

CDO installation and use

Climate Modelling course
Chair of Meteorology

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 [dquesadacr](https://github.com/dquesadacr)



Diese Maßnahme wird mitfinanziert durch Steuermittel auf der Grundlage des vom Sächsischen Landtag beschlossenen Haushaltes.

1. From the CDO documentation

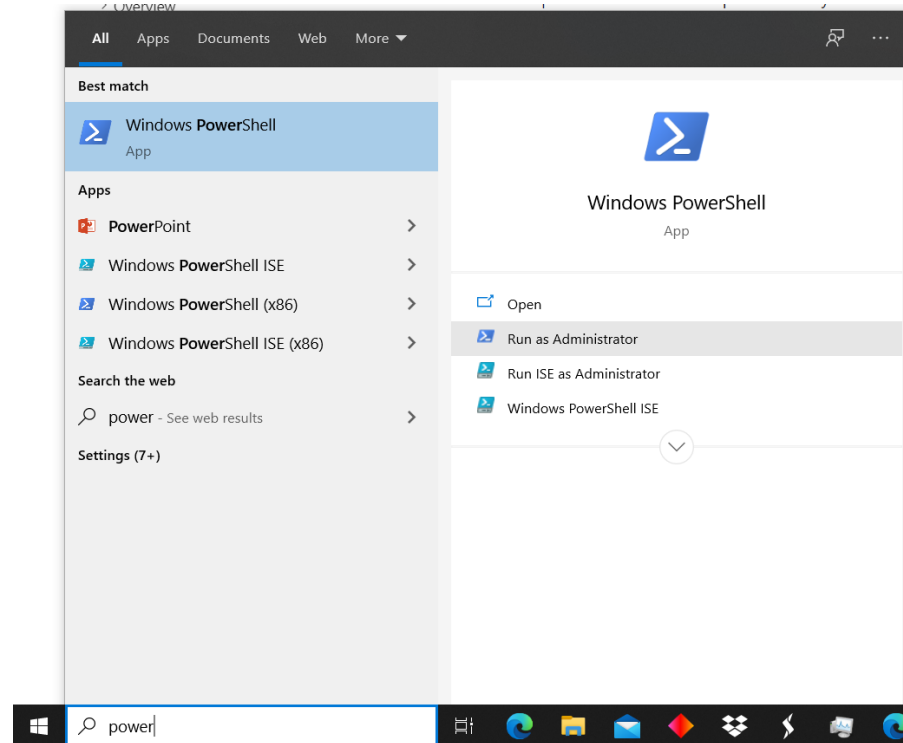
- **CDO** stands for [Climate Data Operators](#)
- CDO is [meant](#) for Posix compatible operating systems (like Linux)
- Nevertheless, [here](#) you can find the official recommendations to run CDO on Windows
 - The *Windows Subsystem for Linux* version 2 (wsl2) installs a Linux kernel to create a proper compatibility layer for Windows
 - The following steps correspond to option #2 on the documentation and works for *Windows 10*
 - In case of *Windows 8*, wsl1 should be installed (not yet tested for our purpose)
 - *Windows S* is incompatible
- Should also work in [MacOS](#)

2. Install wsl

- The following steps were taken from [here](#)
- Note that these steps are for *wsl* version 2
- Some visual aid is added

2.1. Enable the Windows Subsystem for Linux

1. Open PowerShell as Administrator:



2. And run (type or copy — paste [right-click on *PowerShell*] and then press enter):

```
dism.exe /online /enable-feature /featurename:Microsoft-Windows-Subsystem-Linux /all /norestart
```

2.2. Update to WSL 2 (check Windows version)

- Windows 10 **version 1903+**, **build 18362+**. For most computers (x64)
- Check with **Win key + R**, type **winver** → **OK**
- Update if needed:

If you are running Windows 10 version 1903 or 1909, open "Settings" from your Windows menu, navigate to "Update & Security" and select "Check for Updates". Your Build number must be 18362.1049+ or 18363.1049+, with the minor build # over .1049.

2.3. Enable Virtual Machine feature

1. From the PowerShell as Administrator run:

```
dism.exe /online /enable-feature /featurename:VirtualMachinePlatform /all /norestart
```

2. Restart to complete WSL install and updates

2.4. Download the Linux kernel update package

- [Download](#) WSL2 Linux kernel update package for x64 machines
- Install as administrator (elevated permissions)

2.5. Set WSL 2 as your default version

- From the PowerShell as Administrator run:

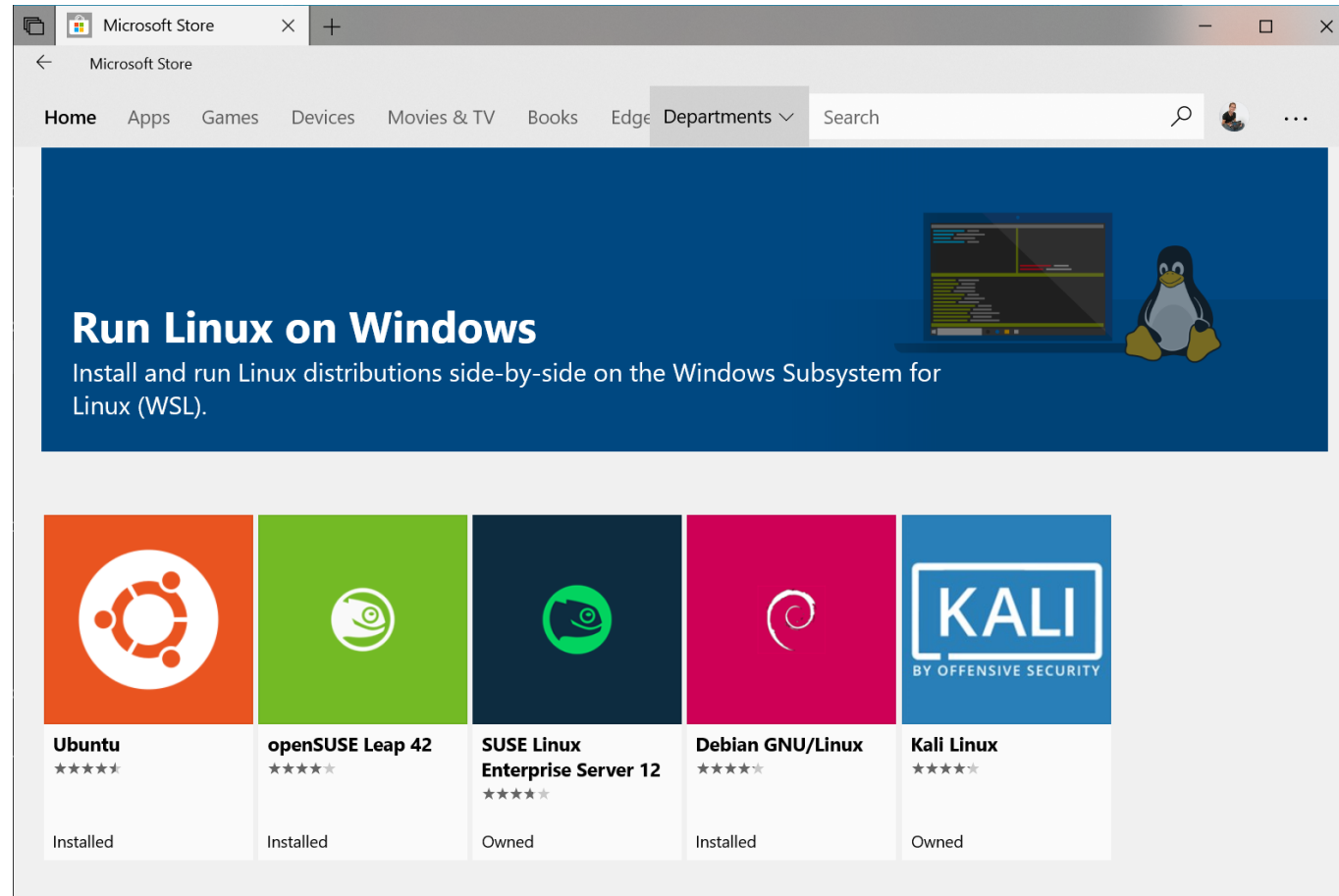
```
wsl --set-default-version 2
```



wsl2 setup finished!

3. Install Linux distro


1. Open the Microsoft Store and select a Linux distribution (distro)



2. Ubuntu 18.04 and 20.04 were tested for CDO. After this, *Ubuntu* should be a searchable program in Windows

3.1. Setting Ubuntu

1. Open the Ubuntu app
2. On the first launch, it will show this:

 Ubuntu 20.04 LTS

```
Installing, this may take a few minutes...  
Please create a default UNIX user account. The username does not need to match your Windows username.  
For more information visit: https://aka.ms/wslusers  
Enter new UNIX username:
```

3. Set credentials, user and password (twice)
4. Output should look like this:

dqc@ ~

```
Installing, this may take a few minutes...
Please create a default UNIX user account. The username does not need to match your Windows username.
For more information visit: https://aka.ms/wslusers
Enter new UNIX username: dqc
New password:
Retype new password:
passwd: password updated successfully
Installation successful!
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.
```

Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 4.19.128-microsoft-standard x86_64)

```
* Documentation: https://help.ubuntu.com
* Management:   https://landscape.canonical.com
* Support:      https://ubuntu.com/advantage
```

System information as of Sat Oct 17 17:22:44 CEST 2020

```
System load: 0.1          Processes:            8
Usage of /:  0.4% of 250.98GB Users logged in:         0
Memory usage: 0%          IPv4 address for eth0: 192.168.115.158
Swap usage:  0%
```

```
1 update can be installed immediately.
0 of these updates are security updates.
To see these additional updates run: apt list --upgradable
```

```
The list of available updates is more than a week old.
To check for new updates run: sudo apt update
```

```
This message is shown once a day. To disable it please create the
/home/dqc/.hushlogin file.
```

dqc@ ~\$

3.3. Update and upgrade

- Run from the Linux terminal:

```
sudo apt-get update  
sudo apt-get upgrade -y
```

