Tornado disaster assessment of rubber plantation in western Hainan Island using Landsat and Sentinel-2 time series images

Bangqian Chen[1], Tin Yun[2] , Fen An[1], Zhixiang Wu[1]

1. Rubber Research Institute (RRI), CATAS, Hainan Island, China.
2. Nanjing Forestry University, Nanjing, China.

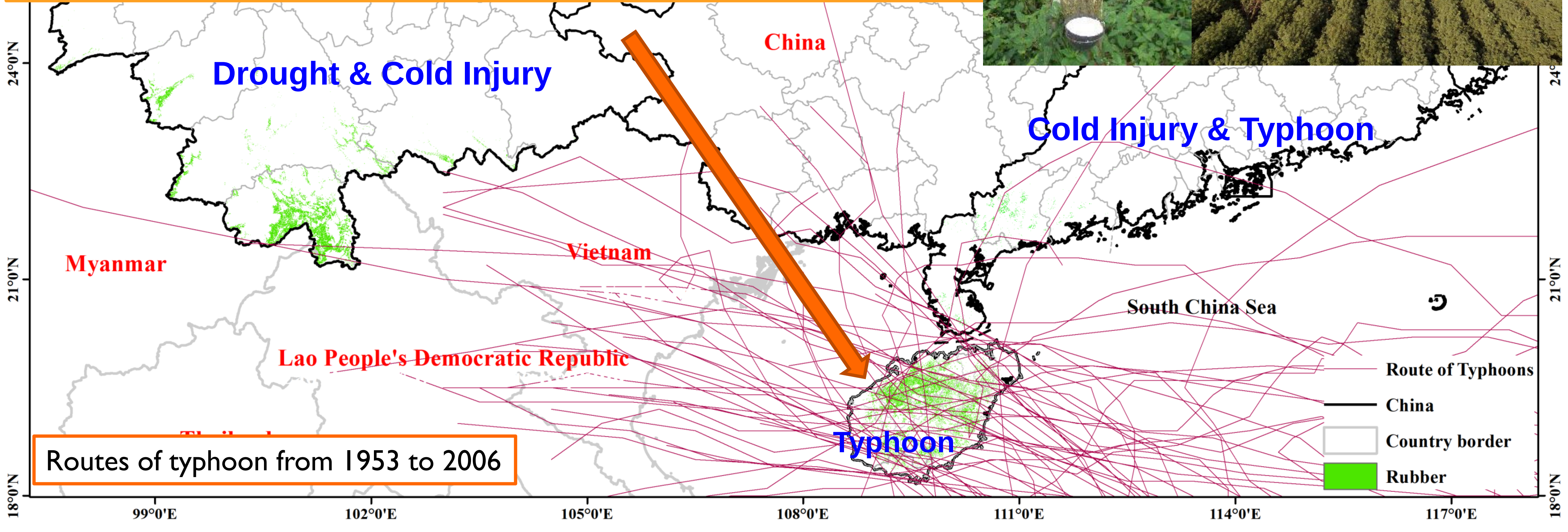
chbq40@163.com

Wednesday, June 24, 2020

1. Introduction

Rubber plantation (RP) in China

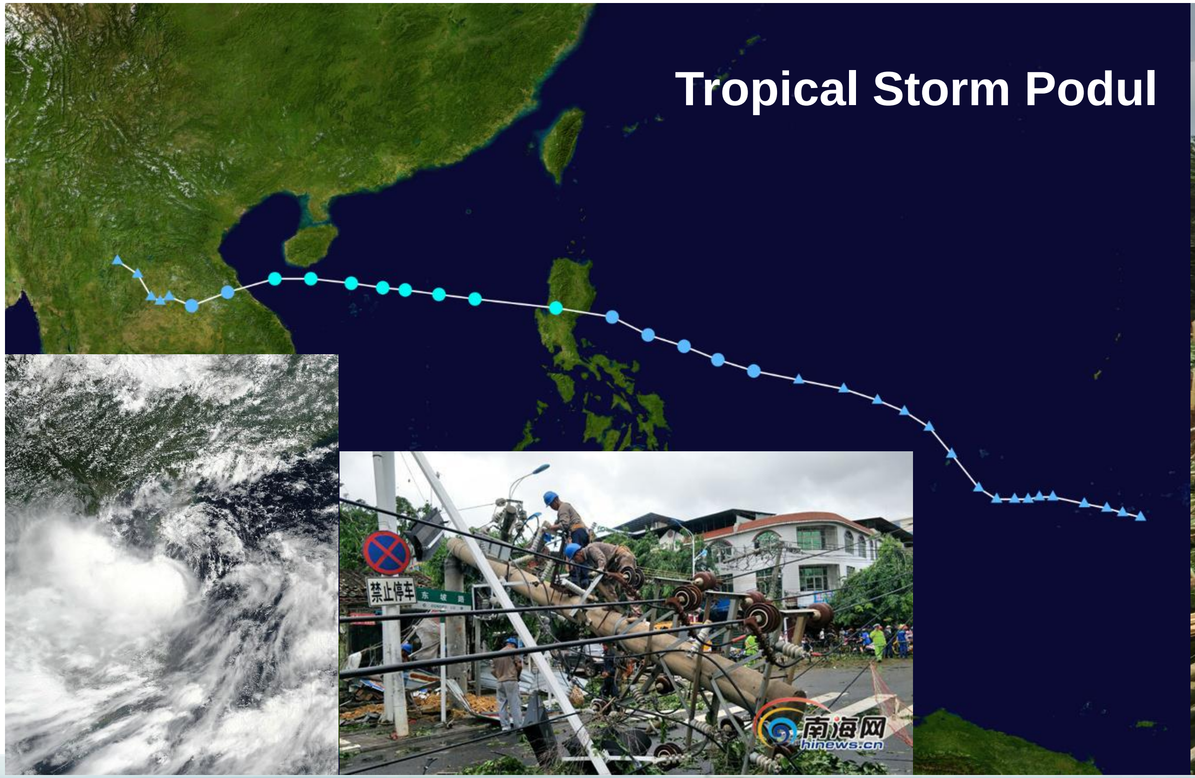
- About 1,157,000 ha in 2017, rank 3th in the world;
- Three production bases: Hainan (47%), Yunnan (50%), Guangdong (3%);
- All regions face serious natural disaster threats.



Routes of typhoon from 1953 to 2006

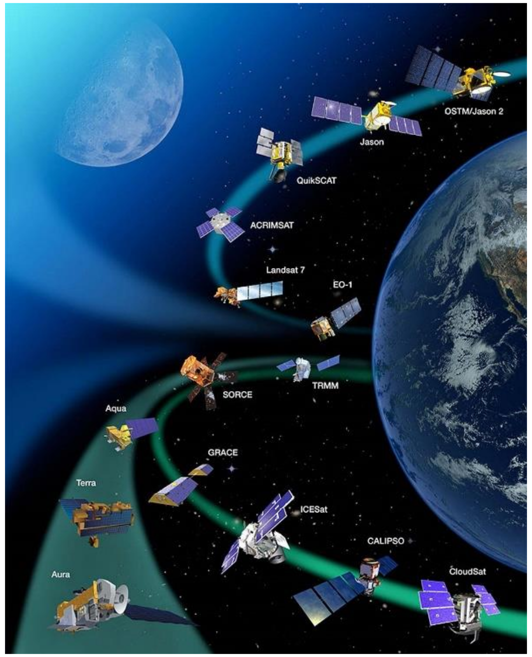
Tornado in western Hainan Island

2019/8/29, **Podul** triggered **tornado** (EF2 level, 49-74m/s) in Hainan, killed 8 people, destroyed many rubber plantation, damage reached $2.27 million.



Disaster assessment, challenges and opportunities

Remote sensing is the most important way for large scale disaster assessment



Increased satellites

Improved resolution

More open-access big data

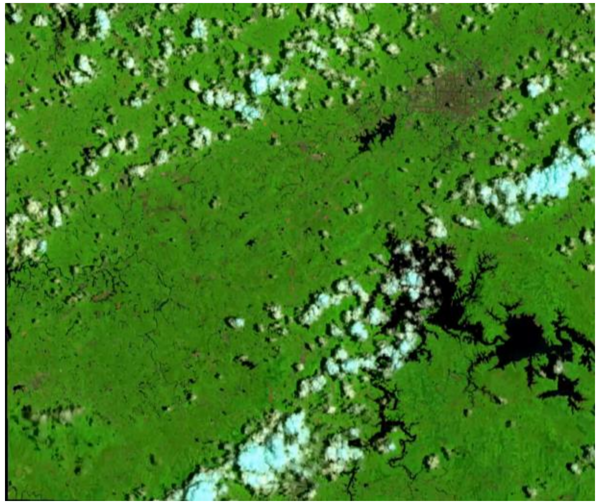
Cloud computation

Cloud contamination in optical images

Limited SAR data

Fragment landscape

Land use change



Opportunities

Challenges

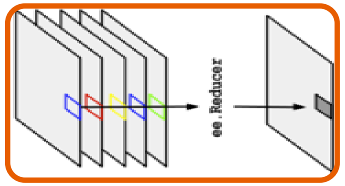
Objectives

A case study of monitoring damage of rubber plantation caused by Tornado using remote sensing big data.

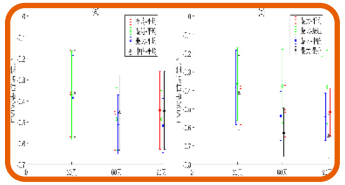
Why monitor Tornado?

