# CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| | **Solar-Heliosphere Models**<br>**Black = capabilities to incoporate in coupled model**<br>**Green = evaluations, test** | | | |
| **CORHEL** | **3.4** | **MAS, ENLIL, CONE** models.<br>Inputs from full set of observatories (NSO/KP, Wilcox, Mt. Wilson, MDI), giving excellent data availabiltiy and ability to compare and verify input fidelity.<br>Web-based GUI interface.<br>Cone Model incorporated for ICME propagation and SEP shock source.<br>Steady state solution within Carrington rotation. | 5 | Global ambient solar wind specification, including points of particular interest, e.g., L1.<br><br>Psuedo-ICME initiated by observed CME geometry, provides interplanetary propagation, shocks, IMF draping, earth arrival timing and geometry. |
| **CORHEL** | **3.5** | Add: Option to run MAS heliosphere code. | 6 | |
| **CORHEL** | **4.0** | Add: MAS and ENLIL MPI, increasing corona & heliosphere resolution; improved ENLIL numerics for, e.g., shock resolution. | 6 | ENLIL enables 1 deg. resolution (instead of 2 or 4 deg). Delivered to CCMC, continuing test. |
| **CORHEL** | | CME/ICME comparisons for May 1997 | 6 | |
| **CORHEL** | **4.2** | Incorporates WSA, using MAS potential solver, directly into CORHEL. | 7 | MHD-WSA comparisons w/ same maps. Higher res or non-uniform potential field solutions, 6 observatories. |
| **CORHEL** | **5.0** | Add: 1st Thermodynamic MAS in CORHEL.<br>Includes coronal energy transport processes, i.e. radiation, corornal heating, thermal conduction.<br>Recalibrated heliospheric free parameters in ENLIL. | 8 | Adds: realistic modeling of active regions within global coronal model, providing physical underpinning to simulate active region CMEs.<br>Simulated EUV and X-ray emission from improved coronal density & temperature modeling. |
| **CORHEL** | **5.5** | Add: MAS tools for emission & white light computation and comparison. | 8 | |
| **CORHEL** | **6.0** | Add: MAS driven time-dependently by flux-evolution model for photospheric B (not thermodynamic).<br>Coupling procedure for rotating coronal field and strong localized transient structures. | 9 | Adds coronal and solar wind features from temporal variations during Carrington rotation; coupling for self-consistent computations under general conditions. |
| **CORHEL** | **6.5** | Add: Improved heating/sw acceleration parameters for thermodynamic MHD MAS; ENLIL code modernization, optimization, compatibility w/ latest standards, parallel NetCDF/HDF, etc. | 9 | Improves solar wind fidelity, code efficiency and portability, …. |
| **CORHEL** | **7.0** | Add: Thermodynamic MHD MAS driven by flux-evolution model. Adapt ENLIL coupling procedure as required. | 10 | |

# CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| MAS | | First results from new MAS simulation ("*Event-A*", likely May 2005 event) | 6 | |
| MAS | | Completed results from *Event-A* MAS simulation. Begin "*Event-B*" simulation. | 8 | |
| MAS | | Completed results from *Event-B* simulation | 10 | |
| ENLIL | | Develop field coupling procedure; verify on MAS "A" event. | 7 | |
| ENLIL | | Test nested grids for interplanetary shocks approaching geospace | 8 | |
| ENLIL | | Develop thermodynamic coupling procedure; verify on MAS "A" and "B" events. | 9 | |
| CONE | | Interim model of CME-like ejection. Does not include internal magnetic fields of ICME.<br>Inputs: source location, angular extent, and speed (observables), density and temperature. | 5 | CME-like ejection for propagation in solar wind model (e.g CORHEL). Produces shocks and background fields for SEP model; predicts timing and geometry of an ICME, accounting for effects of realistically modeled interplanetary medium. |
| CONE | | Add: Improved shock simulation in Cone Model. (Tentatively multi-grid ENLIL for increased resolution; TBC.) | 7 | |

# CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| SEPMOD | 1.0 | Energetic particles from parameterized shock source, using shocks and fields from cone model ICME initialization in CORHEL. | 5 | SEPs may be calculated for any position out to the 1.6 AU CORHEL boundary. |
| SEPMOD | | Routine SEPMOD runs with the Cone Model. Outputs include observer-connected field lines, shock information and proton time profile. | 6 | Results from analysis of three events in preparation for publication (Luhmann et al., 2009). |
| SEPMOD | | Test SEPMOD particles input into geospace | 6 | |
| SEPMOD | | Test SEPMOD on multi-point SEP event observations, e.g. from STEREO + ACE. | 6 | |
| SEPMOD | | SEPMOD shock identification capability in presence of multiple shocks. (Need for additional transport physics to handle scattering and/or further acceleration by multiple-shock interactions to be assessed later.) | 7 | |
| SEPMOD | | MAS fields (& shocks?) in SEPMOD-CORHEL coupled runs | 7 | |
| SEPMOD | 2.0 | Add x-ray based flare source option to SEPMOD-CORHEL coupled model, including heavy ions. (SEPMOD assumes specified solar source, regardless of which coronal model is used for subsequent transport along field lines.) | 8 | |
| SEPMOD | 3.0 | Improved shock source description in SEPMOD from hybrid code and observational studies | 9 | |
| SEPMOD | | Test SEPMOD corotating shock-generated particles simulation capability | 9 | |
| SEPMOD | | Test SEPMOD extreme events capability | 10 | |

## CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| WSA | 1.4.2 | Empirical solar wind model.<br>**Baseline model** for several validation skill scores, forcing only NSO/KP input.<br>**Forecast model**, driven by Mount Wilson, NSO/KP, and Wilcox. | 4 | Running realtime in SEC Development Environment and at CCMC. |
| **WSA-ENLIL** | | Daily updated magnetograms from drive coronal portion of WSA, which drives ENLIL MHD solar wind model to provide ambient SW in the heliosphere and at L1. Research and Forecast model. **SEC Goal 2 of Jan. 2006.** | 5 | Running realtime in SEC Development Environment and at CCMC. |
| **WSA-ENLIL-CONE** | | Solar wind event-driven model, using observation-derived Cone Model for intializing ICME into background heliosphere of WSA-ENLIL. | 6 | Validation ongoing. Running at CCMC. Tests of sensitivity to cone intialization procedures being pursued. |

# CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| | **Geospace Models** | | | |
| **CMIT** | **2.0** | **LFM, TIE-GCM.**<br>Geospace model driven by measured (e.g. ACE) or modeled (e.g. CORHEL) solar wind parameters at L1.<br>LFM(OMP) & TIE-GCM (MPI) two-way coupled with InterComm.<br>TIE-GCM gives low latitutde electric field. | 5 | |
| **LTR** | **1.0** | **CMIT 1.0 (LFM, TING), RCM**.<br>LFM two-way coupled to both RCM and TING.<br>RCM drifts give accurate pressure and density to LFM; LFM gives plasma boundary conditions and magnetic field for RCM.<br>Provides Region 2 currents and penetration electric fields. | 5 | |
| **CMIT** | **2.5** | Add: MPI parallel LFM; modular Overture coupler/solver, InterComm communication between parallel codes. | 6 | Running on SWPC wJET. Transitioning to CCMC: parallel LFM running on 8-processor system at CCMC; runs-on-request being finalized; TIE-GCM v1.91 next; then CMIT. |
| **CMIT** | **2.6** | Add: measured solar forcing in CMIT (TIE-GCM and TIMED-GCM). Solar data from TIMED/SEE + SORCE/SOLSTICE (future: SDO/EVE replaces TIMED/SEE) | 7 | Implemented in TIE-GCM 1.9.2 |
| **CMIT** | **2.7** | Add: Corotation electric field in LFM using CMIT neutral wind current; extended ionosphere model (closed field line extension) in TIE-GEM (no input to LFM). | 7 | |
| **CMIT** | **2.8** | Add: Volume refilling;<br>High-res. TIE-GCM (2.5 deg). | 7 | High-res in yr-7. Volume refilling may be in yr-8. |
| **CMIT** | **2.9** | Add: assimilated ionosphere (GAIM) | 9 | GAIM initialization demonstrated with TING. Further implementation deferred. |
| **LTR** | **2.0** | **CMIT 2.5, RCM**.<br>Adds: MPI parallel LFM;<br>Two-way coupled TIE-GCM replaces TING;<br>Modular Overture coupler/solver. | 7 | |
| **LTR** | **2.1** | **CMIT 2.6, RCM** | 7 | |
| **LTR** | **2.5** | **CMIT 2.8** + asymmetric (Euler potential based) RCM. | 8 | |

## CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| **LTR** | **3.0** | **LFM, TIME-GCM, RCM, SEP Cutoff**. TIME-GCM replaces TIE-GCM. | 8 | Provides mesospheric response, more sophisticated treatment of middle atmosphere & troposphere, SEP and downward chemical transport effects to middle atmosphere. |
| **LTR** | **3.1** | Short-term solar irradiance forecast incorporated. Tentatively semi-empirical model based on previous rotation | 8 | |
| **LTR** | **4.0** | **MF-LFM, TIME-GCM, RCM, SEP Cutoff**. Add: Multi-fluid LFM, populated by H+ inflow from solar wind, H+ & O+ at ionospheric boundary. | 8 | |
| **LTR** | **4.1** | Precipitating SEPs and auroral protons in TIME-GCM | 8 | |
| **LTR** | **4.2** | High resolution (2.5 deg) TIME-GCM | 9 | |
| **LTR** | **4.3** | Inductive coupler for MI gap region. | 9 | |
| **LTR** | **4.4** | Improved auroral precipitation module. | 9 | |
| **LTR** | **4.5** | NCEP coupling to CMIT. (NCEP analysis fields for stratosphere/ troposphere forcing of TIME-GCM. 30 km) | 10 | |

# CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| RADBELT | | **2D, 3D Radbelt; SEP Cutoff**.<br>Three models for energetic particles in earth's magnetosphere:<br>2D Radbelt - efficient guiding-center tracking in time-dependent MHD fields; post-processing gives fluxes using flux-weighting; polar grid.<br>3D Radbelt - 3D trajectories with choice of GC or Lorentz calculation in time-dependent fields; cartesian grid.<br>SEP Cutoff - Full 3D Lorentz trajectories determine SEP cutoffs in time-independent fields; cartesian grid. | 5 | |
| RADBELT | | 2D and 3D weighting schemes compared and frozen in repository as radbelt model validation tool. | 6 | |
| RADBELT | | SEP access and trapping models use first spectral input from SEPMOD. | 6 | |
| RADBELT | | RADBELT and SEP Cutoff codes running in LTR fields, with SEPMOD input; initial validations. | 7 | |
| RADBELT | | RADBELT and SEP Cutoff codes run in LTR fields including ion outlfow. | 8 | |
| RADBELT | | Incorporate phenomenological losses. | 9 | |
| RADBELT | | Radial diffusion module complete; frozen for valiation. | 9 | |
| RADBELT | | RADBELT and SEP Cutoff codes run in LTR fields with TIME-GCM. | 9 | |

## CISM Model Timeline, Years 6-10

| *Model* | *Version* | *Description* | *CISM Yr* | *Model Capabilities, Notes* |
|---|---|---|---|---|
| | **End-to-End Models** | | | |
| **CISM** | **1.0** | **CORHEL 1.2, CMIT 1.0.**<br>Ad hoc coupled CORHEL and CMIT with automated coupler at L1.<br>Provides solar wind and geospace properties.<br>Inuts: same as CORHEL. | 4 | |
| **CISM** | **2.0** | **CORHEL 3.4, CMIT 2.5, SEPMOD 1.0** | 7 | |
| **CISM** | **3.0** | **CORHEL 4.0, LTR 2.0** | 8 | |
| **CISM** | **4.0** | **CORHEL 5.0, SEPMOD 2.0, LTR 3.0** | 9 | |
| **CISM** | **End-State** | ***TBD*** *Specific component versions, capabilities in Year-10 CISM model LTR 4.0 + TBD.* | 10 | |
| **CISM** | | CME-ICME-Geospace end-to-end event simulations | 10 | |
| | **Forecast Models** | | | |
| **Ap Forecast 3hr** | | Empirical model with lead time of 1-7 days. Inputs: L1 SW velocity and recent Ap history. 3-hr running average ap with 24-hr derived Ap added per SEC following evaluation of daily model. **SWPC Goal 1 of Jan. 2006.** | 4 | |
| **WSA** | | See description under Solor-Heliosphere models. | 4 | |
| **WSA-ENLIL** | | See description under Solar-Heliosphere models.<br>**SWPC Goal 2 of Jan. 2006.** | 5 | |
| **Geomag Disturb** | | **CMIT 2.0 with Auxilliary Models**<br>Regional ground magnetic variations calculated from model currents, initially from CMIT 2.0. Global Ap calculation as top-level indicator for comparison and assessment of model confidence. **SWPC Goal 3 of Jan. 2006.** | 6 | Ground variations derived. Forecaster displays and tools in development. CMIT 2.5 installed at SWPC (formerly SEC). |
| | | Follow-on SEC goals to be established jointly with SWPC, pending assessment of existing deliveries, SWPC priorities & resources. | 7 | WSA-ENLIL-Cone identified as high SWPC priority. |