Opportunities for ARMS and LARE at the CCMC

C. R. DeVore

Space Weather Laboratory
NASA Goddard Space Flight Center

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What are ARMS and LARE?

- Magnetohydrodynamic simulation models, homed at GSFC, for three-dimensional, time-dependent phenomena in the solar atmosphere (outer convection zone to inner heliosphere)
- ARMS – Adaptively Refined MHD Solver (DeVore)
- LARE – LAgrangian REmap (Leake/Arber)

Outline

- Magnetic energy buildup and release at the Sun
- Filaments and channels – space weather creators
- Science highlights from models
- Computational features and requirements
- Opportunities and challenges at CCMC

Magnetic Energy Buildup and Release

- A new team effort at NASA GSFC is examining magnetic energy buildup and explosive release at the Sun using theory, modeling, and observations

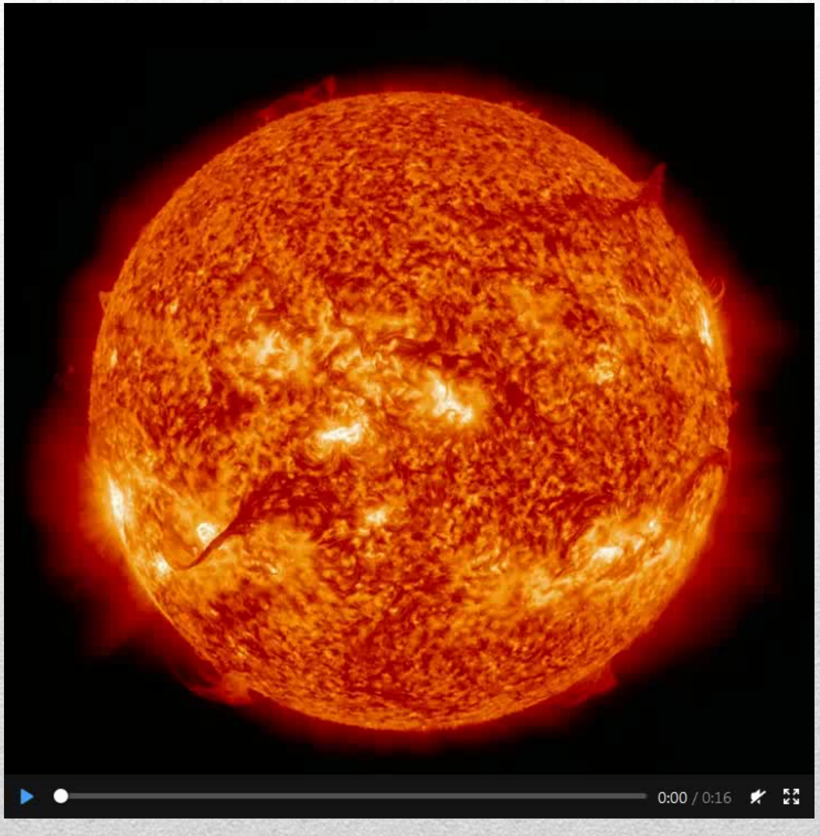
- Specific focus is formation, evolution, and eruption of filaments and the channels where they form

- A service component is to provide data sets, analysis techniques, and models to the community

