中国科学院遥感与数字地球研究所
Institute of Remote Sensing and Digital Earth ,CAS

GEOSS Asia-Pacific Symposium

18-20 September 2017, Vietnam Academy of Science and Technology, Hanoi, Vietnam

Activities of AOGEOSS Task 6 :

Monitoring of drought and terrestrial water deficit in Asia-Oceania region – DroughtMonitor and ETMonitor

Li Jia (PhD, Prof.)

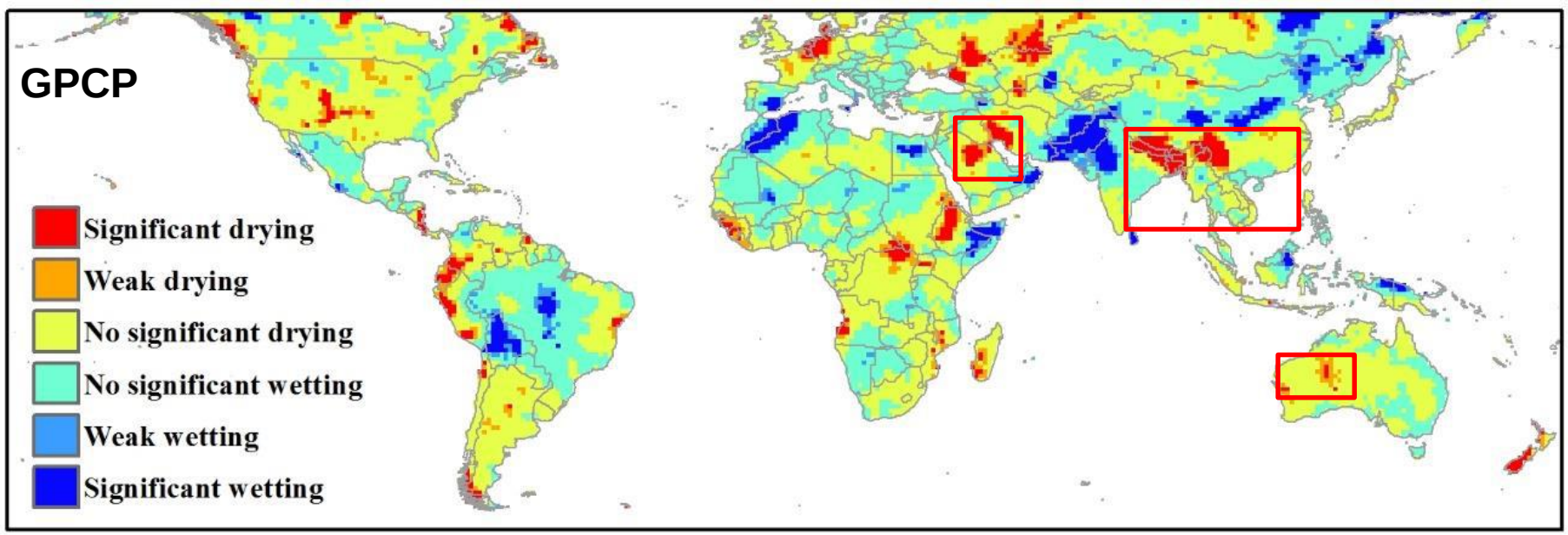
jiali@radi.ac.cn

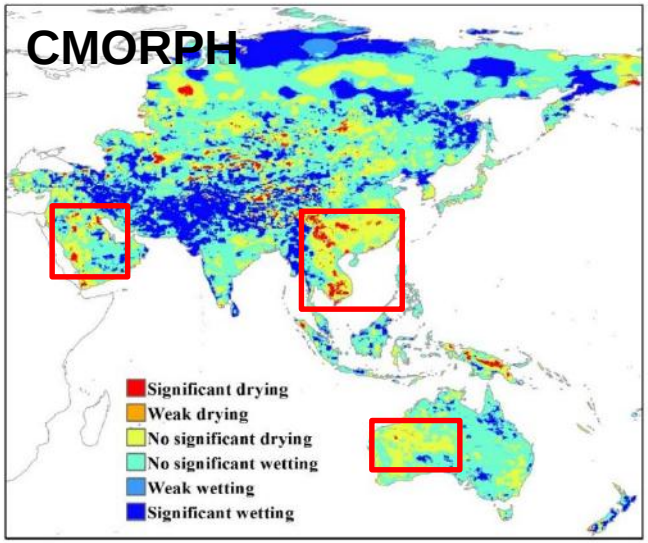
Institute of Remote Sensing and Digital Earth (RADI), Chinese Academy of Sciences

Outline

- **DroughtMonitor: Drought Monitoring**
- **ETMomitor: Evapotranspiration and Water Deficit**

Global Trend of Drought





- ✓ Southern Asia: drying trend ;
- ✓ Southern China, northeastern India, Thailand: frequent drought occurrence areas.

Definition of Drought

- **Meteorological Drought:** **Driven by precipitation deficit and its duration**

  - Less rainfall
  - Warmer air
  - Energy excess of water

- **Hydrological Drought:** **occurs after longer period of precipitation deficit**

  A reduction in water resources (stream flow, lake level, ground water, underground aquifers) below a specified level for a given period of time

- **Agricultural Drought:** **Insufficient soil moisture level to meet the plant needs for water during growing period**

  Impact of meteorological/hydrological drought on vegetation condition and crop yield

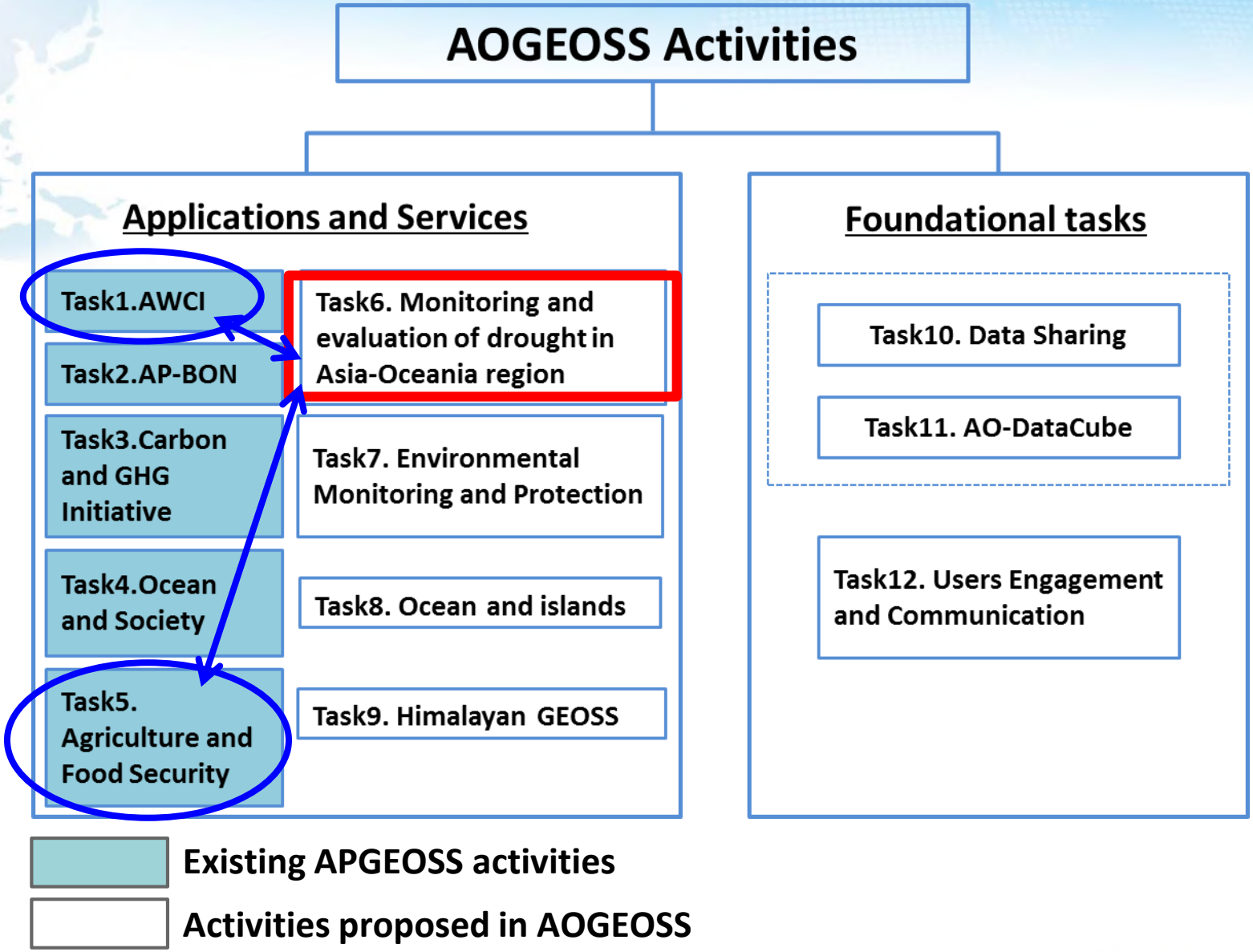
- **Man-induced Drought**

  Diversion of river water
  Groundwater depletion
  Increasing water demand ➔ economical development and living standards

Outflow exceeds inflow

➔ **Current study focus on agricultural (ecosystem) drought induced by meteorological drought**

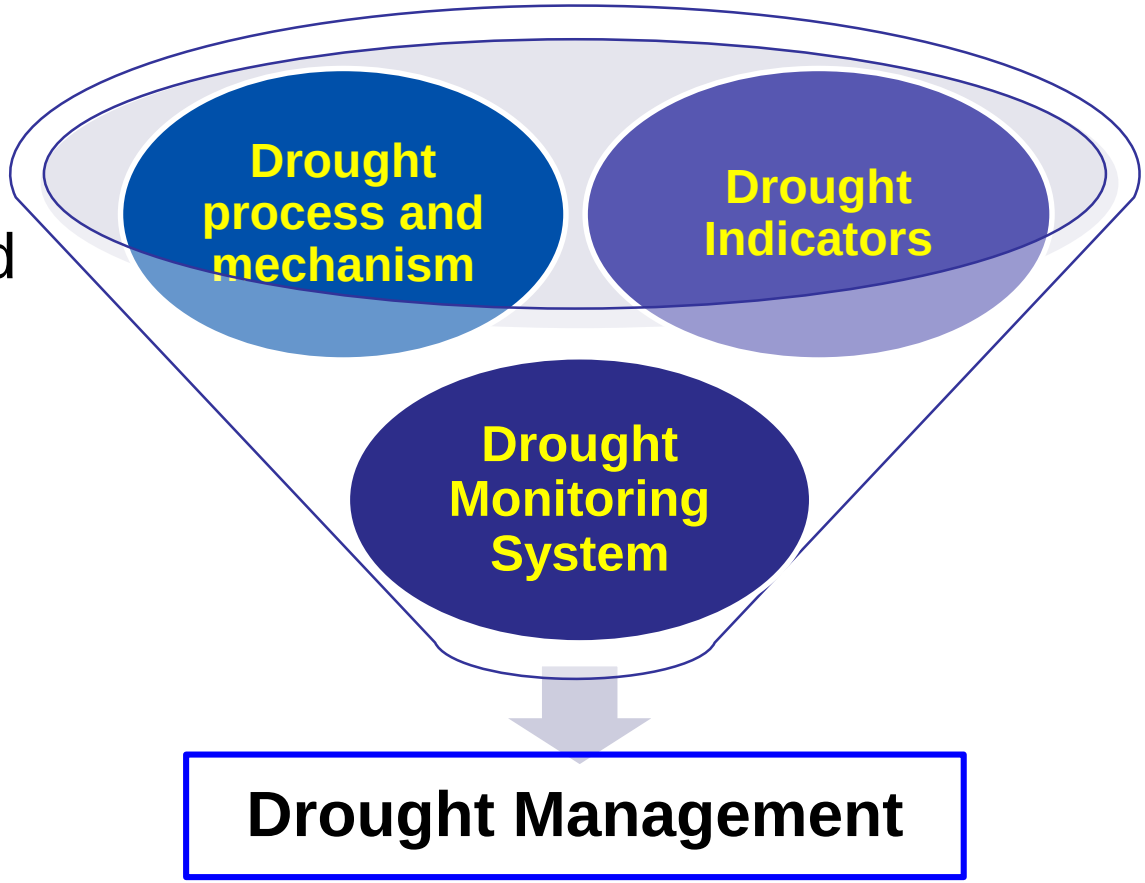
Joint APGEOSS & AOGEOSS Tasks



AOGEOSS Task 6

Task 6. Monitoring and evaluation of drought in Asia-Oceania region

- **Objectives**: Applying Earth Observations and other space-based technologies for drought monitoring, evaluation, and management.



