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NANJING UNIVERSITY

Impact of Revegetation of China's Loess Plateau on the Regional Growing Season Water Balance

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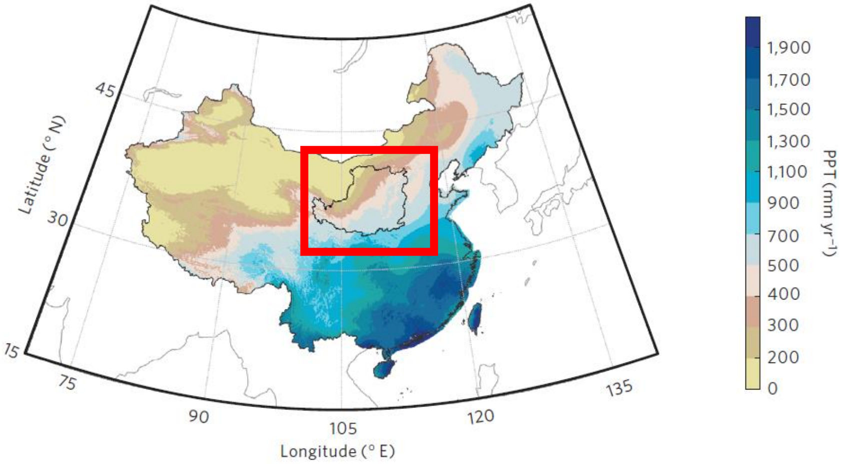
Outline

1. Introductions
2. Methods
3. Results
4. Conclusions

1 Introductions

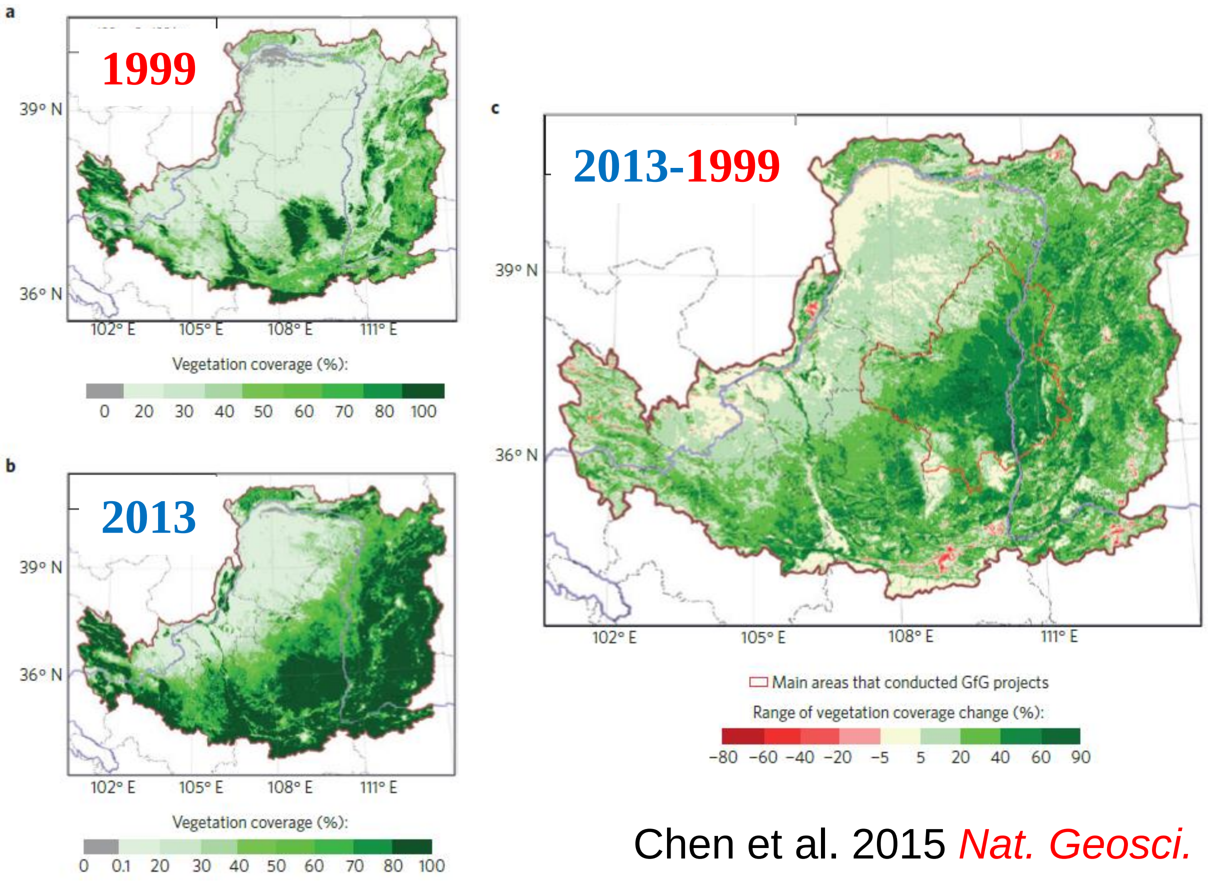
Loess Plateau



Feng et al. (2016) *Nat. Clim. Change*

Grain for Green Program (GFGP)

