Paleoceanography of the Red Sea: regional and global lessons

Hezi Gildor

The Institute of Earth Sciences

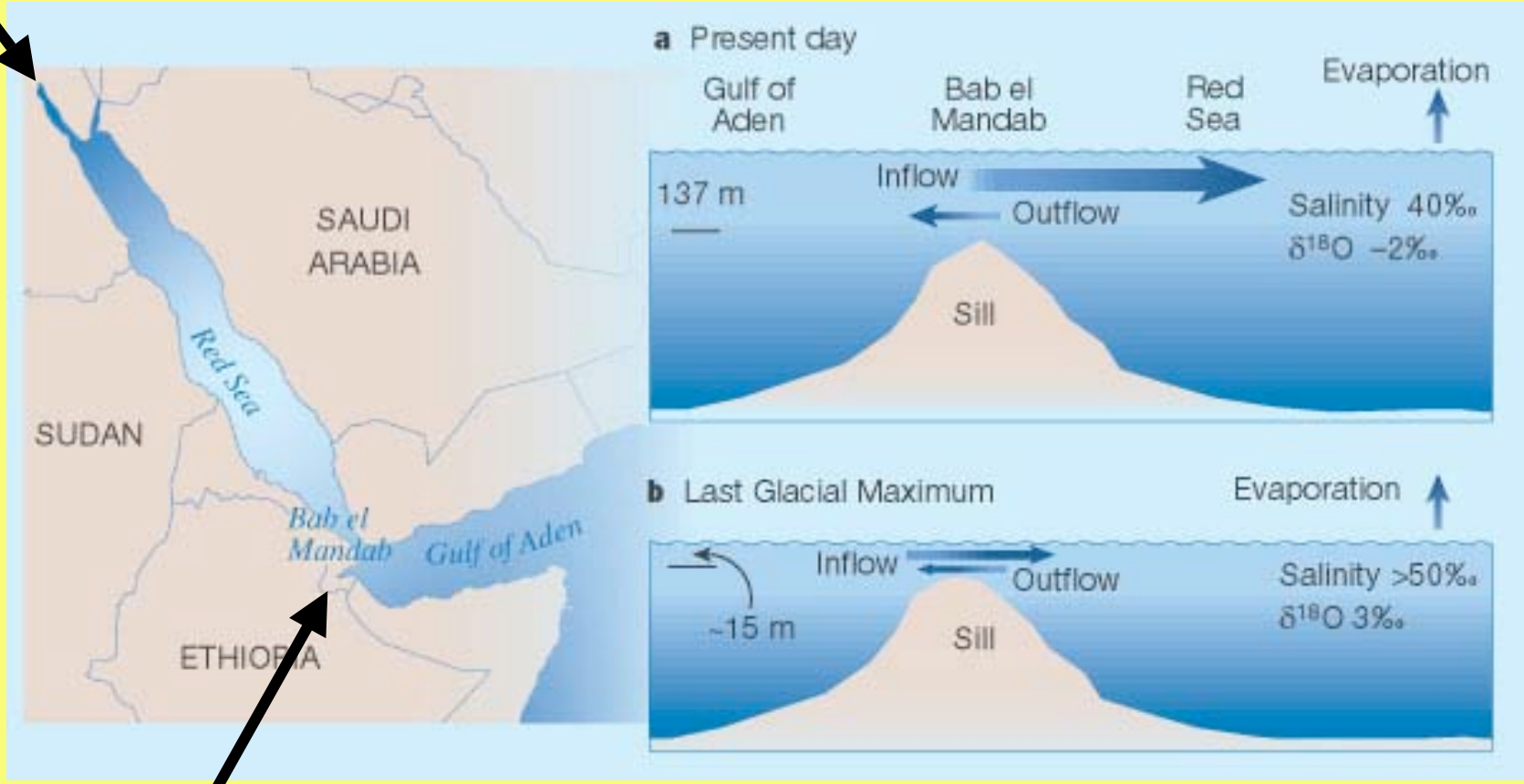
The Hebrew University

Acknowledgments:
Eli Biton, Mark Siddall, Eelco Rohling, Dick Peltier
Michal Kucera, Michael Siccha, Gabriele Trommer

The Red Sea "amplifier"

Thunell et al. [1988]; Reiss et al. [1980]; Hemleben et al.[1996]; Siddall et al., [2003]

