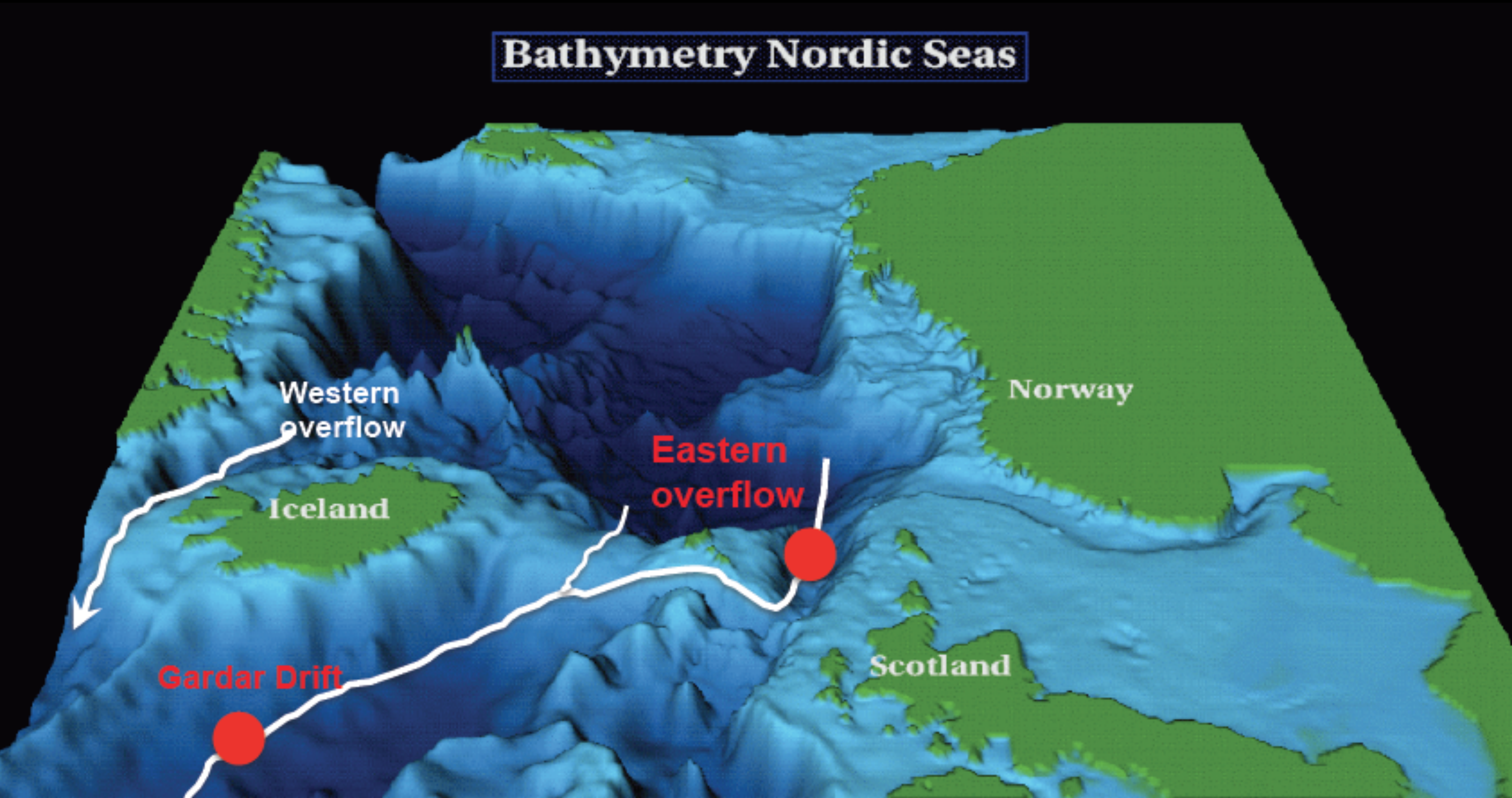
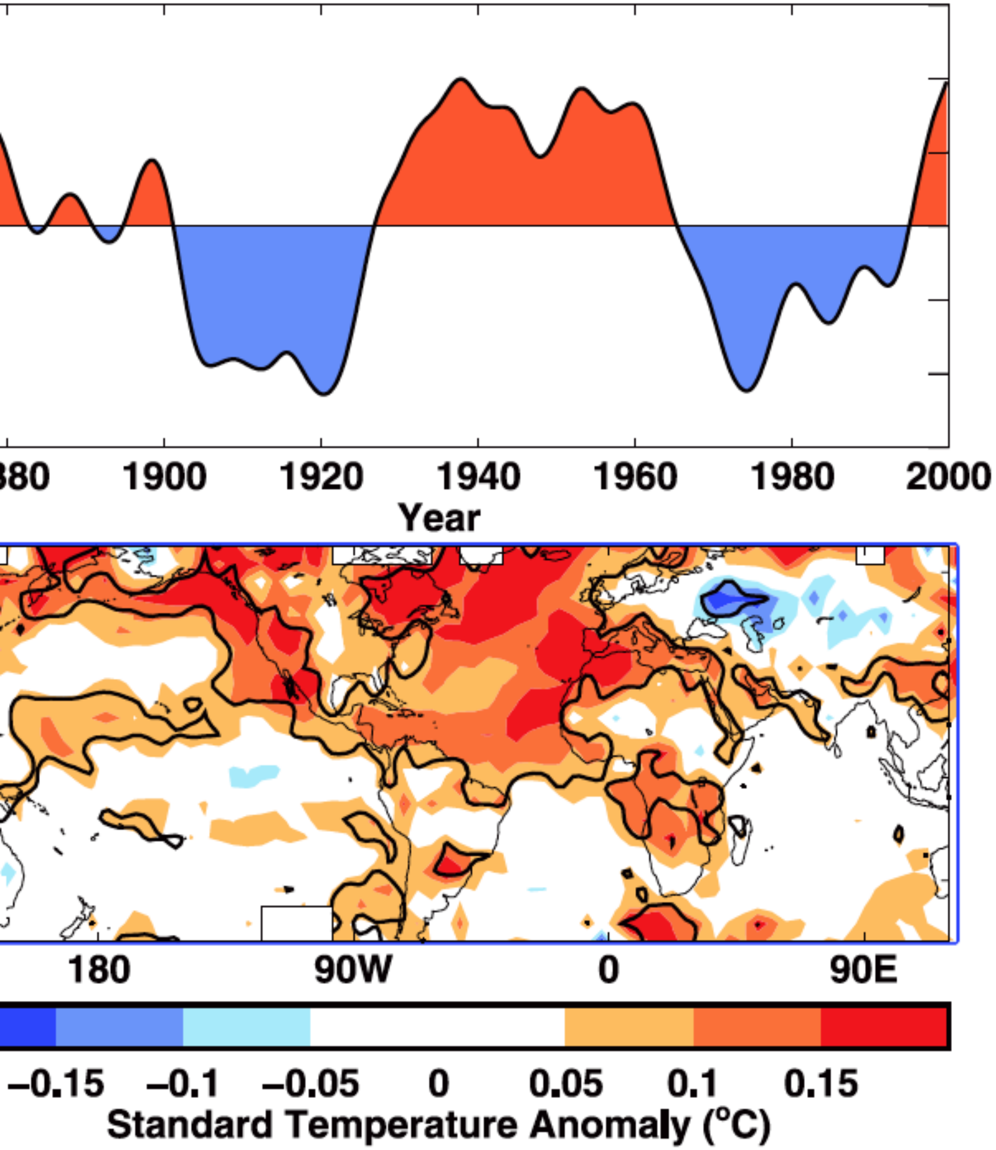
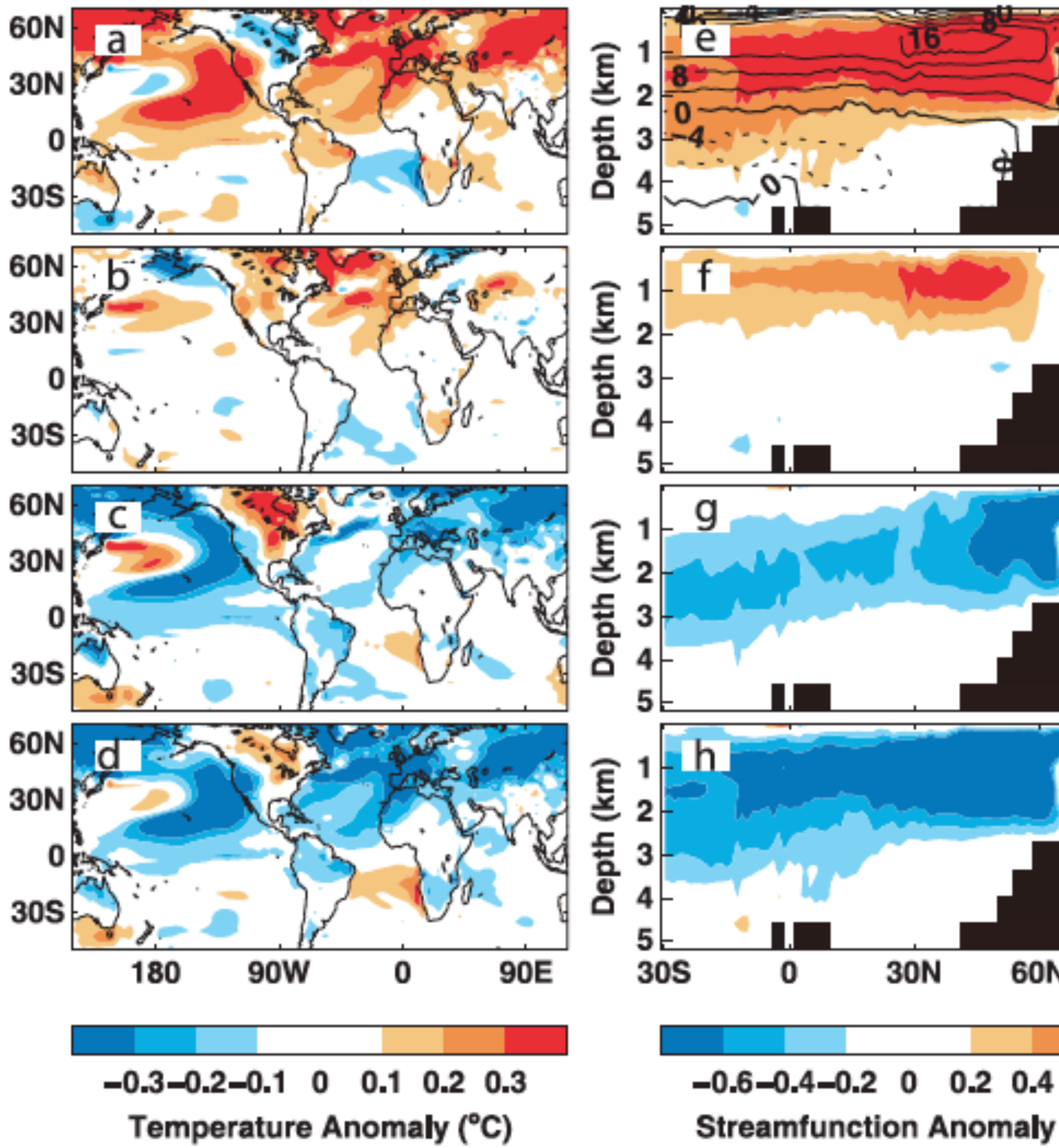
U. Ninnemann,
contributions from: T. Mjell, H. Kleiven, H. Langehaug, T. Eldevik, A. Olsen, M. Eide,
Ottera, Y. N. Irvali, Rosenthal, I. Hall



Observed pattern



Model variability (70-180 band



ne Atlantic Multidecadal
scillation without a role for
ean circulation

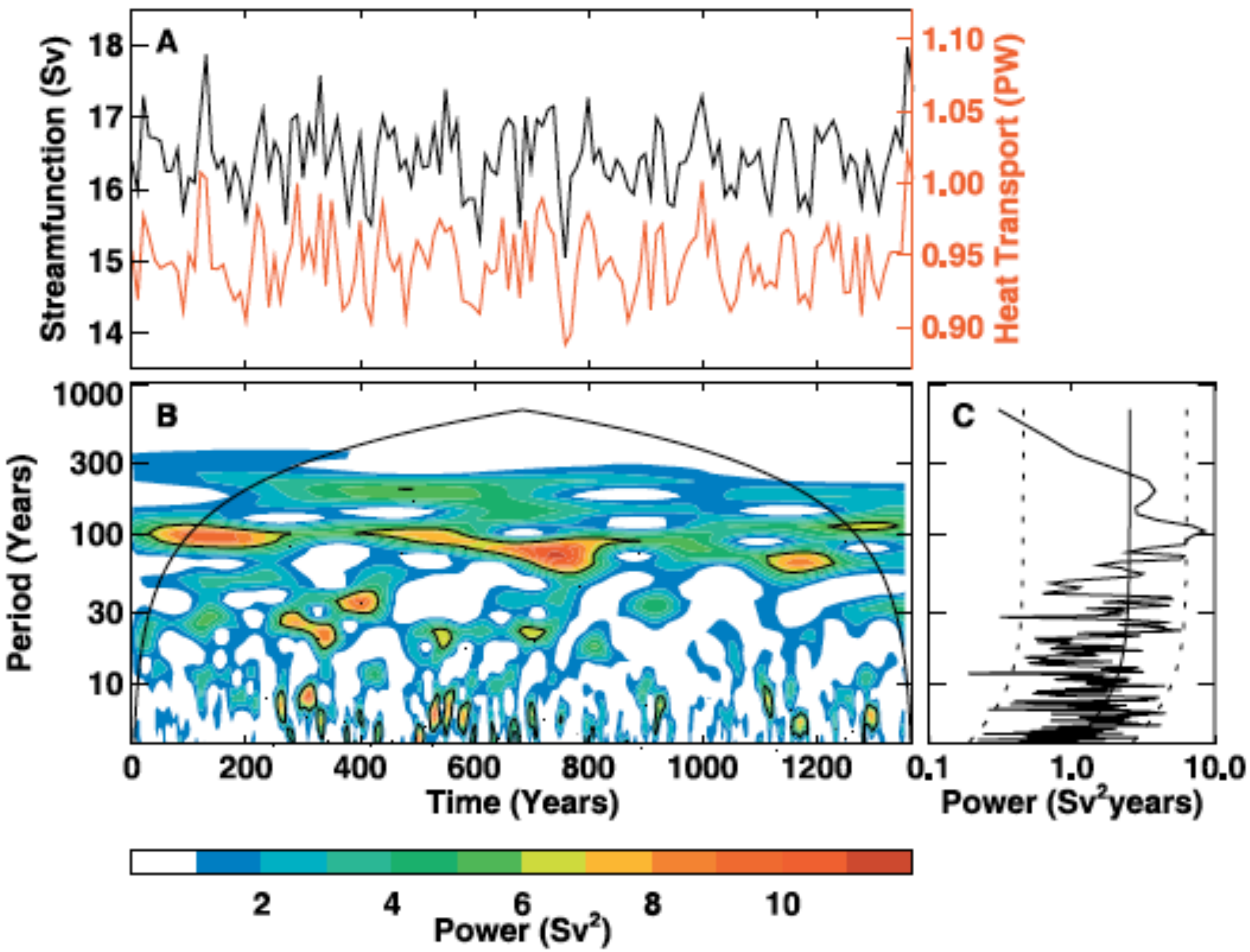
Clement,[1*] Katinka Bellomo,[1] Lisa N. Murphy,[1] Mark A. Cane,[2]
ten Mauritsen,[3] Gaby Rädel,[3] Bjorn Stevens[3]

Simulate AMO features w/prescribed OHT

Atmospheric forced

Ocean may be response to, not driver of, AMO

models (yes), reconstructions (?)



