

Supplementary Material

Records Segmentation methodology

The G/B composite time series used for record segmentation analysis was created using four coral G/B records, *i.e.* MASB, MAS1, MAS3 and ANDRA. Prior to averaging the G/B measurements, we subtracted the mean 1961 - 1990 G/B value from each record. For the part of the record where the composite record consists of all four cores (1930 – 2006.75), the average standard error was 0.010 units. For the part of the record where the composite record is composed of three coral records (1914 – 1930), the standard error was 0.013 units. For the part of the record where the composite record is only composed of two coral records (1904 – 1914), the standard error was 0.012 units.

To detect shifts in the G/B composite, PDO index and SST time series, we applied a segmentation analysis (Fig. C1). Webster (1973) proposed to divide a given time series into relatively (statistically) homogeneous segments. In order to do so, a window, split about its midpoint, is moved along the sequence, from one end to the other, while at each position in the record the two halves are statistically compared by calculating the D^2 statistic, *i.e.* the Mahalanobis distance. In the next step, the D^2 statistic is plotted as ordinate against the window midpoint position, thereby indicating division points in the time series as local maxima (Webster, 1973 and Webster, 1980). We here chose a window size of 20 years, hence comprising two half windows of each 10 years, allowing us to detect points of maximum change at decadal time scales (Webster, 1980). Given our record has a monthly time resolution, $10 \times 12 = 120$ points comprise the half window size. This means that at every point in

the time series we compare the statistics of 120 points backward to the statistics of a window of 120 points forward. We apply the segmentation analysis predominantly to detect points at which a major transition takes place in the G/B, PDO and SST time series. Although the 95% significance of the D^2 statistic is reached at a level of $D^2 = 0.05$, it is important to note that it is not the absolute value but rather the local maxima which should be considered as the transitions or change point in the time series. Finally, we note that, given the window size of 2×10 years, we are not able to interpret change points in the first and the last 10 years of the time series.

References

- Webster, R.: Automatic Soil-Boundary location from transect data, Mathematical Geology, Vol. 5, No.1, 1973.
- Webster, R.: Divide: A FORTRAN IV program for segmenting multivariate one-dimensional spatial series, Computers and Geosciences, 6, 61-68, 1980.

Supplementary Table

a) G/B

CORE NAME	n (months)	Mean	SD	Range	Max.	Min.
MAS1	1234	0.93	0.03	0.24	1.08	0.84
MAS3	922	0.92	0.03	0.17	1.01	0.84
MASB	3601	1.05	0.04	0.41	1.35	0.94
ANDRA	1112	0.89	0.03	0.17	0.98	0.81

b) Ba/Ca ($\mu\text{mol mol}^{-1}$)

CORE NAME	n (months)	Mean	SD	Range	Max.	Min.
MAS1	1234	5.61	0.77	7.12	10.06	2.94
MAS3	857	5.28	0.65	6.80	9.88	3.08

c) Mn/Ca ($\mu\text{mol mol}^{-1}$)

CORE NAME	n (months)	Mean	SD	Range	Max.	Min.
MAS1	1234	0.84	0.26	2.13	2.44	0.31
MAS3	857	0.94	0.67	8.46	8.70	0.24

Table S01. Statistical description of coral proxy data for MAS1, MAS3, MASB and ANDRA. The mean, standard deviation (SD), range, maximum value (Max.) and minimum value (Min.) were calculated from the monthly interpolated data of G/B (a), Ba/Ca (b) and Mn/Ca (c), covering the individual core period (n). Geochemical data only exists for MAS1 and MAS3.