AOGEOSS Task 6

Task 6. Monitoring and evaluation of drought in Asia-Oceania region

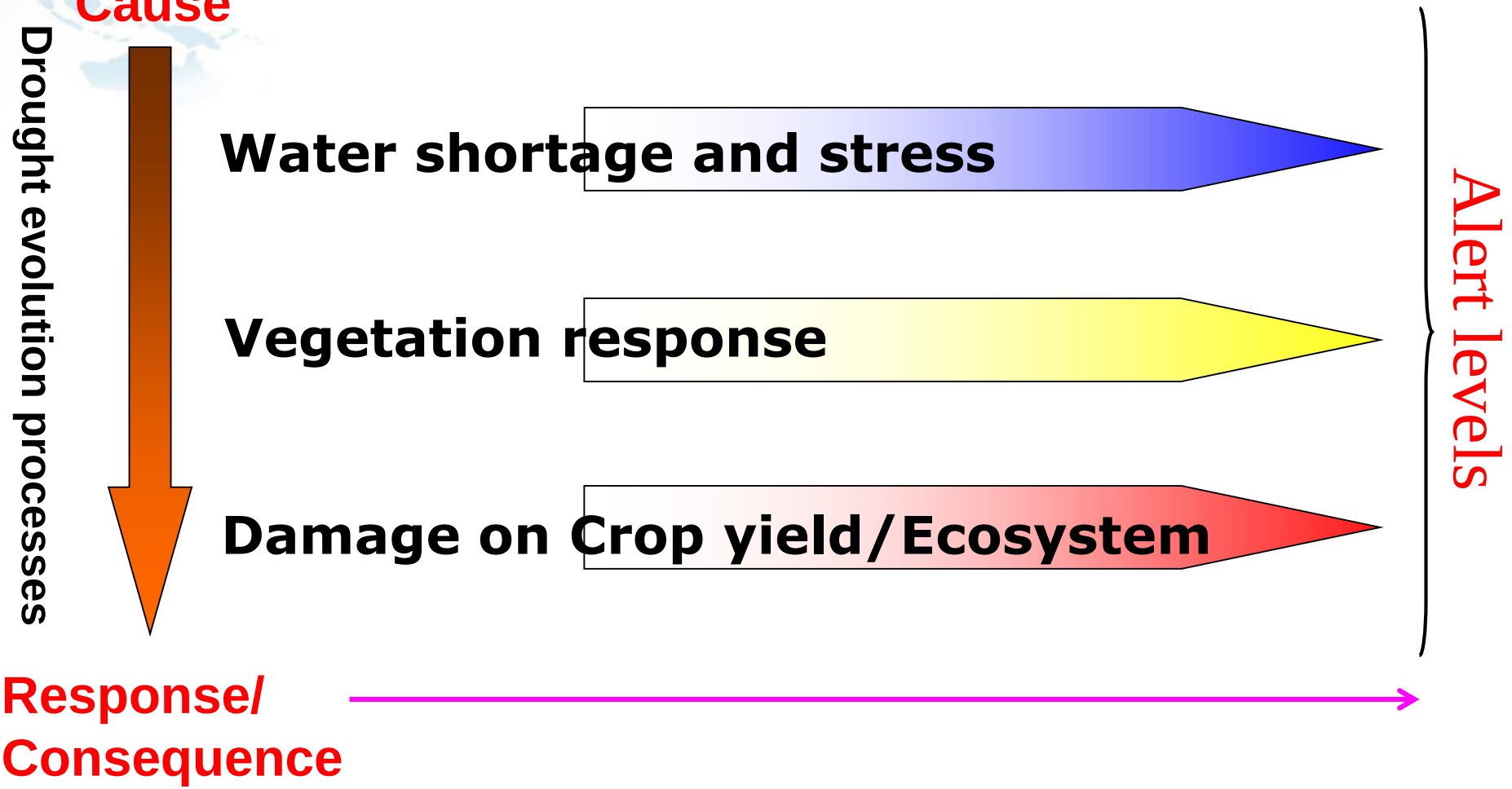
- **Sub-Tasks (milestones)**
  - **Subtask 6.1** Create and maintain a drought monitoring cooperative mechanism (end of 2017)
  - **Subtask 6.2** Establish a framework/methogology to integrate multiple EO data by different satellites and by different Countries to monitor and evaluate drought (mid of 2018)
  - **Subtask 6.3** Develop a comprehensive, inclusive and robust information system (end of 2018)
  - **Subtask 6.4** Generate policy-relevant advices to support governments to make evidence-based decisions (end of 2019)

Issues Related to Drought Monitoring

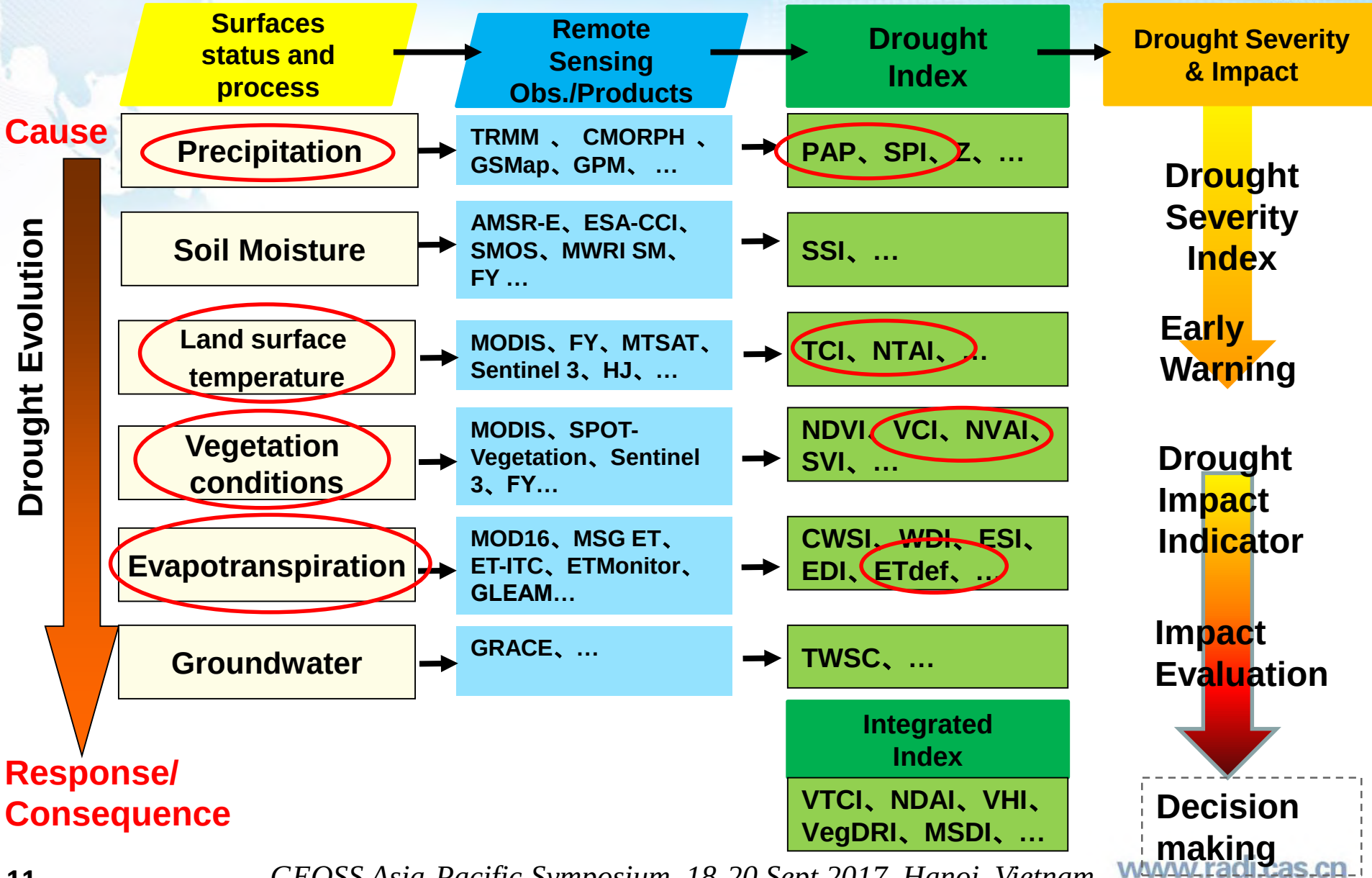
- Ground observations
- Satellite observations:
  - Satellite data quality (time series reconstruction);
  - Linkage between anomalies and drought severity
- Methodologies and Indicators
- Cooperation and Partnership

Drought indicators by EO Data

Monitoring: Towards severity alert levels

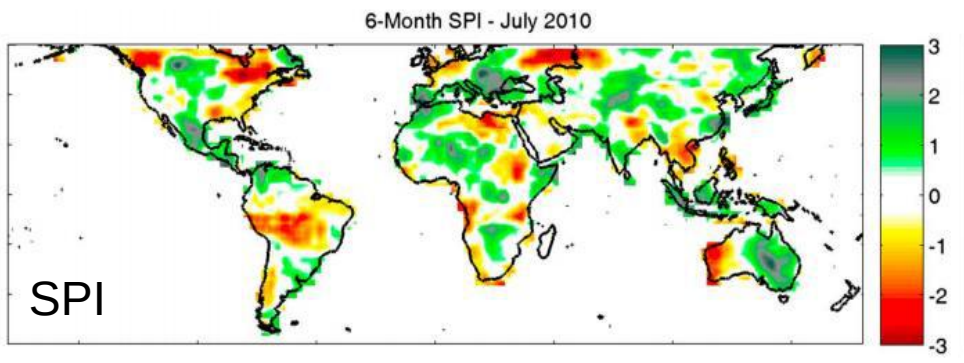


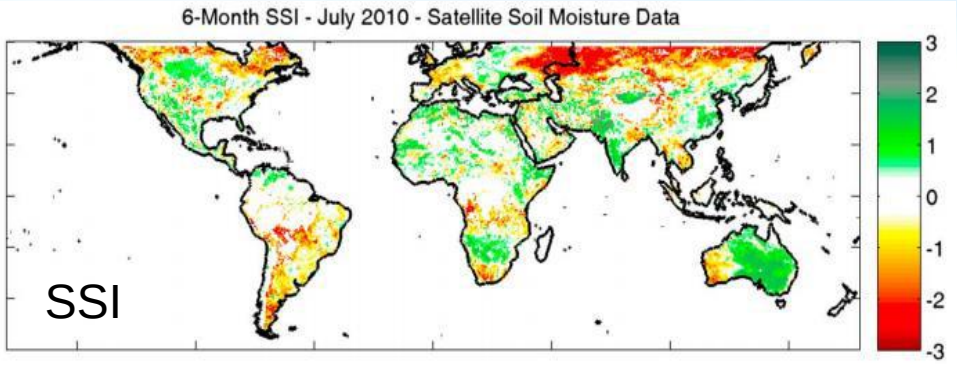
Methods for Drought Monitoring by EO Data

