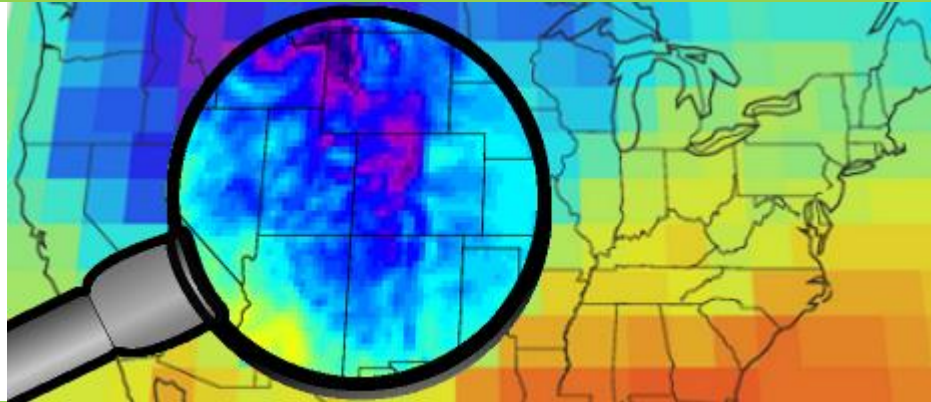
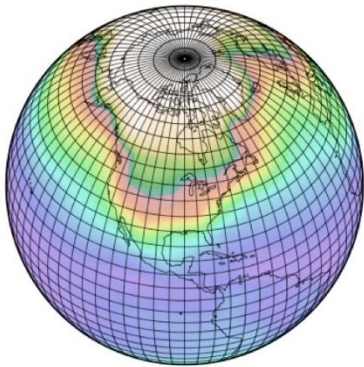




# Drought Monitoring and Forecasting using *rDrought*



**Jaepil Cho**

**2016/08/25**

# Overview

## 1. Introduction

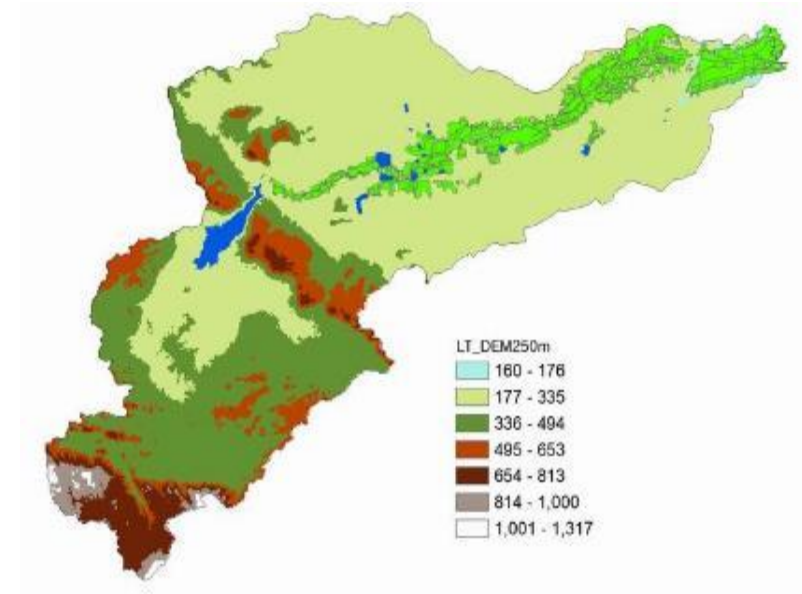
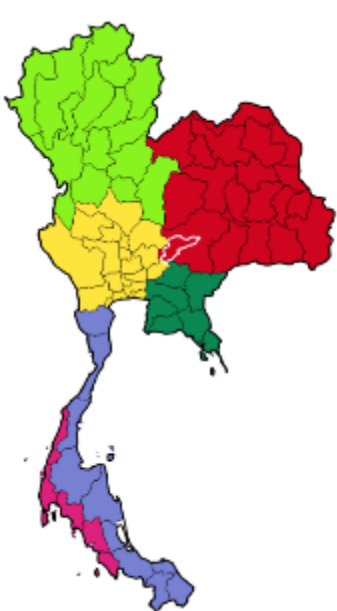
## 2. Effective Drought Index (EDI)

