



HUAZHONG UNIVERSITY  
OF SCIENCE & TECHNOLOGY

HS1.2.4 Panta Rhei: Hydrology, Society &  
Environmental Change

School of Hydropower & Information Engineering

# An index to quantifying the impacts of agricultural drought and its application in China

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# Introductions

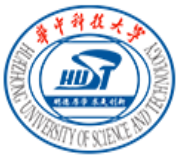


- Drought is a recurring and stochastic natural hazard.
- It is a primary option to develop and apply drought indices for drought monitoring and characterization.

- Drought types:

Drought can be classified into four types: meteorological, agricultural, hydrological, and socio-economic (Mishra and Singh, 2010).

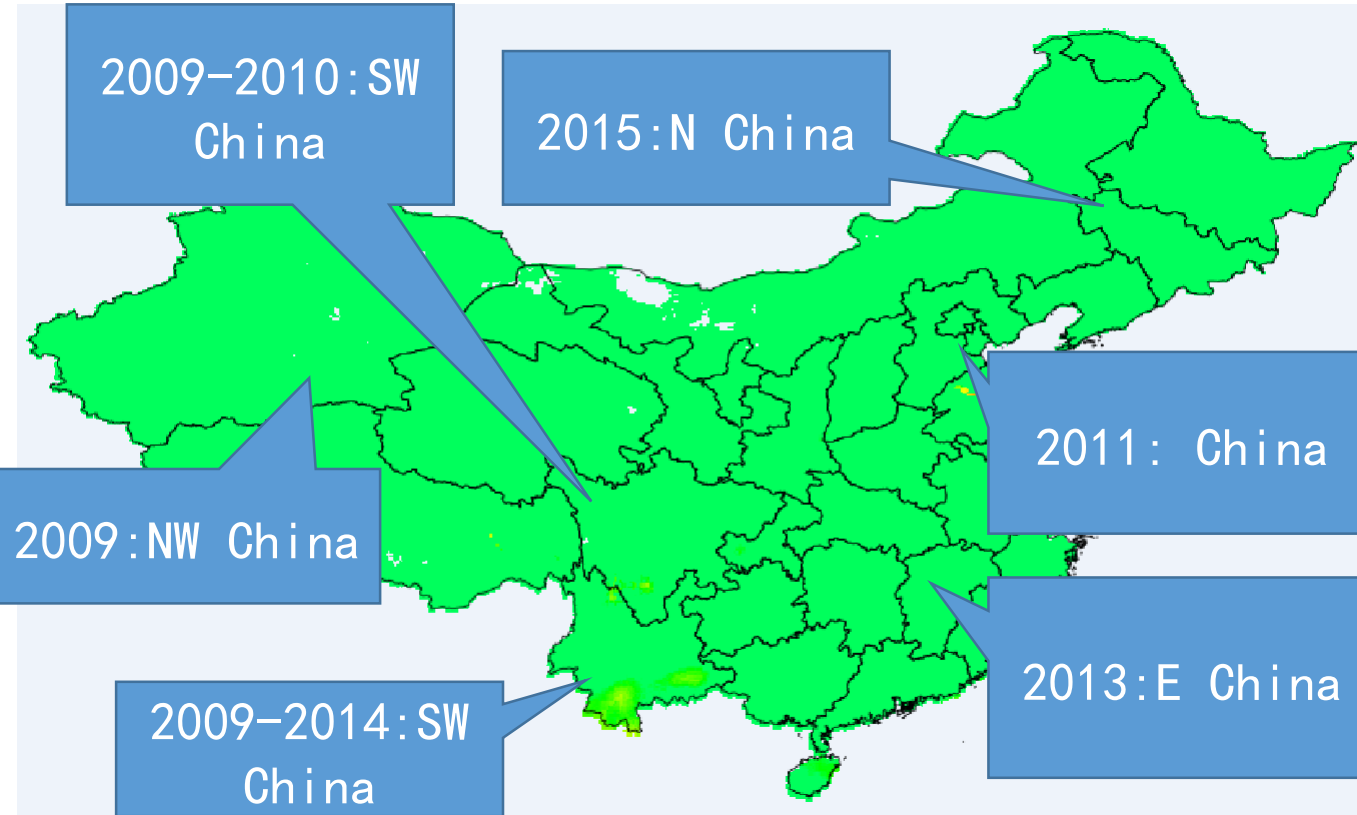
- Meteorological ()
- Agricultural ()
- Hydrological ()
- Socio-economic ()



