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Thermohaline circulation and its box models simulation

Kateryna Bazyura, Alexander Polonsky, and Viktor Sannikov
Marine Hydrophysical Institute of the National Academy of Sciences of Ukraine (Sevastopol)(bazyura@yahoo.com)

Ocean Thermochaline circulation (THC) is the part of large-scale World Ocean circulation and one of the main climate system components. It is generated by global meridional density gradients, which are controlled by surface heat and freshwater fluxes. THC regulates climate variability on different timescales (from decades to thousands years) [Stocker (2000), Clark (2002)]. Study of paleoclimatic evidences of abrupt and dramatic changes in ocean-atmosphere system in the past (such as, Dansgaard–Oeschger and Heinrich events or Younger Dryas, see e.g., [Rahmstorf (2002), Alley & Clark(1999)]) shows that these events are connected with THC regimes. At different times during last 120,000 years, three THC modes have prevailed in the Atlantic. They can be labeled as stadial, interstadial and Heinrich modes or as cold, warm and off mode.
THC collapse (or thermohaline catastrophe) can be one of the consequences of global warming (including modern anthropogenic climate changes occurring at the moment). The ideas underlying different box-model studies, possibility of thermochaline catastrophe in present and past are discussed in this presentation. Response of generalized four box model of North Atlantic thermohaline circulation [developing the model of Griffies & Tzippermann (1995)] on periodic, stochastic and linear forcing is studied in details. To estimate climatic parameters of the box model we used monthly salinity and temperature data of ECMWF operational Ocean Reanalysis System 3 (ORA-S3) and data from atmospheric NCEP/NCAR reanalysis on precipitation, and heat fluxes for 1959-2011. Mean values, amplitude of seasonal cycle, amplitudes and periods of typical interdecadal oscillations, white noise level, linear trend coefficients and their significance level were estimated for every hydrophysical parameter.
In response to intense freshwater or heat forcing, THC regime can change resulting in thermohaline catastrophe. We analyze relevant thresholds of external forcing in cases of using linear and nonlinear seawater state equation.
In the frame of four-box model it is shown that:
1) The occurrence of the thermohaline catastrophe, which is likely happened at Younger Dryas period or developed as Heinrich events in the past, is improbable in modern climate epoch.
2) Choice of nonlinear seawater equitation of state leads to stabilization of warm mode of THC, which corresponds to modern climate state.
3) Typical white noise in heat and freshwater fluxes leads to generation of multidecadal oscillations of volume transport. Time-scale of these oscillations coincides with Atlantic Multidecadal oscillation periodicity.
So, it is shown that that recent climate is characterized by quasi-periodical stable multidecadal THC warm regime.

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