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Ice core evidence on East Asian and Indian Monsoon variations during the last glacial period

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Ice cores from central Greenland are the temporally best resolved records of northern hemisphere climate of the last glacial period. Here we show that during the last glacial period (MIS 4 to MIS 2) East Asian Monsoon variations are directly recorded in the North-GRIP ice core (north-central Greenland). The East Asian Winter Monsoon (EAWM) strength as inferred from Chinese loess deposits correlates well with the concentration and size distribution of insoluble mineral particles in the North-GRIP core, and we infer that the ice core microparticle record can be taken as a proxy for EAWM. Further, reconstructions of the Indian Summer Monsoon (ISM) strength, which controls the transport of moisture into the source regions, correlate well with the $CaCO_3$ content at North-GRIP: e.g. the early onset of ISM after approx. 18 ka BP and the depression during MIS4, which have been inferred from East Asian loess-paleosol sequences, are also seen at NGRIP. These findings yield a new basis for ice core interpretation and put tighter constrains on the dating of Chinese loess-paleosol sequences. Finally, we take $\delta^{18}O$ as a proxy for North Atlantic temperature (NAT) and compare the timing of NAT, EAWM and ISM changes at rapid climatic transitions during the last glacial period; this can be done with high accuracy because all proxies are from the same archive and do not underlie relative dating uncertainties. We find that at rapid cold-to-warm transitions during the last glacial period EAWM changes synchronously with NAT, while ISM lags by approx. 45 years. Apart from the climatological implica-

tions this may become important for high-precision cross-dating records of NAT with East Asian records of Summer Monsoon strength such as speleothems.