NASA LWS TR&T and AISR Programs

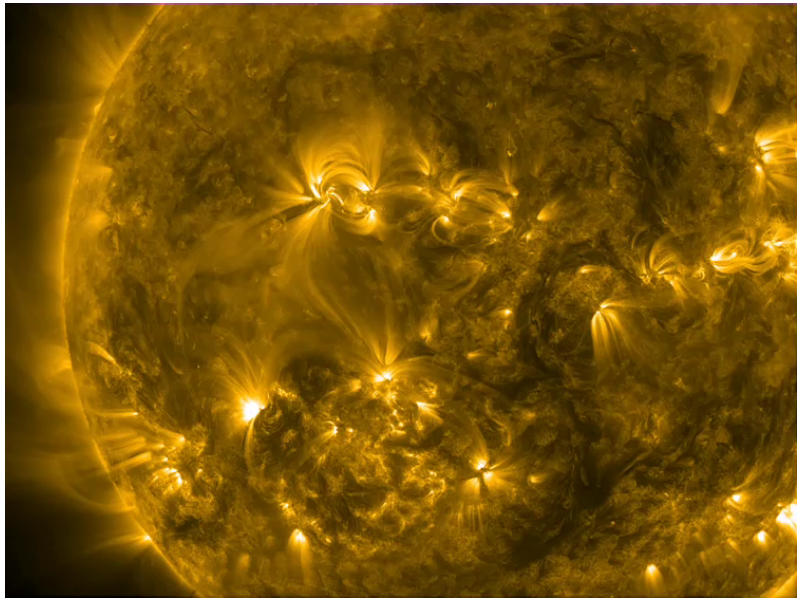
Community Coordinated Modeling Center

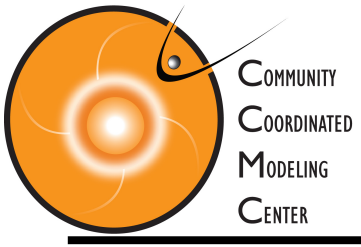
GENESIS
LWS Strategic Capability Call

- 2006 LWS TR&T Strategic Capability solicitation
  - Need for a community model suite to study pre-flare build up of magnetic energy in coronal field of active regions

– To be driven by a time series of vector magnetic field data

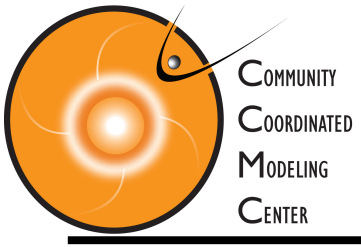
– And their implied photospheric flows





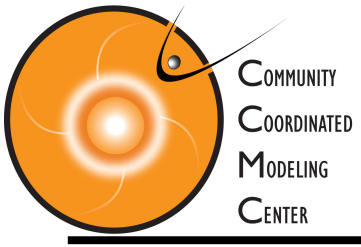
Motivation

- Models driven by time series of photospheric magnetograms need to modify the magnetograms to,
  1. Match magnetogram data to the model's spatial and temporal grid
     - resolution and field of view issues
  2. 'Propagate' magnetograms to the desired height in the atmosphere
  3. Manage the induction equation constraint
     - Determine surface flows consistent with magnetogram time series and constraint equations



Grid Mismatch

- Model algorithms and their solutions dictate the grid resolution and timestep requirements
- In general these do not match the properties of the magnetograms
  - Best HMI vector magnetogram cadences are 12 minutes (for limited field of view – so called HMI SHARPs)
  - MHD codes may require integration timesteps of order 1 second or less for accurate time evolution
- No guarantee that a single magnetogram source will match the field of view of the model
  - Probably need to combine magnetogram sources and types



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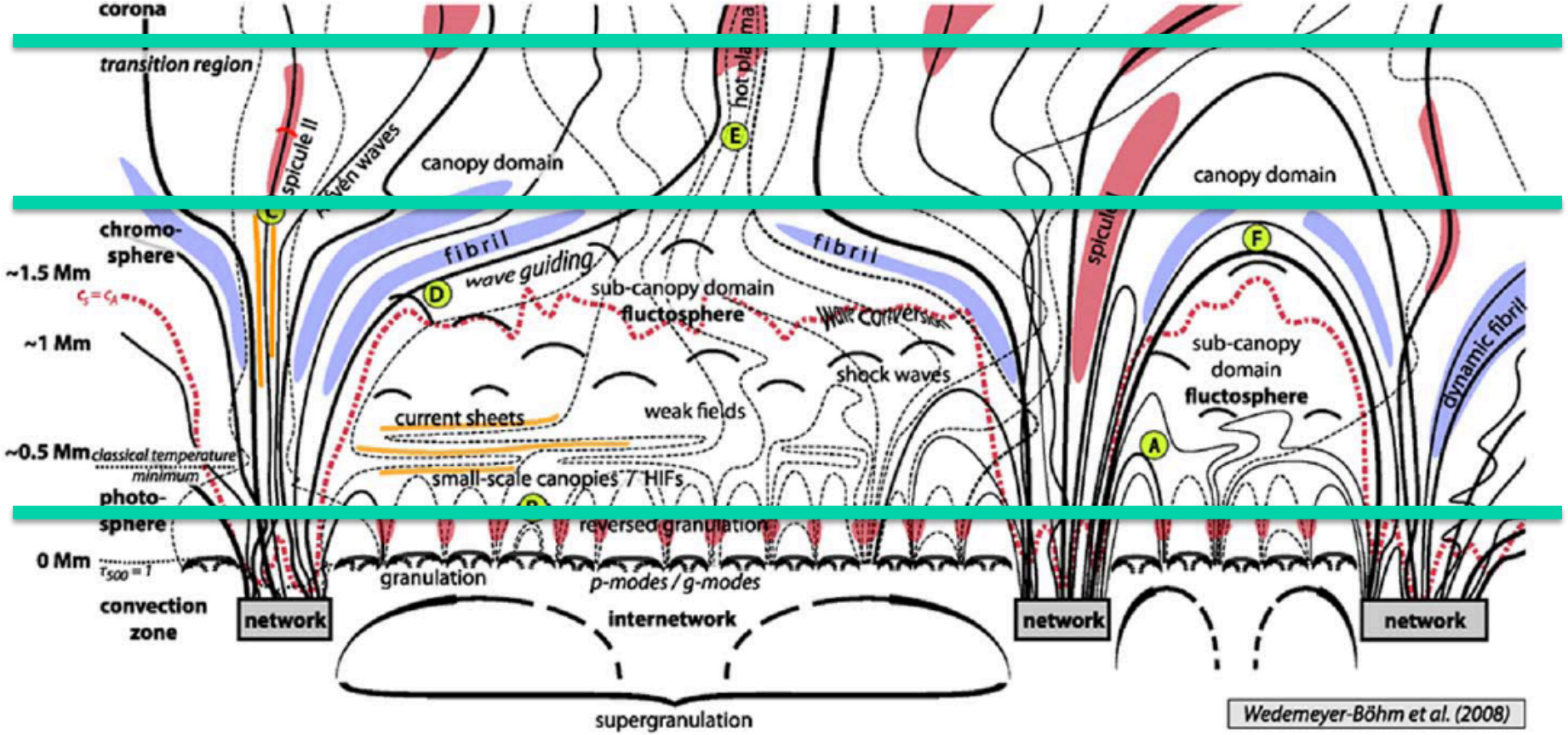
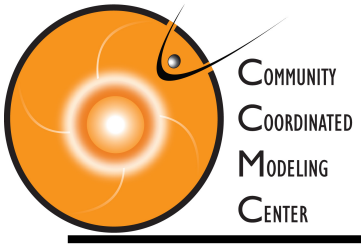
Magnetogram Height and Model Inner Boundary





