A southern Portuguese margin perspective of Marine Isotope Stage 47 – an interglacial in the 41 kyr world

Antje H. L. Voelker and Teresa Rodrigues

Instituto Português do Mar e da Atmosfera (IPMA) & Centro de Ciências do Mar (CCMAR), University Algarve, Portugal

Samanta Trotta and Maria Marino

Dipart. di Scienze della Terra e Geoambientali, Università degli Studi di Bari Aldo Moro, Bari, Italy

Henning Kuhnert

MARUM, University Bremen, Germany

antje.voelker@ipma.pt

Supported by:

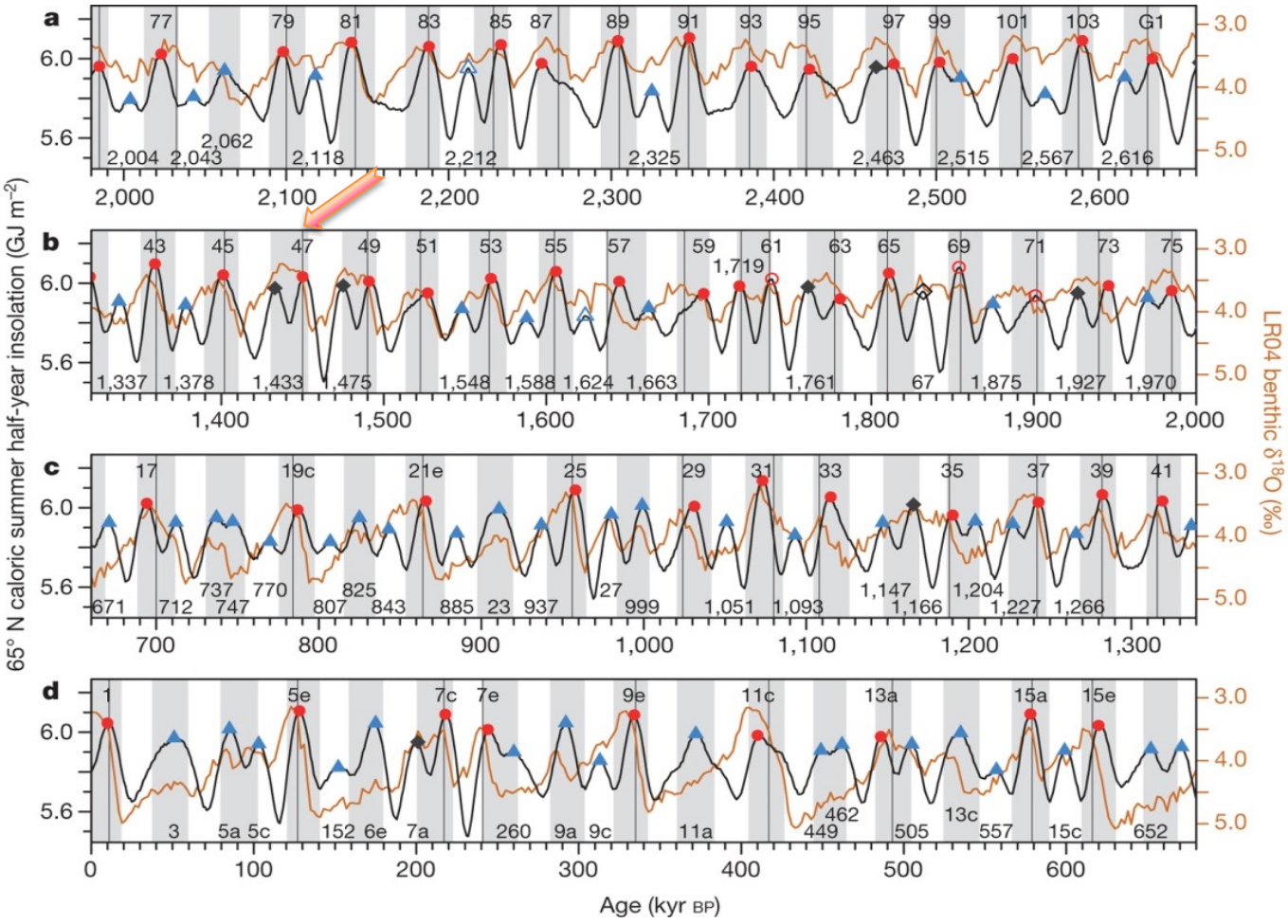
IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM

FCT Fundação para a Ciência e a Tecnologia

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Motivation for the study

Interglacials, continued interglacials and interstadials over the past 2.6 Myr



MIS 47: continued interglacial with two insolation maxima;
sea level about 20 m higher than today (Med Sea)

