Australasia, and are providing a synoptic/dynamical basis for interpreting and understanding past climates. In essence, the synoptic patterns reconstructed for New Zealand, Australia, and other locations in the SH should fit together like jigsaw puzzle pieces, and the reconstructions that result commonly (but not always) appear analogous to distinct hemispheric circulation modes that are temporally fractal (self-similar). We suggest the large-scale patterns that generate distinct atmospheric pressure anomalies across the SH mid-latitudes are important to recognize for paleoclimate science, and provide a mechanism for rectifying contrasting archive signals. The patterns also provide a means to link proxies spaced by large distances, and for surmounting difficulties that arise where local climatic effects guided by orographic influences are strong. The addition of new high resolution proxy reconstructions from speleothems, lakes, tree rings, coastal and glacial deposits on land, as well as corals and other biogenic archives (like corals, shells and otoliths) are expected to enrich the chronology of changes that are emerging from the Australasian region.

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References

Goodwin, I.D., Cohen, T., Mayewski, P., Lorrey, A., Browning, S., Curran, M., van Ommen, T. and Renwick, J., 2010: *The Medieval Climate Anomaly – A view from down under*. Abstract PP34B-06 presented 2010 Fall meeting, American Geophysical Union, San Fransisco, Dec. 13-17.

Graham, N.E., Ammann, C.M., Fleitmann, D., Cobb, K.M. and Luterbacher, J., 2010: Support for global climate reorganization during the "Medieval Climate Anomaly", *Climate Dynamics*, doi: 10.1007/s00382-010-0914-z.

Lorrey, A.M., Fowler A.M. and Salinger, J., 2007: Regional climate regime classification as a qualitative tool for interpreting multi-proxy palaeoclimate data spatial patterns: A New Zealand case study, *Palaeogeography, Palaeoclimatology, Palaeoecology*, **253**: 407-433.

Mohtadi, M., Romero, O.E., Kaiser, J. and Hebbeln, D., 2007: Cooling of the southern high latitudes during the Medieval Period and its effect on ENSO, *Quaternary Science Reviews*, **26**(7-8): 1055-1066.

Schaefer, J.M., et al., 2009. High-frequency Holocene glacier fluctuations in New Zealand differ from the northern signature, *Science*, **324**: 622-625.

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Climate during the Medieval Climate Anomaly in China

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Various climate archives reveal a heterogeneous occurrence of the Medieval Climate Anomaly in China in terms of timing, amplitude and duration. Uncertainty analyses indicate that it is difficult to assess whether the medieval warmth exceeded that of the late 20th century.

During the past few decades, the Medieval Climate Anomaly (MCA), a supposed interval of elevated temperatures between approximately AD 900 and 1300, has generated considerable interest due to its potential value as a "natural" analogue of 20th century "greenhouse" warming. Recently published National Research Council (2006) and IPCC (2007) reports have placed a high priority on identifying the confidence level in regional to hemispherical temperature changes during the past 2000 years, including the putative MCA.

China is one of the few regions in the world with almost all types of climate archives that could provide high-resolution proxy data, including the world's longest continuous written historical records. Temperature time series of the last 500 to 2000 years have been reconstructed based on historical documents and natural archives (e.g., tree rings, ice cores, stalagmites, lake sediments) from China. In this paper, the results of regional proxy-based reconstructions are reviewed and the associated reconstruction uncertainty is assessed.

Regional reconstructions

Five climate regions of China have been selected (Northeast, Northwest, Central East, Tibet, and Southeast) to conduct the uncertainty assessment of the regional reconstructions (Ge et al., 2010). However, the Southeast has been excluded from the regional reconstructions assessment because the time series from that region are too short to cover the MCA. Examples of regional reconstructions from the climate zones are shown in Figure 1.