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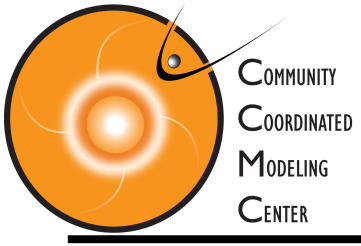
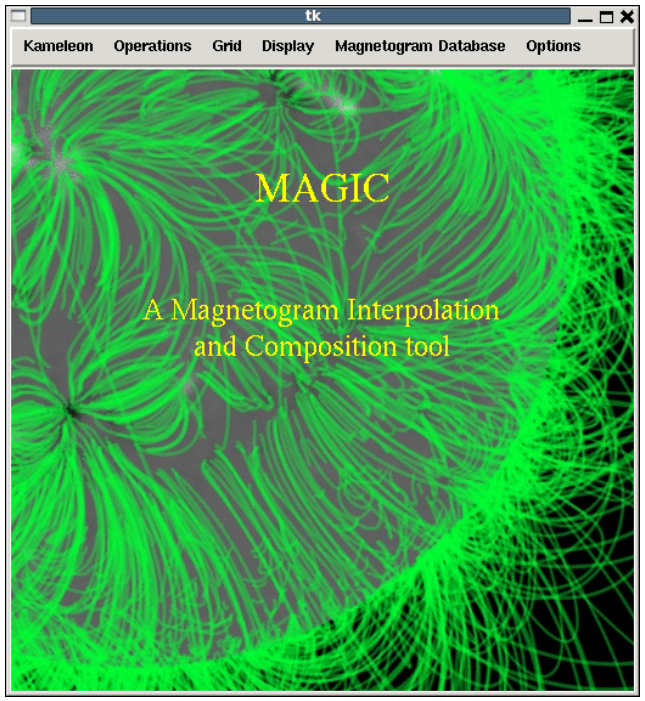


The Message

- All models consuming magnetograms need to process them.
- MHD models need to do EXTENSIVE processing
- Much of this processing has yet to be defined.
- Magnetogram processing MUST be under the control of the model user !!
- The infra-structure to do this needed its own Strategic Capability
- We have created the initial framework.

MAGIC – A Tool Suite for Preparing Magnetograms for Model Use

- GUI Driven
- Incorporates
  - Magnetogram Database
  - Extensive List of the more obvious tools
  - Simple interface to 3rd party programs to support yet-to-be-defined heavy duty processing needs
  - DAVE4VM surface flow analysis tool
  - Non-Linear Force Free Model
- Uses CCMC's KAMELEON libraries for internal file formatting and interpolation
- Visualization Tool
- Beta Version delivered Jan 2013.



