Model output for aerosol-induced cooling after the Chicxulub impact

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and also the article for which this data are supplementary material:
Brugger, J., Feulner, G., and Petri, S. (2017): Baby, it's cold outside: Climate model simulations of the effects of the asteroid impact at the end of the Cretaceous, Geophysical Review Letters, Volume 44, Issue 1, pages 419–427, https://doi.org/10.1002/2016GL072241.

Contents

Abstract

In *Baby, it's cold outside: Climate model simulations of the effects of the asteroid impact at the end of the Cretaceous* we study the effect of sulfate aerosols and carbon dioxide after the Chicxulub impact on the end-Cretaceous climate using the coupled climate model CLIMBER-3α. CLIMBER-3α consists of a modified version of the ocean general circulation model MOM3, a dynamic/thermodynamic sea-ice model, and a fast statistical-dynamical atmosphere model. It models climate globally on a 3.75 ° x 3.75 °(ocean) and 22.5 °(longitude) x 7.5 °(latitude) (atmosphere) grid. More information about the model can be found in the manuscript.

Our impact simulations are based on a climate simulation of the end-Cretaceous climate state using a Maastrichtian (70 Ma) continental configuration. The solar constant is scaled to 1354 W/m^2, based on the present-day solar constant of 1361 W/m^2 and a standard solar model. The atmospheric CO_2 concentration of the baseline simulation is 500 ppm and 1000 ppm for a sensitivity experiment. The impact is assumed to release 100 Gt sulfur and 180-540 ppm CO_2. We simulate stratospheric residence times of 2.1 y, 4.3 y and 10.6 y of the sulfate aerosols.

The data presented here is the model output on which the results described in the corresponding manuscript are based on. The model output is provided in different netcdf files.The structure of the model output is explained in this Readme file (Part 1). Additionally, the generation of the model input data is described and the figures of the publication, and scripts (Python) to analyse the model output and generate the figures are contained (Part 2).

Part 1: Description of model output data

Each run's name gives all relevant information about the parameter setting:

Example: `c3beta_cret_066Ma_0500ppm_P2003_10p6yrs_540ppm`

c3beta model version

cret period in Earth history (Cretaceous)

066Ma continental configuration

0500ppm pre-impact atmospheric CO_2 concentration was set to 500 ppm CO_2

P2003 this scenario is based on Pierazzo et al. 2003, as all simulations for this publication

10p6yrs stratospheric residence times for aerosols assumed at 10.6 years

540ppm 540 ppm CO_2 are added during the impact

`c3beta_cret_066Ma_0500ppm` and `c3beta_cret_066Ma_1000ppm` are the control runs without impact event.

Impact runs

- Our assumptions for modeling the climatic effects of the impact are based on geophysical impact modeling by Pierazzo et al. (1998) and Pierazzo et al. (2003).
- Pierazzo et al. (1998) model the impact of a dunite projectile with 50% porosity, a velocity of 20 km/s,and a diameter between 15 and 20 km, on a 2.9 km thick target region consisting of 30% evaporites and 70% water-saturated carbonates, leading to a sulfur mass of 100 Gt.
- Therefore, for all impact runs the atmospheric effect of 100 Gt S is considered using transmission curves for the different stratospheric residence times of Pierazzo et al. (2003) to scale the solar constant. The transmission curves assume a ratio of 20% SO_3 and 80% SO_2.
- The additional CO_2 is added instantaneously to the atmosphere.
- Both sulfate aerosols and CO_2 are distributed globally and uniformly in our model simulations.
- Impact year is year 2205

Model output

Most relevant files: snapshots contain monthly values of the variables for the model year given in the name.
Ocean model data: `snapshots.00....01.01.dta.nc`
Atmosphere model data: `snapshots_potsdam2.00....01.01.dta.nc`
Sea-ice model data: `snapshots_isis.00....01.01.dta.nc`

history files contain yearly values of the variables for each model year the simulation was run.
Ocean model data: `history.nc`
Atmosphere model data: `history_potsdam2.nc`
Ice model data: `history_isis.nc`

`topog.dta.nc` contains information about ocean topography and cells.
`oro.dat` contains land orography data.

