HYCOM modelling in the OSCAR project

Alex Megann[1], Miguel Angel Morales Maqueda[1,2]
and David Smeed[1]

[1]National Oceanography Centre, UK
[2]University of Newcastle, UK

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The OSCAR project

- Background

- Introduction: geothermal heat input and ocean circulation

- The OSCAR project
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  - Aims of the project

- The modelling component of OSCAR
  - Aims
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- So HYCOM no longer forms part of strategic research in the UK.

- **Continuing work on layered models depends on us gaining specific funding for that purpose**.

Introduction: geothermal heat input and ocean circulation

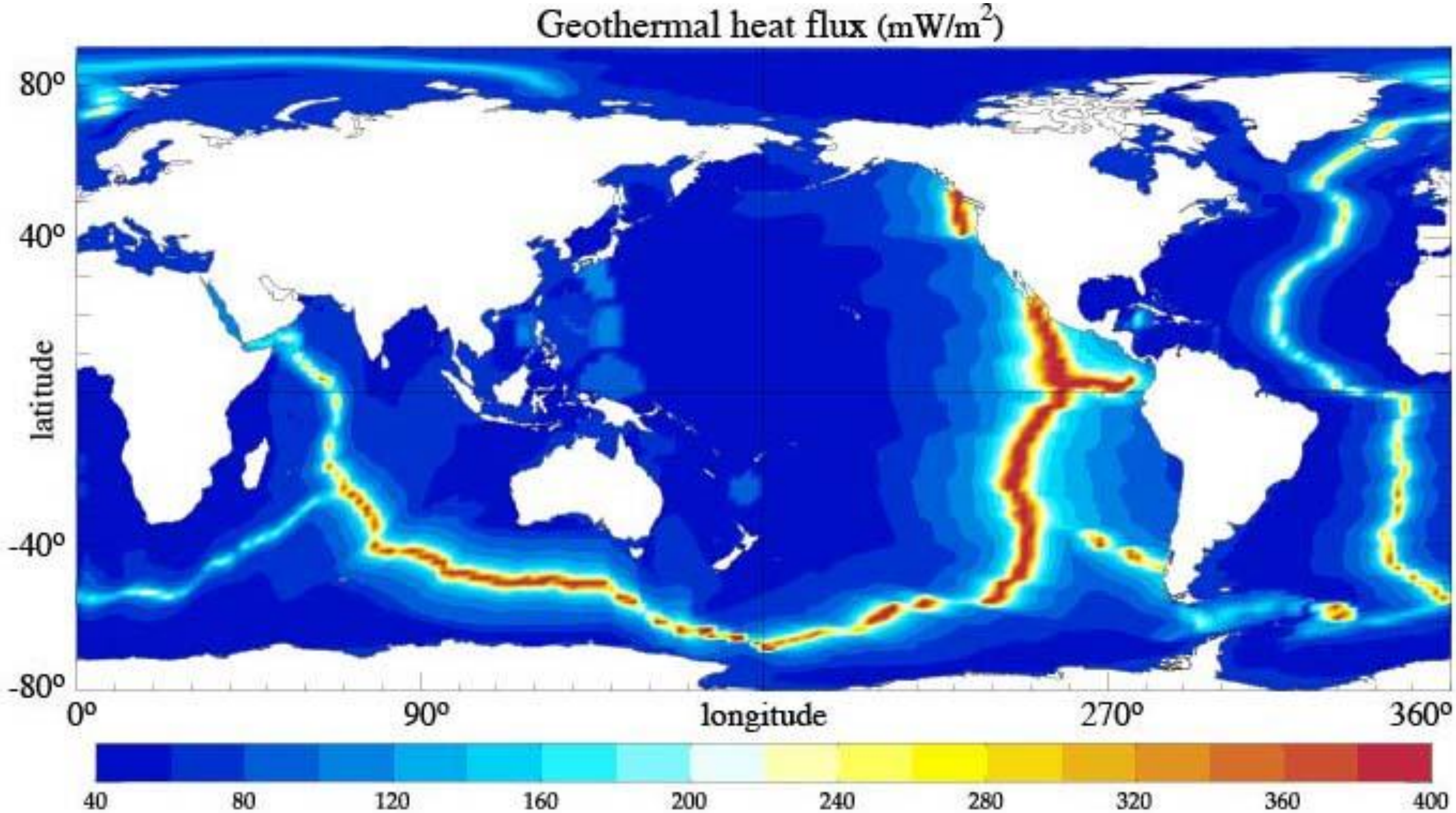
Numerical models suggest that geothermal heating plays an important role in the global ocean circulation.

- Global mean heat flux from geothermal sources is 0.08-0.09 W m^{-2}.

