Directly assimilate proxy in paleoclimate data assimilation: a case study in High-Asia air temperature reconstruction

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1. Introductions

In view of (1) the urgent demand of developing a long-term, spatial-temporal continuous, high-quality air temperature dataset of the high-Asia during the past 1000yrs, and (2) the outstanding advantages of paleocliamte data assimilation (PDA), we carried out reconstruction experiments based on PDA to meet the above demand, in which we directly assimilated climatic proxy (e.g., 154 tree-ring width records) because assimilating proxy is almost always more efficient than assimilating proxy-based climatic variables (Goosse 2016).

2. Methods and Data

In our Offline PDA experiments, 154 tree-ring width records form PAGES2k Consortium (2013) were used as assimilated data and a proxy forward model relating tree-ring width to both temperature and precipitation served as observation operation. Additionally, EnSRF with covariance localization (CL) is employed as our PDA algorithm. The static background ensemble is randomly drawn from Twentieth Century Reanalysis (V2c)(Compo et al. 2011), and a Monte Carlo sense also is considered in the experiments.

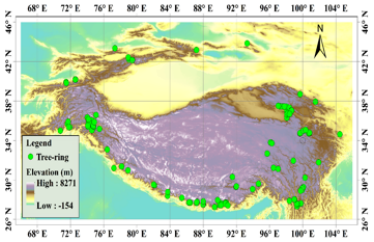

Fig.1. Map of the high-Asia and the spatial distribution of 154 tree-ring width records used in this study

The linear, bi-variate proxy forward model take the form:

$$\mathbf{Y}^{\boldsymbol{e}} = \beta_0 + \beta_1 \mathbf{T} + \beta_2 \mathbf{P} + \varepsilon$$

where **T** and **P** are the annual-mean air temperature and precipitation anomalies from calibration dataset (CRU TS3.24)(Harris et al. 2014), respectively.

3. Results

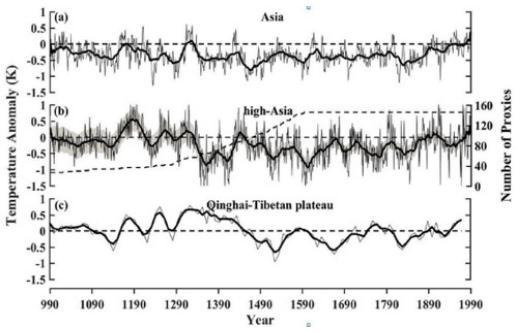

Fig.2 (a) is the Asia reconstruction of PAGES 2k Consortium. Fig.2 (b) shows the high-Asia reconstruction from PDA. Fig.2 (c) is the Qinghai-Tibetan Plateau of Yang et al. (2003), using multi-proxies, including tree-ring, ice core, lake sediments, peat and glacier fluctuation.

We compare our reconstruction with those two proxy-based reconstructions (1) to verify the reconstruction skill of PDA and (2) to find the differences and similarities between PDA reconstruction and the two proxy-based reconstructions, as well as (3) to explore the temperature change in different spatial-scale.

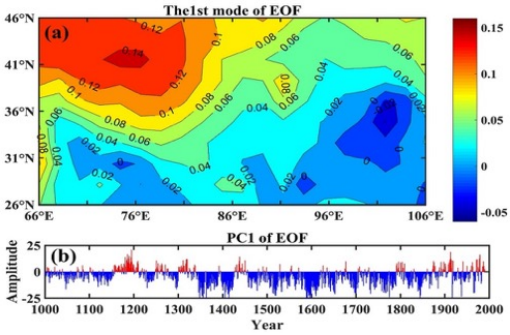

Fig.3. The first mode of EOF analysis (a) and corresponding principal component (PC) time series (b) of annual air temperature anomalies (unit: K) of the high-Asia.

The space-time characteristics of air temperature variation over the high-Asia during the past 1000yrs is studied through performing an EOF analysis on the annual air temperature anomalies field from PDA results.

4. Conclusions

Our reconstruction demonstrate that: (1) during the past 1000yrs, the high-Asia experienced four obvious climatic episodes, namely a cold with cooling trend period before about 1150; following this cold period is a significantly warm period lasted about 200yrs, and during which air temperature is greater than the mean value of air temperature during 1961-1990; after this warm period, a long-term cold period lasted about 500yrs occurred; since about 1850, an obviously warming trend has been found in the high-Asia. (2) Although the air temperature change in nearly the whole high-Asia showed consistent in space, different portions of the high-Asia still have their own variabilities; in general, air temperature variabilities decrease gradually from the northwest to the southeast; climate in the northwest high-Asia is more sensitive to external forcings and internal variations than in other portions of the high-Asia.