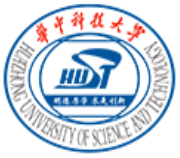
# Introductions



## ❖ Recent drought events in China



- Under the global warming in  $1.5^{\circ}\text{C}$ , the direct economic loss by drought will reach 46 billion US dollars in China (market value in 2015)
- Under the global warming in  $2.0^{\circ}\text{C}$ , the direct economic loss will be 1.8 times of  $1.5^{\circ}\text{C}$  (Su et al., 2019)



# Methods



## ❖ Drought and the crop water production functions (CWPF)

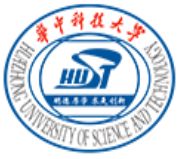
➤ Agricultural drought care about the crop growth and production.

➤ The response of crops to drought:

stress response - active adaptation - passive adaptation

(mild drought - moderate drought - severe drought - extreme drought).

➤ Crop water production functions (CWPF) generally refer to the functional relationship between crop yield ( $y$ ) and evapotranspiration (ET).



# Methods



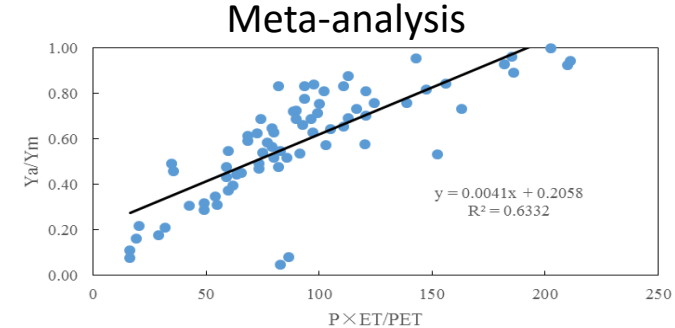
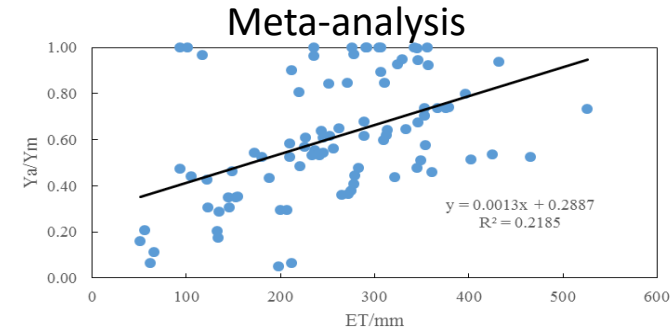
## ❖ Drought and the crop water production functions (CWPF)

Linear CWPF  $\frac{Y_a}{Y_m} = \frac{ET_a}{ET_m}; \frac{Y}{Y_m} = \frac{T}{T_m}$

Nonlinear CWPF  $Y_a = a + b \left[ 1 - \left( 1 - \frac{ET_a}{ET_m} \right)^2 \right]$

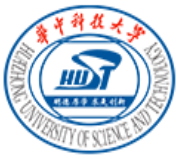
Addition CWPF  $\frac{Y_a}{Y_m} = \sum_{i=1}^n B_i \left[ 1 - \left( 1 - \frac{ET_a}{ET_{mi}} \right)^2 \right]$

Multiplication CWPF  $\frac{Y_a}{Y_m} = \prod_{i=1}^n \left[ 1 - \left( 1 - \frac{ET_a}{ET_{mi}} \right)^2 \right]^{\delta_i}$



➤ Many CWPF rely on the ET.

