Center for Academic Research & Training in Anthropogeny (CARTA)

Human-Climate Interactions and Evolution: Past and Future

Public Symposium • Friday, May 15, 2015

Chairs:
Charles Kennel, *SIO/UC San Diego*
Rick Potts, *Smithsonian Institution*

This CARTA symposium is sponsored by:
The G. Harold and Leila Y. Mathers Charitable Foundation *and* ***Rita Atkinson***

ABSTRACTS

African climate change and human evolution

Peter deMenocal, Columbia University

Analytical advances, new sediment archives, and heroic international collaborations have advanced our understanding of the role that climate change may have played in shaping major junctures in early human evolution. Gone is the dated view of our ancestors emerging from some ancient dark forest to assert dominion over the grassy plains. In its place is new evidence from ocean and terrestrial sediment archives and faunal remains that document large orbital-scale climate cycles that shifted, stepwise after 2.8 and then again after 1.8 million years ago, to establish the African savannah we know today. These observations show the dual influences of orbital-scale hydroclimate variability as well has longer-term secular shifts toward increasingly open landscapes. These climate transitions are coincident with clusters of hominin speciation, extinction, and behavioral innovation milestones that came to define us as human. Much remains to be known but evidence is mounting for the significant role climate change played in shaping the physical and behavioral attributes that define us as human.

The climatic framework of Neandertal evolution

Jean-Jacques Hublin, Max Planck Institute for Evolutionary Anthropology

Neandertals represent the best-documented group of Middle to Late Pleistocene archaic hominins. They are best documented in Western Europe but have also been present at some point in their evolution in the Levant, central Asia and some parts of southern Siberia. There is growing evidence that their evolutionary trajectory started much earlier in time than was previously thought. The paleontological record is quite scarce when considering the earliest peopling of Eurasia, and in general populations pre-dating the rise of the Neandertals. However, climatic conditions seem to have had considerable influence in modulating the colonization processes of the middle latitudes of Eurasia. Some aspects of the Neandertal anatomy have been tentatively related to cold adaptation. There is little evidence of Neandertal presence in periarctic environments but cultural buffering in response to climatic stress was likely limited among these hominins. Recent advances in paleogenetics have also allowed us to better understand the demographic profile of archaic humans in Eurasia. It is proposed that considerable changes in the amplitude and length of the climatic cycles in the course of the last half million years played a major role in triggering the evolutionary divergence between human populations living north and south of the Mediterranean. Isolation and successive demographic crashes might have been a powerful engine explaining the rapid emergence of the Neandertals.

Climate instability and the evolution of human adaptability

Rick Potts, Smithsonian Institution

How environmental dynamics may have shaped the adaptations of early human ancestors is one of the profound questions in the study of human evolution. A synthesis of African paleoclimate data suggests that significant events in human origins tended to occur during lengthy eras of strong climate fluctuation. For example, the origin of several hominin genera, major stone technologies, and key dispersal events all corresponded with prolonged intervals of increased climate variability. Between 350,000 and 200,000 years ago, complex climate dynamics and resource uncertainty coincided with early expressions of adaptive versatility and innovation prior to the origin of *Homo sapiens*, evident in the expansion of mobile technologies, symbolic behavior, and social networks. An increasing ability to alter the surroundings, associated with the evolution of adaptability during eras of climate uncertainty, has become an important new theme in the environmental story of human origins.

Abrupt climate transitions and humans
Jeff Severinghaus, Scripps Institution of Oceanography/UC San Diego

Rainfall patterns at low latitudes shifted abruptly northward 14,700 years ago, and again 11,700 years ago. From studies of ice cores and tree rings, it is clear that these transitions were extremely fast, on the order of a decade, with up to half of the change occurring in one year. Remarkable archaeological evidence from western Asia, including precise radiocarbon dating, suggests that major changes 1) away from nomadic lifestyles and 2) initiation of agriculture began within error at precisely these dates, respectively. The ice core, cave deposit, and marine sediment record show that these abrupt events recurred hundreds of times over the past million years, with a roughly millennial periodicity, raising the question of whether they influenced human development. Radical environmental change ought to select for individuals capable of innovation and learning, rather than pre-programmed behavior. Finally, the study of these events has shown conclusively that they are caused by shifts of the Earth's thermal equator in a north-south direction, wrought by ocean and atmosphere circulation changes. This raises a warning flag for our future: if we humans decide to manipulate the climate, we must be careful not to cool one hemisphere without cooling the other, because the tropical rain belts will move toward the warmer hemisphere. For example, if sulfate aerosol is sprayed into the northern hemisphere, but (to save money) it is not done in the southern hemisphere, we would likely trigger a southward shift of rain belts away from African and Asian monsoon regions where billions of people depend on rain for their livelihood.

How humans took control of the climate
William Ruddiman, University of Virginia

Until the last decade, the consensus opinion had been that significant human effects on greenhouse gases and climate began during the Industrial Era (the last 200 years). But this paradigm is under assault based on evidence from several fields of research that suggests human intervention in the climate system thousands of years ago. Greenhouse-gas concentrations measured in bubbles of ancient air trapped in the Antarctic ice sheet show that carbon dioxide (CO2) and methane (CH4) concentrations fell during the early parts of previous interglaciations, but have risen during this one since 7,000-5,000 years ago. This 'wrong-way' (upward) trend suggests that early farming emitted large amounts of CO2 and CH4, with a warming effect on climate. In addition, comprehensive summaries of 'ground-truth' evidence from archeology and paleoecology in Europe and China reveal large-scale CO2-emitting forest clearance and CH4-emitting rice irrigation thousands of years before the industrial era. This evidence rules out the previous paradigm and favors a much earlier influence.

