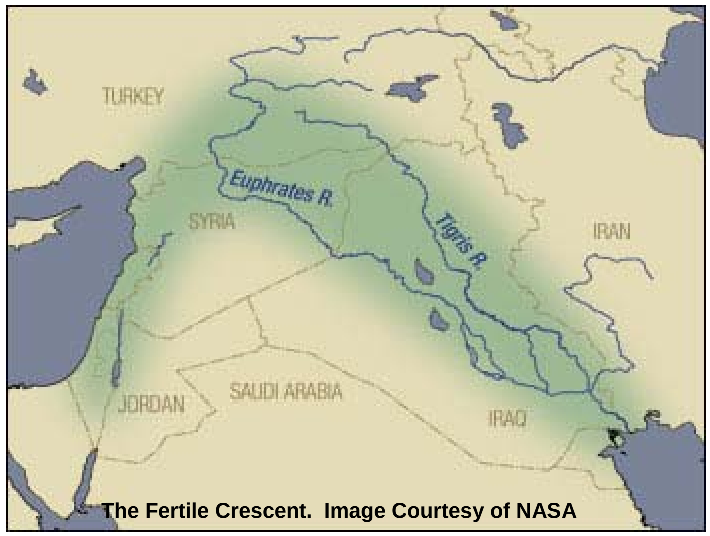
Climate and Civilizations of the Past

Human migration and social change are closely linked to changes in Earth's climate. Climate shifts have both helped to foster the rise of civilizations and contributed to their demises. Over the last few decades, proxy records (tree rings, sediment cores, mineral deposits, etc.) of ancient climates and past climate shifts have become available. Studies of these records show that past periods of significant climate change often correspond to periods of social change across remote parts of the globe. While no universally accepted definition for civilization exists, here civilizations are defined as societies that rely on permanent infrastructure (i.e. cities, granaries and irrigation systems) and intensive cultivation of crops for their survival, meaning that they cannot respond to climate change simply by moving to where the weather is better nor can they readily switch to different food sources.

Civilizations Develop in Ancient Western Asia

As the Earth warmed following the last glacial maximum around 18,000 years ago, the area known as the "Fertile Crescent" transitioned from an arid steppe to oak parkland where wild cereal species were common. The people (known as the Natufians) that moved into the area transitioned from being hunter-gatherers to semi-agriculturalists. The abrupt discharge of glacial meltwater into the North Atlantic around 12,900 years ago caused a "shutdown" of the thermohaline circulation and a 1300-year long cold period in the Northern Hemisphere. The region's population responded to this sudden freeze by settling in microclimates where intentional and intensive cultivation of grains was possible. Over the next few millennia, these societies grew until around 8,400 years ago, when another abrupt meltwater discharge and a sudden drying drove the population to the southern Fertile Crescent where they learned to construct irrigation systems.



The Fertile Crescent. Image Courtesy of NASA

The development of irrigation systems necessitated greater political organization and labor specialization, which resulted in larger societies and more urbanization. This marked the beginning of Sumerian Civilization, characterized by independent city states, the development of writing, the wheel, metal tools, laws, religious temples, militaries, etc. Another short, severe drought period between 3200 and 3000 BCE led to economic collapse. Better grain storage and water regulation technologies following the drought coincided with the rise of more centralized and socially stratified governments, and by 2300 BCE the world's first empire expanded from the city of Akkad (near modern day Baghdad). This empire existed only briefly, however, as declines in rainfall beginning in about 2200 BCE resulted in influxes of people from the northern part of the region (which was directly dependent on rainfall for grain production) to the irrigated lands in the south. Despite efforts to repel such invaders, including the construction of a 100-mile long wall, social disruption ensued and the political structure disintegrated.

This abrupt drop in rainfall was not only felt in the Fertile Crescent, but also appears to have affected early civilizations in the Aegean and the Indus Valley regions – two areas where economic activity peaked around the time the Akkadian Empire rose. Rain-fed grain production in these regions relied on the Mediterranean westerlies for summertime rainfall and a weakening/displacement of these westerlies around 2200 BCE made crop production difficult. The simultaneous occurrence of a severe drought in southern tropical East Africa, where convective intensity strongly influences the strength and position of the Northern Hemisphere subtropical jet (which affects the strength of the Mediterranean westerlies), suggests an ultimate link to the tropical Pacific Ocean. Variability there is characterized by the behavior of the El Niño-Southern Oscillation (ENSO).

ENSO: Again, the Linchpin
Surface temperature distributions in the tropical Pacific, which are determined by the dominant phase of the ENSO, guide upper-atmospheric movement. Variations in this flow cause fluctuations in rainfall levels on regional scales. The surface temperature distributions in the tropical Pacific are in turn dependent upon variations in solar intensity and even slight changes in solar or volcanic activity can have marked effects on the tropical Pacific and Earth's climate properties. ENSO fluctuations have been shown to strongly alter weather as far away as India and southern East Africa. The link with southern Africa makes a persistent El Niño state a possible cause for the 2200 BCE climate anomaly that established drought there, causing jet stream alterations that led to drying in the northern Fertile Crescent and the collapse of the Akkadian Empire. Civilizations in South and Central America have also been strongly affected by ENSO. For example, increases in the intensity of the cycle between 500 and 700 CE made both droughts and torrential rainfall along the Peruvian coast more common. One particularly strong El Niño caused enough rainfall to destroy irrigation channels that had taken centuries to build.

