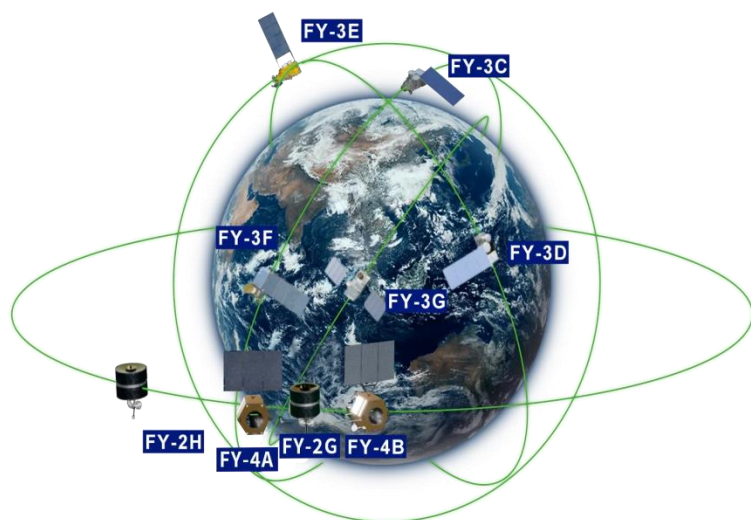




中国气象科学研究院  
CHINESE ACADEMY OF METEOROLOGICAL SCIENCES

## Merging ground observation and satellite remote sensing and its' application in agriculture drought and water-logging



Shibo Fang, et al

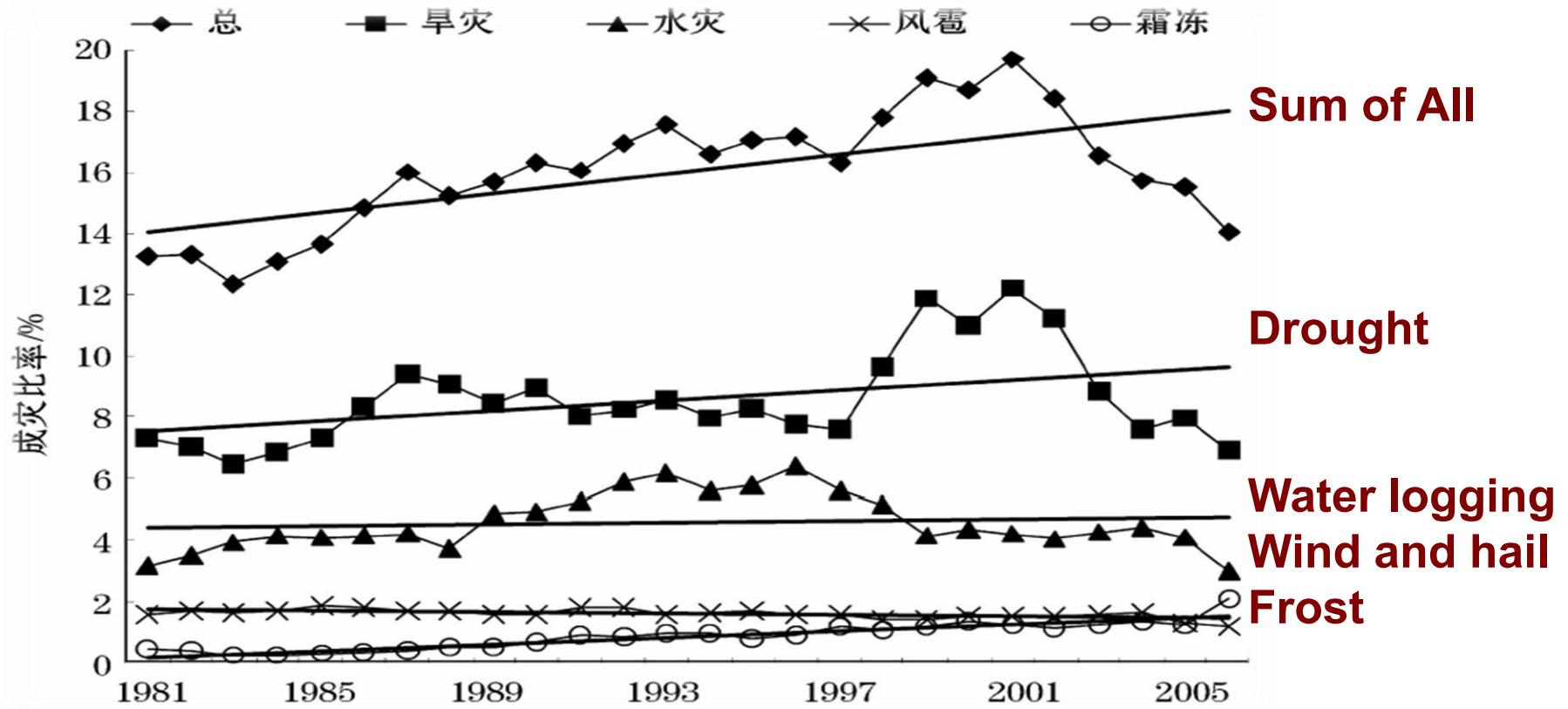
Contact: Dr. Shibo Fang

[sbfang0110@163.com](mailto:sbfang0110@163.com) WeChat:



# Agro-Metrological Disaster lost in China

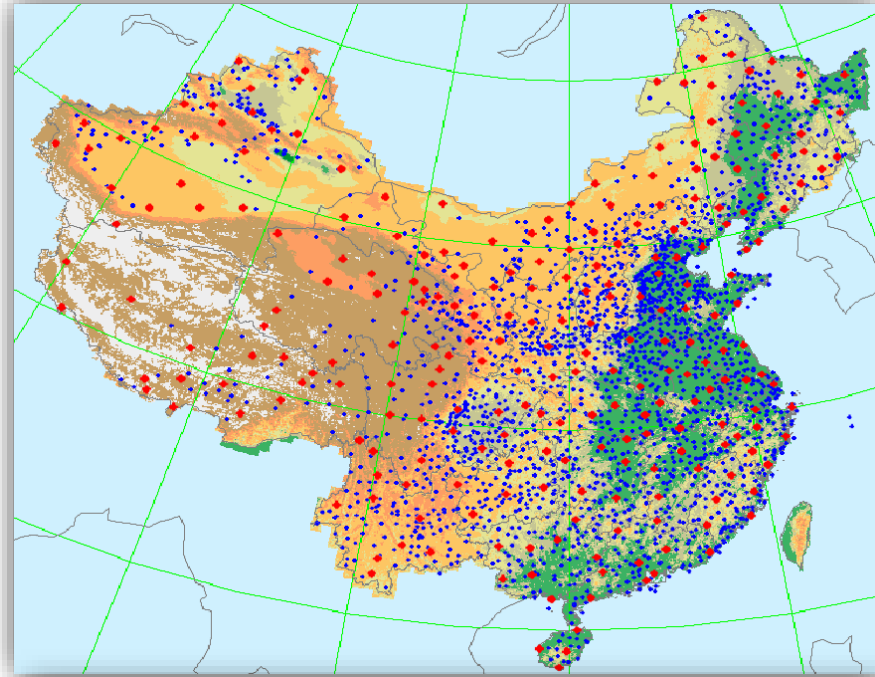
**Drought Lost 75.69 bn RMB/a, 1.2% of GDP**



(房世波, 等. 2011, 自然灾害学报)

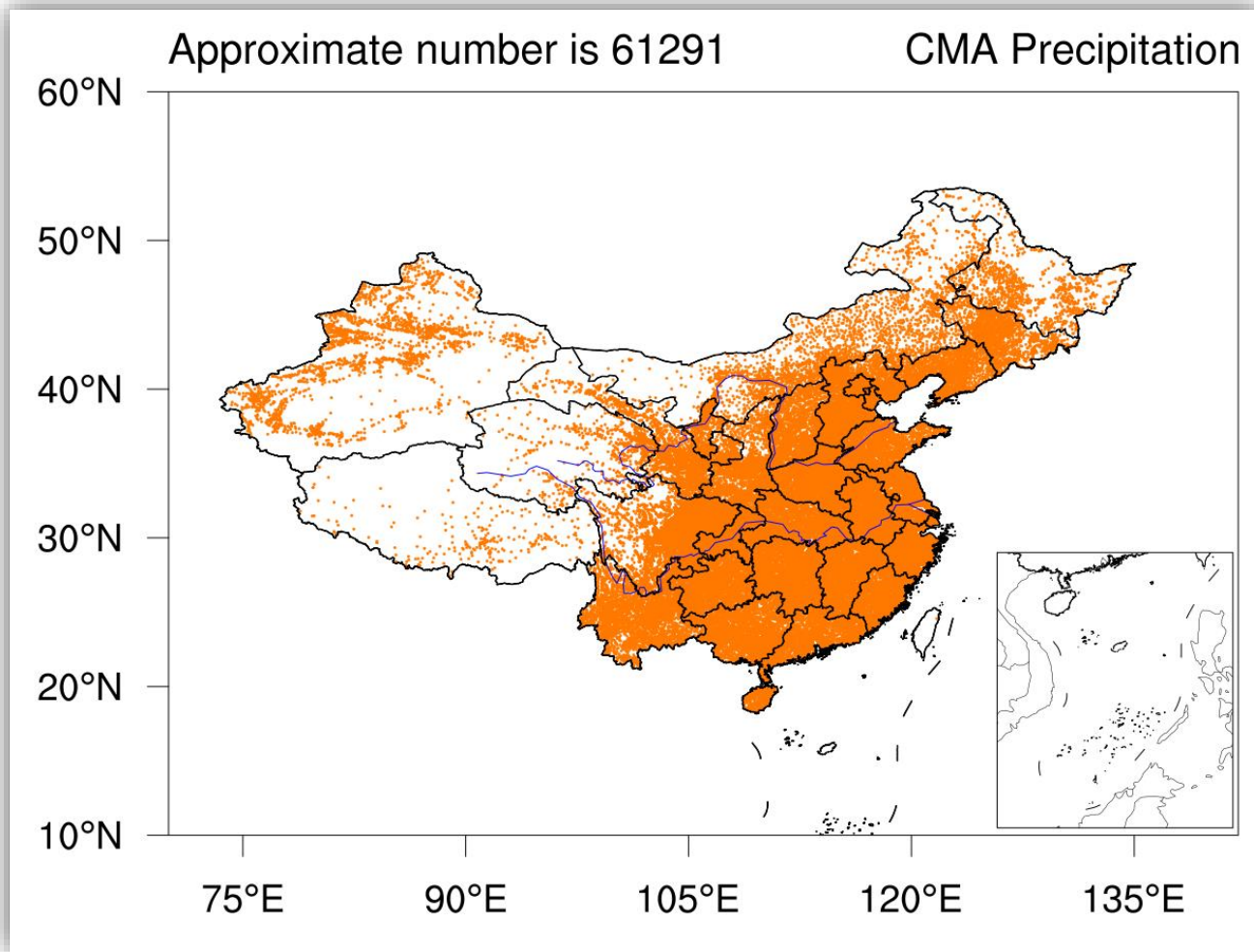
# Meteorology Observe in China (manual observation)

- National station ,241
- Basic station, 620
- Normal staiton,1562



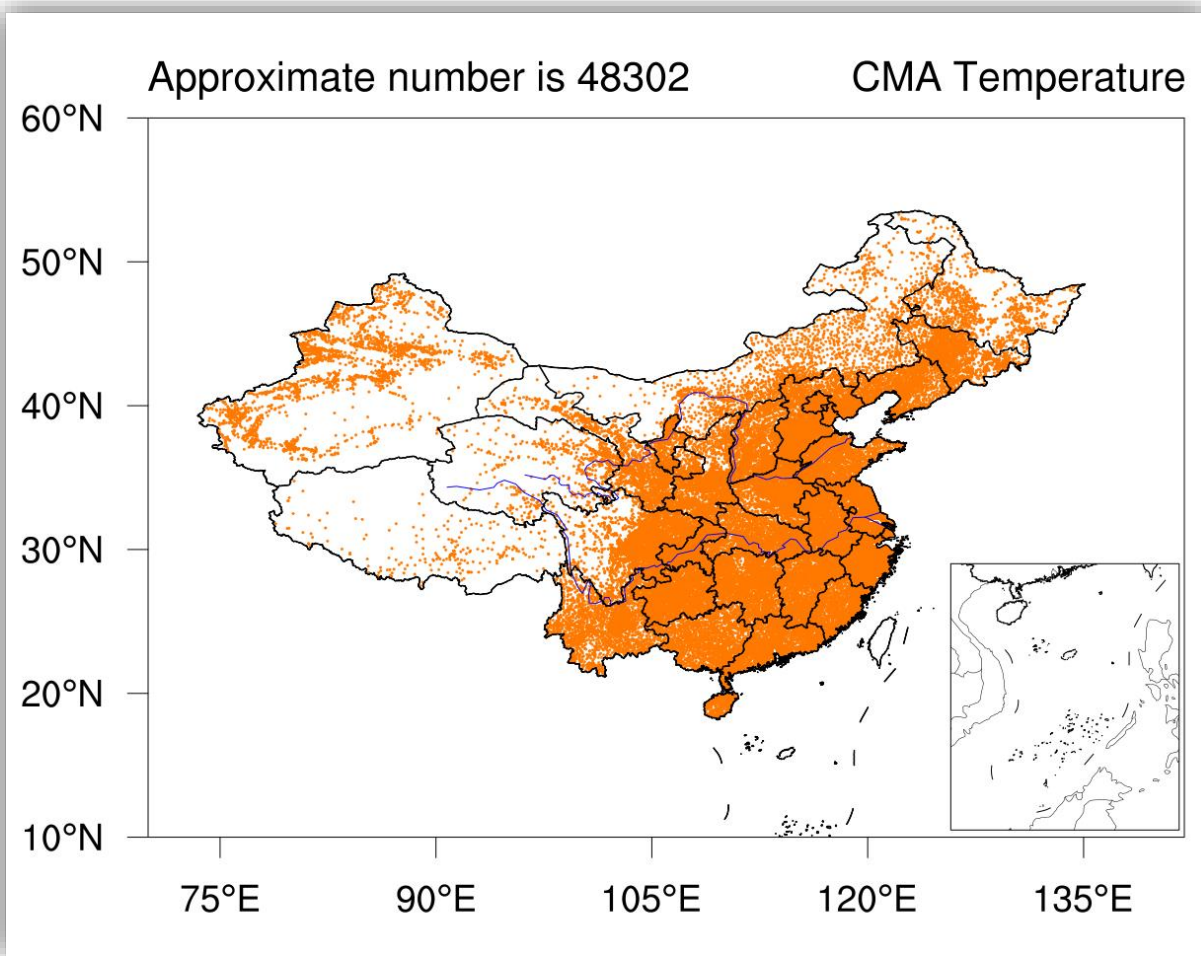
# Meteorology Observe in China (Automatic observation)

