

On the Over-Estimation of Radiation Stress (and your model is wrong, Part 1)

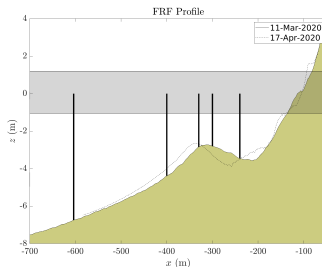
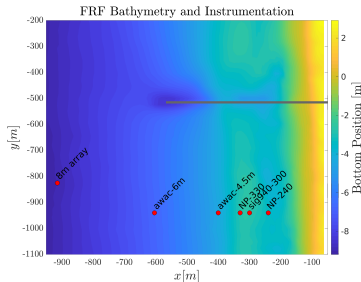
Brad Johnson

November 30, 2021

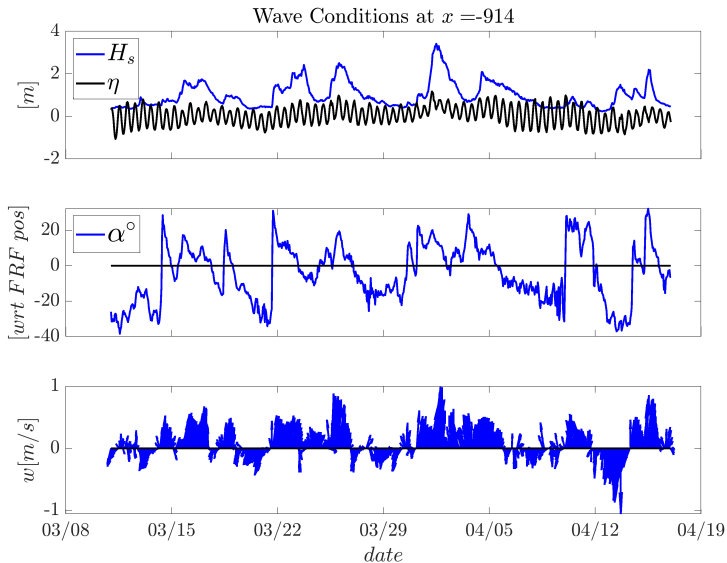


Nearshore Current Data

- Five stations, currents, waves
- Focus on week following survey, bed assumed steady
- Coordinate system is corrected from FRF coords
- Waves with positive angles make positive (South-directed) currents
- Detailed momentum balance at one position, both inside and outside of the surf

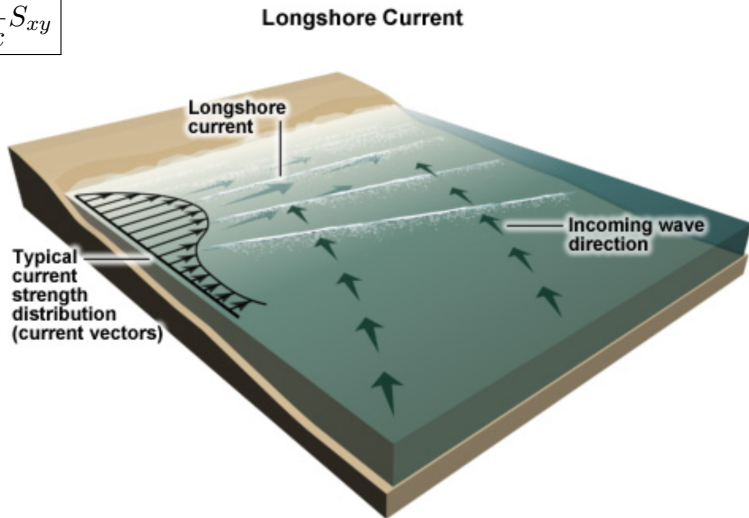


Environmental Conditions



Wave-Driven Longshore Current

$$\tau_b = -\frac{\partial}{\partial x} S_{xy}$$



Wave-Driven Longshore Current

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Bottom Shear Stress: All practical models utilize a quadratic bottom friction :

$$\tau_b = \rho c_f |\mathbf{u}| v$$

where

$0.1 > c_f > .001$ and is solved, in this case, for v

Radiation Stress: A closure problem for time-average of products:

