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Soil Moisture Initialization Input Scale Effect on Parameter Value Identification of a Physically Based Distributed Hydrologic Modelling

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Abstract

Data acquisition and an efficient processing method for hydrological model initialization, such as soil moisture, and parameter value identification are critical for a physics based distributed watershed modelling of flood and flood related disasters such as sediment and debris flow. Site measurements can provide relatively accurate estimates of soil moisture, but such techniques are limited due to the need for a variety of measurement accessories, which are difficult to obtain to cover a large area sufficiently. Available satellite-based digital soil moisture data is at 9 kilometers to 50 kilometers in resolution which completely filters the soil moisture details at the hill slope scale. Moreover, available satellite-based digital soil moisture data represents only a few centimeters of the top soil column that informs nothing about the effective root-zone wetness. A recently developed soil moisture estimation method called SERVES (Soil moisture Estimation of Root zone through Vegetation index-based Evapotranspiration fraction and Soil properties) overcomes this limitation of satellite-based soil moisture data by estimating distributed root zone soil moisture at 30 meter resolution. In this study, a distributed watershed hydrological model of a sub-catchment of Reynolds Creek Experimental Watershed was developed with GSSHA (Gridded Surface Sub-surface Hydrological Analysis) Model. SERVES soil moisture estimated at 30 meter resolution was deployed in the watershed hydrological parameter value calibration and identification process. The 30 meter resolution SERVES soil moisture data was resampled to 4500 meter and 9000 meter resolutions and was separately employed in the calibrated hydrological model to determine the effect soil moisture resolution has on the simulated outputs and the model parameters. It was found that the simulated discharge significantly decreased as the initial soil moisture resolution was coarsened. To compensate for this underestimated simulated discharge, the soil hydraulic conductivity value decreased logarithmically with respect to the decreased resolutions. This study will reduce parameter value identification uncertainty especially in flood and soil erosion modelling at multi scale watershed in a changing climate. processes.

SERVES, Soil-moisture Estimation of Root-zone through Vegetation-index based Evapotranspiration-fraction and Soil-properties (Pradhan, 2019).

$$\theta_i = (1.33NDVI - 0.049)(\theta_{fci} - \theta_{wpi}) + \theta_{wpi}$$

θ = soil moisture content

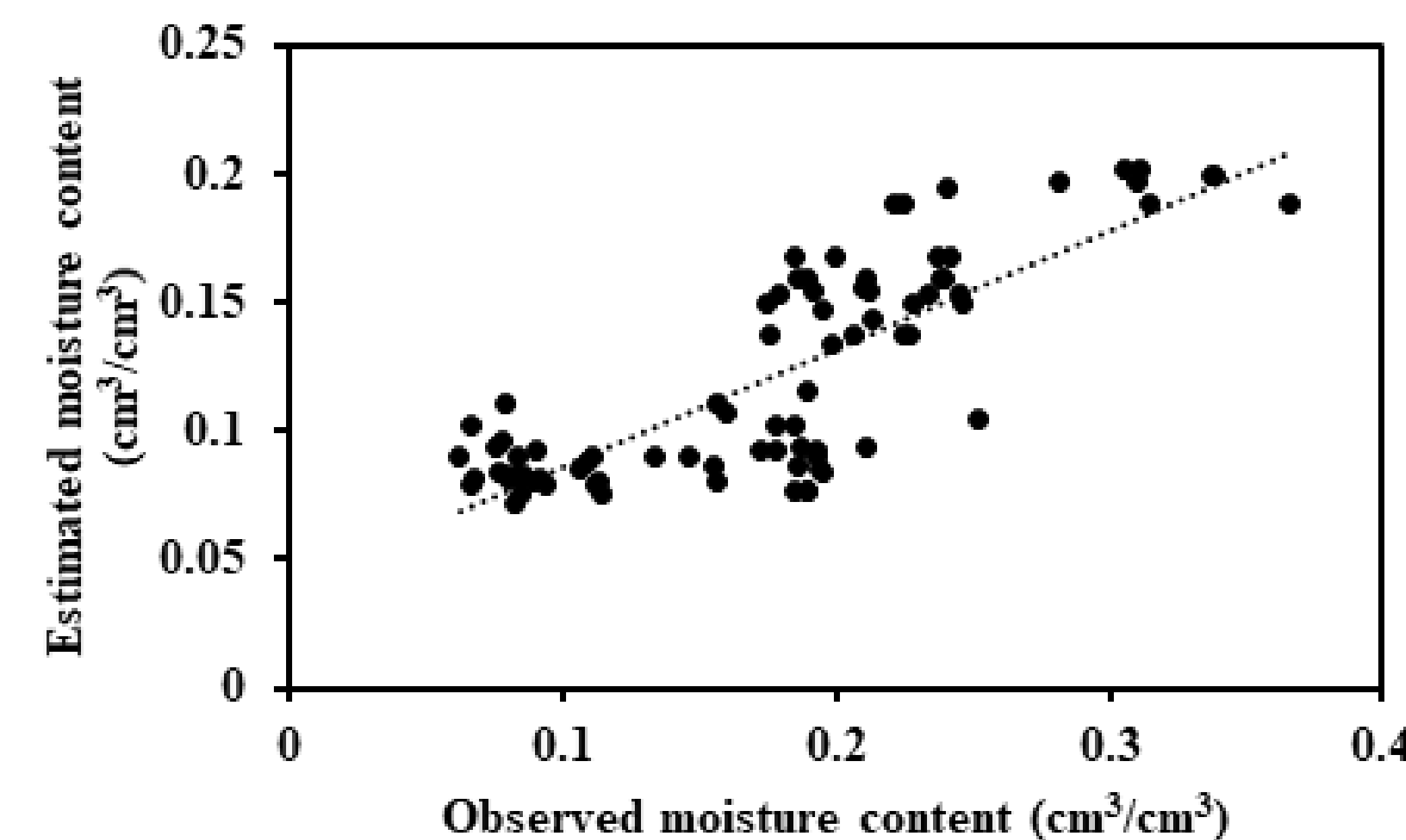
θ_{fc} = field capacity soil moisture content and

