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Surface radiative forcings and effects on heat waves and greenhouse warming over the last decades in Europe

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Since 1980, surface temperature over land in Europe increased considerably faster than the northern hemisphere average. Detailed month-by-month analyses show large temperature and humidity changes for individual months that are similar for all Europe. These changes well correlate with Potsdam recorded weather patterns, which apparently influence temperature uniformly over large scales. However, superimposed to these changes a strong west-east gradient is observed for all months, which is not related to circulation but rather due to non-uniform water vapor feedback. Surface radiation measurements from the Alpine Surface Radiation Budget (ASRB) network in central Europe were used to investigate effects of radiative fluxes and forcings on changes of temperature and humidity. Clouds strongly modulate individual shortwave and longwave fluxes but show little net effects on the total surface absorbed radiative flux. Solar radiation rather decreases since 1980 except for the large but short increase during the summer 2003 heat wave. However, high correlation between cloud-free longwave downward radiation and increasing temperature and absolute humidity, demonstrates greenhouse forcing with strong water vapor feedback. Overall our analysis indicates that heat waves are driven by strong but short-term shortwave forcing, whereas the rapid warming in Europe over the last two decades is primarily related to longwave greenhouse forcing and a strong water vapor feedback.