A Global Picture of the Depth and Origin of Soil Water Uptake by Vegetation

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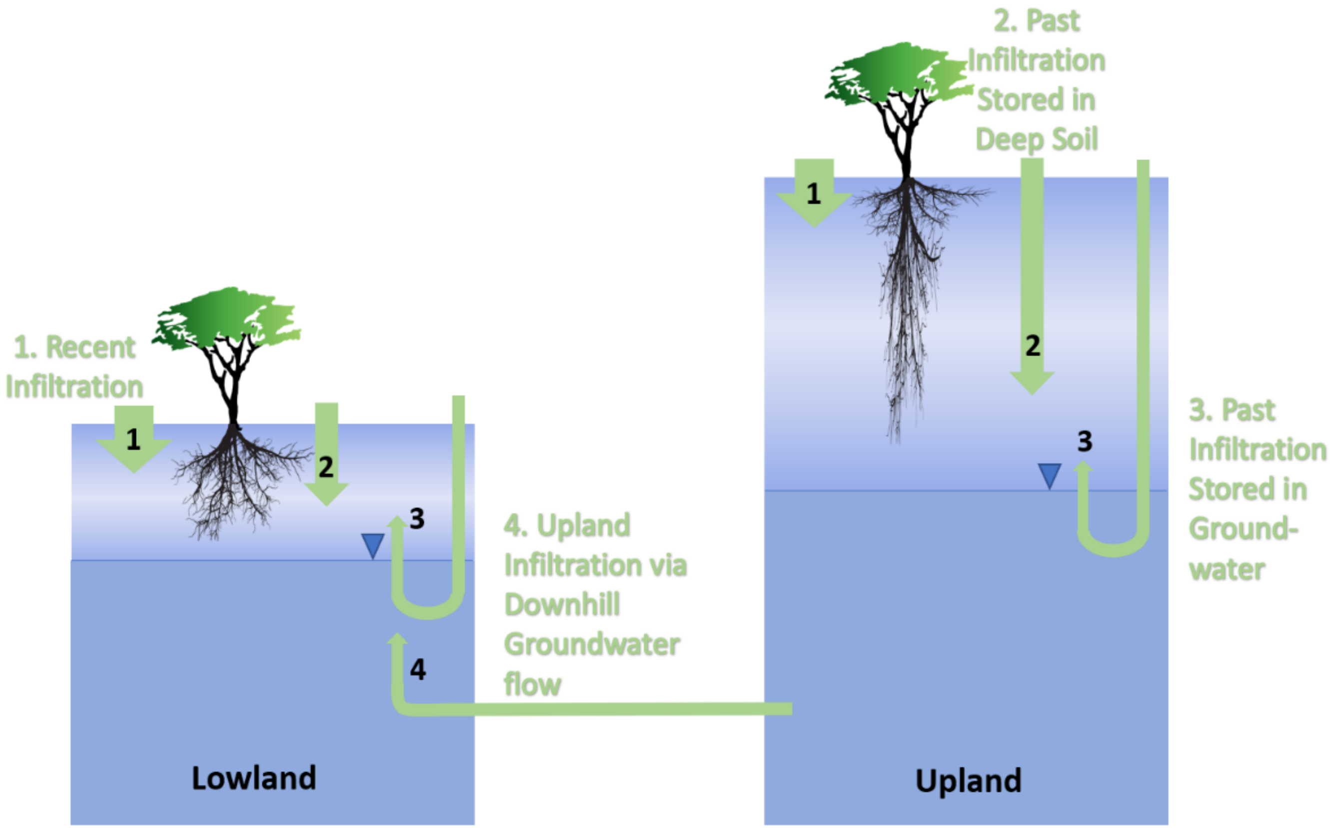

Question: To what extent is the soil water uptake source for vegetation …

1) the recent rain reaching shallow soils
2) past wet-season rain stored in deep soils
3) past rain that reached the water table, which sends the water back up through capillary flux
4) past rain that flowed down the topographic gradient from ridges to valleys (i.e. upland to lowland subsidy). ?

