The Time-Scale Problem in Model-Data Comparison Studies

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High-resolution numerical climate models require extensive computing time to resolve climatic boundary conditions and to reach equilibrium. There are numerical techniques to speed up simulations used to calculate such climatic equilibriums. However, transient long-term climate simulations of thousands to millions of years cannot be easily resolved with state of the art coupled ocean-climate models. For paleoclimate simulations the approach is generally to select a range of initial boundary conditions that reflect extreme conditions for the particular climate being modeled (e.g., orbital parameters reflecting “cool-orbits” to model glaciations). These simulations can only lead to a snapshot of the potential climate for the modeled time period.

Unless deposited under extreme environmental conditions (e.g., lack of bioturbation), most sedimentary layers reflect time-averaged deposits that lack temporal resolution and filter out short-term variations. Therefore, data obtained from these deposits generally do not reflect the most extreme climate conditions, causing potential problems for the interpretation of model-data datasets.

For instance, eruptions of supervolcanoes can have dramatic effects on the global climate system. The estimated dense rock equivalent of the Late Ordovician Deicke K-bentonite (DKB) has been estimated to have been larger than the Toba ash fall (Indonesia, 75 kyr)1. As the eruption of Toba has been identified as a potential contributing factor in the transition of warm to cool climates, and might have caused a bottleneck for human evolution2, the DKB event could have also impacted Late Ordovician earth systems. However, temperature estimates using oxygen isotopes spanning the DKB indicate that it did not cause long-term cooling. This would support numerical model results of the Toba Eruption that show that the climate system recovers within decades from short-term cooling of 10-17K due to a “volcanic winter”3. However, these (and similar) short-term cooling events cannot be resolved using traditional stratigraphic proxies.

1 Christidis, G. E. & Huff, W. D. Geological Aspects and Genesis of Bentonites. Elements 5, 93-98 (2009).
2 Rampino, M. R. & Ambrose, S. H. in Volcanic Hazards and Disasters in Human Antiquity eds F.W. McCoy & G. Heiken) 71-82 (Geological Society of America Special Paper 345, 2000).
3 Robock, A., et al., Did the Toba volcanic eruption of 74 ka B.P. produce widespread glaciation?, J. Geophys. Res., 114, (2009)