For the Northeast region temperature proxy data from lake sediments, peats and stalagmites cover the last 2000 years. The MCA is heterogeneously expressed in all three series in terms of timing, amplitude and variation patterns. The annually resolved 2650-year warm season (May, June, July and August: MJJA) temperature series reconstructed by a stalagmite layer thickness record from the Shihua Cave (115°56'E, 39°47'N), Beijing, indicates a pronounced warmth occurring from the 9th to 13th centuries (Fig. 1e) (Tan et al., 2003). The $\delta^{18}O$ proxy record from peat cellulose with a 20-year resolution from the Jinchuan peat (126°22'E, 42°20'N), Jilin Province, reveals a pronounced warm period at around AD 1100-1200 (Hong et al., 2000). However, the MCA is not visible in the quantitatively reconstructed mean July temperature from the Daihai Lake sediment (Xu et al., 2003).

The Tibet region has four reconstructed temperature series covering more than 950 years. One is a composite of the ice cores Dasuopu, Dunde, Guliya and Puruogangri (Fig. 1c), one is based on tree rings and two are individual lake sedimentary records. The MCA is discernable in form of a $\delta^{18}O$ maximum in Dunde and Guliya ice records, invisible in Puruogangri ice record, and shows a negative trend in the Dasupu record (Thompson et al., 2006a). When the four ice cores are composed as one series, the MCA is not discernable (Thompson et al., 2006b) (Fig. 1c). The temperature reconstruction based on tree-ring widths of *Qilian juniper* from Wulan (Fig. 1b), Qinghai Province, indicates a moderate warming around AD 1144-1264 (Zhu et al., 2008). A lower resolution Total Organic Carbon (TOC) record form Qinhai Lake sediment in the Qinghai Province reveals warm and dry conditions from AD 1160-1290 (Shen et al., 2001); while the sediment record of Sugan lake in the same province shows a pronounced warm period from AD 500-1200 (Qiang et al., 2005).

In Central East China, Ge et al. (2003) reconstructed winter (October to April) temperatures at a 10- to 30-year resolution from phenological observations recorded in Chinese historical documents

