Field and numerical study of the internal tide dynamics in the Browse Basin, Western Australia

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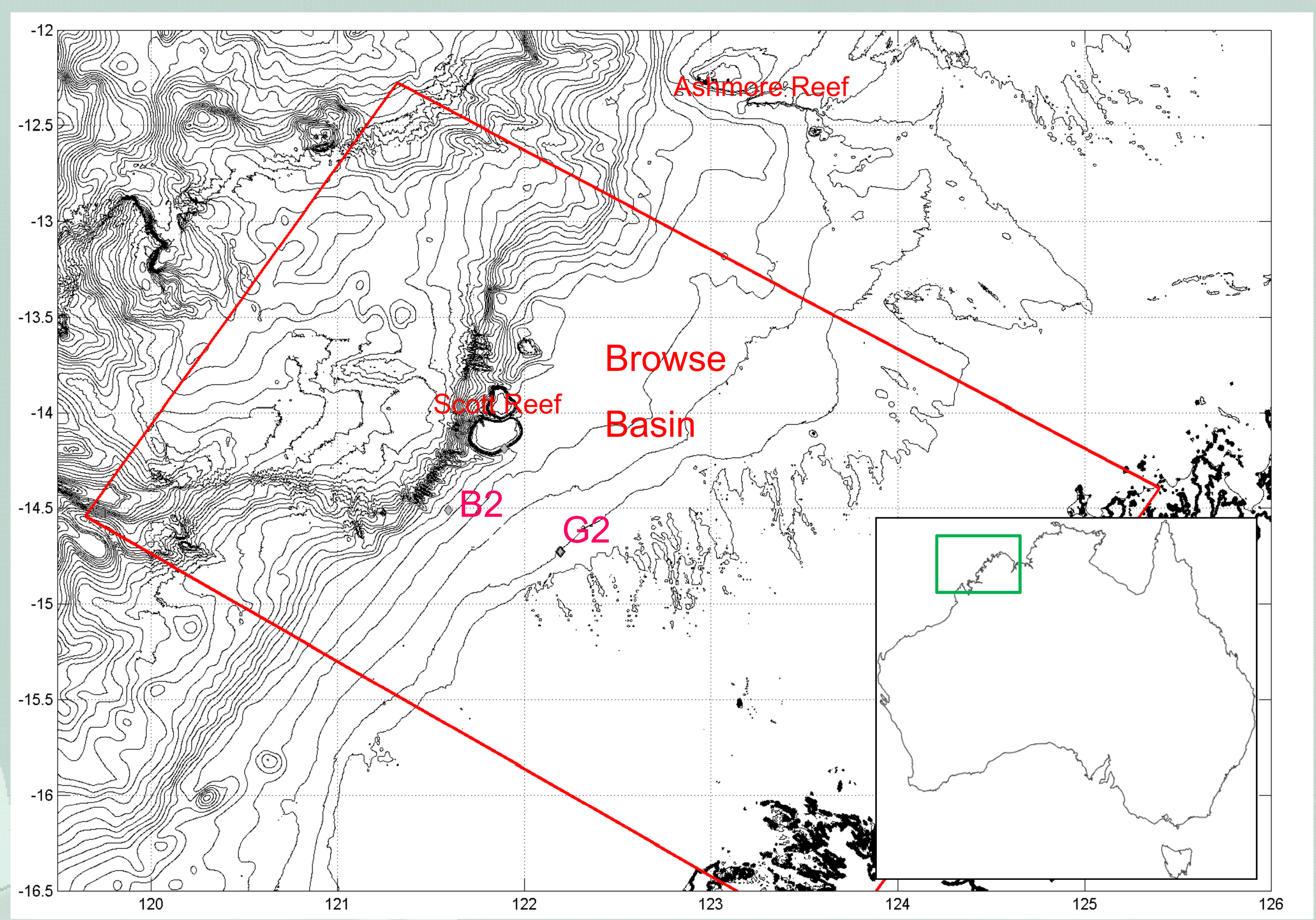
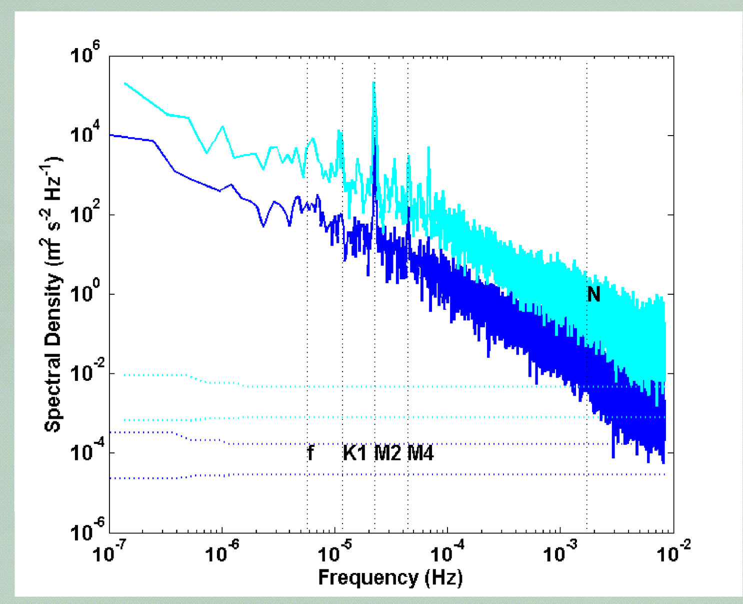
1. Background

