降雨季节性对半干旱区灌丛生态系统蒸散发年际变异的影响

Rainfall seasonality regulates the interannual variations in evapotranspiration over a temperate semi-arid shrubland

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报告目录：

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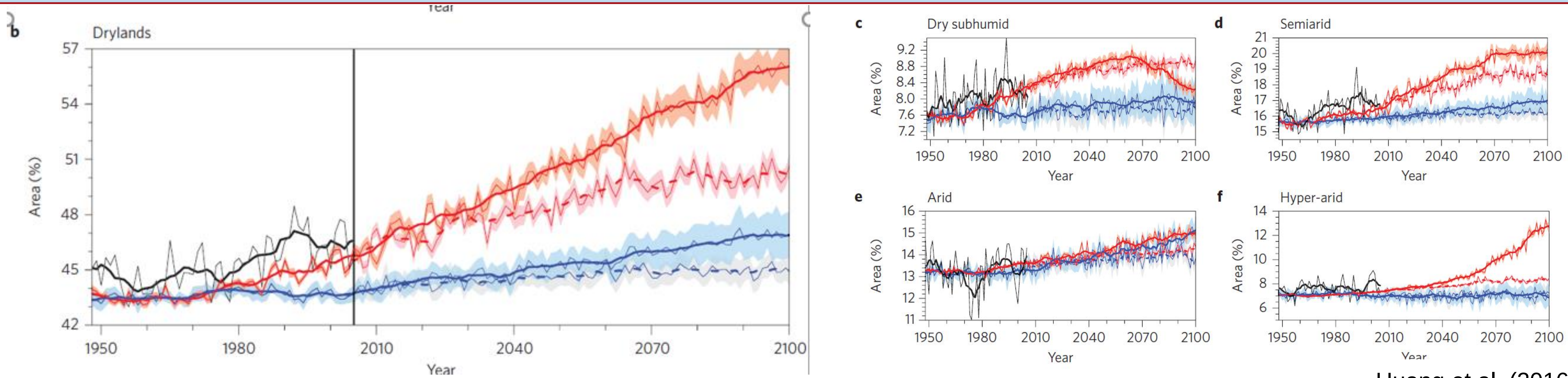
01. Background

Knowledge gaps …

- Evapotranspiration (ET) plays an important role in the coupling between carbon and water cycles, and determines the strength of linkage between water and energy budgets.
- Drylands (i.e., arid and semi-arid areas) account for over 40% of the land surface, have profound impacts on the global hydrological cycle .
- Dryland ecosystems are highly susceptible to climate change (e.g., altered precipitation pattern) and extreme climatic events (e.g., droughts).
- Current understanding on the dynamics and controls of ET is based largely on observations from croplands, grasslands, and forests. Less is known about ET from desert shrub ecosystems, which are widely distributed in temperate Eurasia.



Huang et al. (2016) NCC

01. Background

The objectives of this study were to …

- characterize the temporal variations in ET, and to examine the biophysical controls over ET at seasonal and interannual timescales.

Hypotheses …

- whether factors related to water supply (soil water content and rainfall amount) are better than biotic factors at explaining the dynamics of ET at different timescales.
- the seasonal pattern of rainfall would play an important role in determining annual ET.