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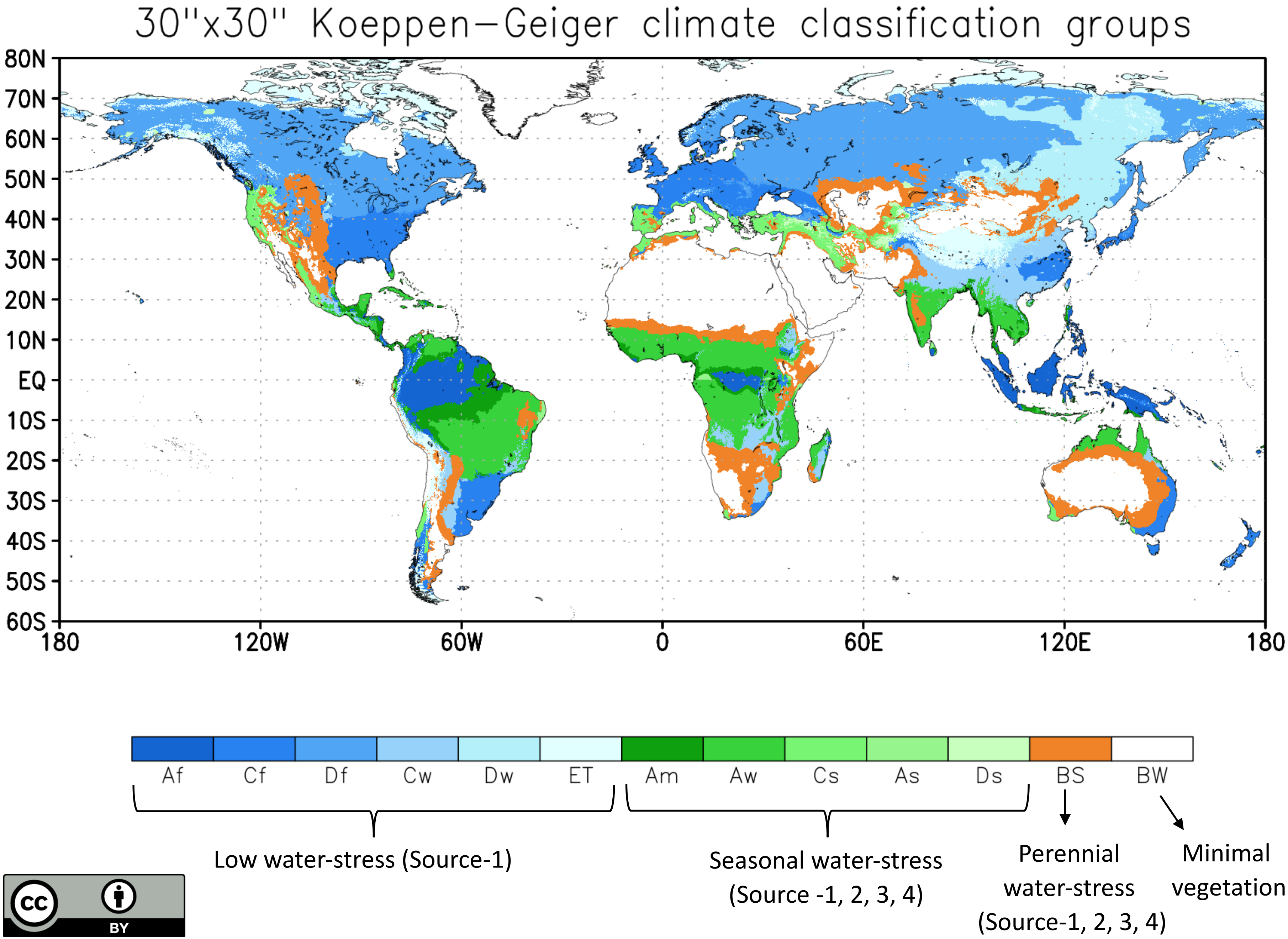
Does the dependence on the different sources depend on climate?



