# Worksheet 2b: Creating future climate scenarios and analysing change

The following exercises demonstrate analyses of changes in climate simulated using two PRECIS experiments (driven by HadCM3Q0 and ECHAM5.) As with worksheet 2a, these are just examples of some of the analyses that you might perform using CDO.

## Contents

**Note:** The data used here has been processed in the same way as Worksheet 1. The 8 point-rim has been removed and it has been converted from PP to netCDF format.

## 2.7 Creating climate change fields

**1 a. )** Calculate the future change in JJAS precipitation for both the HadCM3Q0 (**cahpa**) and ECHAM5 (**cahpb**) driven PRECIS runs.

Use the 1961-1990 mean calculated in worksheet 2a as the baseline, and calculate the 2021-2050 JJAS mean for the future.

```
% cd $DATA/monthly
% cdo timmean -selmon,6/9 -selyear,2021/2050 cahpa/05216
/cahpaa.pm.2150.05216.rr8.nc $HOME/climatology/cahpaa.JJAS.mean.future.05216.nc
% cdo timmean -selmon,6/9 -selyear,2021/2050 cahpb/05216
/cahpba.pm.2150.05216.rr8.nc $HOME/climatology/cahpba.JJAS.mean.future.05216.nc
```

Now find the change

```
% cd $HOME/climatology
% cdo sub cahpaa.JJAS.mean.future.05216.nc cahpaa.JJAS.mean.baseline.05216.nc
```

```
cahpaa.JJAS.mean.diff.05216.nc
% cdo sub cahpba.JJAS.mean.future.05216.nc cahpba.JJAS.mean.baseline.05216.nc
cahpba.JJAS.mean.diff.05216.nc
% panoply cahpaa.JJAS.mean.diff.05216.nc
```

**1 b. )** Calculate the future change in JJAS precipitation as a percentage.

Calculate 100*(diff/baseline)

```
% cdo mulc,100 -div cahpaa.JJAS.mean.diff.05216.nc
cahpaa.JJAS.mean.baseline.05216.nc cahpaa.JJAS.mean.diff.05216.perc.nc
% cdo mulc,100 -div cahpba.JJAS.mean.diff.05216.nc
cahpba.JJAS.mean.baseline.05216.nc cahpba.JJAS.mean.diff.05216.perc.nc
% panoply cahpba.JJAS.mean.diff.05216.perc.nc
```

**2. )** Calculate the future change in JJAS temperature for both the HadCM3Q0 (**cahpa**) and ECHAM5 (**cahpb**) driven PRECIS runs.

```
% cd $DATA/monthly
% cdo timmean -selmon,6/9 -selyear,2021/2050 cahpa/03236
/cahpaa.pm.2150.03236.rr8.nc $HOME/climatology/cahpaa.JJAS.mean.future.03236.nc
% cdo timmean -selmon,6/9 -selyear,2021/2050 cahpb/03236
/cahpba.pm.2150.03236.rr8.nc $HOME/climatology/cahpba.JJAS.mean.future.03236.nc
```

Now find the change

```
% cd $HOME/climatology
% cdo sub cahpaa.JJAS.mean.future.03236.nc cahpaa.JJAS.mean.baseline.03236.nc
cahpaa.JJAS.mean.diff.03236.nc
% cdo sub cahpba.JJAS.mean.future.03236.nc cahpba.JJAS.mean.baseline.03236.nc
cahpba.JJAS.mean.diff.03236.nc
```

**3. )** Plot the future change in precipitation and a percentage and temperature in degrees C.

The script **change_precip_temp.ncl** uses the fields generated in section 2.7 to plot the future change in precipitation and 1.5m temperature. It outputs a .png plot called **change_precip_temp.png**. Open the script for editing.

```
% cd $DATA/ncl_scripts
% emacs change_precip_temp.ncl &
```

Before running this script two changes need to be made. At the top of the script, change data_dir to be the location of the climatology directory which contains the data to be plotted. Also change plot_location to the location of the climatology directory.

```
% ncl change_precip_temp.ncl
% display change_precip_temp.png
```

**How does the precipitation and temperature future change of HadCM3Q0 and ECHAM5 compare?**

## 2.8 Future time series

**1 a. )** Calculate and then plot a 2021-2050 monthly time series of precipitation anomalies for land points only relative to the 1961-1990 baseline monthly mean. Do this for both **cahpa** and **cahpb**.

