Understanding the Effects of Re-vegetation on Energy, Water and Carbon Fluxes Using STEMMUS-SCOPE Model: A Case Study in a Desert Steppe Ecosystem

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Motivation

Eddy Covariance Tower and vegetation in July 2022

- Re-vegetation: planting shrubs in the desert (steppe) regions, to combat soil erosion and desertification.
- Conserve soil? or Deplete soil water?

Research questions:

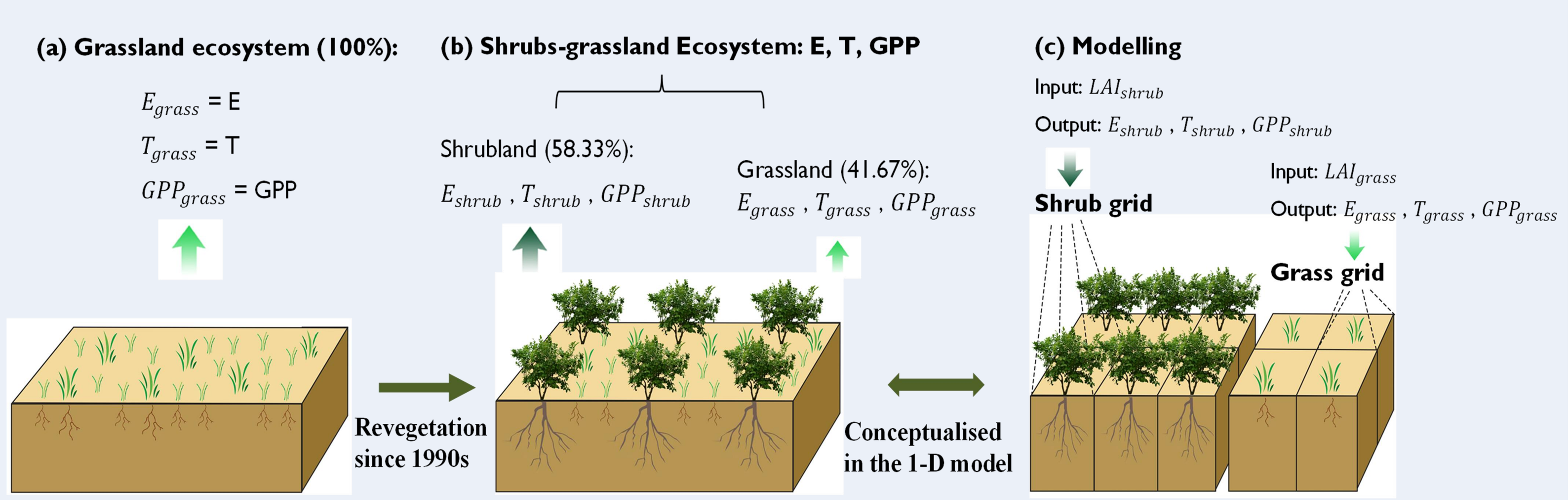
1. To what extent the STEMMUS-SCOPE can represent the ecohydrological process in this mixed land covers area?
2. What are the main components in energy, water and carbon cycles that were affected by the re-vegetation? How does their temporal variability appear?