- To run `sudo` you will be asked for the password set in the previous step
- This might take a while, you should see something like this:

```
Fetches 17.4 MB in 4s (4629 kB/s)
Reading package lists... Done
dqc@~$ sudo apt-get upgrade -y
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
The following packages have been kept back:
  base-files sosreport ubuntu-server
The following packages will be upgraded:
  alsa-ucm-conf apport bcache-tools bind9-dnsutils bind9-host bind9-libs bolt bsdutils busybox-initramfs busybox-st
  cryptsetup-run curl fdisk finalrd gcc-10-base gir1.2-packagekitglib-1.0 initramfs-tools initramfs-tools-bin initr
  libc-bin libc6 libcryptsetup12 libcurl3-gnutls libcurl4 libdns-export1109 libfdisk1 libgcc-s1 libgl1 libglvnd0 li
  libpam-modules-bin libpam-runtime libpam0g libproxy1v5 libpulse0 libpulsedsp libpython3.8 libpython3.8-minimal li
  locales mdadm mount open-vm-tools packagekit packagekit-tools pulseaudio-utils python3-apport python3-commandnotf
  python3-software-properties python3-urllib3 python3.8 python3.8-minimal rsyslog secureboot-db show-motd snapd sof
  ubuntu-wsl unattended-upgrades update-motd util-linux uuid-runtime xz-utils zlib1g
97 upgraded, 0 newly installed, 0 to remove and 3 not upgraded.
Need to get 55.9 MB of archives.
After this operation, 3645 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 bsdutils amd64 1:2.34-0.1ubuntu9.1 [63.1 kB]
Get:2 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 gcc-10-base amd64 10.2.0-5ubuntu1~20.04 [19.7 kB]
```

4. Install and check CDO

- To install, simply run from the Ubuntu terminal:

```
sudo apt-get install cdo -y
```



Installation finished!

- The last step works also for other Ubuntu based distros
- It is also available for other distros e.g. Arch based

4.1. CDO version

- Check that CDO is working with:

```
cdo --version
```

```
dqc@: /mnt/e/HSE/Thesis/Data/Taurus$ cdo --version
Climate Data Operators version 1.9.3 (http://mpimet.mpg.de/cdo)
CXX Compiler: g++ -g -O2 -fdebug-prefix-map=/build/cdo-g3Qjnd/cdo-1.9.3+dfsg.1=. -fstack-protector-strong
-Wformat -Werror=format-security -fopenmp
CXX version : g++ (Ubuntu 7.3.0-1ubuntu1) 7.3.0
C Compiler: gcc -g -O2 -fdebug-prefix-map=/build/cdo-g3Qjnd/cdo-1.9.3+dfsg.1=. -fstack-protector-strong
-Wformat -Werror=format-security -Wall -pedantic -fPIC -fopenmp
C version : gcc (Ubuntu 7.3.0-1ubuntu1) 7.3.0
F77 Compiler: f77 -g -O2 -fdebug-prefix-map=/build/cdo-g3Qjnd/cdo-1.9.3+dfsg.1=. -fstack-protector-strong
F77 version : unknown
Features: 12GB C++14 Fortran DATA PTHREADS OpenMP45 HDF5 NC4/HDF5/threadsafe OPeNDAP SZ UDUNITS2 PROJ.4
MAGICS CURL FFTW3 SSE2
Libraries: HDF5/1.10.0 proj/4.93 curl/7.58.0
Filetypes: srv ext ieg grb1 grb2 nc1 nc2 nc4 nc4c nc5
  CDI library version : 1.9.3
  GRIB_API library version : 2.6.0
  NetCDF library version : 4.6.0 of Feb  9 2018 19:21:24 $
  HDF5 library version : library undefined
  EXSE library version : 1.4.0
  FILE library version : 1.8.3
```

5. CDO installation in MacOS

- The following solutions have not been tested by us but they reportedly work for MacOS. This information was taken from the CDO [wiki](#)

1. With [MacPorts](#) simply run from the terminal:

```
port install cdo +grib_api +magicssp +szip
```

2. With [homebrew](#):

```
brew tap moffat/sciencebits  
brew install cdo
```

- If needed, to install [homebrew](#):

1. To install with [ruby](#), run this:

```
ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"
```

2. If the last command doesn't work, try:

```
curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install > \  
    brew_install_script  
ruby brew_install_script  
    rehash
```


6. Basic shell commands

- To work from the terminal, some basic commands are needed:
 1. `mkdir` → creates directory. The following creates the folder `data` in the current directory

```
mkdir data
```

2. `pwd` → print working directory. To check the current working directory
3. `cd` → change directory. To access the created folder:

```
cd data
```

4. `ls` → list contents of current directory
5. `cp` → copy file. This copies `file1` to `file2`

```
cp file1 file2
```

6. `mv` → move files or directories (also to rename). The following moves `file1` into the created folder while renaming it to `file2`

```
mv file1 data/file2
```

7. `cat` → prints the content of a file (text)
- More info [here](#) and [here](#)

7. Accessing Windows files from Linux

1. Download the provided `test.nc` file
2. If the file was downloaded to `C:\User\Downloads`, to access the downloads folder do:

```
cd /mnt/c/User/Downloads
```

3. Try some *CDO* commands as:

```
cdo sinfo test.nc # short description of the file
cdo griddes test.nc # grid description
cdo graph,device="png" -selgridcell,1 test.nc plot # quick plot
```