Red dots: insolation maxima nearest to the onset of interglacials

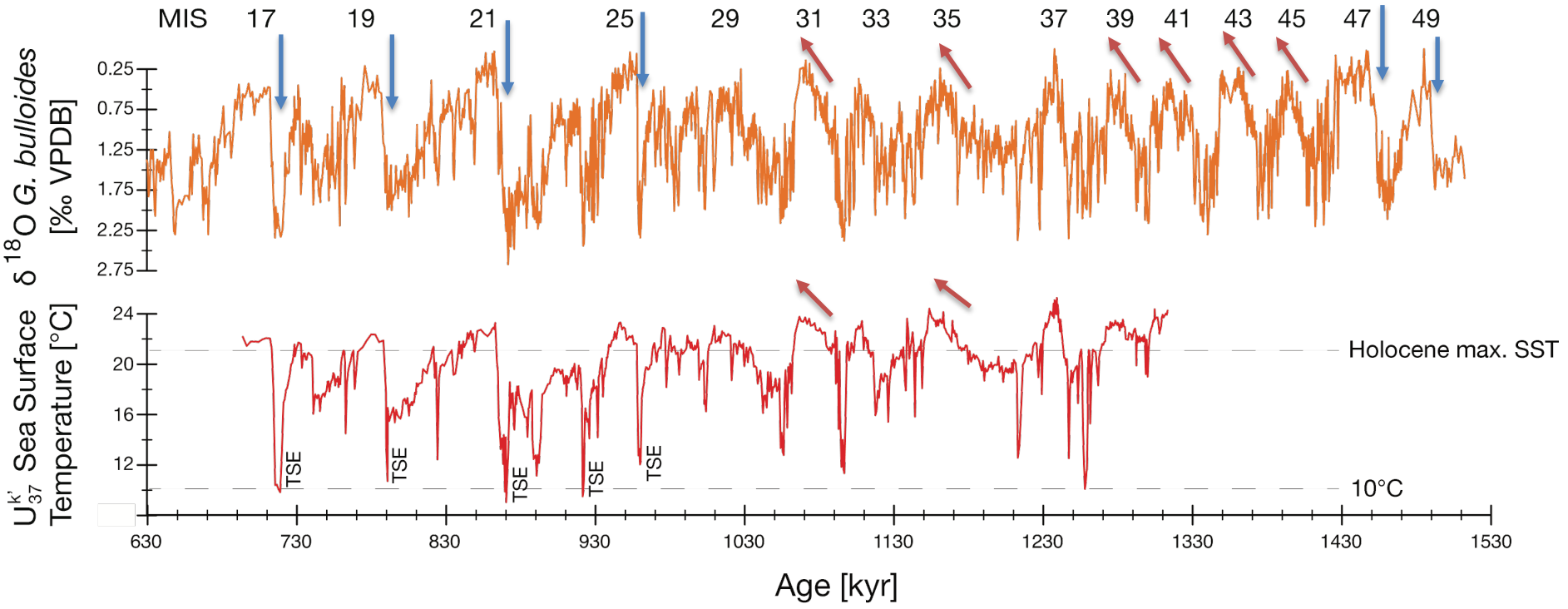
Black diamonds: continued interglacials;

Light blue triangles: interstadials

P C Tzedakis *et al. Nature* **542,** 427–432 (2017) doi:10.1038/nature21364

The IODP Site U1387 middle to early Pleistocene record

MIS 47 is an early Pleistocene interglacial with an abrupt glacial/interglacial transition



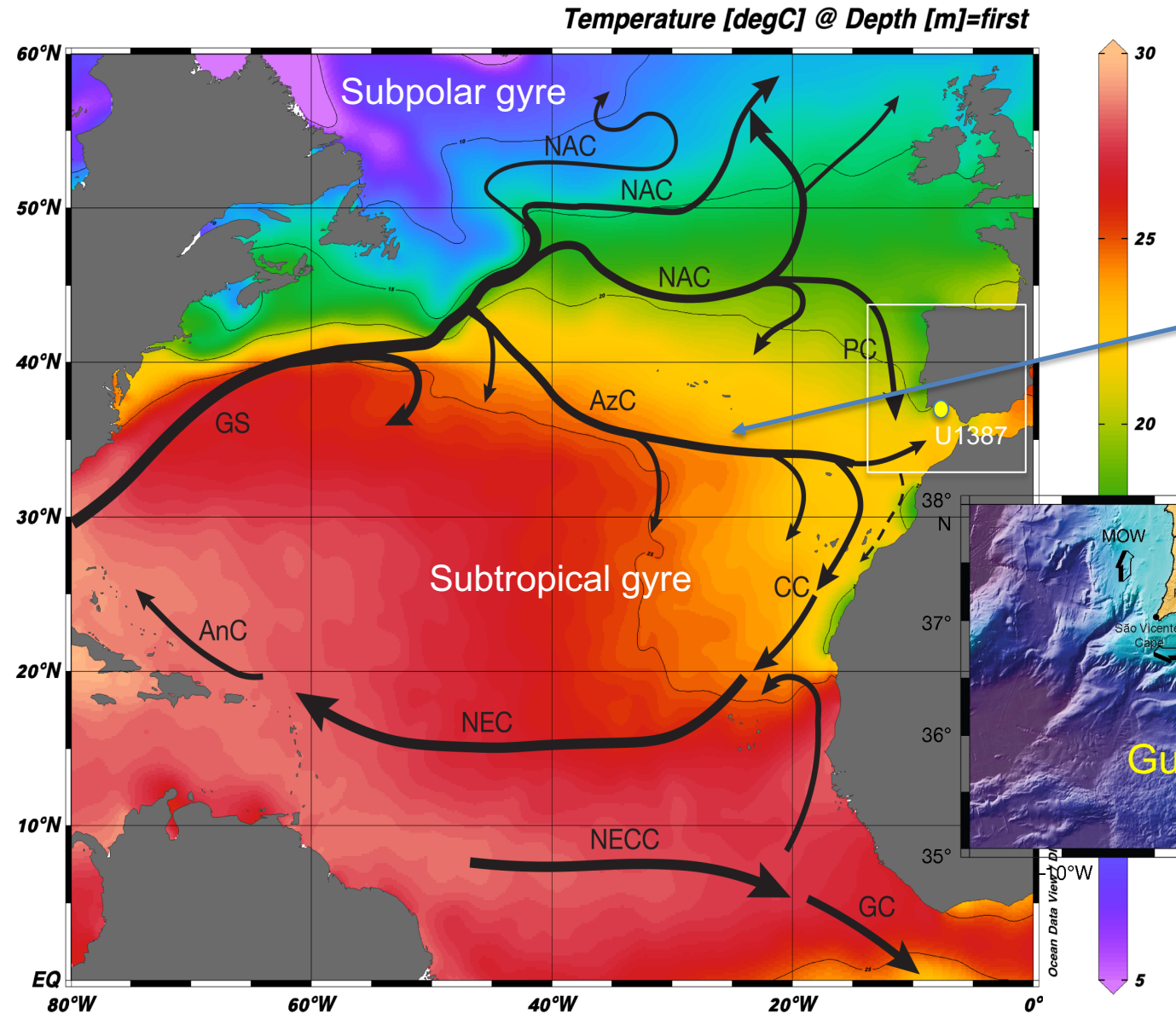
TSE = Terminal Stadial Event (Hodell et al., 2015 GPC)

