Capacity Building

National Training

Drought Management Team

DROUGHT MONITORING AND FORECASTING CONCEPT

Training Course in Sept and Oct 2018

CONTENT

- Background
- Expected outcomes of the training
- Drought indices and references
- Model calculation and data used
- Results and drought early warning website
- Practices

Background

- DMT collaborated with SERVIR Mekong in October 2015 to jointly develop a drought early warning system for the Lower Mekong Basin
- NASA has built up a satellite data hub for both SERVIR and MRCS for nowcast and forecast from 2016-2017
- DMT and SERVIR Mekong have developed their own drought early warning system website but using the same data
- There were some errors in the scripts of RHEAS and therefore MRCS has produced its own products by using the NASA data

Expected Outcomes of the training

After the training, trainees will get built their capacity in:

- Basic GIS and fundamental understanding of Arc Toolbox for image analysis
- Understanding the concept of drought indicator indices including SPI, SRI, SDMI, CDI, and Dry Spells
- Ability to calculate the above drought indices and analyse drought condition for monitoring and forecasting

Drought Indices and Reference

Main indicators for drought monitoring:

❖Meteorological drought indices
- Rainfall anomalies
- Standardize Precipitation Index (SPI)
- Moisture Availability Index
- Dry Spells, Drought Condition, RD

❖ Hydrological drought indices
- Stream flow
- Water level
- Standardized Runoff Index (SRI)
- Groundwater level
- Reservoir storage

❖Agricultural drought indices
- Normalized Difference Vegetation Index
- Normalized Difference Water Index
- Soil Moisture Anomalies
- Soil Moisture Deficit Index (SMDI)
- Temperature Anomalies
- Evapotranspiration deficit

Drought Indices and Reference

- **Meteorological drought** is defined by the degree of dryness in terms of an accumulate rainfall deficit.

- **Hydrological drought** refers to shortages in both surface and ground water which normally presents as low flow condition.

- **Agricultural drought** expresses the precipitation shortfall primarily in terms of its impact upon crop production through insufficient soil moisture.

Drought Indices and Reference

We are using the drought indices of the WMO Handbook of Drought Indicators and Indices 2016:

- Standardized Precipitation Index (SPI1 daily)
- Standardized Runoff Index (SRI1 daily)
- Soil Moisture Deficit Index (SMDI daily)
- Combined Drought Index (CDI daily)
- Dry Spells (Number of days with CDI<-1.5)
- Drought Condition (accumulated dry day for more or less than 15 days)
- Number of No-rain Day (Number of days with rainfall less than 1 mm)

Drought Indices and Reference

Forecast Model:

- **esp**

(Ensemble Streamflow Prediction approach that resamples the climatology)

- Forecast for 90 days

- **iri/nmme (North-American Multi-Model Ensemble)**

Resample climatology based on the probabilities in IRI/NMME meteorological forcing)

