



## Are we in a return to the climate of the Cretaceous

W Hay

Geological Sciences, University of Colorado, Boulder, CO, United States

The Cretaceous was the classic age of general global warmth and equable climates. Global average temperatures were 5 to 8°C warmer than during the last century. Except for brief cooler episodes, both poles were ice free. Sea-ice formed on the Arctic Ocean only during the winter if at all, perhaps aided by its low salinity. There is a consensus that the primary factor responsible for the climate of the Cretaceous was enhanced greenhouse gas concentrations in the atmosphere.

Numerical climate modelling indicates that Cretaceous winds were much more variable than those of today. Because of the lack of the ice-albedo feedback Earth has today, there were seasonal reversals of atmospheric pressure at the poles. The North Pole was covered by water but surrounded by land and the South Pole covered by land, but mostly surrounded by water. This geographical peculiarity forced simultaneous development of low and high pressure systems over both poles. The result was a global atmospheric circulation system alternating between two-cell and three-cell per hemisphere circulation with the seasons. Winter temperatures in the Cretaceous were rarely below freezing, even in the continental interiors. Transport of latent heat into the continental interiors by water vapor was more efficient not only because the actual land areas were smaller, but because the water-conserving C4 plants, which make up many of our modern crops, were not present in large numbers. Instead of the modern large oceanic gyres, the Cretaceous circulation was a disorganized myriad of mesoscale eddies. A much larger area of marginal seas in the arid zones served as sources for ocean interior and deep waters.

The modern ongoing rapid increases of greenhouse gases, particularly CO<sub>2</sub>, is unprecedented in Earth history. It is occurring at a rate more than 100 times faster than at any time in the past. The massive melt-back of Arctic sea ice which began in the 20th century and accelerated dramatically in 2007, presages a return to seasonal and then perhaps perennial ice-free conditions in the Arctic in the foreseeable future. By the end of this century we may see an ice-free northern polar region with an alternation of 2 to 3 cell atmospheric circulations in the northern hemisphere. The replacement of C3 forests by C4 grasses and crops is promoting desertification. These changes may already be irreversible. Earth may be well returning to a climate state resembling that of the Cretaceous. At present the deep water of the ocean interior is formed by sinking of cold saline waters in the polar regions. Although warm marginal seas, particularly the Mediterranean, make a major contribution to interior waters only in the Atlantic, they are critical to the “global ocean conveyor.” The conveyor depends on a very delicate balance between the Mediterranean outflow and inflow into the Norwegian-Greenland-Sea across the Iceland-Scotland Ridge. This situation could change rapidly as the planet warms.

The most realistic scenario over the next few centuries is for increasingly chaotic climate change, especially in the northern hemisphere, as Earth attempts to change to an ice-free state. Whether we will eliminate the southern polar ice and make a full return to something like that of the Cretaceous remains uncertain.