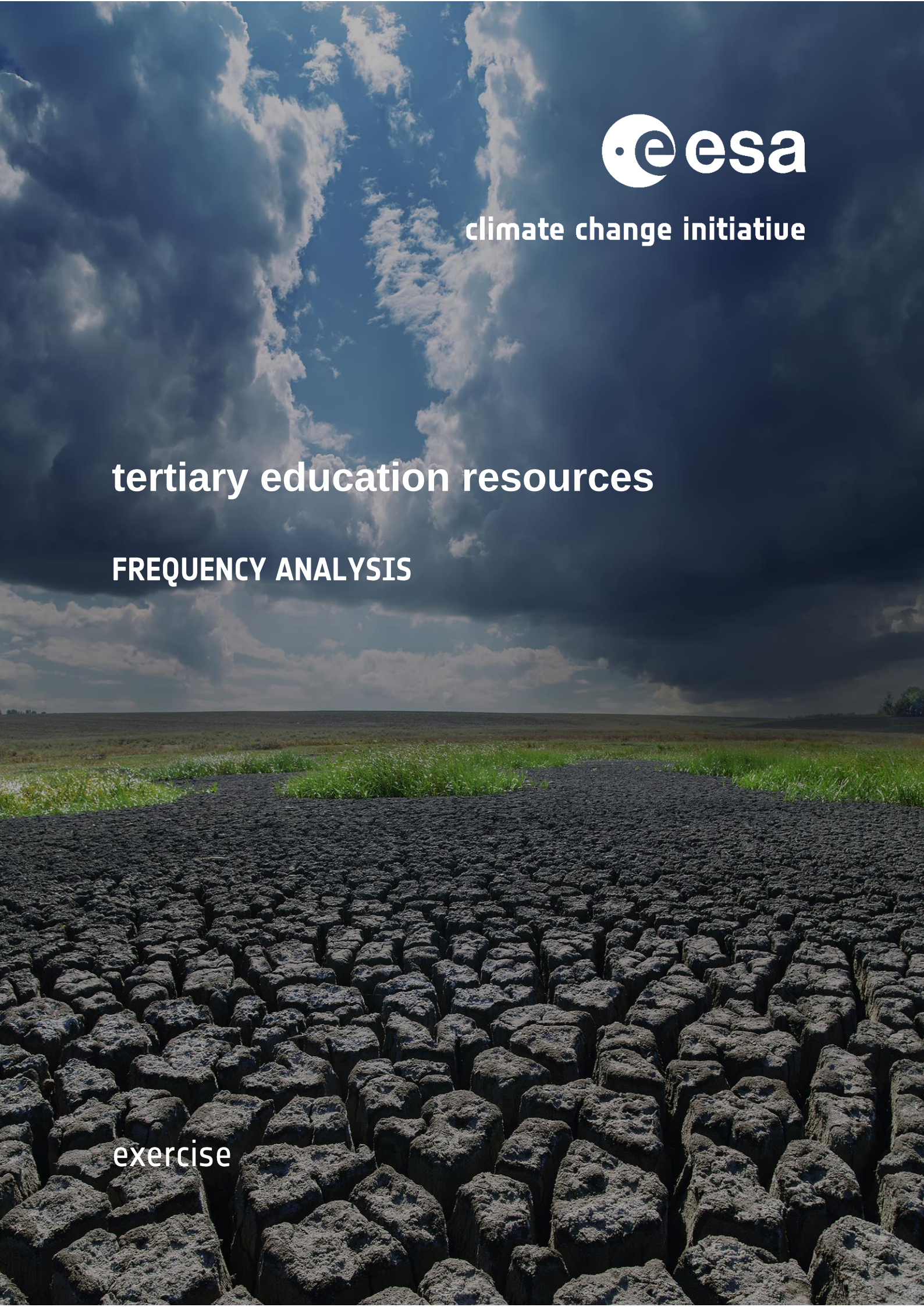


tertiary education resources

FREQUENCY ANALYSIS

exercise

Contents

climate change initiative tertiary education materials – FREQUENCY ANALYSIS
https://climate.esa.int/educate/

Developed by University of Twente (NL)

The ESA Climate Office welcomes feedback and comments
https://climate.esa.int/helpdesk/

Produced by the ESA Climate Office

FREQUENCY ANALYSIS

Fast facts

Subjects: statistical inferences

Type: exercise

Complexity: medium to advance

Lesson time required: 3 hours

Cost: none

Location: indoors

Includes the use of: internet, and spreadsheet software

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

Brief description

The main purpose of this exercise is to apply what you have learned during the lecture on frequency analyses of climate data records.

