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# Mapping Global Agricultural Drought with Chinese Meteorological Satellite Data

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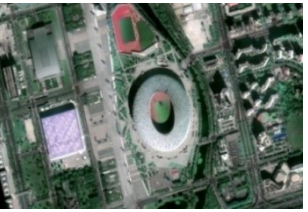
# Outlines

- 1 Brief Introduction of China Meteorological Satellite
- 2 FY Satellite Data Processing for Global Agricultural Drought
- 3 Global Agricultural Drought Map
- 4 Conclusions and Questions

# 1. Brief Introduction of Chinese Meteorological Satellite



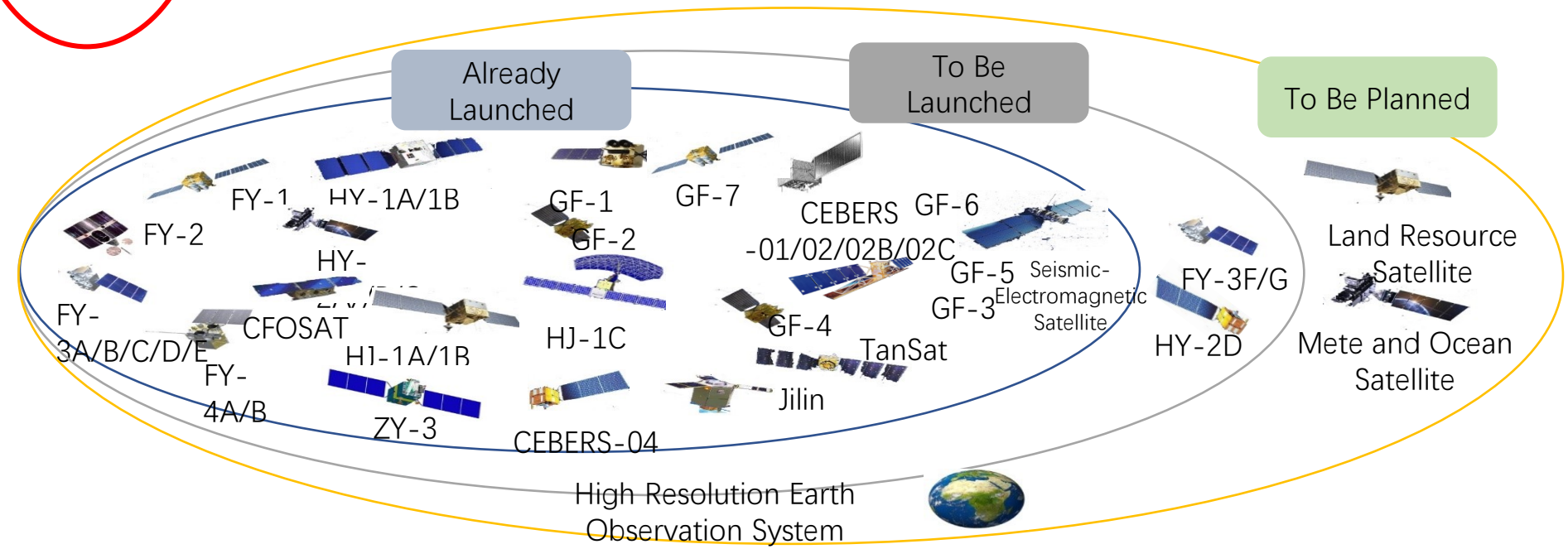




## Components of China EO Systems

7 satellite series formed or forming

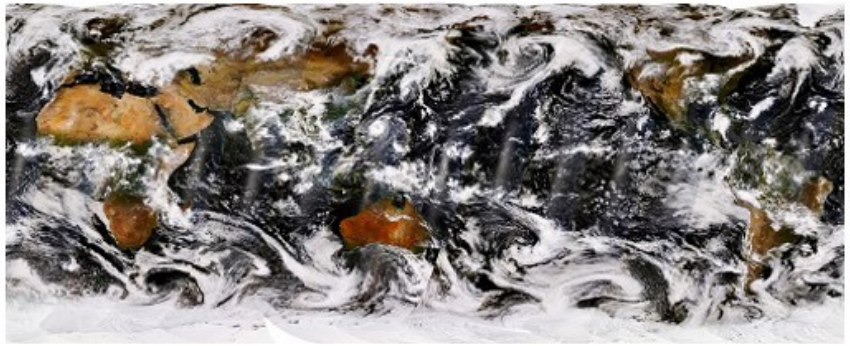
- Meteorological Satellite FY
- Oceanic Satellite HY
- Earth Resources ZY/CBERS
- Disaster Mitigation HJ
- High Resolution Satellite GF
- Seismic-Electromagnetic
- Private Satellite Series

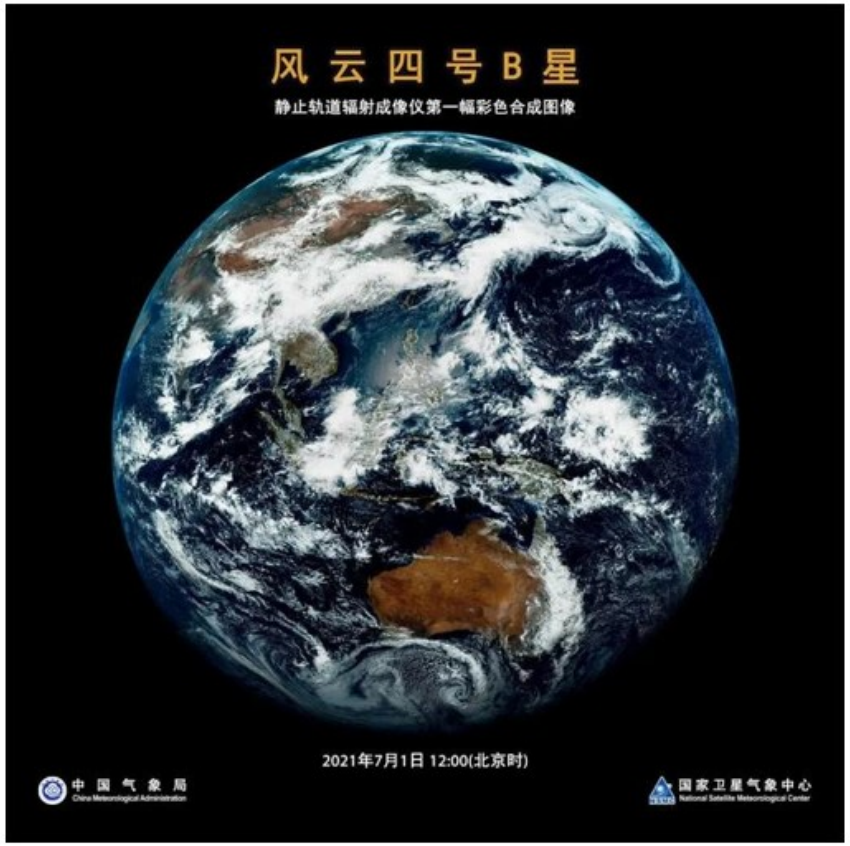






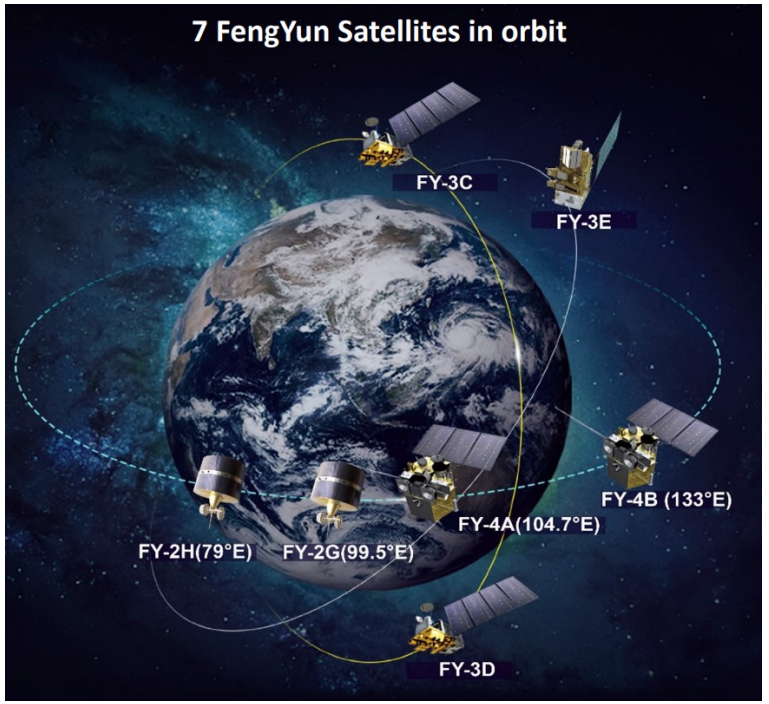

# 1. Brief Introduction of Chinese Meteorological Satellite

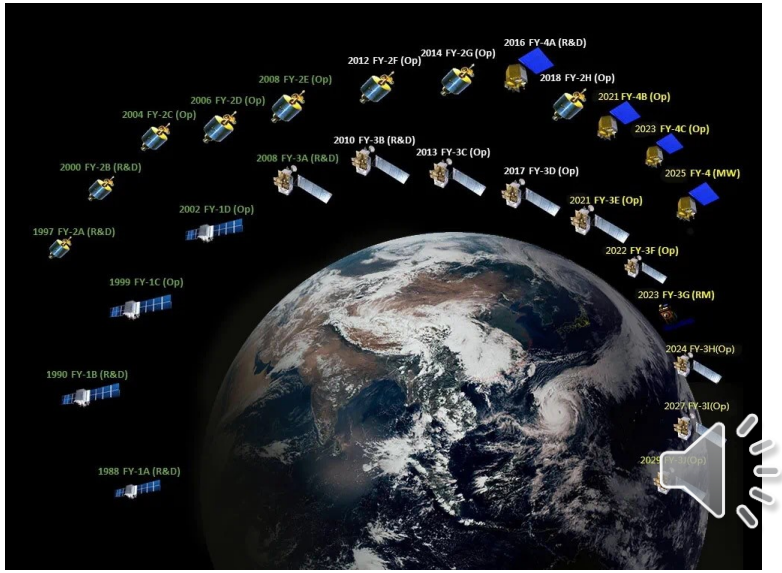





## Polar Orbiting and Geostationary Satellite

| 极轨 | 发射日期 | 静止 | 发射日期 |
|---|---|---|---|
| FY-1A | 1988 年 9 月 7 日 | FY-2A | 1997 年 6 月 10 日 |
| FY-1B | 1990 年 9 月 3 日 | FY-2B | 2000 年 6 月 25 日 |
| FY-1C | 1999 年 5 月 10 日 | FY-2C | 2004 年 10 月 18 日 |
| FY-1D | 2002 年 5 月 15 日 | FY-2D | 2006 年 12 月 8 日 |
| FY-3A | 2008 年 5 月 27 日 | FY-2E | 2008 年 12 月 23 日 |
| FY-3B | 2010 年 11 月 5 日 | FY-2F | 2012 年 1 月 13 日 |
| FY-3C | 2013 年 9 月 23 日 | FY-2G | 2014 年 12 月 31 日 |
| FY-3D | 2017 年 11 月 15 日 | FY-2H | 2018 年 6 月 5 日 |
| FY-3E | 2021 年 7 月 5 日 | FY-4A | 2016 年 12 月 11 日 |
| | | FY-4B | 2021 年 6 月 3 日 |



