Worksheet for ERA5 and Copernicus seasonal forecasts

ERA5 and seasonal systems

- Search for "C3S climate" in google to find the C3S homepage (or click here)
- The datasets are top-right: "data", then data tab

Coverage of analysis system:
https://www.ecmwf.int/en/forecasts/charts/monitoring/dcover?facets=undefined&time=2019052406,0,2019052406&obs=synop-ship&Flag=all

the official WIKI start point to set up your account:
https://cds.climate.copernicus.eu/api-how-to

Also helpful WIKI:
https://confluence.ecmwf.int/display/CKB/How+to+migrate+from+ECMWF+Web+API+to+CDS+API

A handy blog guide:
https://retostauffer.org/code/Download-ERA5/

Steps to follow [ERA5, seasonal forecasts, Satellite and CMIP]:
1. Register for a CDS account (ERA5/Seasonal)
2. copy your CDS API key displayed in the window here [www] to .cdsapirc file in your home directory
3. Install the cdsapi package [pip3 install cdsapi]
4. Try an example retrieval!

Similar for ECMWF databases [ERA Interim, S2S, TIGGE, MACC…]
1. Register for an ECMWF account
2. Copy your ECMWFAPI key from [www] to a .ecmwfapirc file in your home directory
3. Install the ecmwfapi package [pip3 install ecmwfapi]
4. Try an example retrieval

A couple of tips:

Tip 1, Data format: The ERA5 data can be provided in native GRIB or the request can also be made for netcdf format. If you download in grib you can convert using the command Cdo -f nc4 copy in.grb out.nc (this is problematic for forecasts data however due to the multiple time axes, for those you need gribapi or its recent replacement eccodes to have access to grib2netcdf).

Install eccodes guide for linus:
https://confluence.ecmwf.int/display/ECC/ecCodes+installation

Install eccodes on MAC:
```
brew unlink grib-api # if you have eccodes already
brew install eccodes
```

Tip 2, Retrieval of smaller regions: To save on download times/desk space you can opt to cut out a specific region, using the option "AREA": ["N","W","S","E"], (don't forget the trailing comma!).

Tip3, Loops in retrievals:
If you want to loop over a set of retrievals (e.g. one retrieval per year) then you need to know how to use a loop in python. Python enforces strict typing and good coding practise by recognising loops though indentation (usually 4 spaces), The loop ends when you return to the original indentation. You can use the range function to make a list of integers (note the last integer is NOT includes, i.e. the following example gives, 2000, 2001, 2002, 2003, 2004.

```
for y in range(2000,2005):
    print(str(y))

more code outside loop
```

You will note that all arguments need to be supplies as a list of strings in python. If you want to specify a list of strings without typing them out painstakingly, you can do this:

```
ylist=[str(y) for y in range(2000,2005)]
```

Climate Data Operators (CDO) and NCO

CDO is set of 150+ command-line utilities that are extremely helpful for manipulating grib/netcdf file data and calculating statistics. It has a large number of climate-related functionality in addition to basic mathematical operators.

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

Installation

On Linux:
```
sudo apt-get install cdo
```

On MAC :
```
brew tap moffat/sciencebits
brew install cdo --with-grib2
```

On Windows 10
It is now possible to install pure linux ubuntu directly within windows, (not dual boot, not wineserver, and not Cygwin) – follow one of the many online blogs to see how to do this, then follow the linux instructions.

Common useful functions:
```
cdo sellonlatbox,lon1,lon2,lat1,lat2 in.nc out.nc
cdo add/sub/mul/div in1.nc in2.nc out.nc
cdo addc,val in.nc out.nc  # c= constant, sub etc also of
course
cdo gec,val in.nc mask.nc # gec = greater-equal constant
[gtc,gec,ltc,lec,eqc]

cdo fldmean in.nc out.nc # area average
cdo timmean in.nc out.nc # time average
cdo monmean in.nc out.nc # mean stats over months
[can use mon=months, day=days, hour=hours…]
[can use mean, max, min, avg, stddev, var…]

cdo percen,X in.nc out.nc # calculate Xth percentile
cdo timcor in1.nc in2.nc out.nc # correlation maps
cdo enlarge,rlonxlat in.nc out.nc # repeat a single value
timeseries spatially
[r360x180 = 1x1 degree regular grid ]
cdo enlarge,in1.nc in2.nc out.nc # expand in2 to match in1
grid
cdo remapbil,lon=X/lat=Y in.nc out.nc
```

You may use which ever software you wish to use to display the results (python, R, GRADS, ncl… etc etc). I will be using **ncview** to investigate the files. If you want to make nicer looking maps without resorting to coding then you may also want to consider **panoply**, free from NCAR.

Exercises: ERA5

For the following exercises we will use the python api utilities combined with CDO

Exercise 1: Making the Nino 3.4 index

1. Write a python script to download the monthly Sea Surface Temperature for 1979-2018 from ERA5
2. cut out the Nino 3.4 region (5N-S, 170W-120W) (or use the AREA command in the retrieval script)
3. Deseasonalise the time series by subtracting the annual cycle
4. Detrend the series
5. Subtract the long term mean
6. Examine the series (ncview, panoply, gnuplot, GRADS, python… whatever you prefer), what are the key years for ENSO

Exercise 2: Heatwave indices and extremes:

Retrieve the daily maximum 2 meter temperature in an area of interest to you for a particular hot month (e.g. July in Europe or April in W Afric etc) for 1979-2018, and calculate the 95% percentile temperature for these days? (Try the same for rainfall or the variable of interest for your research

Exercise 3: ENSO and other influences on TCWV or rainfall.

1. Download the TCWV for the tropics,
2. First of all though we will look at the annual cycle, which months are the wettest and which the driest in terms of the tropics (10S to 10N) mean TCWV ? Examine a map of the difference between the two.
3. Now look at the annual mean of the TCWV. Plot a map of the difference between the upper tercile wet years and the lower tercile dry years (again terciles defined in terms of the tropics mean. What do you think is influencing the variability?
4. we now want to divide the variability of this field into (a) long term trend (b) annual cycle (c) influence of ENSO (d) Influence of Indian Ocean dipole IOD [optional] (e) Residual annual variability
5. To do this you need to make a second index (like ENSO) but for the IOD (find out what the classic IOD index is and make this)
6. To remove the ENSO influence, we will take the deseasonalized TCWV and calculate the covariance between the NORMALIZED ENSO index and the variable. We then subtract the covariance multiplied by the normalized index from the original field.
7. Do the same with the IOD.
8. What does the residual look like? Make the annual mean and plot a map of the upper tercile years minus the lower tercile years, where the tercile is defined using the mean water vapour in the tropics

Exercises: Seasonal

Exercise: Download monthly precipitation anomaly at lead 1 for a region of your choice for June (so lead 1 means you need to use May starts, lead0=May), you can use cdo to convert it to netcdf and then calculate an anomaly correlation using the ERA5 data precipitation.