Oceanographic changes in the Southern Ocean and Antarctic cryosphere dynamics during the mid-Miocene: a view from offshore Wilkes Land

Francesca Sangiorgi[1] (f.sangiorgi@uu.nl), Peter Bijl[1], Julian Hartman[1], Stefan Schouten[2], Henk Brinkhuis[1, 2]
and the IODP Exp. 318 Scientists

[1]Marine Palynology & Paleoceanography, Dept. Earth Sciences, LPP, Utrecht University, The Netherlands; [2] NIOZ Royal Netherlands Institute for Sea Research, Texel, The Netherlands

INTRODUCTION

The **mid-Miocene Climatic Optimum** (MCO, ~17-15 Ma) is one of the most pronounced warming events since the onset of Antarctic glaciation ~34 Ma (1). Ocean temperatures were ~3-6 °C above present-day (2, 3) and CO_2 concentrations were as high as 400 – 500 parts per million in volume (ppmv) (4), conditions very similar to those projected for the near future. Progressive cooling and expansion of global ice volume[4, 14] occurred at the **mid-Miocene Climatic Transition** (MCT ~14.2 – 13.8 Ma) together with a decline in atmospheric pCO_2 to close to 200-300 ppmv (2, 4). Studying the variability of the EAIS during the mid-Miocene can help understanding its sensitivity and improving sea level change projections. For this, ice-proximal records covering the mid-Miocene are essential but scarce.
Here we present new paleoenvironmental reconstructions from well-dated (5) sediment record of Integrated Ocean Drilling Program (IODP) Site 1356, offshore Wilkes Land and compare to those from Ross Sea ANDRILL (Antarctic Drilling) AND-2A (6) and Ocean Drilling Program (ODP) Site 1171 South of Tasmania (2) during the mid-Miocene to get insight into the latitudinal temperature gradients and role of oceanography for the EAIS dynamics. Continental temperatures compared to those of a paleolake in New Zealand (Lake Manuherikia) (7)

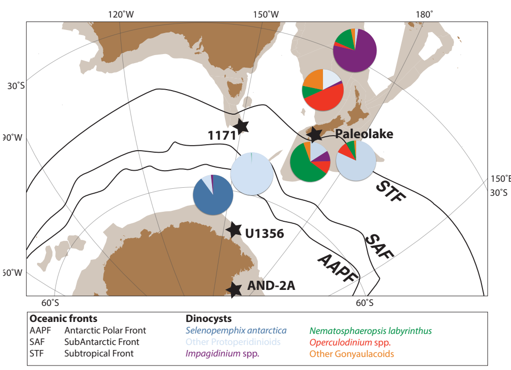

Figure 1: present-day dinoflagellate cyst assemblages across the Southern Ocean fronts (Prebble et al., 2013) and location of the record presented

MATERIALS AND METHODS

IODP Site 1356: **palynology** (pollen and dinoflagellate cysts) for terrestrial and marine environmental and oceanographic changes, **sedimentology** (clast counts as Ice Rafted Debris) and **organic geochemistry** (TEX_{86}^{L}, MBT/CBT and BIT indices) (8, 9, 10) for ocean and land temperature and input soil organic matter. Record covers the interval ~16.7 – 12.7 Ma
We use present day distribution of dinoflagellate cysts across the Southern Ocean fronts (11, *Figure 1*) to reconstruct Miocene environmental conditions and oceanography

AND-2A: TEX_{86}^{L} for sub-surface ocean temperature (8)

ODP Site 1171: Mg/Ca for subsurface ocean temperature (2)

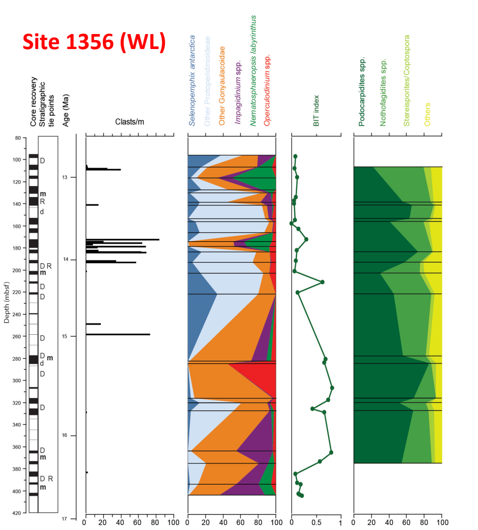

Figure 2: clast counts, dinoflagellate cysts, BIT index and pollen at Wilkes Land

RESULTS MCO Site 1356, Wilkes Land (*Figure 2*)

- Absence of sea-ice dinocyst indicator *Selenopemphix antarctica*, presence of temperate dinocysts
- Absence of clasts (IRD)
- High pollen percentages of temperate pollen *Podocarpites* sp.,
- Mean annual continental temperatures (MATs) of 6-11°C,
- High BIT (high input of soil organic material)
- High TEX_{86}^{L}-based SSTs (11-16)°C

AFTER MCO

- Presence of *S. antarctica*
- Episodic occurrence *N. labyrinthus* (oceanic fronts)
- High *Nothofagidites* pollen (tundra-shrub)
- Pulses of IRD
- MATs of 5°C and lower SSTs

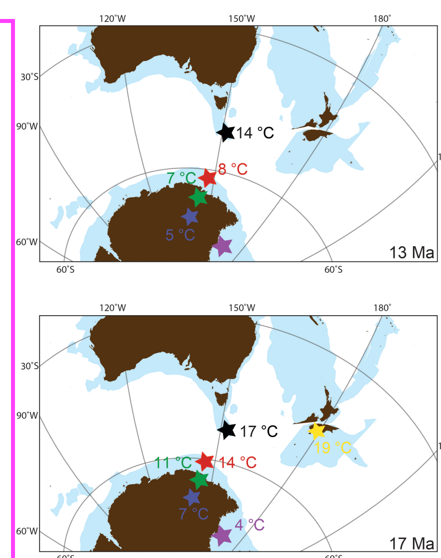

Figure 3: Average marine and continental temperatures during the MCO (below) and after the MCO (above) at the paleo-latitude locations (12)

DISCUSSION AND CONCLUSIONS

MCO was warm enough to sustain melting of continental ice and was mostly sea-ice free at the Wilkes Land margin. Reduced latitudinal temperature gradient between Wilkes Land and ODP 1171 (*Figure 3*) indicates weaker oceanographic fronts. A clear temperature gradient exist between the Wilkes Land margin and the Ross Sea ANDRILL drill sites throughout the MCO. After the MCO the climate becomes on average relatively colder at Wilkes Land and yet very variable. Both continental and marine proxies indicate much warmer than present-day temperatures even with CO_2 concentrations at pre-industrial level. Oceanography plays an important role for the stability of the EAIS

References: (1) Zachos et al., 2008, Nature; (2) Shevenell et al., 2004, Science; (3) Herold et al., 2011, J. Clim.; (4) Greenop et al., 2014, Paleoceanography; (5) Tauxe et al., 2012, Paleoceanography; (6) Levy et al., 2016, PNAS; (7) Reicheldt et al., Paleo3; (8) Kim et al., 2012, GJR; (9) Hopmans et al., 2004, EPSL; (10) Peterse et al., 2012 GCA; (11) Prebble et al., 2013, Mar. Micropal.; (12) Van Hinsberger et al. 2015, PLosOne