↓ abrupt transition; maximum interglacial SST at beginning

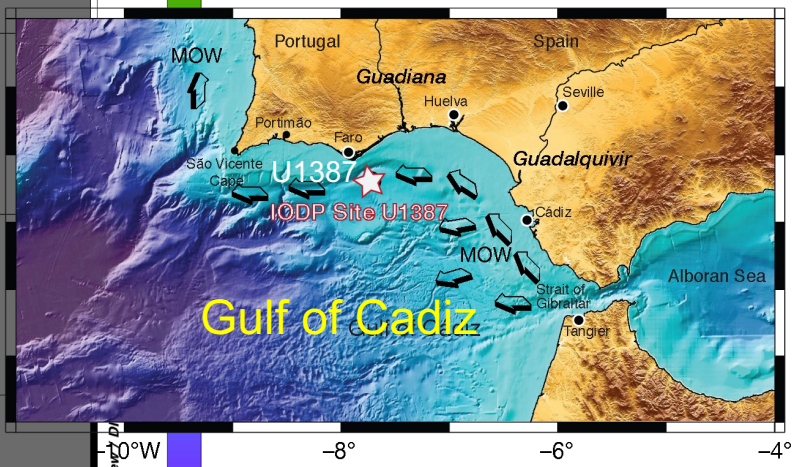
↖ gradual transition; interglacial SST peak later

Voelker et al. (2015 in GPC); Bajo et al. (2020 in Science); Mega et al. (in prep. for Clim. Past); Voelker et al. (in prep.)

Regional Setting of study site – IODP Site U1387



Azores front: more northern position indicates expanded subtropical gyre

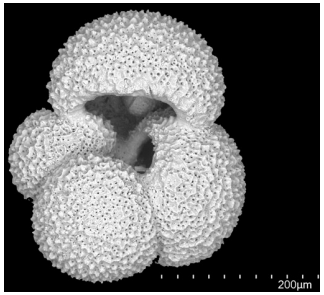


AzC – Azores Current
NAC – N Atlantic Current
PC – Portugal Current
CC – Canary Current

SST data – WOA 2018 July-Sept. 0.25 degree

MOW: Mediterranean Outflow Water

Methods – Proxies for surface water conditions



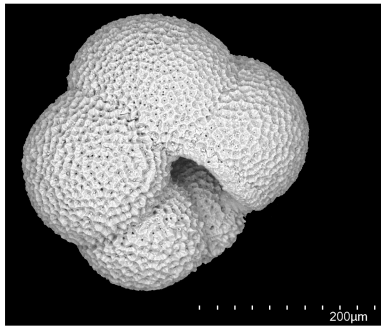
Globigerina bulloides

$\delta^{8}O$ of planktonic foraminifera *G. bulloides*

→ *global signal with local temperature and salinity overprint*

Sea-surface temperature (SST) estimated from $U^{k'}_{37}$ (lipid biomarkers)

→ *annual mean SST*



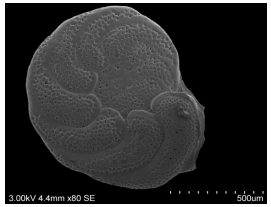
Neogloboquadrina pachyderma

Planktonic foraminifera and coccolith assemblages

→ *(sub)tropical species and warm water taxa: subtropical gyre influence*

→ *N. pachyderma: incursions of subpolar surf. waters*

Methods – Proxies for MOW conditions



Planulina ariminensis

epibenthic foraminifera $\delta^{18}O$ → *local temperature and salinity and global sea level/ continental ice volume*