- It has everywhere a tendency to destabilise the water column:
  - locally contributes up to 0.4 cm^2 s^{-1} to the diapycnal diffusivity
  - estimated to cause around 5 Sv of AABW upwelling in model studies (*Emile-Geay & Madec, 2009*).

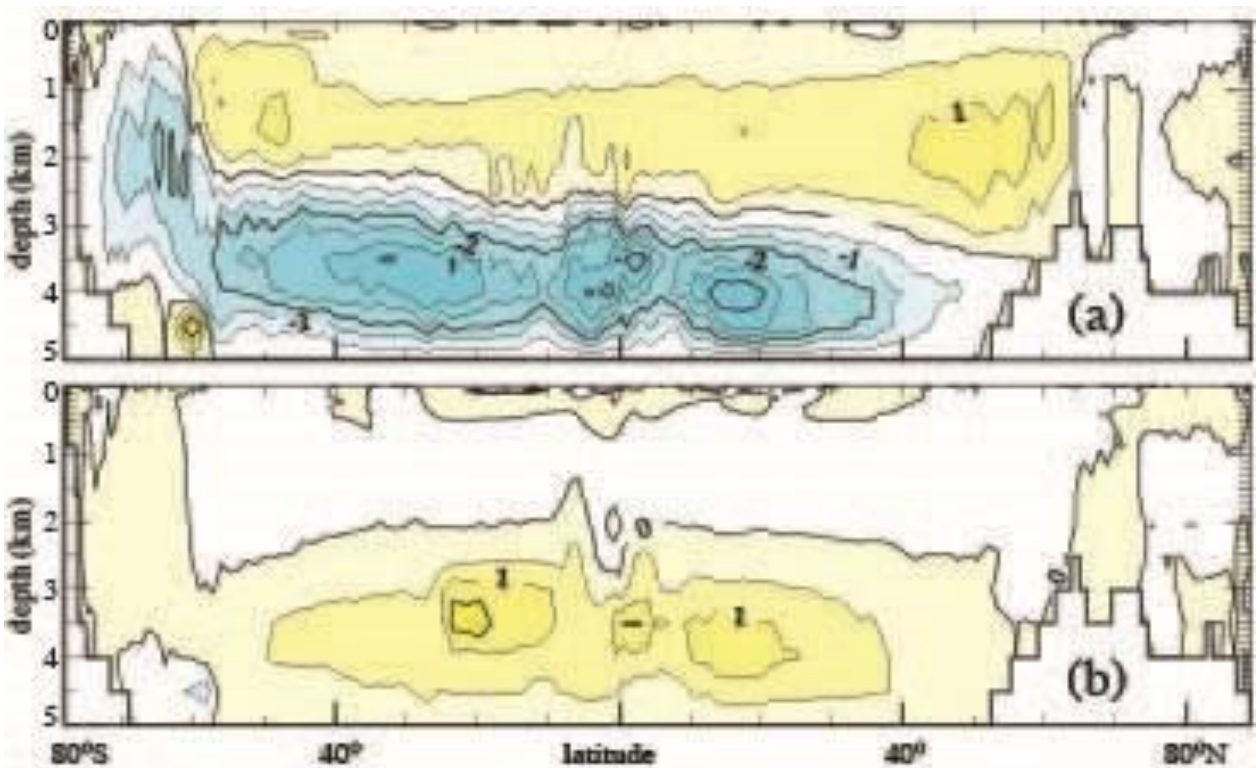
- However, observational evidence supporting this is difficult to obtain: interactions between geothermal processes and ocean circulation are subtle and occur at global scales.

Estimated global geothermal heat flux distribution



Geothermal heat flux, inferred from the formulae of Stein & Stein, 1992 (from Emile-Geay & Madec, 2009)

Sensitivity of MOC to geothermal heat flux



Effect of adding globally uniform heat flux of 86.4 mW m^{-2}

Effect of distributing heat flux realistically

Changes in global overturning from geothermal heat flux (from Emile-Geay & Madec, 2009)

Aims of the OSCAR project

OSCAR is a large multidisciplinary NERC project, involving geophysicists, seagoing oceanographers and modellers from the UK, the USA and Germany.

