

**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

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GEOSS Asia-Pacific Symposium, 18-20 Sept 2017, Hanoi, Vietnam

# Outline

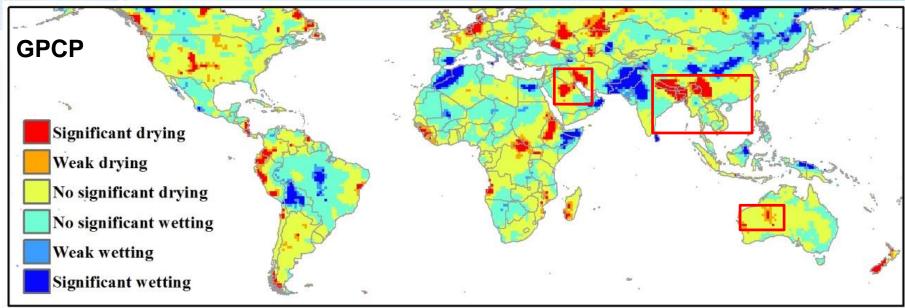


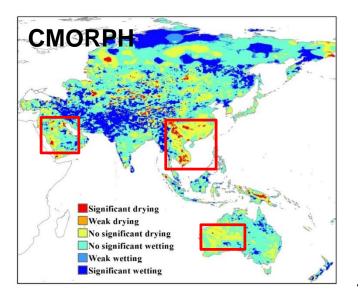
## **DroughtMonitor: Drought Monitoring**

• ETMomitor: Evapotranspiration and Water Deficit

## **Global Trend of Drought**







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

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# **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

Δ

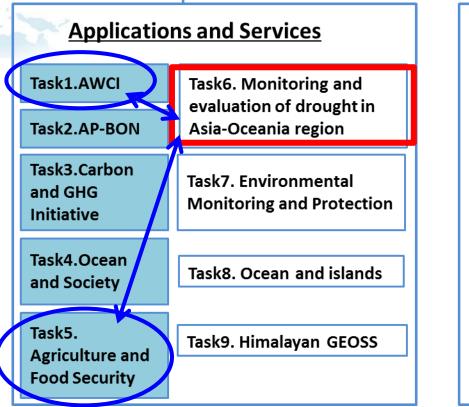
Diversion of river water Groundwater depletion Increasing water demand → economical development and living standards