Cibicidoides pachyderma

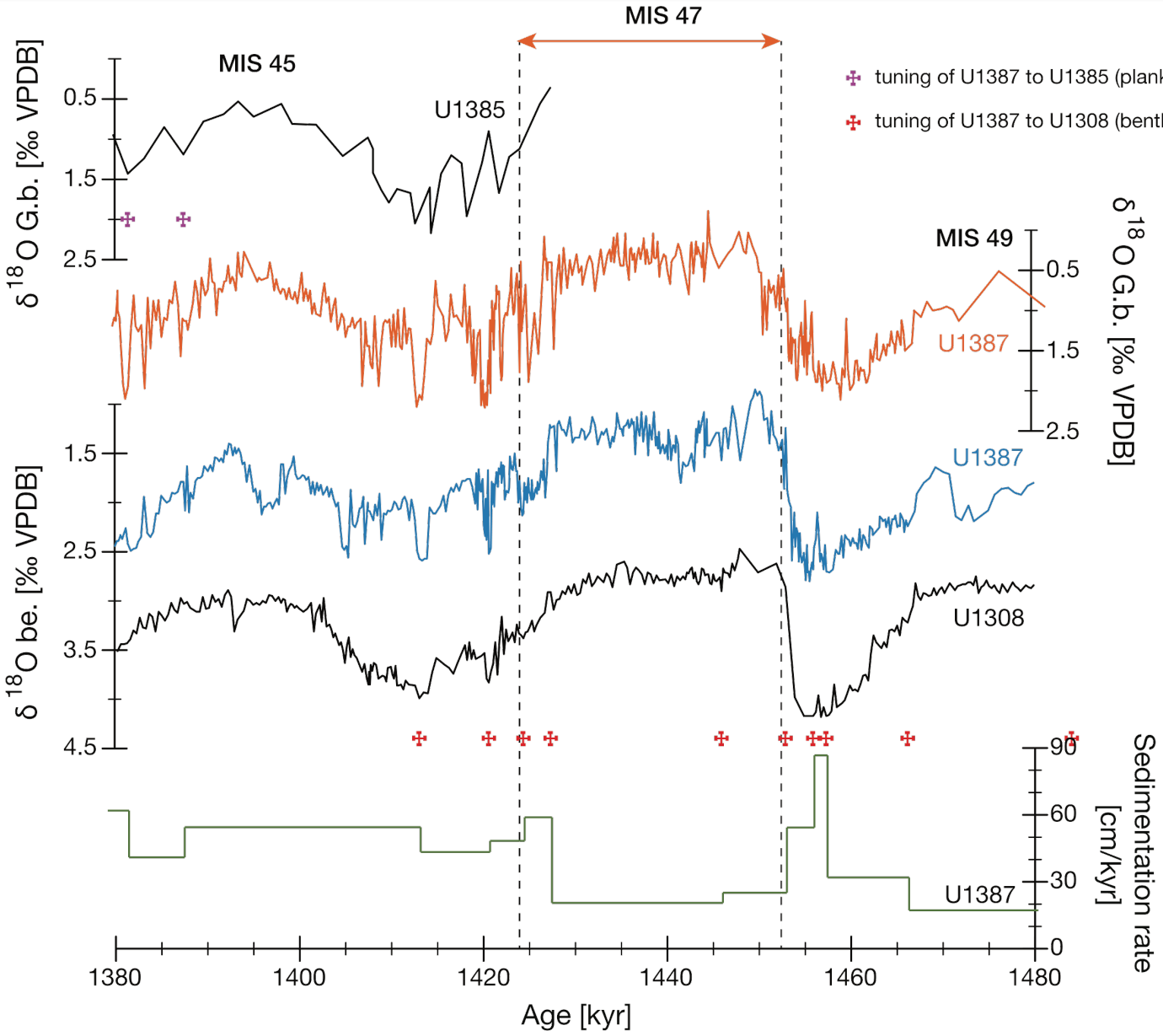
epibenthic foraminifera $\delta^{13}C$ → *MOW ventilation*

weight percent of the sand fraction → *MOW current velocity/ peaks = contourite layer*

(in some levels, this proxy can be biased by gypsum crystals that formed from pyrite oxidaztion after the cores where opened)

Correction of *C. pachyderma* isotope data to *Planulina* levels follows Voelker et al. (2015 in GPC)

Age model construction



MIS 47 age model based on tuning to Site U1308 (LR04 chronology)