Gulf of Suez



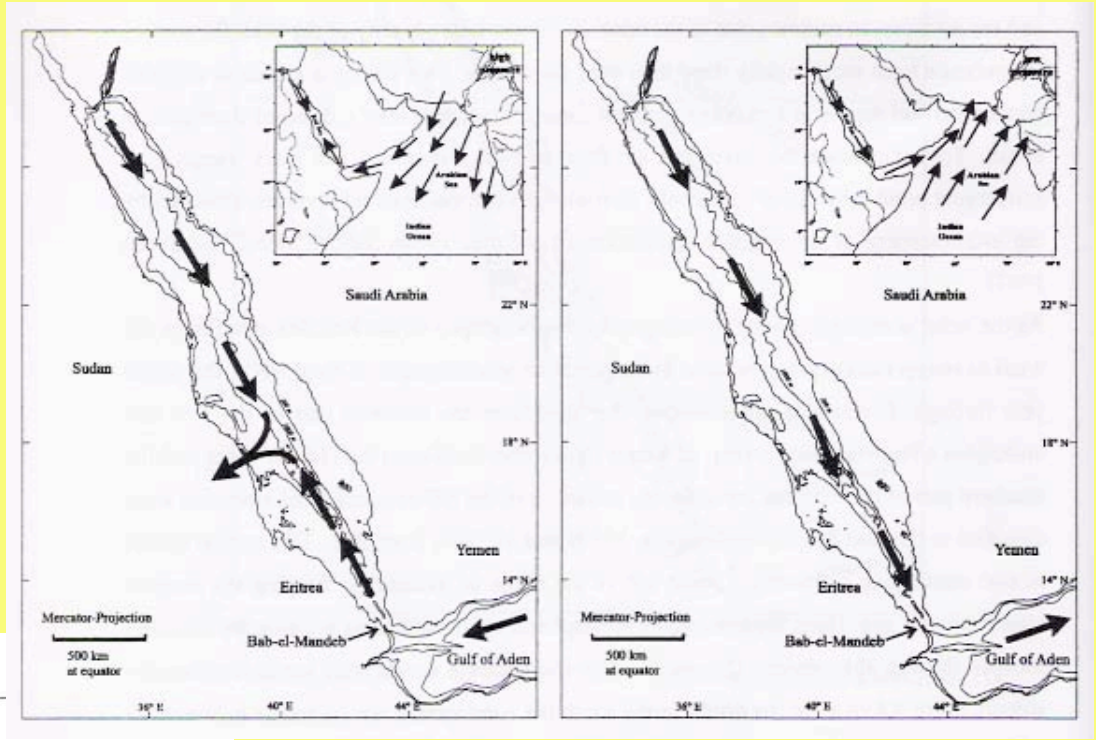
Hannish Sill
Max. depth 137 m

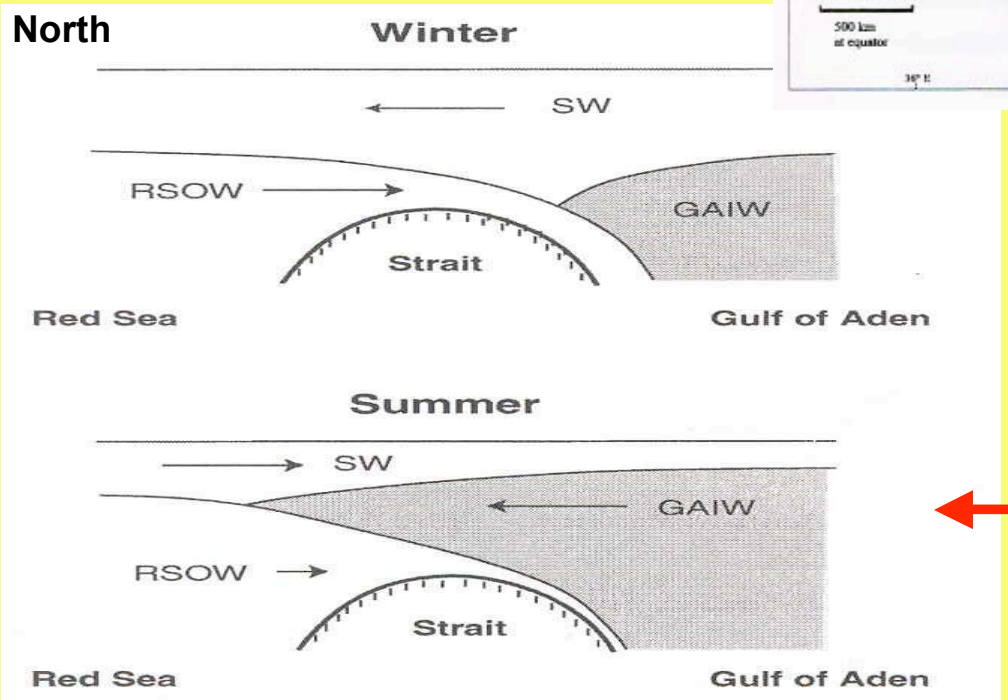
Sirocko 2003

Wind system:

strong orographic effect

Winter: NE monsoon Summer: SW monsoon





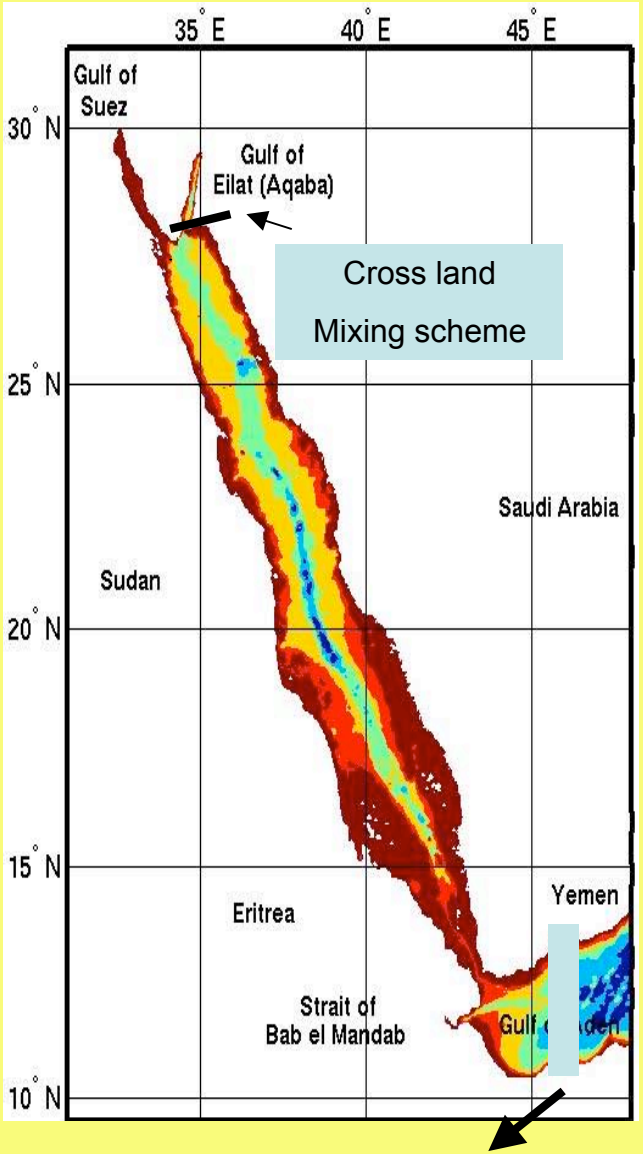
Exchange flux throughout the Strait of Bab el Mandab

Smeed 2004

"All Models are wrong, but some are useful" (Box,1979)

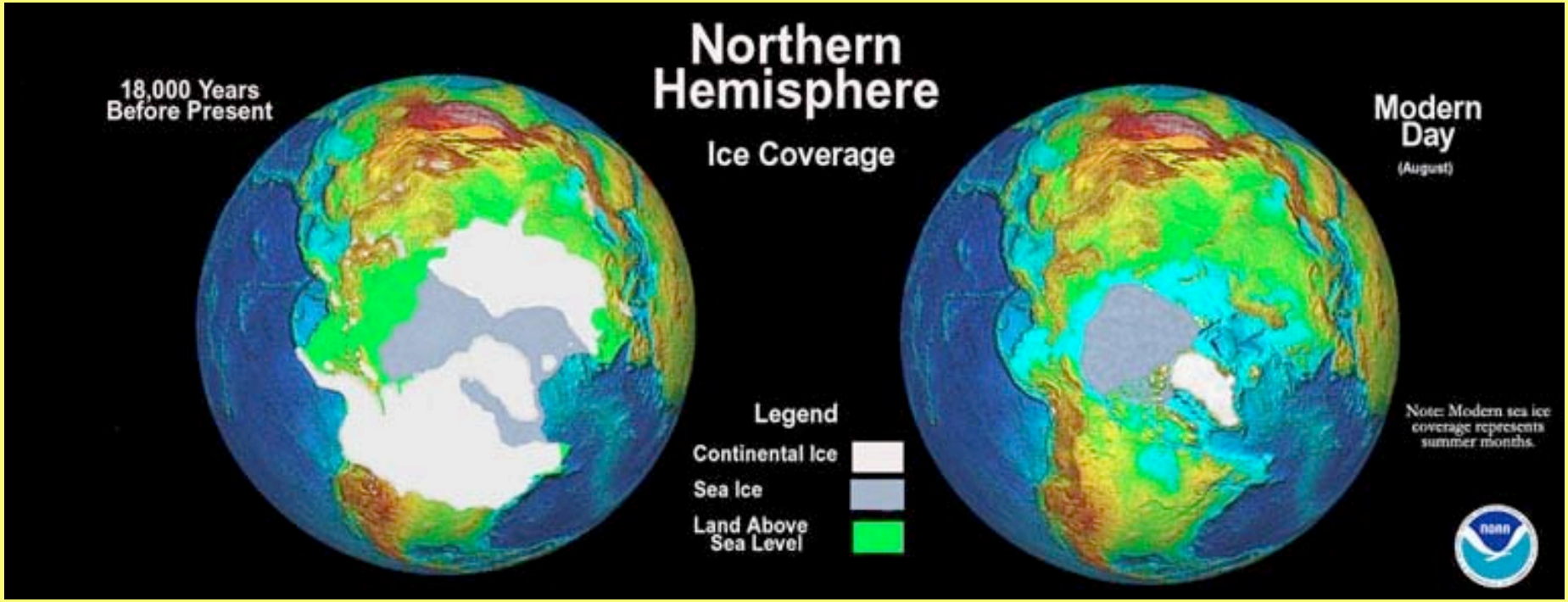
Methodology: a combination of GCM and simple models

- Spatial resolution: 2' across the Red Sea, 5' along the Red Sea
- 13 vertical layers, 7 in the upper 200m
- LGM forcing based on atmospheric GCM, courtesy C. Bitz - class 9
- Sensitivity tests to sea level reduction and to atmospheric conditions



