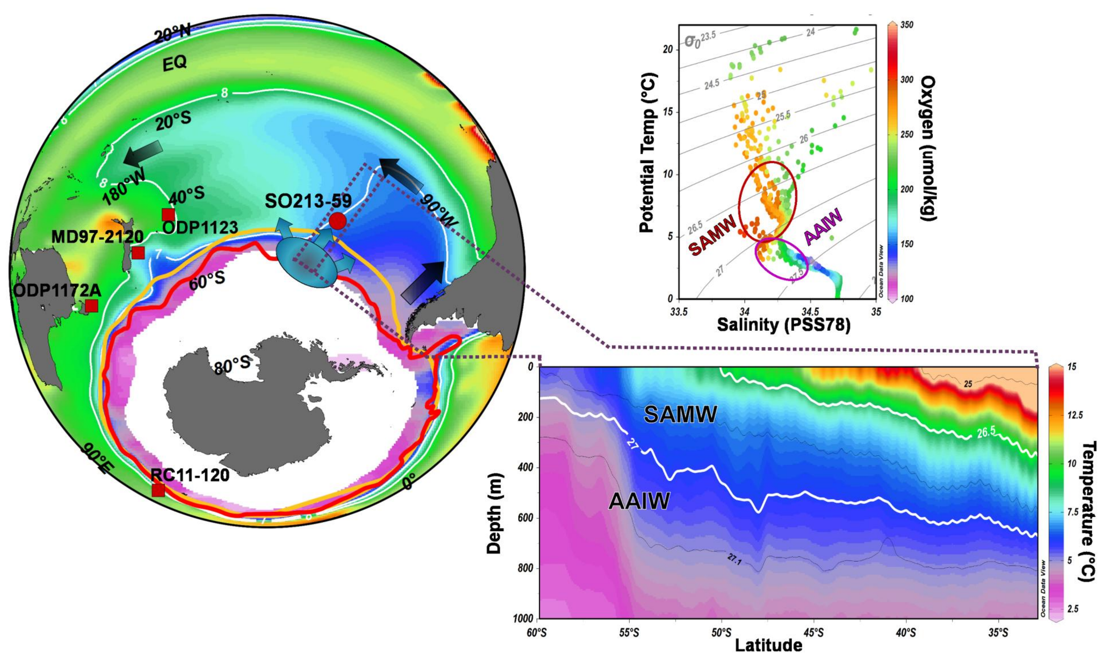
South Pacific intermediate water variability during the Late Quaternary

Raul Tapia[1*], Dirk Nürnberg[1], Ralph Tiedemann[2], Thomas Ronge[2]

[1]GEOMAR, Kiel, Germany.
[2]Alfred-Wegener-Institute for Polar and Marine Research, Bremerhaven, Germany
*rtapia@geomar.de

MOTIVATION

The south Pacific (150°- 70°W) has been identified as a primary site of mode/intermediate water formation. At day, it is widely accepted the major role that mode/intermediate water has in the climate modulation; where the amount and type of mode/intermediate water formed in the Southern Hemisphere affects climate through heat transport/transfer, sequestering atmospheric gases and/or influencing the physical and chemical properties of the upper ocean and equatorial thermocline.



Position of the core SO213-59-2 and similar records recovered from the Southern Ocean (Mashiotta *et al*., 1999; Greaves, 2008; Nürnberg and Groeneveld, 2006; Pahnke *et al*., 2003); modern generalized circulation (arrows), salinity distribution (color shading) and temperature (white lines) observed at 26.9 σ_t (Reid 1997; Herraiz-Borreguero and Rintoul 2010; Iudicone *et al*., 2007). Approximated the area of modern formation of SAMW (yellow line) north to the SAF (red line) in the south Pacific. Purple box denoted the area plotted in water column figures with the physical parameters normally used to identified SAMW and AAIW (eg., potential density (white lines), temperature, oxygen values).

BACKGROUND

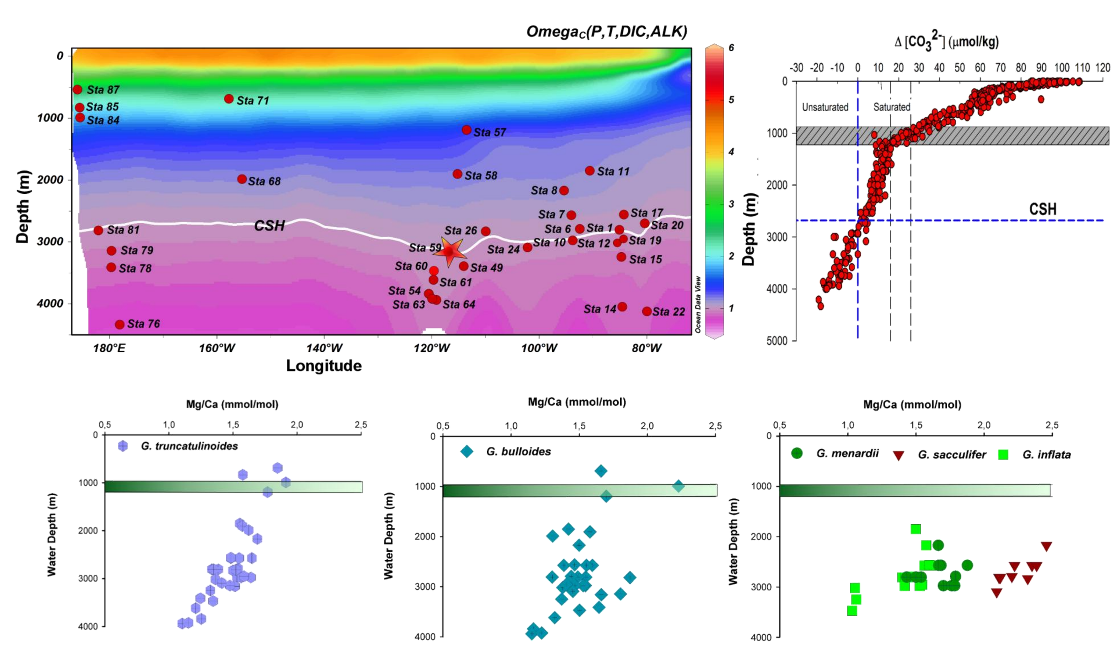
The SubAntarctic Mode water (SAMW) is a homogeneous layer with a σt 26.5 -27.1 extending from near to surface to depths of more than 600 m on the equatorward side of the Subantarctic Front (SAF). The coldest and fresher (denser) variety of SAMW (Antartic Intermediate Water, AAIW) characterized by a subsurface salinity minimum between 600-1100 m is formed in the southeast Pacific being exported to the Atlantic and the Subtropical gyre of the South Pacific (Hanawa and Talley 2001). As a consequence of their formation process SAMW and AAIW can sequester significant quantities of atmospherics gases (Sabine et al., 2004).

Here we present paired measurements of Mg/Ca and stable isotopes from marine sediments retrieved from the Subantarctic Zone (SAZ) in the South Pacific. The main advantage to combine same-sample Mg/Ca and $\delta^{18}O$ analyses is to calculate palaeosalinities using modern $\delta^{18}O_{sw}$–salinity relationships. In order to investigate the SAMW/AAIW evolution and surface ocean temperature and salinity variability along the last two climatic cycles, shallow and deep-dweller planktonic foraminifera were selected. Our deep-dweller foraminifera (G. i*nflata* and G. *truncatulinoides*) monitor the physical and chemical properties of SAMW/AAIW, while the surface-dweller planktonic (*G. bulloides*) monitor the surface ocean.

CORE-TOP

PROXY ASSESMENT

The foraminiferal Mg/Ca signal is affected by calcite dissolution, which causes the selective removal of Mg^{2+} from the biotic calcite, lowers Mg/Ca, and decreases SSTMg/Ca (Regenberg *et al*., 2006; Dekens *et al*., 2002). In order to evaluate the reliability of the South Pacific Mg/Ca signal for paleotemperature reconstructions, we defined the effect of the calcite saturation state (CSH, $\Delta[CO_3^{2-}] = 0$) on foraminiferal Mg/Ca for selected planktonic species. The total Mg/Ca values preserved in the foraminiferal calcite from the core top samples ranged from ~2 to 1.3 mmol/mol. Notably, only G. *truncatulinoides* Mg/Ca ratios with increasing water depth.



Depth position of the sediment samples in relationship to the Calcite saturation (Ώ calcite). The calcite saturation was calculated for the transect P06 2003, calculated from DIC and alkalinity data taken from the CARINA database (Tanhua *et al* ., 2008). Illustration done with Ocean Data View 4 (Schlitzer, 2009). Ώ calcite = 1 countour is highlighted to show the extrapolated depth of the Compensation Saturation Horizon (**CSH**). The selective Mg2+ removal already starts below the critical $\Delta[CO_3^{2-}]$ values of ~16-26 µmol/kg (shaded area, Regenberg *et al.* 2006); Mg/Ca ratios (355-400 µm size fraction) versus water depth for relevant planktonic foraminifera (*e.g*., G. *bulloides*, G. *truncatulinoides*). Star denoted the position of the core SO213-59-2 (Sta59). Necessary data to calculate the in situ $[CO_3^{2-}]$ were obtained from the World Ocean Circulation Experiment (WOCE) section P6 and calculated using the program of Robins *et al*. (2010) developed for CO2 System Calculations. $[CO_3^{2-}]$ at saturation was calculated after Jansen *et al*., (2002).

DOWN -CORE RECONSTRUCTION

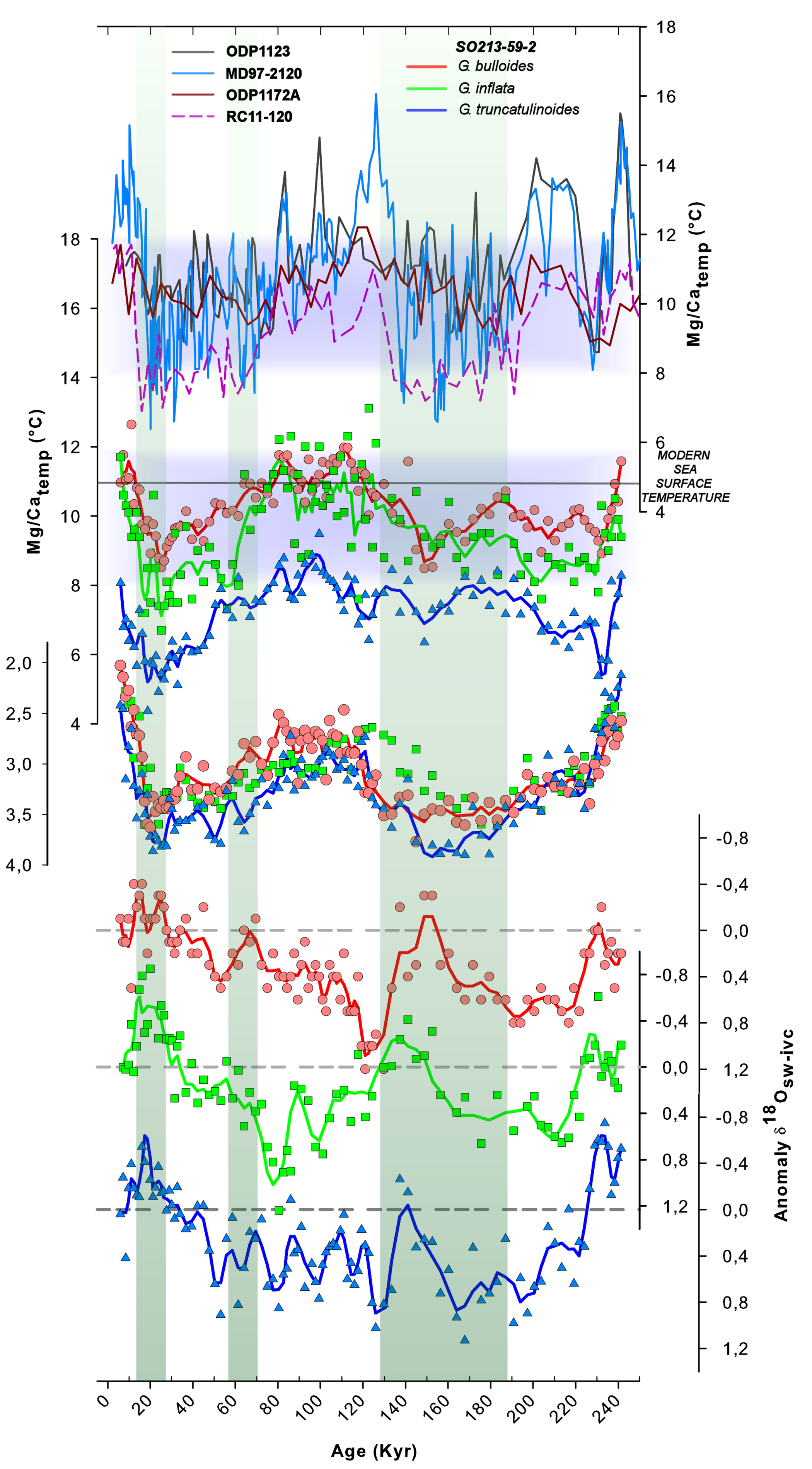
TEMPERATURE

The sea surface temperature record (G. *bulloides)* from the East Pacific Rise: So213-59-2 (3164 m) ranged from ~12° to ~8°C similar in absolute values with other record comparable southern latitudes: MD92-2120 (1210 m; Pahnke *et al*., 2003) and ODP 1123 (3290 m; Greaves, 2008) from Chattham Rise; ODP Site 1172A from East Tasman Rise (2600 m; Nürnberg & Groeneveld, 2006), RC11-120 from the subantarctic Indian Ocean (3135 m; Mashiotta *et al*., 1999). In the other hand, the subsurface temperatures record derived from G. *inflata* (green) and G. *truncatulinoides* (blue) ranged from 7° to 11° C and 5 to 8 °C, respectively.

SALINITY

A general scenario of glacial low-salinity versus interglacial high-salinity conditions can be observed along the water column in comparison with modern values.

Both, G. *bulloides* (red circles) and G. *inflata* (green squares) show a maximum in salinity in MIS 5 and two peaks of low salinity during MIS 2 and MIS 6; in G. *truncatulinoides* (blue triangles) a low salinity peak in MIS 6 is not clearly defined.



