What controls a land surface model's behavior?

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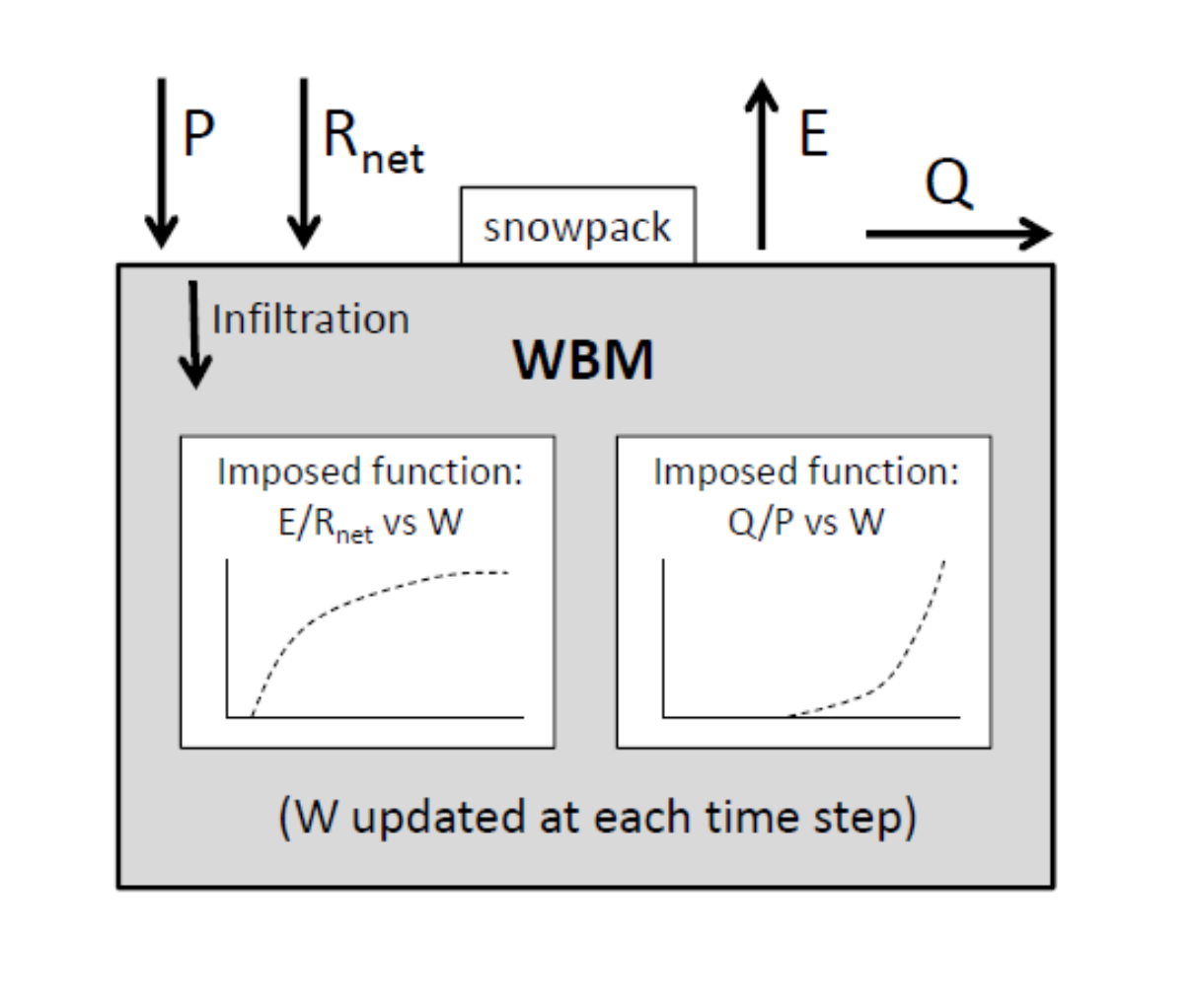
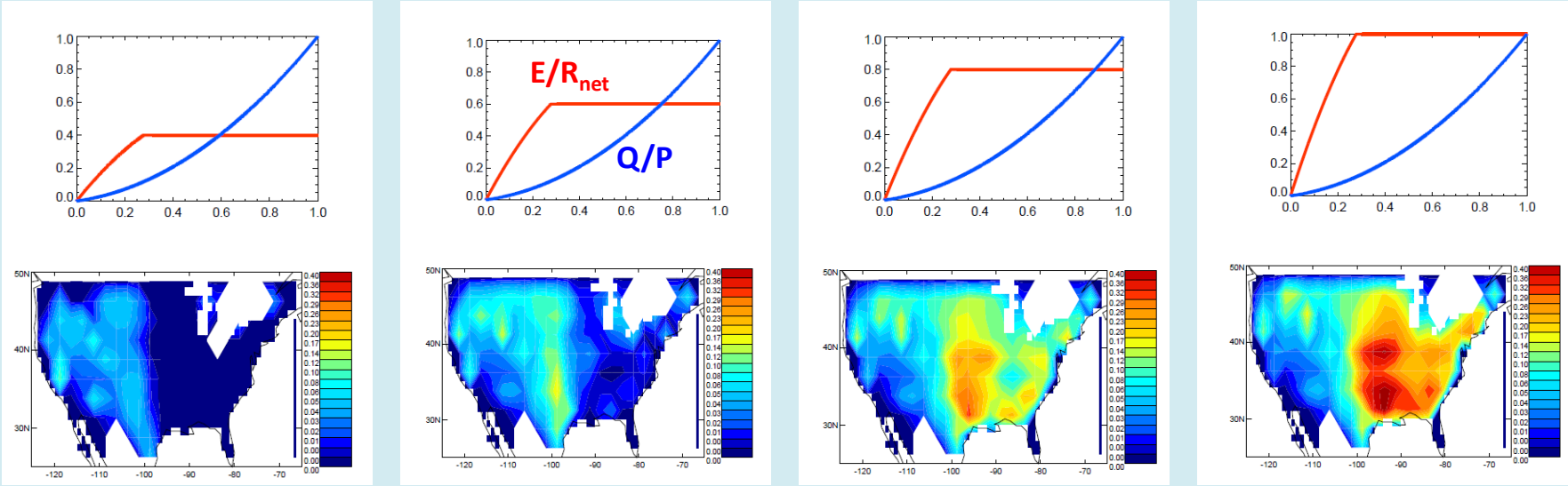