涡度协方差观测

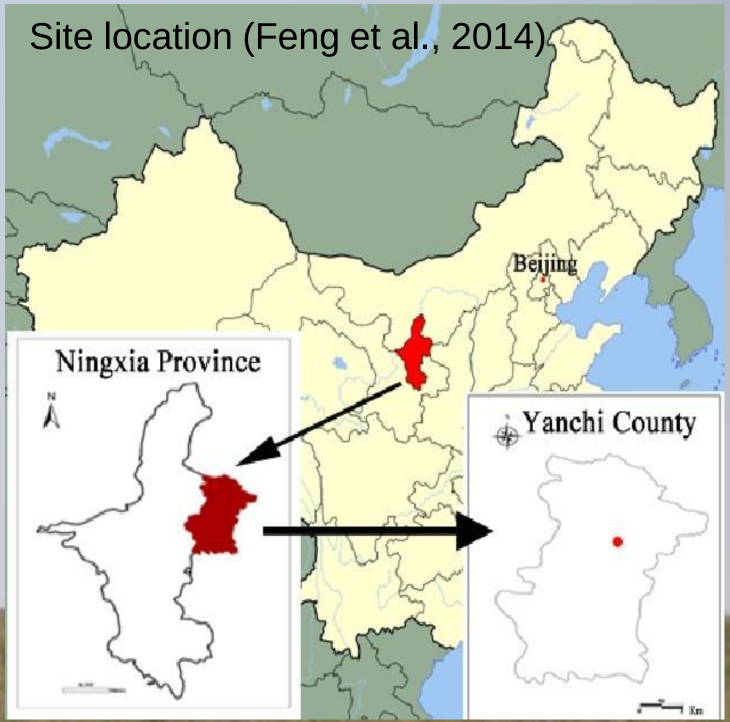
微气象观测

NDVI

02. MATERAILS AND METHODS

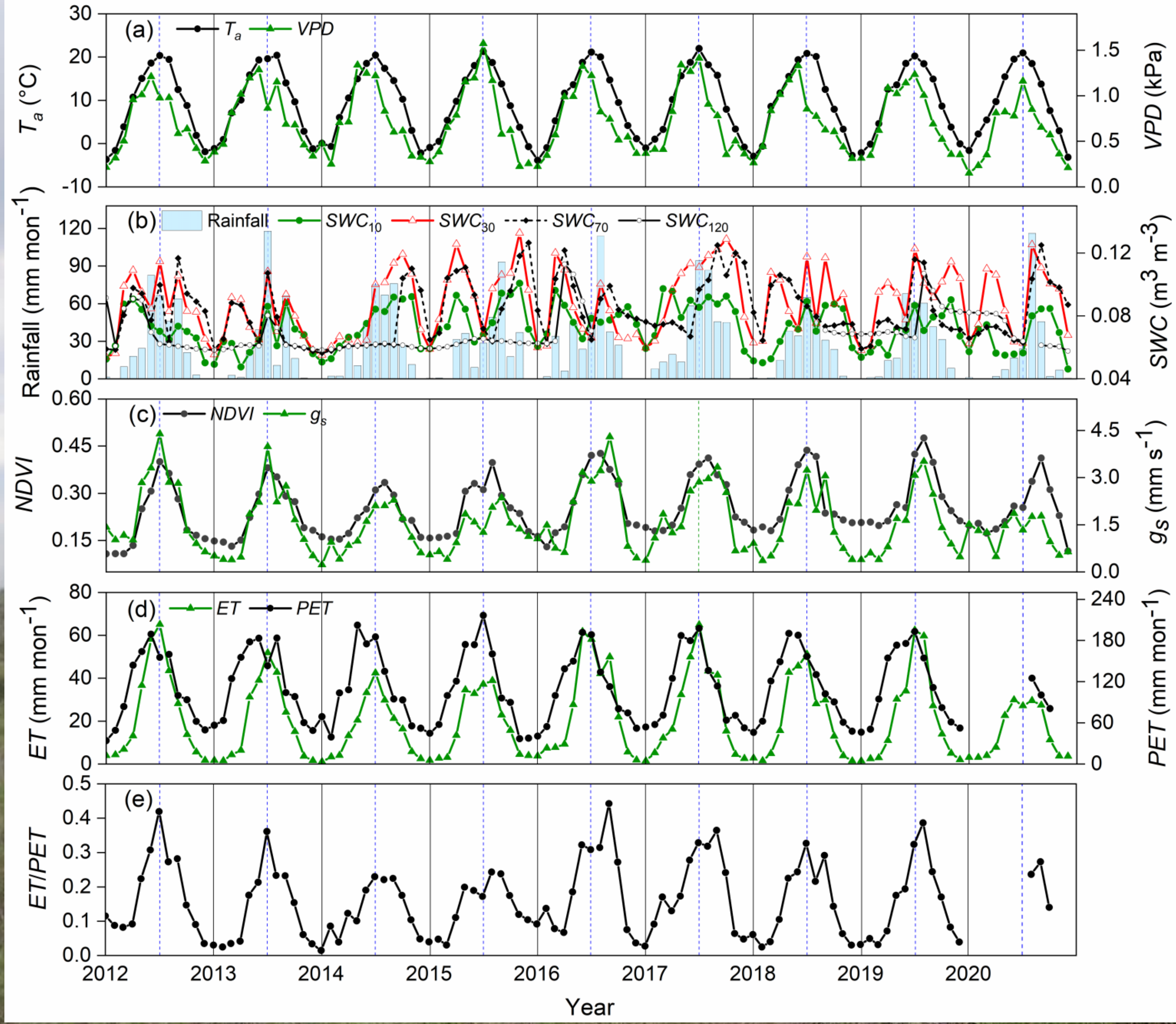
Site information

- **Location:** 37°43’N, 107°14’E, 1550 m a.s.l.
- **Climate:** mid-temperate semiarid continental
- **MAT:** 8.1 °C
- **MAP:** 287 mm (60% in summer)
- **PET:** 2024 mm



Temporal variations in monthly ET and biophysical factors during 2012–2020.

03. RESULTS



Rainfall showed large variability across years in terms of both amount and seasonality (MAP 293 mm, CV: 15.8%).

NDVI and $\mathbf{g_s}$ showed clear seasonal cycles and large interannual variations.

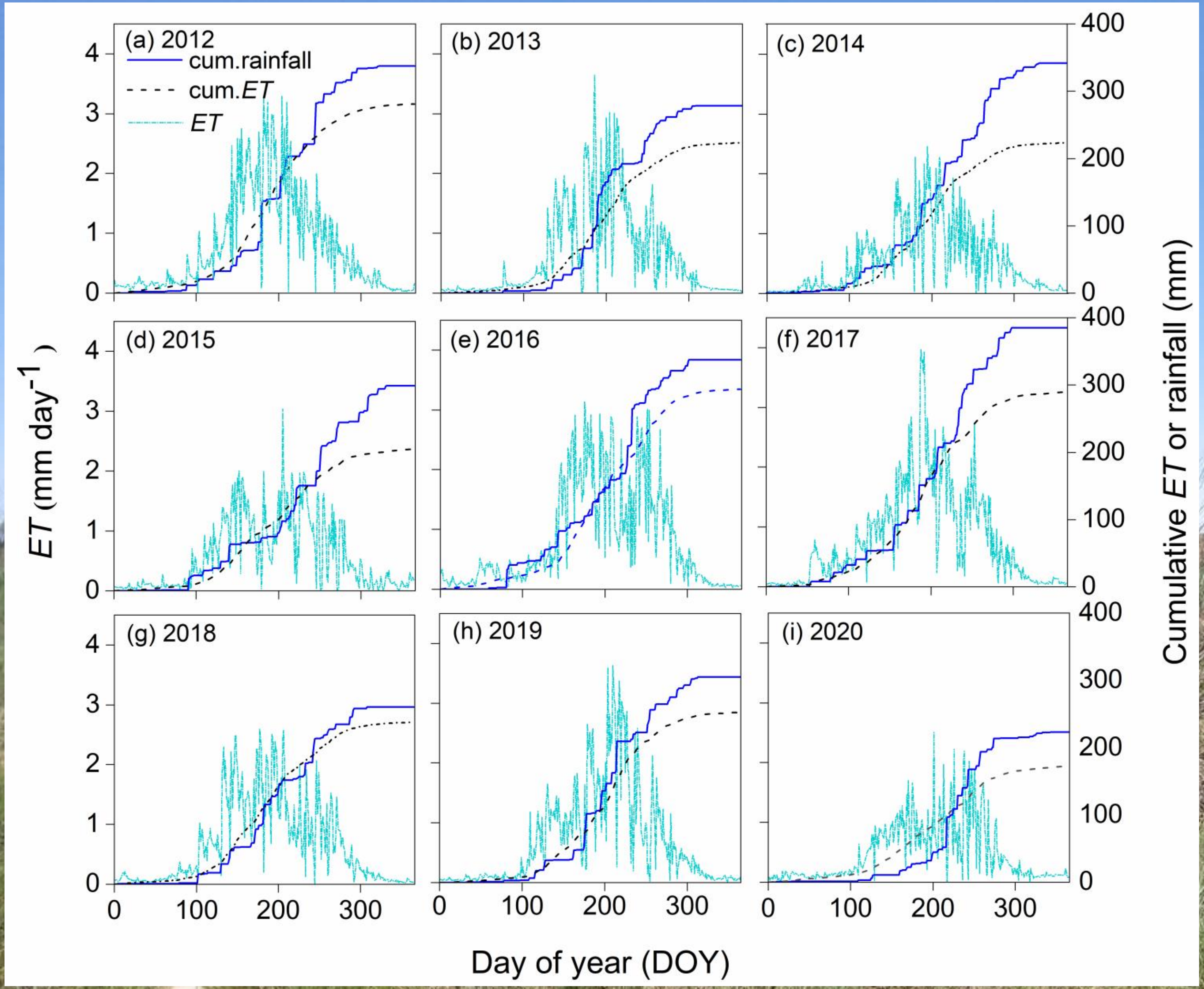
Annual ET varied from 173 mm yr^{-1} in 2020 to 297 mm yr^{-1} in 2016, with an average of 240 mm yr^{-1}, showed a CV of 18%.

Annual PET had similar annual cycles across years, with an average annual value of 1328 mm yr^{-1} and a CV of 3%.

ET/PET followed a pattern similar to that of ET.

Temporal dynamics of daily ET, cumulative ET (cum. ET), and cumulative rainfall (cum. rainfall) during 2012–2020.

