Preparations for NetCDF/CDO tutorial

Overview

There are various methods how you can prepare for the tutorial, where we will use various software tools to analyze and interpret output of two climate states prepared by means of a climate model. The following list of preparations is ordered by preference – the further up a method in the list, the better it is suited for a smooth and hopefully flawless workflow during the tutorial (an exception is list element 7, that is very suitable but will generally involve a bit more of preparatory work). Please follow any of the methods so that you are able to use `CDO` during the tutorial (8th of April).

1. You already have a Linux-system available and just need to install the few additional software tools needed for the tutorial.
2. You have a Windows PC or a MAC and are able to install and use `VirtualBox` which will be used to run an Ubuntu Linux system (provided as a link, see below) inside a virtual machine.
3. You have a PC that is able to boot a Linux live system via USB (provided for the tutorial).
4. You have a MAC and are able to setup the relevant software tools.
5. You have a Windows PC and setup the relevant software tools via `cygwin` etc.
6. You have a Windows PC and install the (inferior) Windows-executable of the `CDO`.
7. You do not have a Linux system available but are willing to install it along your existing operating system. For PC's this is generally possible - for example based on a live CD - provided that you have sufficient hard disk space available and you have made a proper backup of relevant data prior to installing Linux on your machine (normally, there is no need to expect a data loss when installing Linux along your current operating system on a PC – yet, the possibility of a mishap, and related data loss, cannot be fully excluded!!!).
8. If nothing of this is possible: please use the computer pool at the IUP where the necessary software should be available.

On the next pages details to the above listed methodologies are provided. You can follow the provided steps for the method selected by you in order to bring your computer into a state that makes it able to run the software that is necessary to solve the problems provided in the tutorial. At the end of the document you find a short intro on how to use the various software tools.

I cannot and do not guarantee that the describe procedures work (out of the box) for everyone as expected. Yet, experience of the last years suggests that in practice it will be possible for students to have a computer system at hand that enables them to follow the tutorial.

You are allowed to work in groups of two (if necessary, three) students. Therefore, it is sufficient if each of the student groups has one PC available during the tutorial that runs the necessary software.

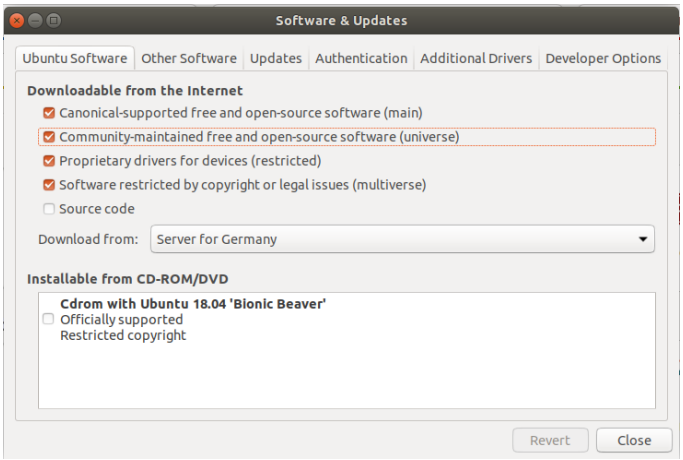
Disclaimer

In case you make changes to your operating system (e.g. change of boot-order to start Ubuntu from a flash drive, installing Ubuntu alongside your operating system, ...) make sure to follow the computer manufacturer's documentation and (if applicable) the Linux distribution's documentation, respectively. I cannot and will not take responsibility if something goes wrong (e.g. data loss).

Installation of necessary software on an existing Linux-system

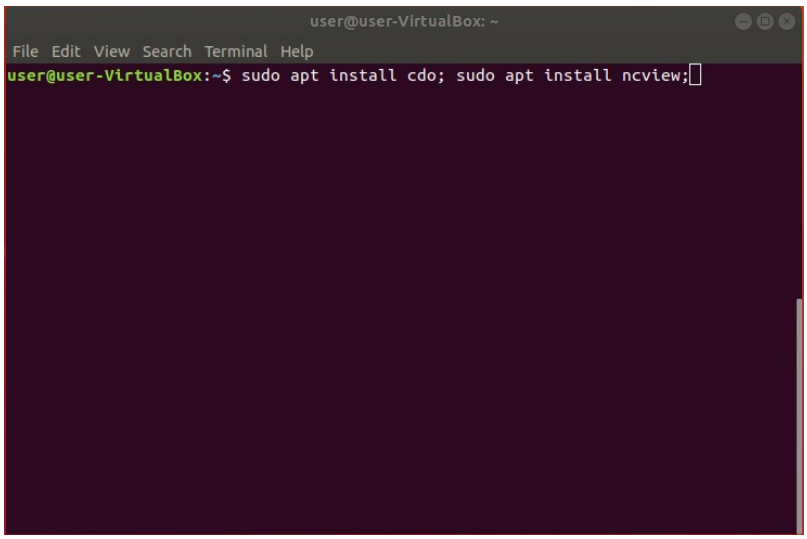
If you already have a Linux system available, you can relatively easily install all the necessary software. The relevant steps are illustrated here for Ubuntu, details may be different in case you have a different Linux distribution.

Note: In case some software cannot be found by the Ubuntu software manager, check that the Option “Community-maintained free and open-source software (universe)” is activated in the “Software and Updates” settings dialogue (follow the method described at https://help.ubuntu.com/stable/ubuntu-help/addremove-sources.html.en).



