Porting of the Finite Area Method to OpenFOAM Plus

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The Finite Area Method (FAM) is a variant of the Finite Volume Method (FVM) operating on a two-dimensional curved surfaces in three-dimensional space. This method handles the three dimensional basal topography in a simple way, making the model suitable for arbitrary curved surfaces. The method operates with vectors and tensors in global Cartesian space. Effects of surface curvature is built into the differential and discretisation operators, with suppoft for polygonal surface meshes.

In layout, the Finite Area Method in OpenFOAM follows the structure of the FiniteVolume discretisation library, sharing the basic field algebra, linear system support, layout of boundary conditions and discretisation techniques. The Finite Area mesh is created either as a stand-alone surface object or as a boundary patch of the FV mesh for convenient coupling with volumetric model. For coupled simulations, the volume-to-surface mapping tools are implemented as a part of the library.

Parallelisation of the FAM follows the FVM pattern, with domain decomposition either being separate or tied to the of the decomposition of the volume mesh.

Two surface-based mathematical models have been implemented and validated against analytical solution: passive transport of a scalar on a curved surface and the thin liquid film model.

The Finite Area models are regularly used in industrial applications of various phenomena, ranging from surfactant transport on the surface of a rising bubble, simulation of vehicle soiling in rain, calculation of rain loading and dimensioning of down-pipes on complex roof geometries, loading of topographical surfaces by rain in flooding simulations and simulation of shallow granular flows on three-dimensional surfaces, such as Alpine avalanche simulations.

The method was being developed by Tukovic and Jasak and Tukovic since 2002 and has been available in foam-extend, as well as the early versions. Within this project, and on request of a customer, the Finite Area library, top-level solvers and FAM manipulation utilities have been made available in OpenFOAM Plus.