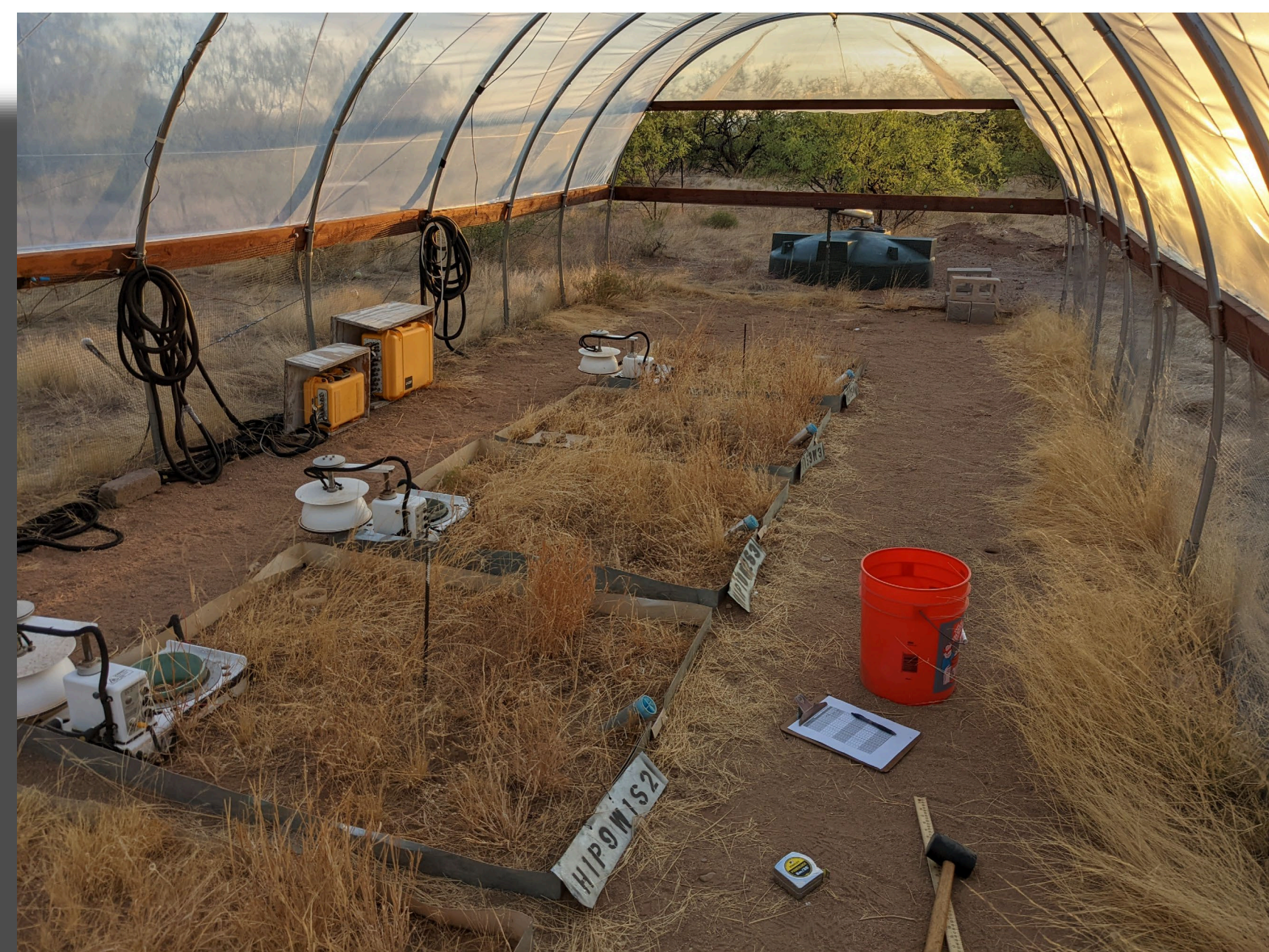