Knight & Sutton, 2005

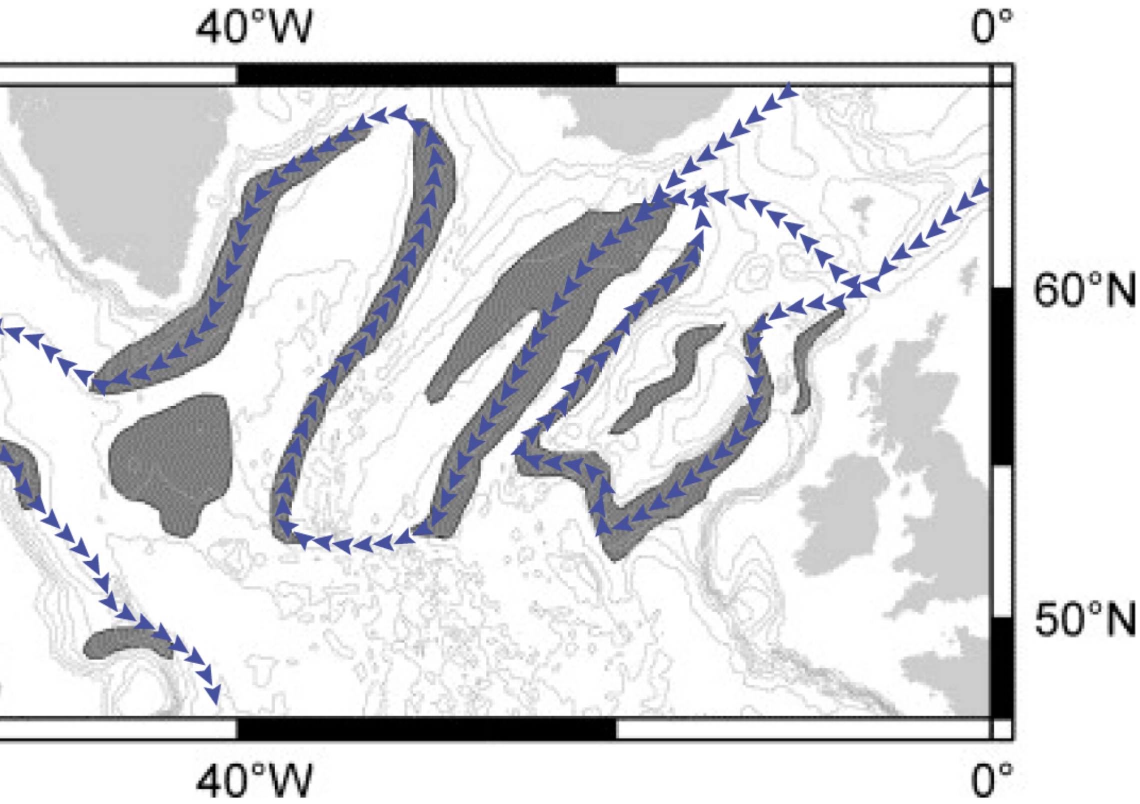
Q's remain unanswered:

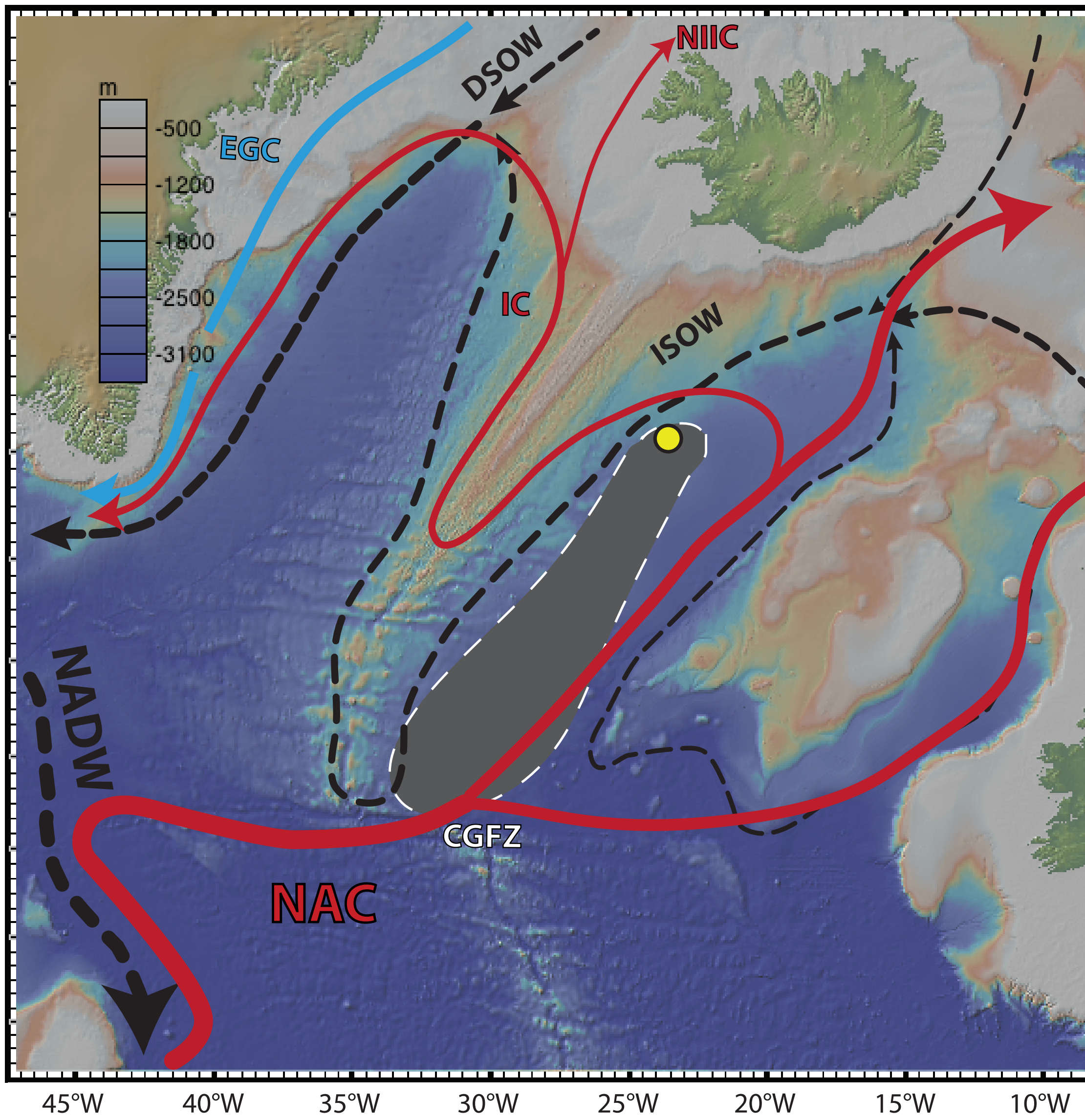
chanisms (is the ocean overturning involved, which elements)?

oustness (persistence? presence and timescale of the change…aspec
r on predictability of the system)

Do the overflows vary? (Mainly ISOW)
- On what timescales?
- What aspects (velocity, density etc.)
- Effects (e.g. relationship to ventilation and ocean carbon chemistr
- *Why*

