atmosphere increases. Therefore, an accurate assessment and analysis of DLR fluxes is essential to detect, understand and predict changes in the energy fluxes and thus in the Earth's climate.
We analyzed 15 years of surface cloud-free down-welling long-wave radiation, surface temperature and humidity observations from four stations of the Alpine Surface Radiation Budget Network (ASRB) in Switzerland. The network covers an altitude range from 370 meters above sea level (masl) up to 3580 masl. The calculated trends reveal an upward tendency of air temperature and humidity associated with an increasing DLR at all four stations. However, these positive trends are not consistent throughout the year: In the winter months the trends tend to be rather negative, whereas in summer, they show an upward tendency. By comparing the measured DLR with calculated DLR data using a cloud-free model, we quantitatively determined the origins of the observed DLR changes: More than 50 % are temperature and humidity induced. Less than 10 % of the DLR trends can be explained by rising CO_2 concentrations. The remaining DLR variability of about 40 % is attributed to changes in thin cirrus clouds which are not directly detectable by the cloud algorithm used in the data selection process. Results obtained from stations located in the South of Switzerland give evidence of a decrease in cirrus clouds, whereas northern sites show an increase in the cirrus cloud cover.