## 3. Drought Monitoring & Forecasting

- ❖ Monitoring
- ❖ Climate change impacts
- ❖ Seasonal forecasting

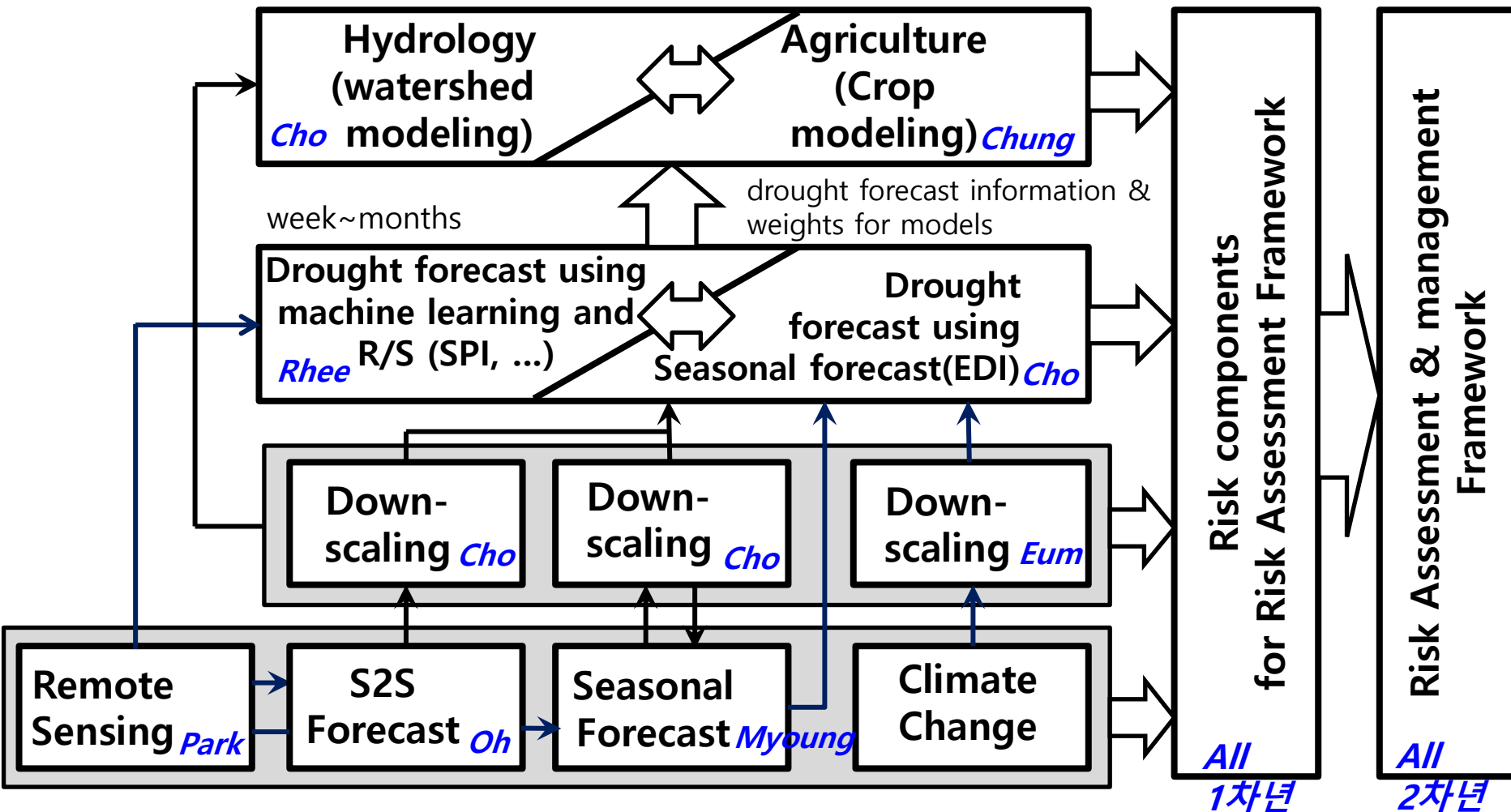
# Introduction

## Climate information-based Water-Agriculture Risk Assessment (Cli-WARA)

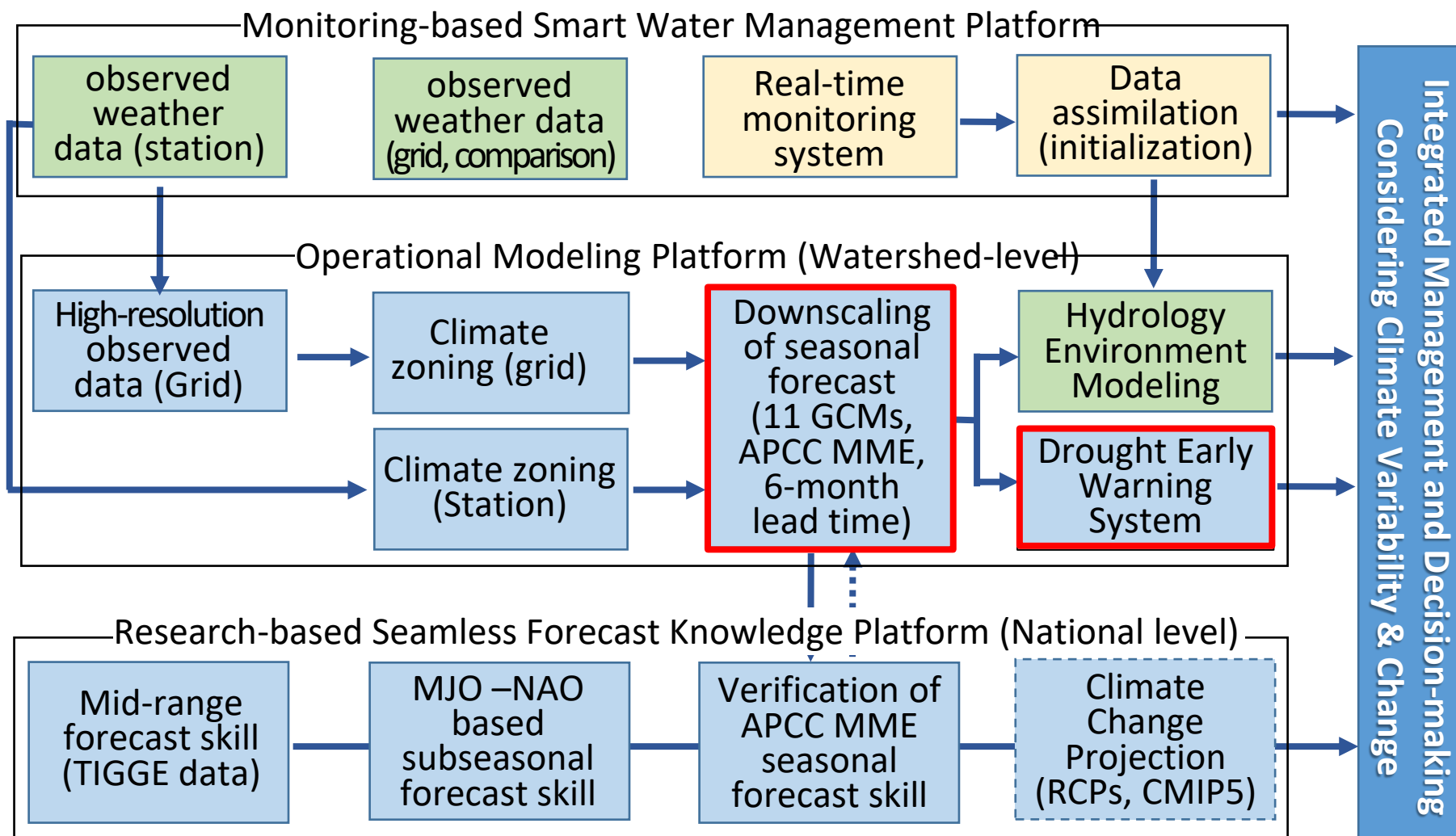


# Project Overview

Forecast mixing in daily time-step (S2S and Seasonal)



# Strategic plan on the collaborative project (KWPA)



# Objectives and Contents

- Understanding of physical mechanisms contributing to climate variability at sub-seasonal to interannual time scale
- Evaluating predictability at sub-seasonal to interannual time range over 6 main river basins in Iran will be analyzed
- Climate zones will be determined over three river basins Khuzestan province
- Producing high resolution gridded datasets for precipitation and temperature at daily and monthly time scale
- Statistical downscaling of dynamic seasonal climate model outputs
- Developing a system to detect and forecast drought based on several meteorological drought indices
- Capacity building programs that might include organizing training programs, research exchange

# Effective Drought Index (EDI)

## Objective Quantification of Drought Severity and Duration

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DONALD A. WILHITE

*National Drought Mitigation Center, University of Nebraska, Lincoln, Nebraska*

(Manuscript received 17 March 1998, in final form 12 August 1998)

### ABSTRACT

Common weaknesses of current drought indexes were analyzed. First, most of the current indexes are not precise enough in detecting the onset, end, and accumulated stress of drought. Second, they do not effectively take into account the aggravating effects of runoff and evapotranspiration, which build up with time. Third, they have a limited usefulness in monitoring ongoing drought because they are based on a monthly time step. Fourth, most of them fail to differentiate the effects of drought on surface and subsurface water supply.

A new series of indexes are proposed to solve these weaknesses and to improve drought monitoring. In the new indexes, daily, rather than monthly, time steps are used. A new concept, effective precipitation (EP), the summed value of daily precipitation with a time-dependent reduction function, is proposed as a basic tool.

Three additional indexes complement EP. The first index is each day's mean of EP (MEP). This index shows climatological characteristics of precipitation as a water resource for a station or area. The second index is the deviation of EP (DEP) from the MEP. The third index is the standardized value of DEP (SEP). By using these three indexes, consecutive days of negative SEP, which can show the onset, the ending date, and the duration of a water deficit period is categorized.

With the duration categorized, four additional indexes that can show drought severity are calculated: 1) accumulation of consecutive negative SEP, which shows the duration and severity of precipitation deficit together; 2) accumulated precipitation deficit, which shows precipitation departure from the normal during a defined period; 3) precipitation for the return to normal; and 4) effective drought index, a standardized index that can be used to assess drought severity worldwide. The merits and weaknesses of each index are compared. New quantified definitions on drought and its onset, end, and duration are proposed.

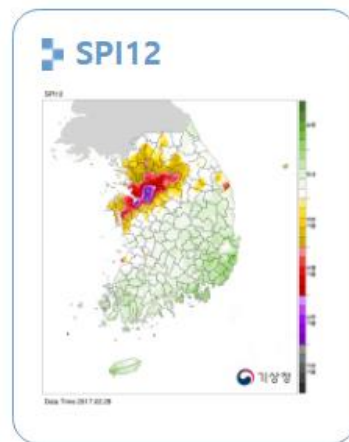
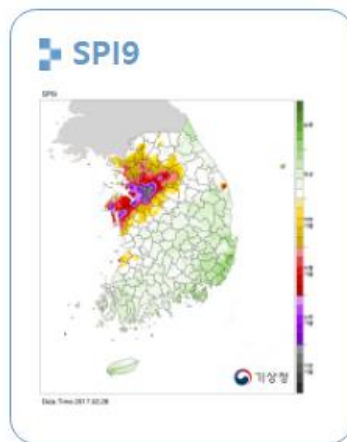
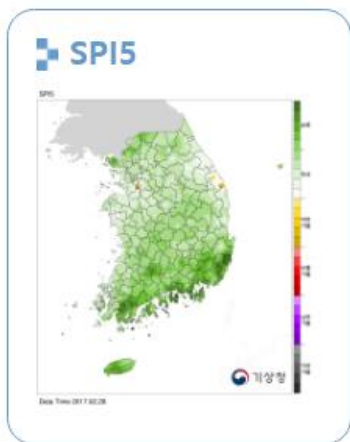
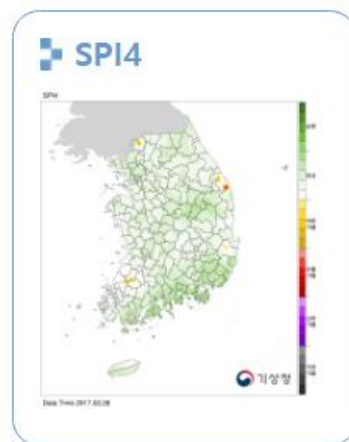
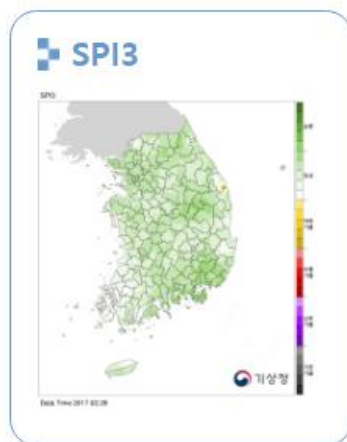
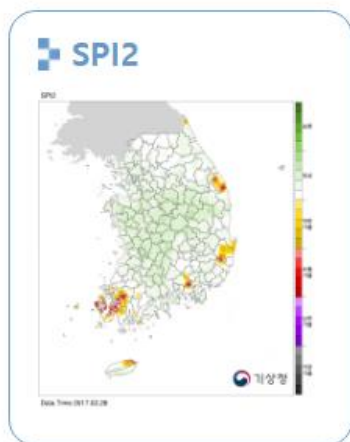
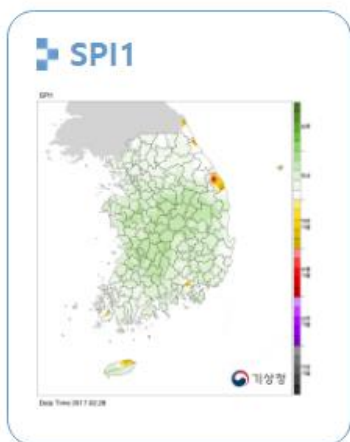
These indexes were tested in the High Plains region of the United States from 1960 to 1996. The results were compared to historical reports of drought. From this analysis, it was concluded that the new indexes not only advanced objectivity, but also offered a number of advantages in practical use. These are 1) a more precise determination of drought duration, 2) the usefulness in monitoring an ongoing drought, and 3) the variety of ways a drought's characteristics can be described.



