Impacts of long term climate change during the collapse of the Akkadian Empire

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Abstract

Four thousand years ago what is often considered to be the world's first empire, the Akkadian Empire, collapsed. Proxy data has suggested a regional aridification event coincided with this collapse, but there is a lack of records collected from within the Mesopotamian region, where the Akkadian Empire was based. Here we analyse a suite of simulations from the HadCM3 climate model covering the last 6000 years. The results show that long-term drivers produced a shift to a more arid climate, showing minima in both precipitation and river flow at 2000 BCE, whilst temperatures were colder at 2250 BCE. These changes were sufficient to have a negative impact on the natural vegetation in Mesopotamia, suggesting that this climate change would have also impacted the agriculture sustaining local communities. We suggest that the combined effects of climate change and land mismanagement would lead to shortages of water and food, which may have contributed to social disruption and the collapse of the Akkadian Empire. We also find examples of resilience through the surviving cities such as Tell Brak and Tell Mozan. These could provide lessons for adapting to climate change in the future, as modern-day climate change threatens food and water security.

Highlights

- Mesopotamia experienced significant climate change around 4.2kyrs ago
- Simulations show a Holocene low in Tigris-Euphrates water availability at this time
- Mesopotamia experienced reduced rainfall due to changes in Western Disturbances
- This affected sustainability in the region and contributed to societal collapse

Keywords

Climate, Mesopotamia, 4.2kyr event, societal collapse, Holocene

Introduction

Approximately 4,200 years ago, the first unequivocally urban polities controlled large areas of Africa and Asia. However, within 200 years each of the four major civilisations of this period, the Old Kingdom of Egypt, the Indus Valley civilisation, the Longshan culture of China, and the Akkadian Empire in Mesopotamia, underwent significant societal transformations. The extent and nature of these transformations is much debated (Middleton, 2018), but they have been characterised as collapse events (Szczęsny, 2016). The socio-political shifts visible during this period are associated with a period of increasing aridification, inferred from various natural archives such as speleothem, dendrology, and sediment records.

The Egyptian Old Kingdom experienced a reduction in Nile River flow and a decrease in lake levels, shown by diatom assemblages found in sediment cores from the Omo River, Lake Turkana, and the Nile delta (Butzer, 2012; Krom et al., 2002; Halfman et al., 1992). Furthermore, this water shortage was recorded on the tomb inscription of Ankhtifi alongside details of starvation, famine, and civil war (Butzer, 2012). Meanwhile, the Indus Valley civilisation suffered from drought as a result of changes in both the Indian summer monsoon and winter rains from Western Disturbances (Giesche et al., 2019). This has been shown in pollen records and in sediment cores from Lonar Lake and the Indus delta. (Giesche et al., 2019; Prassad et al., 2014; Staubwasser and Weis, 2006; Staubwasser et al., 2003).

Archaeological evidence suggests this had significant effects on settlement and social organisation, although these do not fit into a simple collapse narrative (Petrie et al., 2017). Also affected by changes in the monsoon were those of the Longshan culture, who resided in the Yellow River valley of China. Here, soil records and oxygen isotope data showed a transition to a drier climate (Li et al., 2015; Shao et al., 2006; Xu et al., 2002). In addition, the changes in settlements' size and location can be traced through the ceramic records (Dong et al., 2013; Underhill et al., 2008). Significantly, these three locations are heavily impacted by the monsoonal systems of the Indo-Pacific region, whereas Mesopotamia is solely reliant on Mediterranean sourced weather, through the winter rainfall of the Western Disturbances. Furthermore, northern Mesopotamia differs in the timing of collapse. Although the Akkadian Empire likely fell sometime between 2200 BCE and 2100 BCE, several urban centres persisted until 2000 BCE before experiencing a similar decline, while others continued into the Middle Bronze Age.

The debate about the nature of the 4.2kyr event has taken on a new significance and become more widespread with the definition of Holocene Stages. The latest Stage, the Meghalayan Age, is bounded by the event (Walker et al., 2012). Of the great civilizations that experienced the 4.2kyr event, perhaps the most controversial is the Akkadian Empire, with suggested impacts ranging from the complete collapse of society due to a long, intense period of droughts (Weiss, 2017) to very limited socio-political reorganisations affecting particular areas, themselves, part of long term cyclical trends in the move to centralisation and urbanisation (Schwartz, 2007, 2017). Here we look to an ensemble of climate model simulations to examine how the past climate may have changed, and to identify what specific impacts this may have had on the communities living in the Mesopotamian region.

Methods

HadCM3 Climate Model

To model the changing climate for the last 6000 years, the Hadley Centre coupled general circulation model (GCM), known as HadCM3, was used (Gordon et al., 2000; Pope et al., 2000). The model is able to successfully simulate historical climate change responses to anthropogenic and natural forcings (Met Office 2016; Stott et al., 2000). It encompasses an atmospheric model which has a resolution of 3.75° x 2.5° with 19 hybrid levels, alongside an ocean component with a horizontal resolution of 1.25° x 1.25° with 20 levels. At the latitude of Mesopotamia (~35°N), this atmospheric resolution corresponds to roughly 278km north-south and 340km east-west.

Precipitation simulations are produced by using both a penetrative convective scheme and a large-scale precipitation and cloud scheme. The penetrative convective scheme includes an explicit downdraught representation and calculates convective rainfall. The large-scale precipitation calculations however, use the water and ice contents of clouds where the radius of cloud droplets are a result of water content and droplet number concentration. Furthermore, evaporation of falling precipitation is also modelled (Johns et al., 2003; Johns et al., 1996). Although HadCM3 would be considered relatively low resolution by the standard of the most state-of-the-art climate models, it is able to capture the broad scale features of observed precipitation across the Mesopotamia region (Figure 1).