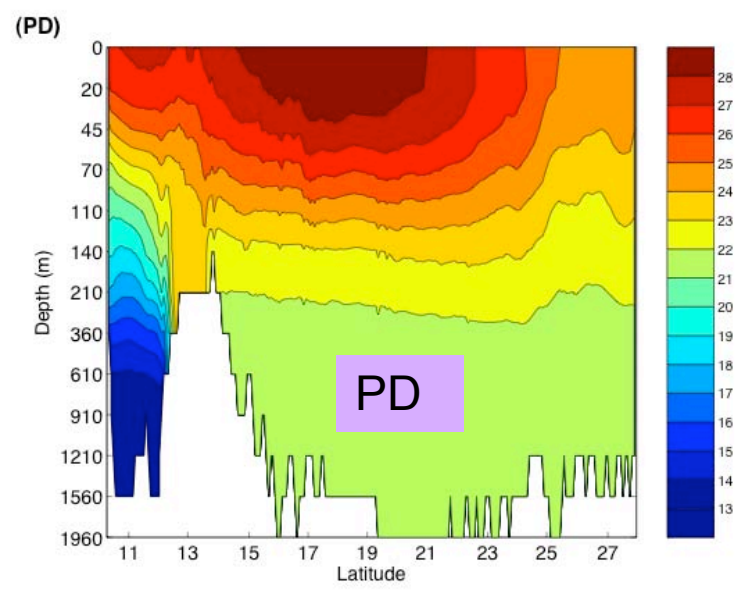
Good agreement with observations, including the seasonality if the exchange flow

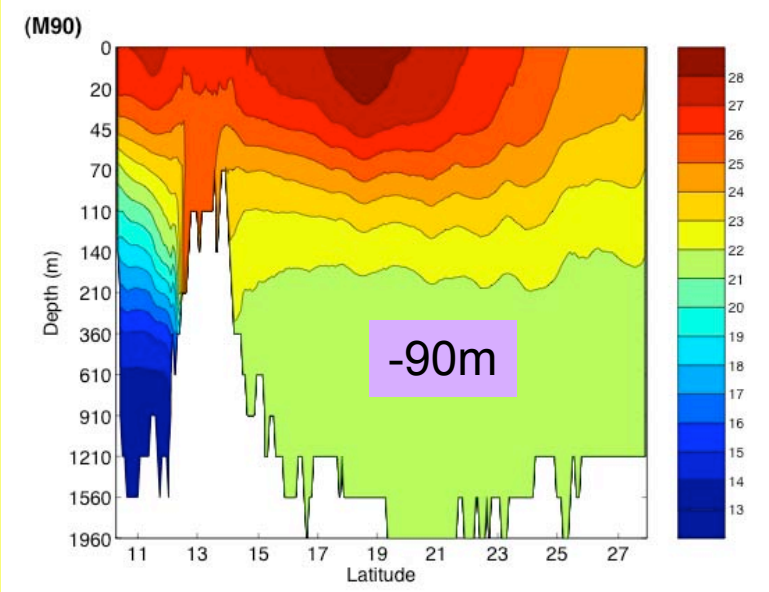
The Red Sea during the LGM

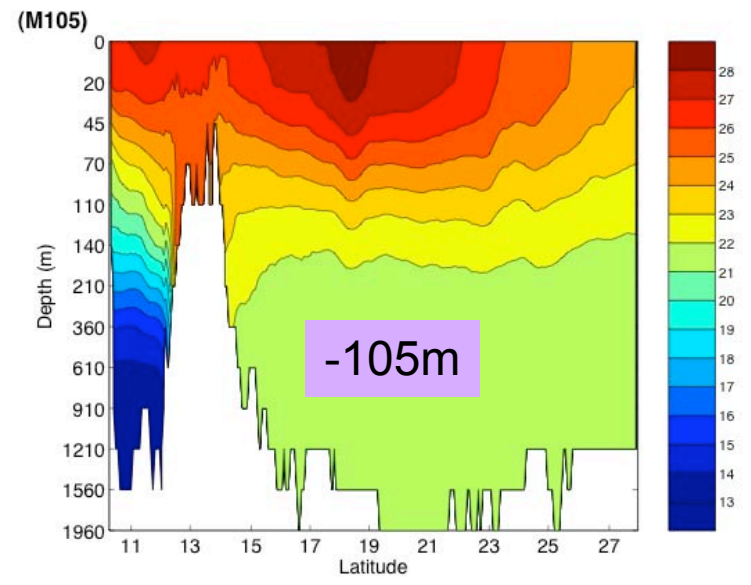


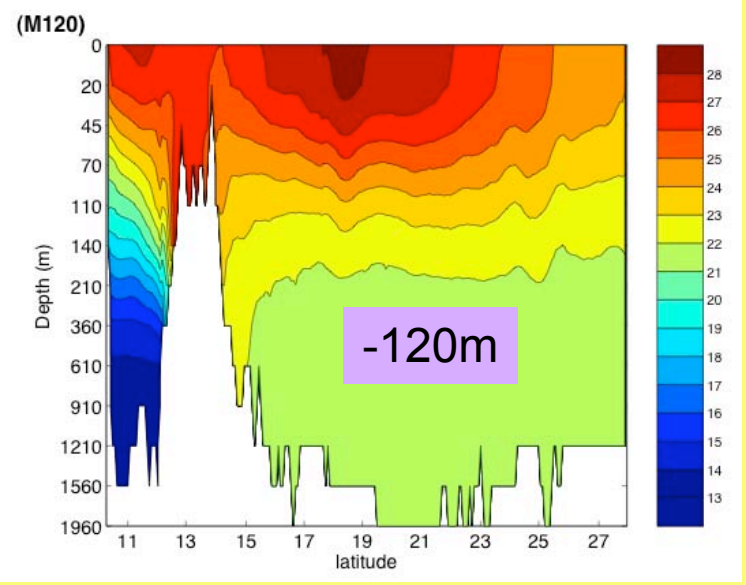
- Surface area reduced by 50%, no Gulf of Suez
- Summer SW monsoon was weakened, winter NE intensified
- Salinity ~ 10-17 psu higher than at present

