Tutorial

This tutorial refers to the trend analysis of global cloud coverage regarding the different cloud levels low, middle and high using the CM SAF R-Toolbox. All steps on how to create the maps and plots with the R-Toolbox are documented in here. The order is based on the order of the report.

- First of all, you need to download global monthly mean data of fractional cloud cover (cfc) for the time span 1991-2020. The exact data names are written down in the report
- All data is available on: https://wui.cmsaf.eu/
- All necessary variables (low, middle, high, day, night cloud coverage) are included in the CFC-dataset
- Choose as much TCDR-data as possible and ICDR for the remaining

How to create a…

✓ …trend analysis of global cloud coverage of low, middle and high clouds and the corresponding significances?

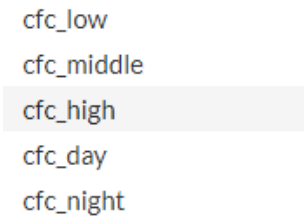
1. **Prepare**: Untar and unzip the global monthly mean data, which you already downloaded, by selecting the date range you want to analyze (1991-01-01-2020-12-01).

   To be able to use the whole data range, you must combine the downloaded TCDR and ICDR data!

   It might be helpful to know that TCDR and ICDR data can be combined by giving them same names in ascending order.

   → if you need more help, please take a look at the tutorial on how to create a “Monthly report”

2. Then, choose one of the following variables:



Select your longitude and latitude range of interest if you want to limit the area. Then create the corresponding .nc-files:

- cfc_low → cfc_low_1991-01-01-2020-12-01.nc
- cfc_middle → cfc_middle_1991-01-01-2020-12-01.nc
- cfc_high → cfc_high_1991-01-01-2020-12-01.nc

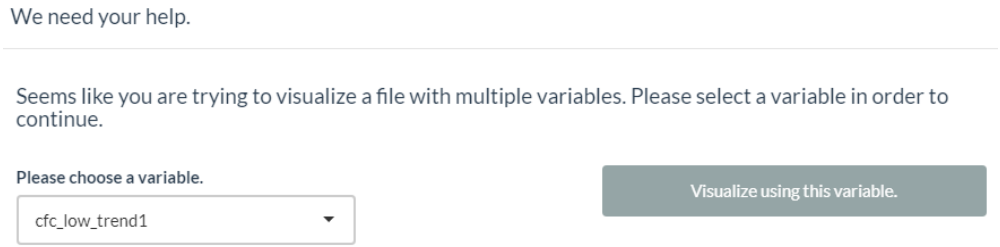
3. Repeat step 2. for every variable you want to analyze. Always select the same date range or select the corresponding timeframe directly when ordering your data!

4. **Analyze:**
   a) Choose the variables low, middle and high sequentially
   b) Select “Temporal Operators” as the group of operators as well as “Linear Trend” as the operator and create the output files!

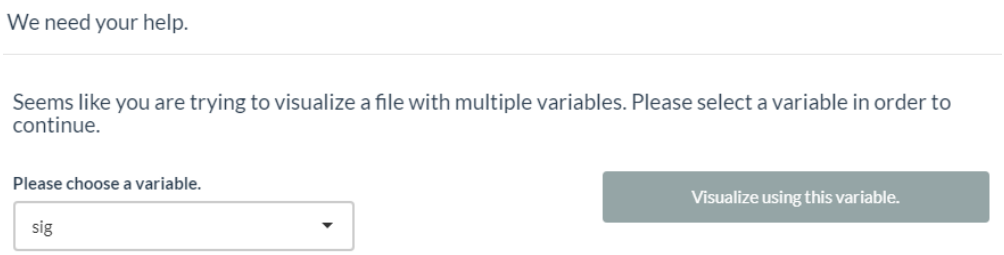
   c) You can choose fast computation if your data is not too big, otherwise untick the box; in this example, fast computation has been selected

5. After some seconds, the following window will appear and you will be asked to choose one of the variables:

   a) To illustrate a **simple linear trend**, select “trend_1” and visualize your data!



   b) To illustrate the significance of the linear trends as a map, select “sig” as a variable and start visualizing!