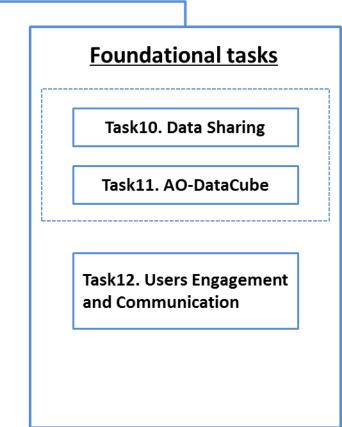
**Outflow exceeds inflow** 

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

## Joint APGEOSS & AOGEOSS Tasks

#### **AOGEOSS** Activities





**Existing APGEOSS activities** 

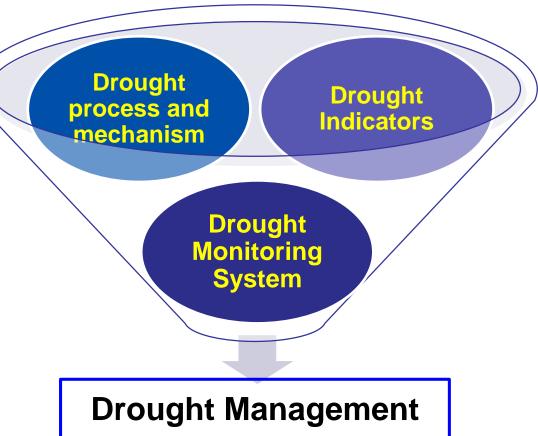
Activities proposed in AOGEOSS

# **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

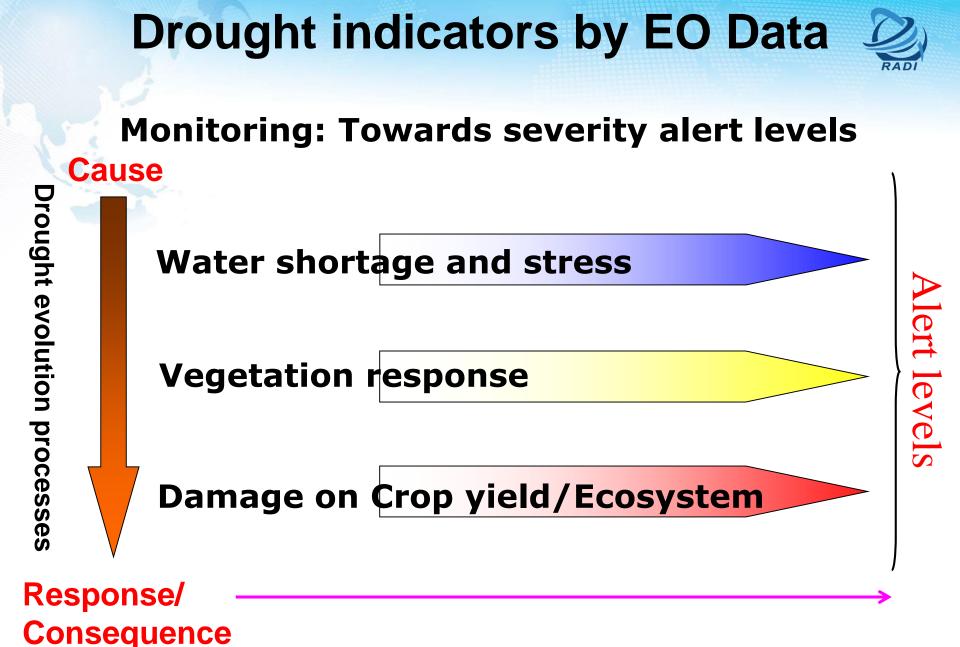
#### Sub-Tasks (milestones)

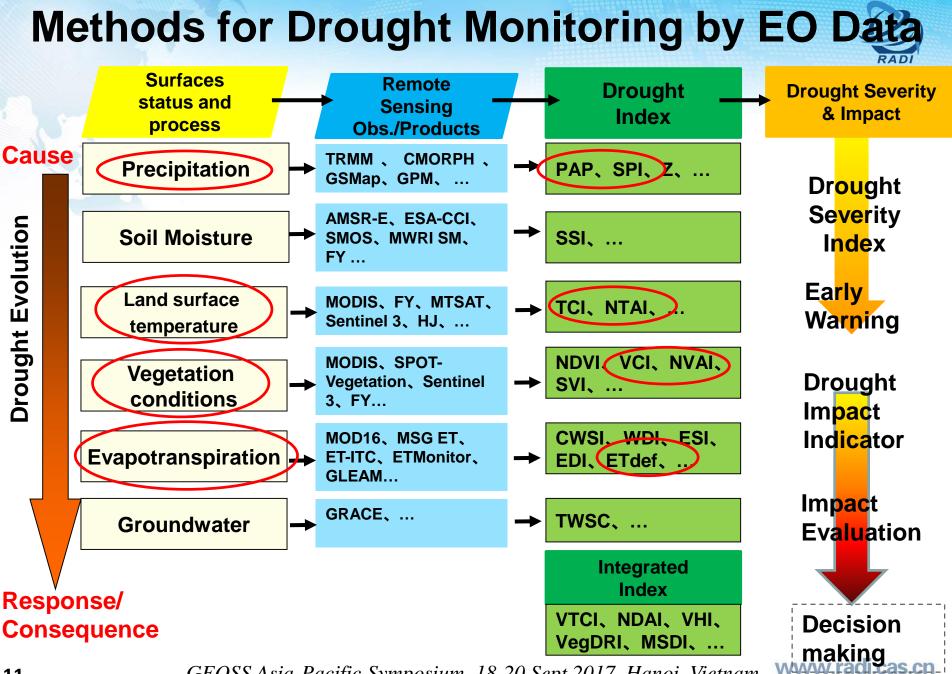
- Subtask 6.1 Create and maintain a drought monitoring cooperative mechanism (end of 2017)
- Subtask 6.2 Establish a framework/methogology to integrate multiple EO data by different satellites and by different Countries to monitor and evaluate drought (mid of 2018)
- Subtask 6.3 Develop a comprehensive, 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**