EDI(Effective Drought Index, Byun and Wilhite, 1999)

# Drought monitoring by KMA using SPI

Which one is representing current drought situation?



# Concept of EDI: Effective Precipitation

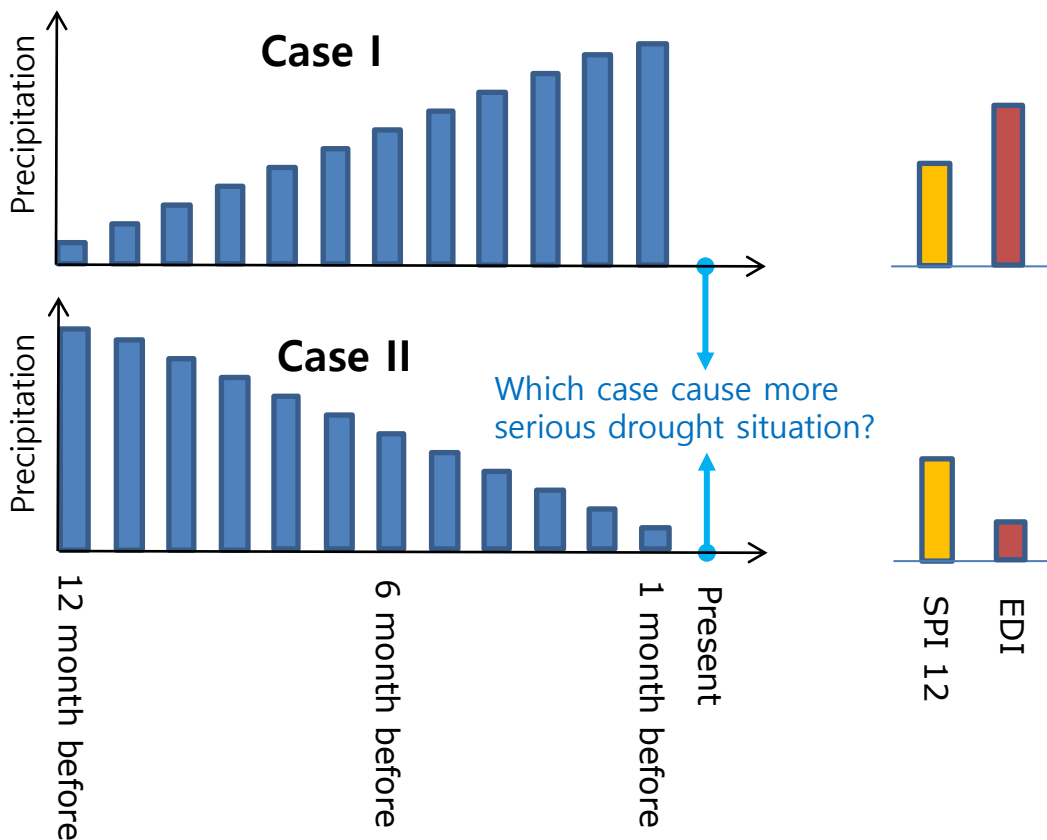
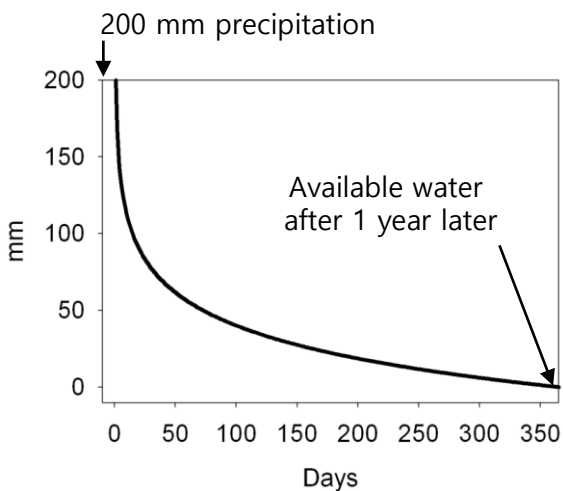
EP (Effective Precipitation)

$$EP_i = \sum_{n=1}^i \left[ \left( \frac{\sum_{m=1}^n P_m}{n} \right) \right]$$

$$DEP = EP - MEP$$

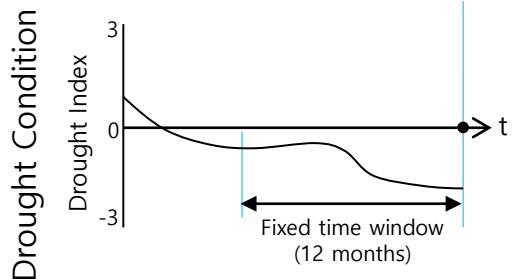
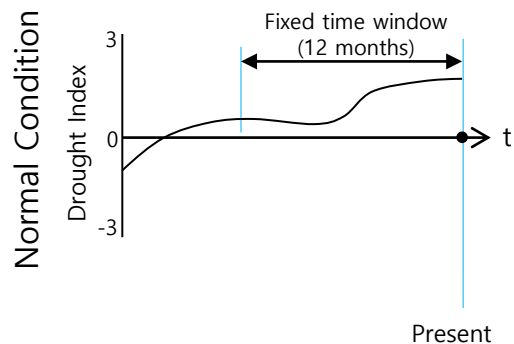
$$EDI = DEP / ST(DEP)$$

Available water decrease as time goes on

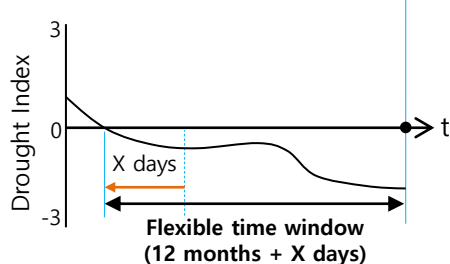
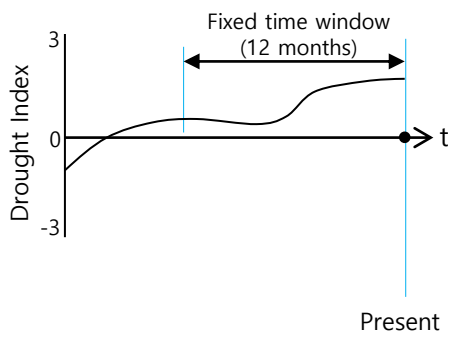


