# 2. Further ideas

## 2.0 **Hosing investigations**

What is the largest freshwater flux that can be sustained without 'collapsing' the AMOC? Is there a 'threshold' ('tipping point') of freshwater input, beyond which the AMOC rapidly decreases in strength?

Is the precise location of the freshwater input important (i.e., try tipping it in somewhere else)? What would you expect to see in the paleo (e.g., ice core) record of both hemispheres if such a shutdown occurred in the past?

Are any other major regions of deep water formation (where are they) sensitive to freshwater perturbation and what are the consequences (could it happen in the future)?

## 2.1 **'Anti-hosing' investigations**

There are questions concerning past changes in the AMOC as to whether it is 'pushed' or 'pulled'. i.e. if the AMOC shoals in depth and/or weakens, is it because its production has weakened, or as Antarctic Bottom water (AABW) strengthened and 'pushed' it out of the way (to shallower depths)?

What you might try then is to inject salt in the Southern Ocean as opposed to fresh water in the North Atlantic. All you need do is pick an appropriate grid point (this is worth thinking about carefully and maybe testing different locations) and rather than giving the parameter `bg_par_ocn_force_scale_val_2` a negative value, you give it a positive one. (Start by trying similar magnitudes of value as before and see what happens.)

**Is the AMOC (for the same magnitude of forcing) more sensitive to being 'pushed' or 'pulled'?** (Obviously the answer will very much depend on where the perturbations are being applied.)

## 2.2 **Ocean circulation response to transient warming (or cooling)**

A current concern regarding global warming is the ocean circulation response to a strong warming of the surface, as it is assumed (and demonstrated in models) to result in surface stratification of the ocean, likely restricting the nutrient supply to phytoplankton and reducing ventilation of the ocean interior with dissolved oxygen.

You can explore the transient response of ocean circulation to warming by simply adjusting the radiative forcing parameter used in the snowball Earth experiments: `ea_radfor_scl_co2`. By default in the modern continental configuration it has a value of `1.0`, corresponding to 278 ppm atmospheric $CO_2$. A value of 2.0 would reflect warming equivalent to 556 ppm CO2. And 3.0 more like an end-of-the-century warming. Note that you are applying the warming *instantaneously* by manipulating the climate system in this way and hence the changes will be more extreme than those occurring over the time-scale of this century. Also note that a cooling could be applied instead. A *user-config* – `LAB_2.EXAMPLE` – is provided as a template for these experiments.

Potentially interesting properties of the Earth system to look at include sea-ice extent and AMOC strength (in the ASCII time-series files), and the overturning streamfunction and sea-ice extent (2-D netCDF output).

**How much radiative forcing is required to collapse the AMOC? What atmospheric $CO_2$ value does this approximately correspond to?**