ed after Faugères et al 1999



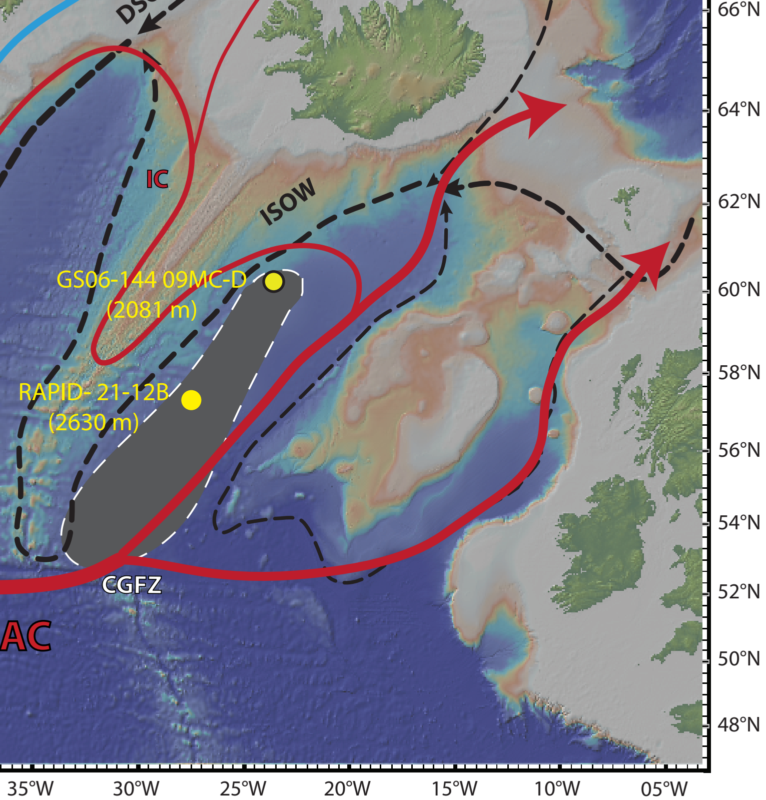


06-144-09 MC-D & GS06-144-08 GC

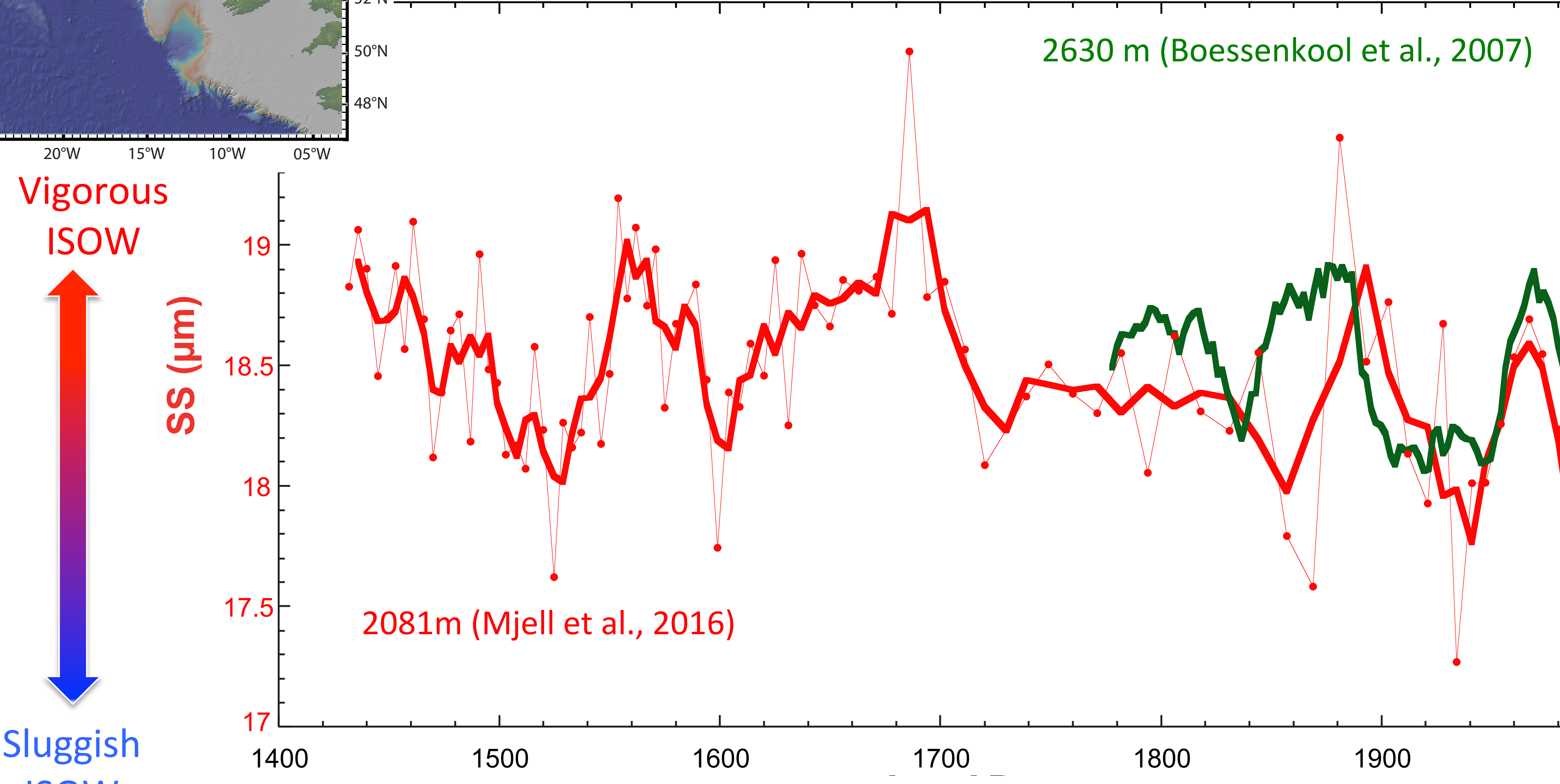
de: 60°19’ N
2081 m

Longitude: 23° 58’ W
Sed. Rate: ≈ 50 cm ka^{-1}

Deeper/southern site = smaller grain size mean and variabilit

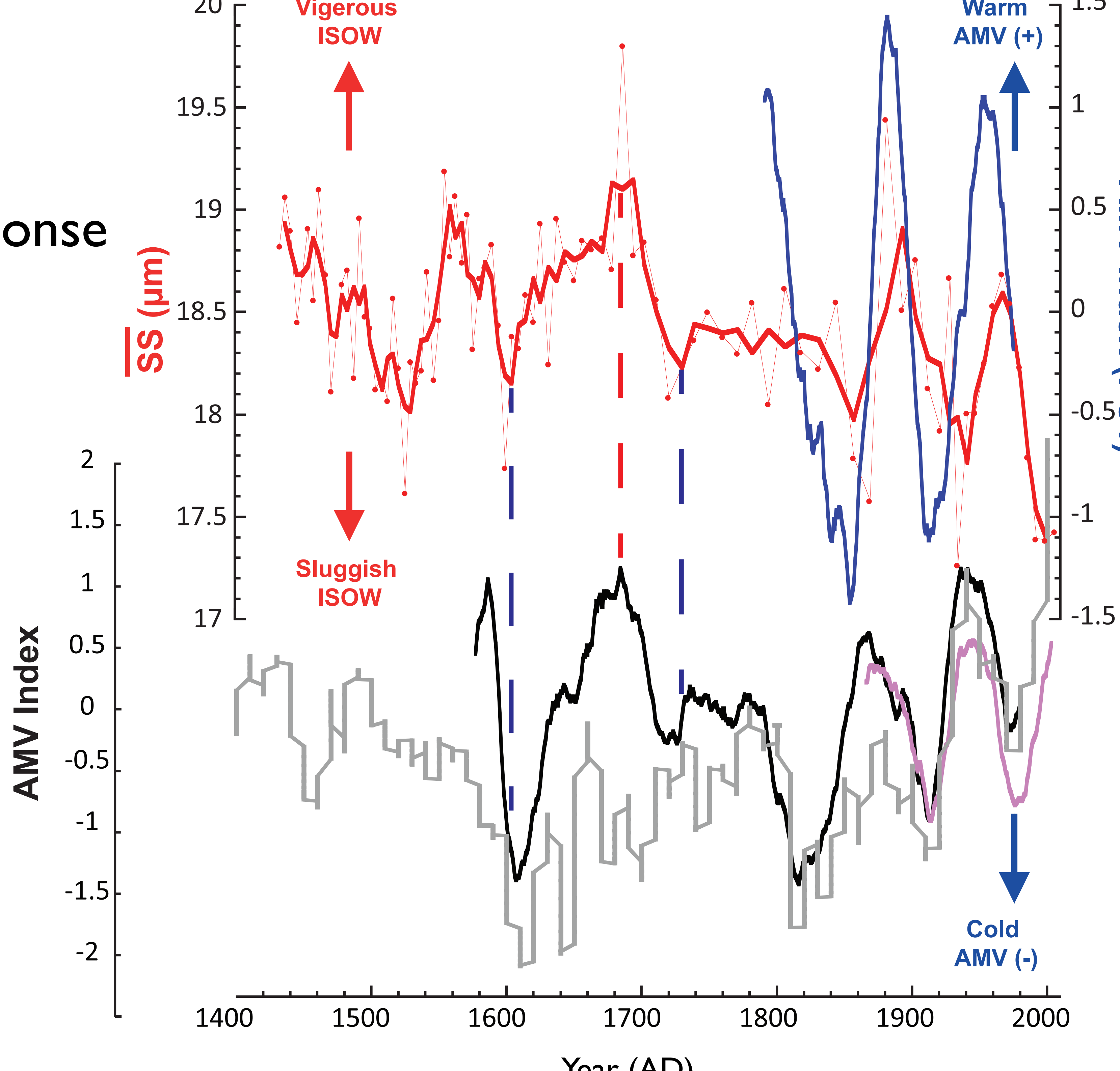


GeoMapApp (Ryan et al., 2009)



milar frequencies

ts ocean role/response
n AMO timescales

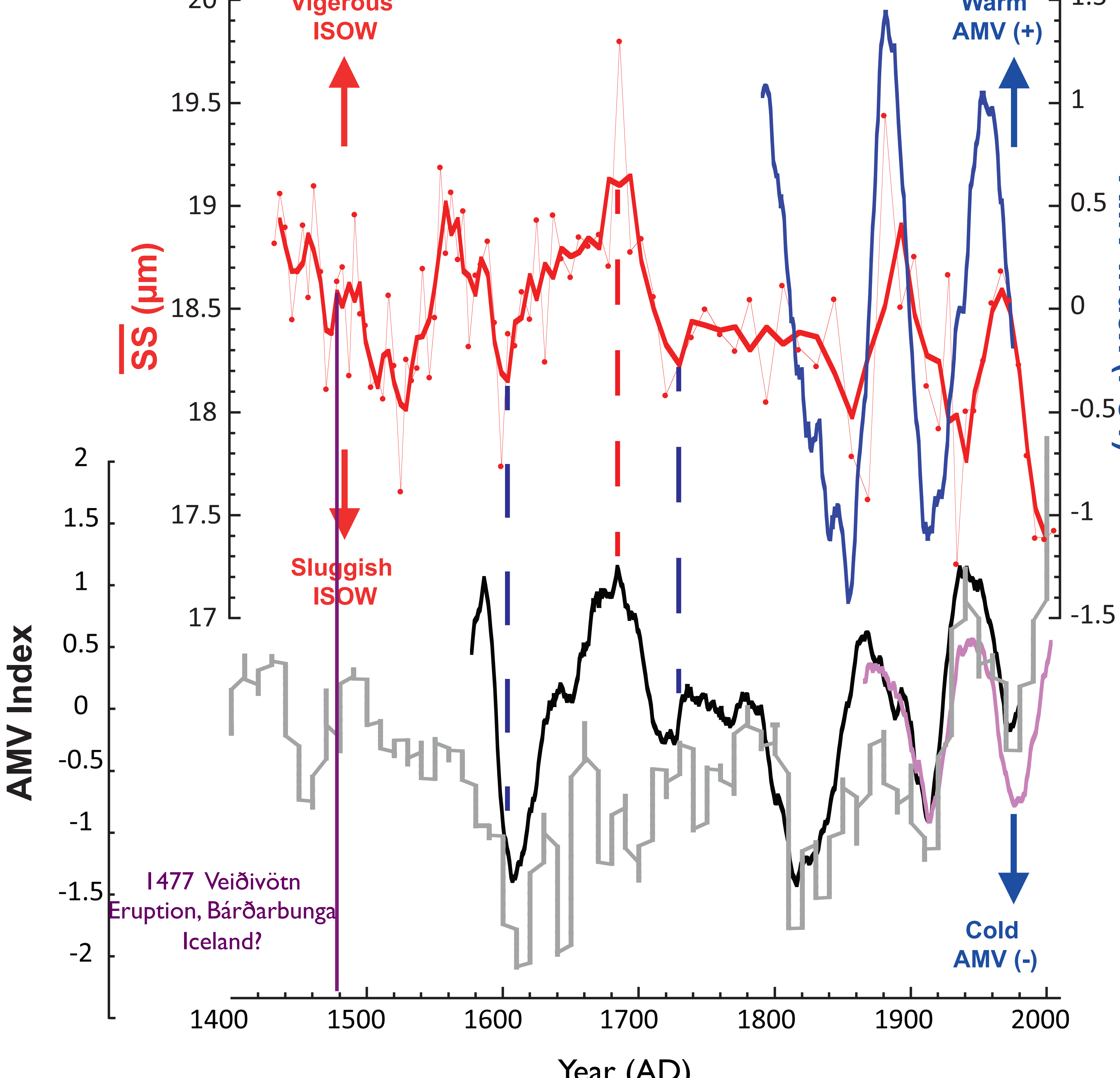


certain-phasing

ean could either
or be driven by
climate.

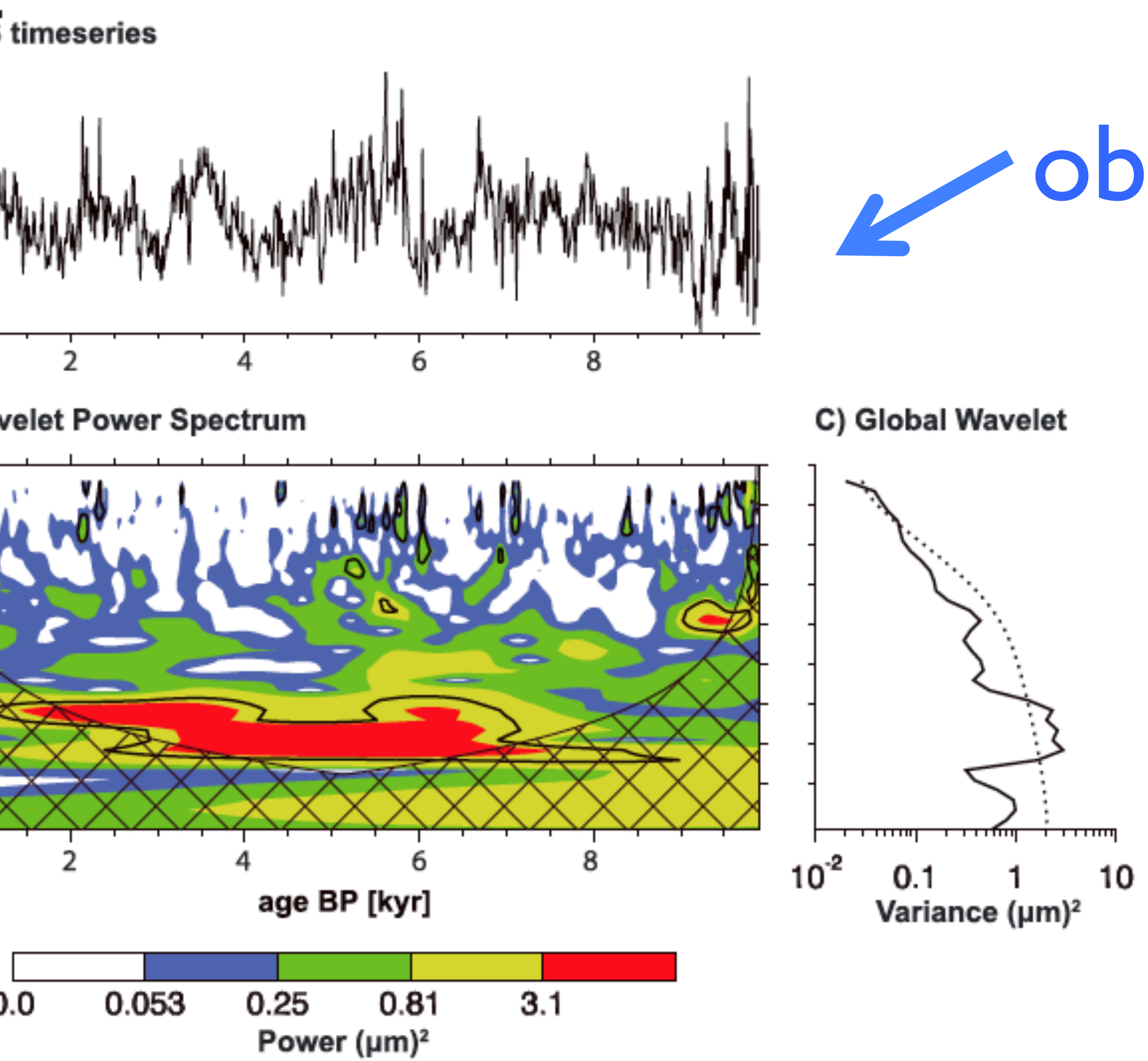
termine phase
elp differentiate
mechanisms

ires absolute age
peaks (Irvali et al
in prep.)