# 1. Brief Introduction of Chinese Meteorological Satellite

China
MVRIS 1999
VIRR 2008
MERSI 2008

USA
AVHRR 1978
MODIS 1999
VIIRS 2011

Europe
VEGATION 1998
MERIS 2002-2012
PROBA-V 2013-2020
Sentinel 3 2016

Japan
AVNIR 1996-1997
GLI 2002-2003
**SGLI 2017**

## FY-3 A/B/C VIRR

| Band No. | Central wavelength(μm) | Spectral Range(μm) | SNR or NEΔT @ specified input |
|---|---|---|---|
| 1 | 0.455 | 0.43 - 0.48 | 3.0 @ 0.5 % |
| 2 | 0.505 | 0.48 - 0.53 | 3.0 @ 0.5 % |
| 3 | 0.555 | 0.53 - 0.58 | 3.0 @ 0.5 % |
| 4 | 0.630 | 0.58 - 0.68 | 3.0 @ 0.5 % |
| 5 | 0.865 | 0.84 – 0.89 | 3.0 @ 0.5 % |
| 6 | 1.360 | 1.325 - 1.395 | 3.0 @ 0.5 % |
| 7 | 1.600 | 1.55 - 1.64 | 3.0 @ 0.5 % |
| 8 | 3.740 | 3.55 - 3.93 | 0.40 K @ 300 K |
| 9 | 10.80 | 10.3 - 11.3 | 0.2 K @ 300 K |
| 10 | 12.00 | 11.5 - 12.5 | 0.2 K @ 300 K |

## FY-3 A/B/C MERSI

| No. | Center wavelength | Bandwidth | SNR or NEρ or NEΔT @ specified input | IFOV at s.s.p. |
|---|---|---|---|---|
| 1 | 412 nm | 20 nm | 300 @ 44.9 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 2 | 443 nm | 20 nm | 300 @ 41.9 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 3 | 470 nm | 50 nm | 100 @ 50% albedo | 250 m |
| 4 | 490 nm | 20 nm | 300 @ 32.1 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 5 | 520 nm | 20 nm | 500 @ 29.0 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 6 | 550 nm | 50 nm | 100 @ 50% albedo | 250 m |
| 7 | 565 nm | 20 nm | 500 @ 21.0 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 8 | 650 nm | 50 nm | 100 @ 50% albedo | 250 m |
| 9 | 650 nm | 20 nm | 500 @ 10.0 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 10 | 685 nm | 20 nm | 0.05 % | 1000 m |
| 11 | 765 nm | 20 nm | 0.05 % | 1000 m |
| 12 | 865 nm | 20 nm | 0.05 % | 1000 m |
| 13 | 865 nm | 50 nm | 100 @ 50% albedo | 250 m |
| 14 | 905 nm | 20 nm | 0.10 % | 1000 m |
| 15 | 940 nm | 20 nm | 0.10 % | 1000 m |
| 16 | 980 nm | 20 nm | 0.10 % | 1000 m |
| 17 | 1030 nm | 20 nm | 0.10 % | 1000 m |
| 18 | 1640 nm | 50 nm | 0.08 % | 1000 m |
| 19 | 2130 nm | 50 nm | 0.07 % | 1000 m |
| 20 | 11.50 μm | 2.50 μm | 0.3 K @ 300 K | 250 m |

## FY-3D MERSI-2

| Band No. | Center wavelength | Bandwidth | SNR or NEΔT | Spatial Resolution |
|---|---|---|---|---|
| 1 | 412 nm | 20 nm | 300 @ 44.9 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 2 | 443 nm | 20 nm | 300 @ 41.9 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 3 | 470 nm | 50 nm | 100 @ 35.3 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 250 m |
| 4 | 490 nm | 20 nm | 300 @ 32.1 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 5 | 550 nm | 50 nm | 100 @ 29.0 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 250 m |
| 6 | 555 nm | 20 nm | 500 @ 21 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 7 | 650 nm | 50 nm | 100 @ 22 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 250 m |
| 8 | 670 nm | 20 nm | 500 @ 10 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 9 | 709 nm | 20 nm | 500 @ 6.9 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 10 | 746 nm | 20 nm | 500 @ 9.6 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 11 | 865 nm | 20 nm | 500 @ 6.4 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 12 | 865 nm | 50 nm | 100 @ 25 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 250 m |
| 13 | 905 nm | 20 nm | 200 @ 10.0 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 14 | 936 nm | 20 nm | 100 @ 3.6 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 15 | 940 nm | 50 nm | 200 @ 15.0 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 16 | 1240 / 1030 nm | 20 nm | 100 @ 5.4 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 17 | 1380 nm | 20 / 30 nm | 60/100 @ 6 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 18 | 1640 nm | 50 nm | 200 @ 7.3 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 19 | 2130 nm | 50 nm | 100 @ 1.2 W $m^{-2}$ $sr^{-1}$ $\mu m^{-1}$ | 1000 m |
| 20 | 3.80 μm | 0.18 μm | 0.25 K @ 270 K | 1000 m |
| 21 | 4.05 μm | 0.155 μm | 0.25 K @ 300/380 K | 1000 m |
| 22 | 7.20 μm | 0.50 μm | 0.30 K @ 270 K | 1000 m |
| 23 | 8.55 μm | 0.30 μm | 0.25 K @ 270 K | 1000 m |
| 24 | 10.8 μm | 1.0 μm | 0.4 K @ 300 K | 250 m |
| 25 | 12.0 μm | 1.0 μm | 0.4 K @ 300 K | 250 m |

## FY-3E MERSI-LL

| Band No. | Central Wavelength(μm) | Band width(nm) | Spatial Resolution(m) |
|---|---|---|---|
| 1 | 0.7 | 400 | 1000 |
| 2 | 3.8 | 180 | 1000 |
| 3 | 4.05 | 155 | 1000 |
| 4 | 7.2 | 500 | 1000 |
| 5 | 8.55 | 300 | 1000 |
| 6 | 10.8 | 1000 | 250 |
| 7 | 12.0 | 1000 | 250 |

# 2. FY Satellite Data Processing for Global Agricultural Drought

## Data and Product Service

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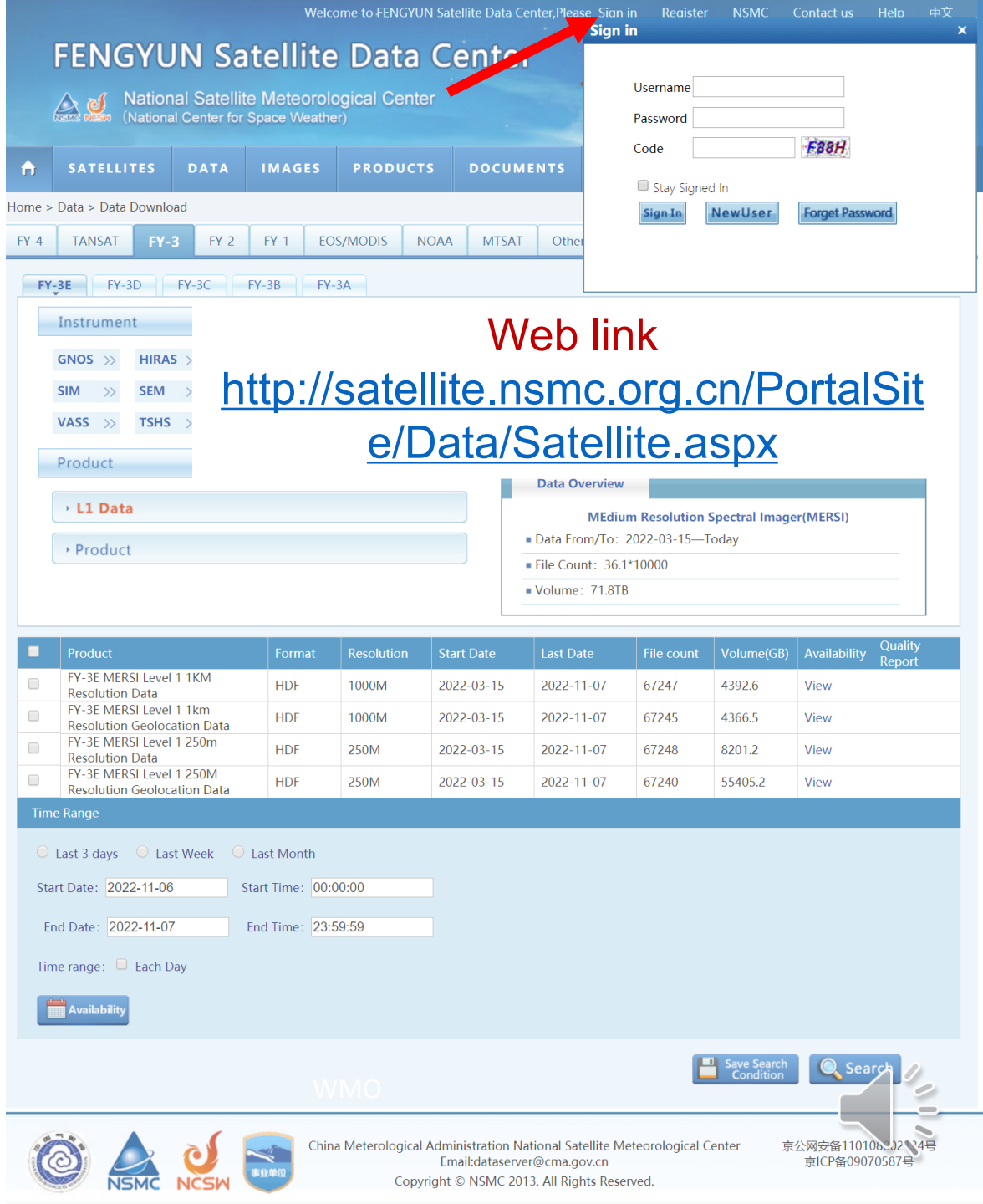
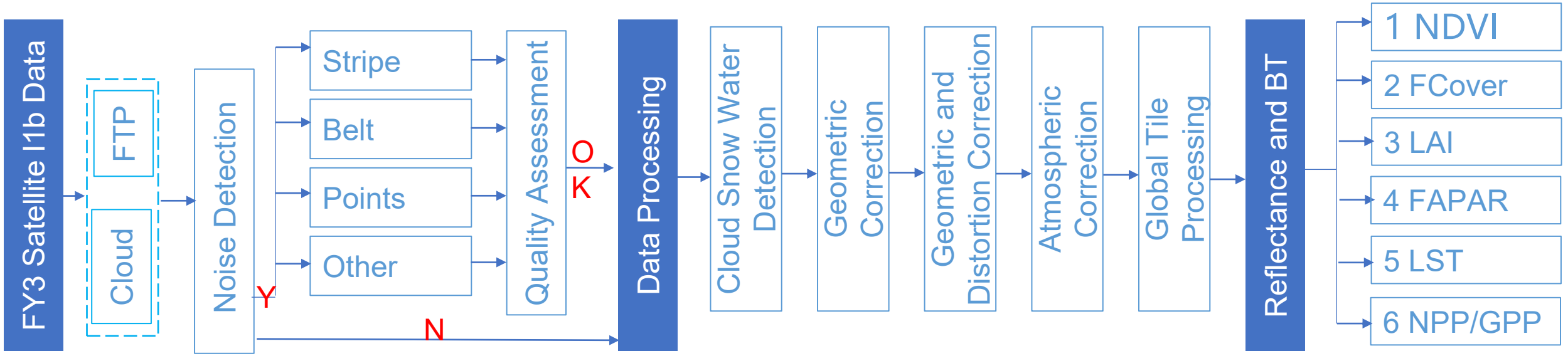


