



Merging Multi-model CMIP5/PMIP3 Past-1000 Ensemble Simulations with Tree Ring Proxy Data by Optimal Interpolation Approach

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Two sets of gridded annual mean surface air temperature in past millennia over the Northern Hemisphere was constructed employing optimal interpolation (OI) method so as to merge the tree ring proxy records with the simulations from CMIP5 (the fifth phase of the Climate Model Intercomparison Project). Both the uncertainties in proxy reconstruction and model simulations can be taken into account applying OI algorithm. For better preservation of physical coordinated features and spatial-temporal completeness of climate variability in 7 copies of model results, we perform the Empirical Orthogonal Functions (EOF) analysis to truncate the ensemble mean field as the first guess (background field) for OI. 681 temperature sensitive tree-ring chronologies are collected and screened from International Tree Ring Data Bank (ITRDB) and Past Global Changes (PAGES-2k) project. Firstly, two methods (variance matching and linear regression) are employed to calibrate the tree ring chronologies with instrumental data (CRUTEM4v) individually. In addition, we also remove the bias of both the background field and proxy records relative to instrumental dataset. Secondly, time-varying background error covariance matrix (B) and static "observation" error covariance matrix (R) are calculated for OI frame. In our scheme, matrix B was calculated locally, and "observation" error covariance are partially considered in R matrix (the covariance value between the pairs of tree ring sites that are very close to each other would be counted), which is different from the traditional assumption that R matrix should be diagonal. Comparing our results, it turns out that regional averaged series are not sensitive to the selection for calibration methods. The Quantile-Quantile plots indicate regional climatologies based on both methods are tend to be more agreeable with regional reconstruction of PAGES-2k in 20th century warming period than in little ice age (LIA). Lager volcanic cooling response over Asia and Europe in context of recent millennium are detected in our datasets than that revealed in regional reconstruction from PAGES-2k network. Verification experiments have showed that the merging approach really reconcile the proxy data and model ensemble simulations in an optimal way (with smaller errors than both of them). Further research is needed to improve the error estimation on them.