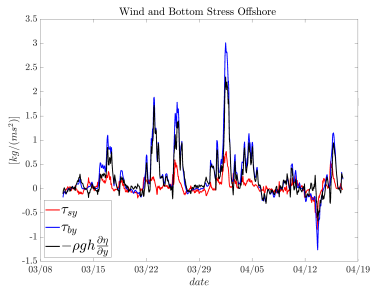
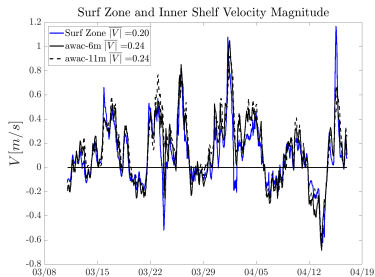
$$\begin{aligned} S_{xy} &= \rho \int_{z_b}^{\eta} \tilde{v} \tilde{u} dz \\ &\simeq En \sin \alpha \cos \alpha \end{aligned}$$

where

$$E = \frac{1}{8} \rho g H_{rms}^2$$

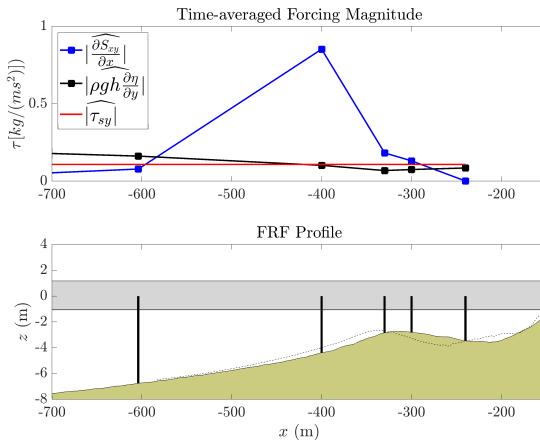
Wind- Wave- Pressure-Driven Longshore Current

$$\tau_{by} = \tau_{sy} - \frac{\partial}{\partial x} S_{xy} - \rho g h \frac{\partial \eta}{\partial y}$$

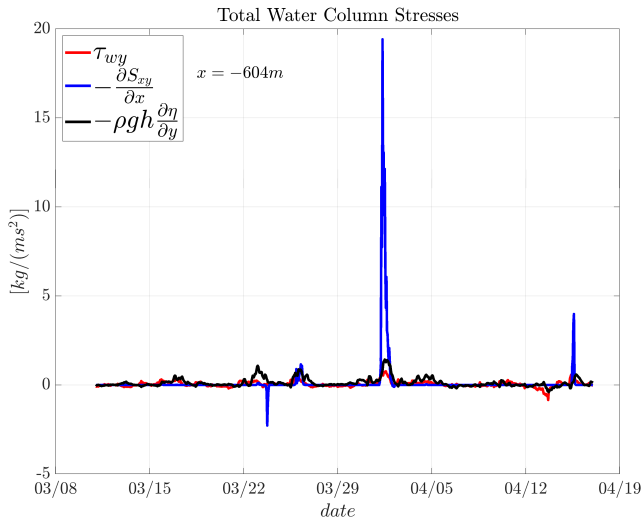


Wind- Wave- Pressure-Driven Longshore Current

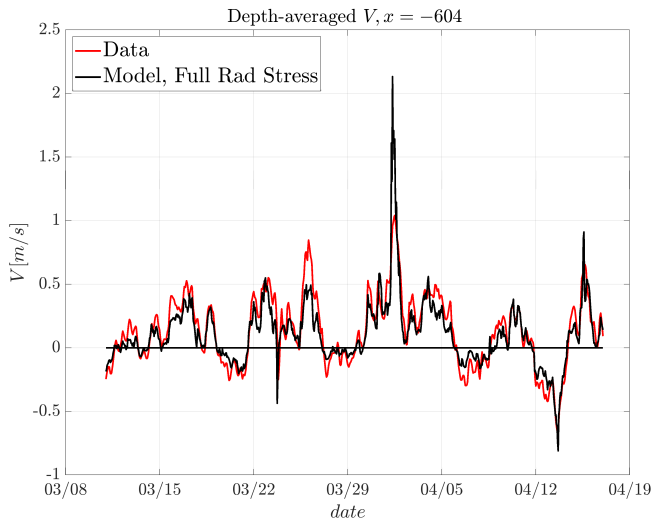
$$\tau_{by} = \tau_{sy} - \frac{\partial}{\partial x} S_{xy} - \rho g h \frac{\partial \eta}{\partial y}$$



