Atmosphere and ocean interaction: ocean circulation and heat content evolution in millennial climate simulations.

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Progress in understanding climate variability and change depends on our knowledge of the transport mechanisms and energy and matter (e. g. freshwater and chemical components) exchanges among the different components of the climate system. Through their energy and mass interactions with the other components of the climate system (atmosphere, cryosphere, biosphere and lithosphere) the oceans act as important pacemakers of climate variability in a wide spectrum of frequencies, from interannual to glacial time scales. The oceans, for instance, store and transport around heat through convection and advection, the latter by means of eddies at different spatial scales in ocean currents. Therefore, heat exchanged at the surface and stored for varying durations and released in different places; thereby ameliorating temperature changes with a thermal regulator effect over continents and contributing substantially to variability of climate on different time scales.

Within a latitude band embracing the tropical regions of both hemispheres the net radiative balance at the top of the atmosphere is positive whereas it is negative at higher latitutudes (Peixoto and Oort, 1984). Thus, achieving balance in the global climate system requires a meridional transport of energy from the Equator to the pole in both hemispheres that is in reality partitioned in comparable quantities for the atmosphere and the ocean. In the atmosphere, such transport is performed mainly by storm tracks; within the ocean, the Meridional Overturning Circulation (MOC) is a major player that contributes to heat transport with a very specific regional pattern: in the Pacific, for instance, meridional transport works poleward in both hemispheres, whereas in the Atlantic basin, transport is directed northward at all latitudes, with a maximum in the tropical regions of the Northern Hemisphere. Within these areas of the Atlantic Basin, surface currents cannot account for the large transport numbers (~ 3 PW) and an alternative mechanism must be invoked, the MOC.

The Atlantic Meridional Overturning Circulation (AMOC) is a key factor in understanding the climate of the Northern Hemisphere, since it transports a substantial amount of heat northwards that contributes to mild the climate in Western Europe. Moreover, through interaction with the atmosphere it is though to account for a significant part of surface variability on interannual and, to a larger extent, on decadal and multidecadal timescales. In this sense, a number of studies suggest an active role of the AMOC in shaping Atlantic and Pacific multidecadal variability (e. g. Delworth and Mann 2000; Dong et al. 2006; Knight et al 2005; Dong and Sutton 2007).

In the context of the last millennium, various proxy reconstructions suggest that the AMOC, through a modulation of the Gulf stream heat transport, could have contributed to the variability in the Little Ice Age (e. g. Lund et al. 2006). Therefore, given the evidence of contributions to variability in a multiplicity of timescales, there is increasing interest in understanding the origins of its variability and investigating its possible response to climate change conditions (von Storch et al. 2004, Wood et al. 1999).

The natural variability of the AMOC has been widely studied through the use of control simulations under current climate conditions performed with a hierarchy of cliamte models (e. g. Timmermann et al. 1998; Mignot and Frankignoul 2005; Hawkins and Sutton 2007). This has lead to the identification of several modes operating at interannual, interdecadal and centennial timescales. Whereas at interannual timescales the variability is mainly dominated by wind-stress variations and changes in Ekman transport (e. g. Eden and Willebrand 2001), at longer timescales it is characterized by a detailed response of the overturning forced by density anomalies in the North Atlantic sinking region (Delworth et al 1993). This talk will address the mechanisms of AMOC variability and its relationship with atmospheric dynamics. This will be done within the context of several millennial-long control and forced climate simulations and focusing on a variety of time scales, from interannual to multi-centennial.

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