is to inform users about the dependence of the upper-bound of I_{split} on tidal ranges, bottom slope in the inter-tidal zone, thickness of the specified viscous layer, external time step, and vertical/horizontal resolution, and provide a guide for choosing I_{split} in realistic applications.

3.5. Finite-Volume Discrete Methods in Spherical Coordinate System

The numerical methods used to solve the spherical coordinate version of FVCOM are the same as those used in the Cartesian coordinate version of FVCOM with two exceptions, the redefinition of the meridian flux and North Pole treatment. In both Cartesian and spherical coordinates, we have introduced a new flux corrected second-order scheme to calculate the tracer advection. The discrete procedure of FVCOM was given in detail in Chen et al. (2003) and Chen et al. (2004), and brief descriptions of the re-definition of meridian flux, the discrete scheme for the tracer advection, and North Pole treatment are given below. The text is directly adopted from Chen et al. (2006b).

Following the same approach used in the Cartesian coordinate version of FVCOM,

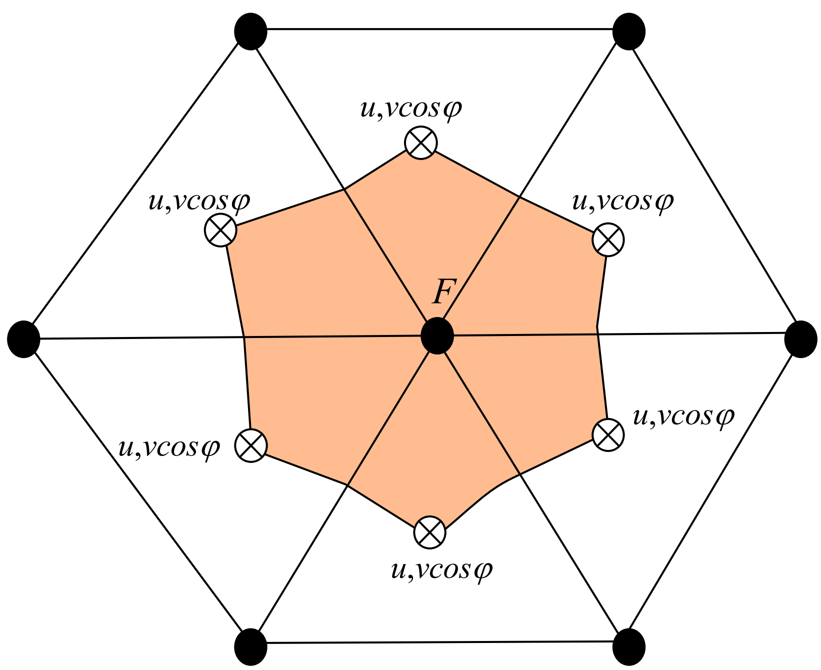

Fig. 3.11: Schematic of the control volume used to calculate scalar variables and vertical velocity used in FVCOM. F is a general symbol representing scalar variables such as ζ, T, S, K_m, K_h, and vertical velocity ω. • is the node of the triangles where scalar variable or vertical velocity is calculated and ⊗ is the centroid of a triangle where the horizontal velocity is calculated.

the horizontal numerical computational domain is subdivided into a set of non-overlapping unstructured triangular cells. An unstructured triangle is comprised of three nodes, a centroid, and three sides (Fig. 3.11), on which *u* and *v* are placed at centroids and all scalar variables, such as ζ, H, D, ω, S, T, ρ, K_m, K_h, A_m, and A_h are placed at nodes. *u* and *v* at centroids are calculated based on the net flux through three sides of that triangle (called the momentum control element: MCE), while scalar variables at each node are determined by the net flux through the sections linked to centroids and the middle point of the sideline in the surrounding triangles (called the tracer control element: TCE).

In both 2-D (external mode) and 3-D (internal mode) momentum equations, the advection term is calculated in the flux form using a second-order accurate upwind finite-difference scheme (Kobayashi et al., 1999; Hubbard, 1999, Chen et al. 2003a), which is the same as that used in the Cartesian FVCOM. In this scheme, the velocity in the

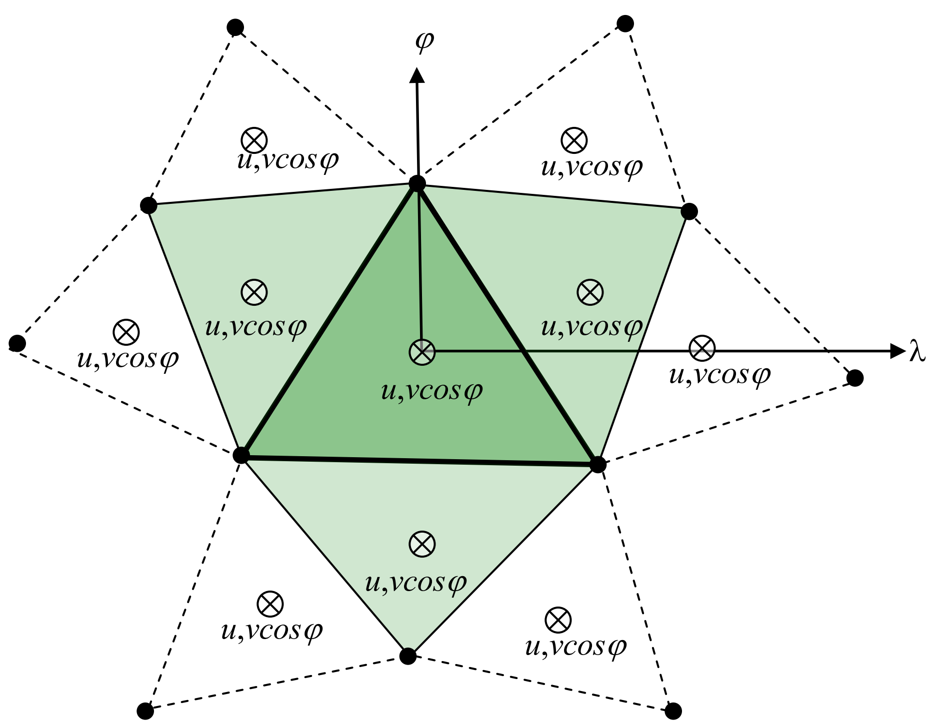

Fig. 3.12: Schematic of the momentum control volume (bounded by heavy solid lines) used to calculate the horizontal velocity. Light gray filled triangles are surrounding meshes required to solve the linear equation to determine the velocity distribution.