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Isotope Reanalysis for 20th century: Reproduction of isotopic time series in corals, tree-rings, and tropical ice cores

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In the present study, an isotope-incorporated GCM simulation for AD1871 to AD2008 nudged toward the so-called "20th Century Reanalysis (20CR)" atmospheric fields is conducted. Beforehand the long-term integration, a method to downscale ensemble mean fields is proposed, since 20CR is a product of 56-member ensemble Kalman filtering data assimilation. The method applies a correction to one of the ensemble members in such a way that the seasonal mean is equal to that of the ensemble mean, and then the corrected member is inputted into the isotope-incorporated GCM (i.e. IsoGSM) with the global spectral nudging technique. Use of the method clearly improves the skill than the cases of using only a single member and of using the ensemble means; the skill becomes equivalent to when 3-6 members are directly used. By comparing with GNIP precipitation isotope database, it is confirmed that the 20C Isotope Reanalysis's performance for latter half of the 20th century is just comparable to the other latest studies. For more comparisons for older periods, proxy records including corals, tree-rings, and tropical ice cores are used. First for corals: the 20C Isotope Reanalysis successfully reproduced the δ18O in surface sea water recorded in the corals at many sites covering large parts of global tropical oceans. The comparison suggests that coral records represent past hydrologic balance information where interannual variability in precipitation is large. Secondly for tree-rings: δ18O of cellulose extracted from the annual rings of the long-lived Bristlecone Pine from White Mountain in Southern California is well reproduced by 20C Isotope Reanalysis. Similar good performance is obtained for Cambodia, too. However, the mechanisms driving the isotopic variations are different over California and Cambodia; for California, Hadley cell's expansion and consequent meridional shift of the submerging dry zone and changes in water vapor source is the dominant control, but in Cambodia more direct influence of ENSO associated with Walker circulation is a primal control for isotope. Thirdly for tropical ice cores: reproduction of tropical ice cores by the model is much more difficult than for other two proxies. In addition to horizontally high resolution simulation for isotopes, consideration of isotopic fractionations associated with snow sublimation, snow melt/refreeze, and horizontal transport of snow due to blizzard are necessary.