4. The *CDO* operators are [here \(explained\)](#) or type:

```
cdo --operators
```

5. If you encounter issues opening or accessing the file do:

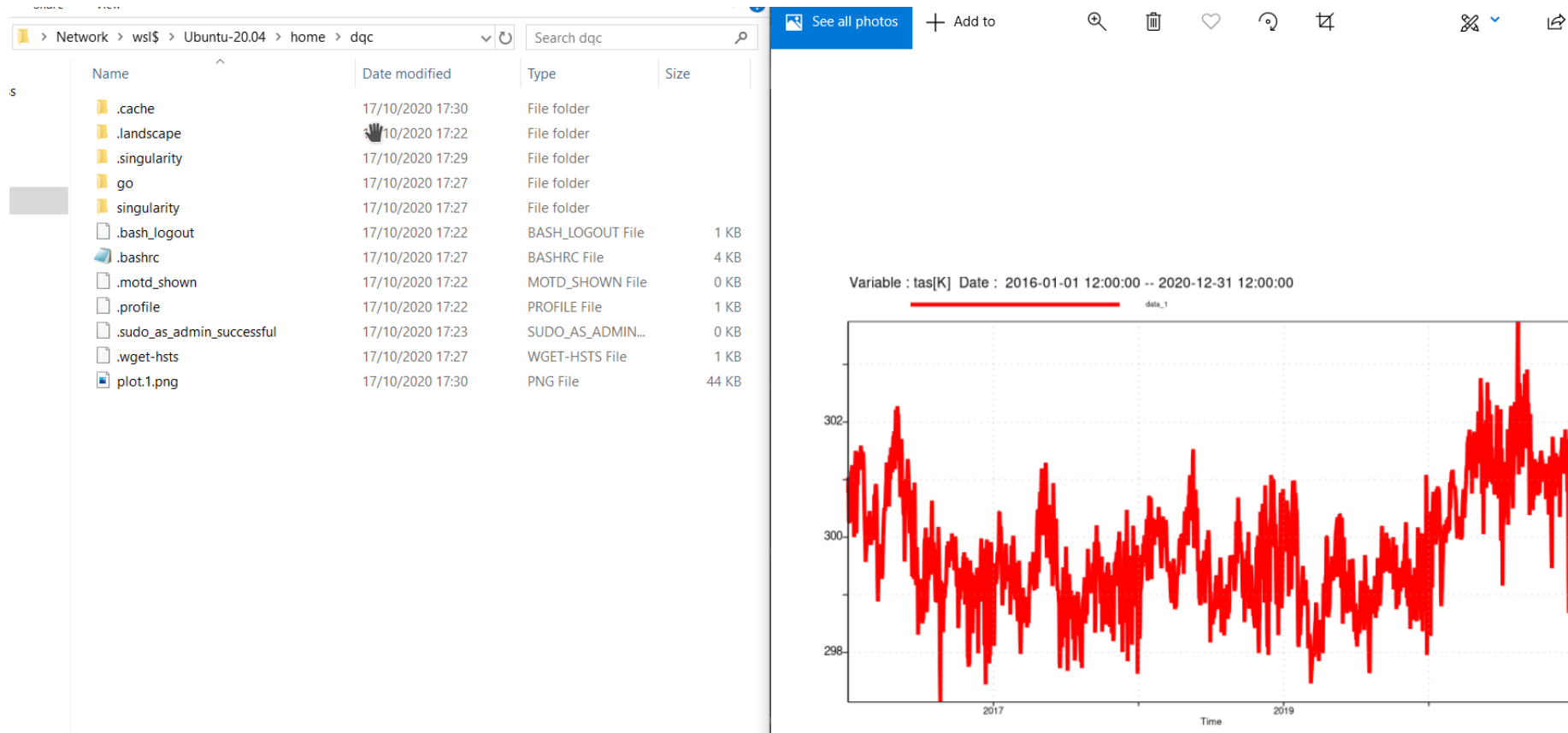
```
sudo chown $USER test.nc
```

7.1. Griddes output

```
dqc@:/mnt/e/HSE/Thesis/Data/Taurus$ cdo griddes test1.nc4
#
# gridID 1
#
gridtype = lonlat
gridsize = 196
xsize    = 14
ysize    = 14
xname     = lon
xlongname = "longitude"
xunits    = "degrees_east"
yname     = lat
ylongname = "latitude"
yunits    = "degrees_north"
xfirst    = 270
xinc      = 0.75
yfirst    = 15
yinc      = -0.75
scanningMode = 64
cdo griddes: Processed 1 variable [0.01s 57MB]
```

8. Accessing Linux files from Windows

1. Type `\\wsl$` on the file explorer path (on the top), enter
2. Then click *Ubuntu* → *home* → *user*
3. Should look something like this (note the plot created before):



9. Exercise

1. Exploration of *NetCDF* files
2. Visualization of the files
 - A set of example files are [\[here\]](#)
3. Manipulation of files
4. Selection of desired coordinates
5. Export data as text for further manipulation in other software
6. Download CORDEX files

10. Exploration

- To have an idea of the contents of the file we can run some commands from the terminal that will print some information to the screen
- Commands to try:
 - `cdo sinfo file` → short description of the contents
 - `cdo griddes file` → description of the grid
 - `ncdump file` → metadata description, not CDO but useful
 - Try with `-h` (header) and `-c` (coordinates)
- See more options with `cdo --operators`
- Check help of a operator with e.g. `cdo --help sellonlatbox` or [here](#)

11. Visualization

- It is possible to create high-quality plots from CDO by using the [Magics](#) software
 - Already included in the installation process explained before
- The documentation of the use of [CDO+Magics](#) is [here](#)
- There are 3 types of plots with this combination
 - 2D Lon-Lat plots: [shaded](#), [grfill](#) and [contour](#)
 - 2D [vector](#) plots: plots vectors (e.g. wind fields) on 2D maps
 - Line [graph](#) plots: generates time-series plots
- Due to the *rotated pole* rotation embedded in **CORDEX** projections, 2D plotting options within CDO are not available
 - They only accept *rectilinear* grids and CORDEX is *curvilinear*
 - Reprojection needed to plot them
 - It can be done with CDO
 - Or check this [repo](#) for an R solution