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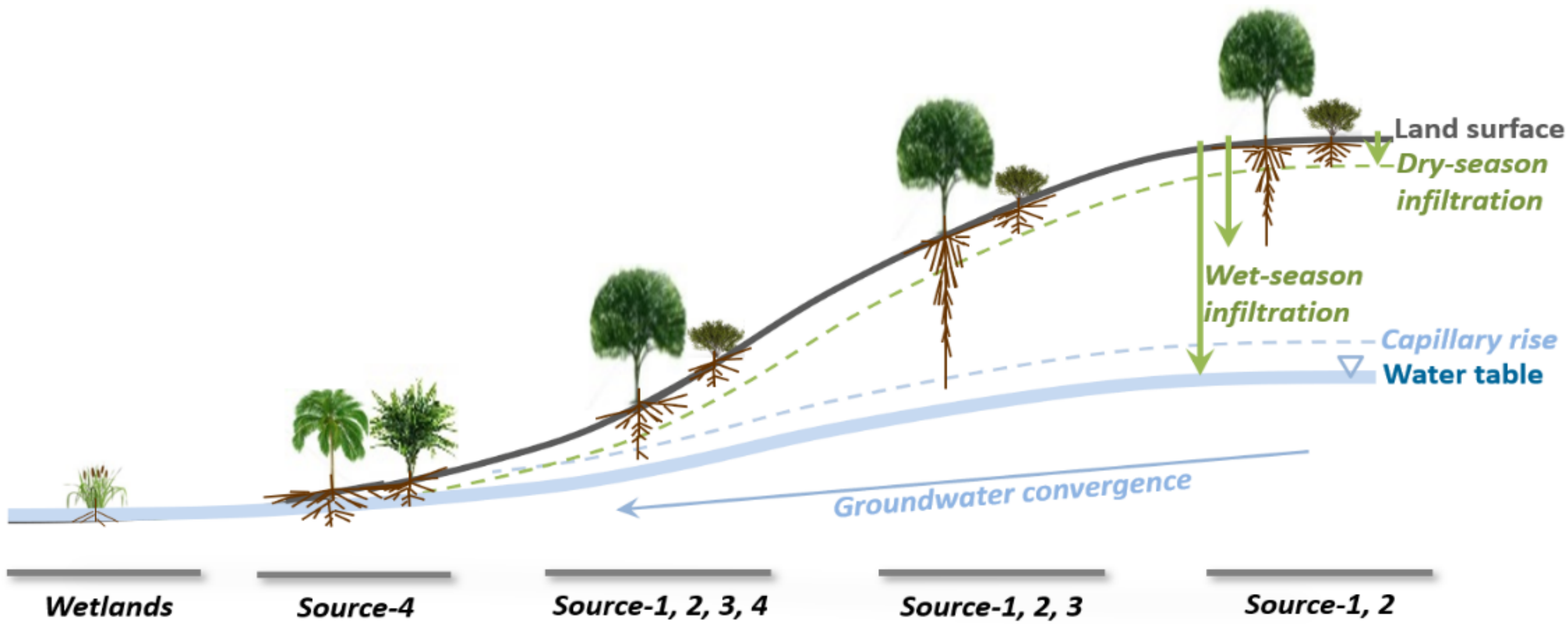
Hypothesis: hillslope hydrology controls local patterns of rooting depth and plant water source



Source-1: recent rain

Source-2: past rain stored in unsaturated soils

Source-3: past rain stored in groundwater

Source-4: groundwater fed by past rain fallen on adjacent uplands

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Does the reliance on the different sources depend also on growth form, genera?

