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Quantifying the long-term changes of land water availability and their driving factors

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Motivation

- ✓ Fresh water is one of the key natural resources for human development and its availability affects water supplies, agricultural yields, energy production, and infrastructure safety and operation.
- ✓ However, the investigation of long-term changes of water availability (WA) and quantification of their natural and anthropogenic drivers remain challenging.

Methods

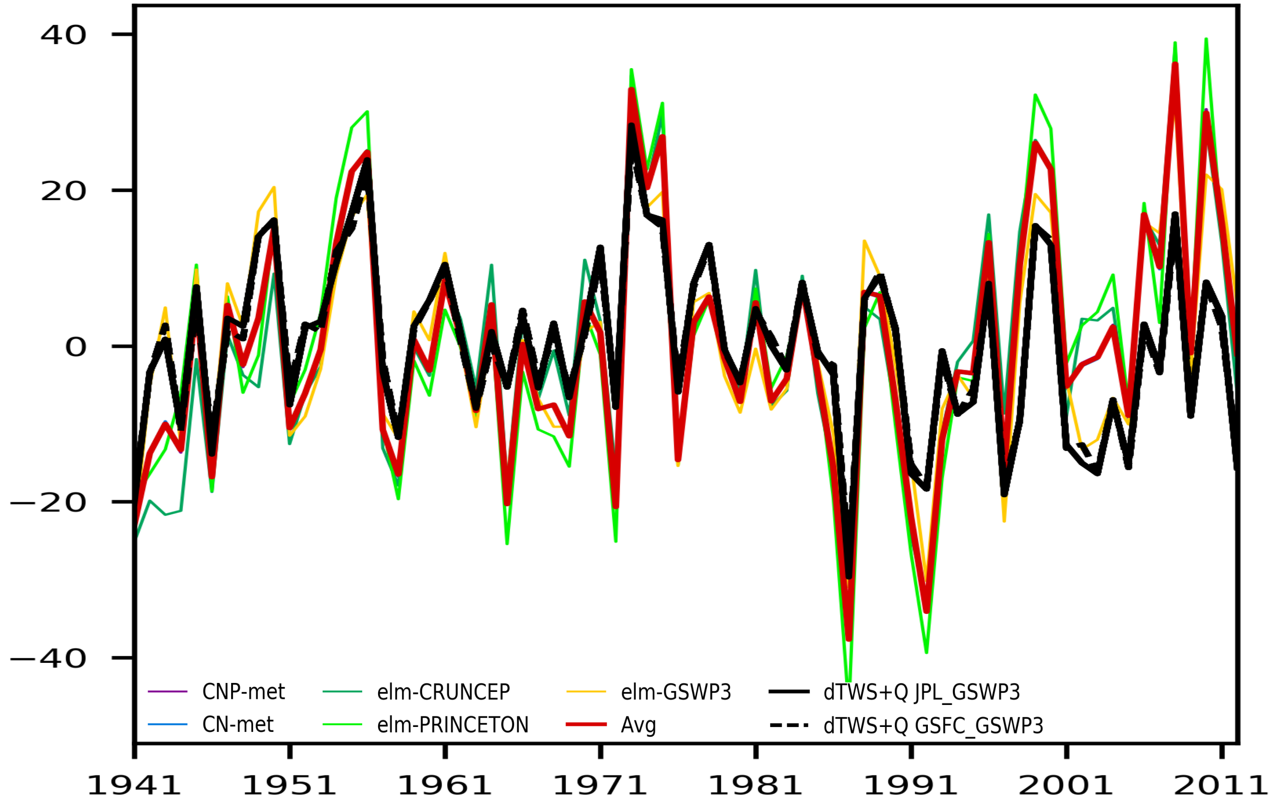
- ✓ The GRACE reconstructions for both *R* and *ΔTWS* (Ghiggi et al., 2019; Humphrey and Gudmundsson, 2019), and the land WA is defined as