`ymonsub` **a command which subtracts multi-year monthly time series.**

Firstly, apply a land mask to the future data.

```
% cd $DATA/monthly/cahpa/05216
% cdo mul cahpaa.pm.2150.05216.rr8.nc $DATA/landmask.nc
cahpaa.pm.2150.05216.rr8.land.nc
```

Now calculate the precipitation anomaly by calculating the baseline (1961-1990) multi annual monthly means and subtracting this from the future time series.

```
% cdo ymonsub cahpaa.pm.2150.05216.rr8.land.nc -ymonmean
cahpaa.pm.6190.05216.rr8.nc $HOME/climatology/cahpaa.future.tseries.diff.05216.nc
```

Do the same for **cahpb**.

```
% cd $DATA/monthly/cahpb/05216
% cdo mul cahpba.pm.2150.05216.rr8.nc $DATA/landmask.nc
cahpba.pm.2150.05216.rr8.land.nc
% cdo ymonsub cahpba.pm.2150.05216.rr8.land.nc -ymonmean
cahpba.pm.6190.05216.rr8.nc $HOME/climatology/cahpba.future.tseries.diff.05216.nc
% cdo infov $HOME/climatology/cahpba.future.tseries.diff.05216.nc
```

**1 b. )** Plot the temperature anomalies of **cahpa** and **cahpb**.

The script **precip_anom_tseries.ncl** uses the fields generated in section 2.8 to plot the time series of temperature anomalies for cahpa and cahpb. It outputs a .png plot called **precip_anom_tseries.png**. Open the script for editing.

```
% cd $DATA/ncl_scripts
% emacs precip_anom_tseries.ncl &
```

Before running this script two changes need to be made. At the top of the script, change `data_dir` to be the location of the `climatology` directory which contains the data to be plotted. Also change `plot_location` to the location of the `climatology` directory.

```
% ncl precip_anom_tseries.ncl
% display precip_anom_tseries.png
```

**1 c. )** Change the line colours and thicknesses.

To make these changes, the script **precip_anom_tseries.ncl** must be edited.

```
% emacs precip_anom_tseries.ncl &
```

To change the line colours and thickness, go to the `begin plot modifications` section of the script and change the following resources:

*- res@xyLineColors*

Currently set at **(/2,60/)**, choose 2 new colours by changing the numbers (must be less than 255.)

*- res@xyLineThicknesses*

Currently set at **(/1.1,1.1/)**, change the thickness values to make the lines thicker.

```
% ncl precip_anom_tseries.ncl
% display precip_anom_tseries.png
```

## 2.9 Creating a future scenario for temperature

There are several different possible approaches to creating climate change scenarios from model projections. This is just one example to demonstrate how CDO tools can be implemented to do this. Some of the different approaches and issues that relate to this are explored in the lecture on creating future climate change scenarios for impacts assessments.

**1 . )** Create a climate change scenario over the Bangkok area for 2021 to 2050, which comprises a timeseries of monthly mean 1.5m temperature which has a mean derived from the observed mean plus the modelled change but has variability directly simulated by the model.

**Note:** *This example assumes that model biases are systematic.*

The monthly means of the baseline have already been calculated for **CRU** observations and the six ensemble members in **worksheet 2a**.

The first step to create the climate change scenario for Bangkok is to find the model bias by subtracting the model monthly means from the observation monthly means.

```
% cd $HOME/climatology
% cdo griddes cahpaa.monmean.baseline.03236.rr8.ext.degC.nc > mygrid
% cdo remapnn,mygrid cru.monmean.baseline.03236.ext.BK.nc
cru.monmean.baseline.03236.ext.BK.rg.nc
% for run in "cahpa" "cahpb"
% do
% cdo sub cru.monmean.baseline.03236.ext.BK.rg.nc
${run}a.monmean.baseline.03236.rr8.ext.degC.nc $run.03236.mod_bias.nc
% done
```

**Note:** *This calculation has been done using a 'loop' (literally:* for *each* runid in *this list of files* do *the following commands, and then it is* done.)

Now from the future time series of monthly precipitation, take the monthly model bias. You will also need to extract the Bangkok area and convert from K into degrees C. This can all be done in one command:

```
% for run in "cahpa" "cahpb"
% do
% cdo ymonsub -subc,273.15 -sellonlatbox,100.3,100.7,13.5,13.8 $DATA/monthly
/$run/03236/${run}a.pm.2150.03236.rr8.nc $run.03236.mod_bias.nc
$run.03236.ccscenario.nc
% done
```

```
% cdo infov cahpa.03236.ccscenario.nc
```

**2 . )** Plot the climate change scenario for temperature over Bangkok.

The script **temp_ccscenaio.ncl** uses the fields generated in section 2.8 to plot the time series of temperature anomalies for cahpa and cahpb. It outputs a .png plot called **temp_ccscenaio.png**. Open the script for editing.

```
% cd $DATA/ncl_scripts
% emacs temp_ccscenaio.ncl &
```

Before running this script two changes need to be made. At the top of the script, change `data_dir` to be the location of the `climatology` directory which contains the data to be plotted. Also change `plot_location` to the location of the `climatology` directory.

```
% ncl temp_ccscenaio.ncl
% display temp_ccscenaio.png
```

**Can you explain another method which could be used to produce a future temperature scenario?**