LATE CRETACEOUS CLIMATE, VEGETATION AND OCEAN INTERACTIONS: AN EARTH SYSTEM APPROACH TO MODELING A PRE-QUATERNARY CLIMATE

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The Campanian age of the Late Cretaceous was warm, with no evidence for permanent or seasonal sea ice at high latitudes. Sea level was high, creating extensive epicontinental and shallow shelf seas. Very low meridional thermal gradients existed in the oceans and on land.

Campanian (80 Ma) climate and vegetation have been simulated using GENESIS (Global ENvironmental and Ecological Simulation of Interactive Systems) Version 2.0 and EVE (Equilibrium Vegetation Ecology) model, developed by the Climate Change Research section of the Climate and Global Dynamics division at NCAR (National Center for Atmospheric Research). GENESIS is a comprehensive Earth system model, requiring high resolution (2° by 2°) solid earth boundary condition data as input for paleoclimate simulations. Boundary condition data define certain prescribed global fields such as the distribution of land-sea-ice, topography, orographic roughness, and soil texture, as well as atmospheric chemistry, the solar constant, and orbital parameters.

A comprehensive, high resolution Late Cretaceous paleogeography has been reconstructed, based on a new global tectonic model. The paleogeography provides the framework for the solid earth boundary conditions used in the paleoclimate simulation. Because terrestrial ecosystems influence global climate by affecting the exchange of energy, water and momentum between the land surface and the atmosphere, the distribution of global vegetation should be included in paleoclimate simulations. However, the reconstruction of pre-Quaternary global vegetation distributions from a fragmented fossil record is difficult. EVE predicts the equilibrium state of plant community structure as a function of climate and fundamental ecological principles. EVE has been modified to reproduce a vegetation distribution based on life forms that existed in the Late Cretaceous and has been applied as a fully interactive component of the Campanian climate simulation.

1500 ppm CO_2 and a QFACTOR of 4 were sufficient to maintain forest over Antarctica and high northern latitudes. The QFACTOR is the multiplicative of the oceanic heat diffusion coefficient in the slab-mixed layer ocean model component of GENESIS. The ocean model transports heat as a linear diffusion down the local ocean temperature gradient as a function of latitude and the zonal fraction of land and sea. Given the low Campanian meridional thermal gradient, the resulting poleward oceanic heat transport has maximum values of about 1.7×10^{15} W at 25° north and 2.6×10^{15} W at 25° south, similar to present day observed values. Late Cretaceous high-latitude forests played an important role in the maintenance of low meridional thermal gradients, polar warmth, and equable continental interiors.