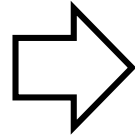
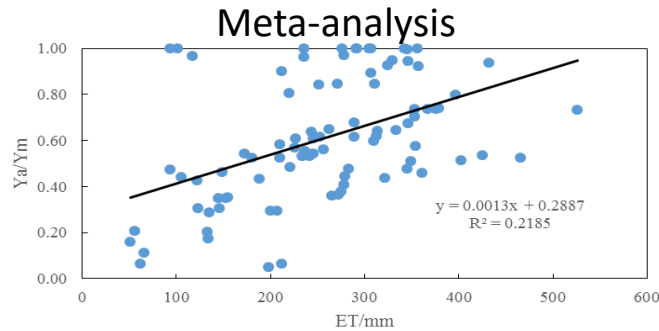
➤ It is more reliable to use the new relationship:  $Y \sim ET * P/PET$ .



# Methods

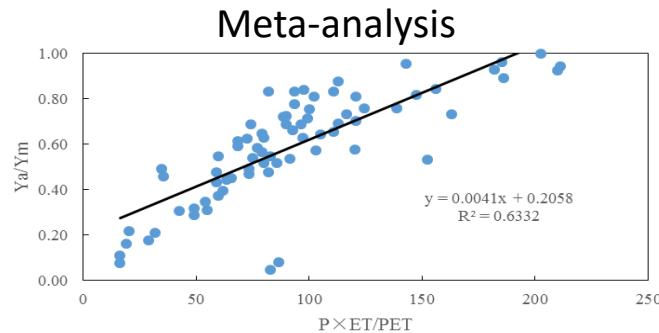


## ❖ A new index for drought monitoring



Crop Water Related Index  
of drought

$$CWRI = P \frac{AET}{PET}$$



Monthly AET、PET

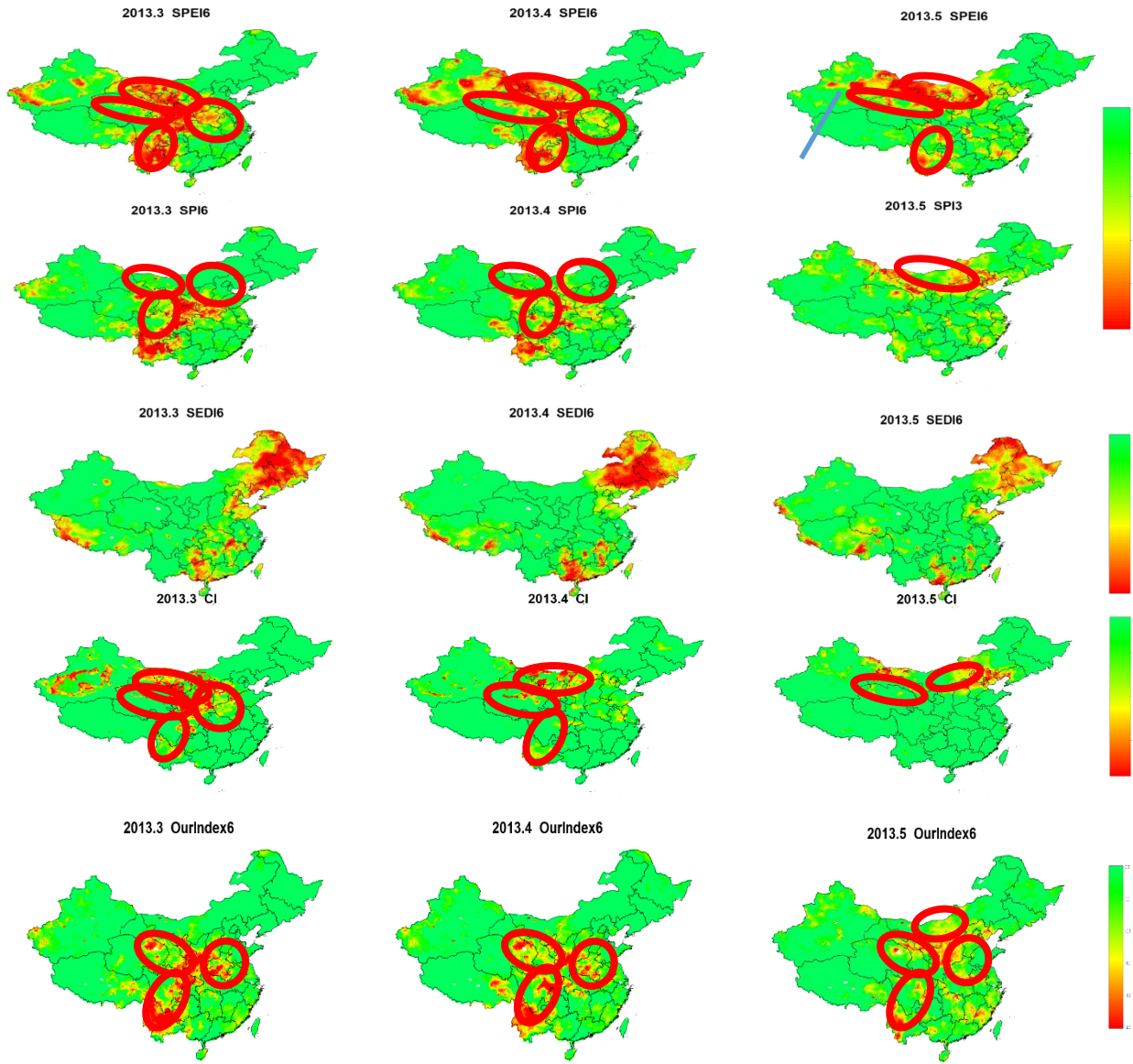
$P \times AET/PET$

Distribution

Standardization

| Level   | SPI             | SPEI            | SEDI         | CI               | CWRI            |
|---------|-----------------|-----------------|--------------|------------------|-----------------|