03. RESULTS

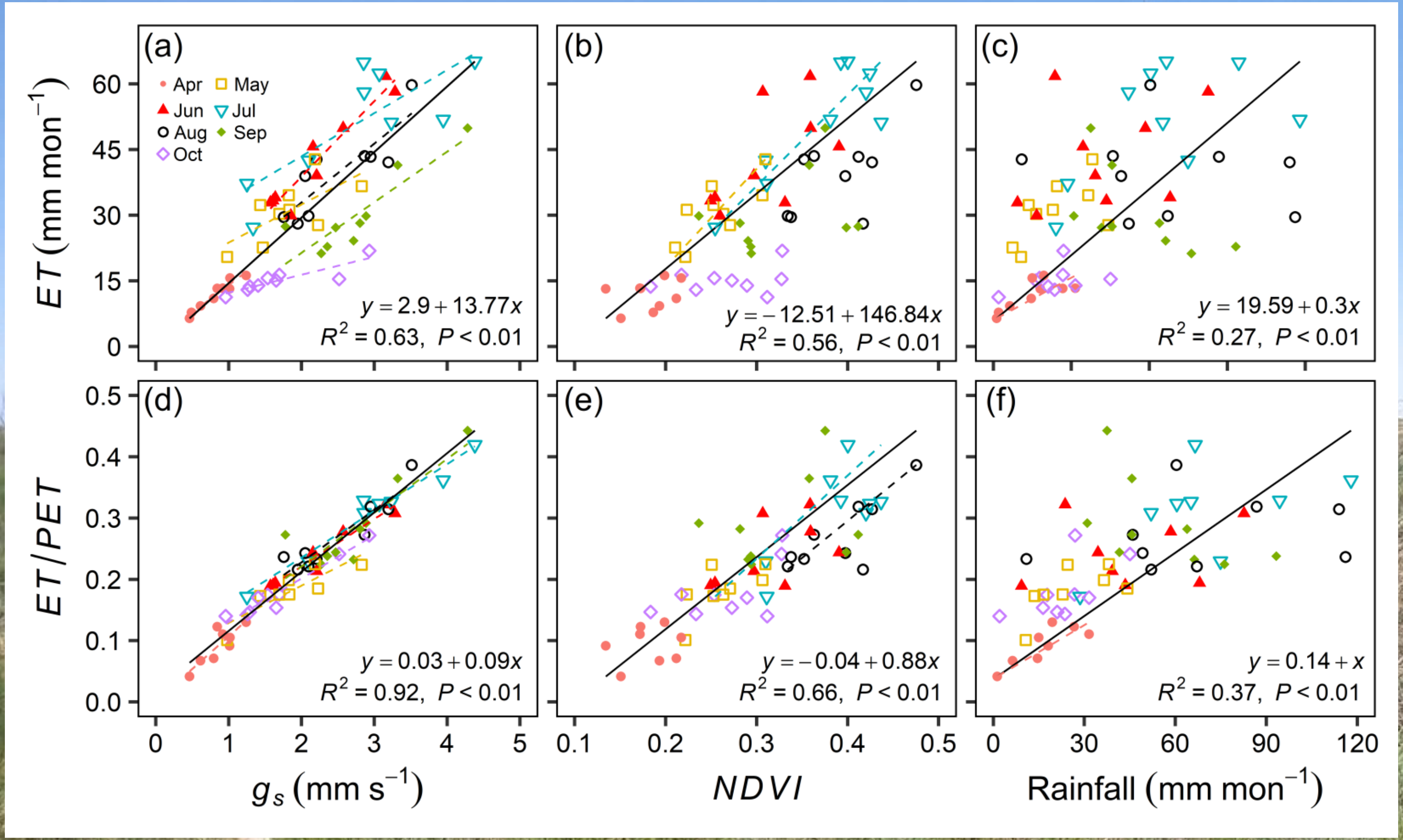


Annual difference between rainfall and ET varied from 23 mm in 2018 to 148 mm in 2014.

Cumulative ET was close to or slightly higher than cumulative rainfall during January–July, but was much lower than cumulative rainfall during the second half of the year.

03. RESULTS

Relationships of monthly ET (a–c) and monthly ET/PET (d–f) with monthly g_s, mean NDVI, and rainfall during the growing season (April – October) of 2012–2020.



Seasonal:

Monthly ET and ET/PET increased with g_s, NDVI, and rainfall during the growing season.

Seasonal variations in ET was driven mostly by biotic factors (ET = 0.53NDVI + 0.37g_s, $P < 0.01$, $R^2 = 0.69$).

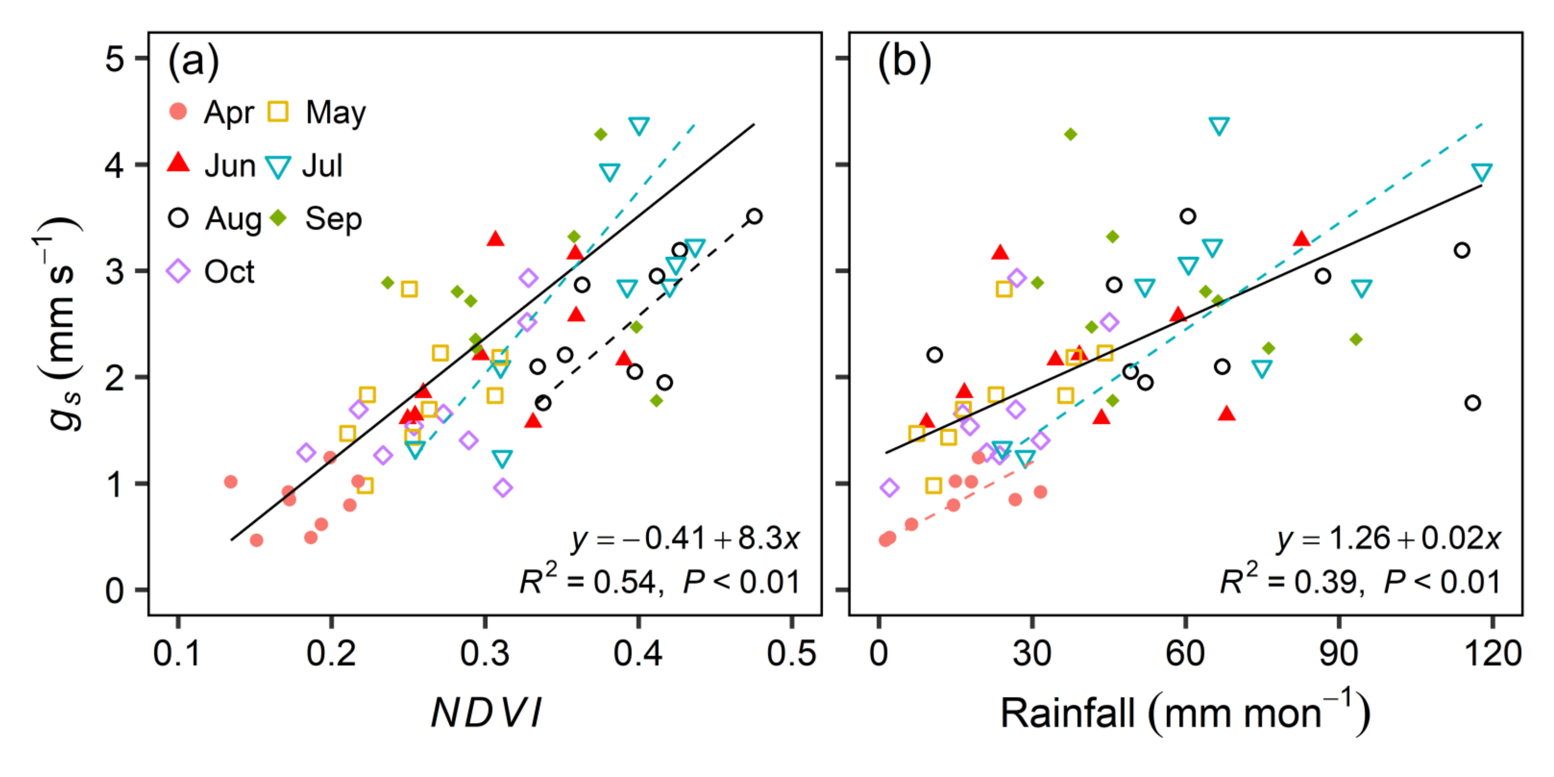
Interannual:

