A global assessment of the spatiotemporal origin of water taken up by vegetation

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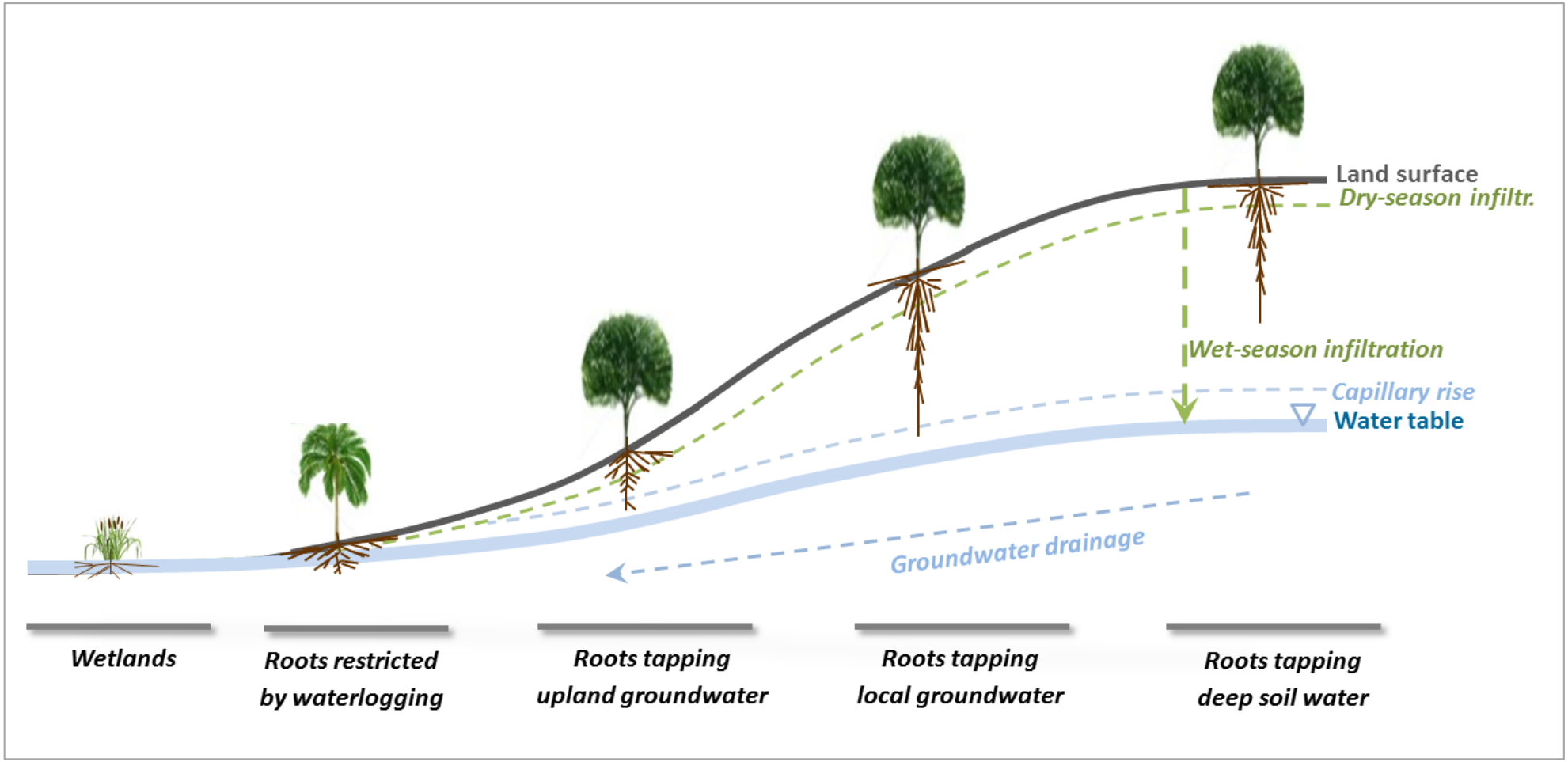
Along a topographic gradient….



