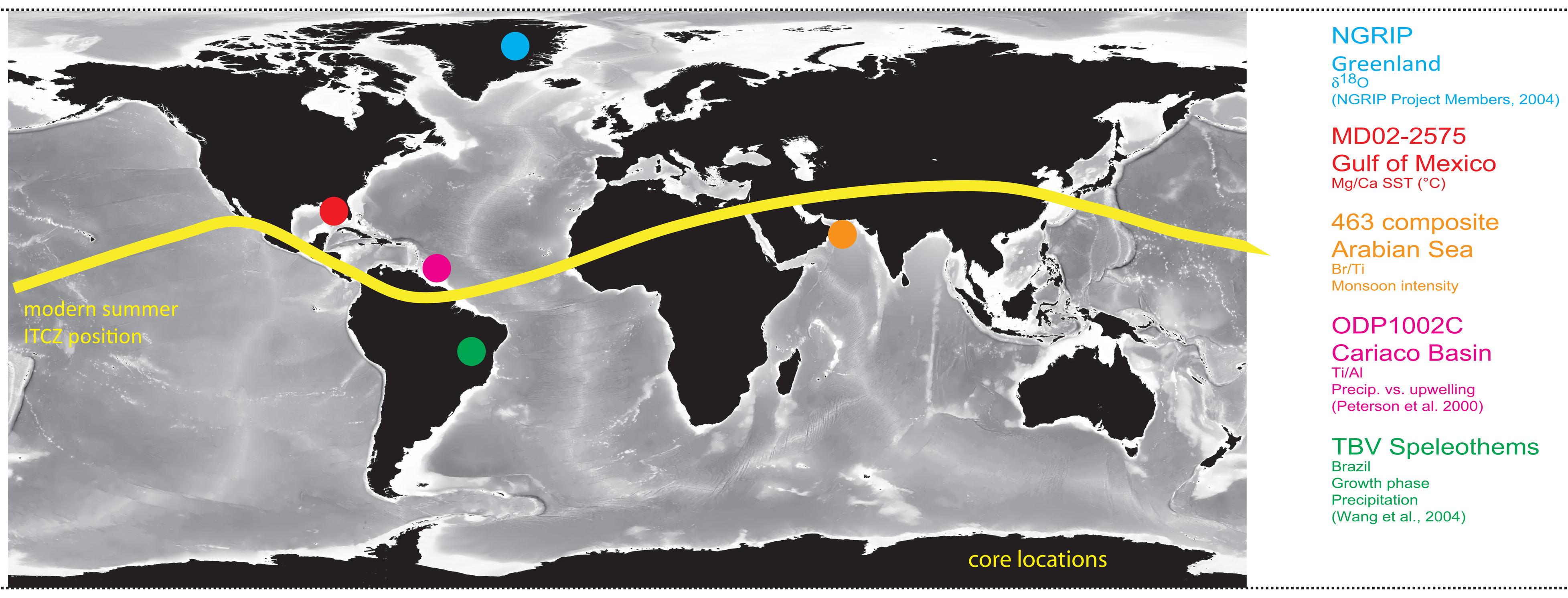
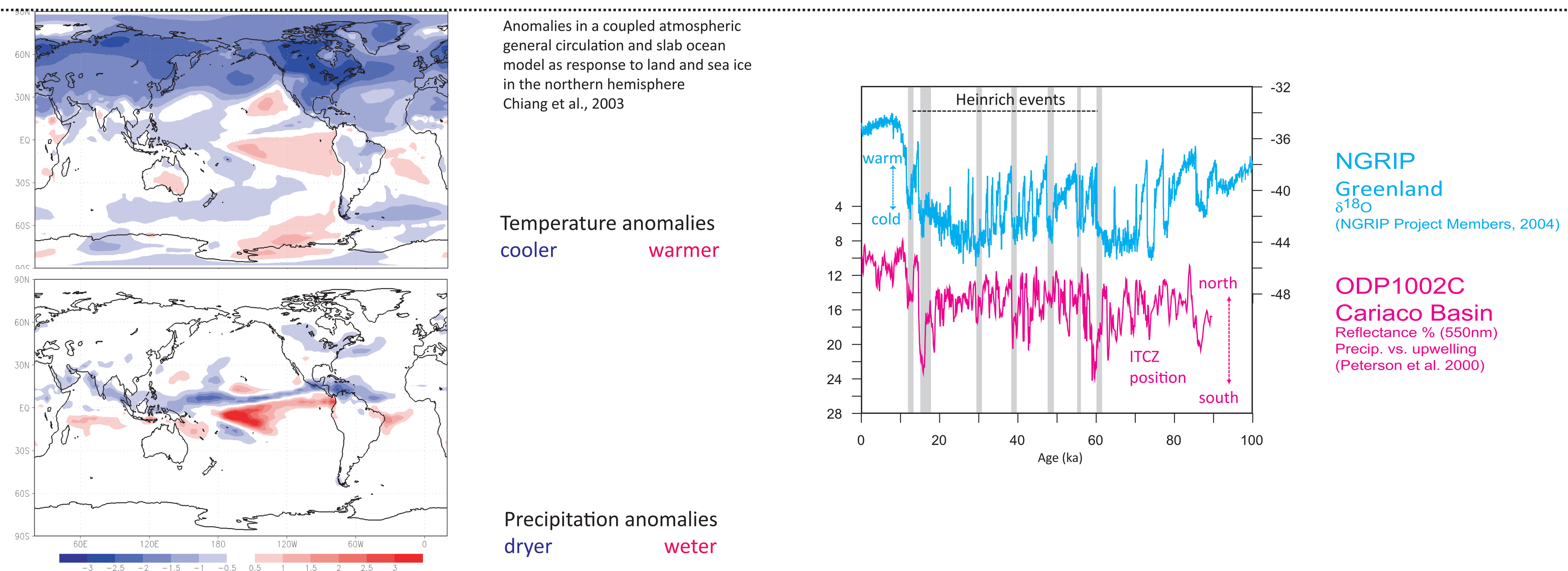
Late Pleistocene abrupt climate change
ITCZ, teleconnections and the impact of seasonality



