The Water Budget for Mesquite-Dominated Watersheds and Use of Remote Sensed Estimates of Soil Moisture in KINEROS

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ARS Global Change Research Program: See description of Research Areas, Program Elements, Objectives and Tasks in Appendix A.

Research Areas:	I	
Program Elements:	A	
Objectives:	1	3
Tasks:	3, 4	1

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Problem

There is general agreement that mean global temperature will increase with continued trends in emission of greenhouse gases, but little consensus exists on the impacts of global change on regional patterns of precipitation and water availability. Many areas and agricultural practices may be able to tolerate small increases in temperature but may not be able to cope with relatively small changes in rainfall and water availability. To better understand and predict regional and local impacts of global change, the critical issue of scaling of hydrologic, atmospheric and biospheric processes must be addressed. This constitutes one of the most critical scientific gaps in understanding and interpreting global change. The need to address scale issues in hydrology requires improvement and development of new hydrologic model components and validation strategies that apply to both the point and basin scale approaches. In addition, methods to identify the dominant hydrologic processes as a function of watershed scale are required to focus limited data collection and modeling resources on those processes controlling water fluxes.

Approach

Task 1.3: Numerous studies have evaluated the water budget of forest and scrub woodlands, but relatively few have evaluated the water budget for mesquite dominated watersheds. A study was initiated to quantify the components of the water budget for mesquite-dominated clusters, native grassland, and bare soil utilizing 9 non-weighing lysimeters, and to evaluate the ERHYM-II model for predicting ET and surface runoff. In addition, the commonly used assumption of spatially uniform rainfall for runoff modeling at the ha scale was tested using data collected from 50 non-recording raingages and 5 recording raingages.

Task 1.4: Soil moisture is a key factor controlling runoff generation. Spatially variable ground estimates and remotely sensed estimates of soil moisture were used to define pre-storm initial soil moisture for the calibrated and validated KINEROS model in 0.04 and 6.3 km^2 catchments. The importance of spatially variable representations of soil moisture and rainfall on runoff generation was assessed. In another study we will investigate the orographic effect on atmospheric processes by analyzing meteorological data collected in the Huachuca Mountains of the San Pedro Basin.

Task 3.1: To effectively utilize hydrologic models for addressing scale or resource management issues, confidence must be established in the hydrologic process representation within the model. A study was carried out to examine validation methods for a research model (KINEROS) and a management model (the watershed version of WEPP) and how these methodologies vary with modeling objectives.

Findings

Task 1.3: Annual evapotranspiration rates of shrub clusters and grass interspaces were found to be similar, and both significantly greater than evaporative losses from bare soil. Results of these studies indicate that the simulated water budget was within two percent of the measured evapotranspiration for the shrub and grasslands. Based on our analysis, the ERHYM-II model has the potential for simulating annual water balance for semiarid rangeland plant communities where runoff and deep drainage are limited components of the water balance. From a small-scale rainfall variability study it was found that the uniform rainfall (single raingage) assumption is invalid in Walnut Gulch and this variability imparts significant uncertainty in runoff modeling. This has important implications as many models are tested on small ARS experimental watersheds with a single raingage. Thus model runoff uncertainty may be mistakenly attributed to model parameters or model structure when it is in fact due to input rainfall variability.

Task 1.4: Analysis of two Walnut Gulch sub-watersheds showed that representation of the spatial variability of soil moisture was secondary to proper representation of rainfall variability indicating a strong dominance of rainfall over soil moisture in the control of runoff generation. Therefore, in the semi-arid Walnut Gulch environment, soil moisture estimates obtained from the ground or remotely sensed measurement methods could be used to obtain reasonable runoff predictions but adequate resources must be devoted to proper definition of spatial rainfall variability. At the larger scale (6.3 km^2) it was found that a single spatial average of initial remotely sensed soil moisture was adequate for runoff modeling. This has important implications as passive microwave sensors for soil moisture suffer from low spatial resolution. The findings indicate that this will not be a problem for estimating pre-storm initial soil moisture for runoff modeling in this environment. Initial analysis of daily precipitation totals from 4 sites in the Huachucas and 8 National Weather Service sites scattered throughout the San Pedro Basin indicates that the orographic effect is indeed prominent. An approximate annual precipitation gradient of

4 cm per 100 m is found in the mountain stations; however, this amount is highly variable due to both the particular placement of the gage and the erratic spatial variability of storm depth totals.

Task 3.1: Results of this study indicate that model validation should be performed in a multi-stage fashion when the model is complex in terms of geometric or hydrologic sub-process representation. Systematic and careful analysis of interim calibration and validation results must be carried out to avoid the modeling bane of hidden but compensating errors. This is particularly true when models are being constructed from subcomponents which may synergistically affect the final output.

Future Plans

Task 1.3: a) Using rainfall-runoff data from the Walnut Gulch watershed and its nested subwatersheds, three simple measures will be computed to objectively measure the effects of individual process attenuation over a range of Walnut Gulch basin scales; b) Runoff data from the Walnut Gulch Watershed will be summarized and analyzed by month, by season, and by year to determine the optimum basin size for runoff production in a semi-arid environment; c) Runoff data with model results will be used to determine whether runoff response becomes more linear, and thus easier to model as basin scale increases, or more non-linear; d) Cooperative research with ARS scientists in Boise, ID and Beltsville, MD is directed at improving modeling of energy and water fluxes of sparsely vegetated rangeland ecosystems.

Task 1.4: The spatial location of ground cover as a function of plant community has been assembled from 50 plant communities across the western United States to define the distribution of hydraulic roughness coefficient as a function of amount, type, and distribution of litter on rangelands. For the orographic analysis, larger set of data with finer temporal resolution data will be analyzed for diurnal and seasonal trends across elevation.

Task 3.1: To advance to larger basin scales for runoff modeling, routing algorithms for complex channels with different roughness and infiltration values in main and overbank channels will be undertaken and tested using carefully selected Walnut Gulch runoff data.

Publications

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