Figure S01

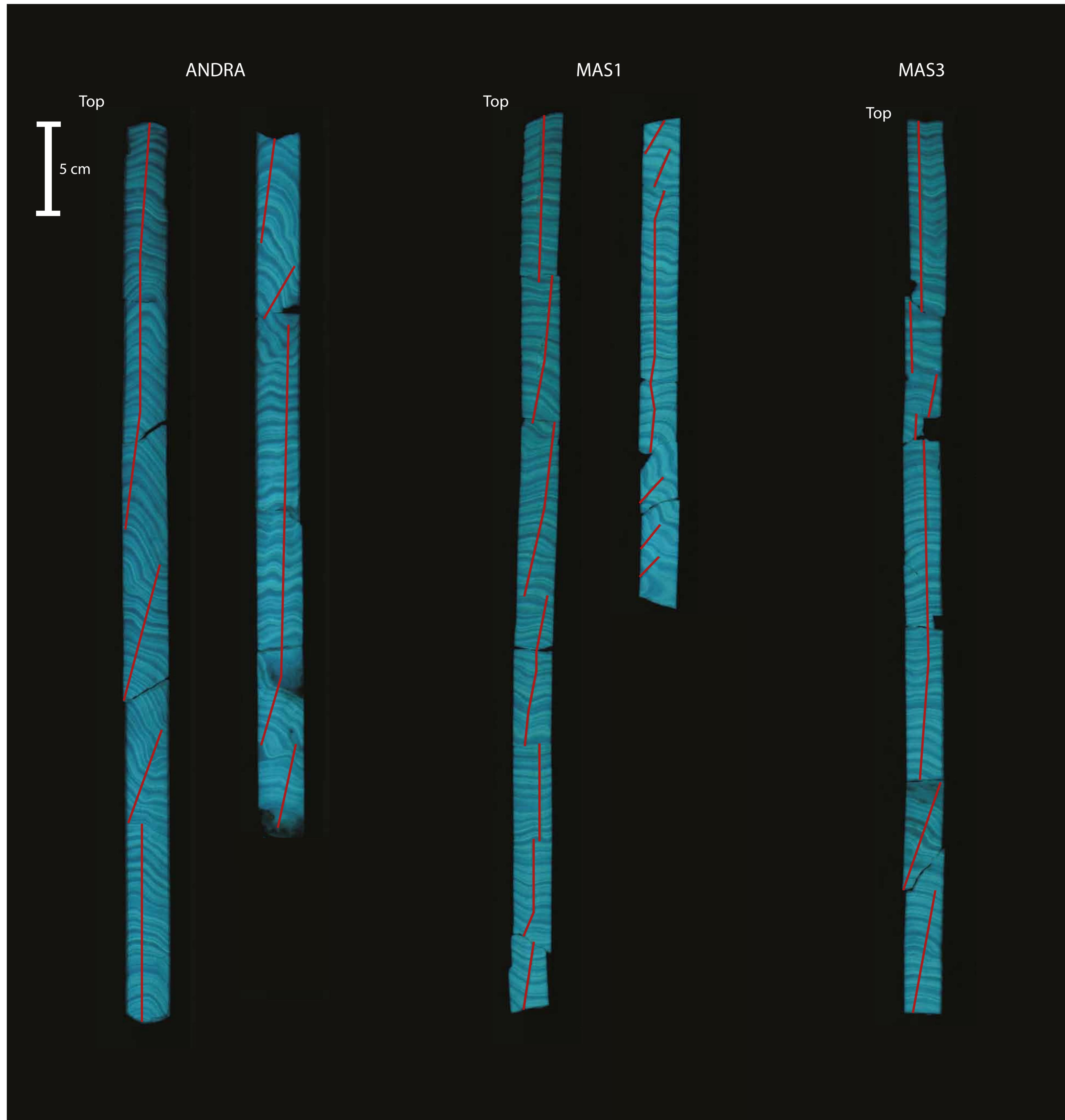


Figure S01. Photoluminescence image of coral cores ANDRA (left), MAS1 (middle) and MAS3 (right) taken using the Spectral Luminescence Scanning (SLS) technique. The red lines indicate transects used to extract the down-core luminescence data.

