Geophysical Research Abstracts
Vol. 13, EGU2011-12484, 2011
EGU General Assembly 2011

Northern constraints on the Atlantic thermohaline circulation

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The Atlantic Ocean's thermohaline circulation is an important modulator of global climate. Its northern limb extends through the Nordic Seas to the cold Arctic, a region that appears to be particularly sensitive to climate change. We present an analytical model, rooted in observations and corroborated by a multi-centennial climate simulation, that constrains the strength and variability of the Arctic/Atlantic thermohaline circulation. The model suggests, maybe surprisingly, that the total circulation is relatively insensitive to anomalous freshwater input or storage; it mainly reflects changes in the northern heat budget. Freshwater anomalies are predominantly balanced by the circulation's partition into an estuarine and an overturning branch. We find in particular that recent variability derived from observed Atlantic hydrography concurs with available current measurements, and that present Arctic sea ice retreat and freshwater input supports a long-term strengthening of the Arctic/Atlantic thermohaline circulation. Our study thus provides a simple framework for constraining the thermohaline circulation's response to observed or estimated past and future change in the northern seas.