# 2. FY Satellite Data Processing for Global Agricultural Drought




Data Download | Noise Removal | Cal/Geometric/Atmospheric Correction/Global Tiling | High Level Products

**Flowchart to retrieve the biophysical parameters for further applications**

# 2. FY Satellite Data Processing for Global Agricultural Drought

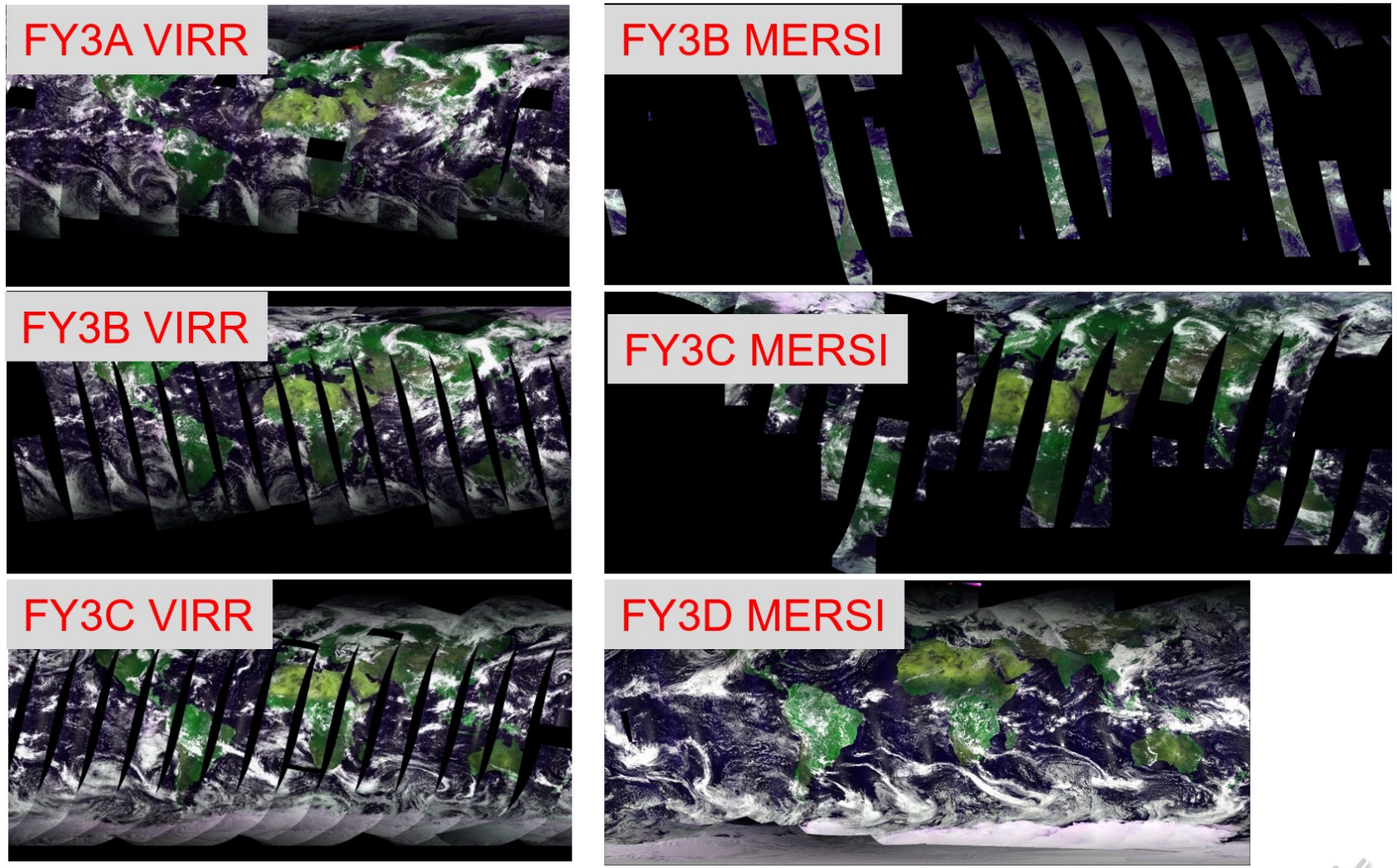
Our team has put efforts in the past 10 years on the development of processing FY3 VIRR/MERSI data under the support of series of research projects mainly from National Key R&D Program:

The processing chain for FY3 VIRR/MERSI L1b data has established with the grant 2016YFA0600301/2.

The hydrometeorological application of FY3 VIRR/MERSI data has developed with the grant 2017YFB0504105.

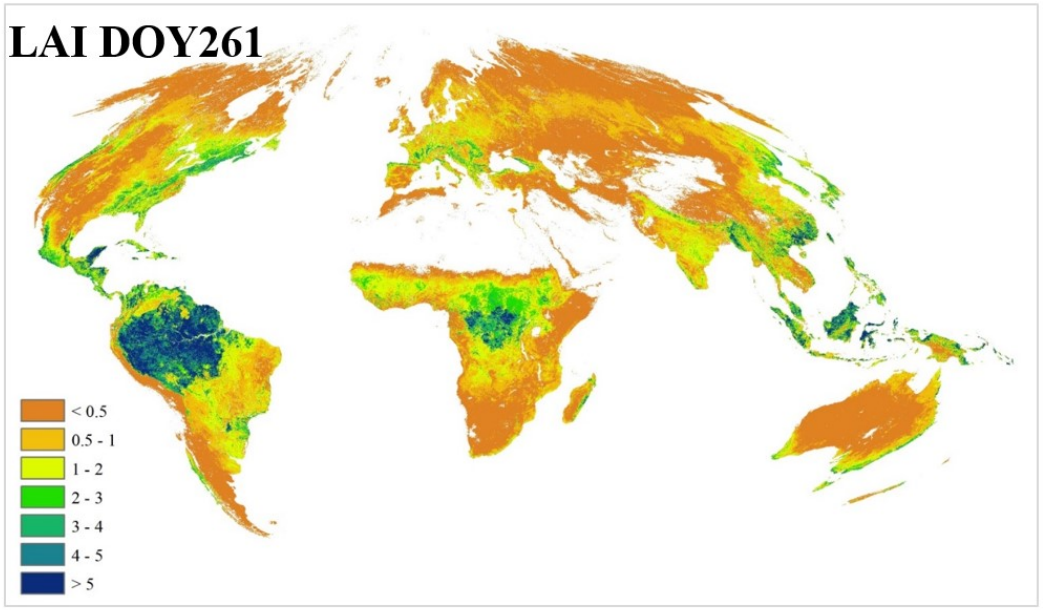
A Global Agricultural Drought Monitoring system is in development with the grant 2019YFE0127600. The drought information has been retrieved completely from FY3 VIRR/MERSI data and served the global user community since this year.

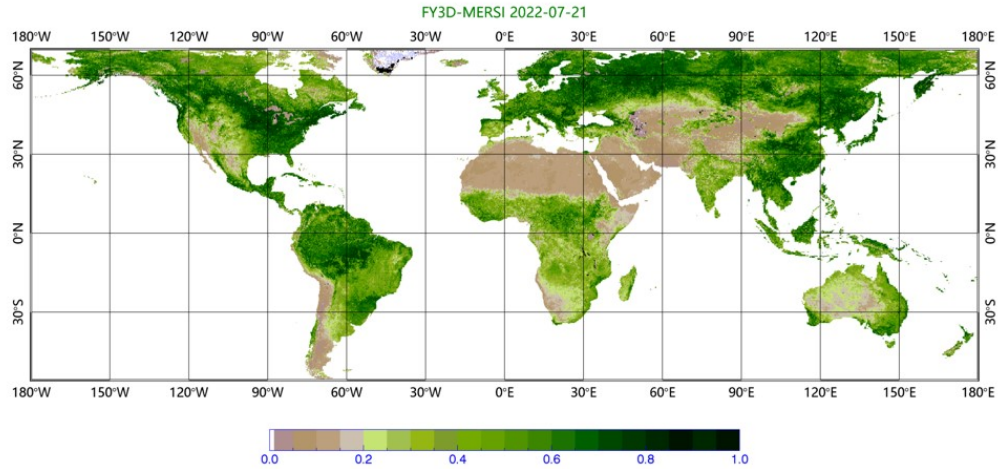
The application of FY3 VIRR/MERSI data for the hydrometeorology will be enhanced in next 3 years supported by the grant 2021YFE0117400. And then this will improve our capability to provide the information to the global community.