CCMC Products

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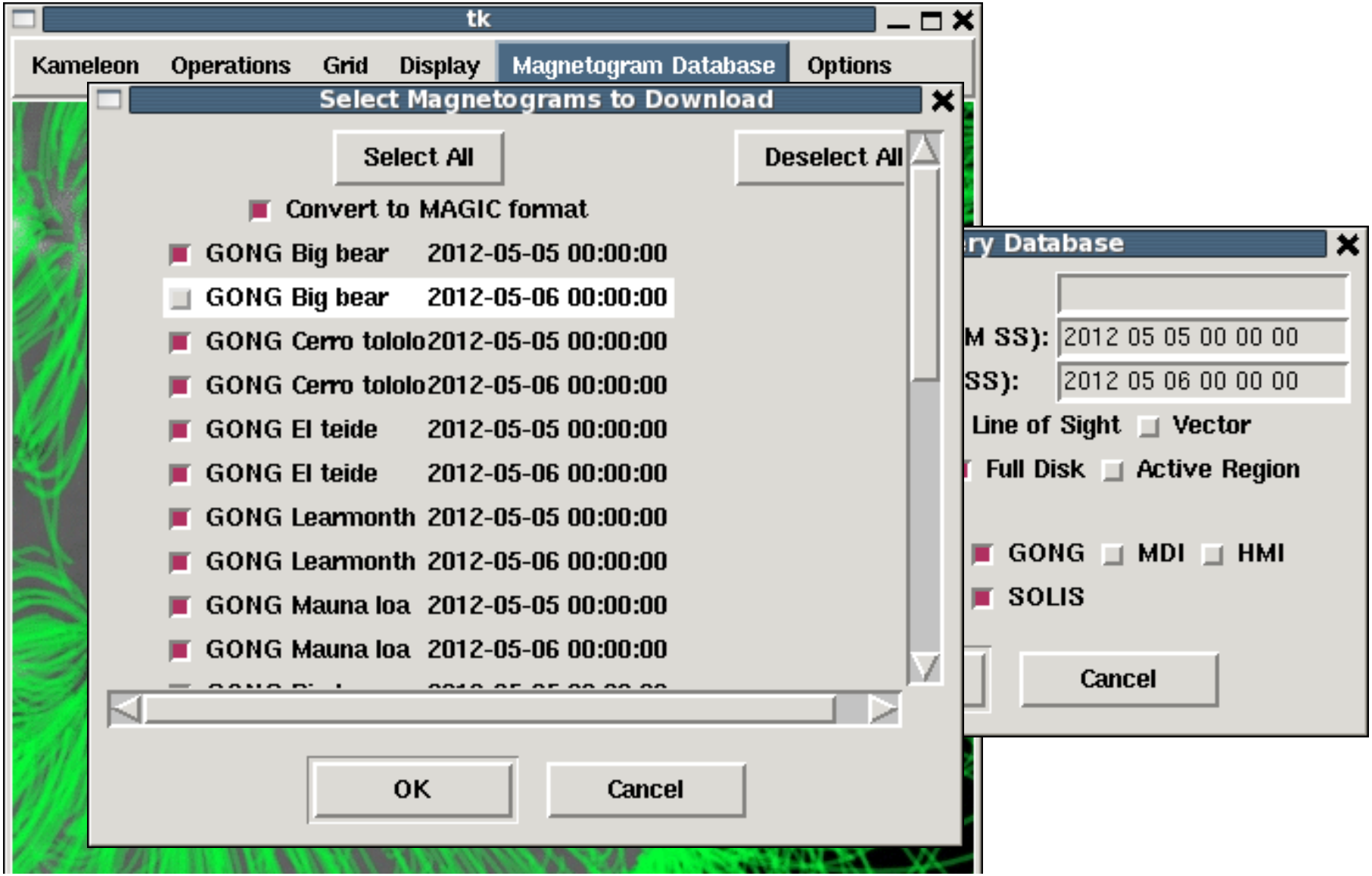