# Concept of EDI: Flexible Time Window

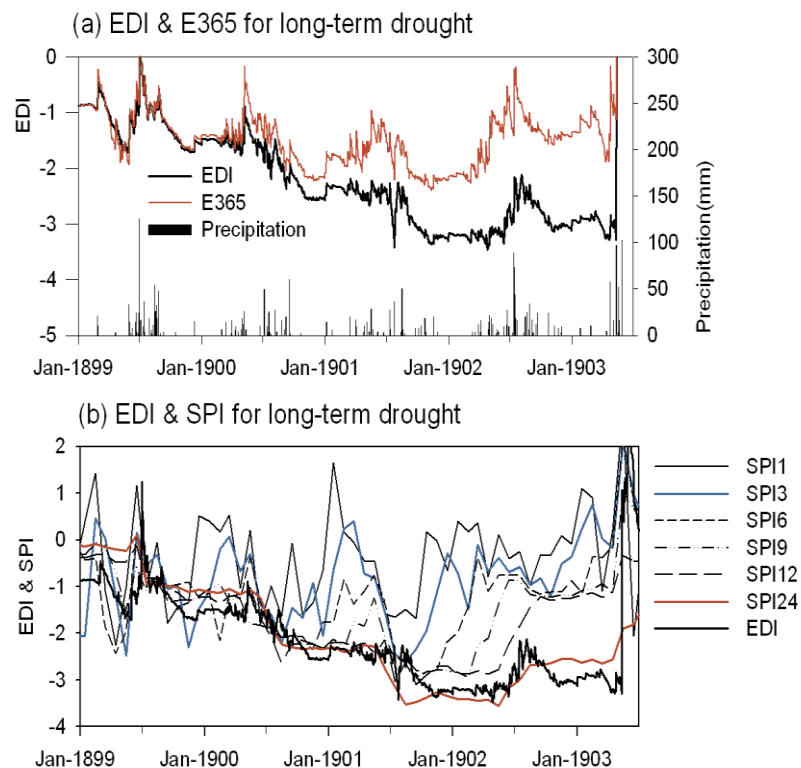
## SPI 12



## EDI



Long-term drought situation



Kim et al., 2009 (Evaluation, modification, and application of the Effective Drought Index to 200-Year drought climatology of Seoul, Korea)

# Consistent drought diagnosis for short-term drought

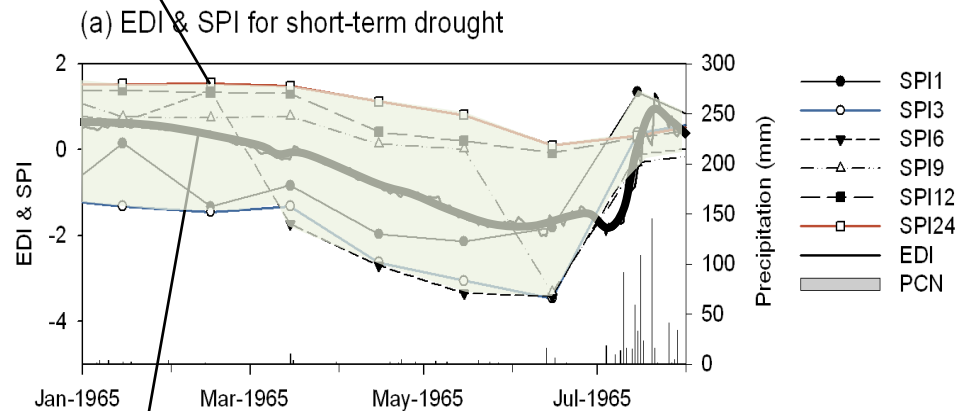
**Table 3**

Sample correlation matrix of Pearson product-moment correlation coefficients computed between paired values of drought index time series for Sagar district.

Row no.	Drought Index	EDI	SPI-1	SPI-3	↔	RDDI-6	RDDI-9	RDDI-12
	1	2	3	4		25	26	27
1	EDI	1.00	0.45	0.64	...	0.72	0.81	0.78
2	SPI-1	0.45	1.00	0.51	...	0.34	0.27	0.23
3	SPI-3	0.64	0.51	1.00	...	0.58	0.45	0.40
4	SPI-6	0.81	0.37	0.63	...	0.91	0.68	0.60
5	SPI-9	0.92	0.30	0.50	...	0.67	0.91	0.79
6	SPI-12	0.87	0.26	0.43	...	0.61	0.78	0.91
↓	...	...	...	...	...	...	...	...
19	RD-6	0.69	0.32	0.53	...	0.77	0.51	0.44
20	RD-9	0.89	0.30	0.47	...	0.60	0.84	0.70
21	RD-12	0.88	0.26	0.44	...	0.59	0.76	0.88
22	RDDI-1	0.36	0.88	0.41	...	0.30	0.23	0.19
23	RDDI-3	0.56	0.49	0.91	...	0.57	0.45	0.39
24	RDDI-6	0.72	0.34	0.58	...	1.00	0.69	0.61
25	RDDI-9	0.81	0.27	0.45	...	0.69	1.00	0.81
26	RDDI-12	0.78	0.23	0.40	...	0.61	0.81	1.00
27	Average correlation	<b>0.72</b>	<b>0.46</b>	<b>0.59</b>	...	<b>0.60</b>	<b>0.60</b>	<b>0.57</b>
28	Average correlation of same time steps*		<b>0.92</b>	<b>0.95</b>	...	<b>0.88</b>	<b>0.91</b>	<b>0.92</b>

\* The average in column SPI-3 is computed from the average correlation of SPI-3 with 3-monthly time step of DIs such as SPI-3, Z-Score-3, CZI-3, RD-3, RDDI-3 and average in column RDDI-6 is computed from the average correlation of RDDI-6 with 6-monthly time step of DIs such as SPI-6, Z-Score-6, CZI-6, RD-6 and RDDI-6.

SPIs: inconsistent drought diagnosis



Kim et al., 2009(Evaluation, modification, and application of the Effective Drought Index to 200-Year drought climatology of Seoul, Korea)

EDI: determined drought diagnosis

- Effective Drought Index (EDI)
- Standardized Precipitation Index(SPI)
- China Z-Index (CZI)
- Statistical Z-Score (Z-Score)
- Rainfall deciles based drought index(RD)
- Rainfall deciles based drought index (RDDI)

# Other EDI applications

INTERNATIONAL JOURNAL OF CLIMATOLOGY

Int. J. Climatol. 26: 971–985 (2006)

Published online 20 April 2006 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/joc.1264

## COMPARISON OF SEVEN METEOROLOGICAL INDICES FOR DROUGHT MONITORING IN IRAN

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Received 11 January 2004

Revised 9 August 2005

Accepted 6 August 2005

### ABSTRACT

Drought monitoring is an essential component of drought risk management. It is normally performed using various drought indices that are effectively continuous functions of rainfall and other hydrometeorological variables. A number of drought indices have been introduced and applied in different countries to date. This paper compares the performance of seven indices for drought monitoring in the Tehran province of Iran. The indices used include deciles index (DI), percent of normal (PN), standard precipitation index (SPI), China-Z index (CZI), modified CZI (MCZI), Z-Score and effective drought index (EDI). The comparison of indices is based on drought cases and classes that were detected in the province over the 32 years of data, as well as over the latest 1998–2001 drought spell. The results show that SPI, CZI and Z-Score perform similarly with regard to drought identification and respond slowly to drought onset. DI appears to be very responsive to rainfall events of a particular year, but it has inconsistent spatial and temporal variation. The SPI and EDI were found to be able to detect the onset of drought, its spatial and temporal variation consistently, and it may be recommended for operational drought monitoring in the Province. However, the EDI was found to be more responsive to the emerging drought and performed better. Copyright © 2006 Royal Meteorological Society.

KEY WORDS: drought monitoring; drought indices; Tehran province; Iran

*The EDI was found to be more responsive to the emerging drought conditions compared with the DI and the SPI, particularly during the 1998–2001 drought spell. Also, compared to other indices, the EDI was found to be able to describe developing drought conditions well – spatially and temporally. The EDI efficiency can be related to the concept of effective precipitation (EP) that the index uses. However, the requirement of a continuous daily precipitation record can be a serious limitation for the wider use of the EDI.*



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Journal of Hydrology

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Comparison of multi-monthly rainfall-based drought severity indices, with application to semi-arid Konya closed basin, Turkey

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<sup>c</sup> Department of Civil & Environmental Engineering, Texas A&M University, College Station, TX 77843, USA

*EDI is preferable for monitoring long term droughts in arid/semi-arid regions even if the input is monthly rainfall data. EDI is recommended for use in comparison studies, since it is timestep independent index and has good correlations with various timesteps of other DIs.*

### ARTICLE INFO

Article history:  
Received 12 May 2012  
Received in revised form 20 July 2012  
Accepted 1 September 2012  
Available online 12 September 2012  
This manuscript was handled by Geoff Syme, Editor-in-Chief

Keywords:  
Drought indices (DIs)  
Drought severity  
Effective Drought Index (EDI)  
Konya closed basin  
Rainfall

