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SMOS Level-4 Drought Index

1. Introduction

Drought can be defined as the lower availability of water compared to the average water availability. Nowadays, drought is more frequent due to climate change (Meze-Hausken et al., 2004; Blanka et al., 2013; Nam et al., 2015; Mukherjee et al., 2018), and it can cause wildfires (Gudmundsson et al., 2014), lack in precipitaion (Wilhite et al., 2005), heat waves (Teskey et al., 2015) etc. Drought can persist for days, weeks, months and evn longer. Drought impacts the environment (Dey et al., 2011), economy (Ding et al., 2015), and society (Edwards et al., 2019). Environmental effects include drying of wetlands, forest fires, loss of biodiversity, etc.; economic issues include loss of water supply, loss of agriculture, etc.; and social effects include the loss of food supply, direct effects on health due to heat waves, increase in food cost, water scarcity, etc.

Drought is generally categorized into three types: meteorological (Palmer et al., 1965), hydrological (Van Loon et al., 2015), and agricultural (Liu et al., 2016) drought. Meteorological drought can be defined as the condition when there is less precipitation than average over a long period. Hydrological drought is the condition when the availability of water reserves is below the normal threshold. Agricultural drought is the condition when there is a shortage of water for agriculture and crop yields are affected.

Agriculture drought is the most prominent sector affected by drought because of its dependence on water resources and the soil moisture reserve at various stages of plant growth. Agricultural droughts have a possible impact on food security in drought prone areas. The information about the agricultural drought can be useful for farming systems, irrigation and availability of the water resources.

Various drought indices have been developed to predict the short and long term drought conditions such as Palmer Drought Index (Palmer et al., 1965), Standardized Precipitation Index (McKee et al., 1993), Crop Moisture Index (Palmer et al., 1968), Surface Water Supply Index (Shafer et al., 1982), Vegetation Health Index (Kogan et al., 1995), Vegetation Drought Response Index (Brown et al., 2008) etc. But all the drought indices are limited to specific regions or require high quality meterological data such as precipitation etc.

So, the satellite based drought indices will be more valuable, it can provide drought indices at a global spatial and temporal scale. The two main requirements to calculate agricultural drought indices- at a global scale- from satellite based information are: First, data about the availability of soil moisture at the root zone, and second, the presence data for a long period of time to account for the severity of the drought condition.

The main aim of this document is to present the drought index generated from the SMOS level-4 Root Zone Soil Moisture product available on CATDS derived from the SMOS level-3 surface soil moisture (Kerr at al., 2013). SMOS level-4 Root Zone Soil Moisture product provides root zone soil moisture data at a depth of (0-100) cm for the period of 2010-present.

The document finally describes the file content and the information related to the SMOS Drought Index product is discussed below.

2. Input data

2.1 SMOS Level-4 Root Zone Soil Moisture

SMOS Level-4 Root Zone Soil Moisture named as SMOS-RZSM is the root zone SM product provides SM information at root zone i.e. the depth of 0-100 cm with a spatial resolution of 40 km on a daily temporal scale. SMOS-RZSM product is derived from the SMOS level-3 surface SM by the diffusion process. Detailed information about the ATBD and the global product of SMOS-RZSM can be found in Al Bitar et al. (2020)
SMOS-RZSM product is available on CATDS from 2010 to present.

3. Algorithm

This section describes the algorithm used to calculate the drought index for a given period, either weekly or monthly, from the SMOS-RZSM data. Narasimhan et al. (2005) used the simulated soil moisture data from the SWAT index to calculate the drought index based on the weekly soil moisture deficit.

Here, SMOS-RZSM data to calculate the drought index using the following steps:

1. Median, maximum and minimum of root zone soil moisture value is calculated for each week (or month) in a year using the data spanning from 2010-2023. They are represented as MSM_1,MSM_2…..MSM_52 (or MSM_1, MSM_2 ….. MSM_12).

2. Using these statistics we calculate Soil Water Deficit (SWD) using the following relation:

$$SWD_{i,j} = (SM_{i,j} - MSM_j) / (MSM_j - minSM_j) * 100, \; if \; SM \le MSM_j$$

$$SWD_{i,j} = (SM_{i,j} - MSM_j) / (maxSM_j - MSM_j) * 100, \; if \; SM > MSM_j$$

   , where SWD is the soil water deficit(%); SM is the soil moisture at the root zone; MSM, minSM, and maxSM are the median, minimum, and maximum root zone soil moisture value. Here i represents the year and j represents the week (or month) of the year.

   SWD removes the seasonal variability and makes the drought index spatially comparable to different climatic conditions.

3. We use SWD calculated in step 2 to derive SMDI.
   To calculate the SMDI incrementally, the SMDI for 1st week (or month) is initialized to

$$SMDI_j = SWD_j / 50$$

where j=1

Using this SMDI from the following weeks (or months) is calculated as:

$$SMDI_j = 0.5 * SMDI_{j-1} + SWD_j / 50$$

The range of values for SMDI lies between -4 to +4, with -4 representing extreme dry conditions and +4 representing extreme wet conditions

4 Output product

4.1 Description of the output Product

Currently, SMOS level-4 Drought Index (SMOS-DI) product is produced monthly for ascending and descending overpasses separately, from 2010 till the present. SMOS-DI products are avaialbe in netCDF format and projected on the EASE-Grid version 2 (Brodzik et al., 2012, 2014), which is an equal area grid, characterized by various pixel size, being 25 km x 25k m at 30 deg of latitude.

4.2 SMOS level-4 Drought Index user product

File Type: MIR_CLF4DD
Description: Level-4 SMOS Drought Index
Name Format:
SM_PPPP_MIR_CLF4Dx_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv_ccc_n

Format: Frequency: Monthly
Variable: lat: Latitude
Lon: Longitude
SMDI: Soil Moisture Drought Index

4.3 Naming Convention

The product name is based on the naming convention of CATDS. Table below represents the naming convention of the Drought index product:

SM_PPPP_MIR_CLF4Dx_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv_ccc_n
e.g.
SM_TEST_MIR_CLF4DX_202001T000000_202001T235959_301_123_7.DBL.nc

Name	Description

SM	It specifically stands for SMOS mission
SCIE	File class: represents data in science mode (SCIE)
MIR	File category: MIR represents the MIRAS (SMOS instrument)
CLF4DX	C: CATDS L: "Land" product F: User product 4: Level-4 D: Drought X: Ascending (A)/Descending (D)
yyyymmddThhmmss	Sensing start time of the data contained in the product yyyy: year mm: month dd: day of the month hh: hour mm: minute ss: second
YYYYMMDDTHHMMSS	Sensing stop time of the data contained in the product YYYY: year MM: month DD: day of the month HH: hour MM: minute SS: second
vvv	Version number of the processor generating product
ccc	File counter; higher the file counter number recent, the more recent product
n	processing site (C-PDC=7, C-EC SM=8, C-EC OS=9)

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