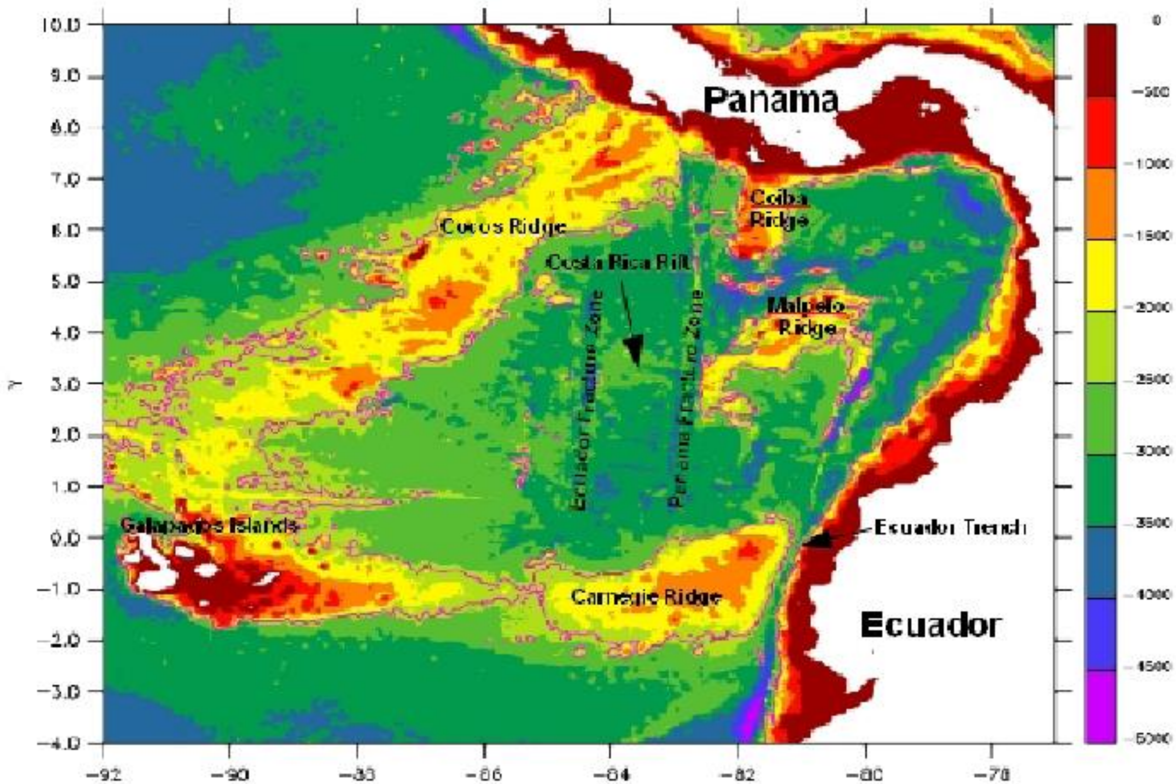
Its main objectives are to address the following questions:

- **How is the heat budget of the Panama Basin established and maintained?**
- **How does diapycnal mixing, whether vertical or horizontal, depend on the distribution and intensity of geothermal heating and hydrothermal venting?**

Three research cruises have been completed by the *James Cook* and the *Sonne* in December 2014-February 2015.

The region of interest

The Panama Basin is a small, almost enclosed ocean basin in which direct effects of geothermal heating on ocean temperature and circulation can be measured and studied in relative isolation from large scale influences.