- Forecast for 90 days

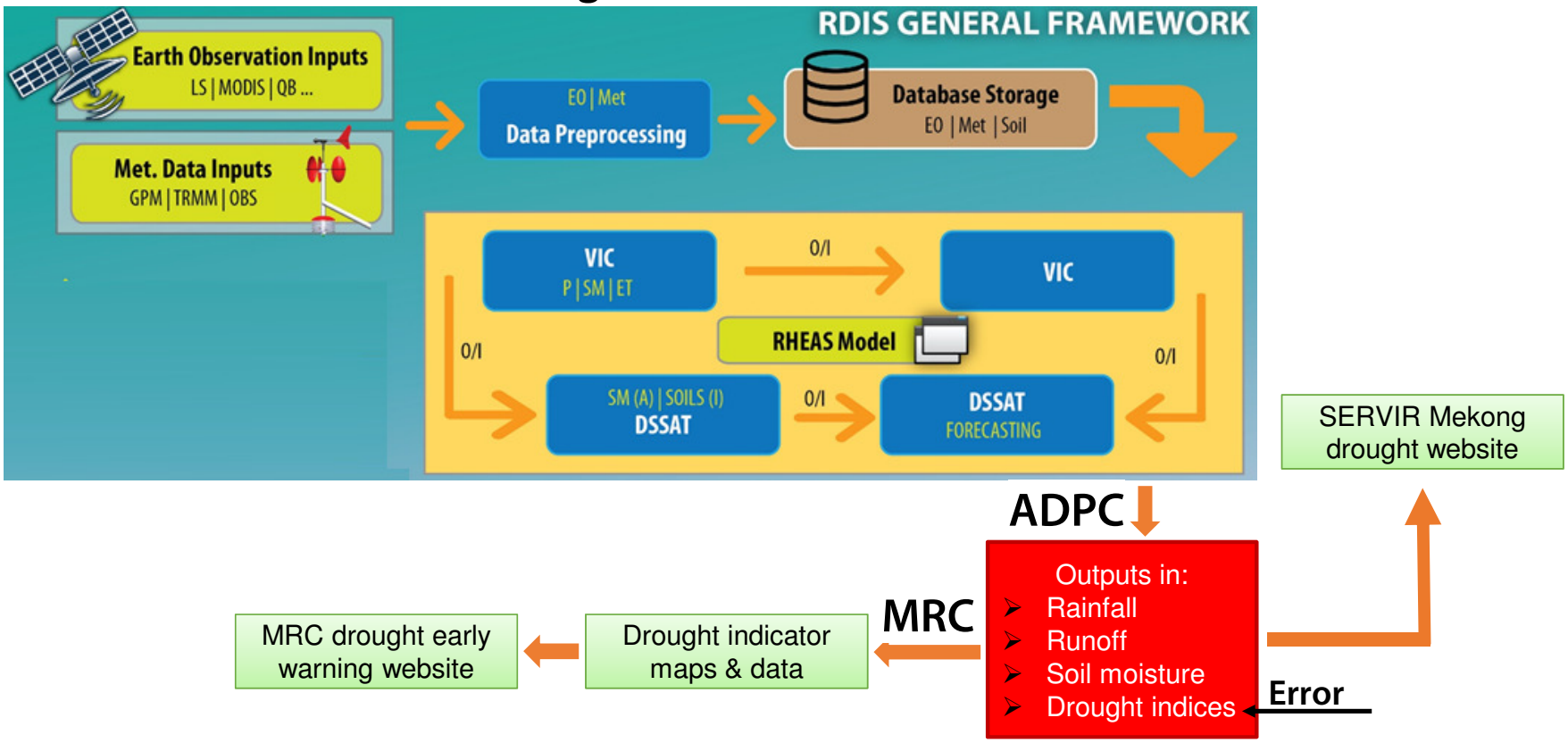
Model Calculation and Data Used

Data Inputs:

Variable	Dataset	Tim. Cov.	Temp. Res	Spat. Res	Spatial Coverage	Table	Mode
Precipitation	CHIRPS	1981-	Daily	5km	Global	precip.chirps	IN
Temp/Wind	NCEP	1981-	Daily	1.875 o	Global	*.ncep	IN
Soil moisture	SMOS	2009-	Daily	~40km	Global	soilm.smos	AS
Meteorology	NMME	2000-	Daily	0.5 o	Global	*.nmme	FC

Model Calculation and Data Used

Data Structure and Processing:



Model Calculation and Data Used

Standardized Precipitation Index (SPI) and **Standardized Runoff Index (SRI)**: SPI & SRI are based on the probability of precipitation and runoff over any duration of interest (days, weeks, months, etc.). SPI can provide early warning that meteorological drought conditions are developing and aid in the assessment of drought severity.

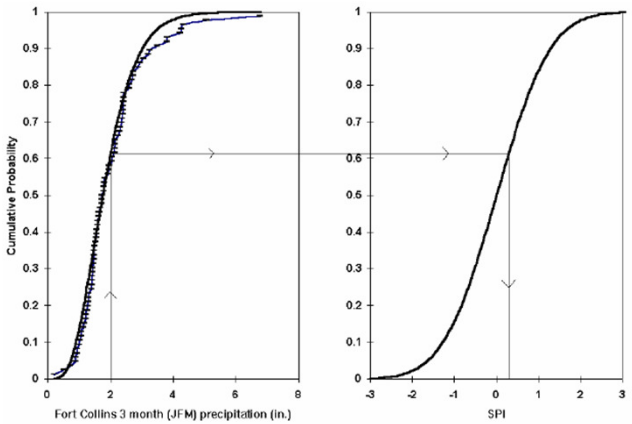
Data source: Daily rainfall and runoff from 1981 to 2018 calculated by VIC (Macro scale hydrologic model) embedded within RHEAS model coming from NASA satellite information. Resolution is 25km.