Temperature



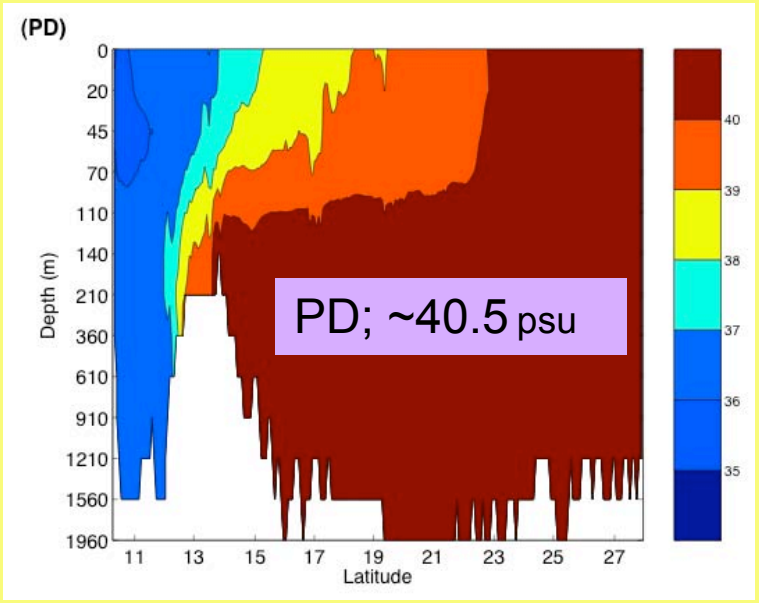


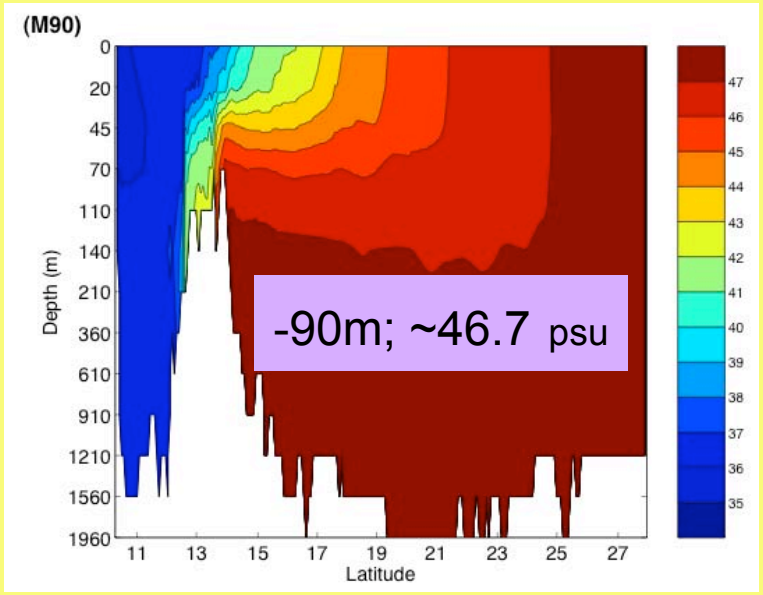


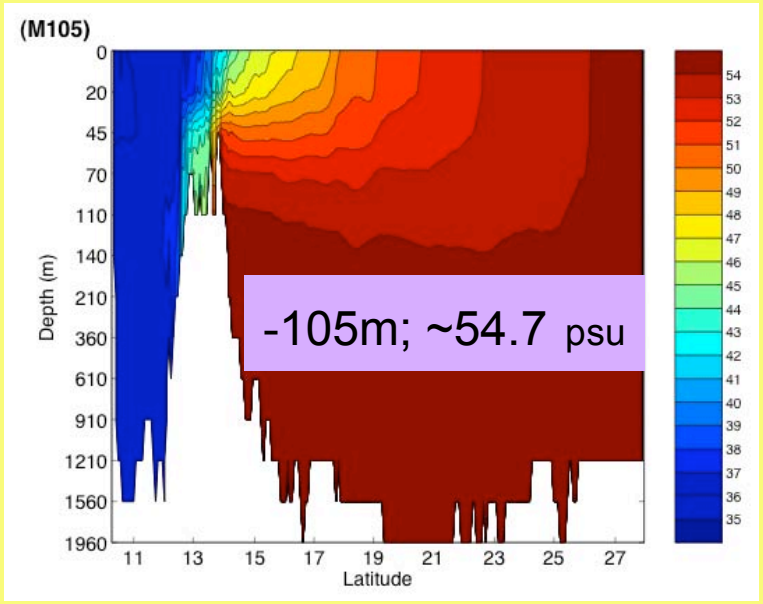


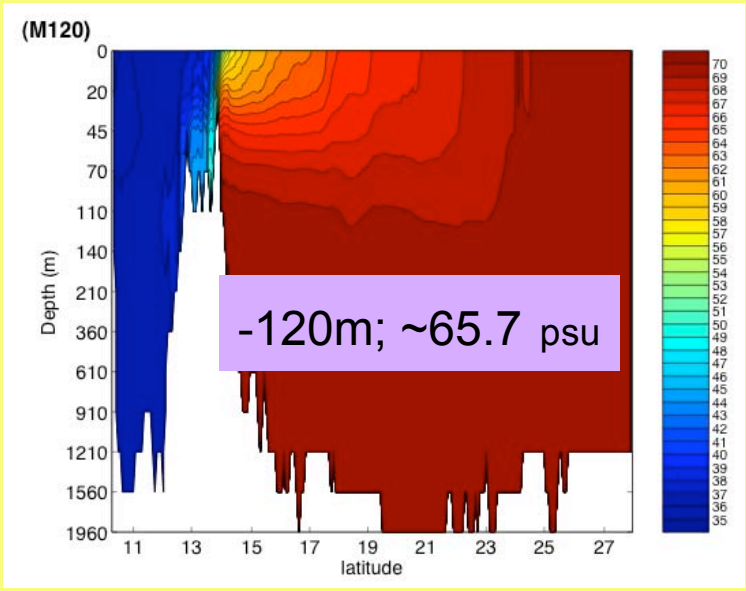
weak sensitivity to reduced sea level

Salinity







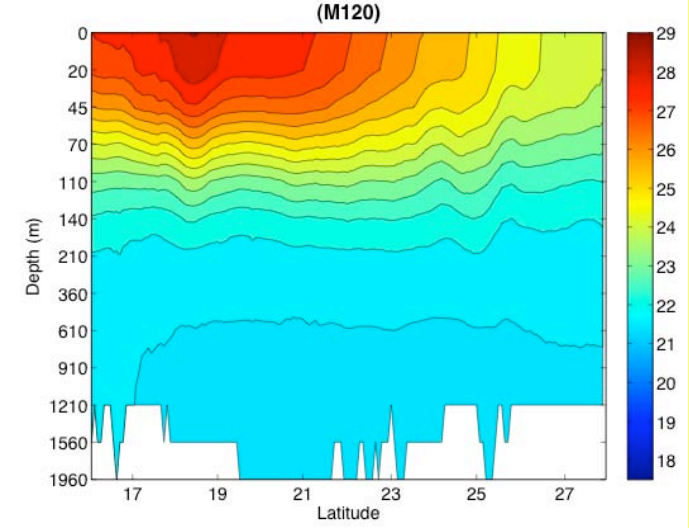


Salinity is ~10 psu(!) too high compared to the estimate

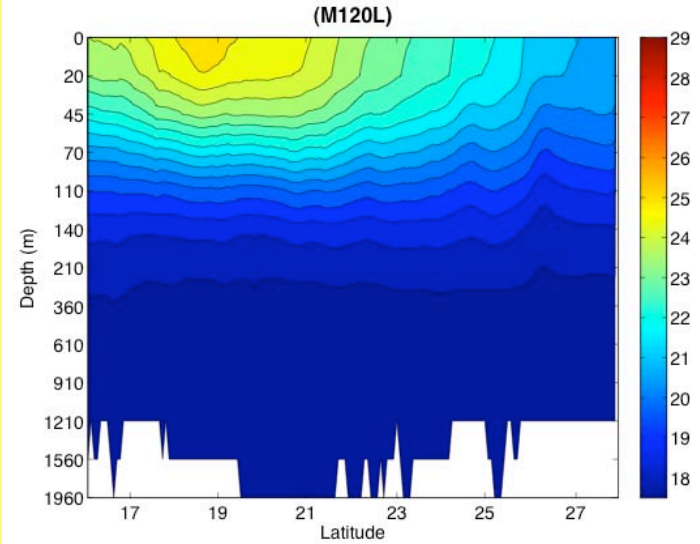
"Full LGM" vs. reduced sea level
Weak sensitivity to atmospheric conditions