$$P - ET = R + \Delta TWS$$

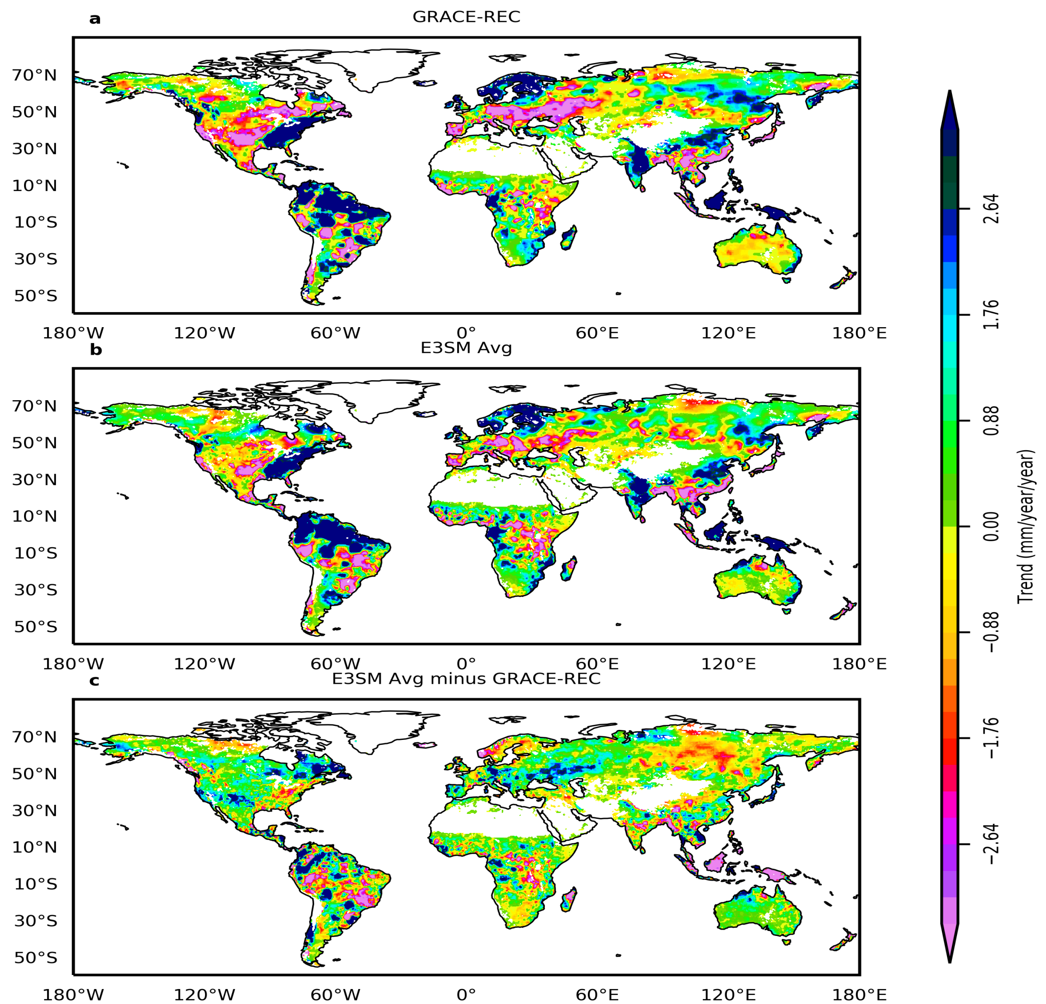
- ✓ 36 half-degree global offline factorial (S1 to S6) simulations of ELMv1.0 with CN or CNP configurations driven by 3 different climatic drivers (right table).

Simulations	Climate forcing		
CNP and CN	GSWP3	CRUNCEP	PRINCETON
S1	Control, 1901-1920 climate cycling and 1850 conditions		
S2	Transient climate only (CN and CNP)		
S3	Transient climate and LULCC		
S4	Transient climate, LULCC and CO_2		
S5	Transient climate, LULCC, CO_2 and Ndep		
S6	Transient climate, LULCC, CO_2, Ndep and aerosol		
S2-S1	Climate only		
S3-S2	LULCC only		
S4-S3	CO_2 only		
S5-S4	Ndep only		
S6-S5	Aerosol only		