- **Latest disaster with Landsat 7/8 and twin satellite of Sentinel-2A/B**
  - S2-A/B revisiting every 5 days
  - Landsat revisiting every 16 days
  - Spatial resolution 10, 20, 30-m
- **Damage characteristics are similar to typhoons**
  - Fast physical destruction

1. **When** is the ideal monitoring time?



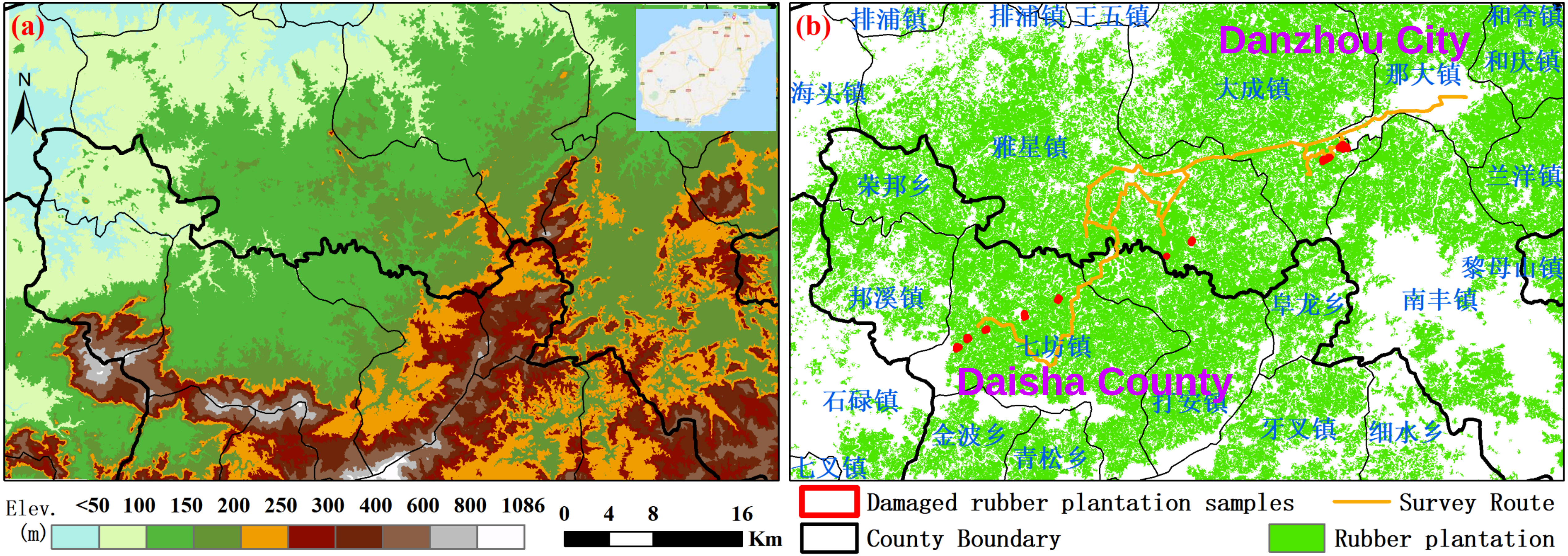
2. **How** to using the dense time series images?



3. **What** are the best monitoring indicators?

2. Material and methods

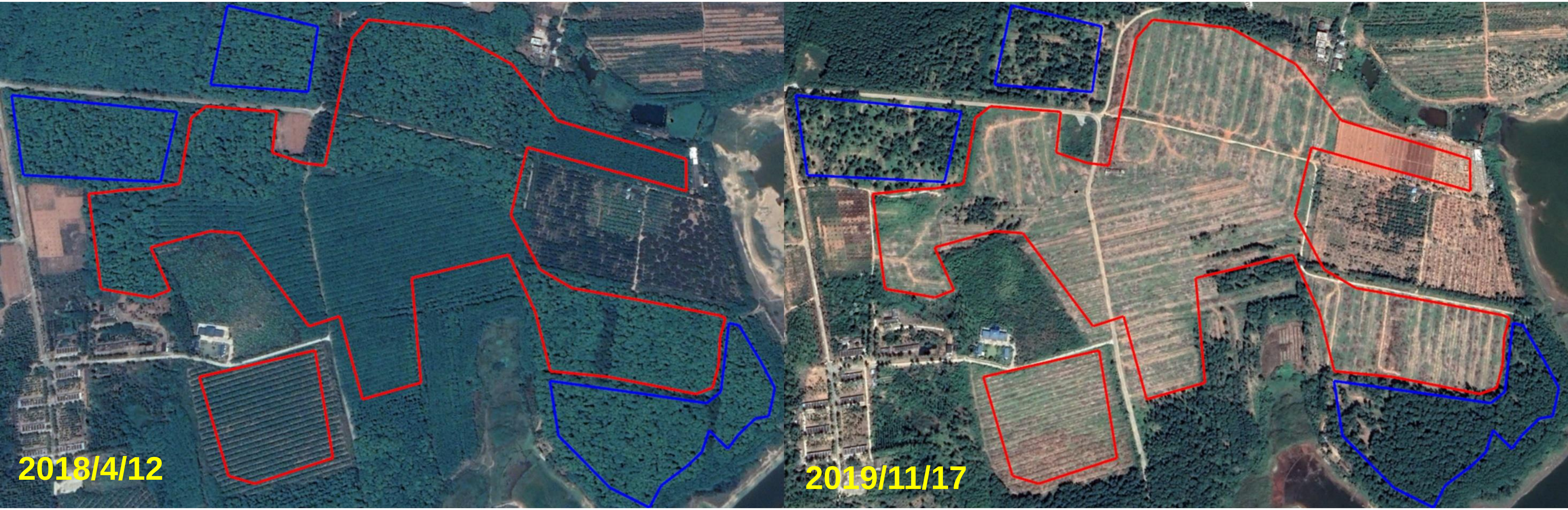
Study area and field survey



Field survey were carried quickly in the next days (8/29 and 8/30).

Study area and field survey

Mark damage plantations using Google Earth



Plantations in red polygon were updated between 2019/8/29 and 2019/11/17

Plantations in blue polygon were updated between 2019/11/17 and 2020/1/15

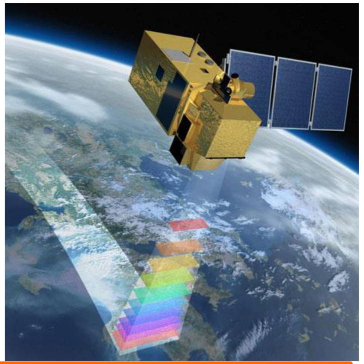
Satellite imagery

Landsat 7/8 Collection 1 TOA reflectance, from USGS

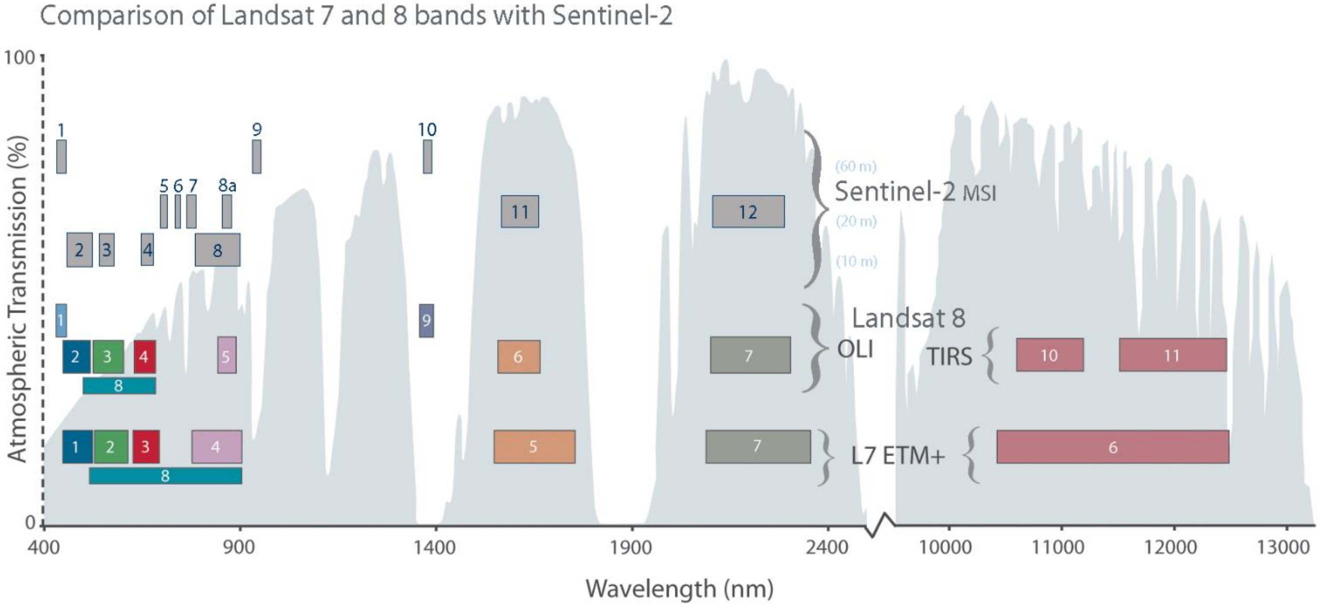
- 30-m resolution
- Revising every 16 days

Sentinel-2 A/B L1C TOA, from ESA

- 10, 20, 60-m resolution
- Revising every 5 days



- Landsat 7, lunched in 1999
- Landsat 8, lunched in 2015
- Sentinel-2A, lunched in 2015
- Sentinel-2B, lunched in 2017