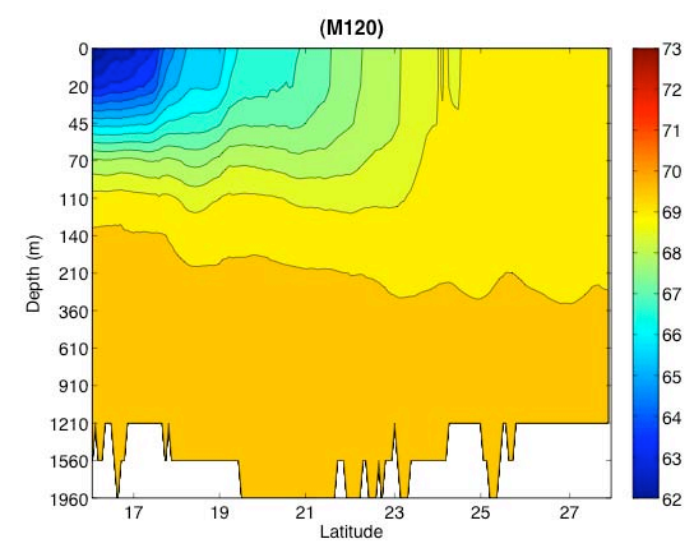
Only sea-level reduction

Full LGM

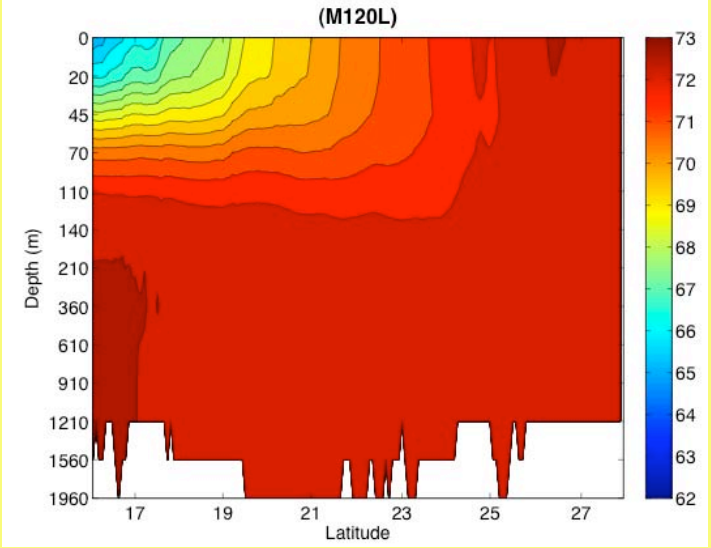


T lower by 3-4°C



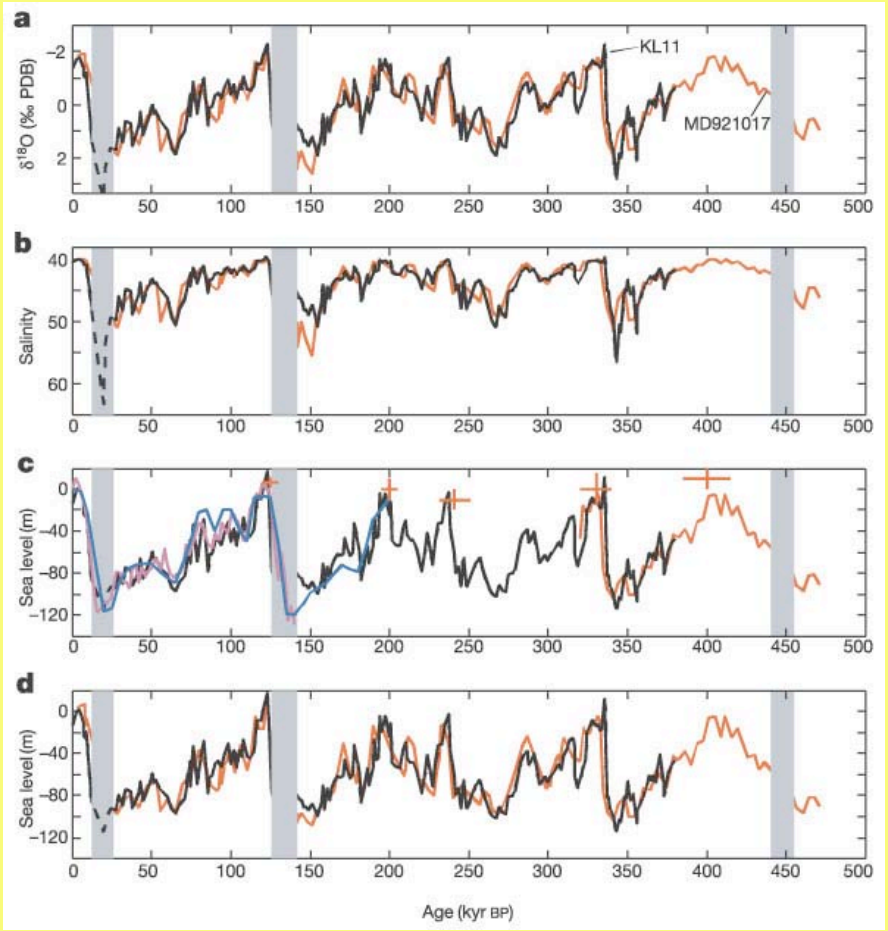


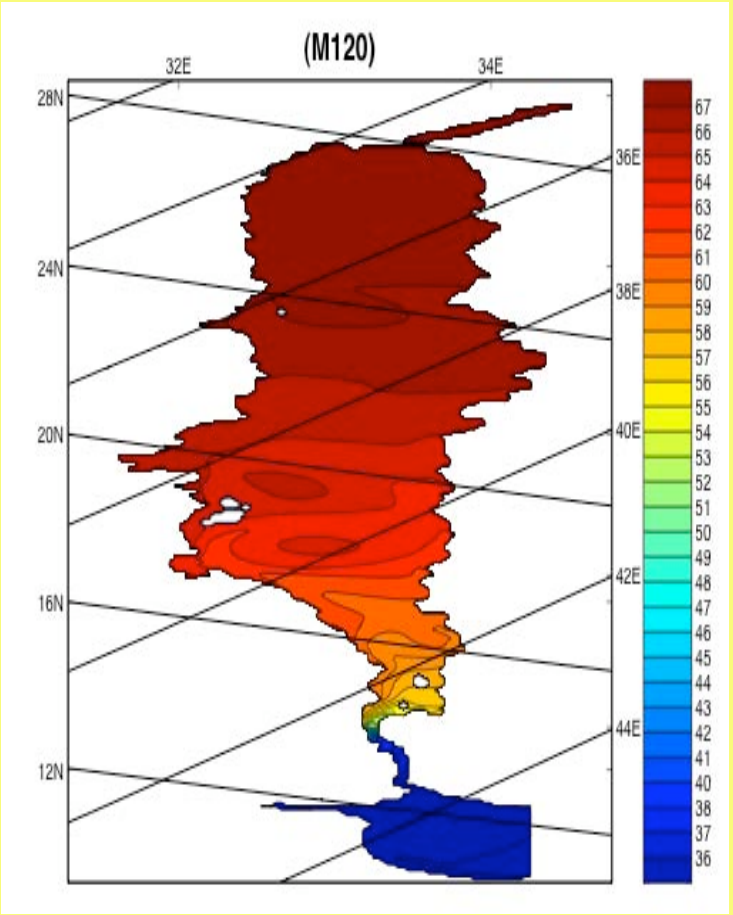
Salinity higher even higher (by ~ 2 psu) than with just reduced sea level