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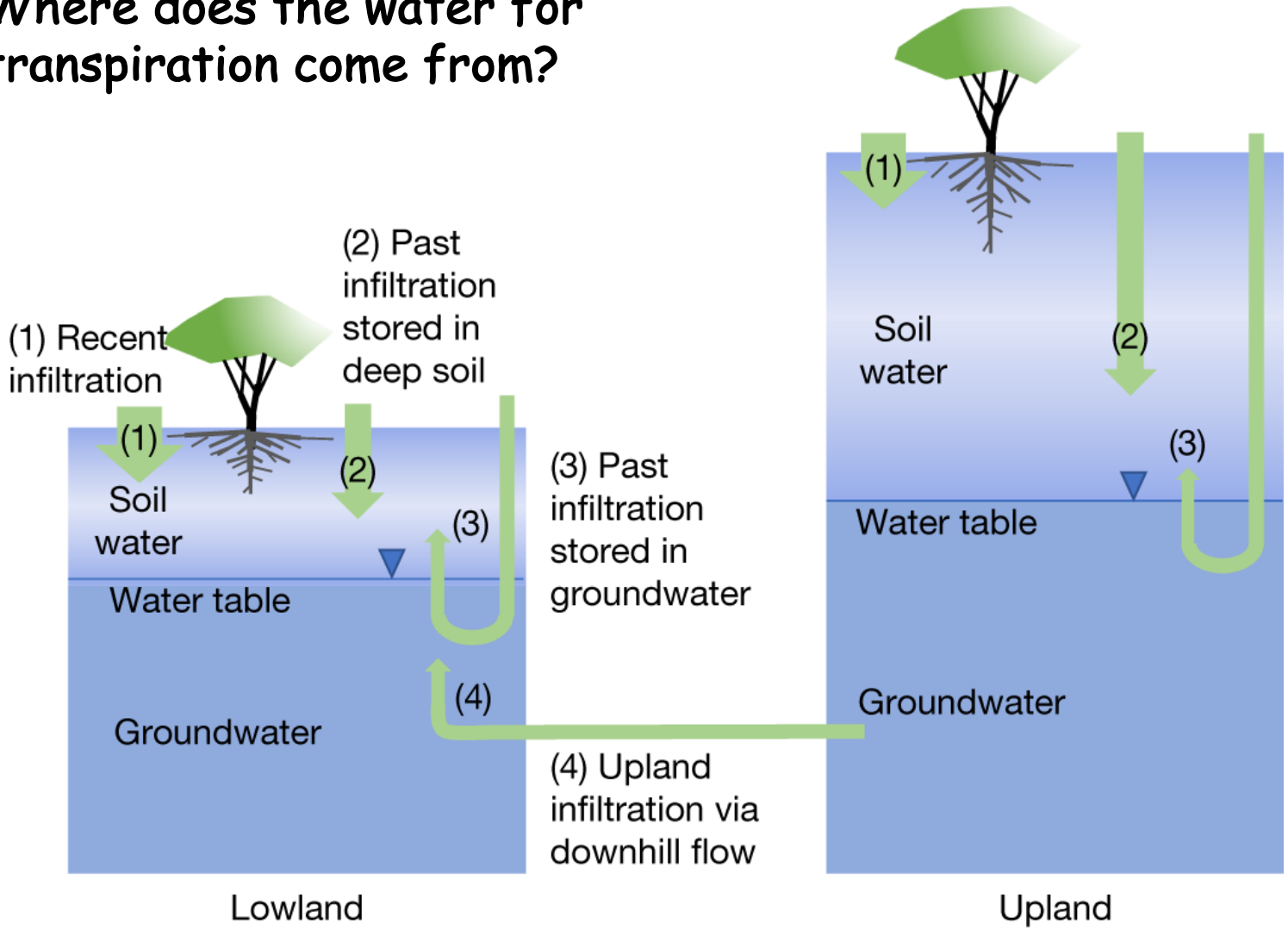
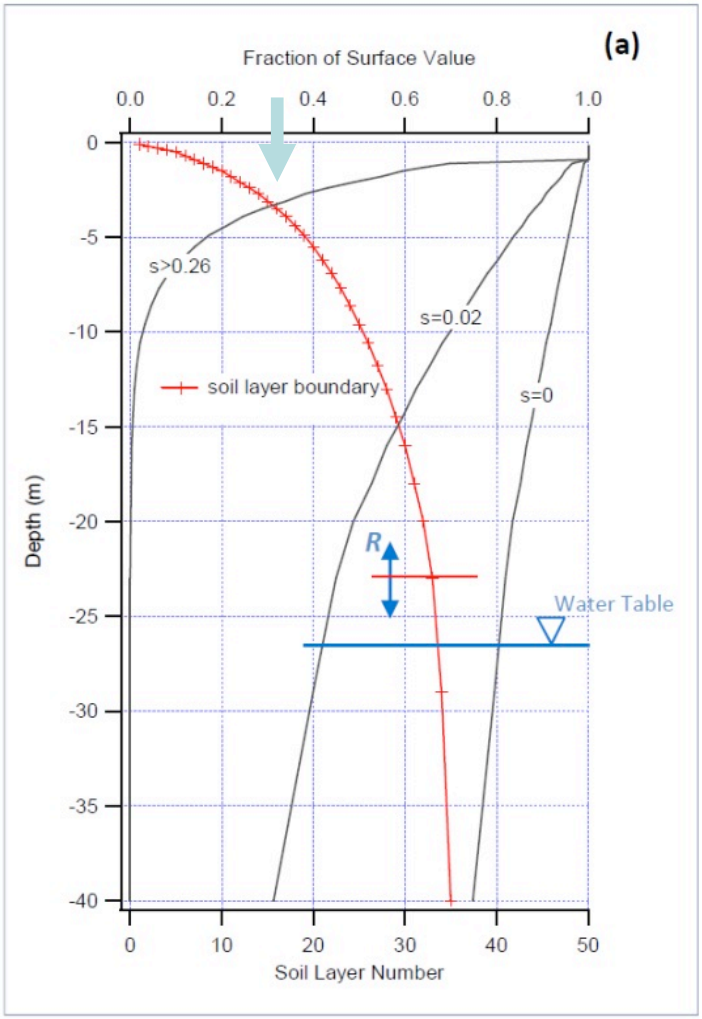
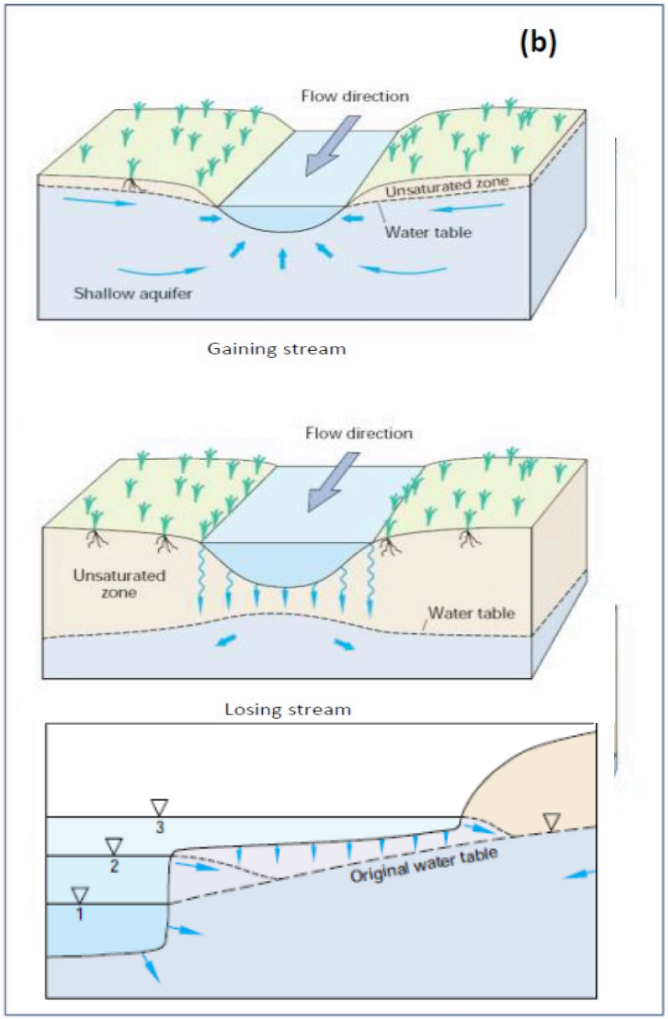
Where does the water for transpiration come from?

