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Observed relationship between surface specific humidity, integrated water vapor and longwave downward radiation at different altitudes

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Atmospheric water vapor and surface humidity strongly influence the radiation budget at the Earth's surface. Water vapor not only absorbs solar radiation in the atmosphere, but as the most important greenhouse gas it also largely absorbs terrestrial longwave radiation and reemits part of it back to the surface. Using surface observations, like longwave downward radiation (LDR), surface specific humidity (q) and GPS derived integrated water vapor (IWV), we investigated the relation between q and IWV and show how water vapor influences LDR. Radiation data from the Alpine Surface Radiation Budget (ASRB) network, surface absolute humidity from MeteoSwiss and GPS IWV from the STARTWAVE database are used in this analysis. Measurements were taken from four different sites at elevations between 388 and 3584 m a.s.l. and for the period 2001 to 2004.

On monthly means the analysis shows a strong linear relation between IWV and q for all-sky as well as for cloud-free situations. The slope of the IWV-q linear regression line decreases with increasing altitude of the station. This is explained by the faster decrease of IWV than of q with height - at lower elevations a constant change of q leads to a larger change of IWV than on higher elevations. Both, q and IWV are strongly related with LDR measured at the Earth's surface. LDR-q and LDR-IWV are best fitted with power functions, which show high correlation (r^2 between 0.95 and 0.97). The high LDR-IWV correlation allows estimating LDR from IWV measurements. At lower altitudes and hence higher humidity, the sensitivity of LDR to changes in q and IWV diminishes due to saturation of longwave absorption in the atmospheric window.