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Combining water and energy balance modeling approaches to improve the reliability of evapotranspiration estimates

G. Somma

National Research Council of Italy - Water Research Institute (CNR-IRSA), Rome, Italy, (g.somma@irsa.rm.cnr.it / Fax: +39-06-8417861)

It is commonly recognized that the analysis of soil hydrological processes by means numerical algorithms has important implications for water resources management at various scales. However, when the domain of application covers large areas - e.g. at regional scale - the use of soil water flow models is seriously limited by the amount of input data required as well as by difficult results' validation.

Thanks to the extensive growth of Earth Observation (EO) systems, the application of water balance models has benefited of Remote Sensing (RS) techniques both in the input phase - by deriving spatially distributed information on land surface attributes - as well as in the validation phase - by means of estimates of moisture exchanges in the Soil-Plant-Atmosphere continuum.

This presentation describes the results obtained using RS data to complete the input data set for the one-dimensional soil-water-flow model SWAP (van Dam and Feddes, 2000), based on Richard's equation, and applied in a distributed way. Observations in the visible and near-infrared (VIS/NIR) ranges have been used to determine input vegetation parameters such as Leaf Area Index, surface albedo and canopy height. Successively, these parameters together with RS data in the thermal infrared (TIR) range have been employed in the Surface Energy Balance System, SEBS (Su, 2002), to estimate actual evapotranspiration rates on the basis of heat and vapor exchange processes between the soil, the vegetation and the atmosphere.

At field scale, compared to Bowen ratio measurements, although SEBS systematically misestimates the latent heat flux, evapotranspiration estimates have been found very

dependable. Compared to both the field measurements and SWAP, SEBS overestimates the evapotranspiration rates by 10% approximately. At district scale, the application of SEBS in combination with Landsat-5 TM data revealed a significant increase of error (up to 30%), mainly due to the high uncertainty introduced by atmospheric correction procedures. These findings hint that most reliable results can be obtained by employing satellite sensors of new generation (e.g. ASTER or MODIS) capable to better sample the spectral, directional, spatial, and temporal dimensions of radiometric magnitudes. However, although some model routines have been refined to better account for actual vegetation cover, the uncertainties related to the parameterization of the “similarity theory” still call for some improvements.

The synergistic use of water and energy modeling approaches in combination with remotely sensed satellite data will certainly improve the description of hydrological processes and support the adoption of data assimilation schemes. Enhancing the reliability of simulation results will therefore allow more reliable estimates of water requirements and detection of stress conditions at various scales, from irrigation district to the regional scale.

Su Z., 2002. The surface energy balance system SEBS for estimation of turbulent heat fluxes. Hydrol. Earth System Sci., 6 (1), 85-99.

van Dam J.C., and Feddes R.A., 2000. Numerical simulation of infiltration, evaporation and shallow groundwater levels with the Richards equation. J. Hydrol., 233, 72-85.