θ_{wp} = wilting point soil moisture content

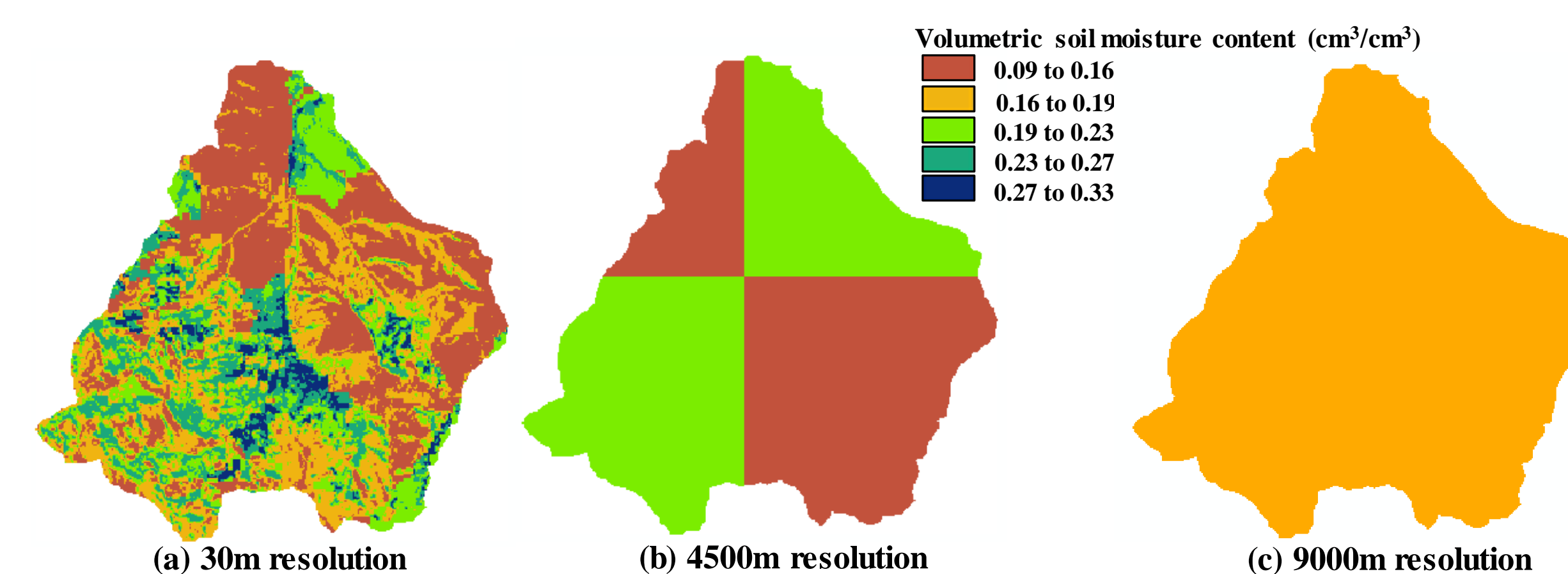
i = any spatial location or grid/tin address for a numerical model.