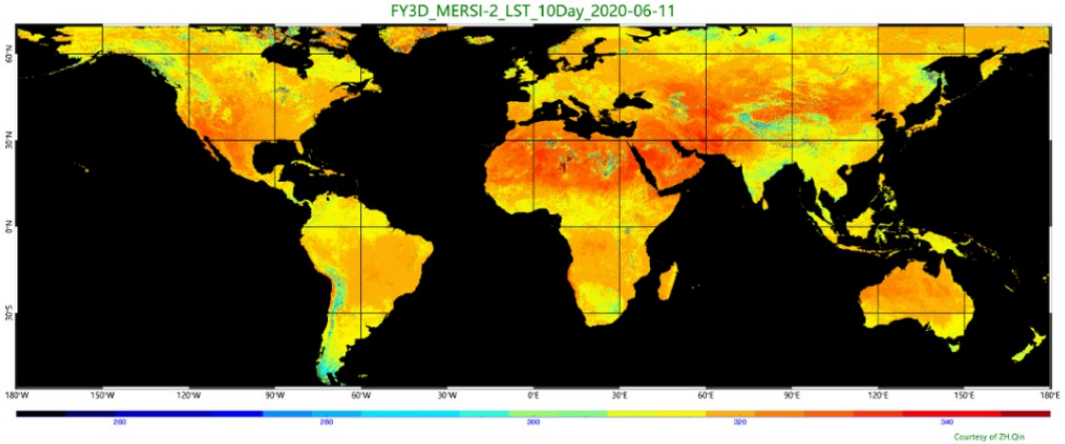


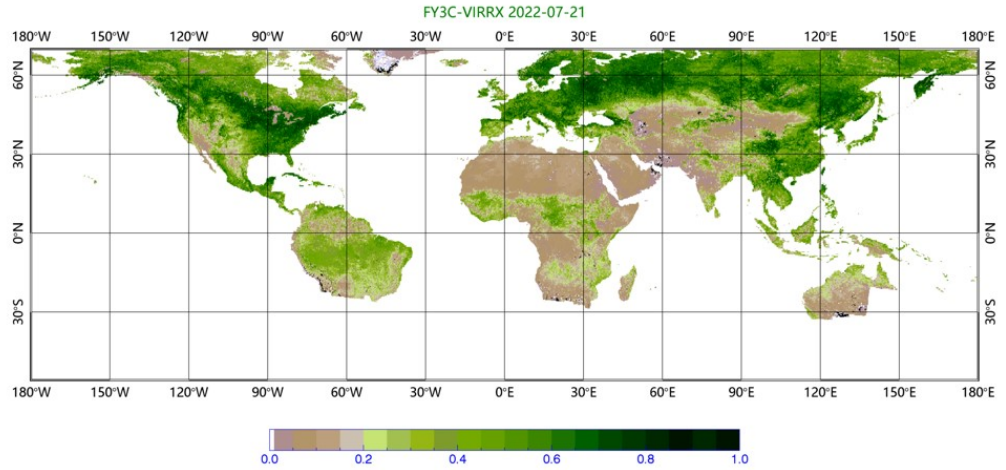

**Global satellite data basic processing capability**

# 2. FY Satellite Data Processing for Global Agricultural Drought



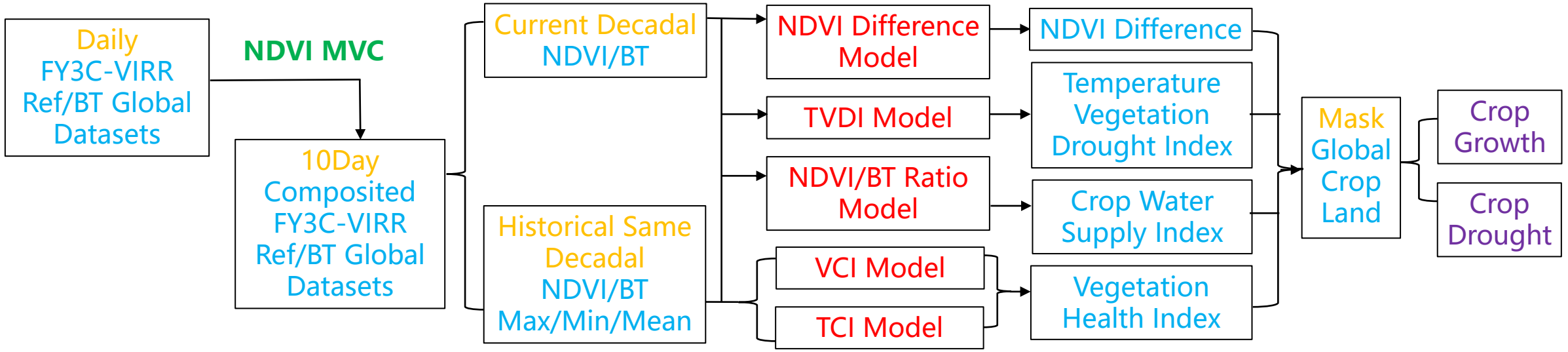




**Biophysical parameters retrieved from FY3 VIRR/MERSI data**

# 2. FY Satellite data processing for Global Agricultural Drought

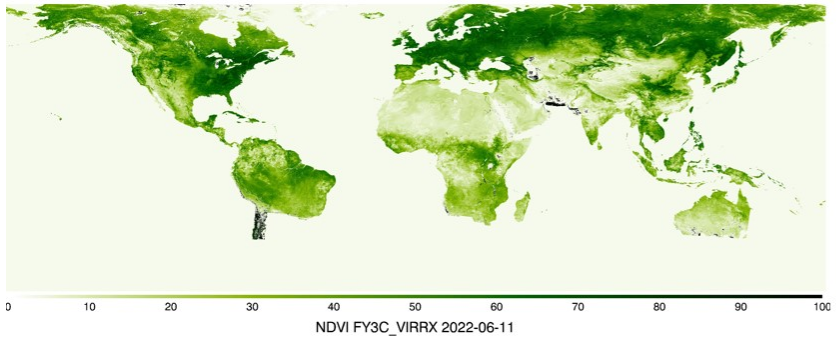


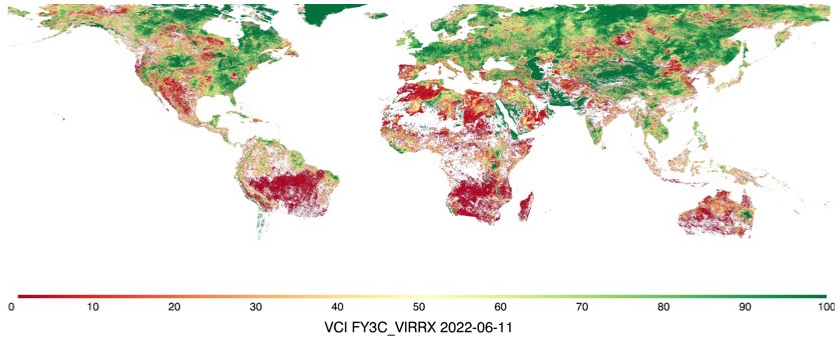

**Flowchart to develop the drought indices**

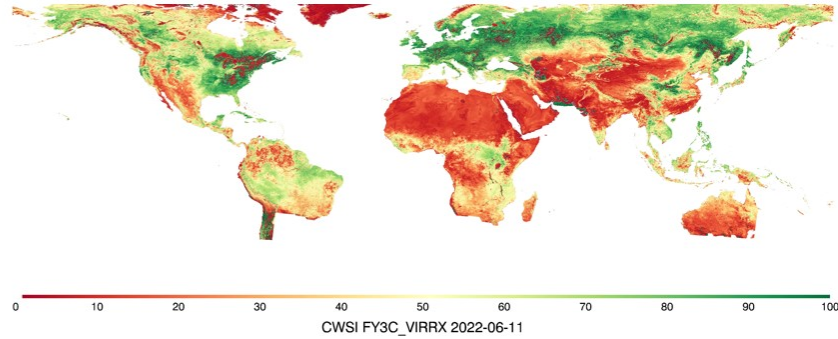
FY3A 2009-2014 + 6-year data
FY3B 2011-2021 +10-year data

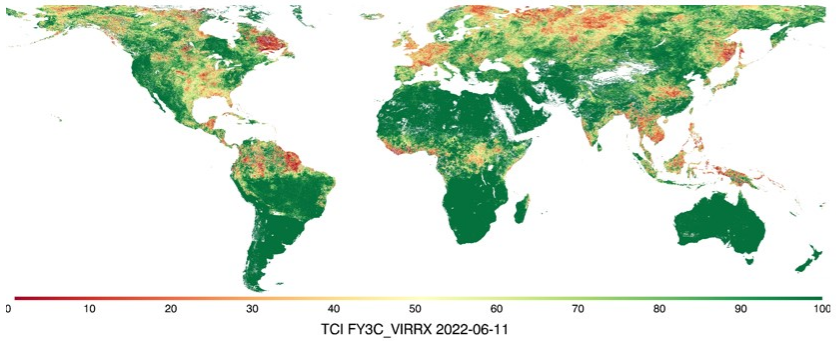
**FY3C 2014- 8-year historical data + 2022**
FY3D 2018- 4-year historical data

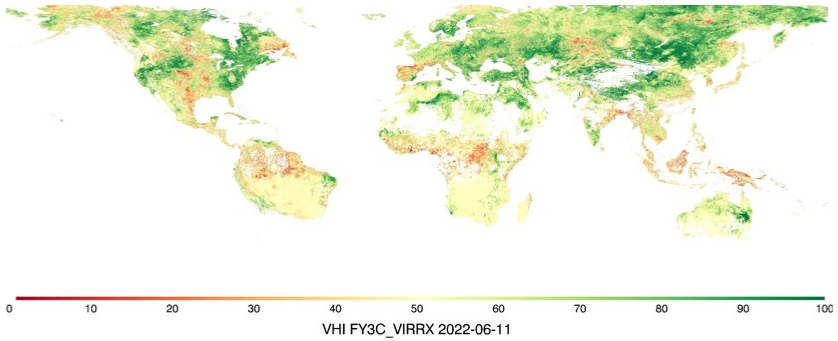
# 2. FY Satellite data processing for Global Agricultural Drought

