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The role of Southern Ocean gateways on the evolution of the Antarctic Circumpolar Current and climatic cooling in the Palaeogene

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The earliest Tertiary period was characterised by warm *greenhouse* climates which progressively cooled in a series of steps. A particularly substantial phase of this trend occurred approximately 34 million years ago (Eocene-Oligocene boundary) and resulted in Antarctic glaciation. It has been argued that the development of the ice-sheet was due to changing ocean circulation. This was in response to the opening of the Tasman and Drake Passages with the subsequent formation of the Antarctic Circumpolar Current (ACC) and the thermal isolation of Antarctica. The Drake Passage has been hypothesised to have opened after the Tasman Passage with recent work suggesting that it opened in the middle to late-Eocene, with the development of a shallow (less than 1000m) opening. Therefore, it is possible that a continuous circumpolar current could have been in existence before the onset of glaciation. This supports the concept of a proto-ACC and ocean driven climate change. This middle-Eocene opening contradicts the well established view that the Drake Passage did not open until the early to middle-Oligocene due to blockages in the flow. This view suggests that there must have been another mechanism that drove climate change, such as declining carbon dioxide concentrations.

To increase the understanding of the effect of changing topography on ocean circulation idealised model runs have been conducted in both FORTE (Fast Ocean Rapid Troposphere Experiment) and will be performed in ICOM (Imperial College Ocean Model). The work using FORTE allows investigation into the effect on ACC evolution on the atmosphere. Two idealised cases were run and compared:

1. Water World, where the entire surface of the globe is water covered
2. Drake World, where a thin strip of land is introduced

Future work will involve more detailed analysis of some of the dominant processes using ICOM, which is a next-generation ocean model that uses adaptive mesh technology to maximise accuracy and computational efficiency. This means that the small scale structures will be modelled. In ICOM the ACC will be idealised as a rotating annulus. It will be modelled with both vertical and horizontal restrictions to the flow representing the evolution of Drake Passage. This will enable the strength of the overturning circulation to be investigated when only a shallow opening was present. Therefore, investigating the hypothesis that a proto-ACC was sufficient to cause glaciation.