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How can we model soil moisture for multiple sectors?

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Soil Moisture sits at the heart of many environmental issues, yet remains to a large extent unknown. Five basic questions related to the functioning of the land are depending on the soil moisture:
1. How much moisture is in the root zone of the overlying vegetation?
2. What is the vertical gradient of the soil moisture?
3. How quickly does the near-surface soil moisture change in response to different drivers?
4. How much precipitation runs off into the rivers either a base flow or surface water?
5. What depth is the water table?
These five questions affect aspects of the land that might be considered by completely different disciplines: plant physiology and phenology, agricultural productivity, bio-geo-chemistry of soils, land-atmosphere interactions, floods, droughts and water resources. They also relate to different scales of problem: from field-scale to landscape and from hourly to annual.
Perhaps it is not surprising that each of these disciplines would develop a different model of soil moisture given such a disparate set of issues that need to be resolved, and given the difficulty of observing the actual soil moisture below the surface.
But there is an increasing need to integrate hydrological, bio-geo-chemical, land-atmosphere, geological and agricultural models. The pressing multi-sectoral stresses of food-energy-water nexus in a changing climate demand that we create tools that can be used to find solutions that span all the issues.
Therefore, a new generation of models is required which incorporates the collective understanding of the different disciplines. This will incorporate physical representation of the soil matrix (the Darcy-Richards equations) linked to other ways that the water interacts with the land (infiltration, runoff generation, macro-pores, groundwater etc). In addition, new analysis of observations covering a range of space and time scales is also required to constrain the model. This will include multi-decadal analysis of vegetation, seasonality of vegetation phenology, time-series analysis of near-surface and root-zone soil moisture (through observations of water content as well as temperature and evaporation) at hourly to annual time scale, river flow records and water-table depth data.
By bringing such a wide-range of approaches in one analysis, we can test and develop the modelling framework that will deliver the multi-sector tool needed. This presentation will show how this can be achieved.