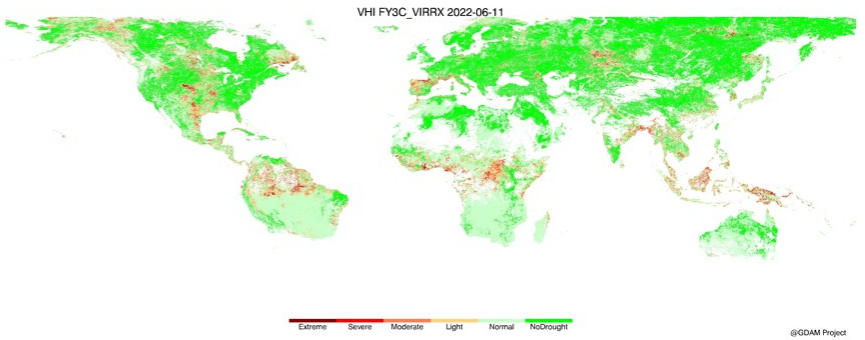


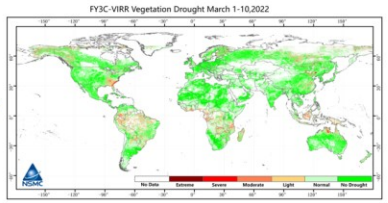
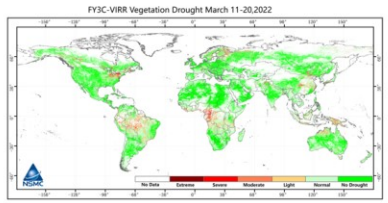
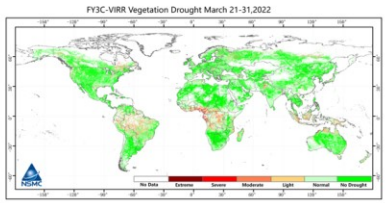
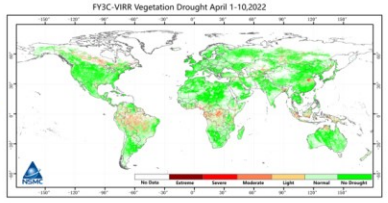
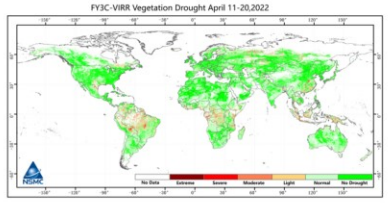
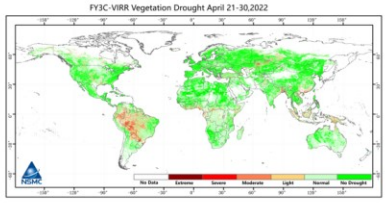
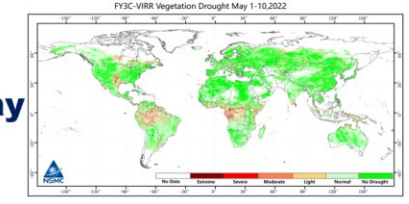
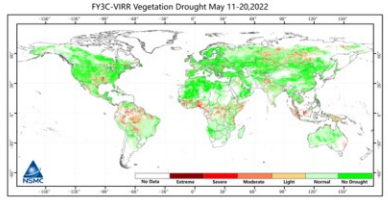
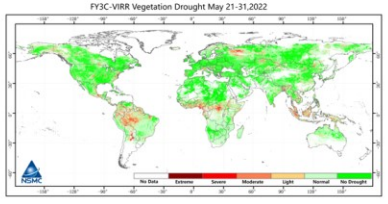
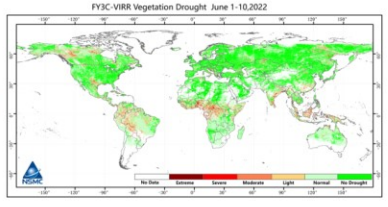
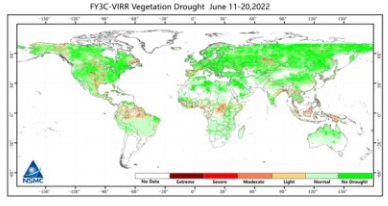
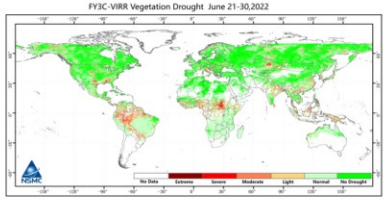



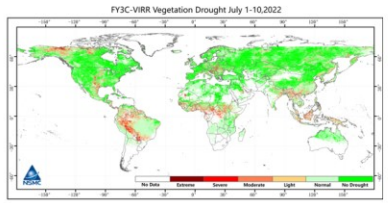
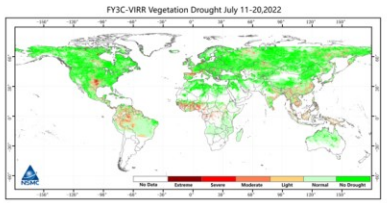
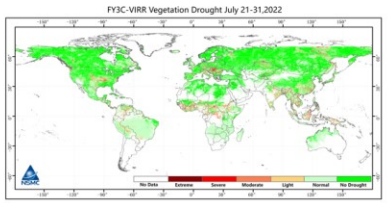
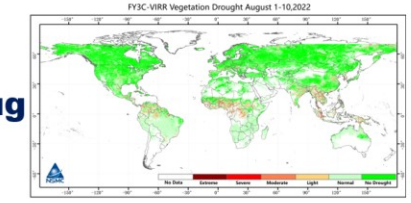
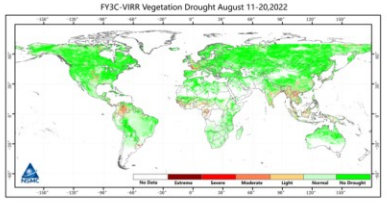
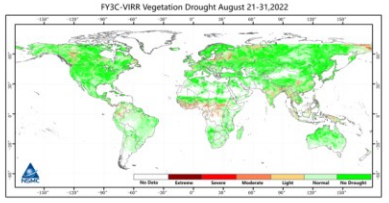
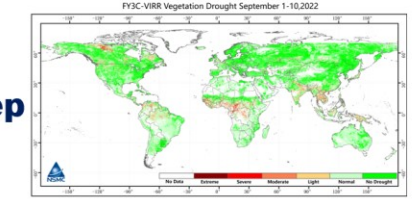
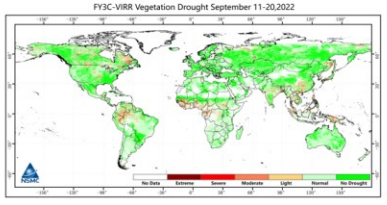
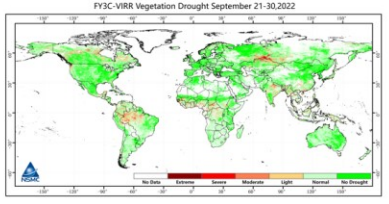
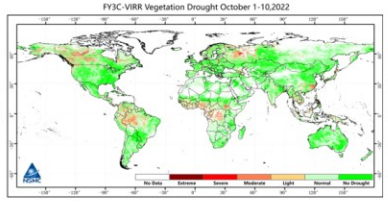
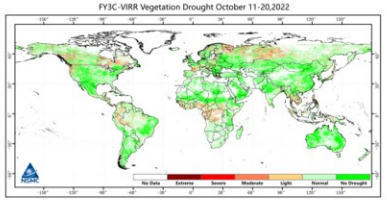
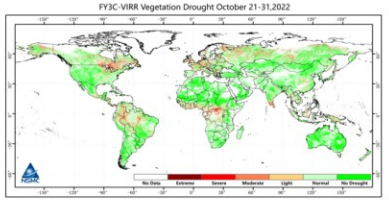




**Drought Indices for the second 10 day of June, 2022**

# 3. Global Agricultural Drought Map

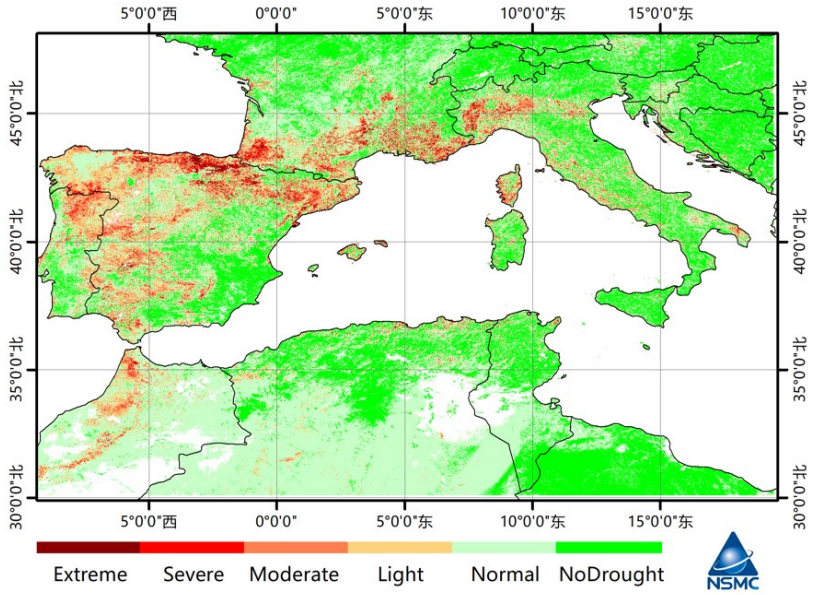
## FY3C-VIRR Global Drought Maps in 2022

| | 1st Dekadal | 2nd Dekadal | 3rd Dekadal |
|---|---|---|---|
| Mar |  |  |  |
| Apr |  |  |  |
| May |  |  |  |
| Jun |  |  |  |

| | 1st Dekadal | 2nd Dekadal | 3rd Dekadal |
|---|---|---|---|
| Jul |  |  |  |
| Aug |  |  |  |
| Sep |  |  |  |
| Oct |  |  |  |