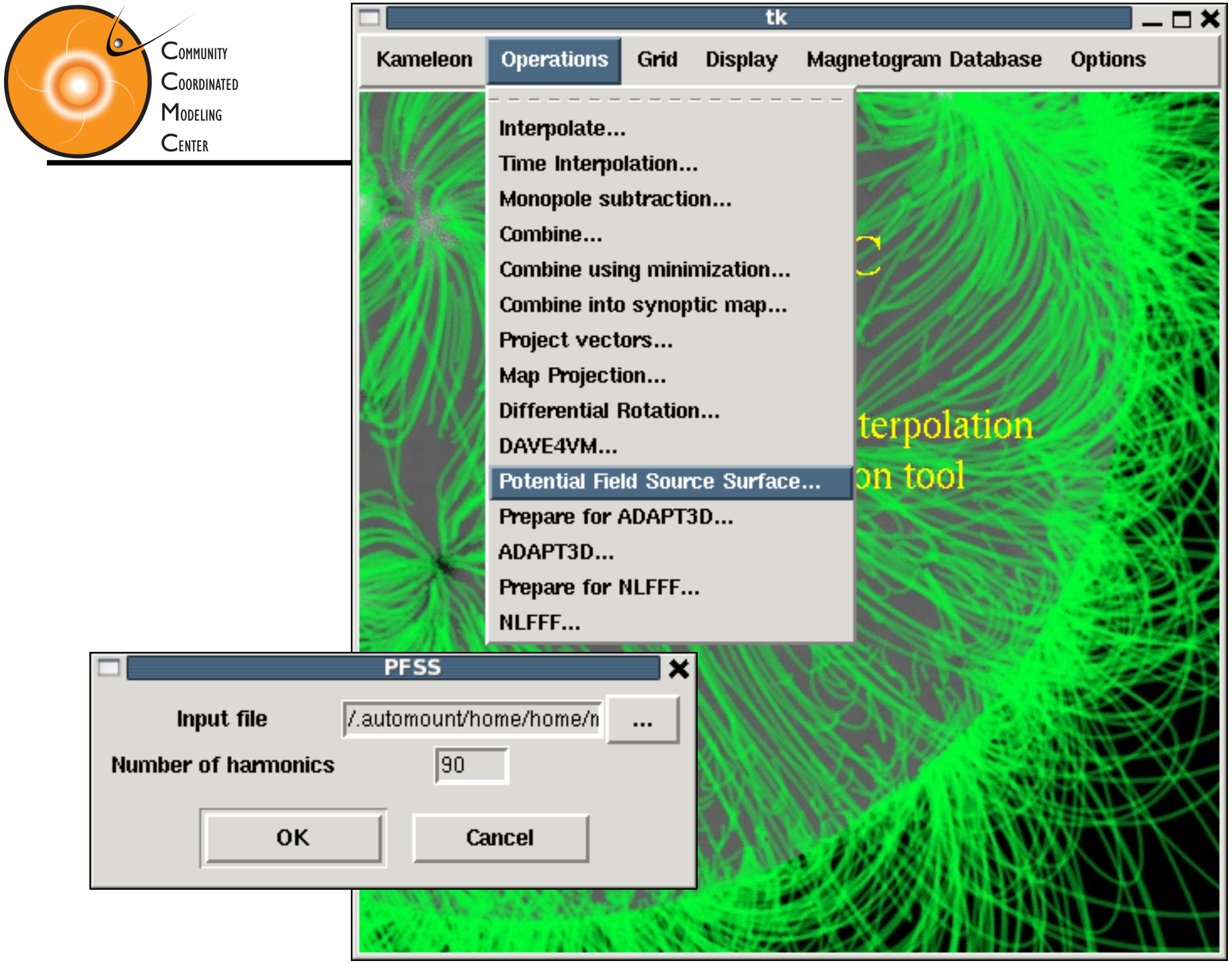
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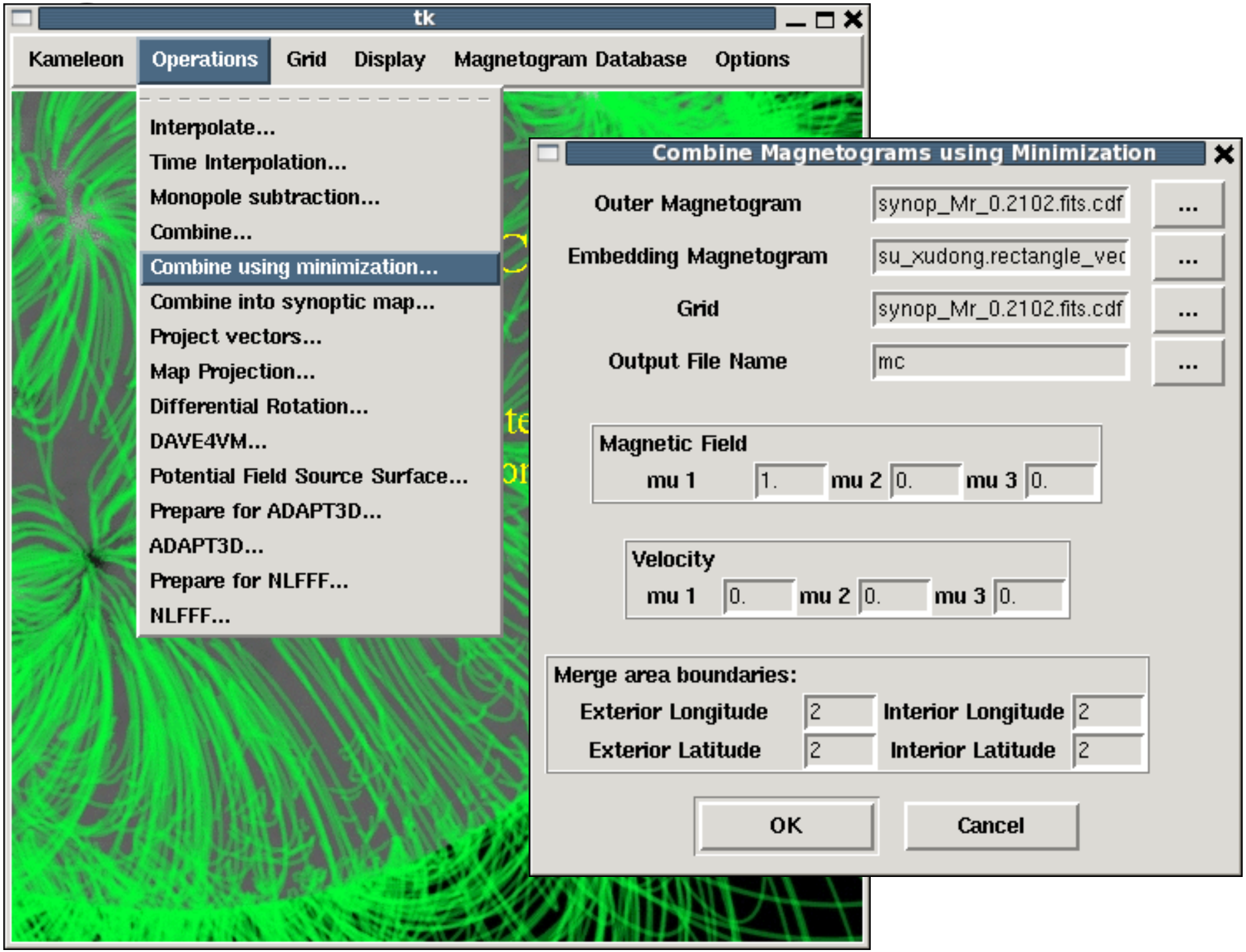
Kameleon
Operations
Grid
Display
Magnetogram Database
Options
Interpolate...
Time Interpolation...
Monopole subtraction...
Combine...
Combine using minimization...
Combine into synoptic map...
Project vectors...
Map Projection...
Differential Rotation...
DAVE4VM...
Potential Field Source Surface...
Prepare for ADAPT3D...
ADAPT3D...
Prepare for NLFFF...
NLFFF...
terpolation
on tool
PFSS
Input file
/.automount/home/home/n
...
Number of harmonics
90
OK
Cancel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Prepare for ADAPT3D...
ADAPT3D...
Prepare for NLFFF...
NLFFF...
Combine Magnetograms using Minimization
Outer Magnetogram
synop_Mr_0.2102.fits.cdf
Embedding Magnetogram
su_xudong.rectangle_vec
Grid
synop_Mr_0.2102.fits.cdf
Output File Name
mc
Magnetic Field
mu 1
1.
mu 2
0.
mu 3
0.
Velocity
mu 1
0.
mu 2
0.
mu 3
0.
Merge area boundaries:
Exterior Longitude
2
Interior Longitude
2
Exterior Latitude
2
Interior Latitude
2
OK
Cancel

