

# Remote Sensing Data for Drought Monitoring

Jakrapong Tawala

Geo-infomatics and Outreach Scientist

Geo-infomatics and Space Technology Development Agency (Public Organization) : GISTDA

Ministry of Science and Technology

[jakrapong@gistda.or.th](mailto:jakrapong@gistda.or.th)

# Spatial Thinking

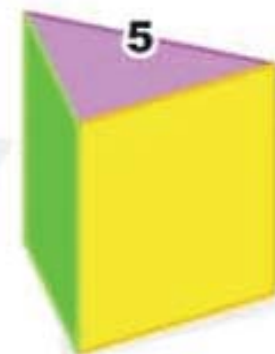
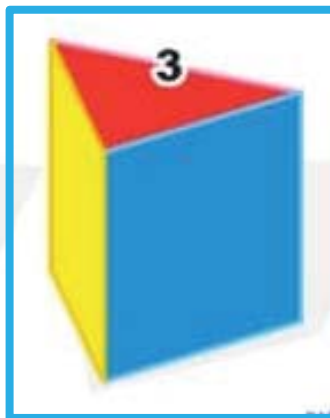
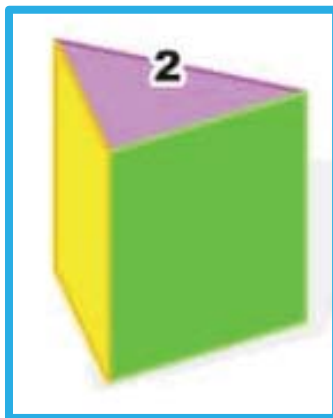
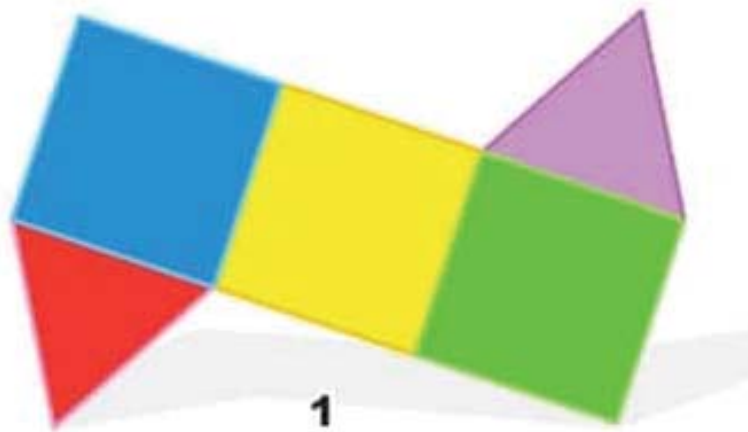


**Spatial thinking** is **thinking** that finds meaning in the shape, size, orientation, location, direction or trajectory, of objects, processes or phenomena, or the relative positions in space of multiple objects, processes or phenomena.

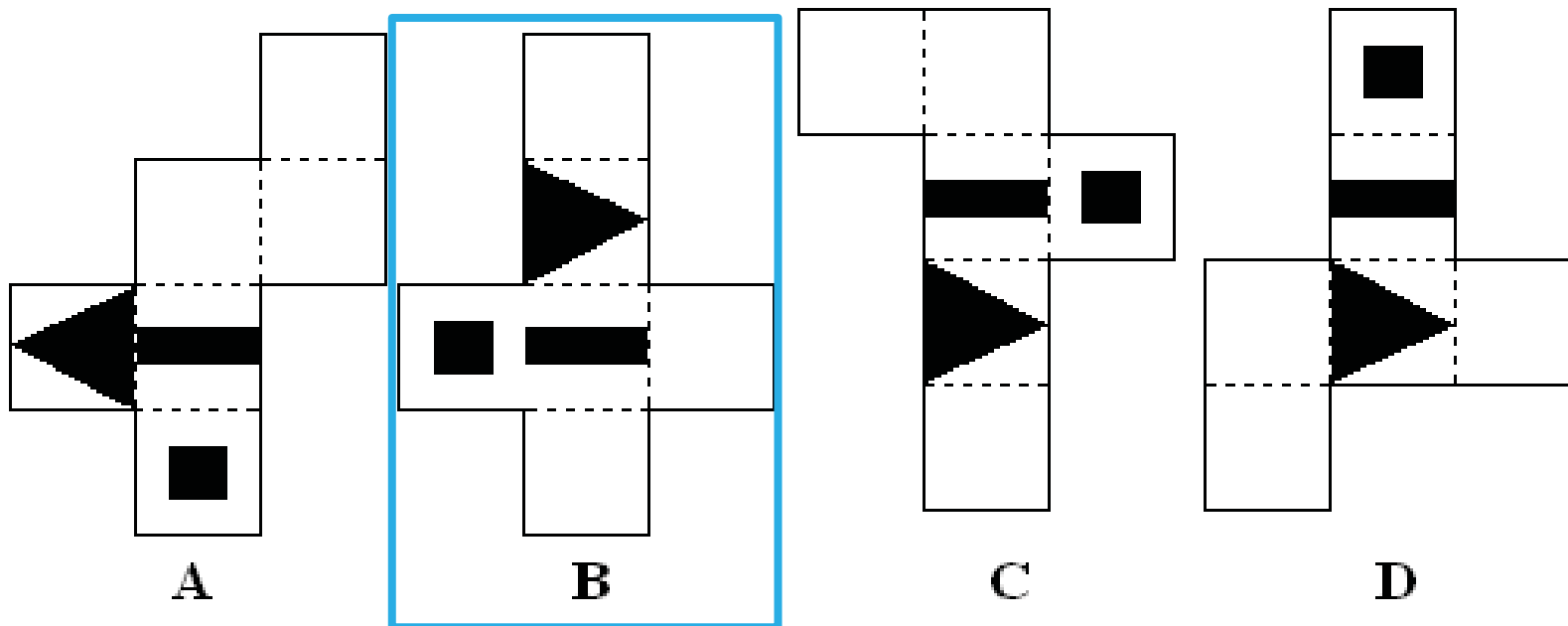
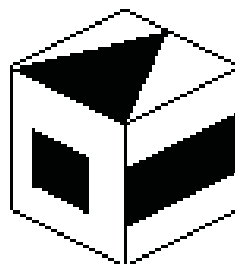
Spatial thinking uses the properties of space as a vehicle for structuring problems, for finding answers, and for expressing solutions

*(National Research Council, 2006)*

Which box can be extended to make the pattern as shown in number 1 ?



Which pattern can be folded to make the cube shown?



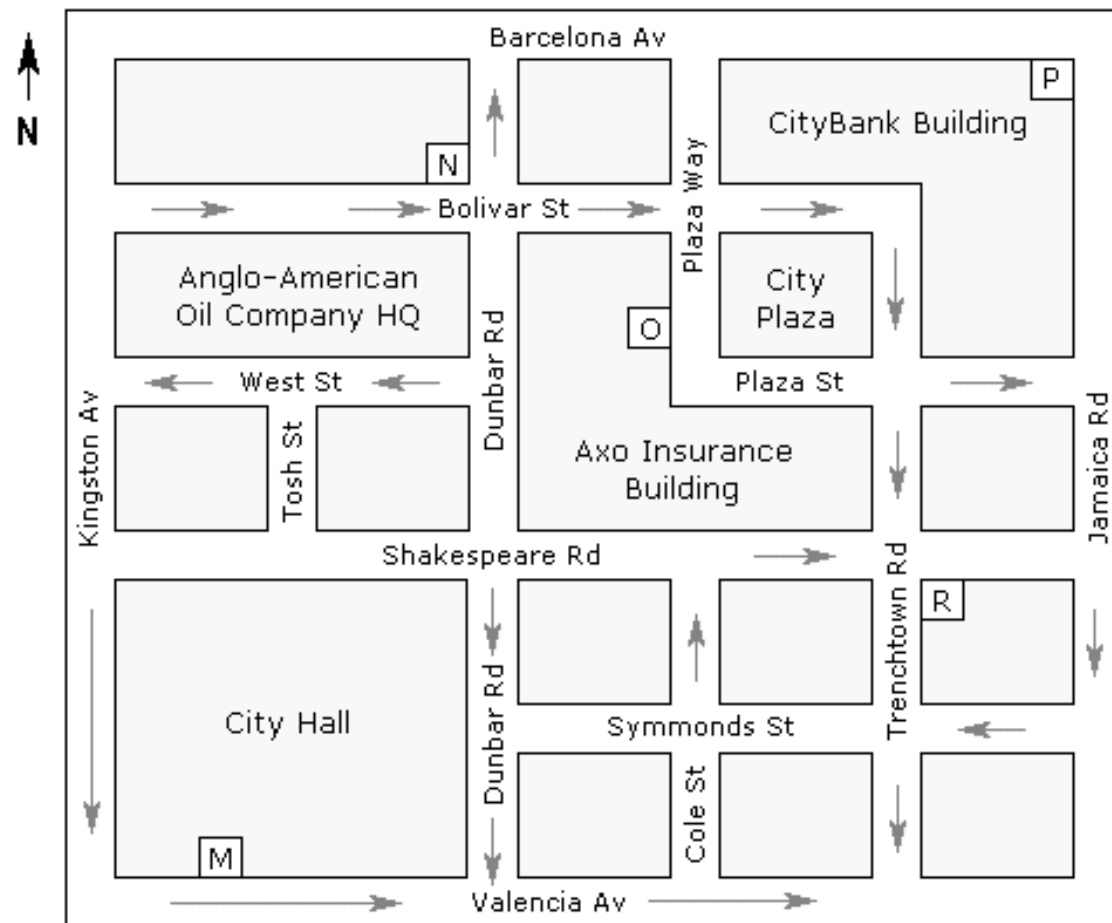
Sophek is facing the Anglo-American Oil Company HQ with the Axo Insurance building behind him, which direction is he facing? \_\_\_\_\_

