Root Water Uptake Modeling

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Understanding the basic concepts of root water and nutrient uptake mechanisms is becoming increasingly more relevant; to better predict responses of sensitive ecosystems to global climatic change and to better manage agricultural resources under constraints of water limitations and environmental concerns. In part, the historical neglect of consideration of water and nutrient uptake processes below ground has led to a knowledge gap of plant responses to nutrient and water limitations, and limited understanding of the soil-root-plant-atmosphere continuum of water uptake and its control by root-soil or plant leaf-atmosphere interfaces. Consequently, root water and nutrient uptake in soil hydrological models are mostly described in empirical ways, often lacking a sound biophysical basis. This has been a major limitation towards understanding the consequences of limited water and/or nutrient resources, as is largely the case for water-limited ecosystems in arid and semi-arid climates and in modern irrigated agriculture. A thorough understanding of plant-soil interactions and the plant's regulatory functions in managing soil environmental stresses is needed to predict their responses to limited water and nutrient resources.

The current need to better understand plant health in water-limited ecosystems justifies the increasing need for combining soil knowledge with plant expertise, in particular as related to root development and functioning. We will present a numerical modeling approach that simulates the soil-root-plant-atmosphere continuum, using the HYDRUS model. In this approach, we approximate both the soil and plant conducting tissues by a porous medium, each with conductive and capacitive properties that are a function of water potential. The Jarvis model will be used to quantify plant transpiration. The model will be tested using data collected for a single white fir tree (CZO-TREE 1) at the Kings River Experimental Watershed, as part of the Critical Zone Observatory (CZO) project in the Southern Sierra mountains in California. Data include soil water content and water potential in 3 spatial dimensions in the root zone, tree stem water content and sap flux, canopy water potential, and atmospheric variables such as net radiation, air temperature and humidity.