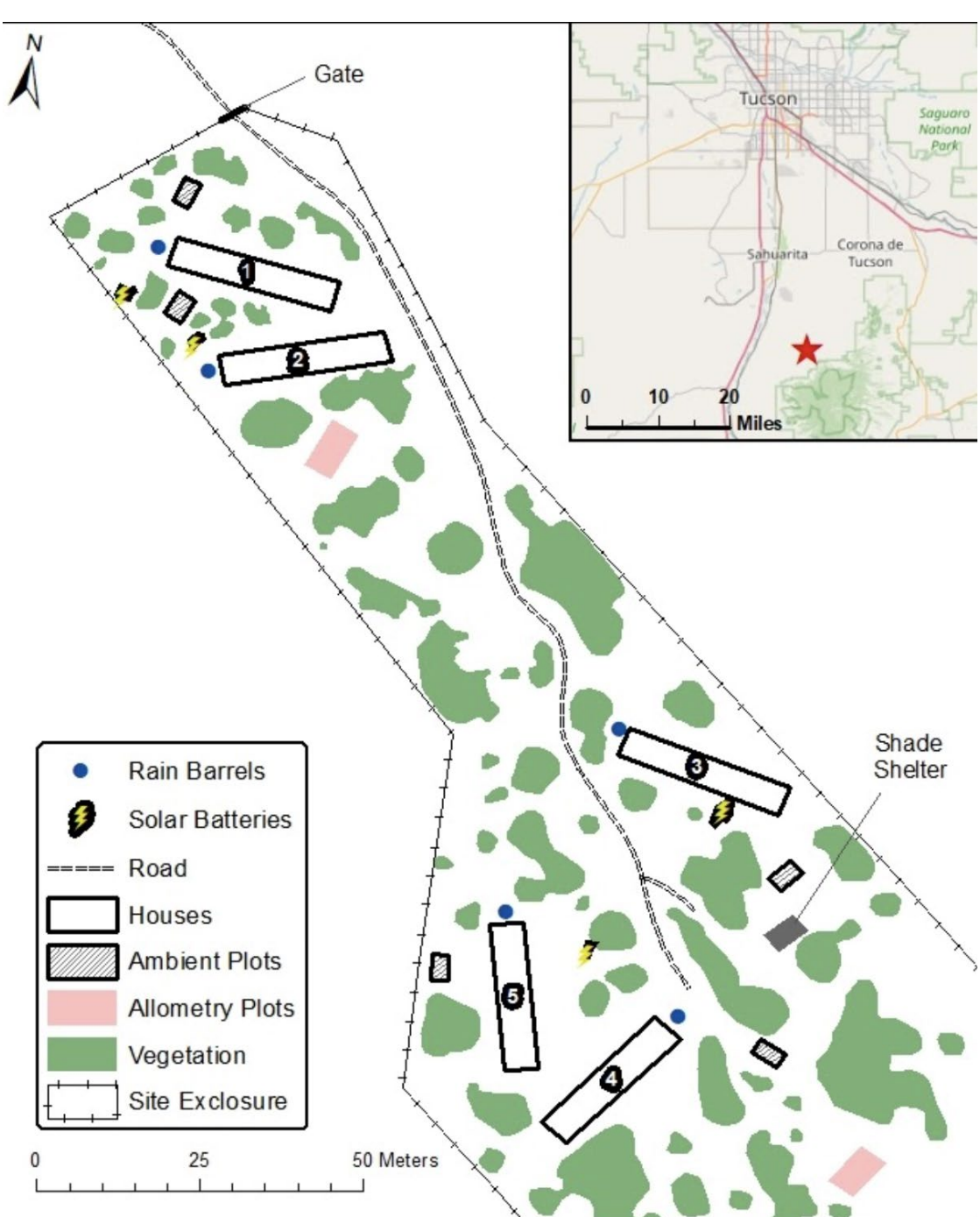


