Thermohaline circulation with three stable regimes of flow

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The North Atlantic thermohaline circulation (THC) carries heat and salt toward the Arctic. This circulation is generally believed to be inhibited by northern freshwater input as indicated by the `box-model' of Stommel (1961). The inferred freshwater-sensitivity of the THC, however, varies considerably between studies, both quantitatively and qualitatively. The northernmost branch of the Atlantic THC, which forms a double estuarine circulation in the Arctic Mediterranean, is one example where both strengthening and weakening of the circulation may occur due to increased freshwater input. We have accordingly built on Stommel's original concept to accommodate a double estuarine
circulation. This model consists of three idealized basins, or boxes, connected by two coupled branches of circulation. The net transport, representing the inflow into the double estuary, was found to be more
sensitive to a change in the distribution of freshwater than to a change in the total freshwater input. Stommel's solutions for a single overturning appear as a limiting case in which all freshwater interferes with the deepwater formation. In general, a double estuarine circulation is found to be more stable than a single overturning circulation. A thermohaline `collapse' requires a larger amount and more localized freshwater input. For the Arctic Mediterranean, these findings imply that the Atlantic Inflow may be
relatively insensitive to a strengthened freshwater cycle. And next to the two flow regimes of Stommel's overturning, the double estuarine circulation allows for a third: the throughflow regime. In this regime, a thermohaline circulation with warm poleward surface flow can be sustained without production of dense waters; high-latitude deep water formation and poleward heat transport may therefore not be as tightly linked as generally thought.