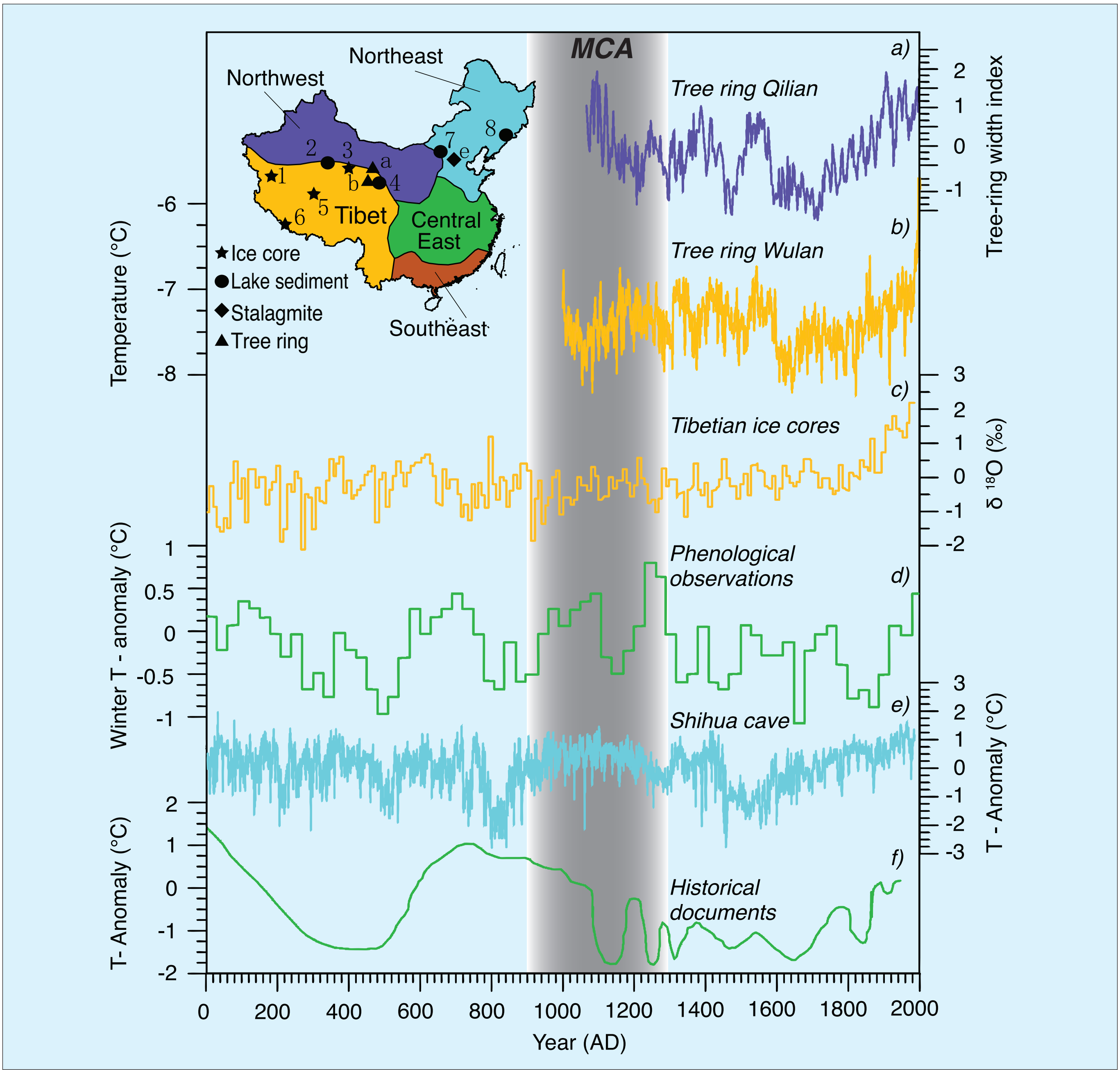

*Figure 1: Locations of proxy temperature series and the five defined climate regions (**inset**), and examples of the longest temperature series from four climate zones: **a**) Ring-width index developed for Qilian juniper in middle Qilian Mountains (Northwest) (Liu et al., 2007); **b**) Reconstructed mean temperature from September to April for the Wulan area (Tibet) (Zhu et al., 2008); **c**) Tibetan Plateau $\delta^{18}O$ composite (Tibet) (Thompson et al., 2006b); **d**) Winter half-year (Oct-Apr) temperature anomaly (Central East) (Ge et al., 2003); **e**) Shihua temperatures from July to August (Northeast) (Tan et al., 2003); **f**) Annual mean temperature variations (Central East) (Chu, 1973). The locations of the archives a, b and e are depicted in the inset. Not shown are c, d and f which are regional composites or represent regional temperature conditions. Other natural archives decribed in the text but not shown in the main panel are: **1**. Guliya ice core; **2**. Sugan lake sediments; **3**. Dunde ice core; **4**. Qinghai lake sediments; **5**. Puruogangri ice core; **6**. Dasupu ice core; **7**. Daihai lake sediments; **8**. Jinchuan peat sediments.*

for the past 2000 years (Fig. 1d). According to this reconstruction, the winter temperatures from AD 930-1310 in central eastern China were 0.2°C higher than those of the 1950s-1970s, with a maximum warming of 0.9°C occurring during the AD 1230-1250 period. This pronounced warm anomaly was once disregarded by Chu (1973), one of the most famous Chinese climatologists who initiated the study of climatic changes by historical documents. He found that the climate turned cold at the beginning of the 11th century. Although it warmed at the 13th century, the mean amplitude during this period was lower than the average conditions during the past 2000 years. So he suggested that as a whole the Song periods (AD 960-1279) were generally characterized by a cold period (Fig. 1f). However, later studies pointed out that Chu's reconstruction were based on an incorrect calendar conversion applied to dates of spring snowfall in Hangzhou, the capital of the Southern Song Dynasty (AD 1127-1279) (Zhang, 1994). Subsequent studies suggested the existence of an MCA in Central East China by using multiple independent subjective phenological evidences, which include the distribution and the north cultivation boundaries of winter wheat, sugarcane, tea plant, citrus and ramie, the safety date for full heading time of rice in Kaifeng, the capital of the Northern Song Dynasty, and plant phenological evidence in Hangzhou (Zhang, 1994; Man, 1996).