The Loess Plateau is greening

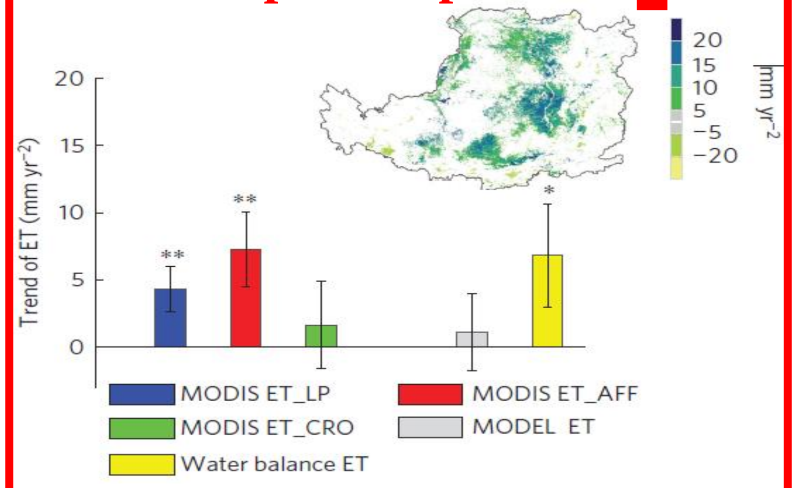


Chen et al. 2015 *Nat. Geosci.*

1 Introductions

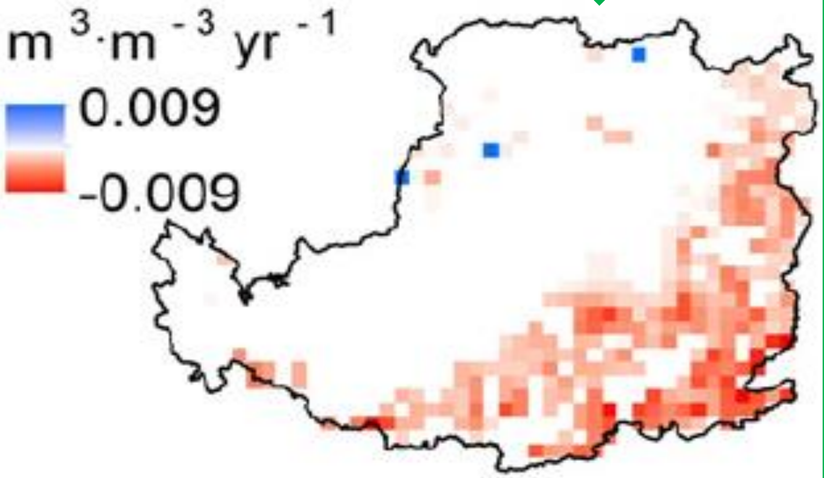
$$\frac{dSM}{dt} = P \, ? - ET - R$$

Evapotranspiration ↑



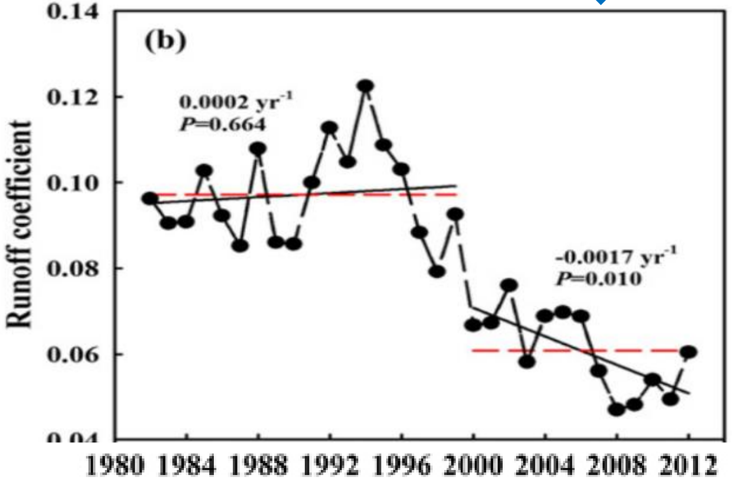
Feng et al. (2016) *Nat. Clim. Change*

Soil moisture ↓



Feng et al. (2017) *Remote Sens. Environ*

Runoff decreases ↓



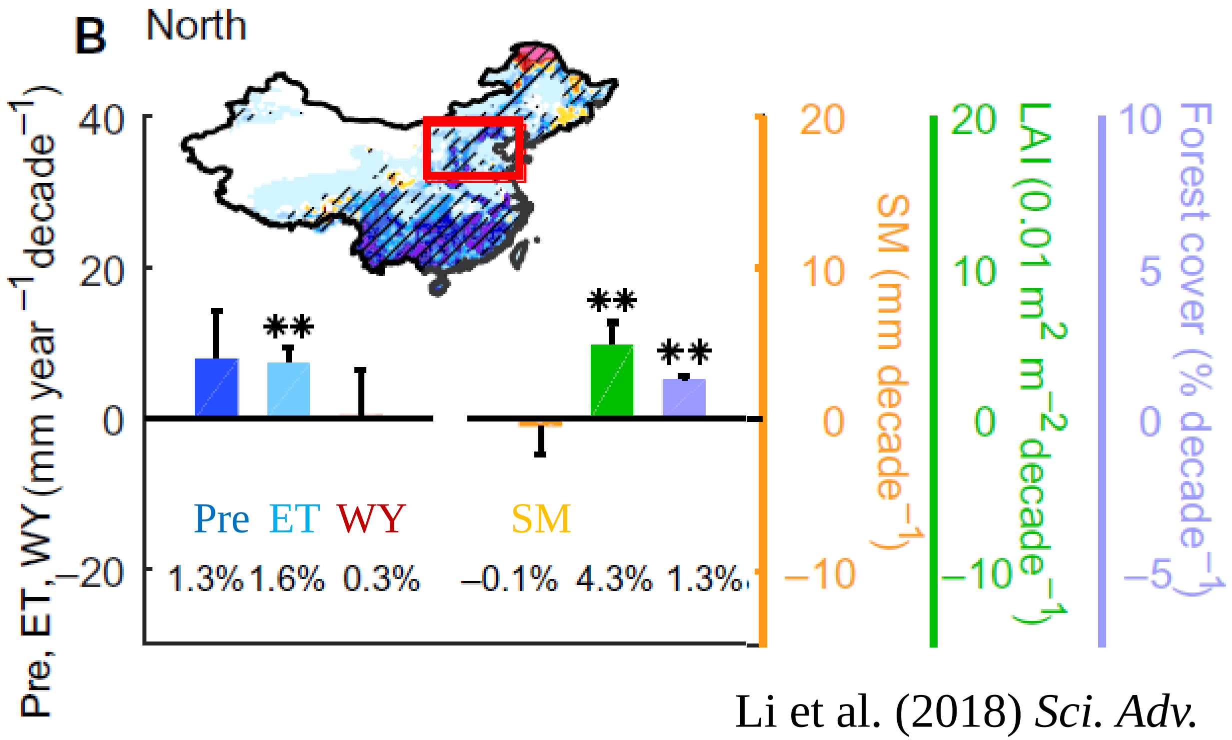
Li et al. (2016) *Sci. Total Environ.*

- MODIS shows the evapotranspiration increased by 4.3 ± 1.7 mm yr^{-1} during 2000-2010
- AMSR-E reveals the soil moisture in growing season decreased by 0.002 $m^3 \cdot m^{-3} \cdot yr^{-1}$ during 2003-2010
- Data from 12 hydrological stations shows the runoff coefficient decreased by 0.0017 yr^{-1} by during 2000-2012

1 Introductions

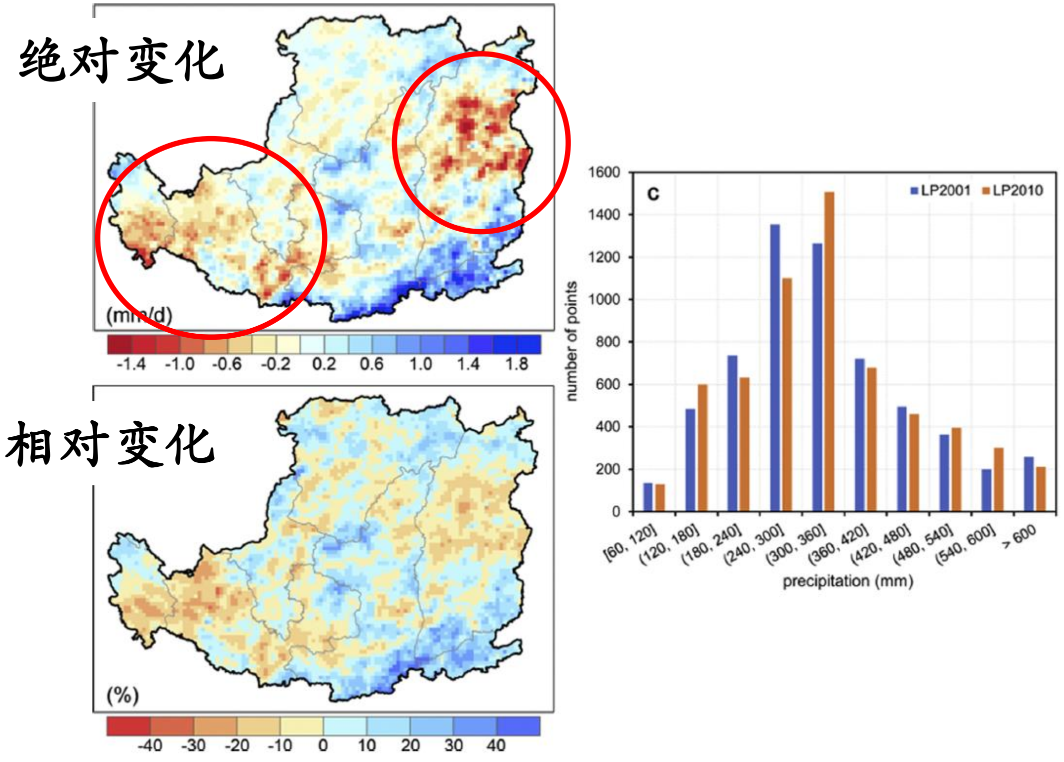
$$\frac{dSM}{dt}\downarrow = P\,? - ET\uparrow - R\uparrow$$

Increased precipitation



Li et al. (2018) *Sci. Adv.*

Decreased precipitation



Cao et al. (2019) *Agr. Forest Meteorol.*

It remains controversial with respect to the response of precipitation to revegetation.

Therefore, we aims to further investigate this issue.

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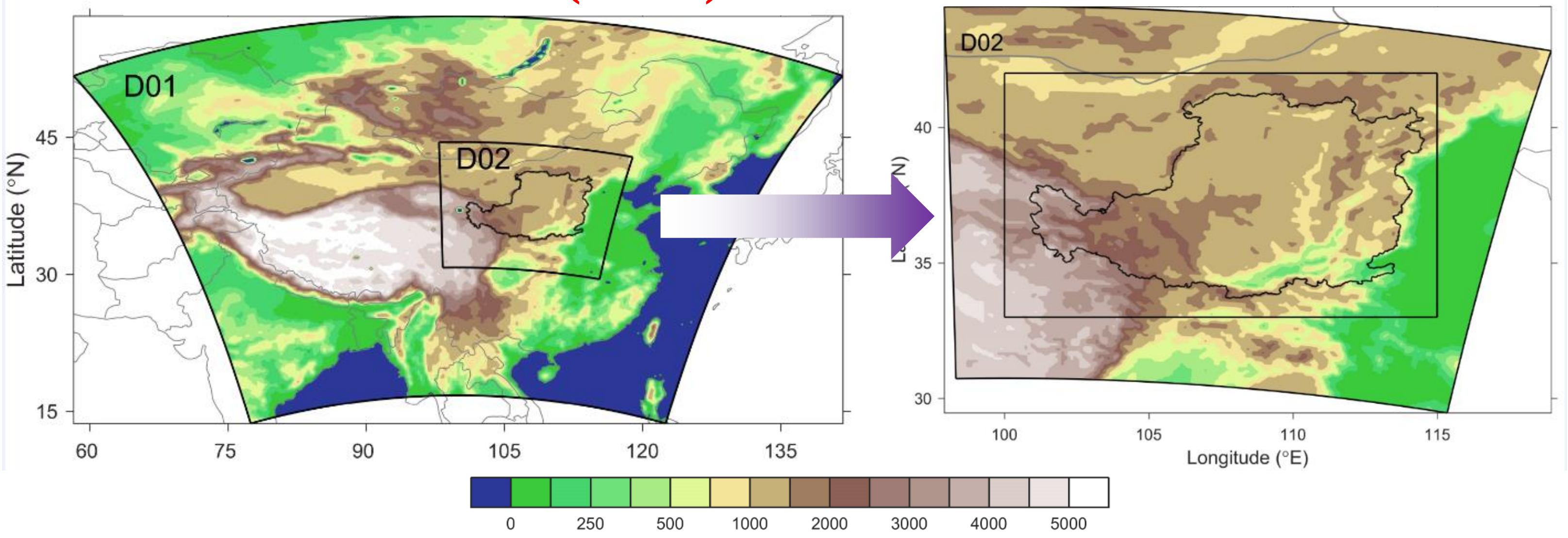
2 Methods

WRF simulation domain

Outer domain (30km)

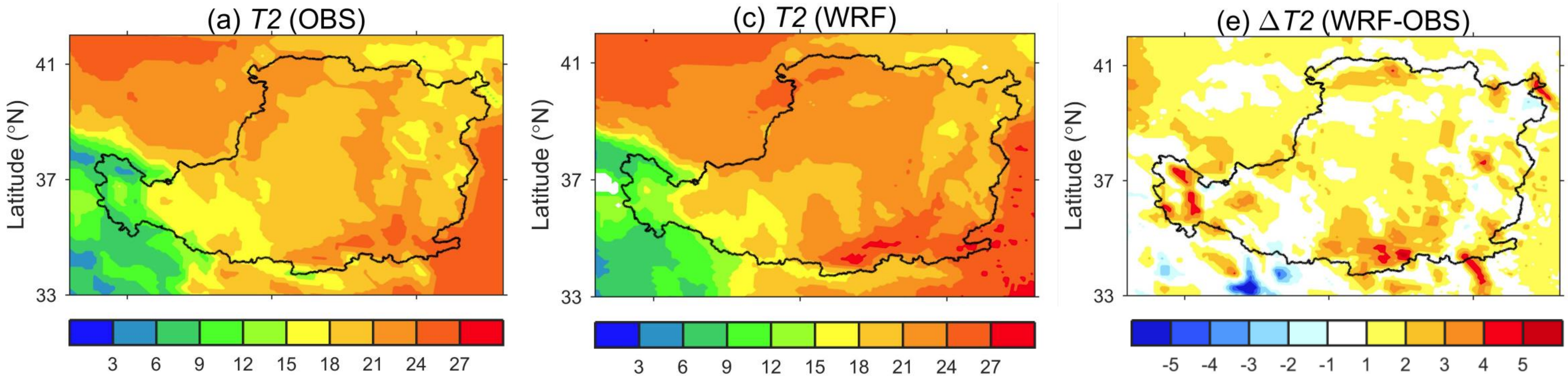
Nested domain (10km)