Both monthly ET and ET/PET for each month during the growing season increased interannually with g_s.

Monthly ET increased interannually with NDVI for May and July, and with rainfall for April.

Monthly ET/PET increased interannually with NDVI for July and August, and rainfall for April.

03. RESULTS



Relationships of monthly g_s with (a) NDVI and (b) rainfall during the growing season (April–October) of 2012–2020.

Seasonal:

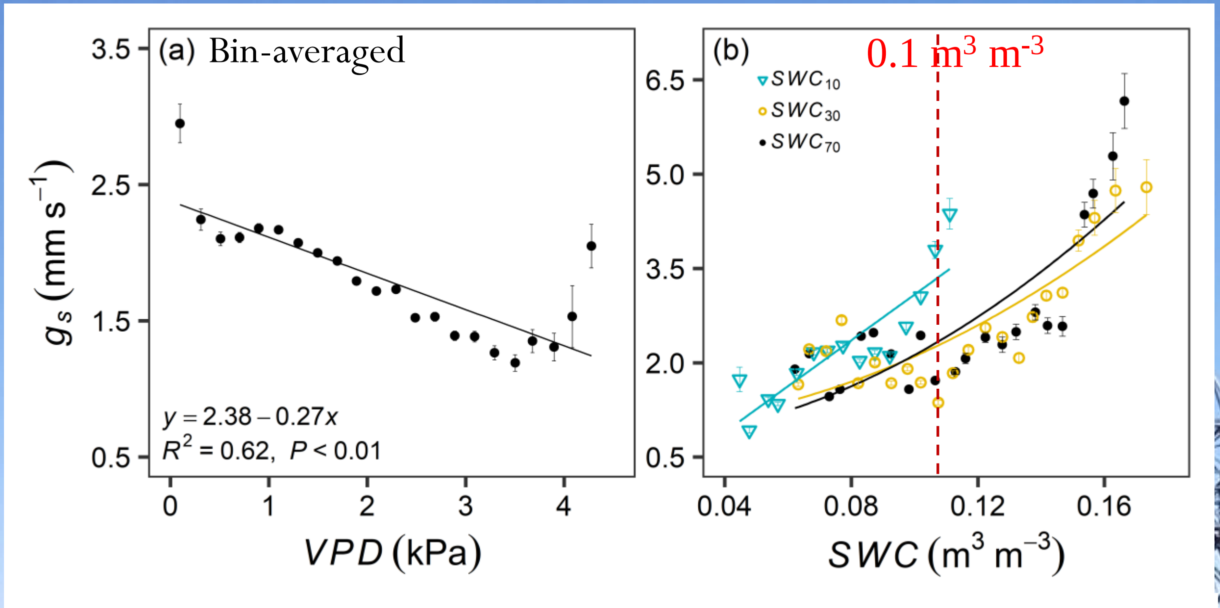
Higher monthly NDVI and rainfall led to higher monthly mean g_s.

