NEOPROTEROZOIC SNOWBALL EARTH? OR SLUSHBALL EARTH?

by Kerrie Sampelayo

Papers Reviewed

Micheels A., Montenari M. (2008) A snowball Earth versus a slushball earth: Results from Neoproterozoic climate modeling sensitivity experiments. *Geosphere* **4,** 401-410.

Pollard D., Kasting J.F. (2005) Snowball Earth: A thin-ice solution with flowing sea glaciers. *Journal of Geophysical Research* **110,**

NEOPROTEROZOIC

- 1000-542 Ma
- Break up of Rodinia
- Increased coastal area, increased rainfall, reducing greenhouse gases
- Cooler temp allows ice to form, increasing albedo, further freeze

Micheels and Monternari

- Climate Modeling Experiments
- Testing the degree of Glaciation
- Focuses on the role of:
  - Reduced Solar luminosity
  - Land surface cover
  - Concentrations of atmospheric CO2
  - Ocean

MICHEELS AND MONTERNARI

Experiment Boundary Conditions

TABLE 1. THE SPECIFICATIONS OF THE PRESENT-DAY CONTROL RUN AND THE NEOPROTEROZOIC SENSITIVITY EXPERIMENTS

Experiment identification	Boundary conditions	
CTRL	CO_2 = 280 ppm, S_0 = 100%, present-day geography, orography, vegetation, SSTs, and SIC	
NEO-1	CO_2 = 510 ppm, S_0 = 94%, paleogeography, paleo-orography, no explicit flux correction	+ desert land + cold ocean + global sea ice
NEO-2		+ glaciated land + cold ocean + global sea ice
NEO-3		+ glaciated land + cool ocean + polar sea ice + sea ice around continent
NEO-4		+ glaciated land + cool ocean + polar sea ice
NEO-5		+ desert land + cool ocean + polar sea ice
NEO-3-280	as NEO-3, but CO_2 = 280 ppm	
NEO-4-280	as NEO-4, but CO_2 = 280 ppm	
NEO-5-280	as NEO-5, but CO_2 = 280 ppm	

Note: CTRL—present-day control experiment; SST—sea surface temperature; SIC—sea ice cover.

MICHEELS AND MONTERNARI

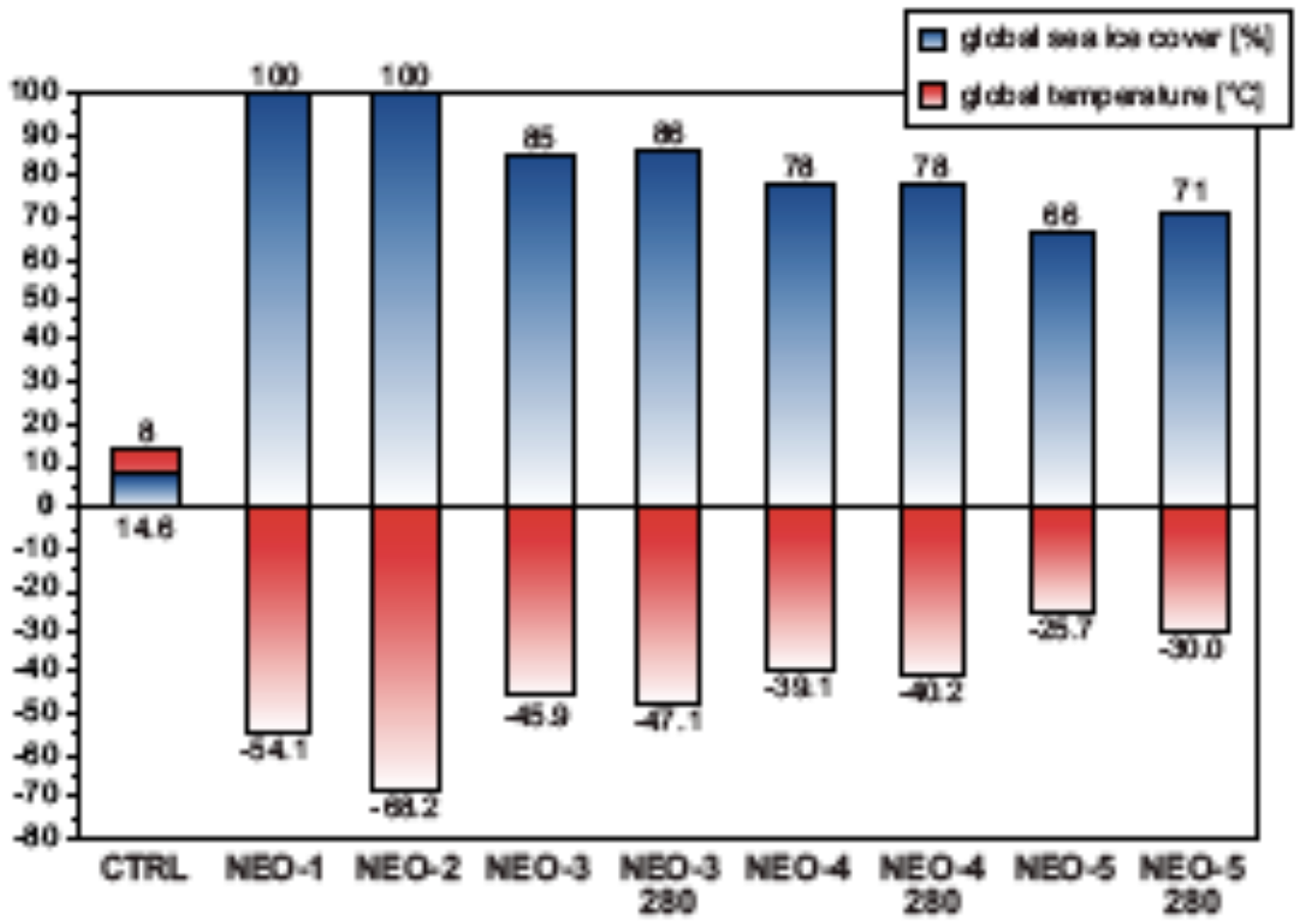

Figure 3. The global average temperatures (red bars) and the global average sea ice cover (blue bars) of the present-day control run and the Neoproterozoic experiments.