As the ice age ended, warm events became more common until about 1200 years ago. From 900 to about 1300 CE, a strong and persistent La Niña state existed. Since this event, which is believed to be the driving force behind the Medieval Climate Anomaly (see below), ENSO has become slightly cooler overall. Also, a 1500-year oscillation in the strength of the North Pacific subtropical gyres appears to affect ENSO's properties.

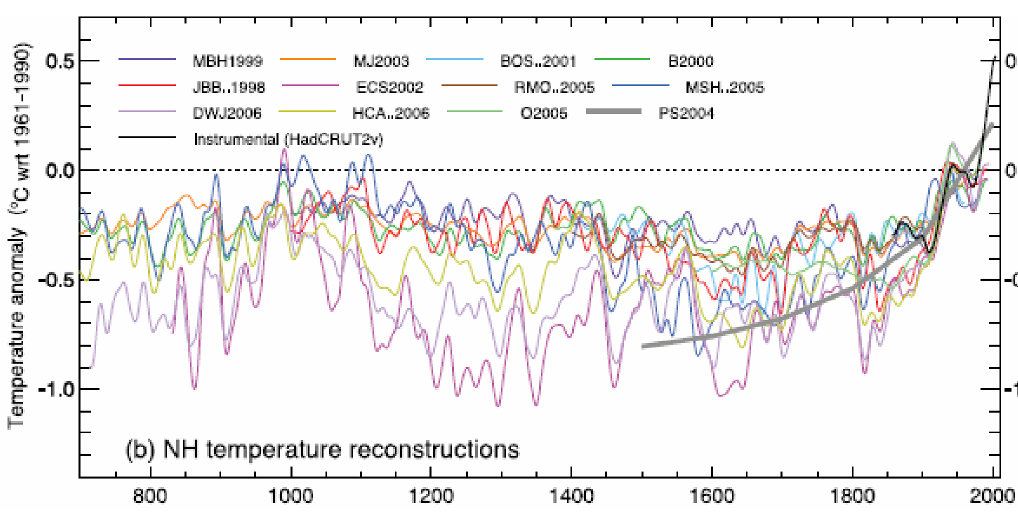
The Medieval Climate Anomaly
From about 900 to 1300 CE, the tropical Pacific was in an almost continuous La Niña state. This persistence helps to explain many of the nuances of Earth's climate that occurred during this period, known as the Medieval Climate Anomaly (MCA). Regions where effects were particularly noticeable include:

Western Europe: The rise of Western European Civilization owes much to the MCA. During this period, the North Atlantic Oscillation was in a persistently positive state, meaning that the westerlies that bring warm and moist air to Europe were strong. In addition to making Greenland habitable for a brief period, this kept winters wet and mild, and summers relatively dry, but rarely too dry – just the right circumstances for healthy crop yields. The increased food security led to population expansions (what is now France had a four-fold expansion during this period; populations in England and Italy doubled), technological advancements, the clearing of most of Europe's forests and the return of cities, which had been all but non-existent since the collapse of the Roman Empire. Such success had its price, as such population expansions made the continent more vulnerable to famines when the MCA ended. In 1307 and subsequent years, the persistent La Niña phase stopped and extreme El Niño conditions, which manifest in Europe through torrential spring rains, caused floods that destroyed budding grain crops.

China: The strength of the summer monsoon winds that bring rainfall to China's millet crops in the Central and Northern provinces are generally weaker during El Niño years. Persistent El Niño conditions and poor crop yields between 700 and 900 CE likely contributed to the downfall of the T'ang Dynasty. The La Niña conditions of the MCA brought rainfall back to Central China, as indicated by Yangtze River delta deposits. Things remained relatively wet after about 1100 CE, but more rainfall fell during the winter instead of the summer. ENSO's effects on China's rainfall are complex, far from completely understood and vary markedly by region.

The American Southwest: While the MCA brought just the right conditions for farming to Europe, La Niña conditions deflect the winter storm tracks that bring moisture to the already dry Southwest. Unlike most of their desert neighbors, who had more diverse food supplies, the Ancestral Pueblo had been using irrigation systems to grow corn and beans for thousands of years. The "Great Houses" of Chaco Canyon, New Mexico were established around 850 as the area became a center for agriculture, trade and culture. By 1150, however, the drought was too severe for agriculture and the people dispersed. The community at Mesa Verde, Colorado had better access to water and was able to survive until the most severe part of the drought occurred near the end of the 13th century.

Image right: Reconstructions of the past 1300 years of Northern Hemisphere surface temperatures. Note how the period from 900 to 1300 CE is noticeably warmer than the rest of the period, except for the 20th century. Also note the cool "Little Ice Age" that ran from the late 16th century until about 1850. Image Courtesy of NOAA.



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