| Extreme | $\leq -2$       | $\leq -2$       | $\leq -4$    | $\leq -2.4$      | $\leq -2$       |
| Serious | $-2 \sim -1.5$  | $-2 \sim -1.5$  | $-4 \sim -3$ | $-2.4 \sim -1.8$ | $-2 \sim -1.5$  |
| Medium  | $-1.5 \sim -1$  | $-1.5 \sim -1$  | $-3 \sim -2$ | $-1.8 \sim -1.2$ | $-1.5 \sim -1$  |
| Mild    | $-1 \sim -0.5$  | $-1 \sim -0.5$  | $-2 \sim -1$ | $-1.2 \sim -0.6$ | $-1 \sim -0.5$  |
| Normal  | $-0.5 \sim 0.5$ | $-0.5 \sim 0.5$ | $-1 \sim 1$  | $\geq -0.6$      | $-0.5 \sim 0.5$ |
| Wet     | $\geq 0.5$      | $\geq 0.5$      | $\geq 1$     |                  | $\geq 0.5$      |

# Results



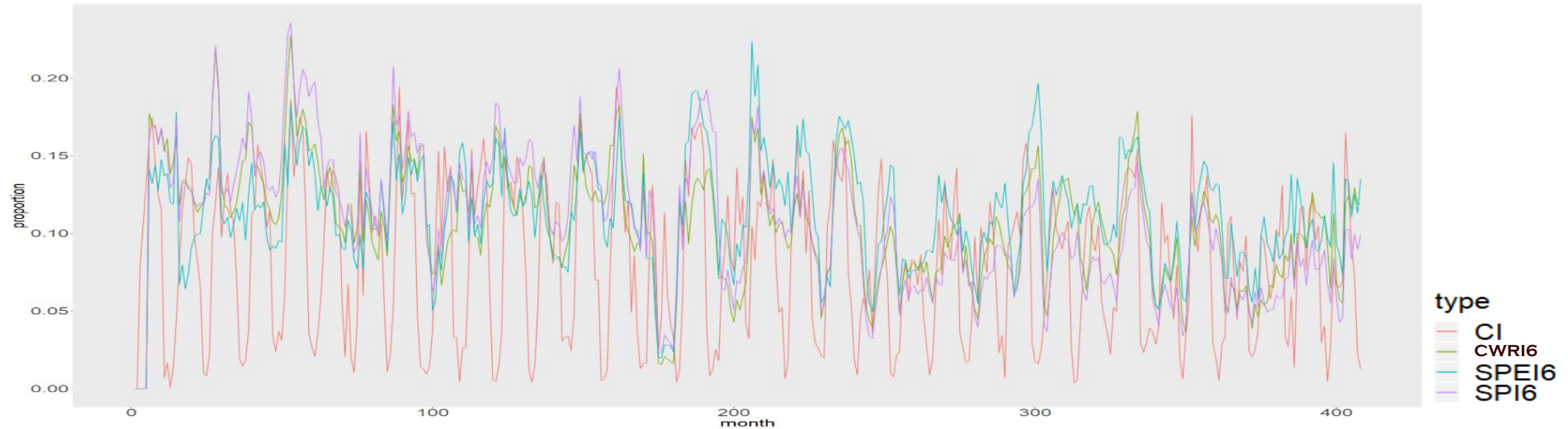
## ❖ Validation with drought events in 2013

