Contribution ID : **222** Type : **Oral**

Climate-carbon cycle dynamics on a warmer-than-modern Miocene Earth

Thursday, 6 September 2018 16:45 (15)

The late Miocene (~11.6 to 5.3 million years ago) represents a geologically recent interval of relative global warmth that was marked by profound environmental change in both terrestrial and marine ecosystems. This period offers the opportunity to assess the sensitivity of the Earth's climate to changing boundary conditions, such as ice volume and radiative forcing, on a warmer-than-modern Earth. However, the uncertainty of the CO2 forcing during the Miocene remains a major challenge for understanding the dynamics of warmer climate states. In particular it is difficult to reconcile late Miocene warmth with current reconstructions of atmospheric pCO2 levels close to pre-industrial values. This apparent decoupling between climate warmth and atmospheric pCO2 has prompted intense debate about the role of pCO2 as driver of climate variations under different background states. Our high-resolution benthic isotope record in combination with paired mixed layer isotope and Mg/Ca-derived temperature data from the subtropical northwest Pacific Ocean reveals that climate cooling and intensification of the southeast Asian winter monsoon from ~7 Ma until ~5.5 Ma were synchronous with decreasing pCO2 within a global context of steepening meridional thermal gradients. The climate shift occurred at the end of the most important global δ13C decrease of the Cenozoic, suggesting that changes in the carbon cycle involving the terrestrial and deep ocean carbon reservoirs were instrumental in driving climate change. Our results further show that intensified monsoonal wind forcing of upper ocean circulation enhanced productivity, thus strengthening the Pacific Ocean's biological pump and increasing global carbon sequestration efficiency. We speculate that this late Miocene climate shift was associated with a relatively small decline in pCO2 and that climate sensitivity was amplified by a conjunction of positive feedbacks.

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Session Classification : 09 Ocean Deoxygenation - how the Past can Inform the Future

Track Classification : 09 Ocean Deoxygenation - How the Past can Inform the Future