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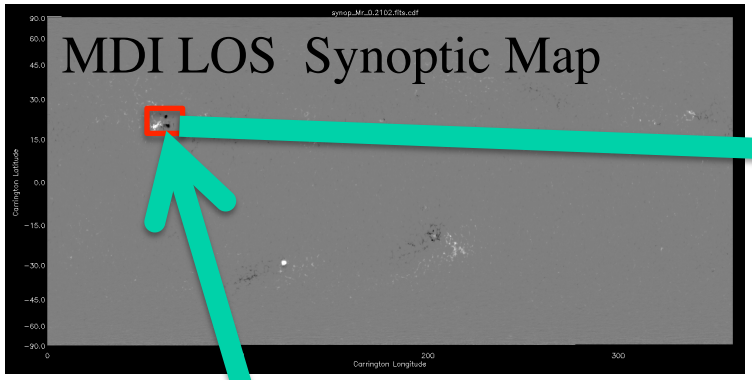
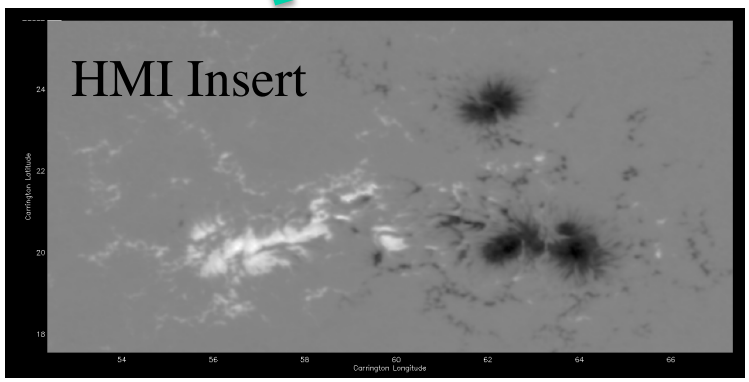
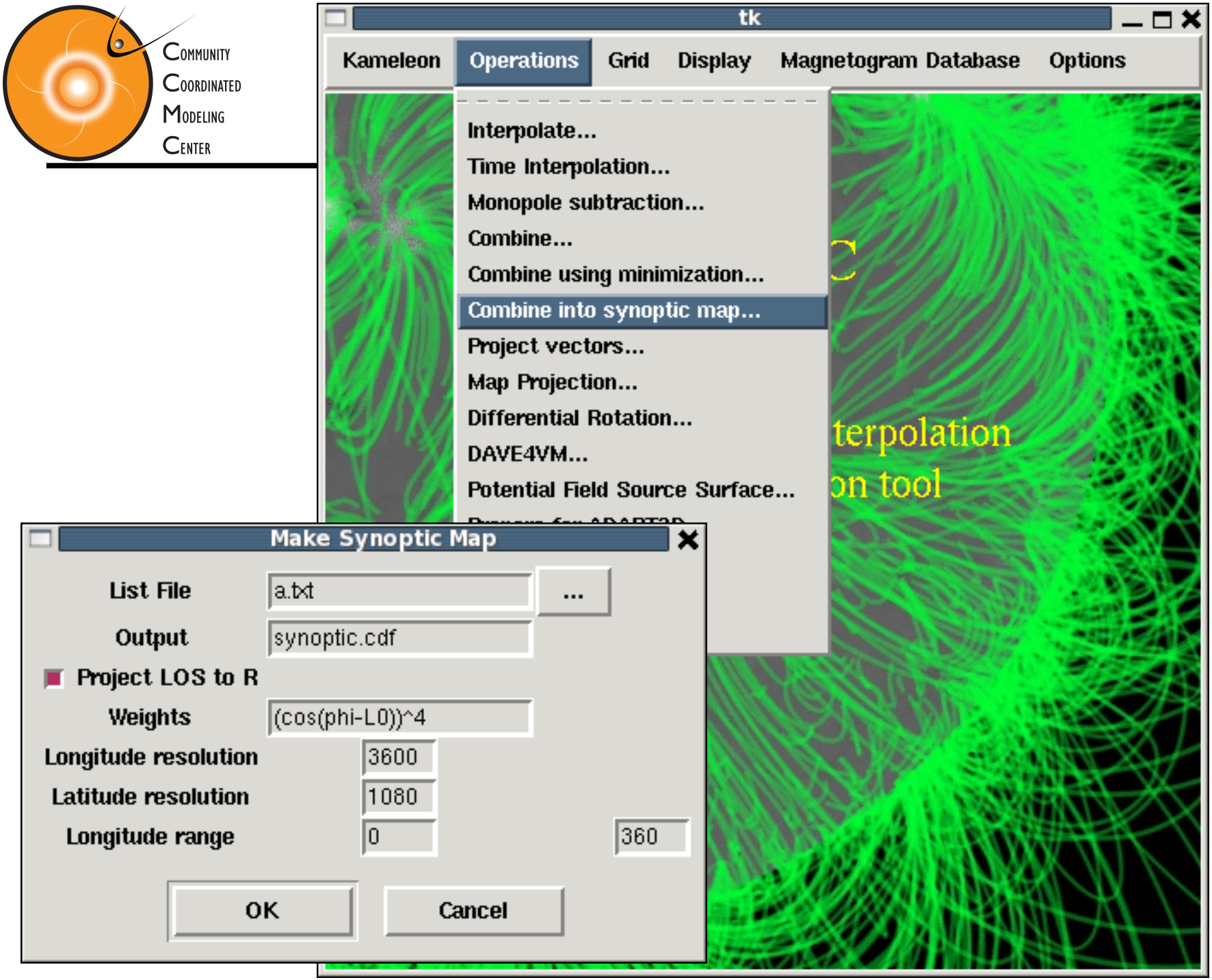
Embed SDO/HMI vector magnetogram in MDI synoptic map





- Inserts limited FOV magnetograms into global magnetograms
- Adjusts field in border region using minimization of user defined integrals that balance
  - smoothness
  - agreement with original field
  - user defined integrals of current density or helicity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DAVE4VM...
Potential Field Source Surface...
terpolation
on tool
Make Synoptic Map
List File
a.txt
...
Output
synoptic.cdf
Project LOS to R
Weights
(cos(phi-L0))^4
Longitude resolution
3600
Latitude resolution
1080
Longitude range
0
360
OK
Cancel

