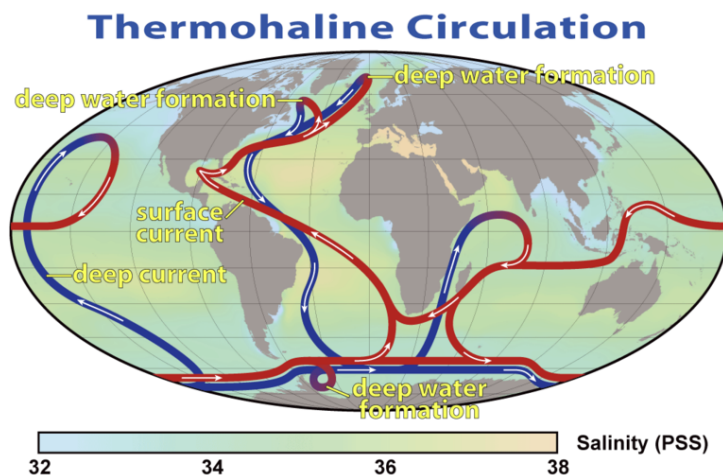


## Abrupt climate change and thermohaline circulation

### Introduction

Thermohaline circulation refers to the circulation of water in the oceans that occurs due to changes in density, changes which are themselves created by both surface heat and freshwater fluxes. “Thermohaline” comes from “thermo” (temperature) and “haline” (salt content); both of these factors determine the density of sea water. Wind-driven surface currents (such as the Gulf Stream) head polewards from the equatorial Atlantic Ocean, cooling and eventually sinking at high latitudes. This dense water then flows into the ocean basins and most of it upwells in the Southern Ocean. On its journey in the oceans, the water transports both energy (in the form of heat) and matter (solids, dissolved substances and gases) around the globe. As such, thermohaline circulation can have a large impact on the Earth’s climate.



Evidence from ice cores and sediment records suggests that thermohaline circulation may have changed abruptly in the past. Many mathematical models have been developed to try to model thermohaline circulation, perhaps the simplest being the so-called “2-box model” developed by Stommel (1961), reviewed and augmented by many since then. Multiple equilibria of the thermohaline circulation are found in a wide range of these models.

### Project

There are several possible avenues for investigation here. A good starting point would be to read and understand Stommel’s 2-box model, and reproduce some of his results. The model could then be used to investigate the effects of increased carbon dioxide on the thermohaline circulation, for example. There are also many other papers with models based on Stommel’s 2-box model, which could be compared and contrasted with it.

### Prerequisites

There are no prerequisites for this project, and in particular you do not need to know any oceanography. You are welcome to attend relevant lectures at the Department of Earth Sciences and will also be referred to suitable reading material.

### Reading

The starting paper for this project is

Stommel, H *Thermohaline Convection with Two Stable Regimes of Flow* Tellus XIII (1961),2.

A short and accessible paper acting as a good introduction is

Marotzke, J *Abrupt climate change and thermohaline circulation: Mechanisms and predicatability* PNAS February 15, 2000, vol.97 no.4, 1347-1350.

With grateful thanks to Dr. Helen Johnson for suggesting this project.