# 3. Global Agricultural Drought Map

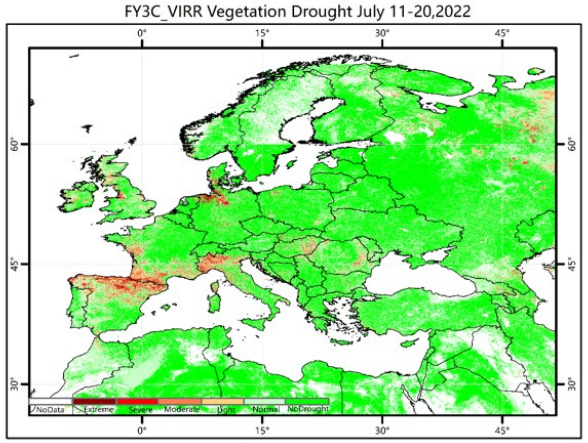
## Drought conditions in Europe

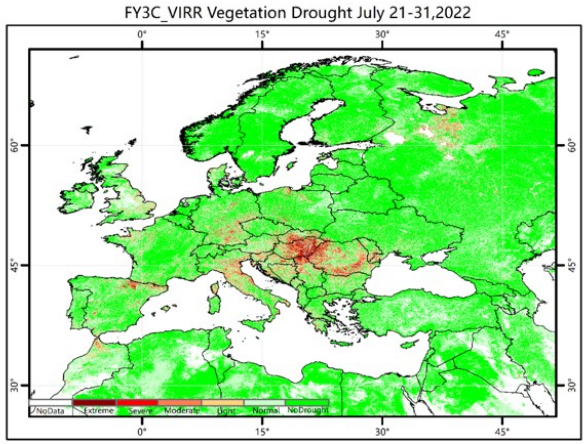


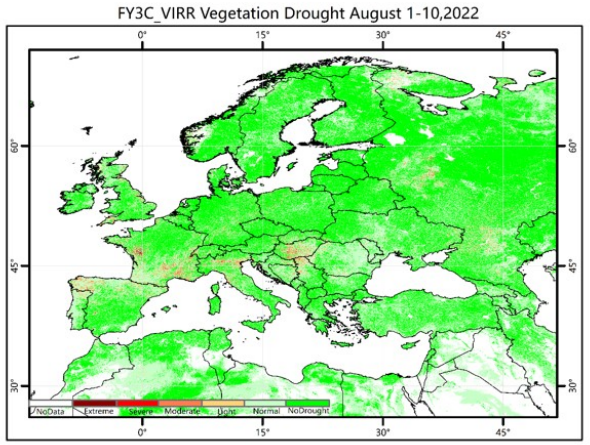

Drought Map for West Europe in **middle of June 2022**

### Rhine

### Danube




- **This Summer's Drought Is Europe's Worst in 500 Years**
- **Europe's drought could signal the death of river cruising**

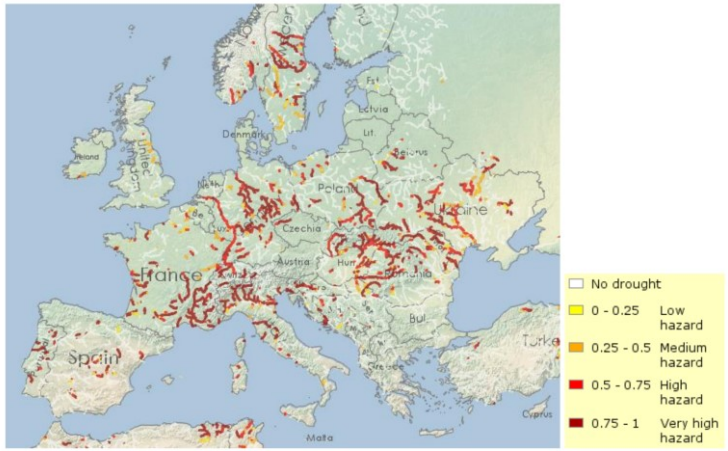
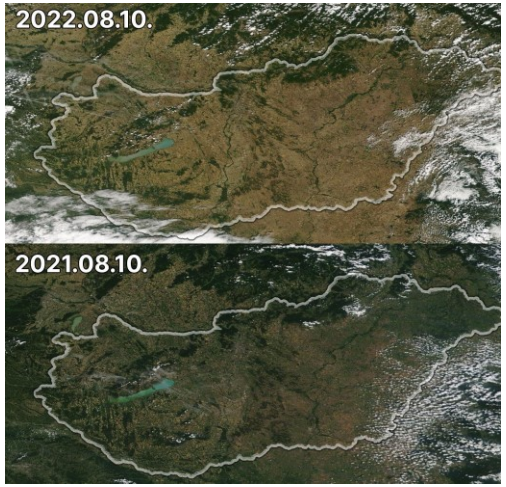



**Figure 7:** *Low-Flow Index (LFI) at the end of June 2022. A Low-Flow Index of 0 corresponds to no drought and a value of 1 to the highest drought hazard.*

@ Drought in Europe July 2022

- **Drought devastates Hungarian agriculture**
- **Drought slashes maize crop in Hungary, could be a net importer –govt**
- **Hungarian farmers battle 'historic' drought**