HadCM3 uses a river-routing scheme, creating an effective basin-wide scheme on both annual and monthly scales. This scheme has predefined river catchments with associated coastal outflow points, to which runoff is transported to (Falloon et al., 2011; Johns et al., 1996). As the Euphrates and Tigris river basin formed in the Neogene and has remained largely constant throughout the Holocene (Nicoll, 2010), despite significant changes in the river channels and delta (Morozova, 2005), these runoff values give us a reliable measure of the simulated total moisture balance on a basin-wide scale and overall water availability in the region.

To simulate vegetation change, the Top-down Representation of Interactive Foliage and Flora Including Dynamics (TRIFFID) vegetation model was used. TRIFFID is a dynamic model and thus changes the plant distribution and soil carbon depending on the CO_2 fluxes at the land-

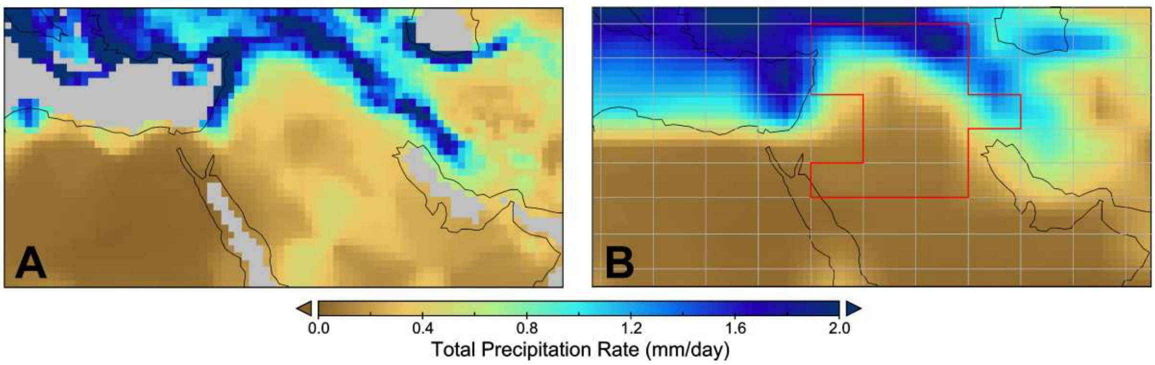

Figure 1. Comparison of average observed precipitation from 1901-2013 from the Global Precipitation Climatology Centre (GPCC; Schneider et al., 2016) dataset (A) and the simulated pre-industrial precipitation from the HadCM3 climate model interpolated to the same 0.5°×0.5° global grid (B). Grey grid in B is the HadCM3 native grid and the red outline is the Tigris-Euphrates river basin, as defined in the HadCM3 model river routing boundary conditions.

atmosphere interface (Cox, 2001). TRIFFID simulates five plant functional types: broadleaf tree, needle-leaf tree, C3 grass, C4 grass, and shrub. Each of these have their areal coverage, leaf area index, and canopy height updated with changes in the carbon flux. Additionally, four non-vegetative land cover types are recognised: urban areas, water, barren, and ice (Cox, 2001). Having a coupled vegetation model embedded in the climate simulations allows us to incorporate an element of land surface change in response to changing climate, although no anthropogenic land use change has been included.

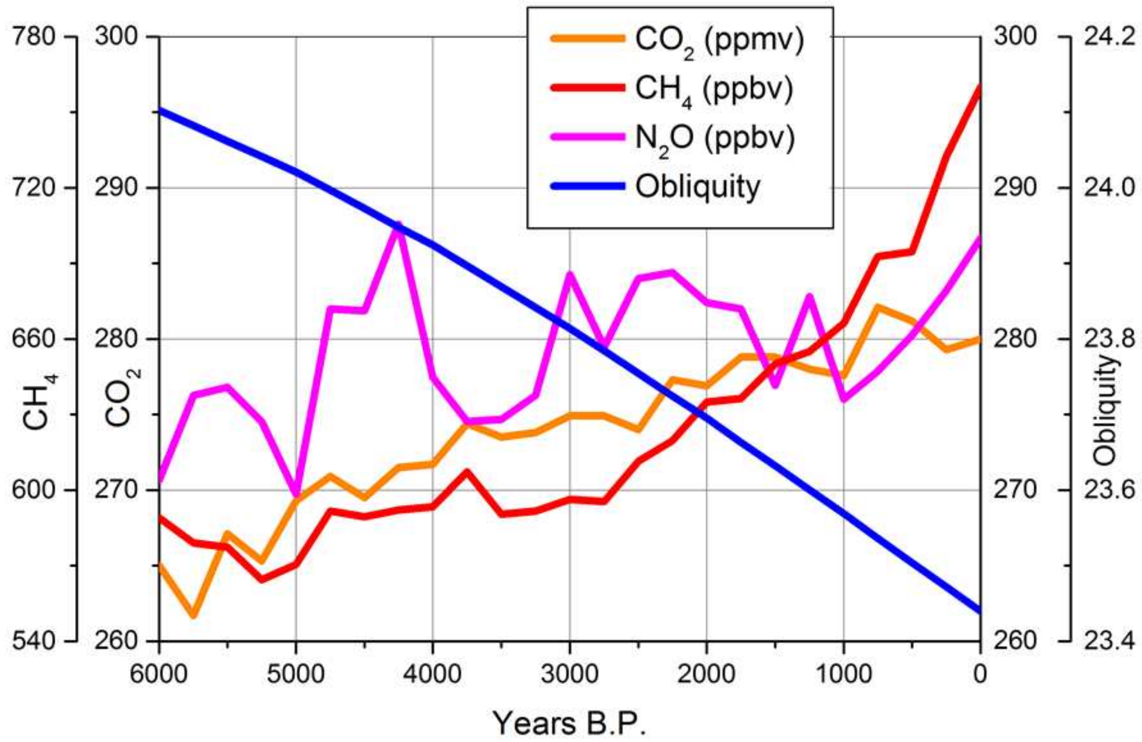

Figure 2. Parameters used in each of the snapshot simulations in the ensemble for the last 6000 years. Atmospheric carbon dioxide (Monnin et al., 2004), methane (Blunier et al., 1995; Flückiger et al., 2002) and nitrogen dioxide (Flückiger et al., 2002) concentrations and obliquity component of the full orbital solution (Laskar et al., 2004) for each simulation representing a snapshot every 250 years of the last 6000. All other parameters are kept the same as the standard pre-industrial simulation.