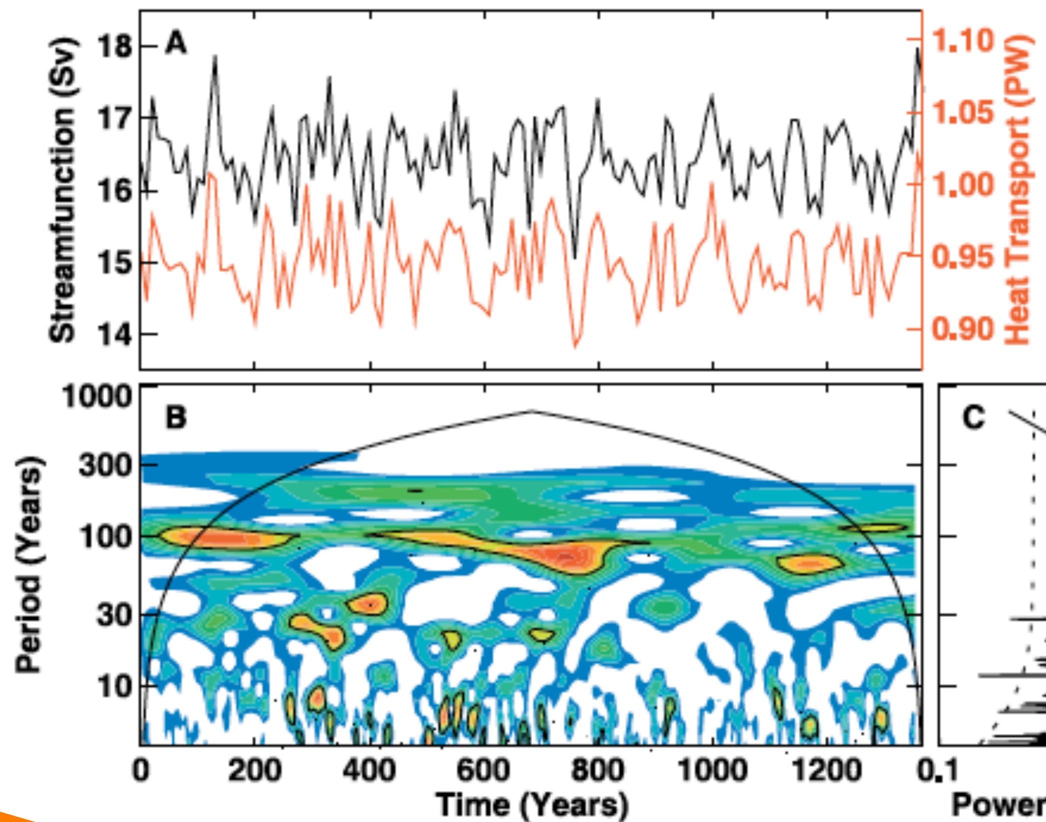


ons on multidecadal-centennial timescales over past 10 kyr

observations

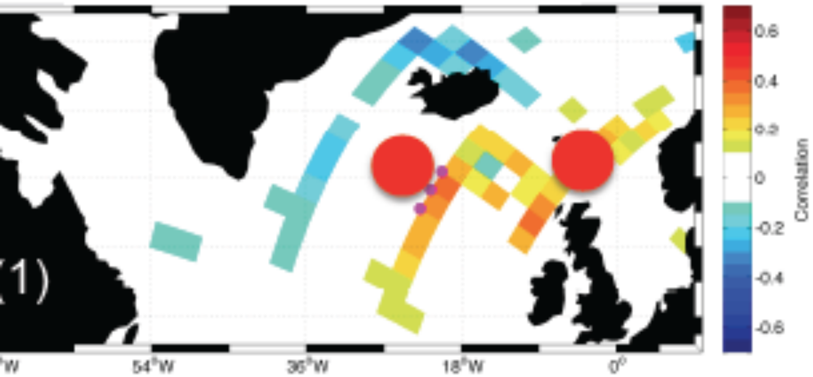


Mjell et al., 2015



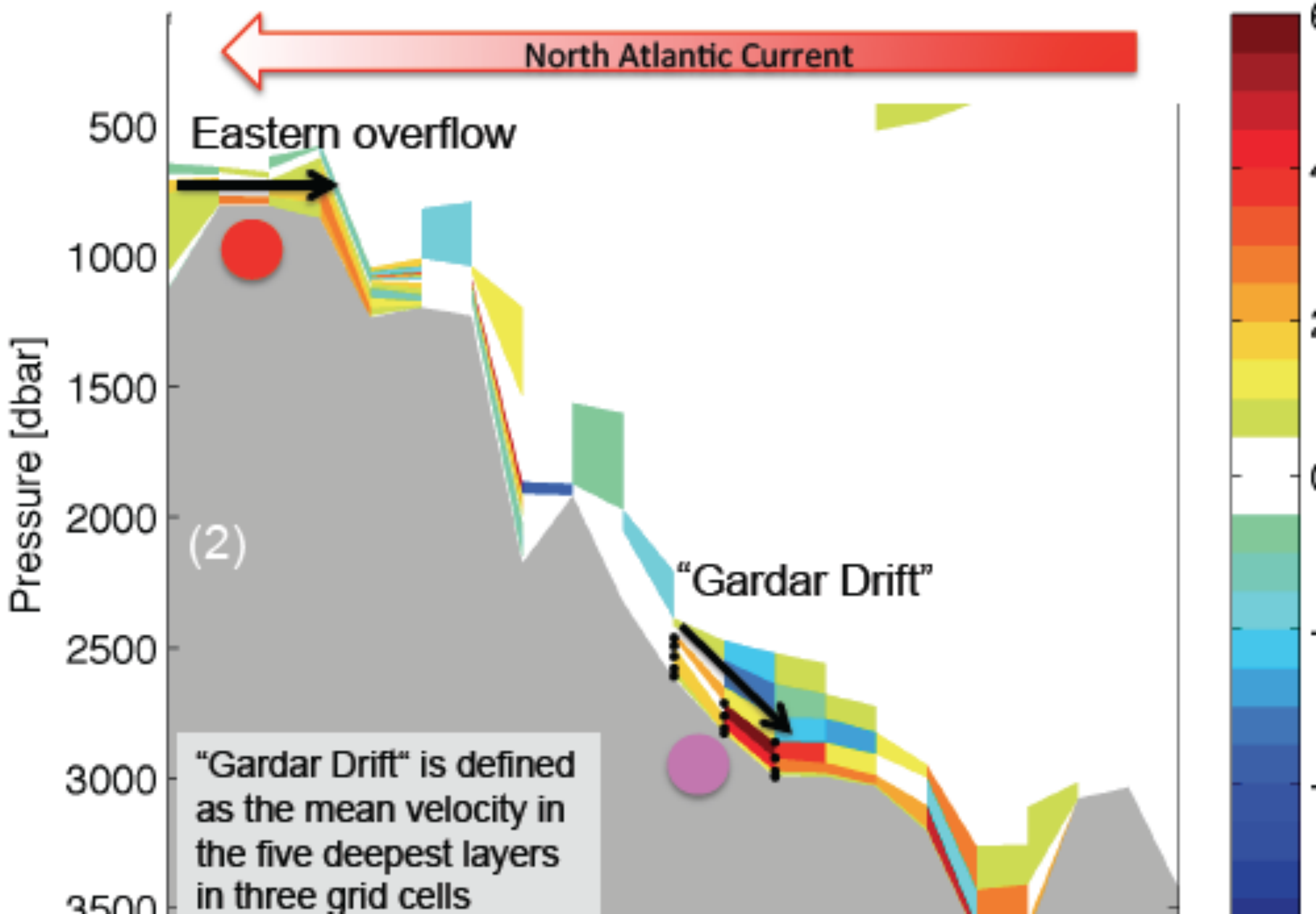
y does bottom flow south of ridge relate to ISOV

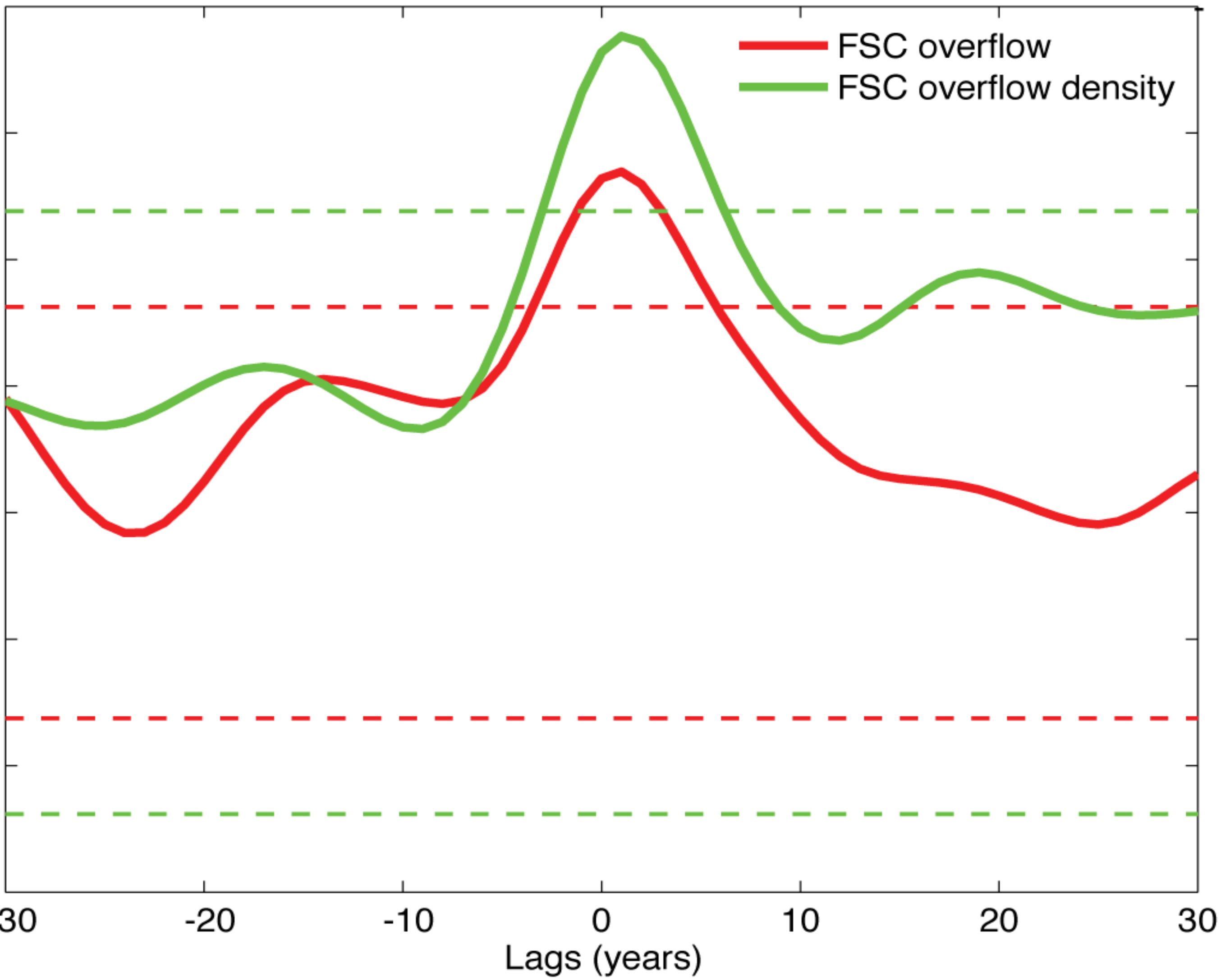
a fully coupled global climate model – Bergen Climate Model (BCM
model has produced a 500-yr long simulation which includes histor
solar irradiance and volcanic aerosol variations



orrelation between the eastern overflow and
wnstream velocity in deep layers

The ocean part of BCM is an isopycnal model, i.e., z-coordinate is defined on density surfaces.





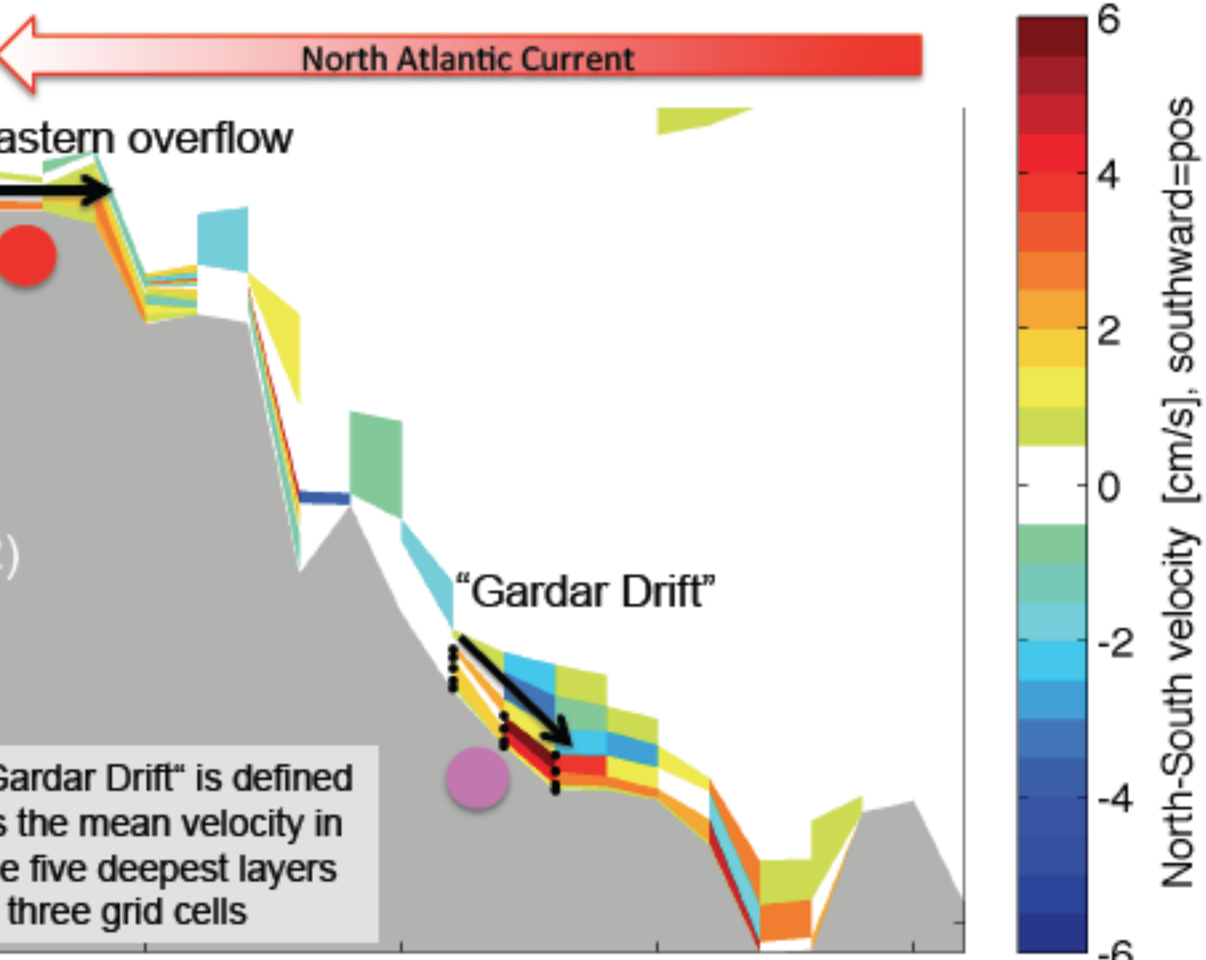
Using FSC density an
transport we are able
explain (r=0.87) **~ 76 %** o
variability in the downst
velocity at the Gardar D

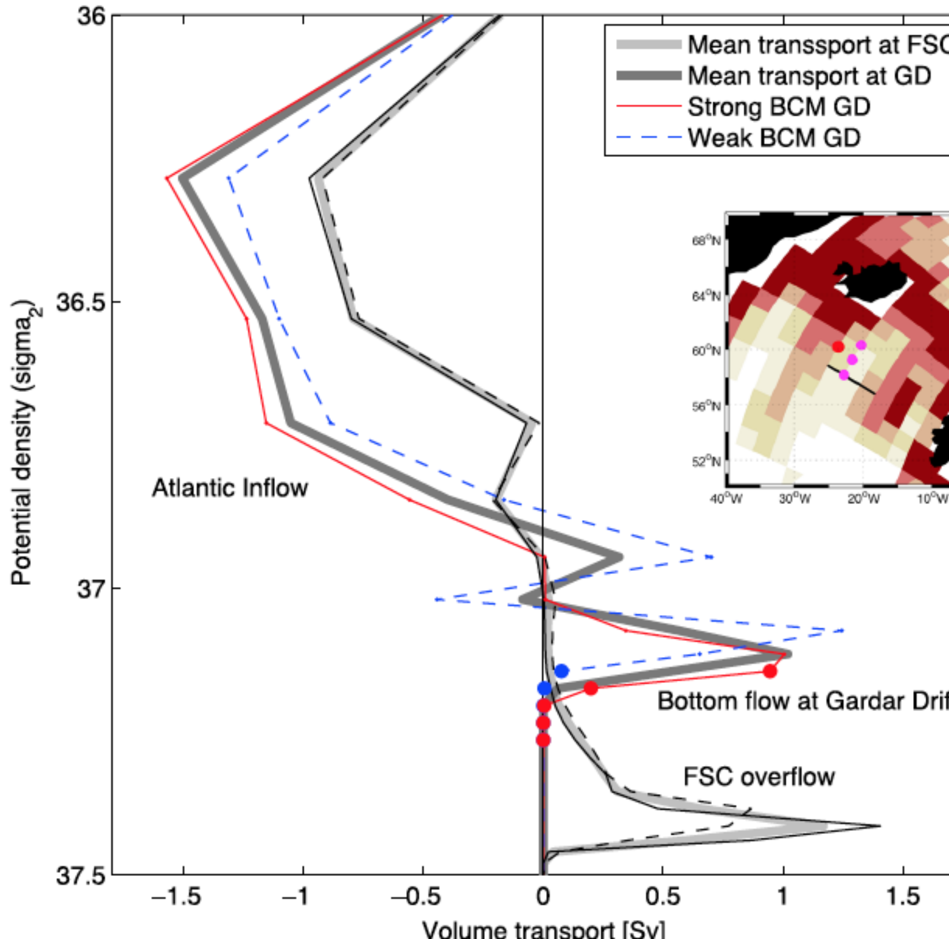
ownstream velocity not simple metric for overflow transport (density more nportant)
onversely, processes controlling FSC overflow transport are not necessarily tho hat drive flow along the GD (important how one upscales the significance of pro gnals using models)

