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Feedbacks and Acceleration of Global Change

William Hay
University of Colorado, Geological Sciences, Estes Park, Colorado, United States (whay@gmx.de)

The burning of fossil fuels since the beginning of the Industrial revolution has increased the level of atmospheric CO_2 by about 45 % over that of earlier times. The increasing greenhouse effect is augmented by a series of feedbacks; most have been positive, but a few are negative. The most important are 1) Slowing of the thermohaline circulation system; 2) Decreasing Atlantic to Pacific vapor transport; 3) Increasing Arctic river runoff; 4) Melting of Arctic sea ice; 5) Periodic replacement of the Arctic atmospheric high by a cyclonic low pressure system; 6) Increased exchange of waters between the Arctic and North Atlantic; 7) Lessening of the Northern Hemisphere ice-albedo feedback effect; 8) Addition of methane from melting permafrost; 9) Overall changes in the rate of ocean mixing; 10) Overall changes in vegetation cover of land; 11) Increase in the area covered by C4 vegetation; 12) Addition of nitrous oxide from agricultural practices; 13) Changes in insect populations and their effect on vegetation; 14) Wildfires; 15) Soot accumulation on snow and ice; 16) Accelerated melting of the Greenland Ice Sheet; 17) Changes in the East Antarctic Ice Sheet; 18) Closing of the ozone hole over Antarctica; 19) Decay of the West Antarctic Ice Sheet; 20) Expansion of Southern Ocean sea ice; 21) Slowing of the rate of organic matter sinking into the deep ocean; 22) Decrease in insolation reaching the surface of the Earth as a result of introduction of aerosols into the atmosphere; 23) Depletion of stratospheric ozone by nitrous oxide.
The global and regional effects and relative importance of many of these feedbacks are uncertain, and they may change both in magnitude and sign with time. New and unexpected mechanisms are constantly being discovered. The uncertainties and complexity associated with climate system feedbacks are responsible for the acceleration of climate change beyond the rates predicted by numerical modeling. To add to the difficulties inherent in predictions of future climate change, the increasingly chaotic weather is an indication that the Earth's climate system is becoming unstable in response to the ongoing perturbations.