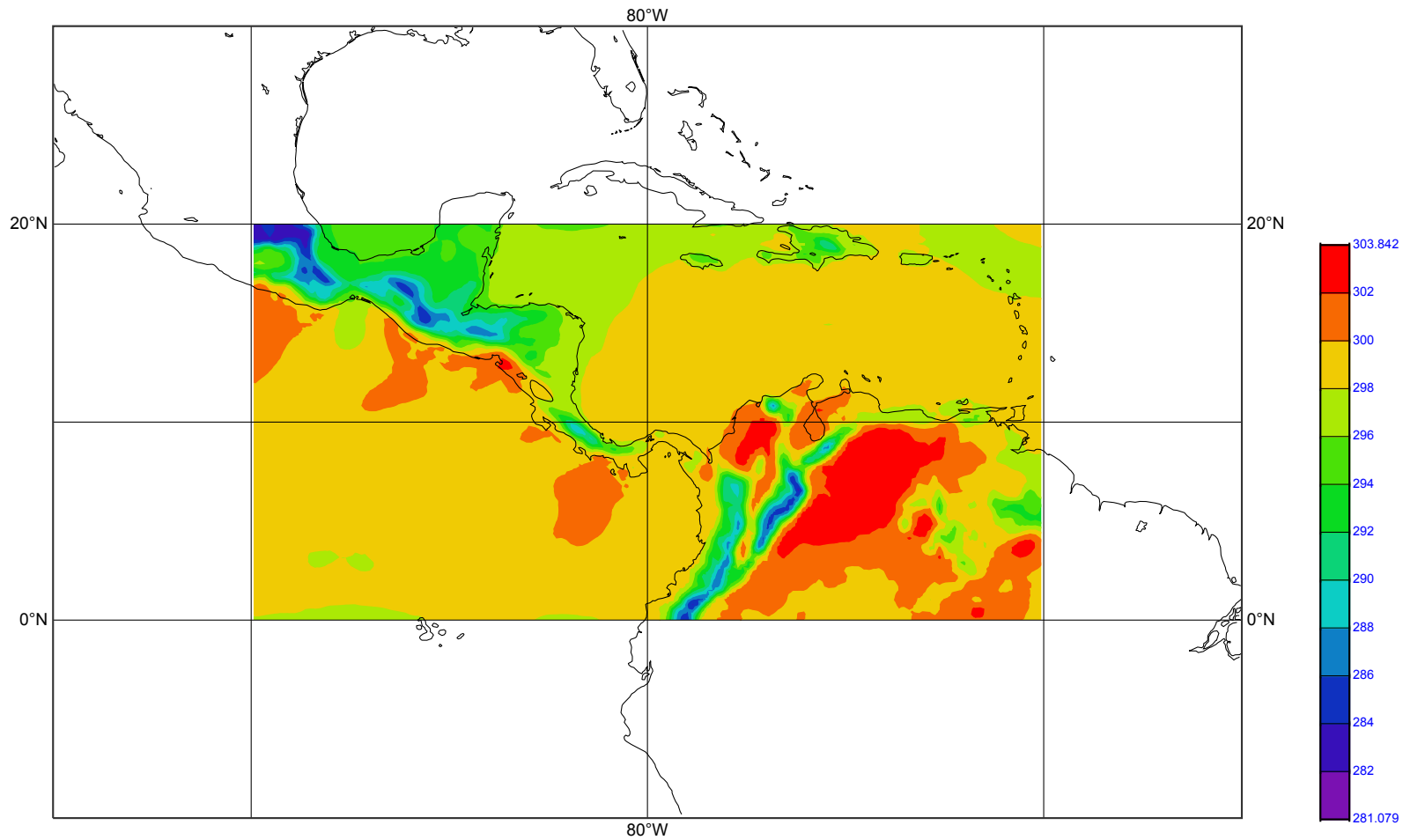
11.1. 2D Lon-Lat

- From the terminal, access the folder where the `2m_temperature.nc` file was downloaded
 - This file is a small example of a *rectangular* grid taken from ERA5
- Run the following command

```
cdo -shaded,device=pdf,lon_max=-50,lon_min=-110,lat_max=30,lat_min=-10,\
    interval=2,colour_triad=cw,colour_min=violet,colour_max=red \
    -seltimestep,42 2m_temperature.nc shaded
```

- Resulting file `shaded_2t.pdf` should be created, shown on next slide
- Note the arguments passed to CDO
 - Two functions, `shaded` and `seltimestep`, are passed with corresponding parameters
 - The `-` allows concatenation of several functions
 - Here we selected only the 42nd step.
 - The `\` are only to break the line, this command could be written in one line
- Try adding `,seq_freq=10` after `red` (no space) and removing `-seltimestep,42`
 - Check resulting file
- Try the `contour` and `grfill` commands

