Deep Time Greenhouse Climates and Ecosystems

Overview

Atmospheric concentrations of greenhouse gases now far exceed the range observed in the last million years, and even optimistic forecasts make it clear there is no precedent for 21st century climate in historical or recent geological archives. Using Smithsonian resources to explore past periods of greenhouse climate, a fellow would have the opportunity to test the skillfulness of climate and/or ecosystem models at predicting future hot conditions, with an emphasis on terrestrial climate and vegetation.

Importance

Human actions have already pushed climatic and atmospheric conditions out of the envelope of variability characterizing the last 2.5 million years of earth history. Atmospheric CO2 concentrations will rise above 500 ppm this century, nearly doubling the pre-industrial concentration of 280 ppm. Changes in earth's climate and ecosystems in the decades and centuries ahead can be predicted by models, but the skillfulness of the models cannot be evaluated adequately against present-day or even geologically recent conditions so much cooler than the future. Only during greenhouse periods deeper in earth history were conditions like those that are coming. This places a high demand on more and better data about the climate and biota of previous greenhouse periods.

This fellowship opportunity would take advantage of resources and expertise available at both the National Museum of Natural History (NMNH) and Smithsonian Tropical Research Institute (STRI). NMNH acquired in 2021 a collection of >19,000 fossil pollen samples from the US Geological Survey, including ~3,200 from the most recent interval of extreme greenhouse climate, the Paleocene and Eocene. The fossil pollen on these glass slides represents the vegetation of North America from the shores of the Arctic Ocean to the Gulf of Mexico at a time when the entire continent was forested, and palm trees grew within the Arctic Circle. The pollen samples give a geographically broader and more temporally resolved history of vegetational change that complements the world's largest collection of fossil leaves and fruits from the same period and continent, which is also held at NMNH. Together these collections provide the basis for understanding how vegetational belts shifted in response to warming, and also for reconstructing paleoclimatic and ecological conditions.

STRI has recently acquired a laser confocal microscope and also the capacity to perform automated imaging of whole microscope slides. The confocal microscope takes super high-resolution images of fossil pollen that improve our ability to distinguish among closely related species and to assign fossil pollen to botanical families. Automated imaging of multiple focal planes through a slide provides digital images that can be examined by AI routines that identify the locations of fossil pollen grains, which can then be much more efficiently discussed and identified by viewers in multiple locations, since the images are shared across the web.

Potential Research Themes

NMNH and STRI seek to support fellows interested in the climate and vegetation of the Paleocene and Eocene, and how the diversity, composition, and function of terrestrial vegetation changes under extreme warm climates.

ADVISORS

The following Smithsonian staff scientists commit to advise climate fellows, facilitate access to datasets, and project assets, and provide guidance throughout the fellowships: Carlos Jaramillo (STRI) and Scott Wing (NMNH). Research ecologists at STRI, SERC and ForestGEO, as well as with systematic botanists, paleoclimatologists and paleobotanists at NMNH and STRI are also available as advisors. Fellows are welcome to seek additional expertise from across the Smithsonian as appropriate.