Holocene Simulations

To be sure to identify any change around 2000 BCE and assess its significance, the snapshot simulations were run every 250 years from 4000 BCE to the pre-industrial climate. This gives us a measure of the equilibrium climate response to the imposed changes in Holocene climate forcings in a computationally efficient experimental design. In these simulations only the orbital forcing and greenhouse gases were changed (Figure 2). Orbital solutions came from Laskar et al. (2004), atmospheric carbon dioxide levels (Monnin et al., 2004) and nitrogen dioxide levels (Flückiger et al., 2002) from EPICA ice core records and methane concentrations were taken to be the average of Antarctic and Greenland ice core values (Blunier et al., 1995; Flückiger et al., 2002), as this is less well mixed in the atmosphere. Each simulation was run for 250 model years, in order to reach a quasi-equilibrium state, with the final 50 years providing an averaging period for the climatological means. Therefore we are not explicitly attempted to simulate the 4.2kyr event, but have snapshots at 2250 BCE and 2000 BCE that should capture the impact of long-term climate changes.

Results

Hydroclimate

Figure 3 shows the simulated mean annual precipitation rate for the Tigris-Euphrates river basin over the last 6000 years. The minimum rainfall in the basin coincides with the time of Akkadian Empire collapse, between 2200 BCE and 2000 BCE. From 2250 BCE to 2000 BCE there is a decrease of approximately 7% (0.1 mm/day). The precipitation rate then increases by around 14% (0.2 mm/day) from 2000 BCE to 1750 BCE. Latest Holocene precipitation rates in the Tigris-Euphrates river basin are much higher than those during the collapse, by more than 21% (0.3 mm/day) on average (Figure 3). These changes could be considered small, but

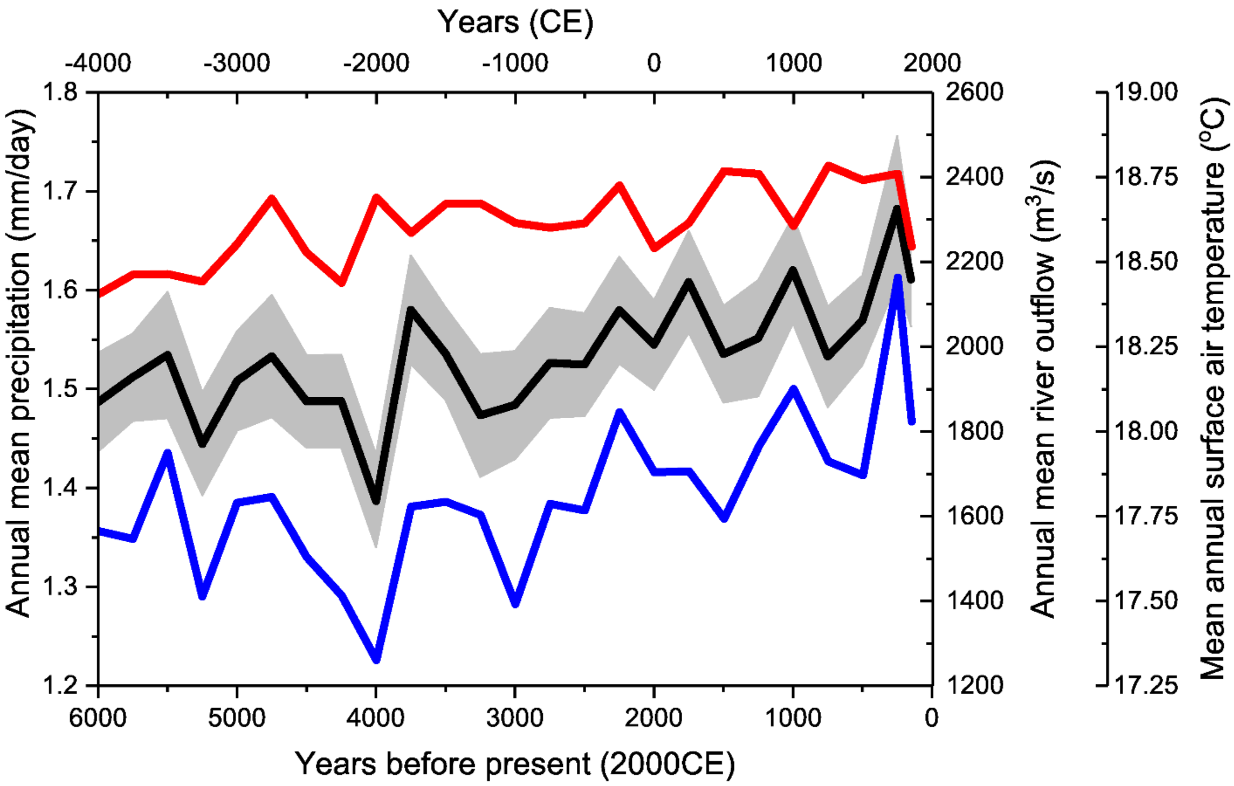

Figure 3. Annual mean precipitation (black) over the Tigris-Euphrates river basin, for each of the snapshot simulations over the last 6000 years. The shading represents standard error in the average for each simulation. Also shown is the mean annual river outflow (blue) and mean annual surface temperature (red) for the Tigris-Euphrates basin, for each of the simulations.

the methodology may not capture the full magnitude of transient or decadal climate changes. However, other civilizations have shown large sensitivities to precipitation reductions (Medina-Elizalde and Rohling, 2012).