Intended learning outcomes

Reading this document, students will be able to:

be able to access and correctly use climate record data

apply statistical methods to calculate the return period of extreme events

Summary of activities

	Title	Description	Outcome	Requirements	Time
1	What is Climate Change?	The main purpose of this exercise is to apply what you have learned during the lecture on frequency analyses of climate data records. Prerequisite	be able to access and correctly use climate record data apply statistical methods to calculate the return period of extreme events	any device that can handle spreadsheets follow the lectures and exercises of the Tertiary Training Kit in this exercise, we will use the Excel file 'ESA CCI_Exercise on frequency analysis-dataset'. It contains two sheets: 1- EX1 Soil Moisture containing time series 2016-2019 of soil moisture deficit index (SMDI) averaged over the whole Netherlands. 2- EX2 rainfall, yearly maxima of rainfall for different durations	4 hours

Times given are for the main exercise activity. They include time for working out the activities using a spreadsheet software, but not experimenting using the Climate from Space application or the CCI Toolbox (CATE).

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

Follow the two lectures on drought monitoring and frequency analysis and carry out the CATE-based exercises on drought: 'ESA CCI _Exercise on drought-food security' and 'ESA CCI_Exercise on drought-water availability'.

Data

In this exercise, we will use the sheet EX1_Soil Moisture on the Excel file 'ESA CCI_Exercise on frequency analysis-dataset'. It contains time series 2016-2019 of soil moisture deficit index (SMDI) averaged over the whole of the Netherlands.

Exercise 1

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 of the Netherlands over the last 4 years.

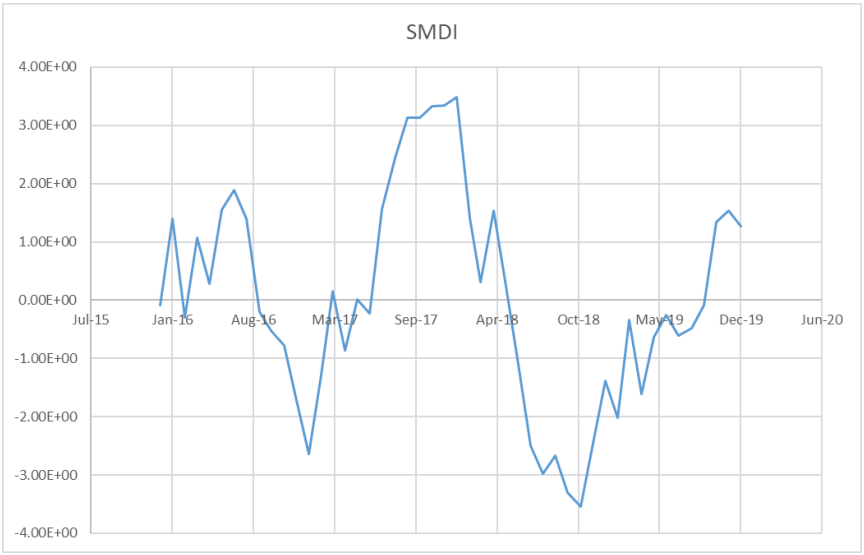


Figure 1: soil moisture deficit index.

Identify all drought events with SMDI values being below 0 (Figure 1) and estimate the return period of the most extreme drought event using the Weibull distribution.

Solution 1

Choose all SMDI values that are below zero, these are regarded as extremely low values.

There are 6 drought events between 2016 and 2018. The most severe and persistent drought event is detected in 2018-2019 and lasts approximately 16 months.

Compute the mean and standard deviation and estimate the scale and shape factors of the Weibull distribution, your solution should produce the following table:

mean	std
1.3328	1.0998

alpha	1.4221
beta	1.2175
theta	0.1042
formula	0.0003

Tr	33.12004

A return period of 33 months will be obtained.

Teaser 1

How can you identify the most severe drought event?
Discuss how to combine the duration and intensity in one measure of severity.

