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# Water Stress and Drought Monitoring Using Satellite Observations

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for Asia-Oceania



- Drought disaster → great hunger, social instability, large scale migration of the population and extinction of civilizations in the history.
- Conflict between water supply and demand → the biggest problem for food security of a huge population in Asia-Oceania. → Major policy responses are needed which relies on effective/efficient information.
- Under climate change, more frequent droughts and flash droughts are anticipated, predication will be
  necessary for preparedness and adaptation will be essential. e.g. how to adapt to future changes and needs?

#### Number of drought events recorded by EMDAT (2002-2019)



Mean flash drought frequency (1980 - 2015)



# **01** Background

#### 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  $\rightarrow$  economical development and living standards

# Water outflow exceeds inflow

# **01** Background

Satellite Observations 🔿 Processes 🔿 Drought Indicators 🔿 Monitoring System Satellite Drought **Drought Severity** Surfaces status **Observations** and process & Impact Index Cause TRMM 、 CMORPH 、 Precipitation PAP, SPI, Z, ... GSMap、GPM、 ... **Drought** Severity Index Evolution AMSR-E, ESA-CCI, Soil Moisture SSI、 ... SMOS, MWRISM, FY .... Early Warning Land surface MODIS, FY, MTSAT, TCI、NTAI、.... Sentinel 3、HJ、 temperature Drought **Drought Impact** Vegetation NDVI, VCI, NVAI, MODIS, SPOT-Indicator conditions SVI, ... Vegetation, Sentinel 3、FY... Impact CWSI, WDI, ESI, MOD16、MSGET、 Evapotranspiration Evaluation EDI、ETdef、ESP ET-ITC, ETMonitor, GLEAM... GRACE, .... Groundwater TWSC、... Decision making Integrated Consequence Index

# **02** Satellite Observations & Drought Indicators

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# **02 Satellite Observations & Drought Indicators**

□ Water stress and drought development



Slow drought vs Flash drought



#### **Flash drought:**

- caused by precipitation deficit while accompanied by abnormal high temperature and dry air, strong solar radiation
- root-zone soil moisture drops down significantly in short time

# **02 Satellite Observations & Drought Indicators**



#### Water stress and drought development



**ET based indicator:** Evaporative Stress Percentile (ESP)



Li, Jia et al., manuscript

# Flash drought:

- caused by precipitation deficit while accompanied by abnormal high temperature and dry air, strong solar radiation
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# **02 Satellite Observations & Drought Indicators**

# Web-GDMAP: Web-based Global Drought Monitoring & Analysis Platform

A monitoring and analysis system using multi-source satellite data products and other EO data.



#### Data quality check and preprocessing

- Filtering (quality control) is necessary to remove poor quality data
- Reconstruction of time series (towards gap-free products) to ensure data usability

#### **Drought indicators**

- Region/process dependence of drought indicators
- Drought indicator vs. drought severity
- **General drought alert**
- Drought impact evaluation
  - Impact on regional water resource
  - Impact on agricultural yield
- □ Information visualization

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# Web-GDMAP: System Architecture



# rasdaman **RWPS** MapServer W3C HIGHCHARTS. 🗧 Leaflet 🅠

#### **Main Functions:**

- Spatial drought information extraction and visualization
- Time series drought information extraction and visualization
- Regional drought alert

#### **System Characteristics:**

- Ad-hoc drought analysis
- Web-based information system
- Big data management and Analysis
- Open source architecture
- User-friendly WebGIS Graphical User Interface (GUI)

# 03 Web-GDMAP

# **Main Functions and System Characteristics**



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# 03 Web-GDMAP

# Severe Drought in Low Mekong River Basin (2016)

The catastrophic drought in 2016 created economic losses of around 650 million \$ and adversely affected 17 million people



# 04 Web-GDMAP Application to Mekong River

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The catastrophic drought in 2016 created economic losses of around 650 million \$ and adversely affected 17 million people

Drought evolution monitored by Normalized Vegetation Anomaly Index (NVAI) (Feb. - Jun. 2016)



# 04 Web-GDMAP Application to Mekong River

#### Severe Drought in Low Mekong River Basin (2016)



# 04 Web-GDMAP Application to Mekong River

# Severe Drought in Low Mekong River Basin (2016)

# **Regional Drought Alert**

![](_page_14_Figure_3.jpeg)

# 04 Web-GDMAP Application to Mekong River Basin

# Severe Drought in Low Mekong River Basin (2019-2020)

The drought in 2019 continued to 2020 was the most severe one in the historical record of the LMR, including the catastrophic drought in 2016 (MRC, technical Report, 2022)

![](_page_15_Figure_4.jpeg)

04 Web-GDMAP Application to Mekong River Basin

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![](_page_16_Figure_4.jpeg)

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![](_page_17_Figure_4.jpeg)

# 04 Web-GDMAP Application to Mekong River Basin

# Improvement of the web-GDMAP

- Impact on hydrological condition (water areas/levels of lakes and reservoirs)
- Impact on agriculture
- Drought risk analysis under global change (climate change and human activities)
- web-GDMAP online for pilot countries or regions (Mekong River Basin ?)

Strengthening of cooperation with AOGEO member countries and users of the drought monitoring system

![](_page_18_Picture_7.jpeg)

![](_page_19_Picture_0.jpeg)

# THANKS

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![](_page_20_Picture_1.jpeg)

# • Short Bio of Speaker: