# A calibration study of Sr/Ca ratios and $\delta^{18}O$ to sea surface temperature and salinity in the West Pacific Warm Pool

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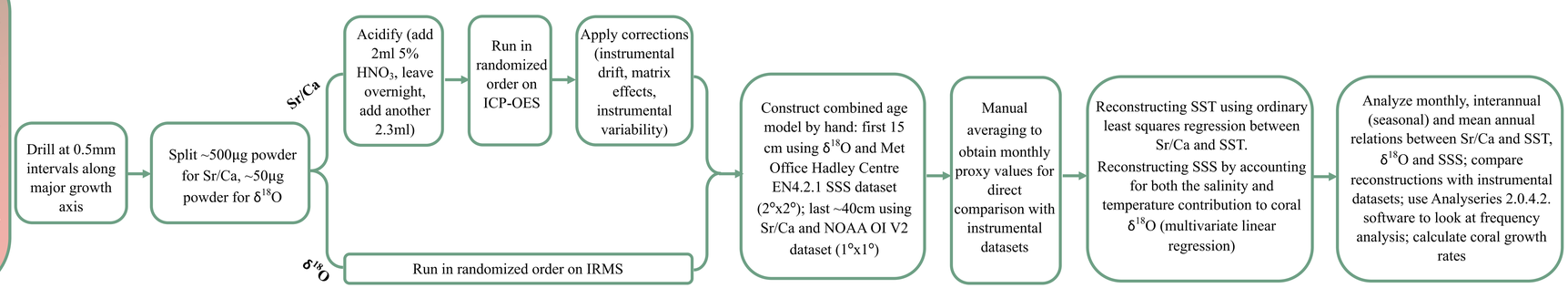
## 1. INTRODUCTION

- The West Pacific Warm Pool (WPWP) is the warmest large water body on the planet, with sea surface temperatures (SST) higher than 28ºC year-round, characterized by intense evaporation and rainfall.
- Several climate models have simulated that centennial SST variability in the WPWP is out-of-phase with eastern tropical Pacific and South China Sea. However, this variability is impossible to resolve with instrumental satellite records, only covering the last ~30 years.
- Paleoclimate archives, such as coral cores, provide proxy records for SST and sea surface salinity (SSS) for long intervals back in time, which can resolve the problem.
- Here we use a *Porites lutea/lobata* core collected in Fall 2012 from Kosrae Island, Federal States of Micronesia.
- Variations in SST are investigated by using Sr/Ca ratios in the coral skeleton, which have been shown to be inversely related to temperature.
- Changes in salinity are assessed by looking at coral $\delta^{18}O$. By accounting for the temperature signature using the Sr/Ca measurements, the $\delta^{18}O$ record is used to reconstruct SSS.
- The coral proxies are calibrated to instrumental data between 1982 and 2012 (top ~55cm of the core).

## 2. METHODOLOGY




## 3. RESULTS

- Strong correlations are found between Sr/Ca and SST at monthly and interannual timescales between 1996 and 2012 (Table 1), with regressions becoming weaker when considering the entire 30-year interval (1982-2012).
- Coral Sr/Ca captures extreme events, such as the large classic El Niños of 1982-1983 and 1997-1998, but the very cold winters of El Niño Modoki (EM) events in 1992 and 1993 are poorly represented (Figure 1).
- Coral Sr/Ca shows strong seasonal cycle (1-yr periodicity dominant—Figure 5) but has systematic offsets to SST at decadal timescales (Figure 3). This low-frequency offset is exacerbated by the reduced SST variability.
- Monthly, seasonal and annual SSS variability is clearly captured by coral $\delta^{18}O$ between 2005 and 2012 (Figure 2), despite a very limited seasonal range (0.5‰).

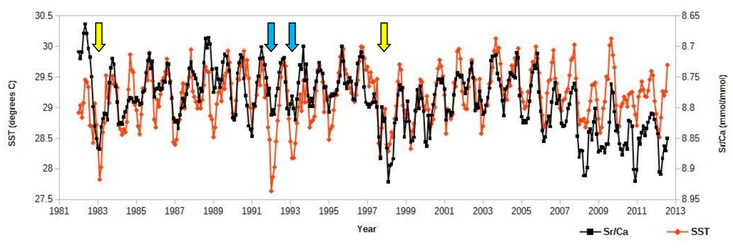



*Figure 1. Time series of monthly variations in coral Sr/Ca and instrumental SST between 1982 and 2012. Yellow arrows indicate the 1982-1983 and 1997-1998 ENSO events. Blue arrows indicate the extremely cold 1992 and 1993 years, not captured by coral Sr/Ca.*

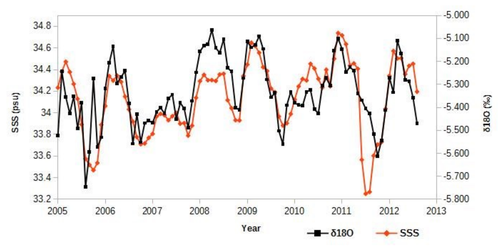



*Figure 2. Time series of monthly variations in coral $\delta^{18}O$ and instrumental SSS between 2005 and 2012.*