The impacts of Arctic sea ice retreat on contemporary climate
Charles Kennel, Scripps Institution of Oceanography/UC San Diego

The *El Niño* event of 1998 caused a transition from growth in global temperature to nearly zero growth. This "hiatus" in warming occurred even though greenhouse gas emissions accelerated after 1998; it is a major public argument against action on climate change. During the hiatus, the Arctic region warmed, and sea ice, land ice, and snow-cover retreated faster than before. The oceans began to bury the expected warming at depths inaccessible to the atmosphere. The extra warming created by sea ice retreat triggered the change in ocean state. The atmospheric circulation induced by a warmer Arctic and a cooler Pacific created *La Niña*-like extreme events.

A tipping point: using the past to forecast our future
Elizabeth Hadly, Stanford University

Earth's environments are rapidly changing. Yet, animals evolved in the face of environmental change. Extracting the responses of animals to perturbations of the past is one of the best ways of unraveling how they will respond to perturbations of the future. Large environmental events provide unique opportunities for insights into resilience of animals over time. The transition from the cold, arid Late Pleistocene (LP) glacial period to the warm, mesic Holocene interglacial witnessed the extinction of two-thirds of all the large-bodied mammalian genera (ground sloths, short-faced bears, giant wombats, etc.) and global expansion of modern humans. The smaller mammalian survivors of the extinction (voles, gophers, ground squirrels, etc.) persisted but showed range changes, species turnover, and diversity decline. Subsequent but smaller climatic events, such as the Medieval Warm Period, continued to exert impacts on animals by causing adjustments in population abundances, body size and changes in genetic diversity. This retrospective view yields predictions for Earth's animals of the future. We will certainly lose many species, while a few will thrive. Other species will abandon their former homes and occupy new areas. Surviving animals may decrease in size and otherwise change in appearance, behavior and/or genetic diversity. Although past climates exerted evolutionary pressures on animals, the rate and magnitude of changes in the next century suggest perturbations too fast for present species to keep pace with, resulting in a world very different than it has been for millions of years. Yet in addition to climatic changes, our planet faces the added pressure of 7+ billion people and all the resources we require to sustain ourselves. No place in the biosphere is now removed from humanity's impact. Charting the future of biodiversity requires not only a historic perspective, which details the timing, scale, and magnitude of past global state shifts, but also now must be combined with complex systems theory to forecast the uncertainty of our planet's future.

Human impacts: will we survive the future?

Naomi Oreskes, Harvard University

I was asked to speak to the question: Will we survive the future? The answer, of course, is yes. With the world population at 7 billion people, it is exceedingly unlikely that humans, as a species, will go extinct any time soon. Humans are highly adaptable. We have faced and survived serious challenges before, and most of us are likely to survive the challenges of the coming century as well. However, with atmospheric CO2 now exceeding 400 ppm, and global fossil fuel usage continuing to rise, the reality of disruptive climate change becomes inescapable. This talk therefore shifts the question slightly to: How will we survive? And will other species survive us? The scientific evidence is overwhelming that humans, through our actions, are driving enormous numbers of species towards endangerment if not extinction. If we continue on our present course, the world of the future will be a biologically, and therefore spiritually, impoverished place. The dystopia of which Rachel Carson warned, of a Silent Spring—which we thought we had averted—may yet come to pass. But it will not just be a dystopia of monoculture. As disruptive climate change becomes more and more severe, and as the costs of dealing with climate change—already evident in California—mount, large numbers of people will be displaced. Our liberal democratic forms of governance will be severely challenged. In wealthy nations, we will increasingly spend our resources on managing climate change, and not on music or art or hospitals or universities. In poorer nations, we will be spending our resources on mere survival, as progress towards development—towards a decent standard of living for all—recedes into a fading and abandoned aspiration. Hence, the challenge of climate change is not so much the challenge of survival, but the challenge of preserving, protecting, and continuing to build the world that we want to live in.

Climate change mitigation: in pursuit of the common good

Veerabhadran Ramanathan, Scripps Institution of Oceanography/UC San Diego

Climate Change has become a defining problem threatening the future well being of humanity and the ecosystems. We find ourselves in this precarious position largely because scientific knowledge has not yet led to timely actions to mitigate the pollution. I will first provide the scientific foundation for the link between atmospheric pollution and climate change. I will then get into the thorny ethical issues such as how most of the pollution is due to unsustainable consumption by just one billion while the worst consequences of climate change will be experienced by the poorest three billion as well as by generations to come in the future. It is still not too late to prevent unmanageable warming and protect humanity provided there is a fundamental change in our attitude towards nature and towards each other. World's faith leaders can bring about such a change and I will conclude with promising efforts towards this goal that are being undertaken by a leading group of natural and social scientists under the leadership of the Vatican and Pope Francis.