Solar Filaments and Channels

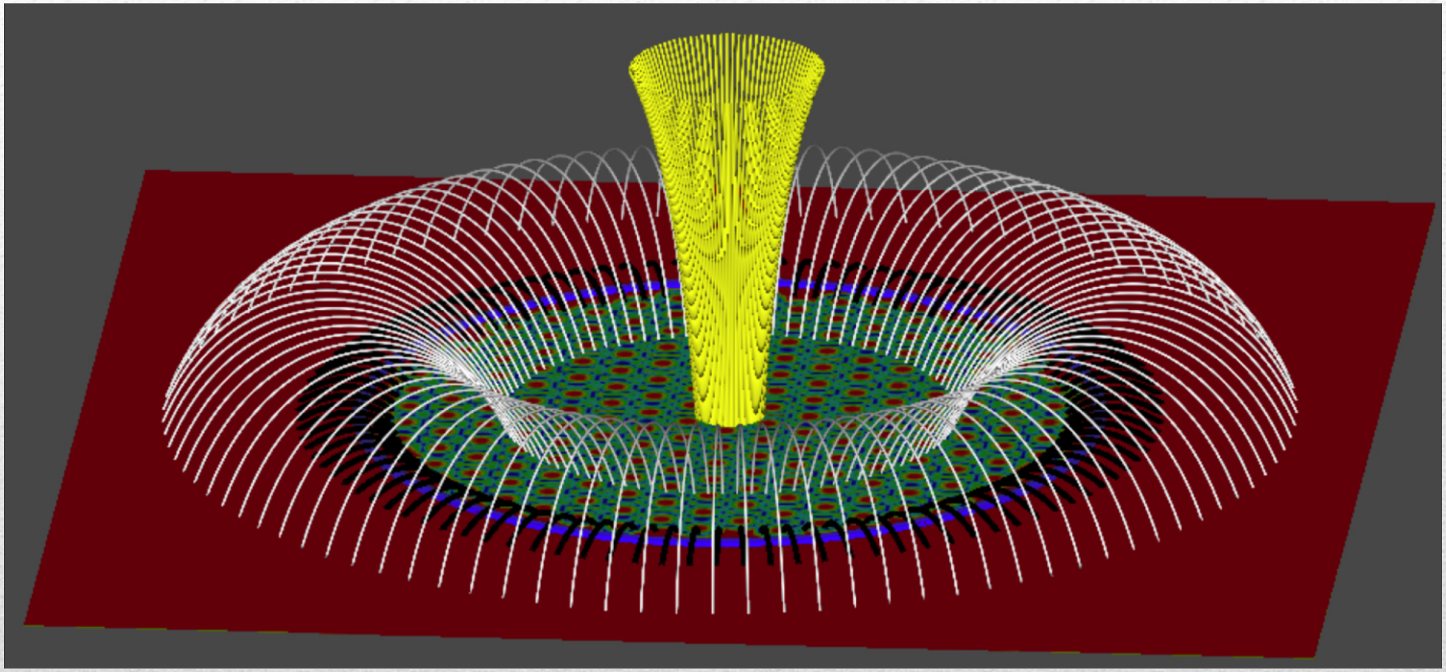
- Magnetic energy needed to power eruptions is concentrated in long, narrow filament channels
- Channels are found in both active and quiet Sun
- All filaments form in channels, but all channels do not host filaments all the time
- The mechanism for formation and maintenance of channels is poorly understood and hotly debated

