Emplacement of a strong meridional temperature gradient 38 Myr ago led to Antarctic glaciation at the EOT

MAXIME TREMBLIN[1], MICHAËL HERMOSO[2,3], AND FABRICE MINOLETTI[1]

[1] Institut des Sciences de la Terre de Paris, Université Pierre et Marie Curie, Sorbonne Universités, CNRS, Paris, France. Email: maxime.tremblin@upmc.fr.
[2] Department of Earth Sciences, University of Oxford, Oxford, United Kingdom.
[3] Institut de Physique du Globe de Paris, Université Paris Diderot, Sorbonne Paris Cité, CNRS, Paris, France.

The Palaeogene represents a pivotal period in the climate history of the Meso-Cenozoic with Earth climate shifting from greenhouse to icehouse settings. This trend culminated in the formation of the first permanent ice sheets on Antarctica at the Eocene-Oligocene transition (EOT), ca 34 Myr ago. This event is relatively well documented, but the causal mechanisms are not well constrained. This deficiency arises from discrepant oceanic temperatures estimated from different proxies, and the lack of reliable temperature estimates at lower latitudes during the Eocene. In this study, we took advantage of the excellent preservation state of coccoliths compared to foraminifera in the equatorial Atlantic (sites ODP 925/929) to reconstruct $\delta^{18}O$-derived SSTs. Recent developments in the biogeochemistry of these phytoplankton concomittantly allowed inference of ambient CO_2 concentrations. Our results show that Palaeogene SSTs in the tropical belt were much more variable than previously reported and reveal an important cooling from the early to Middle Eocene, which is followed by an unexpected warming during the Late Eocene. Concomitantly the austral high latitude realm cooled and reached a freezing point. We interpret this pattern as the entrenchment of a strong meridional temperature gradient, 4 Ma prior to the EOT, which caused accumulation of oceanic heat at low latitudes. We further propose that glaciation was consecutive to the constriction of South Atlantic gyre, itself due to the development of a proto-Antarctic circumpolar current. Such an important redistribution of heat at the surface of the oceans, in the context of long-term pCO_2 decline, was an important contributor to the shift of the Earth's climate system towards icehouse.