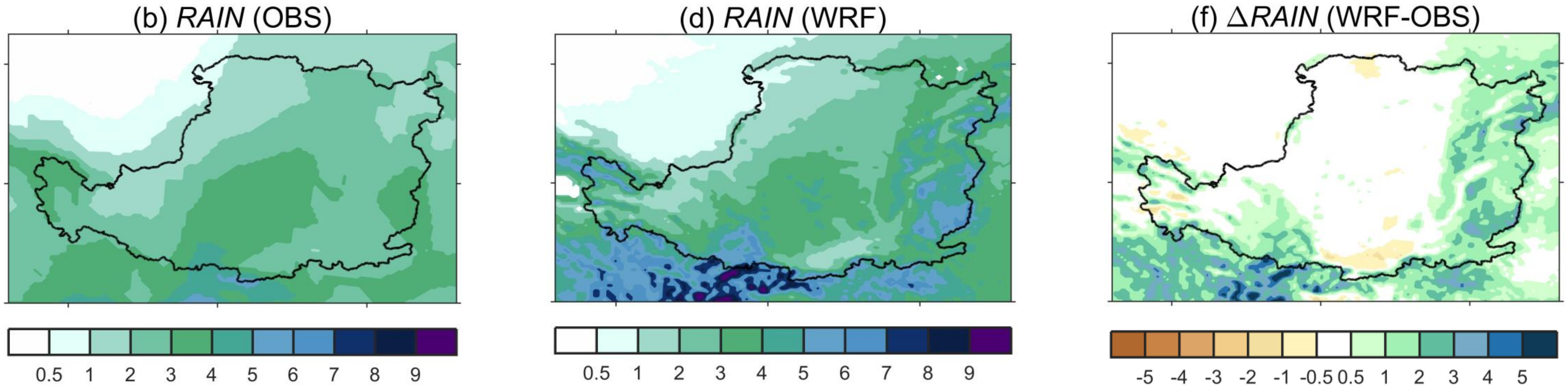
Physics	Option	Physics	Option
Longwave radiation	RRTM	Land surface	Unified Noah
Shortwave radiation	Dudhia	Boundary layer	YSU
Microphysics	WSM-6	Cumulus	Kain-Fritsch
SST、*α*、*LAI*	Update	Land cover type	Mosaic

WRF can basically well simulate the growing season (June to September) 2m temperature and precipitation

2m temperature



precipitation



2 Methods

Experiment	Land cover (LCT, GVF, LAI, albedo)	Simulation strategy
LC_{2001}	2001: Land cover before "GFGP"	1996-2015 Initial time: 05.01* Ending time: 09.30
LC_{2015}	2015: Current land cover	
LC_{FUTR}	Future: Continued GFGP	
$LCENS_{2001}$	2001: Land cover before "GFGP"	2001 Initial time: [04.21-04.30]* Ending time: 09.30
$LCENS_{2015}$	2015: Current land cover	

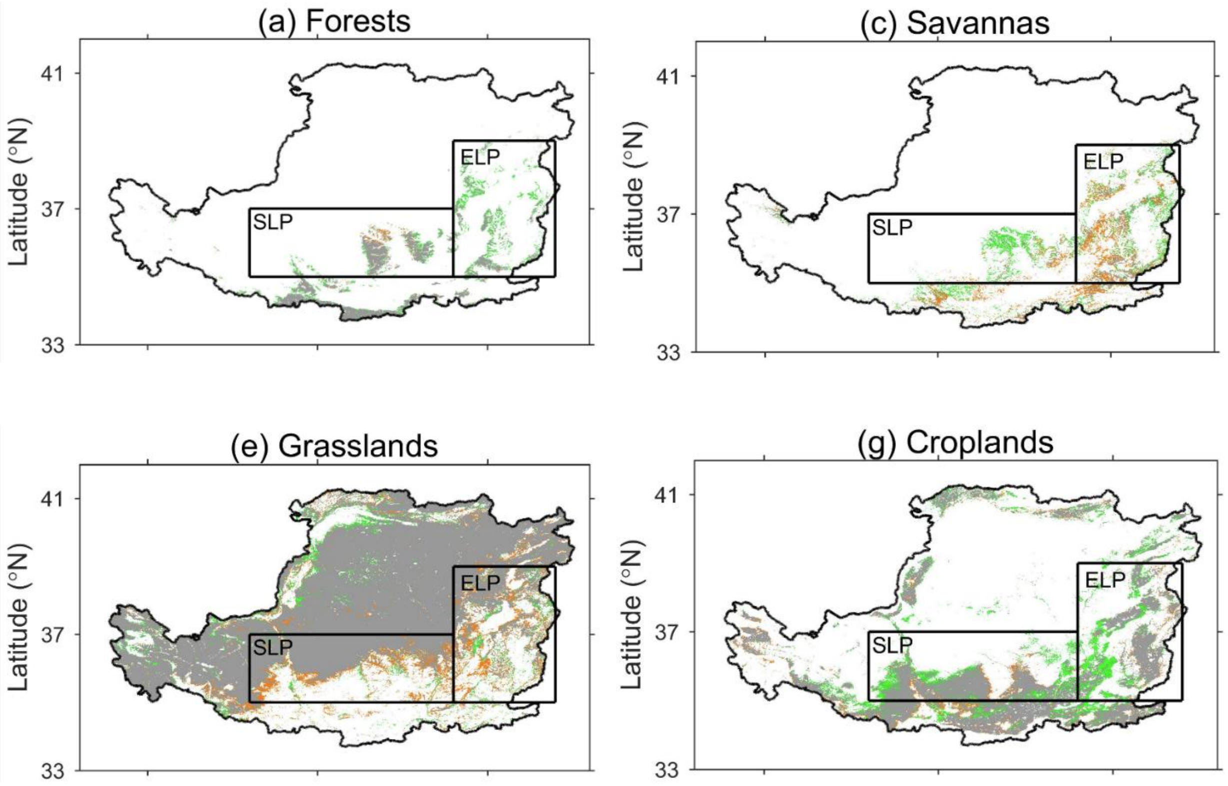
*The simulation before 06.01 was regarded as spin-up and discarded, and we only focused on 6-9 (JJAS) averages.

- Perform the former 3 simulations to isolate the impact of revegetation
- Perform the latter 2 simulations to study the impact of model internal variability induced by intimal perturbations

2 Methods

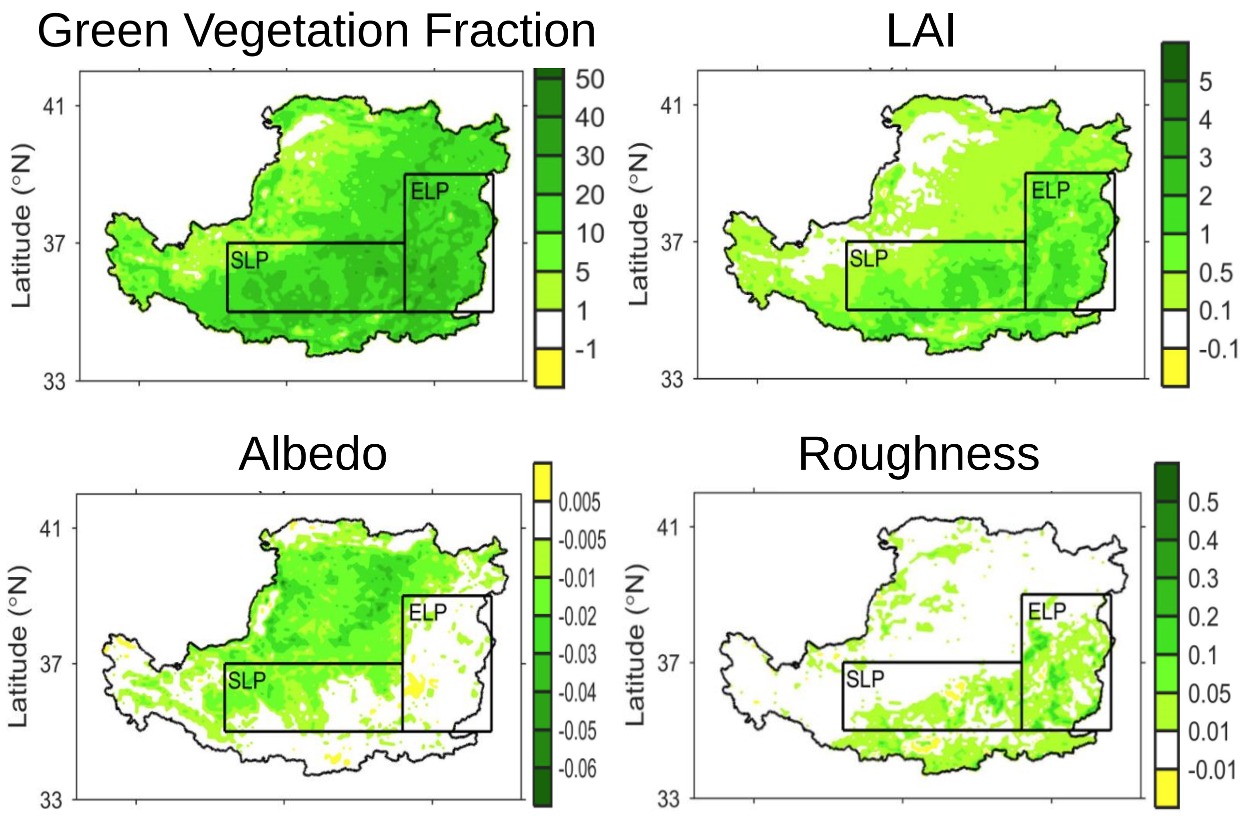
Land cover change since the launch of "GFGP" (2015-2001)

