Direct Assimilation of Water Isotope Observations in the Last Millennium Reanalysis

USC University of Southern California

Feng Zhu[1], Julien Emile-Geay[1], Greg Hakim[2]

1. University of Southern California 2. University of Washington, Seattle

fengzhu@usc.edu
github.com/fzhu2e
http://earth.usc.edu/~fengzhu
@InfNorm

Takeaways

• We utilized process-based models of Stable water isotopes (SWIs)-based observations [Evans et al., 2013; Dee et al., 2015] together with an isotope-enabled model (iCESM) [Brady et al., 2019; Stevenson et al., 2019] to directly assimilate water isotope observations from the PAGES 2k (2017) compilation [PAGES 2k Consortium, 2017].

• In cases where linear regression performs well, our results show comparable performance; in cases where linear regression performs poorly, the process-based ice core $\delta^{18}O$ PSM shows significantly better performance in NINO3.4 index reconstructions compared to a linear statistical PSM, in agreement with Steiger et al. [2017].

• Water isotopes also offer advantages in constraining fields other than surface temperature: directly assimilating coral $\delta^{18}O$ constrains tropical precipitation, while assimilating ice core $\delta^{18}O$ yields only limited information about precipitation.

1. Motivation

• Stable water isotopes (SWIs) are the lingua franca of paleoclimate, and it has long been known that SWI ratios in corals, ice cores, bivalves, tree cellulose or lake sediments capture climate signals that cannot be reduced to temperature. Yet, most approaches to paleoclimate state estimation from such observations involve some form of calibration, usually to local temperature.

• Motivated by the Iso2k data resource [Konecky et al, 2018], this work leverages process-based models of SWI-based observations [Evans et al., 2013; Dee et al., 2015] together with an isotope-enabled model (iCESM) [Brady et al., 2019; Stevenson et al., 2019] to directly assimilate water isotope observations from the PAGES 2k (2017) compilation [PAGES 2k Consortium, 2017].

References

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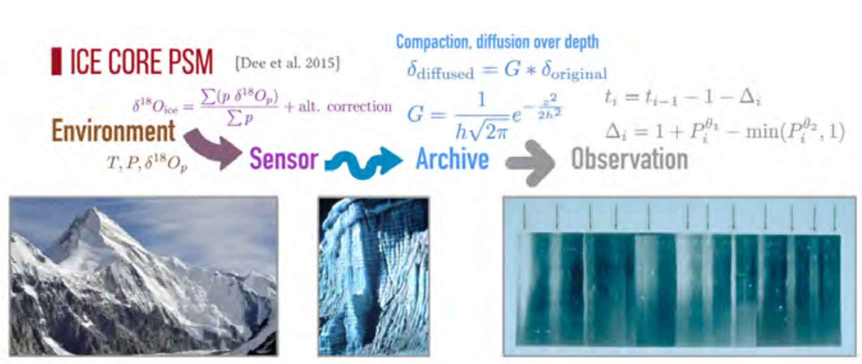