Experimental Set up

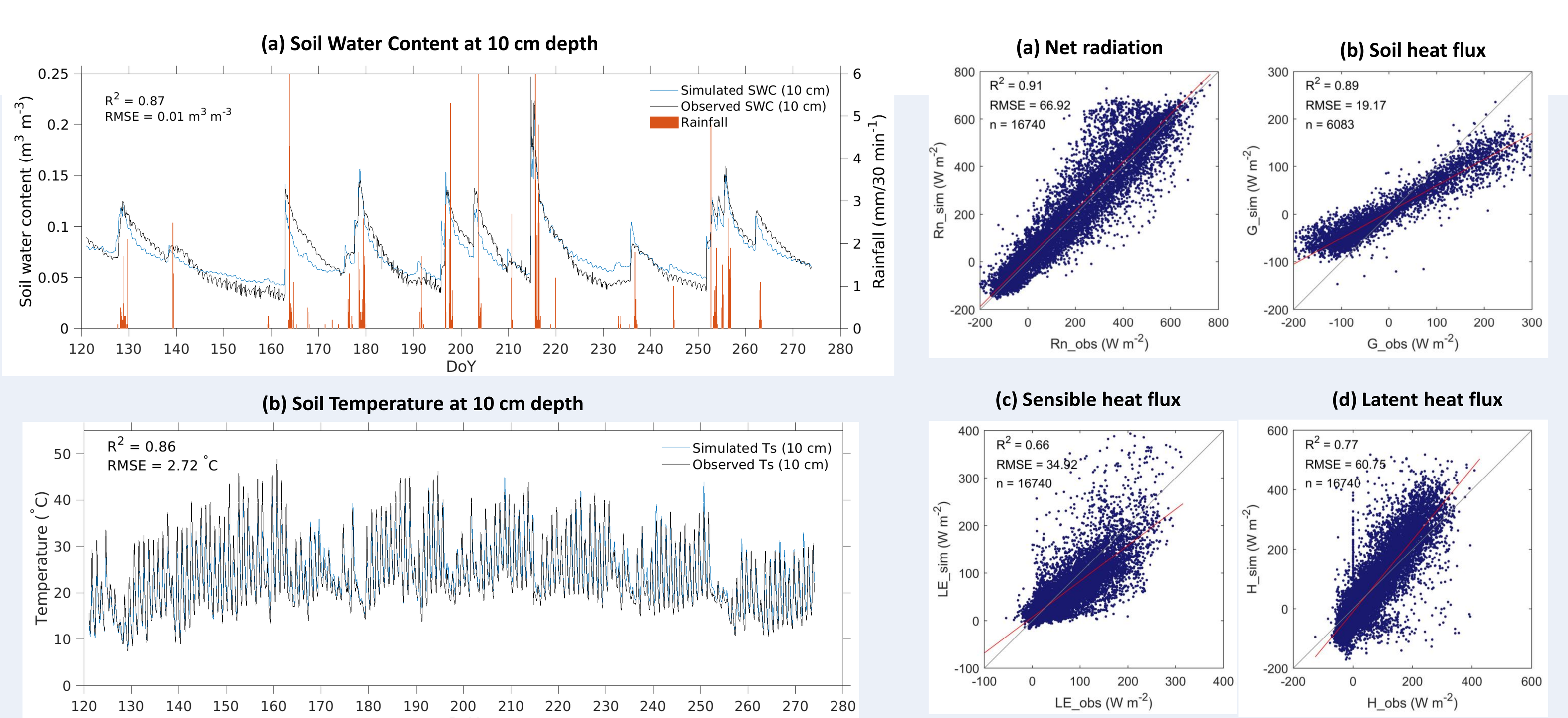
1. Scenarios design: (a) Before the re-vegetation (b) After re-vegetation.

2. Configurations in (c) STEMMUS-SCOPE model:

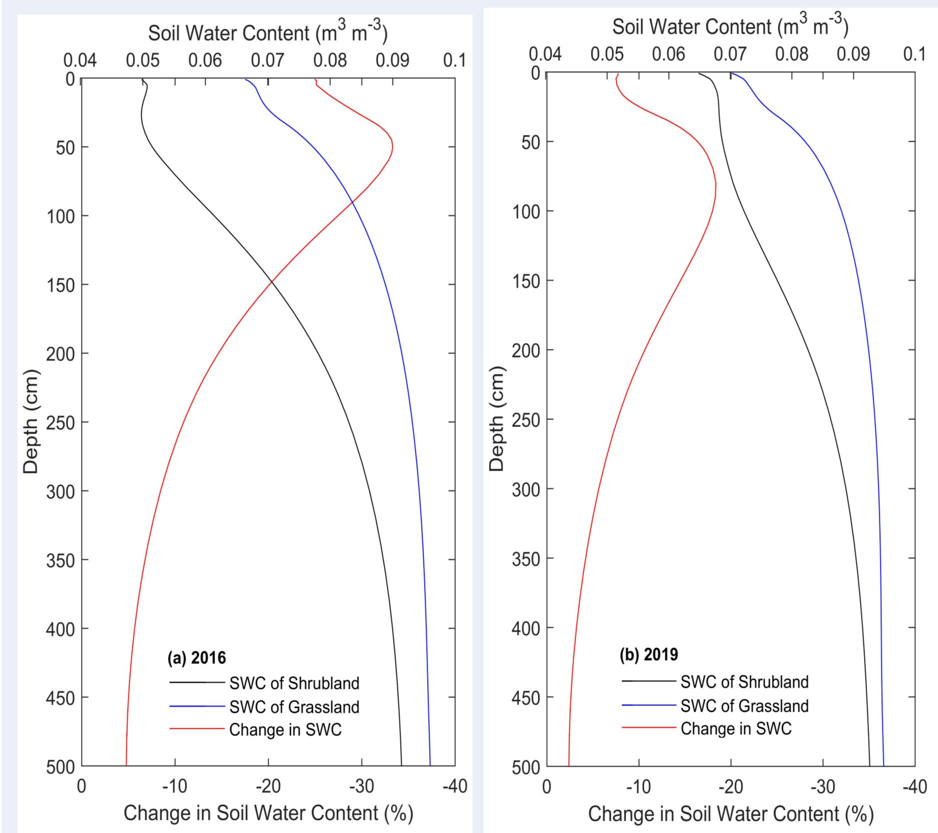
- INPUT: LAI, meteorological forcings, plant traits parameters;
- RUN: Simulated the shrub grid and grass grid respectively and aggregated their output according to the sum weighted by their contributions.



