Factors and processes controlling climate variations at different time scales
SimClimat activity

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Warning: the software is based on a simple model of the earth radiative budget. Results may not always represent the truth. Please keep a critical view on them.

1 Sensitivity to terms in the global radiative budget

Control simulation: 5 ky, starting from pre-industrial state
Important to start from a “stable” state, before present-day climate change.
Click on “new simulation”
Chose initial state (1750) and length.
Add sensitivity tests to radiative budget terms: click on “add”

1.1 Sensitivity to solar constant $S_0$
This is an external forcing to the Earth system.
Astronomic parameters > Earth-Sun distance
e.g. 95 and 105%,
Astronomic parameters > solar power
e.g. 95 and 105%, or like at the beginning of Earth History
• Is the effect on temperature, sea-ice extent and sea level expected?

1.2 Sensitivity to albedo
By default, albedo is interactively calculated as a function of ice-sheet extension.
climate feedbacks > unplug the feedback. Tune the albedo
e.g.: 20%-40%.
• Is the albedo effect on temperature expected?

1.3 Sensitivity to greenhouse gases
CO2 concentration
By default, CO2 concentration is interactively calculated as a function of CO2 sources and sinks.
Concentration or CO2 emissions > set the concentration, then chose the concentration value
e.g. pre-industrial, as today, twice as much as today, zero

water vapor concentration
By default, water vapor concentration is interactively calculated as a function of temperature.
Climate feedbacks > water vapor > unplug the feedback, then chose the concentration value
e.g. pre-industrial, as today, twice as much as today, zero
• Are the effects of CO2 and water vapor expected?
• What is the relative importance of CO2 and water vapor in natural greenhouse effect? And on anthropogenic greenhouse effect?

2 Climate changes at geological time scales

2.1 Climate equilibria and reversibility of climate changes

• In previous tests, have you noticed extreme behaviors in term of temperature and sea-ice extent? How can we interpret them?

Control simulations, 50 ky, starting from pre-industrial. Click on new simulation.

• Reduce the solar power in different proportions: 98%, 96%, 94%, 90%. What happens? What are the different possible climate states?

• Come back to the present-day solar power by extending the previous simulation: New simulation > final state of the previous simulation > solar power = 100%. Does the climate come back to its initial state before solar power reduction? Why?

• Add other simulations with present-day solar power, but at the same time increase the CO2 concentration. Is there a CO2 threshold beyond which the climate comes back to the initial state? Don’t forget to set back the solar power to its present-day value (100%) for each simulation.

• In the real world, how can we get out of a snow ball earth?

2.2 CO2 sources and sinks

Control simulation, 500 ky, starting from pre-industrial state

Test the sensitivity to carbon sources and sinks

• compare the time scales at which geological (volcanism, land alteration) and anthropogenic sources and sinks play a role

LUNCH BREAK

3 Sensitivity to orbital parameters

Control simulation, 50 ky, starting from pre-industrial state

Test the sensitivity to orbital parameters within their range of minimum and maximum values: add > astronomic parameters

• obliquity
• excentricity
• precession

Interpret the results

• why does it impact temperature?

• How do ice-sheet extent, planetary albedo, sea-level and CO2 change? What are the cause-consequence links between these variables?

• chose one case of orbital parameter variation (e.g. obliquity to maximal value). Test the role of ice-albedo feedback: climate feedbacks > albedo > unplug the feedback. Conclude on the role of this feedback.

• on this same case, test the role of oceanic carbon fluxes. climate feedbacks > ocean > authorize oceanic carbon fluxes but without depending on temeprature. Conclude on the role of this feedback.

• what is the consequence on sea-level? Why?
4 Sensitivity to anthropogenic emissions and role of various feedbacks

4.1 Response to anthropogenic emissions

500-years simulation starting from the present-day state. By default, it includes the anthropogenic emissions.

- Consequences on temperature and sea level?

4.2 Carbon cycle feedbacks

Show the evolution of CO2 concentration and emission

- Does CO2 concentration increase as much as expected from CO2 emissions?

Test the impact of carbon fluxes associated with the ocean and with vegetation.

  add > climate feedbacks > ocean > don’t consider oceanic fluxes
  add > climate feedbacks > ocean > don’t consider vegetation fluxes

  What is the sign of these feedbacks? What factors could modulate their effects?

4.3 Relative role of climate feedbacks

- Albedo feedback: add > climate feedbacks > albedo > unplug the albedo feedback

- Water vapor feedbacks: add > climate feedbacks > water vapor > unplug the water vapor feedback

What is the relative importance of these 2 feedbacks, at what time scales do they play?

4.4 Reversibility of changes

Extend the simulation for another 500 years, but without anthropogenic emissions. Are these changes reversible? At which time scales?