In the Northwest, the only highly resolved temperature reconstruction is a tree-ring record form the middle Qilian Mountain covering the last millennium, which reveals that a discernable warm period occurred AD 1050-1150 (Liu et al., 2007) (Fig. 1a).

Seen from a regional perspective, all four studied regions experienced warm periods within the 10th to 14th centuries. However, the timing, duration and magnitudes of these warm periods vary substantially in each region and between regions. The maximal temperature in

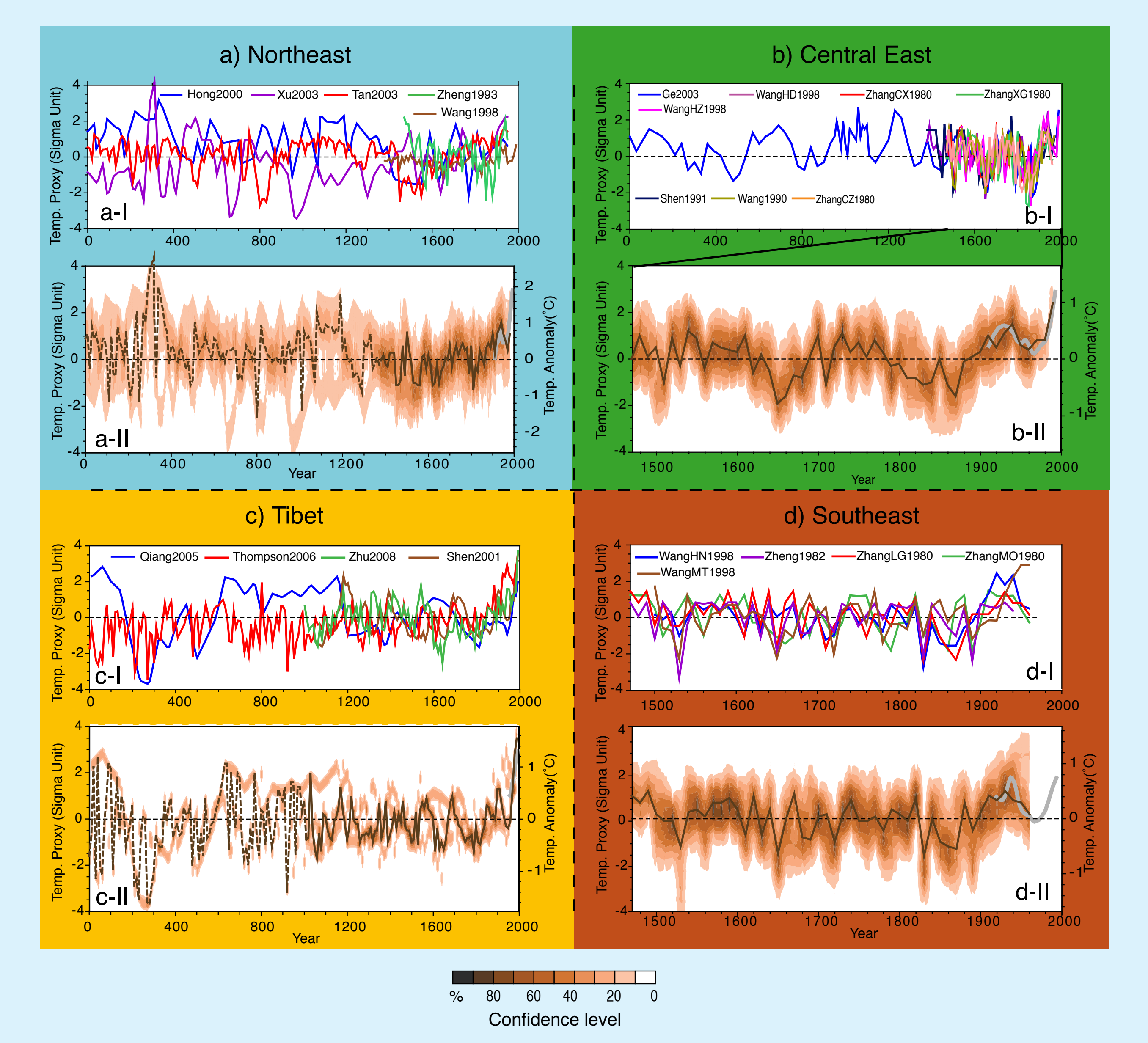

*Figure 2: Upper panels (I): Proxy mean annual temperatures with decadal resolution and their uncertainty range in (**a**) Northeast, (**b**) Central East, (**c**) Tibet and (**d**) Southeast climate zones (see inset Figure 1). Lower panels (II): The bold-brown curve is the regional temperature coherent series, the part with fewer series is marked with a dashed bold brown curve, and the bold gray curve is the 10-year smoothed instrumental temperature. The right axes represent the temperature anomaly with respect to the different period and different regions. Figure after Ge et al. (2010).*

Central East China in the AD 1240s is ~0.8°C above the AD 1901-1950 average (due to the various regions from where reconstructions are available and the variable instrumental data availability, the period AD 1901-1950 has been selected as the common reference period for all areas). The maximal temperatures are 0.4°C warmer in the 1190s for the Northeast and 0.2°C in the 1000s for the Tibet region. In the Northwest, the highest temperatures were reached in the 1100s. Finally, in the Northeast and Central East regions, the warm peaks during AD 900-1300 are higher than temperatures of the late 20th century (Ge et al., 2010) (Fig. 2).

Uncertainty analysis