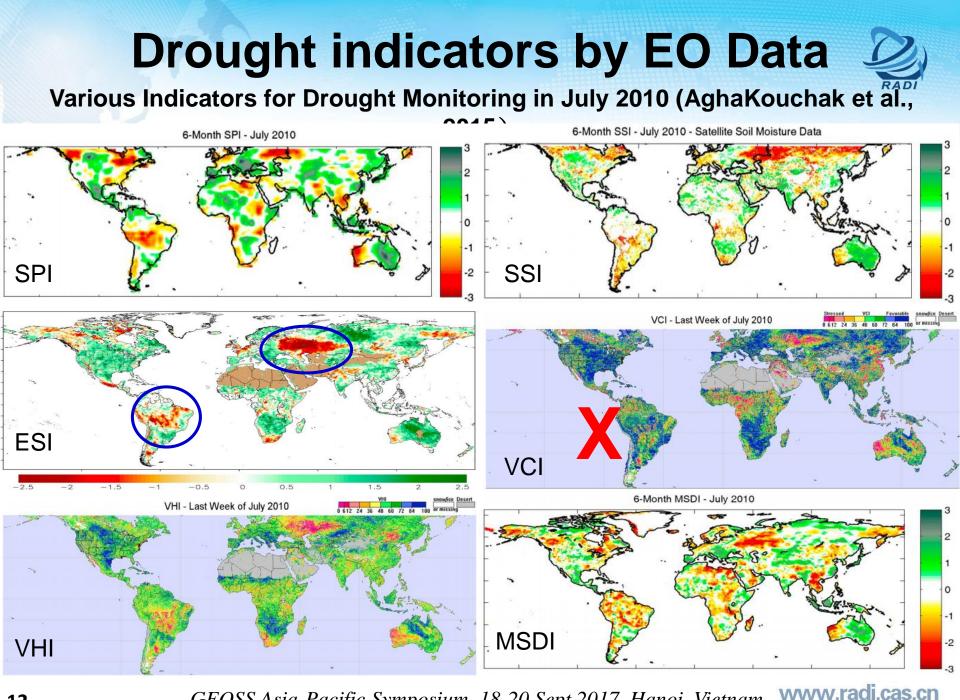


- Ground observations
- Satellite observations:
  - Satellite data quality (time series reconstruction);
  - Linkage between anomalies and drought severity
- Methodologies and Indicators
- Cooperation and Partnership





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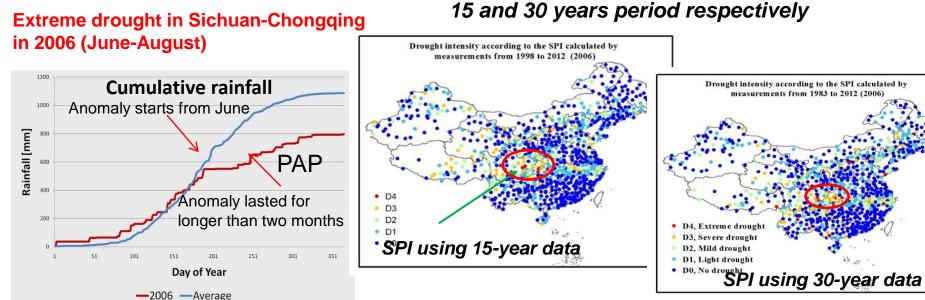


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## (1) Rainfall – driving factor

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



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

Severity level defined by SPI in 2006 from



#### (2) Land surface response to drought

Land Surface Temperature (LST)	Vegetation Condition		
Temperature Condition Index (TCI)	Vegetation Condition Index (VCI)		
(Kogan, 1995, 2002):	(Kogan, 1995, 2002):		
TCI = (LST - LST <sub>min</sub> )/(LST <sub>max</sub> - LST <sub>min</sub> )	VCI = (NDVI - NDVI <sub>min</sub> ) / (NDVI <sub>max</sub> - NDVI <sub>min</sub> )		
0 ← cold extreme	0 : bad vegetation condition		
1 ← warm extreme	1: good vegetation condition		
• Normalized Temperature Anomaly Index (NTAI)	Normalized Vegetation Anomaly Index (NVAI)		
(Jia et al., 2012):	(Jia et al., 2012):		
$NTAI = (LST - LST_{mean}) / (LST_{max} - LST_{min})$	NVAI = (NDVI – NDVI <sub>mean</sub> ) / (NDVI <sub>max</sub> - NDVI <sub>min</sub> )		
<ul> <li>-1 ~ 0 : cooler than normal condition</li> <li>0 ~ 1 : warmer than normal condition</li> </ul>	<ul> <li>-1 ~ 0 : decreased vegetation condition</li> <li>0 ~ 1 : increased vegetation condition</li> </ul>		

#### A combined LST – NDVI Index

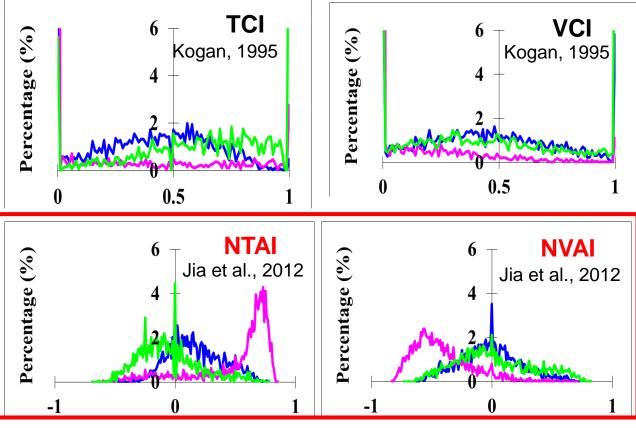
Normalized Drought Anomaly Index (NDAI)NDAI = (NVAI - NTAI) / 2{-1, 1}suspected drought -1 ← NDAI → +1 no drought

