Flexible Vegetation and It's Implementation in the Swash Ocean Model

Vegetation in most ocean models is represented as rigid cylinders, which can account for some of the features of vegetation, but do not realistically capture the ability of vegetation to adapt to flow, or flex, thereby affecting the resultant calculations of turbulence, drag, and inertia in the water column. Existing flexible vegetation solvers use finite elements schemes, which can be prohibitively expensive to calculate for large vegetative fields. We implemented a flexible vegetation solver for the SWASH nearshore ocean model intent on resolving motion of highly flexible vegetative stems and the resultant influences on the flow field. This is included in new subroutines created for SWASH, calculating deflection on a moving sub-grid using a finite difference scheme to solve the fourth order differential equation for highly flexible rods on a Lagrangian grid attached to the stems. It returns the force exerted by the vegetative stem to the existing Navier-Stokes k-epsilon model at the appropriate computational grid points. To validate the accuracy of the scheme and the behavior of the flexible vegetation, the scheme is modeled in MATLAB. It is validated against physical beam bending experiments and against other physical and computational experiments of vegetation in flow fields.

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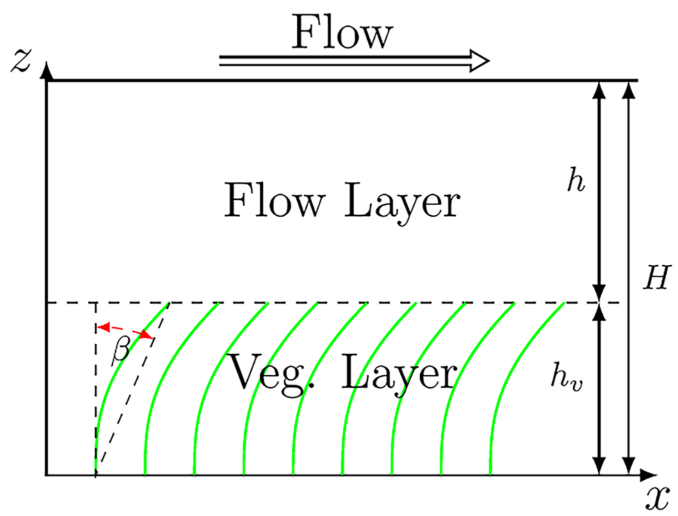
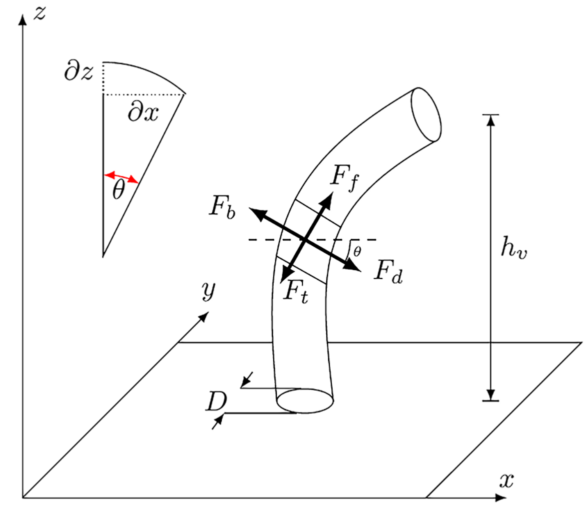
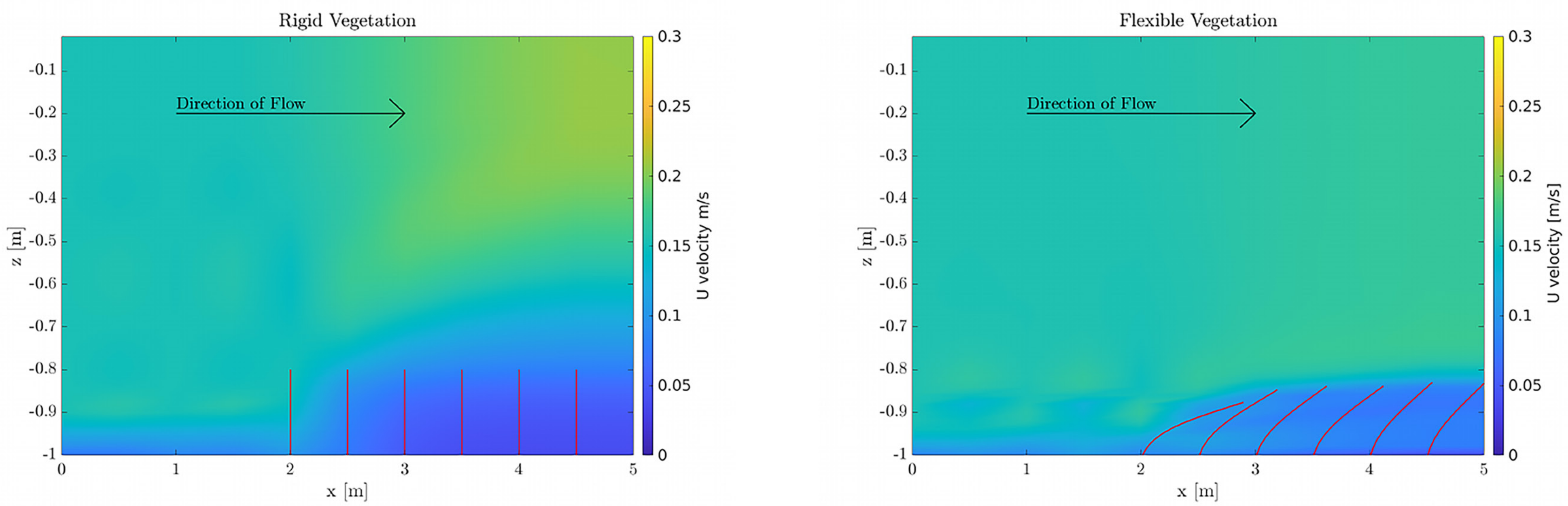


In general, ocean models fix the vegetation layer, and do not allow changes over the course of a simulation.



Physics forces accounted for on a single vegetation branch. F_b is the buoyant force, F_f is friction, F_d is drag, and F_t is tension. h_v is effective height, D is the diameter, and θ is the angle of deflection.



Comparison of rigid versus flexible vegetation and the flow fields generated around them. The flow in these images is 0.2 m/s left to right. The rigid field acts as a step, pushing water up and around the field, while the flexible vegetation absorbs some of the momentum and bends to smooth the passage of the fluid.