The Browse Basin, located off the continental slope of far northern Western Australia, contains vast, previously undeveloped natural gas reserves. Understanding the ocean dynamics is a necessary ingredient for the sustainable development of the region. This study aims to define and quantify the ocean dynamics of the Browse Basin.

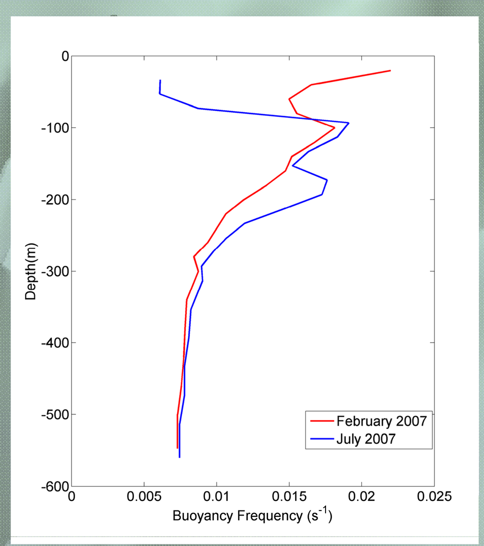
Data from three oceanographic moorings revealed that the barotropic tide is ~4 m in 500 m of water and is dominated by the semi-diurnal (M2 and S2) tidal constituents. An internal tide field, generated by the interaction of the barotropic tides with sloping topography, was observed via isopycnal displacement and baroclinic currents. The internal tide signal was non-stationary and varied on both fortnightly and seasonal timescales. Complex bathymetric features such as Scott Reef further complicate the internal wave field and therefore numerical techniques were required to adequately describe the physical processes.



Bathymetric map of Browse Basin. Moorings marked by diamonds. Model domain indicated by red polygon.



Spectral density of near surface east-west velocity component ,at G2 (light blue) B2 (dark blue) moorings, highlighting the dominance of the semidiurnal tidal signal. G2 data is offset by one decade for clarity. 95% CI indicated by dashed lines.



Monthly average buoyancy frequency profile from the B2 mooring for February 2007 and July 2007 highlighting the seasonal variability of the stratification.

2. ROMS Setup

The model was set up with the sole intention to simulate internal wave generation and propagation and therefore mesoscale ocean processes and atmospheric forcing were not included. Simulations were run for a 28 day period to capture two spring-neap tidal cycles.

Grid

- Curvilinear grid, 500 x 300 km with ~1-2 km resolution
- Bathymetry data: Geoscience Australia 250m dataset merged with Woodside data
- Bathymetry iteratively smoothed so $|H_1-H_2|/(H_1+H_2)<0.2$
- 50 vertical layers ($\theta_s=3$, $\theta_b=0.9$)
- Used Delft Hydraulics software package- RGFGRID

