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Evolution and variability of the East Antarctic Ice Sheet during the Pliocene: Ice-rafted debris provenance and model results

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Evidence for the state of the East Antarctic Ice Sheet during the Pliocene is sparse, difficult to interpret and often contradictory. Recent provenance measurements from ice-rafted debris (IRD) at ODP Site 1165 in Prydz Bay, East Antarctica suggests major iceberg release events from Wilkes Land during the warmer periods of the Pliocene. While this data provides unprecedented geographical information and important constraints on Pliocene ice sheets, the exact nature of the ice sheets they represent and the cause of the measured variability in the source of Prydz Bay icebergs remain unclear.

Here we present an integrated Pliocene climate, ice sheet and iceberg modelling approach to simulate the conditions under which these changes in East Antarctic icebergs could have occurred. Scenarios with little variability in the East Antarctic Ice Sheet cannot reproduce the data from the early Pliocene IRD data at Site 1165, although transition to a modern-like state may explain changes in the latter part of the record. Careful data-model comparison shows that much of the variability in the record can be explained by an East Antarctic Ice Sheet that is sensitive to changes in the orbital forcing during the Pliocene. However, even with an ice sheet that varies by several metres of sea level equivalent volume, the extreme lows in Wilkes Land IRD seen in the record are not reproduced. This suggests there may be additional forcing producing large retreats of the ice sheet in the Wilkes Land region.

IRD data and iceberg modelling provides us with a unique window into the changes and oscillations in the East Antarctic Ice Sheet that must have occurred during the Pliocene. While this approach does not give a complete picture of ice sheets during the Pliocene it helps to evaluate existing reconstructions and provides important constraints on any future reconstructions.