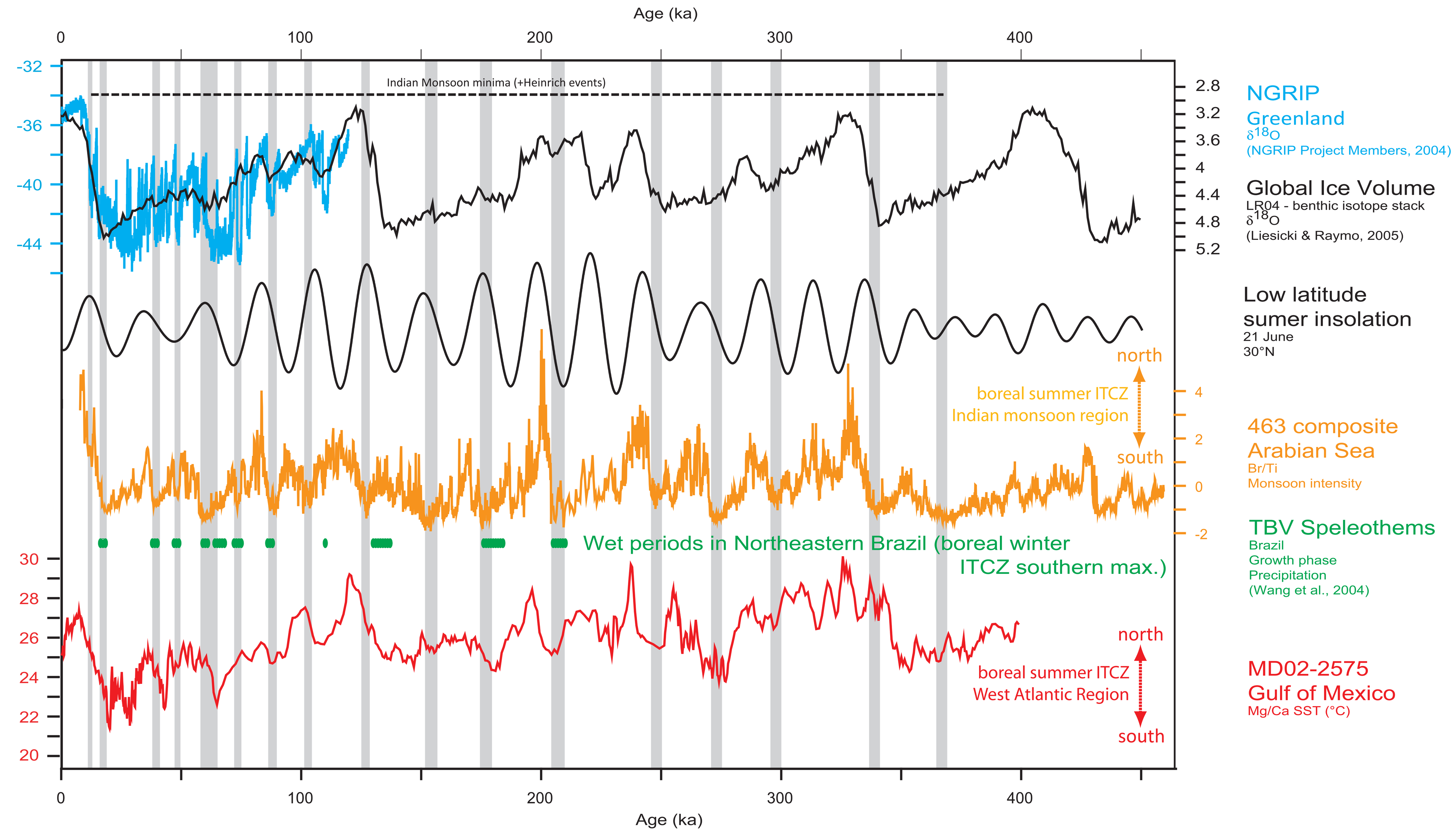
abstract

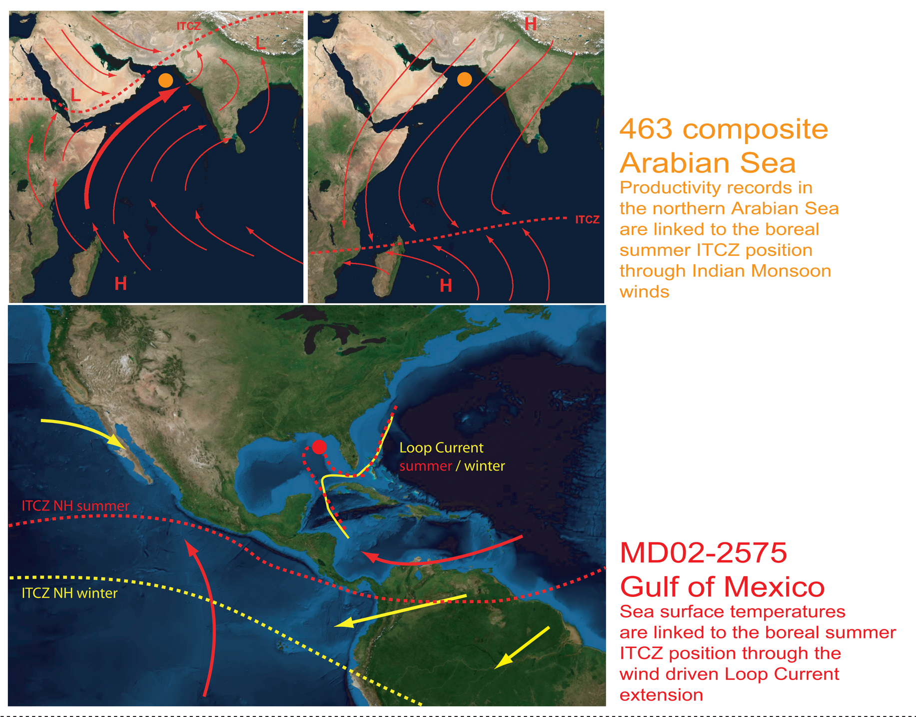
Paleoclimatic records have demonstrated a close link between the annual average position of the Intertropical convergence zone (ITCZ) and millennial scale climate change recorded in Greenland ice cores. The Indian summer monsoon (ISM) is an integral part part of the ITCZ and the manifestation of the seasonal migration of the ITCZ. In this talk paleoclimate records of Indian monsoon intensity from the Arabian Sea for the late Pleistocene will be presented. We show that summer monsoon intensity is largely controlled by northern hemisphere summer insolation, however it becomes suppressed during North-Atlantic originated cooling events, which result in a southward displacement of the ITCZ.
Furthermore, we present a reconstruction of sea surface temperatures (foraminiferal Mg/Ca) from the northeastern Gulf of Mexico for the last 400,000 years, which sensitively records the ITCZ position during boreal summer. Comparison with annually averaging (Cariaco Basin ODP1002) and boreal winter (Brazilian Speleothems) reconstructionsof the ITCZ position during the last glacial cycle suggests that seasonality can be of similar importance for abrupt shifts in the hydrological cycle of the low latitudes as it is for high latitude temperatures. The results demonstrate that the migration of the ITCZ during periods of climate change can vary substantially on a spatial scale