Could it be that salinity was (much) higher than estimated?
Probably not …

1. Short intervals of aplanktonic zones.
2. Continuous record in the south.





Siddall 2004

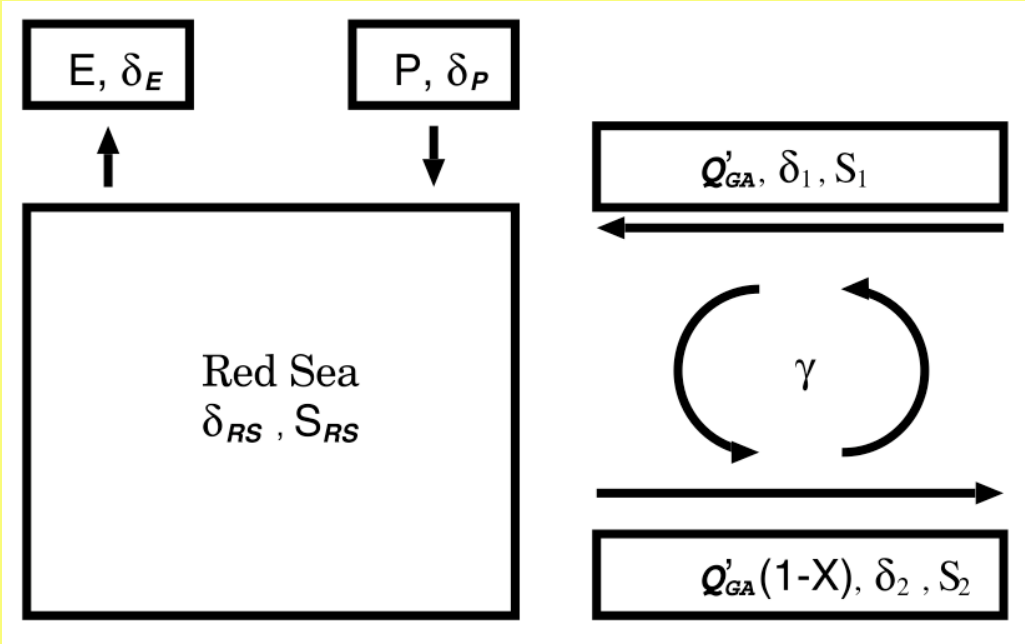
Could it be that salinity was (much) higher than estimated?
Probably not …

1. Short intervals of aplanktonic zones.
2. Continuous record in the south.
3. Isotopic model, considering recent advance in strait sybamics.

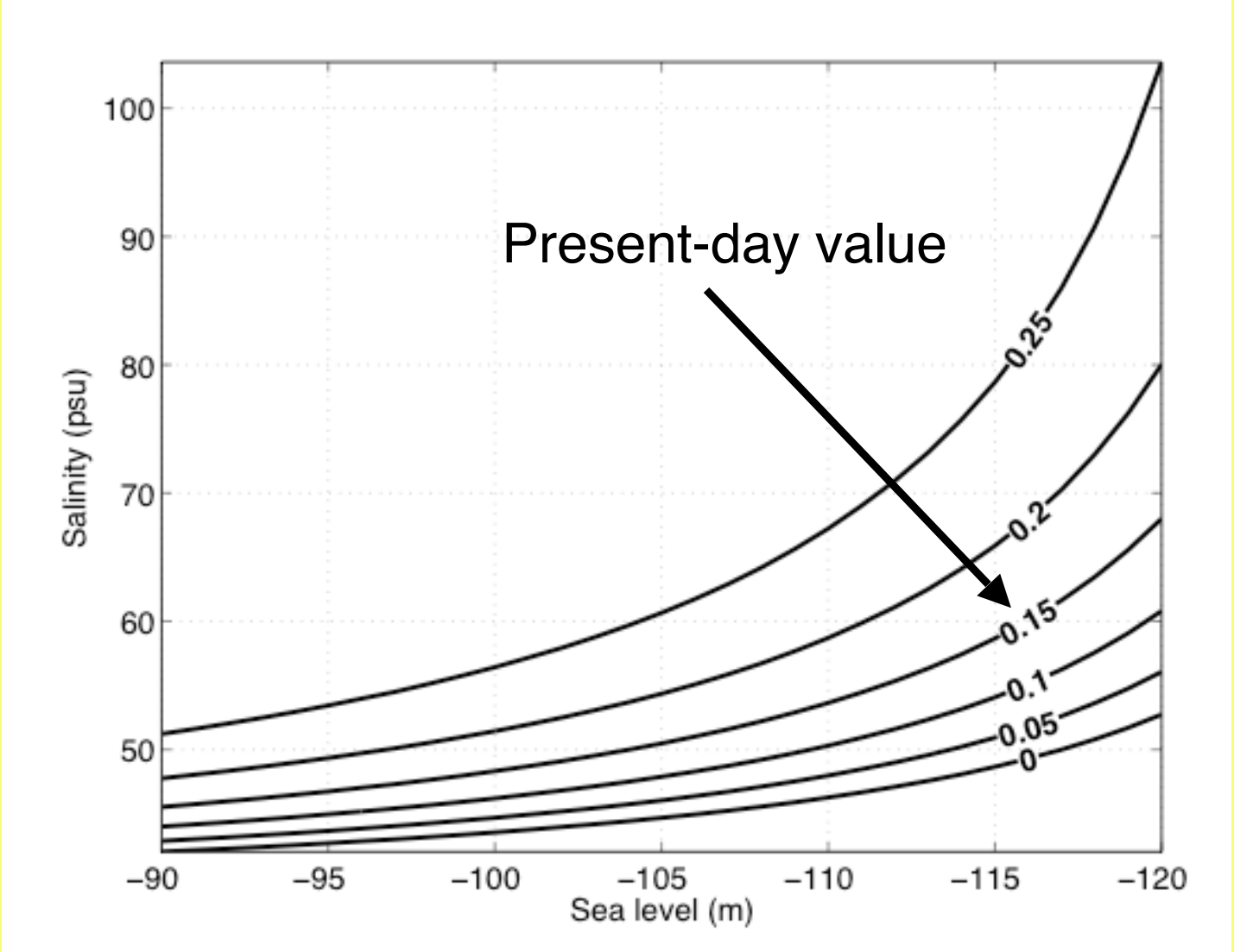
Based on *Rohling* (1999) and *Siddall et al.* (2004) but consider mixing

γ - mixing between the boxes representing the straits (due to tides, wind, friction, buoyancy flux….)

How much mixing occurs and what is the effect on exchange fluxes and salinity within the Red Sea?



