Equilibration of the Beaufort Gyre by baroclinic eddies

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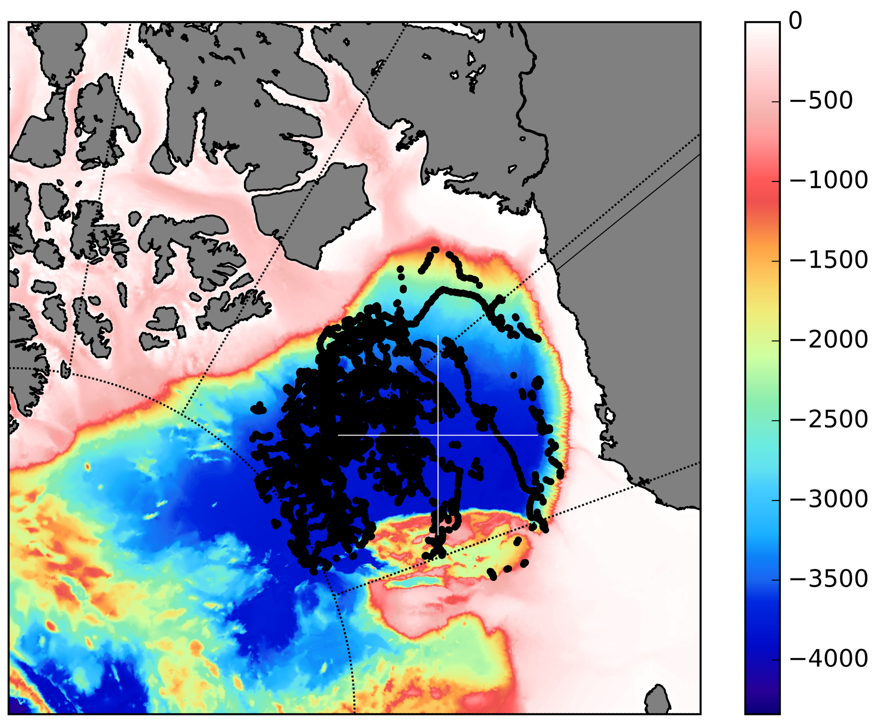
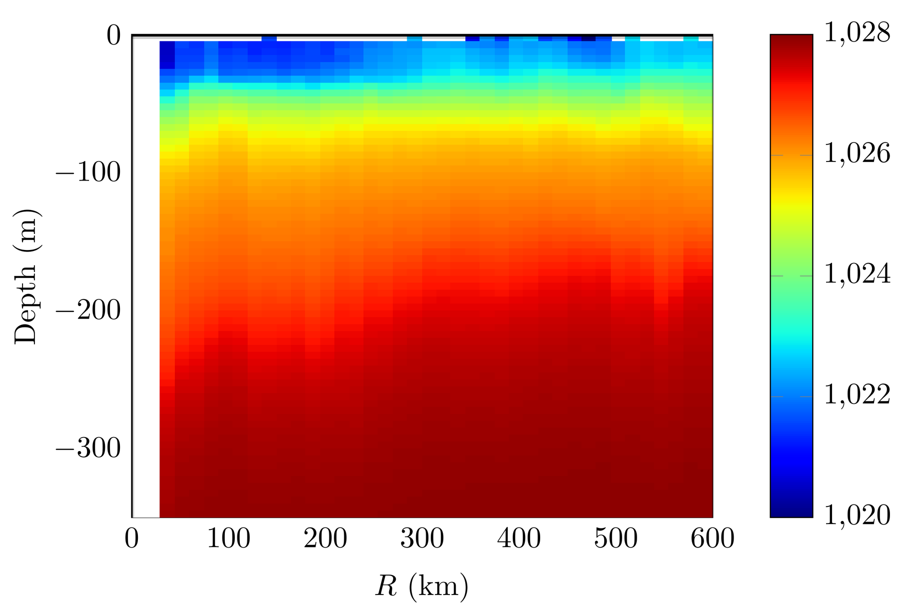
ITP data



