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Numerical methods used in the SAMI2/3 ionosphere models

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We describe the numerical techniques used in the low- to mid-latitude ionosphere models that have been developed at the Naval Research Laboratory: SAMI2 and SAMI3. SAMI2 is a two-dimensional model while SAMI3 is a three-dimensional model. These models use numerical methods that are very different from most other ionosphere models. First, ion inertia, which is neglected in other ionosphere models, is included in SAMI2 and SAMI3. A semi-implicit scheme is used to advance the densities, velocities and temperatures along the magnetic field direction. Although this requires a small time step (e.g., $\Delta t \lesssim 30$ sec) the numerical scheme is robust. Second, a nonorthogonal Eulerian grid is used. Most other ionosphere models use a Lagrangian grid and track the motion of flux tubes. One axis of our grid is the dipole field. The other two axes are defined numerically to provide high resolution at low altitude and sparse resolution at high altitudes; they are not aligned with the $\mathbf{E} \times \mathbf{B}$ drift of the plasma. The $\mathbf{E} \times \mathbf{B}$ transport is based on a finite volume method using the donor cell method. Finally, both SAMI2 and SAMI3 are fully parallelized using the Message Passing Interface (MPI) method and run on a Linux Beowulf system.

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