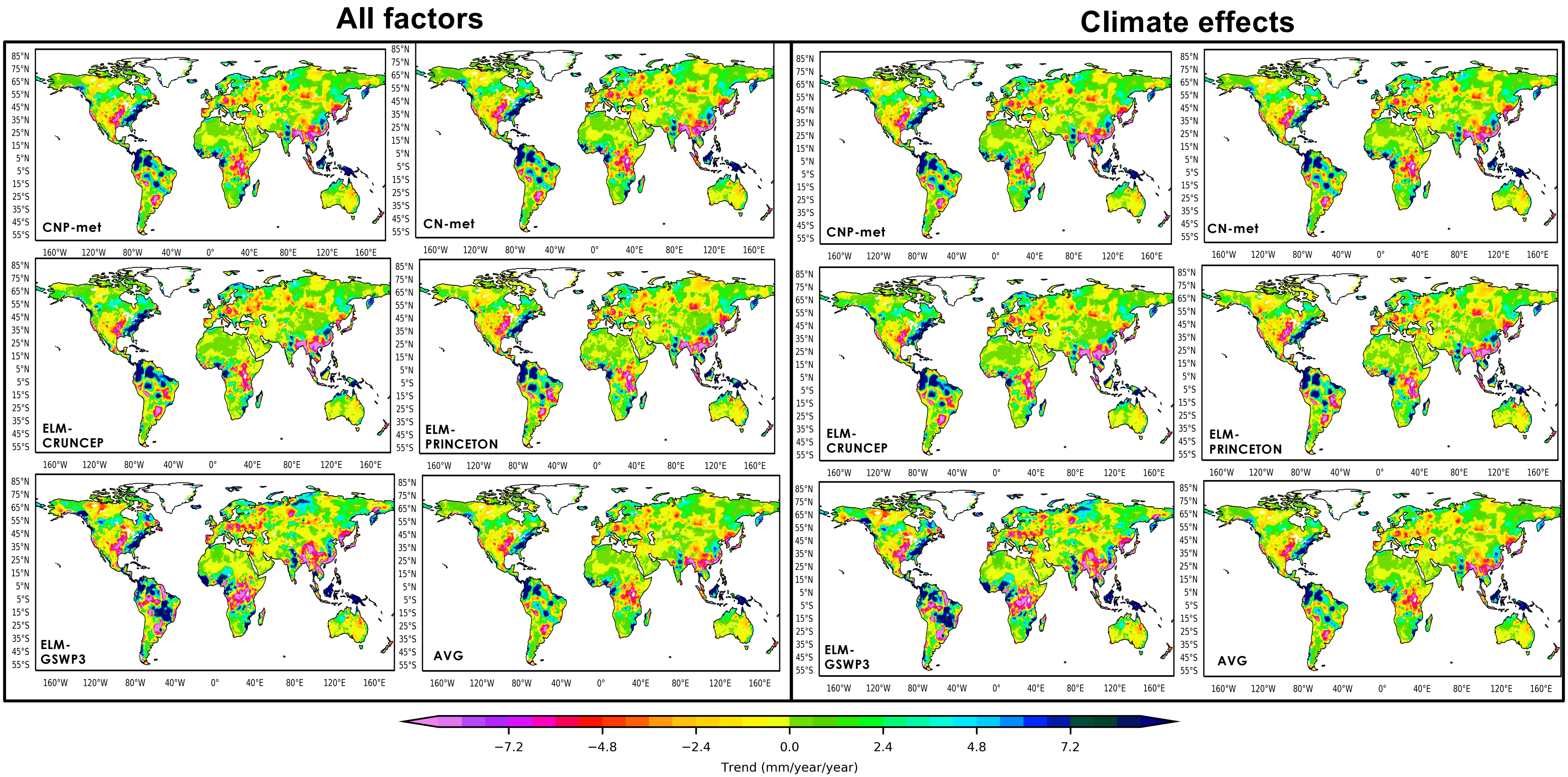
ELM Experimental design



Observed and ELM simulated (S6) annual anomalies (mm) of land WA during 1941-2012



Spatial distributions of observed and ELM simulated (S6) WA trends and their differences (1941-2012)



Spatial distributions of ELM simulated all-factor (left) or climate (right) induced WA changes

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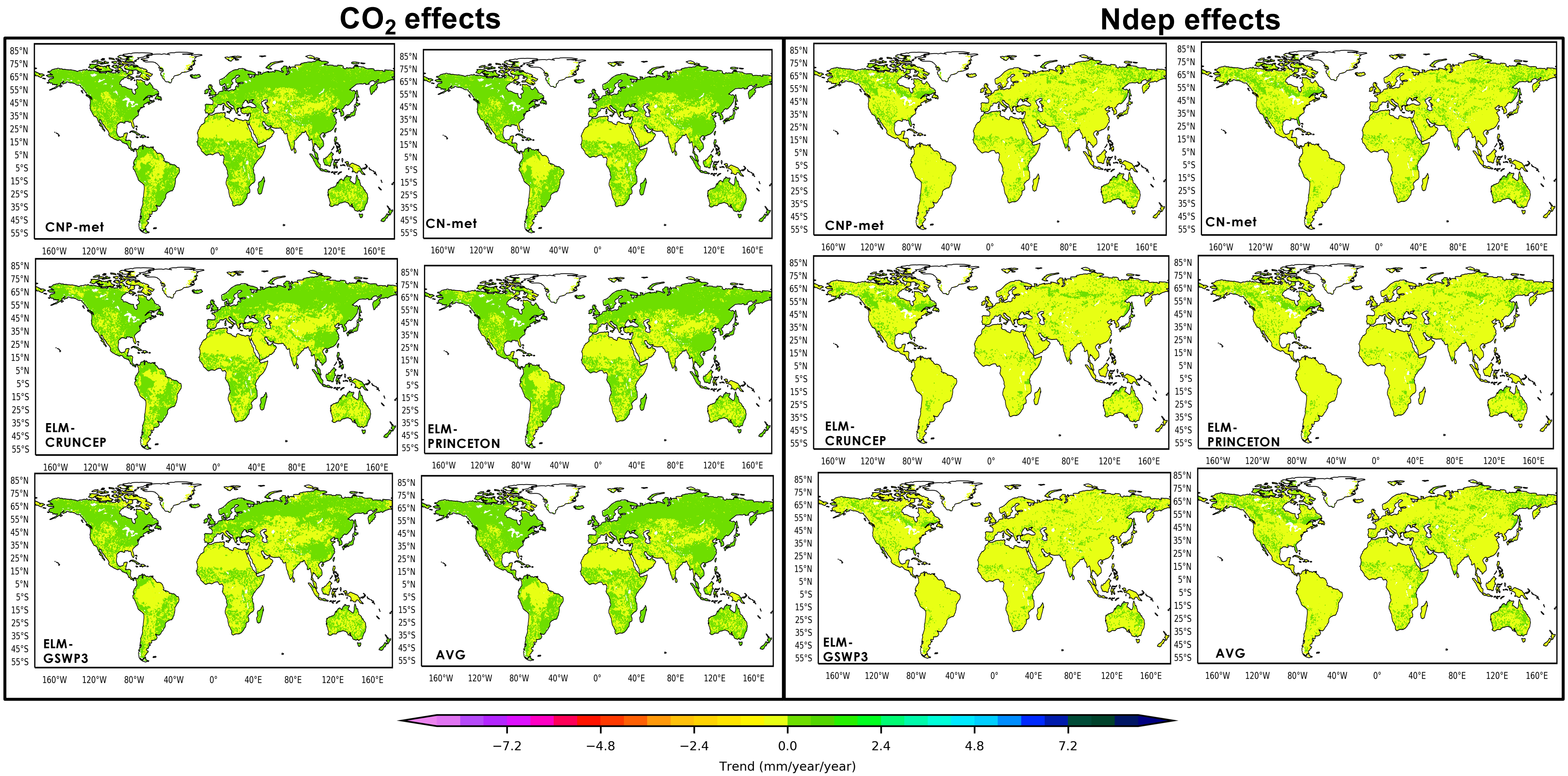

Spatial distributions of ELM simulated CO_2 (left) or Ndep (right) induced WA changes