Model Validation



Water Flux



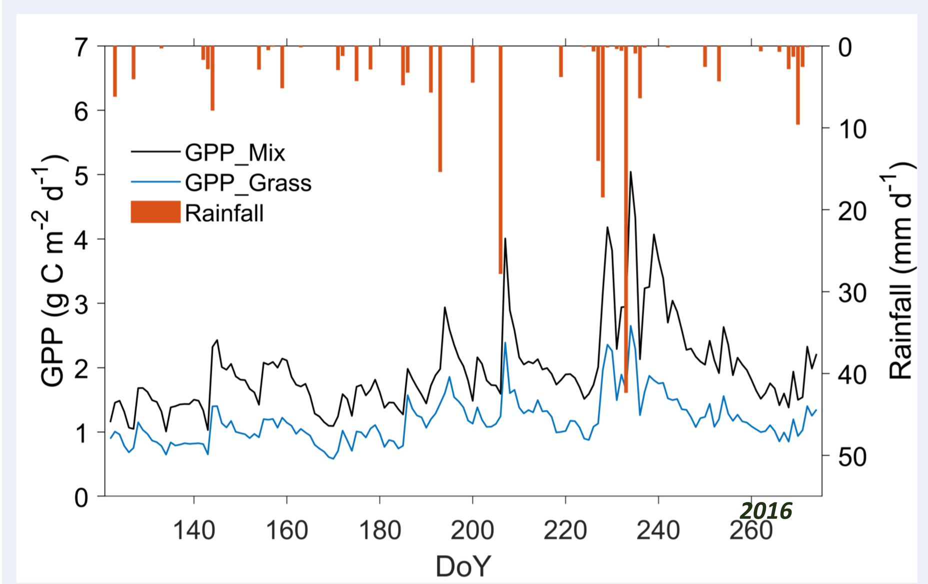
Soil water content

- **SWC decreased** in every soil layer after planting shrubs, especially **at 0-200 cm depth (decreased by 19%).**

Evaporation and Transpiration

- In grassland ecosystem: contributions of evaporation (~ 71 %) and transpiration (~ 29 %) to total ET, as well as averaged SWC remained stable in two years.

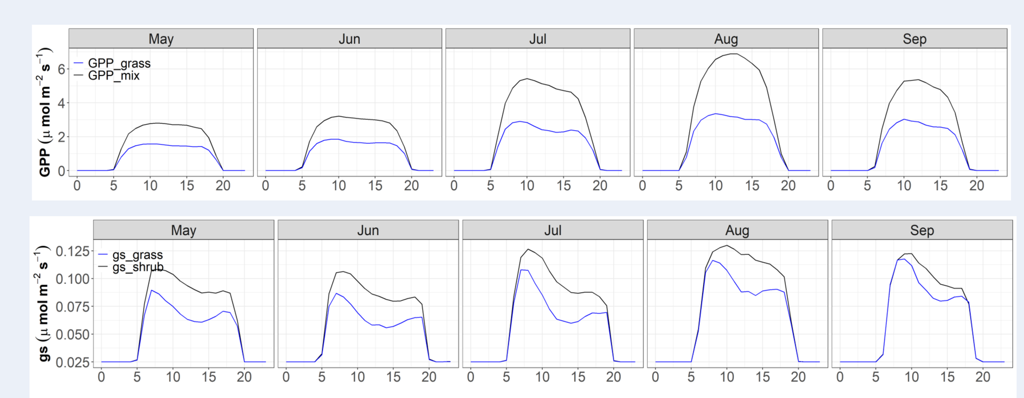
Carbon Flux



Daily Gross Primary Productivity

- **Comparison between ecosystems,** for shrubs-grassland ecosystem:
  - GPP was more responsive to the rainfall;
  - Seasonal GPP increased by **82%.**
- **Comparison between dry and wet years:** Shrubs-grassland ecosystem assimilated **24%** more carbon than in the wetter year 2019.