### SUMMARY

Many drought indices (DIs) have been introduced to monitor drought conditions. This study compares Percent of Normal (PN), Rainfall Decile based Drought Index (RDDI), statistical Z-Score, China-Z Index (CZI), Standardized Precipitation Index (SPI), and Effective Drought Index (EDI) to identify droughts in a semi-arid closed basin (Konya), Turkey. Comparison studies of DIs under different climatic conditions is always interesting and may be insightful. Employing and comparing 18 different timesteps, the objective of comparison is twofold: (1) to determine the effect of timestep for choosing an appropriate value, and (2) to determine the sensitivity of DI to timestep and the choice of a DI. Monthly rainfall data obtained from twelve spatially distributed stations was used to compare DIs for timesteps ranging from 1 month to 48 months. These DIs were evaluated through correlations for various timesteps. Surprisingly, in many earlier studies, only 1-month time step has been used. Results showed that the employment of median timesteps was essential for future studies, since 1-month timestep DIs were found as irrelevant to those for other timesteps in arid/semi-arid regions because seasonal rainfall deficiencies are common there. Comparing time series of various DI values (numerical values of drought severity) instead of drought classes was advantageous for drought monitoring. EDI was found to be best correlated with other DIs when considering all timesteps. Therefore, drought classes discerned by DIs were compared with EDI. PN and RDDI provided different results than did others. PN detected a decrease in drought percentage for

## Introduction of East Asian Drought Monitoring System

Su-Bin Oh<sup>1</sup>, Do-Woo Kim<sup>1</sup>, Ki-Seon Choi<sup>2</sup>, and Hi-Ryong Byun<sup>1</sup>

<sup>1</sup>Department of environmental atmospheric sciences, Pukyong National University, Busan, Republic of Korea

<sup>2</sup>Korea Meteorological Administration, Seoul, Republic of Korea

### Abstract

This paper introduces the East Asian drought monitoring system that has been operational since 2008 (<http://atmos.pknu.ac.kr/~intra2>). It provides the spatial and temporal distribution of droughts using variables such as the drought intensity and duration. The main feature of this system is the effective drought index (EDI; Byun and Wilhite 1999) in which the drought intensity is calculated by considering cumulative precipitation as a weighting function of time. In addition, this system provides an available water resources index (AWRI; Byun and Lee 2002), which represents the hydrological index. These indexes were calculated using the monthly precipitation data obtained from 298 stations in East Asia (Republic of Korea, Democratic People's Republic of Korea, Japan, and China). Information on drought is provided in terms of monthly spatial distribution and is presented in the text and a time series. The period of data collection differs according to the observation start dates of the stations, and the longest period of data collection (Seoul, Korea) started in 1778. This system will contribute to drought prevention by diagnosing drought in real time. It will also provide fundamental data for further studies on drought by detecting the time and location of droughts.

### 1. Introduction

Drought has traditionally been the greatest natural disaster threatening the human population. According to the National Drought Mitigation Center (NDMC), drought causes the greatest damage among all disasters. Four worldwide droughts have been listed by the National Oceanic and Atmospheric Administration as being in the top five greatest natural disasters of the 20<sup>th</sup> century

([www.bcc.cma.gov.cn](http://www.bcc.cma.gov.cn)) provides the spatial distribution information on droughts using the SPI and the percentage of precipitation anomaly. It also provides the spatial distribution of the drought index and the flood index globally and in the East Asian region. Boken et al. (2005) studied the monitoring system of each country.

However, the existing monitoring systems have limitations. First, they provide only limited data. Most systems currently provide only the spatial distribution of droughts and do not provide the time series and index value of drought. Therefore, we cannot obtain the exact drought index value and drought variability for each station. In addition, researchers are required to calculate the drought index for their studies.

Second, each monitoring system uses a different drought index, and the calculated index values are not identical. The most important factor is the technology used for drought quantification in order to monitor drought. However, there are problems with the PDSI and SPI, which are currently the most widely used indexes. Because the PDSI was developed for the Great Plains in the US, it is difficult to apply this index to other regions without modification. In addition, not only precipitation but also evapotranspiration and outflow are used for the calculation, which causes additional complications. The calculation of duration in the SPI method differs according to the subjective view of researchers, and thus, the state of drought can vary with different monitoring systems, even for the same date. Kim et al. (2009) have presented an in-depth comparative analysis of the weakness of SPI.

Third, the existing systems provide only short-term data. Most drought monitoring systems only show drought intensity since 2000, and some monitoring systems only show data in real time. This is inappropriate for studying drought on a long-term basis.

In this study, a new system is presented that overcomes the shortcomings of the existing monitoring systems. Importantly, the system calculates the drought index since 1778 (Seoul, Korea)

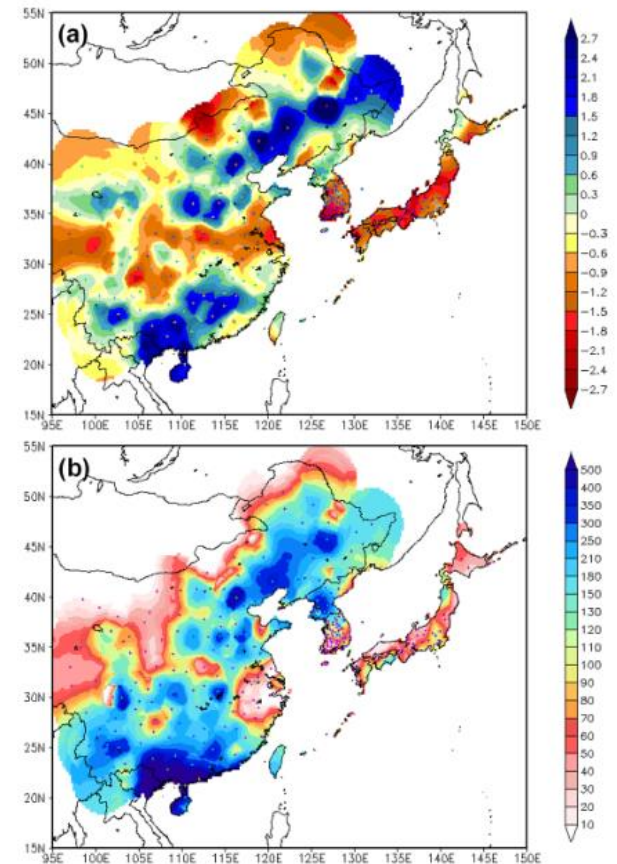


Fig. 5. The spatial distributions of (a) EDI and (b) precipitation in Jul. 1994.