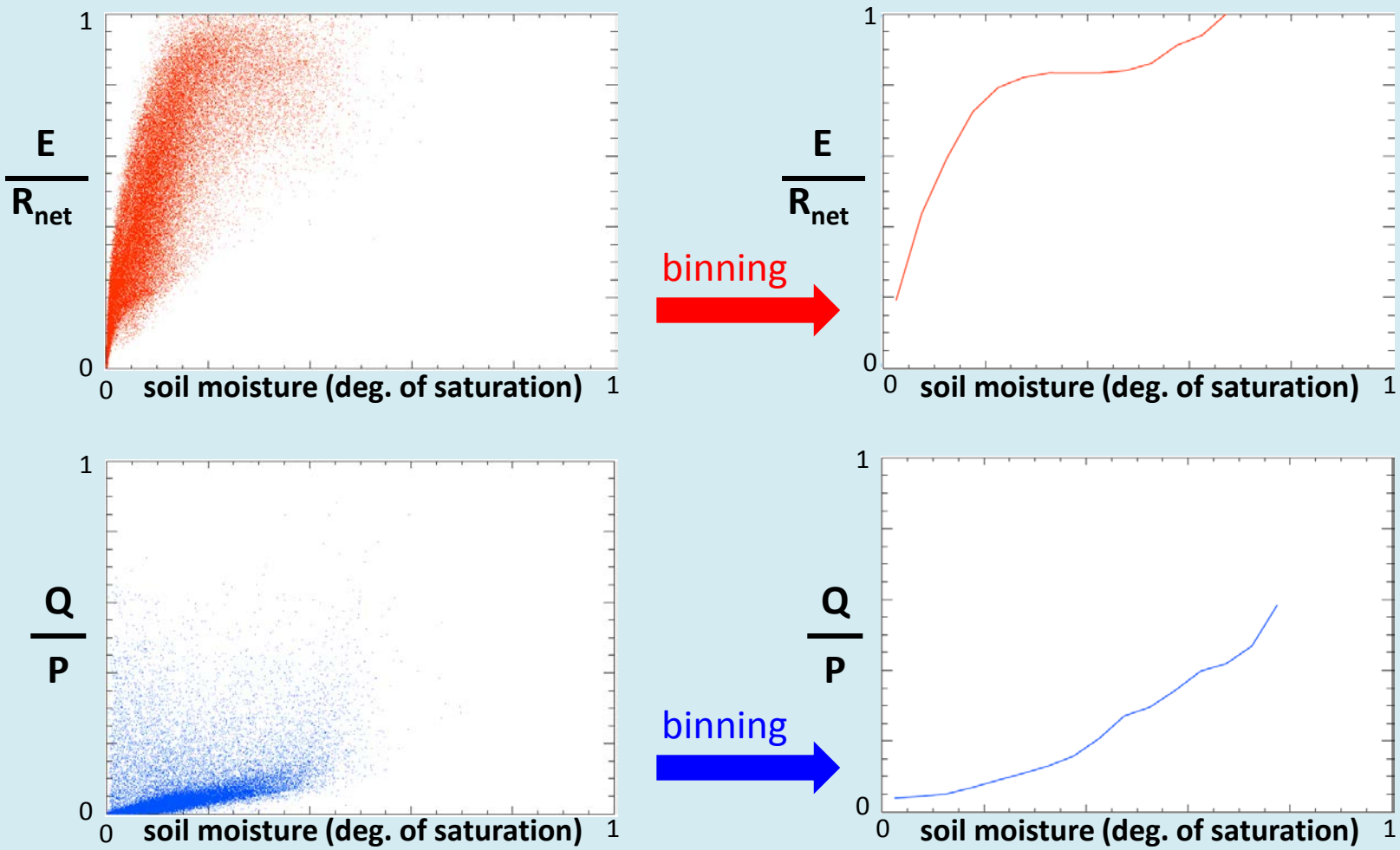
Force a simple water balance model daily with observed distributions of precipitation and net radiation; it produces daily values of evaporation, runoff, and updated soil moisture.

