Effect of surface layer on evaporation from porous media

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ABSTRACT
Evaporation is a process of mass and heat transfer between the atmosphere and the subsurface, and it is critical to many natural and industrial applications. The principles of controlling evaporation have been widely used in agriculture (mulch layer to reduce evaporation), the properties of surface layer have a significant effect on the evaporation process. The goal of this work is to investigate the impact of the properties of surface layer on evaporation. A coupled model which consists of liquid water, water vapor and heat transport was developed. Four cases (coarse sand on the surface and sandy loam on the surface with different thickness) were studied, with two homogeneous configurations as controls. The water content distribution and evaporation rates were presented and analyzed.

RESULTS:
The results demonstrated the significant role of the surface layer. The properties and the thickness of the surface layer affect the evaporation behavior. The coarse sand on the surface reduced the evaporation and helped conserve water. While the fine layer on the surface layer induced longer stage 1 evaporation so as to increase evaporation. In addition, the results suggested that the air invades into the coarse layer first no matter the coarse layer is on the surface or not. It should be noted that further experimental work needs to be done to support and strengthen our results.

1. AIMS AND SCOPE
- Develop and implement a coupled numerical model accounting for liquid water, water vapor and heat transport.
- Study impact of the surface layer properties on thickness on the evaporation process.
- Investigate the water content distribution in the layered porous media.

2. APPROACH
Simulation approach
- Simulation domain: Column diameter:0.13m Height:0.5m
- Initial conditions:
  - Liquid water: \( \rho_{L}(t,x)=\rho_{L}(t,x_0) \)
  - Gas Phase: \( P_{L}(t,x)=0 \)
  - Water vapor: \( \rho_{v}(t,x)=0 \)
- Temperature: \( T_D(x)=293K \)
- Boundary conditions:
  - Liquid water: \( \rho_{L}(t,x_0)=\Delta \rho \) (impermeable)
  - Water vapor: \( \rho_{v}(x_0,t)=\rho_{v}(x_0,t_0) \)
- Temperature: \( T_D(x)=293K \)
- (Experimental work needs to be done further)

3. NUMERICAL MODEL FORMULATION

4. SIMULATION SETTING

5. SIMULATION RESULTS

6. CONCLUSIONS
- The properties and thickness of the surface layer have a significant effect on the water content distribution and evaporation behavior.
- The coarse layer on the surface causes evaporation suppression because it cuts the hydraulic connections of the lower soil.
- The evaporation of fine-coarse configuration has a longer stage 1 evaporation and higher cumulative evaporation.
- Evaporation occurs at the coarse layer first because of its lower air entry value.
- Additional experimental work needs to be done.

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REFERENCES