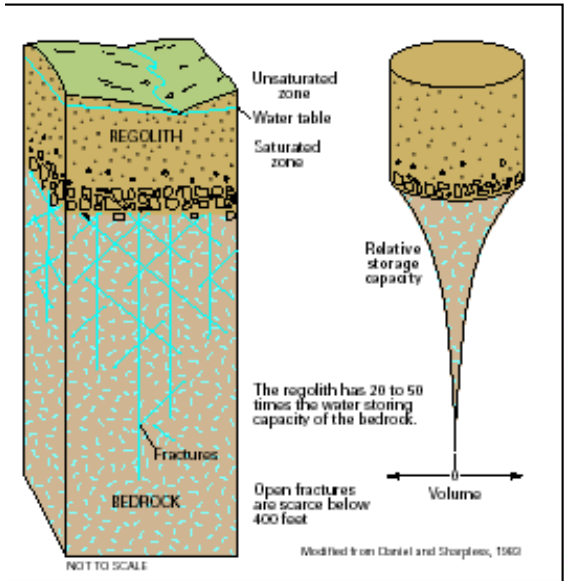


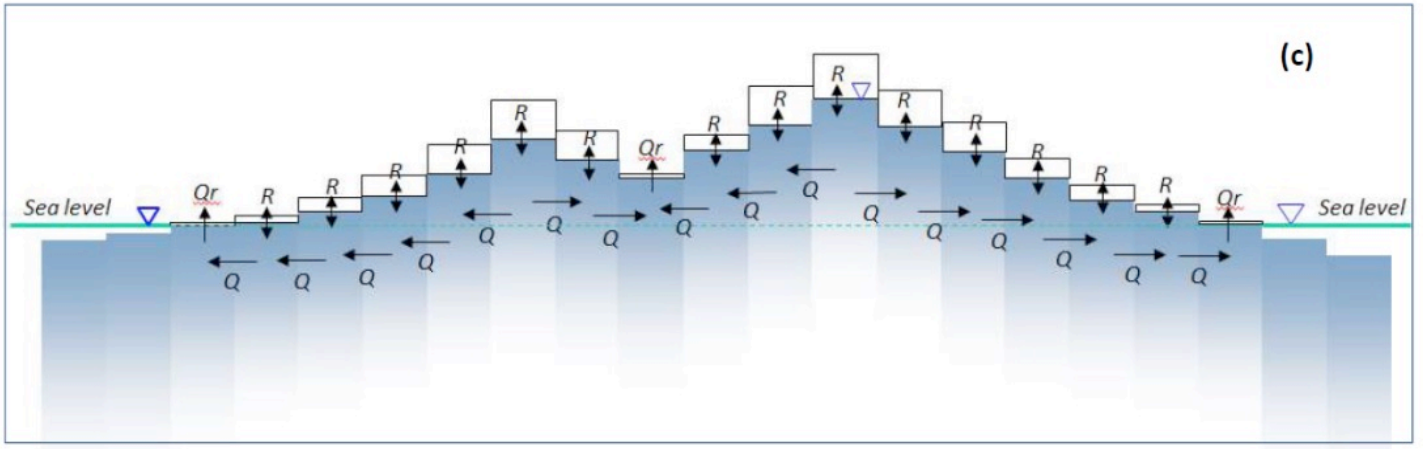
Common Sense Hydrology Model

canopy, soil, groundwater
river/foodplain grwater-fed wetlands
30” (<1km) global grid
hourly
11 yrs (2003-2014)