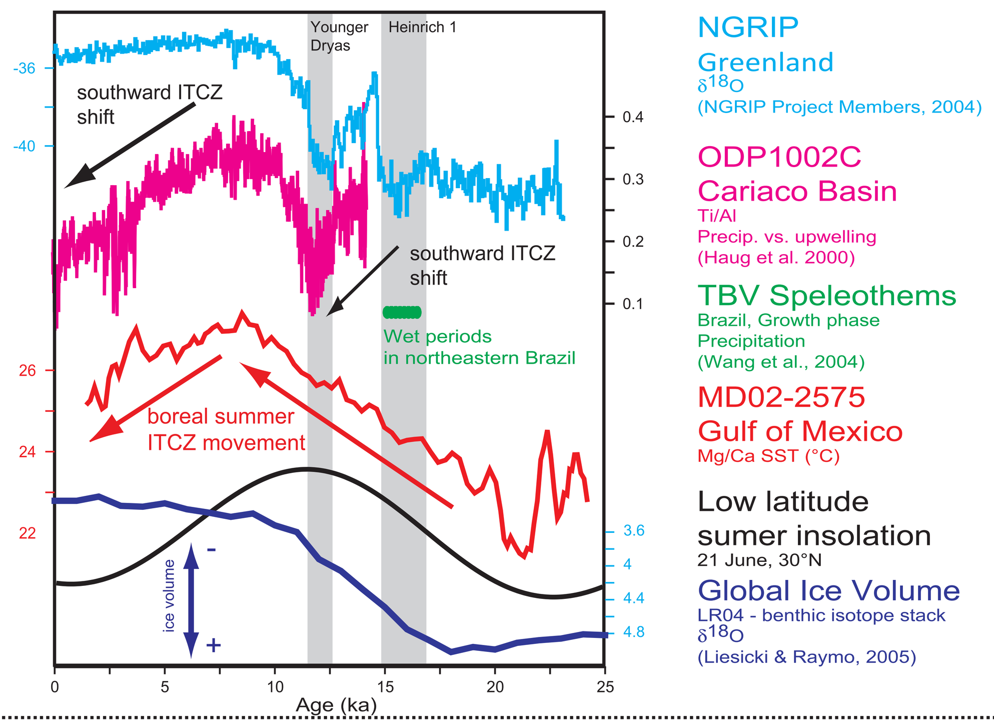


Sensitivity of the Intertropical Convergence Zone to Last Glacial Maximum boundary conditions - Land and Sea Ice as forcing factors