Although HadCM3 has a simplified river routing model, the river outflow provides an integrated indicator of basin scale hydrological conditions, incorporating precipitation, evaporation and soil moisture processes. The river outflow from the Tigris-Euphrates basin also shows a minimum at 2000 BCE (Figure 3). From 2750 BCE the outflow steadily decreased

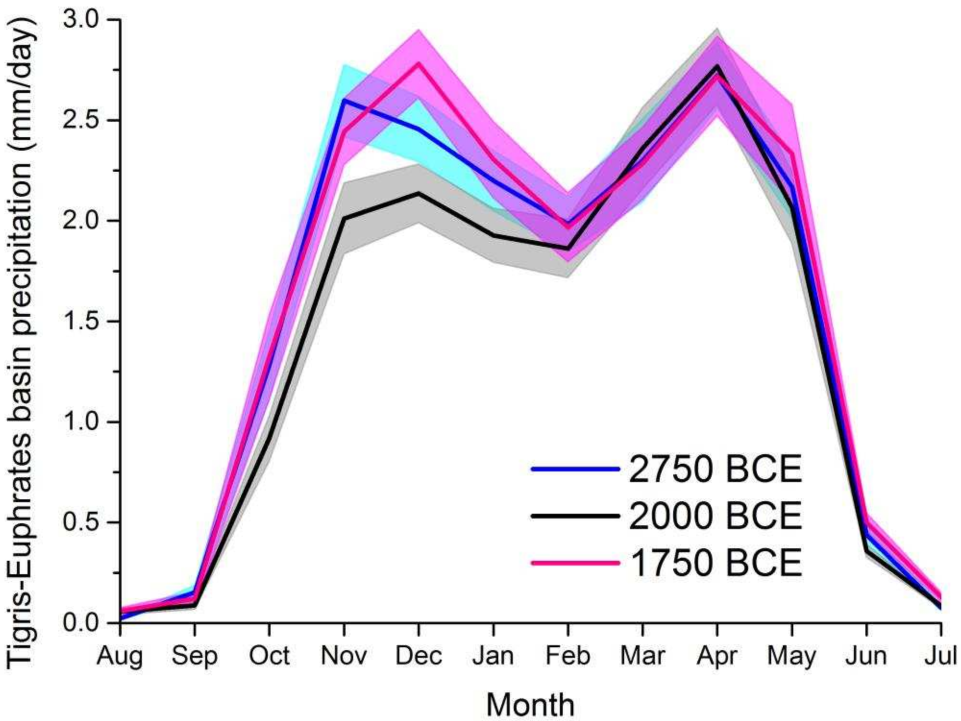

Figure 4. Annual cycle of monthly mean precipitation across the Tigris-Euphrates basin at 2000 BCE (black), prior to the significant decline in precipitation (2750 BCE; blue) and after the recovery (1750 BCE; magenta). The shading represents standard error in the average for each simulation.