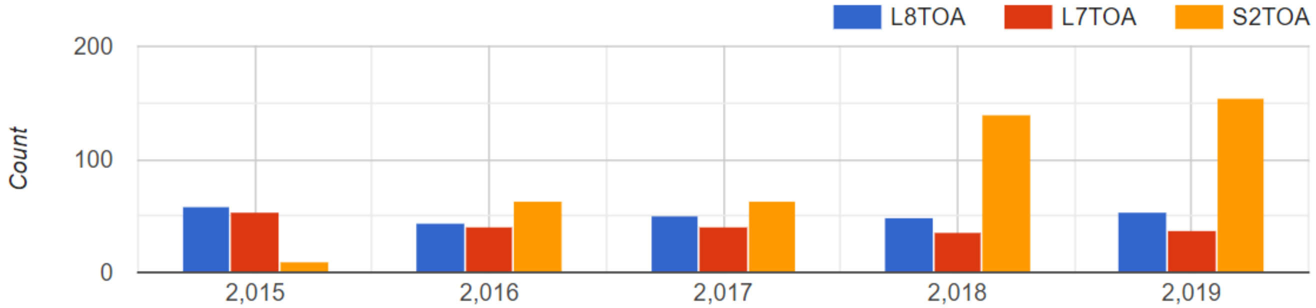


Image count during 2015-2019 in the study area (40 x 70 km)

Imagery pre-processing

Quality controlling

- Cloud masking and scan-off line excluding (ETM+)
- Bands harmonization

Vegetation indices calculation

$$NDVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red}}$$

$$LSWI = \frac{\rho_{NIR} - \rho_{SWIR1}}{\rho_{NIR} + \rho_{SWIR1}}$$

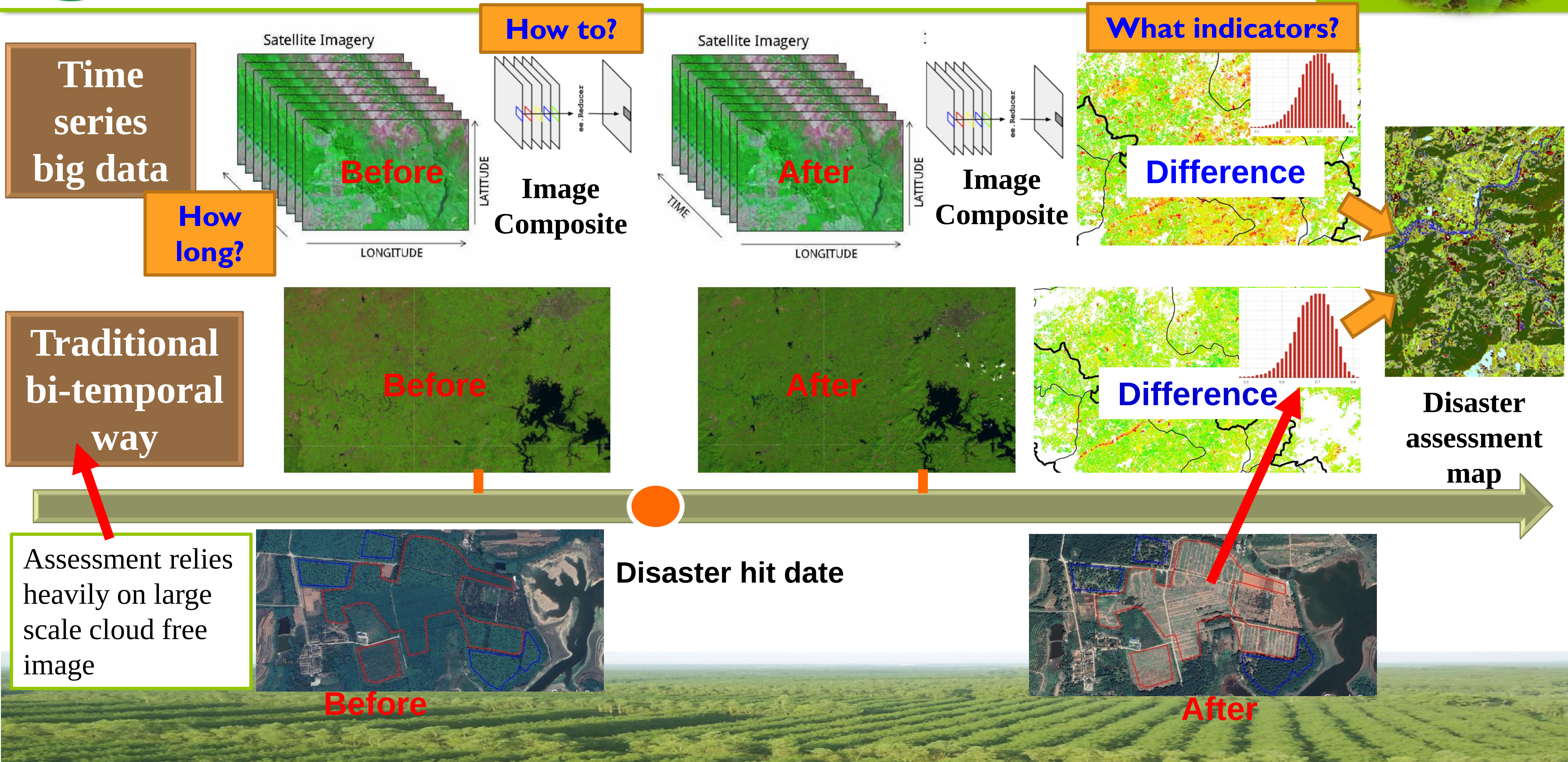
$$EVI = 2.5 \times \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + 6 \times \rho_{Red} - 7.5 \times \rho_{Blue} + 1}$$

$$NBR = \frac{\rho_{NIR} - \rho_{SWIR2}}{\rho_{NIR} + \rho_{SWIR2}}$$

Image composite

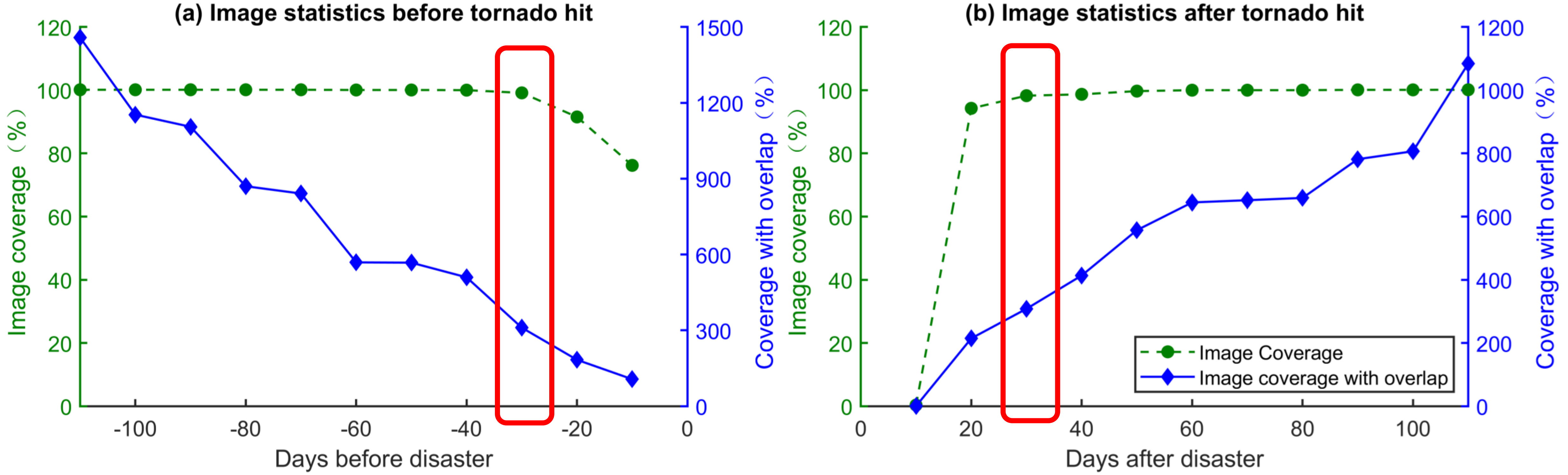
- Max / min / median / latest / mean value composite