Stress in Outer Surf Zone



Velocity in Outer Surf Zone



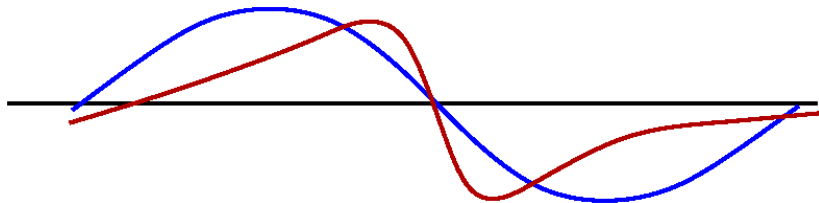
How is Your Model Wrong?

Radiation Stress: A closure problem for phase-averaged vertical integrals of wave orbital velocities:

$$S_{xy} = \rho \int_{z_b}^{\eta} \overline{\tilde{v}\tilde{u}} dz \simeq En \sin \alpha \cos \alpha$$

uses a linear representation of wave-orbital velocities

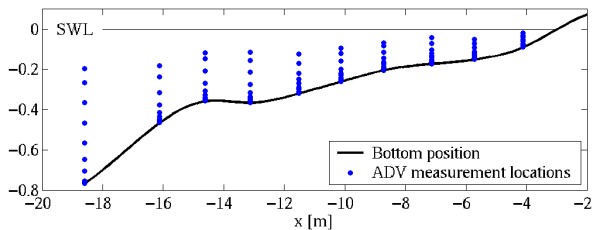
$$(\tilde{u}, \tilde{v}) = \frac{\tilde{\eta}c}{h}(\cos \alpha, \sin \alpha)$$



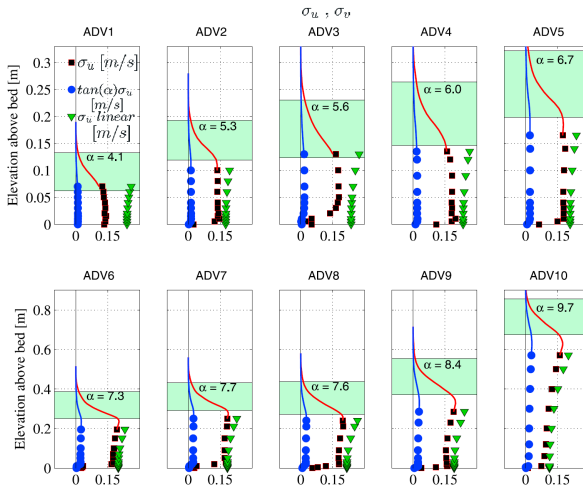
Laboratory Data



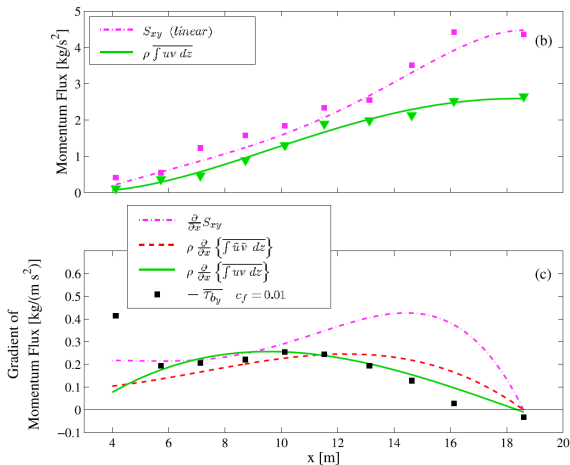
Vertical Measurement locations Test1 Case3



