agropolis fondation

Land surface – atmosphere exchanges within hilly watersheds

Understanding surface-atmosphere exchanges at the scale of an agricultural watershed on a hilly Tunisian landscape: the influence of upward and downward flows on energy and mass transfers

ABSTRACT

Knowledge of evapotranspiration is crucial within Mediterranean agricultural regions under water shortage conditions. One the one hand, evapotranspiration corresponds to the two-thirds of the hydrological budget. On the other hand, evapotranspiration is related to crop water consumption. Agricultural activities have increased within Mediterranean hilly watersheds which structures allow water harvesting for resource management. Nevertheless, estimating evapotranspiration over such hilly areas has been poorly investigated, because of complexities induced by topography, and especially the coupling between reliefs and airflows.

The current project aims to increase our knowledge of evapotranspiration within hilly watersheds devoted to agricultural activities. A first part consists of promoting original results about the influence of upward and downward flows on both the measurements and the magnitude of land surface energy fluxes. A second part consists of deepening these original results in terms of measuring and modeling. This second part relies on conducting a new experiment that additionally involves state variables such as soil moisture and surface temperature, in order to 1/ confirm the influence of upward and downward flows on flux magnitude when considering different relief and land use conditions, and 2/ include the influence of upward and downward flows into the parameterization of turbulent exchange coefficients. The investigations are conducted within the OMERE ORE Tunisian study area, through an ongoing partnership between the Laboratory for Studies of Interactions between Soil - Agrosystem - Hydrosystem (LISAH) in Montpellier and the Tunisian National Institute for Environmental Engineering Research (INRGREF) in Tunis.

Among the original results to be promoted, the first one is related to the influence of upward and downward flows on eddy covariance (EC) measurements. For the upward flows (respectively downward flows), the airflow inclination, as captured with EC measurements, tends to roll away from (respectively come closer to) the topographical slope, as captured with digital elevation model, when the vegetation grows. This induces the necessity to adjust the planar fit based rotational correction of EC measurements, by differentiating between upward and downward flows and between intervals of vegetation height. It is observed that the adjusted planar fit correction allows the improvement of the energy balance closure in most cases. In all cases, the energy balance closure is similar for bare soil and vegetation conditions, similar for upward and downward flows, and similar to that reported in the literature for flat and mountainous conditions. This suggests that EC measurements collected under conditions of hilly topography can be used for monitoring land surface energy fluxes. The second original result to be promoted is related to the influence of upward and downward flows on the magnitude of land surface energy fluxes. It is observed that the latter are larger for downward flows, as compared to upward flows, by up to 50% relative for evapotranspiration. A potential explanation is proposed in the second part of the project, reported hereafter.

The data set collected with the new experiment permits to confirm the original results abovementioned, for different crops and different relief conditions. With the inclusion of additional measurements for state variable such as surface temperature, it is also possible to investigate the parameterization of turbulent exchange coefficients. By inverting momentum flux, it is shown that roughness length for momentum observed for upward flows is similar to that observed over flat conditions, and that it is larger by 30 to 50% for downward flows, according to vegetation height. A possible explanation is the dilatation of streamlines for downward flows, whereas upward flows follow the topographical slope, similarly to flat conditions. By inverting sensible heat flux, it is shown that roughness length for heat follows the same trend than roughness length for momentum. Finally, the new experiment confirms that convective flux

magnitude is larger for downward flows, as compared to upward flows, which is ascribed to changes in roughness lengths.

Keywords : Agroecosystem, Production system, Method/tool/technic, Model, Mediterrannea

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PERSPECTIVES

Further investigations for such hilly conditions, as supported by the MISTRALS / SICMED and IRD / ARTS programs, address the deepening of turbulent exchange coefficients parameterization, including the design of stability functions, and the revision of the FAO-56 evapotranspiration formulation, including both the Penman Monteith relationship and the crop coefficient calculation.