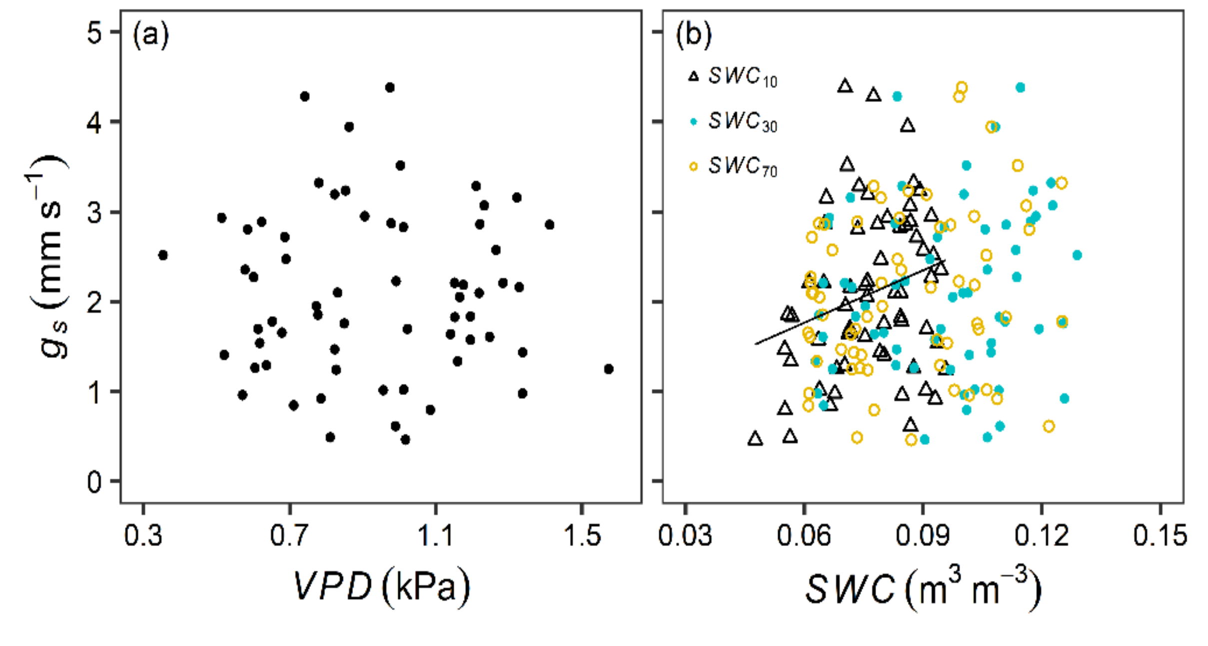
Interannual:

Monthly mean g_s increased with NDVI for July and August, and with rainfall for April and July across years.

03. RESULTS

Relationships of g_s with (a) VPD and (b) SWC at 10, 30, and 70 cm depth (SWC_{10}, SWC_{30}, and SWC_{70}, respectively) during the growing season (April–October) of 2012–2020.





Monthly g_s

- not correlated with monthly VPD and SWC.

Daily g_s

- not correlated with daily VPD, SWC_{30} and SWC_{70}.
- correlated with daily SWC_{10}.