How Rainfall Timing Shapes Evapotranspiration in Semiarid Grasslands

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Santa Rita RainMan Experiment



Semiarid grasslands experience long dry periods interrupted by short wet pulses. This study examined how shifting summer rainfall from frequent small events to fewer, larger ones affects water loss through evaporation (E) and transpiration (T). Understanding ET partitioning supports water retention, productive working lands, and ARS efforts to strengthen resilience in water-limited rangelands.

Objectives

- Test how different rainfall frequencies affect soil moisture depth & persistence
- Quantify evaporation and transpiration responses during wet–dry cycles
- Identify vegetation attributes that control transpiration and ET partitioning.

Methods

We conducted a four-year field experiment at the Santa Rita Experimental Range using rainout shelters and controlled irrigation pulses that delivered the same seasonal total.

- **Normal:** small events every ~7 days
- **Few/Large:** larger events every ~21 days

Plot-scale chambers measured CO₂ and water vapor fluxes during pulse–drydowns. ET was partitioned using an underlying water-use efficiency approach based on plot-level GPP, ET, and vapor pressure deficit. Soil moisture was monitored at two depths, and vegetation cover and greenness were measured using point-intercept surveys and digital imagery.

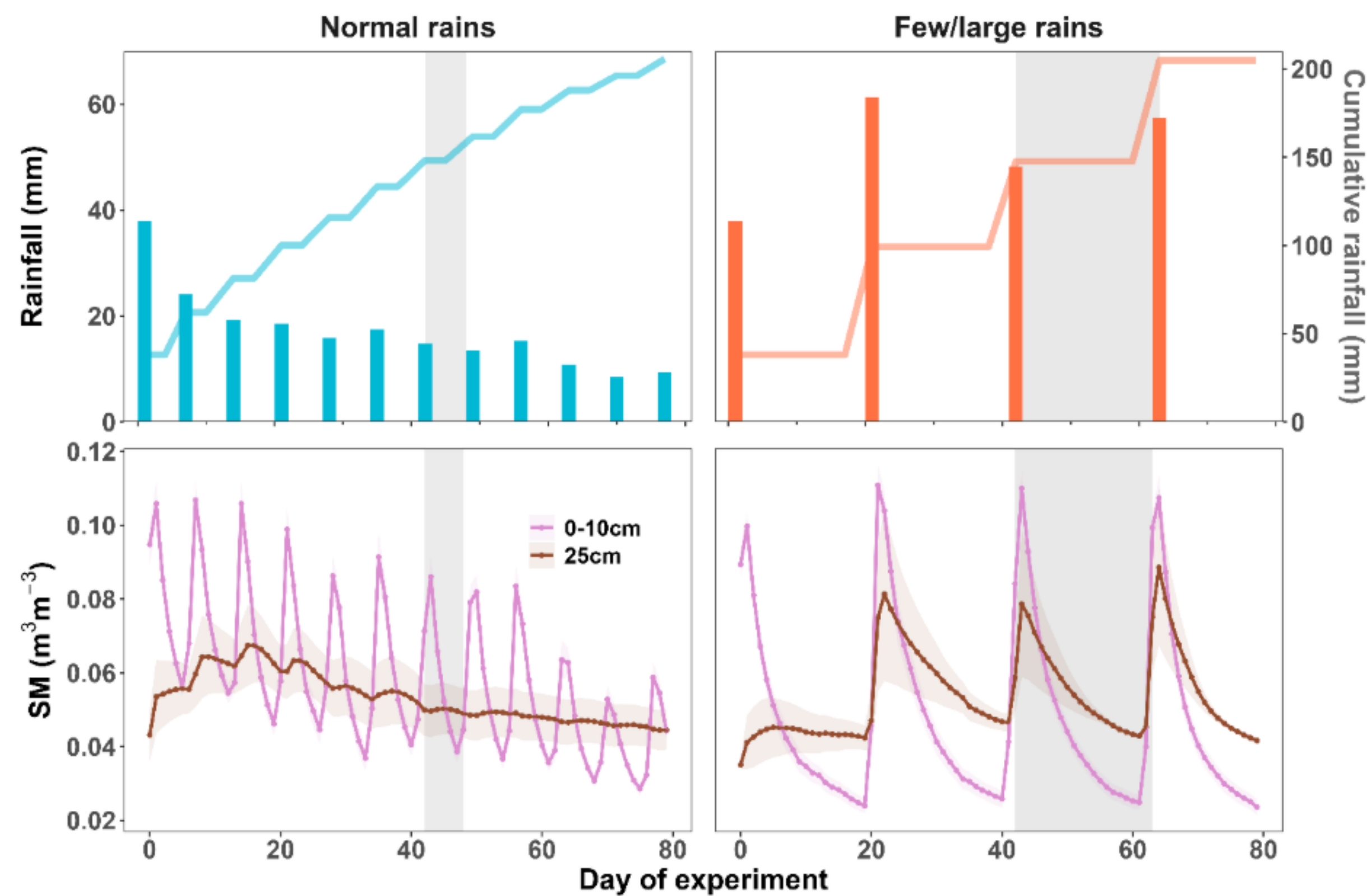


Figure 1. Experimental design showing rainfall pulses and daily soil moisture. Shaded region marks the pulse-drydown focus period.