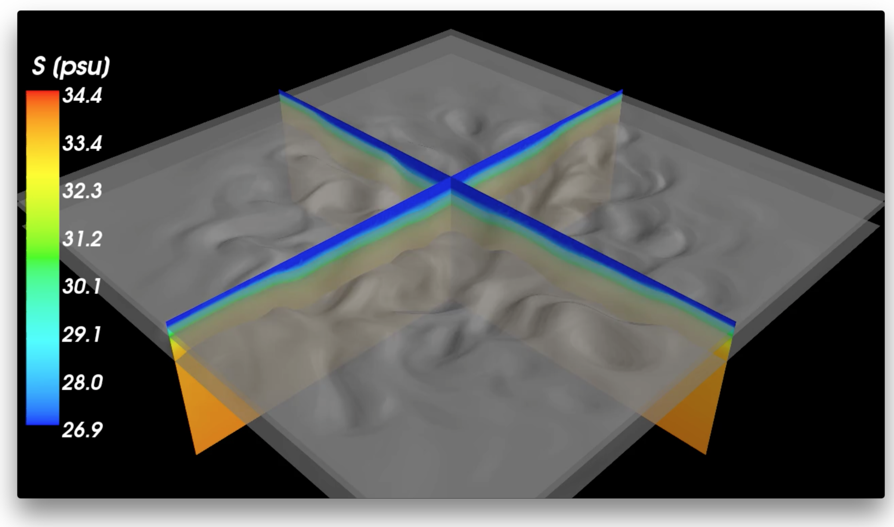
ITP measurements location



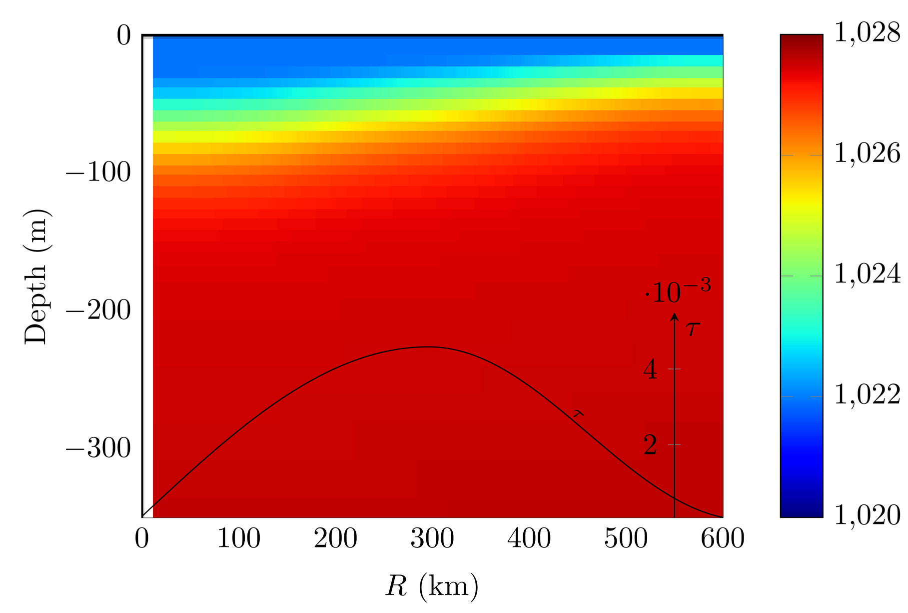
Density — azimuthal and temporal average

Density section as obtained by 13'000 ITP measurements of temperature and salinity between 2004 and 2012, binned as a function of the distance from the center of the Beaufort Gyre (maximum of the Dynamic Ocean Topography's 2003-2014 mean, *Armitage et al. 2016*).