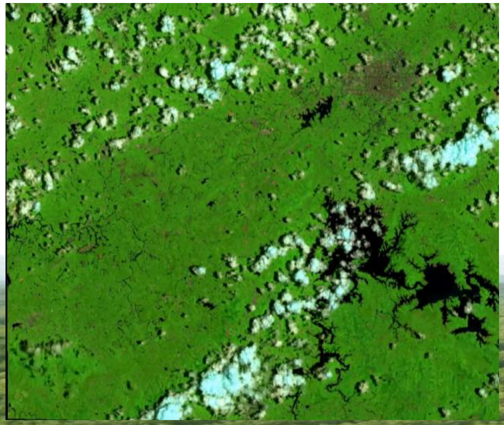
Algorithm— Image difference

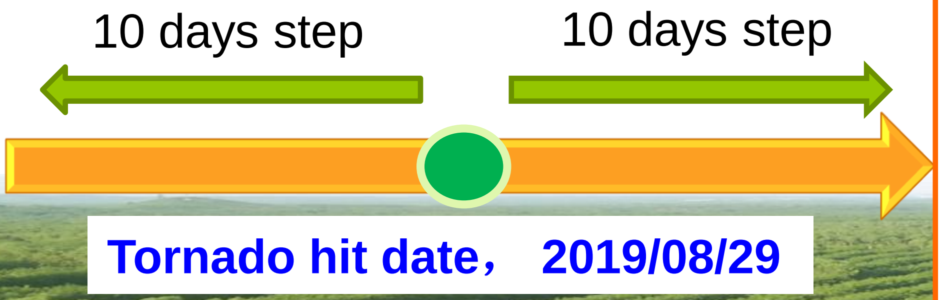


3. Results and discussion

Cloud-free image coverage assessment

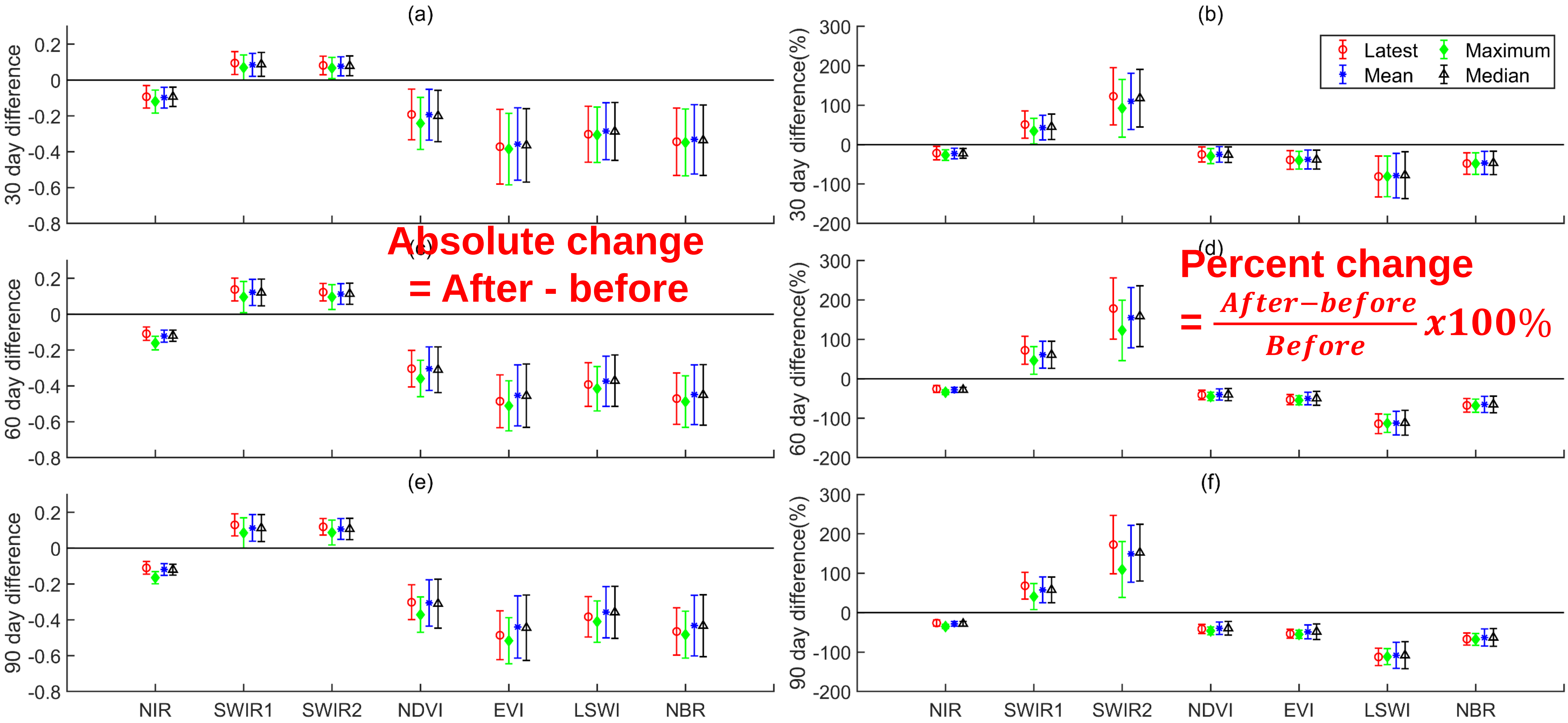




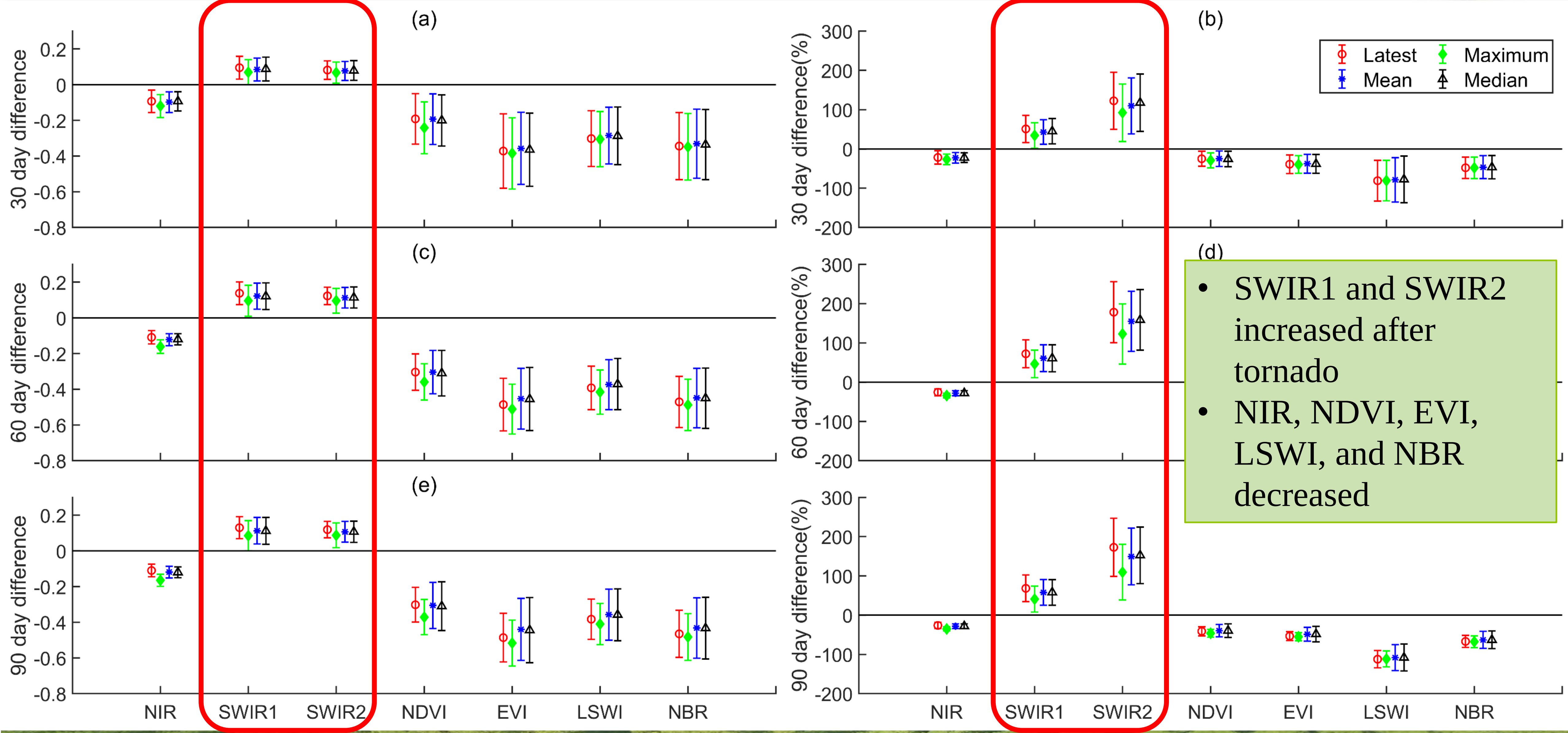


- 30 days almost full coverage, average pixel coverage is three times
- 60 days average pixel coverage is six times
- 90 days average pixel coverage > 8 times