Land cover type changes (2015-2001)



Green: increase **Red: decrease** **Gray: unchanged**

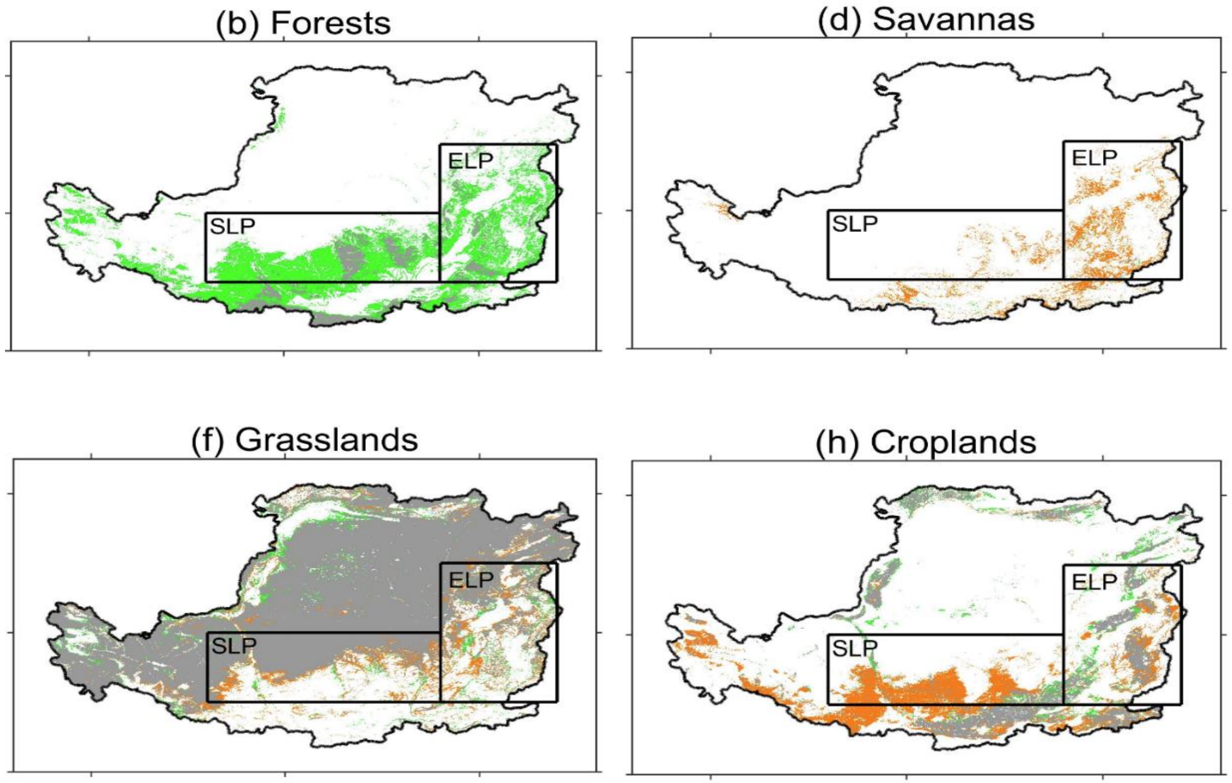
Biophysical changes (2015-2001)



Potential land cover change if "GFGP" is continued

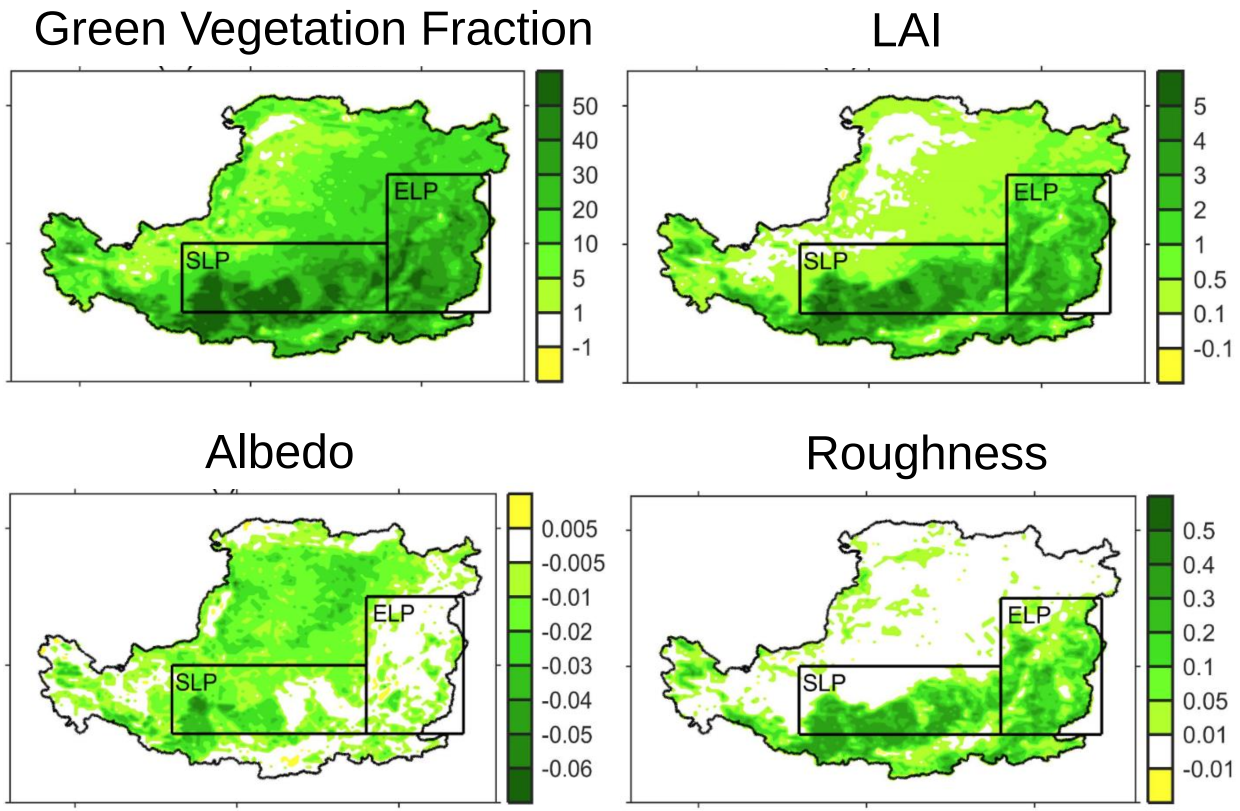
- **Change croplands, barren or savannas on hillslopes (slope>15°) to forests**
- **Change the biophysical values of forests to the values of dense forests (Green vegetation fraction larger than 95 percentile)**