自动雨量站，61291个



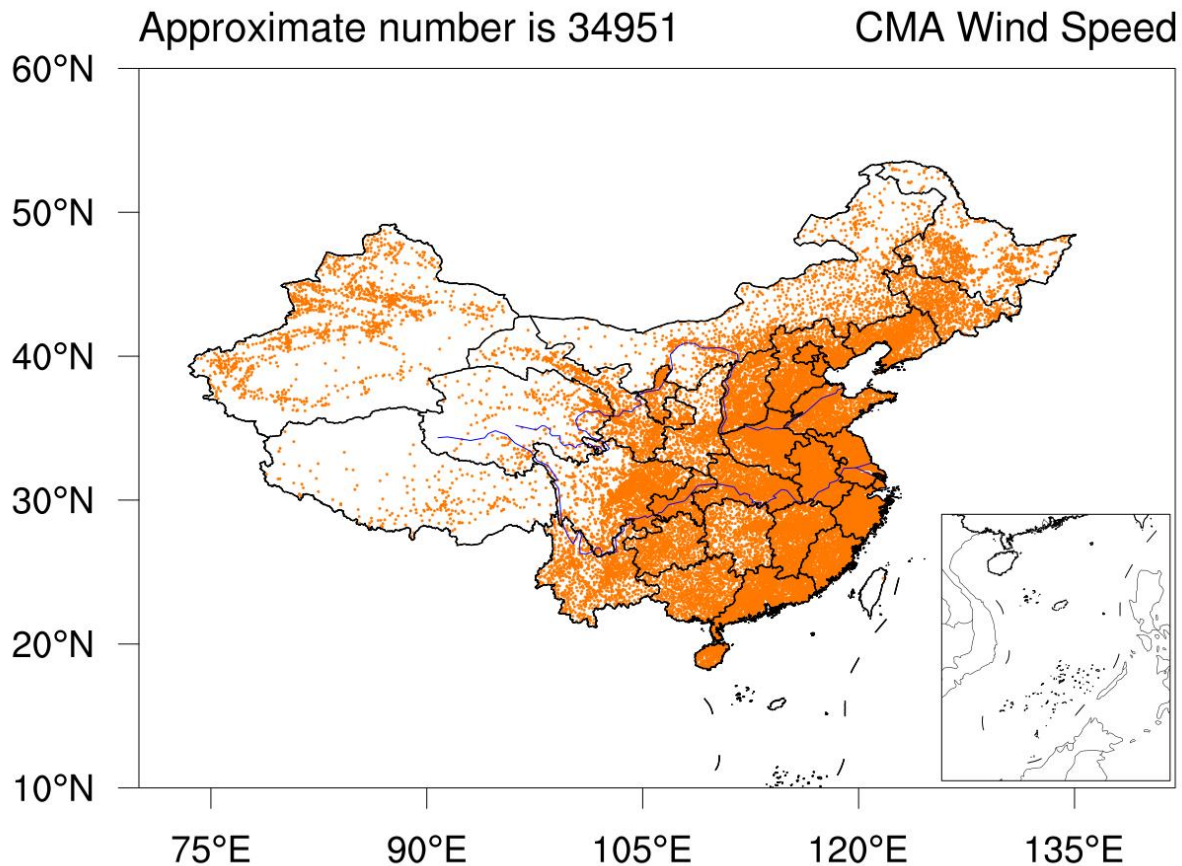
# Meteorology Observe in China (Automatic observation)

自动气温观测，48302个站



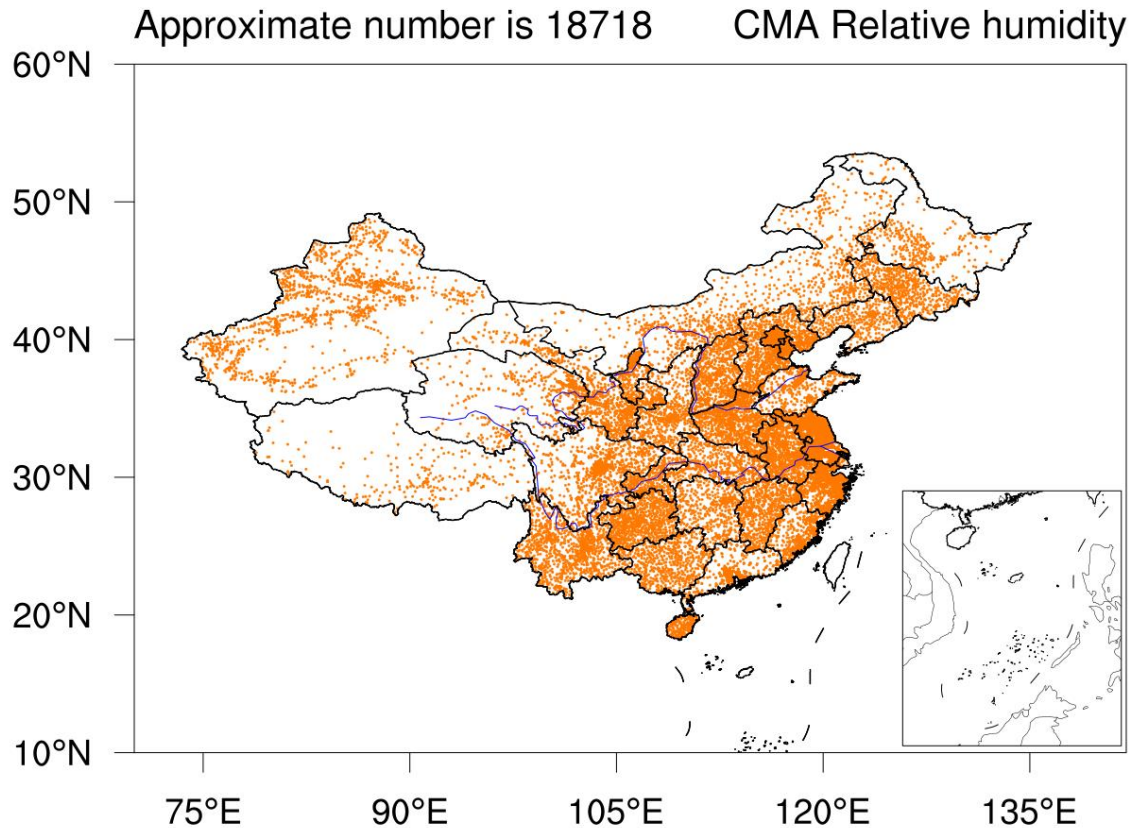
# Meteorology Observe in China (Automatic observation)

自动风速观测，34951个站



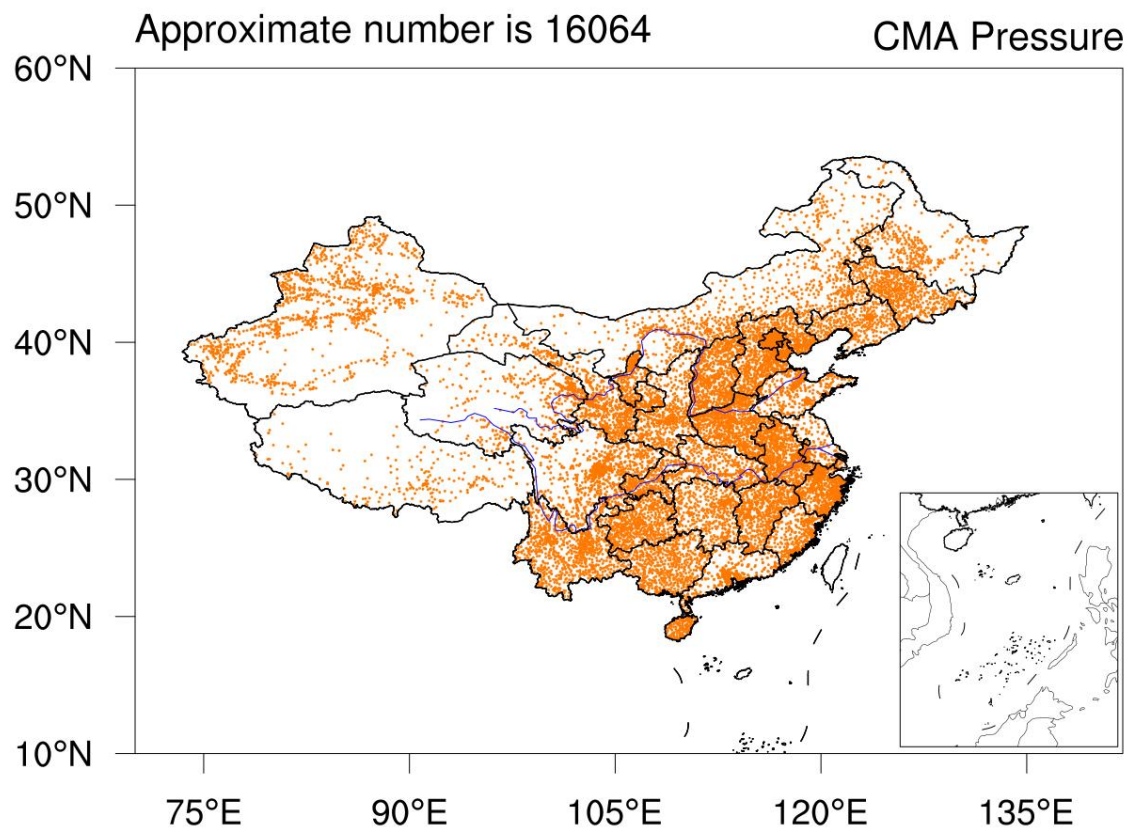
# Meteorology Observe in China (Automatic observation)

自动相对湿度观测，18718个站



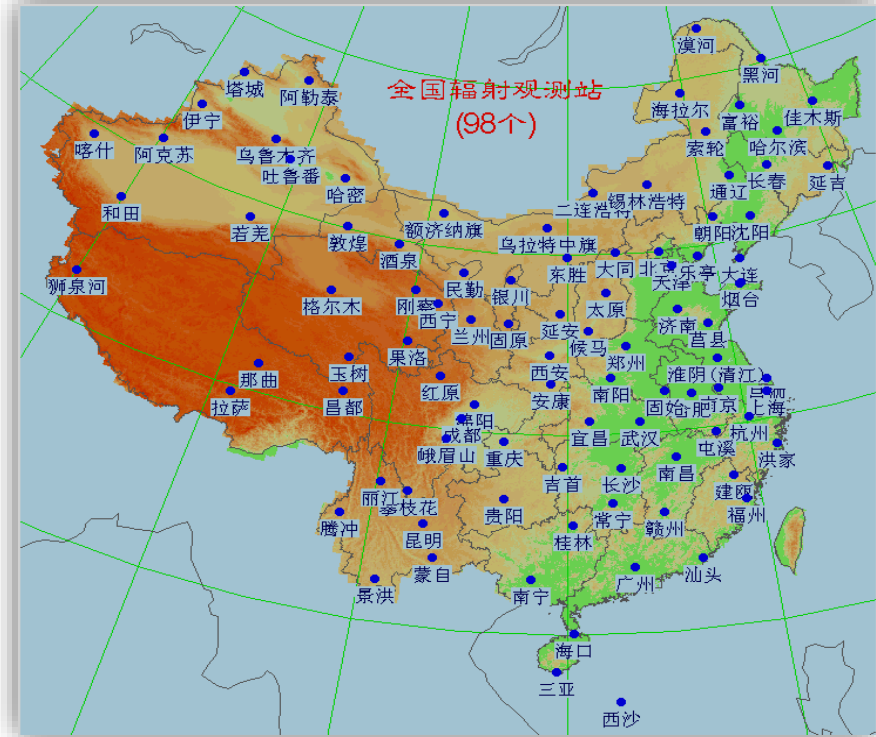
# Meteorology Observe in China

自动气压观测，16064个站



# Meteorology Observe in China

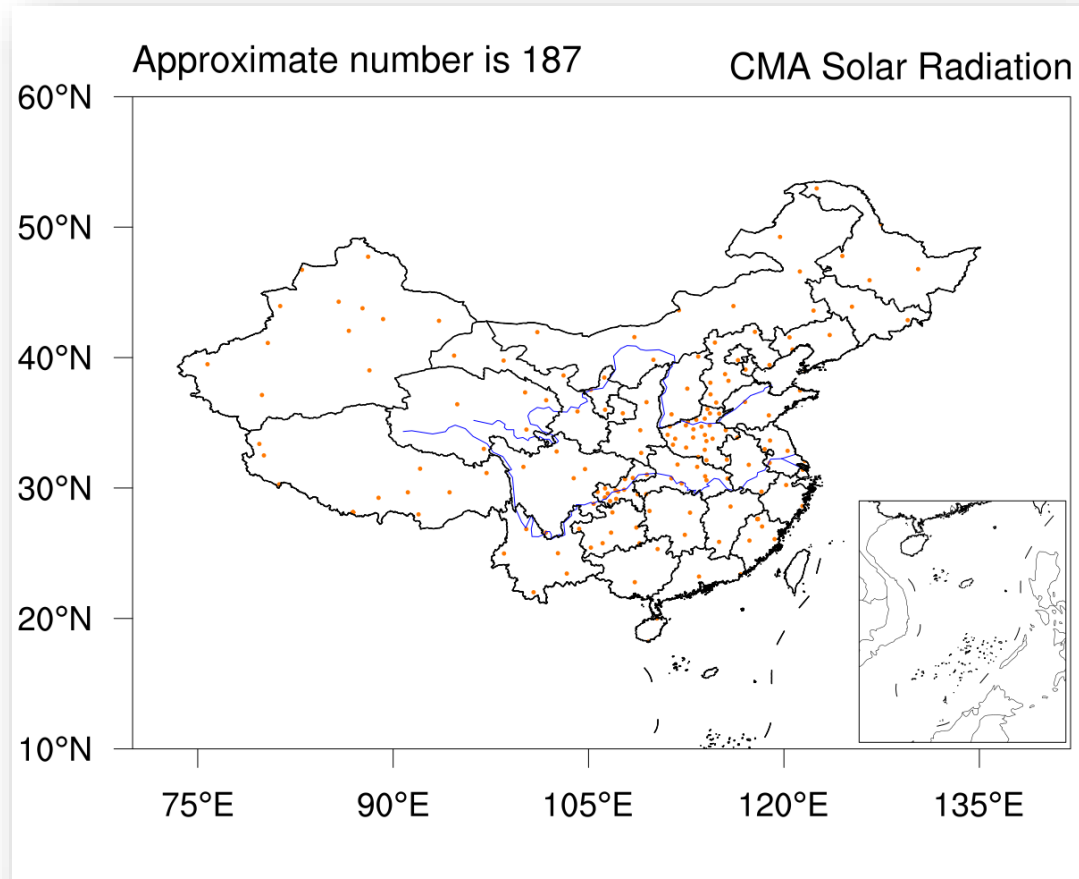
**Radiation station: 98**



# Meteorology Observe in China

Now?

Radiation station: 187



## Crops Growth Observation and SM Observation



Crop growth,  
653 stations

Yields, yield components  
phenological phase,  
Biomass ,etc.

