Internship August 2021

Mini-Project

CLOUD COVERAGE IN SOUTH AFRICA

Monthly report July 2021

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1. Cloud Coverage

1.1 Definition of cloud coverage

CFC = Fractional Cloud Cover

- ➔ Is defined as the fraction of cloudy pixels within a 0.25° x 0.25° grid compared to all pixels analyzed in the grid (CLARA-A2)
  - Unit: [%]
  - Range of values: [0,100]

Source:
https://www.cmsaf.eu/SharedDocs/Literatur/document/2020/saf_cm_dwd_pum_gac_cld_2_6_pdf.pdf?__blob=publicationFile

1.2 Importance of observing clouds

- ❖ the reflection of solar radiation through clouds leads to a reduced amount of radiant energy reaching the surface → cooling effect in the shortwave spectral range
- ❖ on the opposite the outgoing longwave radiation decreases as a result of the absorption of radiation through clouds → warming effect in the longwave spectrum
- ❖ global mean record: -20 W/m^2
- ➔ cooling cloud radiative effect on the current climate

Source:
https://www.dwd.de/DE/forschung/atmosphaerenbeob/lindenbergersaeule/strahlungsprozesse/wolkenbeobachtung_node.html

2. Project outline

2.1 Target of the project

- ➔ Drawing up a sample application for creating a monthly report on the cloud coverage in South Africa plus designing an additional instruction

2.2 Which topics should be considered in a monthly report?

- ✓ general map of cloud coverage in South Africa for a selected month (e.g. July 2021)
- ✓ figures of the months January to July 2021 disposed side by side
- ✓ global map of cloud coverage for the selected month
- ✓ current map in comparison to a map of the long-term mean (1991-2020) of the selected month
- ✓ monthly anomaly of cloud coverage in July 2021 plus an overall analysis
- ✓ time-series of monthly anomalies for a specific location (1991-2020)

- ✓ time-series of monthly averages for a specific location (1991-2020)
- ✓ current year in comparison to the climatology
- ✓ number of time steps above, below or equal to an uniquely defined threshold

3. Application example

3.1 General map of cloud coverage in South Africa in July 2021

The map shows the average cloud coverage in July 2021 in South Africa. The values range from 0% to 100%. Low values indicate little cloud coverage. Higher values show increased cloudiness in the examined extract. Additionally, every map is deposited with a histogram showing the exact values of the dedicated values.

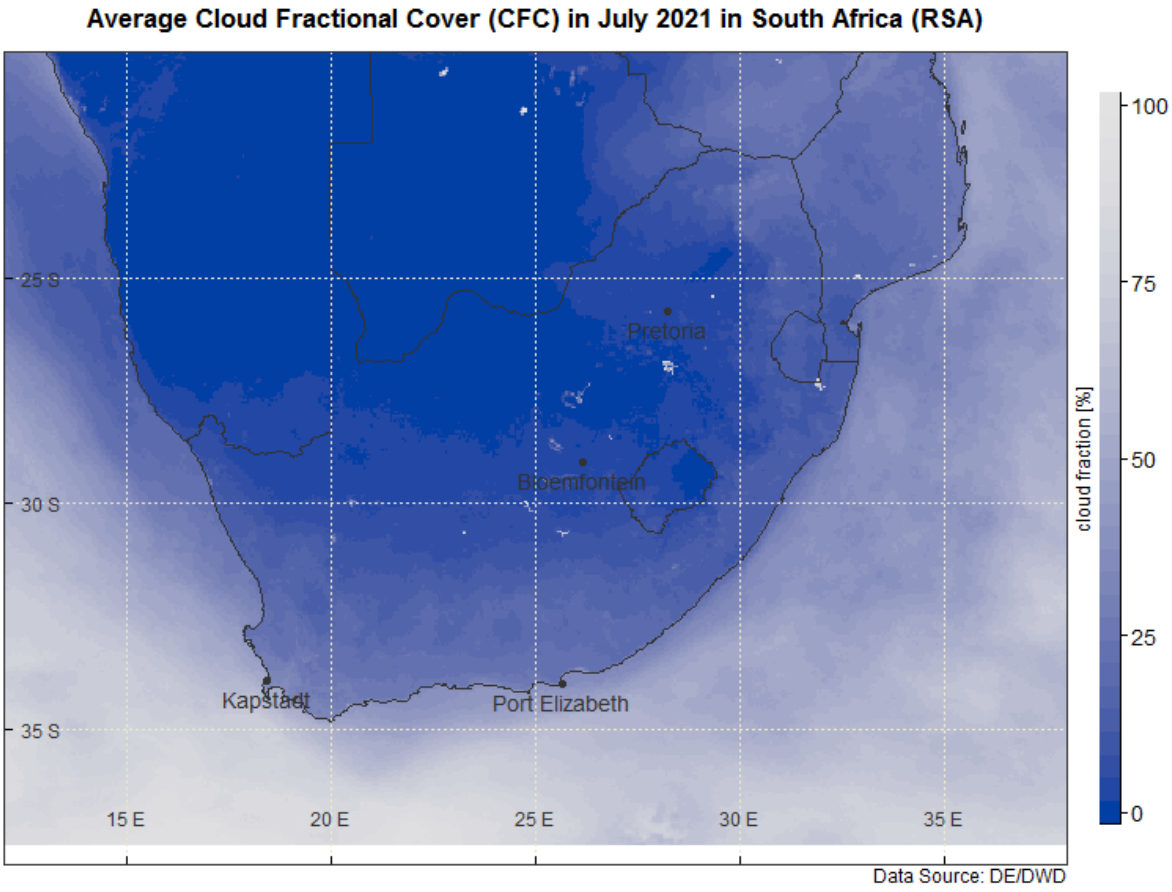

Fig. 1: „Average Cloud Fractional Cover (CFC) in July 2021 in South Africa (RSA)“