1) OBSERVATIONS

528 measurements of stable isotopes of O/H in plant xylem and source waters

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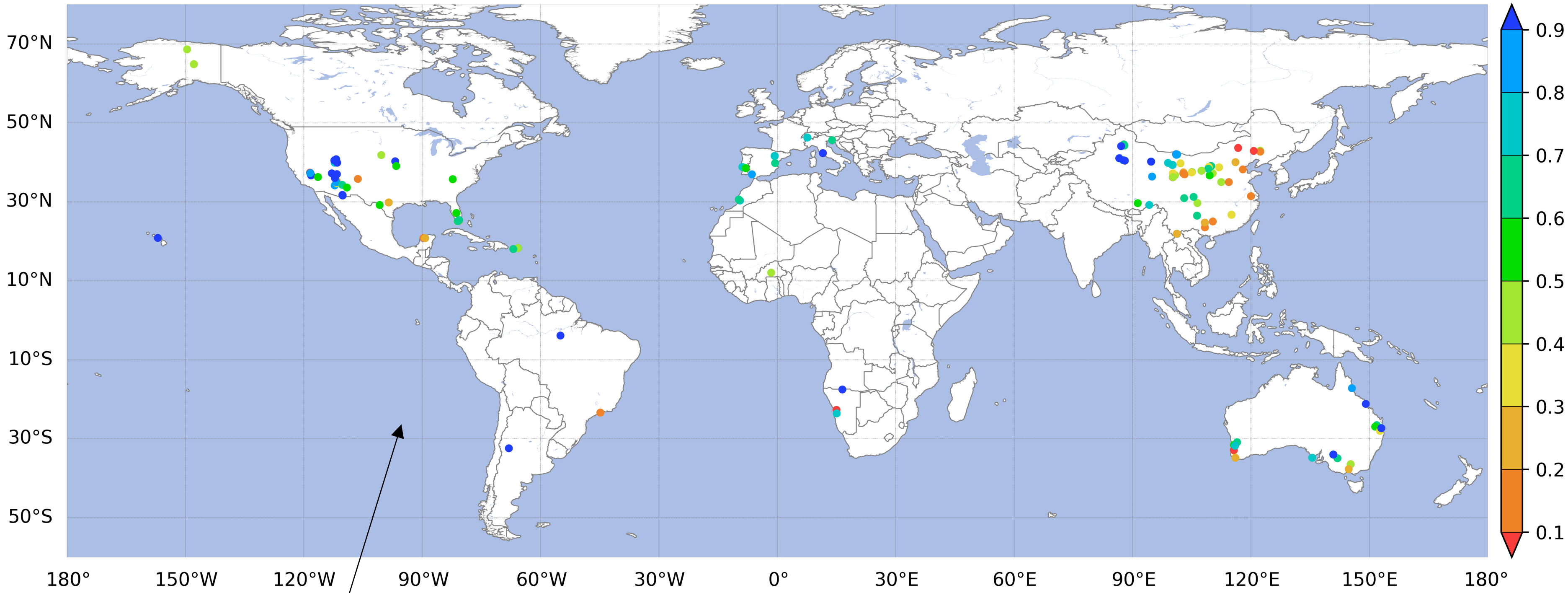
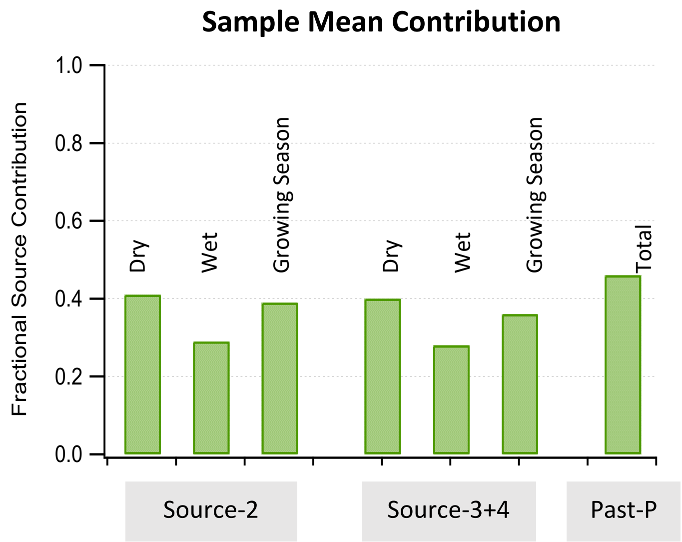
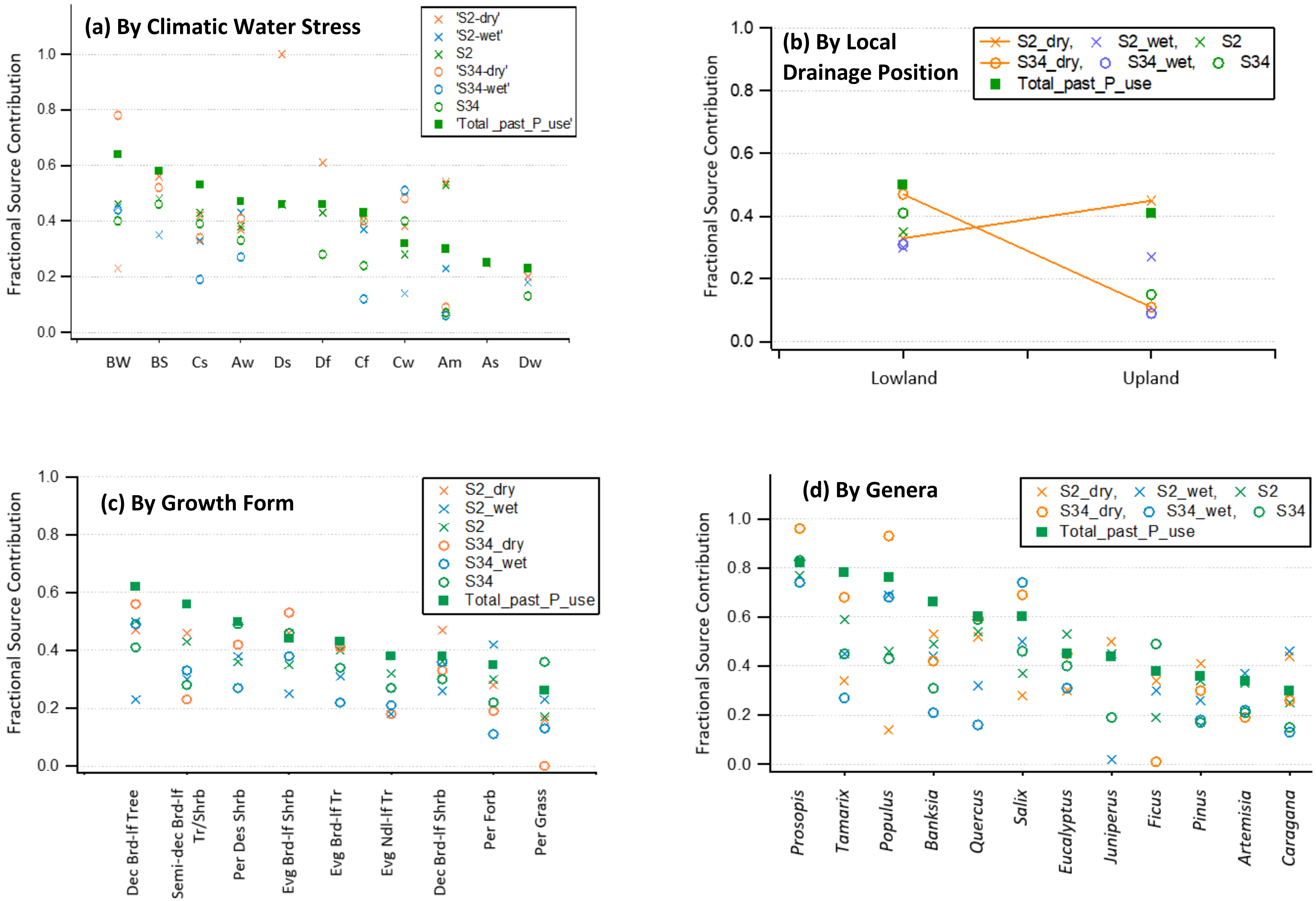
Contribution to Plant Xylem Water from Source-2+3+4