Numerical model



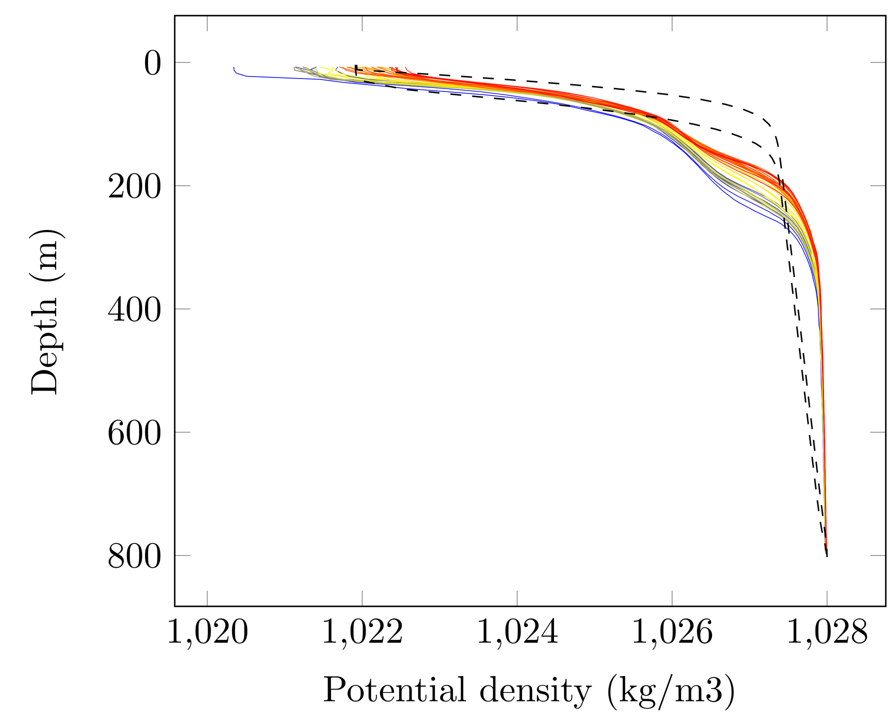
Salinity isosurfaces

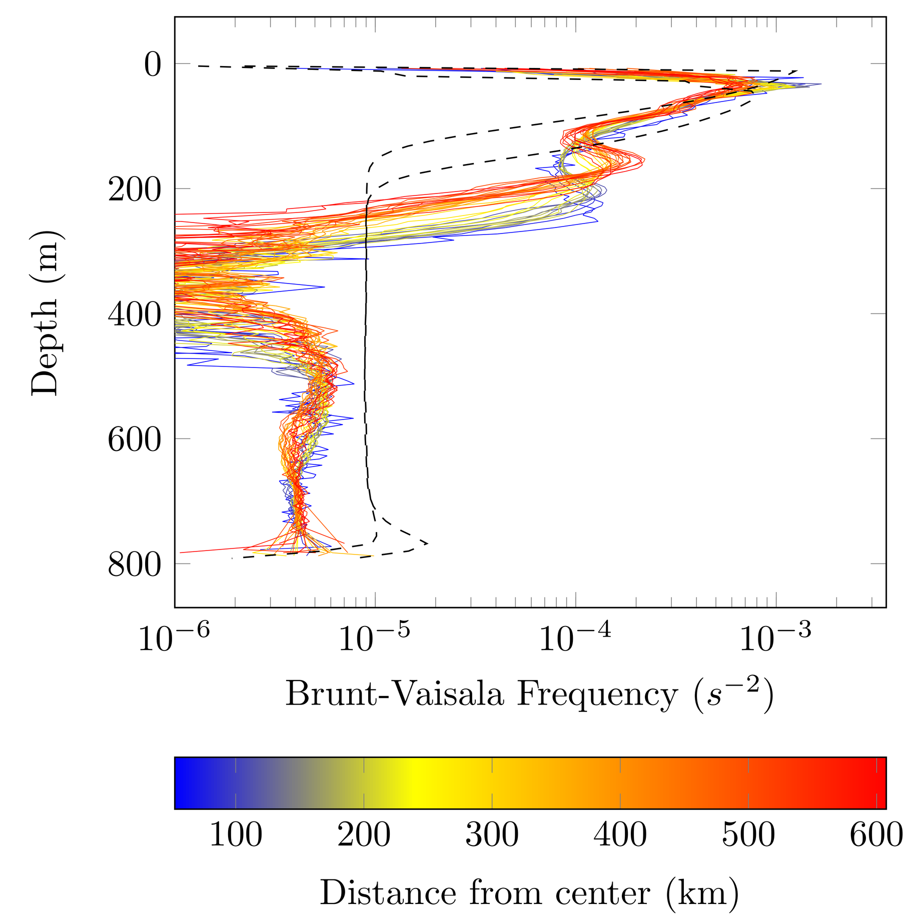


Density — azimuthal and temporal average

Density section from an eddy-resolving numerical model (1200 km wide at 4 km resolution, 800 m deep at $\approx$10 m resolution), averaged over 10 years and azimuthally. Spin up time is 20 years. The axisymmetric, azimuthal wind stress distribution is marked by a black line.