2. Assimilating Coral $\delta^{18}O$

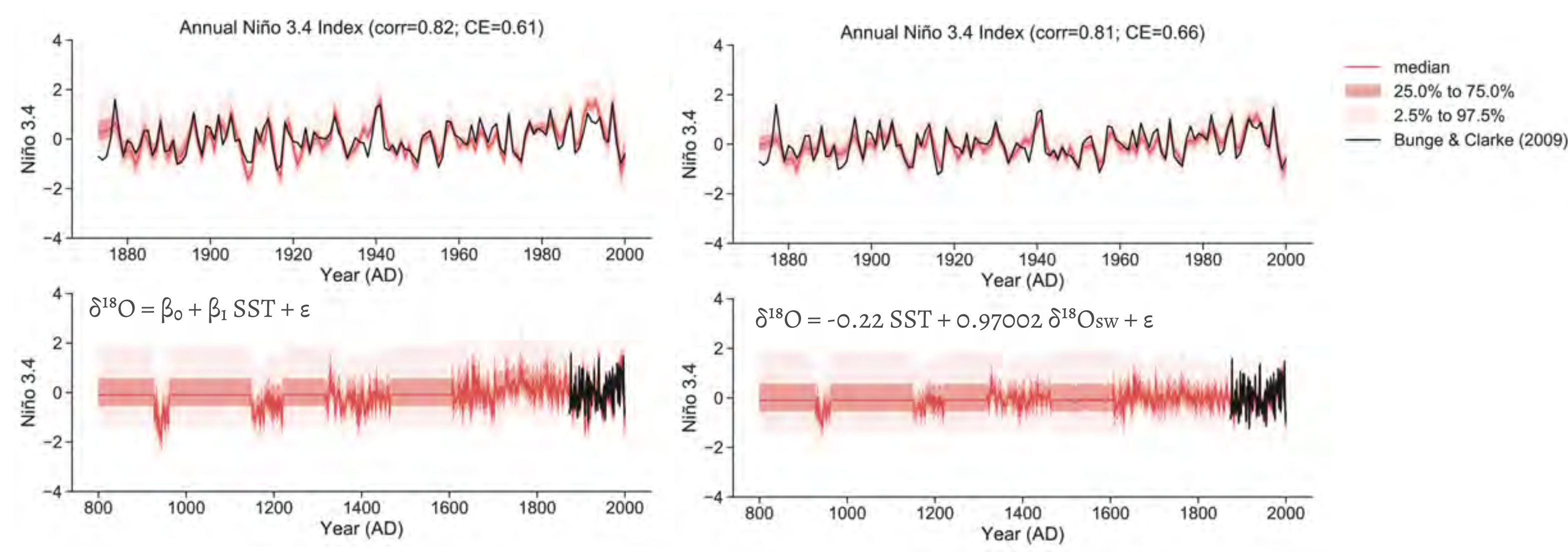

Fig. 1: The correlation between the LMR reconstructed NINO3.4 index and the instrumental-based measurement from Bunge and Clarke (2009) with forward operator as linear statistical PSM and process-based coral $\delta^{18}O$ model from PRYSM.