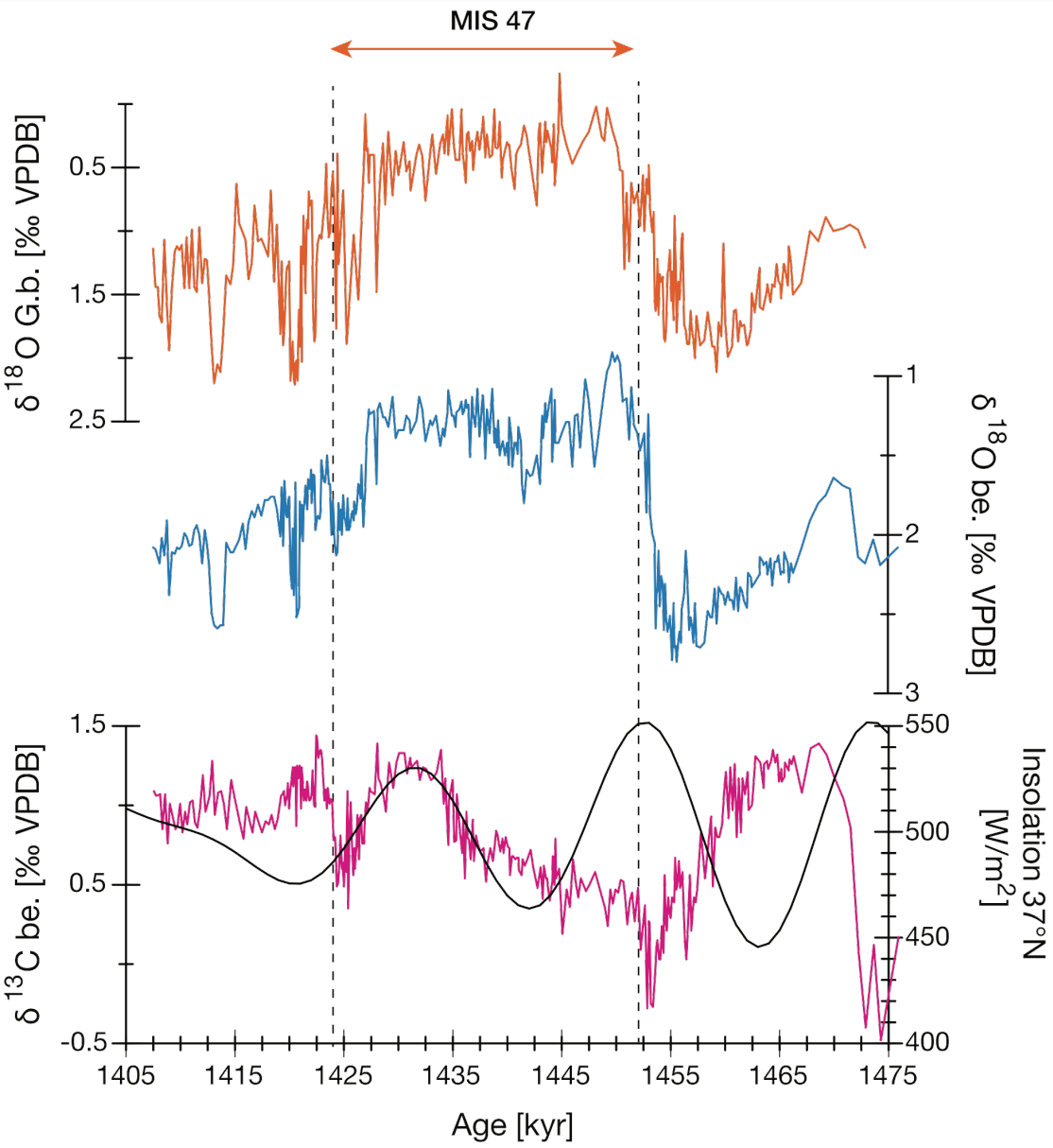
Lower (interglacial) sedimentation rate is similar to MPT interglacials

MPT = Mid-Pleistocene Transition

U1385: Hodell et al. (2015 in GPC)

U1308: Hodell & Channell (2016 in Clim. Past)

High-resolution MIS 47 record at Site U1387



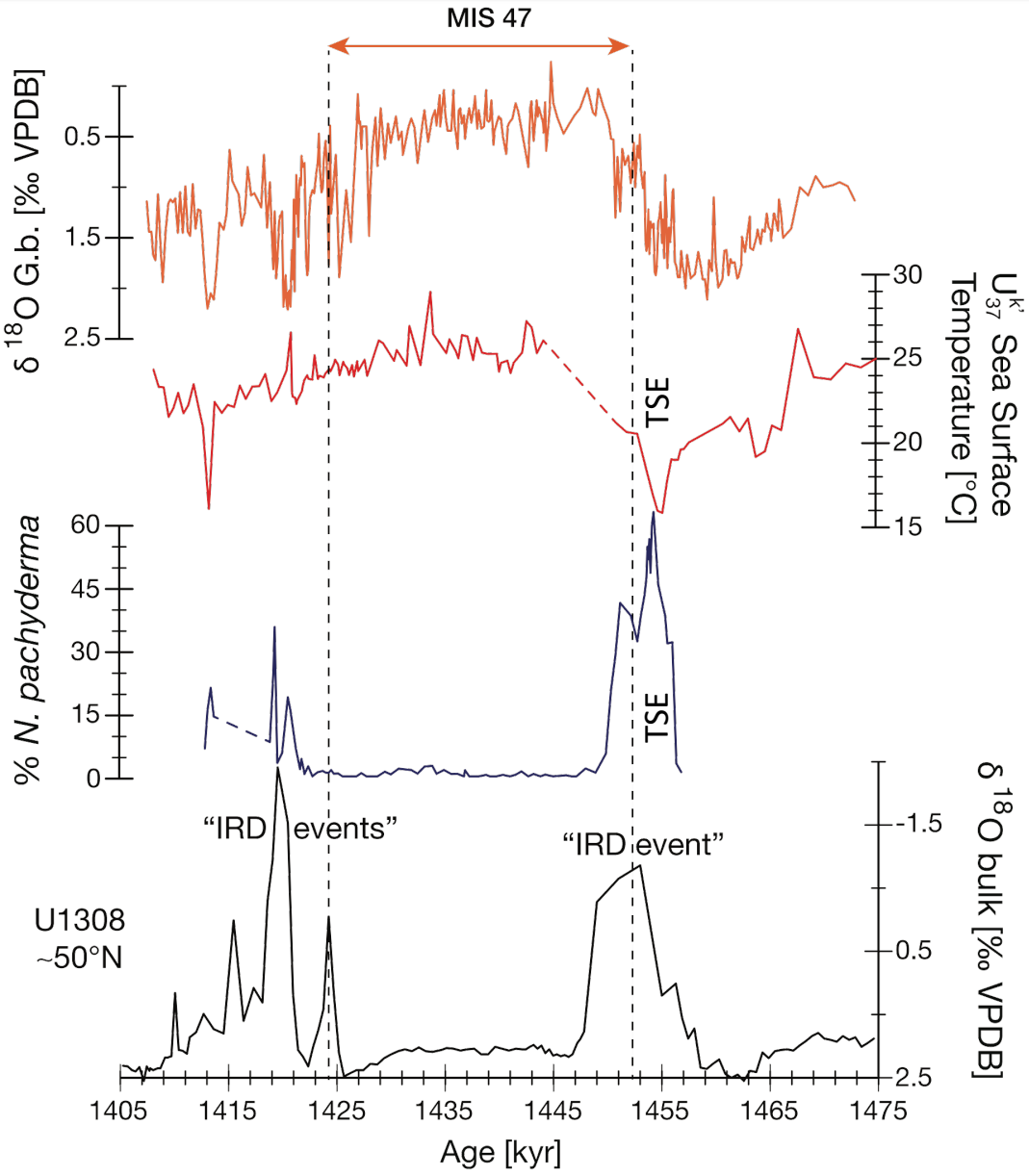
"Abrupt" transition still seen in high-resolution benthic $\delta^{18}O$ record