Part 2: Description of files for creating model input, figures etc

Creating model input:

`Cretaceous_Preprocessing/cretaceous.i` is the script to create the model input data. Based on data from Sewall et al. (2007) it creates the elevation model input data
(`Cretaceous_Preprocessing/ModelInput/70Ma_kmt.dta` and
`Cretaceous_Preprocessing/ModelInput/70Ma_oro.dat`)
and surface type input data
(`Cretaceous\Preprocessing/ModelInput/70Ma\_p2\vegetat\obs.dat`).
In addition, this script produces the files with the scaled solar constant based on the transmission curves in Pierazzo et al. (2003)
(`Cretaceous\Preprocessing/ModelInput/pierazzo_2003_02p1yrs_solarv.dat` and `pierazzo_2003_04p3yr`
and `pierazzo_2003_10p6yrs_solarv.dat`).
To do so, the data of the transmission curves was first digitalised
(files in `Cretaceous_Preprocessing/Data/ImpactScenarios/Pierazzo_2003`).

Analysis of model output

Scripts to create figures of the publication and to calculate certain values can be found in directory
`PythonScripts_GRL012017`:

Figure 1: Global annual mean surface air temperature (a) and sea-ice fraction (b) for 30 years after the impact for different stratospheric residence times and additional CO_2
`convert_to_ascii.py`, `convert_to_ascii_seaice.py`: scripts to read data from model output, write relevant variables in `.dat` files
`readoutfileps_paper_timeplot_500.py` script to generate Fig. 1 (`ts_ice.pdf`)

Figure 2: Maps of surface air temperature before (a) and after the impact (b) for 2.1 years stratospheric residence time and 360 ppm CO_2
`convert_to_ascii.py`: script to read data from model output, writes relevant variables in `.dat` files
`readoutfileps_paper_500.py`: script to generate Fig. 2
(`ts_0&minyear_500_2p1_360_map.pdf`)

Figure 3: Meridional profiles of ocean temperature anomalies for an impact simulation with 2.1 years residence time, and 360 ppm of carbon dioxide from the impact relative to the control run (a) 3 years, (b) 100 years, (c) 500 years, and (d) 1000 years after the impact
`convert_to_ascii_depthtemp.py`: script to read data from model output, writes relevant variables in `.dat` files
`readoutfile_depthtemp_4years.py`: script to generate Fig. 3
(`tempdepthprofile_4years_diff.pdf`)

Figure 4: Ocean mixed-layer depth before the impact and in the coldest year for the baseline simulation with 500 ppm of carbon dioxide, an impact simulation with 2.1 years residence time, and 360 ppm of carbon dioxide from the impact, and a present-day simulation.
`convert_to_ascii_mixedlayer.py`, `convert_to_ascii_mixedlayer_present.py`: scripts to read data from model output, write relevant variables in `.dat` files
`readoutfilemoms_mixedlayerdepth_500.py`: script to generate Fig. 4
(`hmxl_500_2p1_360.pdf`)

Calculation of Land Temperature: Scripts for calculation of all land temperatures discussed in the article
`CalculationoOfLandtemp/convert_to_ascii.py`: script to read data from model output, writes relevant variables in `.dat` files
`readoutfileps_tsland_500.py`: script to calculate land temperatures

Calculation of temperature for certain location: Scripts for calculation of temperatures for one grid cell, representing a certain location
`NewJersey:GulfofMexico/GulfofMexico_singlecell/`
`readoutfile_paper_singlecells_500_GulfofMexico.py` and
`NewJersey:GulfofMexico/NewJersey_singlecell/`
`readoutfile_paper_singlecells_500_NewJersey.py`

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