Investigating Airflow Effect on Evaporation by using a Two-phase Heat and Mass Transfer Model (STEMMUS)

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Why Two-Phase Model?

What is the Key issue in the Model?

"PdV Theory"
(Philip and de Vries, 1957)

\[ q_{vap} = -D_{atm} \nu \alpha \theta_{v} \nabla \rho_{v} \]

Vapor Enhancement Factor

\[ \eta = \left[ \theta_{v} + f(\alpha) \right] \frac{1}{\alpha \theta_{v}} \]

\[ f(\alpha) = \begin{cases} 
\frac{1}{\alpha \theta_{l}}, & \theta_{l} \leq \theta_{t} \leq \theta_{s} \\
\frac{\theta_{t} \theta_{s}}{\theta_{l} - \theta_{s}}, & \theta_{l} > \theta_{s} \\
\frac{1}{\alpha \theta_{l}}, & \theta_{l} < \theta_{s} 
\end{cases} \]


Pore scale mechanisms for enhanced vapor transport through partially saturated porous media

Ehsanil Bahrami and Oré

Figure 1. Vapor flux across liquid island, vapor condensation on the (A) "hot" side of the liquid island and evaporation on the (B) "cold" side, the curvature of the meniscus decreases at A and increases at B, causing capillary transport of the liquid from A to B. The phase change affects the thermodynamic state of both vapor and liquid phases and thus the temperature gradient, the resulting liquid flux through the liquid island and the total flux adjuncs itself to maintain similar vapor pressures in the alternate air filled paths with pores diffusive flux.
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What is the two-phase model STEMMUS?

Simultaneous Transfer of Energy, Momentum and Mass in Unsaturated Soil

Validation of STEMMUS: Ponding Water Exp.

Validation of STEMMUS: Soil Moisture and Heat Flow Exp.
Validation and Calibration of STEMMUS: In-situ Exp.


Advective Effect:

CONCLUSIONS

- In the desert area, after rainfall event, the airflow is important in understanding the evaporation process;

- The advective effect on evaporation is reflected by the underestimation error induced by neglecting airflow;

- The developed two-phase heat and mass transfer model, STEMMUS, is an appropriate tool to investigate this effect;

- The advective effect is not due to the advective flux directly, but the isothermal liquid flow;
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