Solar Filaments and Channels



SDO/AIA filament eruption on 2012/08/31

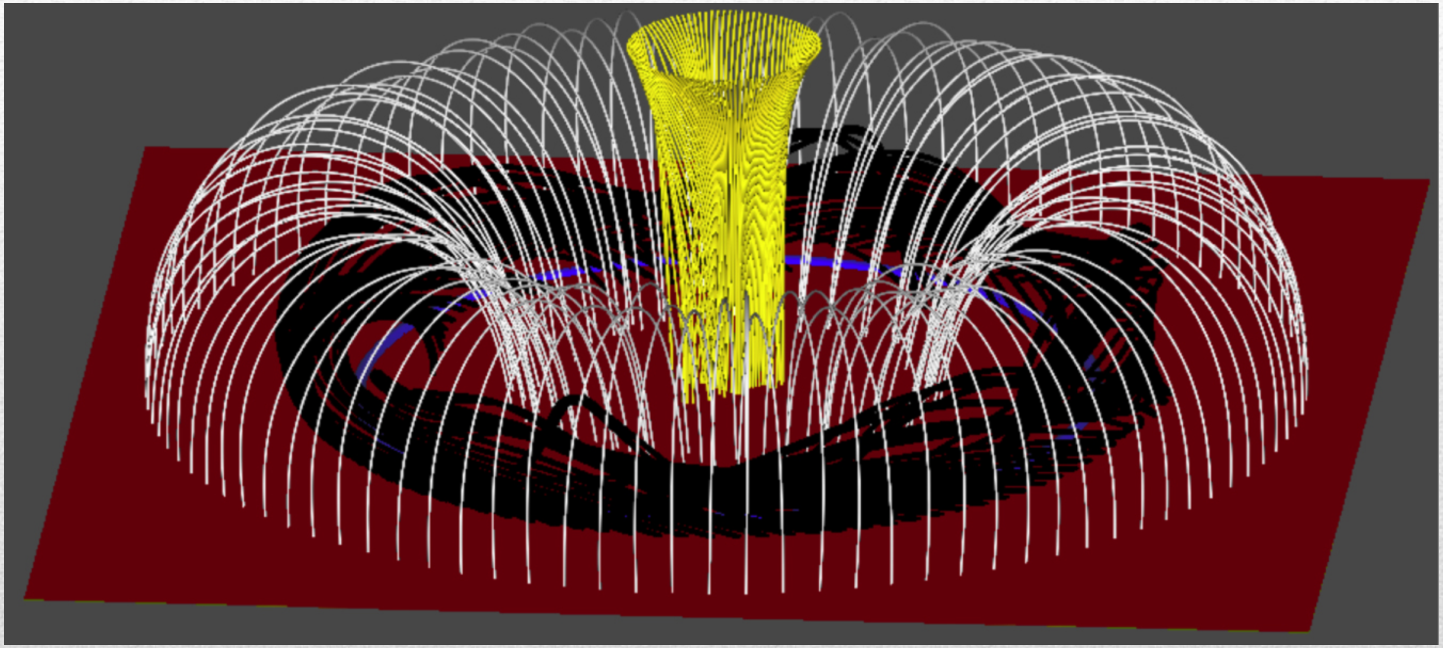
Science Highlight – Helicity Condensation



Small-scale vortical flows (red/green shading) are imposed inside the polarity inversion line (blue) of a sunspot magnetic field

Knizhnik et al. ApJL (2017)

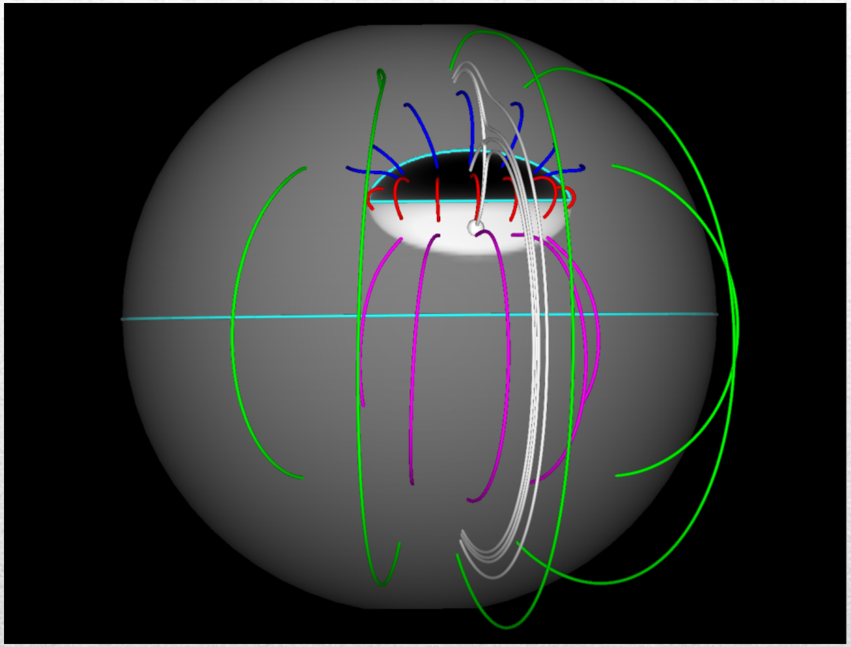
Science Highlight – Helicity Condensation

