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Natural climate change and glaciations

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Highlights

- Natural climate change (NCC) has several causes.
- Glaciations have abrupt onsets and terminations.
- LIPs, climatology, proximity to paleoequator determine onset and end of a glaciation.
- Long-term NCC, faint young Sun problem are determined by carbonate–silicate cycle.

Abstract

We investigated the interactions between continental growth and breakup, inorganic carbonate-silicate cycle, volcanic activity, glaciations, natural climate change, and biotic evolution. As far as volcanism is concerned, the large igneous provinces (LIPs) are proving to be particularly effective. However, this conclusion is not valid without additional assumptions. The effects of the eruptions of LIPs must be seen in connection with the physical climatology at the time of the eruption, the proximity of the LIPs to the paleoequator, the strength of the eruption and the chemical composition of the lava and the emitted gases. The faint young Sun was compensated for by high

atmospheric concentrations of greenhouse gases on the early Earth. These greenhouse gases were subsequently drawdown by climate-dependent silicate weathering as the solar radiation increased. Although some authors have expected, that growth of juvenile continental crust or continental breakup would be followed by a glaciation, this is not always the case. Glaciations have abrupt onsets and terminations, and we examined previously proposed hypotheses to explain glaciations and the abrupt onsets and terminations. The hypothesis that pulses of continental growth or supercontinent breakup events resulted in intensified silicate weathering is essentially correct but does not explain everything. Apparently, the hypothesis refers to an existing mechanism, but there must be other, hitherto hidden influences. Multiple stable states in the climate system are separated by unstable jumps (bifurcations) between stable states. This is primarily a reflection of ice-albedo feedback, particularly between sea ice and sea. Ice-albedo feedback ensures rapid advance and retreat of marine ice margins across the tropics. This explains abrupt onset and termination of snowball Earth periods. We show that hypotheses based on inorganic carbonate-silicate cycle and, to a considerably lesser degree, on biotic factors can explain most natural climate change, but not the abrupt onset and termination of snowball Earth periods. Furthermore, we discuss the temporal distribution of glacials and interglacials within a glaciation. This distribution is controlled mainly by the mechanics of our planetary system, influenced by internal feedback mechanisms of the Earth system. Short-period changes in the weather are caused by changes in the solar magnetic field.