Box TS.5 | Paleoclimate

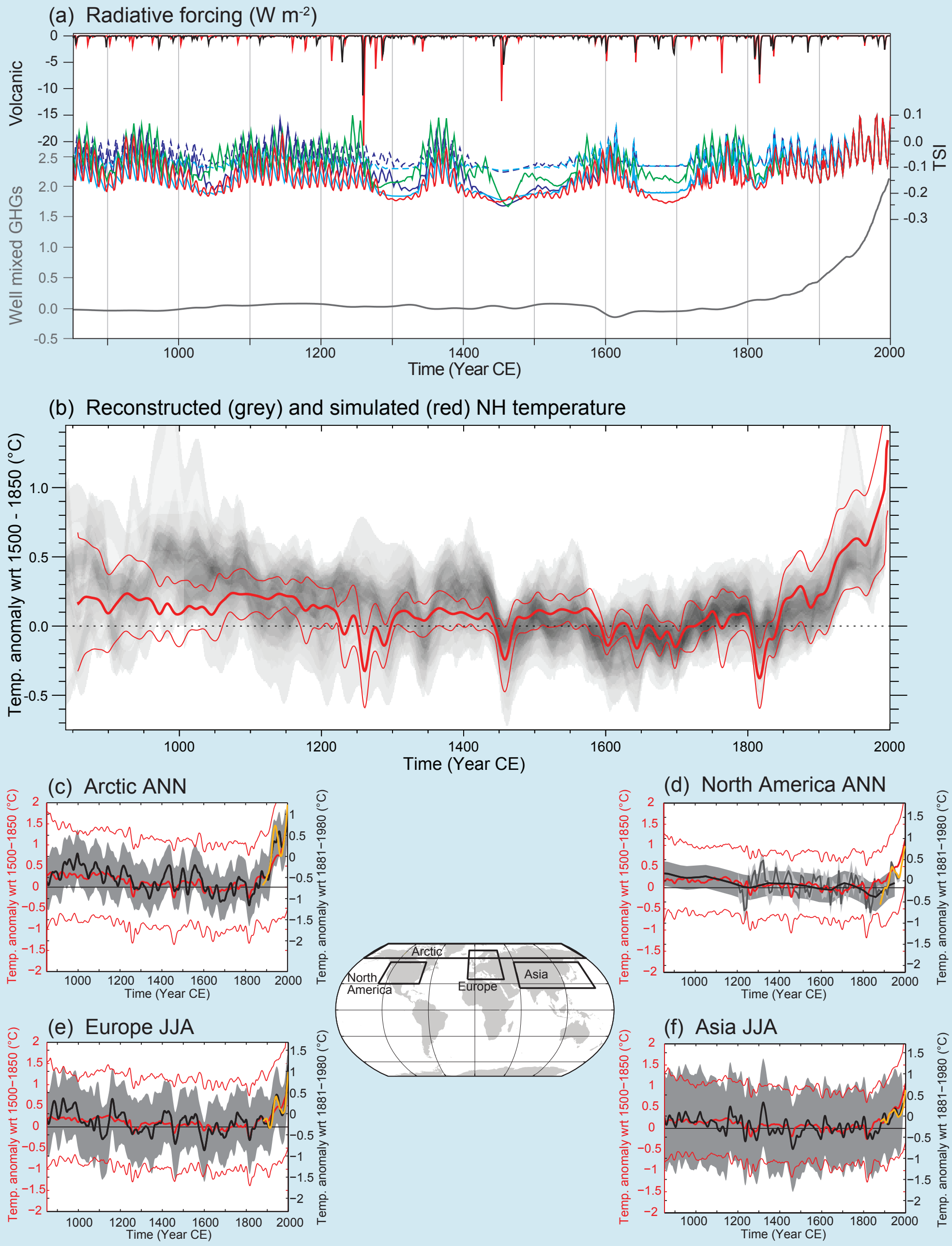
Reconstructions from paleoclimate archives allow current changes in atmospheric composition, sea level and climate (including extreme events such as droughts and floods), as well as future projections, to be placed in a broader perspective of past climate variability (see Section TS.2). {5.2–5.6, 6.2, 10.7}

Past climate information also documents the behaviour of slow components of the climate system including the carbon cycle, ice sheets and the deep ocean for which instrumental records are short compared to their characteristic time scales of responses to perturbations, thus informing on mechanisms of abrupt and irreversible changes. Together with the knowledge of past external climate forcings, syntheses of paleoclimate data have documented polar amplification, characterized by enhanced temperature changes in the Arctic compared to the global mean, in response to high or low CO_2 concentrations. {5.2.1, 5.2.2, 5.6, 5.7, 5.8, 6.2, 8.4.2, 13.2.1, 13.4; Boxes 5.1, 5.2}