Forcing and Initialisation

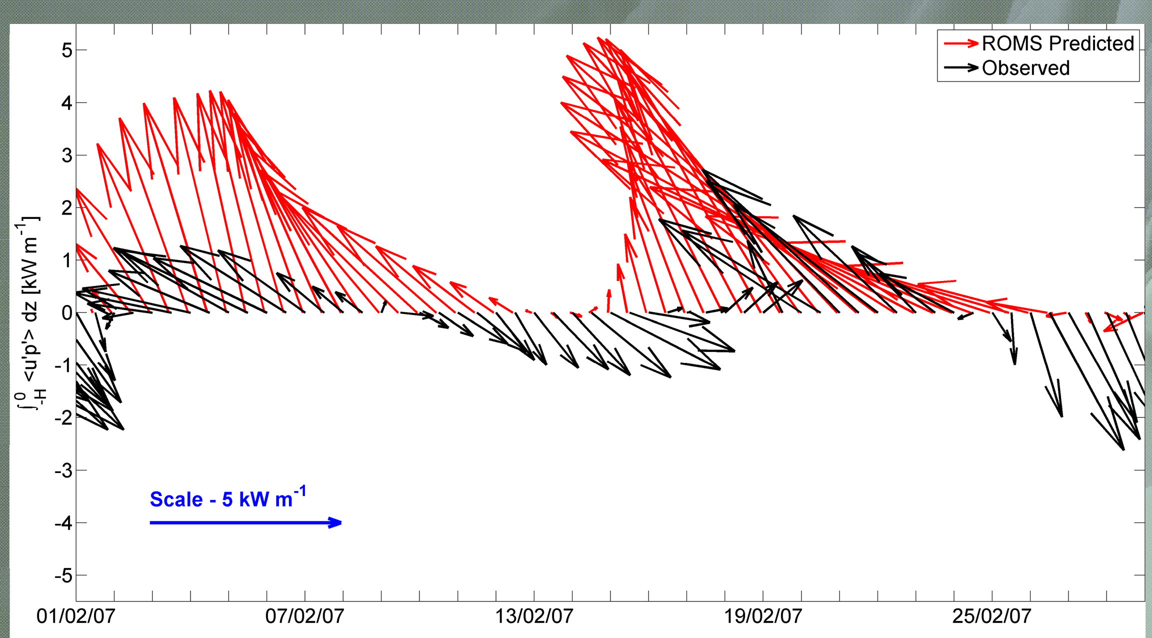
- Monthly average stratification from combined mooring and CSIRO BRaN data
- 8 tidal constituents (M2, S2, N2, K2, K1, O1, P1 and Q1) from TPX0v7.1
- Flather and Chapman conditions used for barotropic current and sea surface BC
- Passive-active radiation condition and sponging used for baroclinic and tracer BC

Subgrid Scale Parameterization

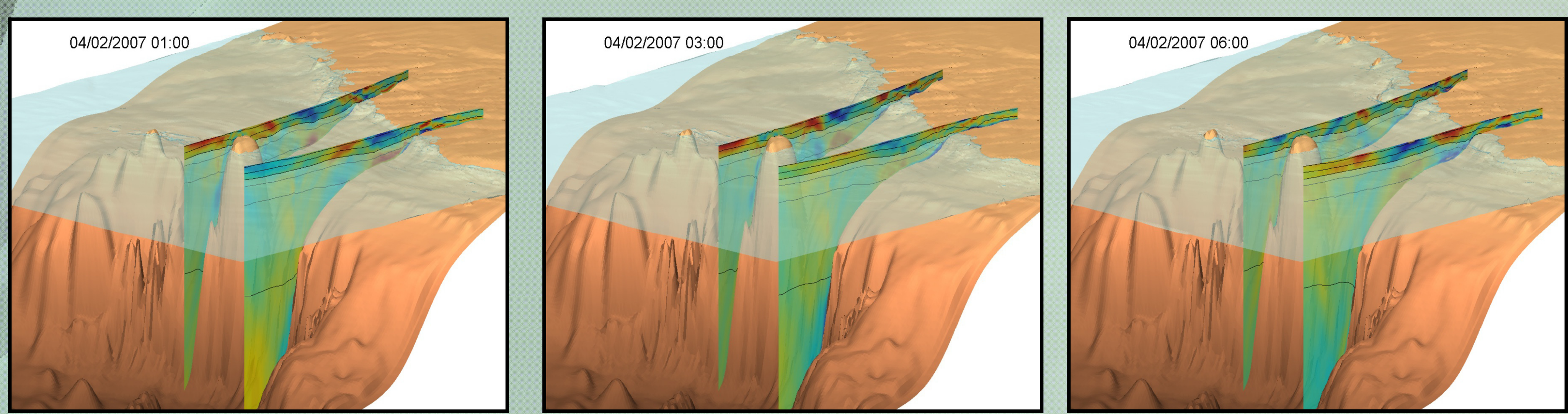
- Horizontal friction: Laplacian operator (K_H = 5.0 m^2/s)
- Turbulence closure: Generic Length Scale (k-ω)

3. Model Results

The ROMS solution was compared to field data to evaluate the effectiveness of the model at capturing the internal wave dynamics. The barotropic tide was well replicated by the model. The baroclinic currents and isopycnal displacements are in reasonable agreement and demonstrate that the model is capable of generating internal waves. To quantitatively compare the field and modelled internal wave field, the baroclinic energy flux term, <**u**'p'>, was calculated (Nash et al. 2005).