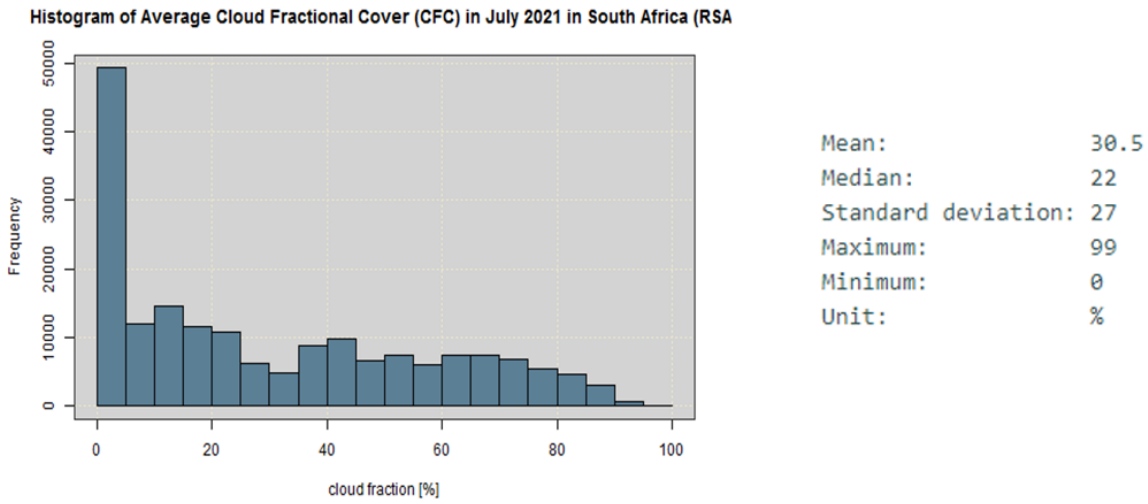

Fig. 2: „Corresponding histogram of the average Cloud Fractional Cover (CFC) in July in South Africa, including important statistical parameters“

3.2 Figures of the months January to July 2021 disposed side by side

The following images are arranged side by side showing the average cloud coverage in South Africa starting in January and ending in July 2021. This allows a month-wise comparison of the cloud coverage throughout the year. Any changes can be recognized immediately. Regarding these figures, a decrease in the cloud coverage throughout the entire country can be noticed. During the first months of the year the cloud coverage is lowest in the western part of the country. In March, the cloud coverage increases at first across the whole country, but then continues decreasing continuously until July.

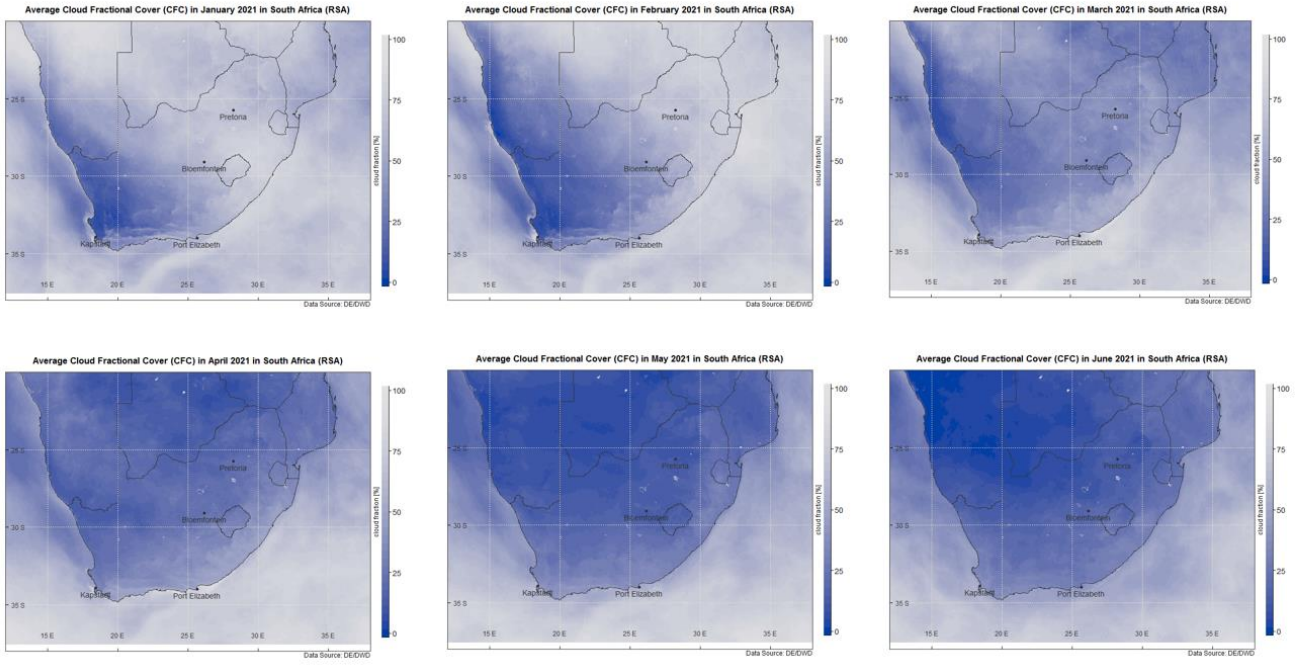

Fig. 3: „Comparison of the monthly maps (January-June 2021)”

3.3 Global map of cloud coverage in July 2021

A depiction of the global average cloud cover in comparison to the observed country can also be interesting. A vivid example can be achieved by illustrating the map as a globe, centered and zoomed in on the country of interest.