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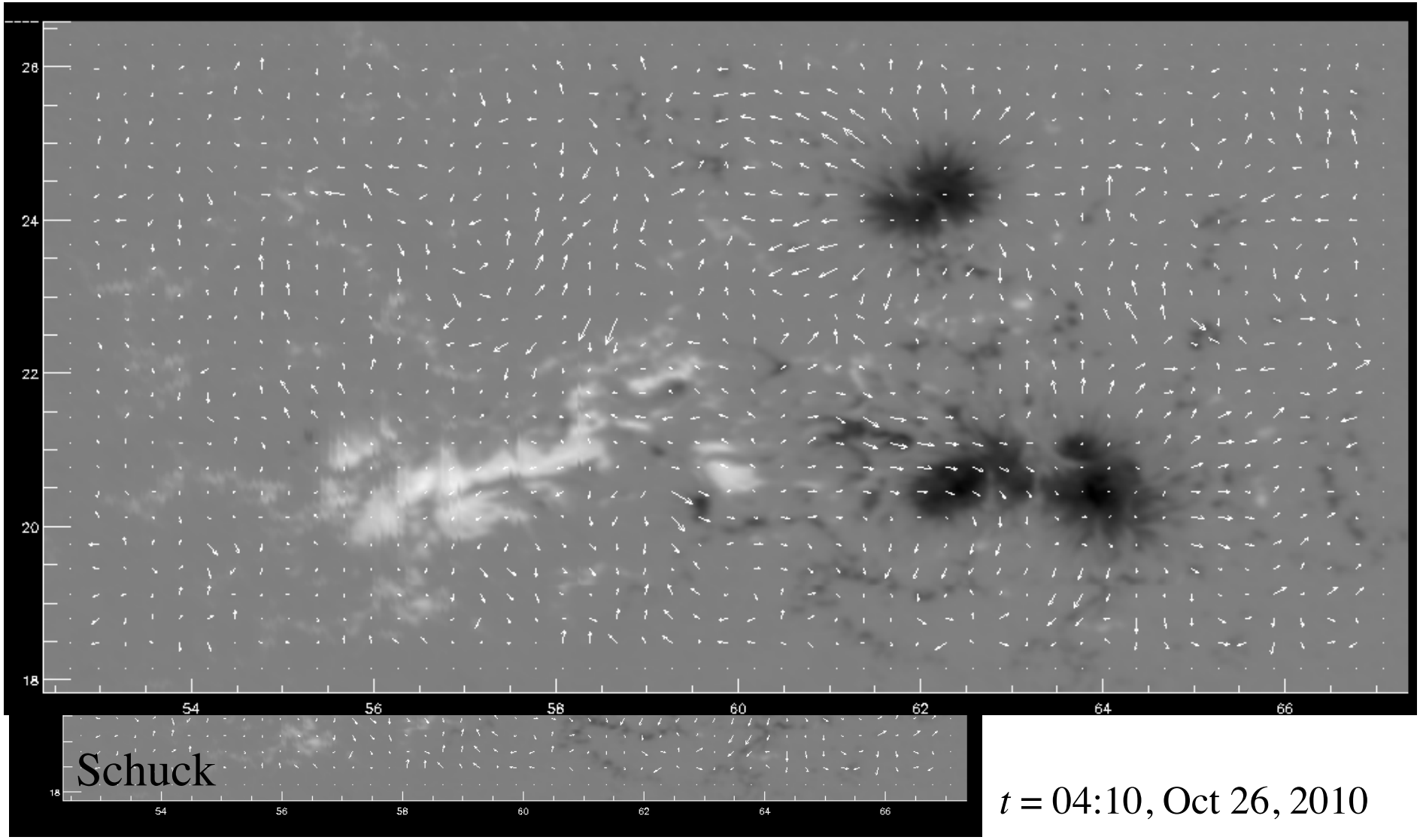
Surface flow analysis



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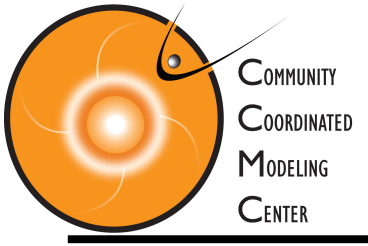
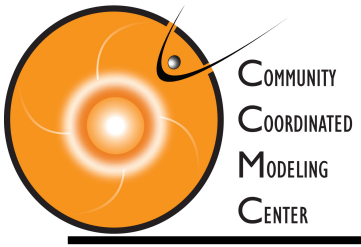


Supporting Efficient Model Execution

- MAGIC is a GUI driven application.
- You cannot stop a large parallel MHD code every timestep to get a new boundary state.
- Solution – process entire magnetogram time series in advance.
  - Return B-spline coefficients of a temporal fit to B and v at each node of the model's surface grid
- Only need to pause and rerun MAGIC if surface grid changes



Supporting all Models

- MAGIC supports all grid types in use in current coronal models!
  - ADAPT3D – unstructured tetrahedral
  - NLFFF – evenly spaced
  - MAS – lat/lon with uneven spacing
  - SWMF – block adaptive
  - ARMS – block adaptive
  - WSA - evenly spaced