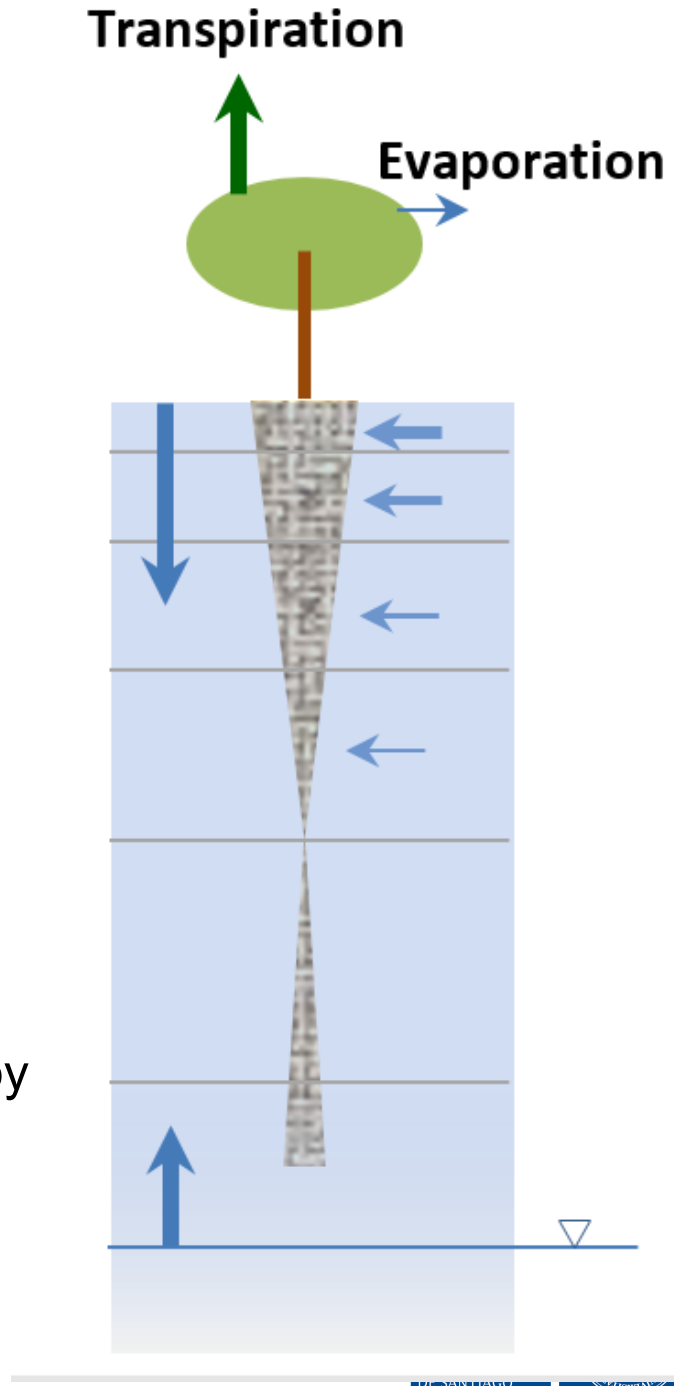
Demand Side:

Panman-Monteith Equ. (Shuttleworth-Wallace)

Transp = function (VPD, LAI)

