

Drought forecasts applying temporal patterns of a satellite-derived drought indicator through machine learning approach

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Abstract: A drought occurs when water deficiency resulting from recording below-average precipitation is prolonged. The drought can continue for weeks, months or even years, which can have a strong influence on ecosystems. In order to reduce damage induced by droughts, the drought monitoring and forecasting are necessary. In this study, drought forecasts were conducted using Scaled Drought Condition Index (SDCI) generated from Moderate Resolution Imaging Spectroradiometer (MODIS) and Tropical Rainfall Measuring Mission (TRMM) products over the Korean Peninsula. Random forest that is one of the machine learning method was applied to forecast drought using SDCI considering different duration of precipitation. Results showed that among different durations of precipitation, 3-, 6-month SDCI provided the best performance to predict the drought intensification compared to SDCI1 and SDCI12 through qualitative assessment.

Keywords Drought forecasting, SDCI, MODIS, TRMM, Random Forest

1. Introduction

A drought is a period of below-average precipitation in a region, resulting in prolonged water deficiency. A drought can last for weeks, months or years so can have a great influence on the ecosystem and agriculture. Due to this reason, monitoring drought is highly important thing in order to organize strategy. To establish long-term strategy, forecasting is also important to us (Singleton.,2012).

In the past, most of study about drought was using observation data, however, it has spatial and time limitation. For that reason, recently, many of studies were conducted using satellite data. Otkin et al.(2015) introduced the way of forecasting drought, mentioned new index, RCI(Rapid Change Index). RCI is developed to show a change of drought condition using satellite data and observation data. It is calculated using weekly anomaly applied z score concept about drought indices, ESI(Evaporative Stress Index), SPI(Standardized Precipitation Index) and Soil Moisture (Otkin et al., 2013). In this study, the magnitude of difference between two values in same drought index was used for forecasting drought.

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2. Study Area and Data

2.1 Study Area

Korean Peninsula is located in northeastern of Asia

and it is divided into two distinct states, South Korea and North Korea. Its latitude range is from N33 to N43 and longitude range is from E124 to E132, total area is 219,155km²(Fig. 1). Many of drought events occur in spring, fall and winter.

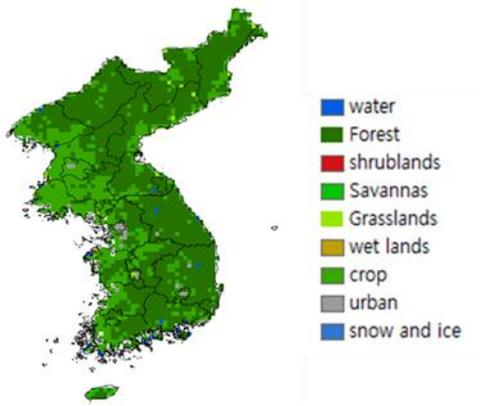


Figure 1 study area

2.2 Data

Data for calculating drought indices were provided from Aqua MODIS which is viewing the entire Earth's surface everyday by passing from south to north over the equator in the afternoon. In this study, Normalized Difference Vegetation Index (NDVI), Land Surface Temperature (LST) and Land cover were used to calculate drought indices, SDCI. All of data are processed to 1km spatial resolution and 8days time resolution.

TRMM is unique dataset of global tropical rainfall and lightning, especially standardized for precipitation. In this study, daily precipitation (3B42) was used. 3B42 daily precipitation data were provided as 0.25 degree spatial resolution and daily time resolution. It is also processed in the same resolution with MODIS data.

SDCI is calculated using Temperature Condition Index (TCI), Precipitation Condition Index (PCI) and Vegetation Condition Index (VCI) by Rhee et al.(2010). TCI is based on the fact that temperature is a sort of thermal stress indicator by Kogan(1995a).

TCI has value from 0 to 1 and if it is close or equal to 0 which means bare soil is under the high thermal stress in 0. PCI is proposed in order to use with VCI and TCI. PCI has value from 0 to 1 which means drought is easy to occur in 0 because of low precipitation. VCI is developed by Kogan(1995b) to detect the influence on vegetation easily. VCI has value from 0 to 1 and it will be close or equal to 0 under poor vegetation condition. Calculated SDCI has value from 0 to 1. When it is close or equal to 0, which means exceptional drought.

3. Methodology

RCI (Rapid Condition Index) was developed by Otkin(2013) which present change of dry condition about difference of two time periods(1-, 2-, 3-, 4week). In this study, prediction date was calculated using difference of 8-, 16-, 32weeks ago from previous date of prediction date. Drought forecast is analyzed using data of previous days and prediction data throughout random forest that is one of the machine learning approach.

4. Results and conclusions

Results of random forest showed that among different durations of precipitation (1-, 3-, 6- month), 6-month SDCI provided the best performance to predict the drought intensification compared to 1-, 6-months SDCI throughout qualitative assessment. The quality of drought forecast is good when drought is intensified, however, it did not show good performance when drought is alleviated as time passes. For the next study, we will apply meteorological model to develop drought forecast.

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