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



#### (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.

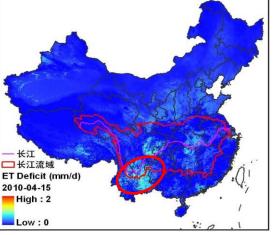
Blue: onset; Pink: severe stage; Green: post-drought



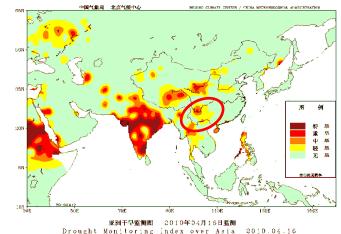
#### (3) Soil Water Stress from ET Deficit

2010 Spring Drought in southwest of China 2010-04-15

#### ET Deficit from ETMonitor

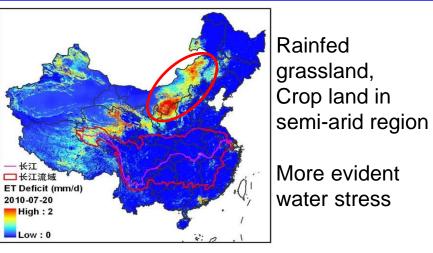


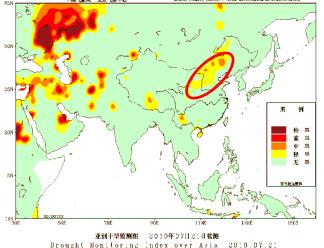
#### **DI from National Climate Center**



2010 Summer Drought in Inner-Mongolia of China

2010-07-20



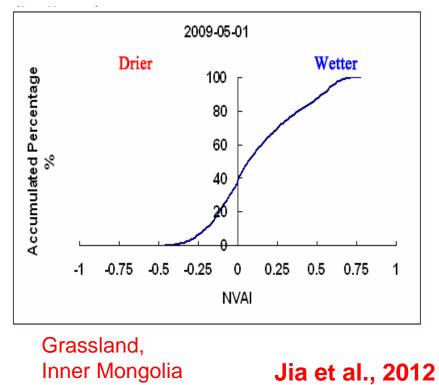


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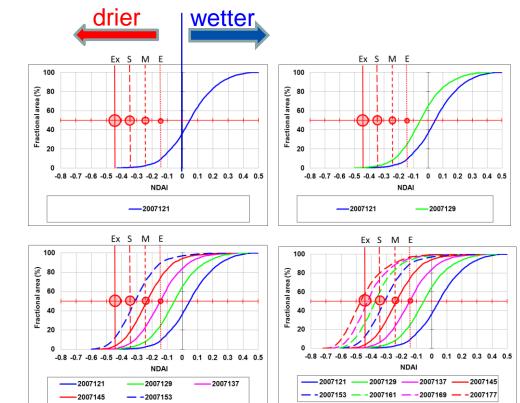
## **Regional Drought Alert**