ERA5 Reanalysis

MODIS

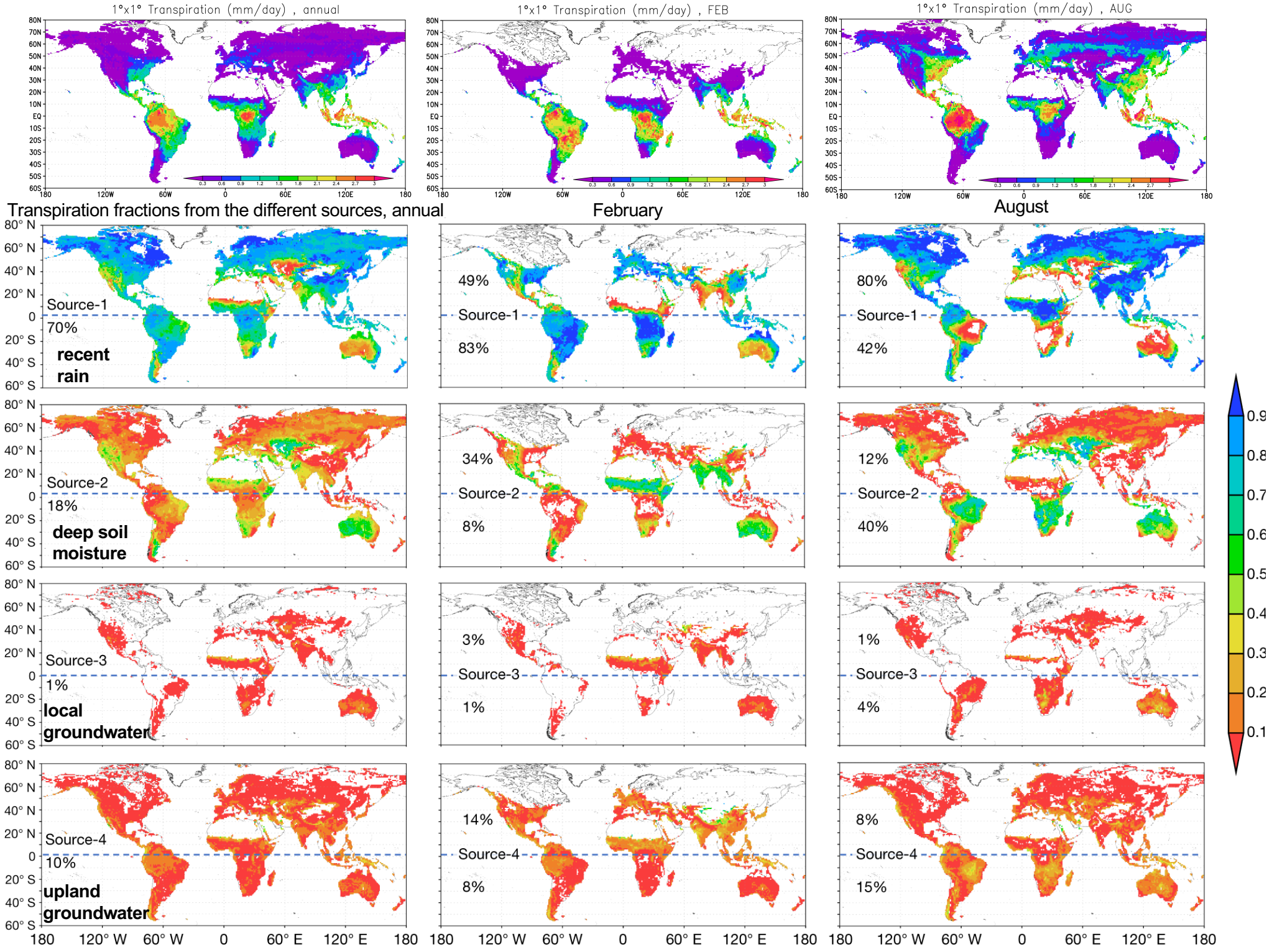


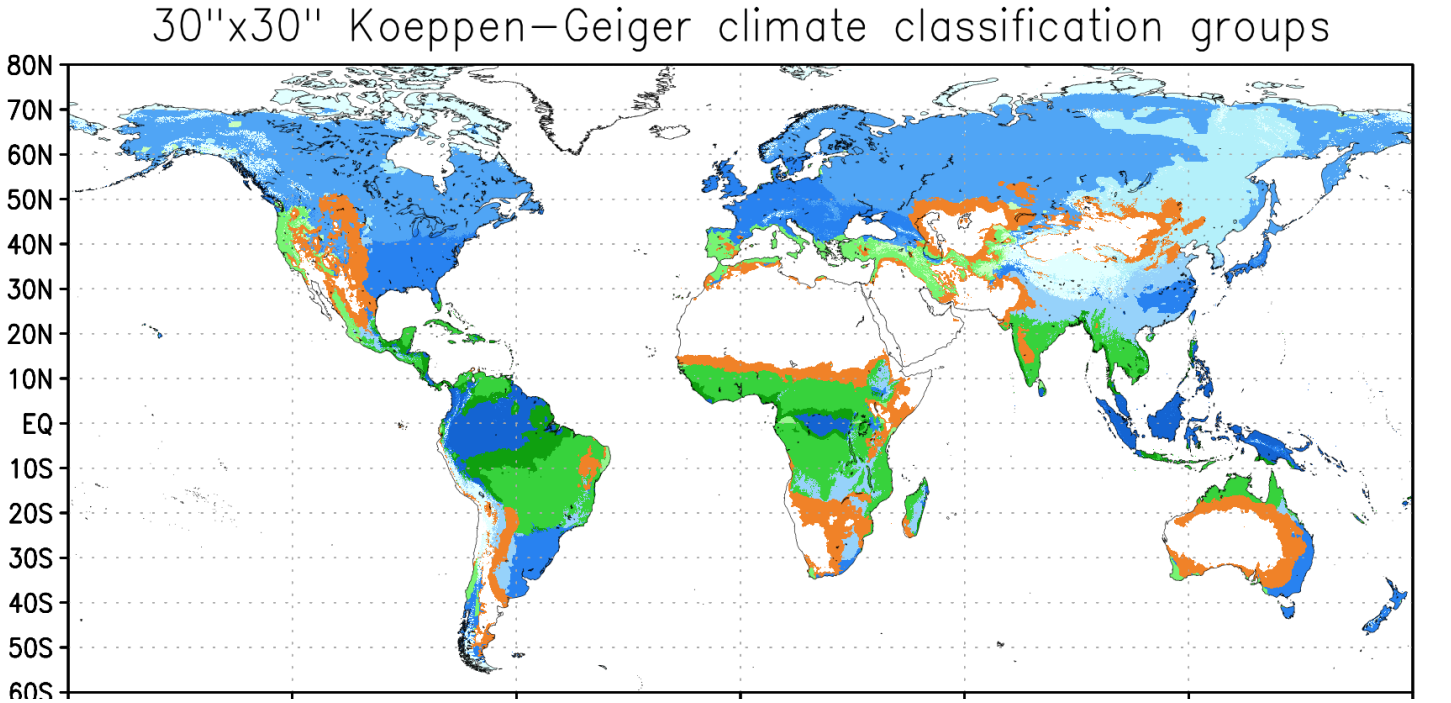
Uptake from layer j:

