Searching for better topographic drag coefficients

Sally J. Warner and Parker MacCready
University of Washington • contact email: sally2@uw.edu

Engineers know drag coefficients for nearly everything:

Drag coefficients are useful because they make it easy to calculate the force that a fluid exerts on an object in a flow field.

\[ F = \frac{1}{2} C_D \rho A u^2 \]

- \( C_D \approx 1.42 \) for objects
- \( C_D \approx 0.38 \) for fusilier fish

It's difficult to measure form drag directly because the pressure and topographic slope must both be known.

But what about drag in ocean models?

In ROMS, the only way to control the drag is to change the frictional drag coefficient. This ignores drag created as fluids flow over topography.

Typical frictional drag coefficient in the ROMS file

Goal: Find better parameterizations of form drag on ocean topography.

How are we going to do this?

We use a numerical model coupled with field observations to measure the form drag at Three Tree Point, a headland in Puget Sound, Washington.

Finding the bottom pressure anomalies: Which parts create form drag and do work?

Max flood tide

An eddy creates a surface depression, but raises the underlying isopycnals

slack tide

The inertial pressure is the biggest part of the dynamic pressure signal at slack tide

What are the biggest problems with this method?

- ROMS is a hydrostatic model whereas flow over topography is inherently a non-hydrostatic process.
- ROMS requires topographic smoothing and has resolution limits, which may lead to inaccurate form drag estimates.

So... what's the drag coefficient of Three Tree Point?

Using the model, we can calculate a drag coefficient of 4.3, which is somewhat higher than expected. By using both the numerical model and field observations, we plan to refine this estimate and make parameterizations for other topography.

Acknowledgements

Thank you to Jim Moum and Jonathan Nash. Thanks also to David Darr for help with ROMS modeling on our Linux cluster. Captains Ray McQuin and Rick Verlini were a huge help during our three cruises at Three Tree Point.