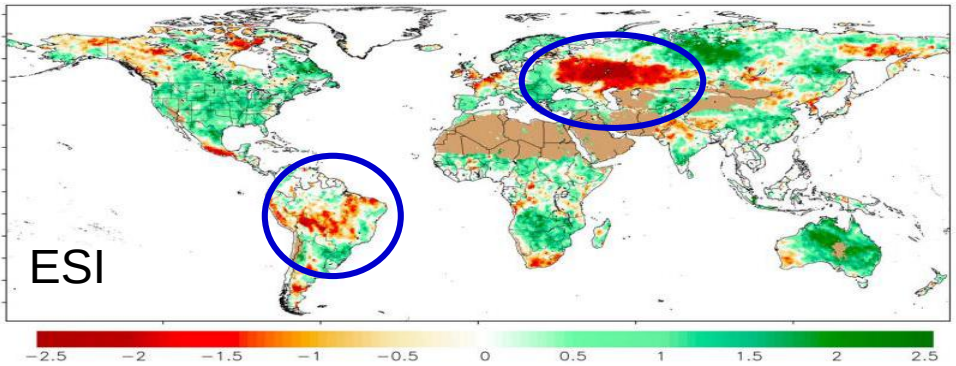


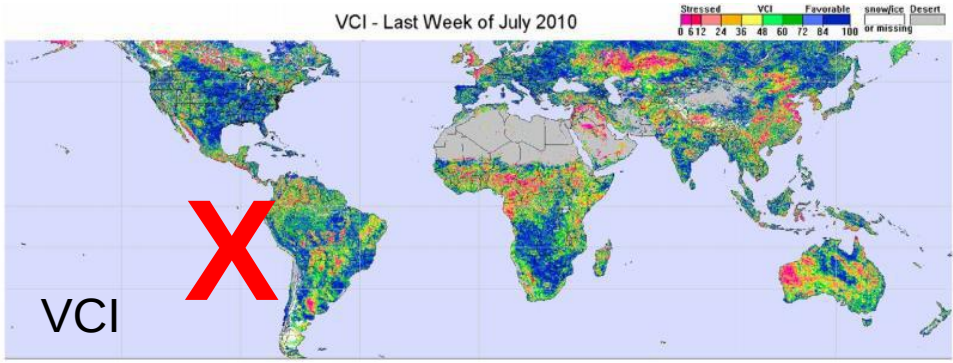
Drought indicators by EO Data

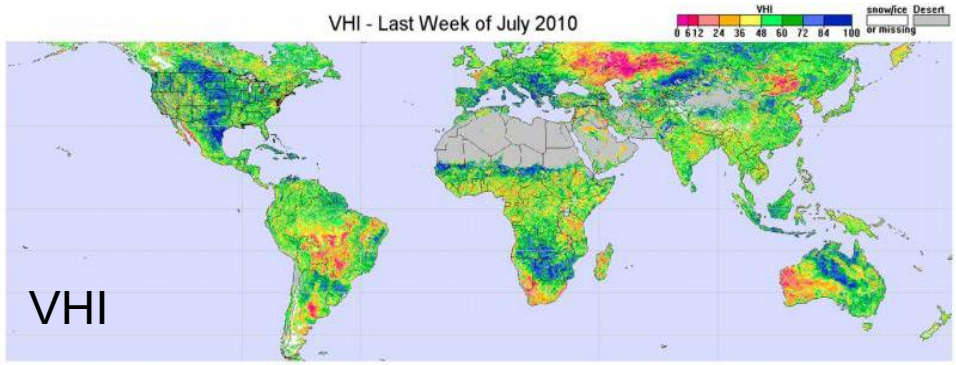
Various Indicators for Drought Monitoring in July 2010 (AghaKouchak et al., 2015）

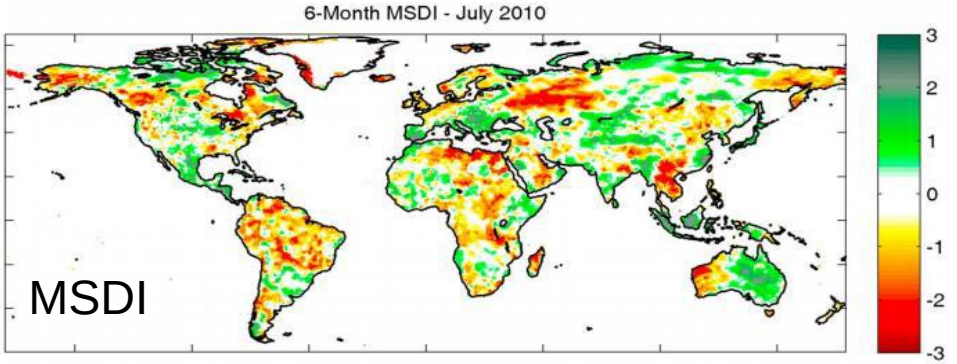










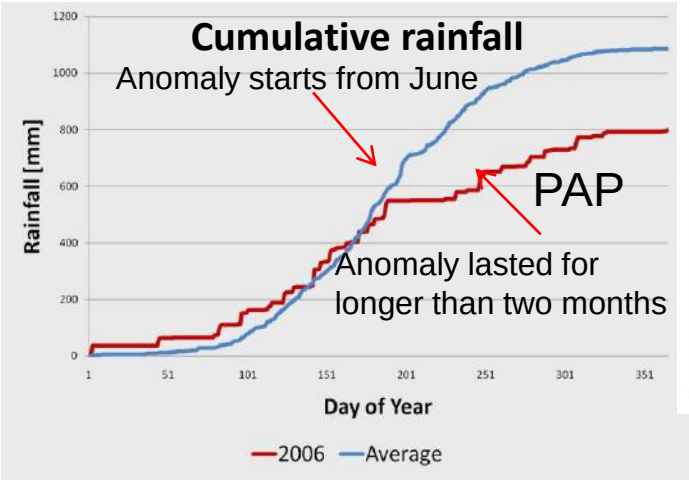


Drought indicators by EO Data

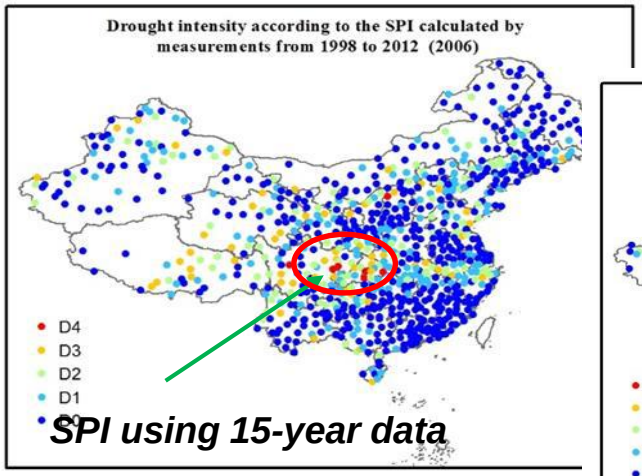
(1) Rainfall – driving factor

- **PAP:** Cumulative precipitation anomaly percentage over given time period:
- **SPI:** Standardized Precipitation Index - cumulative probability over a given time scale

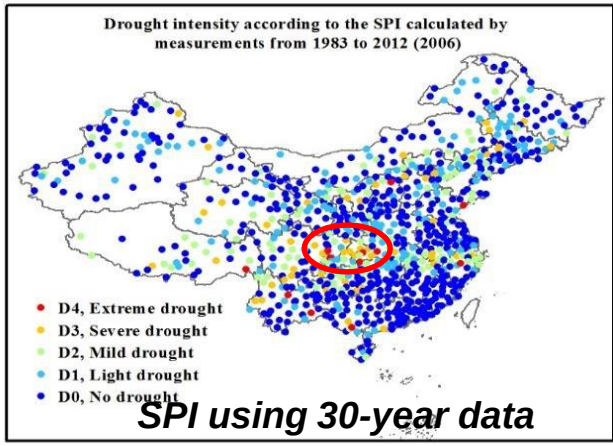
Extreme drought in Sichuan-Chongqing in 2006 (June-August)



Severity level defined by SPI in 2006 from 15 and 30 years period respectively



SPI using 15-year data



SPI using 30-year data

15-year remote sensing data can be used to calculate SPI for drought monitoring

Drought indicators by EO Data

(2) Land surface response to drought

Land Surface Temperature (LST)

- **Temperature Condition Index** (**TCI**) (Kogan, 1995, 2002):

$$TCI = (LST - LST_{min})/(LST_{max} - LST_{min})$$

0 ← cold extreme
1 ← warm extreme

- **Normalized Temperature Anomaly Index (NTAI) (Jia et al., 2012):**

$$NTAI = (LST - LST_{mean}) / (LST_{max} - LST_{min})$$

-1 ~ 0 : cooler than normal condition
0 ~ 1 : warmer than normal condition

Vegetation Condition

- **Vegetation Condition Index** (**VCI**) (Kogan, 1995, 2002):

$$VCI = (NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min})$$

0 : bad vegetation condition
1: good vegetation condition

- **Normalized Vegetation Anomaly Index (NVAI) (Jia et al., 2012):**

$$NVAI = (NDVI - NDVI_{mean}) / (NDVI_{max} - NDVI_{min})$$

-1 ~ 0 : decreased vegetation condition
0 ~ 1 : increased vegetation condition

A combined LST – NDVI Index

Normalized Drought Anomaly Index (NDAI)

NDAI = (NVAI - NTAI) / 2 {-1, 1}

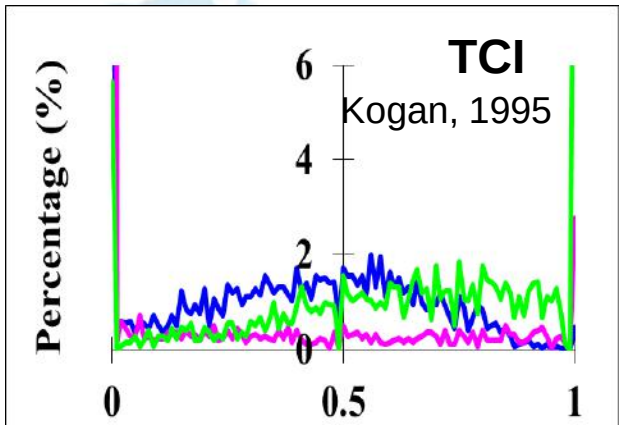
suspected **drought -1** ← **NDAI** → **+1 no drought**

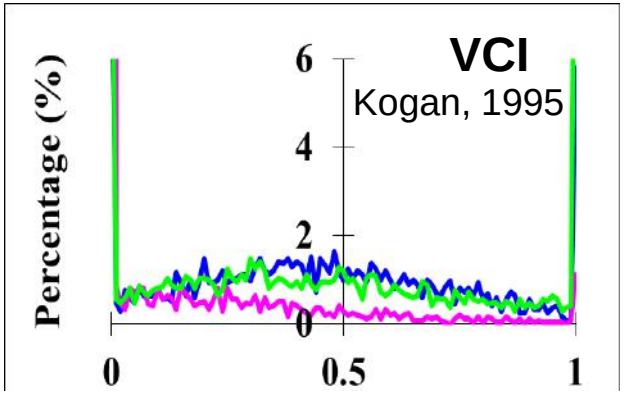
- To eliminate the effect of non-drought damage on vegetation condition
- To collaborate warmer climate favorable for vegetation growth

Drought indicators by EO Data

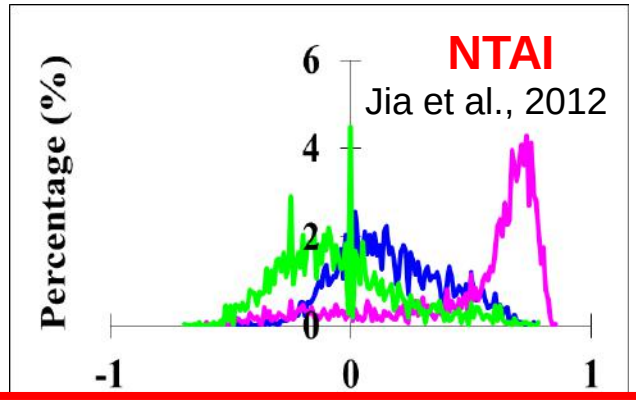
(2) Land surface response to drought

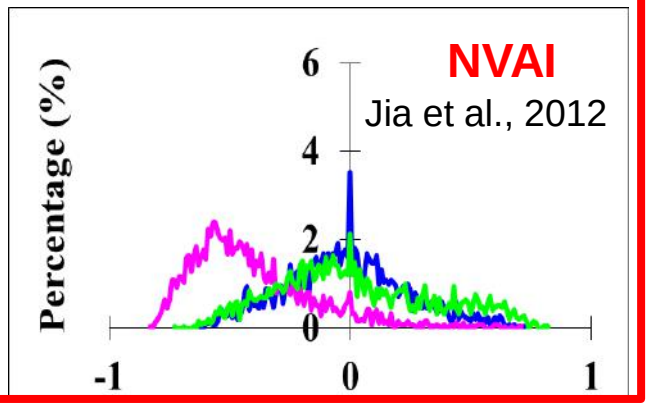
- Land Surface Temperature (LST)
- Vegetation Condition





TCI & VCI: more effective to detect the ultimate damage area other than the evolution





The new indicators NTAI and NVAI: can reveal better the response to drought evolution.