CONCLUSION

- Our results with a increase in the production of AAIW during glacial is consistent with some model simulations (Liu *et al*., 2002) and observations in the Eastern South Pacific (Muratli *et al*. , 2010). However, this results are not consistent with a glacial decrease in production of AAIW inferred from sediments records recovered in the western Pacific .
- The difference in severity during MIS 2 (colder/fresher) and MIS 6 (warmer/saltier) recorded in ours deeper monitors suggest a relevant change in advection process and/or formation areas of the water feeding the middle depth circulation in the South Pacific .

REFERENCES

Deckens *et al*., 2002. Geochem. Geophys. Geosyst., doi:10.1029/2001GC000200**; Greaves M., 2008.** PhD Thesis University of Southampton; **Hanawa & Talley** , 2001. Mode Waters. In: SiedlerG, Churcgh J, Gould J 8eds) Ocean circulation and climate international geophysics series; **Herraiz-Borreguero & Rintoul**, 2010. Ocean Dynamics, doi: 10.1007/s10236-010-0352-9; **Iudicone *et al***., 2007. J. of Phys. Oceang., doi: 10.1175/JPO2985.1; **Jansen *et al***., 2002. Global Biogeochem. Cycles, doi:10.1029/2000GB001279; **Liu *et al***., 2002. Geophysical Research Letters, doi:10.1029/2001GL013938; **Mashiotta *et al***., 1999. Earth and Planetary Science Letters 170 417–432; **Muratli *et al***., 2009. Nature Geoscience, doi:10.1038/NGEO715; **Nürnberg & Groeneveld**, 2006. Geochem. Geophys. Geosyst., doi:10.1029/2005GC000984; **Regenberg *et al***., 2006. Geochem. Geophys. Geosyst., doi:10.1029/2005GC001019; **Pahnke *et al***., 2003. Science; doi: 10.1126/science.1084451; **Reid.**, 1997. Prog Oceanog ., PII: S0079/-6611(97)00012-8;**Robbins**, ***et al***., 2010. U.S. Geological Survey Open-File Report 2010–1280; **Sabine *et al***., 2004. Science, doi; 10.1126/science.1097403;**Schlitzer**, 2009. Ocean Data View software. /http://odv.awi.de/S; **Tanhua *et al*.,** 2008. CARINA Data Synthesis Project, ORNL/CDIAC-157, NDP-091. Carbon Dioxide Information Analysis Center. Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee. doi:10.3334/CDIAC/otg.ndp091.