but

G. bulloides $\delta^{18}O$ record shows step-wise transition. Transition to and MIS 46 have stadial-interstadial oscillations.

Onset of interglacial is marked by an extreme benthic $\delta^{13}C$ minimum (in response to high insolation).

Terminal Stadial Event of MIS 48



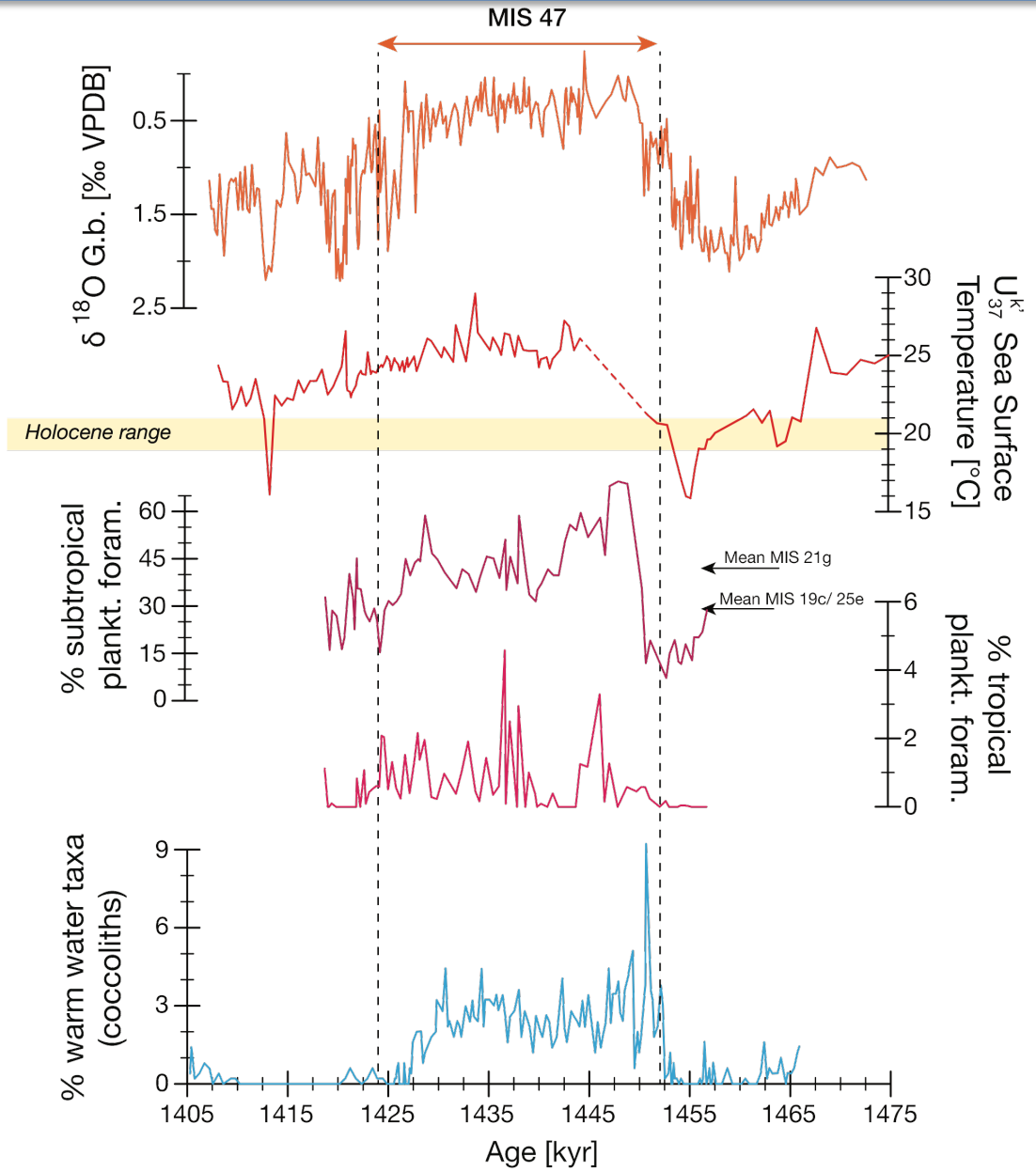
Conform with younger interglacials that had an abrupt glacial/interglacial transition, MIS 48 ended with a terminal stadial event (TSE).