Langehaug et a

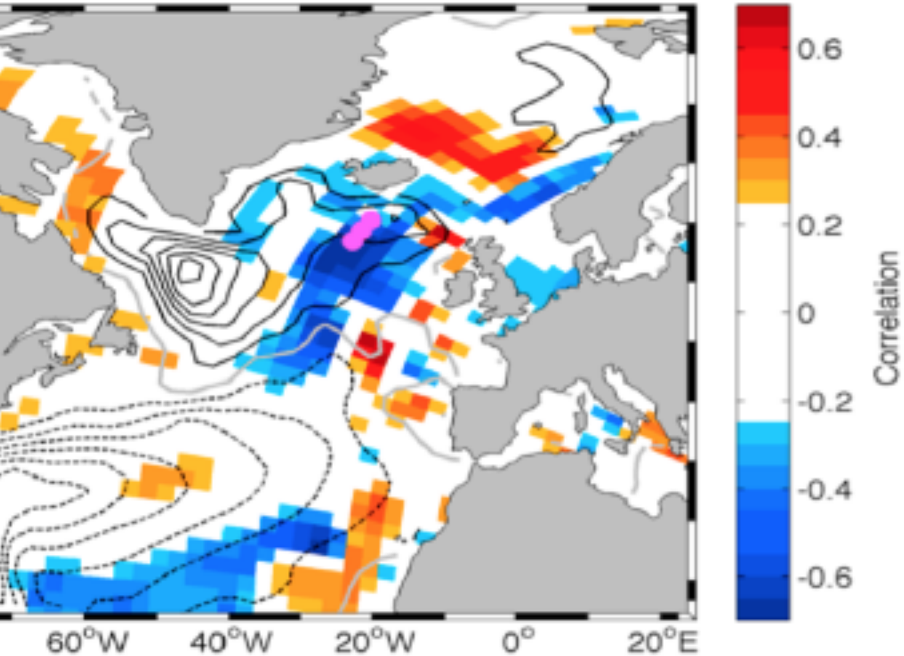
creased bottom flow = decrease overflow (density & transport) & fl
shoals (shallower isopycnals thicken and increase in velocity).

ations for proxy records, location vital, around axis of flow (could va
long timescalesThornally etal, 2013).

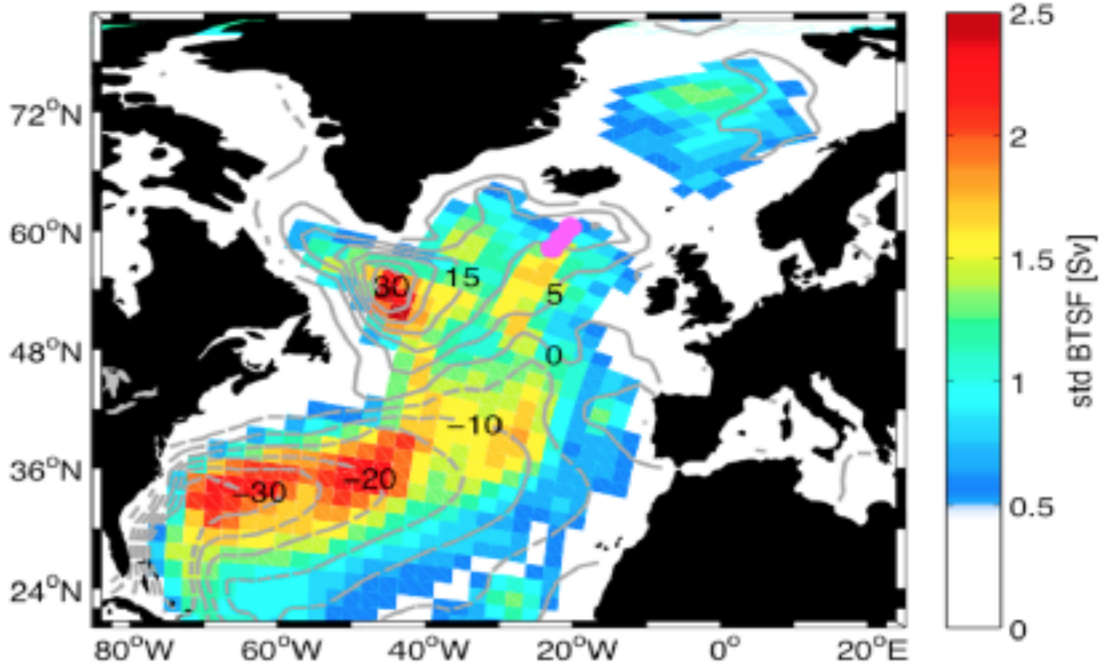




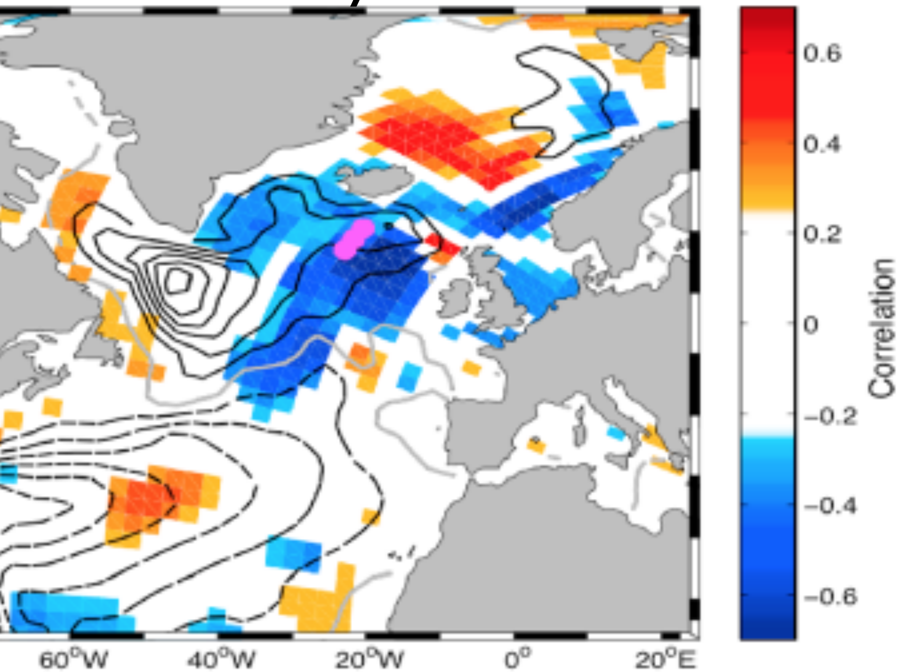
GD & BTSF



Variance BTSF



FSC density & BTSF



Not the (direct) mechanisms driving GD i

Major circulation modes not correlated w

strength of GD operates independently

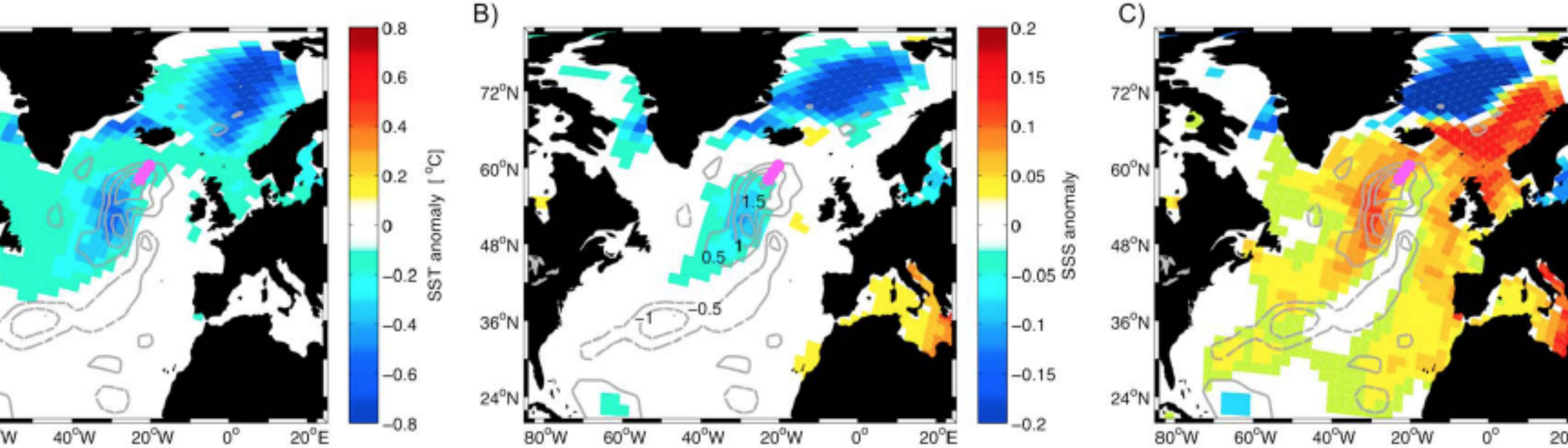
of gyre circulation.