Sensitivity of $\sigma^2_E{}^*$ distribution to evaporation and runoff functions: Simple model experiments. (Example #1)



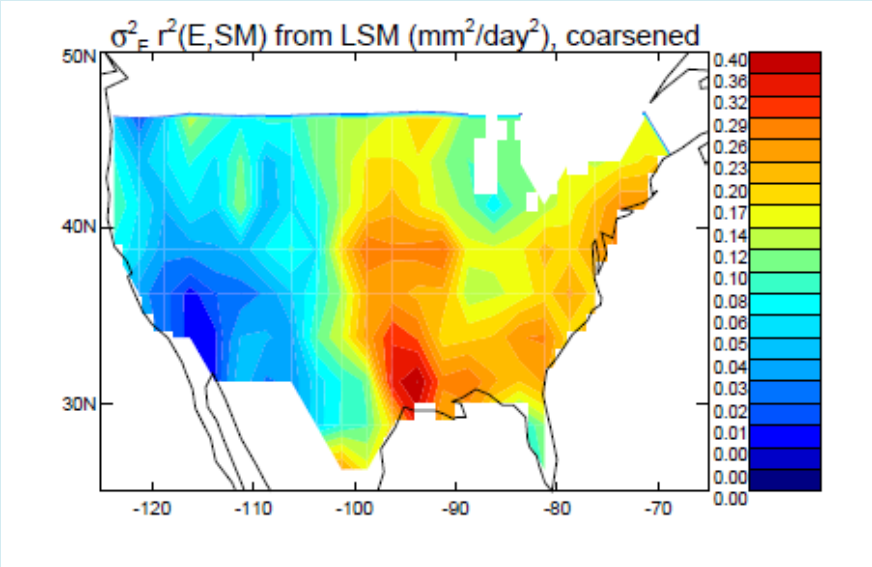
For a given runoff function, increasing the maximum value of the evaporation function shifts the evaporation variance hotspot toward the east and increases its magnitude.