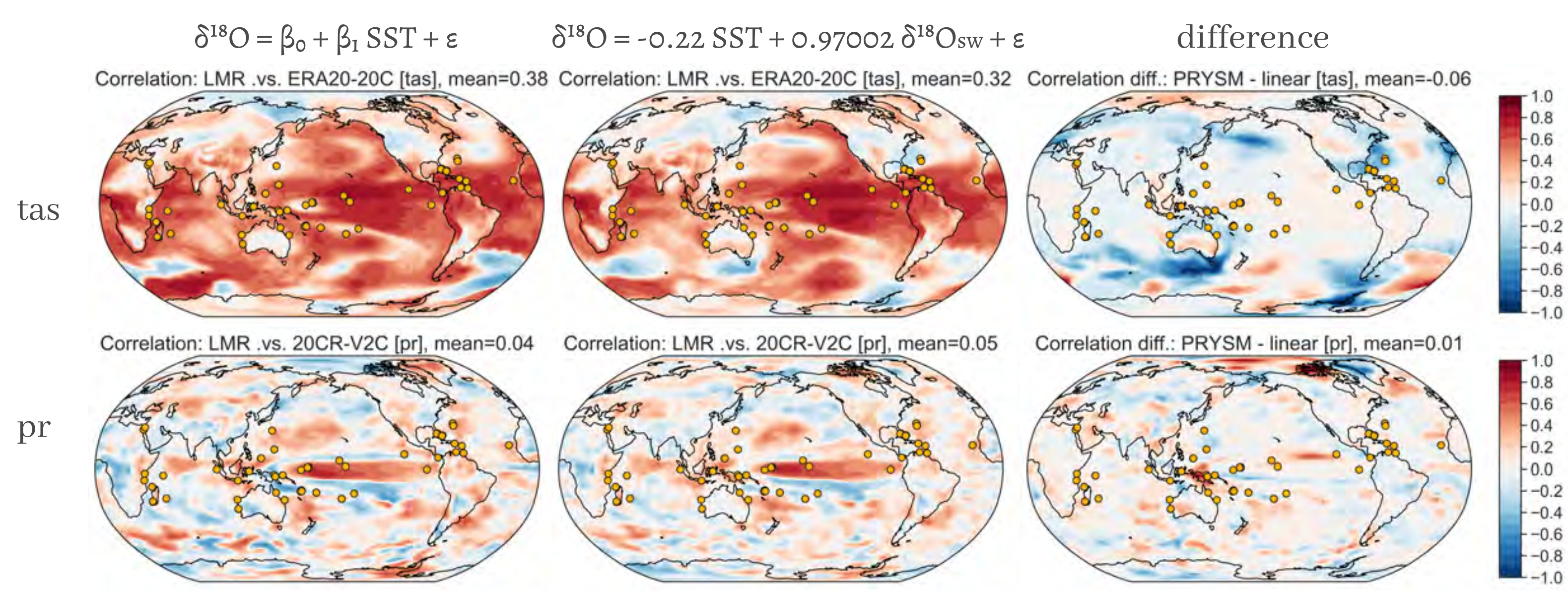

Fig. 2: The correlation maps for surface temperature (tas) and precipitation (pr) fields. The tas target is ERA20-20C [Poli et al., 2016], while the pr target is 20CR-V2C [Compo et al., 2011]. The left and middle columns show the correlation maps based on LMR reconstructed fields with forward operater as linear statistical PSM and process-based coral $\delta^{18}O$ model from PRYSM, respectively, while the right column shows the map for the difference (middle column minus left column).