A  
North

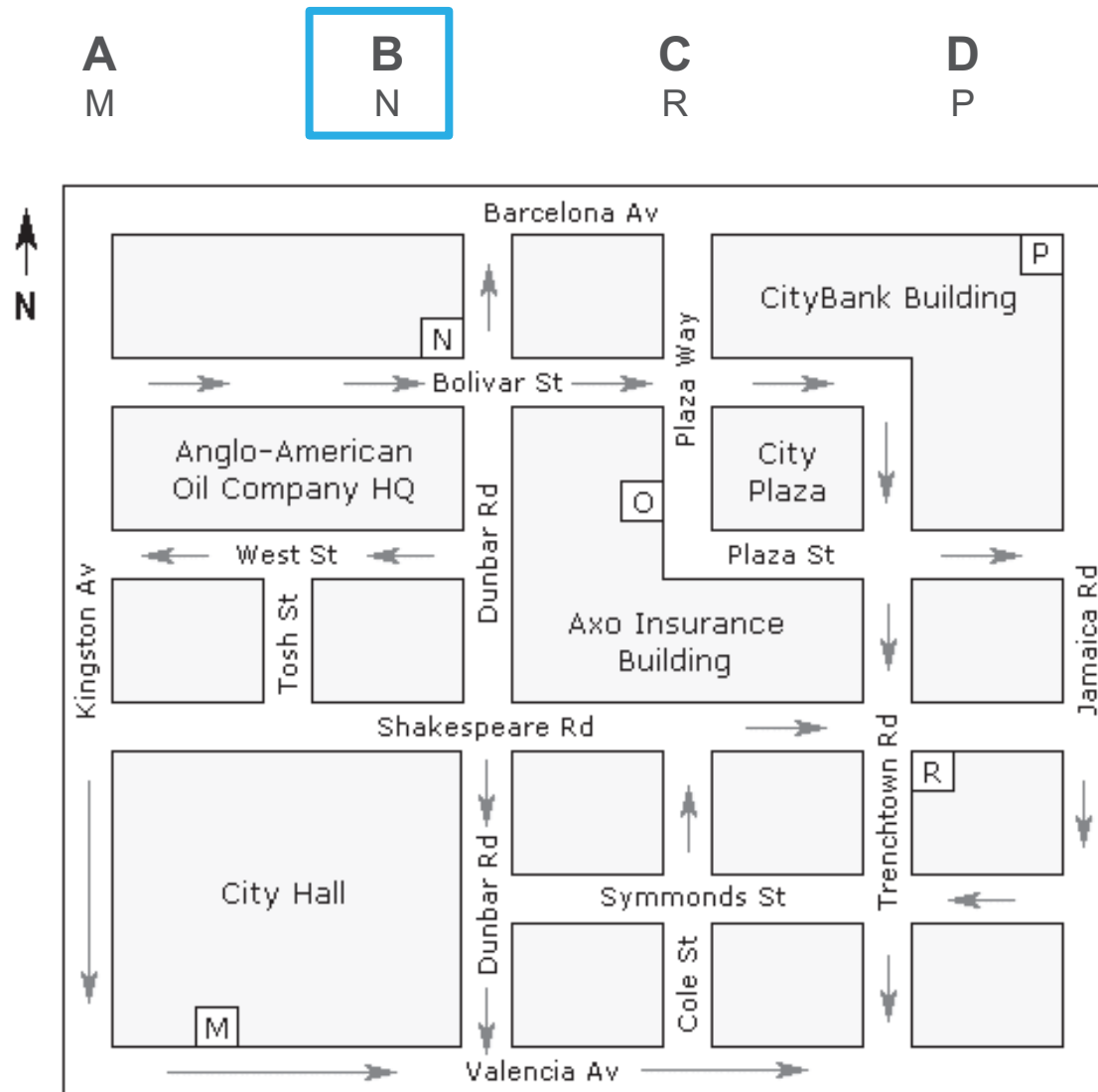
**B**  
South

C  
East

## D West



Sophek starts from location 'O' and proceeds as follows: left onto plaza way - heading North, second left - heading west, second left - heading south, first left - heading east. He proceeds for one block. What is his location?

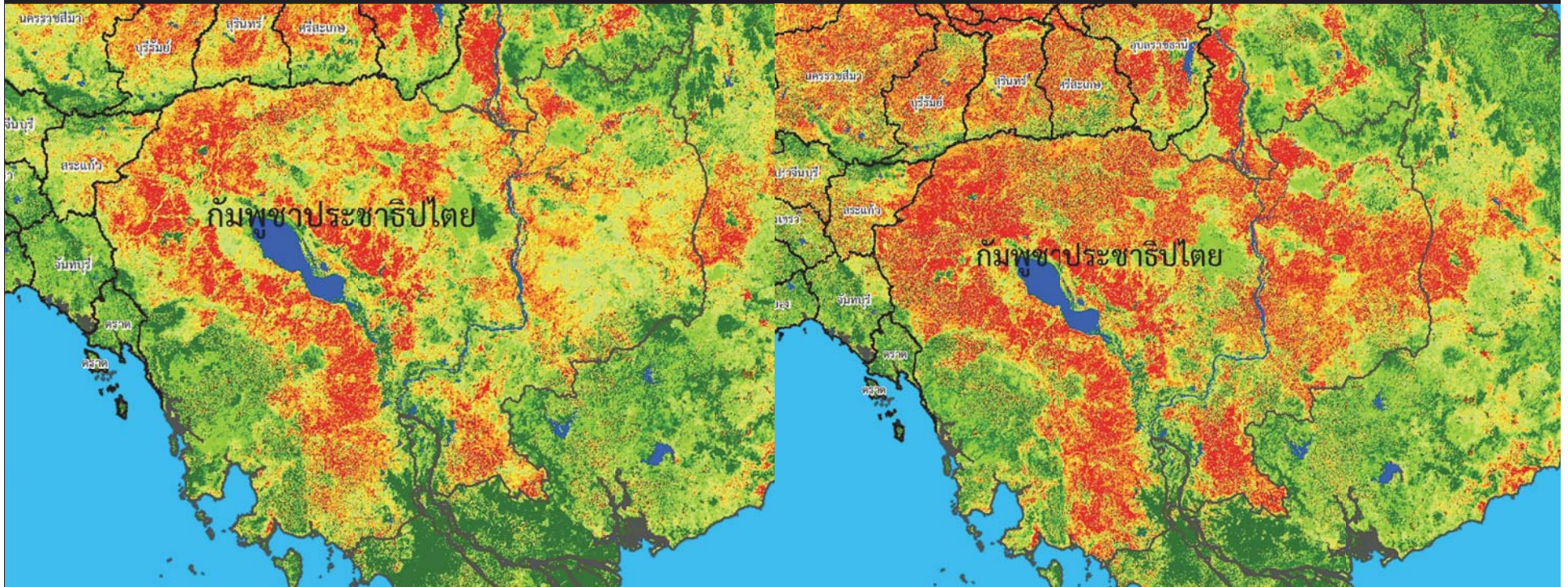




Which year is higher number of dry area  
during first week of March 2017 and March 2018 ?

# Normalized Difference Water Index (NDWI) map from MODIS

*Weekly NDWI map generated from Thailand Drought System*



(01-07 Mar 2018)

(01-07 Mar 2017)

# Types of Drought

- Meteorological drought
- Agricultural drought
- Hydrological drought

# Meteorological drought

- Meteorological drought depends on precipitation deficit and duration of period with precipitation deficit.
- Simply expressed in terms of a rainfall deficit in relation to some average amount and duration of drought period.

# Agricultural drought

- Agricultural drought refers to situations with insufficient soil moisture level to meet the plant needs for water during vegetation period.

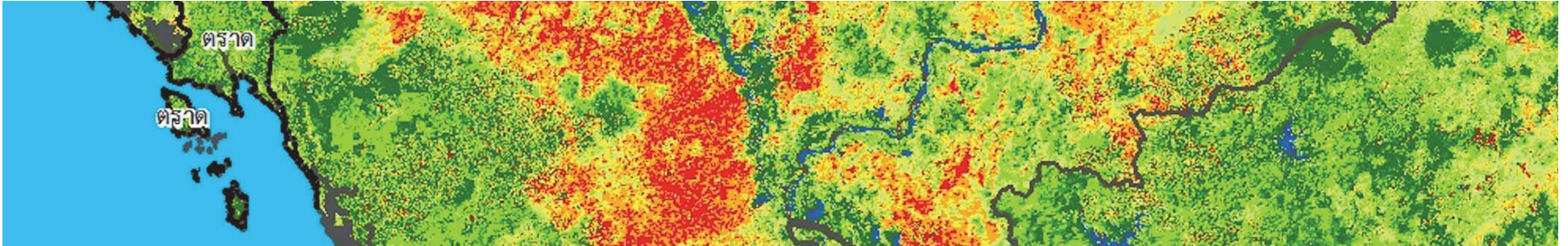
# Hydrological drought

- Hydrological drought occurs after longer period of precipitation deficit.
- Effects of periods of rain shortfall on surface and subsurface water

# DROUGHT INDICES

1. **Normalized Difference Vegetation Index (NDVI)**
2. **Normalized Difference Vegetation Index (NDWI)**
3. **Vegetation Condition Index (VCI)**
4. **Temperature Condition Index (TCI)**
5. **Vegetation Health Index (VHI)**
6. **Normalized Difference Drought Index (NDDI)**
7. **Vegetation supply water index (VSWI)**
8. Standardized Precipitation Index (SPI)
9. Aridity Index (AI)
10. Palmer Drought Severity Index (PDSI)
11. Surface Water Supply Index (SWSI)
12. Moisture Adequacy Index (MAI)
13. Crop Water Stress Index (CWSI)
14. ....