Potential land cover type changes



Green: increase Red: decrease Gray: unchanged

Potential biophysical changes



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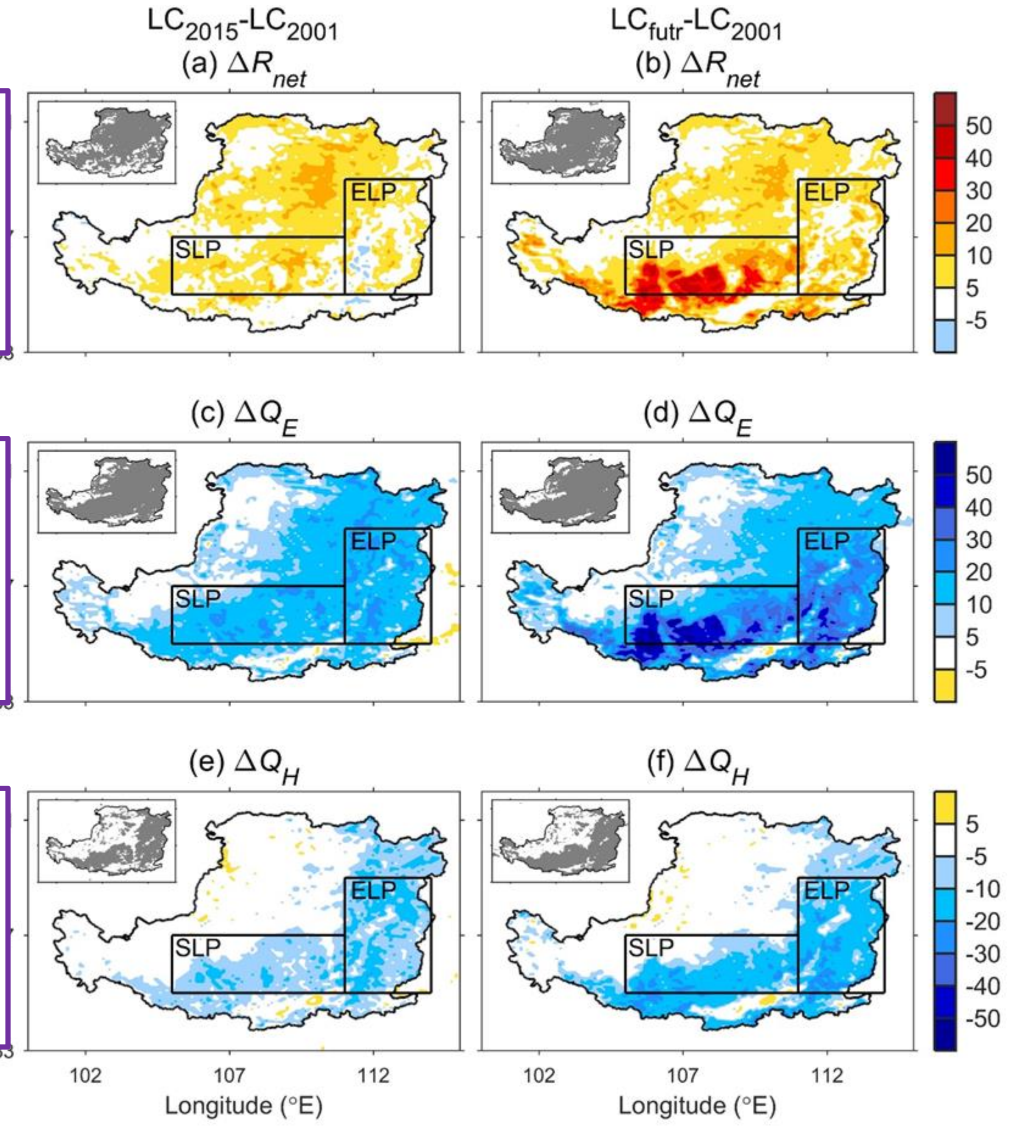
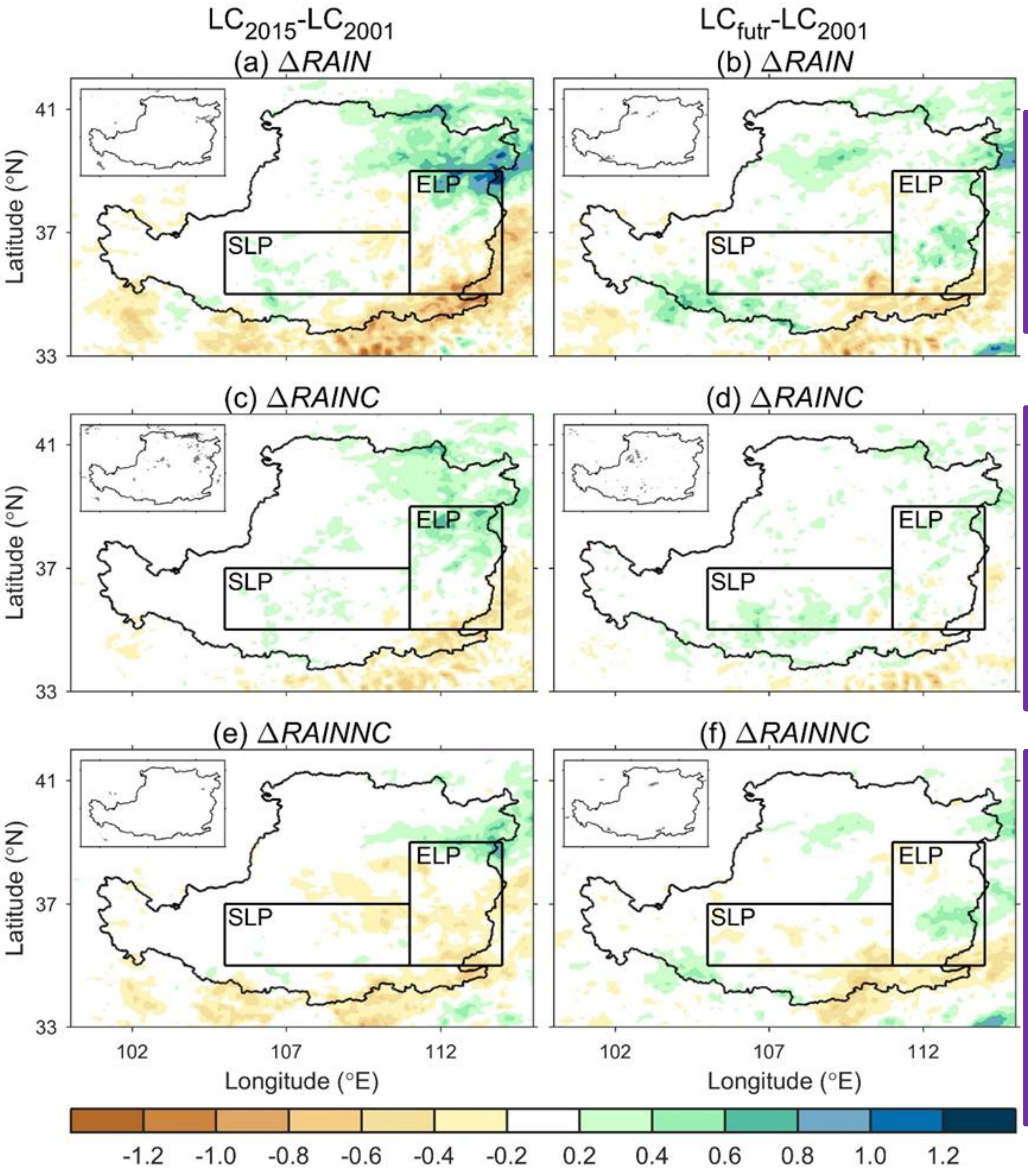
3 Results