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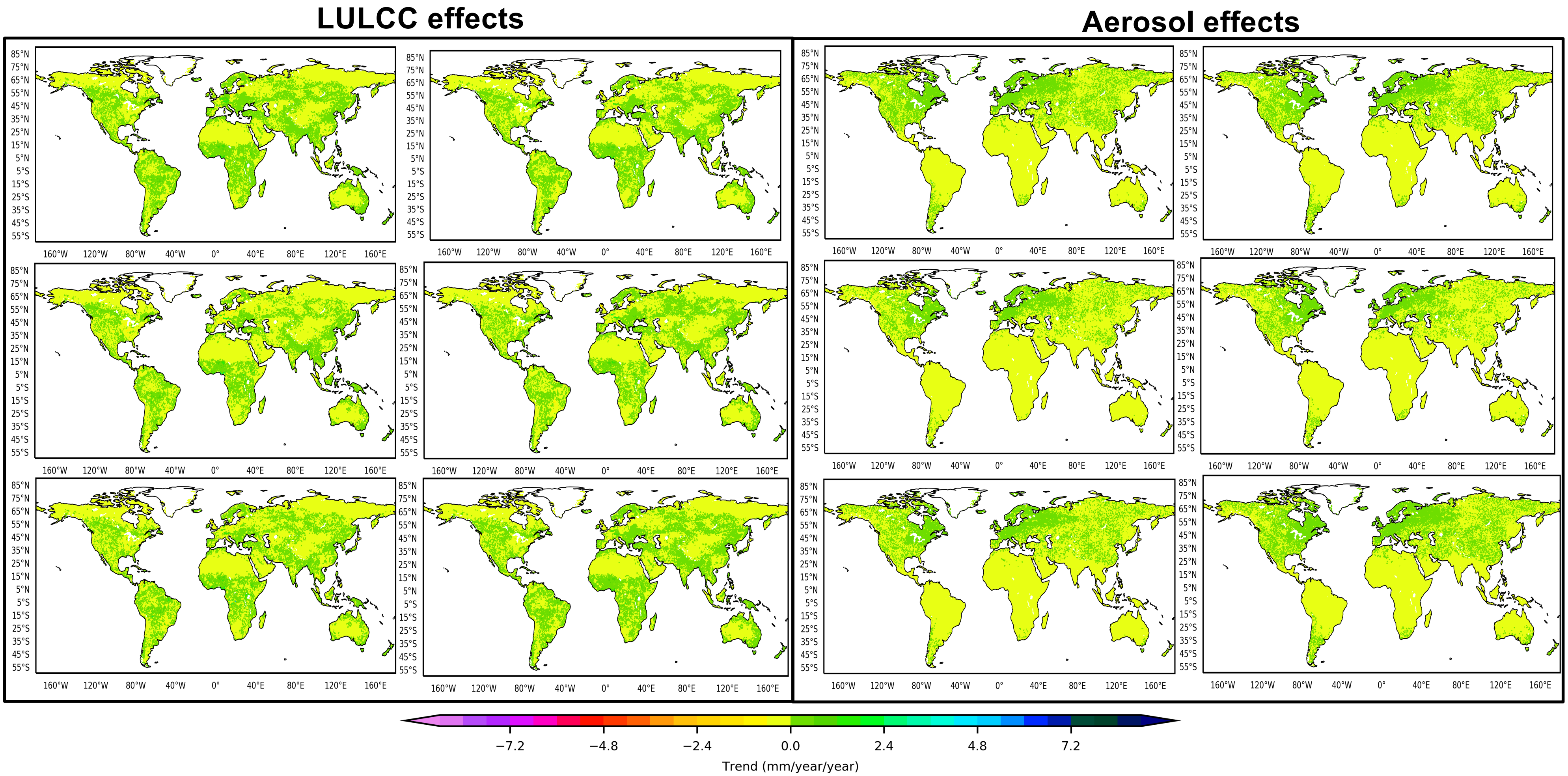
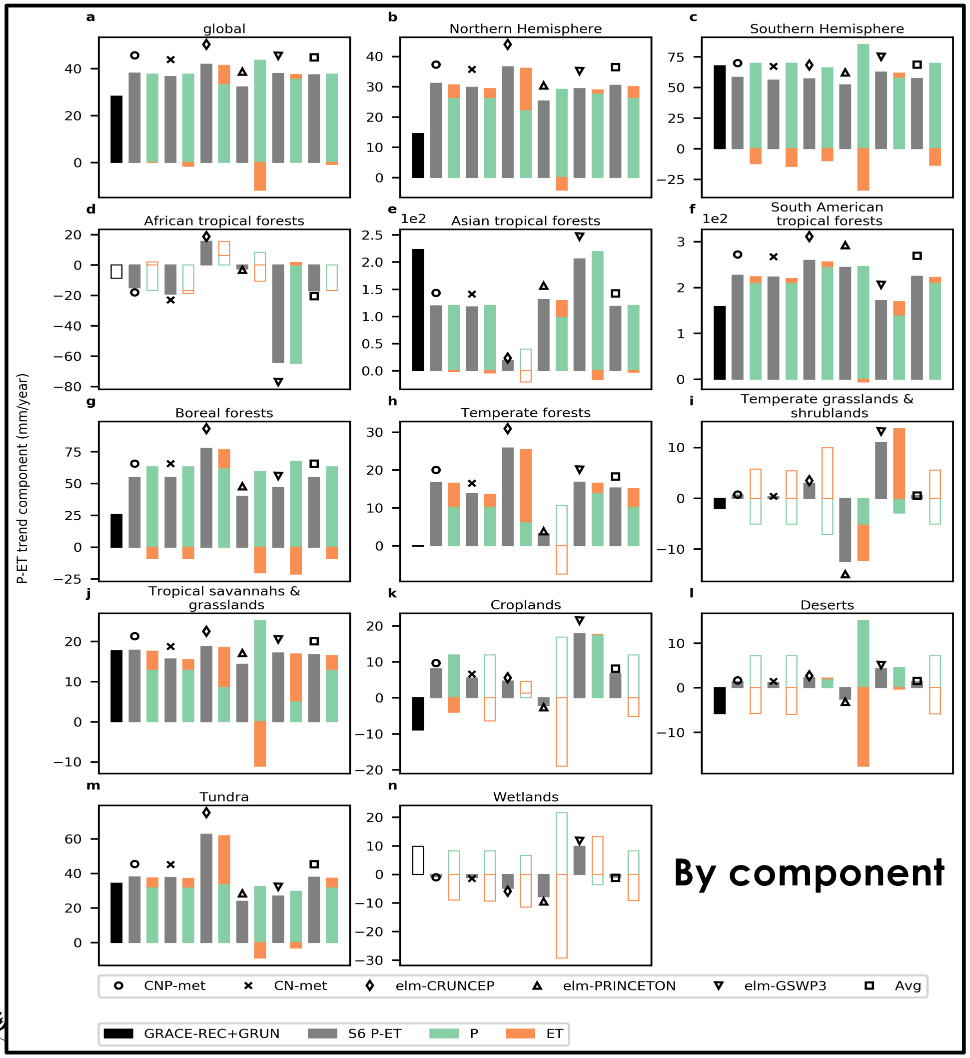