# Advantages of Remote Sensing for Drought Monitoring

## **I. Spatial continuous measurements across large geographic areas.**

- Important in locations where weather stations or other ground observations (human) are sparse or non-existent.

## **II. Frequent revisit time for image acquisition**

- Several satellites acquire image data every 1-2 days or a 1-2 week basis for same location.

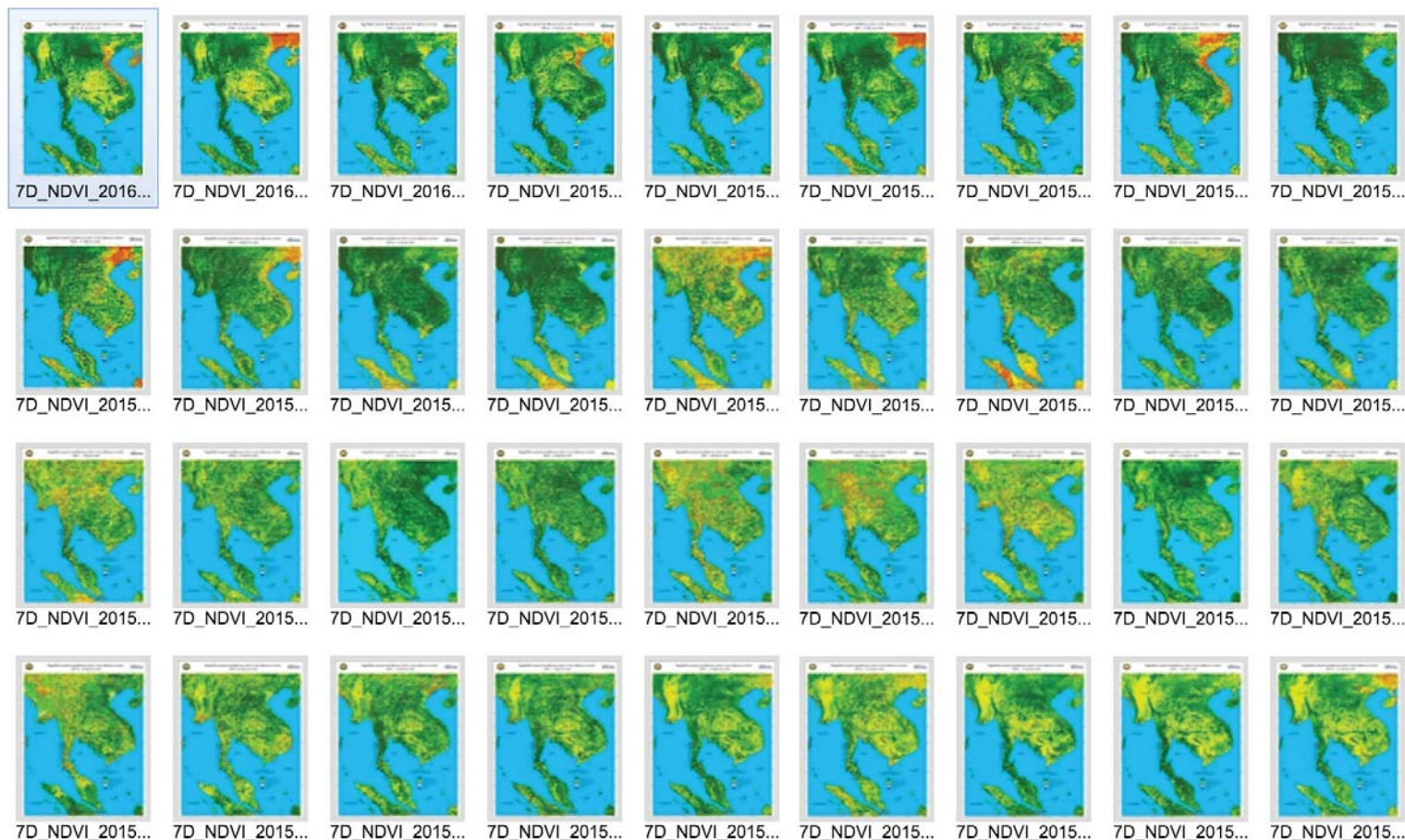
## **III. Historical record of conditions**

- Several instruments (AVHRR and Landsat) provide 20+ years of information with some newer sensors (MODIS) approaching 10+ years of observations.



# 4 Ideals Remote Sensing Data Characteristics for Drought Monitoring

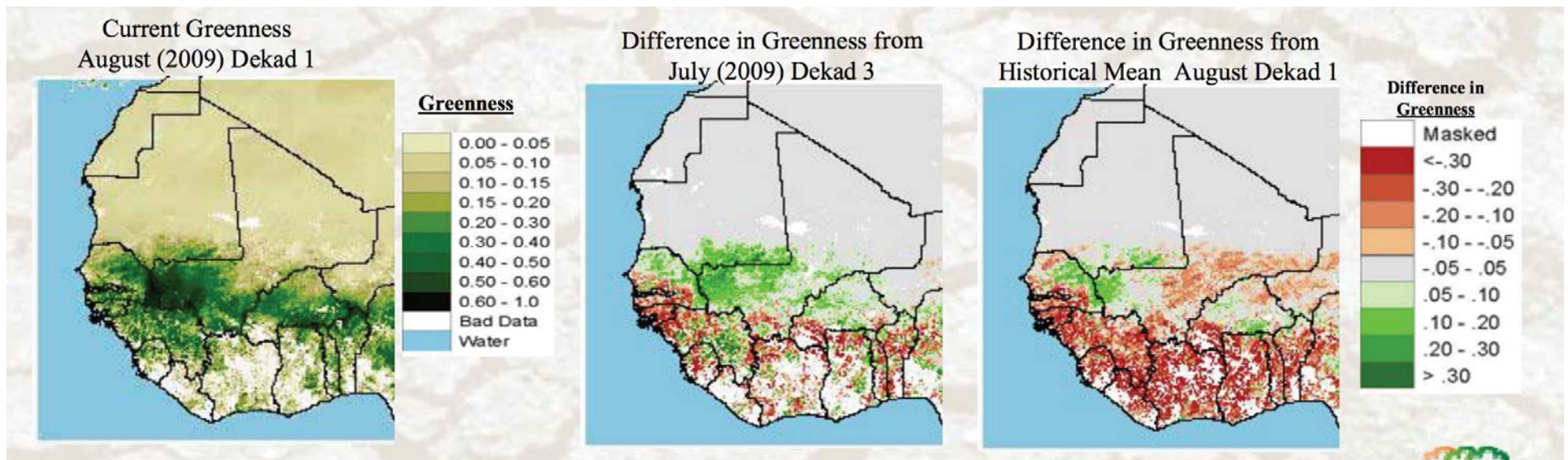
**1. Operational data production** – routinely produce the same data products at a set time interval.



# 4 Ideals Remote Sensing Data Characteristics for Drought Monitoring

## 2. Anomaly, Percent of Normal, Change, or Ranking Maps

- Provide historical context of how current conditions compare to the historical conditions for a specific location and time during the year.
- Easier to differentiate moderate, severe, and extreme drought events.



# **4 Ideals Remote Sensing Data Characteristics for Drought Monitoring**

## **3. Data easy accessible and in multiple formats**

- Digital data in analysis using GIS and computers
- Graphical maps that can be downloaded and printed for visual analysis

## **4. Evaluation of the Information's Accuracy for Your Local Area**

### **Assess Accuracy for:**

- 1) multiple locations across your country or region
- 2) multiple years (drought and non-drought periods)
- 3) spatial gradients between drought and non-drought areas
- 4) trends over time

### **Resources:**

- Expert opinion - climatology, meteorology, agriculture, water resources, and natural resources/ecology
- Local feedback
- Ground measurement - crop/rangeland conditions, meteorological and surface water observations, and
- Comparison with other drought index data and maps

# **Traditional Remote Sensing Information Used for Drought Monitoring**

**(Drought Indices)**



Normalized Difference Vegetation Index

NDVI



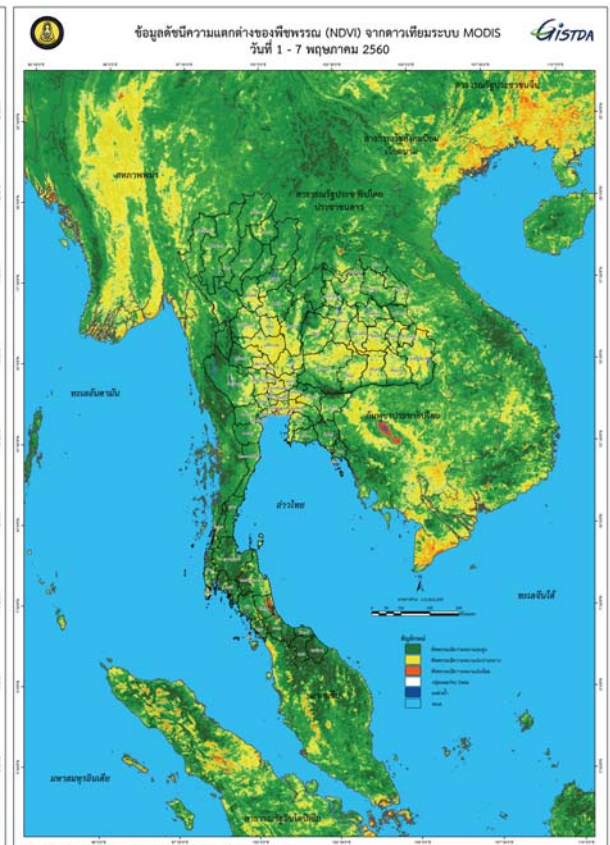
# 1. Normalized Difference Vegetation Index (NDVI)