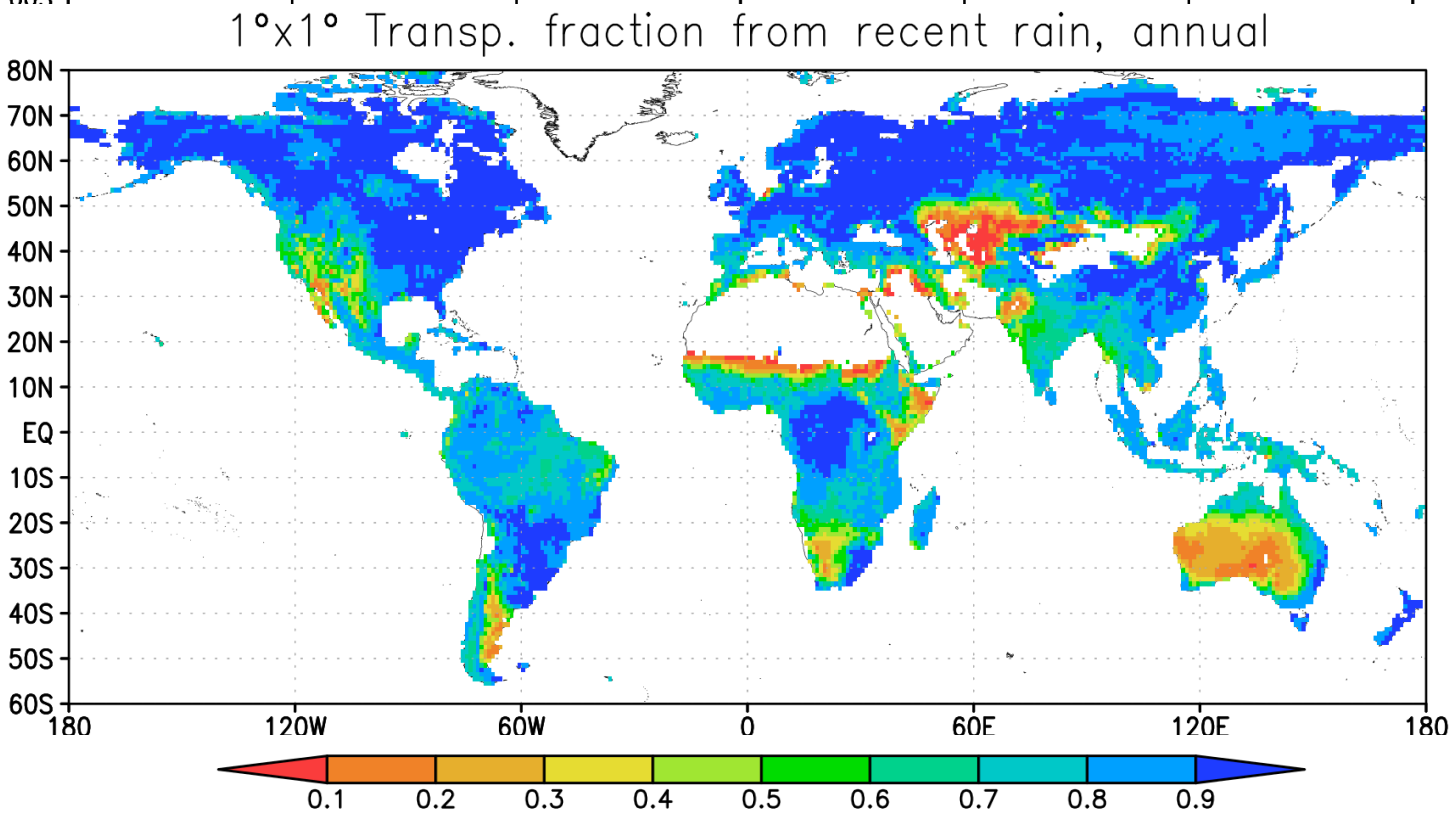
$$e_j = \left(\frac{\psi_{lmin} - \psi_j}{\frac{2}{3} h_{veg} + d_j} \right) \qquad (1)$$

Dynamic root growth driven by minimal resistance to water uptake

$$r_j = \frac{e_j \Delta z_j}{\sum e_j \Delta z_j} \qquad (2)$$


1°x1° Transpiration (mm/day) , annual
1°x1° Transpiration (mm/day) , FEB
1°x1° Transpiration (mm/day) , AUG
Transpiration fractions from the different sources, annual
February
August
Source-1
70%
recent
rain
49%
Source-1
83%
80%
Source-1
42%
Source-2
18%
deep soil
moisture
34%
Source-2
8%
12%
Source-2
40%
Source-3
1%
local
groundwater
3%
Source-3
1%
1%
Source-3
4%
Source-4
10%
upland
groundwater
14%
Source-4
8%
8%
Source-4
15%
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1





On the regional scale, the main driver is climate: there is more reliance on past rain in dry or seasonally dry climates