- 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



#### 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%

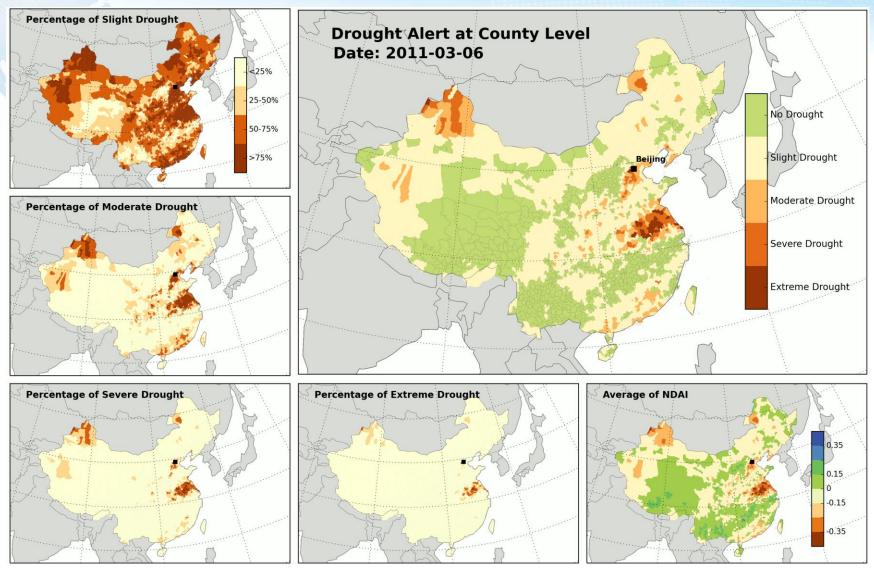


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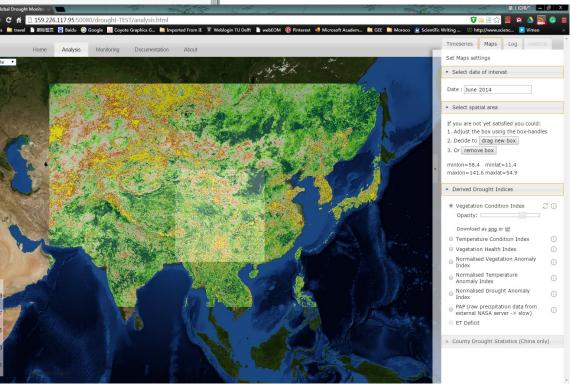
## **Regional Drought Alert**





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

- 🚭 Global Drought Monito 🗴 📰 ← → C ☆ D 159.226.117.95:50080/drought-TEST/ 📕 😢 🍐 📐 🚱 🗎 Q 😈 🗟 🔢 Apps 👛 travel 🚡 新菇蕊页 🔀 Baidu 🔞 Google 🗾 Coyote Graphics G... 👛 Imported From IE 💿 Weblogin TU Delft 🚡 webEOM 🔞 Pinterest 🔌 Microsoft Academ... 👛 GEE 👛 Moroco Global Drought Monitoring & Analysis **Global Drought Monitoring and Analysis platform** Welcome to GDMA, Global Drought Monitoring and Analysis platform. C fi 🗋 159.226.117.95: The platform is under active development at the State Key Laboratory of Remote Sensing Sc III Appl Observation for Water Cycle (EOWater) at the Institute of Remote Sensing and Digital Earth Chinese Academy of Sciences (CAS) Home Analysis Satellite \* GDMA introduces a web-based quasi real-time global drought monitoring system. Multi-sour surface data set like GPCP precipitation, MODIS Normalized Difference Vegetation Index (NI are currently provided as data support for the whole system, where ET data (ETMonitor) will The system is based on two important pillars, namely analysis and monitoring Within the analysis pillar the users can retrieve and analyse various drought relevant informa analysis including drought indices such as NVAI, NTAI and NDAI. The information can be precounty statistics The monitoring pillar provides the users with (near-)real-time drought alerts at county level fc level for the global
  - **Cloud spatial data** management
  - Support Online analysis
  - Web based open source architecture



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

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## 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**

OpenDAP

WCS

WCPS

WPS

JSON

WMS

External request

ternal request

Response

**Distributed storage** 

#### **Technical Framework**

FTP

Drought datasets

Indestion Service (GDAL)

Array DBMS

(Rasdaman: PetaScope, Array

database Engine, SQLite,

PostgreSQL)

Web-based GIS GUI

(OpenLavers & HighCharts to

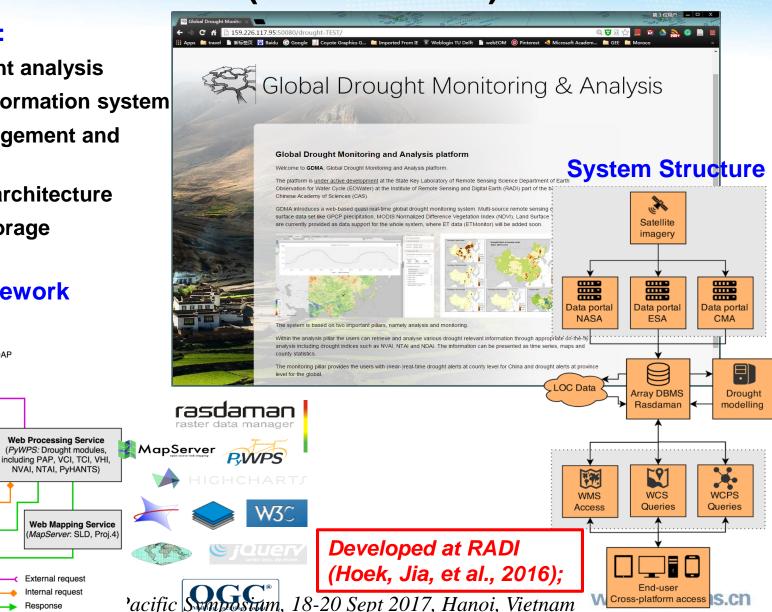
Process, Monitor and Analyze)

WMS

WCS-T

**PvMODIS** 

RasImport



# Outline



## **DroughtMonitor: Drought Monitoring**

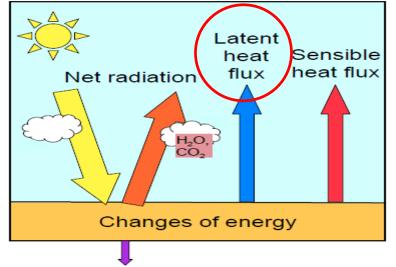
• ETMomitor: Evapotranspiration and Water Deficit