Figure S02

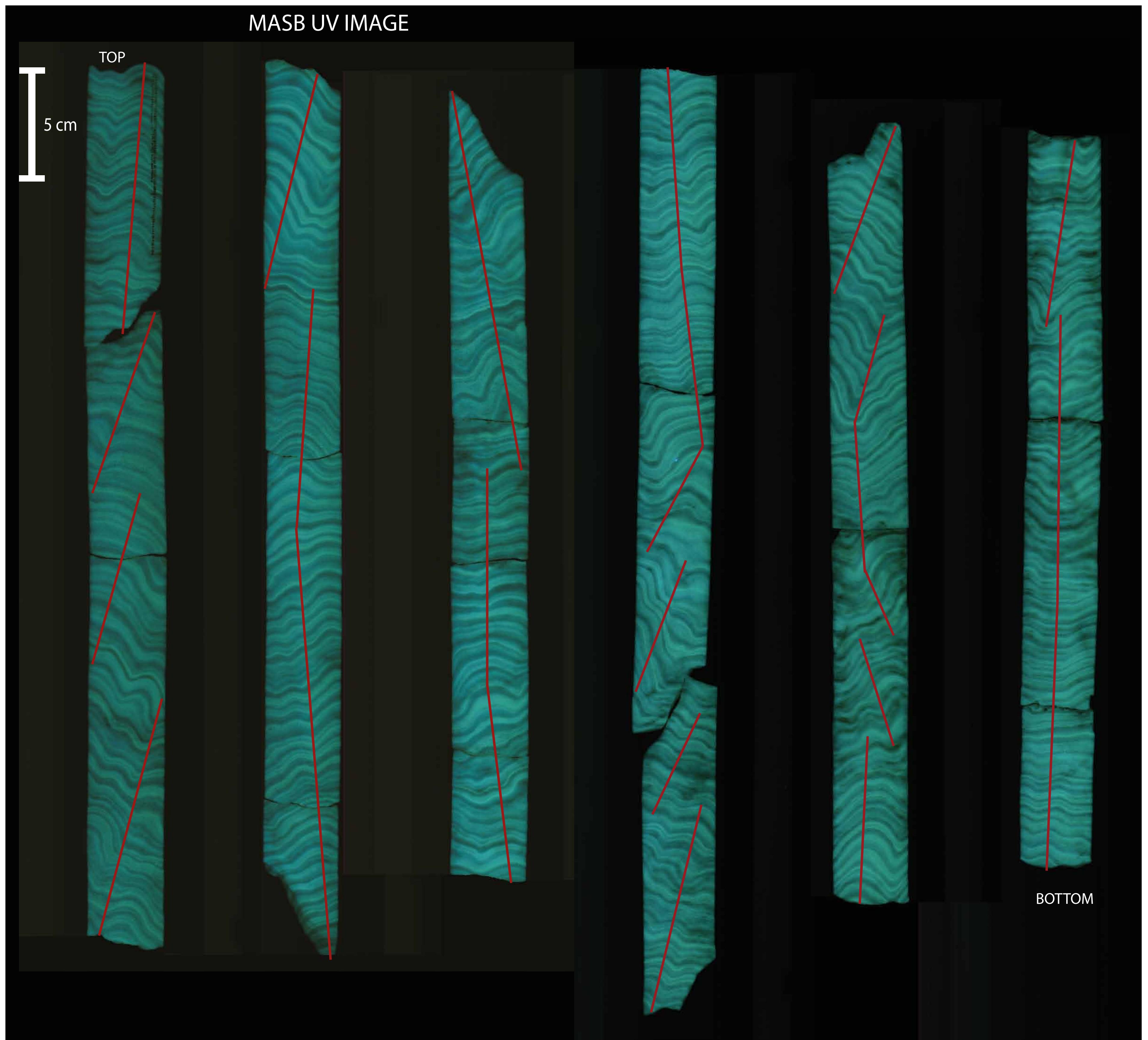


Figure S02. Photoluminescence image of coral core MASB taken using the Spectral Luminescence Scanning (SLS) technique. The red lines indicate transects used to extract the down-core luminescence data.