3. Assimilating Ice Core $\delta^{18}O$

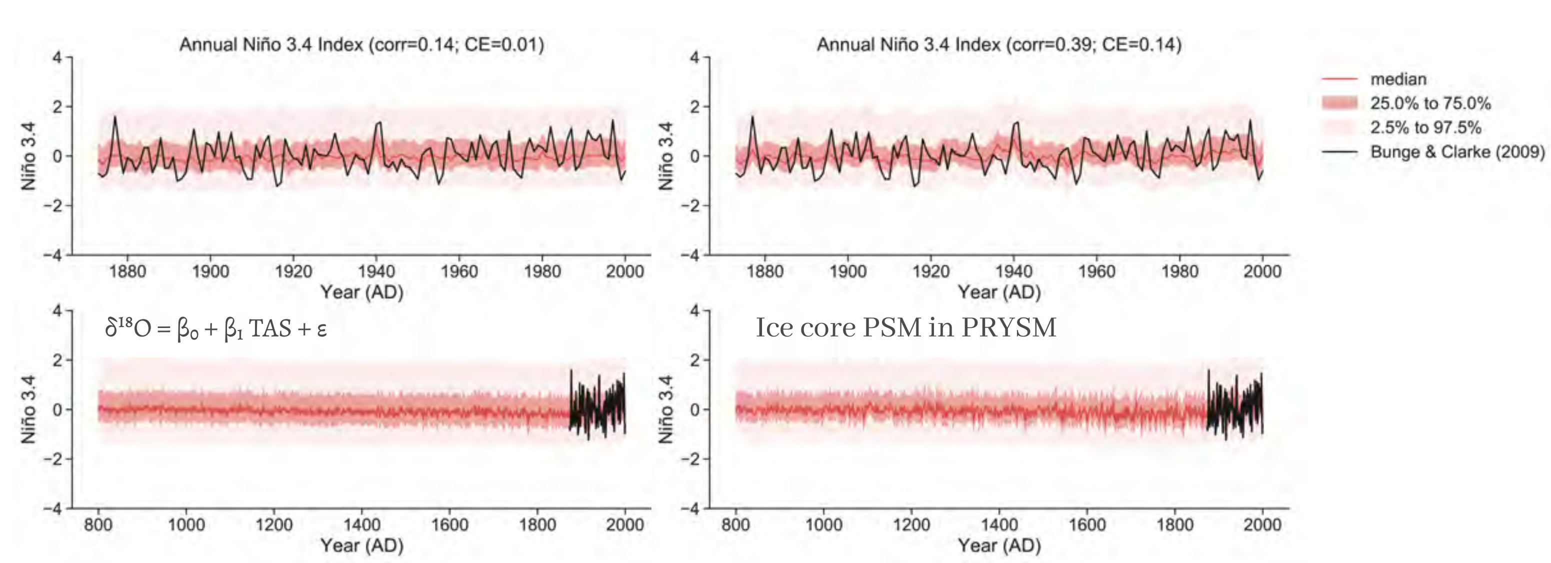

Fig. 3: Same as Fig. 1, but for the reconstruction experiments asssimilating ice core $\delta^{18}O$.

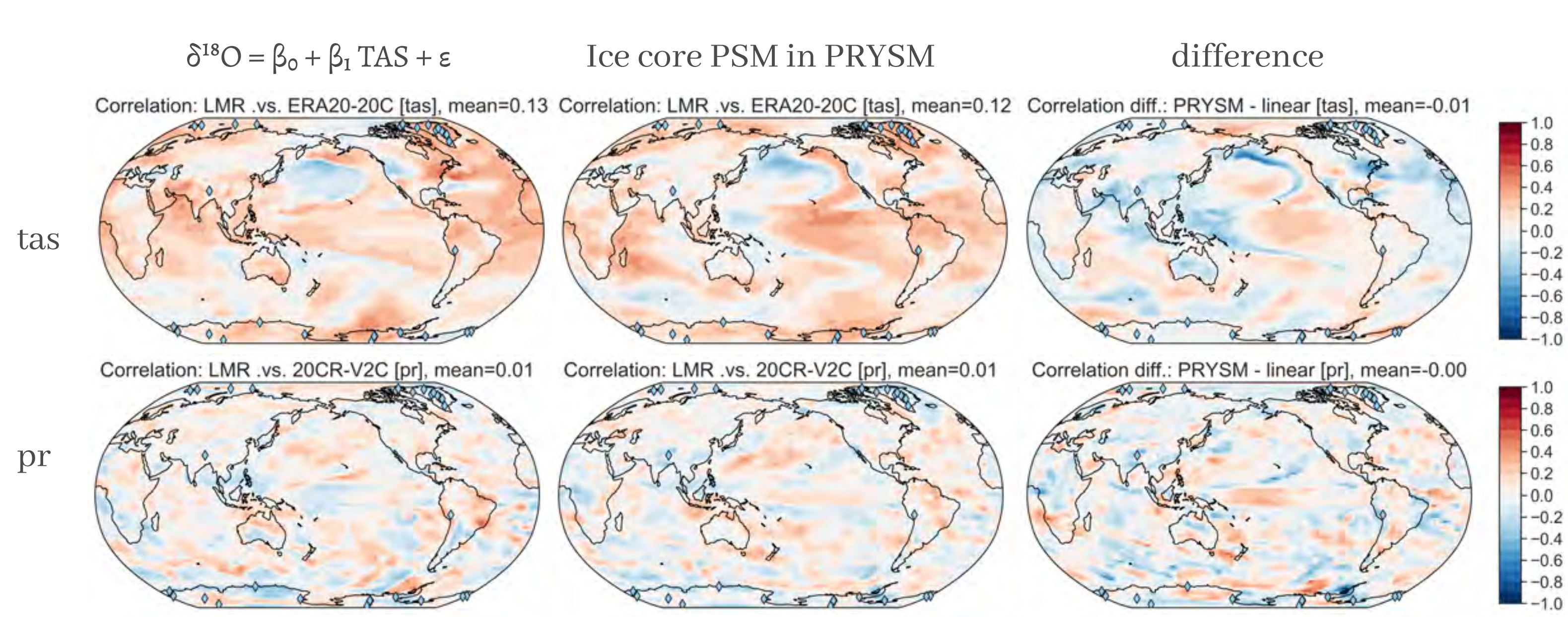

Fig. 4: Same as Fig. 2, but for the reconstruction experiments asssimilating ice core $\delta^{18}O$.