Driven by changes further upstream

FSC density-BTSF relation similar to

Composite of weak flow states

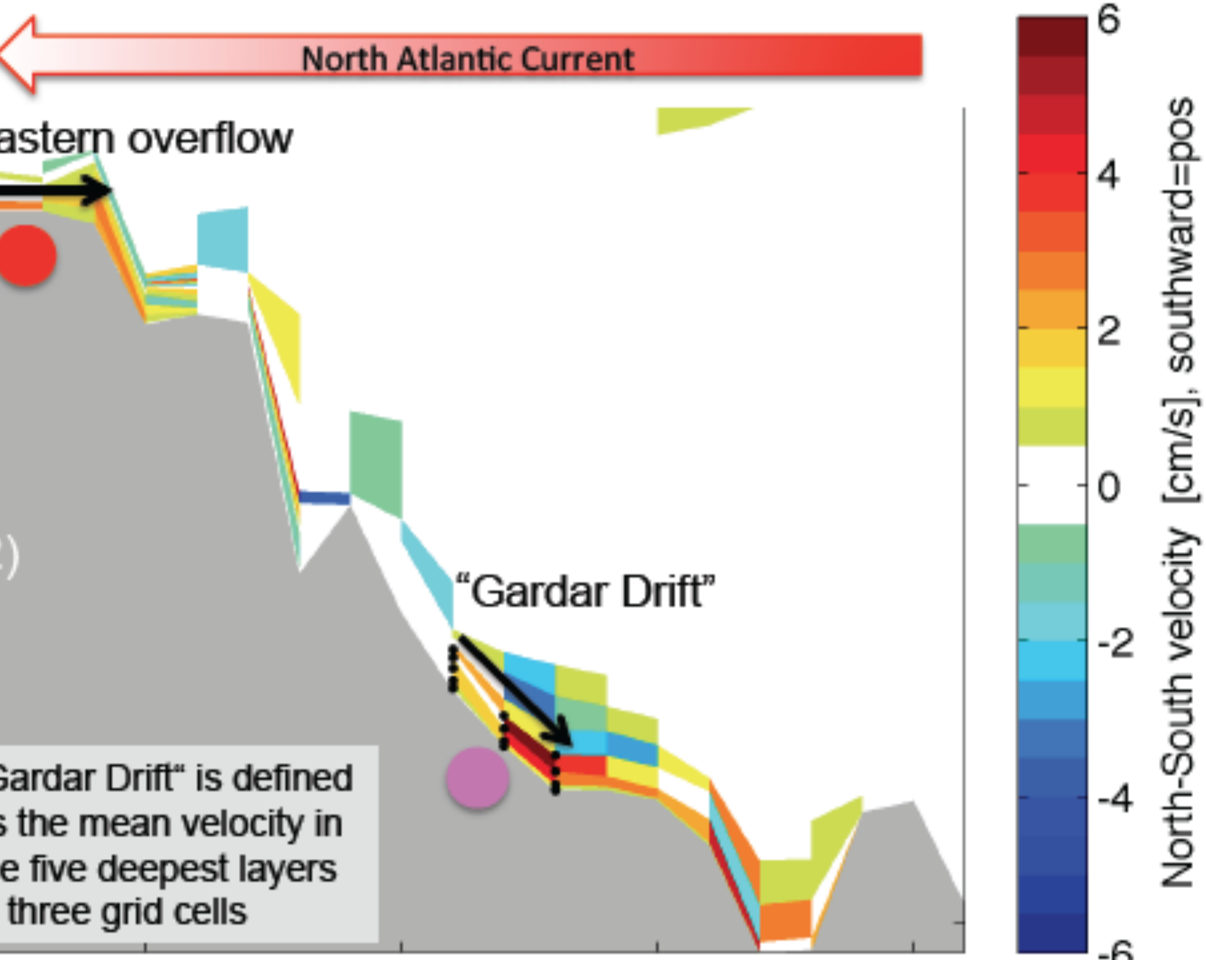
Low SST | Low SSS | Decrease MLD

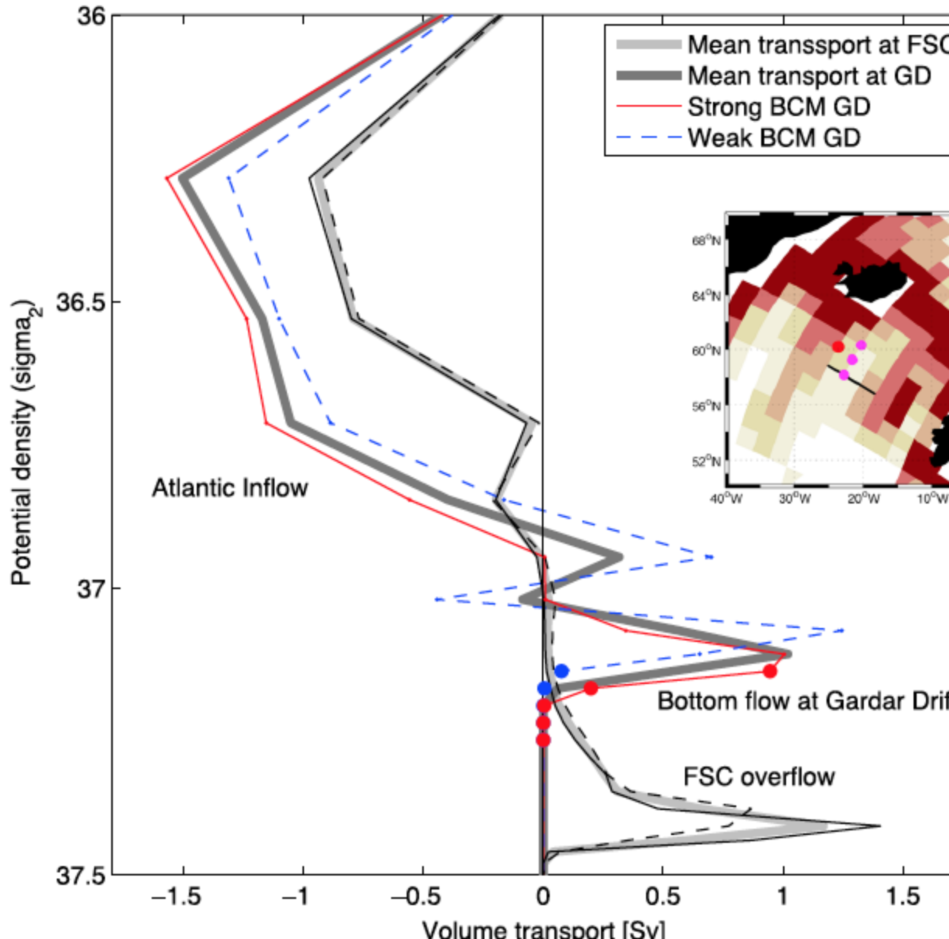


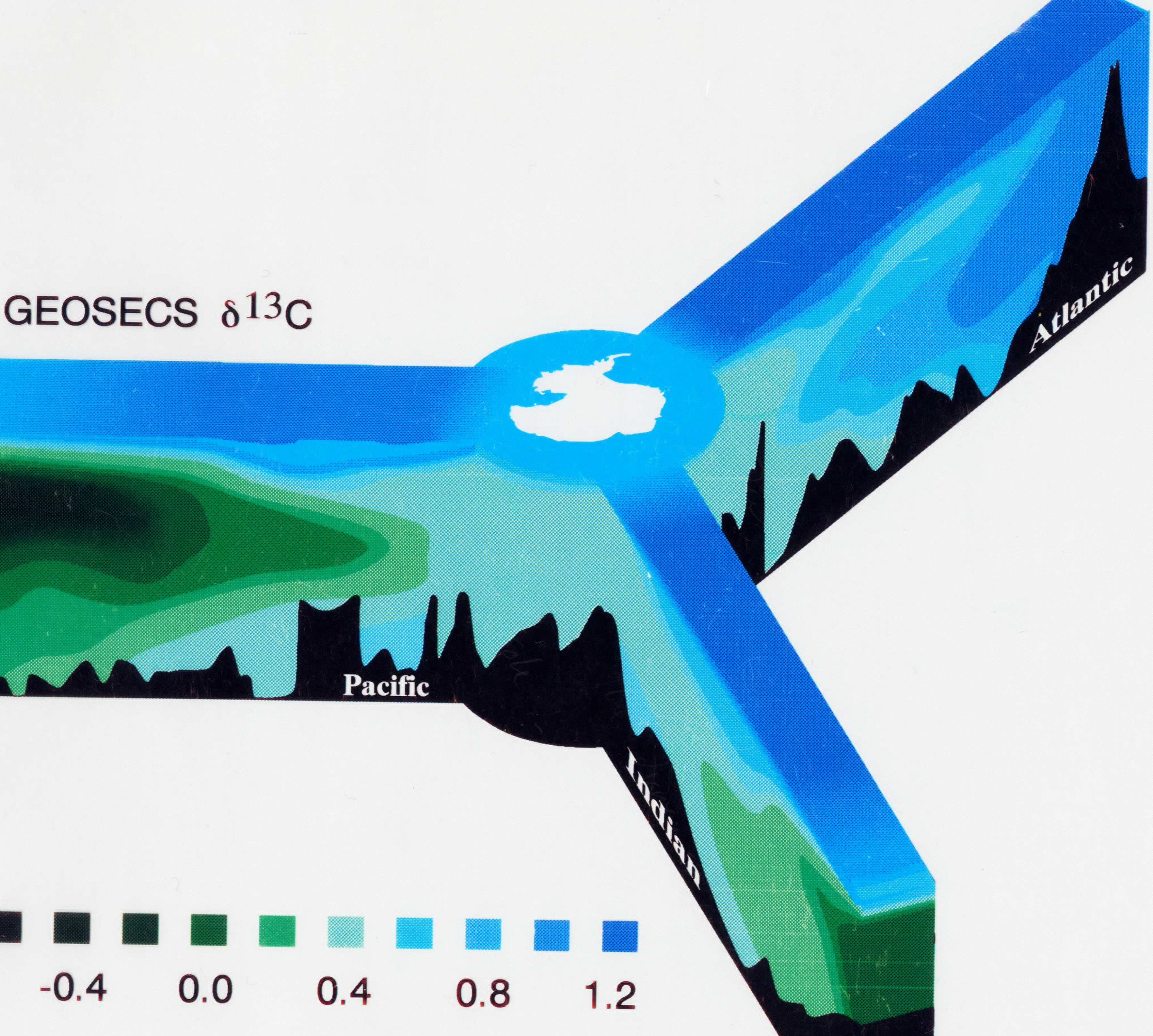
overflow (and GD flow) related to negative SST and SSS anomalies drive r

ry anomalies—decreasing convection and the cross ridge pressure gradient

erflows varying vertically may be hard to metric with one or a few g
records however, may leave a fingerprint in other water mass/ventila
(test with $\delta^{13}C$)







uniformitaria
Problemat

upper ocean
altered by inva
light anthropog

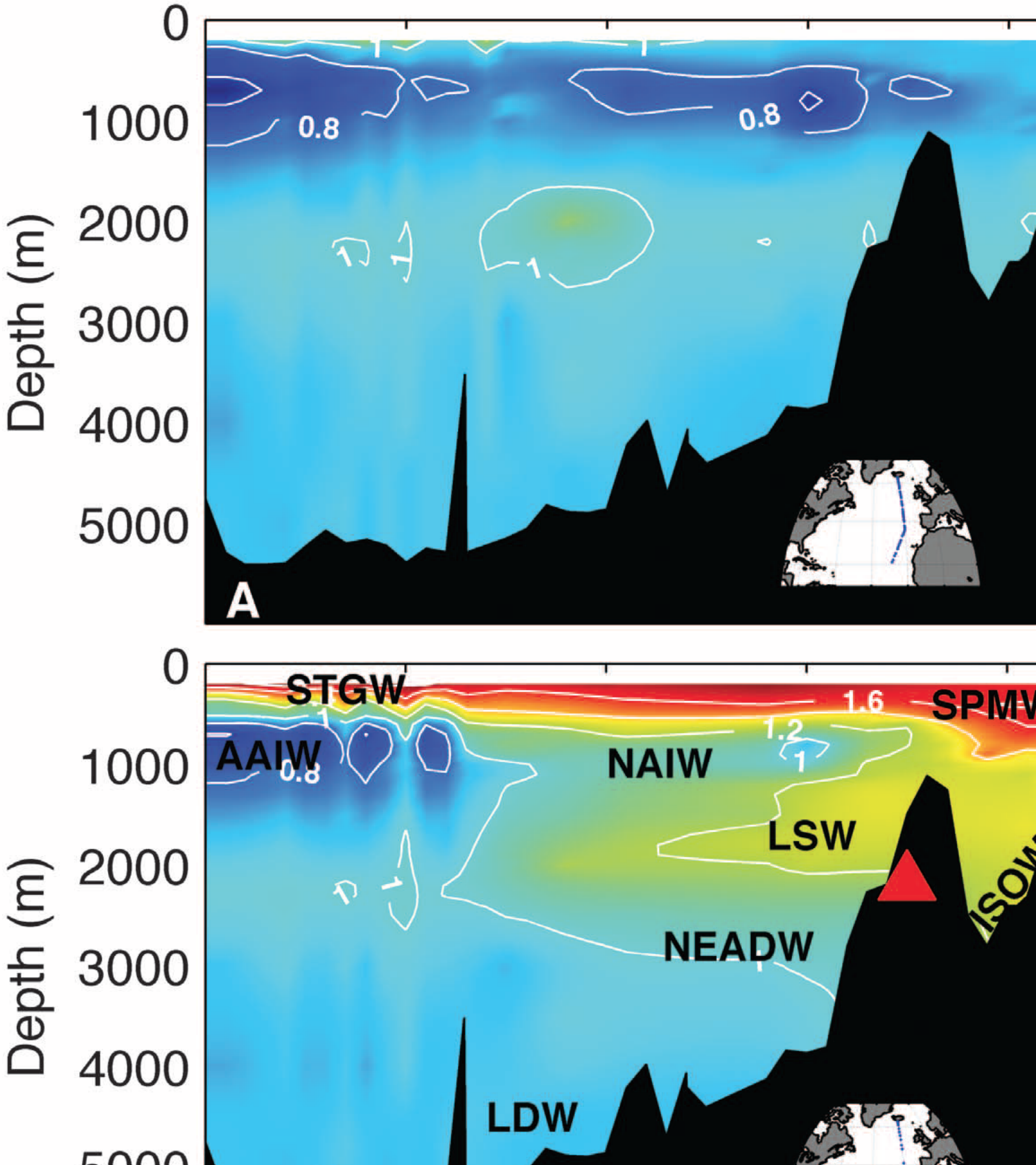
Recovering the *natural* $\delta^{13}C_{\text{pre-Anth}}$ distribution

uncorrected

- ogeneous/small gradients
- absent or low values
- est values >2km
- lear signal of overflows

corrected

- er vertical and horizontal gradients
- ed to specific water masses
- SW



uncorrected

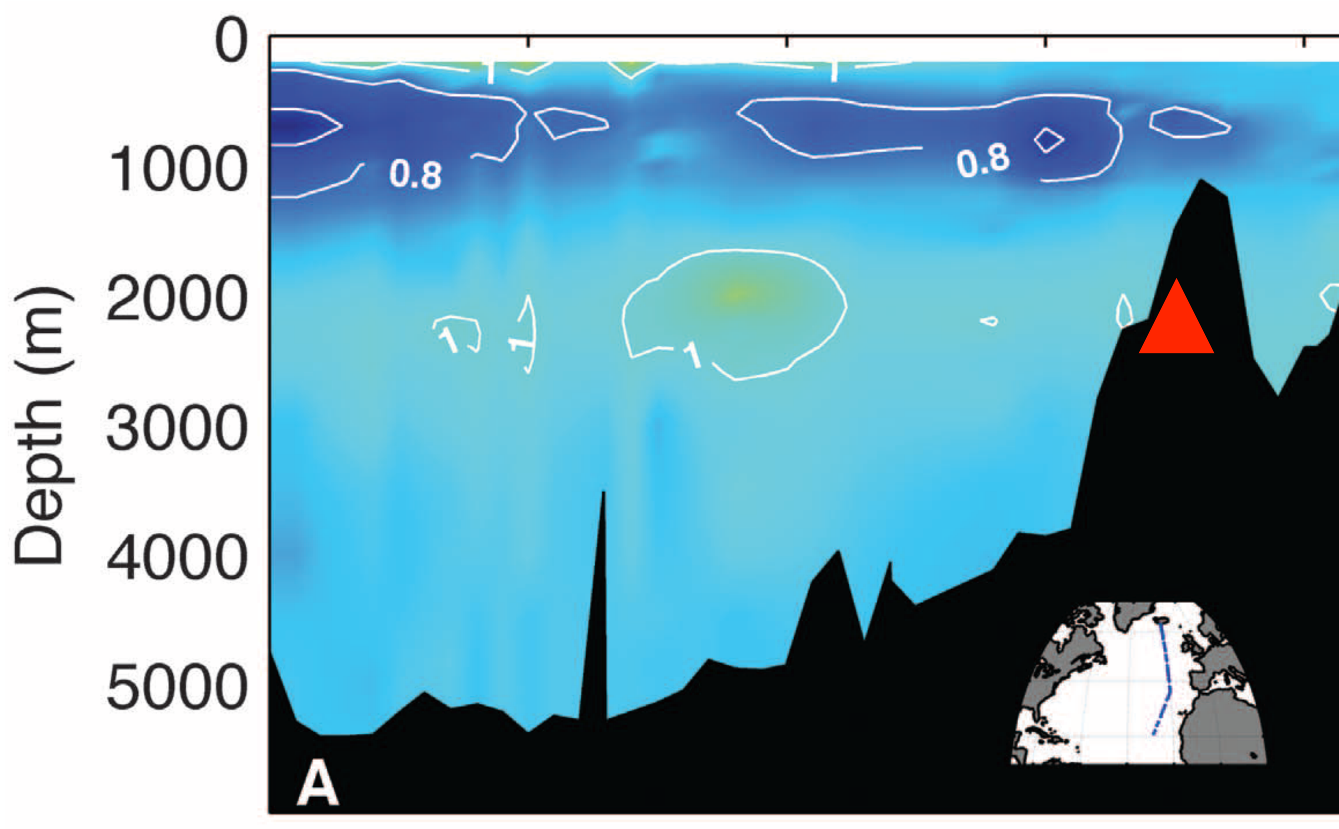
ogeneous/small gradients

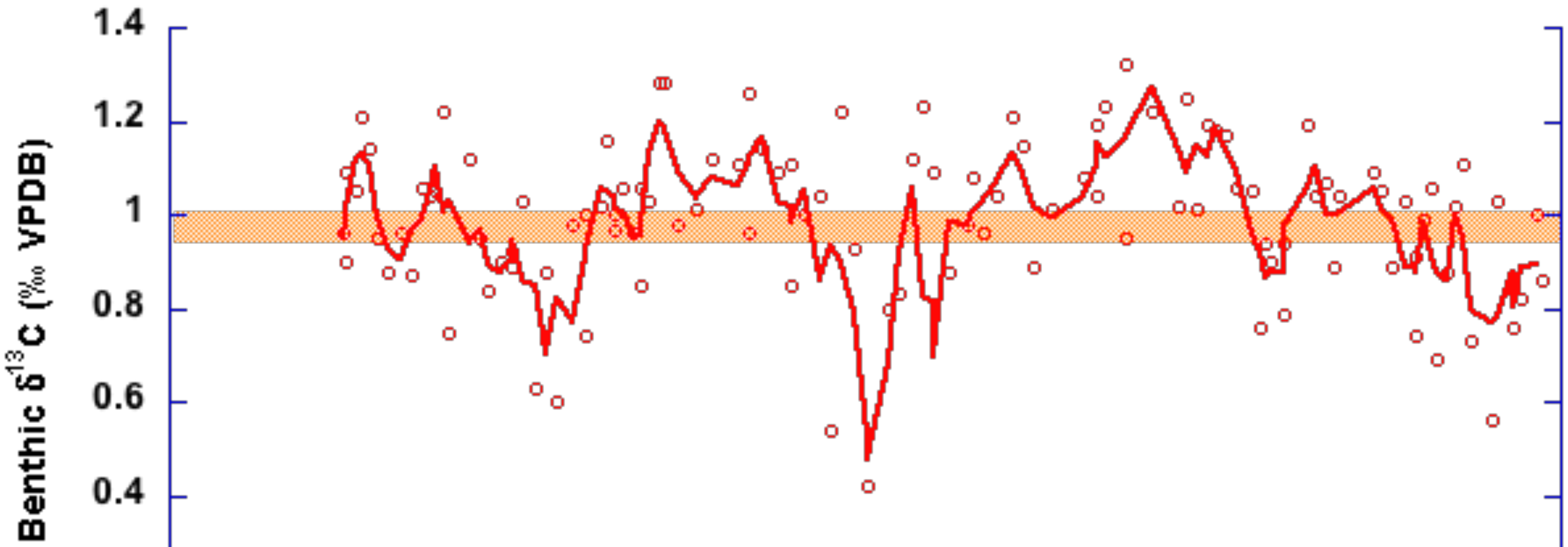
Near Holocene midpoint

- both +/- ventilated more/less carbon uptake?