Open a terminal and enter the following commands in order to install `CDO`, `ncdump`/`ncgen`, `ncview` (depending on your distribution and choices during the installation process, this software may already be available):

```
sudo apt install cdo
sudo apt install netcdf-bin
sudo apt install ncview
```

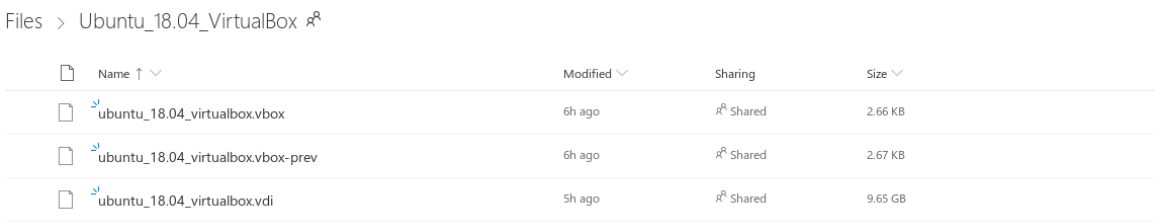


In case you would like to produce customized illustrations of climate data output, also install the Java-based software `Panoply` that is freely available from the following location: https://www.giss.nasa.gov/tools/panoply/

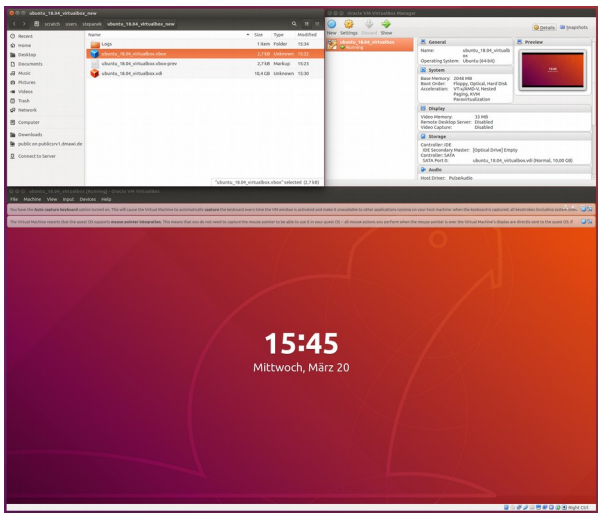
Running Ubuntu in a virtual machine (VirtualBox) from your host operation system

If your computer has sufficient free storage on the hard drive (about 10 GB of additional storage will be occupied if you follow this methodology) and memory to run Ubuntu inside a virtual machine, you can follow these steps (if you run into memory problems, try to only run software along `VirtualBox` that is absolutely necessary – e.g. your web-browser may hog memory):

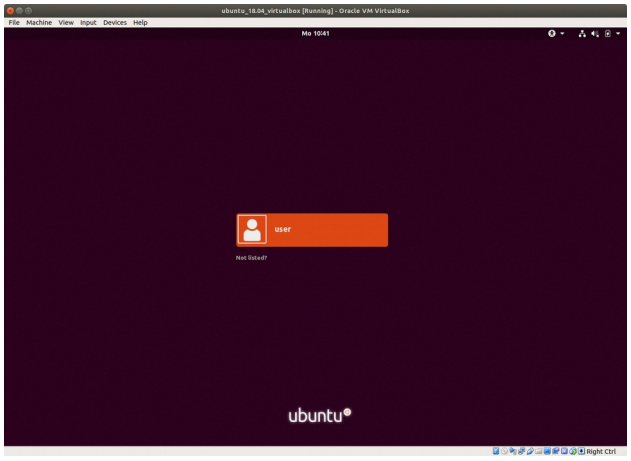
1. Download and install `VirtualBox`, use the version that is the right one for your host operating system: https://www.virtualbox.org/wiki/Downloads. Some details and explanations on `VirtualBox` are also available via the following link (you can selectively read what seems of interest to you): https://www.virtualbox.org/manual/ch01.html
2. Download a Virtual Machine that contains a customized Ubuntu. It already contains all the software and data sets that are necessary to solve the tutorial tasks. You can download the Virtual Machine files via this OneDrive link:
   https://1drv.ms/f/s!AnZSDMNwdkDMgaBENWDE3B7JPkfkJw
   Download all three files that are provided in the folder to which the link points:

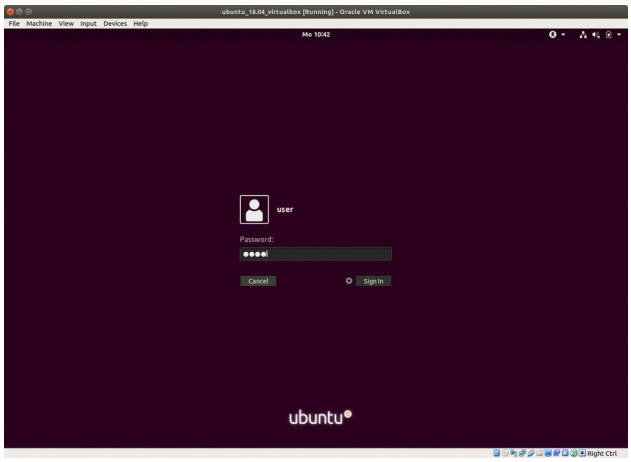


   Make sure to download all this via a fast and cheap internet connection, as about 10.4 GB of data will have to be transferred – after all, you will download a complete operating system with pre-installed auxiliary software and data sets that will be utilized in the tutorial.
3. After downloading the files, navigate to the folder in your preferred file explorer and double click on the file `ubuntu_18.04_virtualbox.vbox` (below, left window). If `VirtualBox` is properly installed on your system, this action should open an instance of `VirtualBox` (below, right window) from which you can start the tutorial Ubuntu system (press the green "Start" button, Ubuntu will start in a new window, below, lowermost window):