Evapotranspiration Partitioning

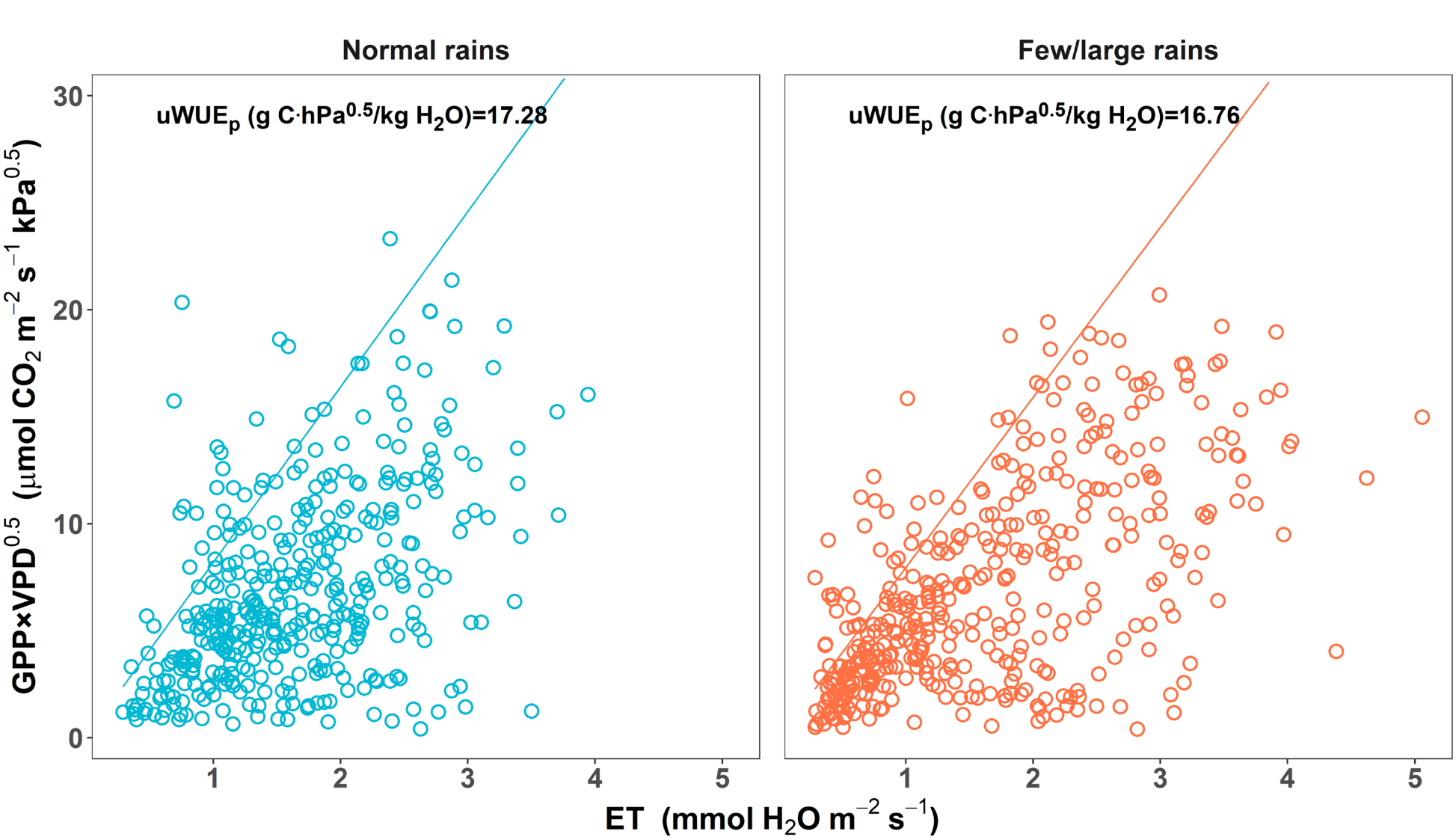


Figure 2. 95th-quantile regressions showing estimated potential uWUE_p for both rainfall treatments