Isotope-based estimates of fractional contribution to plant xylem water from past-P (Source-2+3+4)

Mean contribution over all isotope samples for the dry periods, wet periods, the growing season, and total use of past-P (last column)





To test the hypotheses, panels a-d plot vegetation use of Source-2 (x symbol) and Source-3+4 (o symbol), for dry (orange), wet (blue) periods, and the growing season (green), ranked by total use of past P (green square), along (a) climate gradient, (b) local drainage, (c) growth form, and (d) genera.

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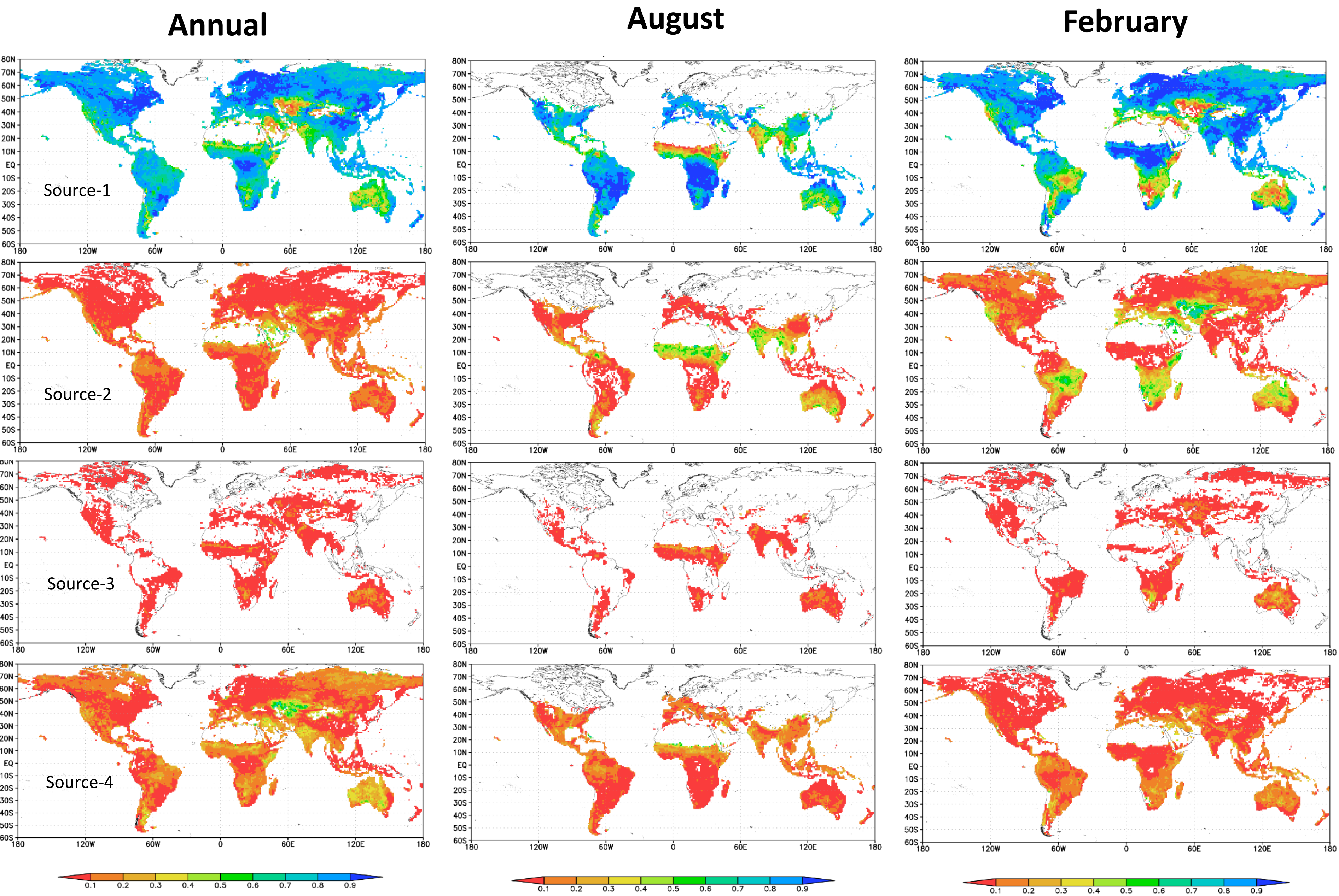
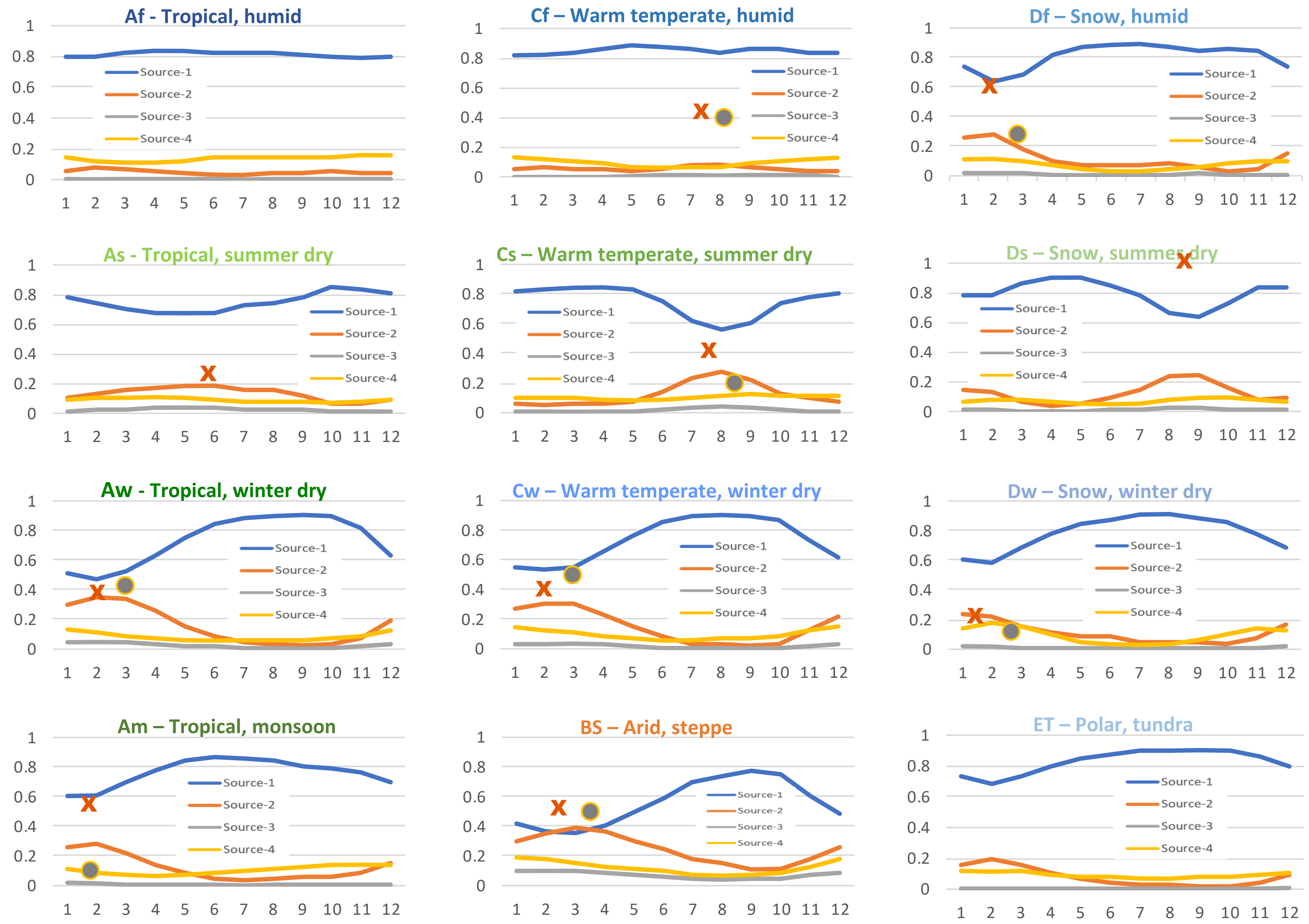
2) MODEL

