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Solving the riddle of interglacial temperatures over the last 1.5 million years with a future IPICS "Oldest Ice" ice core

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The sequence of the last 8 glacial cycles is characterized by irregular 100,000 year cycles in temperature and sea level. In contrast, the time period between 1.5-1.2 million years ago is characterized by more regular cycles with an obliquity periodicity of 41,000 years. Based on a deconvolution of deep ocean temperature and ice volume contributions to benthic δ^{18}O (Elderfield et al., Science, 2012), it is suggested that glacial sea level became progressively lower over the last 1.5 Myr, while glacial deep ocean temperatures were very similar. At the same time many interglacials prior to the Mid Brunhes event showed significantly cooler deep ocean temperatures than the Holocene, while at the same time interglacial ice volume remained essentially the same. In contrast, interglacial sea surface temperatures in the tropics changed little (Herbert et al., Science,2010) and proxy reconstructions of atmospheric CO_2 using δ^{11}B in planktic foraminifera (Hönisch et al., Science, 2009) suggest that prior to 900,000 yr before present interglacial CO_2 levels did not differ substantially from those over the last 450,000 years. Accordingly, the conundrum arises how interglacials can differ in deep ocean temperature without any obvious change in ice volume or greenhouse gas forcing and what caused the change in cyclicity of glacial interglacial cycles over the Mid Pleistocene Transition.

Probably the most important contribution to solve this riddle is the recovery of a 1.5 Myr old ice core from Antarctica, which among others would provide an unambiguous, high-resolution record of the greenhouse gas history over this time period. Accordingly, the international ice core community, as represented by the International Partnership for Ice Core Science (IPICS), has identified such an "Oldest Ice" ice core as one of the most important scientific targets for the future (http://www.pages.unibe.ch/ipics/white-papers).

However, finding stratigraphically undisturbed ice, which covers this time period in Antarctica, is not an easy task. Based on a simple ice and heat flow model and glaciological observations (Fischer et al., Climate of the Past, 2013), we conclude that sites in the vicinity of major domes and saddle positions on the East Antarctic Plateau will most likely have such old ice in store and represent the best study areas for dedicated reconnaissance studies in the near future. In contrast to previous ice core drill site selections, however, significantly reduced ice thickness is required to avoid bottom melting. The most critical parameter is the largely unknown geothermal heat flux at the bottom of the ice sheet. For example for the geothermal heat flux and accumulation conditions at Dome C, an ice thickness lower than but close to about 2500 m would be required to find 1.5 My old ice. If sites with lower geothermal heat flux can be found, also a higher ice thickness is allowed, alleviating the problem of potential flow disturbances in the bottom-most ice to affect a 1.5 Myr climate record.