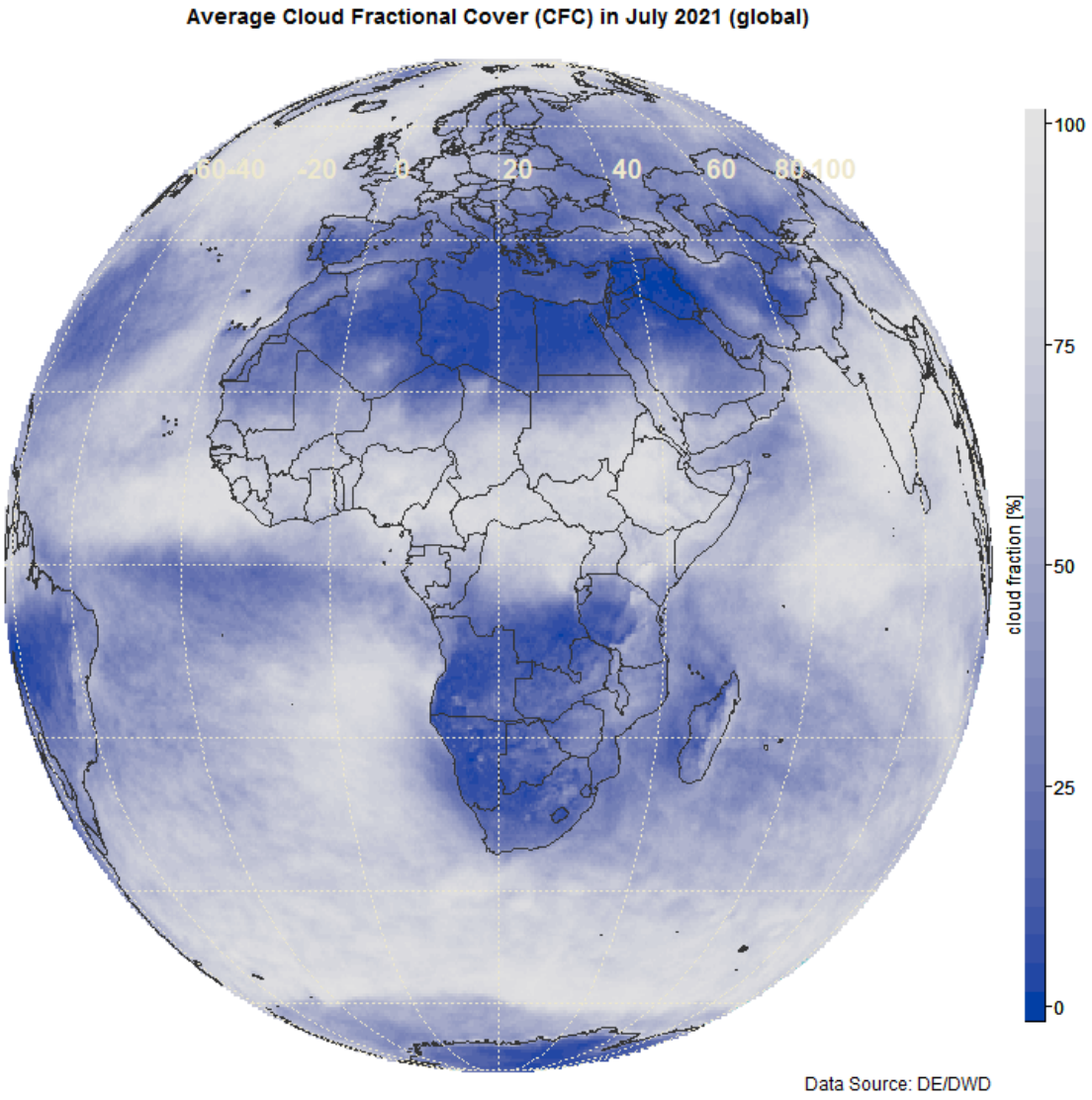

Fig. 4: „Map of the cloud coverage in July 2021 illustrated as a globe, centered and zoomed in on Africa"

3.4 Current map of July in comparison to the long-term mean in July (1991-2020)

When comparing the current map of cloud coverage to a map of the long-term mean in cloud coverage in the same region, it becomes clear that the average of the month of the current year differs from the long-term mean for the same month. The long-term mean refers to the time span 1991-2020.

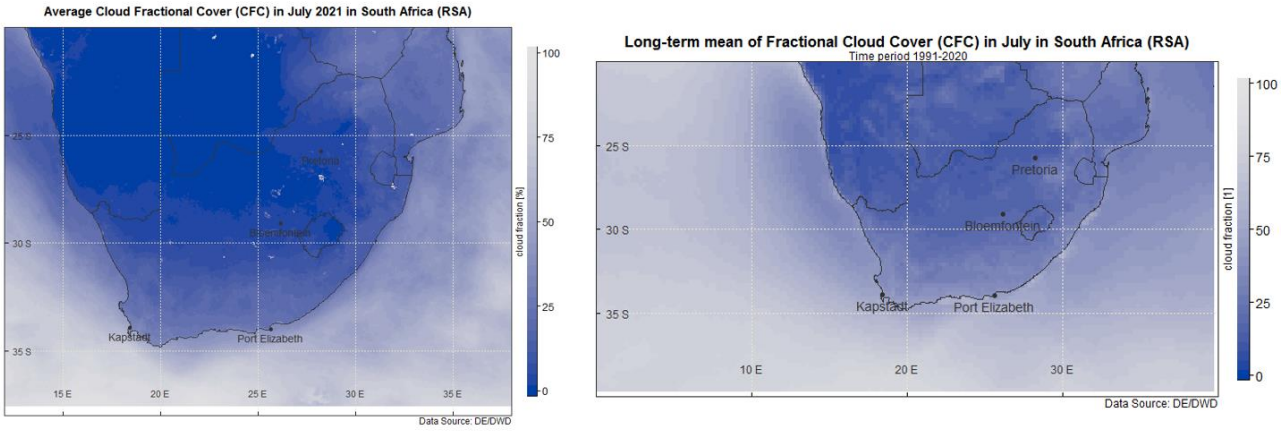

Fig. 5: „Current map of July 2021 compared to the long-term mean map of July 1991 to 2020)"

This example shows the reduction in cloud coverage in July 2021 in comparison to the long-term mean. It implies that the cloud coverage is lower than usual, which is also represented in the anomaly map in the following paragraph.