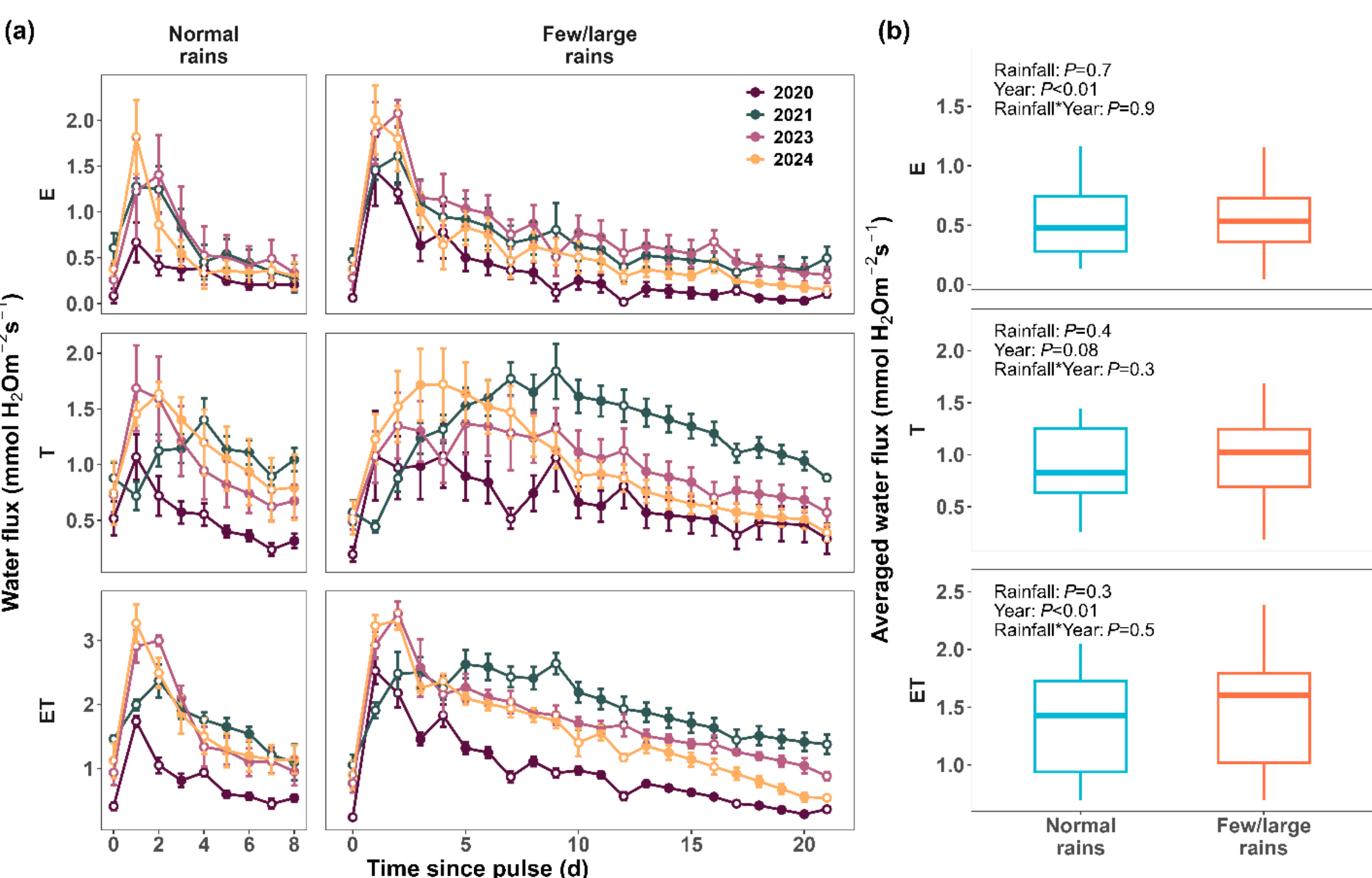


Figure 3. Pulse-drydown daily E, T, ET (a) and average fluxes (b).