The proxy-based reconstructions are subject to uncertainties mainly due to dating, proxy interpretation to climatic parameters, spatial representation, calibration of proxy data during the reconstruction procedure, and available sample sizes. Recently, Ge et al. (2010) conducted an assessment in the uncertainty of the regional reconstructions by adopting the envelope assessment method used in the fourth assessment report of IPCC.

The results (Fig. 2) indicate that the proxies have a high level of confidence in the Northeast, Central East and Southeast for the last 500 years, but large uncertainties exist prior to the 16th century. On multidecadal to centennial timescales, several reconstructions show warming peaks that occurred during the period AD 900-1300, whereas their low confidence levels do not allow to assess whether the MCA has been warmer than the late 20th century.

References

Chu, K.C., 1973: A preliminary study on the climatic fluctuations during the last 5000 years in China, *Scientia Sinica (Series A)*, **16**(2): 226-256.

Ge, Q.-S., Zheng, J.-Y., Hao, Z.-X., Shao, X.-M., Wang, W.-C. and Luterbacher, J. 2010: Temperature variation through 2000 years in China: An uncertainty analysis of reconstruction and regional difference, *Geophysical Research Letters*, **37**, doi: 10.1029/2009GL041281.

Ge, Q., Zheng, J., Fang, X., Man, Z., Zhang, X., Zhang, P. and Wang, W.-C., 2003: Winter half-year temperature reconstruction for the middle and lower reaches of the Yellow River and Yangtze River, China, during the past 2000 years, *The Holocene*, **13**: 933-940.

Tan, M., Liu, T.-S., Hou, J., Qin, X., Zhang, H. and Li, T., 2003: Cyclic rapid warming on centennial scale revealed by a 2650-year stalagmite record of warm season temperature, *Geophysical Research Letters*, **30**: 1617-1621.

Thompson, L.G., Mosley-Thompson, E., Brecher, H., Davis, M., Leon, B., Les, D., Lin, P., Mashiotta, T. and Mountain, K., 2006b: Abrupt tropical climate change: Past and present, *Proceedings of the National Academy of Sciences*, **103**: 10536-10543.

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http://www.pages-igbp.org/products/newsletters/ref2011_1.html