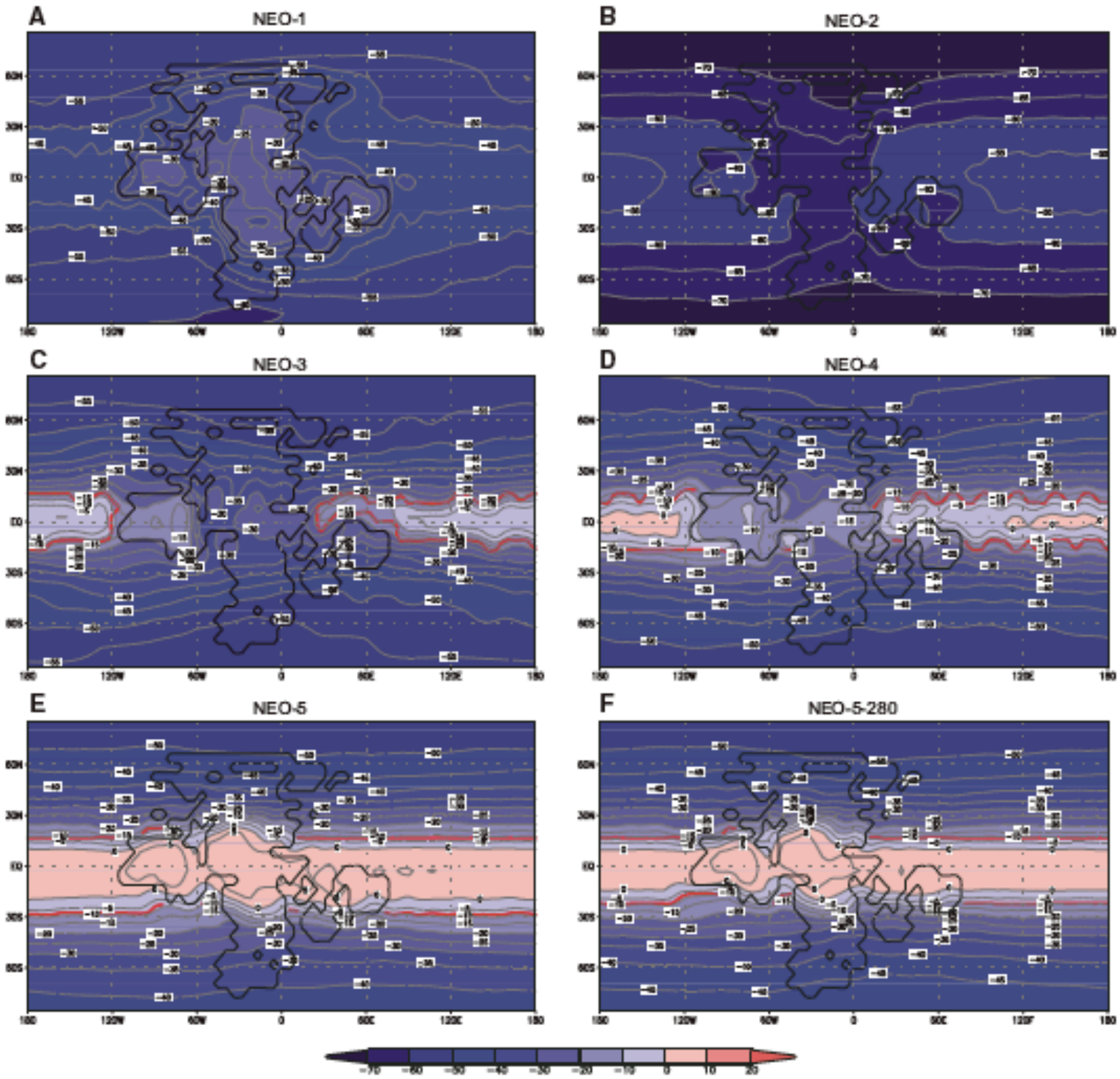

Figure 4. The mean annual temperatures (°C) and sea ice margin (red line) of the Neoproterozoic experiments.

Micheels and Monternari

Conclusions

- Supports Slushball Earth
  - Simplifications limited the reliability of the model
  - Further Model studies should address amount of CO_2 necessary to melt a Snowball Earth

POLLARD AND KASTING

Energy-balance climate / sea-glacier model

- Hard Snowball model
- Thin-ice model

POLLARD AND KASTING

Problem with Hard Snowball Earth model

- Ice thickness (km or more everywhere)
  - Survival of photosynthetic algae
    - no evidence of major biological extinctions
- CO2 concentration needed to deglaciate

POLLARD AND KASTING

Thin Ice Solution

*Tropical ice thins from several meters to only a few tens of centimeters

*Allows more visible Solar radiation to penetrate through the ice base

* A lower concentration of CO_2 is needed to induce recovery

POLLARD AND KASTING

Conclusions

A thin tropical ice could have prevailed in full Snowball Earth, despite the flux toward the equator of thick ice from higher latitudes. Even if thin ice was not present in the tropical ocean, low-latitude lakes and confined seas may have provided sufficient protection for the survival of photosynthetic algae and other marine organisms.