Blue: onset; Pink: severe stage; Green: post-drought

Drought indicators by EO Data

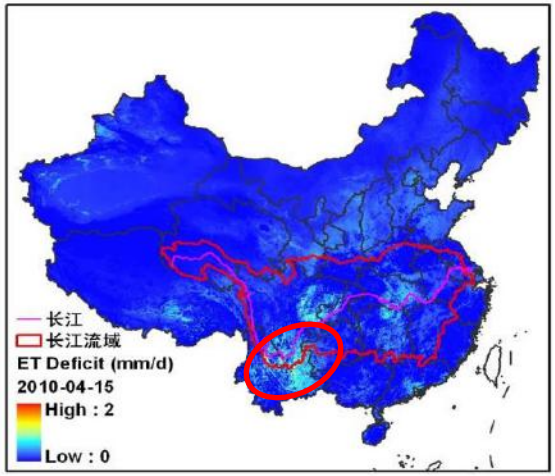
(3) Soil Water Stress from ET Deficit

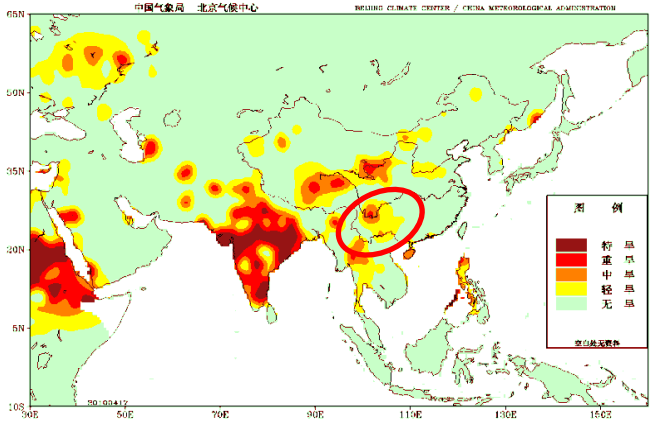
ET Deficit from ETMonitor

DI from National Climate Center

2010 Spring Drought in southwest of China

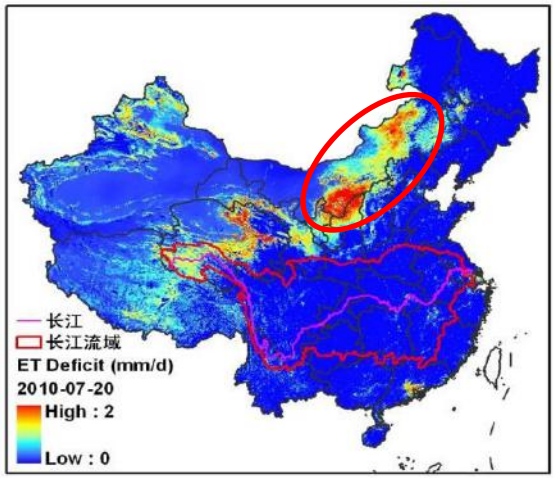
2010-04-15





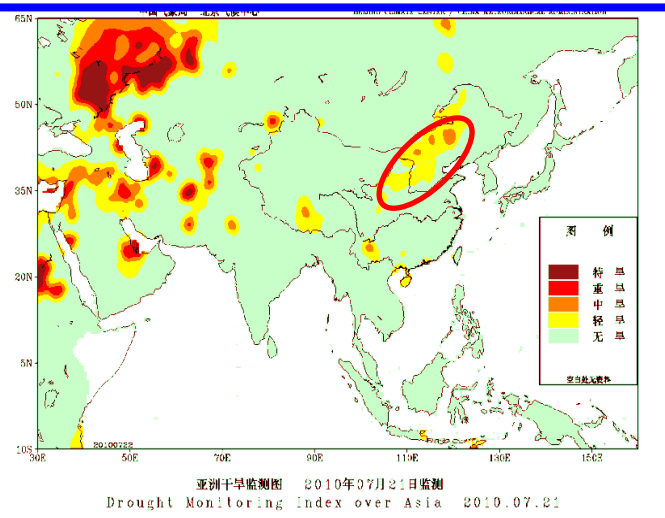
2010 Summer Drought in Inner-Mongolia of China

2010-07-20



Rainfed grassland, Crop land in semi-arid region

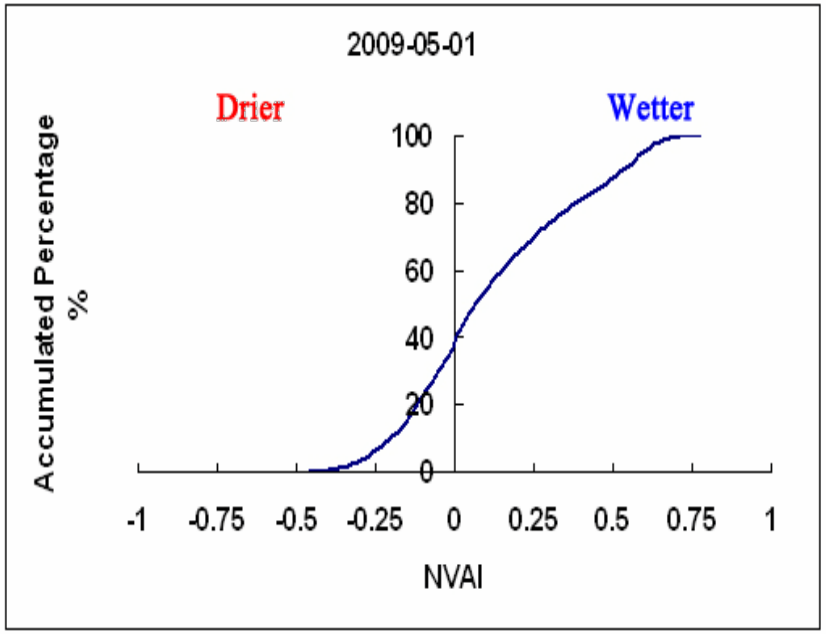
More evident water stress



Regional Drought Alert

- **Regionally integrated information**:
  - regional drought evolution
  - information of affected degrees and area

Statistics of accumulative percentage of area (SAPA) over a region at associated values of drought severity