3.5 Monthly anomaly of cloud coverage in July 2021 plus an overall analysis

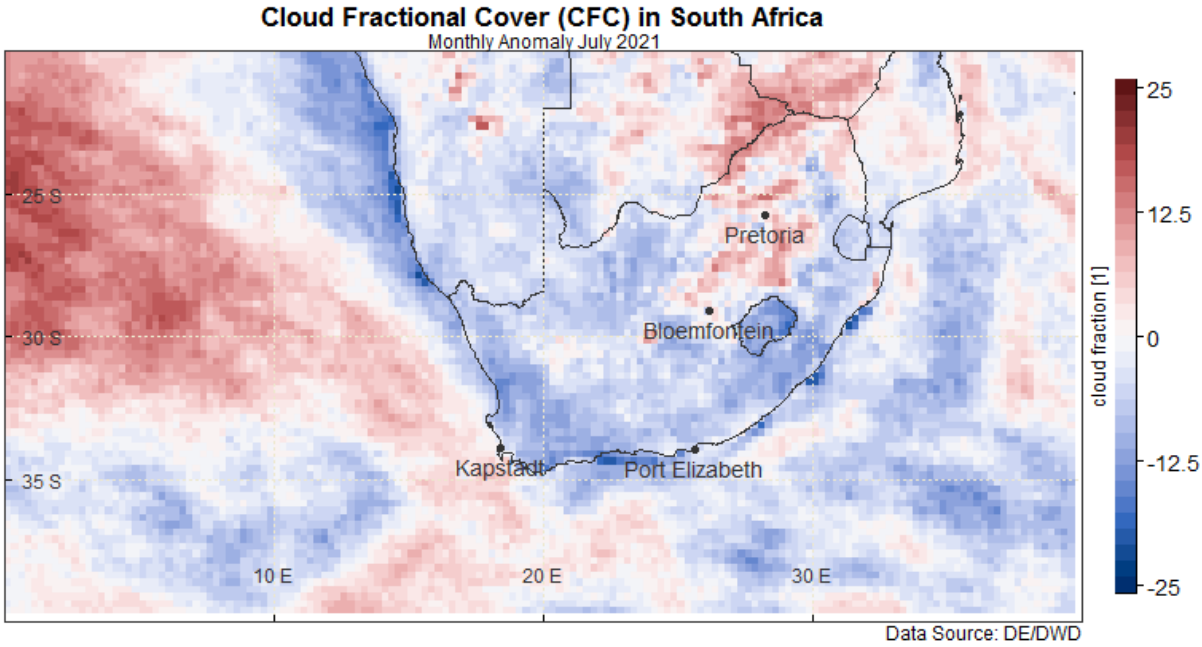

Fig. 6: „Monthly anomaly map of cloud coverage in July 2021 in South Africa"

The deviations are highest around the cities Pretoria, Cape Town (Kapstadt) and Port Elizabeth. Around Pretoria, the cloud coverage was higher than usual, whereas around Cape Town and Port Elizabeth, the cloud coverage was much lower than usual. A much more exact

presentation of the anomaly can be seen in the following image that only shows the selected country.

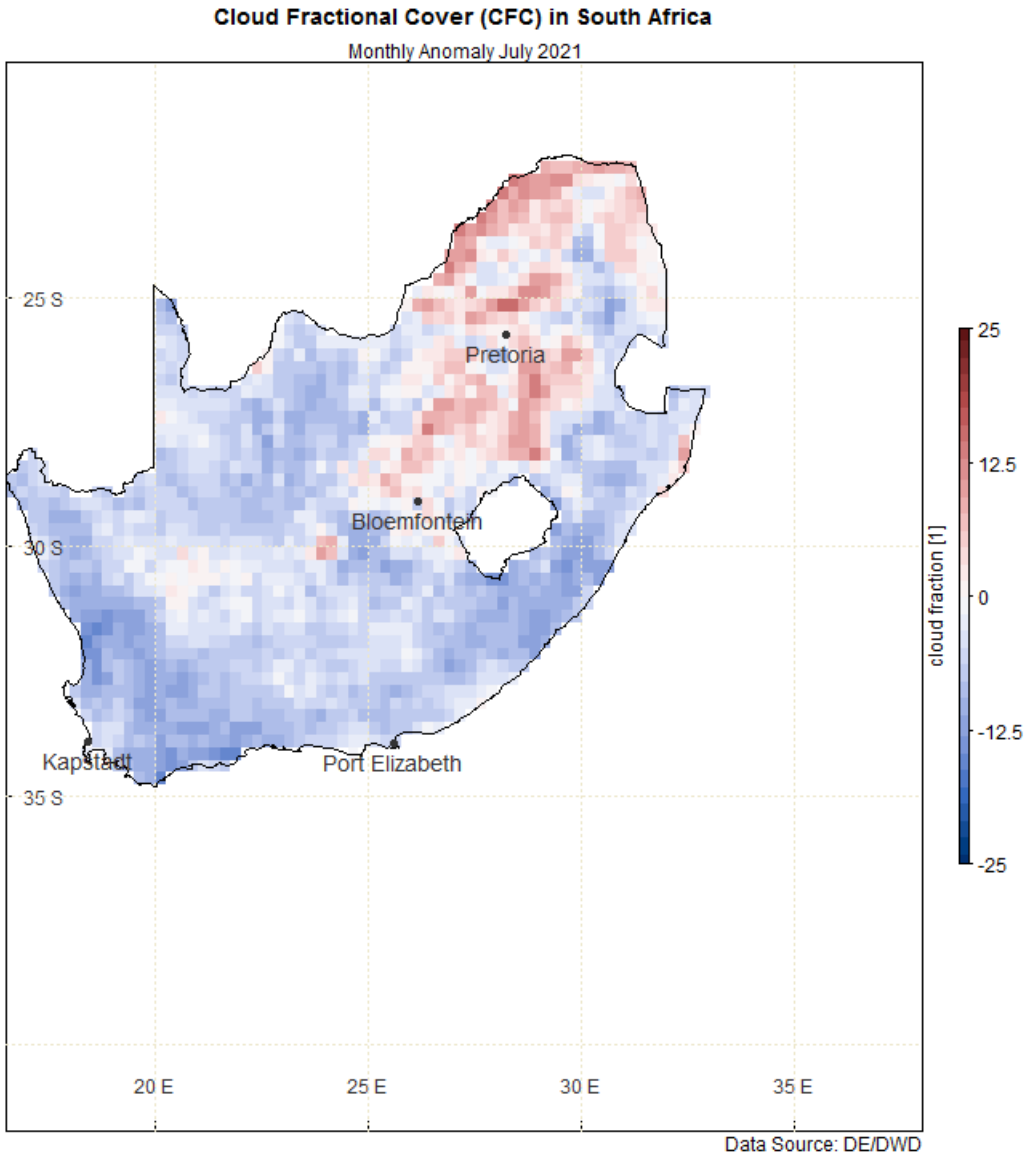

Fig. 7: „Monthly anomaly map of cloud coverage in July 2021 in South Africa, showing the selected country only"

3.6 Time-series of monthly anomalies for a specific location (1991-2020)

Monthly anomalies can also be presented as time-series over a specific period of time. Furthermore, it is possible to insert trendlines. A benefit of using trendlines can be, that the overall change in cloud coverage throughout the time span becomes clear. In this example (South Africa) a slight change in the cloud coverage is noticed: cloudy conditions decline from 1991 to 2020. Alternatively, positive and negative values within the time series can also be displayed in red and blue. In addition, other relevant parameters will be outputted in the overall analysis, which allows precise interpretations.