Quantitative indicator of the relative abundance and activity of green vegetation. Well correlated with several biophysical characteristics of vegetation:

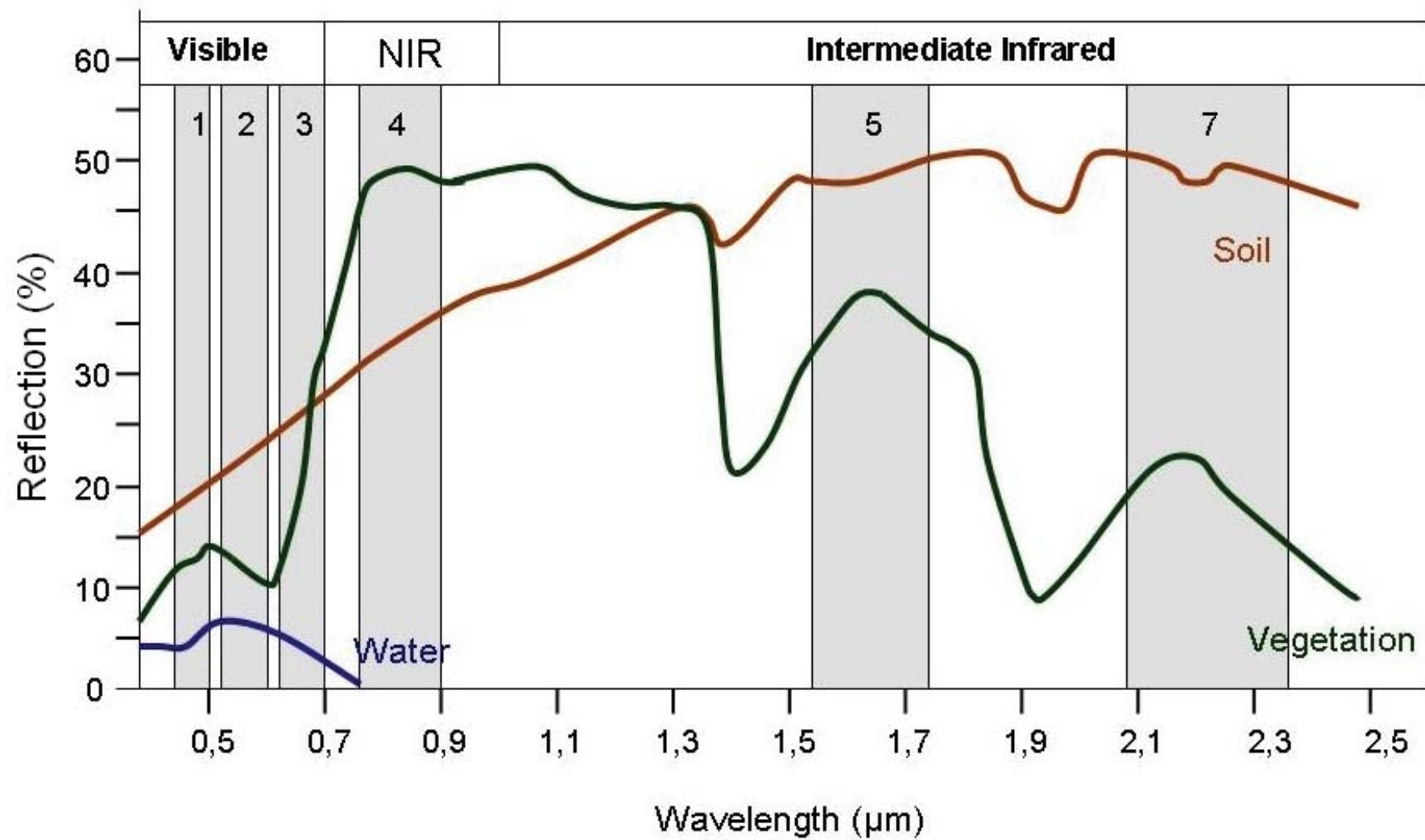
- leaf area index (LAI)
- % green cover
- green biomass
- chlorophyll content



NDVI of Dry season

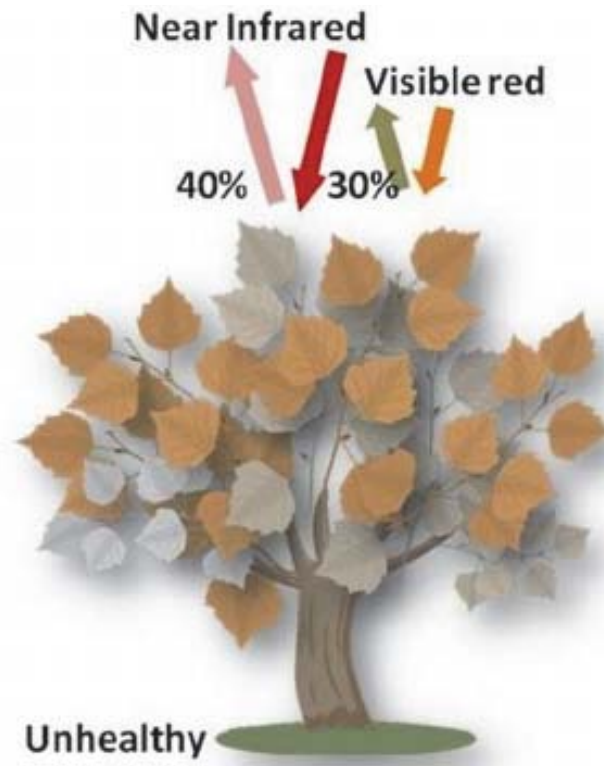


NDVI of Rainy season





$$\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$$







**-1 – 0**

Dead Plant or  
Inanimate Object



**0 – 0.33**

Unhealthy Plant



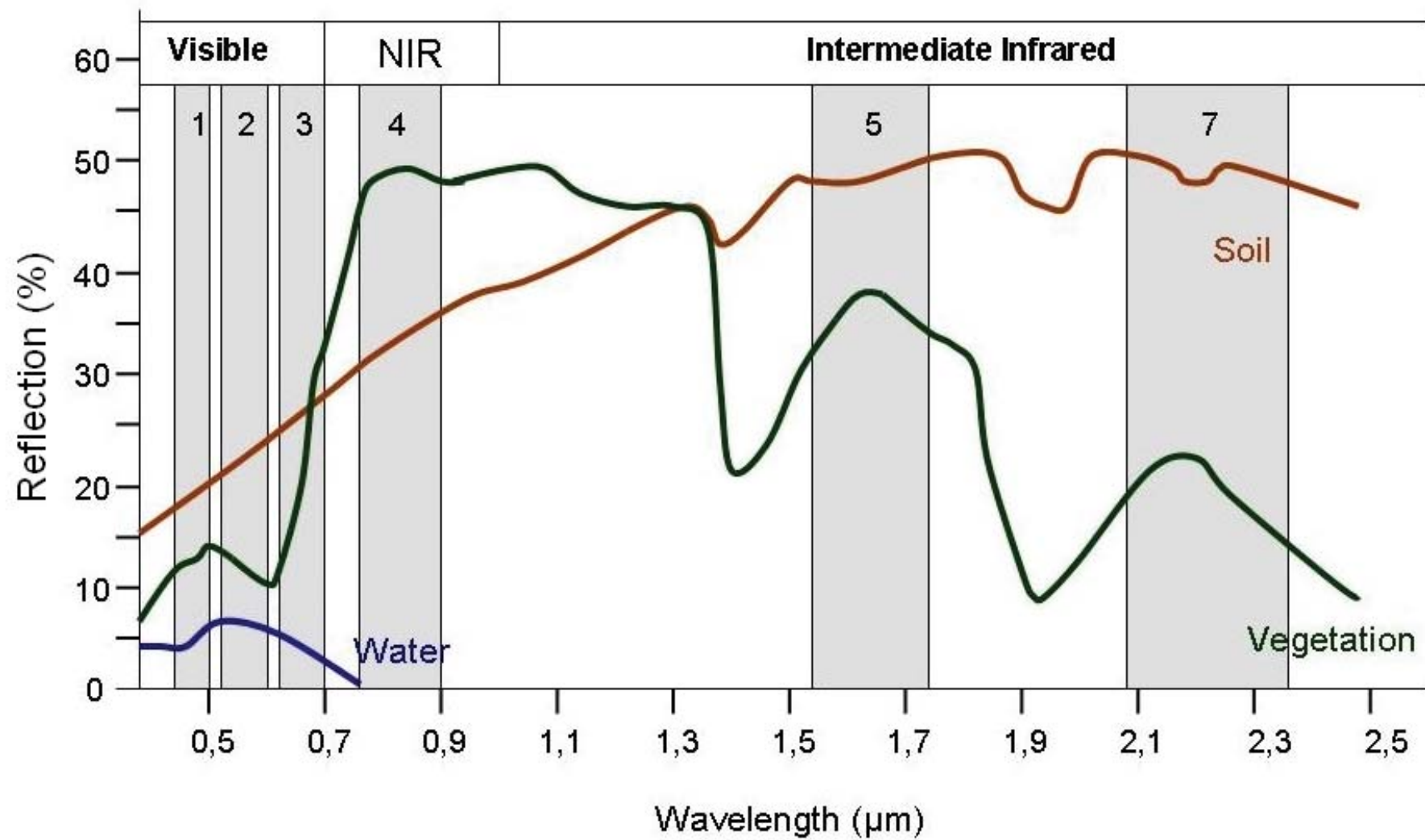
**0.33 – 0.66**

Moderately  
Healthy Plant



**0.66 – 1**

Very  
Healthy Plant



# NDVI – Why is it an Indicator of Vegetation Health?

$$\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$$

**NIR (Near-Infrared)** energy sensed from vegetation is controlled by the plants internal leaf structure.

LOW NIR = stressed or non-green vegetation (wilting)

