Coupling of Southern Ocean climate, dust and CO_2 over the past 10 million years

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Abstract

The climate evolution of the past 10 million years has been characterized by the dramatic transition from conditions significantly warmer than today, and a nearly ice-free Northern Hemisphere (Pound et al., 2011) during the late Miocene (>7 Ma), to the Pleistocene cold house climate regime with presence of massive ice sheet in the Northern Hemisphere (Zachos et al., 2001). In particular, recent SST reconstructions from different parts of the oceans revealed the profound late Miocene global cooling (7.5-5.5 Ma) which was comparable to that of the intensification of Northern Hemisphere Glaciation (~3.5 Ma) (Herbert et al., 2016). The factors driving this change, however, remain unclear mainly because of the large uncertainty in pCO_2 estimates based on existing proxies (e.g., Van der Burgh et al., 1993; Kürschner et al., 1996; Pagani et al., 2005; Pagani et al., 2010; Seki et al., 2010; Bartoli et al., 2011; Martínez-Botí et al., 2015). Southern Ocean significantly exerts global ocean circulation and carbon cycle, and thus is thought to play a critical role in both orbital scale and long-term climate changes in Plio-Pleistocene (Martínez-Garcia et al., 2011). However, the substantial role of the Southern Ocean in long-term climate evolution during the late Neogene is still uncertain. Here I reconstruct SST, primary productivity, dust and atmospheric CO2 concentration from Southern Ocean sediment core (ODP 1123) based on marine and terrestrial biomarker proxies in order to investigate role of Southern Ocean in the late Neogene climate evolution. The biomarker records encompass the last 10 million years, providing a fundamentally new view of climate evolution during the late Neogene. The new pCO_2 data reveals a climate, dust, productivity and CO2 coupling with marked increases in dust and productivity and decreases in SST and CO2 at the onset of the late Miocene global cooling (~7.5 Ma). This suggests a causal link between the late Miocene global cooling and CO2 and substantial role of the Southern Ocean in the drawdown of CO2 during the late Miocene by dust induced biological pump.

Keywords: Late Neogene, Southern Ocean, CO2, SST, dust, productivity

References

Bartoli, G., Hönisch, B., Zeebe, R. E., 2011. Atmospheric CO_2 decline during the Pliocene intensification of Northern Hemisphere glaciation. *Paleoceanography*, 26, 2010PA002055.

Kürschner, W. M., Van Der Burgh, J., Visscher, H., Dilcher, D. L., 1996. Oak leaves as biosensors of late Neogene and early Pleistocene paleoatmospheric CO_2 concentrations. *Marine Micropaleontology*, 27, 299-312.

Martínez-Botí, M.A. et al., 2015. Plio-Pleistocene climate sensitivity evaluated using high-resolution CO_2 records. *Nature*, 518, 49-54.

Martínez-Garcia et al., 2011. Southern Ocean dust-climate coupling over the past four million years. Nature, 476, 312-315.

Pagani, M., Zachos, J. C., Freeman, K. H., Tipple, B., Bohaty, S., 2005. Marked decline in atmospheric carbon dioxide concentrations during the Paleogene. *Science* 309, 600-603.

Pagani, M., Liu, Z., LaRiviere, J., Ravelo, A. C., 2010. High Earth-system climate sensitivity determined from Pliocene carbon dioxide concentrations. *Nature Geosci*. 3, 27-30.

Pound, M. J. et al. A Tortonian (Late Miocene, 11.61–7.25 Ma) global vegetation reconstruction, 2011. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 300, 29–45.

Seki, O., Foster, G. L., Schmidt, D. N., Mackensen, A., Kawamura, K., Pancost, R. D., 2010. Alkenone and boron-based Pliocene pCO_2 records. *Earth Planet. Sci. Lett*., 292, 201–211.
Van Der Burgh, J., Visscher, H., Dilcher, D. L., Kürschner, W. M., 1993. Paleoatmospheric signatures in Neogene fossil leaves. *Science*, 260, 1788-1790.
Zachos, J., Pagani, M., Sloan, L., Thomas, E., Billups, K., 2001. Trends, Rhythms, and Aberrations in Global Climate 65 Ma to Present. *Science* 292, 686-693.