# Toward an adaptive coordinate for ocean modelling

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# Overview

# Motivation

- Isopycnal coordinate represents the interior well
  - But requires mixed layer parameterisations
- z-star coordinate gives control over surface resolution
  - Poor representation of overflows and isopycnal structure
- Combine benefits into a hybrid coordinate

# ALE

- *Arbitrary Lagrangian-Eulerian*, composed of **regridding** and **remapping** steps
- Can define an arbitrary vertical grid with interfaces $z_k(x, y, t)$ through regridding
  - (Actually more robust to give grid as thicknesses $h_{k+1/2}(x, y, t)$)

# HyCOM1

- Adaptation of HyCOM, blending isopycnal/z-star
- Every interface has a target depth and density
  - Actual depth of the interface is the deepest of the target and isopycnal depths
- Enforces resolution in the mixed layer
- Must be conservative to prevent surface boundary parameterisation problems
  - i.e. unphysical mixing well into the interior

# HyCOM1

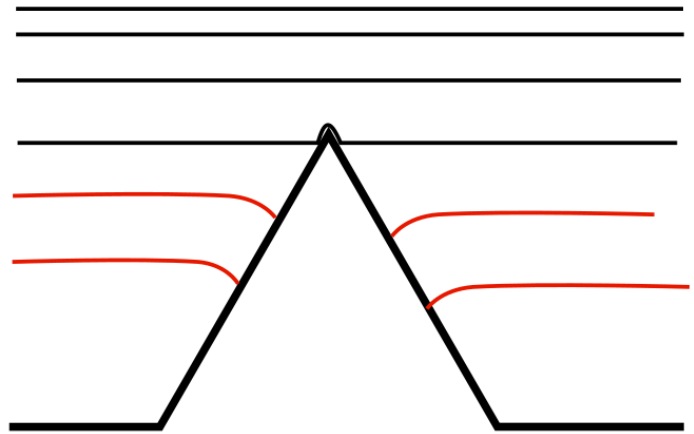

Figure 1: topography intersecting z-star region

# HyCOM1

- Must be prescribed ahead of time
- Because the geopotential region is conservative, it has a negative impact on overflows
- Dense overflows (e.g. Denmark Strait) involve too much entrainment

# Adaptive Coordinate

# Introduction

- Developed in the coastal modelling community (e.g. Hofmeister et al., 2010)

$$\frac{\partial z_k}{\partial t} - \partial_k \left( \kappa^{\text{grid}}_{k+1/2} \partial_k z_k \right) = H$$

- Involves two components:
  - Optimisation of resolution within a single column
  - Lateral smoothing/optimisation

# Modification

$$H_\sigma = \frac{\nabla^2 \sigma}{\partial \sigma / \partial z}$$

- To suit ocean modelling, we introduce a lateral neutral density optimisation
- Minimise curvature of neutral density on coordinate surfaces
  - Gives neutral density surfaces over large scales

# Parameters

- Vertical
  - Near-surface scaling: $\kappa^s = \alpha^s z_0/(z_0 + z_k)$
  - Stratification scaling: $\kappa^{N^2} = (h_{k+1} \sum_k \partial_k \sigma) / (D \partial_k \sigma)$
  - (Shear scaling)
- Lateral
  - Neutral density optimisation: source term involving $\nabla^2 \sigma$
  - Smoothing: source term involving $\nabla^2 h$

# Dense overflow

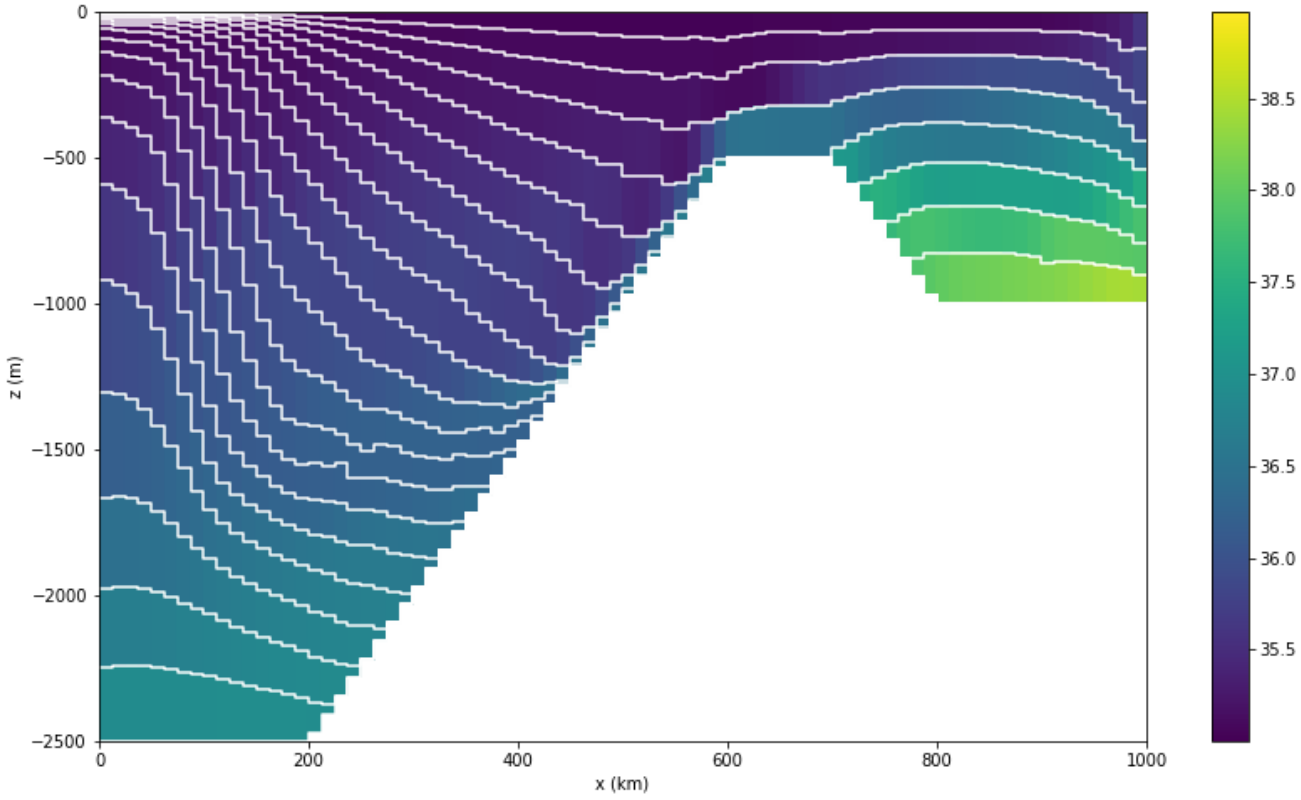


Figure 2: State after 20 days in dense overflow

# Open questions

- What do we want the coordinate to look like?
- How do we replicate near-surface resolution?