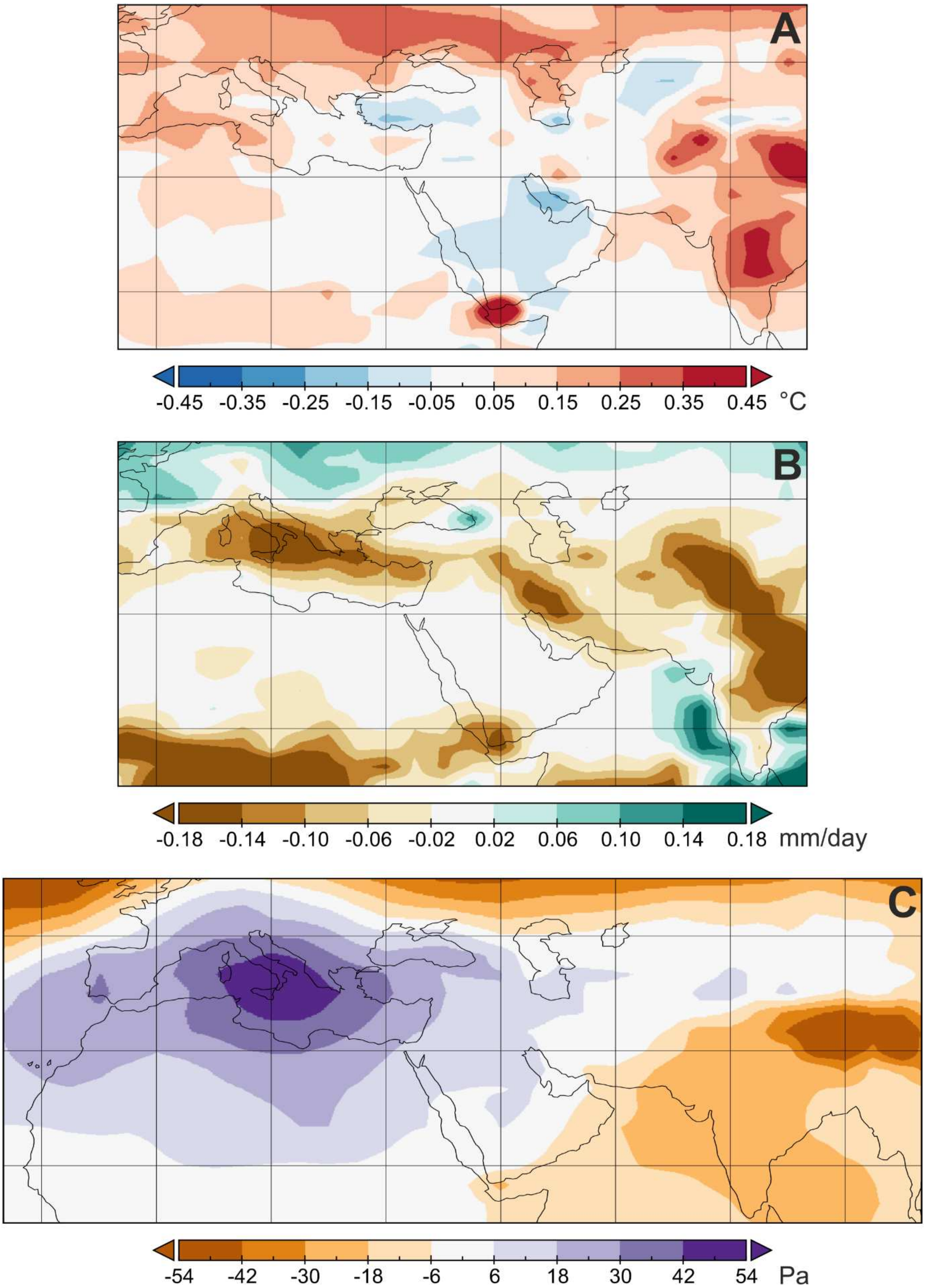

Figure 5. Spatial pattern of (a) mean annual precipitation change, (b) temperature change and (c) mean sea level pressure across the Mesopotamia region from 2750 to 2000 BCE. All panels show values at 2000 BCE minus 2750 BCE.

from 1,685 m^3/s to reach 1,288 m^3/s in 2000 BCE, representing a 30% decrease, only to change back for the following snapshot 250 years later. Figure 4 shows the monthly outflow of the Tigris-Euphrates basin, for the years 2750 BCE, 2000 BCE, and 1750 BCE. The decreases seen in the annual mean outflows occur primarily in the months of peak flow, particularly in the early months of the wet season.

The hydrological changes in the Tigris-Euphrates river basin are primarily driven by reductions in the precipitation, which on the longer term affects the whole of the Mesopotamian region (Figure 5b), but is particularly focussed on the northern part of the Akkadian Empire at the time of its collapse (Figure 6b). The rains of the wet season are produced by the Western Disturbance low pressure weather systems. These are sourced in the Mediterranean basin and travel eastward, supplying winter rainfall across Central Asia (Madhura et al., 2015). The primary reason for changes in this system can be seen by examining the changes in the broad mean sea level pressure patterns (Figure 5c). Our simulations show mean state increases in sea level pressures over the Mediterranean at 2000 BCE (Figure 5c), suggesting a lower incidence of low pressure systems forming. This, along with a reduced pressure gradient between the Mediterranean and the Himalaya, would reduce the atmospheric driving force for Western Disturbances and reduce rainfall across the Mesopotamian region.

Vegetation change and links to agriculture

The gross primary productivity (GPP) is the total amount of carbon fixed by plants and thus can equate to plant growth over a certain period (Roxburgh et al., 2005). The simulated GPP

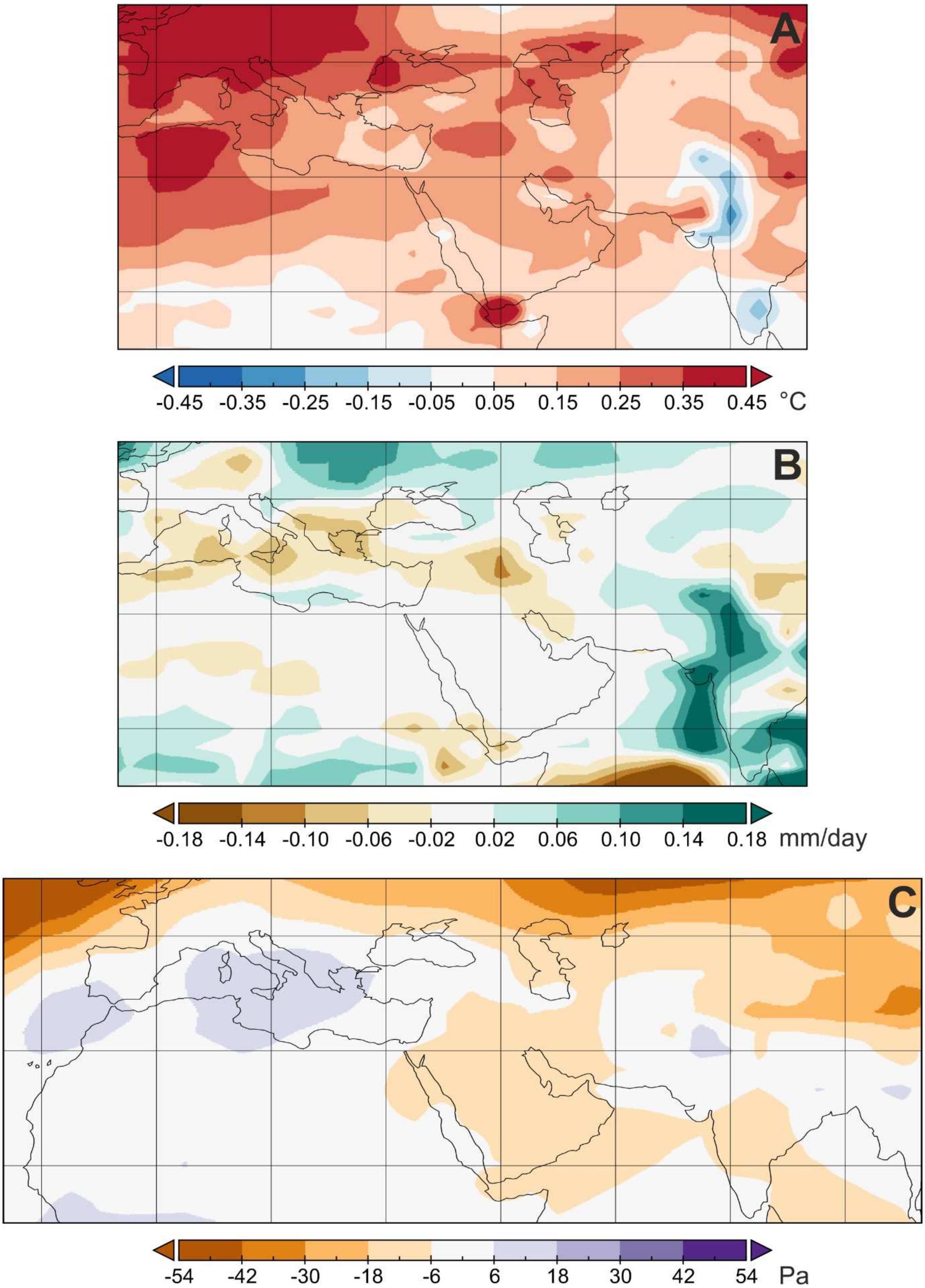

Figure 6. Spatial pattern of (a) mean annual precipitation change, (b) temperature change and (c) mean sea level pressure across the Mesopotamia region from 2250 to 2000 BCE. All panels show values at 2000 BCE minus 2250 BCE.