Requires preformed Δ

- How to increase decrease?

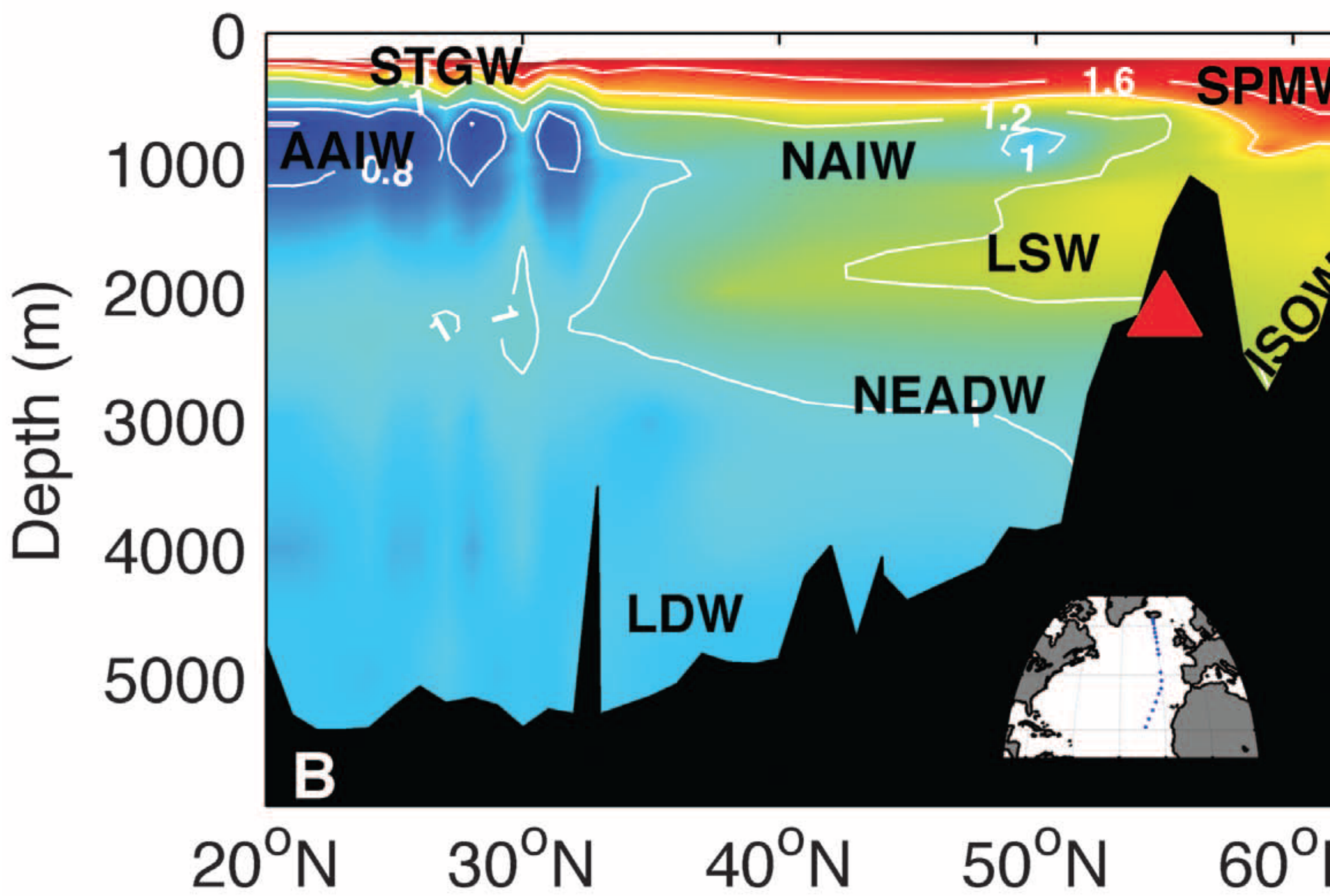


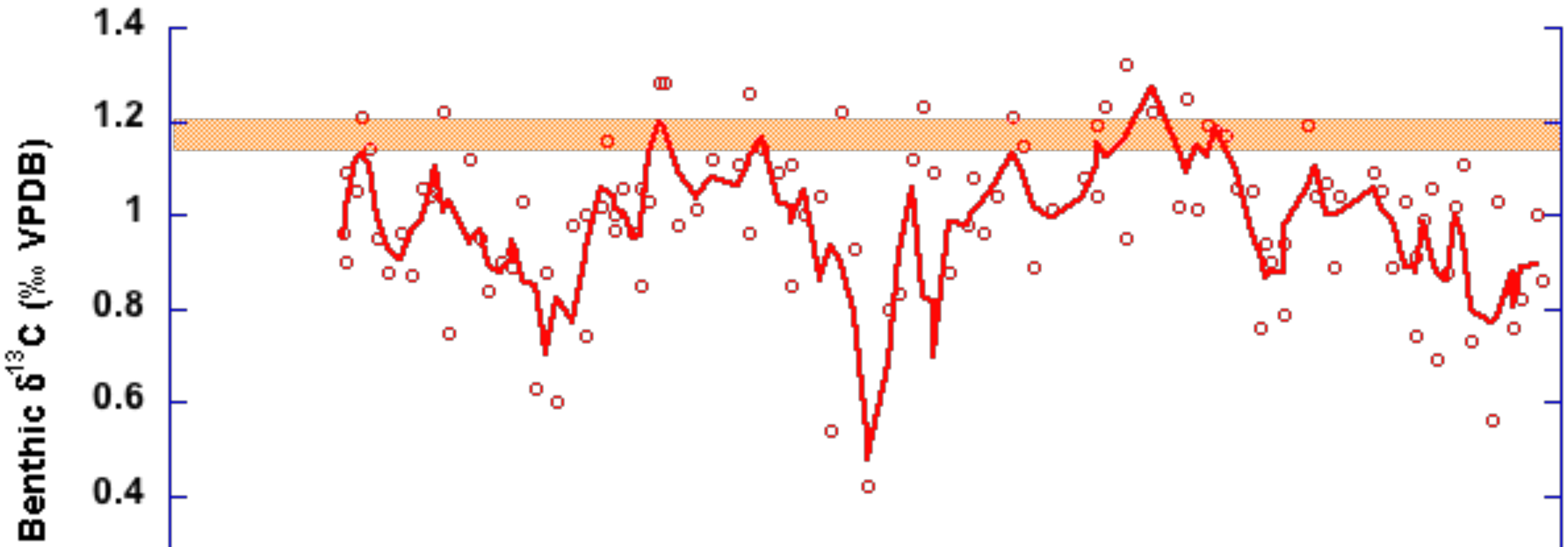


corrected

freq. "chatter" makes sense

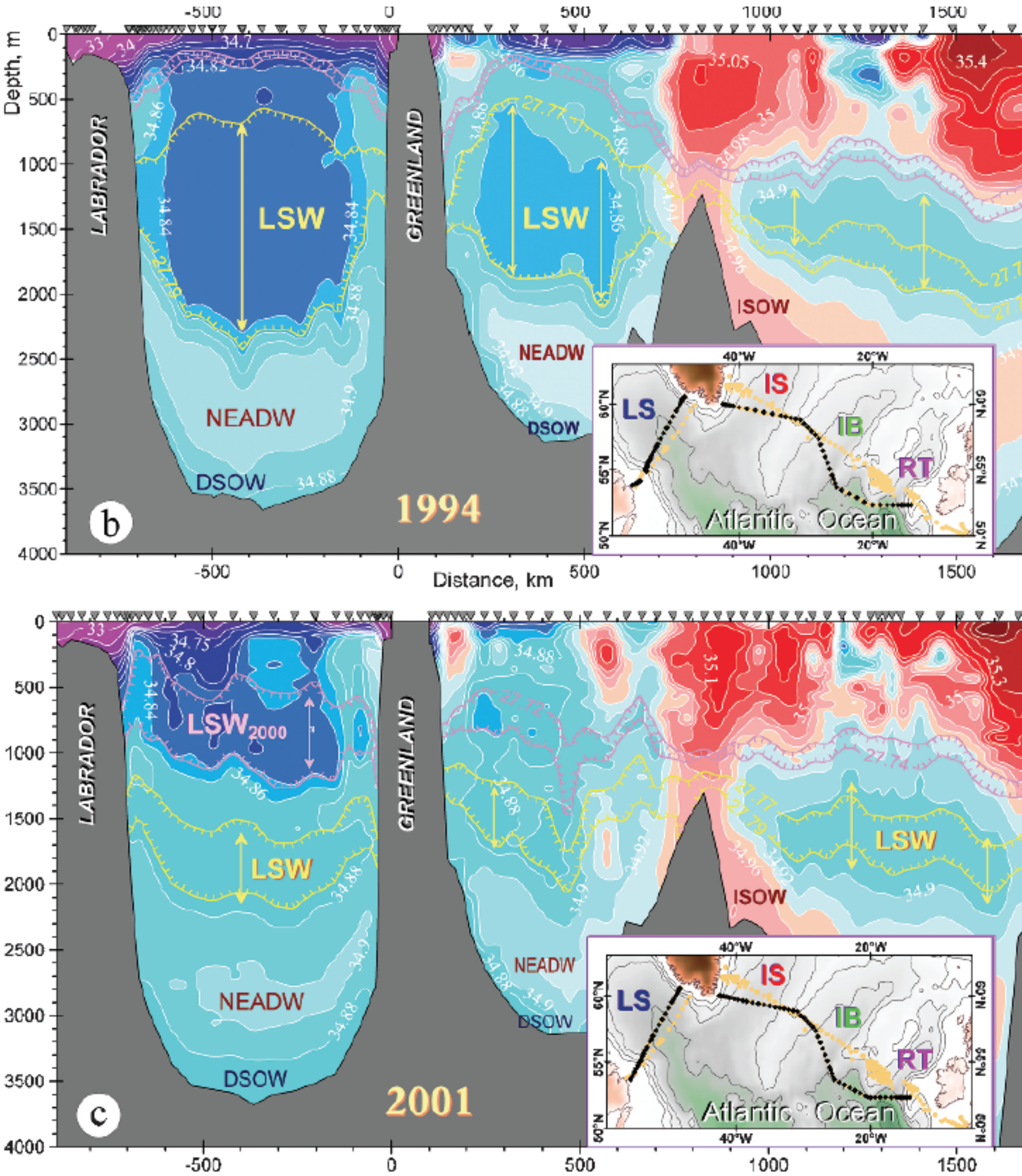
E.g. Δ (decreases) in LSW





corrected

- freq. "chatter" makes sense
  - E.g. Δ (decreases) in LSW



. corrected

ys N.Atl. Near Holocene max

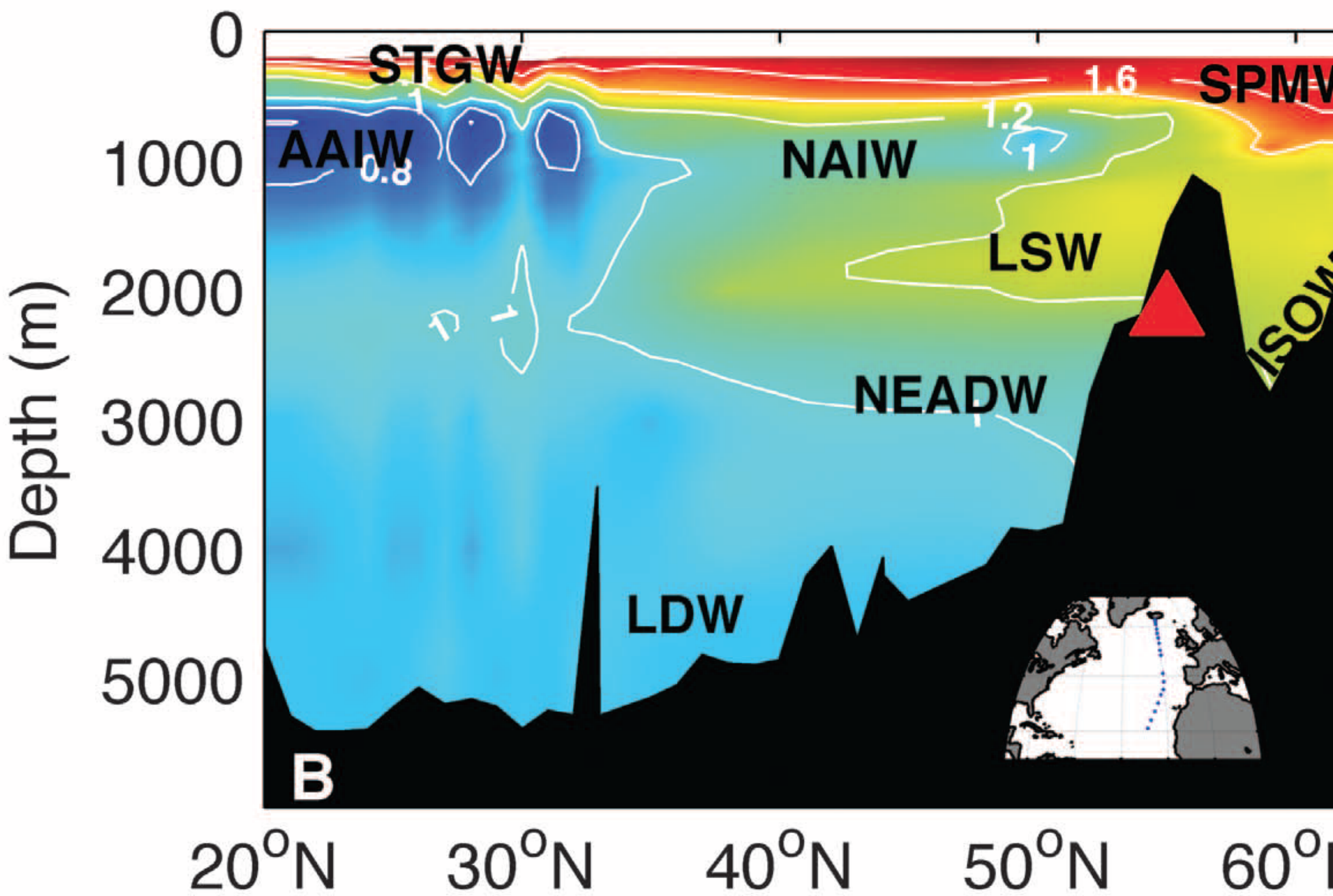
Natural variability--decreased entilation (not +/-)