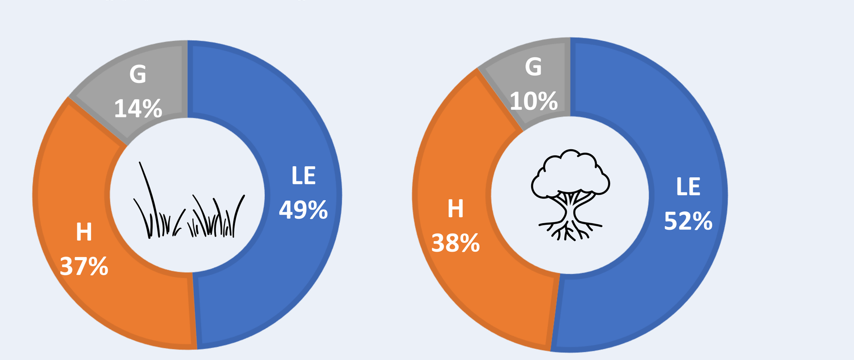
Diurnal GPP and gs



- Larger monthly variation and amount of GPP in shrubs-grassland ecosystem.
- STEMMUS-SCOPE can capture the midday depression phenomenon, reflected by the drop of stomatal conductance (gs).

Energy Flux

Energy partitioning: Ratio between net radiation



Significant changes in latent heat flux and soil heat flux

For more information

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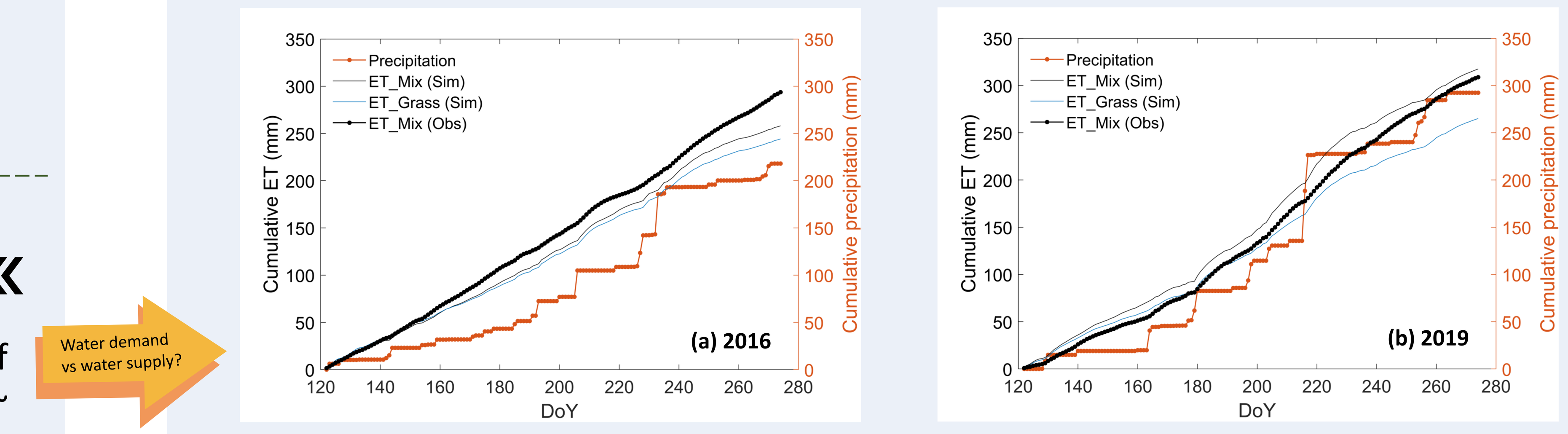
| Source code for STEMMUS-SCOPE

Implication

- The cumulative evapotranspiration (ET) of shrubs-grassland ecosystem **exceeded the precipitation**, suggests an **additional water source** for ET.

