Investigate the impacts of changes in insolation and CO2 on climate based on model simulations

Goals:
After this project, students are expected to know:
- How to diagnose the outputs of a climate model;
- What are the major impacts of precession and CO2 on some fundamental climate variables (e.g. temperature, precipitation, sea ice……).

Project:
Students are divided into three groups. One group works on surface temperature change in Exercises 1 and 2, the second group on sea ice and the third group on precipitation. Each group will write a report and make an oral presentation on the effects of precession and doubling CO2 and their major differences.

Report: no page limit; presentation: maximum 15 minutes for each group.

Exercise 1: Investigate the impact of precession on climate

The outputs (in NetCDF format) of two sensitivity experiments made with the model LOVECLIM will be diagnosed.

Experiment 1: experiment name "**Prec_PI**"
Pre-industrial experiment (Northern Hemisphere summer occurs at aphelion)
Eccentricity=0.016724, obliquity=23.446°, longitude of perihelion=**102.04°**,
CO2=280ppmv, CH4=760ppbv, N2O=270 ppbv

Data location on ELIC server:
- Long-term monthly mean atmosphere output:
/home/yin/student/precession/atmosphere/atmmmwp002400.PrI.nc
- Monthly mean ocean output:
/home/yin/student/precession/ocean/CLIO3m.PrI002400.nc

Experiment 2: experiment name "**Stud1_prec**"
Sensitivity experiment (Northern Hemisphere summer occurs at perihelion)
Eccentricity=0.016724, obliquity=23.446°, longitude of perihelion=**270°**,
CO2=280ppmv, CH4=760ppbv, N2O=270 ppbv

Data location:
- Long-term monthly mean atmosphere output:
/home/yin/student/precession/atmosphere/atmmmwp002400.Stud1_prec.nc
- Monthly mean ocean output:
/home/yin/student/precession/ocean/CLIO3m.Stud1_prec002400.nc

The only difference between Experiment 2 and Experiment 1 is the value of longitude of perihelion. It is 102.04˚ (present-day value) for Experiment 1, which means that Northern

Hemisphere summer occurs close to aphelion. It is 270° for Experiment 2, which means that Northern Hemisphere summer occurs at perihelion. The difference between the two experiments gives the impact of precession. We will plot the differences of some climatic variables between the two experiments by using the software NCL or other softwares.

Exercise II: Investigate the impact of increased CO2 concentration on climate

Experiment 1: "Prec_PI", Pre-industrial experiment
>   Eccentricity=0.016724, obliquity=23.446°, longitude of perihelion=102.04°,
>   CO2=280ppmv, CH4=760ppbv, N2O=270 ppbv

>   Data location:
- Long-term monthly mean atmosphere output:
  /home/yin/student/doubCO2/atmosphere/atmmmwp.002400.PrI.nc
- Monthly mean ocean output:
  /home/yin/student/doubCO2/ocean/CLIO3m.PrI002400.nc

Experiment 2: Sensitivity experiment
>   Eccentricity=0.016724, obliquity=23.446°, longitude of perihelion=102.04°,
>   CO2=560ppmv, CH4=760ppbv, N2O=270 ppbv

>   Data location:
- Long-term monthly mean atmosphere output:
  /home/yin/student/doubCO2/atmosphere/atmmmwp.002400.PrI_doub.nc
- Monthly mean ocean output:
  home/yin/student/doubCO2/ocean/CLIO3m.PrI_doub002400.nc

The difference between Experiment 2 and Experiment 1 gives the impact of doubling CO2 concentration on climate. We will plots the differences of some climatic variables between these two experiments using NCL.

A few examples on modeling the impact of precession and CO2 on climate:

Manabe S, Stouffer RJ, 1980. Sensitivity of a global climate model to an increase of CO2 concentration in the atmosphere. J Geophys Res 85:5529–5554.

Yin, Q. Z., Berger, A., and Crucifix, M, 2009. Individual and combined effects of ice sheets and precession on MIS-13 climate, Climate of the Past, 5, 229-243.

Yin Q.Z. and Berger A., 2012. Individual contribution of insolation and CO2 to the interglacial climates of the past 800,000 years. Climate Dynamics 38:709–724.

Wu Z.P., Yin Q. Z., Guo Z. T., Berger A., 2022. Comparison of Arctic and Southern Ocean sea ice between the last nine interglacials and the future. Climate Dynamics, https://doi.org/10.1007/s00382-022-06140-4.