Model: RHEAS + post processing with ArcGIS application developed by MRCS created with model builder.

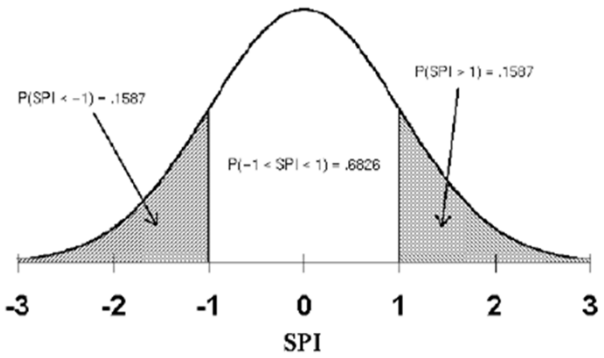
Framework: Statistical analysis by fixing z score to zero using a gamma probabilistic distribution.

Model Calculation and Data Used

Accumulated Gamma probabilistic distribution



z score with normal distribution

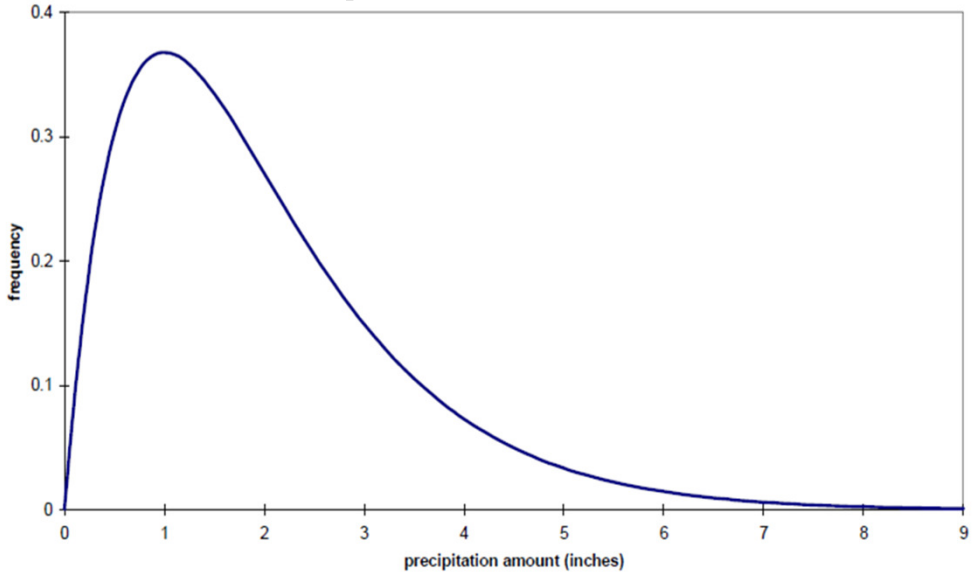


SPI and SRI

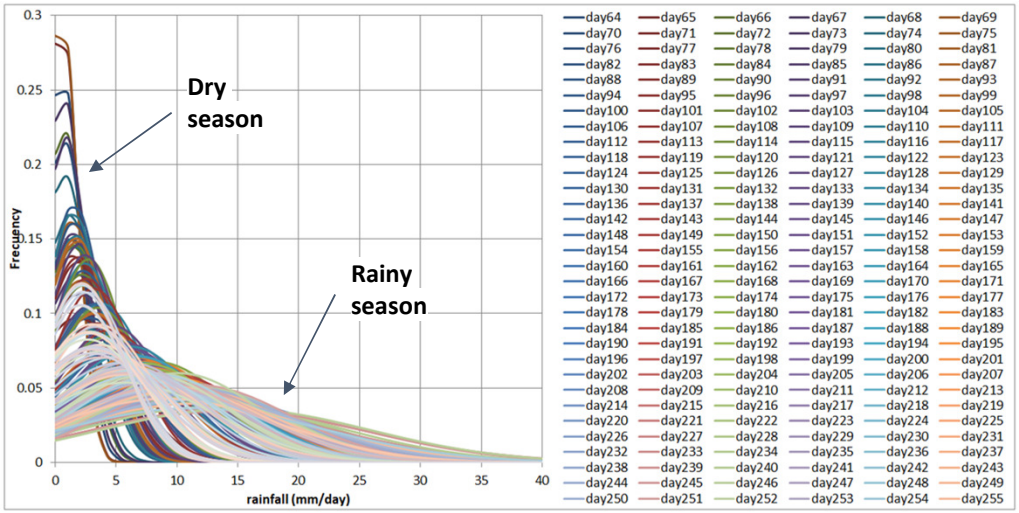
SPI - SRI	Cumulative probability
-3.0	0.0014
-2.5	0.0062
-2.0	0.0228
-1.5	0.0668
-1.0	0.1587
-0.5	0.3085
0.0	0.5000
0.5	0.6915
1.0	0.8413
1.5	0.9332
2.0	0.9772
2.5	0.9938
3.0	0.9986

