Can SST Proxy Data Reconstruct Common Era AMOC variability?

Casey Saenger¹ Mike Evans²

¹ JISAO, University of Washington ² Dept. of Geology, University of Maryland

Summary: Proxy surrogate reconstructions (PSRs) combine the strengths of proxy data and climate simulations. We construct PSRs using the PAGES Ocean2K metadatabase of sea surface temperature anomalies (SSTa) and a subset of CMIP5 piControl, past1000 and historical simulations, with the goal of reconstructing Atlantic Meridional Overturning Circulation (AMOC) and quantifying reconstruction skill. Proxy data appear sufficient for centennial resolution, but greater variance than observed in simulations complicates skill. Empirical scaling of proxy data improves skill, but further work is needed to determine if such a scaling is realistic. Preliminary results suggest suitable AMOC variations of +/- 0.5 Sv over the past 2000 yrs without clear trends during the Little Ice Age or Medieval Climate Anomaly.

Proxy Surrogate Reconstructions (PSRs)

• Simulations are physically realistic, but do not necessarily track the climate's true evolution.

• Proxy data record actual climate climate, but are spatially irregular and noisy.

• PSRs are an analog approach to use the strengths of proxy and GCM data (Graham et al. 2007)

1. Compile a network of paleoclimate data. Here, Ocean2K SST reconstructions +

2. Construct a catalog of model-based estimates of the same variable. Here, CMIP5 historical, past1000 (CCSM4, MPI-ESM1) and piControl (CCSM4, MPI-ESM3), CNRM and INMCC

3. When simulations skillfully capture proxy SS, all model variables can be accessed

Conclusion

• Median proxy SS data in each time box (red circles) overlaps with SSTa variance in simulations (black histograms)

Marginal validation likely related to much larger variance in proxy data than in simulations.

• Local scale processes not captured by simulations

• Changes in interannual variability

• Non-tropical effects on proxy data

What if proxy data were damped on each proxy record had the same variance as its simulation grid point?

See below:

TOWARD AMOC RECONSTRUCTIONS

• Use the 3 highest RE in a timeseries to derive AMOC

• Balances over calibrating and under validating

• Gives similar statistics for calibration and validation

• Each of the 3 highest RE values is based on the mean of 3 iterations

• Median AMOC in 9 simulations (replicates are possible)

Other important considerations and what we’ve learned

Absolute SST vs. anomalies:

• Absolute SST: Strong statistics just capture climatology

• Best choice: Use anomalies

Time period for anomalies:

• 1200-1400CE: Maximum data density, but spurious statistics because proxy/model are “tied” to equal each other

• 0-2000CE: Fewer problems above, but excludes most records

• Best choice: Calculate anomalies over a proxy record’s entire internal. This is unique for each record and requires individualized catalog of all simulations with anomalies calculated in the same way (for past1000).

Seasonality:

• Annual only: Assume seasonal anomalies will be very similar to mean annual at 100 year intervals

• Annual, Spring, Summer: Include MAM and JJA in simulation catalog searched for PSR

• Best choice: Individualized catalog uses seasonality reported by original publication

Skill metrics

• Calibration/validation r > 0

• Calibration/validation p < 0.1

• Intercept within error of 0

• Variation RE > 0

• Validation CE > 0

• Best choice: We adapt 3 highest RE, but are open to ideas.

Calibration/validation ratio:

• Appears largely insensitive to 50/50, 66.33/33 and 80/20

Weighting:

• Appears largely insensitive to no weight vs. 10, 100

AMOC reconstructions

AMOC reconstruction for unscaled PSR: As in panel above (p = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for scaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for unscaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for scaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for unscaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for scaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for unscaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for scaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for unscaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for scaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for unscaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for scaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for unscaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.

AMOC reconstruction for scaled PSR: As in panel above (r = medium AMOC anomaly (+ = LIA) for 3 highest RE iterations (color bar). Gray bars note time steps where validation r > 0.1, mean where calibration r < 0.05 and medium AMOC reconstruction r = 0.25 and p = 0.1. (See also Fig. 12) Calibration and validation CE should be shown.