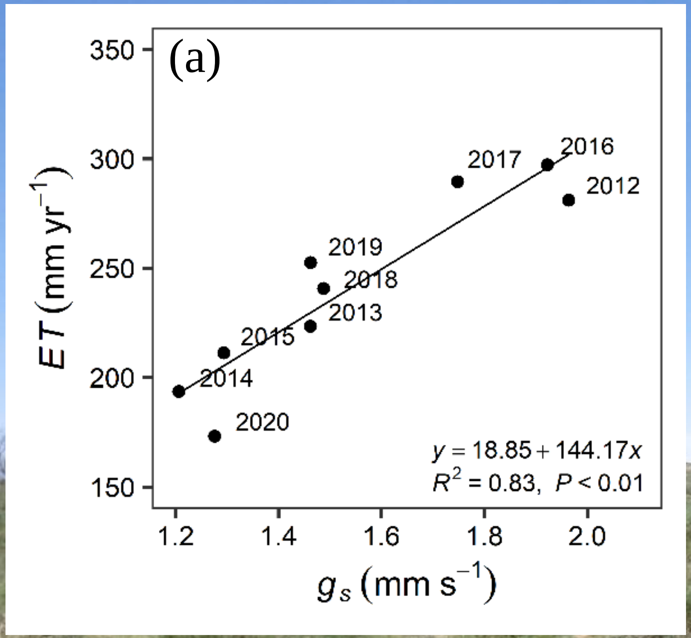
Bin-averaged half-hourly g_s

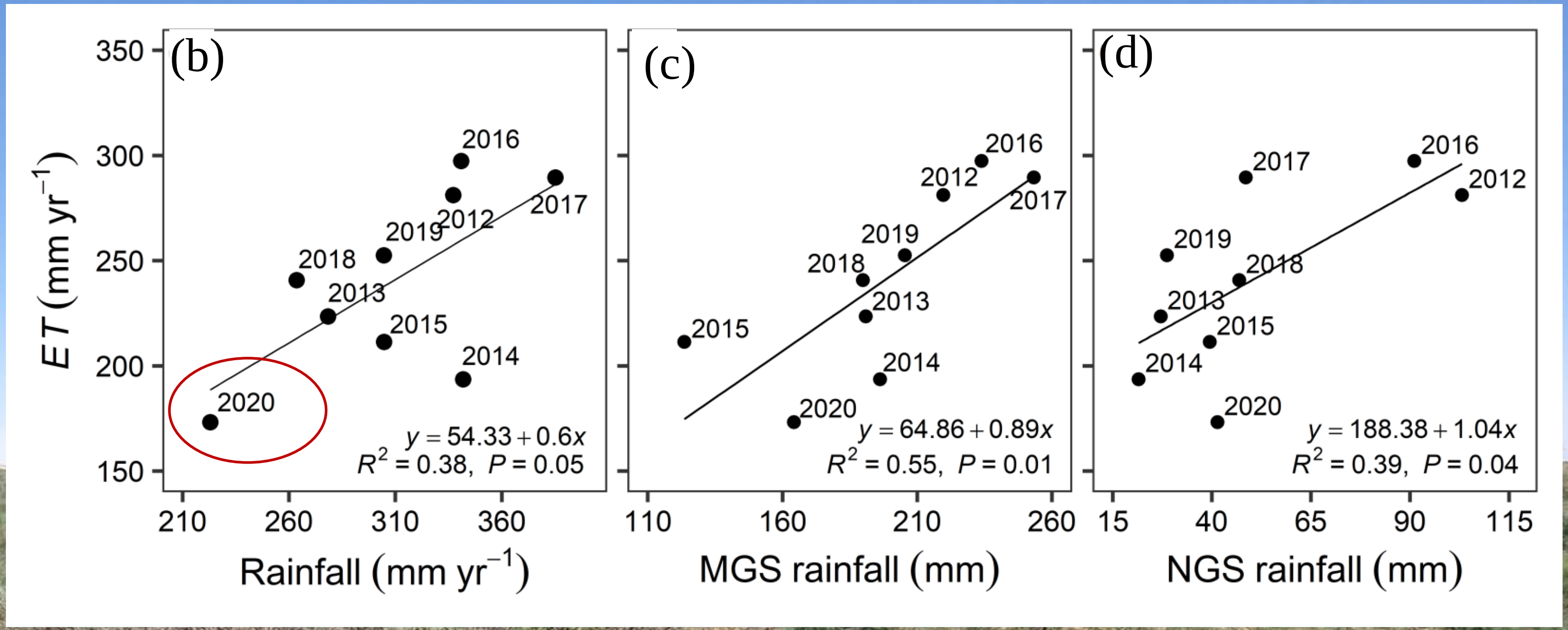
- decreased significantly with increasing VPD during the growing season.
- increased with SWC_{10}, SWC_{30}, and SWC_{70}, but not with SWC_{120}.

Atmospheric evaporative demand and soil moisture mainly affected g_s over short timescales, while their effects on monthly mean g_s can be confounded by multiple factors (e.g., temperature, radiation, precipitation, and canopy greenness).

Soil and atmospheric dryness played an indirect role in regulating the seasonal variations in ET

Relationships of annual ET with (a) annual g_s and (b) rainfall, (c) mid-growing-season rainfall (May–August, MGS rainfall), and (d) non-growing-season rainfall (from previous October to current March, NGS rainfall) across 2012–2020.





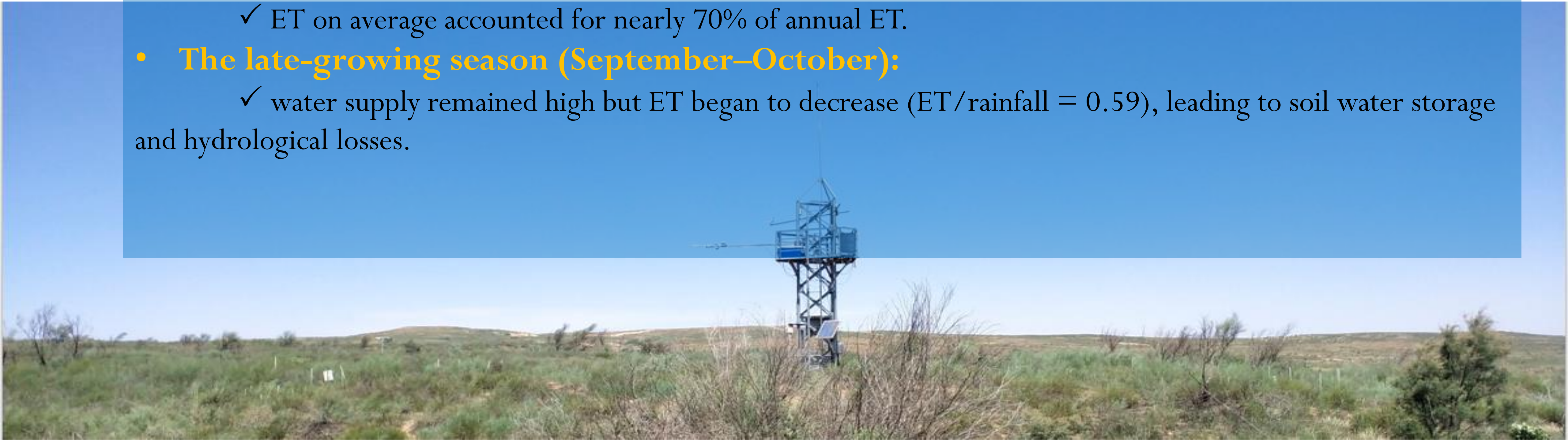
- Annual ET showed a strong positive correlation with annual mean g_s.

- Annual ET showed only a marginally significant correlation with annual total rainfall, and the two variables became decoupled after the data point for 2020 was excluded ($R^2 = 0.10$, $P = 0.23$).
- Annual ET was more closely related to MGS rainfall and NGS rainfall than to annual total rainfall, rainfall seasonality in affecting the interannual variations in ET.