Fully coupled soil-dynamic roots-hydrology forced by observed biomass, terrain and atmosphere. 1 km resolution, global.



Global 1x1° mean annual transpiration fraction derived from the four water sources



Seasonal water use averaged over the 12 Köppen-Geiger water-stress types. Southern hemisphere is shifted by 6 months. Dry-season isotope-based estimates are shown (X: Source-2, O: sum of Source-3 and 4, isotopically undistinguished)

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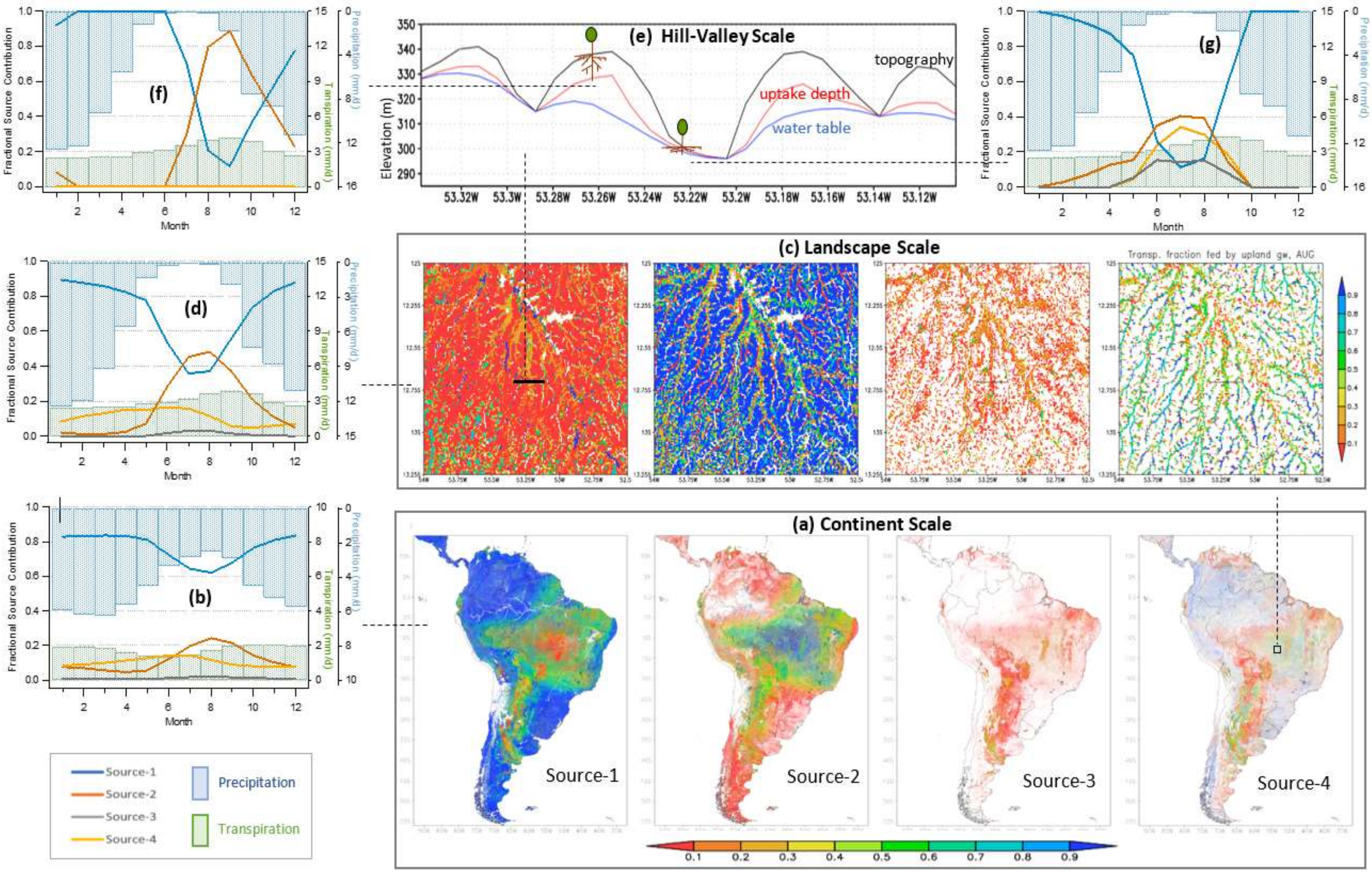

Map of water-use in August (Amazon dry season) over South America (a) with fractional source contributions across the season (b), showing monthly P and modeled transpiration, at the landscape-scale near Xingu National Park (c) and (d), and at hill-valley scale (e) for an upland (f) and lowland (g) grid cell. Location of (c) is marked on (a), and location of (e) is marked on (c).

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Conclusions

Our preliminary results suggest that:

- Plant use of past precipitation is globally prevalent but particularly significant in semi/season-arid climates and lowland ecosystems, and that seasonal shifting to deeper uptake in dry periods is common.

- Isotope sampling, favoring ecosystems under water-stress, indicate that globally 46% of xylem water is from past precipitation, and with the model we obtain 24%. Neither values are negligible. Ecosystem models should account for deep and dynamic water storage and the capacity of land plants to exploit it.

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