Net Radiation

Latent heat

Sensible heat



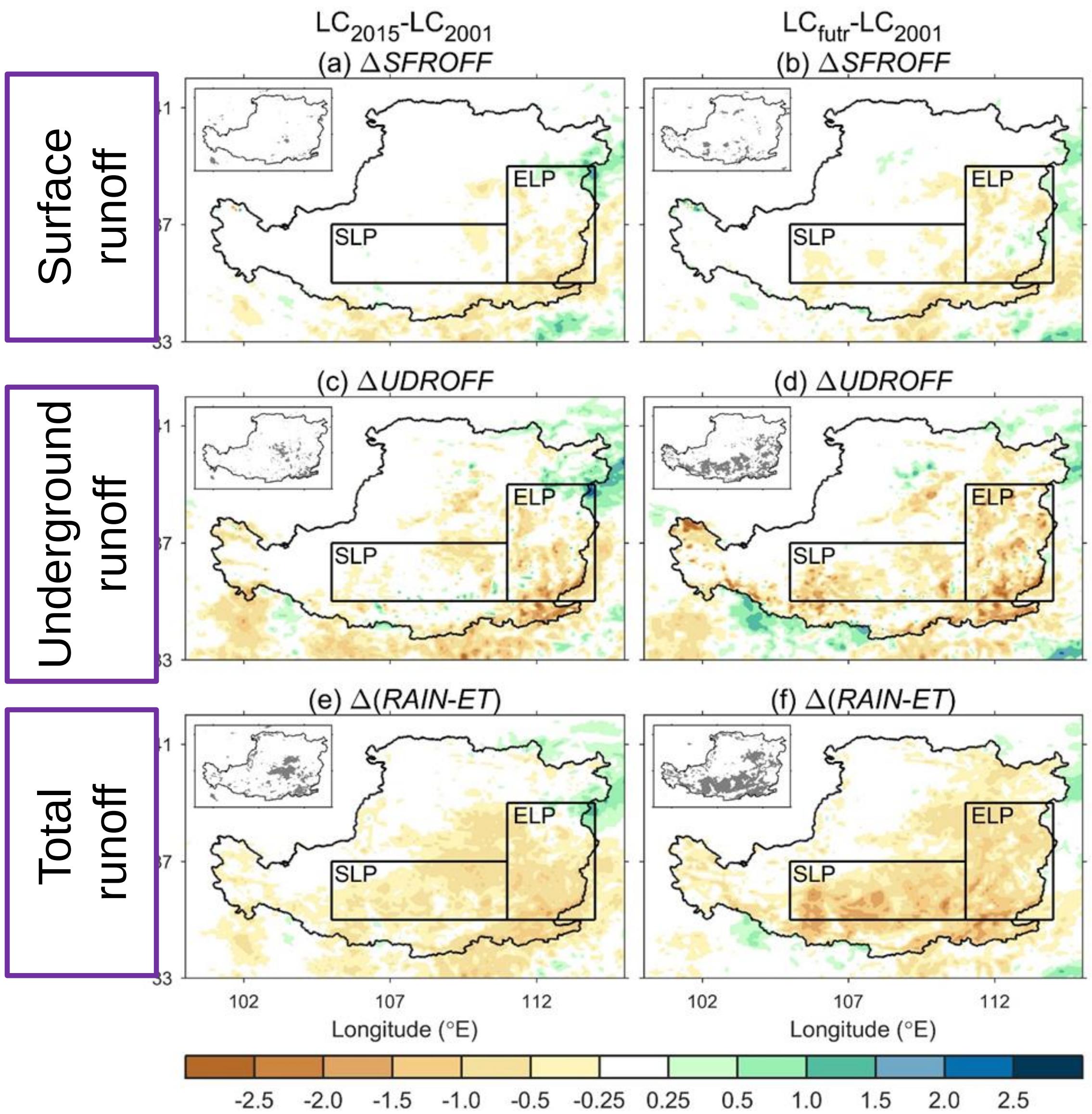


Total P

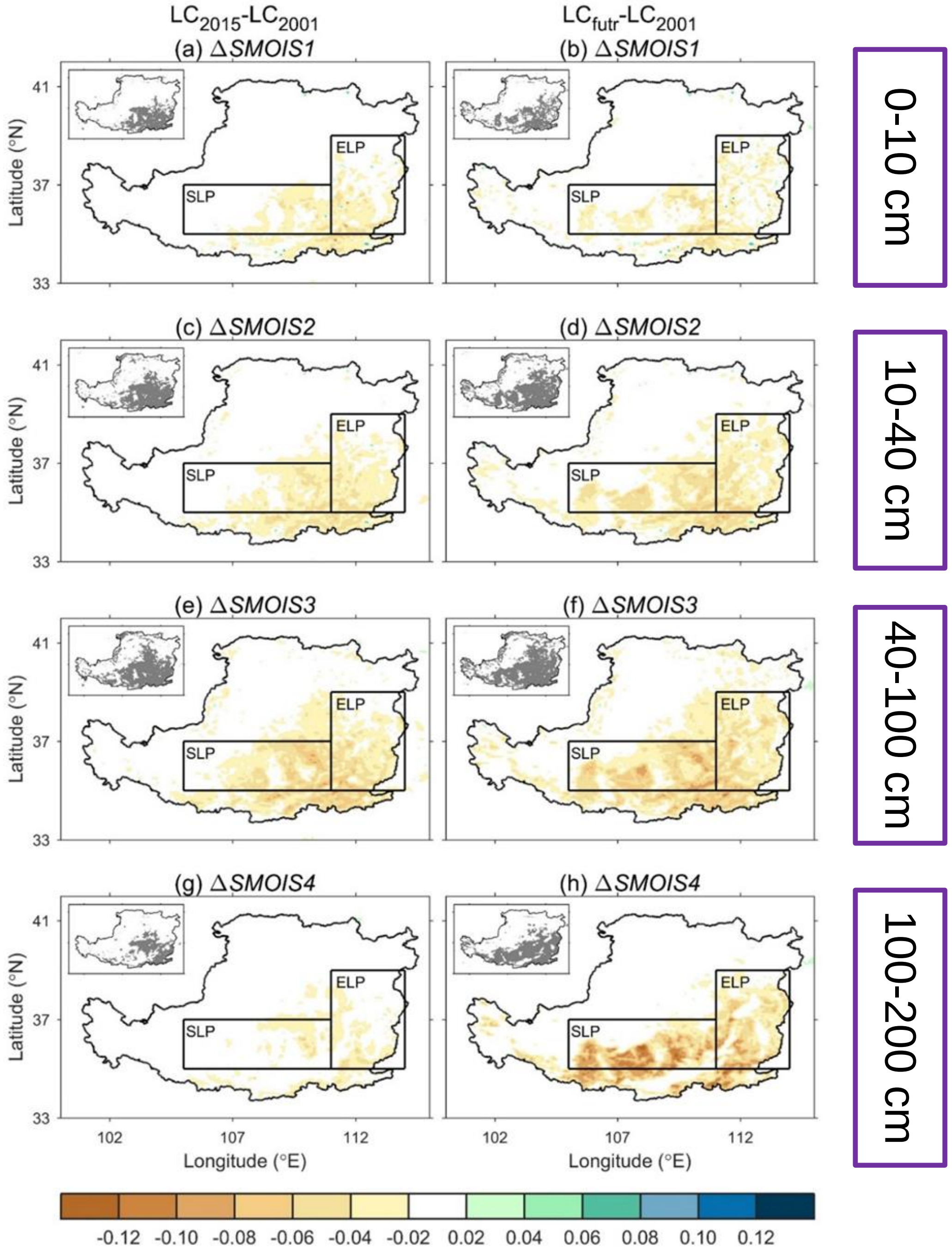
Convective P

Non-convective P

3 Results

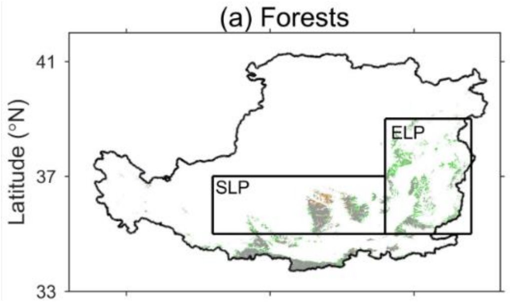


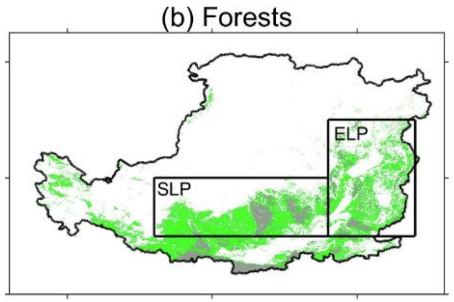
Surface runoff
Underground runoff
Total runoff
LC2015-LC2001
LCfutr-LC2001
(a) ΔSFROFF
(b) ΔSFROFF
(c) ΔUDROFF
(d) ΔUDROFF
(e) Δ(RAIN-ET)
(f) Δ(RAIN-ET)
ELP
SLP
102
107
112
Longitude (°E)
-2.5 -2.0 -1.5 -1.0 -0.5 -0.25 0.25 0.5 1.0 1.5 2.0 2.5



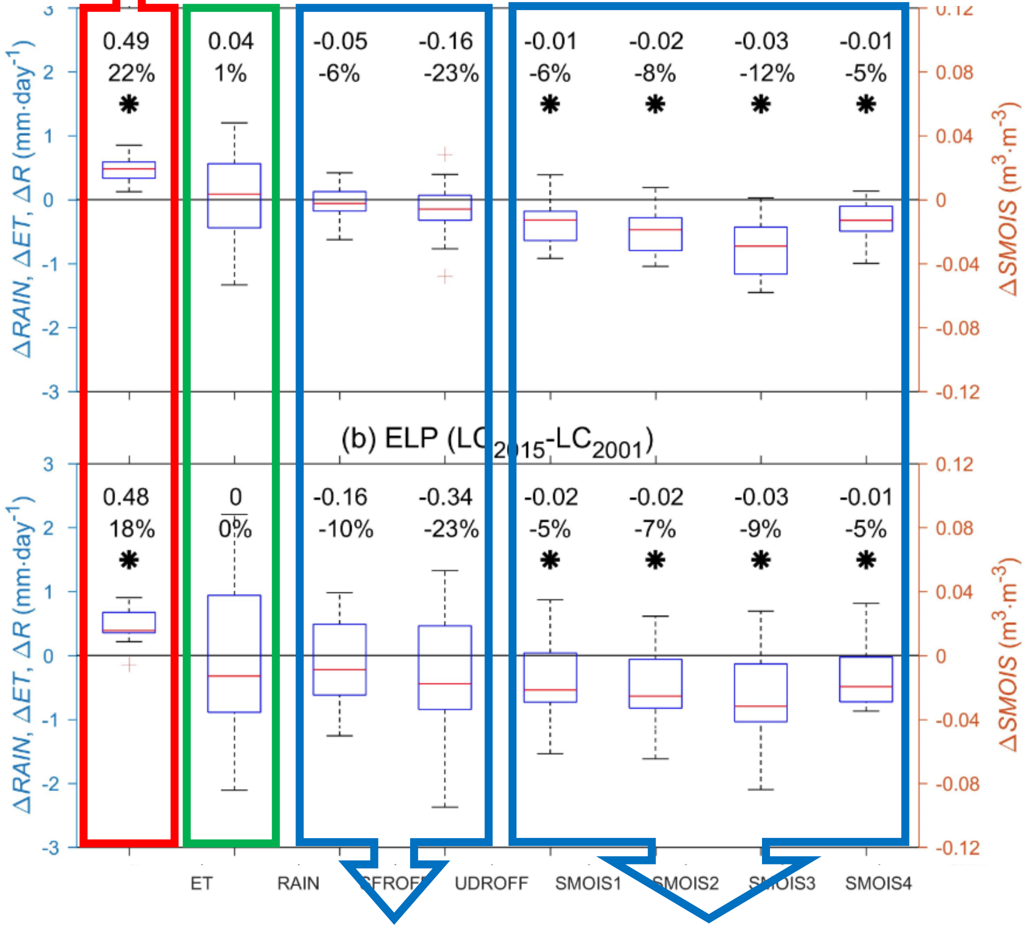
LC2015-LC2001
LCfutr-LC2001
(a) ΔSMOIS1
(b) ΔSMOIS1
(c) ΔSMOIS2
(d) ΔSMOIS2
(e) ΔSMOIS3
(f) ΔSMOIS3
(g) ΔSMOIS4
(h) ΔSMOIS4
0-10 cm
10-40 cm
40-100 cm
100-200 cm
Latitude (°N)
41
37
33
ELP
SLP
102
107
112
Longitude (°E)
-0.12 -0.10 -0.08 -0.06 -0.04 -0.02 0.02 0.04 0.06 0.08 0.10 0.12