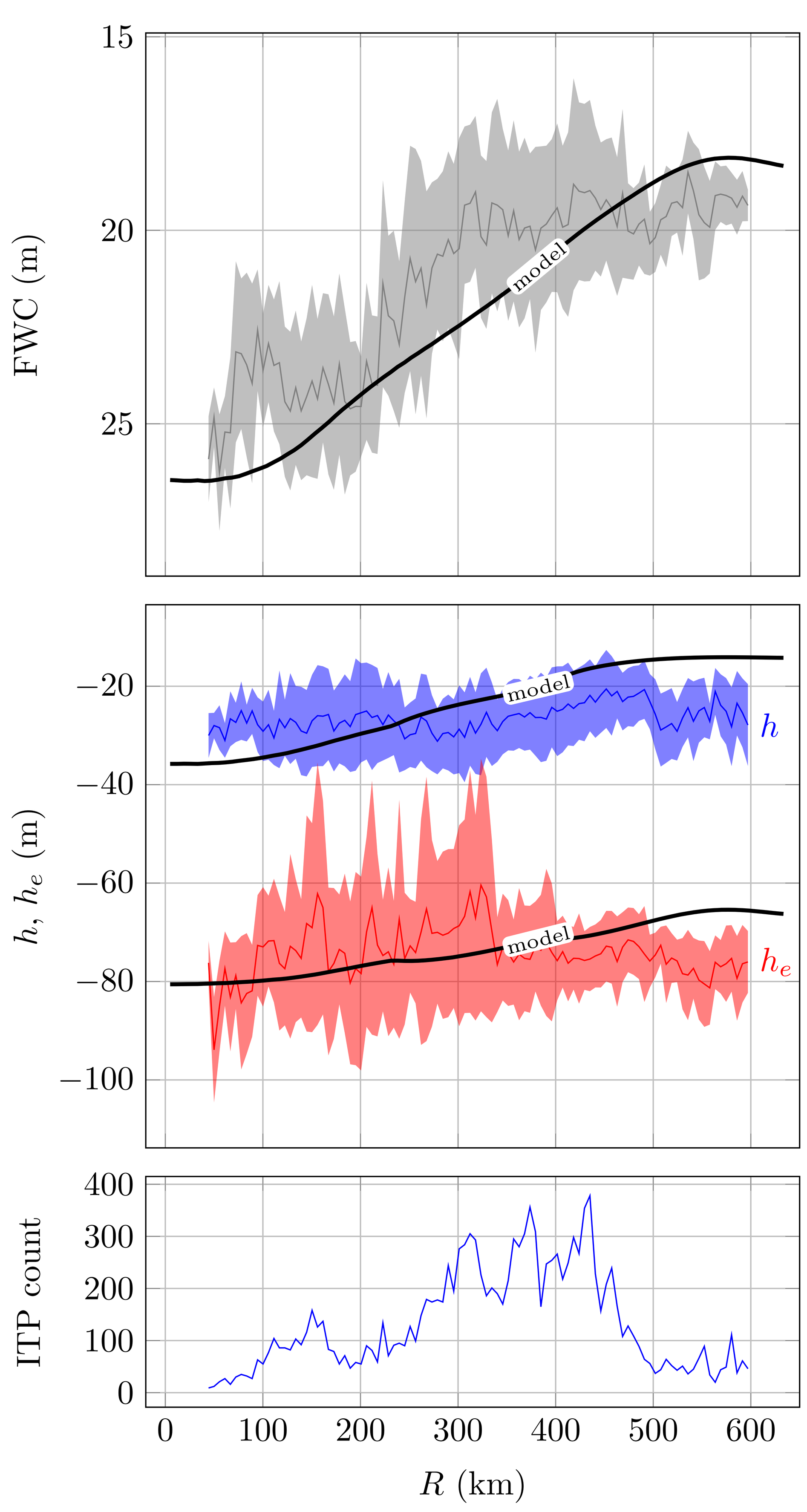
Comparison

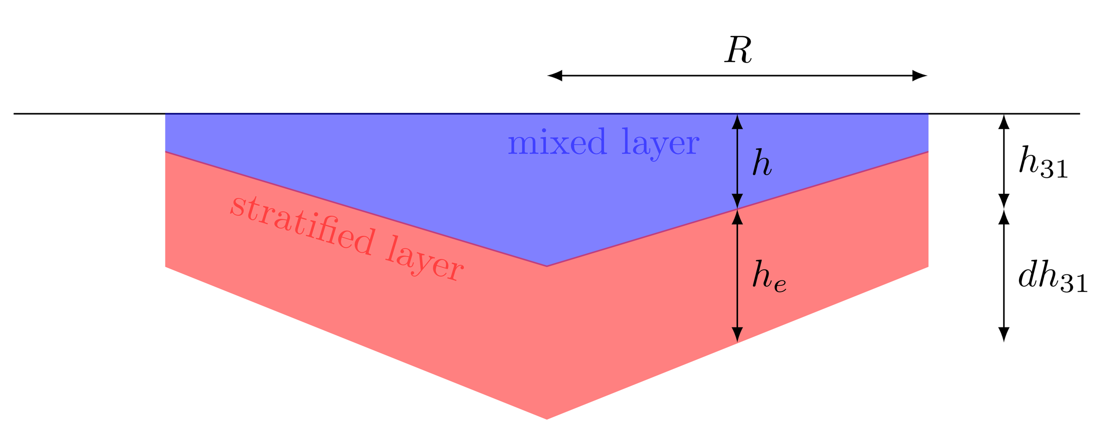




ITP (color) and model (black) density and N^2 profiles. The numerical model captures the upper structure but not the profile inflection right above 200 m depth.