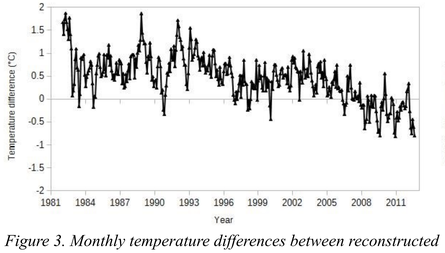



*Figure 3. Monthly temperature differences between reconstructed and instrumental SST between 1982 and 2012.*

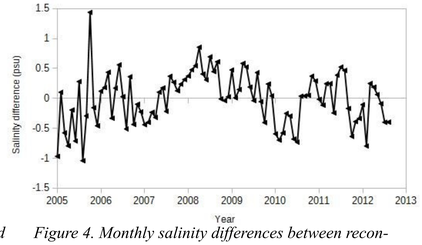



*Figure 4. Monthly salinity differences between reconstructed and instrumental SSS between 2005 and 2012.*

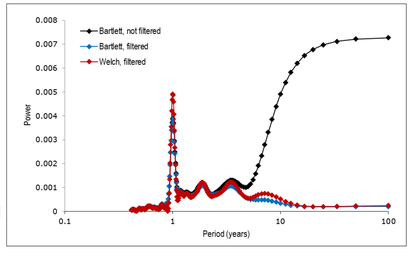



*Figure 5. The results of three frequency analysis tests conducted with Analyseries software using: a Bartlett window and the unfiltered Sr/Ca record (black line); a Bartlett window and applying a filter with frequency 0.01 and bandwidth 0.05 (blue line); a Welch window and filtering the record at frequency 0.05 and bandwidth 0.08 (red line).*

*Table 1. Ordinary least squares (OLS) regressions of Sr/Ca against SST and $\delta^{18}O$ against SSS at monthly, interannual (summer/wet season and winter/dry season) and annual time scales.*

| $\frac{Sr}{Ca} = m * SST + b$ | | | | | | |
|---|---|---|---|---|---|---|
| | m (slope) | 1σ error (m) | b (y-intercept) | 1σ error (b) | $r^2$ | p |
| **Monthly (1996-2012)** n=200 | -0.084 | ±0.006 | 11.278 | ±0.177 | 0.49 | <<0.0001 |
| **Summer (1996-2011)** n=16 | -0.114 | ±0.026 | 12.148 | ±0.790 | 0.56 | 0.0007 |
| **Winter (1996-2012)** n=17 | -0.114 | ±0.033 | 12.124 | ±0.947 | 0.44 | 0.003 |
| **Annual (1996-2011)** n=16 | -0.131 | ±0.034 | 12.646 | ±0.986 | 0.52 | 0.0016 |
| $\delta^{18}O = m * SSS + b$ | | | | | | |
| | m (slope) | 1σ error (m) | b (y-intercept) | 1σ error (b) | $r^2$ | p |
| **Monthly (2005-2012)** n=92 | 0.304 | ±0.033 | -15.729 | ±1.117 | 0.49 | <<0.0001 |
| **Summer/wet (2005-2011)** n=7 | 0.236 | ±0.060 | -13.473 | ±2.032 | 0.75 | 0.01 |
| **Winter/dry (2005-2012)** n=8 | 0.330 | ±0.160 | -16.594 | ±5.523 | 0.41 | 0.08 |
| **Annual (2005-2011)** n=7 | 0.367 | ±0.150 | -17.881 | ±5.131 | 0.54 | 0.058 |

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## 4. DISCUSSION AND CONCLUSIONS

- Limited correlations between Sr/Ca and SST over the entire interval are most probably due to reduced SST variability at the site (1-1.5º seasonal cycle).
- Steep calibration slopes between Sr/Ca and SST indicate that the coral is not affected by bio-smoothing, possibly due to extremely high growth rates, averaging 17.6 mm/yr over 30 years.
- Discrepancies between coral Sr/Ca and SST could be due to large spatial averaging in the satellite datasets (improved correlations are obtained when considering a 1ºx1º dataset rather than a 2ºx2º one).
- SST reconstructions on multiannual timescales are affected by the dampened coral response to El Niño Modoki (EM) events (cooler in the satellite dataset compared to conditions experienced by the coral) during 1989, 1992 and 1993.
- The EM event in 2011 (represented by SSS data as increased rainfall in eastern WPWP) shows less negative coral $\delta^{18}O$ (higher SSS) compared to instrumental data, also implying dampened coral response to EM years.
- Future steps will involve generating $\delta^{18}O$ measurements back to 1982 and investigating the effect of dataset resolution on SSS reconstructions.
- The overall future project will include generating Sr/Ca and $\delta^{18}O$ records for the entire core, going back ~250 years.