Since AR4, the inclusion of paleoclimate simulations in the PMIP3 (Paleoclimate Modelling Intercomparison Project)/CMIP5 framework has enabled paleoclimate information to be more closely linked with future climate projections. Paleoclimate information for the mid-Holocene (6 ka), the Last Glacial Maximum (approximately 21 ka), and last millennium has been used to test the ability of models to simulate realistically the magnitude and large-scale patterns of past changes. Combining information from paleoclimate simulations and reconstructions enables to quantify the response of the climate system to radiative perturbations, constraints to be placed on the range of equilibrium climate sensitivity, and past patterns of internal climate variability to be documented on inter-annual to multi-centennial scales. {5.3.1–5.3.5, 5.4, 5.5.1, 9.4.1, 9.4.2, 9.5.3, 9.7.2, 10.7.2, 14.1.2}

Box TS.5, Figure 1 illustrates the comparison between the last millennium Paleoclimate Modelling Intercomparison Project Phase 3 (PMIP3)/CMIP5 simulations and reconstructions, together with the associated solar, volcanic and WMGHG RFs. For average annual NH temperatures, the period 1983–2012 was *very likely* the warmest 30-year period of the last 800 years (*high confidence*) and *likely* the warmest 30-year period of the last 1400 years (*medium confidence*). This is supported by comparison of instrumental temperatures with multiple reconstructions from a variety of proxy data and statistical methods, and is consistent with AR4. In response to solar, volcanic and anthropogenic radiative changes, climate models simulate multi-decadal temperature changes in the last 1200 years in the NH that are generally consistent in magnitude and timing with reconstructions, within their uncertainty ranges. Continental-scale temperature reconstructions show, with *high confidence*, multi-decadal periods during the Medieval Climate Anomaly (about 950 to 1250) that were in some regions as warm as the mid-20th century and in others as warm as in the late 20th century. With *high confidence*, these regional warm periods were not as synchronous across regions as the warming since the mid-20th century. Based on the comparison between reconstructions and simulations, there is *high confidence* that not only external orbital, solar and volcanic forcing but also internal variability contributed substantially to the spatial pattern and timing of surface temperature changes between the Medieval Climate Anomaly and the Little Ice Age (about 1450 to 1850). However, there is only *very low confidence* in quantitative estimates of their relative contributions. It is *very unlikely* that NH temperature variations from 1400 to 1850 can be explained by internal variability alone. There is *medium confidence* that external forcing contributed to Northern Hemispheric temperature variability from 850 to 1400 and that external forcing contributed to European temperature variations over the last 5 centuries. {5.3.5, 5.5.1, 10.7.2, 10.7.5; Table 10.1} *(continued on next page)*

Box TS.5 (continued)



Box TS.5, Figure 1 | Last-millennium simulations and reconstructions. (a) 850–2000 PMIP3/CMIP5 radiative forcing due to volcanic, solar and well-mixed greenhouse gases. Different colours illustrate the two existing data sets for volcanic forcing and four estimates of solar forcing. For solar forcing, solid (dashed) lines stand for reconstruction variants in which background changes in irradiance are (not) considered; (b) 850–2000 PMIP3/CMIP5 simulated (red) and reconstructed (shading) Northern Hemisphere (NH) temperature changes. The thick red line depicts the multi-model mean while the thin red lines show the multi-model 90% range. The overlap of reconstructed temperatures is shown by grey shading; all data are expressed as anomalies from their 1500–1850 mean and smoothed with a 30-year filter. Note that some reconstructions represent a smaller spatial domain than the full NH or a specific season, while annual temperatures for the full NH mean are shown for the simulations. (c), (d), (e) and (f) Arctic and North America annual mean temperature, and Europe and Asia June, July and August (JJA) temperature, from 950 to 2000 from reconstructions (black line), and PMIP3/CMIP5 simulations (thick red, multi-model mean; thin red, 90% multi-model range). All red curves are expressed as anomalies from their 1500–1850 mean and smoothed with a 30-year filter. The shaded envelope depicts the uncertainties from each reconstruction (Arctic: 90% confidence bands, North American: ±2 standard deviation. Asia: ±2 root mean square error. Europe: 95% confidence bands). For comparison with instrumental record, the Climatic Research Unit land station Temperature (CRUTEM4) data set is shown (yellow line). These instrumental data are not necessarily those used in calibration of the reconstrctions, and thus may show greater or lesser correspondence with the reconstructions than the instrumental data actually used for calibration; cutoff timing may also lead to end effects for smoothed data shown. All lines are smoothed by applying a 30-year moving average. Map shows the individual regions for each reconstruction. {5.3.5; Table 5.A.1; Figures 5.1, 5.8, 5.12}