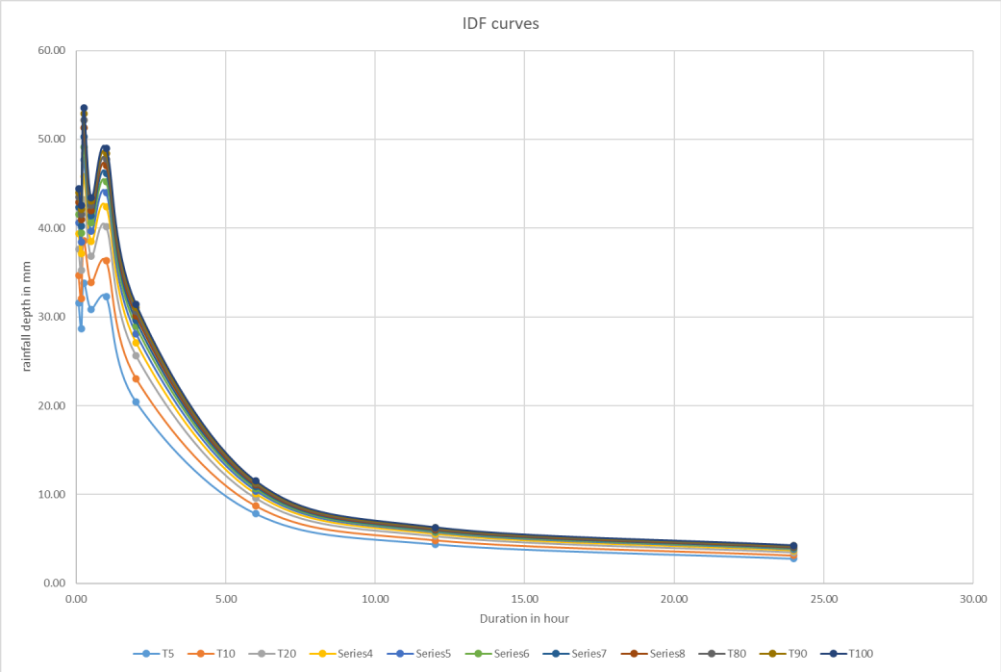
Exercise 2

Use the sample data (sheet 2 rainfall of the Excel sheet ‘ESA CCI_Exercise on frequency analysis-dataset’).

Use Gumbel distribution to estimate the Intensity Duration Frequency curves of maxima.

Solution 2

- Compute the mean and standard deviation for each rainfall period.
- Identify the maximum values for each period, do not forget to unify the unit
- Calculate the return period.



The IDF curves, resulting from this exercise.

Teaser 2

What would be the relationship between rainfall and soil moisture?

By doing so, you should obtain the following:

		0.08	0.17	0.25	0.50	1.00	2.00	6.00	12.00	24.00
xt=	MAX	42.28	39.04	60.28	38.34	46.98	36.92	11.35	6.25	3.89
	mean	27.72	24.54	27.96	27.08	27.29	17.12	6.73	3.82	2.32
	std	5.33	5.75	8.16	5.22	6.91	4.55	1.53	0.79	0.62
	kt	2.73	2.52	3.96	2.16	2.85	4.35	3.03	3.08	2.55
	w	1.02	1.02	1.00	1.04	1.01	1.00	1.01	1.01	1.02
	T	59.67	45.78	285.96	28.79	69.39	470.74	86.97	93.12	47.18

	T	0.08	0.17	0.25	0.50	1.00	2.00	6.00	12.00	24.00
T5	5.00	31.56	28.67	33.83	30.84	32.26	20.40	7.83	4.39	2.76
T10	10.00	34.67	32.03	38.61	33.89	36.30	23.07	8.72	4.85	3.12
T20	20.00	37.67	35.26	43.19	36.82	40.18	25.62	9.58	5.29	3.47
T30	30.00	39.39	37.12	45.83	38.51	42.41	27.09	10.07	5.55	3.67
T40	40.00	40.60	38.42	47.68	39.69	43.98	28.13	10.42	5.73	3.81
T50	50.00	41.54	39.43	49.12	40.61	45.20	28.93	10.68	5.86	3.92
T60	60.00	42.30	40.26	50.29	41.36	46.19	29.58	10.90	5.98	4.01
T70	70.00	42.95	40.95	51.28	41.99	47.03	30.13	11.09	6.07	4.08
T80	80.00	43.51	41.56	52.14	42.54	47.75	30.61	11.25	6.16	4.15
T90	90.00	44.00	42.09	52.89	43.02	48.39	31.03	11.39	6.23	4.20
T100	100.00	44.44	42.56	53.57	43.45	48.96	31.41	11.52	6.29	4.26