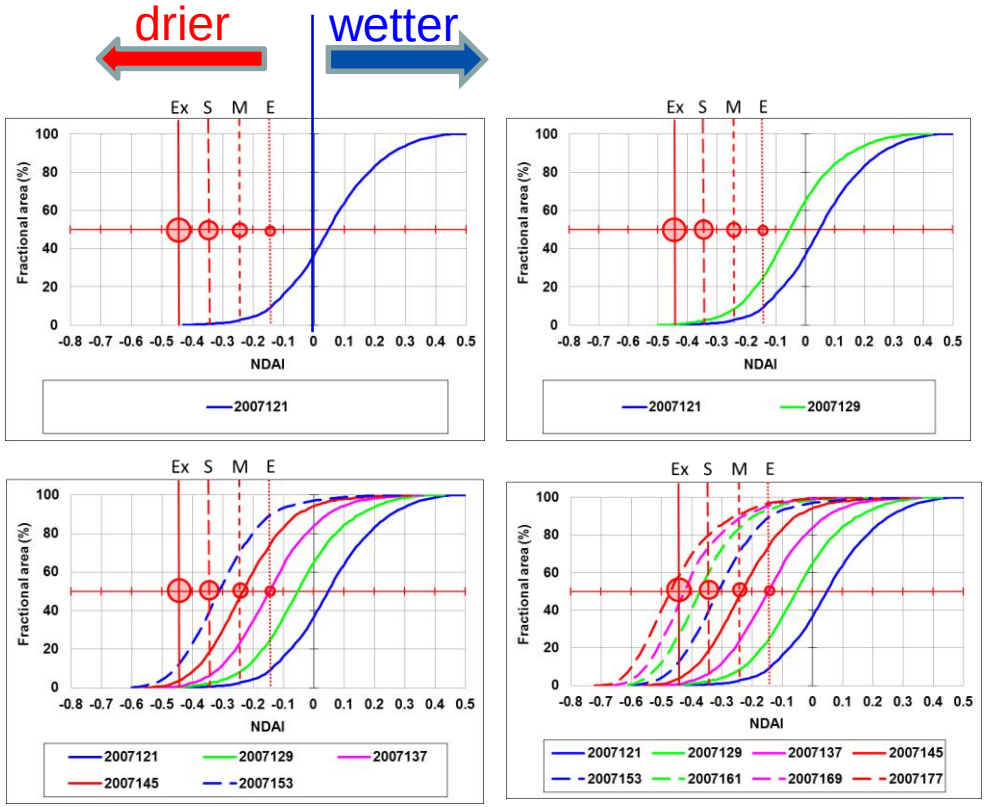


Grassland,
Inner Mongolia

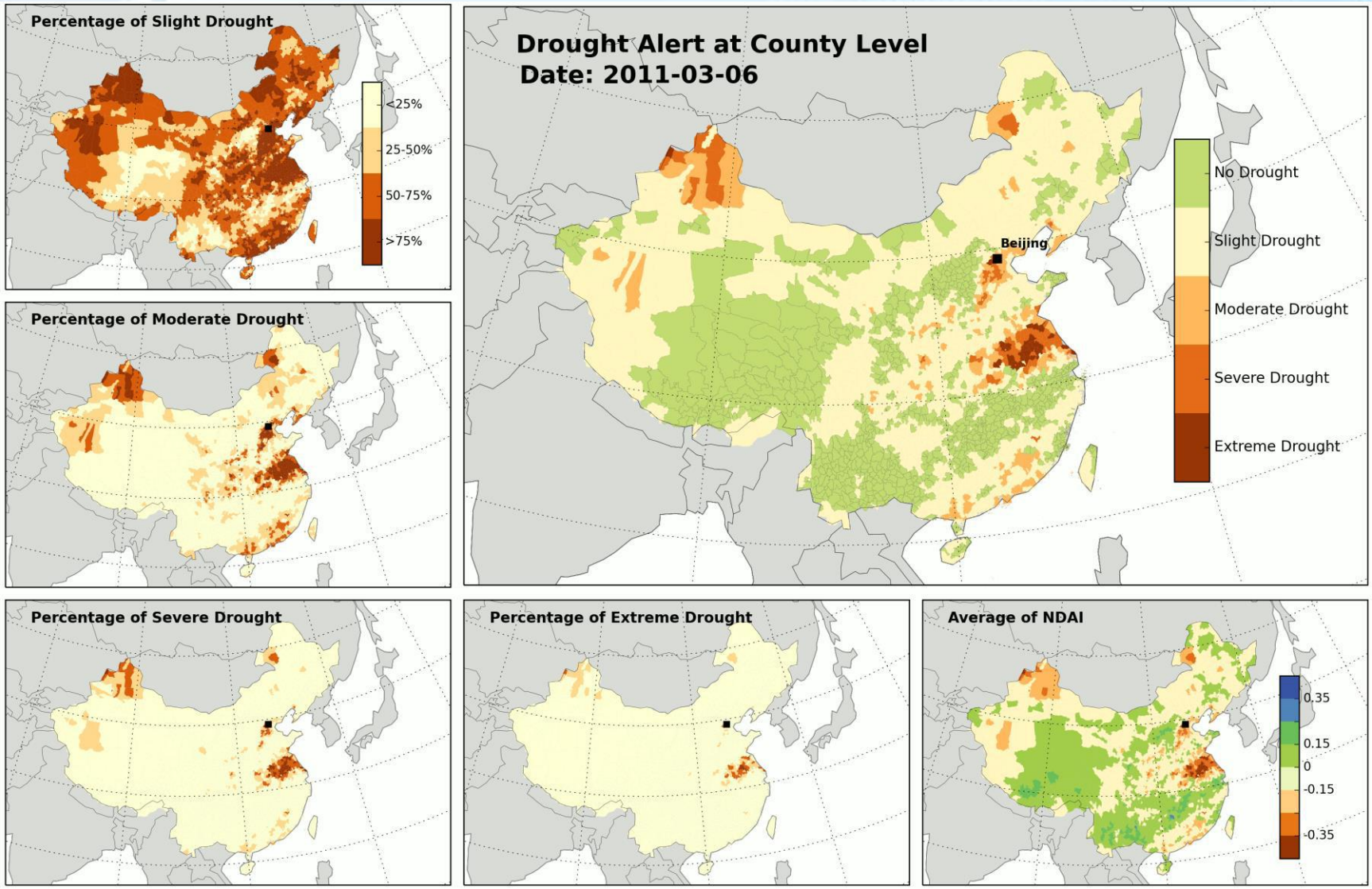
Jia et al., 2012

Regional drought severity alert levels

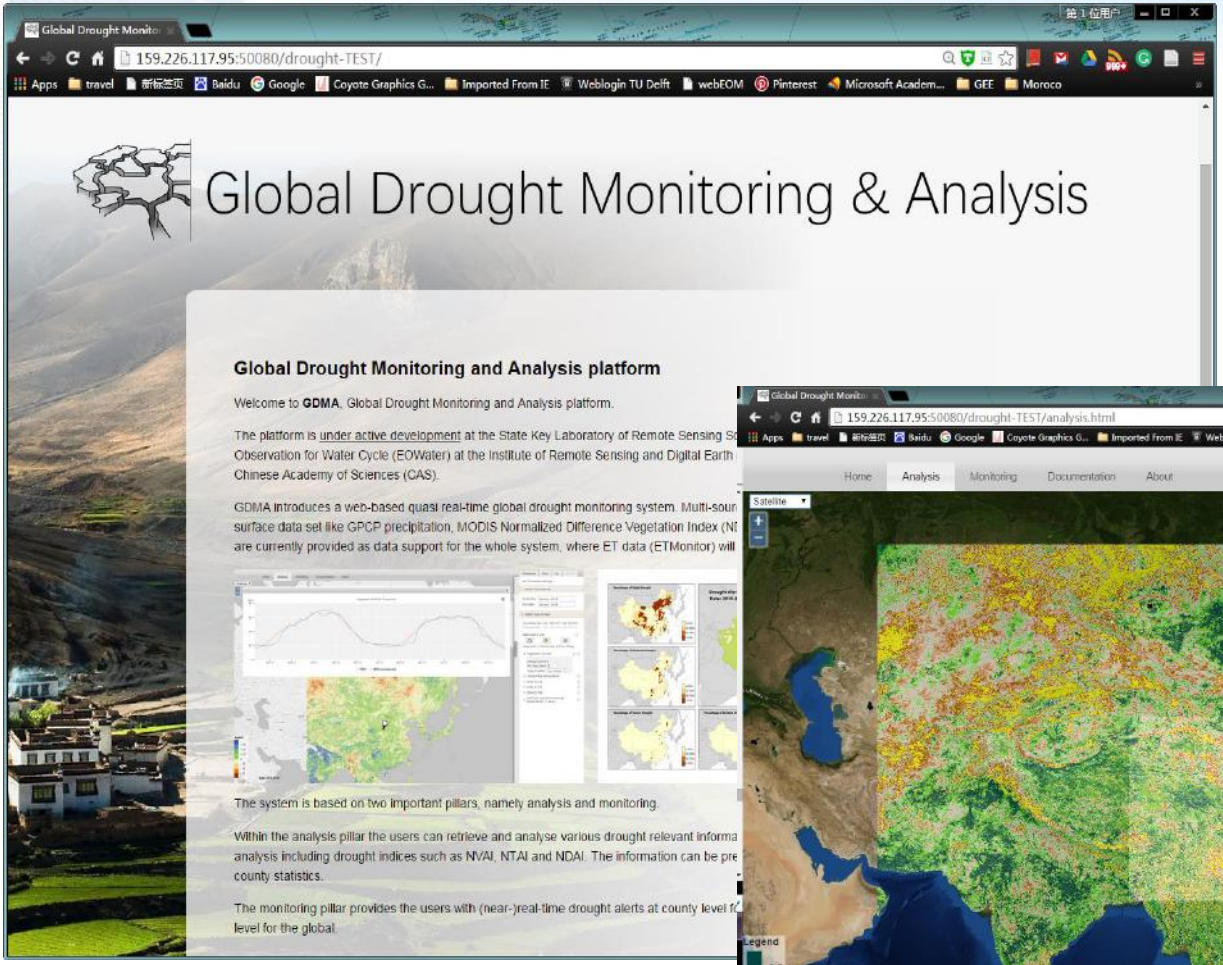
- **Early warning (E)**: SAPA @ **NDAI = -0.15** > 50%
- **Moderate warning (M)**: SAPA @ **NDAI = -0.25** > 50%
- **Severe warning (S)**: SAPA @ **NDAI = -0.35** > 50%
- **Extreme warning (Ex)**: SAPA @ **NDAI = -0.45** > 50%

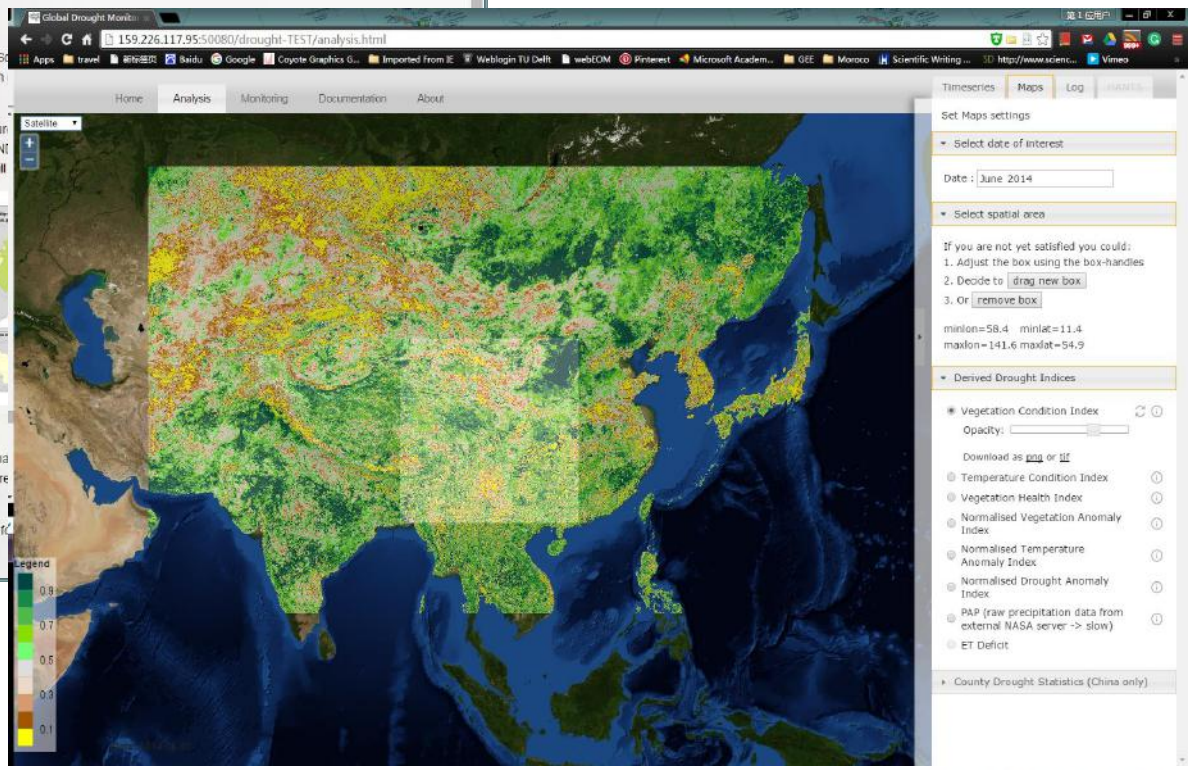


Regional Drought Alert



Web based Global Drought Monitoring & Analysis Platform (Web-GDMAP)





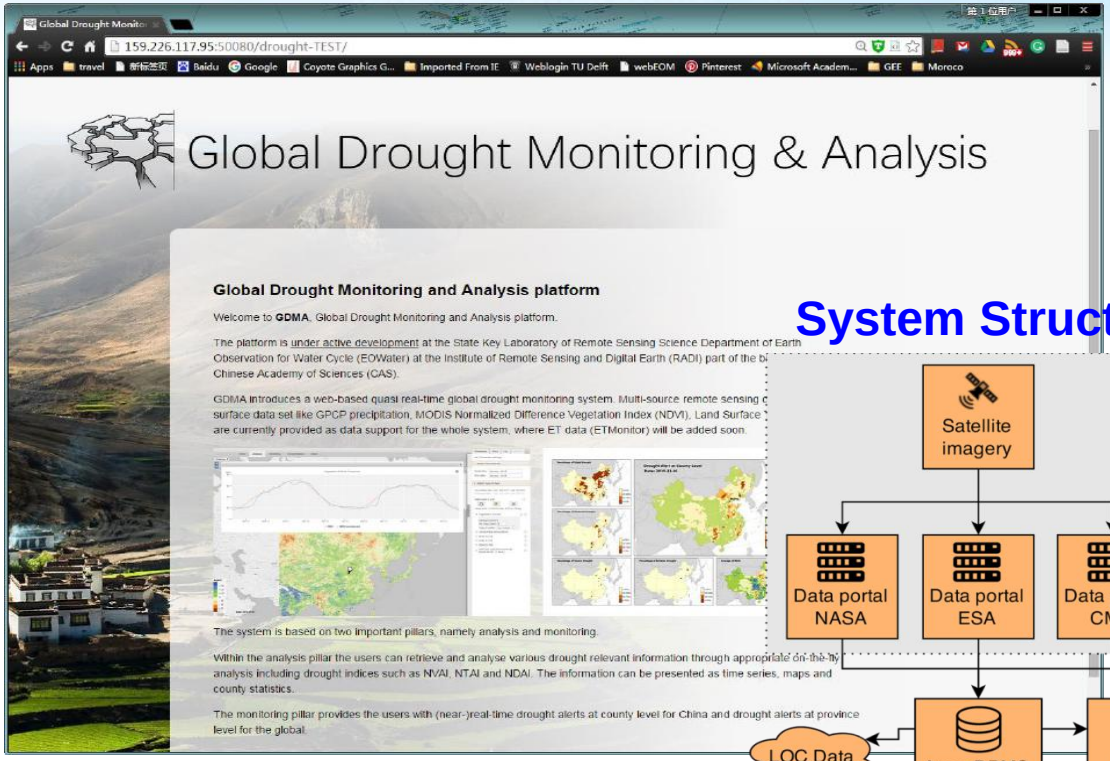
- **Cloud spatial data management**
- **Support Online analysis**
- **Web based open source architecture**

Developed at RADI (Hoek, Jia, et al., 2016);

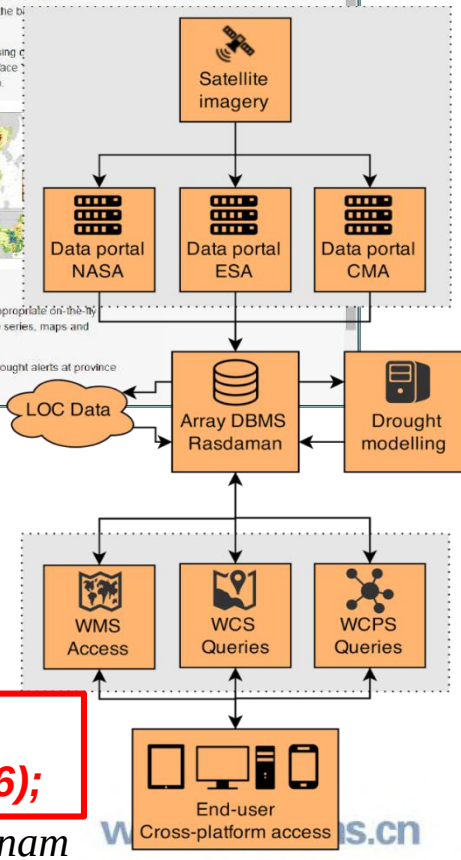
Web based Global Drought Monitoring & Analysis Platform (Web-GDMAP)

Characteristics:

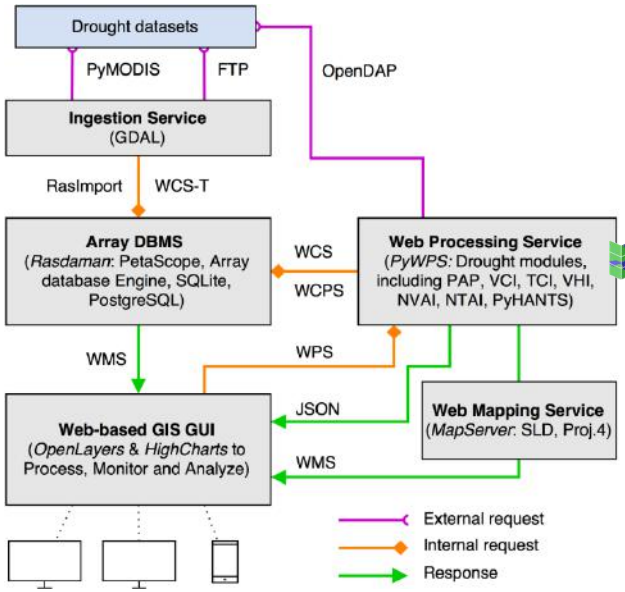
- Ad-hoc drought analysis
- Web-based information system
- Big data management and Analysis
- Open source architecture
- Distributed storage



System Structure



Technical Framework



rasdaman raster data manager

MapServer

PyWPS

HIGHCHARTS

W3C

jQuery write less, do more.

