ADVANCED SPACE WEATHER MODELING

Research Challenge
- Extreme space weather events are caused by the most energetic coronal mass ejections. These events can generate, among other effects, large-scale electric impulses that can melt transformers and cause cascading blackouts. Repair times for replacing the high-voltage transformers are estimated to be several months.
- Accurate modeling of magnetic storms requires prediction of the interplanetary magnetic field of coronal mass ejections and an accurate model for the reconnection process.

Methods & Codes
- Space Weather Modeling Framework (SWMF)
- Block-adaptive grids
- BATS-R-US used as the Spherical Wedge Active Region Model (SWARM)
- Magnetohydrodynamics with embedded particle-in-cell (MHD-EPIC) using iPIC3D embedded into BATS-R-US and coupled through the SWMF

Results & Impacts
- First three-dimensional global study of the solar wind magnetosphere interaction using a high-fidelity kinetic model for the magnetic reconnection
- Breakthrough advances in simulating flux emergence at active-region scale in spherical geometry
- Addresses the most salient questions of space weather

Why Blue Waters
- Blue Waters' capability allows simulating magnetic flux emergence from the convection zone into the corona to create active regions and coronal mass ejections
- Using Blue Waters allows modeling the global magnetosphere with embedded particle-in-cell model covering the magnetic reconnection sites

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Top left: 2D cut of a simulation of Earth’s magnetosphere showing pressure in color. Top right: 3D structure of a magnetic flux rope formed by reconnection. Bottom: Magnetic field emergence through the solar surface with radial velocity in colors. Lines show magnetic field structure.