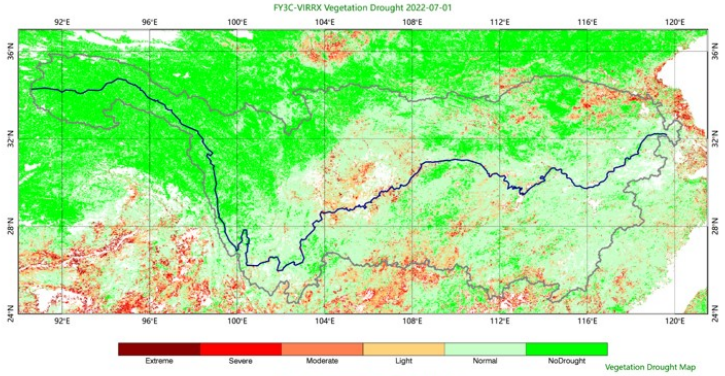


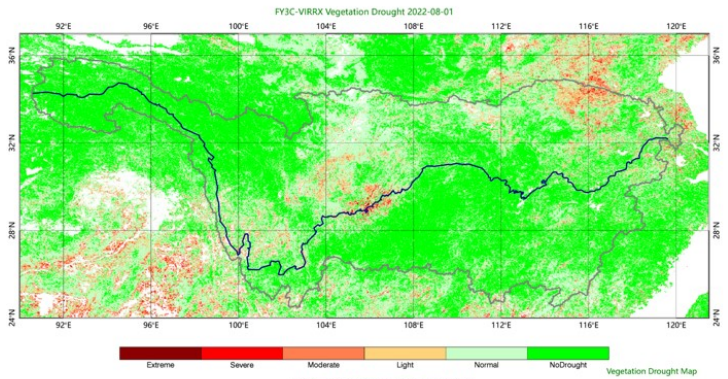
# 3. Global Agricultural Drought Map

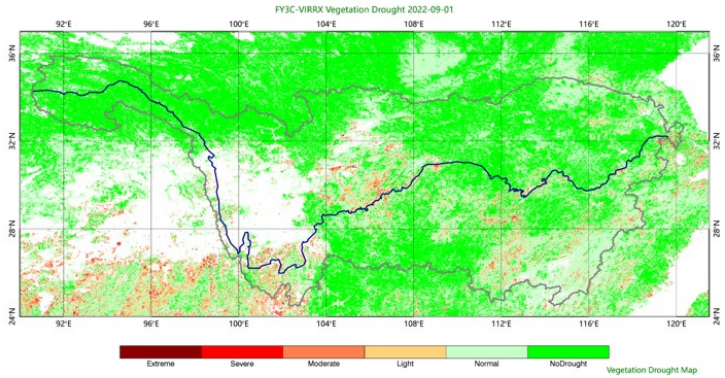
## Drought conditions in China

**Jul** | **Aug** | **Sep**

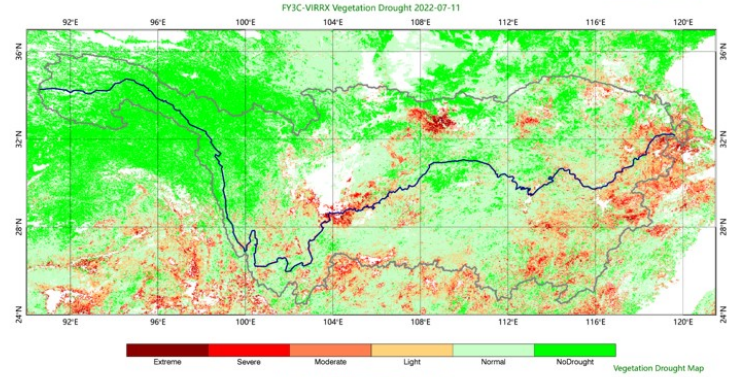
**1st Dekadal**

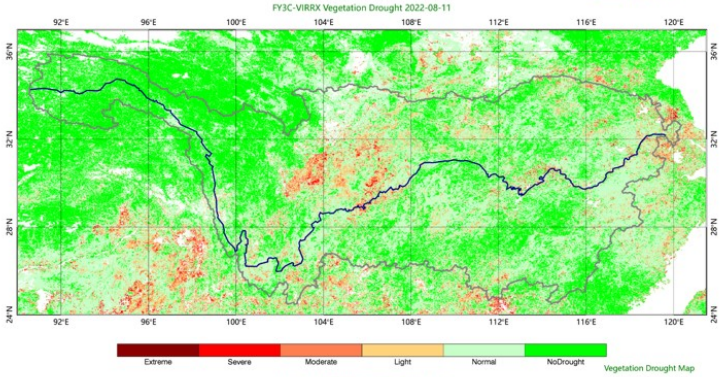


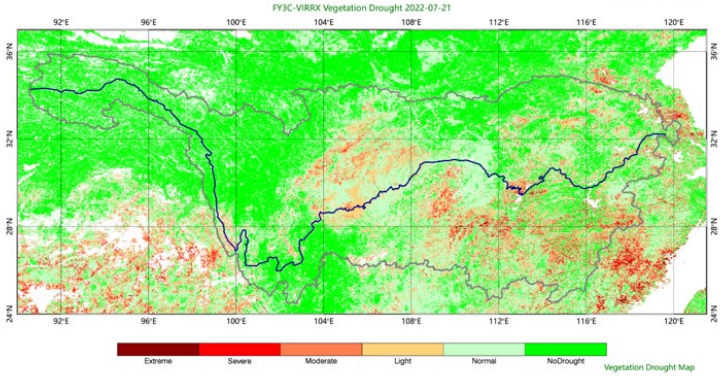



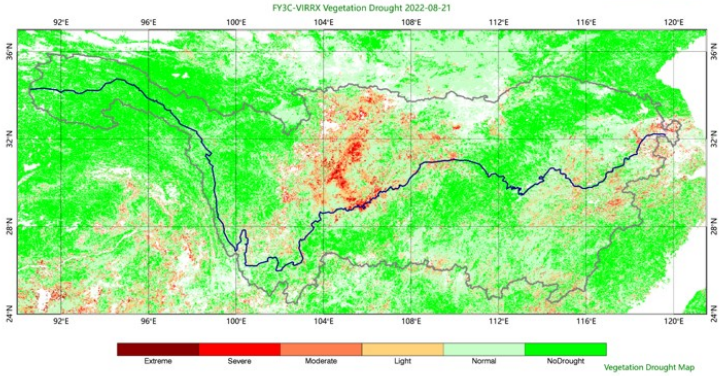

**2nd Dekadal**

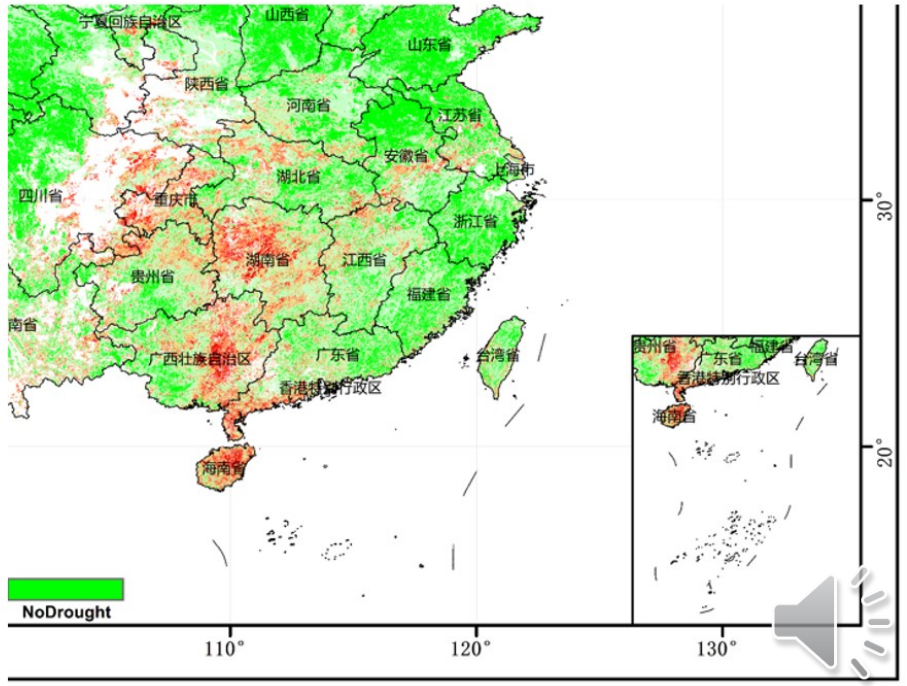



**3rd Dekadal**

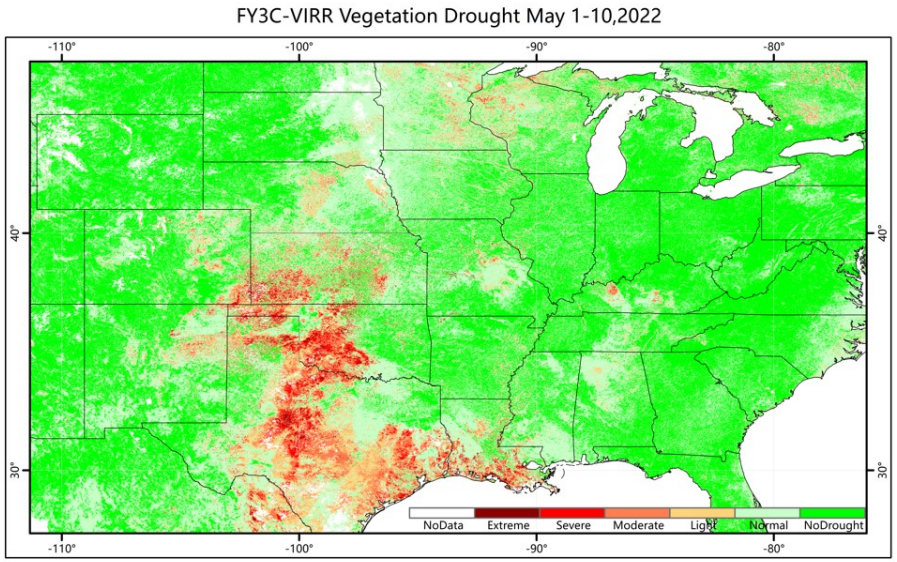


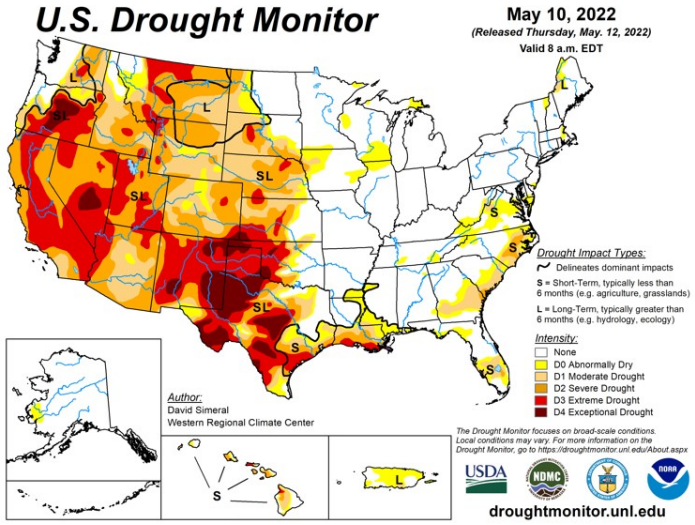



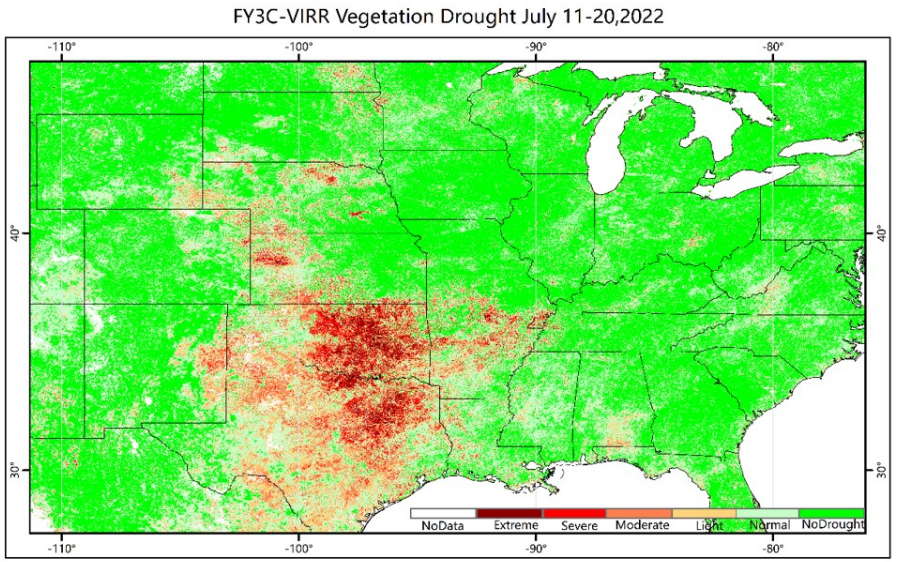



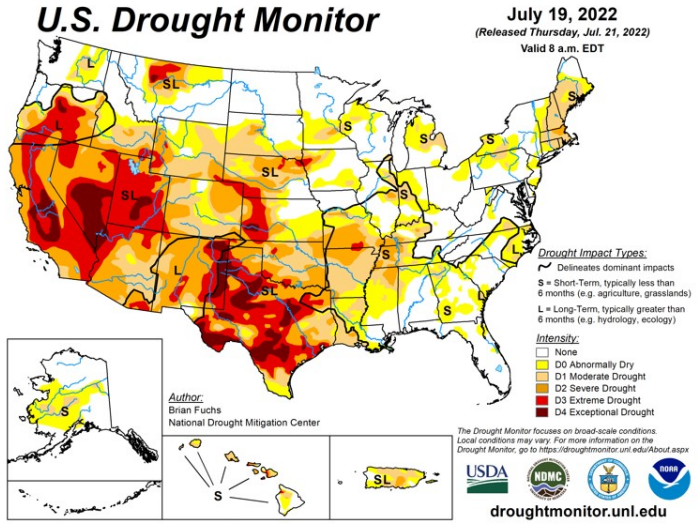
# 3. Global Agricultural Drought Map

## Drought conditions in USA



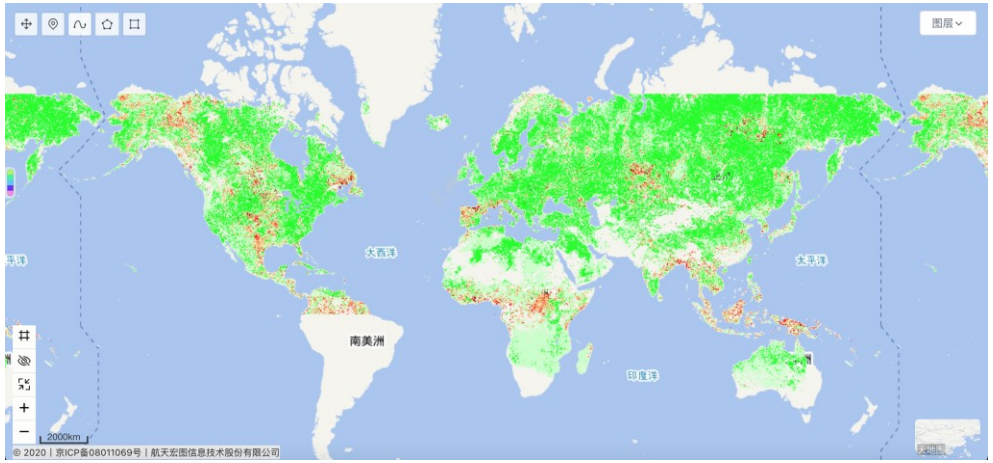



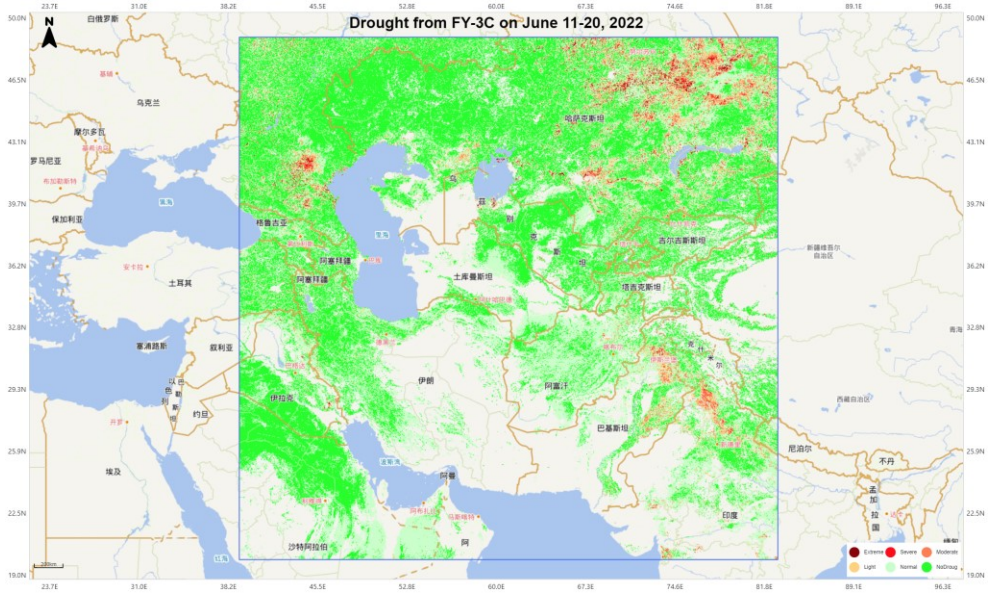



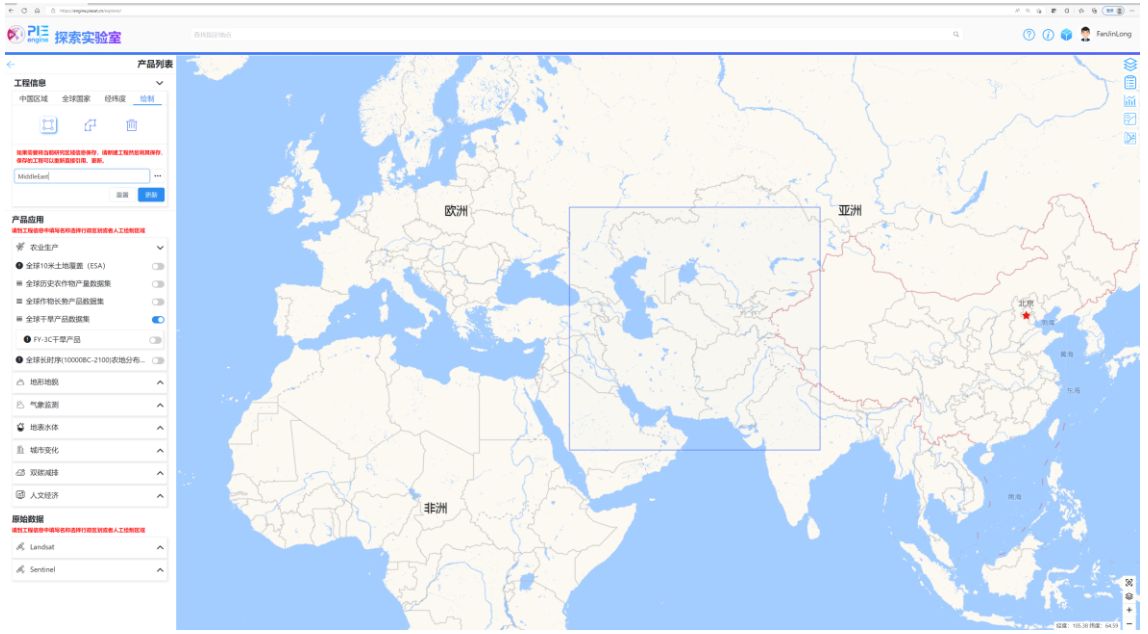



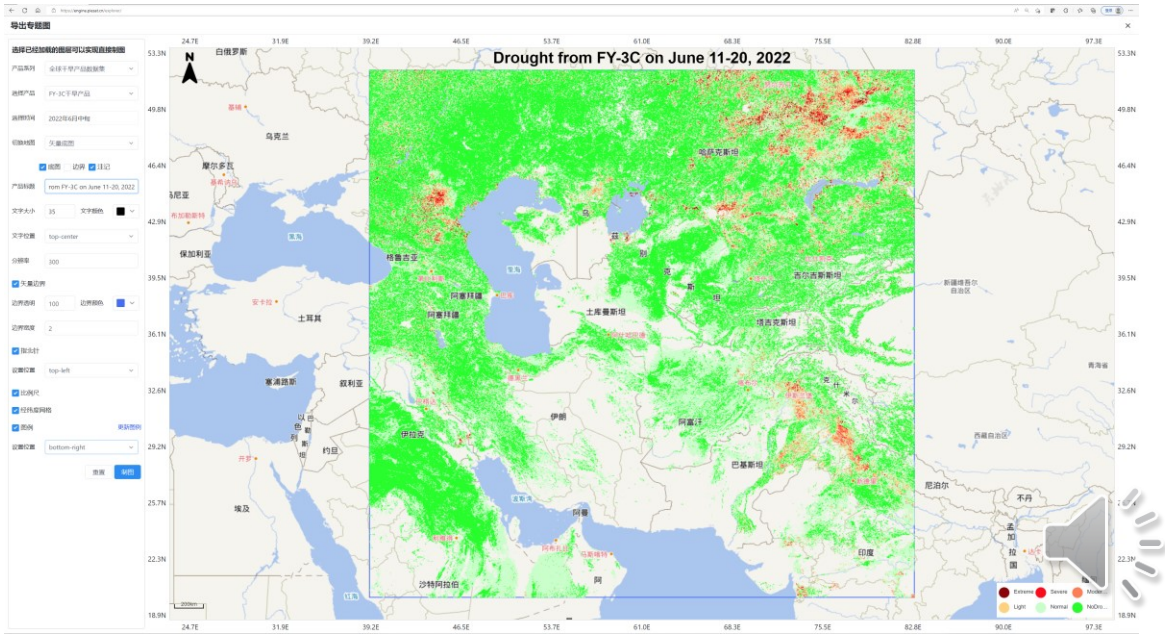
