Everything you ever wanted (or didn’t want) to know about FORM DRAG

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Once upon a time...

I was an engineer.
The coolest thing I learned:

Dimples on golf balls make them fly further than smooth ones.
What is form drag?

Form drag = pressure × area

\[ F = - \int_{A_0} p_B \frac{\partial h}{\partial x} dA_0 \]

- streamlined body: small form drag
- blunt body: large form drag
The easier way:

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

- \( F \) = force
- \( \rho \) = density
- \( A \) = frontal area
- \( C_D \) = drag coefficient
Everything has a drag coefficient...
Really, everything...

Ford Model T
$C_D = 0.8$

Toyota Prius
$C_D = 0.26$
Really, everything...

Eiffel Tower
$C_D = 1.9$

Empire State Bldg
$C_D = 1.4$
Really, everything...

Birds

\[ C_D = 0.3-0.4 \]

Dolphins

\[ C_D = 0.0036 \]
Really, everything...

Ski jumper
$C_D = 1.0$

Bicyclist and bicycle
$C_D = 1.1$
... except for ocean topography

(this is where I come in)
Frictional Drag

\[ F = - \int_{A_0} p_B \frac{\partial h}{\partial x} dA_0 \]

With \( C_D = 7 \)

Edwards et al., 2004; McCabe et al., 2006
Form drag in the ocean

Steady flow over Stonewall Bank:

interior form drag
11-18 x 10^6 N

Moum and Nash, 2000; Nash and Moum, 2001

Oscillating flow at Three Tree Point:

interior form drag
20-50 x 10^6 N

Edwards et al., 2004; McCabe et al., 2006
Can we measure the total \textit{in situ} form drag?

(and then calculate $C_D$)
Cruise plan

- ADCP and PPOD
- PPOD only
ROMS model

Top view of bathymetry

Side view of salinity anomaly
Why care?

Accurate drag coefficients will improve:

- the performance of large scale numerical models.

- our ability to calculate the ocean’s energy budget.
Conclusions

- Drag coefficient have been calculated for nearly everything except ocean topography.

- Our long-term goal is to get accurate drag coefficients for the entire ocean — we’ll start with Three Tree Point.

- Research is slow.