Why is the simple water balance model relevant? Because the evaporation and runoff formulations of a given full LSM can be characterized, to first order, as simple functions of soil moisture content…



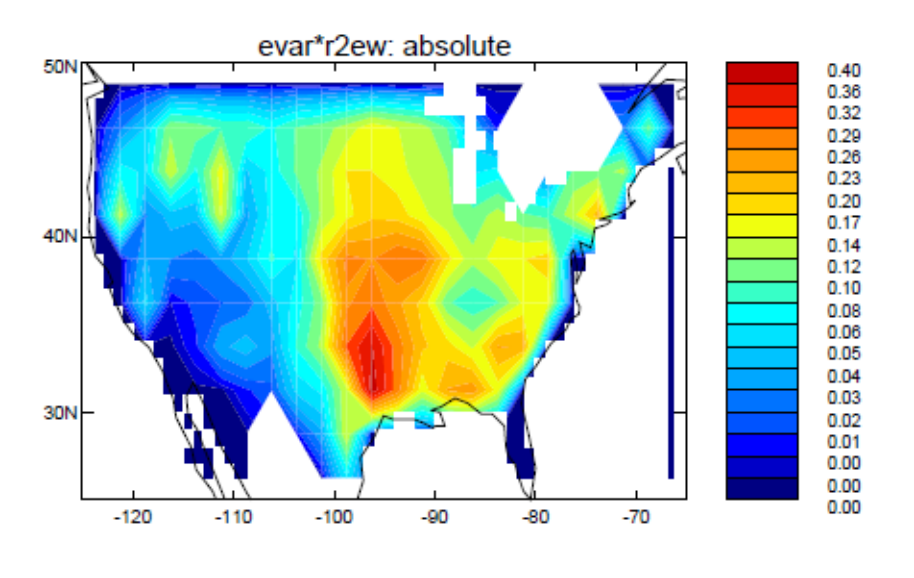
…and to first order, the simple model reproduces, with these fitted functions, what the full land surface model generates.

$\sigma^2_E{}^*$ from full LSM

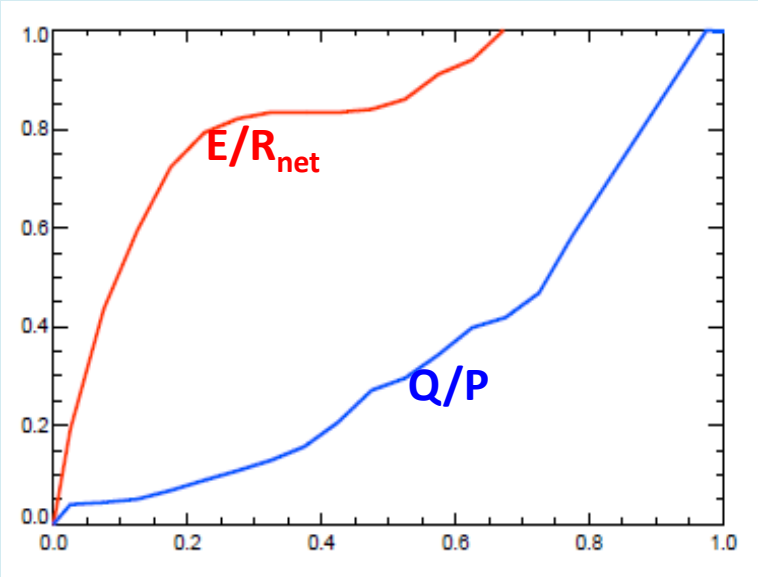


i.e., $\sigma^2_E{}^*$ based on full LSM physics

$\sigma^2_E{}^*$ from simple model



i.e., $\sigma^2_E{}^*$ reflecting simple fitted evaporation and runoff functions:



soil moisture (deg. of saturation)