2t [K] 1979-02-10 11:30:00



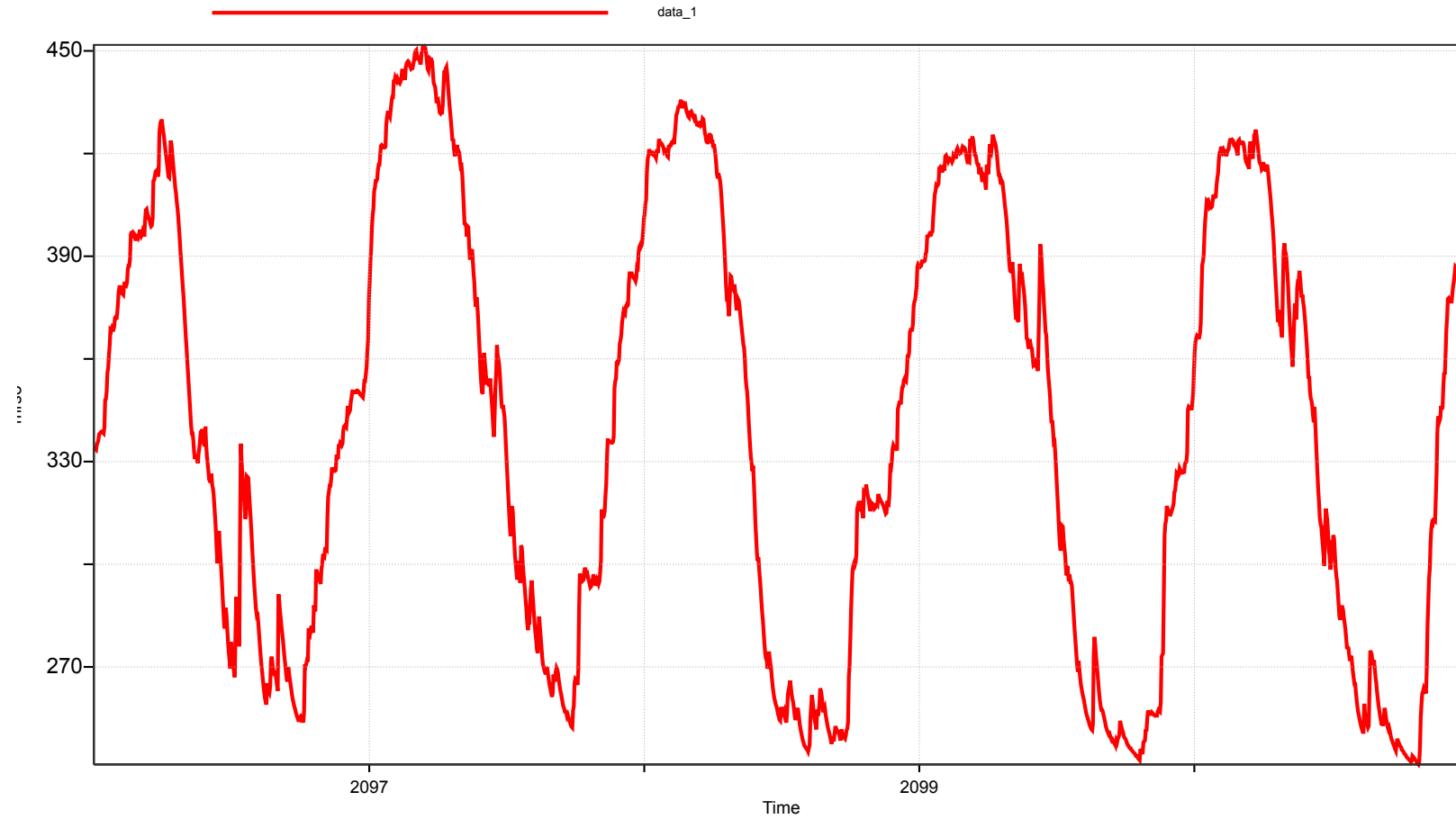
11.3. Line graph plots

- These type of plots are possible with CORDEX files (no need for rectangular grids)
- Let's plot a time series for the city of Dresden
- Run this command from the terminal:

```
cdo -graph,device=pdf,linewidth=4 -remapnn,lon=13.73/lat=51.05 \
mrso_EUR-44_ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4_v1_day_20960101-21001231.nc graph
```

- The file `graph.pdf` should have been created in the working directory
- Note the `remapnn` function → remap to the nearest neighbour
 - Returns the time series related to the pixel in which the given coordinate pair is
- Plot in next slide

Variable : mrso[kg m-2] Date : 2096-01-01 12:00:00 -- 2100-12-31 12:00:00



12. Manipulation of files

12.1. Merge

- Merge all the provided historical run files into one and save into new file

```
cdo -z zip -mergetime \  
mrso_EUR-44_ICHEC-EC-EARTH_historical_r12i1p1_SMHI-RCA4_v1_day_19* \  
historical_1961-1990.nc
```

- Notes
 - `-z zip` to compress the file
 - `-mergetime` is the main function
 - `19*` wildcard to give as input all the historical files instead of typing each
 - `historical_1961-1990.nc` is the name of the output file
- Explore resulting file

12.2. Cropping

- To select only a pixel where our location of interest is, again, for Dresden:

```
cdo -remapnn,lon=13.73/lat=51.05 \  
mrso_EUR-44_ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4_v1_day_20960101-21001231.nc \  
mrso_dresden.nc
```

- To select the pixels inside a boundary box, Saxony (approx.) for example:

```
cdo -sellonlatbox,11.5,15.5,49.7,52.2 \  
mrso_EUR-44_ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4_v1_day_20960101-21001231.nc \  
mrso_saxony.nc
```

- Check the files with `griddes` and `sinfo`

12.3. Exporting to text

- For further analysis and plots, one might want to export some information in text format
- For example, for the previous file for Dresden:

```
cdo -outputkey,year,month,day,lon,lat,value mrso_dresden.nc > table.txt
```

- The file `table.txt` will be created and can be parsed with e.g. R, Python or Excel to do:
 - Further statistical analysis
 - Boxplots comparing historical vs future conditions
 - Day of the year plots, etc.