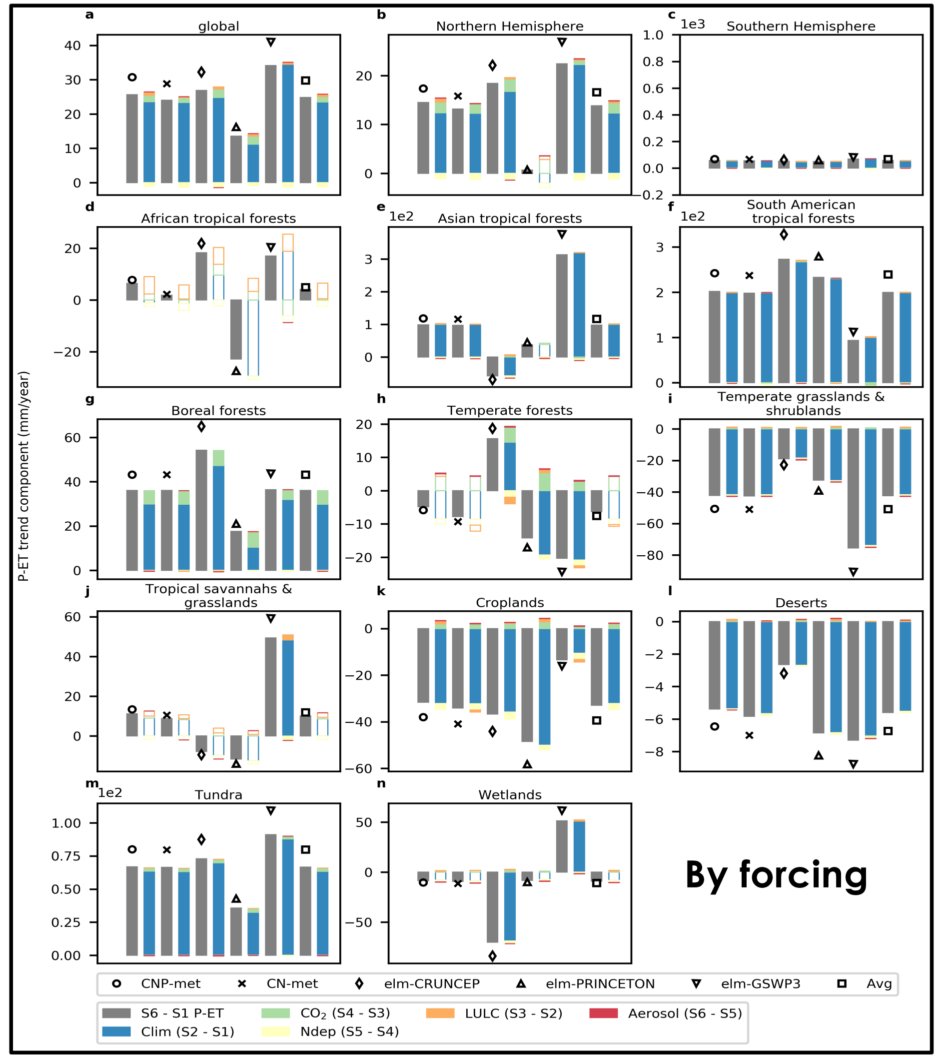
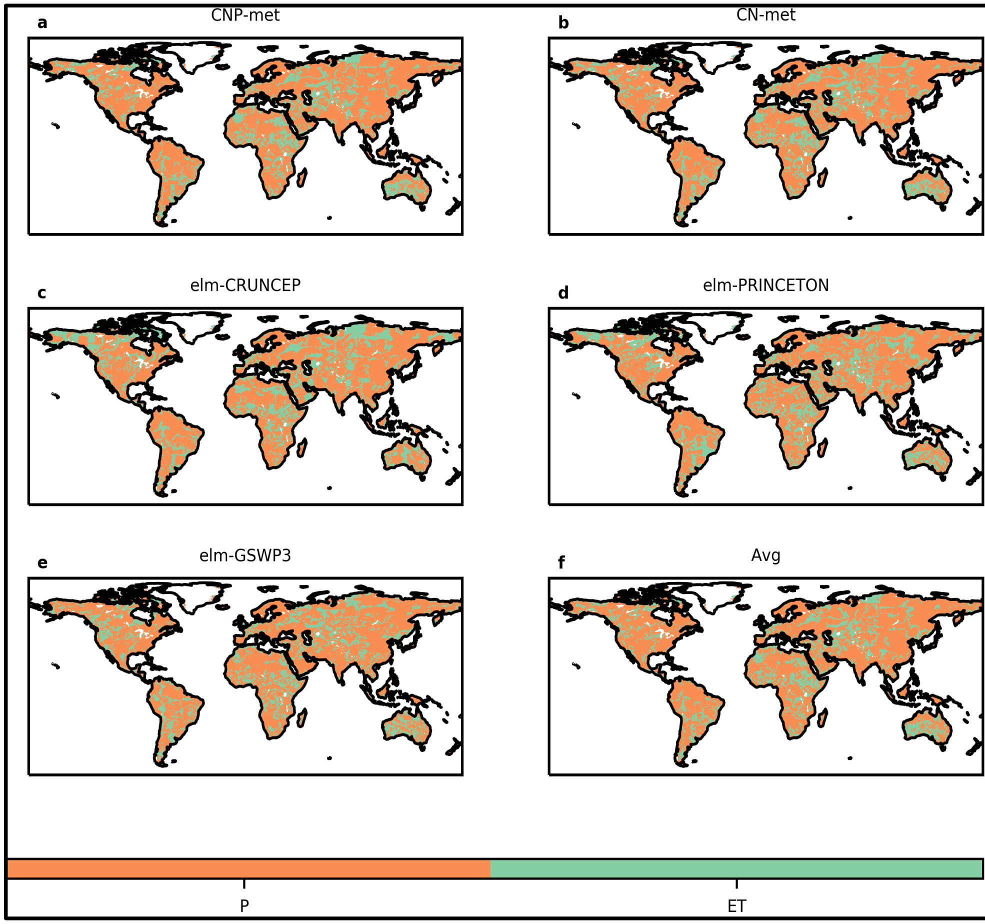