1981- today

## Crops Growth Observation and SM Observation



Soil Moisture

2438 stations

1meter deep

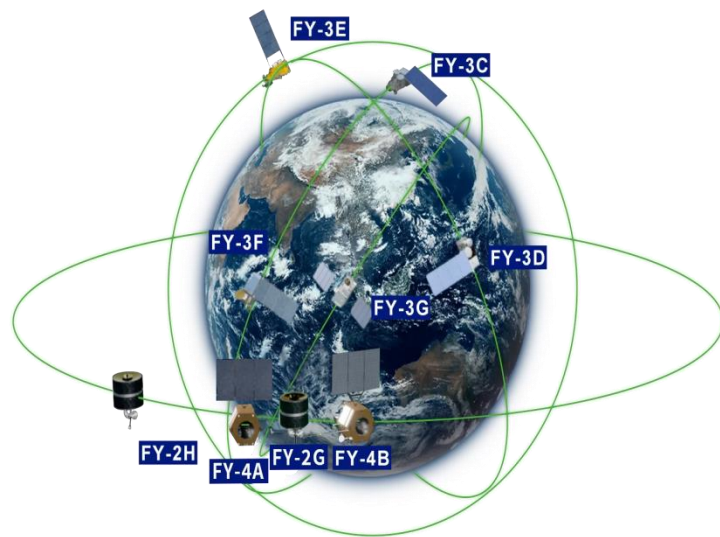
8 layers

# Remote Sensing Satellites in China

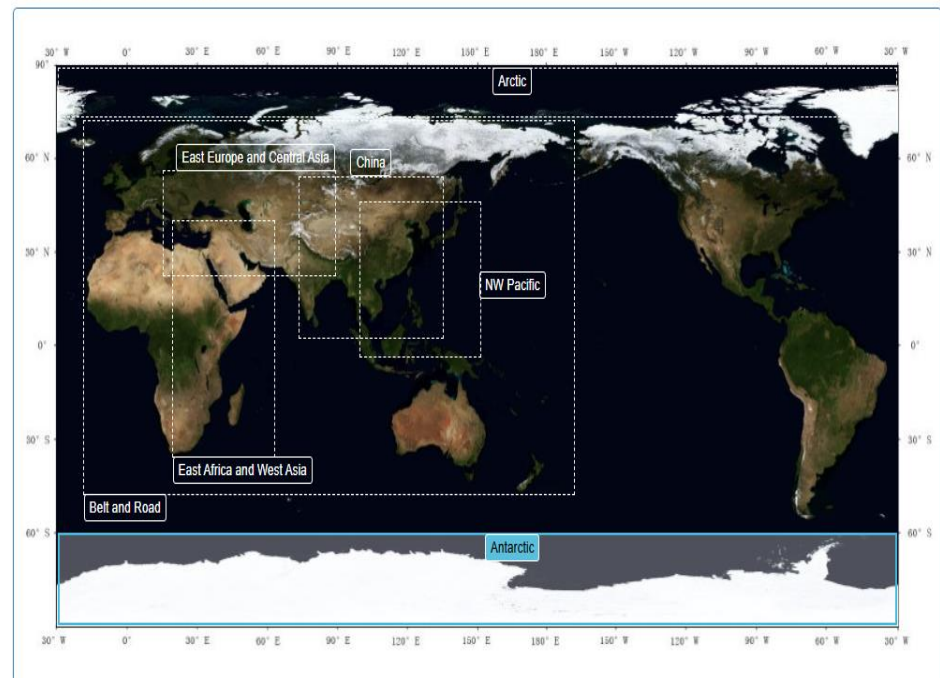
## Meteorological satellites of China:

Satellites in polar orbits **covered the whole earth in every day(FY-3 series).**

Satellites Geostationary Earth Orbit **covered areas of belt and road (FY-2 and FY-4 series)**



Coverage of Regions



# Remote Sensing Satellites in China

## Satellites with high-spatial (0.5m-50m)

- ◆ Series from GF1 to GF12 (0.5m)
- ◆ Jilin-1 Gaofen Series(0.7m, more



Sentinel-2(10m)



Jilin-1

GF(0.5m)



# Soil Moisture Remote Sensing

(1) Optical RS

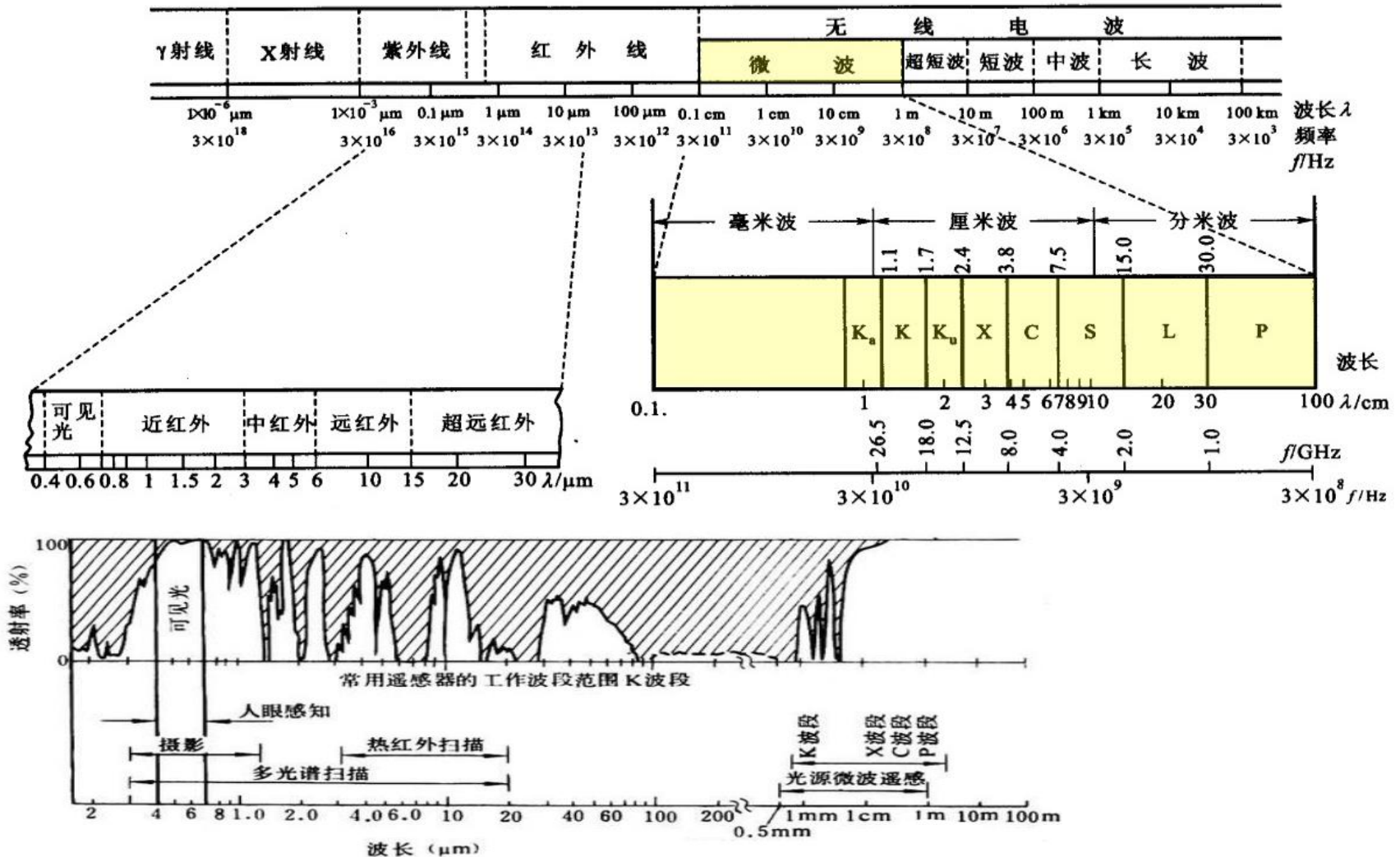
(2) Microwave RS



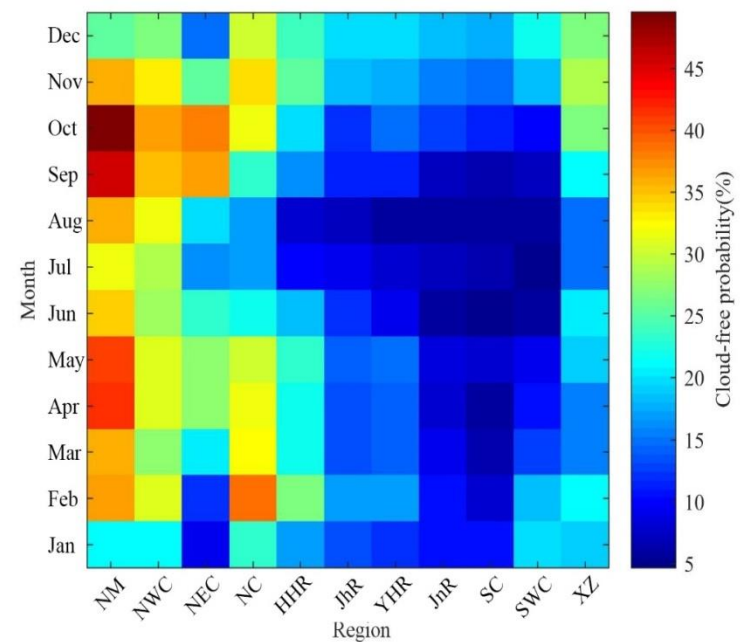
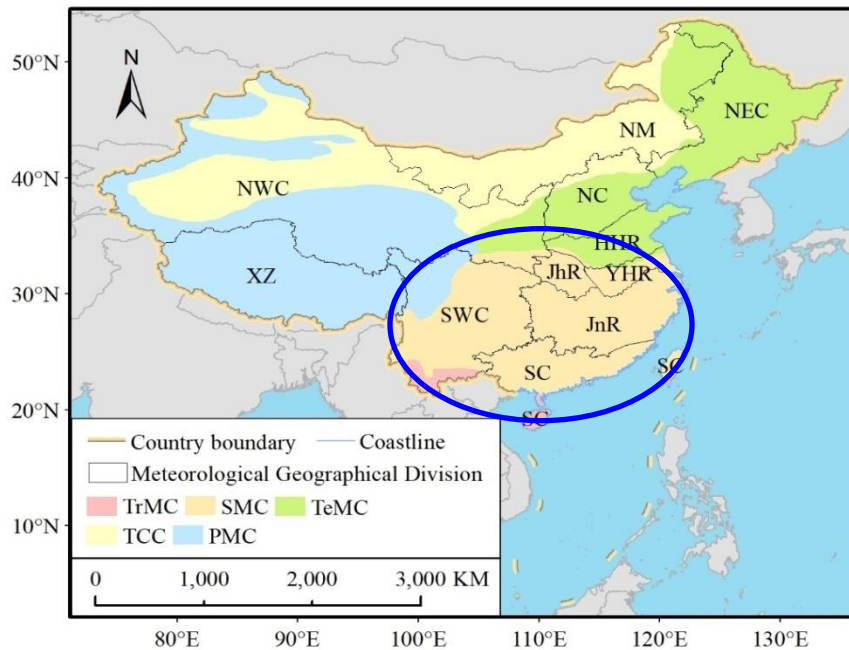
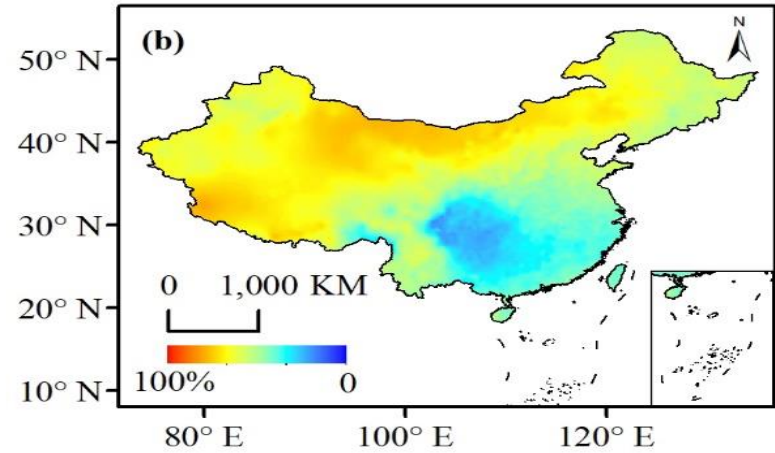
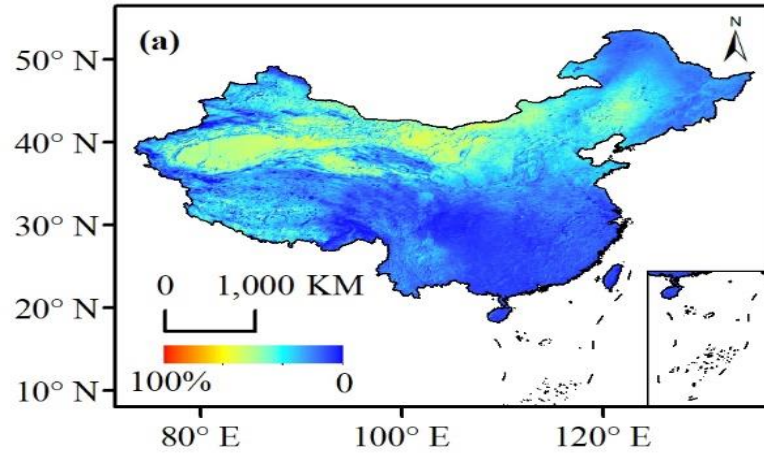
# Soil Moisture Remote Sensing