Salinity - large sensitivity to γ

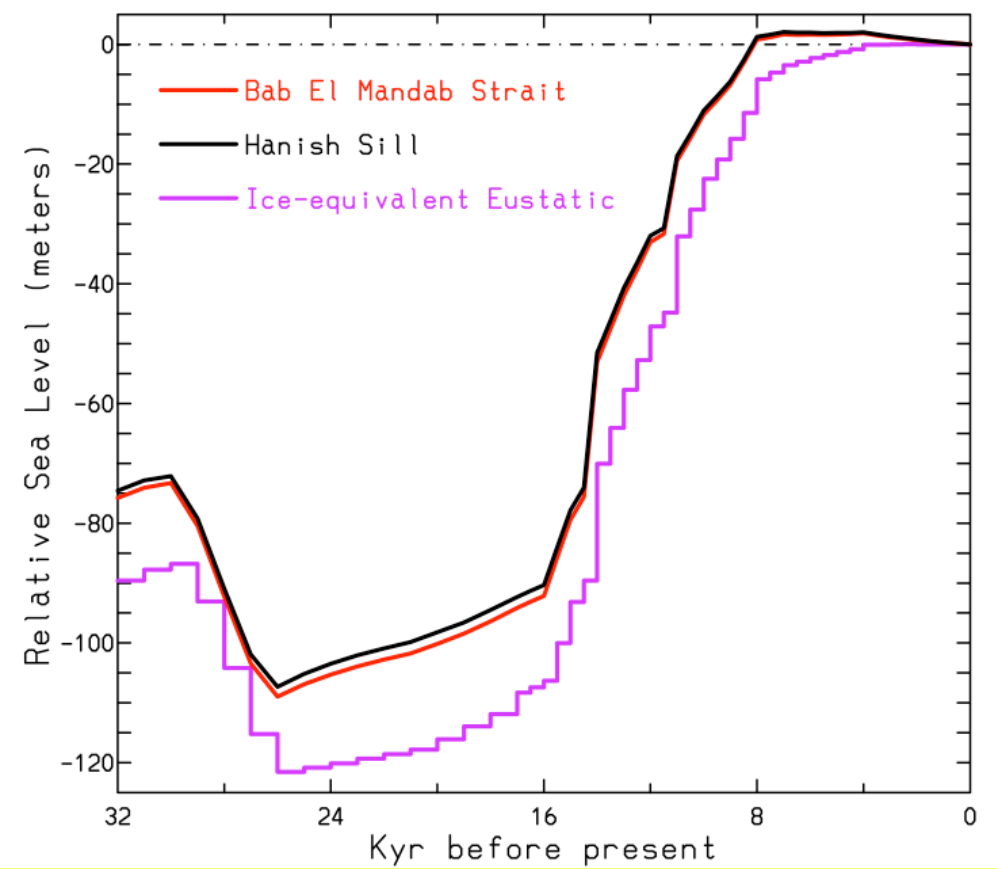


Based on *Murray and Johns* (1997), γ~0.15 for present-day (*Smeed*, 2004)

Global lesson - LGM

Based on both models it seems unlikely that the water column over the Hanish sill was 17 m during the LGM. Our results suggest a relative sea level reduction of approximately 105 m.

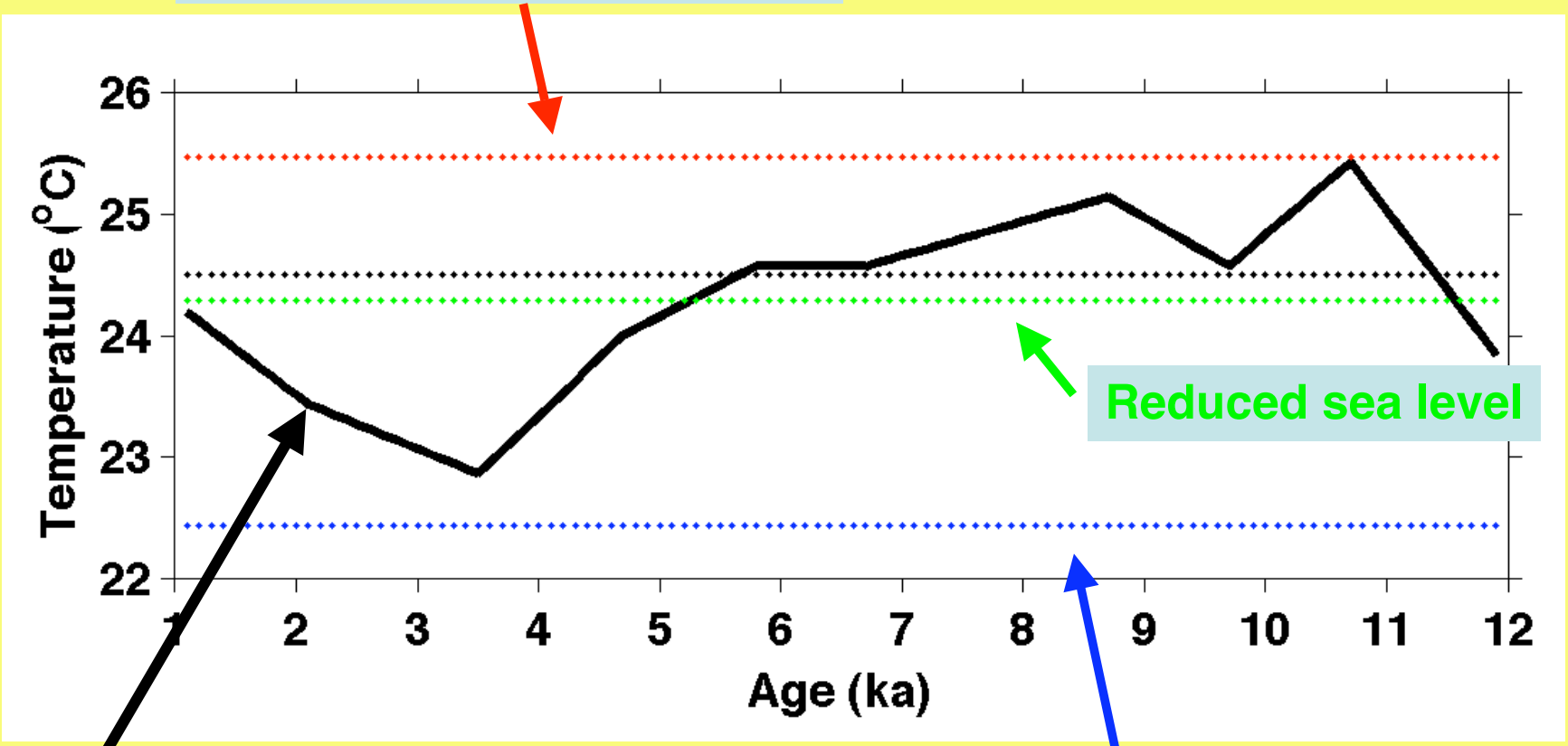
ICE-5G (VM2)
Model (Peltier 2004)



Biton et al., Red Sea during the Last Glacial Maximum: Implications for sea level reconstruction, *Paleoceanography*, 23, 10.1029/2007PA001431, 2008.