Indicators and composite methods before tornado

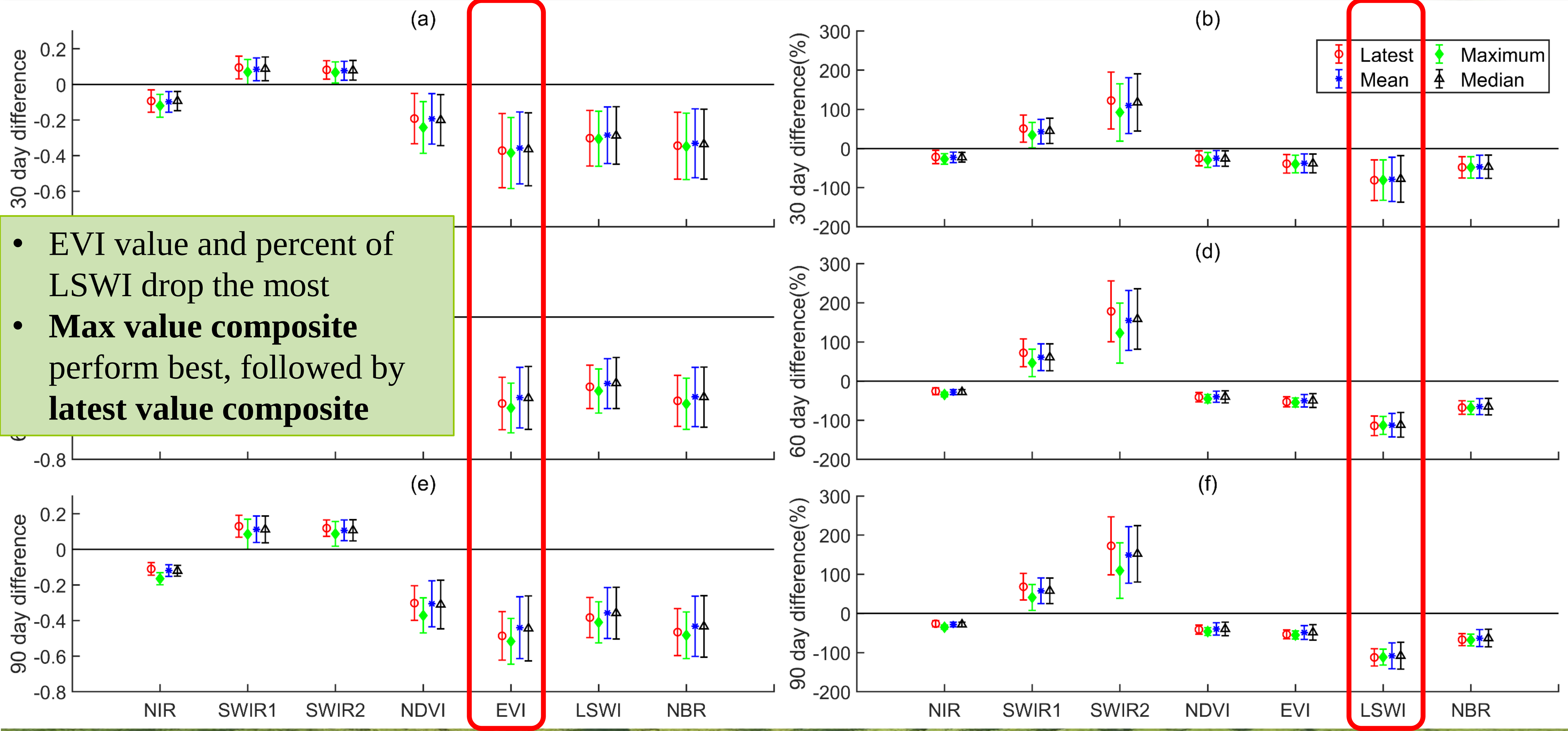


Indicators and composite methods before tornado



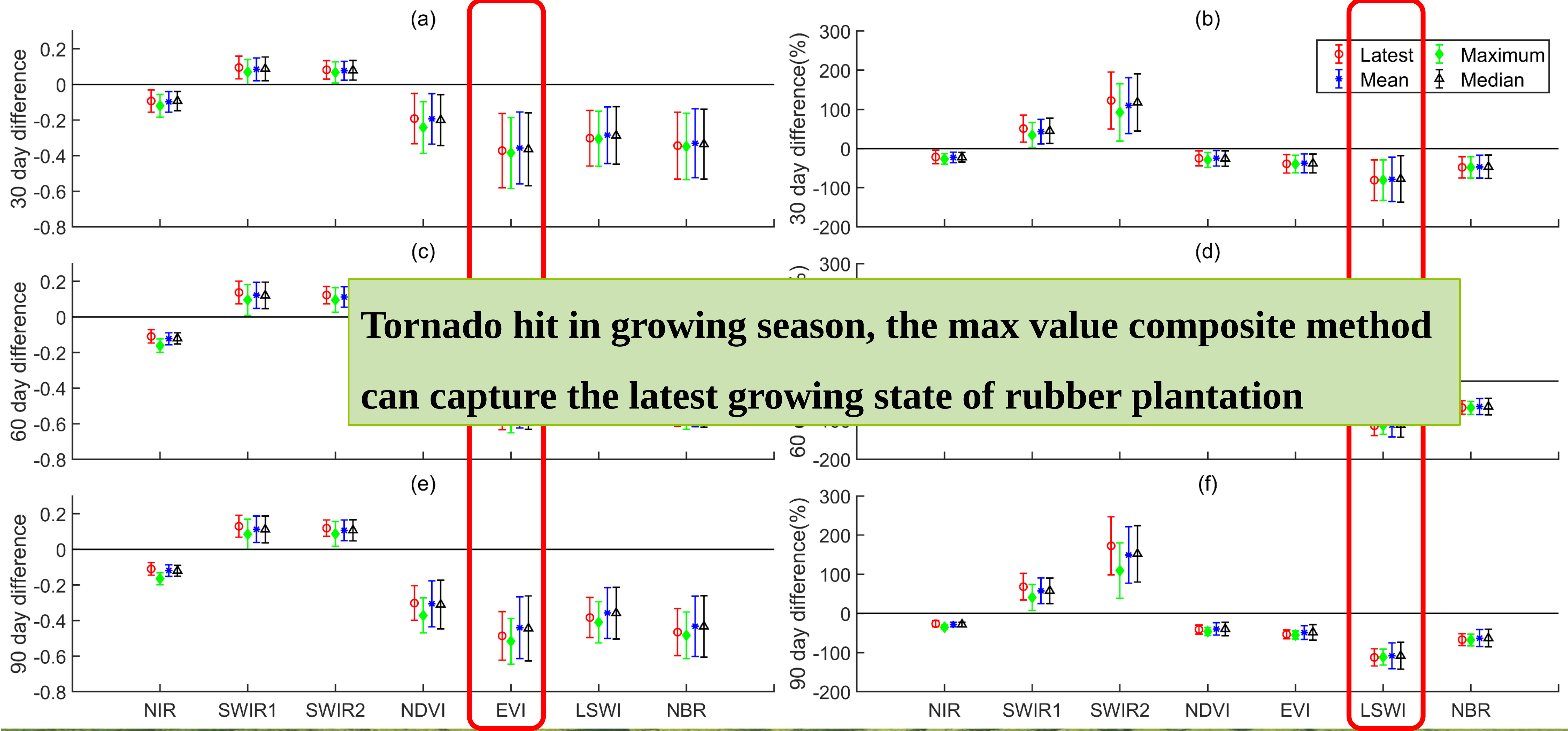
- SWIR1 and SWIR2 increased after tornado
- NIR, NDVI, EVI, LSWI, and NBR decreased

Indicators and composite methods before tornado



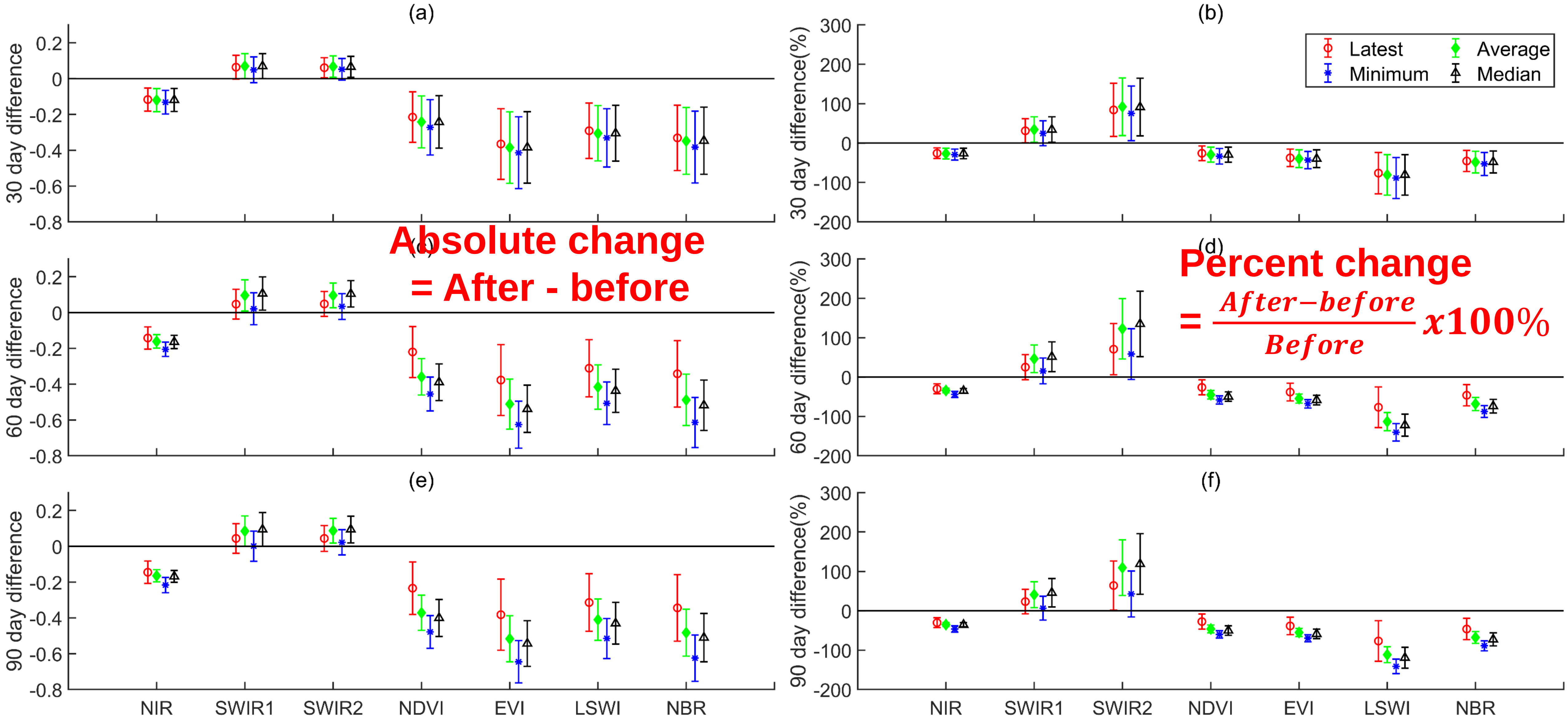
- EVI value and percent of LSWI drop the most
- **Max value composite** perform best, followed by **latest value composite**