## (1) Optical RS

## (2) Microwave RS

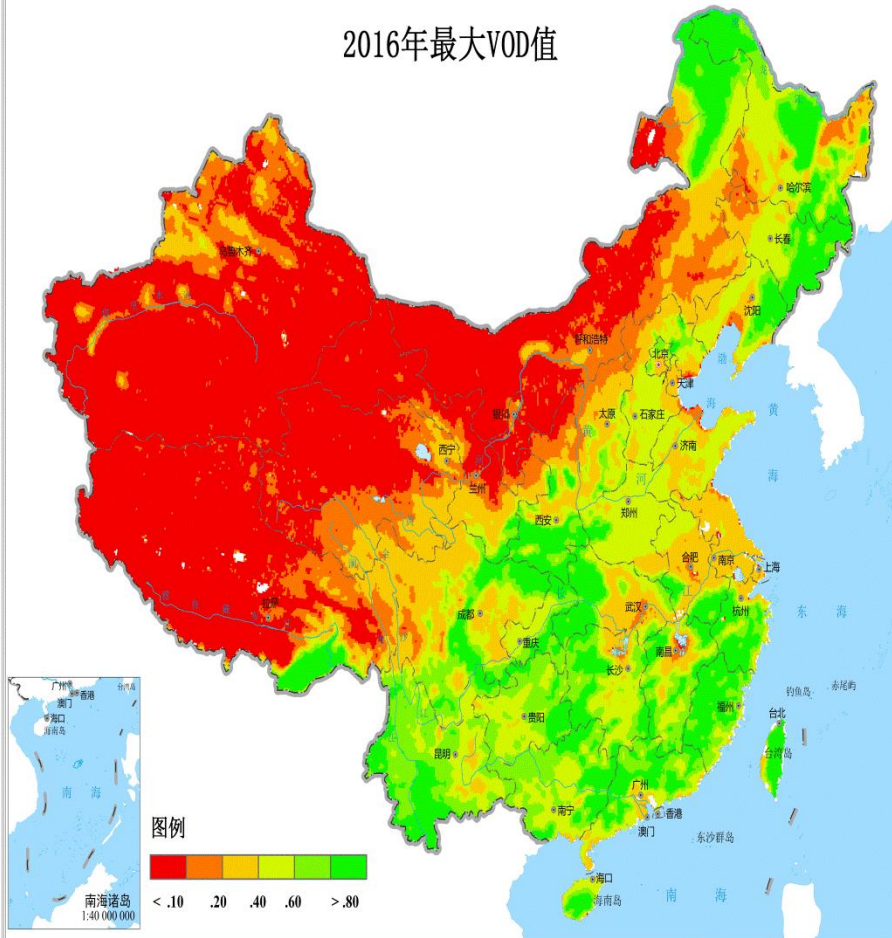


# Cloudy- Free Probability



# VOD and NDVI: which is more reasonable?

2016年最大VOD值

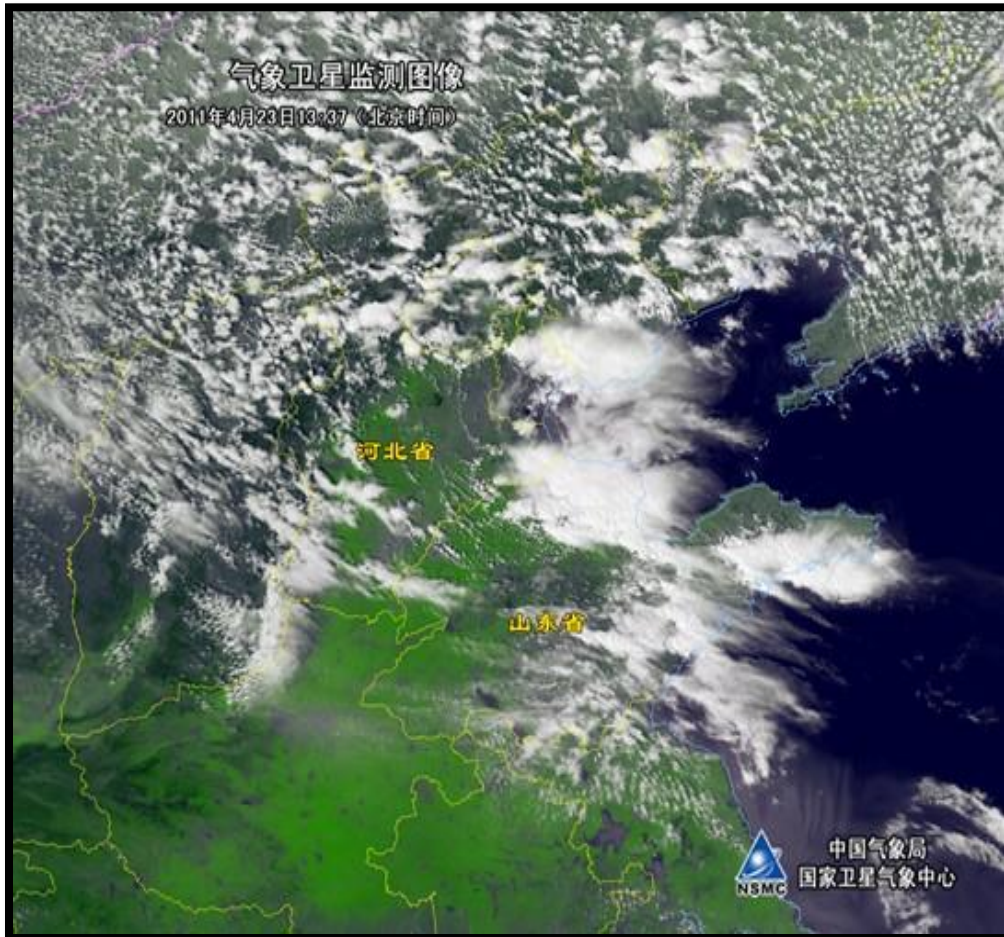


2012年中国植被生态质量



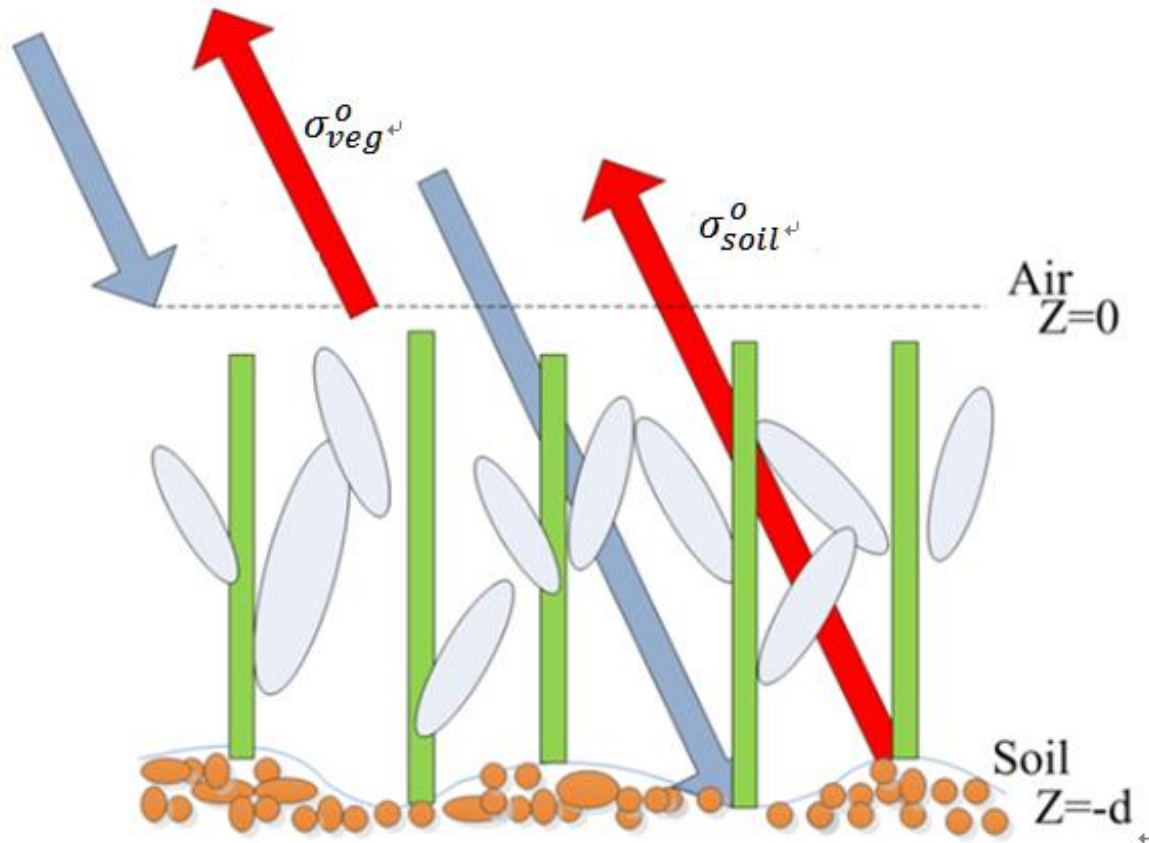
# Active and passive microwave RS

## Synthetic Aperture Radar

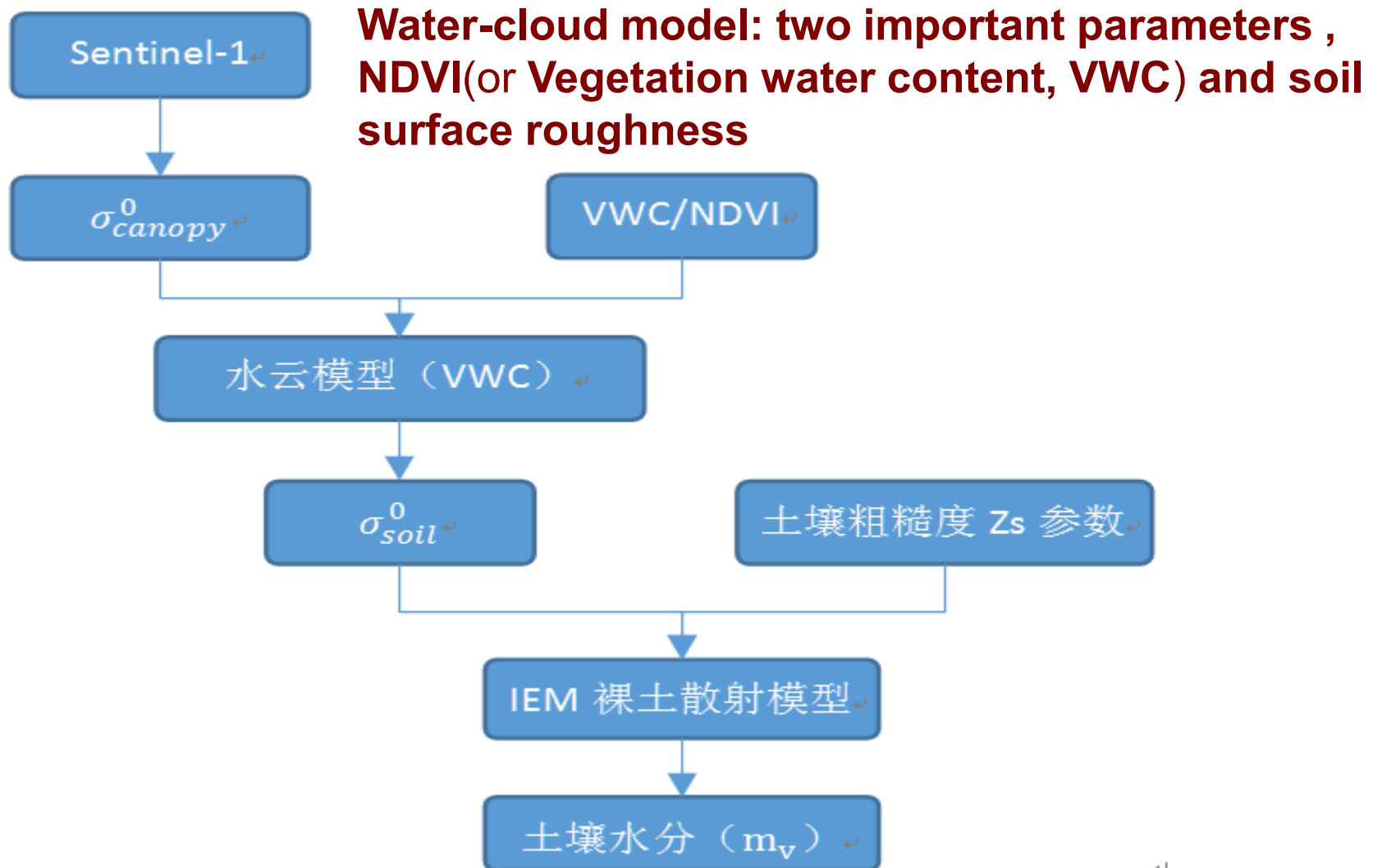


# Retrieve SM of Sentinel-1

A dominant physical model that is developed, based on the above models, is the Integral Equation Model (IEM).

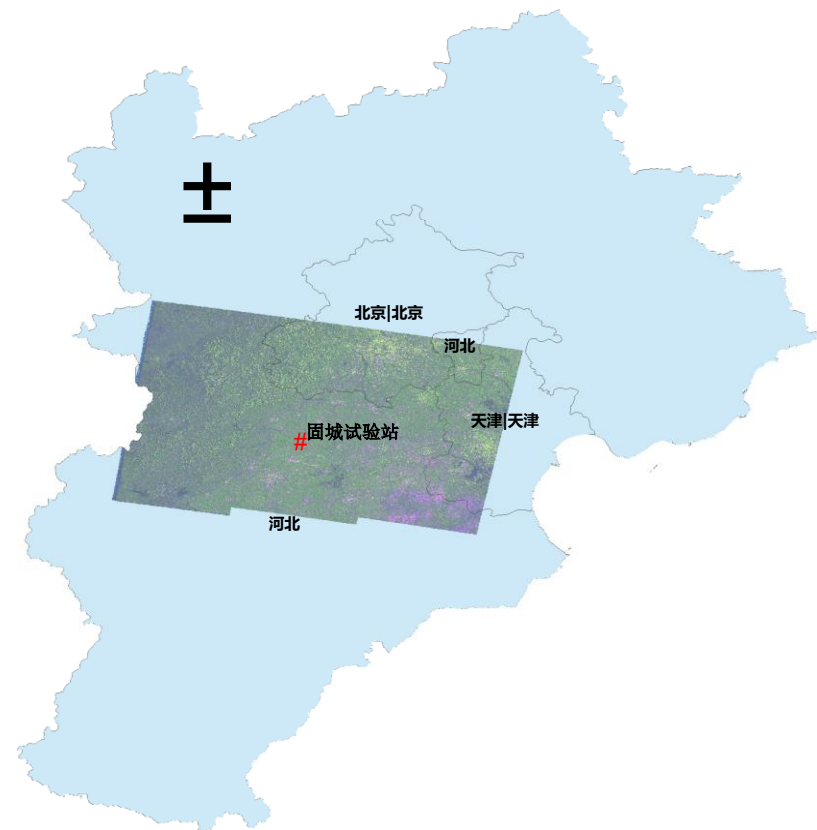
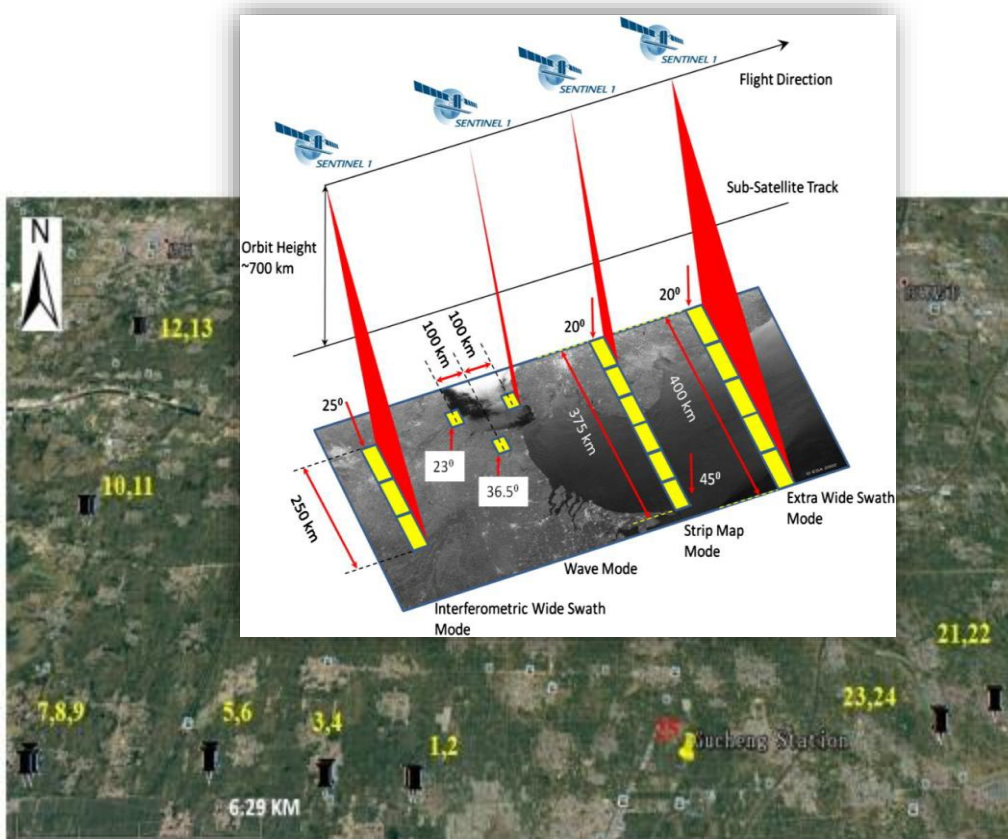


# Retrieve SM of Sentinel-1



a)

# Retrieve SM of Sentnal-1



播种 出苗 三叶 分蘖 停止生长 返青 起身 拔节 孕穗 抽穗 开花 乳熟 成熟 收获

10-12 10-19 11-13 11-20 12-13 2-26 3-14 4-2 4-16 4-25 5-3 5-20 6-8 6-13

## Field observation in wheat grow duration



小麦：



## soil moisture measurements

### Volume soil moisture

- TDR, hand-held sensor;
- accuracy: ~1%;