<http://atmos.pknu.ac.kr/~intra2>

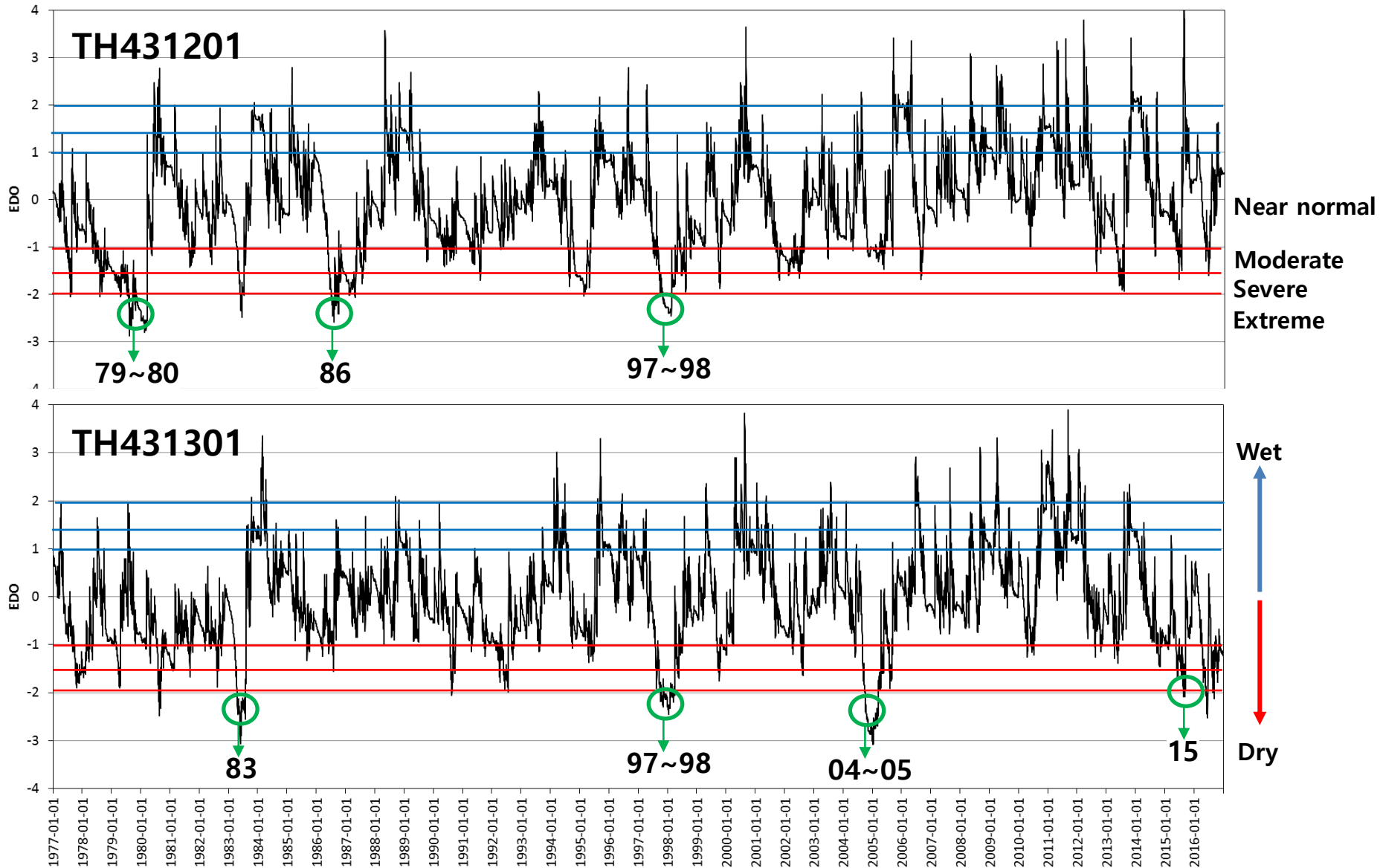


# Drought Monitoring and Forecasting

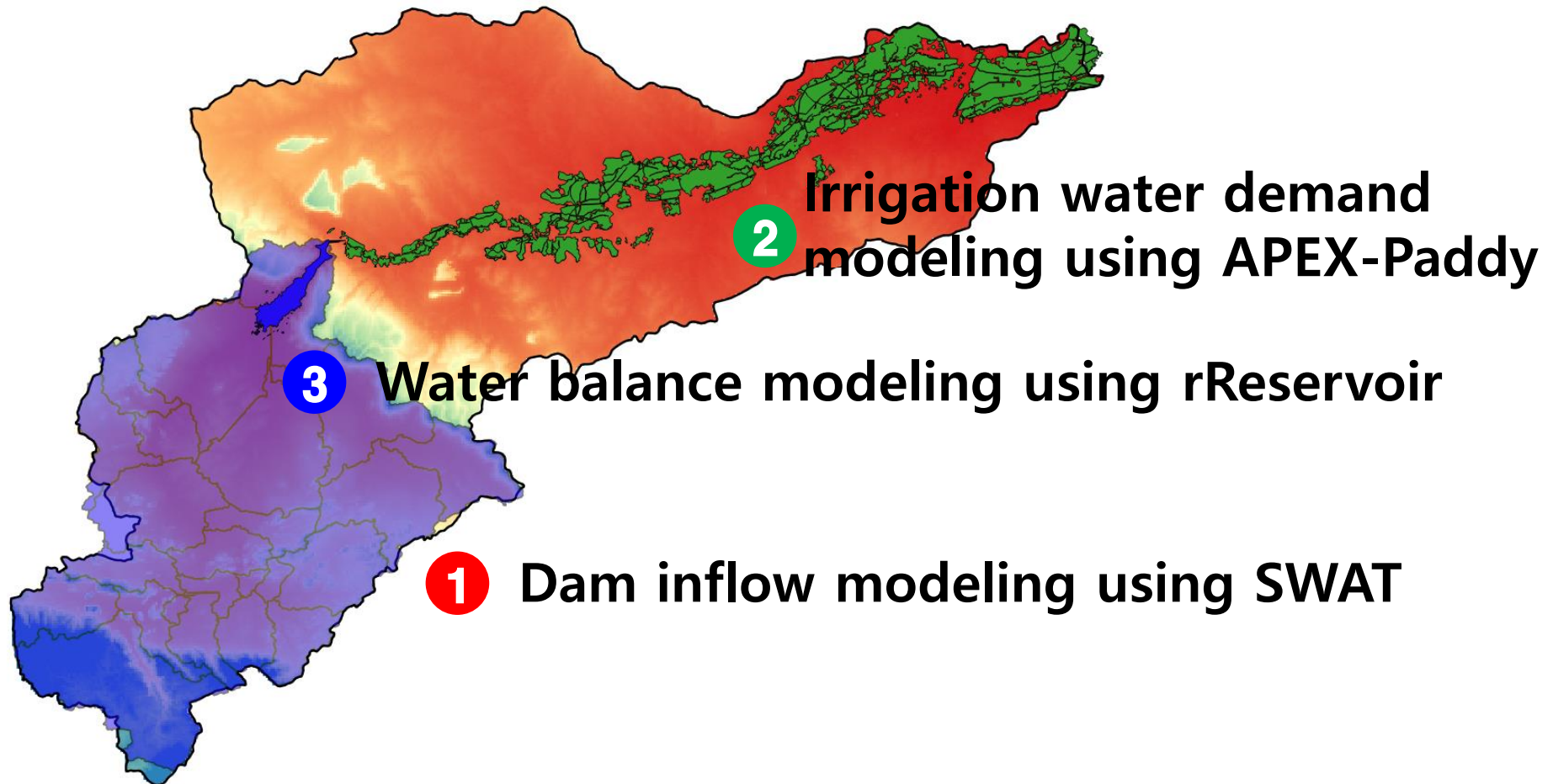
- ❖ Drought monitoring
- ❖ Climate Change Impacts on Drought
- ❖ Drought forecast