During the TSE SST dropped down to 16°C and the abundance of the polar planktonic foraminifera species *N. pachyderma* increased significantly.

This indicates the advection of subpolar surface waters into the northern Gulf of Cadiz, likely caused by a major meltwater event in the N Atlantic and associated AMOC reduction.

U1308: Hodell & Channell (2016 in Clim. Past)

Interglacial MIS 47 surface water conditions



SST are significantly warmer than during the Holocene and many of the MPT interglacials.

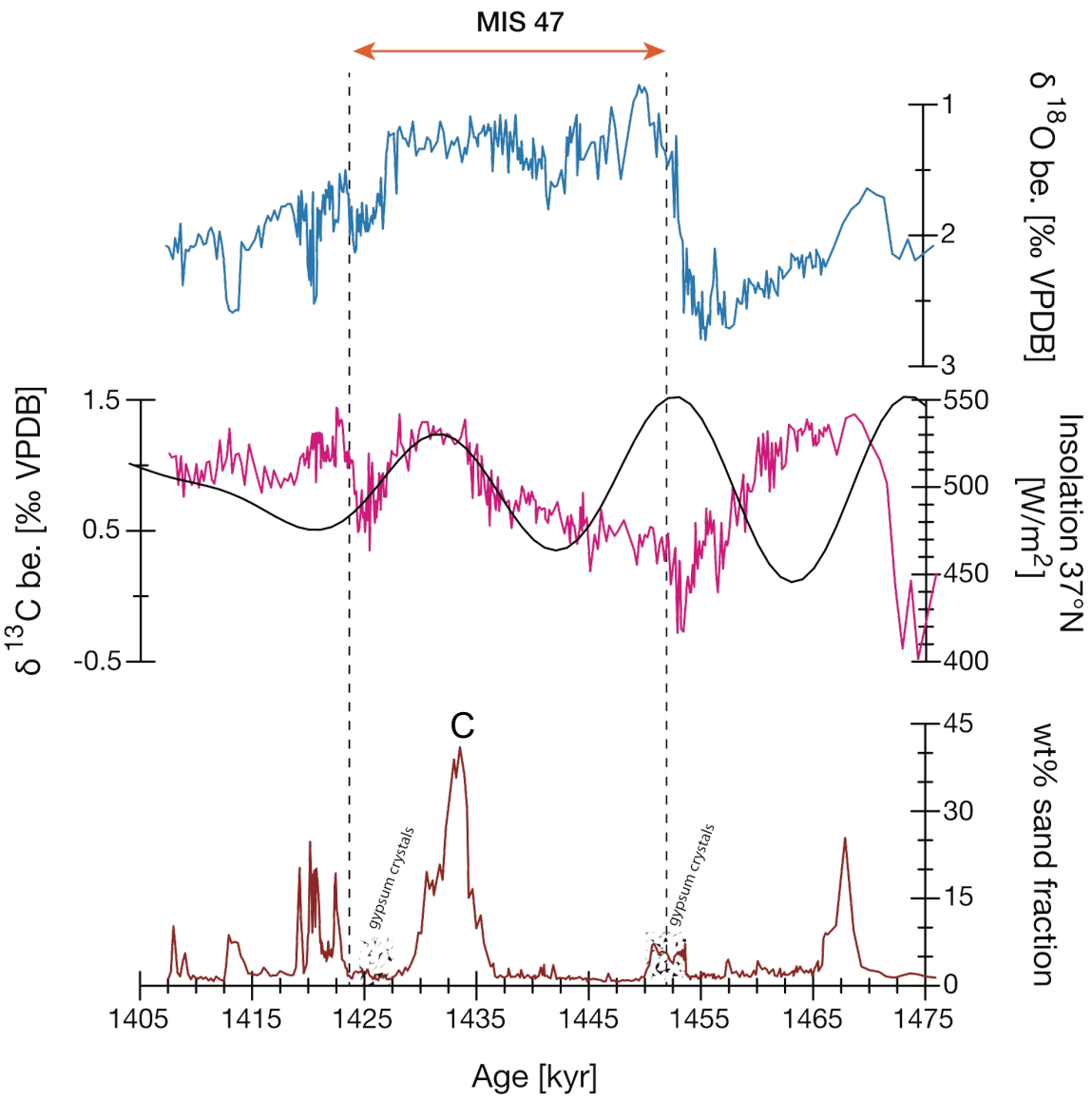
Warmer SST are associated with a major contribution of subtropical planktonic foraminifera species, in particular in early MIS 47. Tropical species, especially deep dwelling *G. crassaformis*, become relevant during some periods.

Coccolithophores respond earlier than planktonic foraminifera, but also record a slight decrease during the middle of MIS 47.

Species data indicates enhanced influence of the subtropical gyre, likely due to a more northern position of the Azores front.

MPT – plankt. foram. data reference: Mega et al. (in prep. for Clim. Past); coccolith data reference: Trotta et al. (in prep.)