Indicators and composite methods before tornado



Tornado hit in growing season, the max value composite method can capture the latest growing state of rubber plantation

Composite methods after tornado

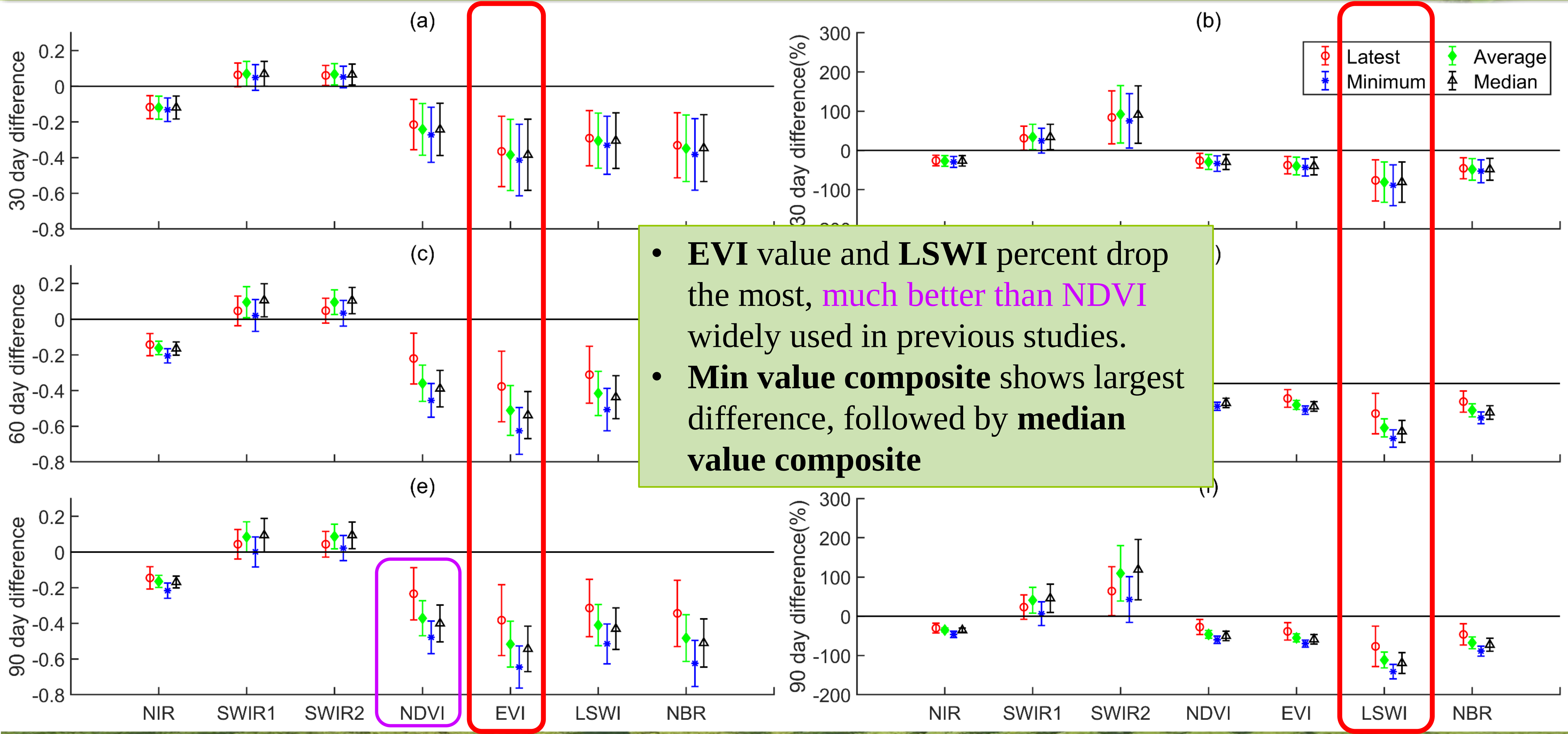


Absolute change = After - before

Percent change

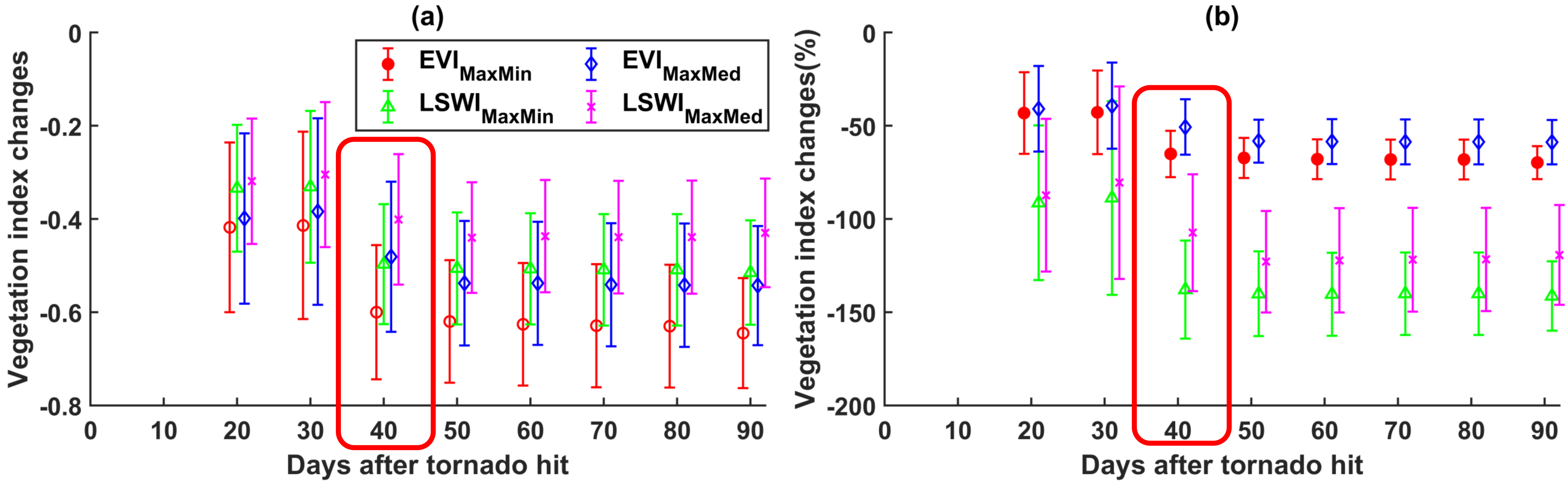
$$= \frac{After - before}{Before} x100\%$$

Composite methods after tornado



- **EVI** value and **LSWI** percent drop the most, much better than NDVI widely used in previous studies.
- **Min value composite** shows largest difference, followed by **median value composite**

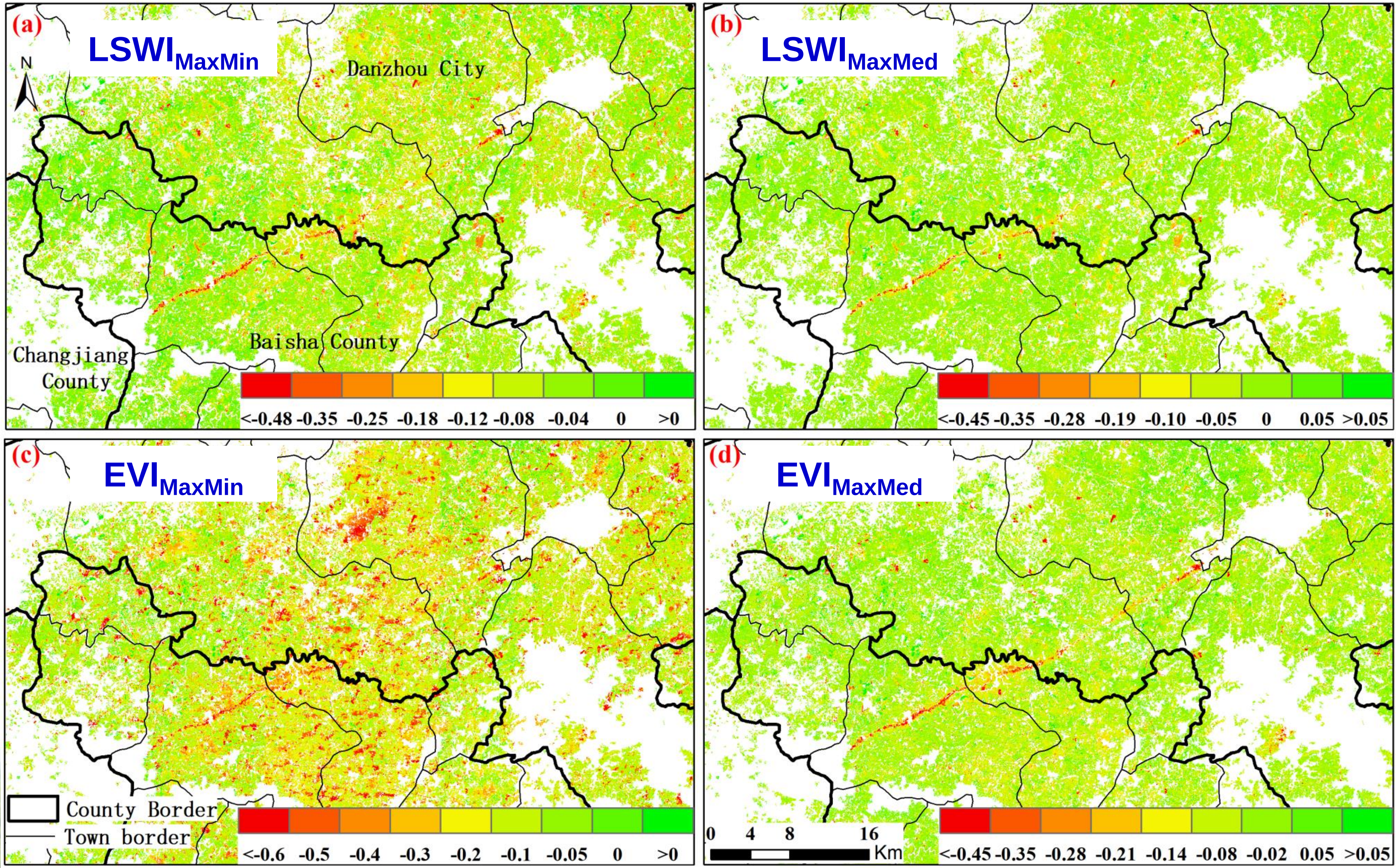
Time window test based on best indicators