HIGH NIR = healthy green vegetation

**Red** energy detected from vegetation is controlled by the vegetation's chlorophyll content.

LOW Red = healthy green vegetation absorbs visible red energy

HIGH Red = stressed or non-green vegetation reflects red energy

**NDVI values** ranging from **-1 to +1**

HIGH NDVI values = healthy, green vegetation (typical range of vegetation values from 0.2 - .08, with values > 0.5 indicative of denser vegetation)

LOW NDVI values = stressed or non-green vegetation

Normalized Difference Water Index

NDWI



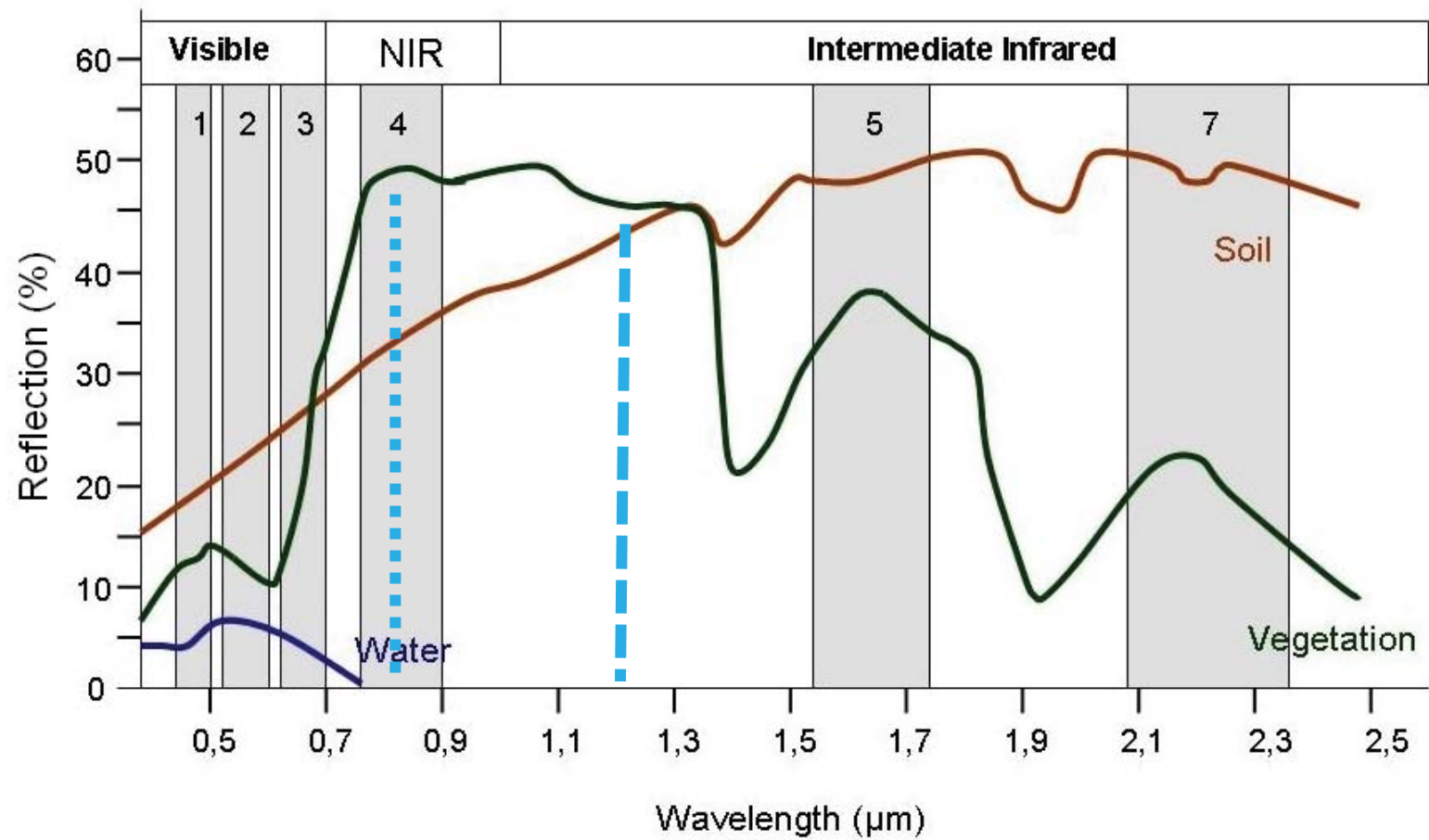
# About NDWI

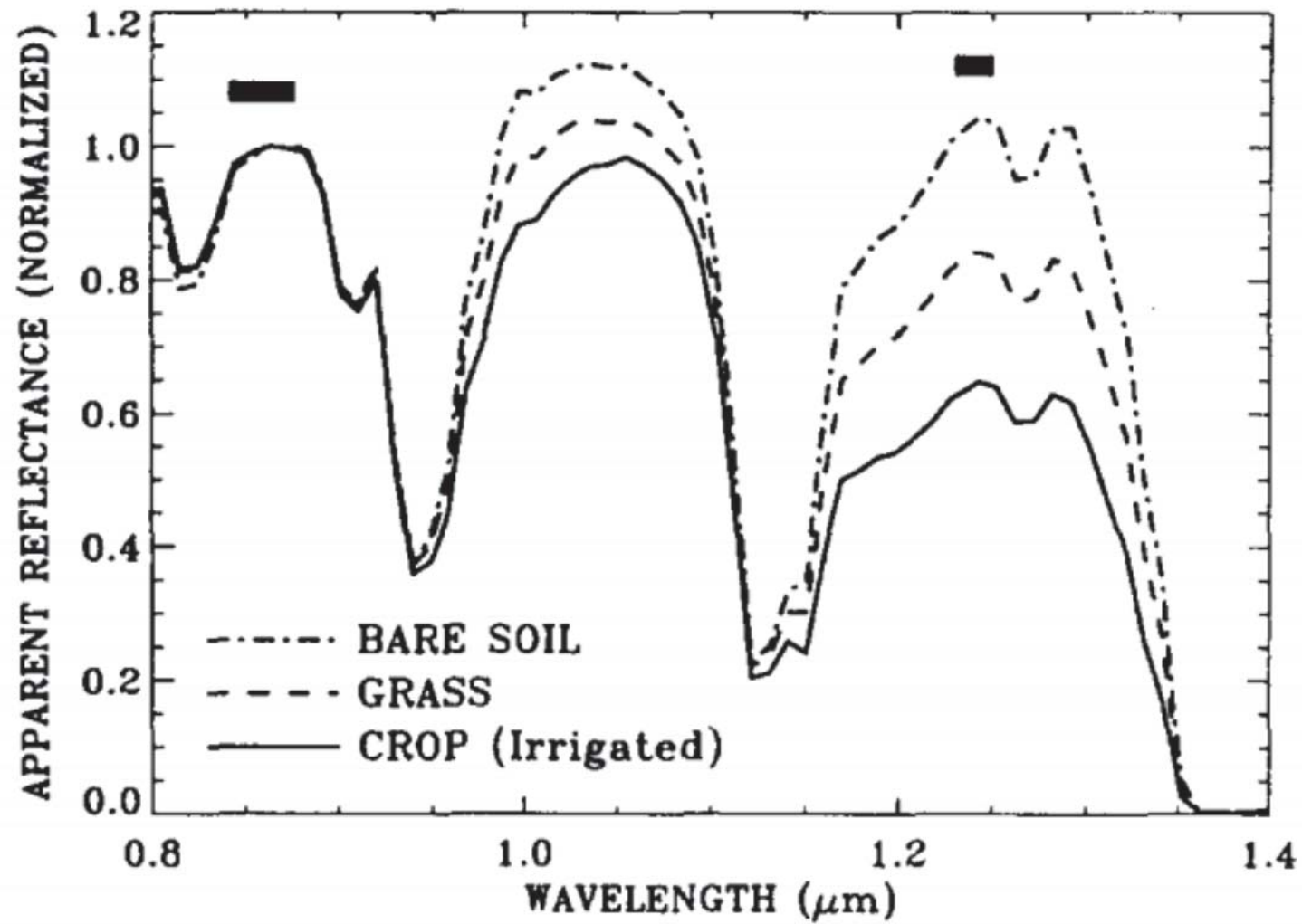
to monitor changes in water content of leaves, using near-infrared (NIR) and short-wave infrared (SWIR) wavelengths, proposed by Gao in 1996