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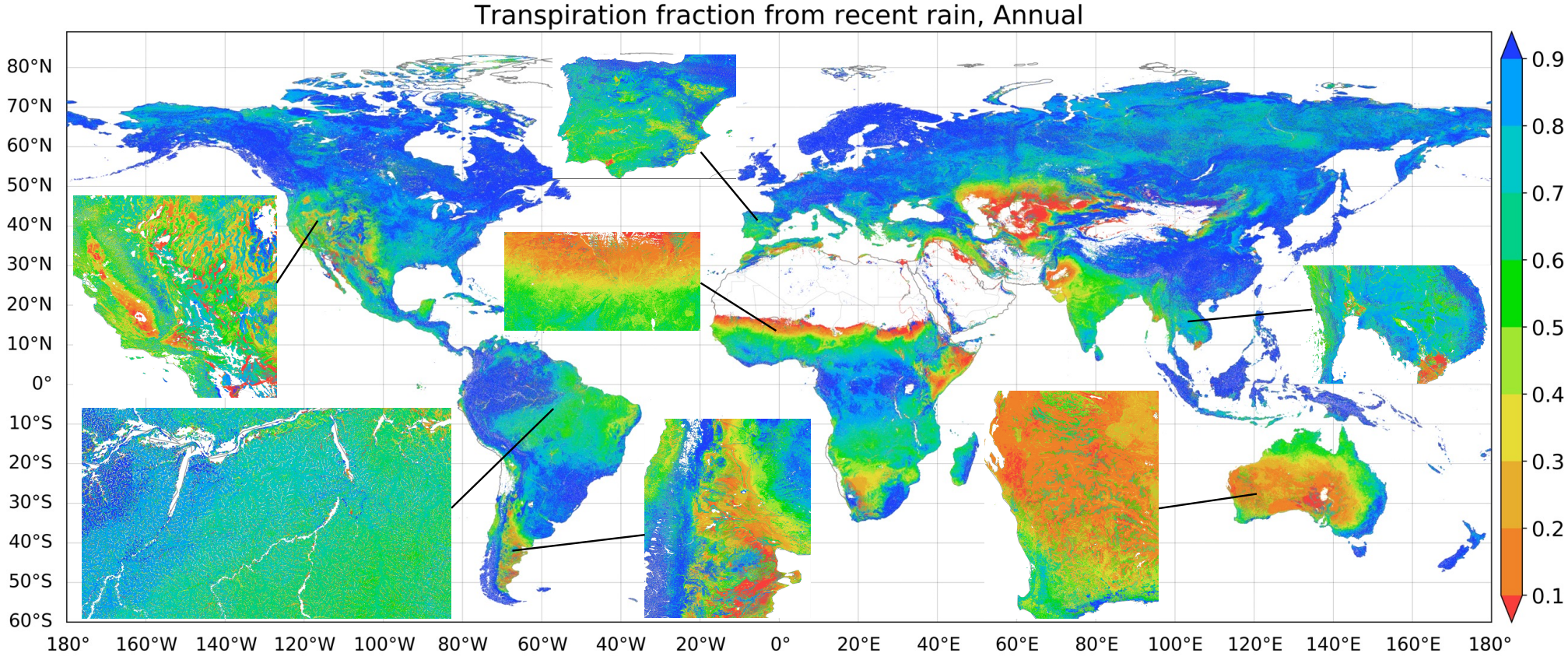

But climate is not the only driver…
At the local scale, topography, e.g. the position on the landscape (hill-valley), is also a key factor because it determines the access to groundwater.