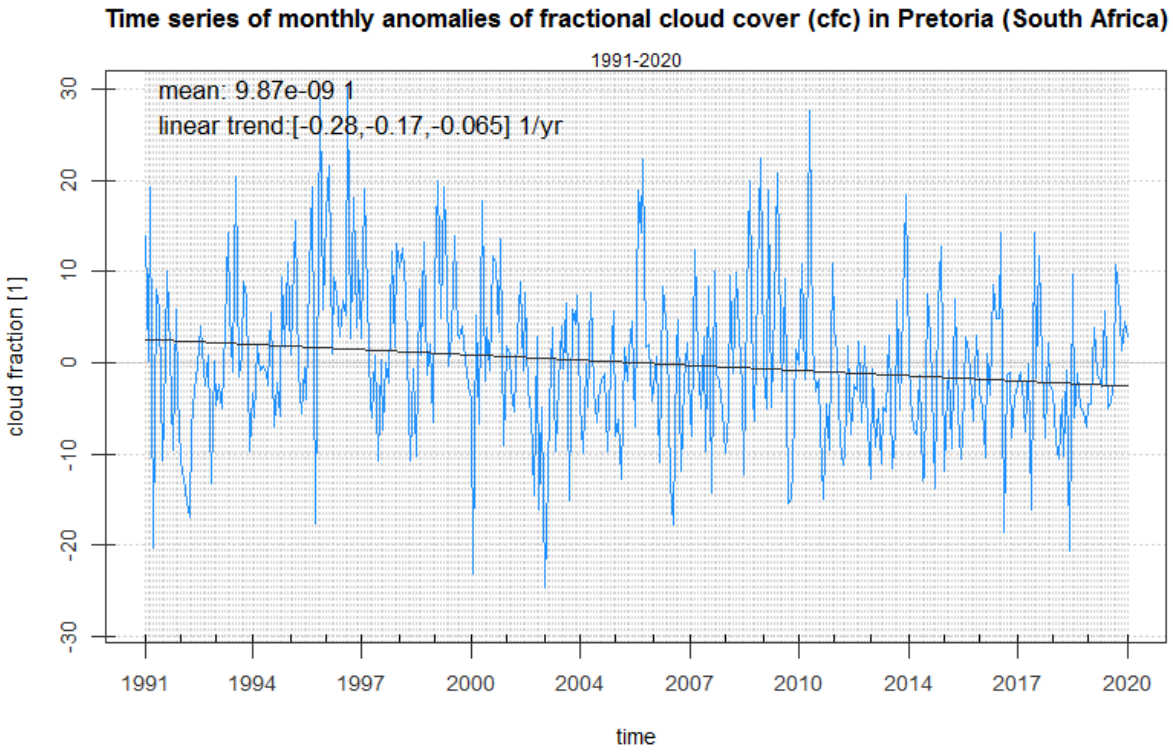

Fig. 8: „Time series of monthly anomalies of fractional cloud cover in the city Pretoria (South Africa) from 1991 to 2020"

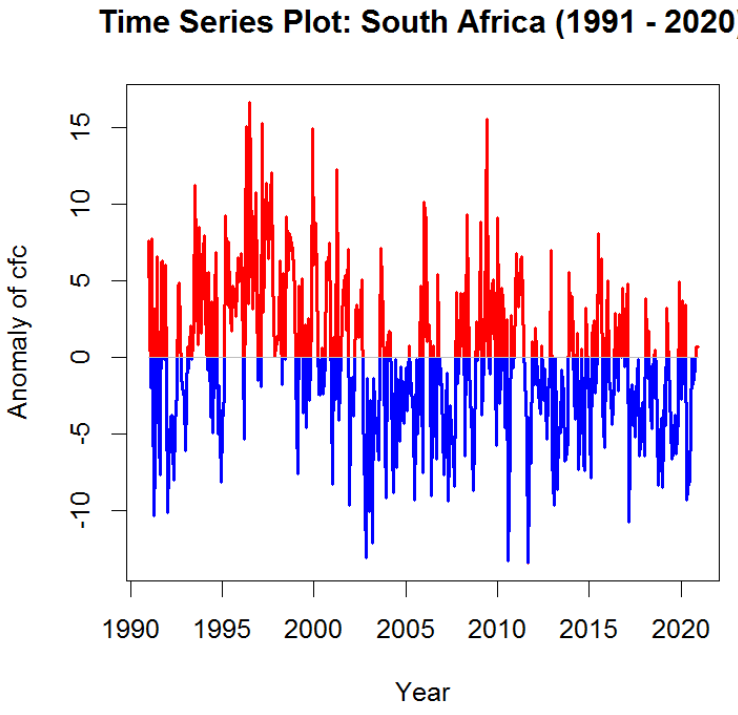

Fig. 9: „Time series of monthly anomalies of fractional cloud cover all over the country South Africa from 1991 to 2020"

Overall analysis:

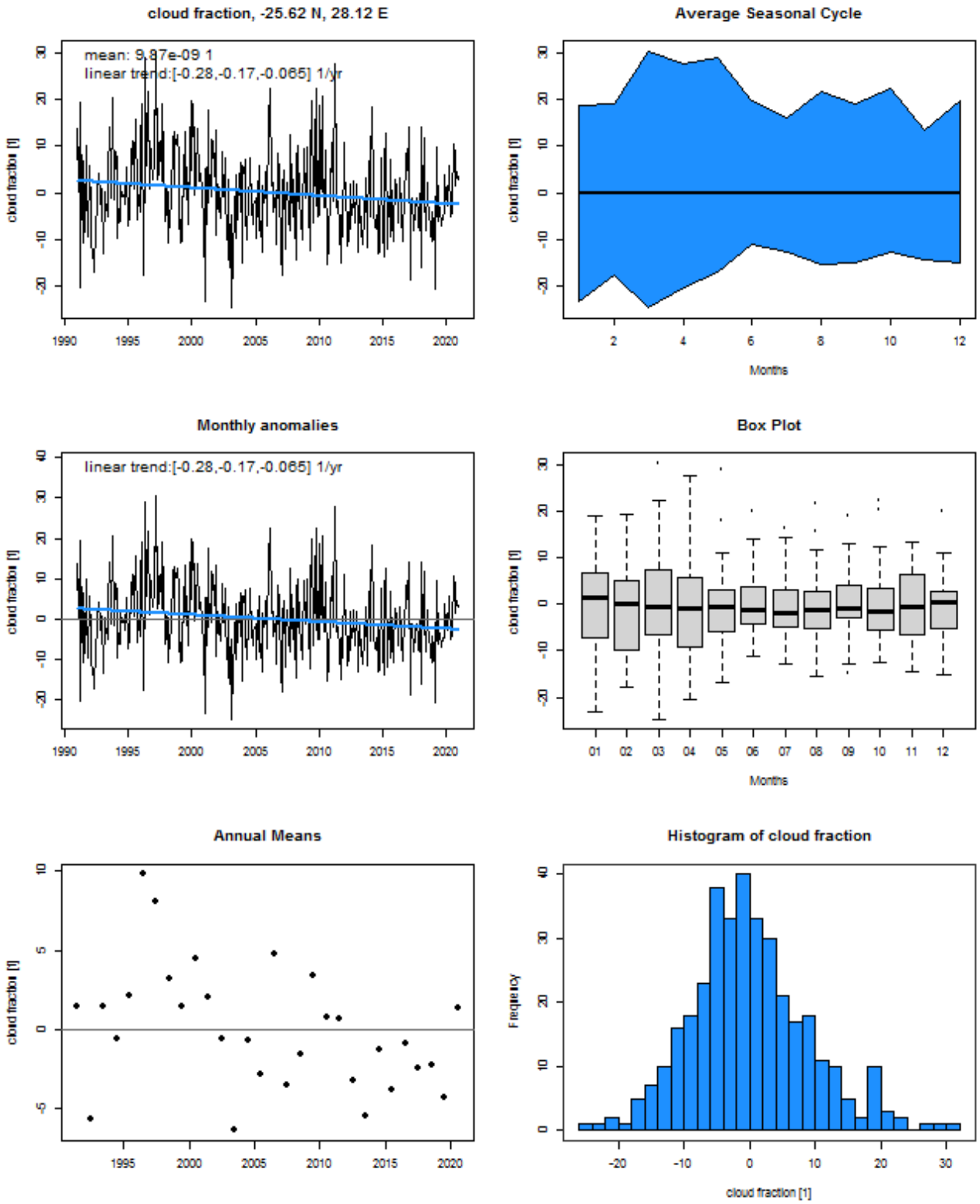

Fig. 10: „Overall analysis of the fractional cloud cover from 1991 to 2020 in Pretoria"

3.7 Time-series of monthly averages for a specific location (1991-2020)

Moreover, there is the possibility of plotting the monthly averages of cloud coverage over the given period of time (30 years).

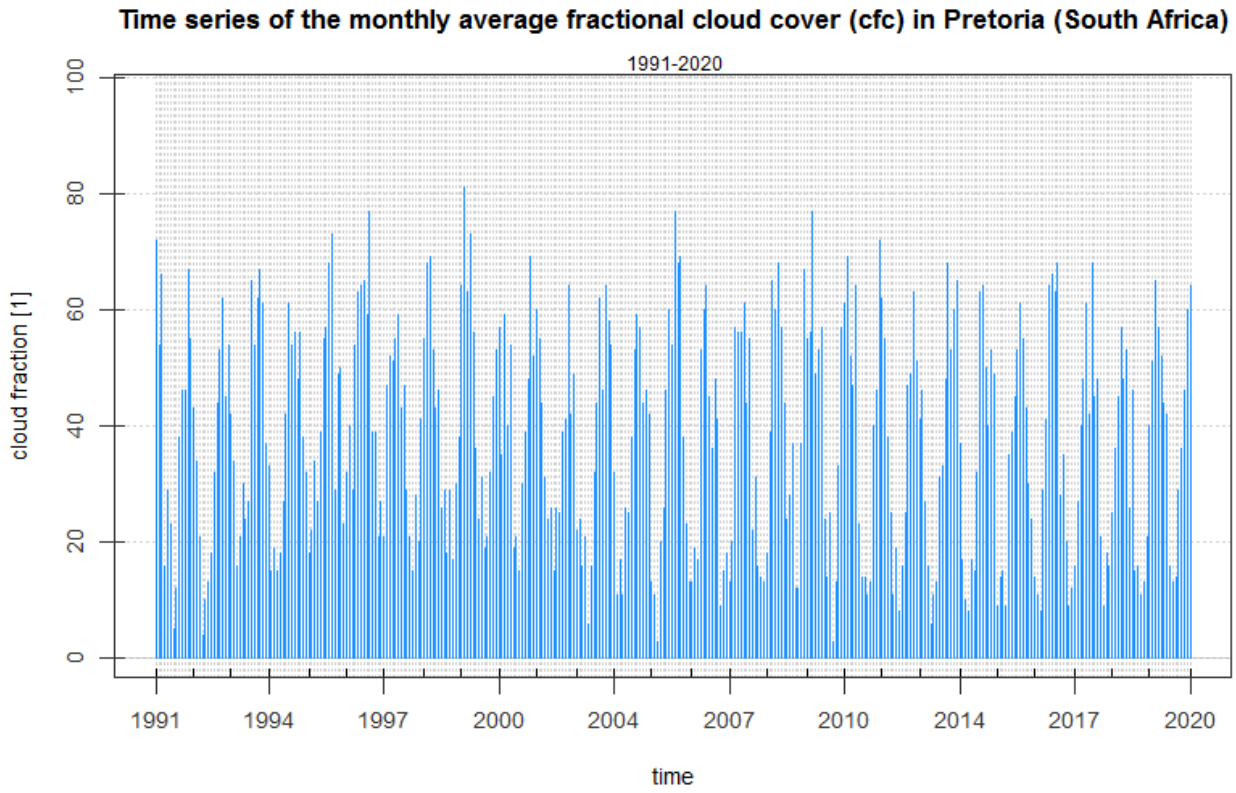

Fig. 11: „Time series of the monthly average fractional cloud cover from 1991 to 2020 in Pretoria"

3.8 Current year in comparison to the climatology

The function „climate analysis" makes it possible to visualize further important aspects. Thereby, the current year can be compared to the long-term mean displayed in graphs. The climatology is presented in multiple graphs while every single graph represents one year during the period observed. This also means that the years with the lowest and highest cloud coverage are given in the diagram. They can easily be read off. Accordingly, the highest cloud coverage has been achieved in 1996, whilst the lowest cloud coverage was measured in 2003. Looking at the black and red graph, we also see, that the cloud coverage in 2021 decreased in general. In addition to the plot, there will be a map outputted. Now it is possible to locate the areas in which the deviations in comparison to the normal condition are for example at its peak. The anomaly map shows accumulated values.