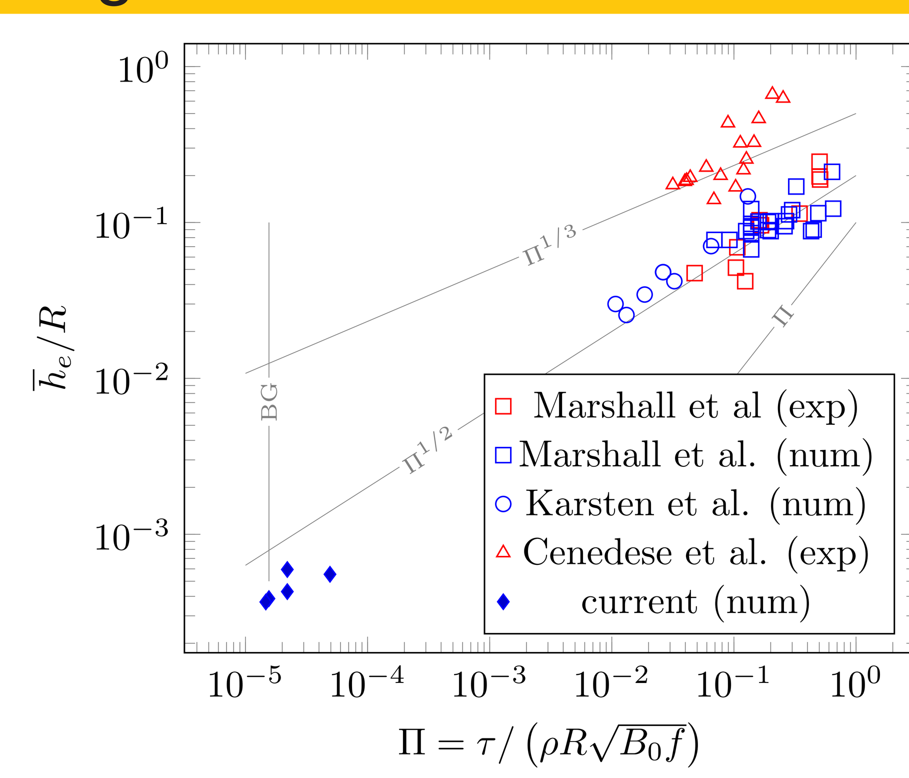
Freshwater content and characteristic depth for the BG





The Arctic's fresh water increase of the past thirty years is in large part concentrated in the Beaufort Gyre (see, e.g. Haine 2015). In order to better understand the main mechanisms behind this change, we build on previous theoretical models by Marshall, Karsten (2002) and Manucharyan (2015) in which the effect of the wind pumping down freshwater in to the gyre is equilibrated by lateral 'bolus fluxes' by eddies. A simple schematic of the Beaufort Gyre is suggested by the density sections shown above: a well-mixed layer of depth h sits on top of an exponentially varying stratified layer with e-folding scale h_e. Plots on the left show azimuthally-averaged freshwater content (top), and the two layers characteristic depths (center), as diagnosed from ITP data (thin lines and colored areas) and from the model (solid black lines). The number of ITP profiles used is shown in the bottom panel.

Scaling



Using data from previous idealized rotating fluid experiments and new numerical experiments, we confirm that a single dimensionless parameter $\Pi = \tau/\left(\rho R\sqrt{B_0 f}\right)$ is sufficient to characterize the buoyancy anomaly over a wide range of values. In the panel above, high values of Π correspond to laboratory (red) and corresponding numerical (blue) experiments performed in 2002 and 2004. The current experiments, for $10^{-5} < \Pi < 10^{-4}$, are marked by blue diamonds. Wind stress τ, characteristic length R, buoyancy flux B_0 and Coriolis parameter f are all varied among the various experiments. Despite offsets between different experiments, all data points align well with the $\sqrt{\Pi}$ line, in accord with the results of Marshall (2002) and Karsten (2002).

Bibliography

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The Ice-Tethered Profiler data were collected and made available by the Ice-Tethered Profiler Program (Toole et al., 2011; Krishfield et al., 2008) based at Whoods Hole Oceanographic Institution (http://www.whoi.edu/itp)

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