Key Results

- Few/large events increased **deep soil moisture (25 cm)** while normal events kept moisture near the surface.
- **Mean ET, E, and T** did not differ between rainfall treatments across years.
- **Evaporation** peaked within 1–2 days after rainfall in all plots.
- **Transpiration** peaked later—up to 9 days—under fewer, larger events.
- Vegetation greenness and canopy cover **strongly controlled T and T/ET**.
- Evaporation was **unrelated** to vegetation metrics and driven by surface moisture

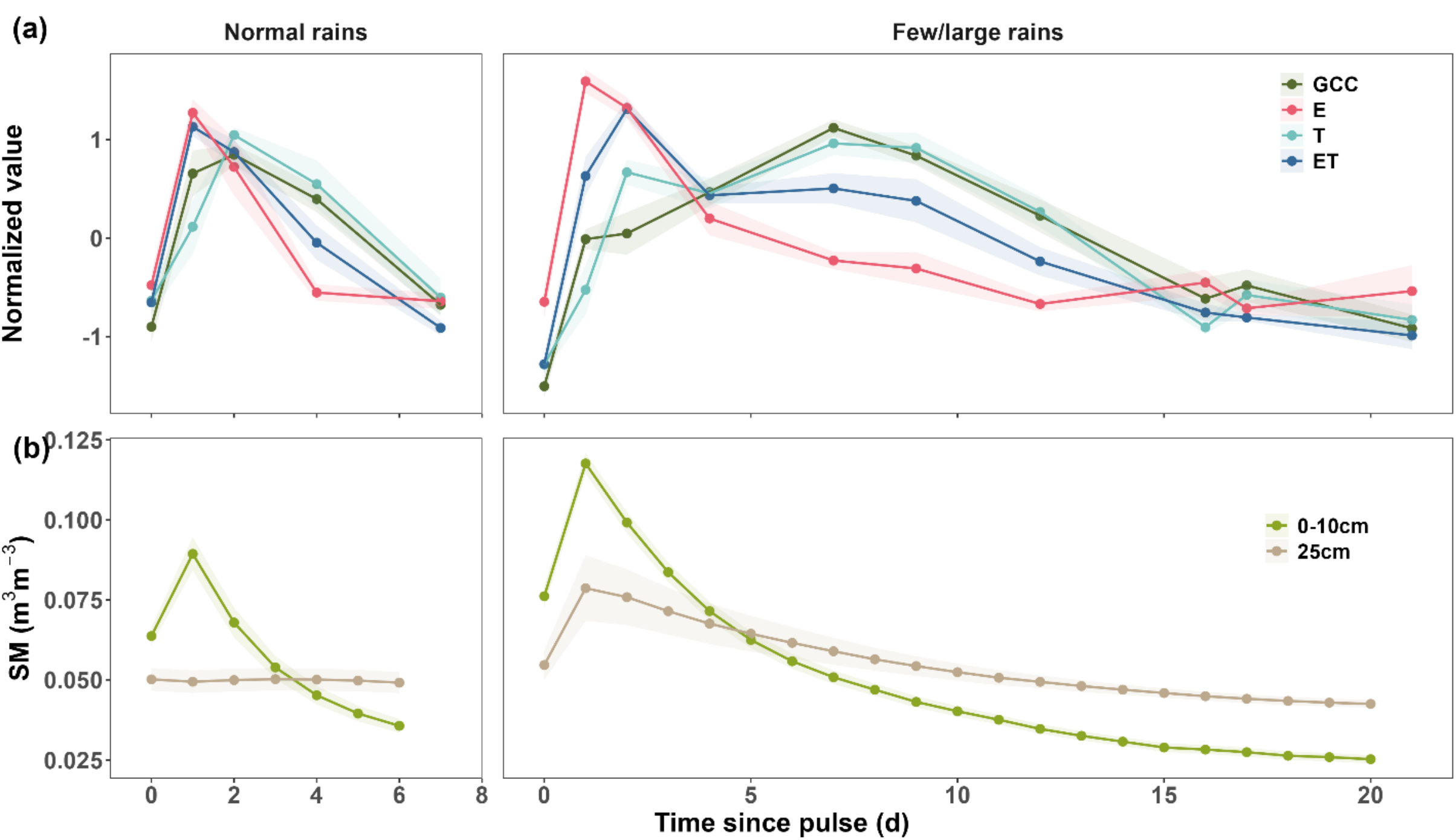


Figure 4. ET, E, T, and greenness (a); soil moisture at two depths (b).