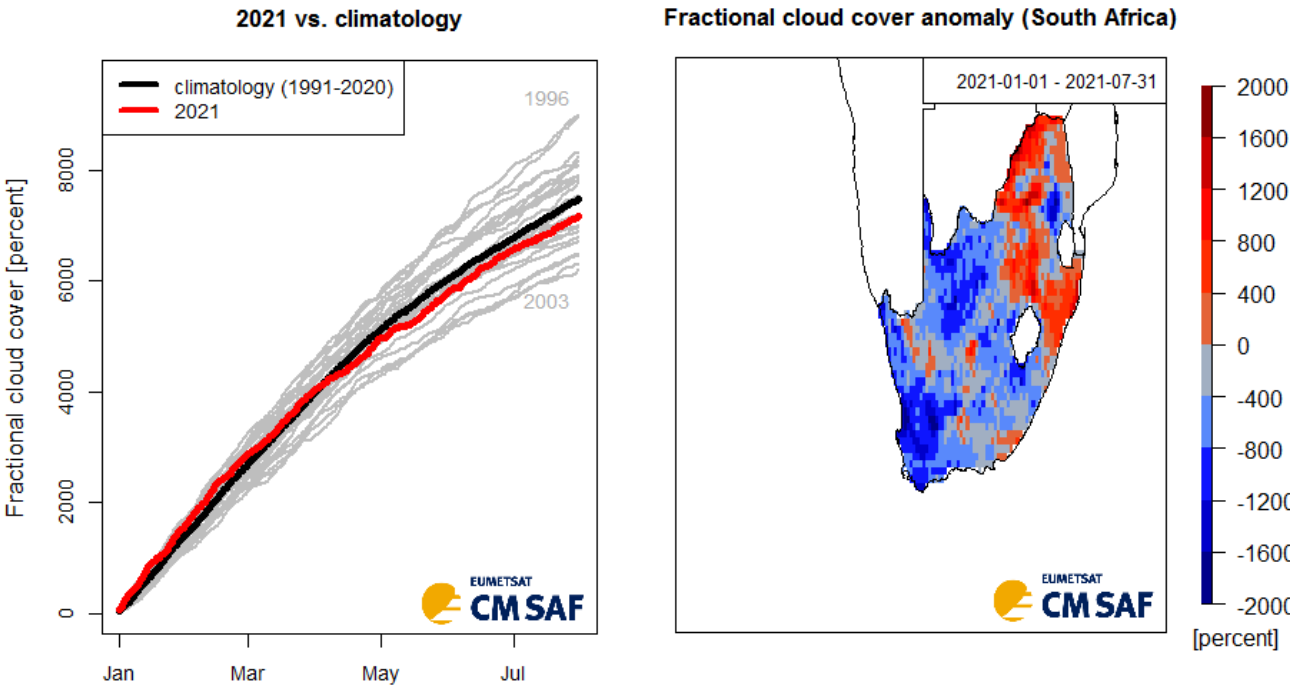

Fig. 12: „Plot of the current year (2021) in comparison to the climatology (on the left) as well as a map of the fractional cloud cover anomaly (accumulated) in South Africa in 2021 (on the right)"

3.9 Number of time steps above, below or equal to an uniquely defined threshold

Sometimes, it may also be beneficial to receive information about the amount of days above, under or even equal to a certain threshold value regarding the cloud coverage at that time, including information about the areas in which these values are attained. The threshold values must be defined beforehand. In the following examples, these threshold values were defined uniquely:

- ≤ 5% = „cloudfree"
- ≥ 95% = „cloudy"

The first image shows the amount of days in July 2021 and the impacted parts of the country that has been cloud free. The second image shows the opposite situation. The amount of cloudy days regarding the same region and same month are presented there.

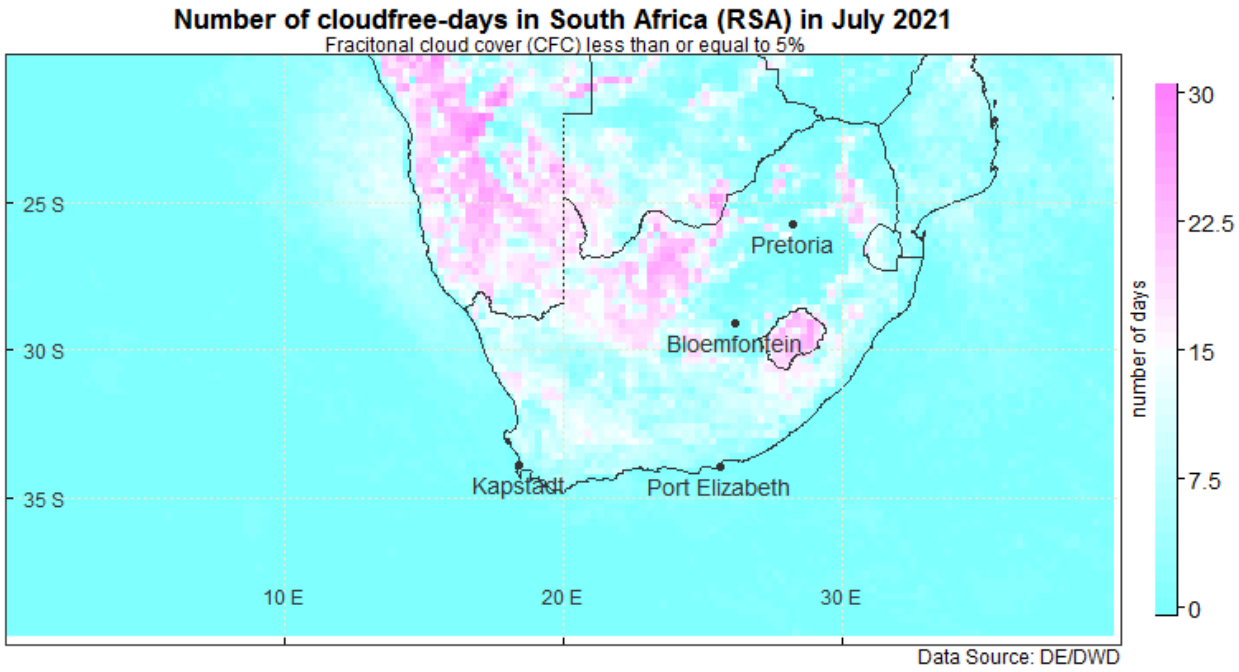

Fig. 13: „ Map of the number of cloudfree-days in South Africa in July 2021"