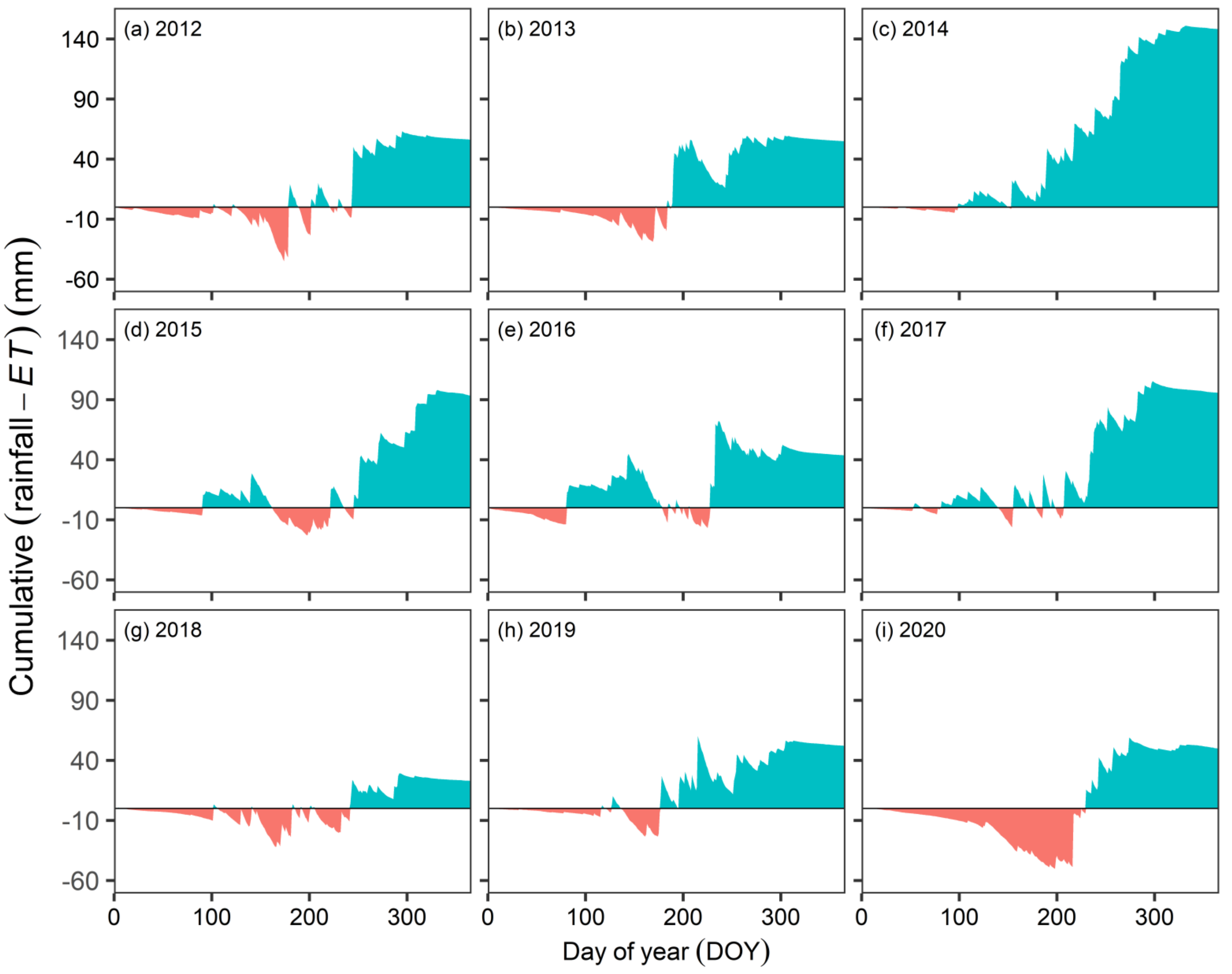
03. RESULTS

- **WHY**: Annual ET was more closely related to MGS rainfall and NGS rainfall.
- water supply and consumption are not always in perfect synchrony.

- **The early-growing season (April):**
  - ✓ high *ET* but low rainfall (*ET*/rainfall = 1.42).
- **The mid-growing season (May to August):**
  - ✓ high water supply but even higher demand (ET/rainfall = 0.85).
  - ✓ ET on average accounted for nearly 70% of annual ET.
- **The late-growing season (September–October):**
  - ✓ water supply remained high but ET began to decrease (ET/rainfall = 0.59), leading to soil water storage and hydrological losses.



03. RESULTS



Temporal dynamics of the difference between cumulative rainfall and cumulative ET during 2012–2020.

The annual difference between rainfall and ET varied from 23 mm in 2018 to 148 mm in 2014.

The imbalance between annual ET and rainfall may be ascribed

- 1) energy balance closure may lead to an underestimation of ET up to about 20%;
- 2) possible lateral water flow after heavy rain events;
- 3) part of water input may be stored in soil or percolated to deep layers.

04. CONCLUSIONS

- Seasonal variations in ET were mainly regulated by biotic factors such as NDVI and g_s, the latter of which was in turn controlled by soil and atmospheric dryness.
- Interannual variations in ET were related to MGS rainfall, NGS rainfall, and gs. MGS rainfall alone explained more than half of year-to-year differences in annual ET.
- Our findings highlight the importance of biological processes (e.g., canopy development and physiological responses) in regulating ET at the seasonal scale and of climatic factors (e.g., precipitation) in affecting ET at the interannual scale.
- Seasonality of precipitation be adequately considered in predicting ecosystem functioning in semi-arid shrublands.

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Thanks for your attention !