Soil Moisture or Vegetation Controls?

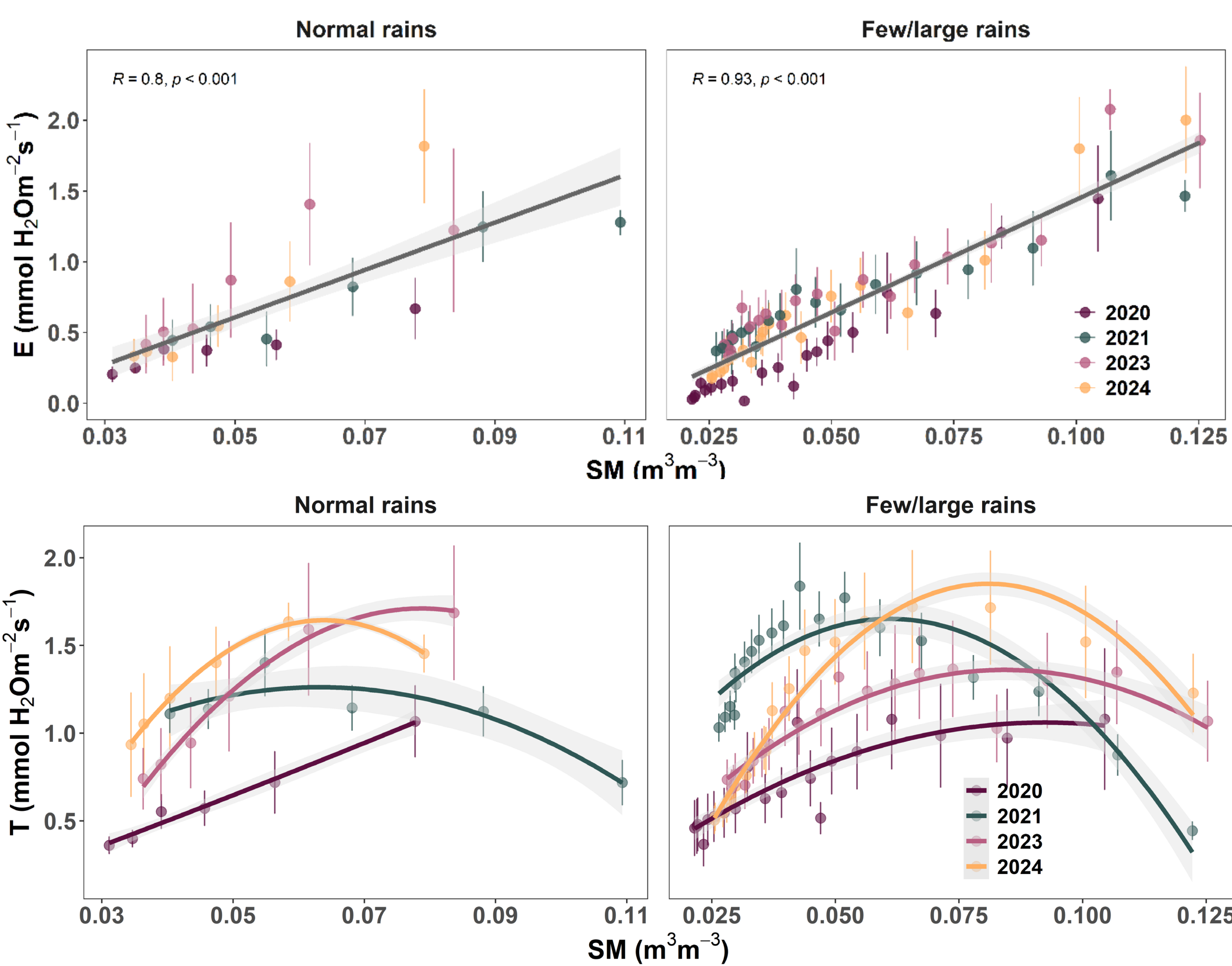


Figure 5. Daily evaporation (E) and transpiration (T) versus soil moisture in the top 10 cm.

