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 <u>you have made a proper</u> 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. <u>At the end of the document you find a short intro on how to use the various software tools.</u>

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 <u>https://help.ubuntu.com/stable/ubuntu-help/addremove-sources.html.en</u>).

80		Soft	ware & Updates			
Ubuntu Software	Other Software	Updates	Authentication	Additional Drivers	Developer Options	
Downloadable fr	om the Internet	open-sour	ce software (mai	n)		
Community-maintained free and open-source software (universe)						
Proprietary drivers for devices (restricted)						
Software restricted by copyright or legal issues (multiverse)						
Source code						
Download from:	Server for Germany					
Installable from	CD-ROM/DVD					
Cdrom with Officially sup Restricted co	Ubuntu 18.04 'B oported opyright	ionic Beav	rer'			
				F	evert Close	

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):



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: <u>https://www.virtualbox.org/wiki/Downloads</u>. Some details and explanations on VirtualBox are also available via the following link (you can selectively read what seems of interest to you): <u>https://www.virtualbox.org/manual/ch01.html</u>
- 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

Devenload all three files that are provided in the folder to which the link pe

Files > Ubuntu 18.04 VirtualBox 🕫

Download all three files that are provided in the folder to which the link points:

Name ↑ ∨	Modified \vee	Sharing	Size 🗸	
ubuntu_18.04_virtualbox.vbox	6h ago	R ^R Shared	2.66 KB	
ubuntu_18.04_virtualbox.vbox-prev	6h ago	x ^R Shared	2.67 KB	
ubuntu_18.04_virtualbox.vdi	5h ago	R ^R Shared	9.65 GB	

<u>Make sure to download all this via a fast and cheap internet connection, as about 10.4 GB</u> <u>of data will have to be transferred</u> – 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: <u>https://www.macports.org/</u>
- "Getting your MAC ready for NetCDF": <u>http://mazamascience.com/WorkingWithData/?</u> p=1474
- Some information on getting CDO running is available on the screenshot below:

Home My page Projects Information Imprint + Privacy Policy Help	
Max-Planck-Institut CDO für Meteorologie	
+ Overview Activity Roadmap Issues News Wiki Forums Files Repository Embedded	
MacOS Platform	🔆 Watch \prec History
The MacPorts software collection contains CDO. View its 🗇 Portfile for detailed information or simply install it with	
port install cdo	
If you want to use GRIB2, szip compression and Magics++ graphic install it with	
port install cdo +grib_api +magicspp +szip	
In addition to standard features, this port provides support for GRIB2. Many thanks to Takeshi Enomoto for providing that port!	
If you prefer ♂ homebrew, it is as easy as	
brew tap moffat/sciencebits brew install cdo	
homebrew can be downloaded and installed in one step:	
ruby -e "\$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"	
Thanks to Luiz Irber for the hint!	
If this doesn't work do	
<pre>curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install > brew_install_script ruby brew_install_script rehash</pre>	

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

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

Home My page Projects Information Imprint + Privacy Policy Help						
Max-Planck-Institut CDO						
für Meteorologie						
+ Overview Activity Roadmap Issues News <mark>Wiki</mark> Forums Files Repository Embedded						
Windows Systems	🚖 Watch ≪ History					
Cygwin - reommended	Table of contents					
Binary Release	Windows Systems					
CDD can be used within 3 cygwin, which is a Unix-like environment for Windows. The non-built screwin history used is the following number dependencies:	Cygwin - reommended Binary Release					
OCC	Custom build - not recommended, but possible Windows 10					
• gc-gfortran • sl+ ssh	Native support					
• curi • zilib						
netcdfdevel udurisdevel						
• proj-devel						
Since nether eccodes nor its predecessor grib_api are available as cygwin packages, the corresponding dll is shipped with the binary release:						
Archive: cdo-1 <mark>1</mark> 9.6rc3-cygwin64-Win10.zip						
Length vate Line name 191720062 2018-11-10 10:52 cdn ava						
11243875 2018-11-19 11:40 cygeccodes.dll						
Please copy both files into a directory that's listed in the \$PATH variable or create a new one and add it to \$PATH. Based on this installation you can make use of the 🖯 scripting language bindings for CDO within cygwin						
Custom build - not recommended, but possible						
If you prefer compilation, you can use cygwins package manager to install the latest version of netcdf, hdf5 and all the other dependencies. Most of them are already available to the second	ole.					
If you installed libranes via cygwins setup.exe, just configure cdo like this:						
./configurewith-hetcdfwith-hdf5						
and the other options you might need.						
If manual installation does not fear you and you have to stick to Windows, we recommend using cygwin for getting the maximum functionality out of CDO.						
Windows 10						
In the current windows 10 version(s) Microsoft included an Ubuntu 16.04 LTS embedded Linux. Older versions needed an additional activation of the developer mode. This environment offers a clean integration with the windows file systems and and the opportunity to install CDO via the native package manager of Ubuntu:						
sudo apt-get install cdo						
The current CDO-version in this Ubuntu release is 1.7.2, which might be sufficient for your purpose. If you need a more recent version, you can						
 update the complete ubuntu system - not sure if this is possible on a Windows10 host system. install cdo manually like on any POSIX system 						
Native support						
A native build for windows systems is not part of our plans for the future since most of our target systems are POSIX-compatible and with cygwin and the built-in Ubuntu system there are two platforms available with very good window integration.						
- > Files (1)						
Powered by Dadmine († 2006. 2019 Jaan Dhillione Jann						
Powered by Redmine © 2006-2016 Jean-Philippe Lang						

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: <u>https://www.lifewire.com/command-prompt-2625840</u>



You should be also able to install Panoply for windows following the instructions on the Panoply download website (<u>https://www.giss.nasa.gov/tools/panoply/download/</u>). 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: <u>https://help.ubuntu.com/community/WindowsDualBoot?action=show&redirect=DualBoot</u> <u>%2FWindows</u>

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 noview

- 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 noview
 - 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).