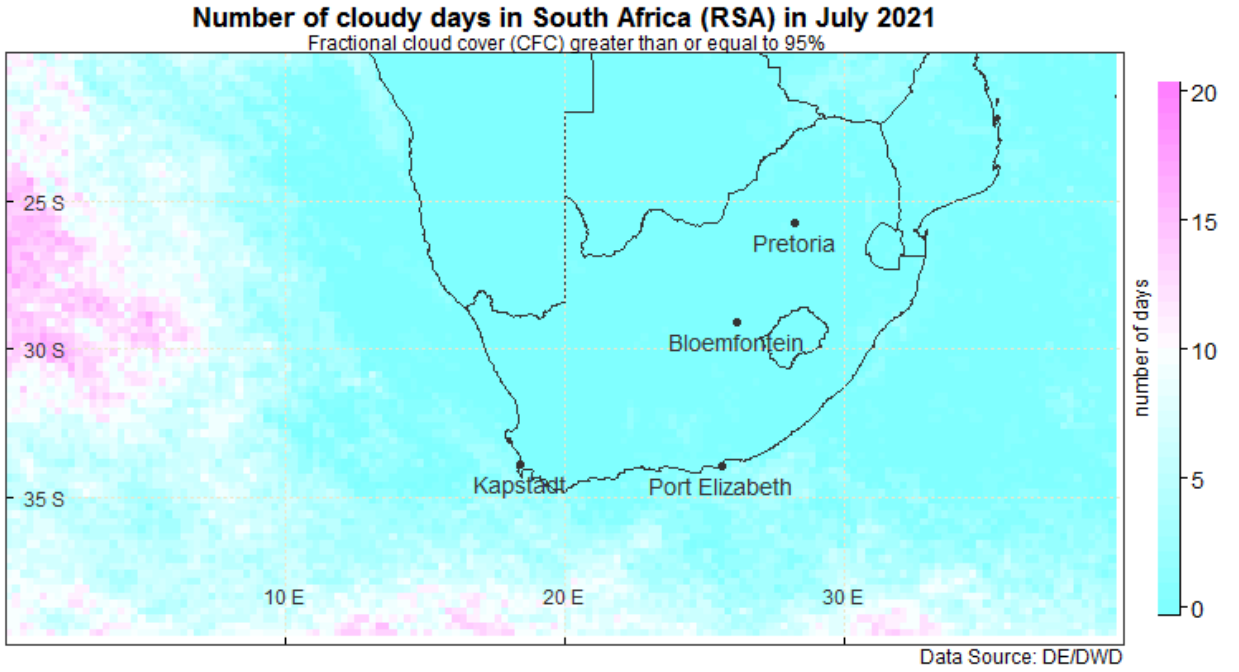

Fig. 14: „ Map of the number of cloudy days in South Africa in July 2021"

Each user can define the threshold values individually. This means that the images showing cloud coverage above, below or equal to a specific value within the range 0 - 100% can easily be adjusted to several different questions.

3.10 Mean number of cloud free days in July (1991-2020)

It is also possible to compare the number of cloud free days in the current month (see fig. 13) to the mean number of cloud free days in July during a 30-year period. By comparing these figures, anomalies during the observed month become visible. It is noticeable that especially in the northern part of the country the number of cloud free days decreased. Around Pretoria, the decline is particularly high.

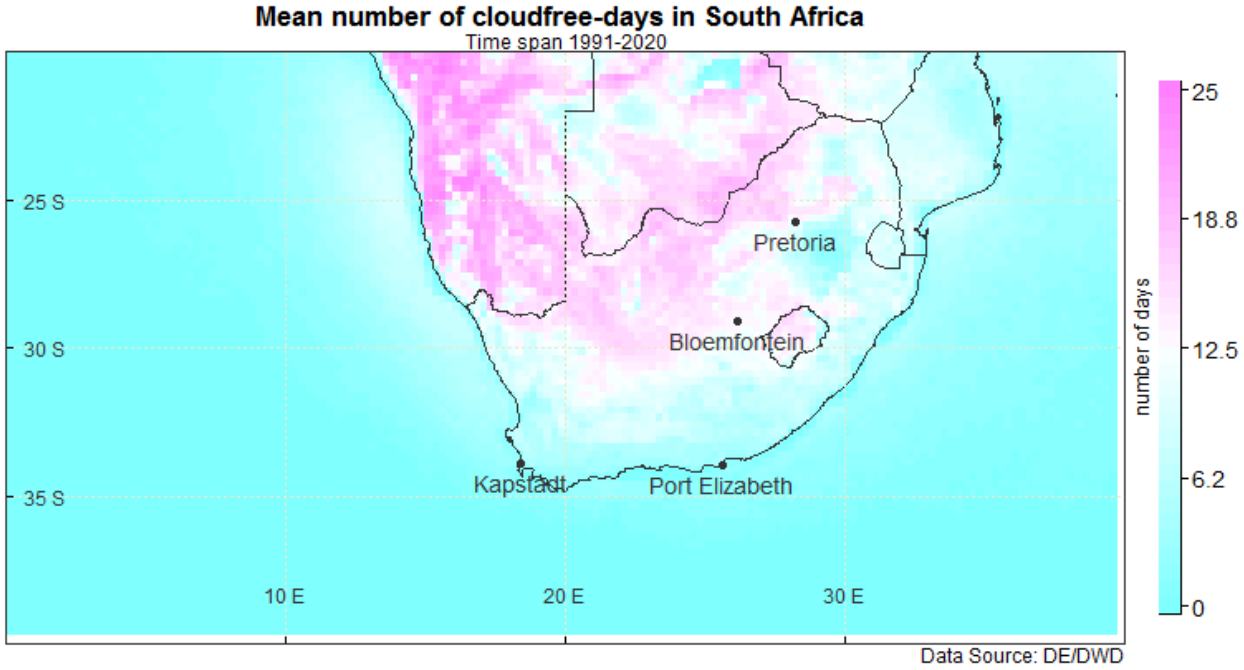

Fig. 15: "Map showing the mean number of cloudfree-days in South Africa in July 1991 to 2020"

4. Accessed data

- EUMETSAT CM SAF data on: https://wui.cmsaf.eu/

- Extract of South Africa:
  - Latitude: 20-40° S
  - Longitude: 0-40° E

- Data names:
  - Daily data July 2021 (01.07.-31.07.2021)
    „2021-07-01 2021-07-31, CFC - Fractional cloud cover, AVHRR on polar orbiting satellites, Daily, Mean, Global“

  - Daily data 1991-2021
    „1991-01-01 2021-07-31, CFC - Fractional cloud cover, AVHRR on polar orbiting satellites, Daily, Mean, Global“

  - Monthly data 1991-2018 (TCDR)
    „1991-01-01 2019-06-01, CFC - Fractional cloud cover, AVHRR on polar orbiting satellites, Monthly, Mean, Global“

  - Monthly data 2019-2020 (ICDR)
    „2019-01-01 2021-07-01, CFC - Fractional cloud cover, AVHRR on polar orbiting satellites, Monthly, Mean, Global“