Measured and Linear \tilde{u}

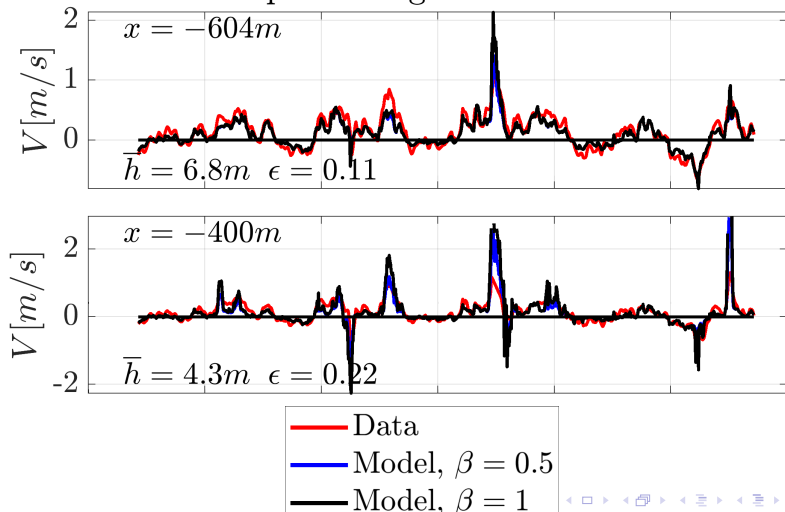


Measured and Linear Momentum Flux

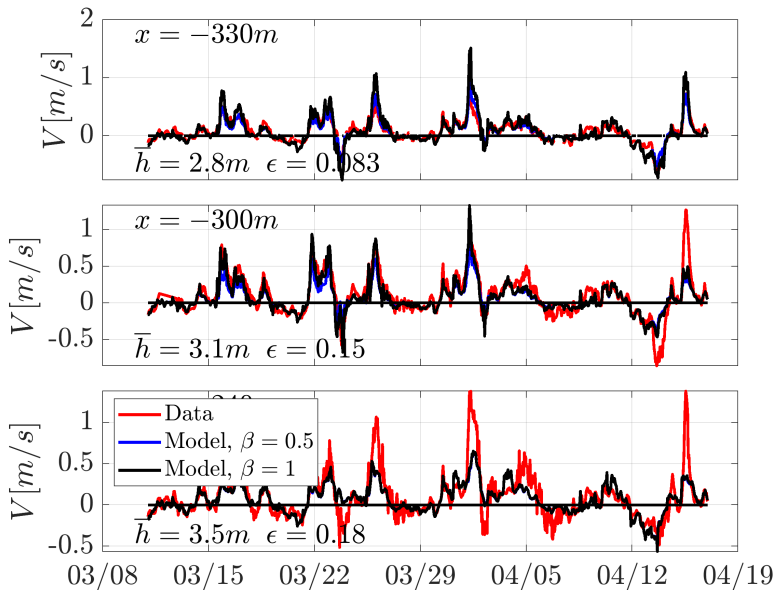


The Remedy: Reduce linear representation

Depth-averaged V $\epsilon = 0.15$

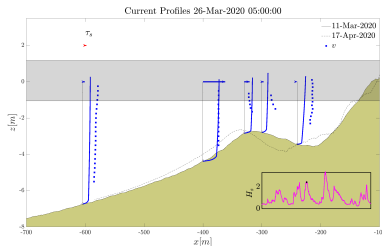


Field Data



Discussion

- New FRF data including waves, currents
- Pressure, wind are both important outside of surf zone
- Three sources of momentum indicate that linear S_{xy} is too large
- Lab data indicate that linear S_{xy} is too large
- Another explanation, like variable friction or altered free-stream velocity



- $V(z) = f(D_B)$? No
- $c'_f = c_f \{1 + f(D_B)\}$? Probably not
- Your Model is Wrong—does it matter?