Idealised modelling of ocean circulation driven by conductive and hydrothermal fluxes at the seabed

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Why investigate heat fluxes at the seabed in ocean models?

- The ocean has more than one active boundary, but interactions with the solid Earth are often ignored. The OSCAR project is researching this interface.
- The mean heat flow through the ocean floor is estimated as 0.1054 Wm\textsuperscript{-2}\textsuperscript{11}. Previous studies have found that including this in global circulation models results in abyssal temperature increases of 0.4°C, and large increases in the meridional overturning circulation\textsuperscript{12}. Hydrothermal discharge is responsible for about one third of the total geothermal heat flux into the ocean, but models currently make no distinction.
- Our investigation attempts to answer the question: How are the abyssal circulation and hydrography affected by the partition of conductive and hydrothermal fluxes?

What have we discovered?

- Hydrothermal fluxes cause the abyssal waters to be slightly warmer than conductive heat fluxes.
- Hydrothermal fluxes with lower temperatures (thus higher velocities) cause greater changes to the average temperature of the deep ocean.
- Higher velocity fluxes cause larger differences in temperature for lower values of $\alpha$, with the temperature changes plateauing as the value of $\alpha$ gets closer to 1.
- The plateauing effect suggests an upper limit to the differences in abyssal temperature between the two types of heat flux.

How do we answer this?

We use NEMO\textsuperscript{9} to run experiments in a rectangular cross section which represents, in a very basic way, features of the Panama basin (shown in the map to the right). This is the area of interest to the OSCAR project due to its bathymetry and geophysical properties.

Improvements to the investigation

The following are currently in progress:

- Modified distribution of heat flux boundary conditions (e.g. alternating discharge and recharge zones across the basin or changing the area over which heat flux is applied, two cases exemplified in the pictures to the right).
- Simulations with weakened or no restoring in the upper ocean.
- Open boundary at the southern end which more accurately reflects the flow dynamics of the Panama basin.

Conclusions

- Using the global average heat flux, average temperatures below 2500m are up to 0.02°C higher when heat is introduced to our model hydrothermally rather than conductively. This is likely an upper limit to the temperature differences between the two systems.
- The temperature differences become more pronounced at greater depths. The average temperature in the bottom layer of the model increases by up to 0.045°C, with localised differences of over 0.1°C in some locations.
- The different distributions of heat are caused by changes in the velocity fields which result from applying the heat flux hydrothermally. The velocity through the seabed draws some warmer water down from the layers above.

References