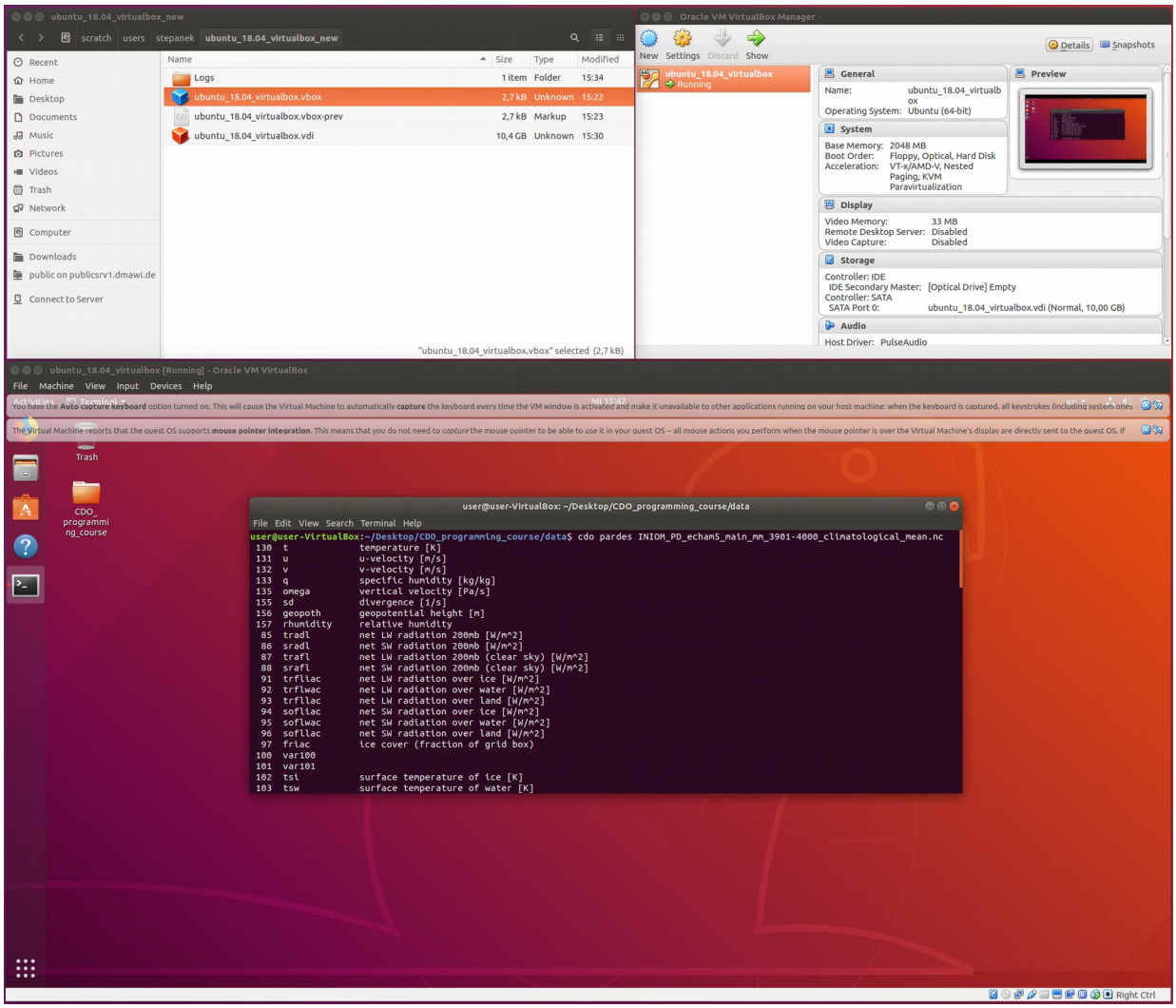


Once Ubuntu has started in `VirtualBox`, you can login with the user name "`user`" and password "`user`".

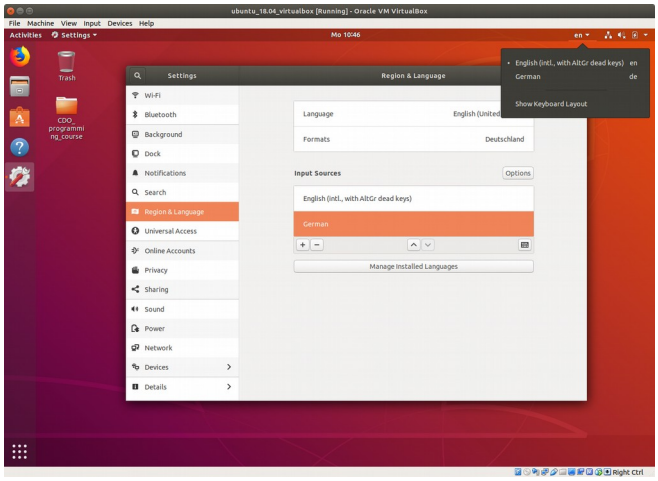




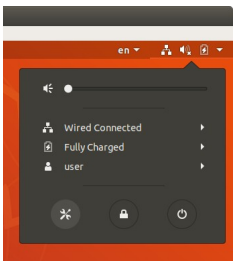
Once logged in, you can open a terminal (`https://linuxconfig.org/how-to-open-a-terminal-on-ubuntu-bionic-beaver-18-04-linux`), navigate to the folder containing the tutorial data sets (by entering the command `cd Desktop/CDO_programming_course/data` into the terminal), and test whether cdo starts by entering as well the command shown in the terminal below:

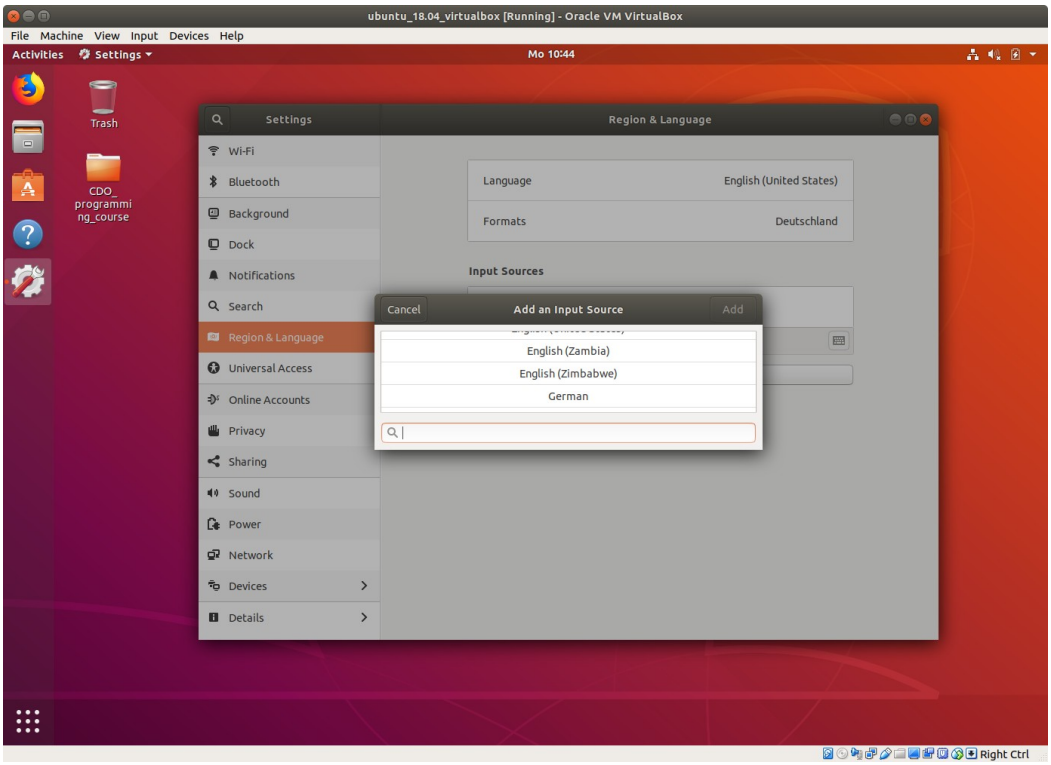


Note, that the keyboard layout is set to "`English (intl., with AltGr dead keys)`". If this does not fit to your computer's keyboard layout, you may change the setting as follows:



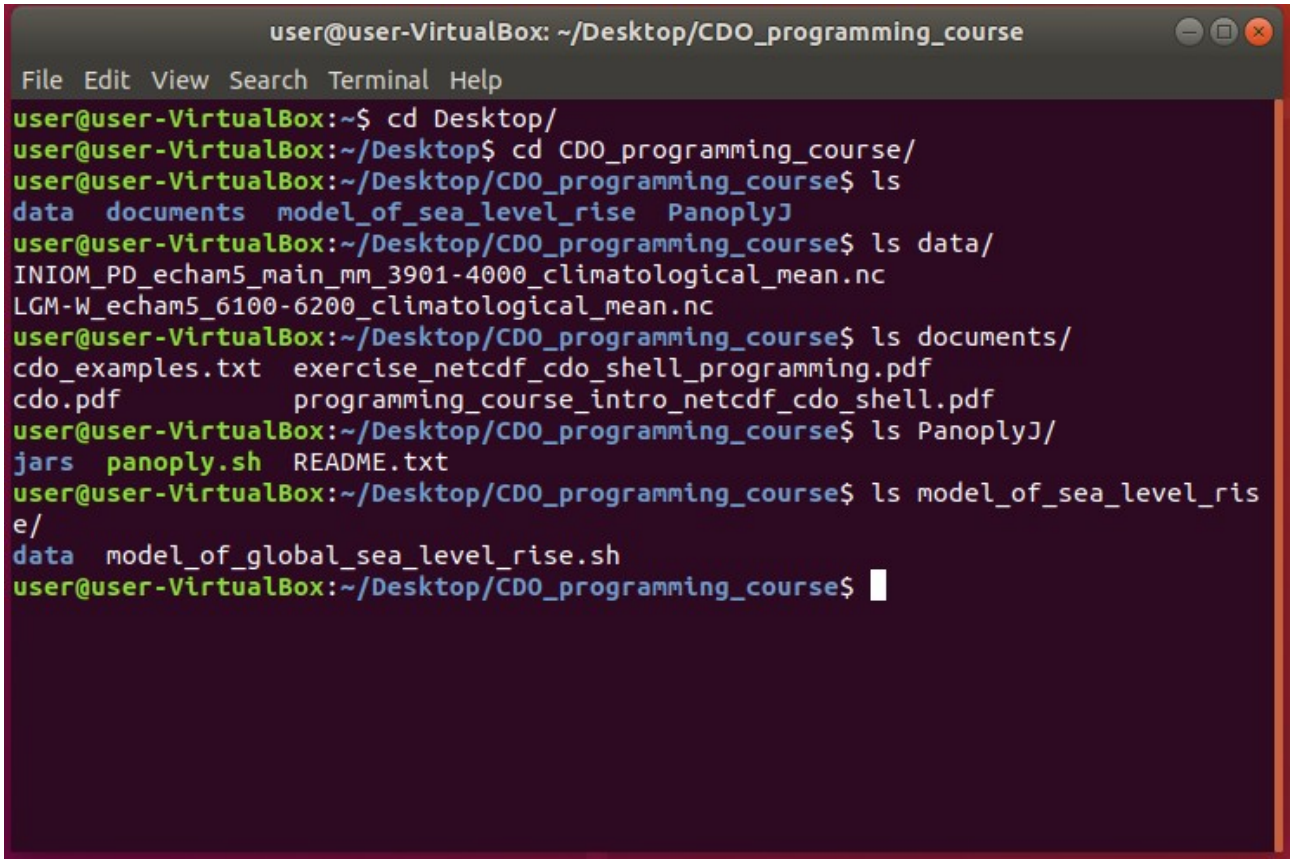
If necessary, first activate the needed keyboard layout after opening the system settings tool that is available via the leftmost tool-button (highlighted in gray in the screenshot directly below) from the drop-down menu that opens when clicking on the down-arrow at the right upper part of the desktop (the symbol right to the battery symbol in the screenshot directly below).