### Mass soil moisture

- Soil cutting ring (100 cm<sup>3</sup>)
- Drying oven: ~24 hours



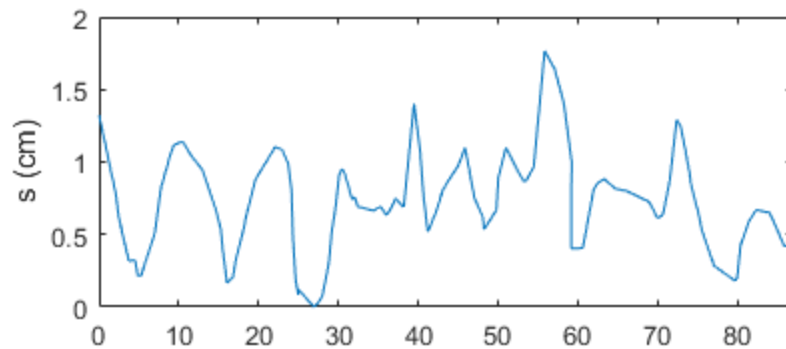
## Vegetation water content(fresh-dry/dry Bio)

| NO | 第 1 次 | 第 2 次 | 第 3 次 | 第 4 次 | 第 5 次 | 第 6 次  | 第 7 次  | 第 8 次  |
|----|-------|-------|-------|-------|-------|--------|--------|--------|
| 1  | 0     | 62.6  | 190.9 | 241.6 | 365.1 | 506.1  | 4357.7 | 2759.6 |
| 2  | 0     | 58.3  | 187.5 | 247.0 | 104.8 | 355.6  | 3264.0 | 4451.1 |
| 3  | 0     | 65.2  | 184.0 | 242.0 | 144.0 | 467.0  | 3099.7 | 2660.5 |
| 4  | 0     | 69.3  | 193.2 | 244.6 | 140.5 | 403.2  | 3332.0 | 4108.3 |
| 5  | 0     | 67.0  | 188.2 | 232.0 | 216.5 | 731.9  | 2892.8 | 3510.5 |
| 6  | 0     | 61.5  | 190.2 | 243.3 | 344.7 | 888.4  | 2181.7 | 3952.5 |
| 7  | 0     | 56.8  | 186.0 | 250.7 | 210.4 | 727.7  | 3368.8 | 3045.8 |
| 8  | 0     | 72.3  | 182.2 | 242.7 | 357.3 | 546.0  | 3380.2 | 3538.8 |
| 9  | 0     | 75.3  | 190.9 | 232.3 | 230.4 | 704.2  | 5086.2 | 4040.3 |
| 10 | 0     | 65.6  | 189.7 | 239.0 | 133.5 | 257.5  | 2567.0 | 1768.0 |
| 11 | 0     | 60.1  | 196.0 | 237.5 | 95.8  | 267.8  | 2867.3 | 3300.8 |
| 12 | 0     | 71.0  | 194.0 | 241.9 | 185.6 | 275.4  | 3289.5 | 2008.8 |
| 13 | 0     | 62.0  | 195.3 | 242.1 | 164.5 | 745.8  | 2977.8 | 5383.3 |
| 14 | 0     | 62.7  | 186.3 | 242.0 | 326.3 | 514.5  | 3213.0 | 5403.1 |
| 15 | 0     | 69.4  | 185.3 | 238.2 | 140.4 | 400.7  | 3822.2 | 3788.1 |
| 16 | 0     | 58.1  | 183.7 | 237.0 | 306.9 | 473.6  | 2637.8 | 2802.1 |
| 17 | 0     | 55.2  | 192.5 | 237.1 | 169.2 | 338.3  | 3459.5 | 3136.5 |
| 18 | 0     | 67.1  | 203.9 | 244.3 | 280.7 | 796.7  | 5536.3 | 4816.6 |
| 19 | 0     | 67.0  | 193.6 | 230.7 | 96.3  | 757.1  | 4669.3 | 2572.6 |
| 20 | 0     | 65.5  | 186.1 | 239.0 | 232.1 | 406.7  | 3725.8 | 4723.1 |
| 21 | 0     | 67.5  | 194.2 | 241.4 | 209.2 | 651.7  | 5423.0 | 3122.5 |
| 22 | 0     | 70.4  | 184.4 | 236.7 | 178.6 | 542.0  | 3431.2 | 4281.1 |
| 23 | 0     | 69.9  | 182.9 | 242.4 | 239.0 | 1285.8 | 3094.0 | 5119.8 |
| 24 | 0     | 62.2  | 193.6 | 239.6 | 138.7 | 413.3  | 3400.0 | 2385.4 |
| 25 | 0     | 69.0  | 186.1 | 235.3 | 290.0 | 711.1  | 6465.7 | 4516.3 |
| 平均 | 0.0   | 65.0  | 190.3 | 239.3 | 212.0 | 566.7  | 3641.7 | 3647.9 |

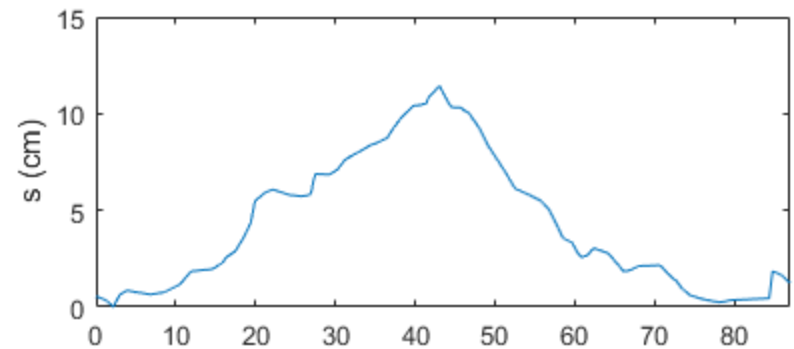
小麦：



# Sampled soil surface roughness



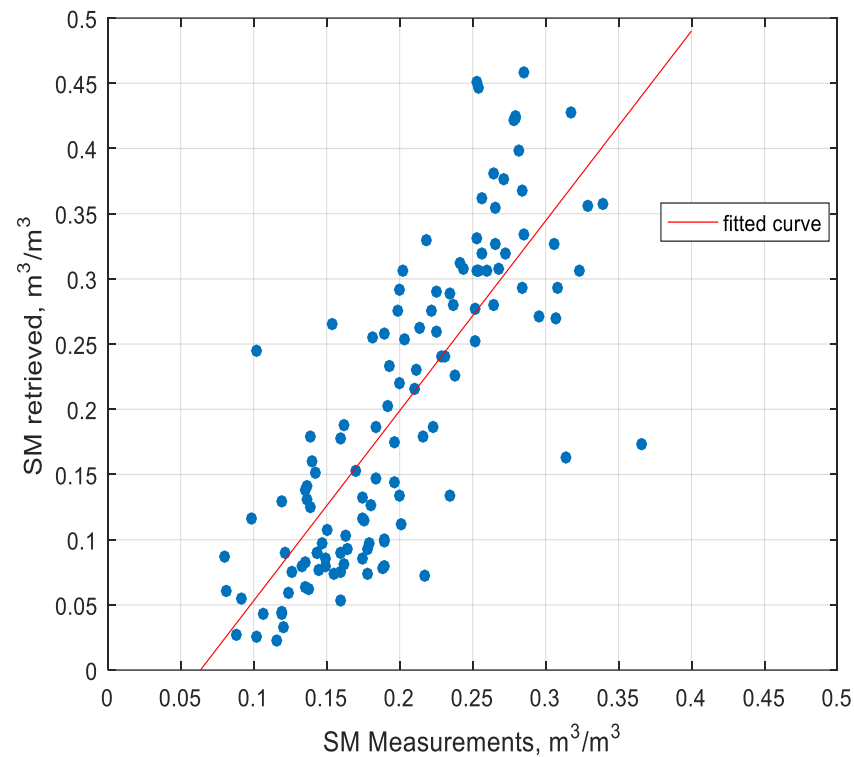
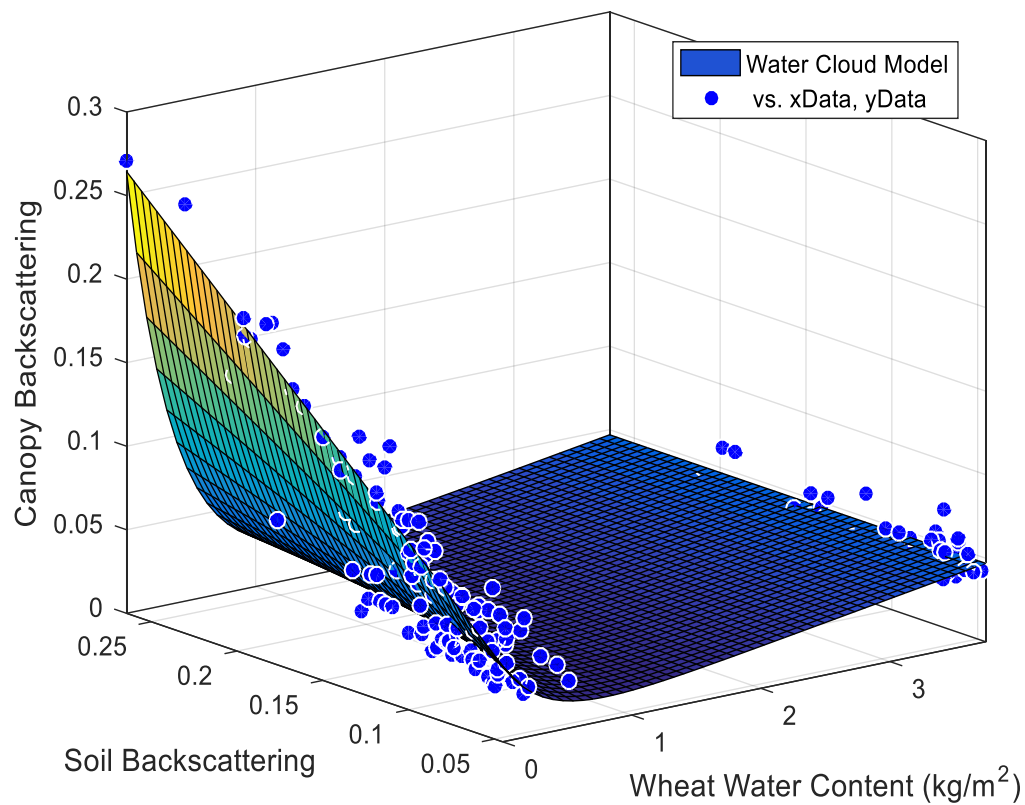
**75 samples**



**22 samples**

a)