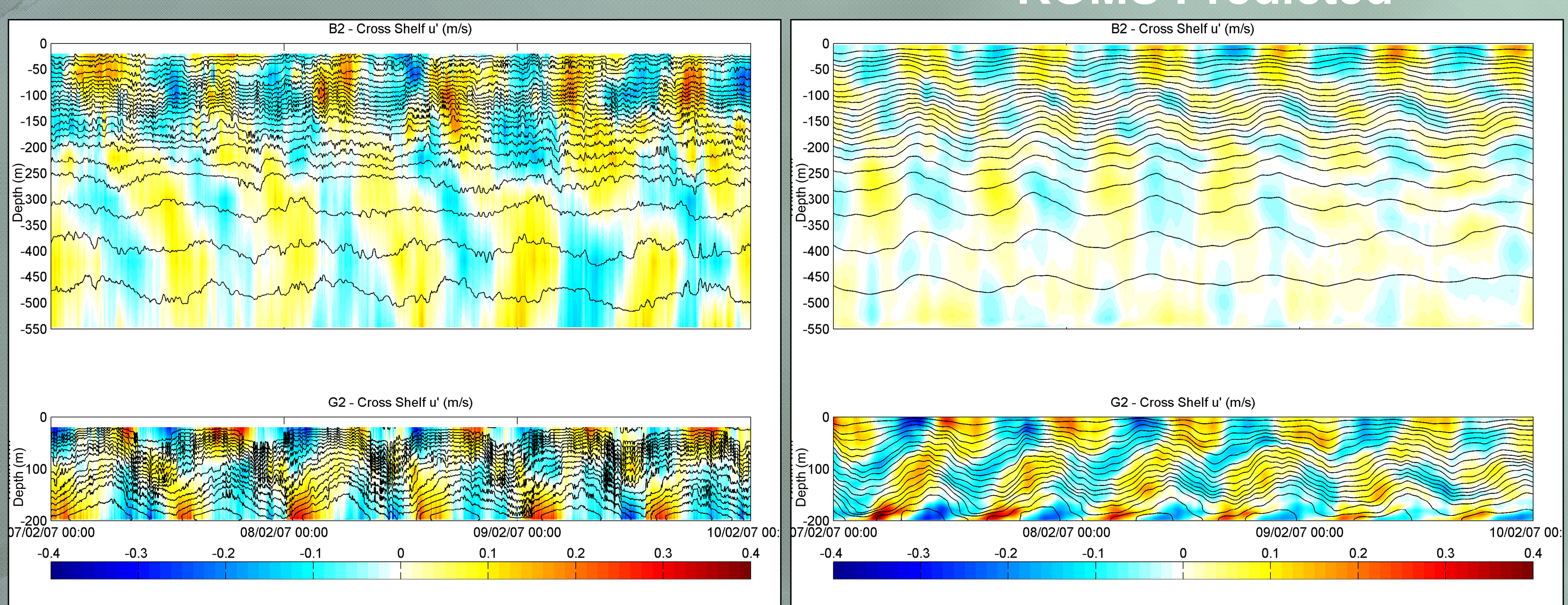


Stick plot of depth-integrated baroclinic energy flux at B2 for field (black) and ROMS (red) over a 28 day period.



Three-dimensional time sequence of ROMS generated internal wave field. Transparent blue surface indicates 20 °C isotherm. Contoured slices are of cross-shelf baroclinic velocity overlaid on 5, 10, 15, 20 and 25 °C isotherms.

Observed | **ROMS Predicted**



Sample three day time series of cross-shelf baroclinic velocity overlaid on one degree isotherms at sites B2 (top) and G2 (bottom). Note that the model does not capture high frequency processes. Field data is sampled at a coarser vertical resolution than the model.

4. Future Work

Future work will include:

- Estimating the error in the calculation of the baroclinic flux term;
- Evaluating the sensitivity of the model to different turbulence closure schemes;
- Quantifying the effect of atmospheric and mesoscale processes on internal wave dynamics;
- Using two-way coupling in ROMS to investigate dynamics within Scott Reef; and
- Investigating the dynamics of the observed highly non-linear internal waves using a non-hydrostatic code.

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