



climate change initiative

tertiary education resources

ASSIGNMENT

skill assessment

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climate change initiative– ASSIGNMENT

<https://climate.esa.int/educate/>

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The ESA Climate Office welcomes feedback and comments

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# ASSIGNMENT

## Fast facts

**Subjects:** skill development with CATE

**Type:** assignment

**Complexity:** advance

**Lesson time required:** 30-40 hours

**Cost:** non

**Location:** indoors

**Includes the use of:** Internet, CATE  
Jupyter notebook, software

**Keywords:** climate change, essential  
climate variables, satellite, soil  
moisture, drought

## Brief description

The main purpose of this assignment is to manipulate climate data records of soil moisture data to create a drought index and compute the return period of drought events.

## Intended learning outcomes

**Carrying out the assignment students will be able to:**

- access and correctly use climate record data;
- create maps, time series and trends of drought indicators using CATE
- apply statistical methods for designing the return period of extreme events

## Health and safety

In all activities, we have assumed you will continue to follow your usual procedures relating to the use of common equipment (including electrical devices such as computers and readers), movement within the learning environment, trips and spills, first aid, and so on. Since the need for these is universal but the details of their implementation vary considerably, we have not itemised them every time. Instead, we have highlighted hazards particular to a given practical activity to inform your risk assessment.

All the activities involve the use of a sample data set, which requires the use of spreadsheet software. If you are not able – or do not wish – to use your desktop, you can use a normal calculator. In both cases, you are reminded of your local Internet and computation safety rules.

## Before you start

Review the exercises on drought that can be downloaded from [here](#):

- ESA CCI\_CATE Tutorial
- ESA CCI \_Exercise on drought-food security
- ESA CCI\_Exercise on drought-water availability
- ESA CCI\_Exercise on frequency analysis

## Introduction

Drought events of high precipitation deficits have become rampant in the Netherlands in recent years. The year 2018 was recorded as the worst drought with associated huge impacts on the economy, agriculture, and navigation industry. Drought indices (often unitless and between 1 and -1) have provided a reliable way of quantifying the characteristics of droughts by comparing prevailing climatic conditions to their long-term normal (mean). In this assignment, you will investigate the potential of satellite data records of the Climate change initiative in monitoring agricultural drought.

## Data

1. CCI soil moisture from the ZARR store: ESACCI-SOILMOISTURE-L3S-SSMV-COMBINED-1978-2020-fv05.3.zarr
2. Soil moisture in-situ measurement at 5 cm in Enschede, from Velde and Benninga (2020): Ten years profile soil moisture and temperature measurements in Twente. DANS. <https://doi.org/10.17026/dans-zrn-n8nh>. The file is provided [here](#) as 'ESA CCI\_Assignment-data\_5cm soil moisture'
3. Precipitation data over Enschede from KNMI station 665 (file provided [here](#) called 'ESA CCI\_Assignment-data\_rainfall\_Enschede\_st665')

## Tasks

From exercise “ESA CCI\_Exercise on drought-water availability” you have computed the soil moisture deficit index (SMDI) for the Netherlands. Figure 1 shows the spatial average of the whole Netherlands over the last 4 years.

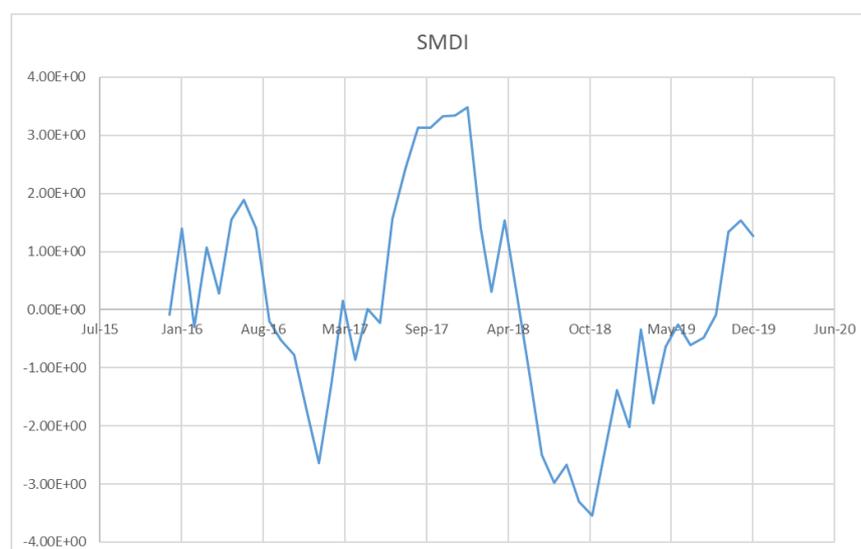


Figure 1: soil moisture deficit index.

