Geophysical Research Abstracts
Vol. 15, EGU2013-886, 2013
EGU General Assembly 2013

From forest to farmland and meadow to metropolis: What role for humans in explaining the enigma of Holocene CO_2 and methane concentrations?

Jed O. Kaplan
ARVE Group, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland (jed.kaplan@epfl.ch)

Did humans affect global climate over the before the Industrial Era? While this question is hotly debated, the co-evolution of humans and the natural environment over the last 11,700 years had an undisputed role in influencing the development and present state of terrestrial ecosystems, many of which are highly valued today as economic, cultural, and ecological resources. Yet we still have a very incomplete picture of human-environment interactions over the Holocene, both spatially and temporally. In order to address this problem, we combined a global dynamic vegetation model with a new model of preindustrial anthropogenic land cover change. We drive these integrated models with paleoclimate from GCM scenarios, a new synthesis of global demographic, technological, and economic development over preindustrial time, and a global database of historical urbanization covering the last 8000 years. We simulate land cover and land use change, fire, soil erosion, and emissions of CO_2 and methane (CH_4) from 11,700 years before present to AD 1850. We evaluate our simulations in part with a new set of continental-scale reconstructions of land cover based on records from the Global Pollen Database.

Our model results show that climate and tectonic change controlled global land cover in the early Holocene, e.g., shifts in forest biomes in northern continents show an expansion of temperate tree types far to the north of their present day limits, but that by the early Iron Age (1000 BC), humans in Europe, east Asia, and Mesoamerica had a larger influence than natural processes on the landscape. 3000 years before present, anthropogenic deforestation was widespread with most areas of temperate Europe and southwest Asia, east-central China, northern India, and Mesoamerica occupied by a matrix of natural vegetation, cropland and pastures. Burned area and emissions of CO_2 and CH_4 from wildfires declined slowly over the entire Holocene, as landscape fragmentation and changing agricultural practices led to decreases in burned area. In contrast, soil erosion increased with increasing human pressure over the last 11 ka, except in areas where topsoils became exhausted, e.g., in the Andes and the eastern and southern Mediterranean. While we simulate fluctuations in human impact on the landscape, including periods of widespread land abandonment, e.g., during the Migration Period in Europe that following the end of the Western Roman Empire, approaching the Industrial Revolution nearly all of the landmasses of Europe and south and East Asia are dominated by anthropogenic activities. In contrast, the collapse of the aboriginal populations of the Americas following 15^{th} century European contact leads to a period of ecosystem recovery. Our results highlight the importance of the long histories of both climate change and human demographic, economic, and technological history on the development of continental-scale landscapes. We emphasize the need for improved datasets that use archaeological data synthesis and build on recent theory of preindustrial economic and technological change. A large source of uncertainty in our results comes from assumptions we make about the rates and timing of technologically driven intensification of land use, and the importance of international trade for the subsistence of preindustrial societies.