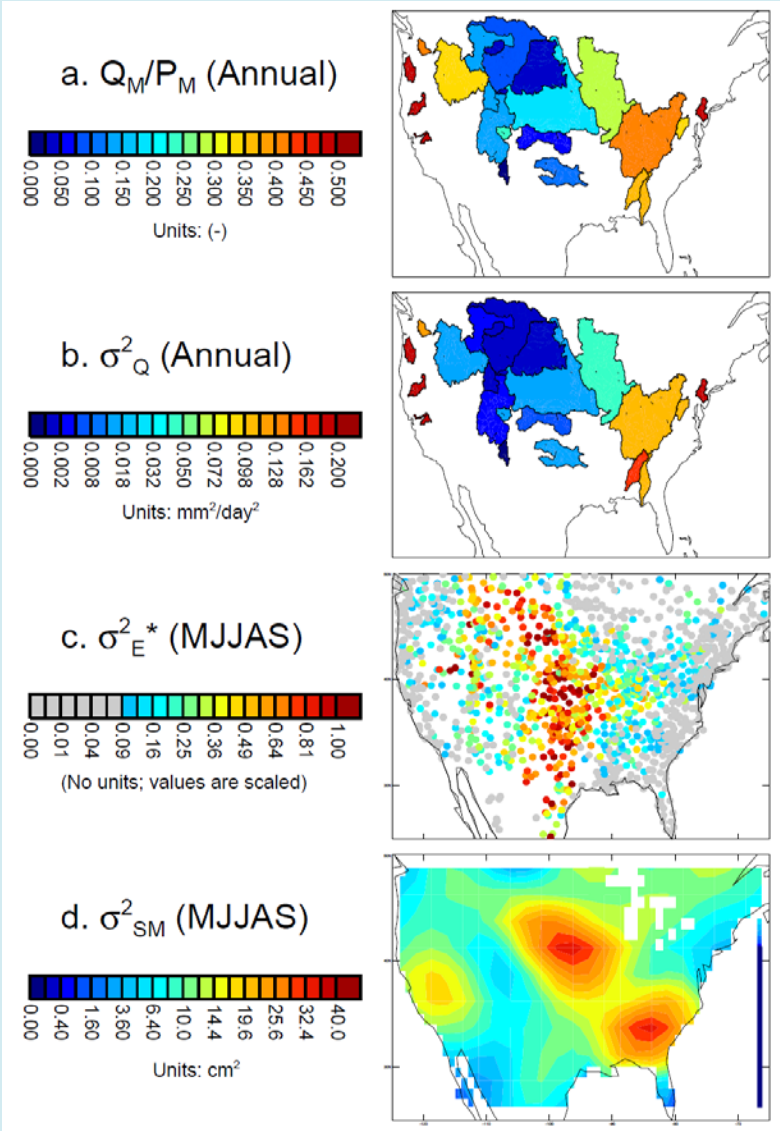
Main lesson: the relative positions of the two effective relationships determine, to first order, the LSM's simulation of hydrological means and variability. Analyses of these two relationships is *key* to understanding an LSM's behavior.

Strategy for analysis:

1. Run the (inexpensive) simple water balance model with a comprehensive set of evaporation and runoff function pairs.

2. Determine the pair(s) that allow the simple water balance model to best mimic observed hydrological means and variability.