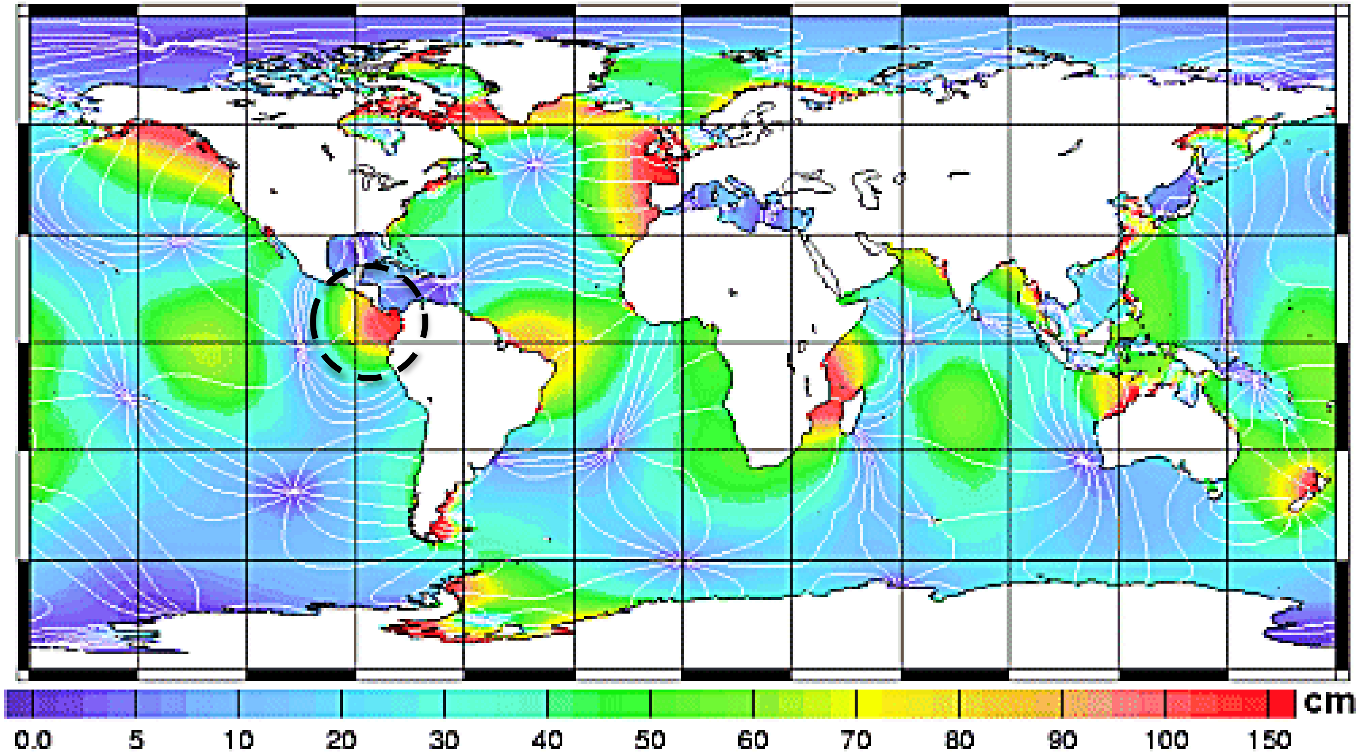
Bathymetry of the Panama Basin

The region of interest (continued)

- Bounded to the north and west by Cocos Ridge, and to the south by Carnegie Ridge.
- Deep inflow into the basin is from the North Peru Current, which enters through the Ecuador Trench. Carries about 0.35 Sv, and has a maximum depth of ~3,000 m.
- Deepest outflow is across sill of the Carnegie Ridge, at about 2,300 m.
- Basin averaged geothermal heat flux in the Panama Basin estimated as 273 mW m^{-2}, or more than 3 times the global average (Mueller et al., 1997, and Stein and Stein, 1992).

Tidal mixing in the Panama Basin

- Barotropic tidal amplitude is high in Panama Basin, so expect large mixing at depth from tidal motions.



Global M2 tidal amplitude (CNRS altimeter data)

Aims of the modelling component

- Modelling programme supplements observational campaign, and is focused on the same questions, but adds potential for sensitivity experiments, as well as allowing much longer time scales to be covered.

- High-resolution (5-10 km) regional model provides a tool for investigating effects of geothermal heating, tides and other mixing processes on the hydrography and circulation of the region.

- We prefer to use a model which has low numerical mixing, particularly when tidal forcing is used, so HYCOM is an obvious choice.

The OSCAR modelling framework

Started April 2015, and funding is available for for modelling for 2 years.

Will be done mainly by me at NOCS, but a PhD and a postdoc at NOC Liverpool/Newcastle will also contribute to analysis

- Spin up control integration for ~150 years

Additional runs to investigate sensitivity to:

- Geothermal heating (on/off);
- Spatial distribution of geothermal heat flux;
- Tidal mixing

Setting up the model

- Test run being setup in the first instance with 1/12° resolution (grid is a subset of the ORCA12 global grid used at NOCS).

- Grid and bathymetry files have been generated in HYCOM .a/b format.

- CORE2 forcing dataset currently being interpolated to model grid.

- About to select model densities: will use existing set chosen for earlier western Pacific cyclone experiments, with extra resolution in deep ocean: around 50 σ_2 layers.

- Work on initial and boundary restoration fields is underway.

Running the model

- Model will be run on NOCS supercomputing platform "mobilis", consisting of 72 compute nodes, each containing two eight-core Intel Xeon Ivy Bridge E5-2650 v2 processors.

- … however CPU time is unlikely to be a limiting factor, given the relatively small model domain.

Plans

- Complete setting up initial, forcing and boundary restoration fields
- Carry out test run of 1/12° model for ~50 years, and do preliminary analysis
- Set up grid and ancillary fields for 1/24° model
- Run production control run with uniform geothermal heat flux for ~150 years
- Set up and execute sensitivity runs
- Potentially set up interactive coupled model incorporating regional hydrogeothermal model (with Vincent Tong at UCL)

Questions for LOM workshop

- Does latest HYCOM include NetCDF I/O?
- Is it worth implementing new HYCOM bottom boundary layer?
- How do we implement tidal forcing?
- Any comments / suggestions?