➤ CWRI can reflect the drought in spring of 2013.

➤ Among monthly, quarterly, semi-annual, and annual scales, we chose the SPI6, SPEI6, CWRI6, and CI for comparison.



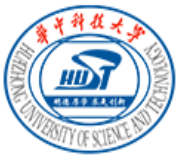
# Results



**Variation of the proportion of drought Area (1982.1-2015.12)**

- Other indices have the problem of unreasonable drought aggravation.
- Such as, CI fluctuates violently especially in the time period without precipitation.

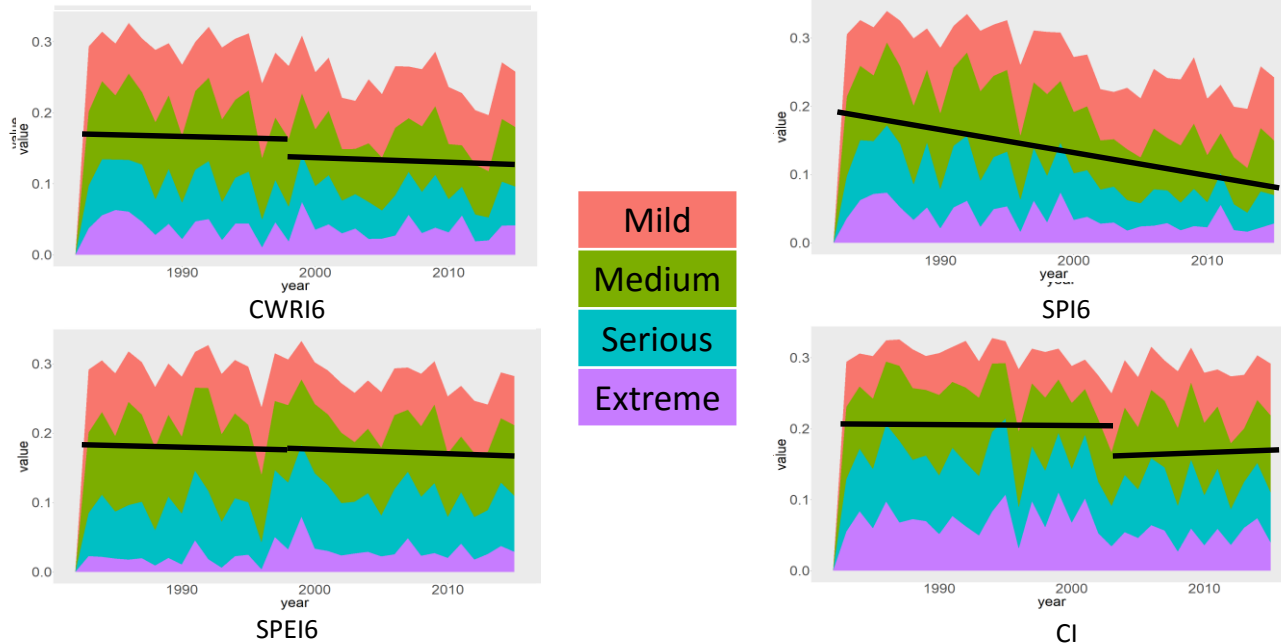




# Results



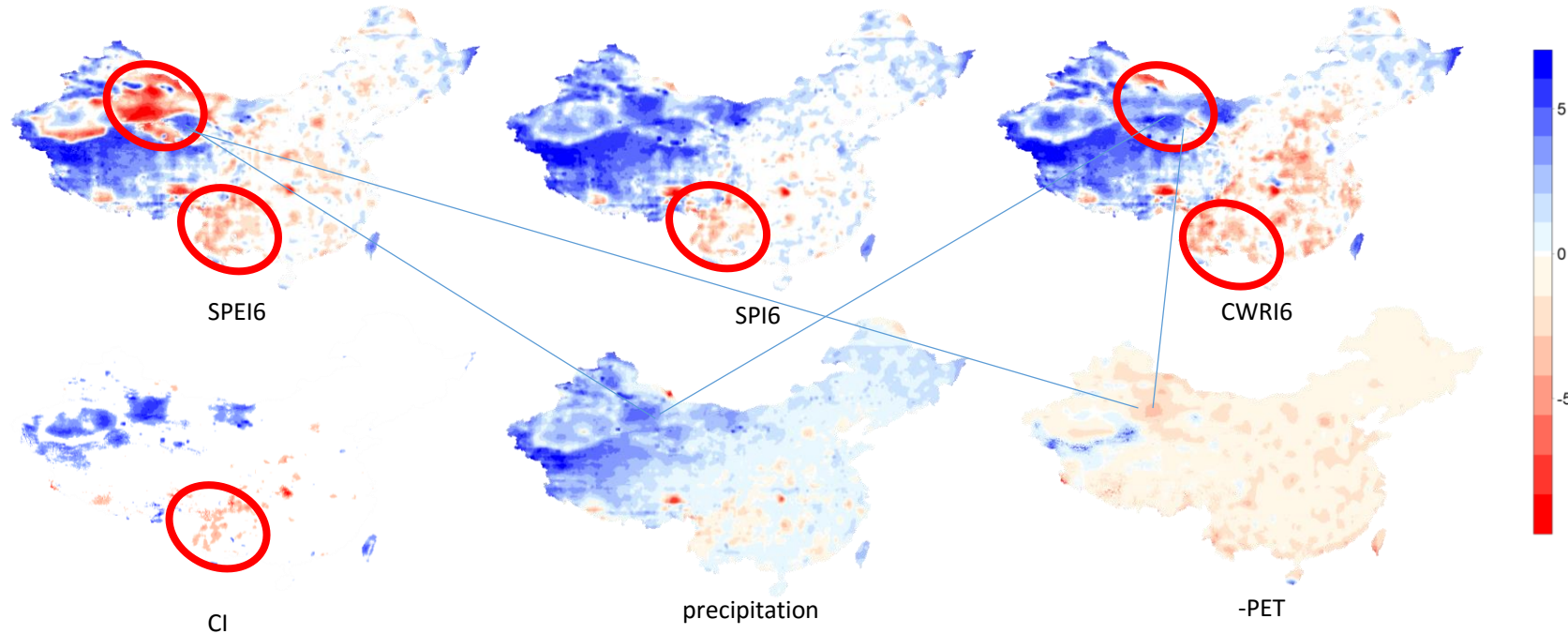
## ❖ Trends of drought



- Among the four indexes, SPI shows a downward trend, which is quite different from the actual situation.
- The change of SPEI is non significant.
- CWRI and CI show a phased characterize.

# Discussions

## ❖ Trends and the relationship with P and ET



- Several drought indexes reflect the increasing trend of drought in Southwest China, especially in Yunnan Province.
- CWRI is reasonable, and suitable for drought monitoring.



谢谢!

Thank you!

vielen Dank für Ihre Aufmerksamkeit

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The R tool named “RMEP”, developed by our team for ET calculation and be available in R platform using the folling code:

```
install_github("Yangyonghust/RMEP")
```

Github access: <https://github.com/Yangyonghust/RMEP>

A VIC model in R, developed by our team:

```
install_github("MomentVon/EDHM")
```