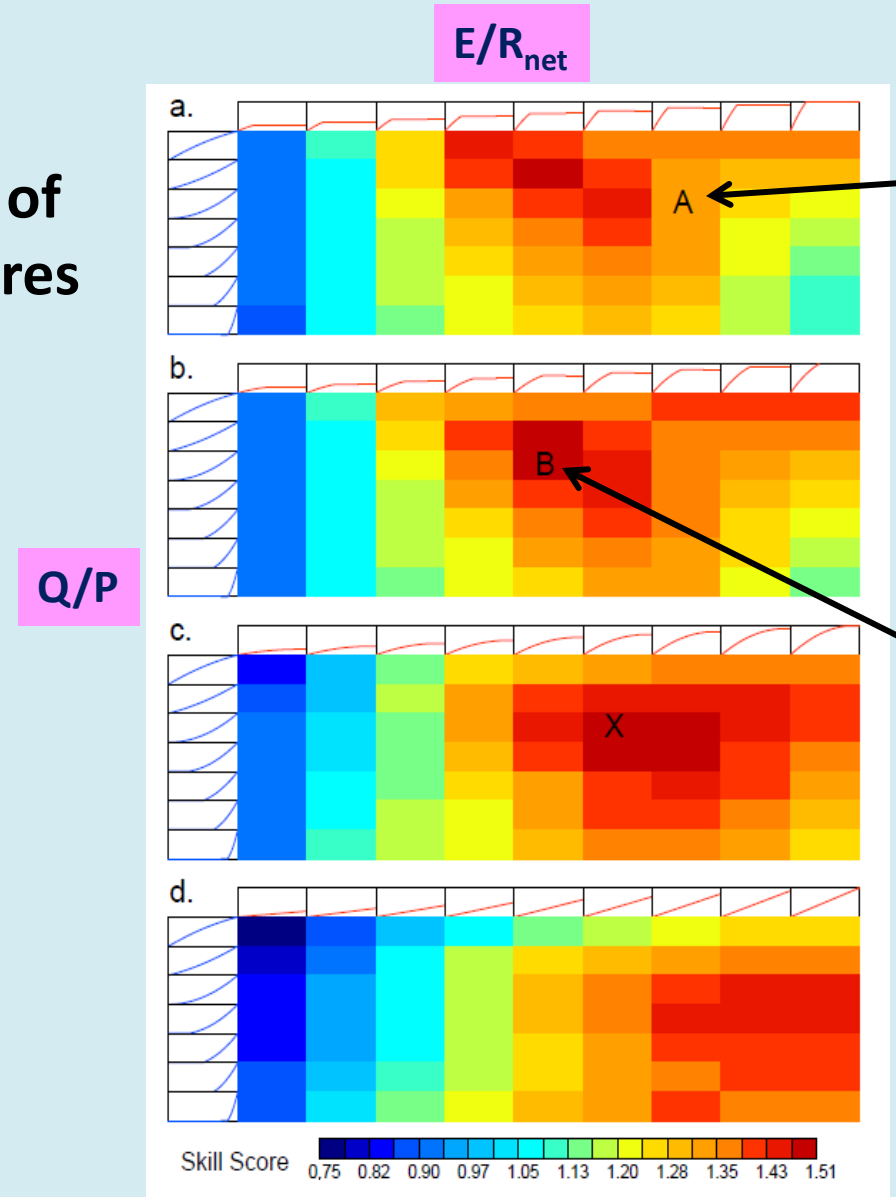
3. Use those optimized pairs to guide the improvement of a full land surface model's evaporation and runoff formulations.



Continental-scale observations of hydrological means and variability exist for evaluating simulated values.

Ability of simple model to reproduce observed hydrological means and variability can be quantified for different combinations of E/R_{net} and Q/P functions.

