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Study on thermal heterogeneity of vineyard canopy in complex terrain: measurements and modeling

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Heat exchanges between terrestrial vegetation and the overlying atmosphere are by nature heterogeneous at all spatial scales due to the effect of canopy architecture on radiative and convective processes both within canopy and above it, particularly for partially covered surface under arid or semi-arid climate conditions. The study site is a vineyard canopy enclosed by irrigated corn fields, matured onion field, grass and bare soil with different soil and canopy water conditions. The thermal heterogeneity of the vineyard itself is significant because of the contrast between sunlit and shaded canopy elements (i.e. soil and foliage). Moreover, its interaction with the overlying atmosphere is influenced by land surface conditions in the upwind fetch, which changes with wind direction In the vineyard, temperature difference between sunlit soil and sunlit leaves can be as large as 15 degrees and between sunlit and shaded leaves about 10 degrees. Such contrast in canopy component temperatures led to strong angular dependence of the observed canopy brightness temperature as shown by thermal camera measurements in the field and by thermal radiance measurements by the airborne sensor Airborne Hyperspectral System (AHS). Such thermal heterogeneity makes difficult to apply single-source heat transfer models to estimate heat and water fluxes from the canopy. Limitation of single-source models under such canopy conditions are investigated in terms of excess resistance, a parameter usually used to adapt single-source models to the thermal heterogeneity of a canopy. A model based on the dual-source concept, which describes heat exchange by taking into account the interactions between soil and foliage, is employed to estimate heat and water fluxes from the vine-

yard canopy. Thermal infrared observations collected by the airborne sensor AHS and by the satellite sensor ASTER were used to estimate sensible and latent heat fluxes over the entire experimental site, i.e. including other land cover types besides the vineyard, using a single source model. The heat transfer excess resistance, however, was parameterized more accurately for the vineyard by forcing the single-source model to reproduce the heat flux density calculated with the dual-source model. For the remaining land cover types the excess resistance was estimated on the basis of literature. The estimated fluxes show significant spatial variations especially in the pixels close to the boundaries between different patches. The significant impact is from the corn field located in the upstream of prevailing wind of the vineyard and irrigation was given on a few days schedule which led to the corn field being much wetter on the days of the experiment.. The results are evaluated by using sensible heat flux measurements by different techniques, e.g. Large Aperture Scintillometer (LAS), eddy correlation systems mounted at different heights and different locations in the vineyard field to represent different footprints of measured fluxes. The effect of varying foot-print in relation with the difference in the parameterization of excess resistance between vineyard and its surrounding was evaluated.

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