MIS 47 MOW record

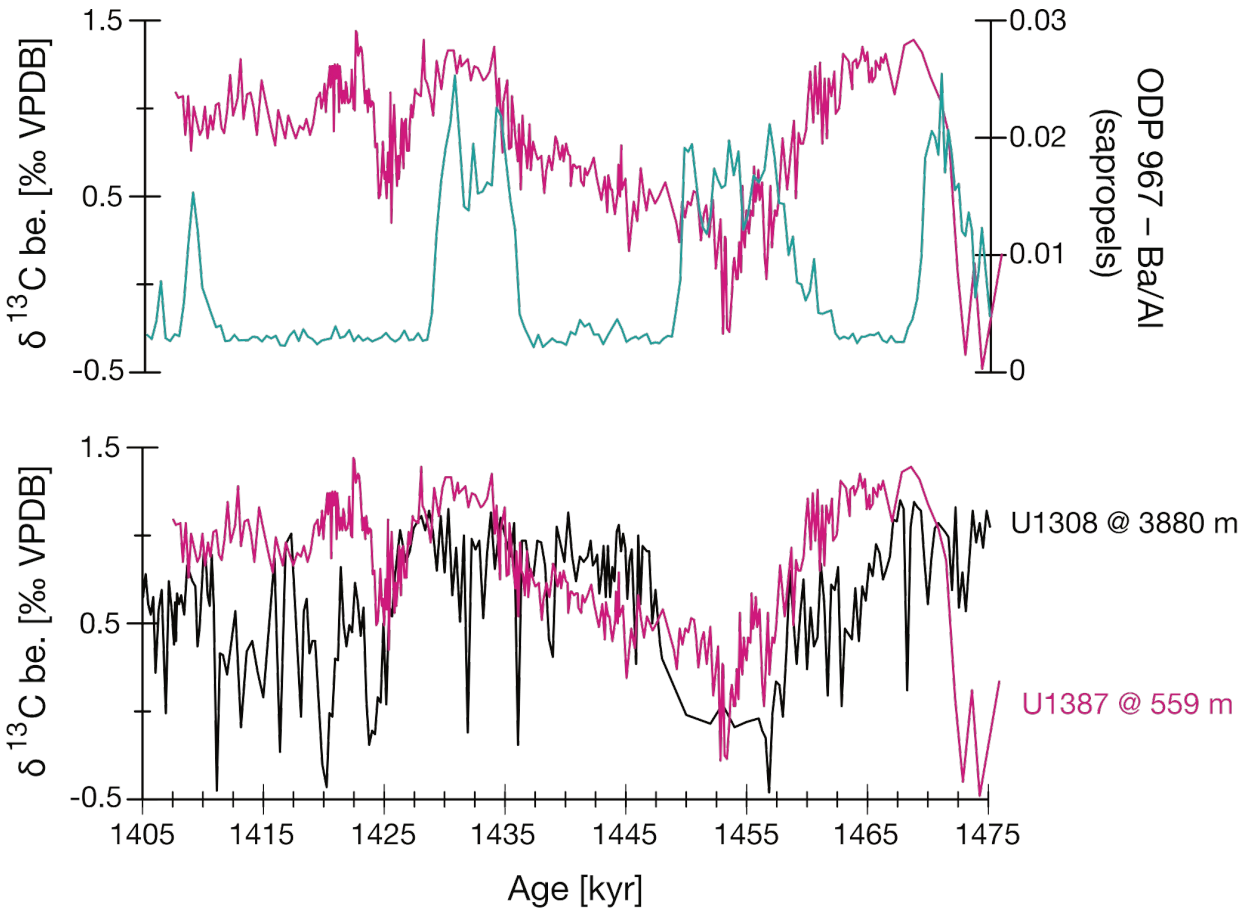


Low benthic $\delta^{13}C$ values indicating a poorly ventilated (oxygen poor) MOW in association with an insolation maximum –and sapropel formation in the Mediterranean Sea- is a common feature through-out the Pleistocene.

However, this does not apply to the 2nd insolation maximum of MIS 47!

The 2nd maximum is actually associated with a well ventilated MOW and the formation of a contourite layer (C; wt% sand peak) indicating a strong MOW bottom current. A similar occurrence was already observed during MIS 31 (Voelker et al., 2015 in GPC).

Understanding the MOW $\delta^{13}C$ signal



(De)coupling between MOW $\delta^{13}C$ signal and sapropel formation in the eastern Mediterranean Sea is shown by comparison with ODP Site 967 record.

2nd $\delta^{13}C$ minimum at end of MIS 47 is concurrent with change in deep N Atlantic ventilation (AMOC reduction) as recorded at Site U1308.

However, the gradual rise in $\delta^{13}C$ values at Site U1387 throughout MIS 47 is a local feature and might be linked to the admixing of generally less well ventilated subtropical waters into the MOW.

ODP Site 967: Grant et al. (2022 in Comm. Earth & Environment) U1308: Hodell & Channell (2016 in Clim. Past)

Conclusions

At Site U1387 on the southern Portuguese margin:

- The MIS 48/MIS 47 transition was associated with an extreme cooling event (terminal stadial event) in the surface waters and a very poorly ventilated MOW at the bottom.
- Interglacial MIS 47 experienced significantly warmer surface waters in regard to absolute SST values and plankton assemblage composition with the planktonic foraminifera fauna being dominated by subtropical and tropical species. All of this points to a stronger subtropical gyre influence in the region than during younger interglacial periods.
- Ventilation of the MOW increased gradually during MIS 47 indicating that the subtropical water influence observed in the surface waters also affected intermediate depths, i.e. admixing of less well ventilated subtropical waters into the MOW.
- During the 2nd insolation maximum a well ventilated and high velocity MOW formed a contourite layer.

Thank you for your attention !

This study will be submitted to MDPI Atmosphere Special Issue
"Earth's Climate Response to Astronomical Forcing" by June 30th, 2022.