OGC®

Developed at RADI (Hoek, Jia, et al., 2016);

Outline

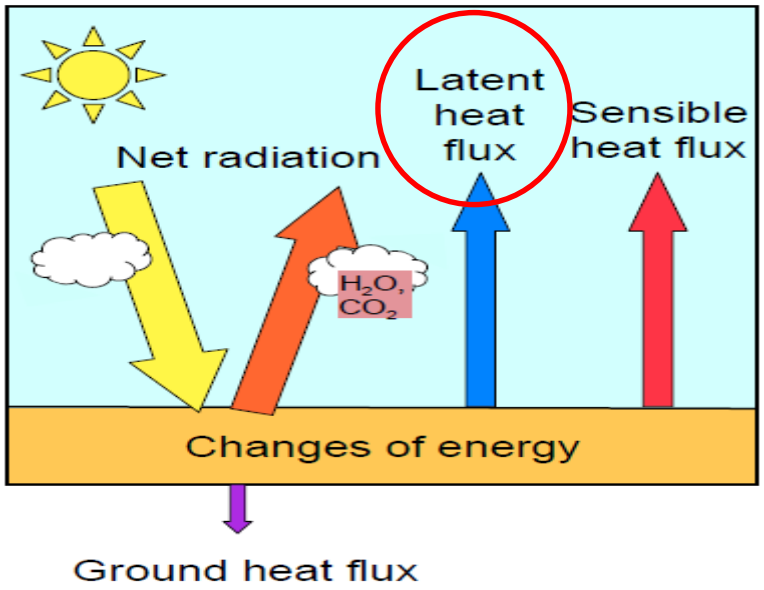
- DroughtMonitor: Drought Monitoring

- **ETMomitor: Evapotranspiration and Water Deficit**

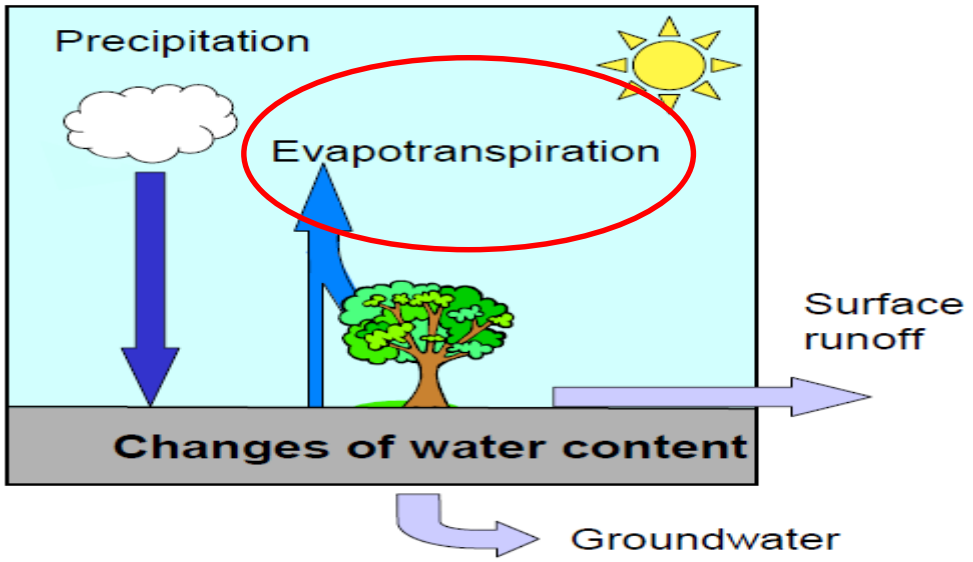
Land Evapotranspiration

- ET is a term involving **Surface Energy Balance (SEB)** and **Surface Water Balance (SWB)**

Surface Energy Balance (SEB)



Surface Water Balance (SWB)



More than 50% of the solar energy absorbed by land surfaces is currently used to evaporate water.

Global land evapotranspiration (ET) returns about 60% of annual land precipitation to the atmosphere.

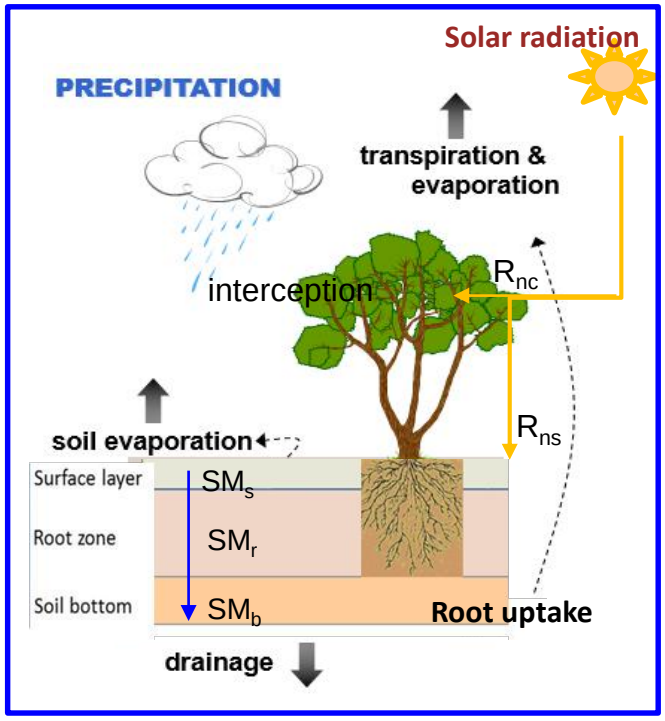
Remote Sensing ET Products

ET Product	Spatial Res.	Temporal Step	Spatial Coverage	Theory	Input RS Data	OutPut
LandSAF (MSG) ET	3–5 km	30 min, daily	Europe, Africa, S. America	H-TESSEL SVAT scheme	LAI, FVC, Albedo, Downwelling Fluxes, LC	ET
MODIS ET (MOD16)	1 km	8 days	Global	P-M	LAI, fPAR, Albedo, LC	ET, LE, Potential ET/LE
ET-VUA (GLEAM)	25 km	daily	Global	P-T + Soil Water Balance	LST, Vegetation Optical Depth, Precipitation, Soil Moisture, LC	ET, Interception
USGS (SSEBop)	1 km	monthly	Global	SSEBop	LST, NDVI, Albedo	ET
ALEXI	5 km	monthly	Global	ALEXI	LST, NDVI, Albedo	ET
ET-ITC	5 km	monthly	Global	SEBS	LST, NDVI, Albedo, LC	ET
ETMonitor	1 km 250 m 25 m	daily	Global Regional / Basin scale	Multi-Param. (Shuttleworth–Wallace, etc.)	LAI, Albedo, Precipitation, Soil Moisture, LC	ET, E, T, Interception, Potential ET, ET Deficit

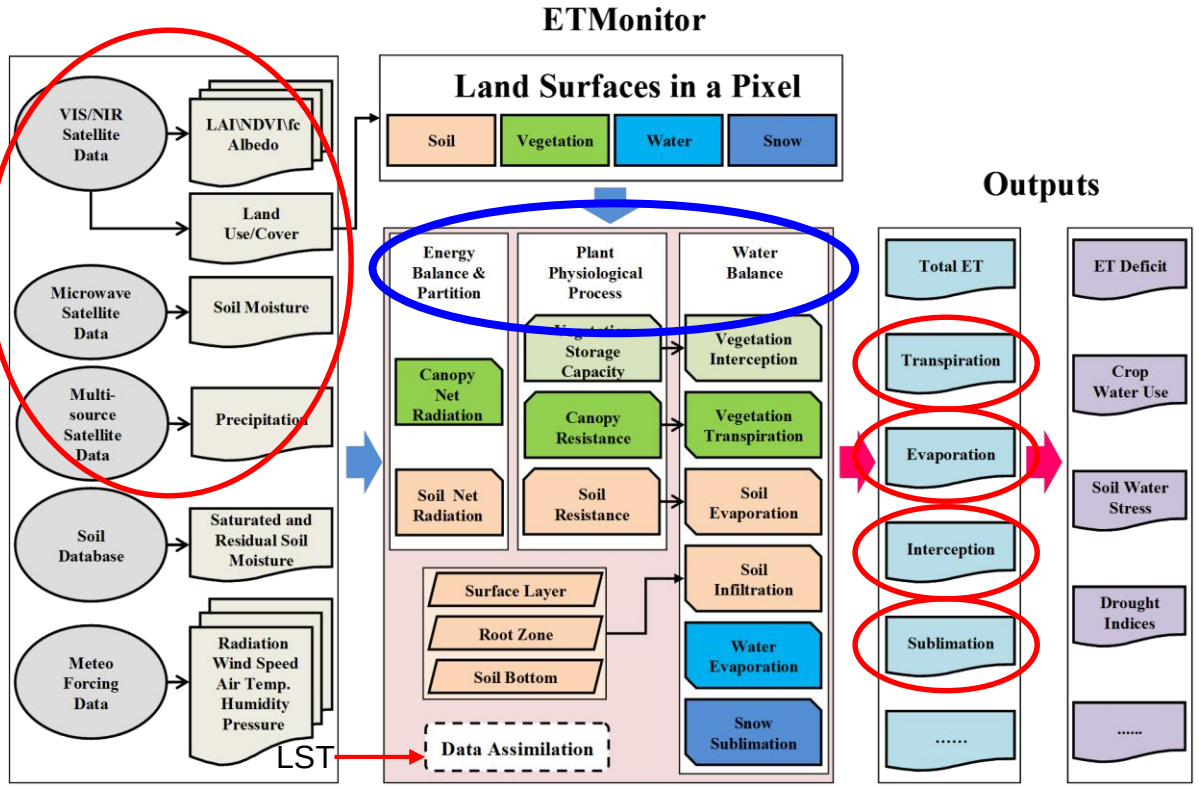
Evapotranspiration from Remote Sensing

ETMonitor:

- A process based model implementing processes of energy balance, plant physiology and soil water balance developed by EOWater Lab at RADI