Model Calculation and Data Used

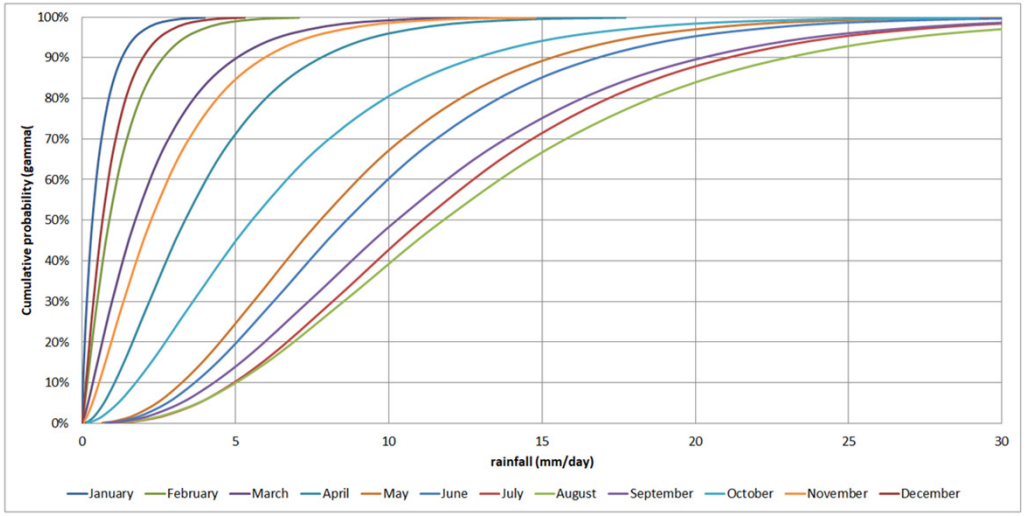
Gamma probabilistic distribution Alpha=2, Beta = 1



Daily gamma probabilistic distribution for LMB

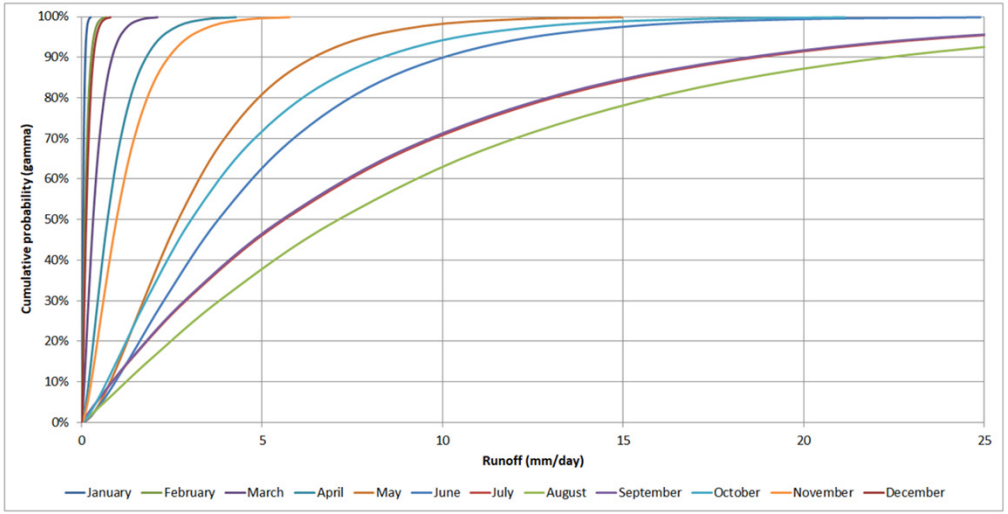


Model Calculation and Data Used



Gamma probabilistic distribution for daily rainfall each month

Gamma probabilistic distribution for daily runoff each month



Model Calculation and Data Used

Soil Moisture Deficit Index (SMDI): Daily soil moisture deficit

Data source: Daily soil moisture layer one from 1981 to 2018 calculated by VIC (Macro scale hydrologic model) embedded within RHEAS model coming from NASA satellite information.