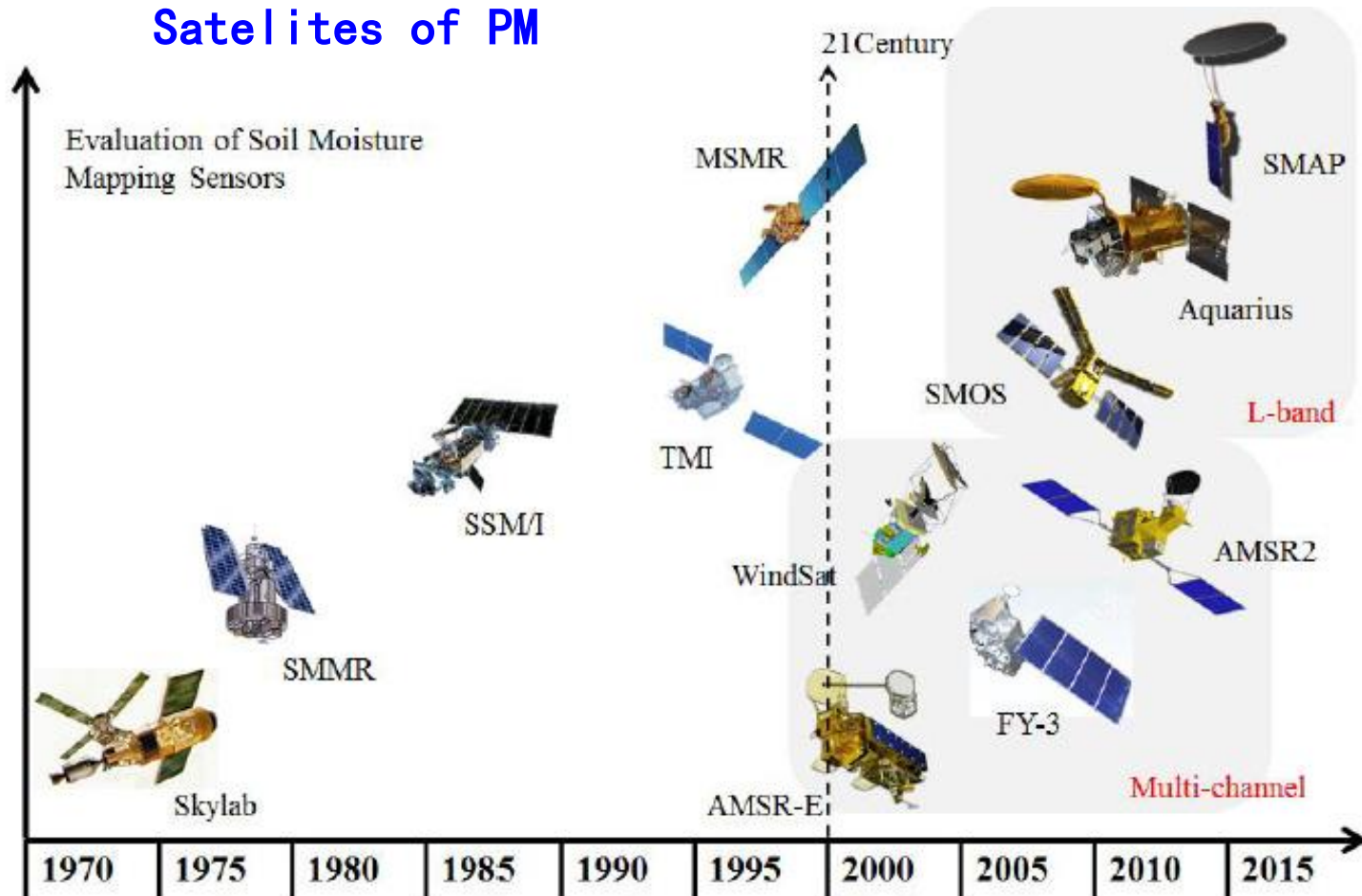
## Retrieve SM of Sentinel-1



**( $r = 0.7966$ ;  $\text{rmse} = 0.0709$ )**

# Passive Microwave RS

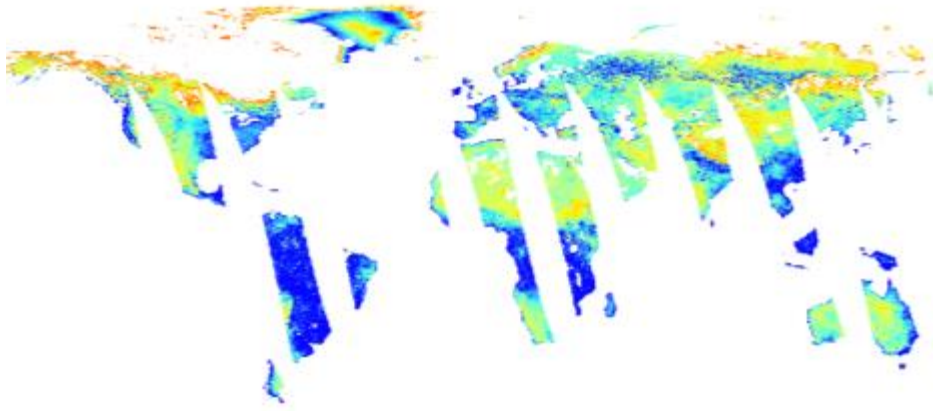
## Satellites of PM



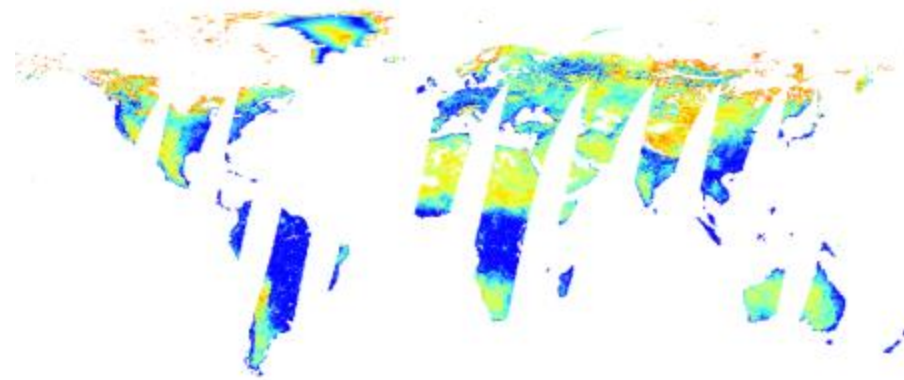
## SM FY-3B/MWR I

### SM of Ascending and Descending orbit

SM of Ascending orbit

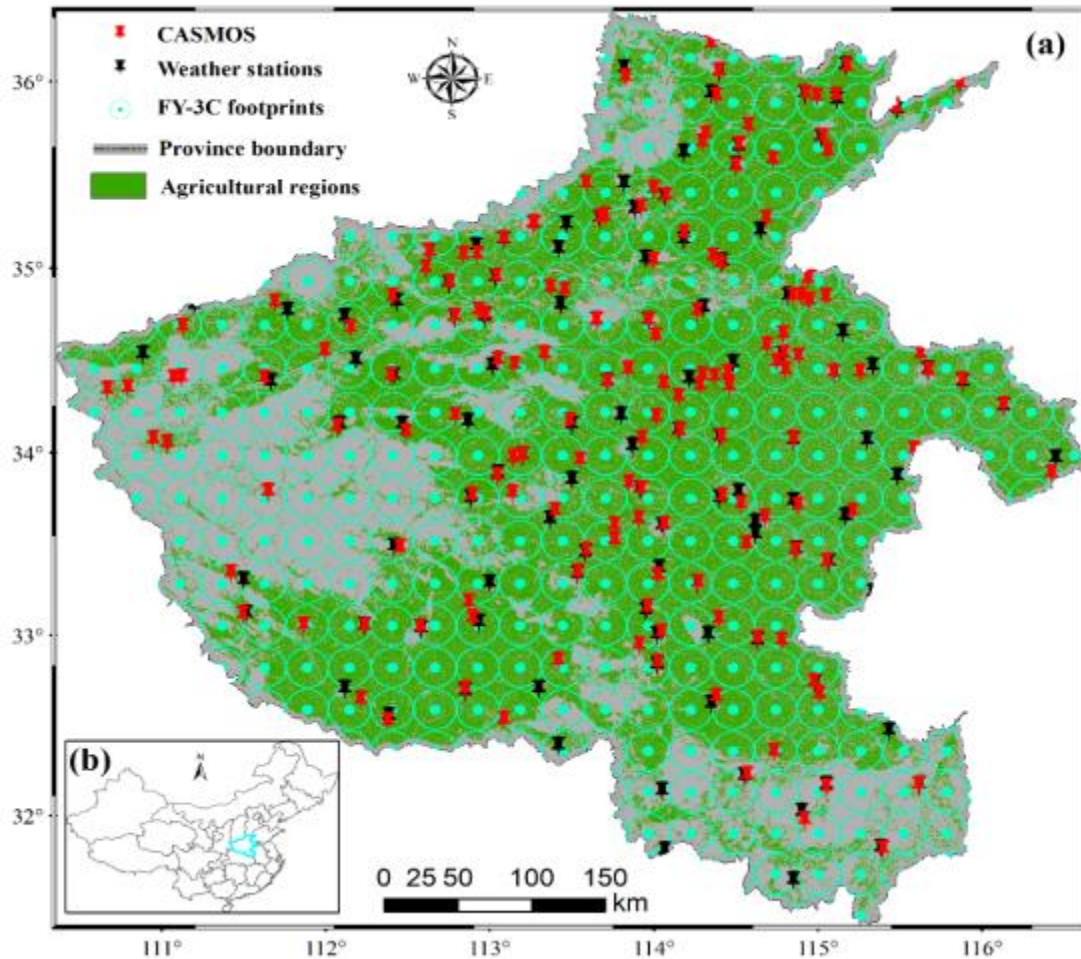


SM of Descending orbit



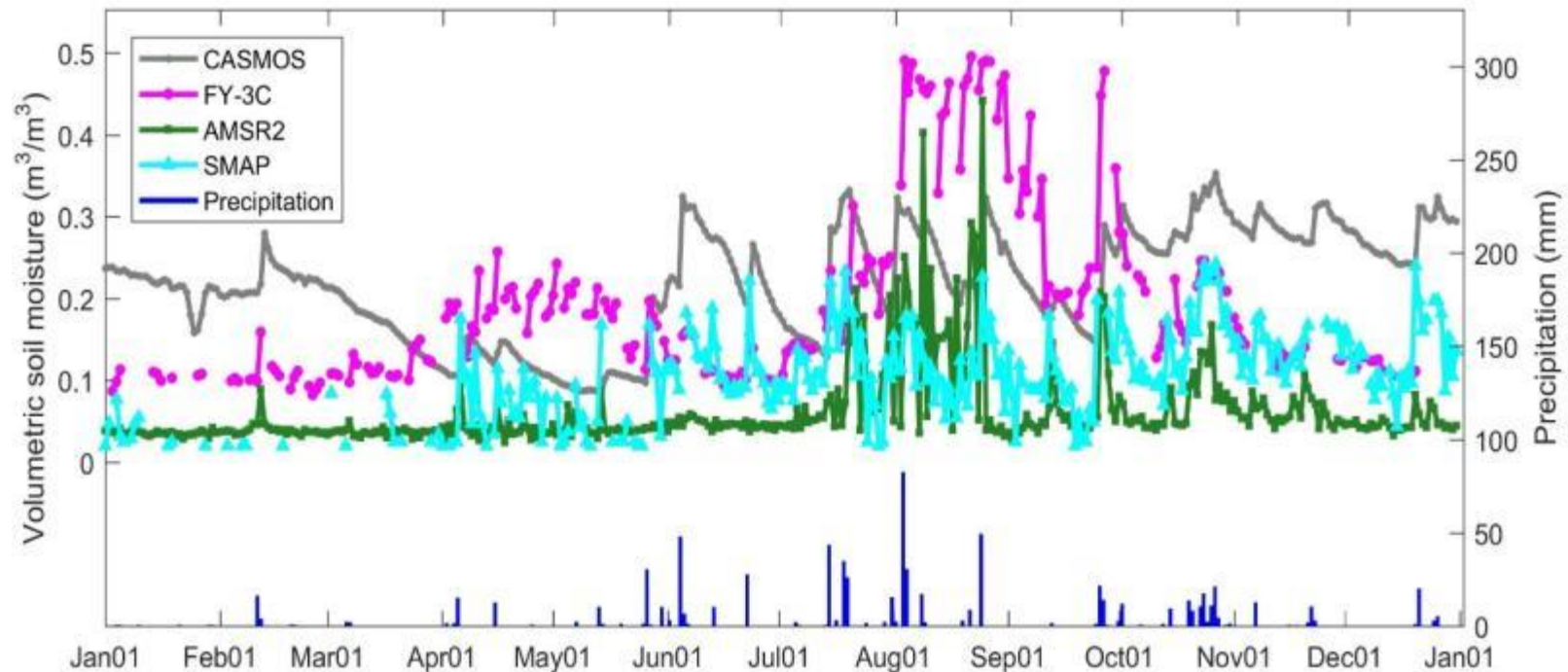
**5days product was combined by each days of 5days**

# Field observation



1. Jan. –Dec.,
2. Field observation  
(CASMOS) : 158
3. 0-10 cm(surface SM)

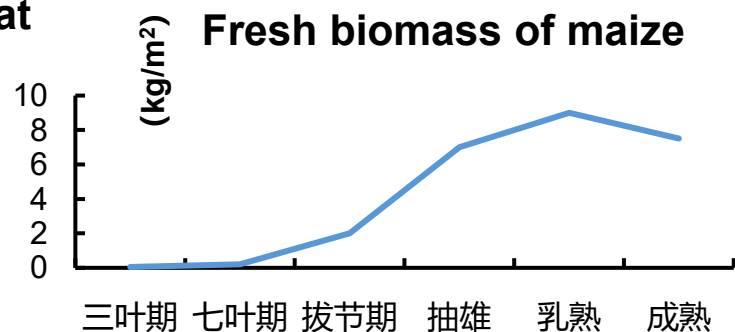
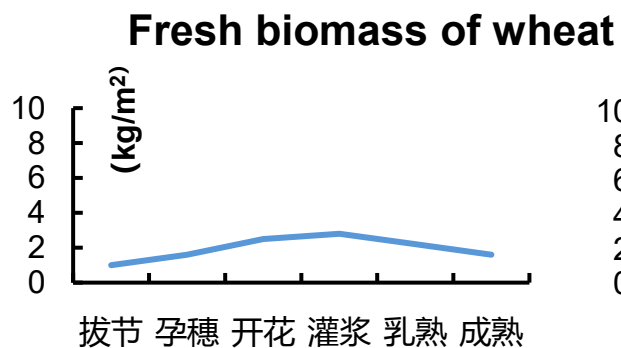
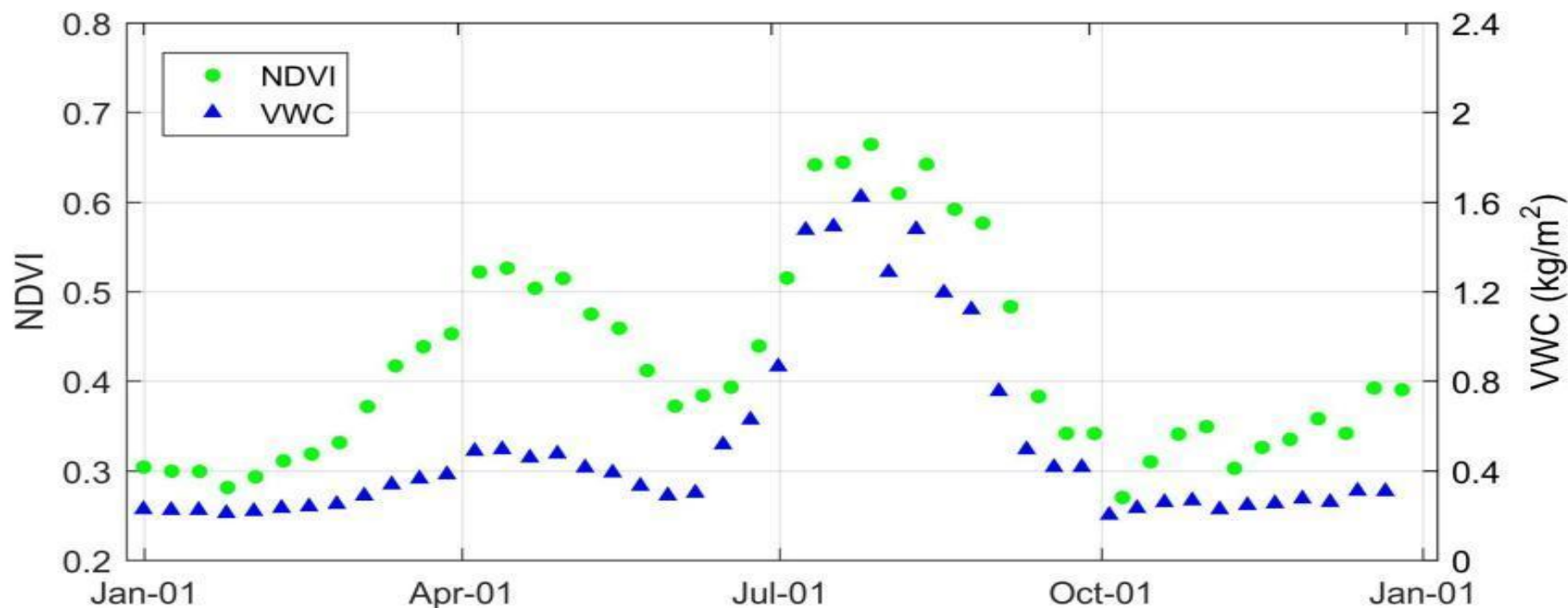
## SM between passive microwave and the field



### O2342: SM of FY3C,AMSR2 and SMAP compared with the field SM

|       | MD<br>( $\text{m}^3/\text{m}^3$ ) | RMSE<br>( $\text{m}^3/\text{m}^3$ ) | ubRMSE<br>( $\text{m}^3/\text{m}^3$ ) | R    |
|-------|-----------------------------------|-------------------------------------|---------------------------------------|------|
| AMSR2 | -0.15                             | 0.17                                | 0.07                                  | 0.27 |
| FY-3C | -0.02                             | 0.12                                | 0.11                                  | 0.21 |
| SMAP  | -0.12                             | 0.13                                | 0.05                                  | 0.63 |

## FY-3 Soil Moisture and NDVI in a Year



# FY-3C VSM Vs field observation

**RMSE、MAE R**  
**between FY-3C VSM and field observation**

| Error<br>Month | R     | RMSE(cm <sup>3</sup> /cm <sup>3</sup> ) | MAE(cm <sup>3</sup> /cm <sup>3</sup> ) |
|----------------|-------|-----------------------------------------|----------------------------------------|
| January        | 0.467 | 0.116                                   | 0.092                                  |
| April          | 0.500 | 0.114                                   | 0.094                                  |
| July           | 0.621 | 0.164                                   | 0.120                                  |
| October        | 0.558 | 0.147                                   | 0.113                                  |

**soil moisture (0-5 cm)**

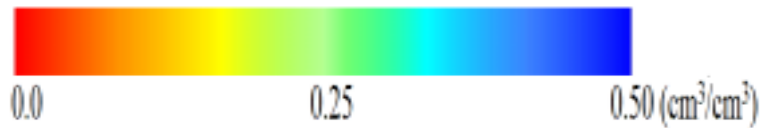
## How to improve SM

**Multivariate linear regression (MLR) and multivariate back-propagation neural network (MBPNN) models with different numbers of input variables were built to improve the SM monitoring results. Multiple factors, including vegetation coverage, location, and elevation**

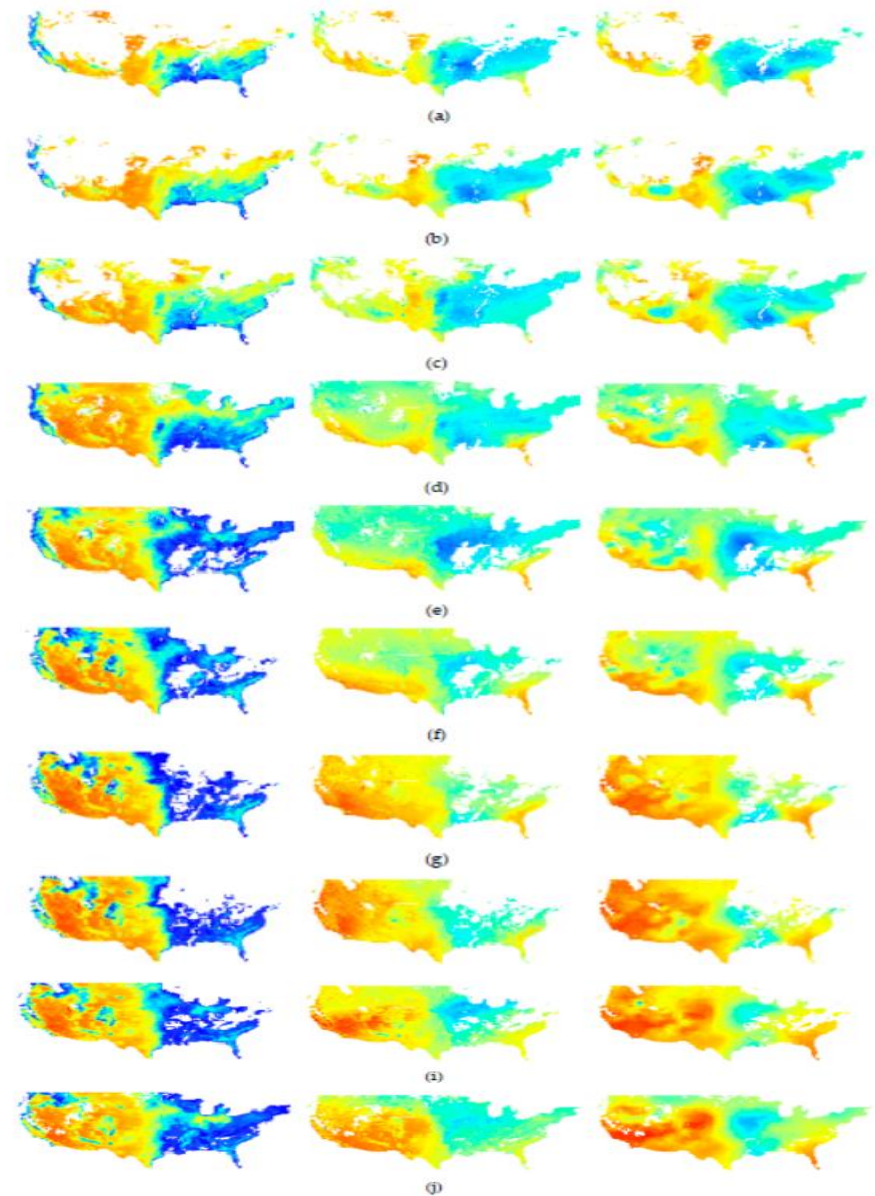
| Error<br>Model | R     | RMSE<br>(cm <sup>3</sup> /cm <sup>3</sup> ) | MAE (cm <sup>3</sup> /cm <sup>3</sup> ) | MRE (%) |
|----------------|-------|---------------------------------------------|-----------------------------------------|---------|
| MLR-1          | 0.640 | 0.050                                       | 0.039                                   | 32.0    |
| MBPNN-1        | 0.690 | 0.056                                       | 0.044                                   | 38.0    |
| MLR-2          | 0.661 | 0.049                                       | 0.038                                   | 30.4    |
| MBPNN-2        | 0.708 | 0.054                                       | 0.041                                   | 35.2    |
| MLR-3          | 0.694 | 0.047                                       | 0.035                                   | 27.3    |
| MBPNN-3        | 0.871 | 0.034                                       | 0.026                                   | 20.7    |