ET_{rf} = evapotranspiration fraction

NDVI = Normalized Difference Vegetation Index



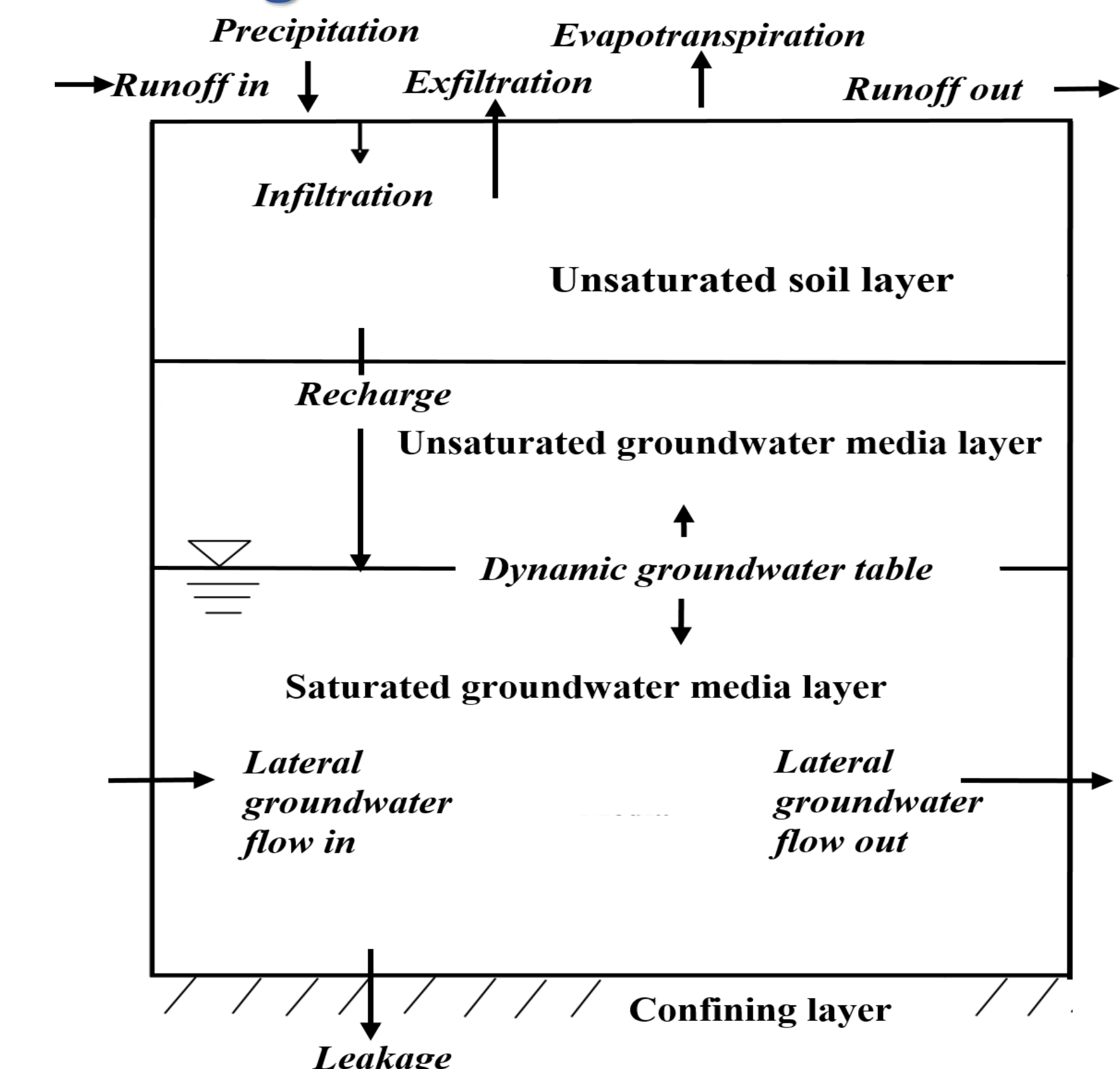
Resolution effect on the initial soil moisture