Model: RHEAS + post processing with ArcGIS application developed by MRCS created with model builder. Resolution is 25km.

If $SWi \leq MSWi$

$$\mathrm{SDi} = \frac{\mathrm{SWi} - \mathrm{MSWi}}{\mathrm{MSWi} - \mathrm{minSWi}} \times 100$$

And

$$\mathrm{SMDIi} = 0.5\mathrm{SMDIi} - 1\,\frac{\mathrm{SDi}}{50}$$

If $SWi > MSWi$

$$\mathrm{SDi} = \frac{\mathrm{SWi} - \mathrm{MSWi}}{\mathrm{maxSWi} - \mathrm{MSWi}} \times 100$$

(Shamsnia, Seyed Amir and Dehkordi,Davoud Khodadadi)

- SW: Average daily moisture for a week period
- MSW: median of average daily moisture for a week period
- minSW: minimum of average soil moisture for a week period
- maxSW: maximum of average soil moisture for a week period
- SD: soil moisture deficit (-100 to 100)

Model Calculation and Data Used

Combined Drought Index (CDI): is a combination of three drought indicators of meteorological, hydrological, and agricultural drought.

Ref: National drought monitor of the US, Nebraska university & EU research

Data used: Products of daily SPI, SRI, and SMDI

Model:

$$\boldsymbol{CDI} = \frac{SPI + SRI + 1.5SMDI}{3.5}$$

- We weigh soil moisture index by 1.5 because we consider soil moisture has more influence on agriculture than other two indices

Model Calculation and Data Used

Drought Condition: Calculating long and short-term drought through CDI value less than -1.

Data used: Products of daily CDI

Consecutive value of <-1,5 more than 15 days is considered long-term drought

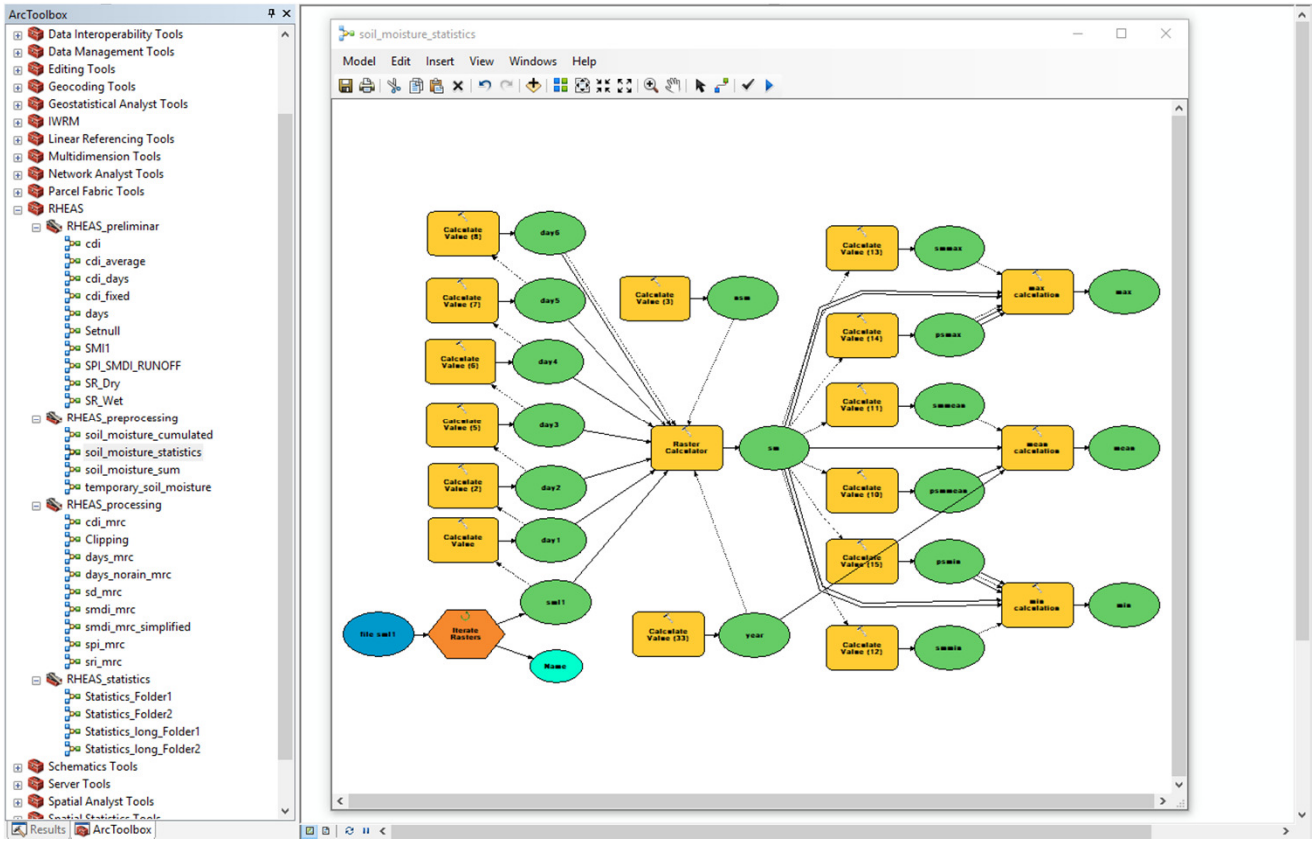
Consecutive value of <-1,5 between 1 to 15 days is considered short-term drought