# 3. Global Agricultural Drought Map

**Cloud development for easily making drought map**



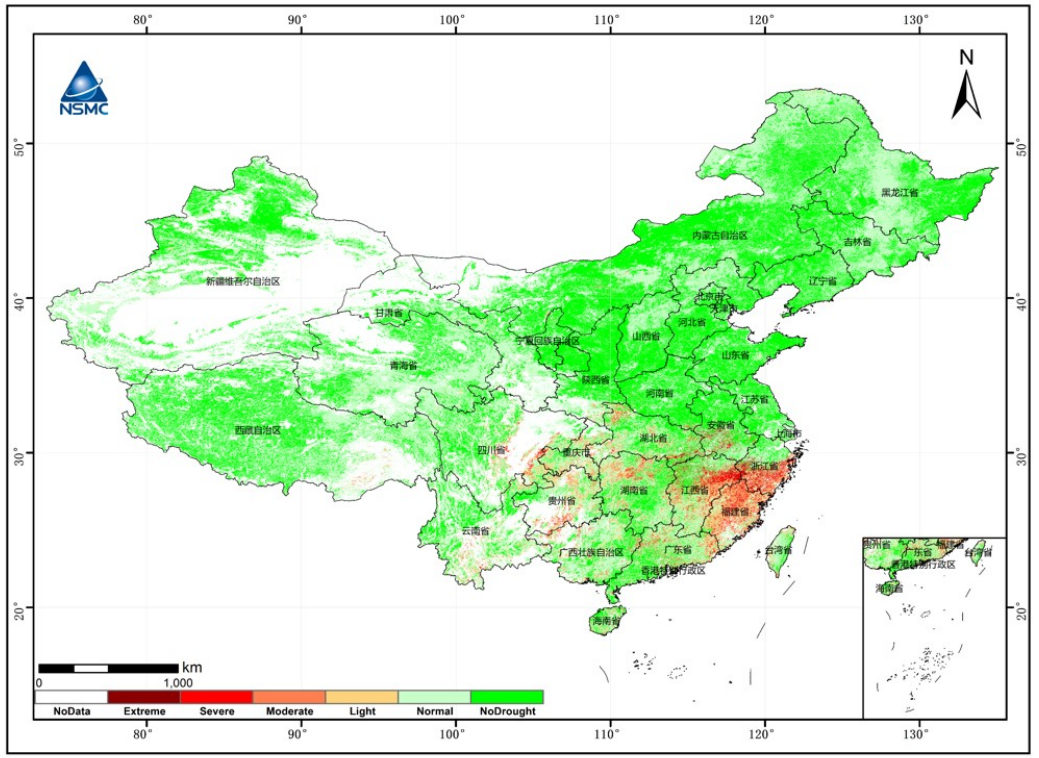



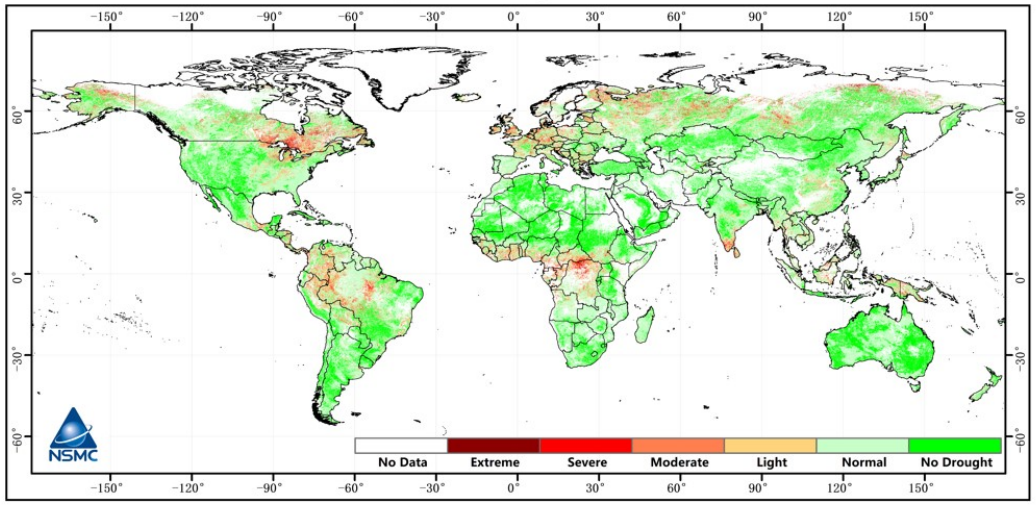
# 4. Conclusion and Question

- Under the support of series National Key R&D Project, an approach for the global agricultural drought monitoring with Chinese own satellite data is coming true.
- Biophysical parameters retrieved from FY3C VIRR were used to further compute the remote sensing based drought indices with the vegetation health index model.
- The spatial condition of global agricultural drought was mapped every dekadal and the drought intensity was categorized into five classes, such as extreme, severe, moderate, light and normal.
- The maps and the data are becoming available on the website and the PIE cloud.

FY3C-VIRR Vegetation Drought October 1-10,2022




FY3C-VIRR Vegetation Drought October 21-31,2022



# Thank you very much for your attentions!

GADM
全球农业干旱监测