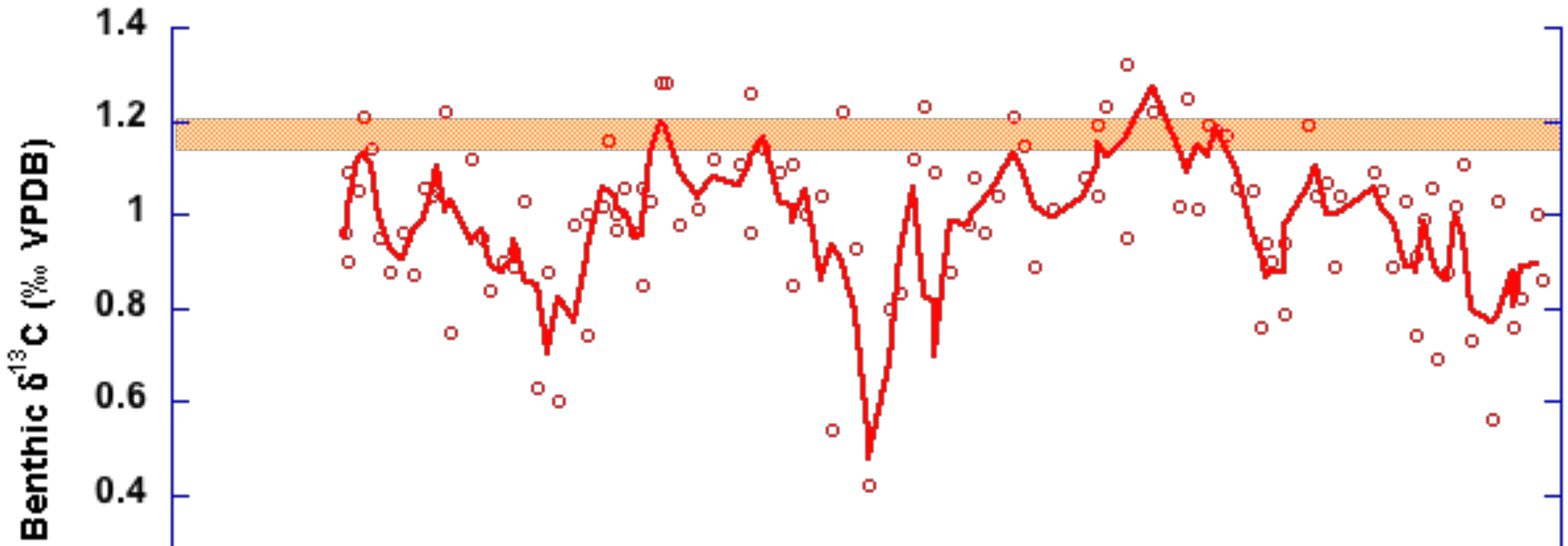
e decreases

associated w/cooling

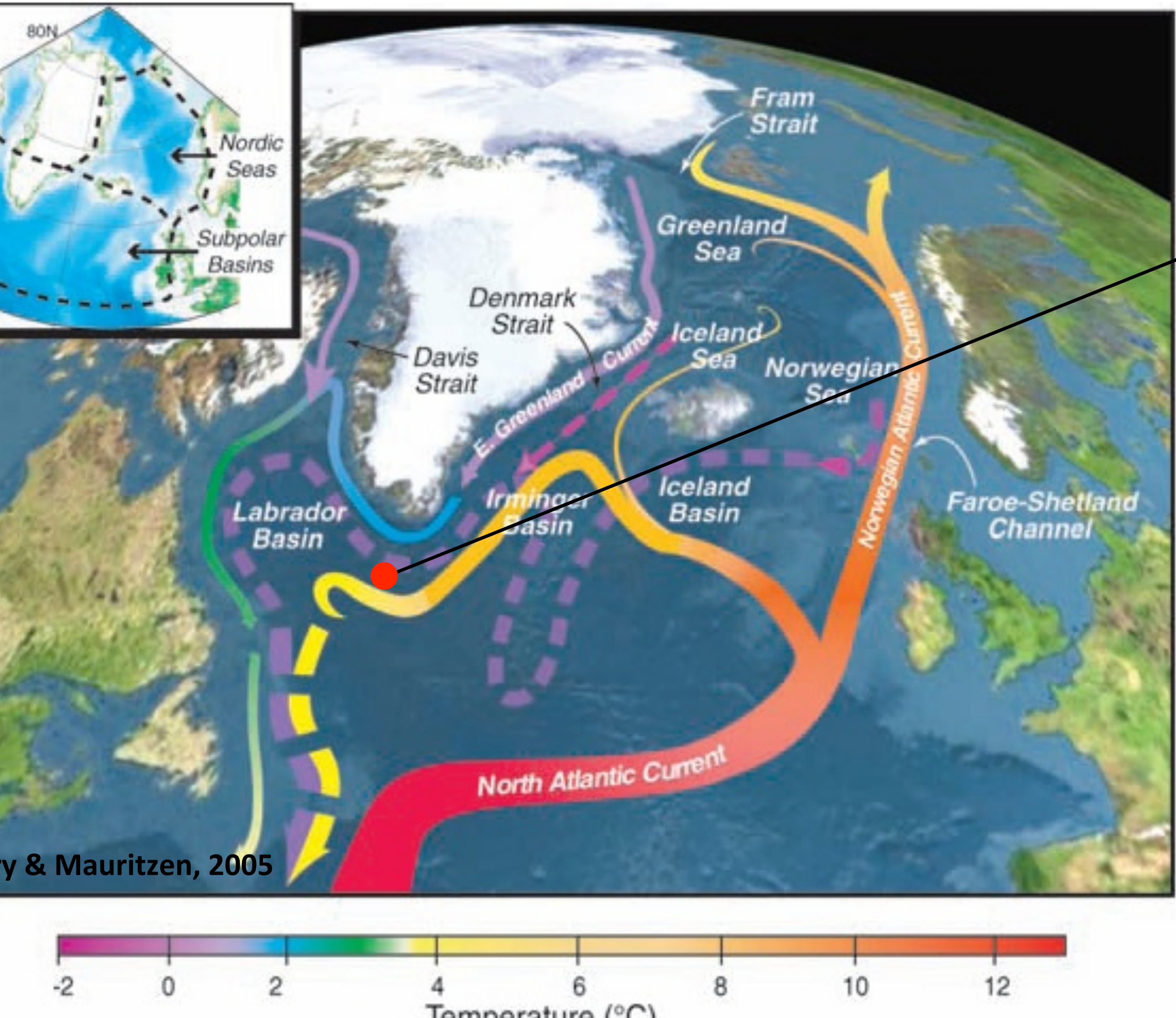
require additional Δ

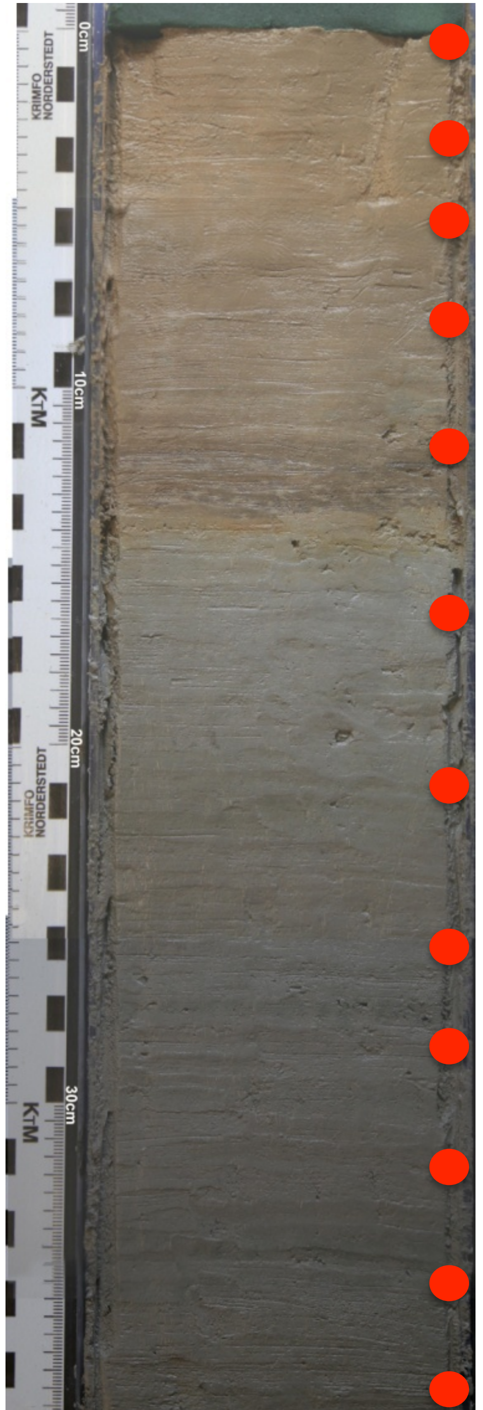
- not just short term LSW
  - *SSW*
  - *Persisting LSW Δ?*

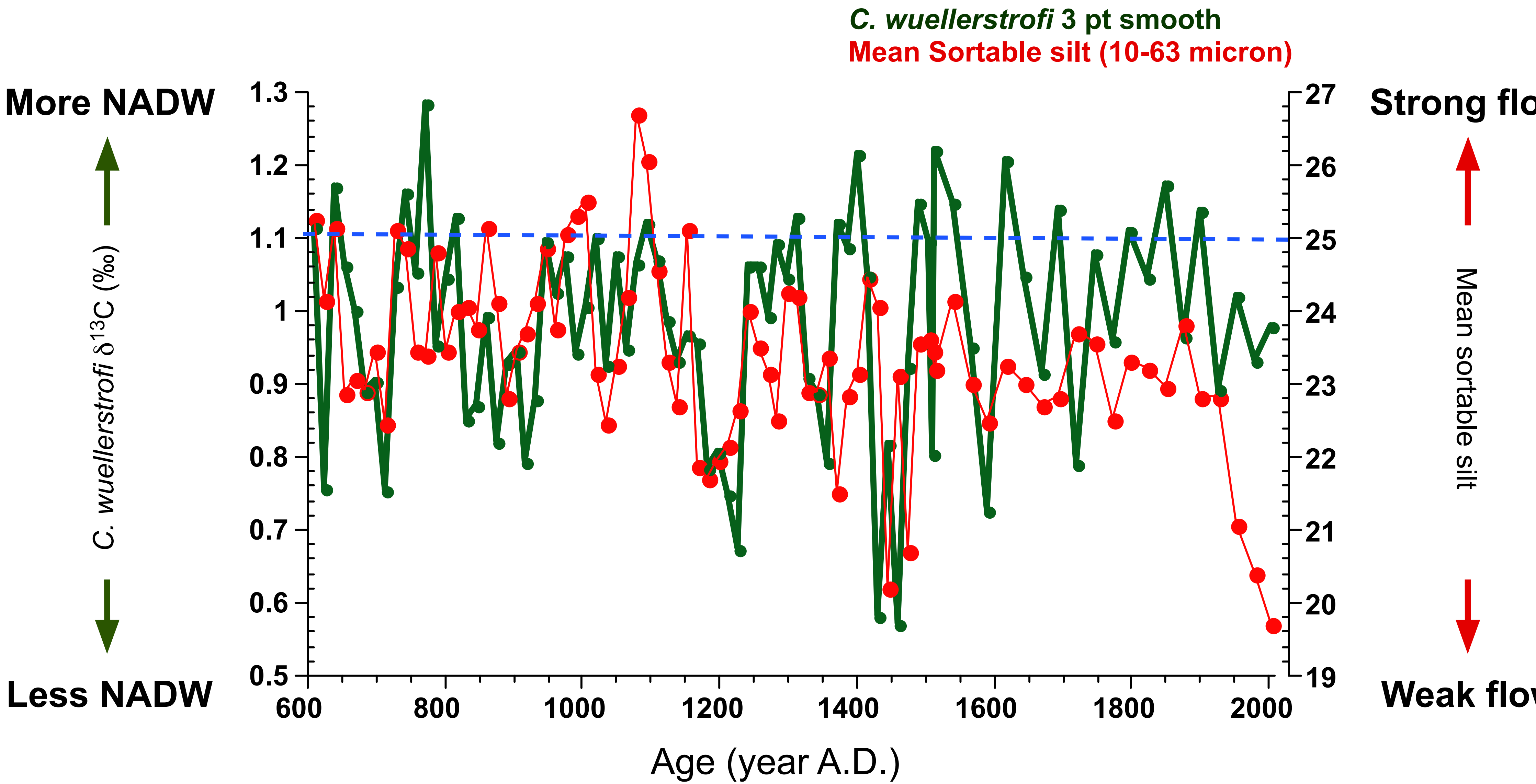




GS06-144-03MC A







flow speed (mean sortable silt)

ventilation (benthic $\delta^{13}C$)

…*climate-circulation phasing TBD*

V flow on Gardar (model) related to ISOW (density&transport)

V flow (model GD) migrates vertically and driven by Nordic Seas changes (
ridge density gradients)[Lohmann et al., 2015; Langehaug et al, 2016]

V ventilation varies on decadal-centennial timescales (DSOW&ISOW)
SPG cold, fresh, *lower density* = weaker BW ventilation & flow (LSW?)
(salinity dominance for buoyancy)

odern BW ventilation ($\delta^{13}C$) near its Holocene peak

- Recent natural variability marked by decreases from modern state.

ltidecadal BW variability through Holocene (intermittent strength), larger
iability on centennial and millennial timescales.
-millennial most prominent (esp. last 8 kyr)
-prominent variability (centennial events) early Interglacials