

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
- eccentricity
- 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 temperature*. 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?