# Daily EDI using observed precipitation (Calibration period : 1981~2010)

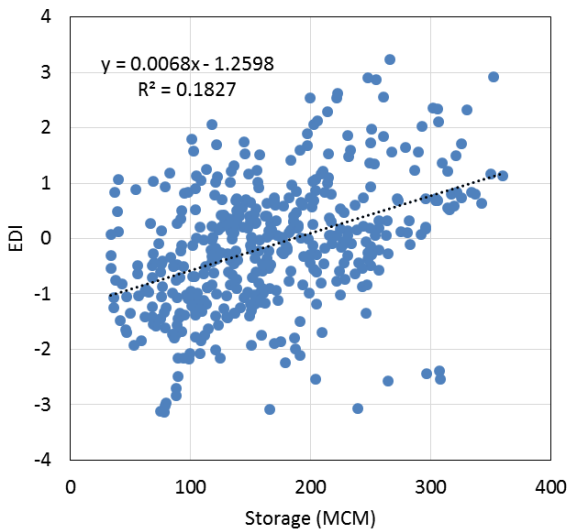


# Components of Hydrological modeling

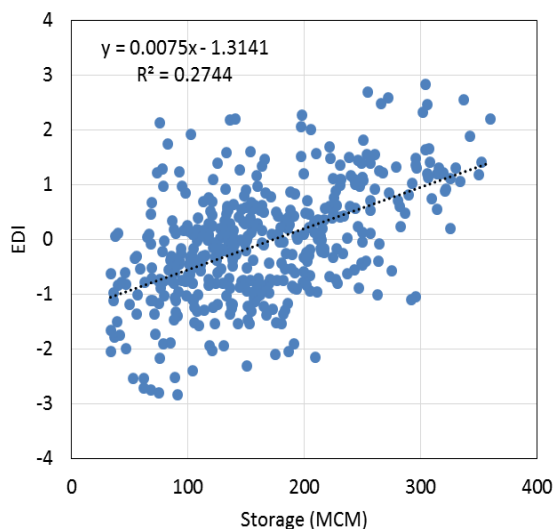


# Comparison between EDI and storage level

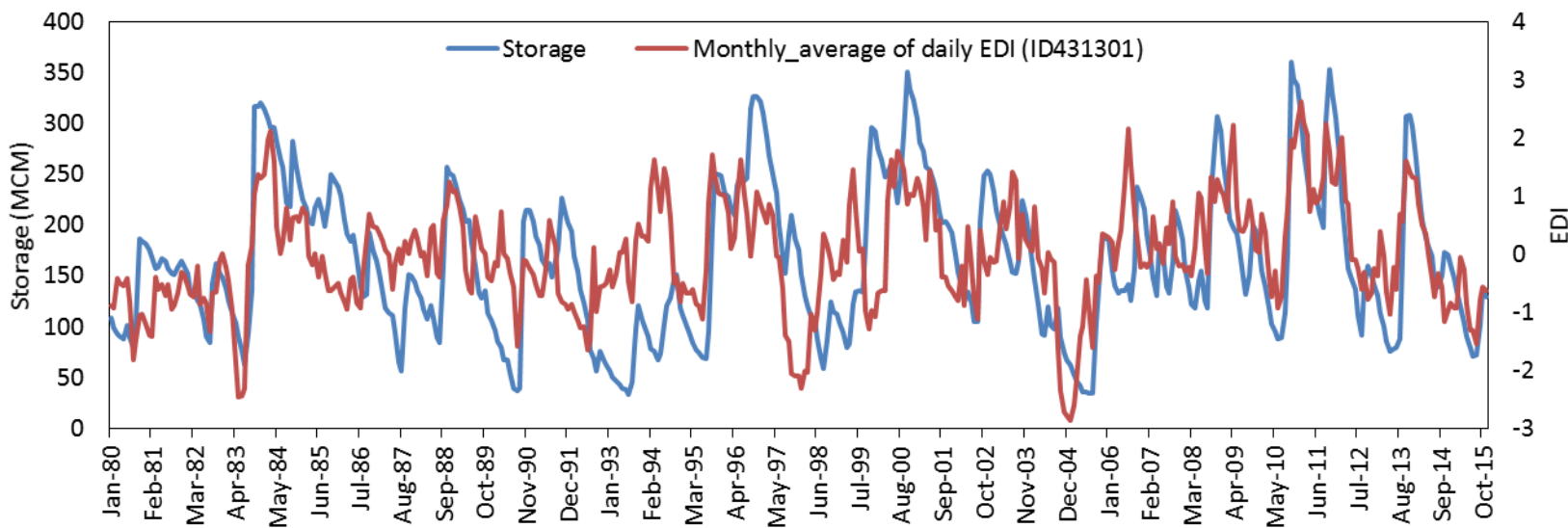
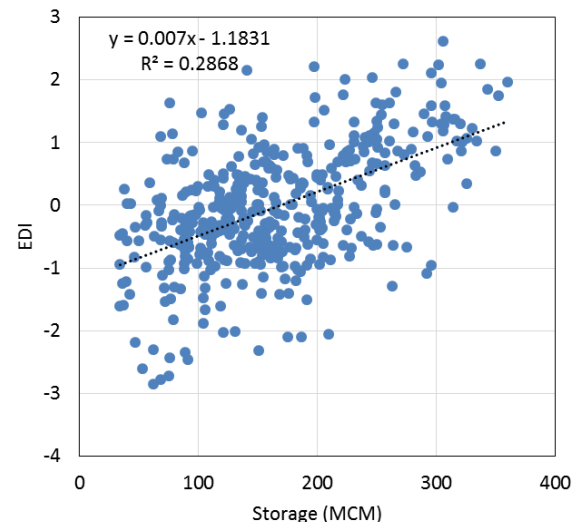
Monthly EDI on NE region (22 Stations)



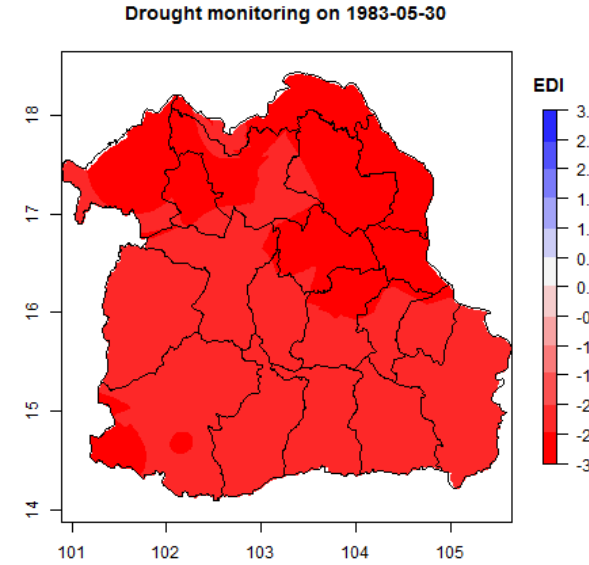
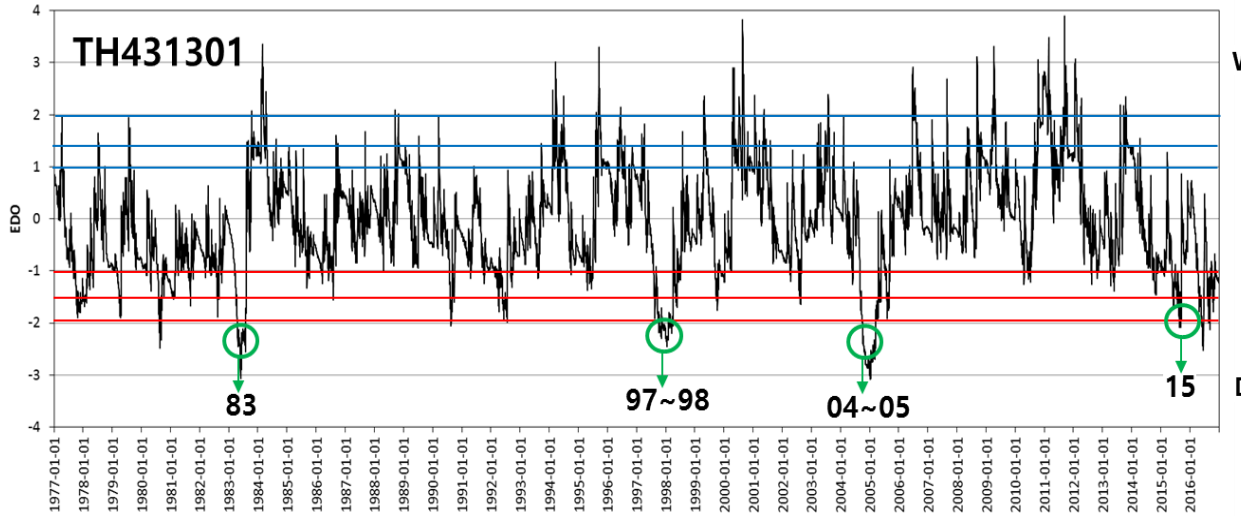
Monthly EDI (ID431301)



Monthly average of daily EDI (ID431301)



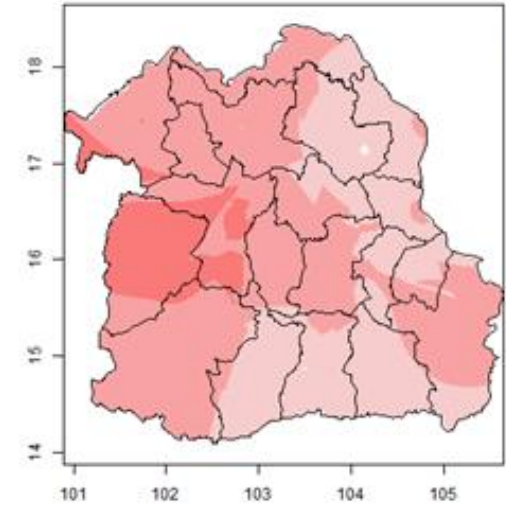
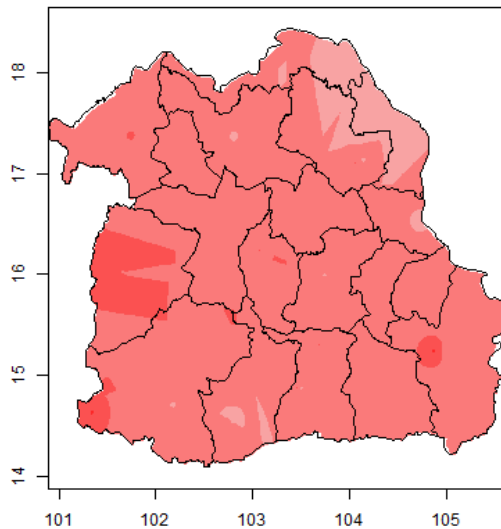
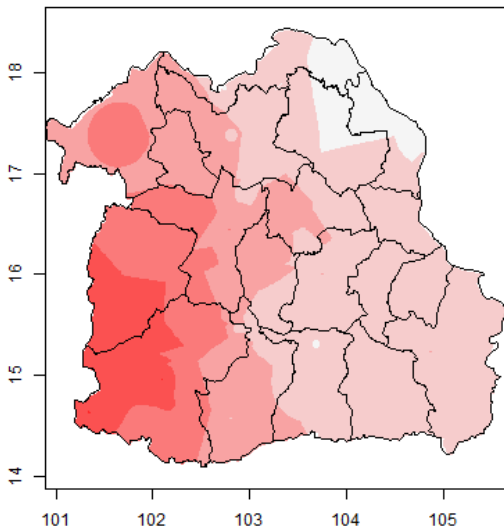
# Spatial and temporal changes in EDI