6. **Visualize:**
   - ❖ The colorbar “Blue-Red 3” is well-suited to illustrate trends in a map
   - ❖ You can also adjust the range of values individually to make the trends more visible

➔ **Result:** “Significance of the linear trends presented in maps (at the top) in comparison to the global maps of linear trends in the different cloud coverages (below) within the time span 1991-2020” (see fig. 3)

✓ …long-term mean of the respective cloud coverage?

1. **Starting with Analyze:** The already created .nc-files of low, middle and high clouds can now be used to depict the long-term mean for each of them

2. Choose again “Temporal operators” but then “all time mean” for every variable and visualize the data

3. Repeat these steps for every variable one after another!

➔ **Result:** “Maps of the long-term mean cloud coverage of low, middle and high clouds (below) within the time span 1991-2020” (see fig. 1)

✓ …global time series of cloud coverage regarding different cloud levels?

1. **Starting with Analyze:** choose again the already created .nc-files of low, middle and high clouds

2. Next, choose “Spatial Operators” and “Spatial means” and apply the operators!

3. **Visualize:** In addition, tick the box “linear trend” to insert a trend line.

4. Repeat these steps for every variable one after another!

➔ **Result:** “Global time series of cloud coverage of low, middle and high clouds (at the top)” (see fig. 2)

✓ …map of seasonal analysis of linear trends in cloud coverage of low, middle and high clouds?

1. **Starting with Analyze**: Choose again the already created .nc-files of low, middle and high clouds

2. Select “Seasonal statistics” as a group of operators as well as “Seasonal means” as the operator

3. Tick the box saying: “do you want to apply another operator afterwards?” and apply the operator

4. Then, choose “Selection” and “Select list of months”

> Please note that if you want to illustrate summer season (June – August) you only have to select “June” in the list of months. This also applies for winter season (December – February). It is only necessary to select “December”.
>
> → which means that in this case, selecting only the first month of the season refers to the whole season! (see pt.6)

5. Afterwards, select “Temporal Operators” and “Linear Trend”, untick the box and visualize the seasonal analysis!

6. **Visualize:** select the right time time → June for summer season and December for winter season, for example:

   - ❖ Please note that 1991 is the start year, but covers the whole time range from 1991 to 2020!

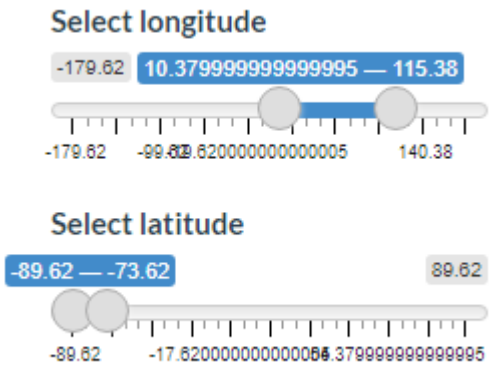
5. Repeat these steps for every variable one after another!

➔ **Result:** “Seasonal analysis of linear trends in cloud coverage of low, middle and high clouds” (see fig. 4)

✓ …time series of monthly means in selected regions?

1. Same process as before:
   Starting with Analyze: choose again the already created .nc-files of low, middle and high clouds

2. Next, select “Selection” and “Select region by longitude and latitude”, set the range of the area you want to analyze
   a) In a previous version you have to set the range by using sliders:
   For example: (a selected region in the Antarctica)



   b) In a newer version you can directly type in the longitudes and latitudes of your chosen area (in boxes)

3. Tick the box saying: “do you want to apply another operator afterwards?” and apply the operator

4. Then choose “Spatial Operators” and “Spatial means”, untick the box and visualize the time series!

5. Repeat these steps for every variable one after another!

➔ **Result:** “Time series of monthly means in selected regions in the northern and southern hemisphere” (see fig. 5)

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