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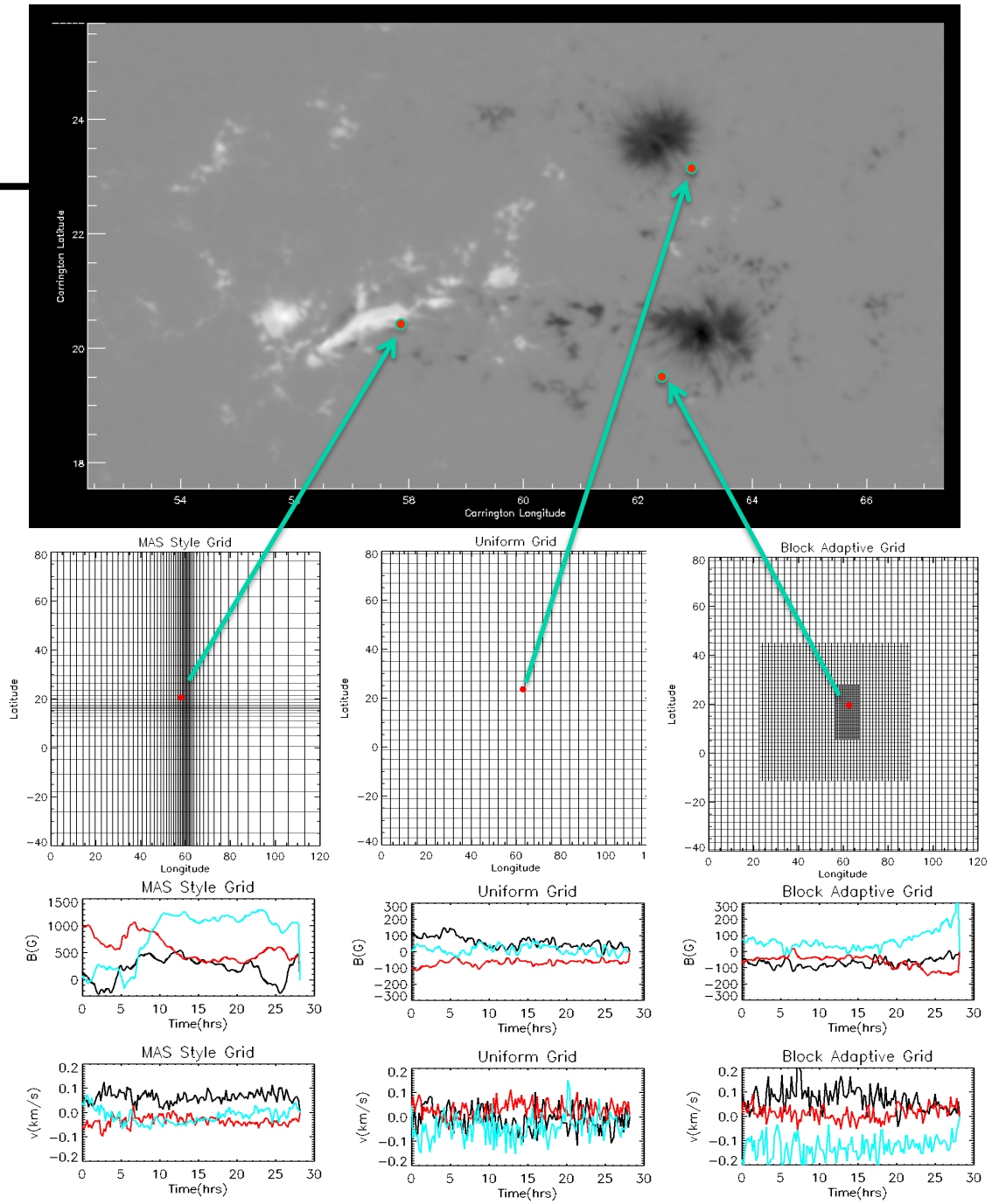
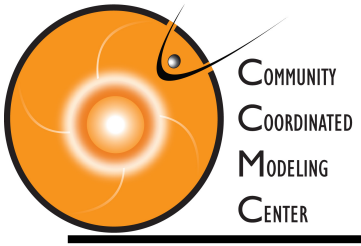
- AR11117
- HMI Vector magnetogram time series
- Grids
  1. MAS
  2. Uniform spacing
  3. SWMF, ARMS
- B-spline timeline reconstruction at grid nodes for $\boldsymbol{B}$,$\boldsymbol{v}$





MAGIC

- Interface supporting third party applications
  - Any third party program, provided it can read from, and write to, our Kameleon file format.
  - We provide sample read and write routines in both C and Fortran.

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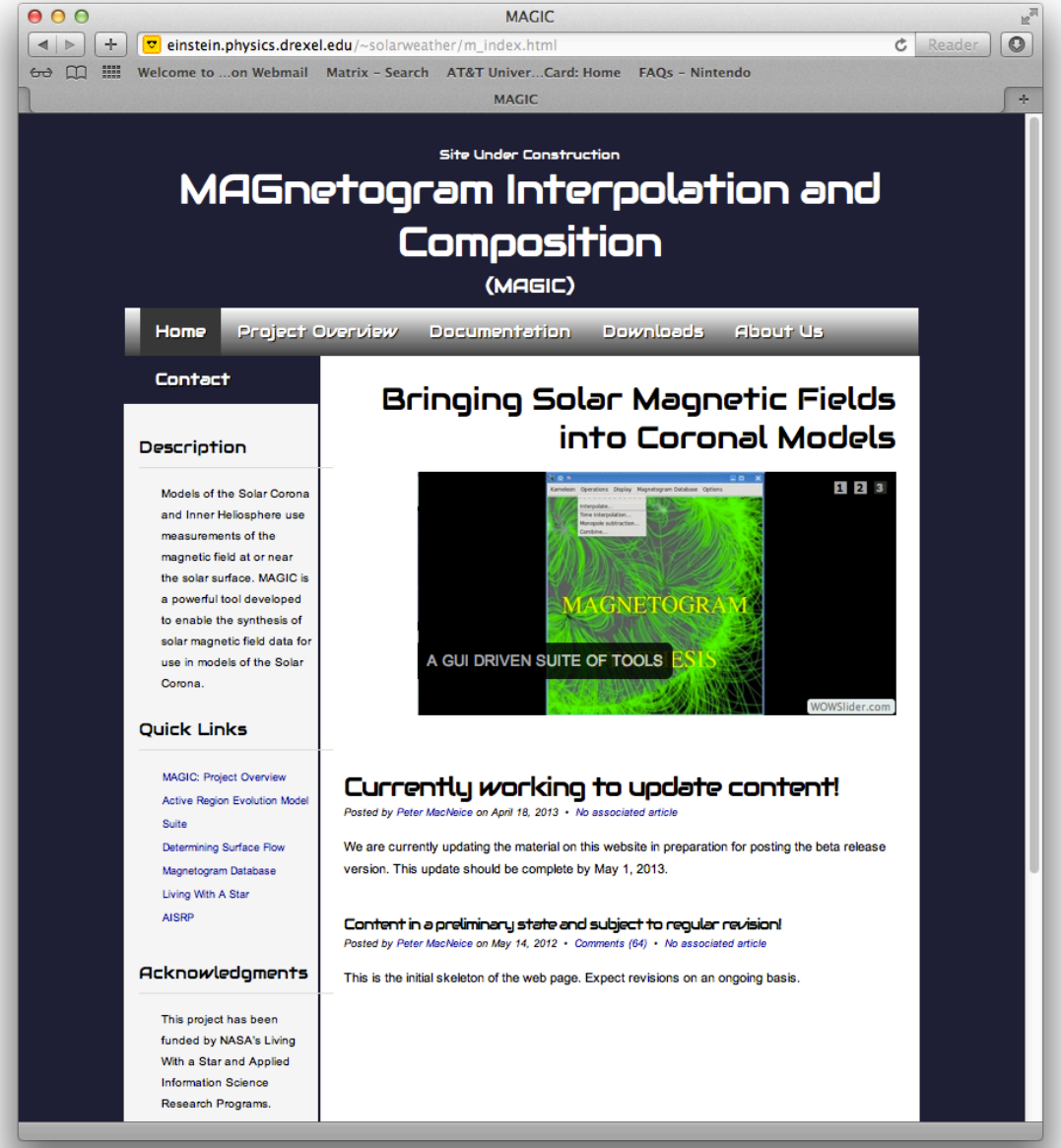
Web Page