3 Results

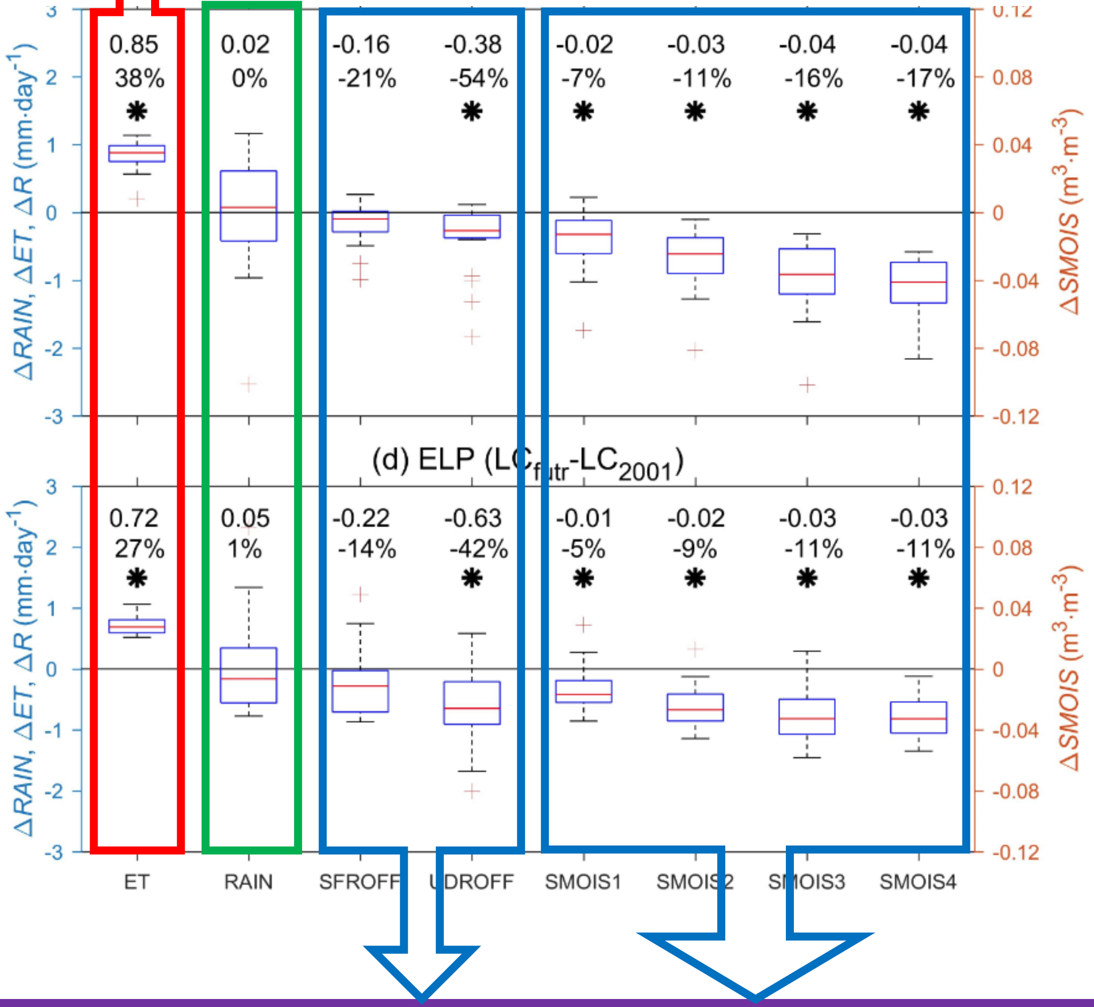




LC_{2015}-LC_{2001}



LC_{FUTR}-LC_{2001}

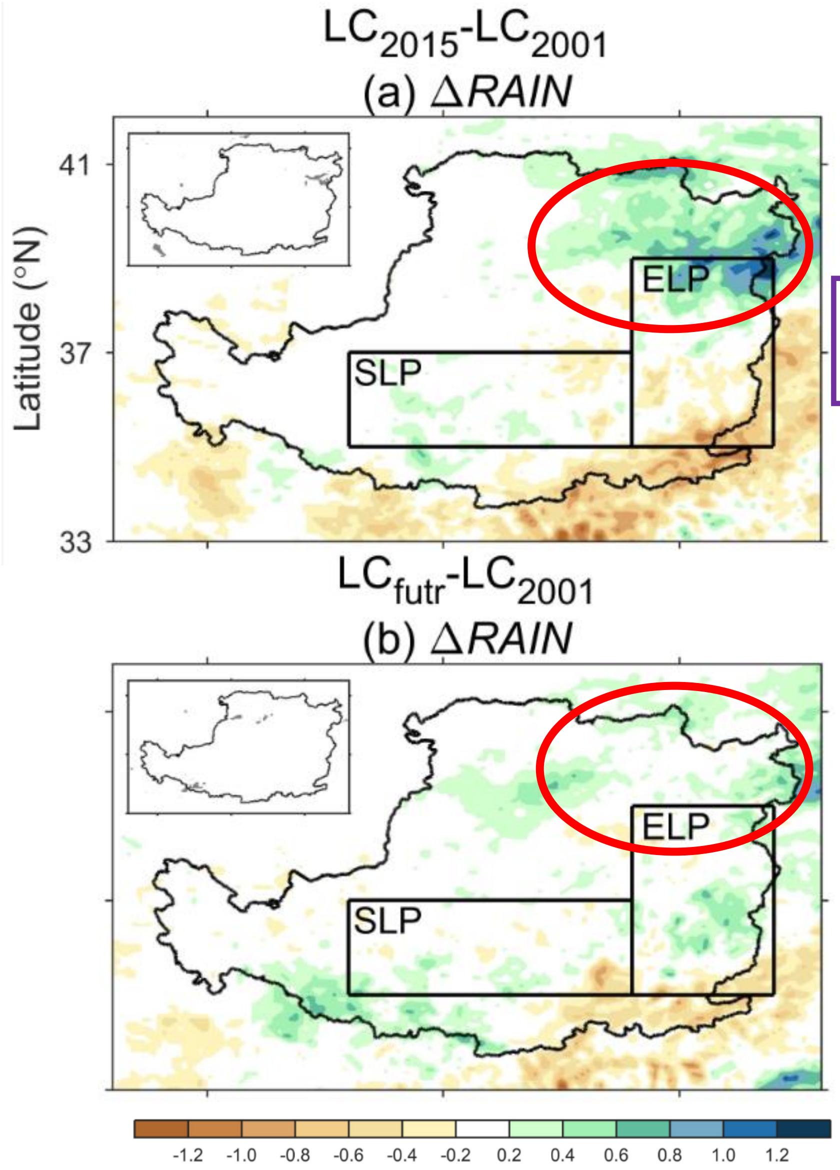


3 Results

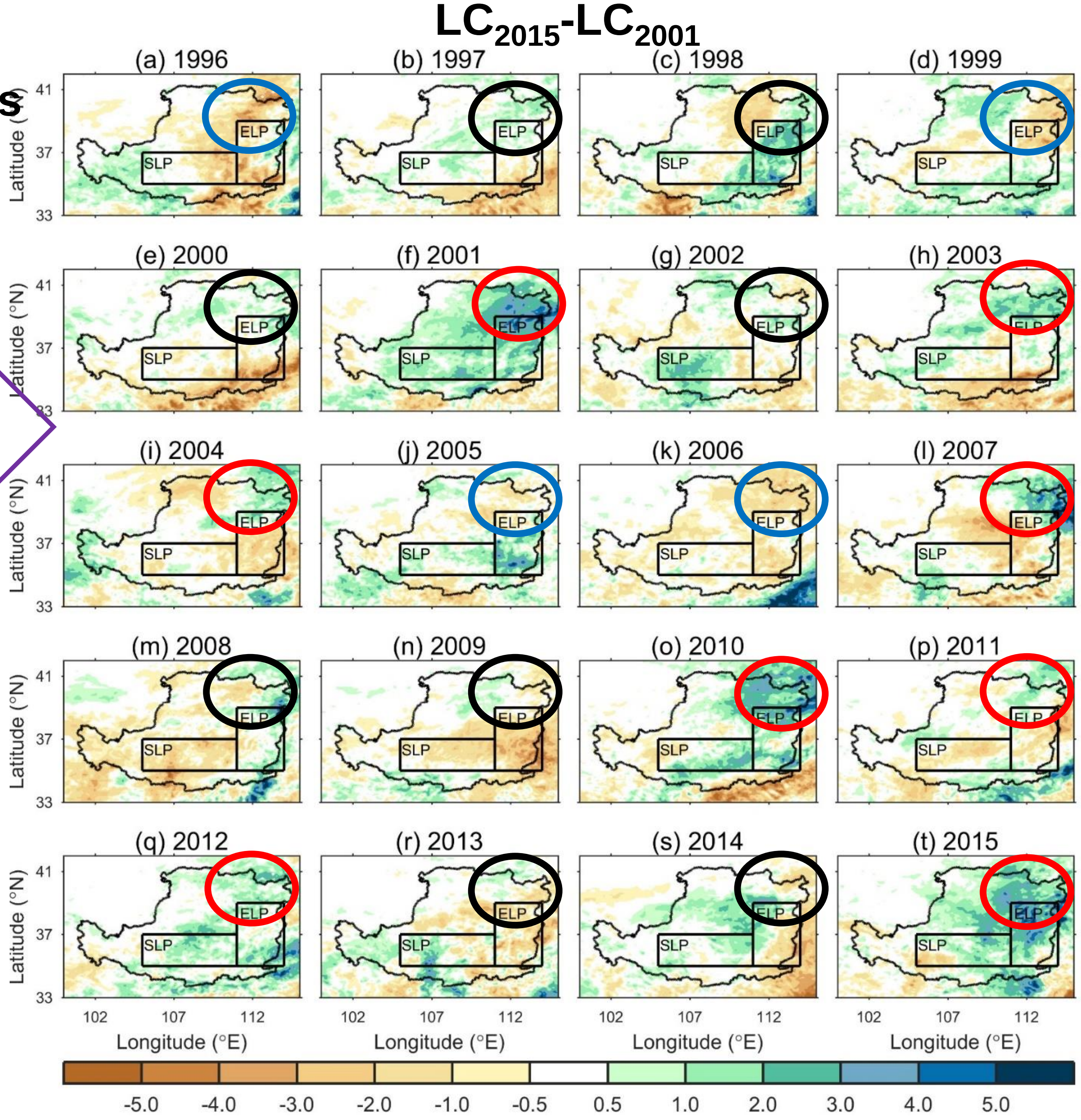
Increase: 8 years

Decrease: 4years

Unchanged: 8 years

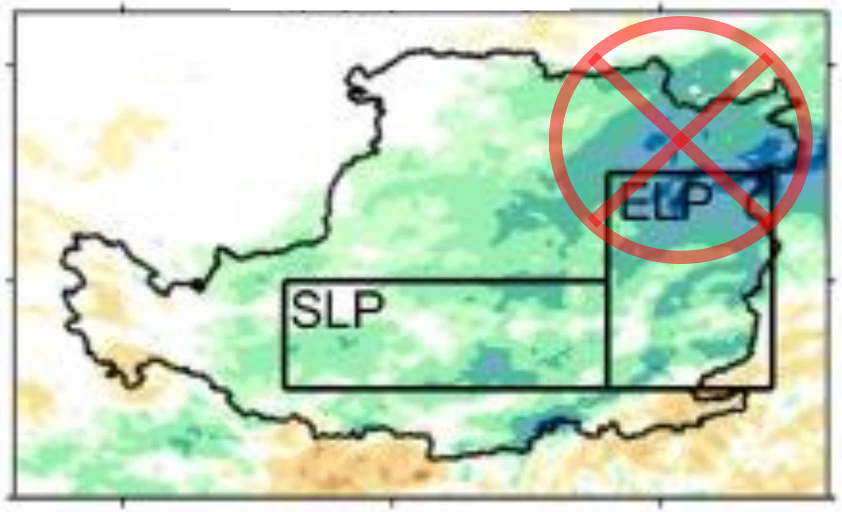


Examine each year

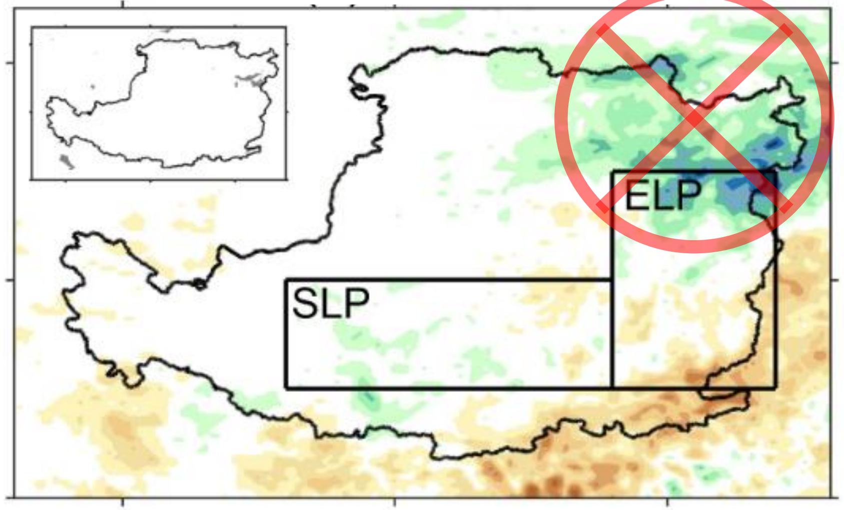


3 Results

2001

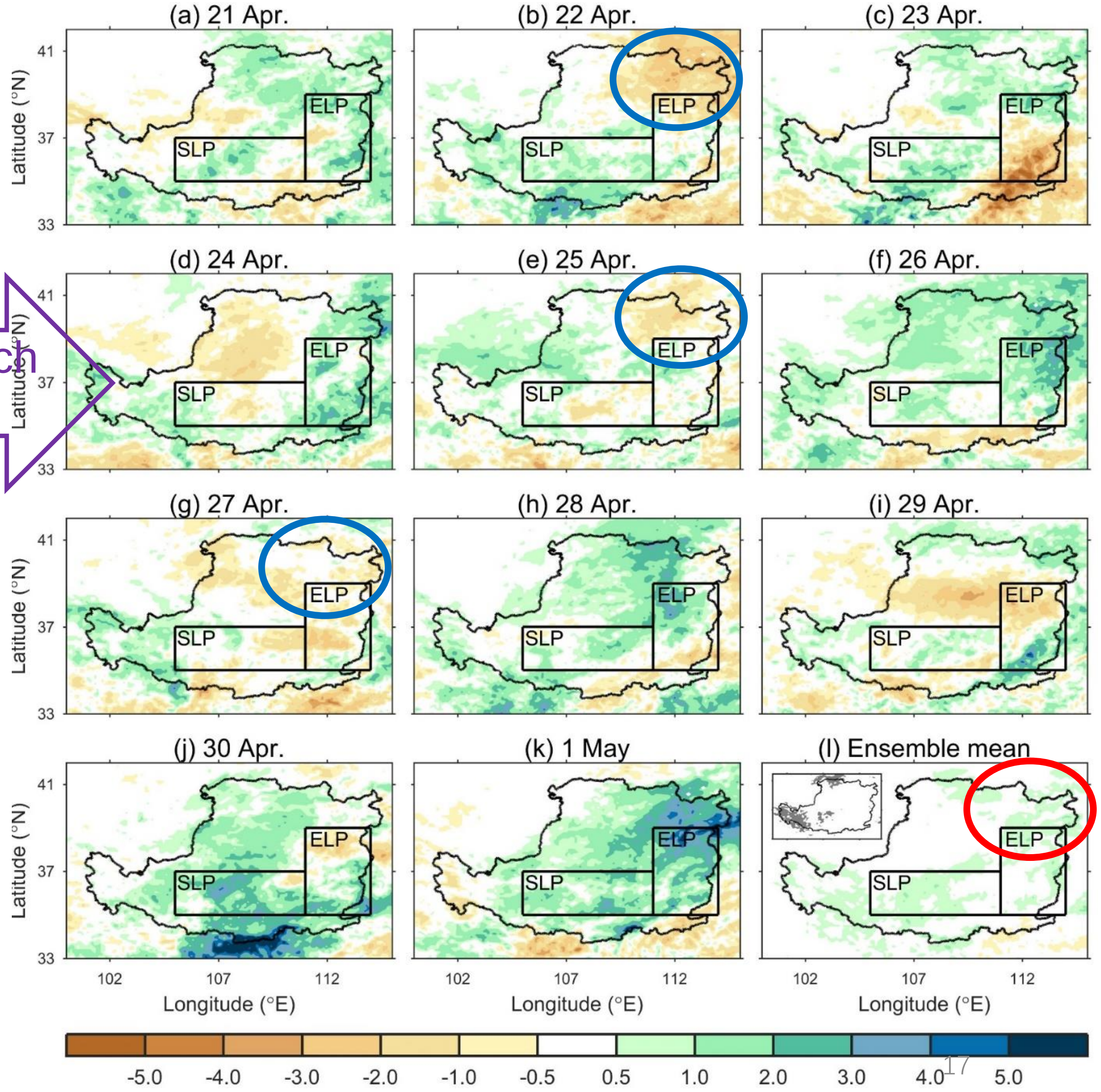


LC2015-LC2001



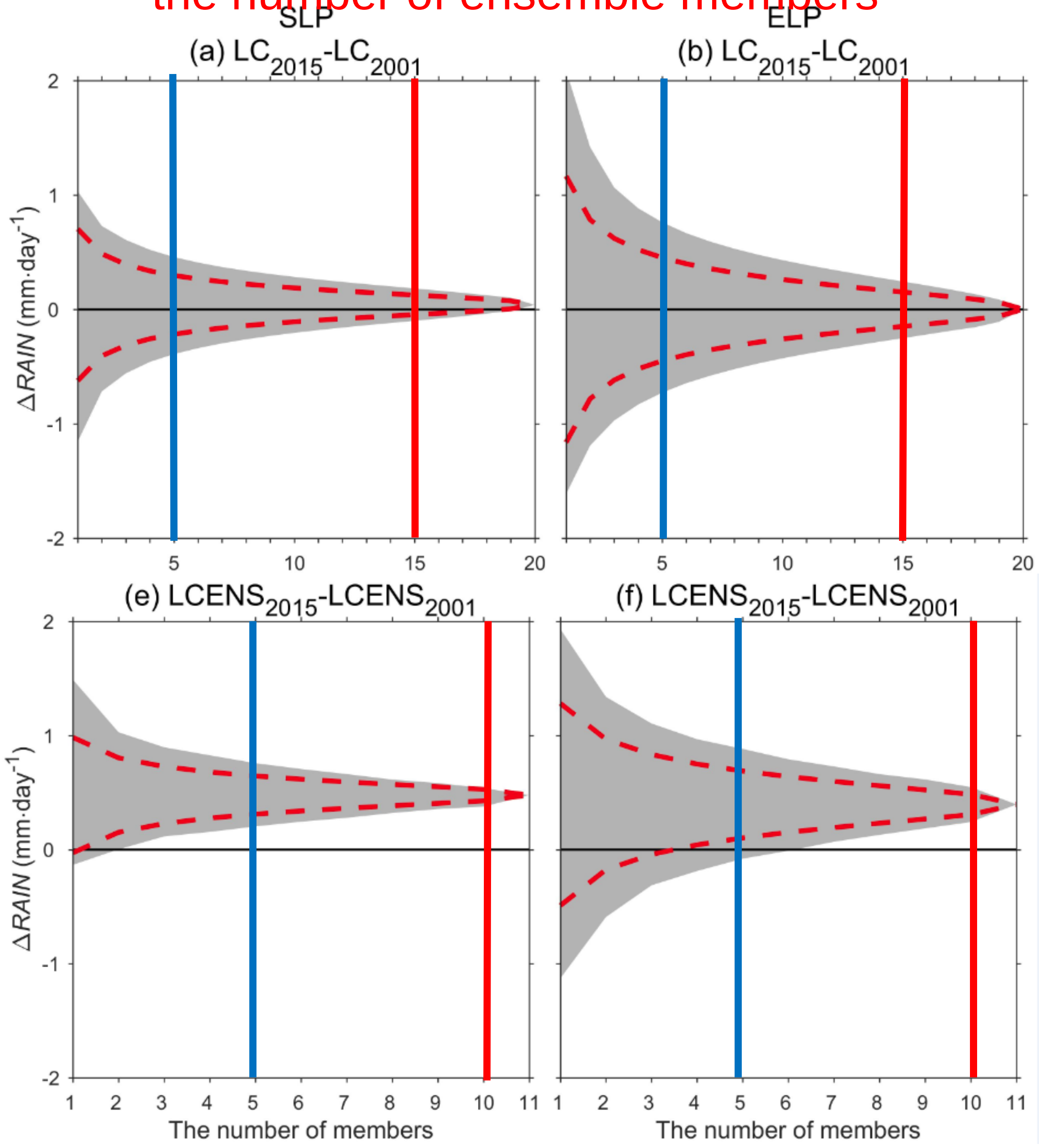
Examine each member

$LCENS_{2015}$-$LCENS_{2001}$



3 Results

The relationship between precipitation changes and the number of ensemble members



The less the ensemble members, the more likely we mistakenly attribute the model internal variability induced precipitation changes to land cover change.

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4 Conclusions

- **Historical and further revegetation tend to reduce runoff and soil moisture due to enhanced evapotranspiration, but have weak impact on precipitation.**
- **Given the reduction in water available for agriculture and human settlements, the "Grain for Green Program" might be unsustainable.**

Ge, J., Pitman, A. J., Guo, W. D., Zan, B. L. and Fu, C. B. (2020). Impact of revegetation of the Loess Plateau of China on the regional growing season water balance. ***Hydrology and Earth System Sciences***. 24(2), 515-533.

Thanks for Your Attention！