The Red Sea during the Holocene

Humid conditions,
Weaker winter monsoon,
Stronger summer monsoon

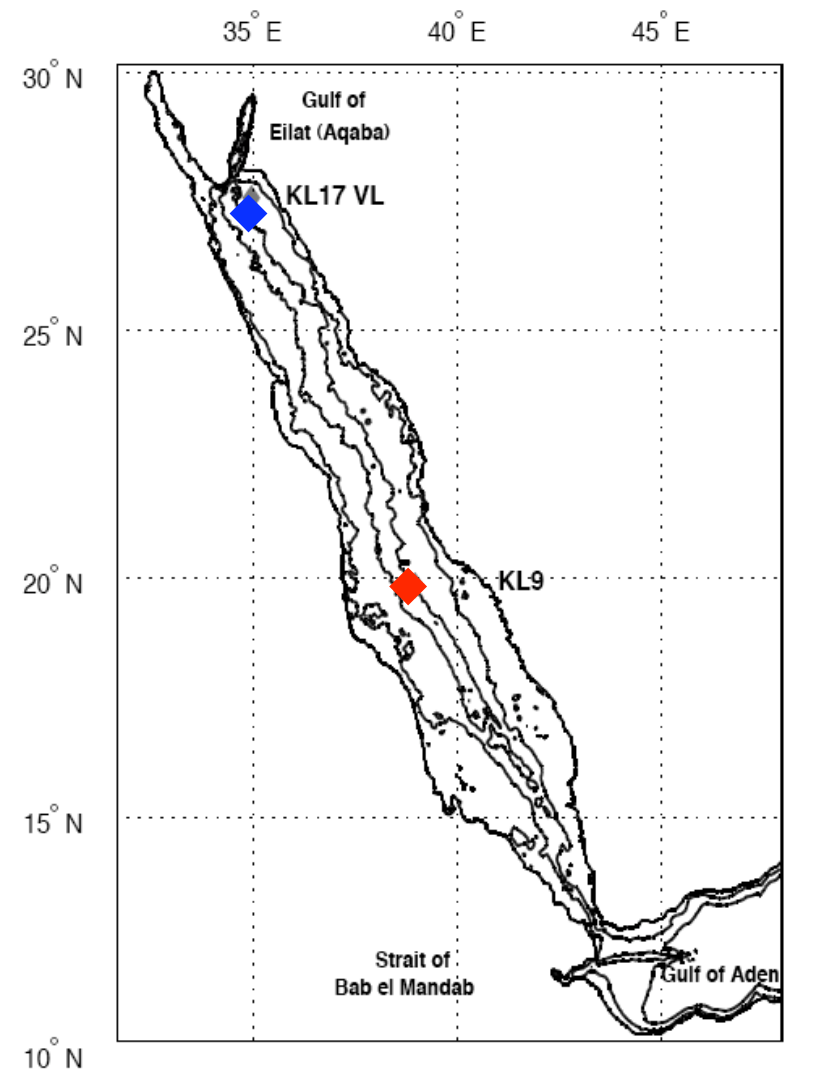


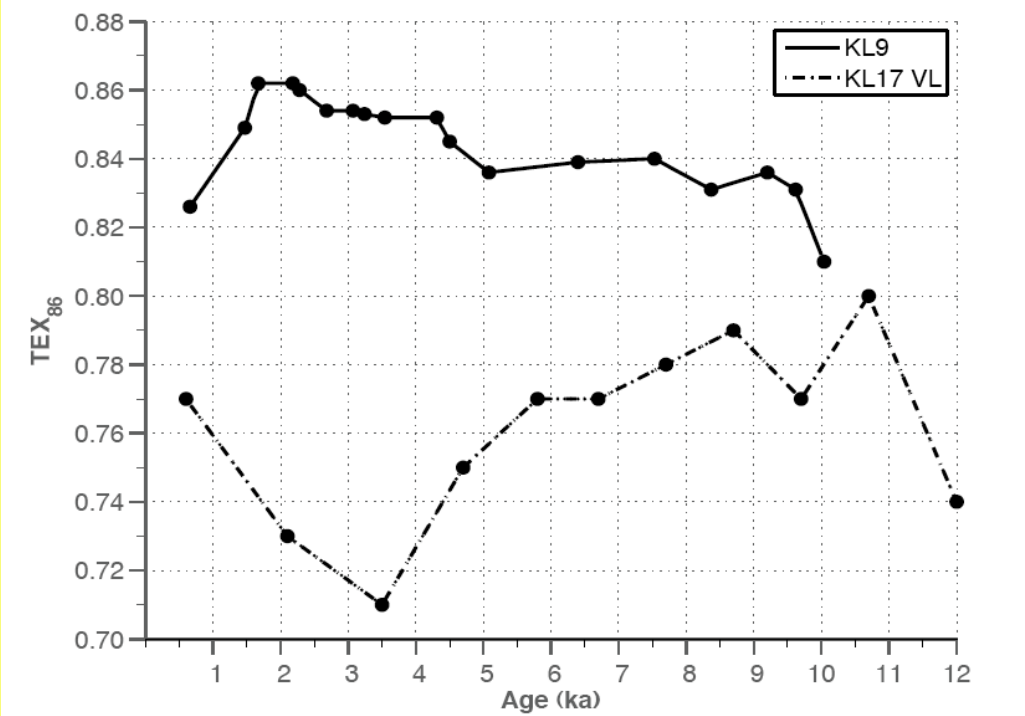
Reduced sea level

TEX_{86},
KL17

Dry condition
Stronger winter monsoon
Weaker summer monsoon

Endemic population of Crenarchaeota in the north (KL 17 VL) and mixed population in the center (KL 9)





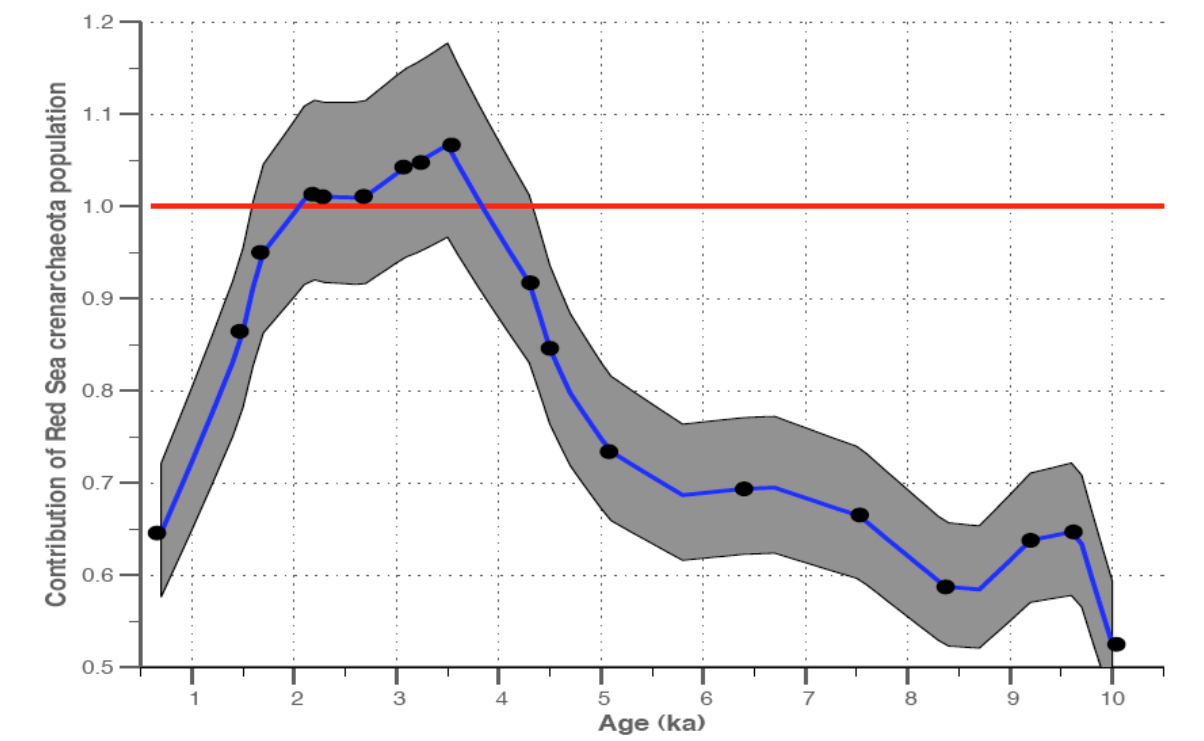
Trommer et al. (2009)

TEX_{86} record:
can we get from it useful dynamical information?

$$TEX_{86}mix=a*TEX_{86}rs(T)+b*TEX_{86}gl(T)$$

$$TEX_{86}mix=(0.02*a+0.015)*T-0.37*a+0.28$$

Penetration depends on exchange flow into the Red Sea - Index for Monsoonal variability



Regional lesson - Holocene

1. The RS is sensitive to both sea level and atmospheric conditions.
2. Sea surface temperature reconstructed from proxy records and our model results supports “wet” conditions during the early Holocene and “dry” condition during the late Holocene.
3. Monsoon-driven changes in the exchange flow affected the crenarchaea population structure, potentially providing an index for summer Monsoon strength during the Holocene.

Biton et al., Sensitivity of Red Sea circulation to Monsoonal variability during the Holocene: A modeling and sediment record study, Paleoceanography, 25, PA4209, doi:10.1029/2009PA001876, 2010

Why paleoclimate?

"..in this house, we obey the laws of thermodynamics!"

- ♣ The past as a key to the present
- ♣ How to deal with future climate
- ♣ Separate anthropogenic effects from natural variability
- ♣ Evaluate our climate models


Thank you!
"Always remember, a bad day at sea is better than a good day in the office",
Confucius.