through this time period shows a significant drop across the Mesopotamian region at 2000 BCE (Figure 7a), although these reductions are largely reversed by 1750 BCE. The net primary productivity (NPP) is the carbon uptake remaining after taking the plant respiration from gross primary productivity (Roxburg et al., 2005). Therefore, NPP can also be related to the plant biomass. A similar signal is found is in NPP, with a temporary minimum at 2000 BCE, and this is also seen within the C3 grass plant functional type, which could be related to the main Mesopotamian crops (Figure 7b). Overall, these data suggest a significant climatic impact on the Mesopotamian biosphere, which would surely be reflected in agricultural yields. Murray-Tortarolo et al. (2016) found that longer and more intense dry seasons correlated with a decrease in NPP throughout the whole year. Changes in the dry seasons are smaller in these simulations (Figure 4), but the signal is towards a longer, drier dry season.

Discussion

Change in Western Disturbances

The rainfall in much of Mesopotamia is solely driven by the Mediterranean low-pressure systems, also known as the Western Disturbances (Riehl, 2012; Babu et al., 2011; Winstanley, 1973). During winter the Mediterranean Sea is warmer than the neighbouring land, creating low-pressure systems. These are then driven by westerly winds, moving the system eastwards

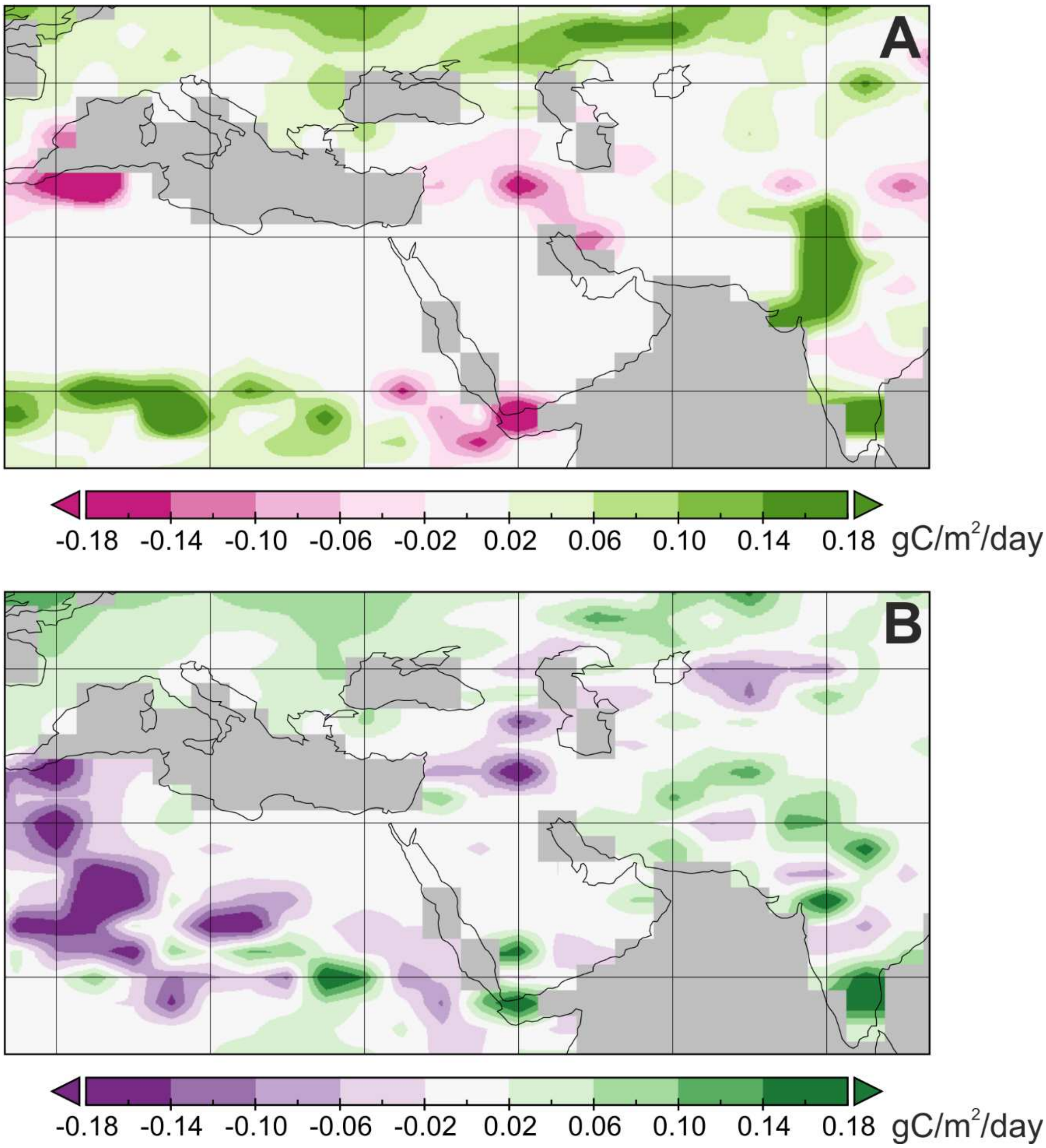

Figure 7. (a) Total gross primary productivity and (b) net primary productivity of C3 grass plant functional type change between 2250 and 2000 BCE simulations from the TRIFFID global dynamic vegetation model (Cox, 2001). All panels show values at 2000 BCE minus 2250 BCE.

over the Mesopotamian region (Babu et al., 2011). The weakening of the simulated Western Disturbances, associated with changes in the Mediterranean lows (Figure 5c) and the regional pressure gradients (Hill, 2019), resulted in the observed decrease in precipitation which the region, especially the north, was reliant on. Consequently, the flow of the Tigris and Euphrates rivers would have decreased (Figure 3), reducing the water available for irrigation in southern Mesopotamia. As a whole, the weakened Western Disturbances would have created drier weather throughout Mesopotamia for this period.