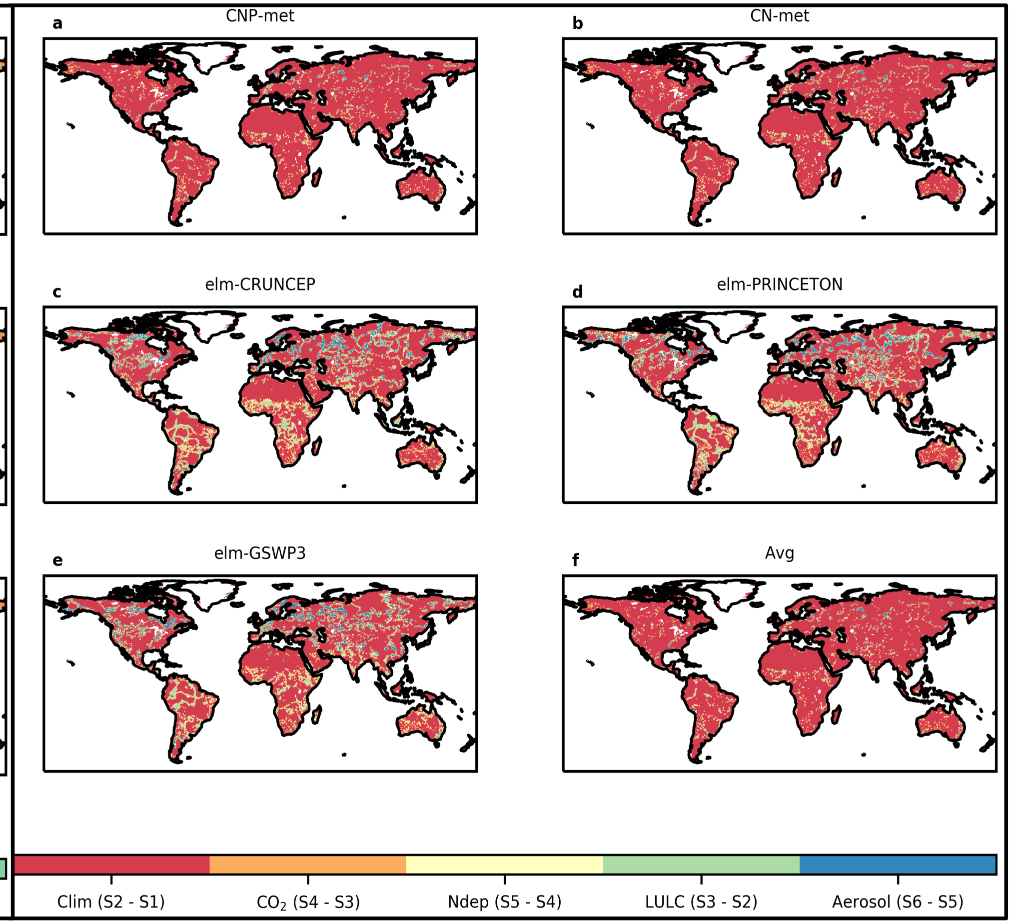
Spatial distributions of ELM simulated LULCC (left) or Aerosol (right) induced WA changes

Summaries of component (left) and factorial (right) contributions to WA









Spatial distributions of dominant component (left) or factor (right) driving the WA changes

Summary

- ✓ **Both observation-based and ELM simulated global-averaged annual WA showed significant increasing trends for the 1941-2012 period;**
- ✓ **ELM basically captured the changing sign and magnitudes of the spatial patterns of the WA trends, albeit with differences for ecoregions including the cropland, wetlands and deserts;**
- ✓ **For each component of WA, the precipitation controlled the WA changes across most global areas; but ET demonstrated primary local effects, especially over the temperate grassland and shrubland, deserts and wetlands;**
- ✓ **Although the climate change was identified to determine the long-term trends of WA, anthropogenic CO_2 concentration, nitrogen deposition, land use/land cover changes, and aerosol induced significant WA changes at regional scales. For example, CO_2 demonstrated evident effects over the boreal forests, and LULCC mattered over west Europe and African tropical forests;**
- ✓ **The impacts of different factors on the changes of WA are sensitive to the model configurations and climatic forcings.**