Internal Baroclinic Motion along 26°N in the Atlantic: do Rossby Waves reflect off of the western boundary?

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1. Introduction
Motivation: The 26°N overturning array measures full depth density and velocity at the western boundary. The observations contain a wealth of information about internal motion at periods of hours to years that can be used to evaluate processes that occur at the western boundary of a subpolar gyre.

Approach:
1. Potential and kinetic energy levels are unambiguous descriptors of the dynamic regime.
2. Energy flux indicates wave propagation at periods from 2 hours to 2 years spanning regimes from gravity to earth's rotation.
3. Changes between measurements of average energy indicate sources/transfer/sinks of energy.
4. The frequency distribution of energies and energy fluxes reflects the underlying wave regime.

2. Methods
Start with individual instrument records (synchronized CTDs and current meters). For depth-integrated energy, perform trapezoidal integrations to approximate:

\[ \int_{z=0}^{z=H} \rho' \omega' \, dz \]

Where \( \rho' \) and \( \omega' \) are the density and velocity perturbations, respectively. For band-passed calculations, filter single-instrument records prior to calculations.

3. How do Rossby waves reflect?
The transport of energy into a western boundary eddy and Rossby waves is central to ocean dynamics. It is unknown from observations what fraction of energy is reflected (e.g. Gill, 1982; Zhai et al., 2010), transformed into boundary waves (e.g. Unno et al., 2012), or transferred to the atmosphere (e.g. Käse, 2015).

4. Data
Frequency Spectra & Band Integrals

Table: Frequency Spectra & Band Integrals

- **PE** is the spectral energy density.
- **KEu** and **KEv** are the spectral energy density of the zonal and meridional components of velocity, respectively.
- **Fy BC1** and **Fy BC2** are the band-integrated energy fluxes for the zonal and meridional components of velocity, respectively.

5. Interpretation
The measured patterns exclude linear Rossby wave reflection. **PE** at WB5 and WB6 indicates planetary waves in 100-1000 days band: high PE, dominance of BC1 (Szuts et al., 2012), high correlation with SSH (Szuts et al., 2012; Clement et al., 2014).

Low-frequency energy flux at WB4 is westward:
- Low-frequency energy loss toward the boundary, which starts between WB4 and WB5, which is 1-2 Rossby radii (Ro=45 km) from the boundary.

What happens instead? These are indicators:
- Relative energy in the 1-10 day band increases toward the coast — a result of unstable turbulent motion?
- Zonal energy flux is eastward at WB5 — some reflection occurs?
- Zonal energy flux converges at WB2-WB5. It is a Rossby motion — does the Deep Western Boundary Current absorb energy?
- Meridional energy flux is northward at low frequencies — a result of a compressed coastline and large low-frequency wave lengths?
- Meridional energy flux for 1-10 days is southward — describes boundary waves (e.g. Käse, 2015), but how much energy do they gain?
- The largest amount of energy is lost from WB4 to WB5.
- Meridional velocity and energy flux is controlled differently than zonal velocity and energy flux.

The Deep Western Boundary Current (located at WB5) and the Antilles Current (located at WB4) are strong mean currents that could absorb the low-frequency energy.

6. Conclusions
- PE and PE lose energy near the coastal zone, which is 10-100 days.
- PE and PE lose energy near the coastal zone, which is 100-1000 days.
- The transport of energy into a western boundary eddy is a Rossby wave, which is controlled differently than a zonal velocity.
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- Zonal energy flux has spectra in the 1-10 day band: high energy, decreasing toward the coast.
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References