Geophysical Research Abstracts
Vol. 12, EGU2010-5168, 2010
EGU General Assembly 2010

Ocean energetics and the driving mechanisms of the AMOC

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Research over the past decades has demonstrated that the Atlantic meridional overturning circulation (AMOC) is strongly affected by three main effects: 1) high-latitude cooling; 2) turbulent diapycnal mixing; 3) the southern winds at the latitude of Drake passage. These results have been so far interpreted as suggesting that the AMOC derives its energy primarily from the wind and tides, and that the surface buoyancy forcing merely shapes it. This result is often thought to result from Sandstrom's "theorem", which is widely interpreted as forbidding surface buoyancy forcing to be associated with any significant power input. To shed light on these issues, energetics has been proposed as a way to clarifying the relative role and importance of the above effects. In this talk, rigorous energetics considerations rooted in first principles will be used to suggest that contrary to current (mis)conceptions, the surface buoyancy forcing can be a significant source of power input to the oceans, comparable to that due to the wind and tides. The important new twist, however, is that the buoyancy power input itself is strongly dependent on the mechanical forcing in the oceans. The new paradigm proposed in this work is that the oceans should be regarded as a mechanically-controlled heat engine. This is to say that although it is high-latitude cooling that is the source of energy for the AMOC, the latter is strongly controlled by the power input due to the wind and tides. It will be shown how the latter explain the sensitivity of the AMOC to the southern winds and turbulent diapycnal mixing without the need for the latter to be regarded as a source of energy for the AMOC.