This shift to a drier climate is likely to have been amplified by the biogeophysical feedback effects of changing soil moisture (Charney et al., 1975). As soil moisture decreases, it leads to a decrease in the available atmospheric water content over the land. This creates a drier atmosphere and reduces precipitation, in turn amplifying the decrease in soil moisture and causing a change in vegetation (Krakauer et al., 2010; Baudena et al., 2008). This change may include a shift to vegetation types that are more drought-tolerant and an overall decrease in vegetation coverage, further reducing the water vapour available in the atmosphere due to the decrease in evapotranspiration. Changes and decreases in vegetation may also lead to a decrease in surface roughness, resulting in a decline in turbulence and its associated cloud formation (Eltahir, 1998) and changes to surface albedo that can affect precipitation (Charney et al., 1975).

On an archaeological timescale, studies derive evidence for palaeoenvironmental conditions and variability from proxy datasets including pollen, diatom and foraminifera records and stable isotopes held in natural archives such as speleothems. This is problematic in the area investigated here because the nearest high quality proxies are located outside the main region of interest, either in the Southern Levant or Eastern Turkey. Although new data from Kurdistan is beginning to emerge, at present this is restricted to later periods (Flohr et al., 2016). Of the available proxies located close to the study region, Lake Van in eastern Turkey (Lemcke and Sturm, 1997), Soreq

Cave in Israel (Bar-Matthews et al., 2011) and Jeita Cave in Lebanon (Cheng et al., 2015) show a shift to increased aridity over this time period. However, the proxy values are within the range of fluctuations seen over the middle to late Holocene, perhaps reflecting the fact that these records are on the periphery of the Mesopotamia region. The record of enhanced dust activity, which has been related to regional aridity (Carolin et al., 2019), suggested a prolonged period of drier conditions, at least from 4.5 kyrs ago, which came to an abrupt end shortly after 4 kyrs ago. This seems to match very well with the regional precipitation simulated here, both in the extent and timing, which may reflect the spatial dependency suggested for this speleothem record (Carolin et al., 2019).

Impact on northern Mesopotamia

In contrast to the irrigated landscapes of southern Mesopotamia, there is very little evidence for large scale water management systems in northern Mesopotamia prior to the Iron Age. This means that winter and spring rainfall levels have a direct impact on the crop growing season. Reductions in precipitation during these seasons would decrease soil moisture and cause a large amount of stress to the crops, resulting in reduced yields (Riehl, 2008; Morozova, 2005). Increased water stress has also been indicated by archaeobotanical data which showed variations in $\delta^{13}C$, specifically during the grain-filling period (Riehl et al., 2012).

Model results also suggest a decrease in both GPP and NPP (Figure 6), reflecting a decrease in both the rate of growth and the overall biomass. It can be inferred that an overall decline in crop yield would have also occurred, causing increased stress on current and stored resources. Modelling involving population sizes, crop types and agriculture areas based on evidence from landscape archaeology indicate that many settlements in northern Mesopotamia at this time operated close to the limits of sustainability (Kalayci, 2016; Wilkinson, 1994). Even relatively minor decreases in yield, especially over multiple years, would have likely exhausted reserves, causing migration or famine (Ur, 2010). Evidence for attempts to mitigate drought are present in the archaeobotanical data, which suggests there was a change in crops cultivated in northern Mesopotamia around the time of 2100 BCE (Riehl et al., 2012). Crop species with low drought tolerances seem to have seen reduced cultivation, including garden pea, einkorn wheat, free-threshing wheat and various species of flax, with many all but disappearing. In some instances inhabitants switched to more drought tolerant species, for example from garden peas to bitter vetch peas (Riehl et al., 2012).

Barley is a key component of agriculture, particularly in southern Mesopotamia, before, during and after 2100 BCE (Riehl et al., 2009), due to its short reproductive cycle and high economic value (Riehl, 2012; Riehl and Bryson, 2007). Emmer wheat, which has a high drought tolerance and was an important cultivar in northern Mesopotamia, saw a significant drop at 2100 BCE, although, this may be a result of declining local populations being unable to sustain the demanding labour required to process and prepare the wheat for consumption (Riehl et al., 2009). However, at Tell Mozan and Tell Brak, cities in northern Mesopotamia that managed to survive the 4.2kyr event, emmer wheat continued to be harvested. There is little evidence to suggest that either Tell Mozan or Tell Brak practised irrigation. It has been shown that Tell Mozan had higher proportions of free-threshing wheat, whilst Tell Brak favoured Barley (Riehl, 2012). Despite this, they both farmed emmer wheat throughout this period of climatic instability and neither suffered collapse. This suggests that societies with a greater diversity of crop species had greater resilience than those which practiced monoculture farming.