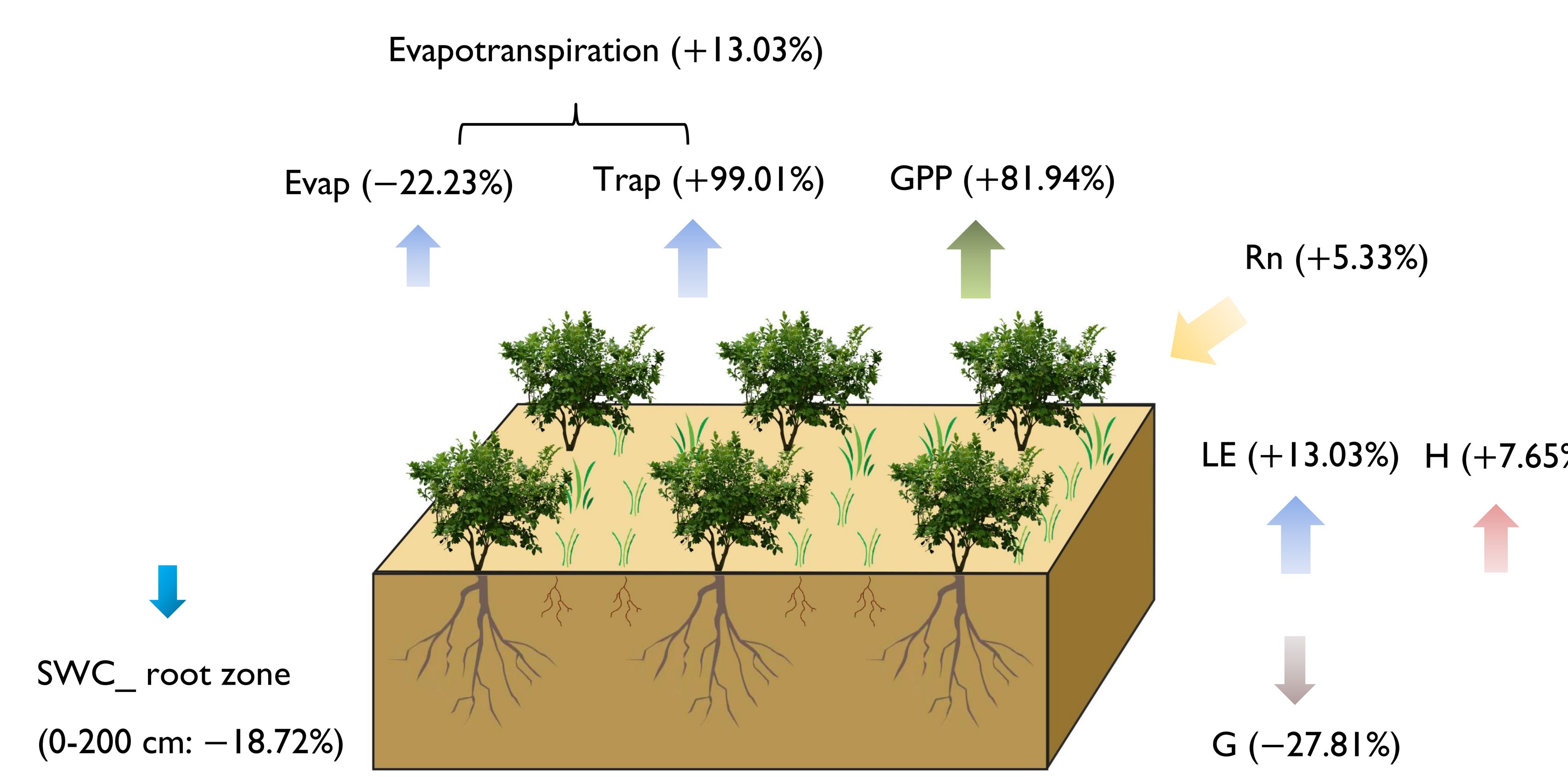


The drier the year, the more water drainage from the deep soil, with the evidences of:

- Larger reduction on SWC in 2016 ;

- Larger gap between cumulative ET and precipitation in 2016.

Conclusions



Re-vegetation caused the:

- **Increase in LE** and H and **decrease in G;**
- Decrease in SWC at 0-500 cm soil depth (especially 0-200 cm) via **root water uptake**;
- Excessive water consumption, with a **remarkable increase in transpiration**;
- **Imbalance** of the water cycle, manifested by **greater ET than received precipitation**.

Moreover, the above effects were more pronounced in the drier year. Future re-vegetation practice should be cautiously applied, especially under prevailing droughts and heatwaves.