$$NDWI = \frac{(X_{nir} - X_{swir})}{(X_{nir} + X_{swir})}$$

to monitor changes related to water content in water bodies, using green and NIR wavelengths, defined by McFeeters (1996)

$$NDWI = \frac{(X_{green} - X_{nir})}{(X_{green} + X_{nir})}$$





Bo-Cai Gao  
REMOTE SENS. ENVIRON. 58:257-266 (1996)  
©Elsevier Science Inc., 1996

$$\text{NDWI} = \frac{(X_{nir} - X_{swir})}{(X_{nir} + X_{swir})}$$

**NDWI** is sensitive to changes in liquid water content of vegetation canopies.

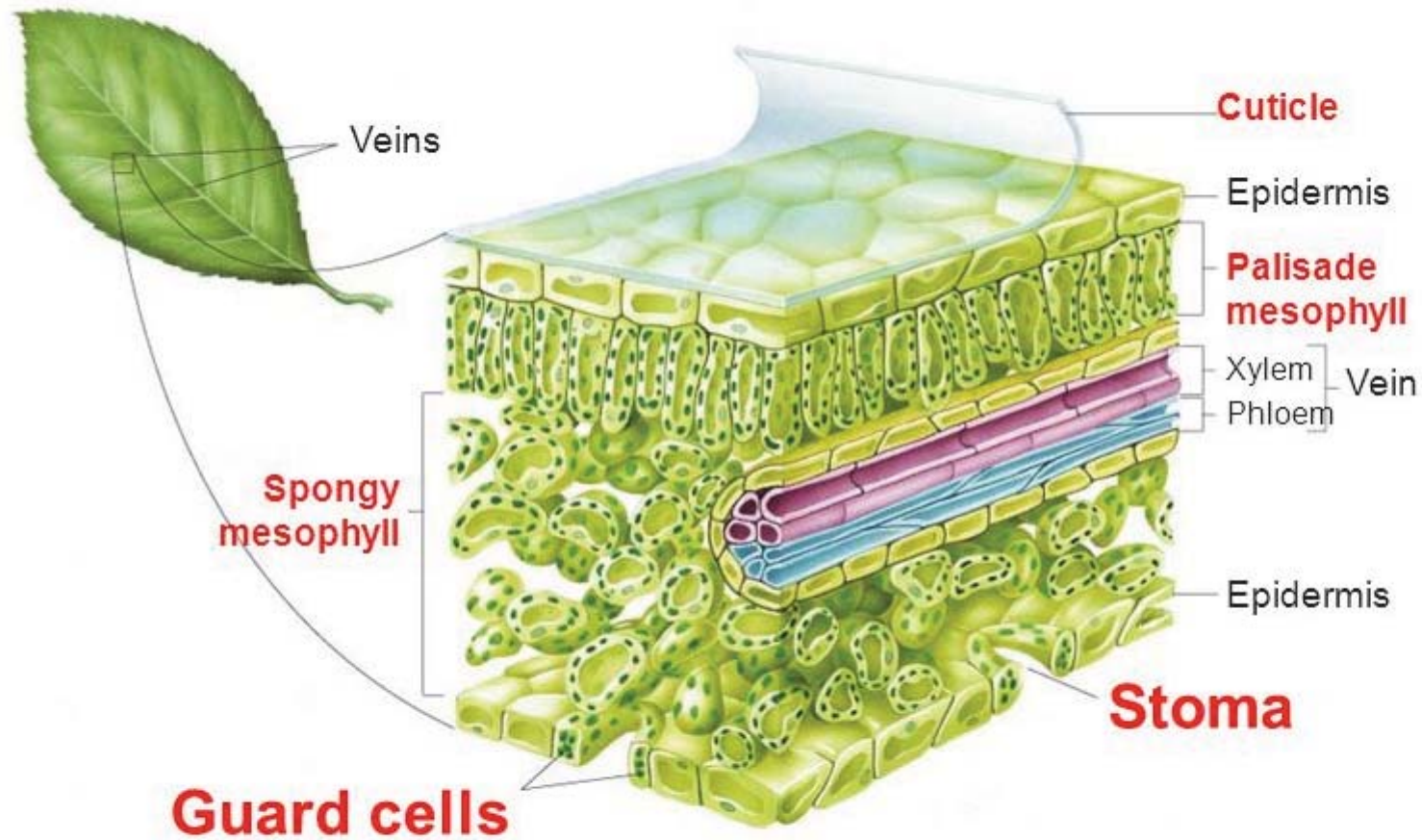
**The NIR reflectance** is affected by leaf internal structure and leaf dry matter content, **but not by water content**.

**The SWIR reflectance** reflects changes in both the vegetation water content and the spongy mesophyll structure in vegetation canopies.

The combination of the NIR with the SWIR removes variations induced by leaf internal structure and leaf dry matter content, improving the accuracy in retrieving the vegetation water content.



# The Internal Structure of a Leaf





# Normalized Difference Water Index: **NDWI Map**

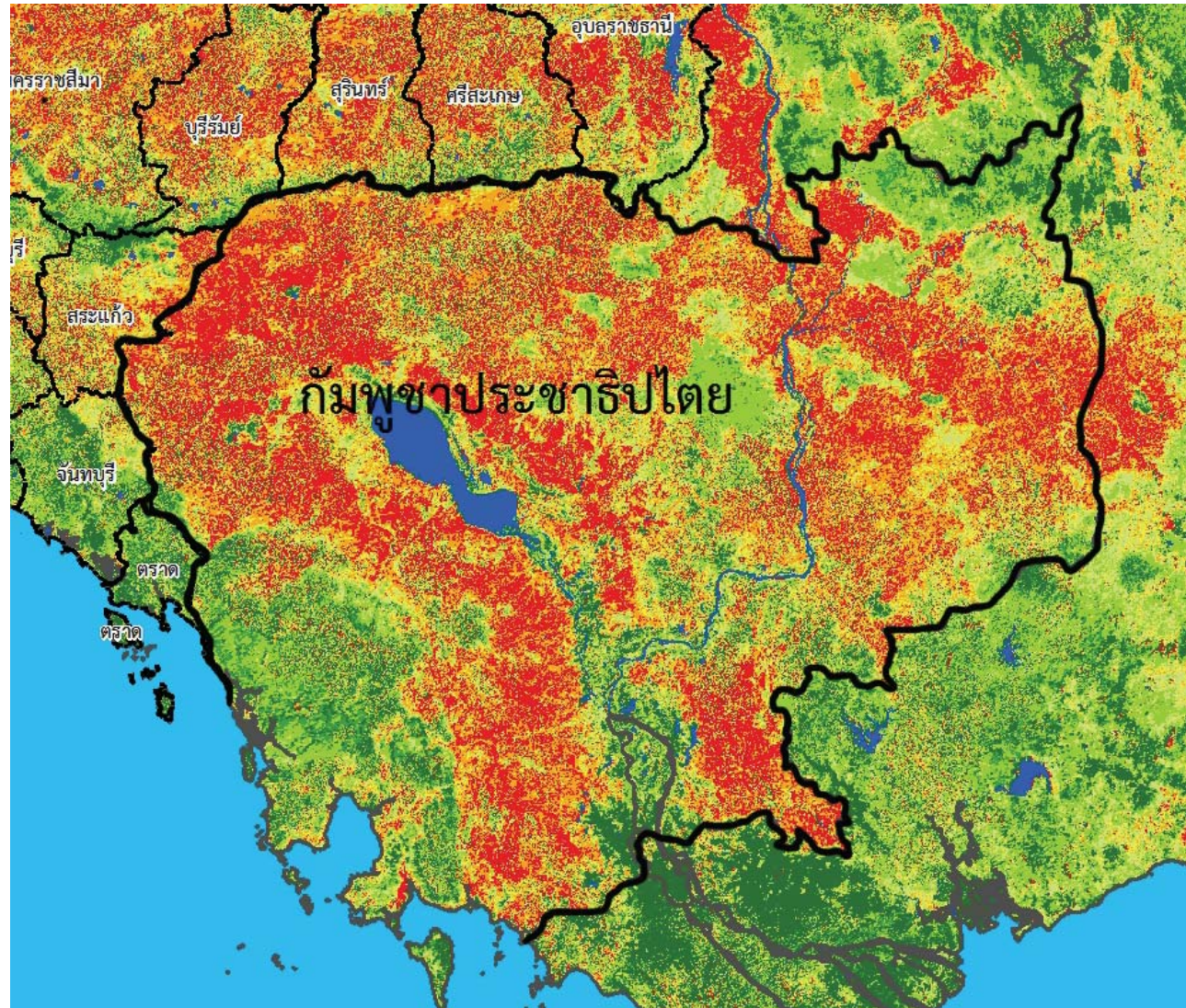
**+1**

+1 : represent  
high water content  
in vegetation

**0**

-1 to 0 :  
low water content  
in vegetation

**-1**



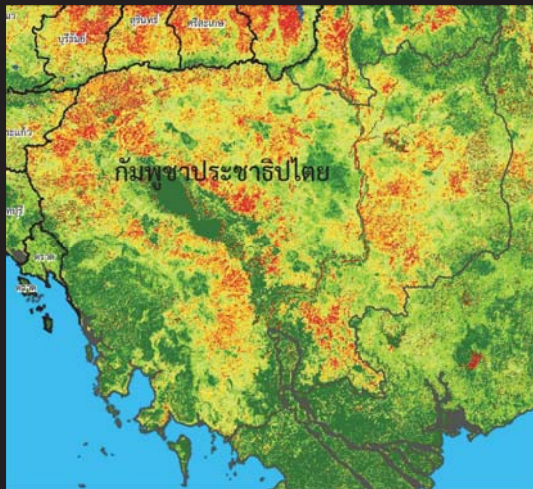
**Cambodia NDWI Map**

**2018**



# Normalized Difference Water Index (NDWI) map from MODIS

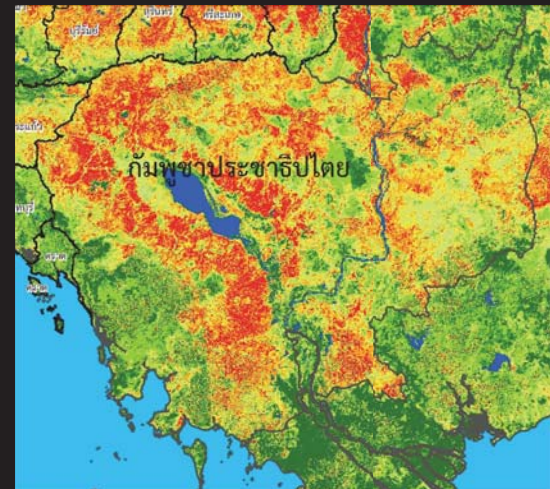
*Weekly NDWI map generated from Thailand Drought System*



