Magnetogram Synthesis

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Model Dependency on Magnetogram Data

Stating the obvious to this audience!

- Current Models
  - WSA, MAS, SWMF corona
    - By extension ENLIL and SWMF Heliosphere
  - various Force-Free models etc
- Future Models
  - LWS Strategic Capability Models
    - Ambient Corona and Heliosphere (Gombosi et al, Linker et al)
    - Active Region Evolution (MacNeice et al)
  - Models require
    - Global surface fields
    - Adaptively refining meshes
    - Must capture coronal field evolution driven by photospheric flows and flux emergence

Magnetograms Sources

- LOS
  - Kitt Peak, Mt Wilson, GONG, MDI, Wilcox
  - Hinode, SDO
- Vector
  - IVM, Kitt Peak VSM, Hinode, SDO, Marshall
- Compare and Contrast
  - Cadence differences
  - Spatial resolution differences
  - FOV differences
  - Duty cycle differences
  - Method of field determination differences
    - Lines used
    - Zero point behavior
    - Numerous instrumental issues

Modeler Requirements

Modelers will need to make the most of this very inhomogeneous body of data!

Quality of coronal field models ?

Have a reasonably good handle on the strengths of the various field modeling techniques (FF, LFF, NLFF, MHD)

Coronal field model quality will depend most on two other components

1. the quality of the input data – Magnetogram synthesis component !
2. If data is photospheric, on how photospheric magnetic flux and flows imprint themselves on the upper chromosphere

A Hypothetical Modeling Challenge

- Active Region evolution Model
  - Suppose we need a model for slow evolution of Active Region A
- There is a second active region B on disk
- Synoptic vector magnetogram data is available from Kitt Peak along with individual vector magnetograms taken 3 times per day. However data for region B is poorly sampled due to instrument problems.
- Marshall Vector Magnetogram has data for B but at different times and resolution than Kitt Peak.
- Also have LOS magnetograms at selected times from Kitt Peak, Mt Wilson and MDI.
- How do we provide global surface vector fields and flow fields to an active region model at the spatial and temporal resolution required by the model?

Modeler Requirements

Using this data requires,

- Ability to synthesize datasets into a greater whole
  - More than just stitching images together
  - Nobody knows what it will take to make synthesized maps accurate
  - <u>this really is a separate modeling challenge.</u>
- Consistent data formatting
  - Data needs a quality layer
- Also incorporates determination of surface flows to drive coronal field evolution
  - Why? – is it better to determine velocities from each magnetogram and then ‘combine’ velocities, or combine magnetograms and determine a single velocity map? Not clear yet!

Modeler Requirements

A tool is needed to do this synthesis.

Who will develop it ?

- Not the data providers
- Not the modelers
- This is middleware – but every bit as important as the data acquisition and the modeling.
- This infrastructure element is very much IT in nature.

What will it take to eliminate this need?

- <u>Full globe</u> high resolution high cadence vector magnetograms in both photosphere and chromosphere! – not within the next decade (or two?) !
- Even this does not facilitate future scientific analysis of historical events or older archived data.

Tool Design

- Ability to interpolate in space and time
- Ability to handle many file formats
  - Data – usually fits, sometimes ascii
  - Model – customized at whim of developer
  - Graphics – IDL, TecPlot, OpenDx etc
- Ability to support complex processing algorithms (with many yet to be defined)

MAGIC

- Submitted proposal to AISRP* competition while still a Drexel employee.
- Selected this summer.
- 3 year effort to develop a magnetogram synthesis tool called MAGIC (MAGnetogram Integration and Composition)
  - work to be done by Drexel personnel.
- Although not a CCMC effort this project is of fundamental interest to the CCMC

* Applied Information Systems Research Program

MAGIC Design

- Backbone already in hand in CCMC’s Kameleon Tool.
- KAMELEON (Maddox)
  - two components, a file formater and an interpolator
  - handles many file formats
  - handles many model coordinate systems
  - has both spatial and temporal interpolation functions
  - portable – an interactive interface and a callable library (from C, Fortran and IDL).

MAGIC Design

- Modular design – 6 components
  - GUI
  - A magnetogram database manager (MySQL)
    - VSO interaction ?
  - Lightweight magnetogram processing layer, executing interactive single line calls to Kameleon functions and simple canned Python routines for frequently used processing tasks
  - A third-party program execution interface
  - Small suite of basic visualization tools (IDL and OpenDx)
  - A command recorder function to facilitate batch processing.
- Open Source Linux Application (except for Kameleon formater – CCMC will build customized formater for users on request)

Typical Basic Use

- User requests a menu of all available data for time frame from database
- User selects their preferred data for each time
- User imports their model surface grids for all required times
- MAGIC does default ($\boldsymbol{x}$,t) interpolation for each dataset to the appropriate grid
- User calls basic composition function for first grid - at prompt they input requested dataset weights or weighting rule
- MAGIC returns a composed surface vector field with a set of default images (B_r, B_θ, B_ϕ, $\boldsymbol{J}$)
- MAGIC asks if this synthesized magnetogram is acceptable
  - No - go back and rework
  - Yes - move on to next grid
- MAGIC reads in second grid
- Etc
- MAGIC outputs synthesized magnetograms in KAMELEON format files

Summary

- Developing a magnetogram synthesis tool using KAMELEON as the low-level manager of the data structures, I/O interfaces and basic interpolation layer
- Upon this foundation we add two processing layers (lightweight and heavyweight)
- Use of KAMELEON
  - means we waste no time on development of low-level support
  - Can focus much better on the design of the higher level processing layers
  - Our tool will interface effortlessly with any models hosted at CCMC

KAMELEON can do MAGIC!