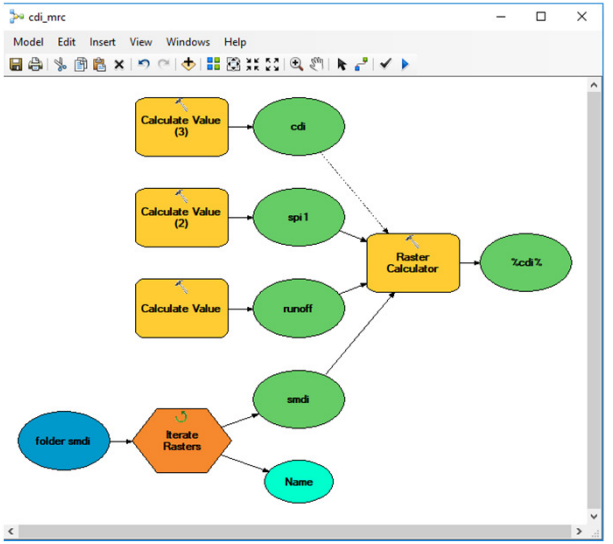
Model Calculation and Data Used

Number of No-rain-day: Calculated by summing up consecutive daily rainfall. The value less than 1mm a day is considered as no-rain-day.

Data used: Daily rainfall from 1981 to 2018 calculated by VIC (Macro scale hydrologic model) embedded within RHEAS model coming from NASA satellite information.