Jan 2018



Feb 2018

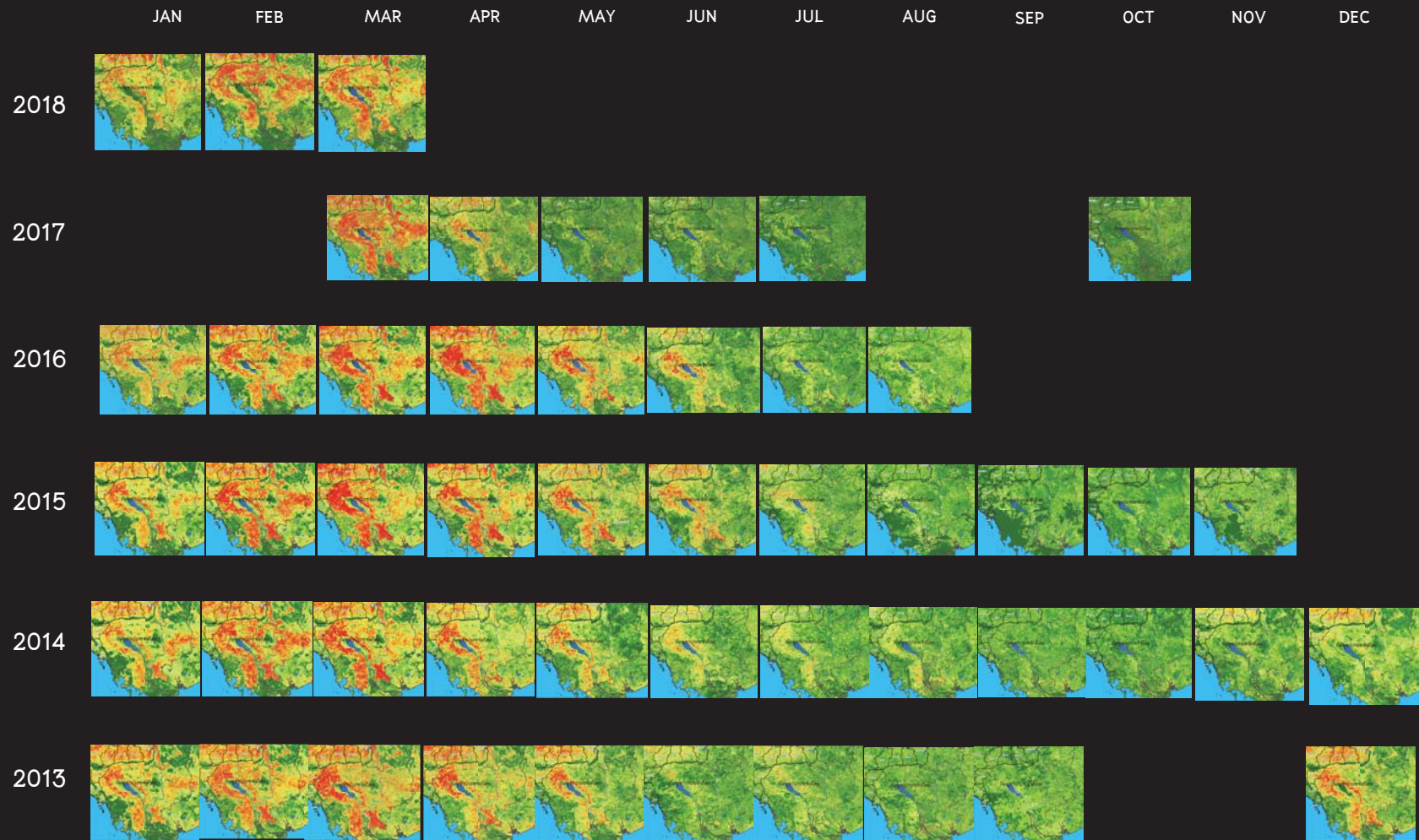


Mar 2018

# Normalized Difference Water Index (NDWI) map from MODIS

## 2013 – 2018

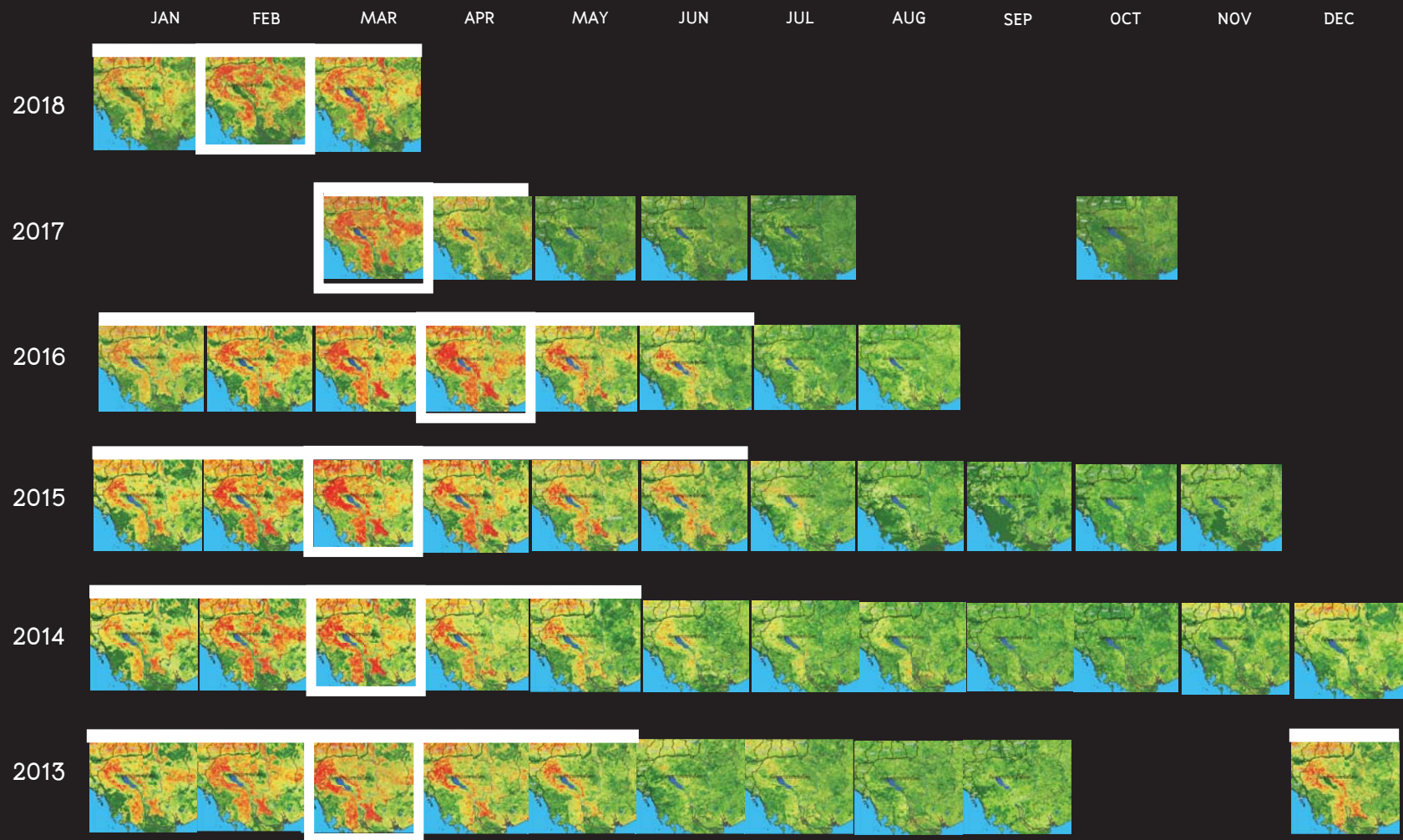
*Weekly NDWI map generated form Thailand Drought System*