# Land Evapotranspiration

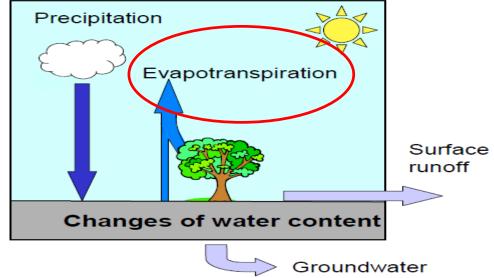


 ET is a term involving Surface Energy Balance (SEB) and Surface Water Balance (SWB)





Surface Water Balance (SWB)



Ground heat flux

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**

Spatial Res.	Temporal Step	Spatial Coverage	Theory	Input RS Data	OutPut
3–5 km	30 min, daily	Europe, Africa, S. America	H-TESSEL SVAT scheme	LAI, FVC, Albedo, Downwelling Fluxes, LC	ET
1 km	8 days	Global	P-M	LAI, fPAR, Albedo, LC	ET, LE, Potential ET/LE
25 km	daily	Global	P-T + Soil Water Balance	LST, Vegetation Optical Depth, Precipitation, Soil Moisture, LC	ET, Interception
1 km	monthly	Global	SSEBop	LST, NDVI, Albedo	ET
5 km	monthly	Global	ALEXI	LST, NDVI, Albedo	ET
5 km	monthly	Global	SEBS	LST, NDVI, Albedo, LC	ET
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
	Res.         35 km         1 km         25 km         1 km         5 km         5 km         1 km         25 km	Res.Step35 km30 min, daily1 km8 days25 kmdaily1 kmmonthly5 kmmonthly5 kmdaily	Res.StepCoverage3-5 km30 min, dailyEurope, Africa, S. America1 km8 daysGlobal25 kmdailyGlobal1 kmmonthlyGlobal5 kmmonthlyGlobal5 kmdailyGlobal1 kmdailyGlobal	Res.StepCoverage3-5 km30 min, dailyEurope, Africa, S. AmericaH-TESSEL SVAT scheme1 km8 daysGlobalP-M25 kmdailyGlobalP-T + Soil Water Balance1 kmmonthlyGlobalSEBop5 kmmonthlyGlobalALEXI5 kmmonthlyGlobalSEBS1 km 25 mdailyGlobalMulti-Param. (Shuttleworth- Wallace, etc.)	Res.StepCoverageIntervention3-5 km30 min, dailyEurope, Africa, S. AmericaH-TESSEL SVAT schemeLAI, FVC, Albedo, Downwelling Fluxes, LC1 km8 daysGlobalP-MLAI, fPAR, Albedo, LC25 kmdailyGlobalP-T + Soil Water BalanceLST, Vegetation Optical Depth, Precipitation, Soil Moisture, LC1 kmmonthlyGlobalSSEBopLST, NDVI, Albedo5 kmmonthlyGlobalALEXILST, NDVI, Albedo, LC5 kmmonthlyGlobalSEBSLST, NDVI, Albedo, LC1 km 25 om 25 omdailyGlobalLALXI1 km 25 omMonthlyGlobalLEXI1 km 25 omMonthlyGlobalSEBS1 km 25 omMailyGlobal Regional / Basin scaleMulti-Param. (Shuttleworth- Wallace, etc.)LAI, Albedo, Precipitation, Soil Moisture, LC

## **Evapotranspiration from Remote Sensing**

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## **ETMonitor**:

A process based model **ETMonitor** implementing processes of energy balance, plant Land Surfaces in a Pixel VIS/NIR LAI\NDVI\fc physiology and soil water Satellite Soil Vegetation Water Snow Albedo Data **Outputs** balance developed by Land Use/Cover EOWater Lab at RADI Energy Plant Water **Total ET ET Deficit** Balance & Physiological Balance Microwav Partition Process Soil Moisture Satellite Solar radiation Data Vegetation Storage Interception Transpiration PRECIPITATION Canopy Capacity Crop Multi-Net Water Use Radiation Vegetation source Precipitatio Canopy Satellite Transpiration Resistance transpiration & Evaporation Data evaporation Soil Water Soil Net Soil Soil Stress Radiation Resistance Evaporation Saturated and Soil **Residual Soil** Interception R<sub>nc</sub> Database Moisture *interception* Soil Infiltration Surface Laver Drought Indices Root Zone Radiation Water Sublimation Meteo Wind Speed Evaporation Soil Bottom Forcing Air Temp. R<sub>ns</sub> Data Humidity Snow soil evaporation +--> Pressure Sublimation ٦S **Data Assimilation** Surface layer SM.