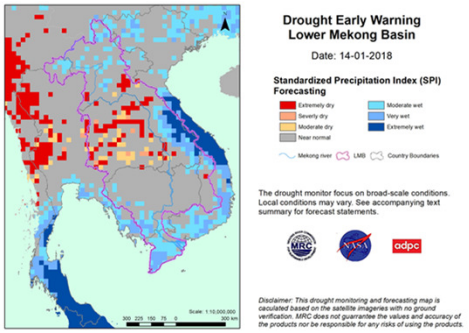
Model Calculation and Data Used

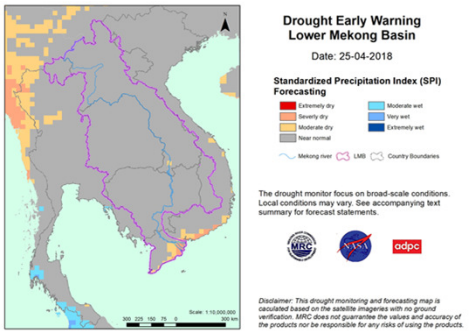




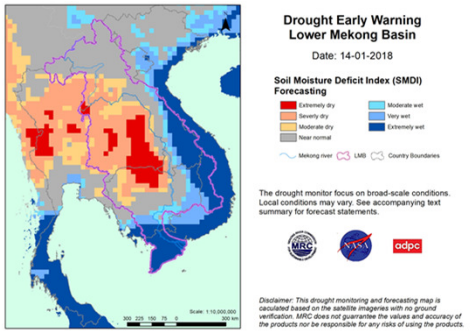
Results and the website

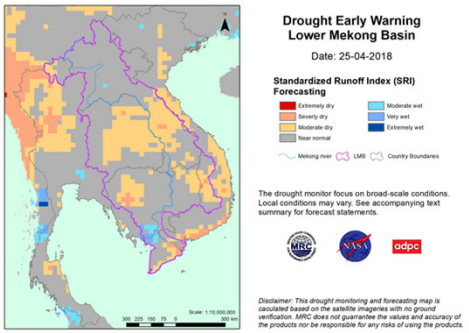
SPI



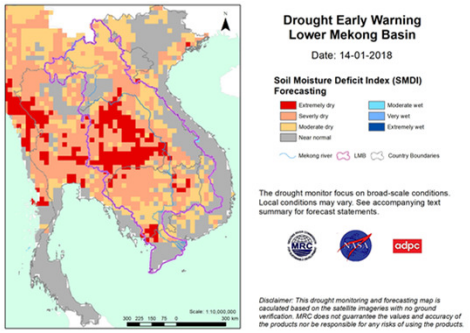


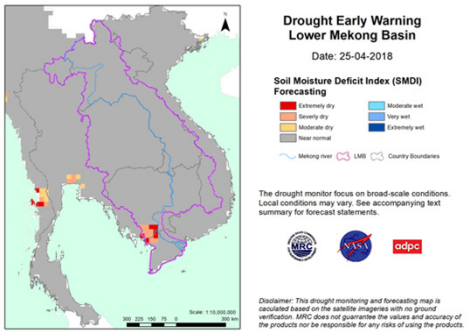
SRI



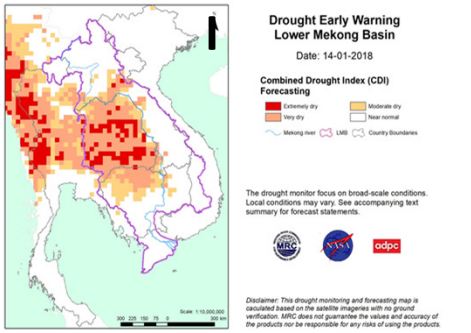


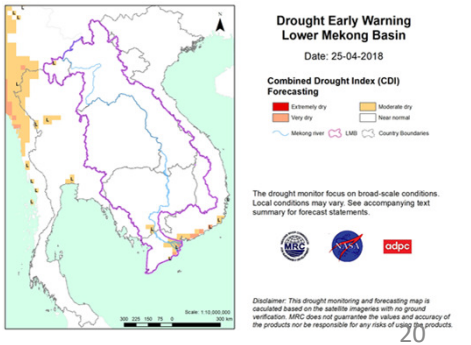
SMDI





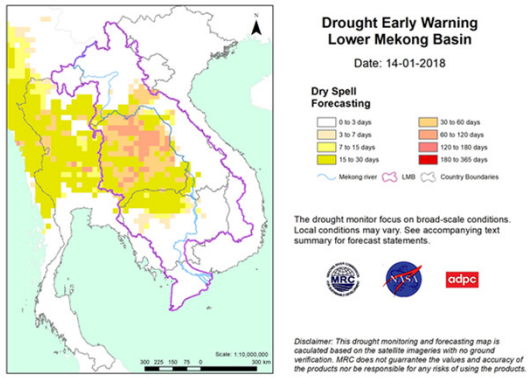
CD

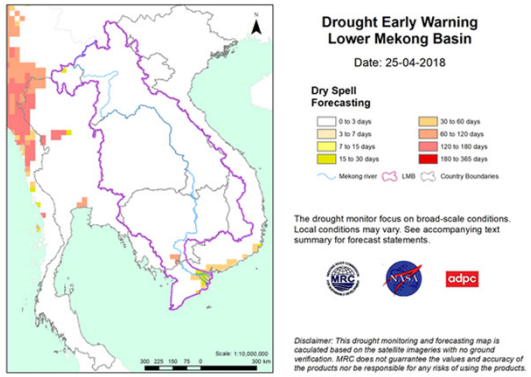




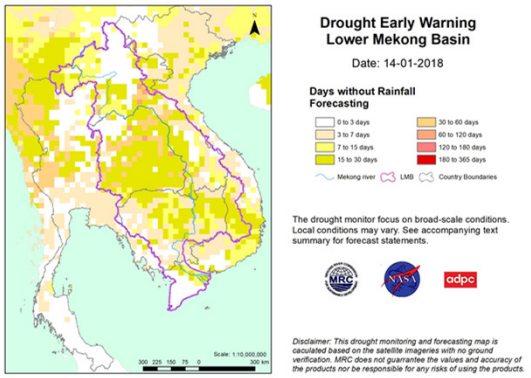
Results and the website

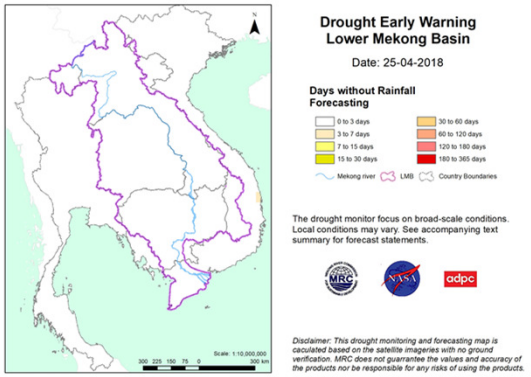
Dryspell



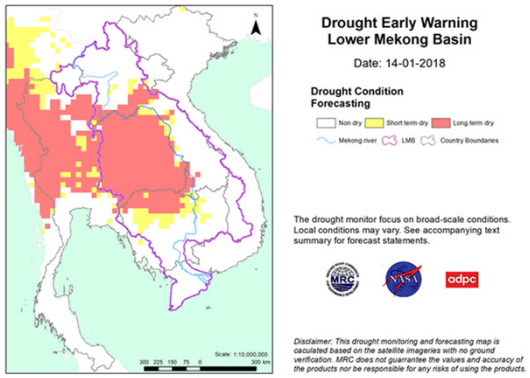


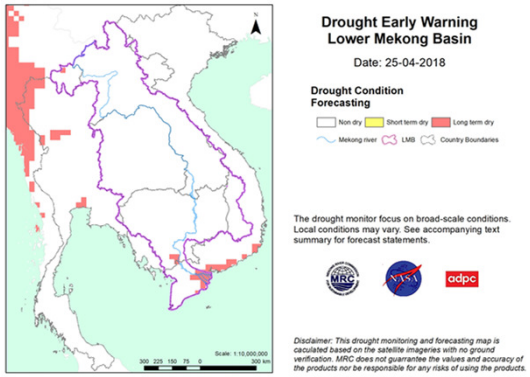
Non rain days





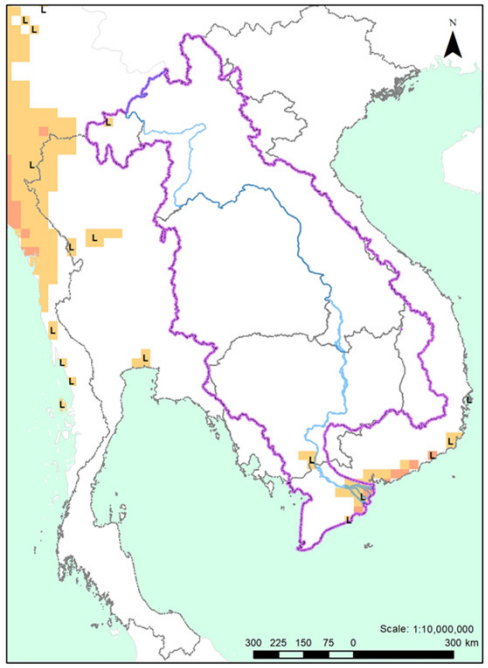
Drought Condition





Results and the website

Lower Mekong Basin
Drought Monitoring and Forecasting



Drought Early Warning
Lower Mekong Basin

Date: 25-04-2018

Combined Drought Index (CDI) Forecasting

Extremely dry
Very dry
Moderate dry
Near normal
Mekong river
LMB
Country Boundaries

The drought monitor focus on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Disclaimer: This drought monitoring and forecasting map is caculated based on the satellite imageries with no ground verification. MRC does not guarrantee the values and accuracy of the products nor be responsible for any risks of using the products.

Practices

- **ArcGIS Software Installation**
- **Data Preparation**
- **Application Practice**

THANK YOU VERY MUCH!