**Drought monitoring on 1998-01-20**

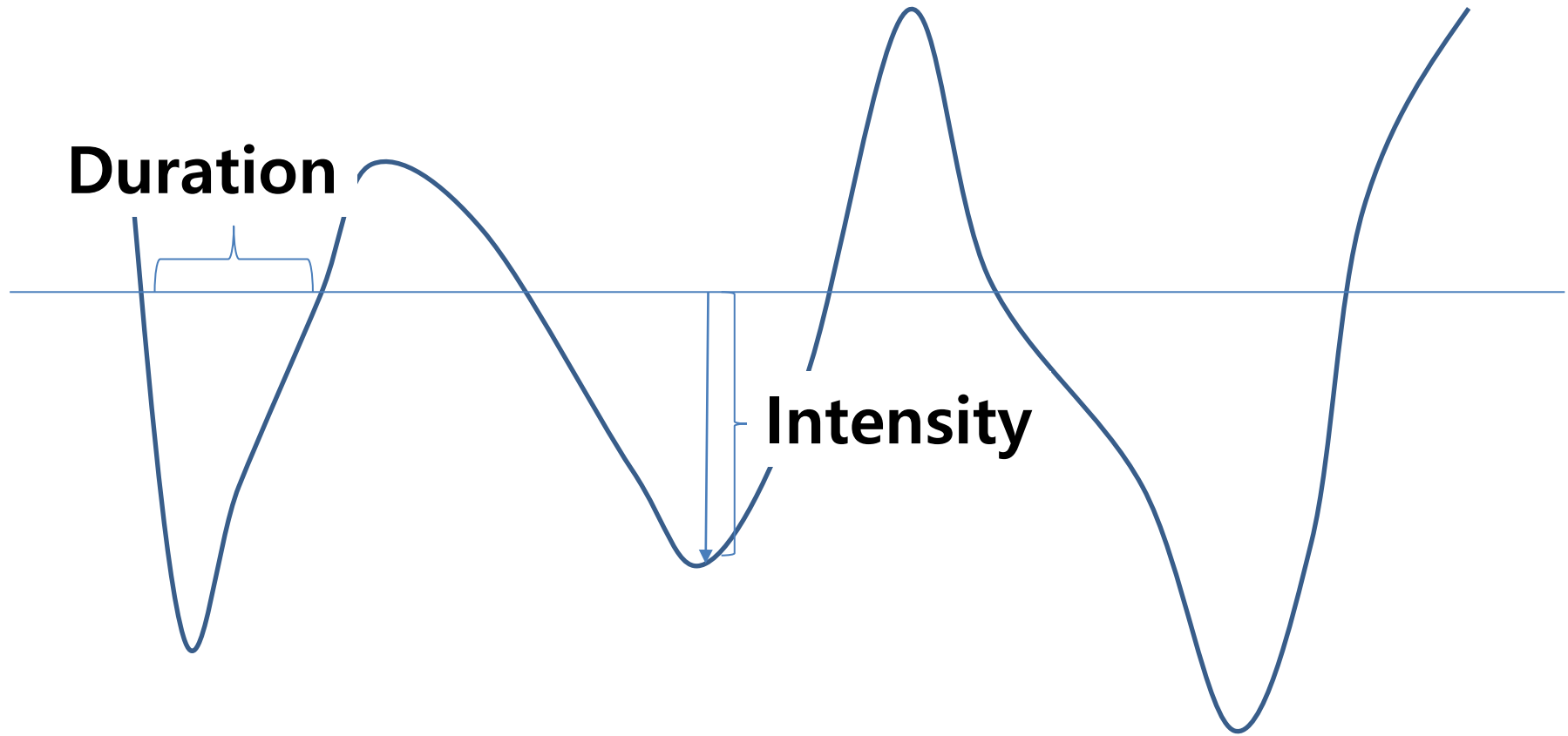
**Drought monitoring on 2005-03-10**

**Drought monitoring on 2015-05-20**

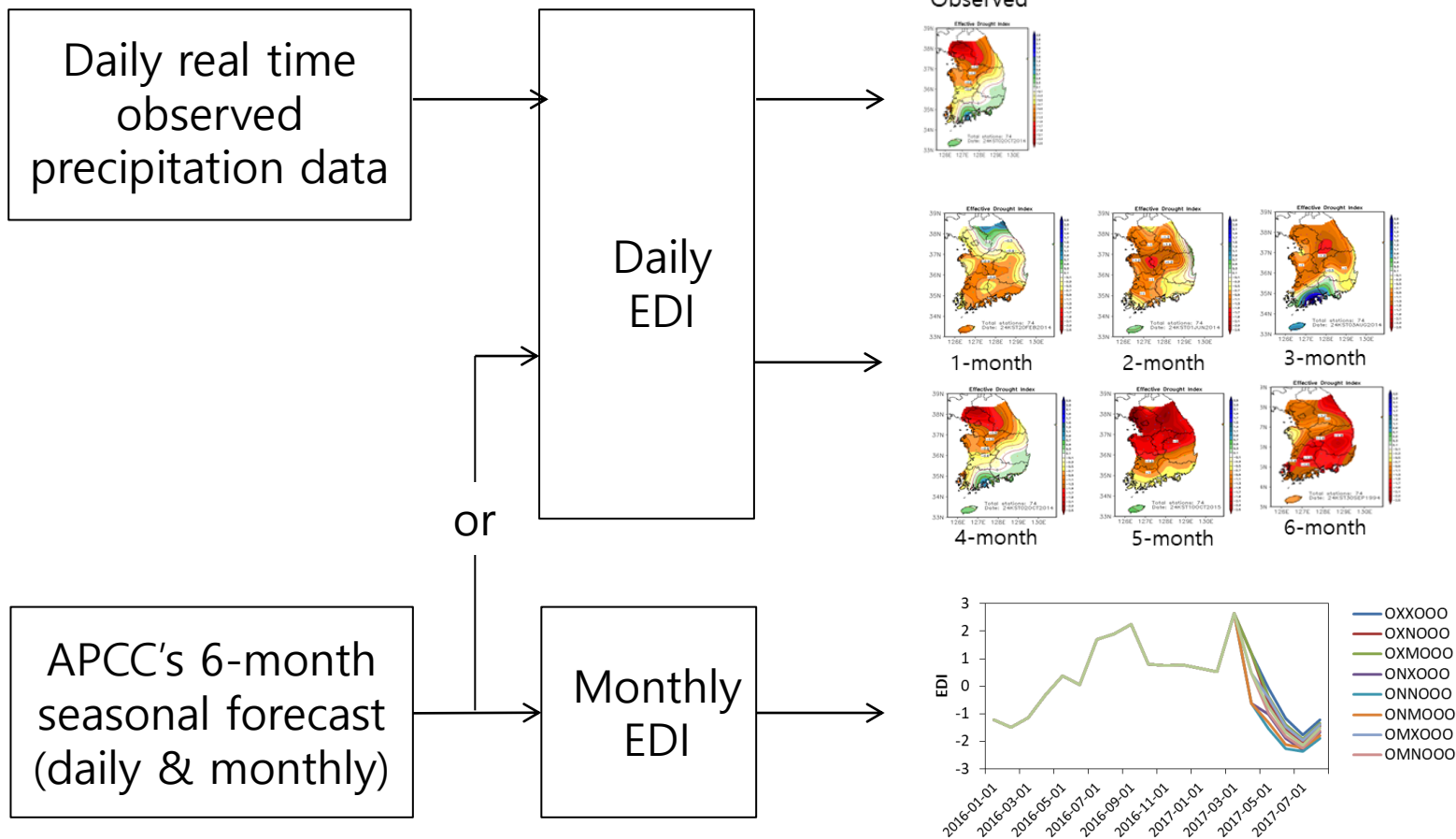




# Climate Change Impacts on duration and intensity of Drought



# Seasonal drought forecast using EDI



# Hands-on training for C.C. Impact Assessment

AIMS - Papua New Guinea Test Project
🏠
▶️ ↺
👤

SDQDM (Spatial Disaggregation-Quantile Delta Mapping) ▾

↓

**Modeling: Drought Index**

**Modeling method**

Drought Index ▾

[How to add your custom modeling method](#)

**GCM names**

bcc-csm1-1

**Period**

	Start Year		End Year
Calibration	<input type="text" value="1981"/>	~	<input type="text" value="2010"/>

**Downscale method**

SDQDM (Spatial Disaggregation-Quantile Delta Mapping) ▾

Remove Section

+ Add Modeling Section

**Project Information** ⚙️ 📁

**Project Name**

Papua New Guinea Test Project

**Target Country**

Papua New Guinea

**Method Type**

Climate Change

---

**Data Source**

Open working directory

Show log

Reset section

---

**Local Data**

Open working directory

Show log

Reset section

---

**Downscale**