- Combining optical and microwave remote sensing observations

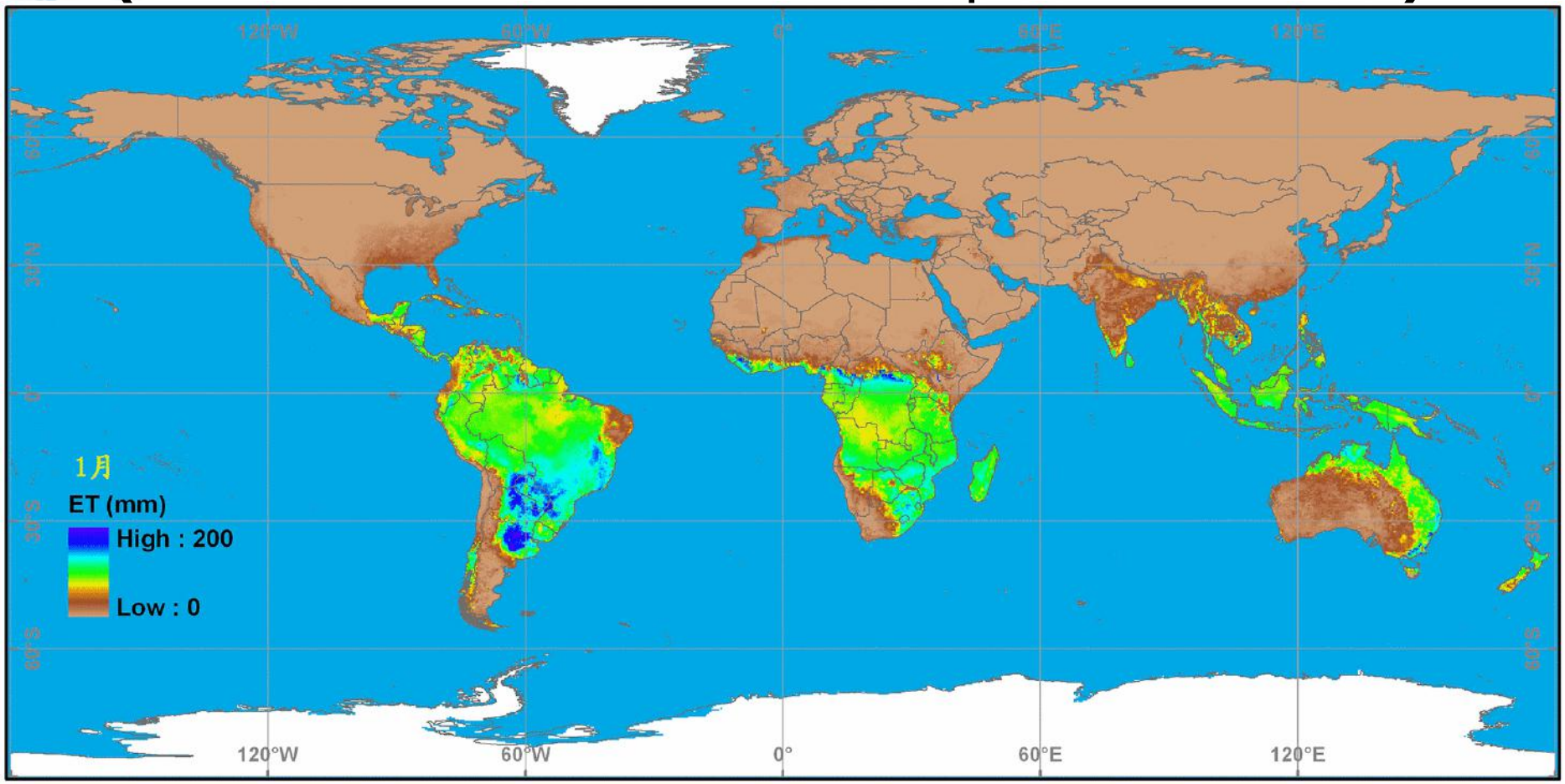


Hu and Jia, 2015, Remote Sensing
Cui and Jia, 2014, Water
Cui, Jia, et al., 2015, IEEE GRSL
Zheng, et al., 2016, IGARSS

Evapotranspiration from Remote Sensing

ETMonitor Global ET Product

(2008-2013, mm/month, 1km spatial resolution)

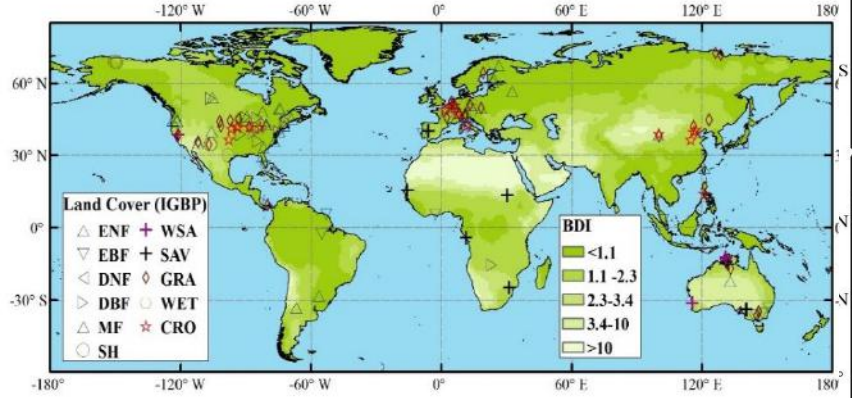


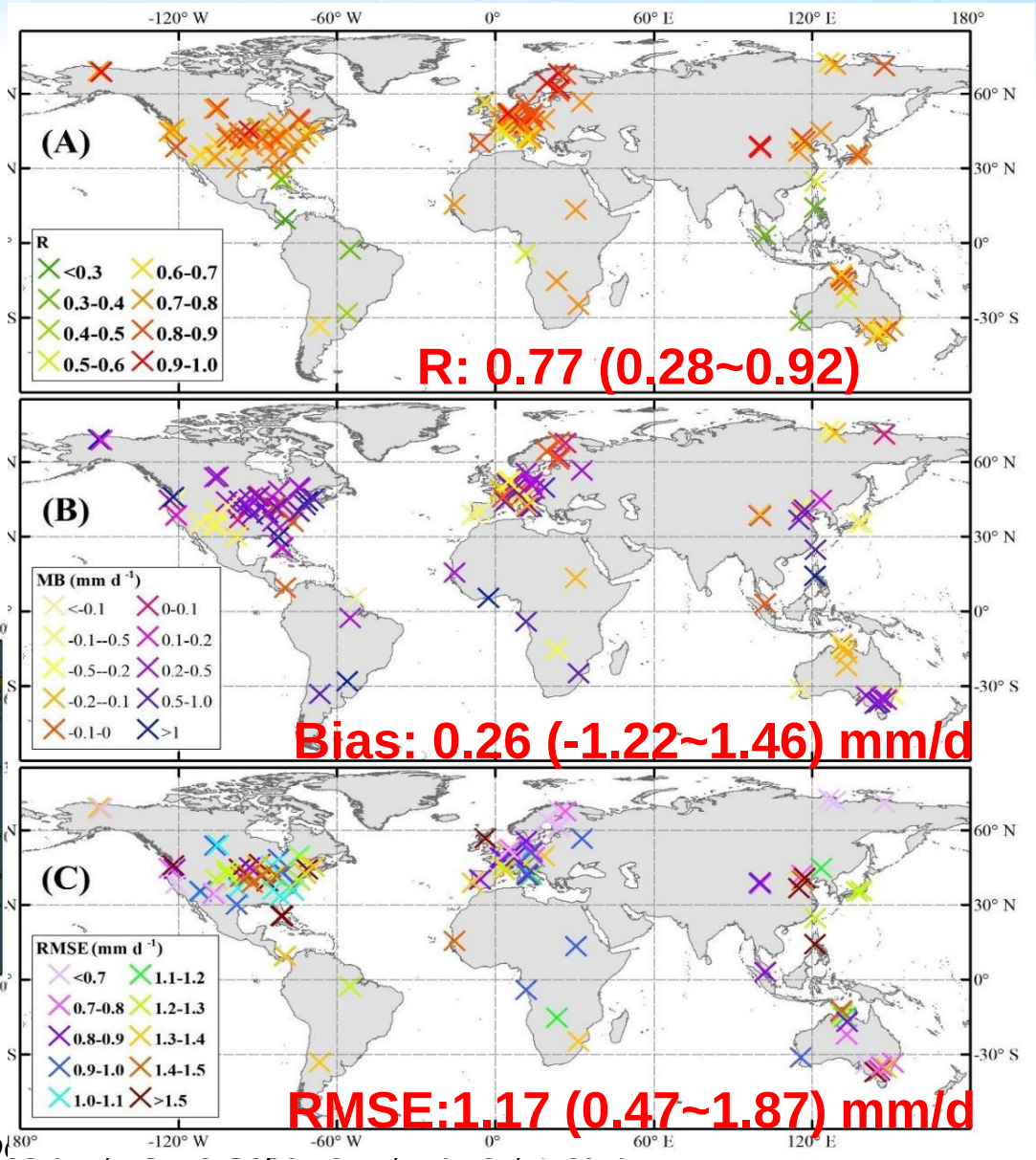
Global ET product from ETMonitor @ daily, 1km spatial resolution

Evapotranspiration from Remote Sensing

Validation

- 153 flux sites **(FLXUXNET2015数据)**
  - 98 from Fluxnet2015
  - 6 from HiWATER
  - 37 from AmeriFlux
  - 8 from EuroFlux
  - 4 from AsiaFlux