Paleoevidence from the last glacial period and deglaciation show significant changes in the position of the Atlantic ITCZ that occur concomitantly with climate changes in the North Atlantic Marine productivity maxima and increased precipitation and riverine discharge from northern South America are closely linked to climate events of marine isotope stage 3, as recorded in Greenland ice cores (Peterson et al., 2000).
The tropical Atlantic in a coupled atmospheric general circulation and slab ocean model responds to Last Glacial Maximum conditions with a southward displacement of the ITCZ (Chiang et al., 2003). This response arises primarily through the land ice sheet that forces increased North Atlantic trades. Changes to sea ice coverage and to ocean heat transport associated with a weakened Atlantic thermohalinecirculation cause a similar response. The results highlight the potential for tropical Atlantic paleoclimate to be driven from the high latitude influences, in particular, land ice and sea ice on glacial-interglacial timescales.







Boreal summer ITCZ position indicators - Gulf of Mexico sea surface tempertures and Indian monsoon intensity

Indian Monsoon record "463 composite" is based on Br/Ti measurements, that indicate changes in monsoonal upwelling related productivity (Ziegler & Jilbert et al., submitted). The Indian Monsoon intensity changes are related to local summer insolation, which determines the land-sea heat contrast that drives the ITCZ onto the Asian continent during the monsoon season. However, minima in monsoon intensity clearly coincide with wet periods in northeastern Brazil (southward extremes of the ITCZ during boreal winter) and cold events in the North Atlantic, demonstrating the sensitivity of the monsoon system to cold boreal winter temperatures . In line with earlier studies, we interpret the SST variability in the Gulf of Mexico being related to variable northward extension of the Loop Current ultimately linked to the position of the ITCZ (Poore et al., 2003). As modern SSTs in the northeastern gulf change by 10°C between the summer and winter season related to a changing Loop Current impact, we argue that the observed large temperature changes are also related to a changing influence of the Loop Current (lower left panel). We hypothesize that the large SST increase is related to a boreal summer insolation driven northward propagation of the summer ITCZ position and therefore leads to a gradual northward extension of the Loop Current into the Gulf. It is important to note that there is no expression of the "Heinrich 1-Boelling-Alleroed-Younger Dryas sequence" present in the deglacial SSTs. Here, the continuous temperature increase is in contrast to the millennial scale variability that is observed in the Ti/Al record from Cariaco Basin (Peterson et al., 2000). The observed pattern poses the question why the gulf SST record shows a good correspondence to Cariaco Basin during the interglacial Holocene period, however displays a different variability during the last glacial and in particular during the last deglaciation, where it shows no response to the cold Younger Dryas event. The answer might be related to seasonality differently impacting on those records. It has been recently suggested, that the large temperature changes observed in Greenland ice cores during MIS3 and the deglaciation (Alley, 2000) are related to extreme winter cooling as a response to increased sea ice formation during periods of a weakened thermohaline overturning circulation (Denton et al., 2005; Chiang et al., 2003). Modelling studies demonstrate that extreme sea ice formation in the North Atlantic leads to a southward migration of the ITCZ (Chiang et al., 2003). This mechanism links high and low latitudes during millennial scale climate change, and at the same time explains moderate summer temperature changes in high northern latitudes (Isarin et al., 1998). Over the Asian continent a longer lasting snow cover is potentially responsible for a weakened Asian summer monsoon and a southward shifted position of the summer ITCZ during cold events in the North Atlantic. We suggest that South-American records (Wang et al., 2004;Peterson et al., 2000) documenting the position of the ITCZ show a sub-Milankovitch variability as a consequence of the southward shifted boreal winter/austral summer position of the ITCZ.

What drives the ITCZ position during boreal summer?

Indian monsoon:
1. local insolation + Ice volume
2. North Atlantic cold events (snow cover feedback related to cold boreal winter temperatures)
Gulf of Mexico:
1.local insolation + Ice volume
Decoupled from NA cold events (influence on boreal winter ITCZ position)

Utrecht University

Martin Ziegler[1], Lucas Lourens[1], Gert-Jan Reichart[1], Dirk Nürnberg[2]

1: Geosciences University of Utrecht, 2: IFM-GEOMAR Kiel, Germany
corresponding e-mail: ziegler@geo.uu.nl