

THERMOHALINE CIRCULATION CHANGES

FACT SHEET

The thermohaline circulation

is a global ocean circulation pattern, driven by density differences caused by variations in salinity and temperature. These variations arise from the heating and cooling of the surface waters and influxes of more or less saline waters.

For Western Europe, the most important current of this circulation pattern is the Gulf Stream which increases the temperature on the western seaboard of Europe by several degrees.

A second and smaller thermohaline circulation exists in the Mediterranean where evaporation and winter cooling in the east cause dense water to sink and move to the west. These denser waters flow out at the Straits of Gibraltar where they are replaced by less dense Atlantic water that enters the Mediterranean as a surface flow.

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SUMMARY

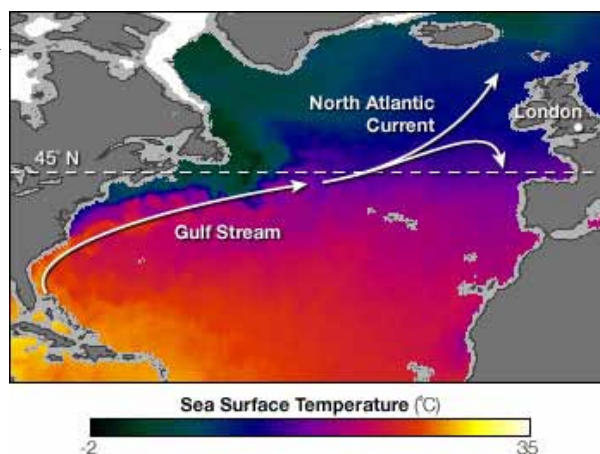
The dangers of thermohaline circulation change for European coasts include the possibility of a rapid shut-down of the Meridional Overturning Circulation (after: Parry *et al.*, 2007), potentially causing:

- Reductions in run-off and water availability in southern Europe;
- Major increase in snowmelt flooding in Western Europe;
- Increased sea-level rise on western European and Mediterranean coasts;
- Reductions in crop production with consequent impacts on food prices;
- Changes in temperature affecting ecosystems in Western Europe and the Mediterranean, e.g. affecting biodiversity, forest products and food production;
- Disruption to winter travel opportunities and increased icing of northern ports and seas;
- Changes in regional patterns of cold and heat-related deaths and ill health;
- Movement of populations to southern Europe and a shift in the centre of economic gravity;
- Requirement to refurbish infrastructure towards Scandinavian standards.

WHAT ARE THE FUTURE PROJECTIONS?

Studies have shown that an abrupt shutdown before 2100 is very unlikely and that global impacts of any slowing in circulation before then are likely to be offset by temperature increases related to greenhouse gas build up. However, on a local scale some areas, such as the Western margin of Europe, could be adversely impacted.

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Gulf Stream in the North-Atlantic is visible as a warm water current travelling northward along the coast of North America and eastward into the central Atlantic Ocean. As it continues its journey, heat from the ocean is lost to the atmosphere, warming the air above it.

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HOW CLIMATE CHANGE COULD INFLUENCE THE THERMOHALINE CIRCULATION?

- Increased melting of the ice sheets in Greenland could reduce the salinity of sub Arctic waters, making them less dense and thus less prone to sink. This could result in a reduced water/heat transport by the thermohaline circulation leading to a dramatic cooling of parts of Scandinavia and the United Kingdom.
- A decreasing frequency of cold dry spells in Southern France, responsible for generating dense sinking waters in the Mediterranean thermohaline circulation, could reduce oxygen transport to deeper parts of the water column.

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Top section of a RAPID mooring about to be deployed at 26N from RRS Discovery

ONGOING RESEARCH

The main focus currently lies in monitoring and increasing the amount of long-term data sets available. This is done, for instance, by using floating observational instruments as well as moored instruments that together provide a semi-continuous stream of data.

These datasets, in combination with an increased understanding of the different components leading to thermohaline circulation changes, are then used to increase the accuracy of the models used to make future projections.

RESEARCH GAPS AND PRIORITIES

Key open questions include*:

- What changes in freshwater input of the North Atlantic will result from global warming?
- What is the risk of exceeding a threshold for thermohaline circulation collapse for a given warming?
- What other thresholds exist?
- What consequences would result for marine biodiversity and whole ecosystems?
- How would climate over land be affected by a collapse scenario?
- How predictable is the system using today's generation of climate models and how can these predictions refine climate forecasts (particularly on the decadal scale)?

FURTHER READING

- Cunningham SA, Kanzow T, Rayner D, Baringer MO, Johns WE, Marotzke J, Longworth HR, Grant EM, Hirschi JJ-M, Beal LM, Meinen CS and Bryden HL (2007). Temporal variability of the Atlantic meridional overturning circulation at 26.5°N. *Science* 317(5840):935-938.
- Bryden HL, Longworth HR and Cunningham SA(2005). Slowing of the Atlantic meridional overturning circulation at 25° N. *Nature* 438:655-657.
- Kanzow T, Cunningham SA, Rayner D, Hirschi JJ-M, Johns WE, Baringer MO, Bryden HL, Beal LM, Meinen CS and Marotzke J(2007). Observed flow compensation associated with the MOC at 26.5°N in the Atlantic. *Science* 317(5840):938-941.
- Parry ML, Canziani OF, Palutikof JP, Van der Linden PJ and Hanson CE. (eds) (2007). Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press 976 pp.

*Partially taken from Ramsdorf (http://www.pik-potsdam.de/~stefan/thc_fact_sheet.html)

This fact sheet is based on a chapter of the CLAMER / Marine Board Special Report *Synthesis of European Research on the Effects of Climate Change on Marine Environments* (Deliverable 1.2) written by **Phil Weaver** from the National Oceanographic Centre, Southampton, United Kingdom