## Precision of SM was improved After MBPNN

- a) FY-3C VSM (Left)
  - b) MBPNN-3 SM (Middle)
  - c) Field SM (Right)
- Up to Down is Jan. to Dec. 2019



(Wang Lei, Fang Shibo\* et al.,  
Remote sensing, 2020,12,1038)



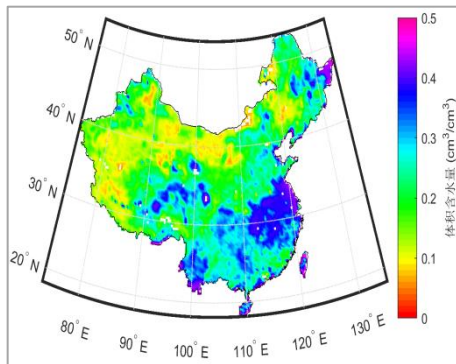
# SM blended and merged

SM blended and *merged* from 2075 filed observation stations and passive satellite



2075 filed observation stations

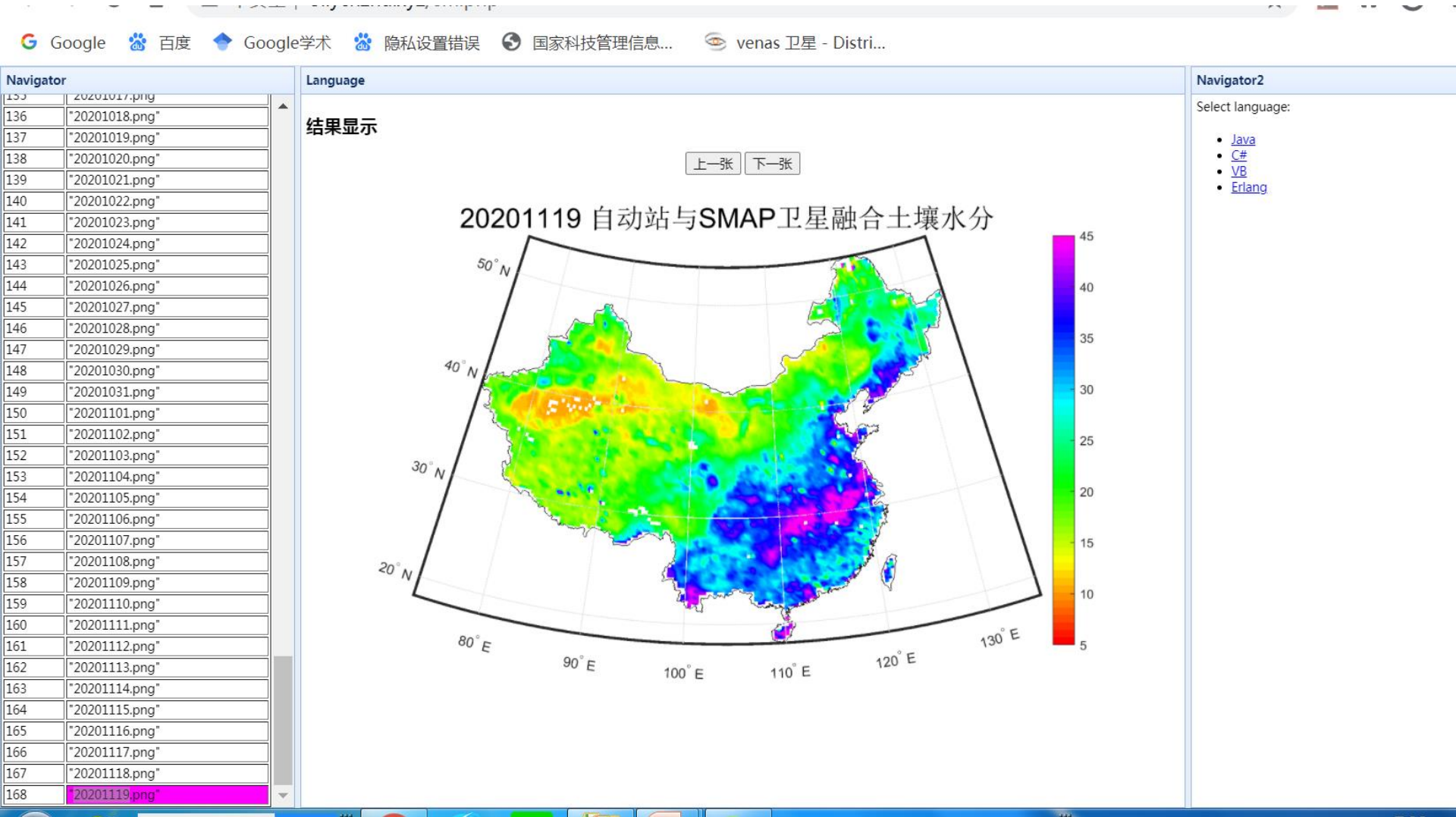
SMAP



SM after blended and *merged*

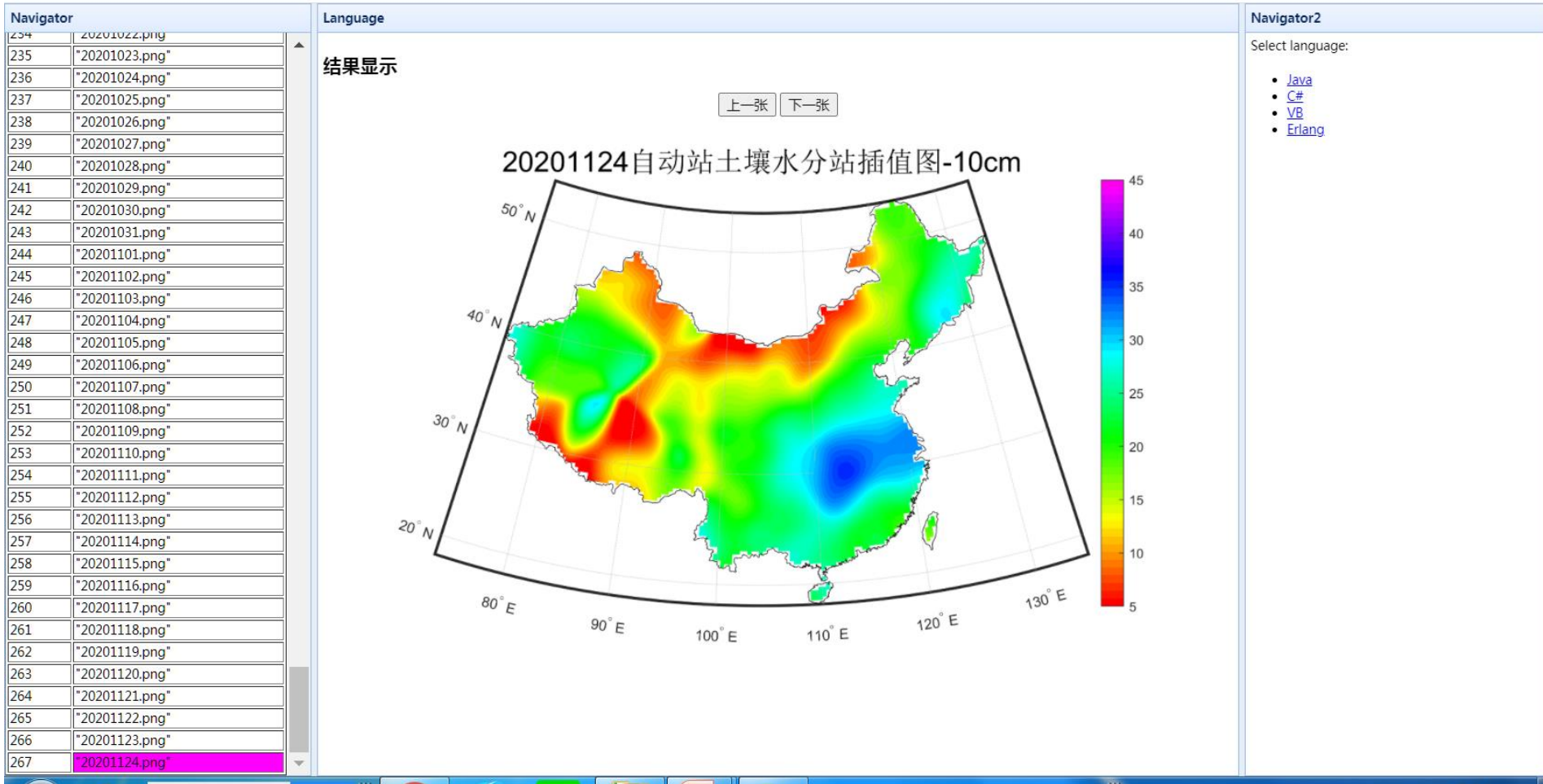
|              | RMSE<br>( $\text{m}^3/\text{m}^3$ ) | ubRMSE<br>( $\text{m}^3/\text{m}^3$ ) | R    |
|--------------|-------------------------------------|---------------------------------------|------|
| SM<br>Merged | -0.015                              | 0.04                                  | 0.79 |
| SMAP         | 0.13                                | 0.05                                  | 0.63 |

# SM online (after merged )

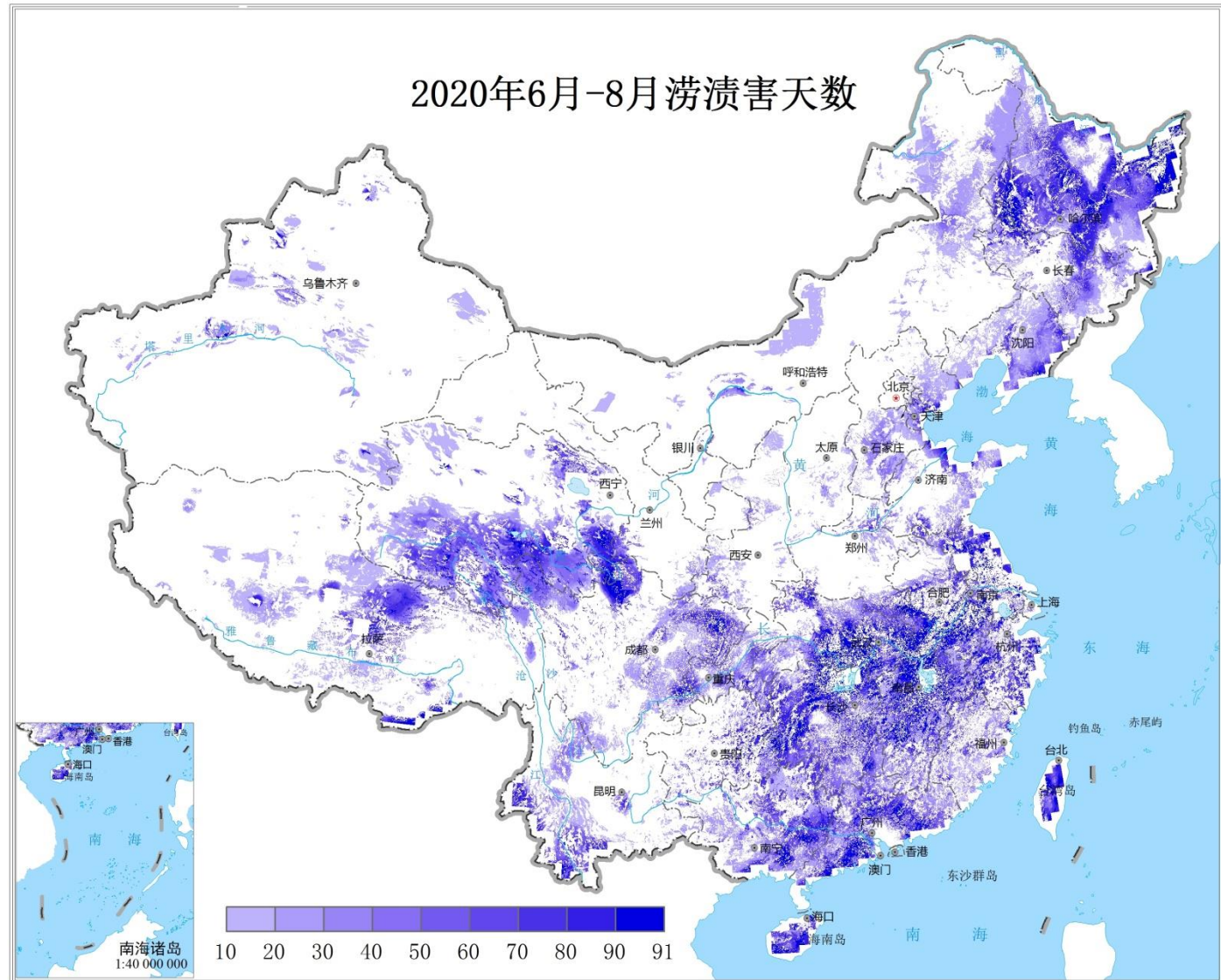


# SM online (interpolation of field stations)

Google 百度 Google学术 隐私设置错误 国家科技管理信息... venas 卫星 - Distri...