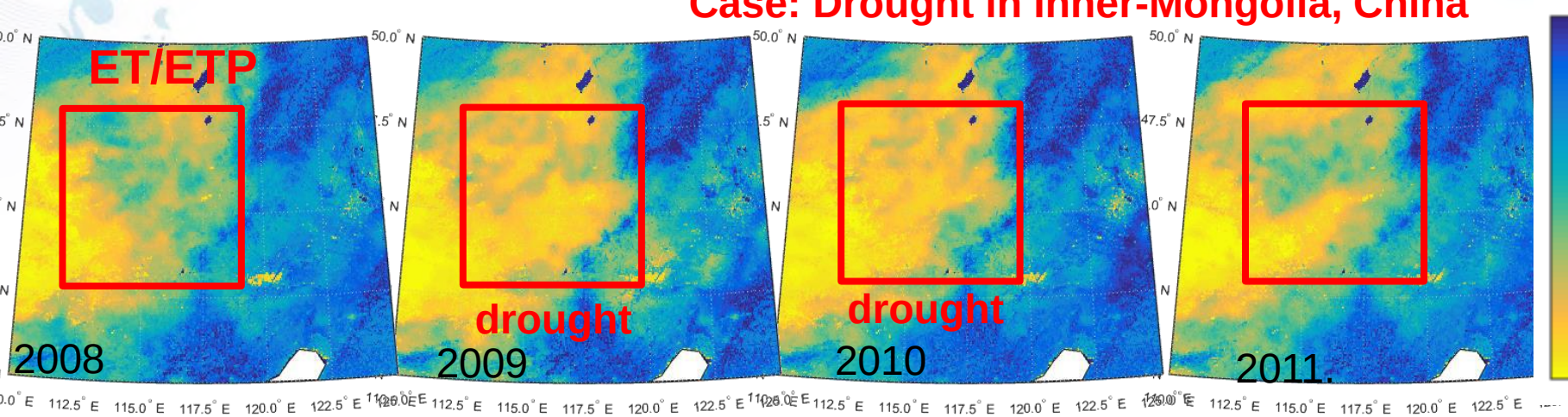


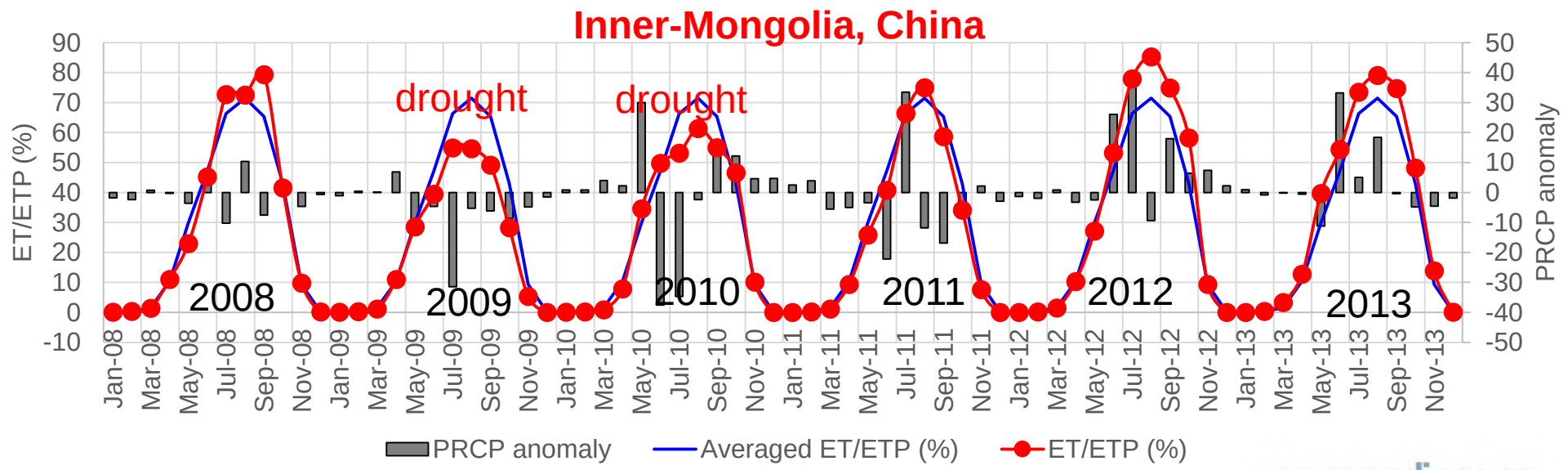
Zheng and Jia, 2017, manuscript

ET Based Drought Monitoring

ET/ETP

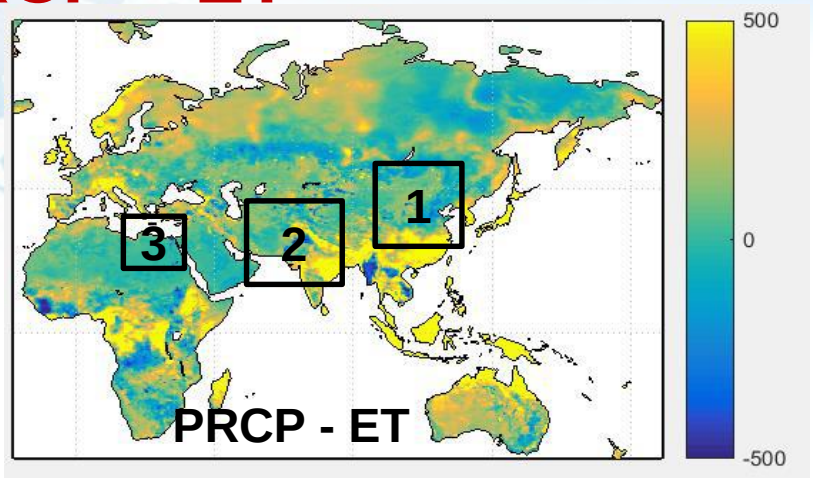
Case: Drought in Inner-Mongolia, China

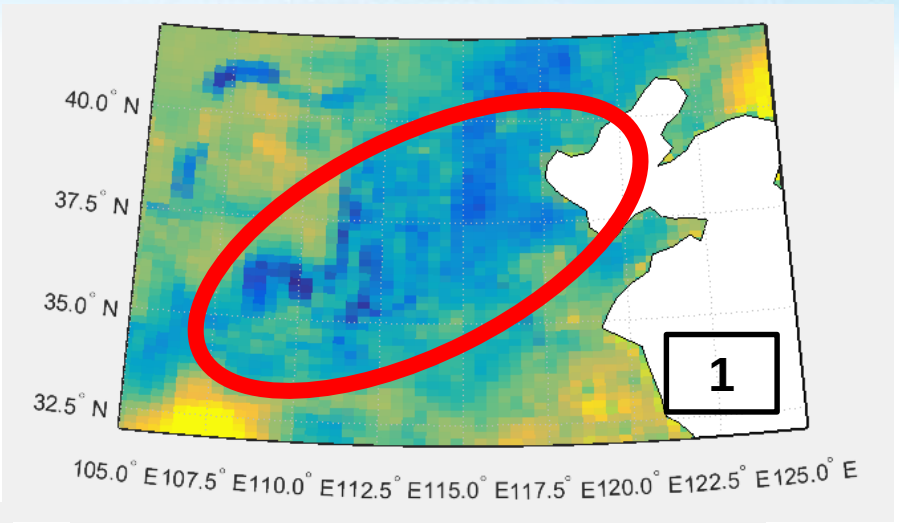


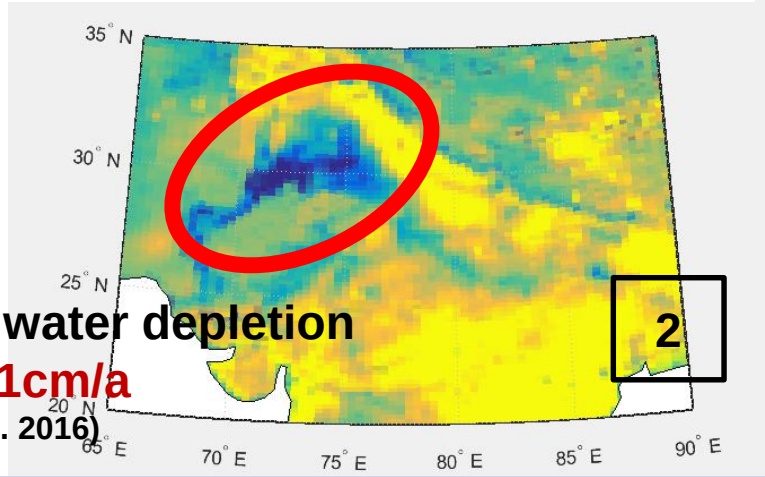


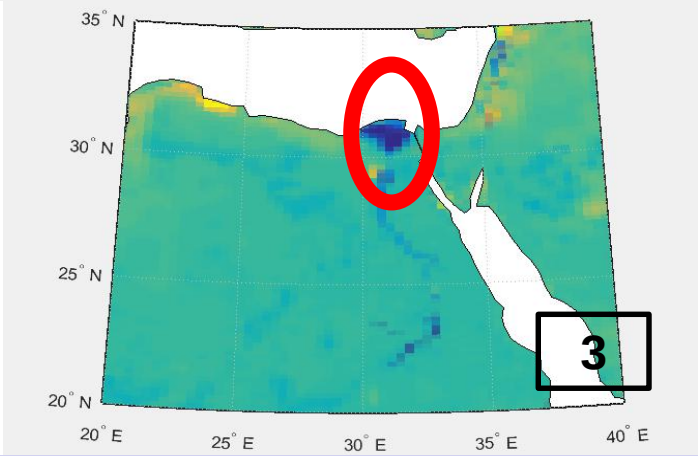
ET Based Water Deficit Evaluation

PRCP – ET





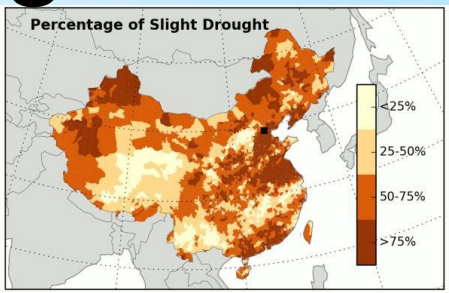


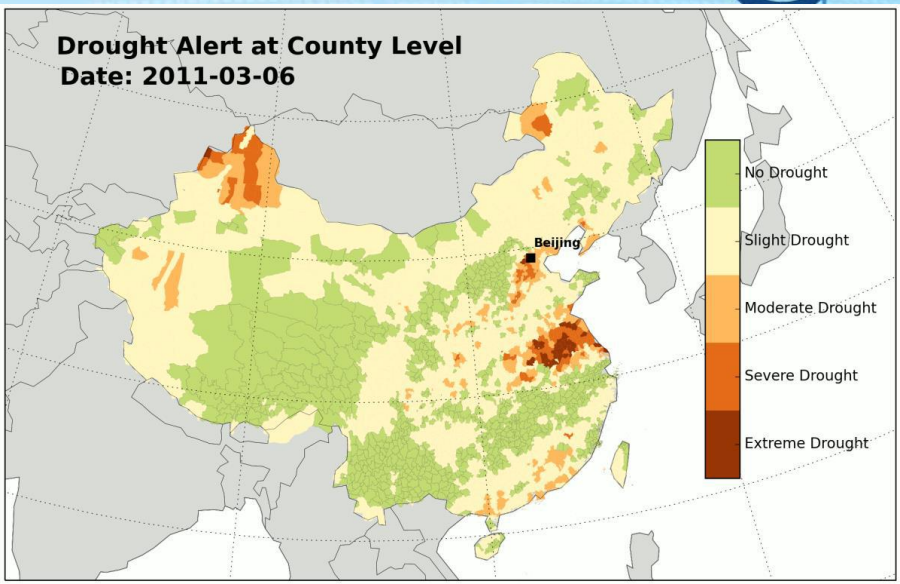


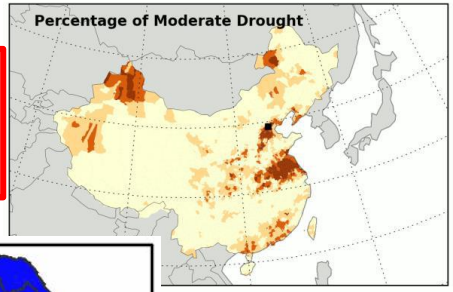
groundwater depletion rate: 3.1cm/a
(Long et al. 2016)

Very low PRCP – ET value can be found in many agriculture regions, e.g. north China, northwest India, lower reach of the Nile basin, where ET exceeds precipitation, indicating **surface water** use or using **groundwater**.

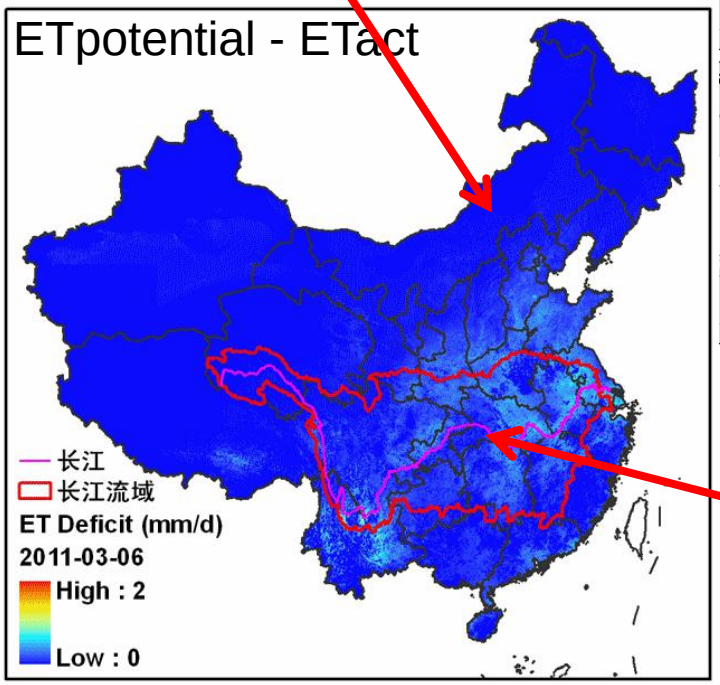
Drought and Water Deficit

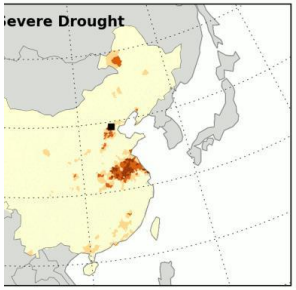


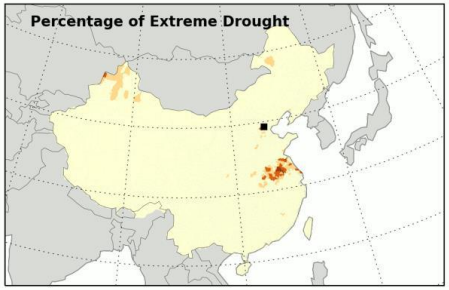


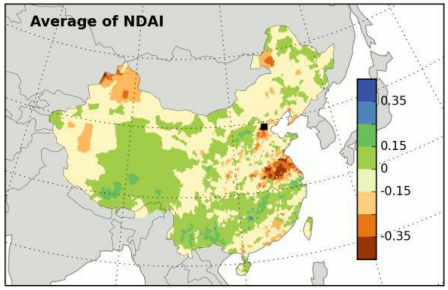


2011 Inner-Mongolia summer drought









2011 spring-summer drought in Yangtze river basin

Summary

- Data quality and reliable gap-free time series are vital.
- Better understanding and quantification of terrestrial water cycle processes, e.g. relations between forcing and response.
- Effective use of multi-source data.
- Linkage between satellite derived variables/indicators/indices and land surface processes.
- Linkage/distinguish between physical and societal processes and impact is important and yet a challenging issue.
- Time lag between anomaly in precipitation and response of vegetation.

AOGEOSS T6 Working Group

Sub-WGs:

- WG1：Drought Mechanism and Indicators from EO；
- WG2：Data and Monitoring Platform；
- WG3：Drought vs Agriculture (Impact and Mitigation)；
- WG4：Drought vs Climate Change；
- WG5：Drought vs Economy

AOGEOSS T6 Network

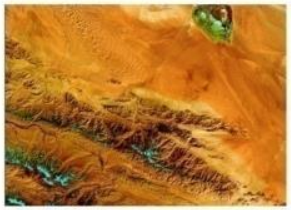
- Countries:
  - India, Vietnam, Malaysia, Sri Lanka, Thailand, Australia, Mongolia, Japan, Pakistan, Iran
  - Netherlands, Italy

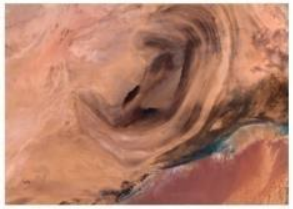
  (MoUs signed with relevant institutions)

- Connections to International/Regional Organizations/Programs

Thank you for your attention!

谢 谢 ！






Li Jia (PhD, Prof.)

jiali@radi.ac.cn

Institute of Remote Sensing and Digital Earth (RADI),
Chinese Academy of Sciences