13. Downloading CORDEX files

1. Create account for ESGF [node](#)
2. Login with your [OpenID](#) after receiving confirmation email
3. Register to the CORDEX group
4. Explore and select desired data (checked boxes, note, for later where the pointer is)

Project

☒ CORDEX (8)

Product

Domain

☒ CAM-44 (8)

Institute

Driving Model

☒ MPI-M-MPI-ESM-LR (8)

Experiment

☒ historical (4)
☒ rcp85 (4)

Experiment Family

Ensemble

RCM Model

Downscaling Realisation

Time Frequency

☒ day (8)

Variable

Variable Long Name

☒ Near-Surface Air Temperature (2)
☒ Precipitation (2)
☒ Total Runoff (2)
☒ Total Soil Moisture Content (2)

CF Standard Name

Datanode

Enter Text:

Search

Reset

Display

10

results per page

[More Search Options](#)

☐ Show All Replicas

☐ Show All Versions

☐ Search Local Node Only (Including All Replicas)

Search Constraints:

☒ CAM-44

☒ CORDEX

☒ historical,rcp85

☒ day

☒ Near-Surface Air Temperature,Precipitation,Total Runoff,Total Soil Moisture Content

☒ MPI-M-MPI-ESM-LR

Total Number of Results: 8

-1-

[Add all displayed results to Data Cart](#)

[Remove all displayed results from Data Cart](#)

Expert Users: you may display the search URL and return results as XML or return results as JSON

1. cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.historical.r111p1.RCA4.v1.day.mrso

Data Node: esg-dn1.nsc.liu.se

Version: 20141105

Total Number of Files (for all variables): 11

Full Dataset Services: [Show Metadata](#) [List Files](#) [THREDDS Catalog](#) [WGET Script](#)

[Add to Data Cart](#)

2. cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.historical.r111p1.RCA4.v1.day.mrro

Data Node: esg-dn1.nsc.liu.se

Version: 20141105

Total Number of Files (for all variables): 11

Full Dataset Services: [Show Metadata](#) [List Files](#) [THREDDS Catalog](#) [WGET Script](#)

[Add to Data Cart](#)

3. cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.historical.r111p1.RCA4.v1.day.pr

Data Node: esg-dn1.nsc.liu.se

Version: 20141105

Total Number of Files (for all variables): 11

Full Dataset Services: [Show Metadata](#) [List Files](#) [THREDDS Catalog](#) [WGET Script](#)

[Add to Data Cart](#)

4. cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.historical.r111p1.RCA4.v1.day.tas

Data Node: esg-dn1.nsc.liu.se

Version: 20141105

Total Number of Files (for all variables): 11

Full Dataset Services: [Show Metadata](#) [List Files](#) [THREDDS Catalog](#) [WGET Script](#)

[Add to Data Cart](#)

5. cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.rcp85.r111p1.RCA4.v1.day.mrso

Data Node: esg-dn1.nsc.liu.se

Version: 20141105

Total Number of Files (for all variables): 19

Full Dataset Services: [Show Metadata](#) [List Files](#) [THREDDS Catalog](#) [WGET Script](#)

13.1. File by file

1. To download file by file through your browser click on **list files**
2. Then click on **HTTP Download**, this will open a prompt

1. cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.historical.r1i1p1.RCA4.v1.day.mrso
Data Node: esg-dn1.nsc.liu.se
Version: 20141105
Total Number of Files (for all variables): 11
Full Dataset Services: [[Show Metadata](#)] [[Hide Files](#)] [[THREDDS Catalog](#)] [[WGET Script](#)]

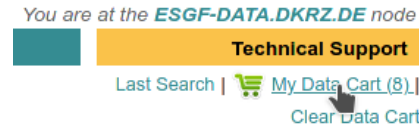
Total Number of Files: 11

1	mrso_CAM-44_MPI-M-MPI-ESM-LR_historical_r1i1p1_SMHI-RCA4_v1_day_19510101-19551231.nc checksum: f4d8a4d4765f2d223fba8363de8b9b9e94fb381012b6044601d50f7bdfbdf1f size: 37739270 tracking_id: d9260c16-9ad2-43d9-9f0b-8d8f844f5546 [More File Metadata]	Single File Access: HTTP Download OpenDAP Download
2	mrso_CAM-44_MPI-M-MPI-ESM-LR_historical_r1i1p1_SMHI-RCA4_v1_day_19560101-19601231.nc checksum: 31ece25e10fc0d792e1ab8a65d5374429bf91b5c7d68f36baaa5181b116a116d size: 37689982 tracking_id: 90e9c48b-6b23-4981-b604-4ca1f8b2e5f4 [More File Metadata]	Single File Access: HTTP Download OpenDAP Download
3	mrso_CAM-44_MPI-M-MPI-ESM-LR_historical_r1i1p1_SMHI-RCA4_v1_day_19610101-19651231.nc checksum: 14ec240b7c5d512c31980f5012878d3246cde526a242d80397091f4d648d741f size: 37747450 tracking_id: 417fb167-0055-490d-8c83-228bd63f4056 [More File Metadata]	Single File Access: HTTP Download OpenDAP Download

