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A chemical pacemaker to refine chronology for the deep East Antarctic ice cores

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Dating of the deep East Antarctic ice core spanning more than 100,000 years of climate records is challenging but benefited recently from iterative and complementary approaches. As a principle, ice core dating relies on ice flow modelling (thinning function of ice layer) as well as on the (modelled) estimate of the past snow accumulation rate. The inverse method allows integration of various dated horizons from other records assuming the physical properties of the ice (its deformation) remain within realistic boundaries. The modelled ice chronology is generally constrained by few dated horizons (volcanic, 10Be peaks from solar or from magnetic inversion related events…) and/or by orbital tuning process (temperature proxy, 18O of air bubbles…). Due to the scarcity of absolute dating, the use of orbital tuning from ice proxies may serve as a test of the modelled ice age. As a prerequisite, the proxy should not already be used to constrain the modelled chronology. Also, to prevent gas-age/ice age uncertainties, a preference should be given to a proxy associated to the ice instead to the air bubbles. Also, the physical link with the insolation should be rather direct, and a preference given to proxies sensitive to precession band (20kyr) instead obliquity band (41kyr).

The continental dust and marine sodium records were so far not used to constrain the modelled chronology of EPICA and Vostok ice core. The dust and marine sodium appear firstly correlated to patterns of temperature and therefore to the hydrological cycle which influences at the same time the source emissions (for dust), the atmospheric cleansing and the deposition onto the ice sheet. Once the overall temperature effects is compensated, the residual signal for dust and sodium concentrations over the last 400 ky from EPICA Dome C and Vostok records display strong precession oscillations for both sites. Interestingly, the sodium residuals appear to increase with austral summer insolation while the dust residuals decrease, and remaining out of phase. Such behaviour could be understood by a positive effect of insolation on sodium emission (strengthening of spring cyclonic activity…) and negative effect on dust sources (reduction of Patagonian dust emission by strengthening of Southern American monsoon…). This dual behaviour which needs to be determined, allows combination of sodium and dust residuals providing a "chemical pacemaker" dominated by precession which could be used to refine the modelled chronology. A test was done on the EDC3 modelled age of the Epica Dome C deep ice core which covers the last 800ky.