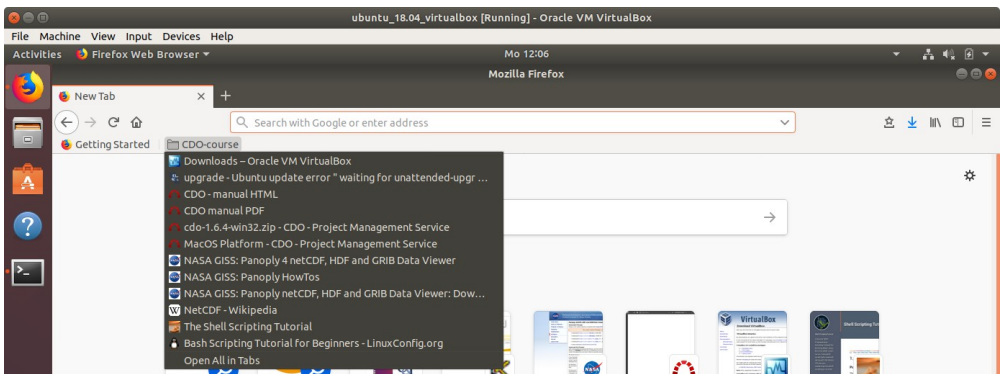


On the desktop you find a folder `CDO_programming_course`, that contains material needed during the tutorial. The folder's contents are:

- a folder `data`, containing the file on which `CDO` commands will be applied
- a folder `documents`, containing the exercise, the lecture slides, as well as some auxiliary information
- a folder `PanoplyJ`, containing the Panoply software that can be used to generate geographic maps of climate data
- a folder `model_of_sea_level_rise`, where a simple toy model, programmed with Linux shell tools, is provided for those of you who want to go beyond the tutorial's curriculum and study a shell program that is a bit more complex than what is presented in lecture/tutorial



For more information and documentation, you can open the `Firefox` browser. In it's link-toolbar I have collected some references to online material that may be of relevance for you.



Performing the tutorial tasks based on a Linux Live-system on a USB flash drive

During the tutorial you can borrow a flash drive that contains an Ubuntu live system containing both the climate data to be used in the tutorial as well as the most relevant software that is needed to perform the tutorial tasks. Towards employing this method you need to be able to modify the BIOS of your PC towards changing boot order, so that when booting the operating system your PC gives preference to the USB flash drive over your normal host operating system on your laptop's hard drive. How these settings are changed (and whether one can change the settings in the necessary manner) strongly depends on your hardware. If questions appear please consult the documentation provided by your computer manufacturer as I will not be able to provide support.

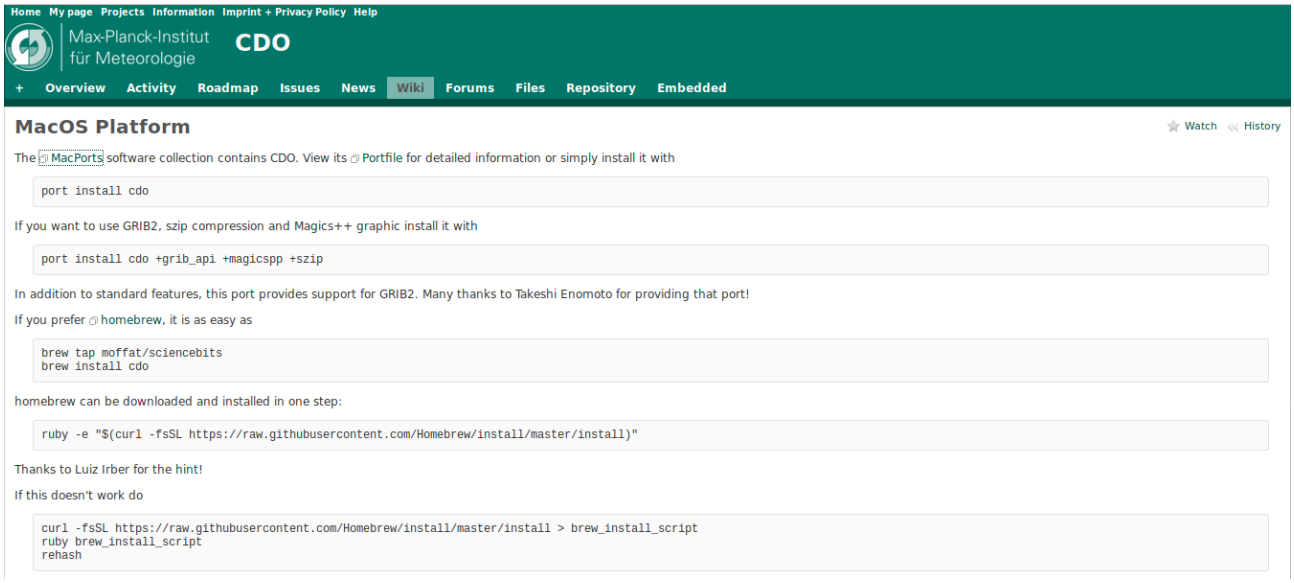
Once the boot order has been modified, plug in the USB flash drive into your computer's USB port and boot the contained Ubuntu system. As flash drives are slower than your hard disk, booting the Ubuntu guest operating system may take significantly longer than a conventional booting of your laptop.

Once the system is booted up you should be directly being logged in without entering a password. You will see the desktop where there is a folder containing data and documents relevant to the tutorial (you can open a terminal as on the screenshot by following `https://linuxconfig.org/how-to-open-a-terminal-on-ubuntu-bionic-beaver-18-04-linux`):

Performing the tutorial tasks based on a MAC computer

There are ways to install `CDO` and other necessary software packages on MAC via various ports. I am not a MAC user, so I cannot provide help based on my own experience. Yet, I know that some colleagues work with a MAC and use `CDO` etc. via ports, so it is clear that using a MAC for the tutorial is in principle possible. There is a bit of documentation available online that hopefully explains the steps necessary to setup `CDO` on MAC in their entirety (I have not tested any of these!):

- The MAC-ports: https://www.macports.org/
- "Getting your MAC ready for NetCDF": http://mazamascience.com/WorkingWithData/?p=1474
- Some information on getting `CDO` running is available on the screenshot below:

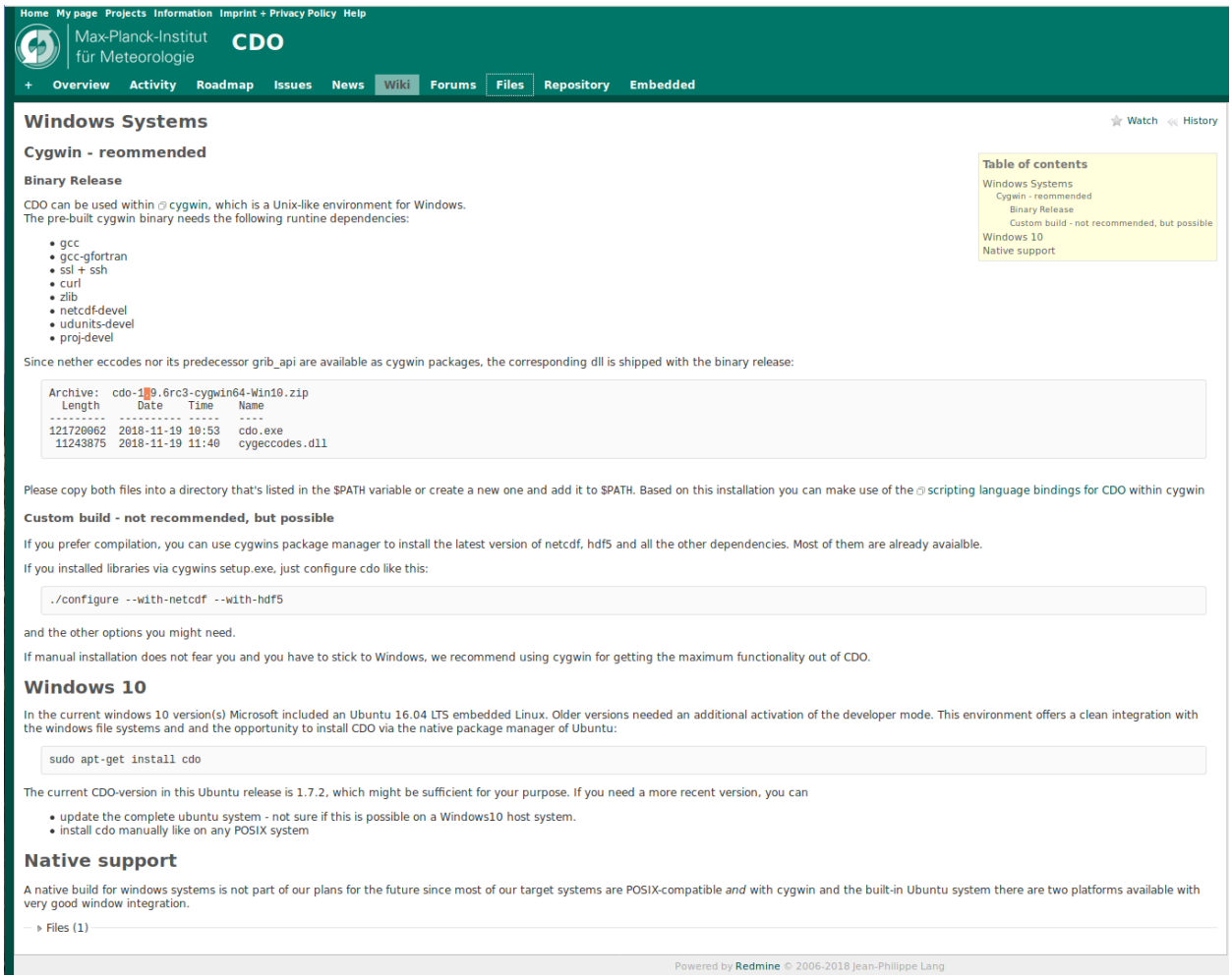


  - the link to the Portfile is here: https://trac.macports.org/browser/trunk/dports/science/cdo/Portfile
  - the link to homebrew is here: https://github.com/Homebrew/legacy-homebrew

Performing the tutorial tasks based on a Windows computer (using emulators such as cygwin)

The Max-Planck-Institute gives some advice how to setup `CDO` on Windows. There are various methods that also depend on the Version of Windows that you have on your computer, and I cannot provide support due to my lack of experience with Windows. You may check whether any of the methods described by the MPI (screenshot and link below) enables you to run `CDO` on Windows:

https://code.mpimet.mpg.de/projects/cdo/wiki/Win32



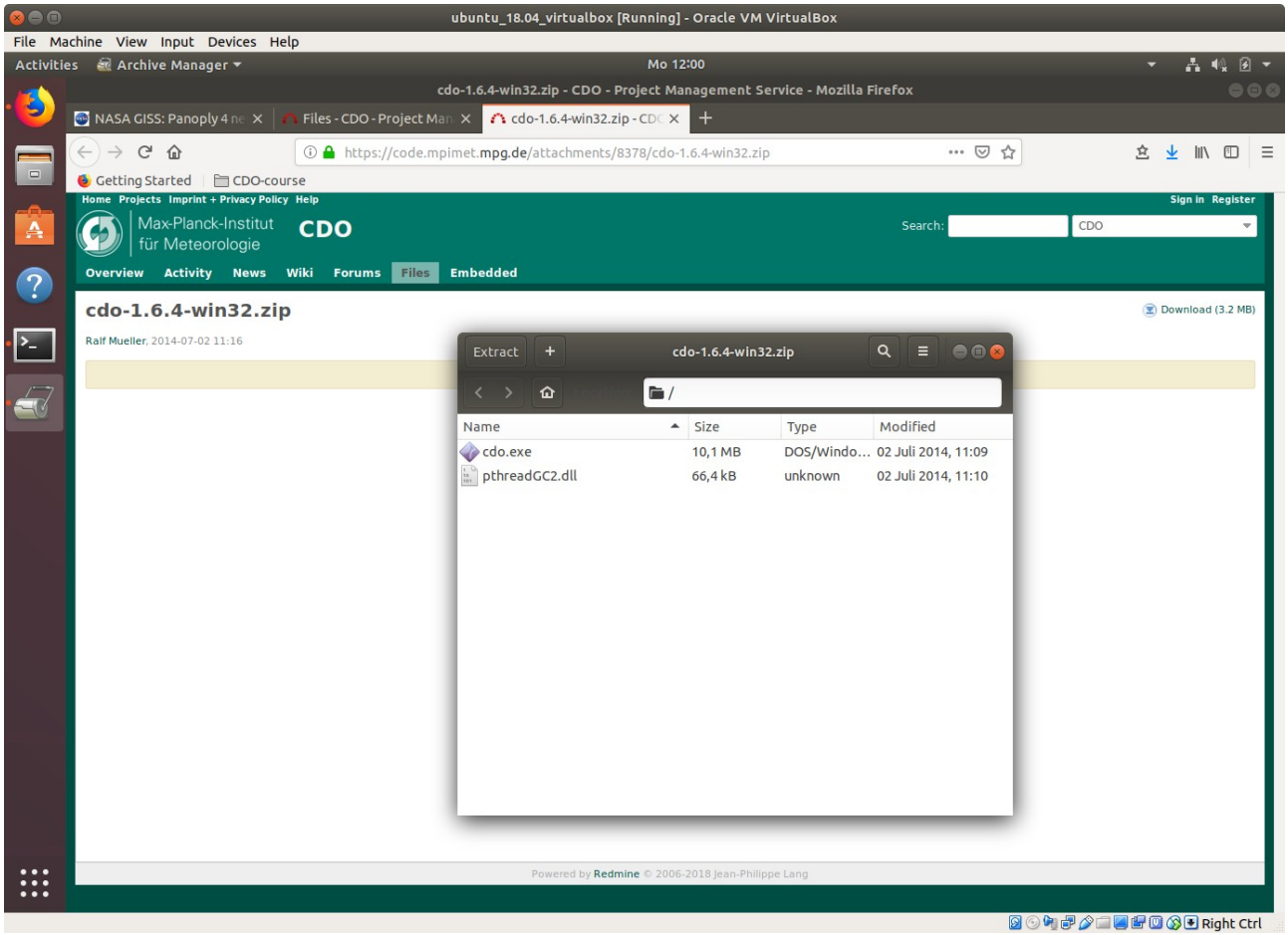
The link to the various `CDO` zips that may be used with `cygwin` is here:

https://code.mpimet.mpg.de/projects/cdo/files

Installation of CDO for Windows

There is a (pretty outdated) executable version of `CDO` for Windows. It does not offer the full functionality of the standard `CDO` for Linux, but it can be used to do the majority of the tutorial. If you want to go that route, download the `CDO` for windows zip file and extract the contents to a location from where you will invoke `CDO` (via the Windows command line). It would be probably sensible to store the `CDO` program at the location where you stored the data for the tutorial.

I cannot provide any guidelines on how to use the Windows command line (as I do not have access to a Windows system); yet, for a first overview maybe this link will be useful: https://www.lifewire.com/command-prompt-2625840



You should be also able to install `Panoply` for windows following the instructions on the `Panoply` download website (https://www.giss.nasa.gov/tools/panoply/download/). Yet, other software, that might be of help during the tutorial, will not be directly available on a Windows system (unless you want to try an emulator like `cygwin`).

Installation of an Ubuntu system alongside your current operating system

If you want to go that route make sure all your relevant data on hard disks is backed up. Then follow the outlines as provided for your Linux distribution of choice (e.g. Ubuntu). For Ubuntu, you can follow for example the methodology outlined here: https://help.ubuntu.com/community/WindowsDualBoot?action=show&redirect=DualBoot%2FWindows

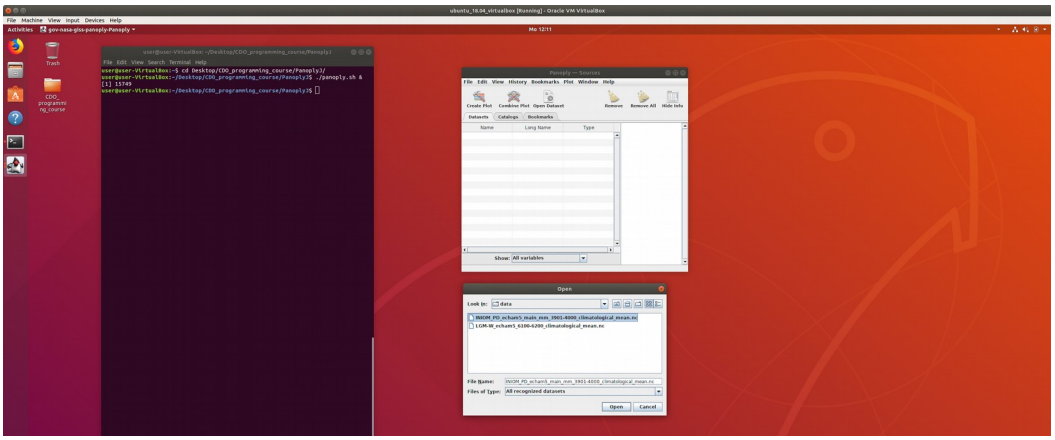
The version 18.4.2 of Ubuntu would be appropriate as a working environment that will be supported with updates for four more years. You can download it from here:

https://www.ubuntu.com/download/desktop

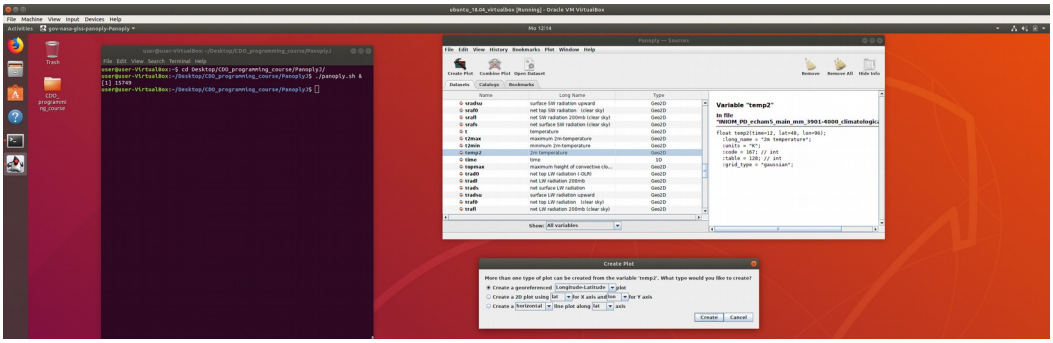
Make sure to use an installation methodology that suits your hardware (UEFI or not), current operating system (Windows 7 / Windows 10, …), and Linux-Distribution of choice (in case you are not planning to install Ubuntu but a different Linux distribution).

How to use auxiliary software tools Panoply and ncview

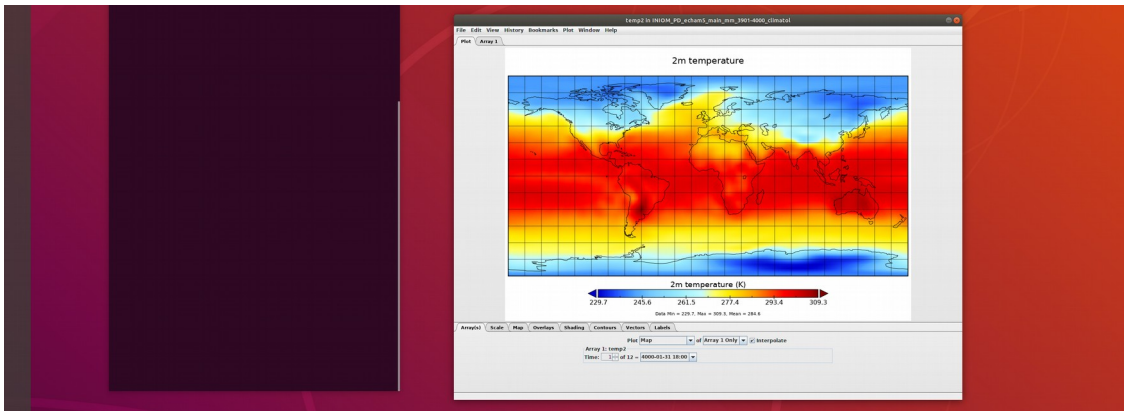
1. Create a geographic map of simulated climate data with `Panoply`
    1. Open a terminal, cd into the folder `Desktop/CDO_programming_course/PanoplyJ` (left hand side on the screenshot below). From there, execute the script that starts the Panoply software by entering the command `./panoply.sh&`
    2. A data load dialogue window will open. Load the file that you would like to visualize.



    3. A window will open from which you can select a variable of interest (e.g. temp2, upper right window in the screenshot below). Upon pressing the button `Create Plot` you can define the configuration for your plot (e.g. longitude/latitude, lower window). You may test the impact plot options, but pre-defined parameters are generally suitable for us.



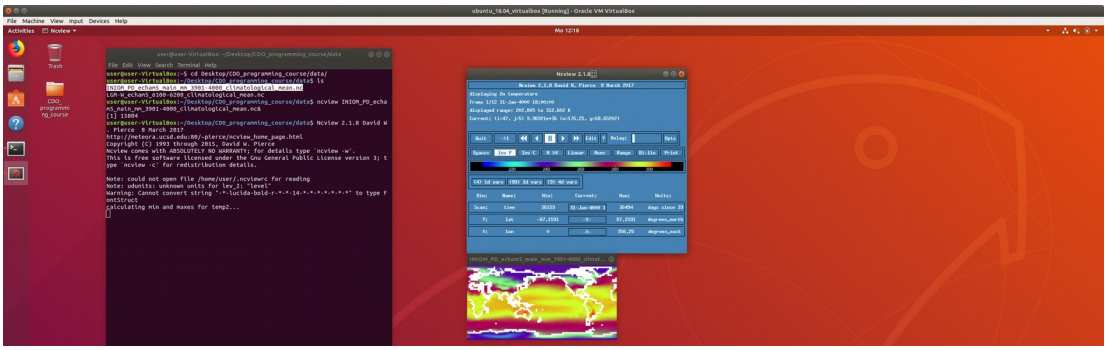
    4. Once you press `Create` a plot will appear. You are able to customize its appearance via changing the settings in the control tabs below the plot.



2. Visualize NetCDF data with the software `ncview`
    1. You can display simple maps and a selection of derived analyses (e.g. time series at a specific geographical location) of the contents of a NetCDF file by means of the software ncview. Just open a terminal, navigate to the folder where the relevant NetCDF data is stored, and enter the command `ncview` followed by a space and the name of the file that you want to be displayed, e.g.:

        ```
        ncview LGM-W_echam5_6100-6200_climatological_mean.nc
        ```

    2. An instance of the `ncview` software will open (see screenshot below) where you can choose a variable to be displayed (e.g. by pressing on button “3d vars” and selecting “tsurf” – note that 3d vars (i.e. three-dimensional variables) in this context means two-dimensional geographic data with a time parameter – if you are aiming to visualize a three-dimensional data set like the temperature of the atmosphere across all available pressure levels, you need to select from the menu ”4d vars” if the data has a time parameter).



In case there are time steps resolved in the data (as it is the case for the NetCDF data sets distributed for the tutorial), you can scan trough the time series in `ncview` by using the play, skip, and pause buttons in the upper control bar. Below that control bar you find a selection of control buttons that let you control the appearance of the visualization. If you want to remove the white coastline (as you are interested in details along the coast obstructed by the coastline) you may do this via clicking on `Opts` at the upper control bar and select from the `Set Options`-menu the `Overlays`-setting `None` (see screenshot).