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

Combining optical and microwave

remote sensing observations

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Root zone

Soil bottom

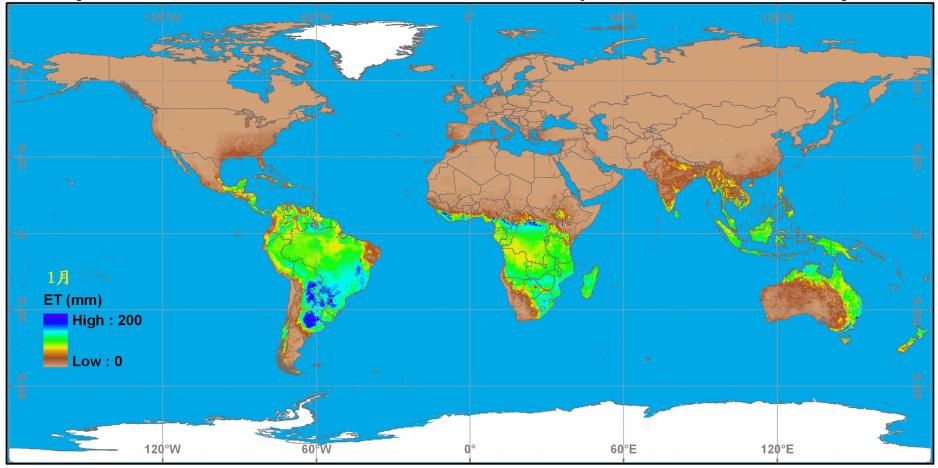
SM,

SM

drainage

Root uptake

## Evapotranspiration from Remote Sensing ETMonitor Global ET Product (2008-2013, mm/month, 1km spatial resolution)



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

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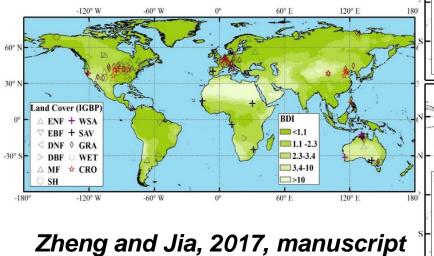
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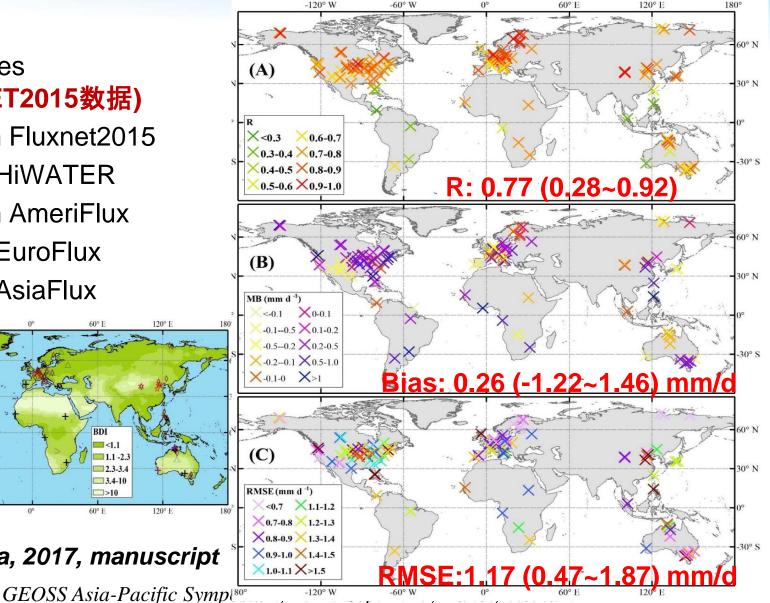
## **Evapotranspiration from Remote Sensing**

## Validation

#### $\geq$ 153 flux sites (FLXUXNET2015数据)

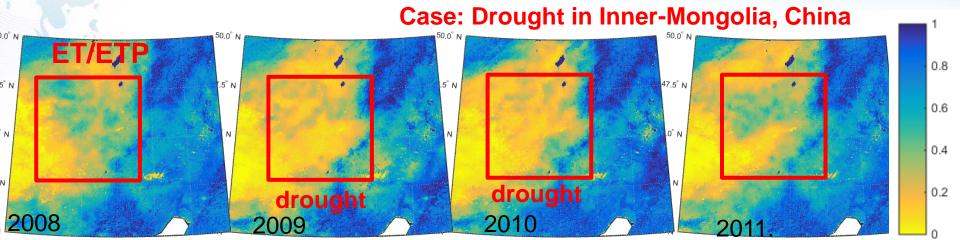
- 98 from Fluxnet2015
- 6 from HiWATER
- 37 from AmeriFlux
- 8 from EuroFlux
- 4 from AsiaFlux