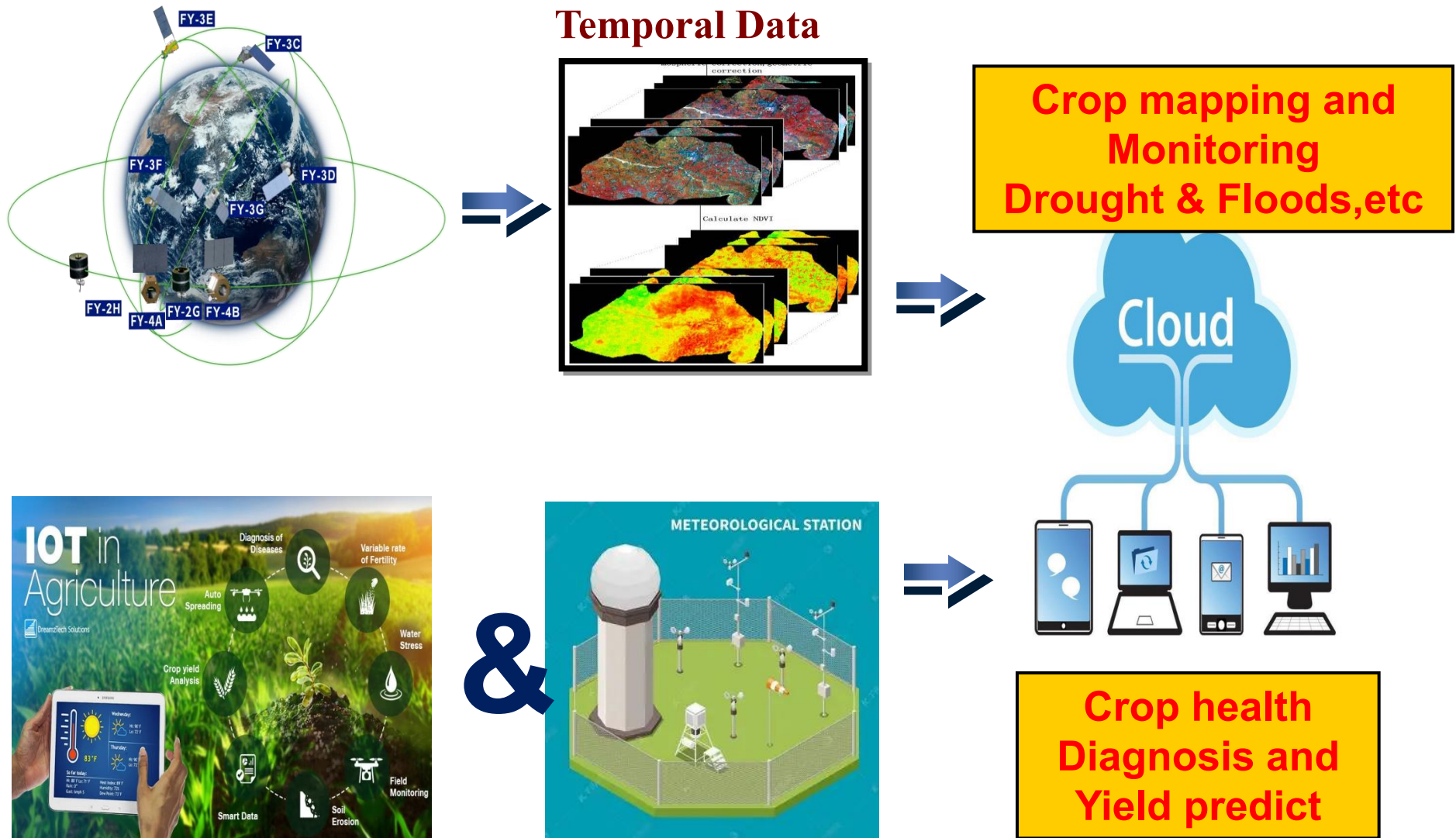


**Waterlogged Field:  $SM > \text{maximum field water capacity}$  (Soil water saturated) more than 10days**





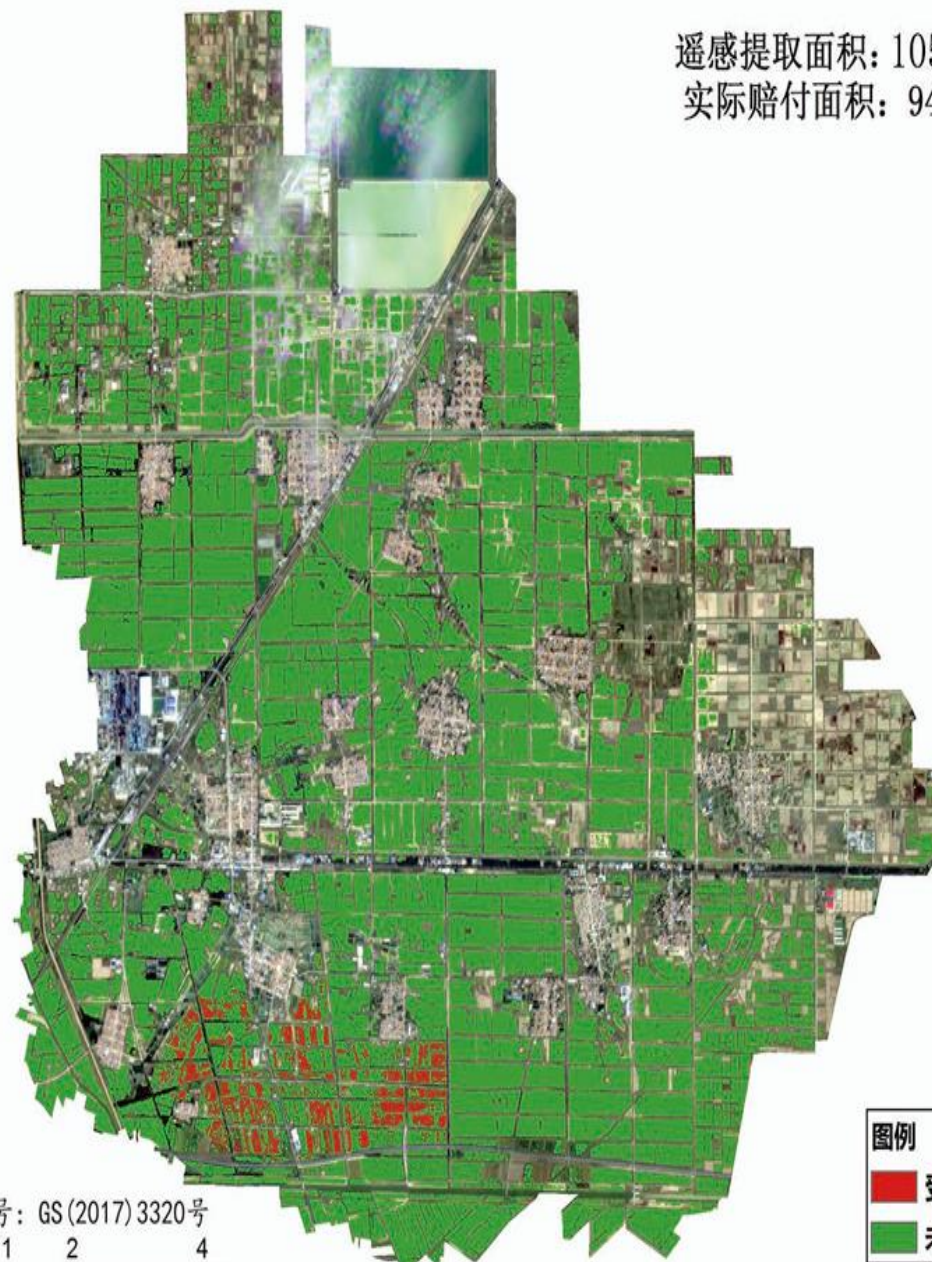
# Disasters Monitoring and Crops Health Diagnosis by Satellites and Ground Observation



# 滨州市博兴县纯化镇玉米风灾 2021年10月11日

## Crops

遥感提取面积: 1050亩  
实际赔付面积: 945亩



审图号: GS(2017)3320号  
0 1 2 4 km

图例

■ 受灾  
■ 未受灾

# 临沂市沂水县承保乡镇冬小麦干旱遥感监测图

2022年5月2日

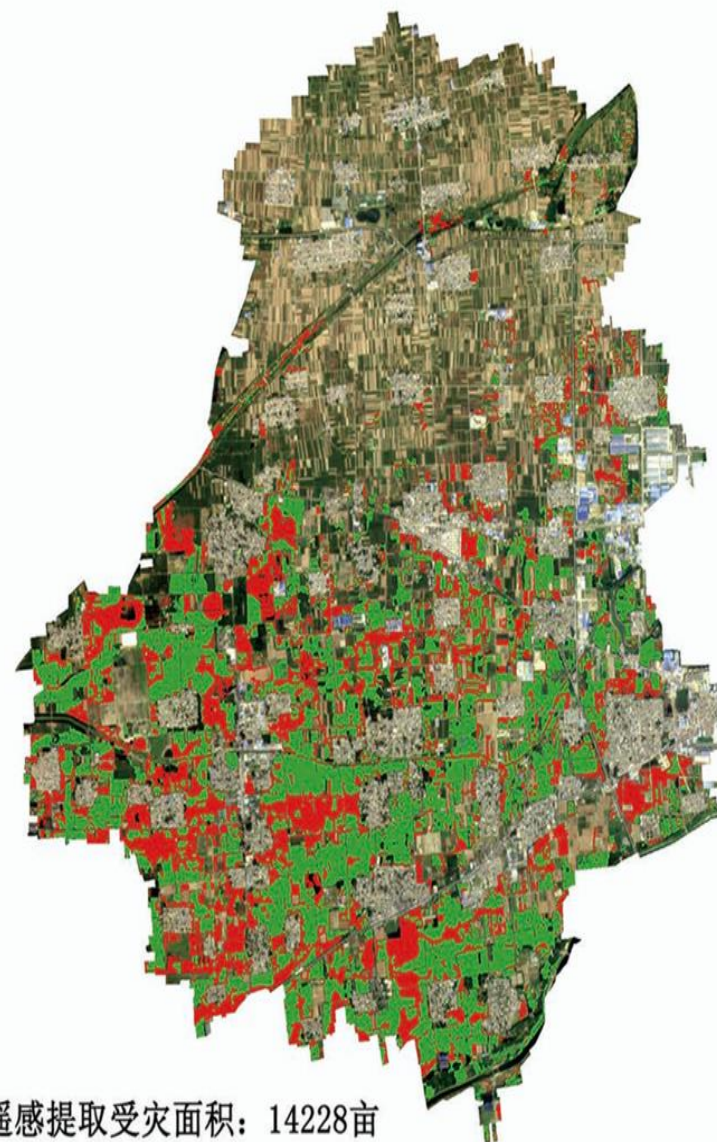
Di



审图号: GS(2017)3320号

# 枣庄市滕州市姜屯镇玉米暴雨灾情

2020年9月4日



审图号: GS(2017)3320号

0 1 2 4 km

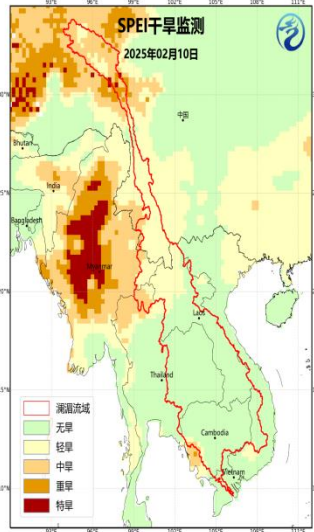


# Drought & Floods Monitoring and Crops Health Diagnosis by Satellites and Ground Observation

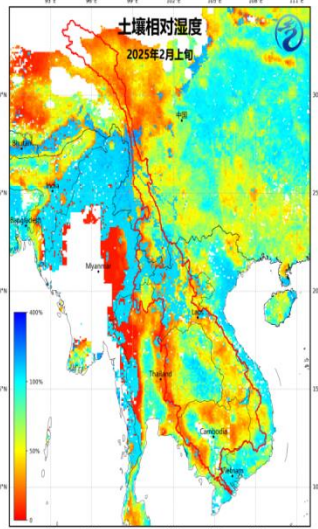
## The three practices in south and west Asia.

### 1. Drought & Vegetation Monitoring in Indochina Peninsula

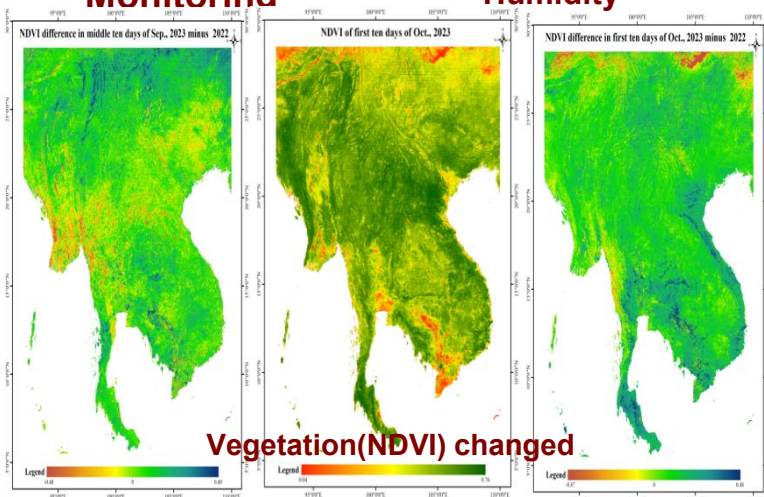
<https://www.wmc-bj.net/lm-en/index.html>



**SPEI Drought Monitoring**

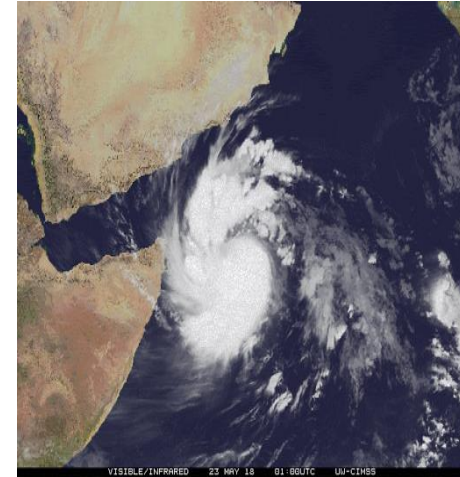
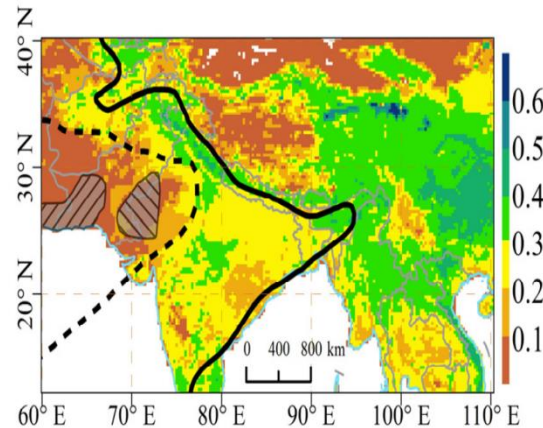


**Relative Soil Humidity**

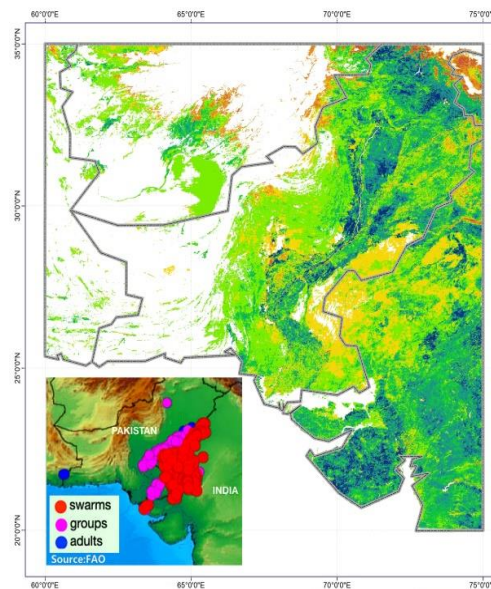


**Vegetation(NDVI) changed**

### 2. Soil Moisture averaged in 2008–2019 with Tropical Cyclones



### 3. Crops or Vegetations damaged by Desert Locust



# 谢谢!



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**Chinese Academy of Meteorological Sciences**

**China Meteorological Administration;**

**TEL: 15801635580**

**E-mail: [sbfang0110@163.com](mailto:sbfang0110@163.com)**

**WeChat:**