# Normalized Difference Water Index (NDWI) map from MODIS

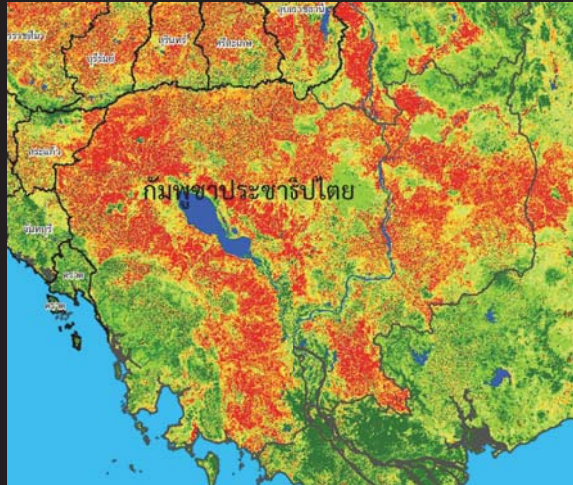
## 2013 – 2018



# Normalized Difference Water Index (NDWI) map from MODIS

*Weekly NDWI map generated from Thailand Drought System*

Mar 2017



Apr 2017



May 2017



Jun 2017



Jul 2017



# Standardized Precipitation Index (SPI)

SPI, based on probability of precipitation for any time scale, widely used index to characterize meteorological drought on a range of timescales and is calculated as :

$$SPI = \frac{X - X_m}{\sigma}$$

Where X = Precipitation for the station

X<sub>m</sub> = Mean precipitation

σ = Standardized deviation

## SPI Drought Classes

Less than -2.00 >>> Extreme drought

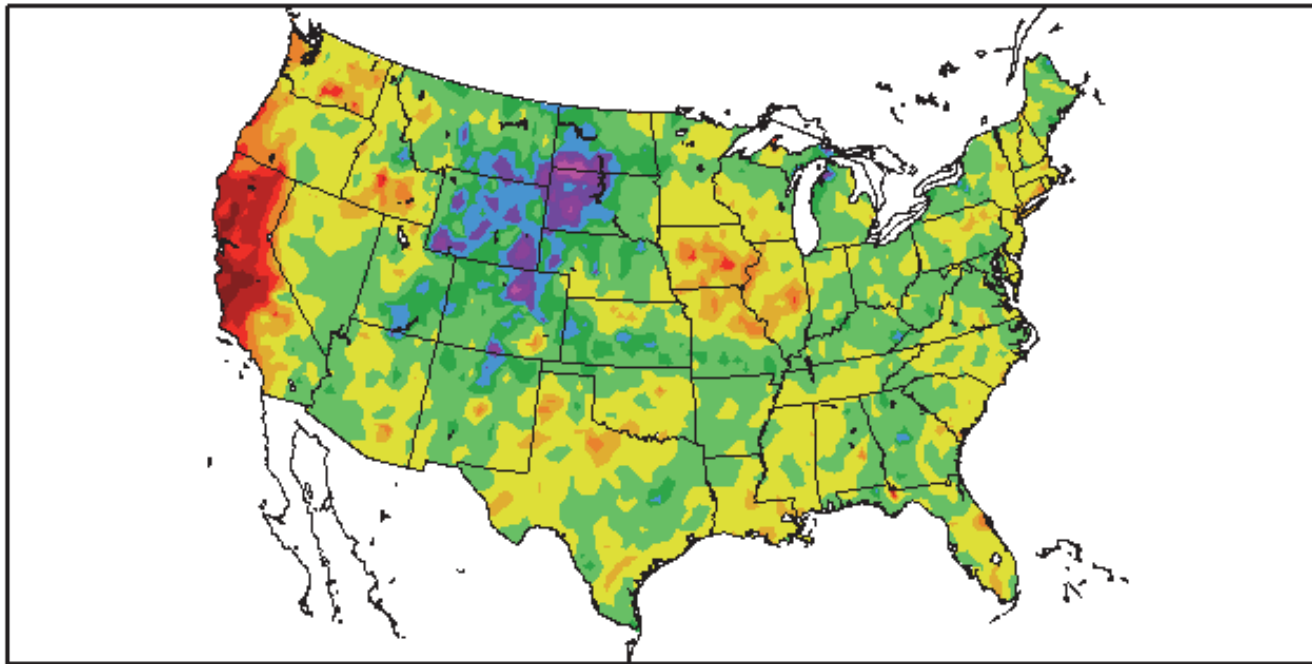
-1.50 to -1.99 >>>> Severe drought

-1.00 to -1.49 >>>> Moderate drought

-0.99 to 0.00 >>>> Mild drought



6 Month SPI  
7/31/2013 – 1/30/2014

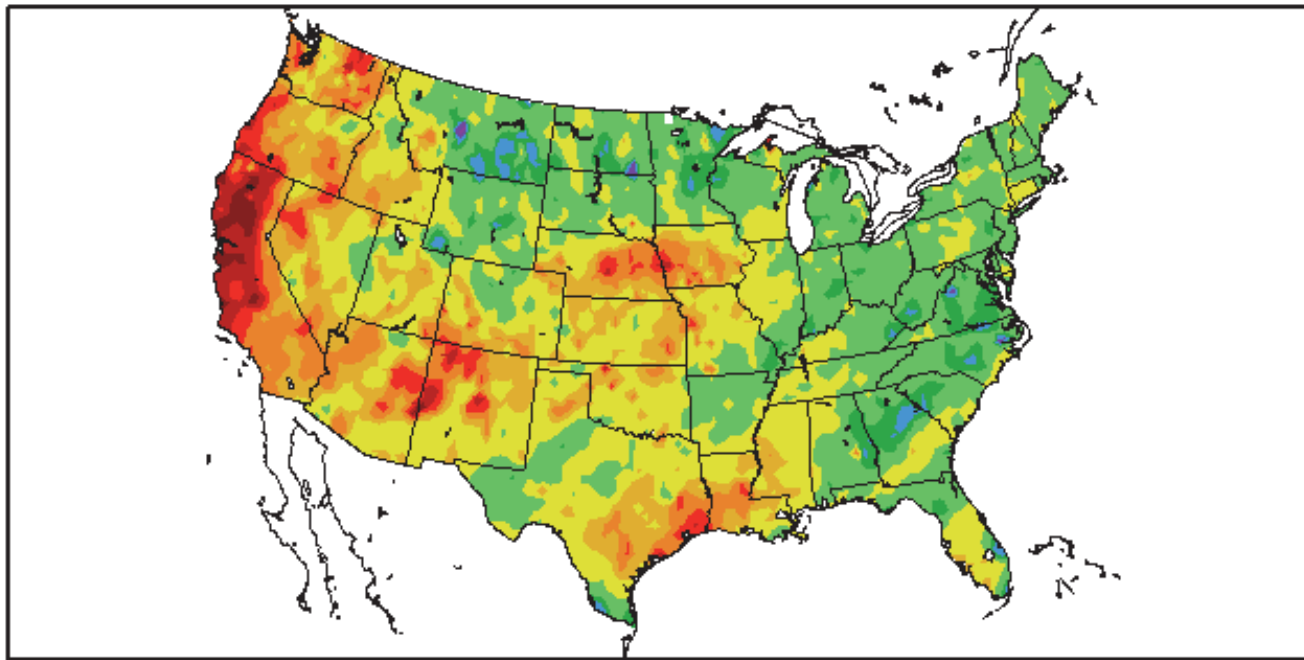


Generated 1/31/2014 at HPRCC using provisional data.

Regional Climate Centers

6-month SPI through January, 2014 capturing drought  
in California and late-summer heavy rains in the Front Range of Colorado

60 Day SPI  
12/2/2013 - 1/30/2014



Generated 1/31/2014 at HPRCC using provisional data.

Regional Climate Centers

2-month SPI through January, 2014 capturing ongoing drought  
in California and near-normal conditions in north-central Colorado.

# Standardized Precipitation Index (SPI)

SPI, based on probability of precipitation for any time scale, widely used index to characterize meteorological drought on a range of timescales and is calculated as :

## **KEY STRENGTHS:**

Uses precipitation only; can characterize drought or abnormal wetness at different time scales which correspond with the time availability of different water resources (e.g. soil moisture, snowpack, groundwater, river discharge and reservoir storage)

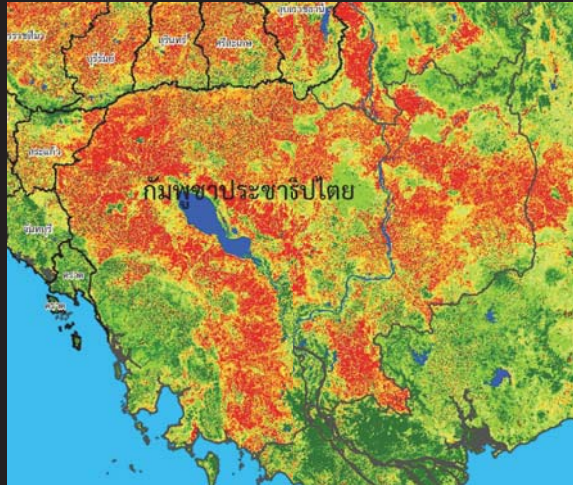
## **KEY LIMITATIONS:**

- As a measure of water supply only, the SPI does not account for evapotranspiration, and this limits its ability to capture the effect of increased temperatures (associated with climate change) on moisture demand and availability
- Sensitive to the quantity and reliability of the data used to fit the distribution; 30-50 years recommended
- Does not consider the intensity of precipitation and its potential impacts on runoff, streamflow, and water availability within the system of interest

# Normalized Difference Water Index (NDWI) map from MODIS

*Weekly NDWI map generated from Thailand Drought System*

Mar 2017



Apr 2017



May 2017



Jun 2017



Jul 2017





# Thank you

Jakrapong Tawala

Geo-infomatics and Outreach Scientist

Geo-infomatics and Space Technology Development Agency (Public Organization) : GISTDA

Ministry of Science and Technology

[jakrapong@gistda.or.th](mailto:jakrapong@gistda.or.th)