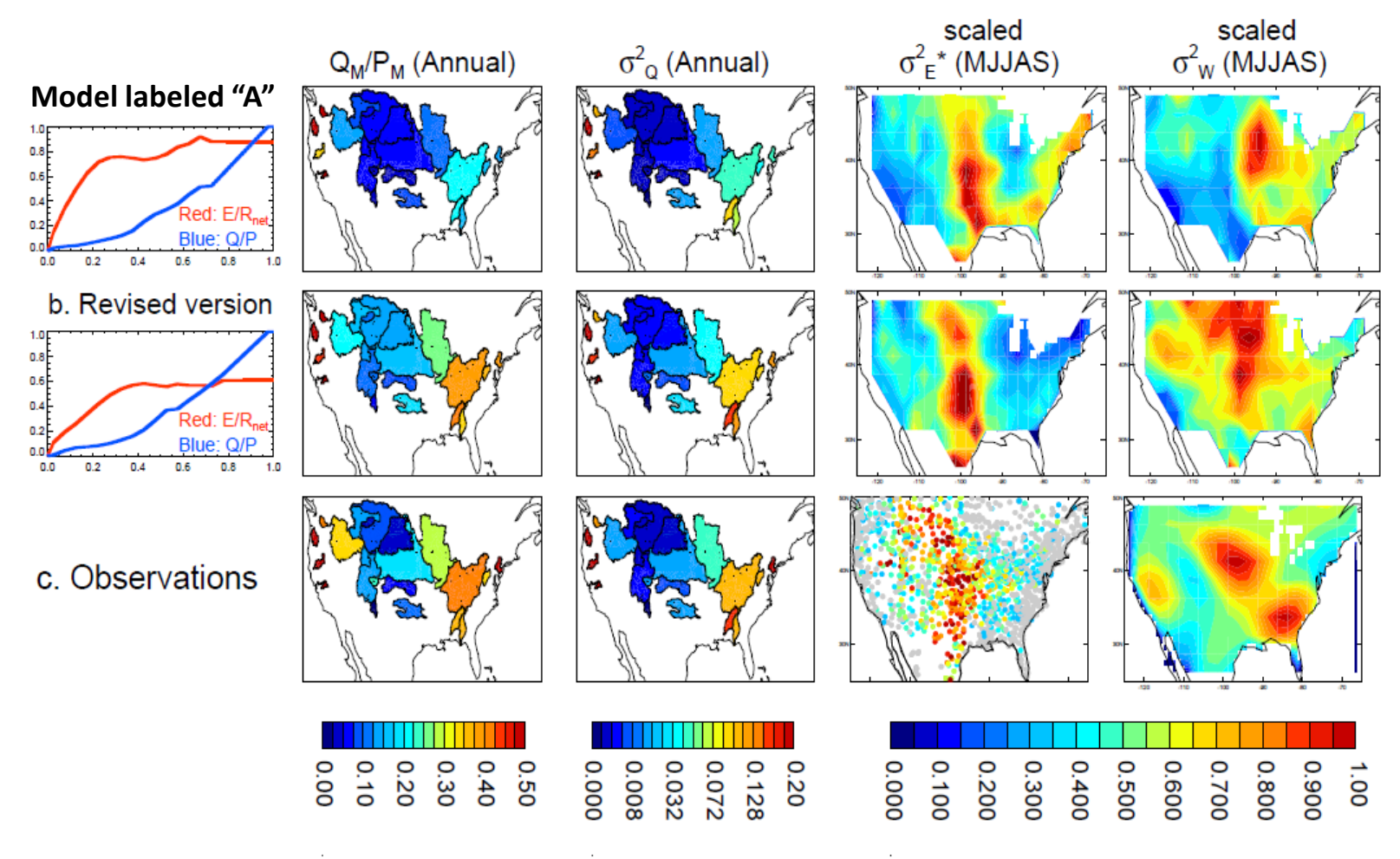
Matrix of skill scores



Skill score achieved by a specific land surface model → skill apparently could be improved by a first order modification to its E/R_{net} function.

One potential "best guess" for functions operating in nature (assuming a single set of functions).

The effective E/R_{net} function used by the model labeled "A" on the preceding plot was modified based on the advice of the simple model results. The result: highly improved simulation of hydrological means and variability.



I’ll repeat the take-home message: these underlying forms of the evaporation and runoff functions exert a first order control on model behavior. They deserve high-priority attention, and they can be examined efficiently in the context of the simple water balance model.