Figure S03

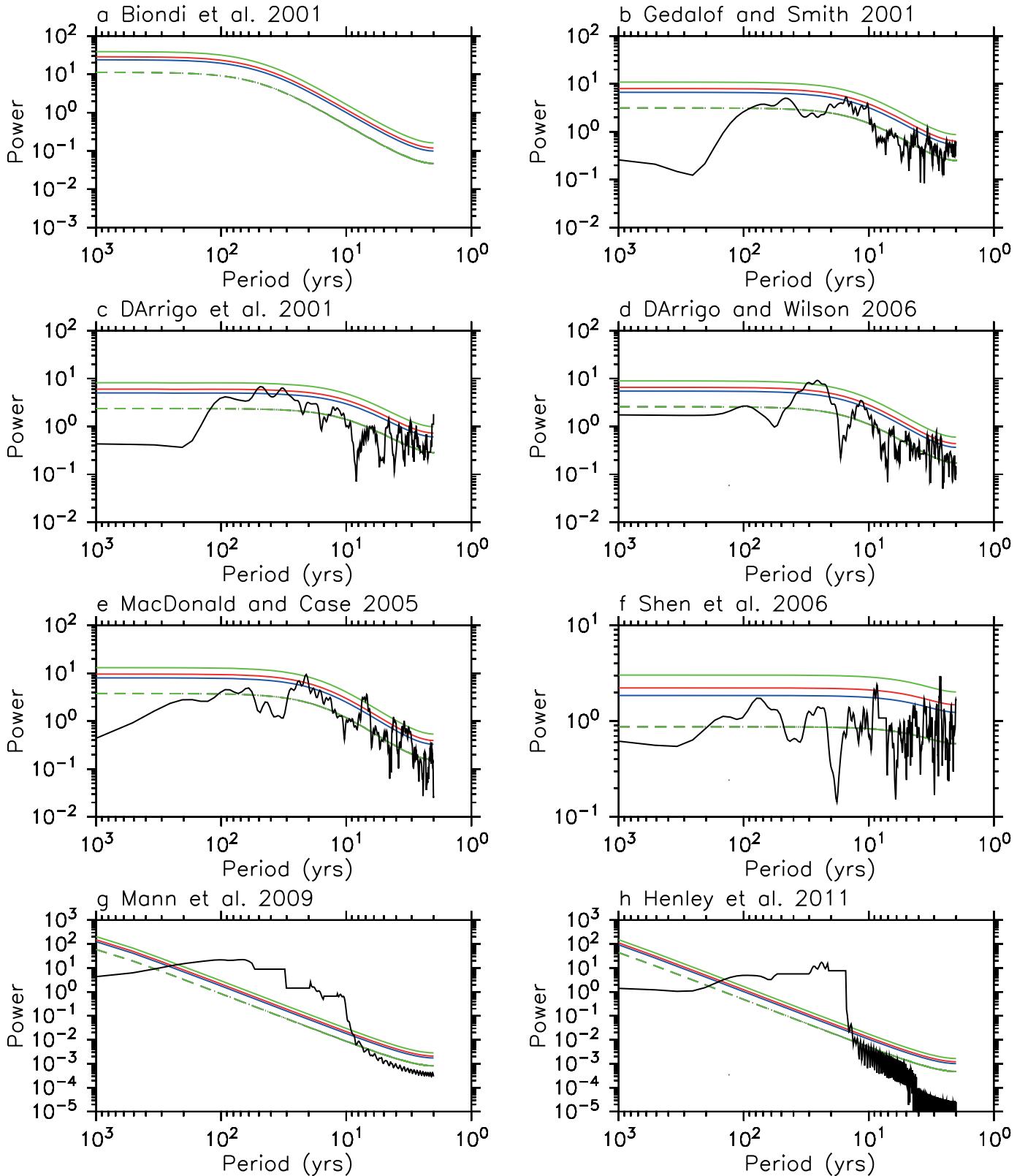


Figure S03. Spectra of the reconstructed PDO indices for 1709-1920, as shown in Fig. 3; including the (a) Biondi et al. (2001), (b) Gedalof and Smith (2001), (c) D'Arrigo et al. (2001), (d) D'Arrigo and Wilson (2006), (e) MacDonald and Case (2005), (f) Shen et al. (2006), (g) Mann et al. (2009) and (h) Henley et al. (2011) records. Confidence levels are indicated with green (99%), red (95%), blue (90%) and green dashed (median) lines, respectively.