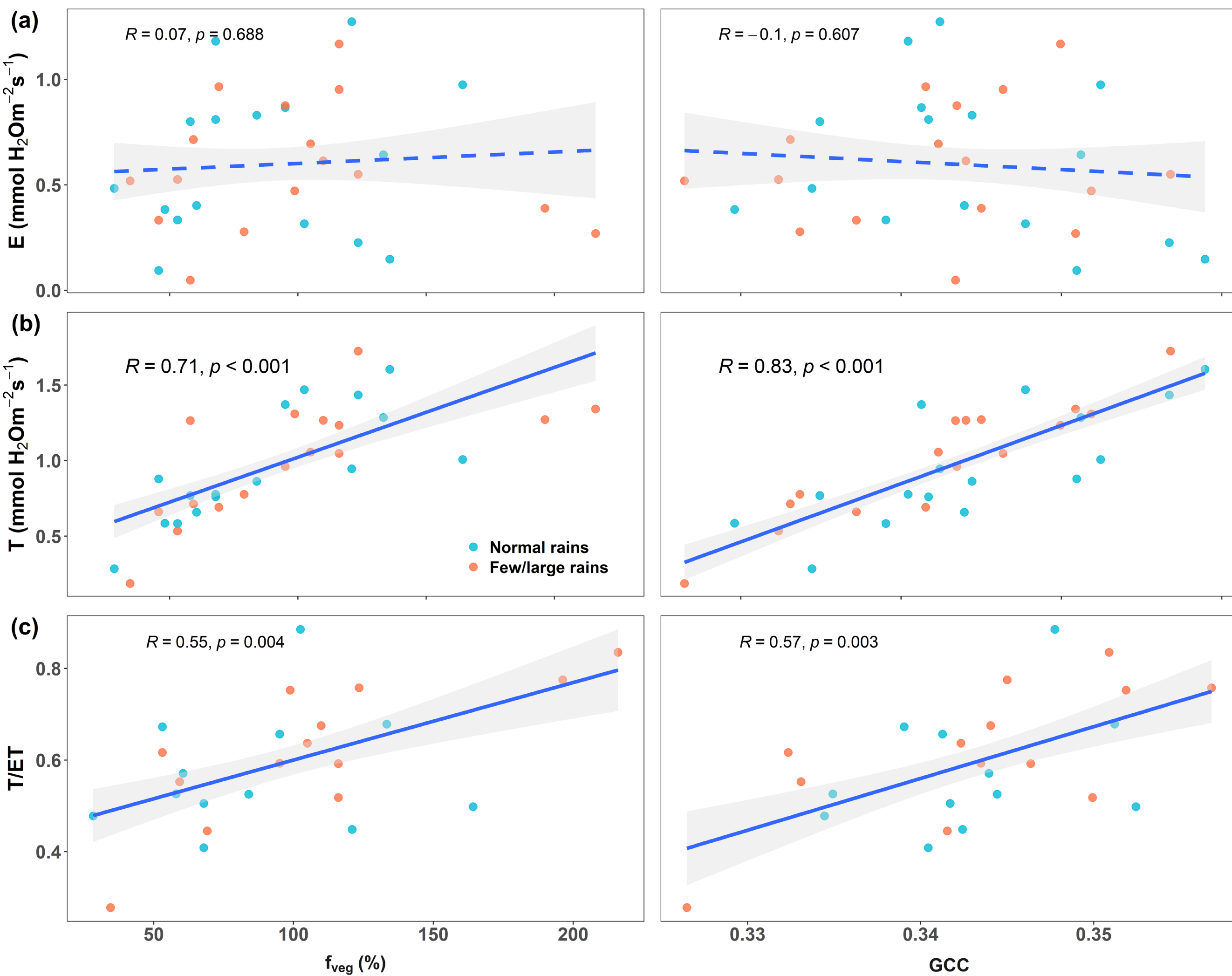


Figure 6. Mean E, T, and T/ET in relation to vegetation cover and greenness.

Interpretations and Conclusions

- **Larger rainfall pulses increased deep soil moisture**, but plants did not immediately use that water because vegetation needed time to recover after drying.
- **Evaporation responded immediately** to surface wetting, while **transpiration responded later**, depending on canopy condition.
- **Timing differences in E and T balanced out**, producing similar cumulative ET across rainfall treatments.
- **Vegetation functional status—greenness, cover, active canopy—was the dominant control** on transpiration and the T/ET ratio.
- **Rainfall timing affected soil moisture depth**, but average E and T depended more on vegetation condition than on rainfall packaging or soil moisture.