http://einstein.physics.drexel.edu/~solarweather/m_installation.html



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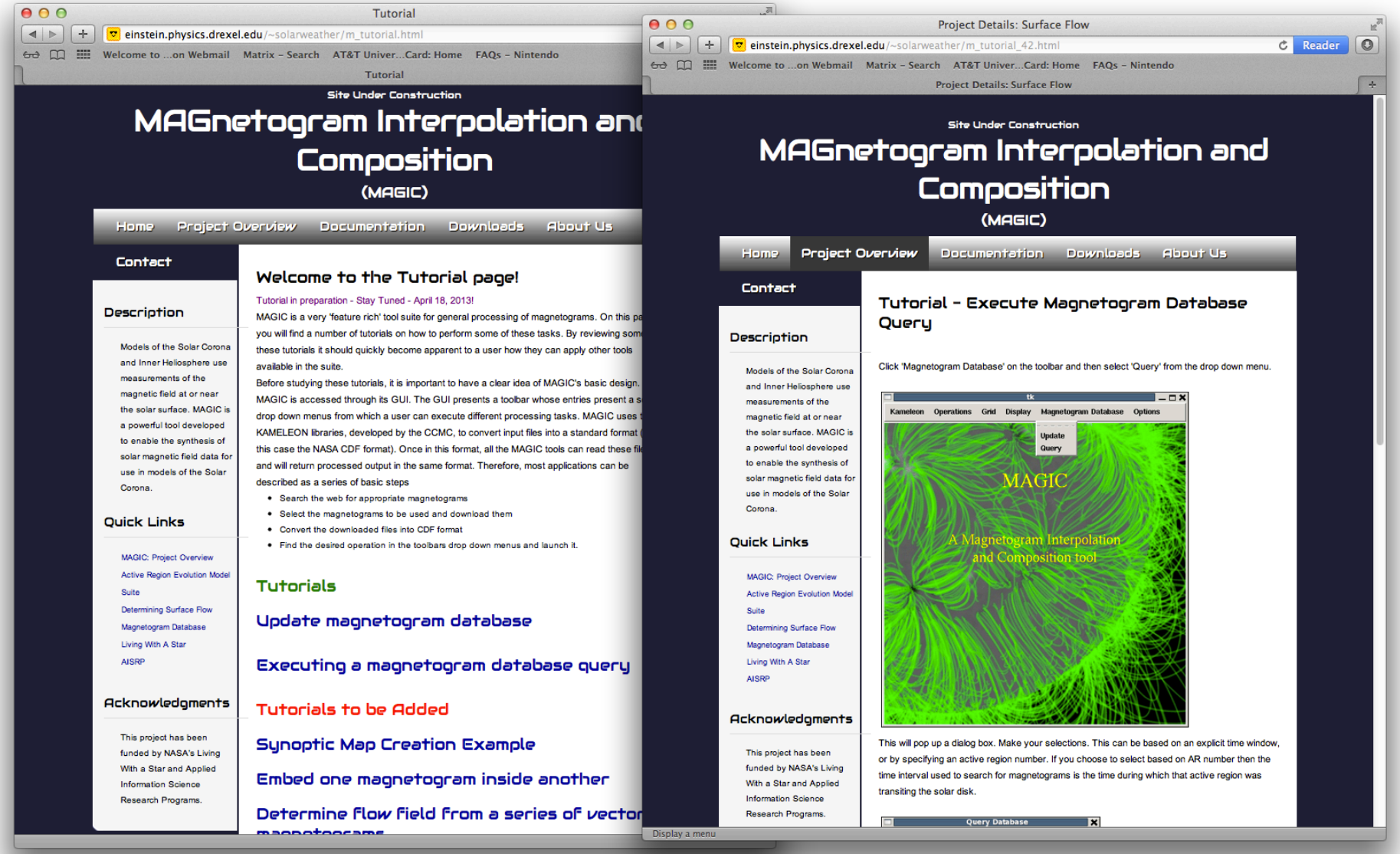
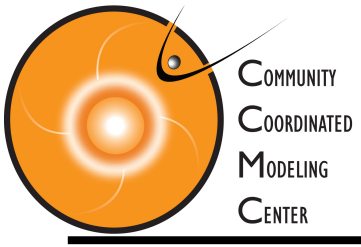
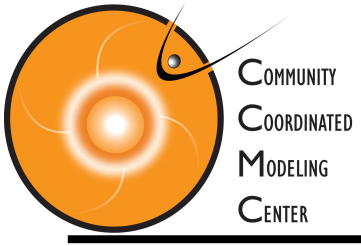




Status

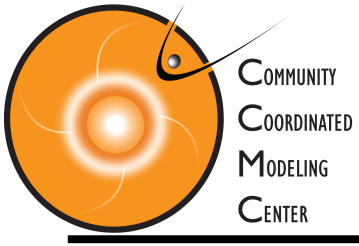
- Beta version delivered Jan 2013
- Latest version downloadable from web site
  - Tested on both Linux and OS X
- Building extensive set of tutorials
- Collaborating with NSO
- Collaborating with U.Michigan Strategic Capability

http://einstein.physics.drexel.edu/~solarweather/m_index.html



CCMC Specific Applications

- Customized synoptic map creation
- NLFFF Code will feed ISWA estimates of free-energy build up in active regions



The End