3. Save file and repeat
4. Note that CORDEX files are usually on a 5 years basis (daily)

13.2. The automated way

1. Click on **Add all displayed results to Data Cart** (where the pointer was in the penultimate image)
2. Go to your **data cart**



3. Here you can select datasets to download. When ready, click on **WGET Script**

Collective Services for All Selected Datasets: [**WGET Script**] [LAS Visualization] [Globus Download] [Collection PID]

When 'List Files' is clicked, or when using WGET or Globus, you may use an optional string to sub-select the filenames:

<input checked="" type="checkbox"/>	Select All Datasets	Remove All
<input checked="" type="checkbox"/>	cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.rcp85.r11p1.RCA4.v1.day.tas Data Node: esg-dn1.nsc.liu.se Version: 20141105 Total Number of Files (for all variables): 19 Full Dataset Services: [Show Metadata] [List Files] [THREDDS Catalog] [WGET Script]	Remove
<input checked="" type="checkbox"/>	cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.rcp85.r11p1.RCA4.v1.day.pr Data Node: esg-dn1.nsc.liu.se Version: 20141105 Total Number of Files (for all variables): 19 Full Dataset Services: [Show Metadata] [List Files] [THREDDS Catalog] [WGET Script]	Remove
<input checked="" type="checkbox"/>	cordex.output.CAM-44.SMHI.MPI-M-MPI-ESM-LR.rcp85.r11p1.RCA4.v1.day.mrro Data Node: esg-dn1.nsc.liu.se Version: 20141105 Total Number of Files (for all variables): 19 Full Dataset Services: [Show Metadata] [List Files] [THREDDS Catalog] [WGET Script]	Remove

4. Depending on your dataset, there might be several **WGET Scripts**. Click and save them.

For better performance, WGET scripts are generated for each Data Center separately.
Click on each link below to retrieve the script for each Data Center.

[WGET Script for esg-dn1.nsc.liu.se](#)

13.3. Run script

1. Open a Linux terminal
2. Go to your downloads folder (see point 7)
3. Run the following command (change the name appropriately):

```
bash wget-20201026140831.sh -H
# The -H is to interactively enter your credentials
```

4. Give credentials, the full OpenID looks like <https://esgf-node.llnl.gov/esgf-idp/openid/user>
5. This will start the download process of the NetCDF files
6. This process will take a while and should look like this:

```
[root@ Downloads]# bash wget-20201026140831.sh -H
Running wget-20201026140831.sh version: 1.3.2
Use wget-20201026140831.sh -h for help.

Script created for 120 file(s)
(The count won't match if you manually edit this file!)

Retrieving Federation Certificates...--2020-10-26 13:28:26-- https://github.com/ESGF/esgf-dist/raw/master/installer/certs/esg-truststore.ts
Loaded CA certificate '/etc/ssl/certs/ca-certificates.crt'
Resolving github.com (github.com)... 140.82.121.4
Connecting to github.com (github.com)[140.82.121.4]:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://raw.githubusercontent.com/ESGF/esgf-dist/master/installer/certs/esg-truststore.ts [following]
--2020-10-26 13:28:27-- https://raw.githubusercontent.com/ESGF/esgf-dist/master/installer/certs/esg-truststore.ts
Resolving raw.githubusercontent.com (raw.githubusercontent.com)... 151.101.112.133
Connecting to raw.githubusercontent.com (raw.githubusercontent.com)[151.101.112.133]:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 55437 (54K) [video/mp2t]
Saving to: '/root/.esg/esg-truststore.ts'

/root/.esg/esg-truststore.ts      100%[=====] 54.14K  --.-KB/s  in 0.06s

2020-10-26 13:28:27 (956 KB/s) - '/root/.esg/esg-truststore.ts' saved [55437/55437]

done!
Enter your openid : https://esgf-node.llnl.gov/esgf-idp/openid/
Enter password :

mrro_CAM-44_MPI-M-MPI-ESM-LR_historical_r1i1p1_SMHI-RCA4_v1_day_19510101-19551231.nc ...Downloading
sha256 ok. done!
mrro_CAM-44_MPI-M-MPI-ESM-LR_historical_r1i1p1_SMHI-RCA4_v1_day_19560101-19601231.nc ...Downloading
sha256 ok. done!
mrro_CAM-44_MPI-M-MPI-ESM-LR_historical_r1i1p1_SMHI-RCA4_v1_day_19610101-19651231.nc ...Downloading
```

14. Homework

1. Download CORDEX files for your home region (if not available choose Lisbon or Delft)
 - Historical period: 1961-1990
 - Projected: RCP 8.5 2070-2100
 - Variables: temperature, precipitation and either run off or soil moisture content
2. Merge and crop files for your country and city
3. Perform statistical analysis for the 3 variables in another software
 - Box plots of historical vs projected for your city
4. Plot time series for your home city
 - Both periods and all variables
5. Extra points for:
 - Probability density function plot for both periods
 - *Average Day of the year* (1-365) comparison plot
 - Monthly comparison boxplots
 - 2D map of average difference between the periods in your home country
 - Tips: [sellatlonbox](#), this [repo](#), or reprojection with CDO ([remapbil](#))

15. Questions — ideas for the extra points?



You can contact [me!](#)