4.2ka event and ancient civilization collapse

Egypt, the Indus Valley, and the Yellow River Valley all experienced aridification events and a subsequent decline of urban sites and overall population around 2200 BCE (Li et al., 2017; Welc and Marks, 2014; Staubwasser et al., 2003). The main climatic changes identified at this time were cooling and drying, which have been associated with changes in the Bond Cycle as well as changes in sea surface temperatures of the North Atlantic and Indian Ocean (Szczęsny, 2016; Booth et al., 2005). These other riverine civilisations appeared to experience the aridity associated with the 4.2kyr event and this cooling simultaneously; their decline shortly followed (Li et al., 2017; Welc and Marks, 2014; Staubwasser et al., 2003). Mesopotamia experienced little change in temperature (Figure 3), although there may have been a minimum around 2250 BCE, however the precipitation and river flow data (Figure 4) suggest an offset of increasing aridity to 2000 BCE, which is consistent with well dated records of enhanced dust activity (Carolin et al., 2019). As the precipitation in northern Mesopotamia is produced by the Western Disturbances, its response to the change in orbital forcing and incoming solar radiation is offset from the largest changes in the main monsoonal systems of the Indo-Pacific region, which occur at a lower latitude. The resilience of the civilisation can also contribute to the timing of civilisation collapse. As northern Mesopotamia's agriculture was largely C3 crops, they were resilient to the decreasing temperatures, but not the increasing aridity. As a result, the new environment was no longer suitable to sustain the yield of C3 grasses needed to sustain the population.

Collapse should be considered and understood within the context of the episodic phases of fluctuating city growth and decline. Lawrence et al. (2016) investigated the relationship between the size and population of urban sites and climate change. This study found that the first urban sites in Northern Mesopotamia had appeared during the Late Chalcolithic, a time of high atmospheric moisture. This may have allowed the large-scale extensification of agriculture to provide for significant increases in the size of urban centres (Styring et al., 2017). Following 2000 BCE there was an apparent decoupling of climate and settlement patterns which would have impacted the long-term stability and sustainability of these cities. Between the Late Chalcolithic and the 2000 BCE transition to the Middle Bronze Age, there were two cycles of social expansion and decline (Ur, 2010). Many of the cities of northern Mesopotamia were deserted by the end of the 3rd millennium BCE. Archaeological data suggests that if the cities were repopulated, it would have been a “clean break” from the previous societies (Ur, 2010). This is likely the result of operating close to the limits of sustainability, evident as the largest of settlements were required to outsource products to sustain their populations (Lawrence et al., 2016; Ur, 2010; Wilkinson, 1994). As freshwater and crops declined, the stress on the remaining available resources increased. As a consequence, the complex nature of Mesopotamian society could not be sustained leading to famine, hunger, migration, and possibly conflict.

Evidence shows that the settlements in the southern part of Northern Mesopotamia, where rainfall was lower, were abandoned earlier than those in the more northern region (Riehl et al., 2012, Schwartz 2017), which also seems to fit with the precipitation change simulated in this study (Figure 5b and Figure 6b). A decline in one area may have led to migration to the surviving cities, increasing the population. This would therefore also increase the demand for food and, as a result, increase agricultural intensity. However, an increase in the farming intensity would have been unsustainable under the declining soil moisture conditions of the time, without expansion of the farmed area (Wilkinson et al., 2007). Therefore, where it occurred, the collapse of urban sites in Mesopotamia could be strongly attributed to the over exploitation and mismanagement of land. However, management and mitigation played a large role in the trajectories of many cities. This is suggested as settlements in dry areas, such as Tell Brak and Tell Mozan, survived. Although these cities did appear to shrink, other populations in relatively moist locations collapsed completely (Frahm and Feindberg, 2013; Wilkinson et al., 2007). Archaeobotanical data suggests that Tell Brak and Tell Mozan were the only known locations to continue to harvest emmer wheat, while many other locations shifted towards monocultures of species with higher yields and less labour-intensive processes. This act could be considered as a form of buffering which increased their resilience, contributing to their survival (Riehl et al., 2012). In other areas, a greater integration of sheep and goat herding into the economy may have allowed communities to switch between agricultural and pastoral resources depending on which was more likely to generate better yields (Wilkinson et al., 2014). How far the Akkadian Empire played a role in mitigating or driving the collapse of particular areas is still open for debate, and depends on the general degree of control it is considered to have had over the region (Middleton 2019). However, the uneven nature of the changes in the settlement record argues against a pan-regional factor such as a large political entity playing a significant causal role.

Conclusions

Overall, the model and proxy data signal changes in climate between 2250 BCE and 2000 BCE in Mesopotamia. This climatic change is driven by reduced Western Disturbances over the region and resulted in a decrease in precipitation, initiating a shift towards more arid conditions. This reduced water availability pressured societies to move towards farming more water efficient species. However, large urban populations were already surviving on the edge of sustainability. In order to cope with the reduced moisture, certain groups may also have attempted to change cropping practices, either by extensification of farmed areas or intensification, through increased manuring or violation of fallowing. Shifts to greater reliance on pastoral resources may also have played a role. Our models suggest that the climate changes associated with the 4.2kyr event in Mesopotamia may not be directly correlated to changes in the monsoonal systems, which severely impact other key civilizations that showed change around 4.2yrs ago. This may explain why regional scale comparisons of settlement decline have not produced clear patterns (Wilkinson et al., 2014; Wossink, 2009). Progress on this topic will require detailed analysis of settlement patterns and archaeobotanical data to establish how different crops being grown may have allowed communities in different sites and regions to respond to the changes identified. Further climate modelling work would also enable a more detailed and nuanced picture of the changes surrounding the 4.2kyr event to emerge. Further work is required to understand quite how these changes impacted the Akkadian Empire, or how community choices were constrained or enabled by being part of larger political units. Outside the Akkadian imperial zone, it seems likely that the degree to which the different small scale polities which remained in the region were able to adapt to the new conditions likely determined their survival. Today, the Mesopotamian region is also suffering from water stress and lower crop yields and recent droughts, made more likely by anthropogenic climate change (Kelley et al., 2015). The drought centred on 2008 was probably a contributor to political upheavals in the region, but land management policy probably determined the magnitude of the impacts (Eklund and Darcy, 2017; De Châtel, 2014). The history of Mesopotamia and the recent drought in the region, show the importance of agricultural policy and practice in mitigating the impact of reductions in water availability, particularly in the light of anthropogenic climate change.

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