A Modular Capability for Community Modeling of Flares/CMEs and their Interplanetary Impacts

GSFC / UMichigan

Overview and Status

Team:

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• Chip Manchester, Co-I, Umich
• Pete Schuck, Co-I GSFC
• Igor Sokolov, Co-I, UMich
• Gabor Toth, Co-I, Umich
• Numerous PostDocs and students
Modular Solar Eruptions Capability (MSEC)

Science Objective: Eruptive flares & CMEs (SEE) and their interplanetary impacts

Methodology: Enable *community* exploratory science
MSEC Modeling Successes

- **AWSoM**: quasi-steady 3D background from chromosphere to 5 AU
  - Includes comprehensive physics of corona and wind at CCMC
- **AWSoM-R**: 3D background model with breakthrough soltn. to TR problem
  - Runs faster than real time,
  - Ideal candidate for transition to operations, at CCMC
- **EEGGL**: eruptive event generator model
  - First community model for exploratory studies
  - True game changer, at CCMC

- All models at CCMC have extensive analysis tools for direct validation with mission data
  - COADRED breakthrough soltn. to SDO/HMI artifacts
- 250p training manual for suite of models with library of examples
  - all interfaces being developed with CCMC (e.g., EEGGL) incorporating user feedback
MSEC Modeling Successes

- **SWARM**: Active region scale flux emergence model
  - Includes full convection dynamics
  - Under development for delivery to CCMC
- **MHD-EPIC**: breakthrough software technology for embedding PIC physics into global extended MHD model
  - Validated and being used for science runs
  - See following talk for application to magnetosphere
- **MFLAMPA**: SEP shock acceleration and transport
  - Couples MHD and diffusion equation
  - Under development for delivery to CCMC
- **AMPS**: particle tracker suite
  - Extensive capabilities, at CCMC
MSEC Science Successes

• First demonstration of SEE free energy buildup by helicity condensation
  – (Antiochos, Zhao et al, Knizhnik et al)

• First demonstration of dynamic slow wind with large angular extent in heliosphere
  – (Higginson et al)

• First demonstration of jet driven by breakout
  – Key implications for all eruptions
  – (Karpen et al, Szente et al, Wyper et al)
MSEC Science Successes

- Eruption cannot be due to ideal instability
- Due to breakout reconnection (Wyper et al, Nature 2017)
MSEC Educational Successes

Six PhDs trained:

• Zhenguang Huang. A New Feature of the Quiet Sun Corona During Solar Minimum. (2014)
• Kalman Knizhnik. The Role of Magnetic Helicity in the Structure and Heating of the Sun’s Corona (2016)
• Aleida Higginson. The Dynamics of the S-Web and Implications for the Solar Wind and Heliosphere (2017)
• Dmitry Borovikov. Towards a Forecasting Capability in Solar Energetic Particle Modeling (2017)
Future Directions

Modeling:
• Extend EEGL to variety of onset mechanisms
• Incorporate emergence SWARM into AWSoM/EEGL
• Incorporate kinetics from MHD-EPIC into AWSoM/EEGL
• Transition to operational capability

Science:
• Self-consistent eruption from emergence or helicity condensation or …
• Incorporate kinetic resistivity into eruption/activity models