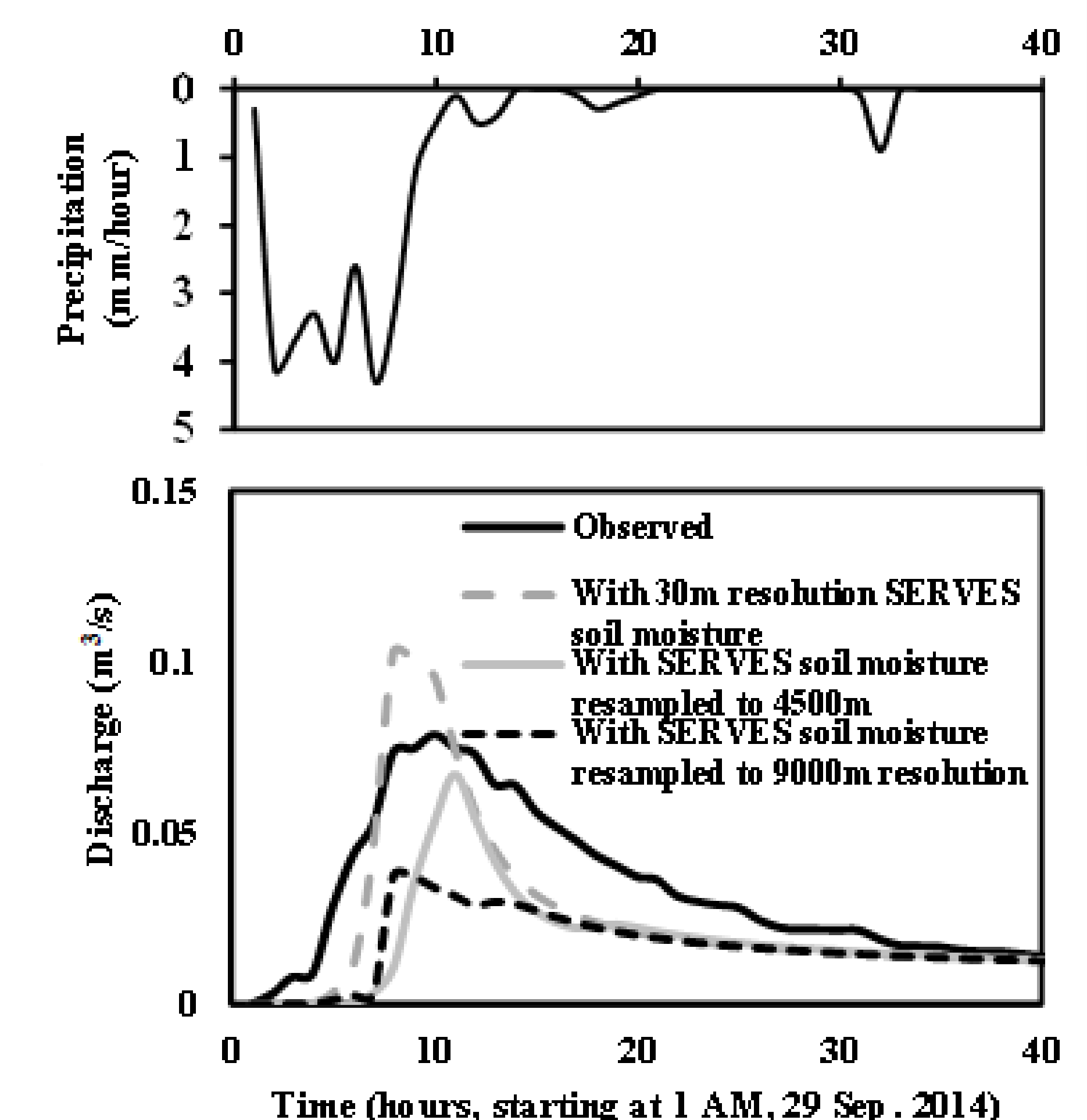
Conclusion

Changing the input resolution of the initial soil moisture condition to coarser grid scale would produce significantly underestimated discharge and inconsistent moisture distribution state when simulated with hydrological model parameters calibrated / identified at finer resolution initial soil moisture resolution.

Linking surface water and ground water through soil moisture model



Simulated discharges at different initial soil moisture input resolution



References

Pradhan, N. 2019, Estimating growing-season root zone soil moisture from vegetation index-based evapotranspiration fraction and soil properties in the Northwest Mountain region, USA, Hydrological Sciences Journal 64 (7), 771-788, <https://doi.org/10.1080/02626667.2019.1593417>