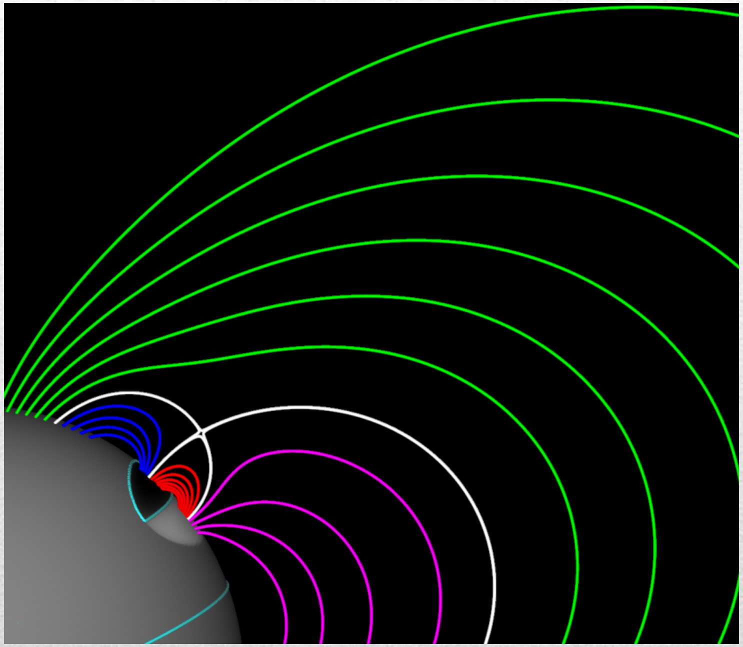


Filament channel structure (black) forms beneath overlying arcade (white) straddling the polarity inversion line (blue)

Knizhnik et al. ApJL (2017)

Science Highlight – Helicity Condensation

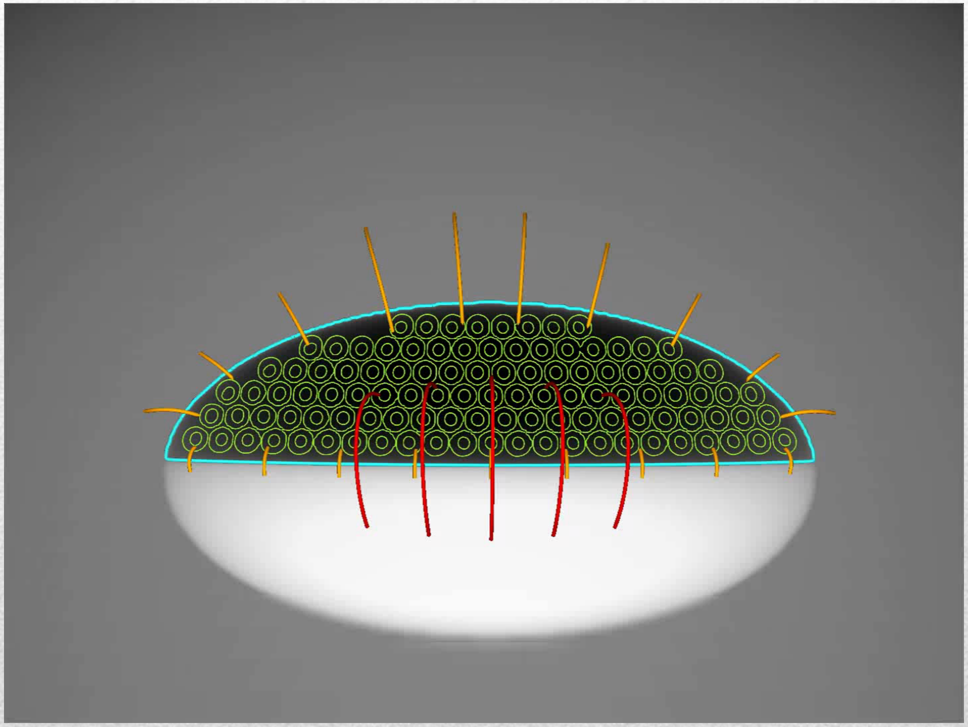




Spherical-geometry extension forms a filament channel beneath two arcades (red/blue) straddling the polarity inversion line (cyan)