- Indicators become **stable** about **40 days**
- Recommend **60 days** window, **Max-Min best**, then is **Max-Med** by ground reference.

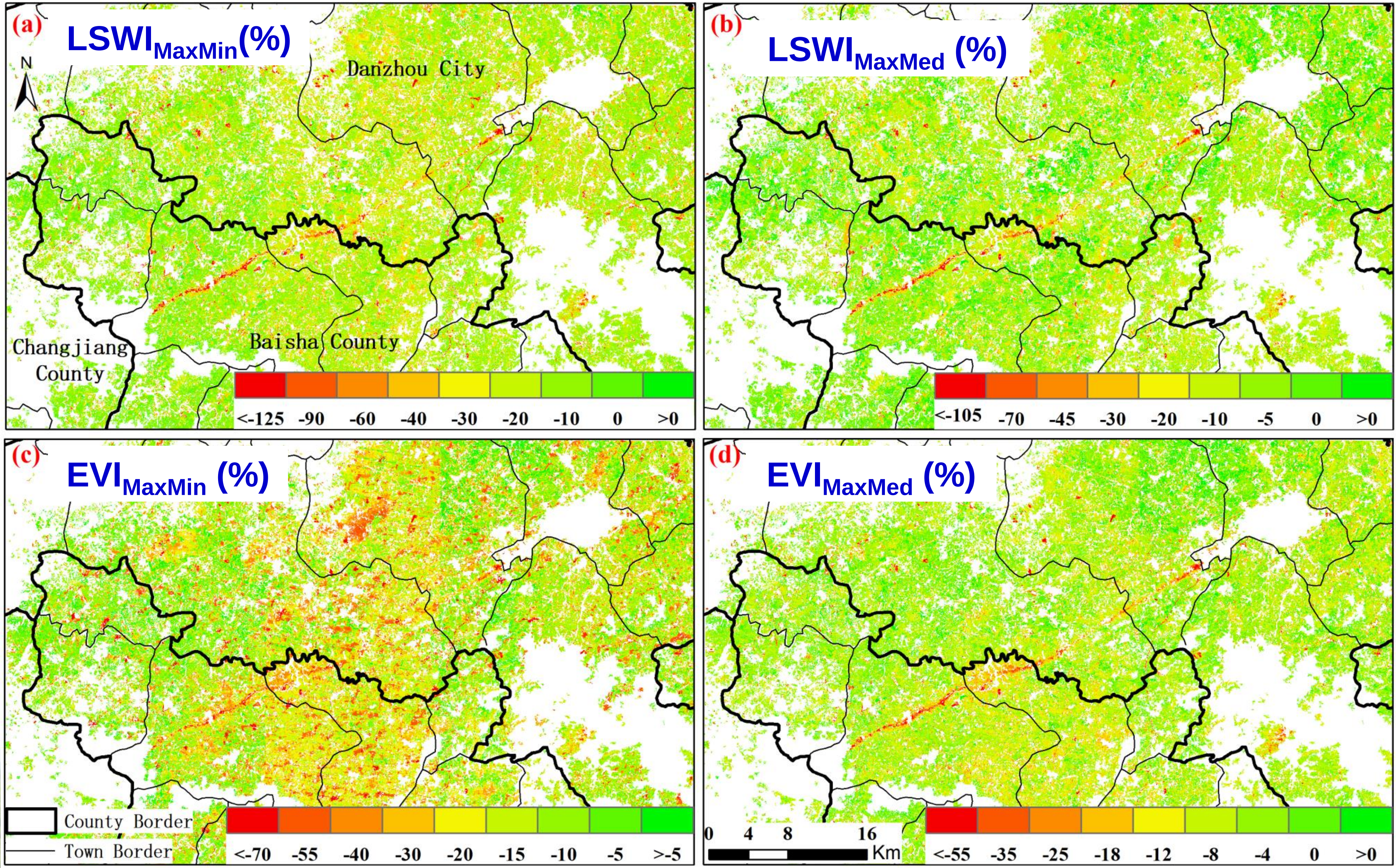
Spatial change of EVI/LSWI values

- All maps clear show tornado route except EVI_{MaxMin};
- Lots of noise in difference image come from Max-Min composite images
- Max-Med composite show better performance
- EVI_{MaxMed} is slightly better than $LSWI_{MaxMed}$



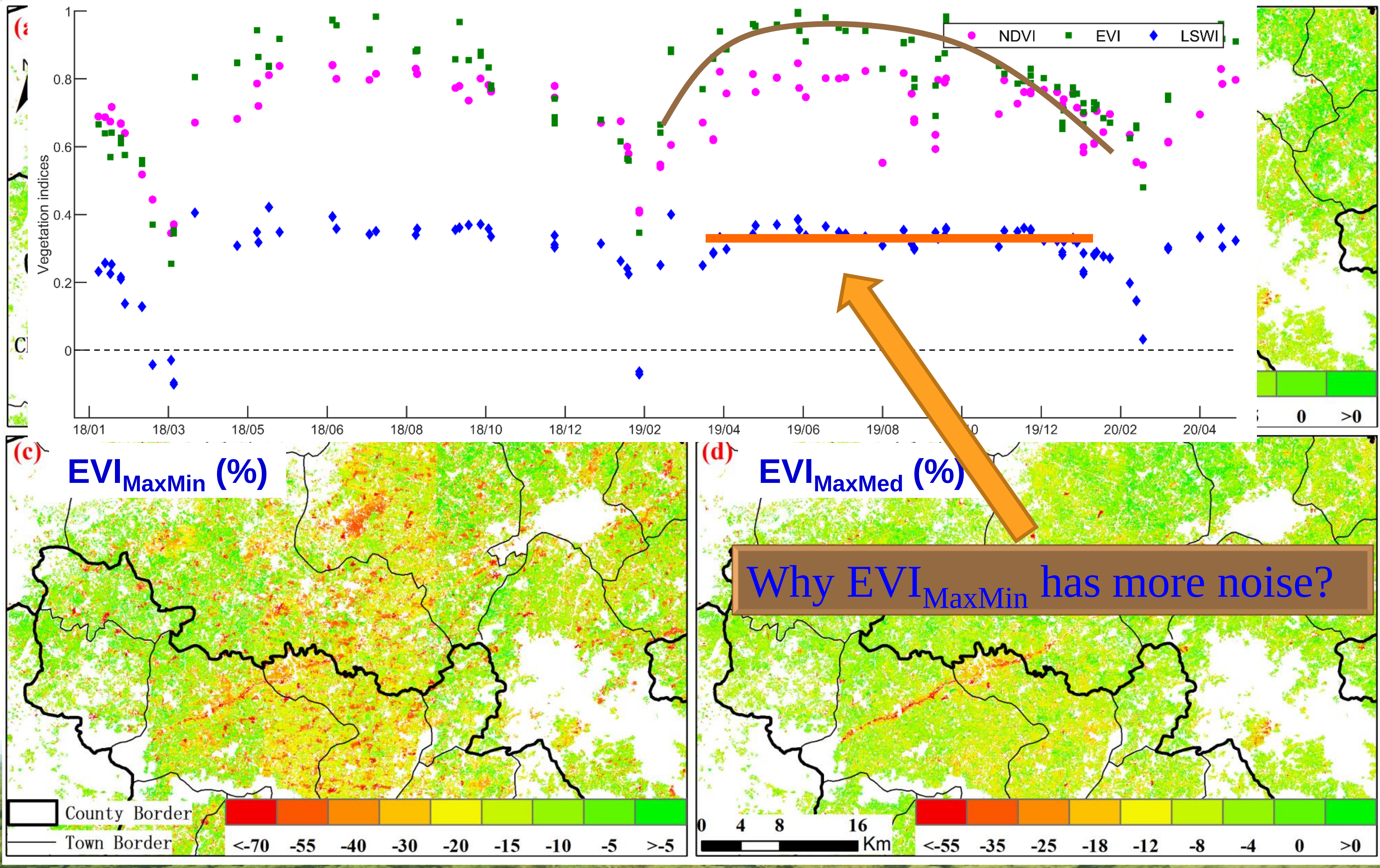
Spatial change of EVI/LSWI percent value