Please carry out the following tasks:

1. Extend the time series of soil moisture to cover the period from 2010-1-1 to 2019-12-31;
2. Carry out the exercise as you did in the class but extract soil moisture monthly data for Enschede Lat 52.2 long 6.9

You could use the following scripts to extract soil moisture data. Change the shaded capital words to fit your data set and files:

```
DATASET.sm.sel(lat=ilat, lon=ilon,method="nearest"). to_series()  
.to_csv("FILENAME.txt"),
```

3. Validate the extracted soil moisture data with field data, obtained from <https://doi.org/10.17026/dans-zrn-n8nh> and provided in 'ESA CCI\_Assignment-data\_5cm soil moisture' that can be downloaded from [here](#)
4. Comment on the goodness-of-fit resulting from the validation step
5. Calculate the Standardized Precipitation Index using rainfall data over Enschede obtained from KNMI station 665. The file is 'ESA CCI\_Assignment-data\_rainfall\_Enschede\_st665' and provided [here](#)  
You could use the tool <https://drought.unl.edu/droughtmonitoring/SPI/SPIProgram.aspx>

6. Identify the most extreme drought event in SPI and SMDI and compute its return period (in python or excel)  
The return period should be estimated using the analytical approach and Weibull 2-parameters probability distribution function

7. Identify the most extreme drought event in SMDI and compute its return period (in Python or Excel)  
The return period should be estimated using the analytical approach and Weibull 2-parameters probability distribution function

8. Compare SPI and SMDI and their detected drought events (onset, termination, magnitude, and return periods. Here you should carry out a cross-correlation of SPI and SMDI. The code in the box illustrates how it is done in python.

Suppose the SPI is denoted  $x$  and SMDI is denoted  $y$

```
from scipy import signal  
import numpy as np  
import matplotlib.pyplot as plt  
corr = signal.correlate(x, y)
```

```
lags = signal.correlation_lags(len(y), len(x))
corr /= np.max(corr)

Choose the lag with the highest correlation and plot lag
versus correlation

fig, (ax_x, ax_y, ax_corr) = plt.subplots(3, 1,
figsize=(4.8, 4.8))

ax_x.plot(x)
ax_x.set_title('SMDI in the EU country..')
ax_x.set_xlabel('Month')

ax_y.plot(x)
ax_y.set_title('SMDI in the African country ')
ax_y.set_xlabel('Month')

ax_corr.plot(lags, corr)
ax_corr.set_title('Cross-correlated SMDI')
ax_corr.set_xlabel('Lag')

ax_x.margins(0, 0.1)
ax_y.margins(0, 0.1)
ax_corr.margins(0, 0.1)

fig.tight_layout()

plt.show()
```

## Cross-correlation time series analysis

Cross-correlation measures how well two (or more) sets of time series data compare relative to one another and determine at what point in time the two-time series compare best. Figure 2 shows how this is carried out using a spreadsheet.

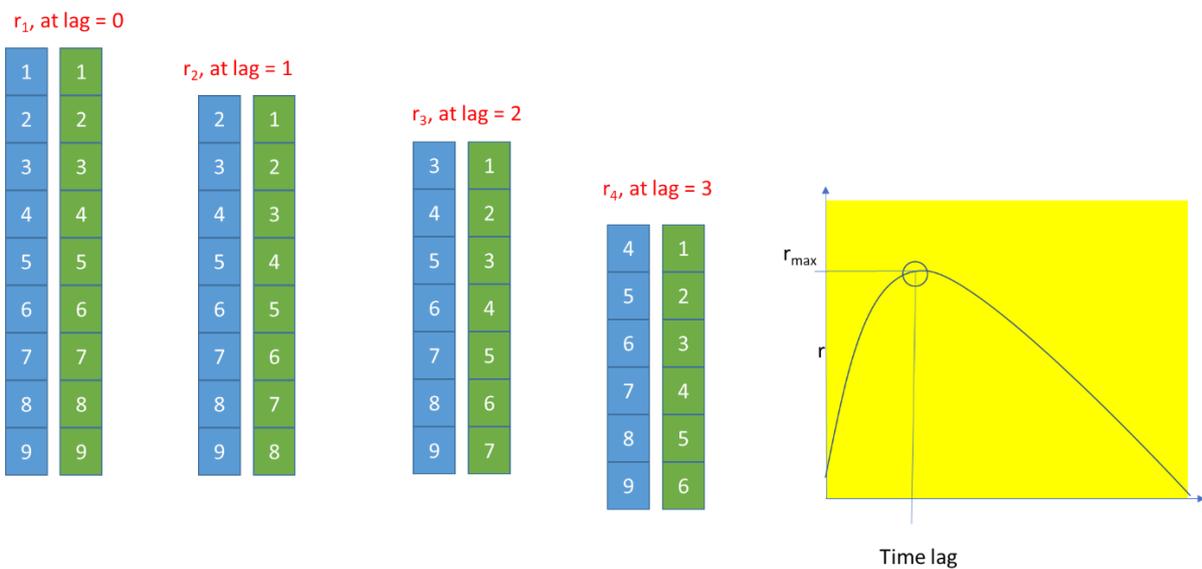


Figure 2: cross correction using a spreadsheet

## Pitch your finding

Good luck

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