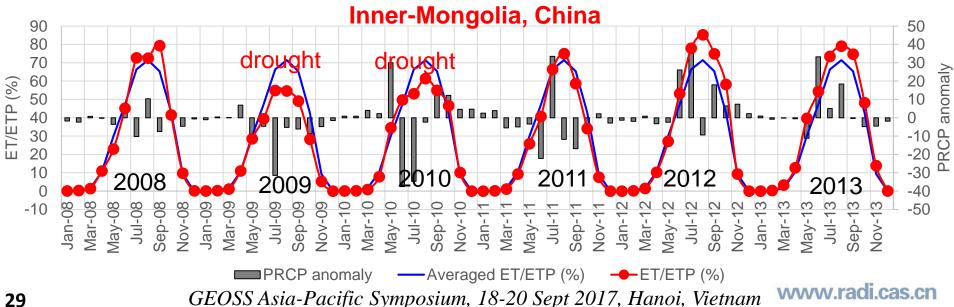


# ET Based Drought Monitoring

#### **ET/ETP**

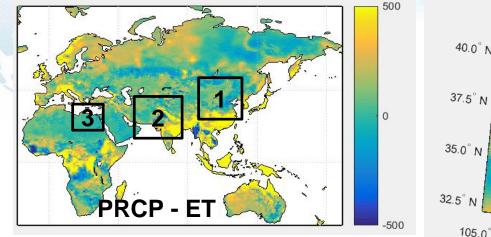


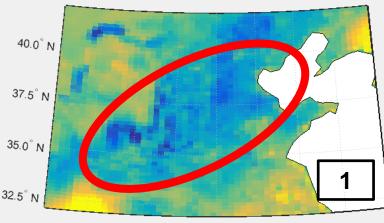
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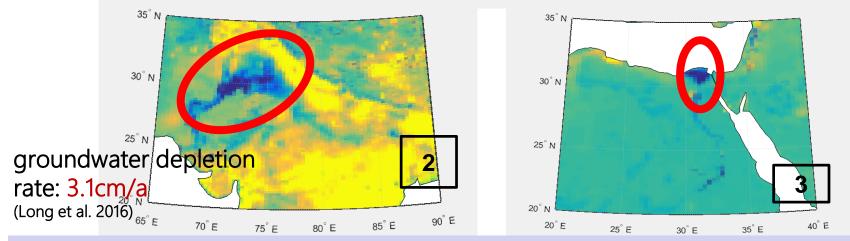
## **ET Based Water Deficit Evaluation**

PRCP – ET





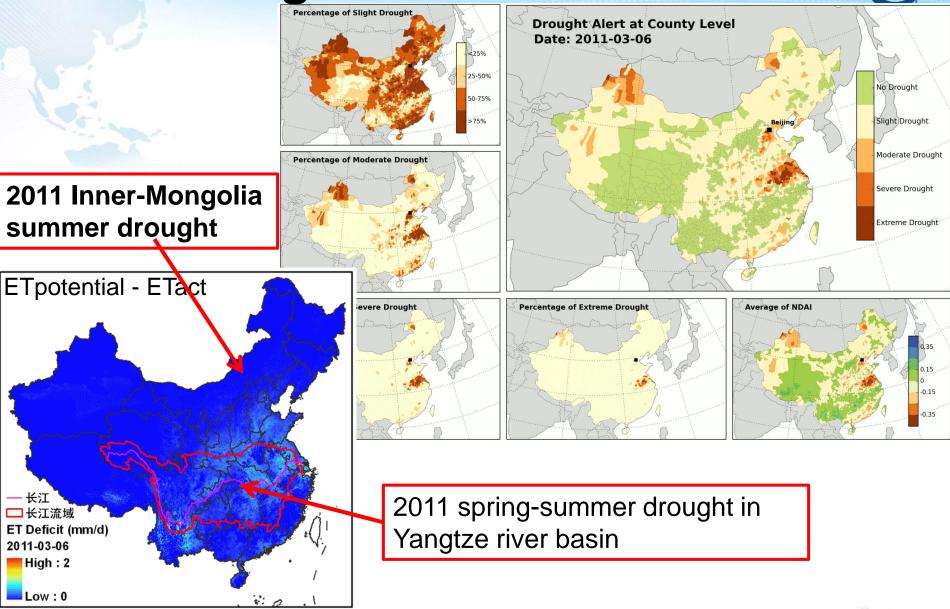
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Very low PRCP – ET value can be found in many agriculture regions, e.g. north China, northwest India, lower reach of the Nile basin, where ET exceeds precipitation, indicating surface water use or using groundwater.

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## **Drought and Water Deficit**



# 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! **讷打 讷打**!



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