MULTISCALE SPACE WEATHER SIMULATIONS

Research Challenge
The research solves fundamental problems in plasma physics, solar physics, and magnetospheric physics that relate to magnetic field energization and reconnection. Consequently, the results are significant to solar and plasma scientists, as well as magnetosphere and space weather scientists.

Methods & Codes
The research team approach combines the efficiency of global fluid-type models with the local kinetic models. The resulting magnetohydrodynamic with embedded particle-in-cell (MHD–EPIC) model is 100 to 10,000 times more efficient than a global kinetic model. The flux emergence and CME initiation simulations are carried out with the high-resolution MHD code BATS–R–US in a configuration called the Spherical Wedge Active Region Model (SWARM). Using SWARM, they performed rigorous flux-emergence calculations and the formation of active regions with no ad hoc assumptions about coronal or photospheric conditions.

Why Blue Waters
The team used the Blue Waters resources to study how the global and local plasma scales are related and how the numerical simulations can be sped up. Despite the algorithmic advances that sped up the simulations by several orders of magnitude, they still require the computational capabilities that are only available at the largest systems, like Blue Waters.

Results & Impact
Using the kinetic scaling in combination with the MHD-EPIC method, the research team was able to perform the very first three-dimensional global Earth magnetosphere simulations with an embedded kinetic model. Currently they run simulations where the reconnection process of the magnetotail is covered by the kinetic model. The preliminary simulations show that the model can produce the observed dynamics and suggest that the model can capture the interplay of global magnetospheric and local kinetic processes.

Allocation: NSF PRAC/3000 Knh
PI: Gabor Toth
University of Michigan
Space Science