- All maps clear show tornado route except EVI_{MaxMin};
- Lots of noise in difference image come from Max-Min composite images
- Max-Med composite show better performance
- $LSWI_{MaxMed}$ is slightly better than EVI_{MaxMed}



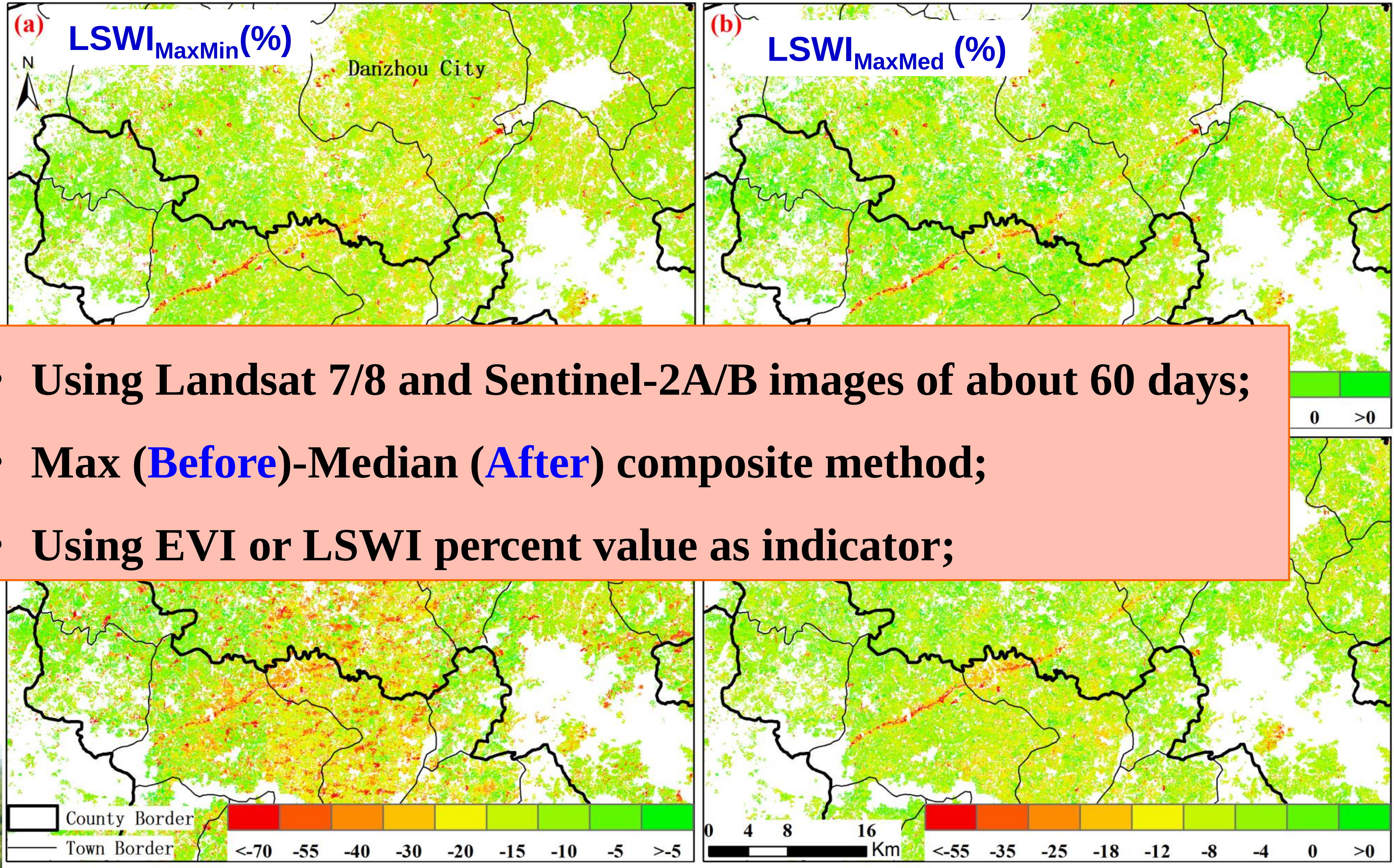
Recommend ways for tornado damage assessment

- All maps clear show tornado route except EVI_{MaxMin};
- Lots of noise in difference image come from Max-Min composite images
- Max-Med composite show better performance
- $LSWI_{MaxMed}$ is slightly better than EVI_{MaxMed}



Recommend ways for tornado damage assessment

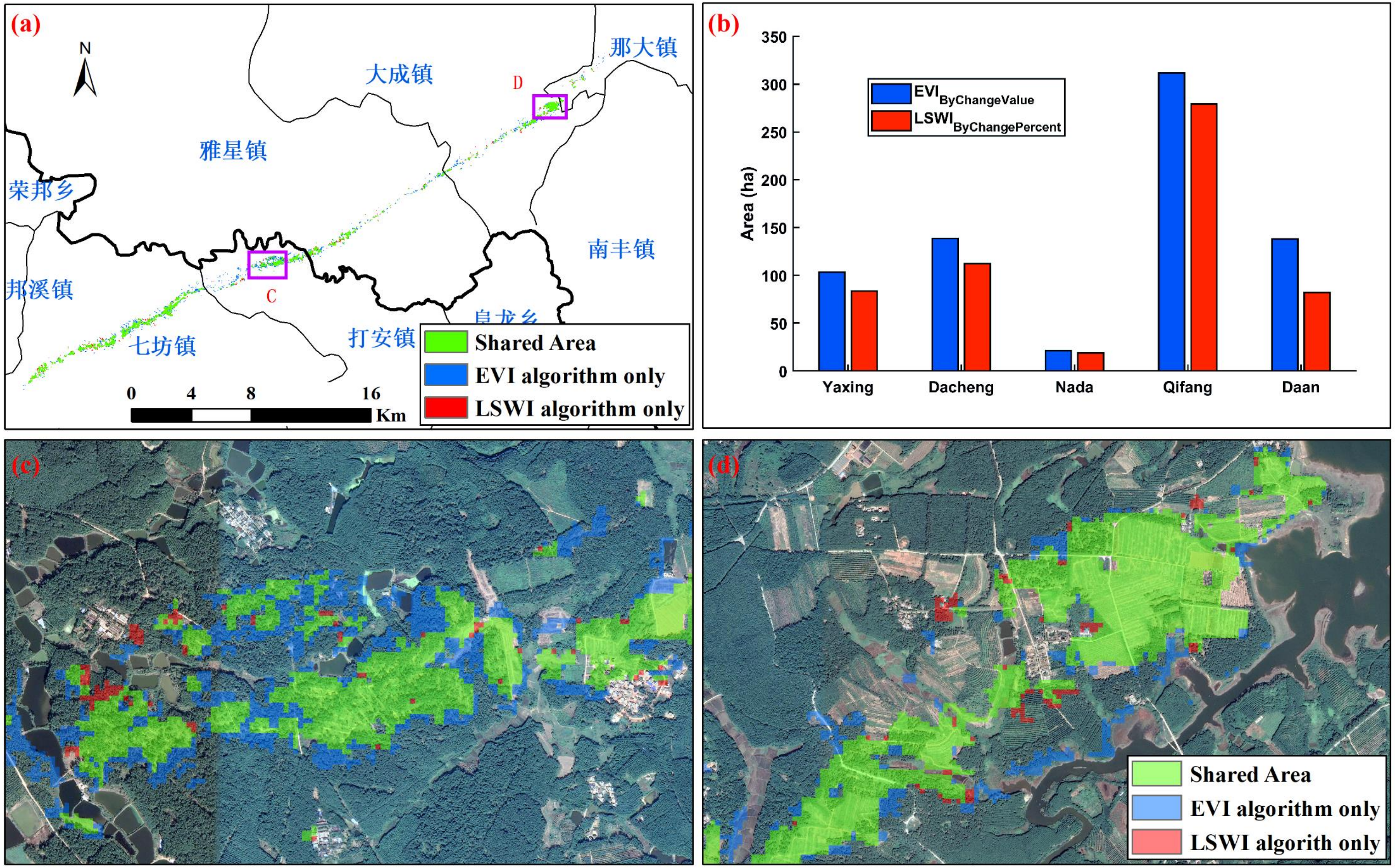
- All maps clear show tornado route except EVI_{MaxMin};
- Lots of noise in difference image come from Max-Min composite images
- Max-Med composite show better performance
- $LSWI_{MaxMed}$ is slightly better than EVI_{MaxMed}



- **Using Landsat 7/8 and Sentinel-2A/B images of about 60 days;**
- **Max (Before)-Median (After) composite method;**
- **Using EVI or LSWI percent value as indicator;**

Damage area statistics

- Two algorithms agree well with most towns;
- Qifang town rank the top, loss about 300 ha of rubber plantation;
- Total damage area ranges from 576 to 712 ha;
- Manual adjustment is necessary if need very high accuracy damage data.



4. Conclusion

Take home message

Increasingly extreme weather and natural disasters under climate change pose huge challenges to rubber industry.

Remote sensing big data brings lots of opportunities for disaster assessment

For tornado/typhoon disaster of rubber plantation, we recommend:

- Using Landsat 7/8 and Sentinel-2A/B images of about 60 days;
- Max (Before)-Median (After) composite method;
- Using EVI or LSWI percent value as indicator;


Thank you!
Question and
suggestion?