Dahlin et al. (2018)

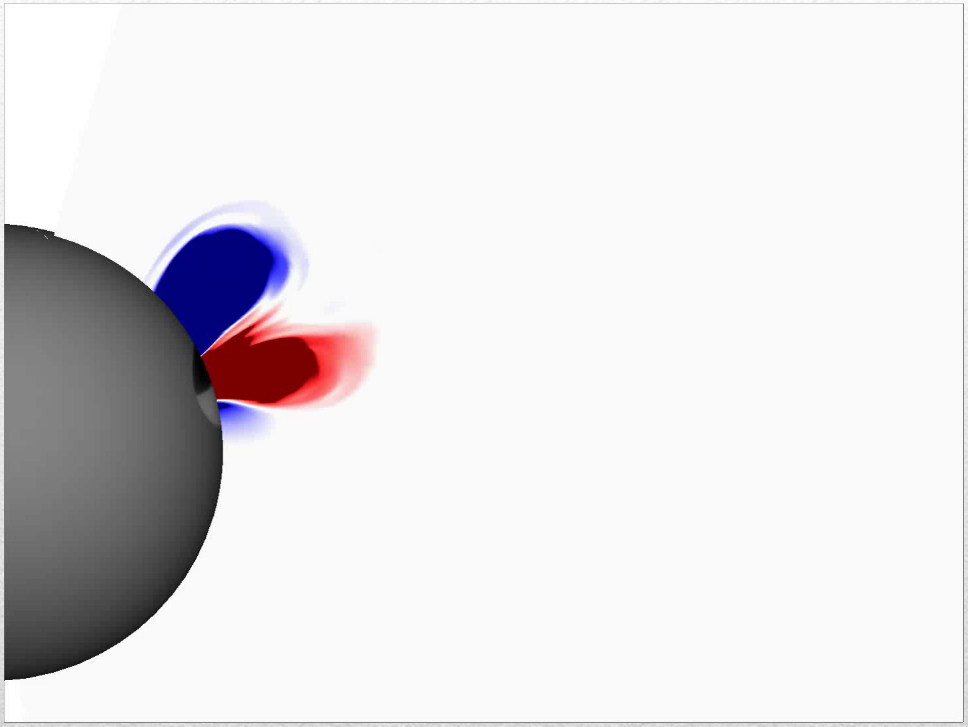
Science Highlight – Helicity Condensation



Small-scale vortical flows (green contours) are imposed inside the polarity inversion line (cyan) in the same way as before …

Dahlin et al. (2018)

Science Highlight – Helicity Condensation



… but in this case sympathetic eruptions are driven from the low- and high-latitude segments of the polarity inversion line

Dahlin et al. (2018)

Computational Features and Requirements

- Solar processes investigated include:
  - Flux emergence
  - Flux cancellation
  - Helicity condensation
  - Magnetic reconnection
  - Thermal nonequilibrium
  - Magnetic levitation

Computational Features and Requirements

- Physical processes simulated include:
  - Convection
  - Magnetic and gravitational forces
  - Viscosity
  - Resistivity
  - Thermal conductivity
  - Optically thin radiative losses
  - Partial ionization in Ohm's Law

Computational Features and Requirements

- ARMS uses locally structured block-adaptive grids + Eulerian finite-volume Flux Corrected Transport
- LARE uses globally structured fixed grids + Lagrangian convection w/ Eulerian remap
- Both require High End Computing resources (discover @ NCCS, pleiades @ NAS) to achieve separation of local and global macro scales

Opportunities and Challenges at CCMC

- Post and share simulation data sets for analysis (e.g., extrapolate nonlinear force-free field or synthesize spectropolarimetric images)
- Perform simulation Runs on Request (requires defining restricted parameter spaces that are relevant to users and manageable by CCMC)