Response of deep percolation in the vadose zone to climate variability

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A vadose zone monitoring network was instrumented in 2000-2002 beneath rangeland and agricultural settings across the High Plains regional aquifer with the objectives of measuring water and chemical fluxes, chemical storage and transit times through the thick (15 to 50 m) vadose zone. Generally, observations from individual monitoring stations reveal large nitrate reservoirs from natural and anthropogenic sources and long chemical transit times, suggesting the vadose zone will be a spatially extensive and long-term source of contaminants to the groundwater. During the past year, the total annual precipitation in the southern High Plains subregion was approximately twice the 20-year average and was partially coincident with natural climate variability, particularly the North American Monsoon System (NAMS), as identified from spectral analysis of hydrologic time-series data. This monsoon-driven precipitation increase resulted in a previously unobserved infiltration and deep (>7m) percolation event in the southern High Plains subregion, recorded using real-time monitoring of matric potential measured from a series of heat dissipation sensors installed vertically within the vadose zone. Adjacent subsurface moisture profiles obtained using a neutron moisture meter indicated a substantial increase in volumetric water content and further evidence of the deep percolation. The significance of the event is further illustrated using "before and after" chemical profiles from continuous core that reveal a downward mobilization of chloride and nitrate reservoirs beneath the rangeland setting. Water and chemical profiles and corresponding hydrologic time series are presented as evidence that episodic, deep-wetting events in semiarid and arid ecosystems results in nitrate leaching from the soil pool to the subsoil reservoir, producing characteristic conservative solute-accumulation profiles. Our findings show the importance of long-term monitoring of the vadose zone to characterize transient responses to natural climate variability and understand the effects of changes in climate and land use on chemical transport and aquifer recharge. Identifying events that produce infrequent, yet substantial mobilization of subsurface chemical reservoirs has important implications for groundwater quality and resource sustainability.

DE: 1831 Groundwater quality