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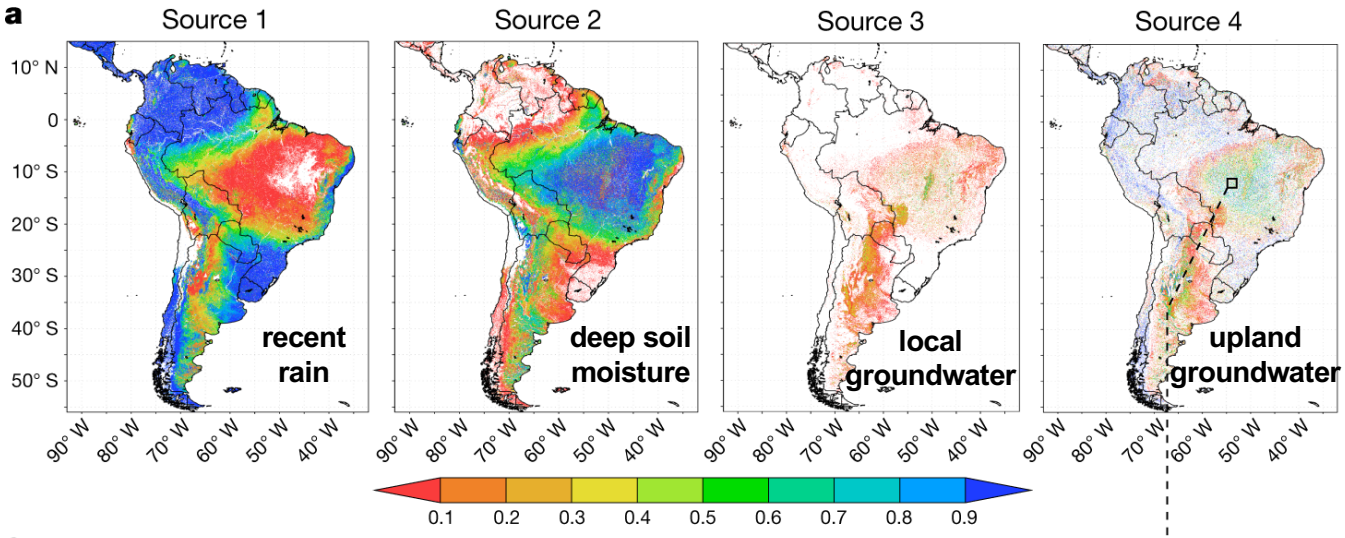
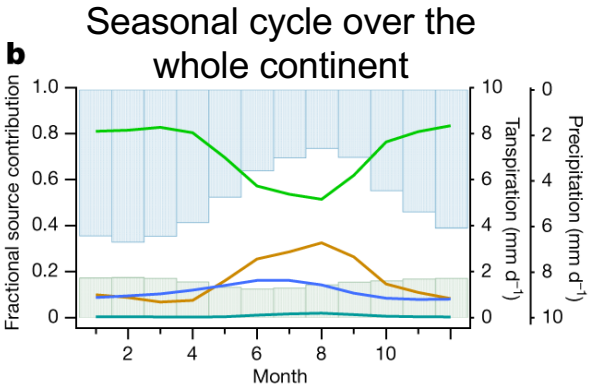
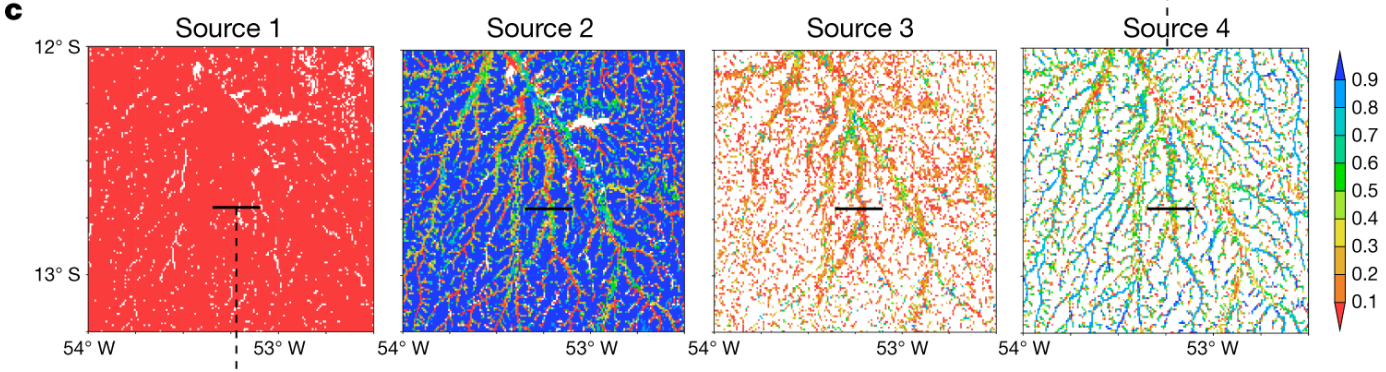
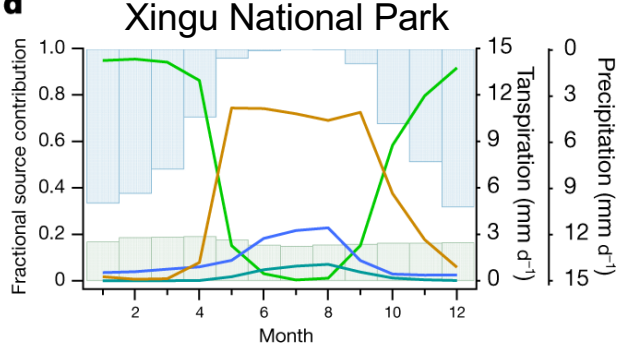
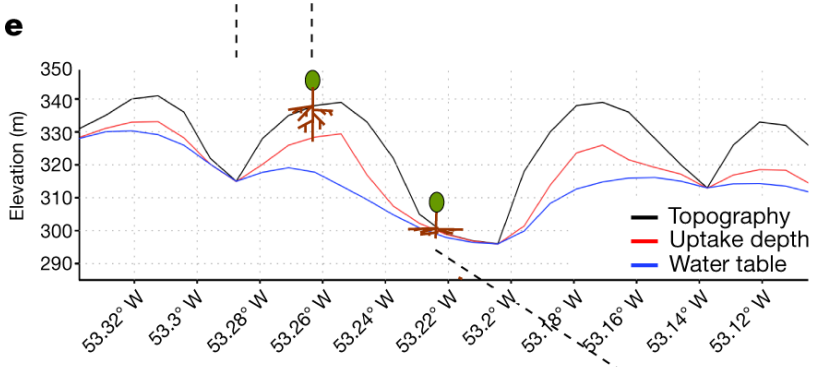
Transpiration fraction from the different sources in August (Southern Amazon dry season)

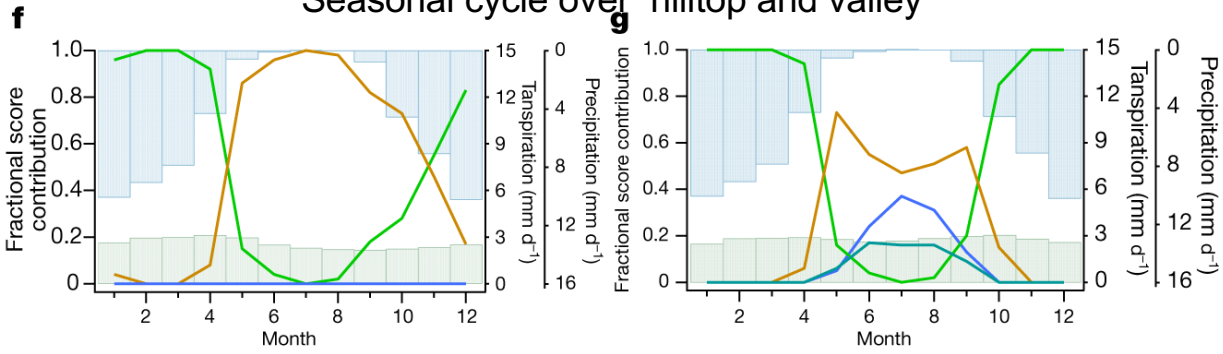












CONCLUSIONS

- Vegetation reliance on past precipitation is common.
- Implications for ecosystem functioning and ET fluxes, recharge rates to groundwater, carbon cycle, biogeochemistry

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