

TRANSITIONING EEGGL TO THE CCMC.

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+Thanks to Maria M. Kuznetsova and Spiro Antiochos

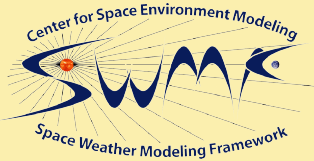
April, 11, 2016.

CCMC Workshop, April, 11-16, 2016. Annapolis, MD, USA.

Transients in the Solar Wind and Their Simulation in Real Time



- M** We present and demonstrate a new tool, EEGGL (Eruptive Event Generator using Gibson-Low configuration) for simulating CMEs (Coronal Mass Ejections).
- M** CMEs are among the most significant space weather events.
- M** Some of these effects may be efficiently simulated using the “cone model” (as we heard) The cone model provides a capability to predict the location, time, width and shape of the hydrodynamic perturbation in the upper solar corona (at ~ 0.1 AU), which can be used to drive the heliospheric simulation (with the ENLIL code, for example).
- M** At the same time the magnetic field orientation in this perturbation is uncertain within the cone model, which limits the capability of the geomagnetic activity forecast.



Eruptive Event Generator (Gibson-Low): EEGGL



- M** The new EEGGL tool recently developed at the CCMC in collaboration with the University of Michigan, provides a capability to simulate the magnetic field evolution at 1 AU too
- M** Based on the magnetogram and evaluation of the CME initial location and speed, the user may choose the active region from which the CME originates and then the EEGGL tool provides the parameters of the Gibson-Low magnetic configuration to parameterize the CME.
- M** The recommended parameters may be used then to drive the CME propagation from the low solar corona to 1 AU using the global code for simulating the solar corona and inner heliosphere.
- M** At the CCMC The Community Coordinated Modeling Center (CCMC) provides the capability for CME runs-on-request, to the heliophysics community.
- M** EEGGL is a new animal in the CCMC Zoo, which is well integrated with the other animals (Donki, STEREOCat).

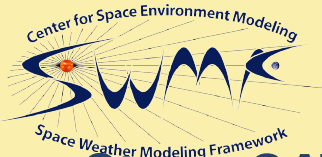
Demo for CME 2012-07-12



M We demonstrate how the new tools are used to simulate a halo CME 2012-07-12 (<https://kauai.ccmc.gsfc.nasa.gov/DONKI/view/CME/14/1>)

The List of CME Analysis already entered:

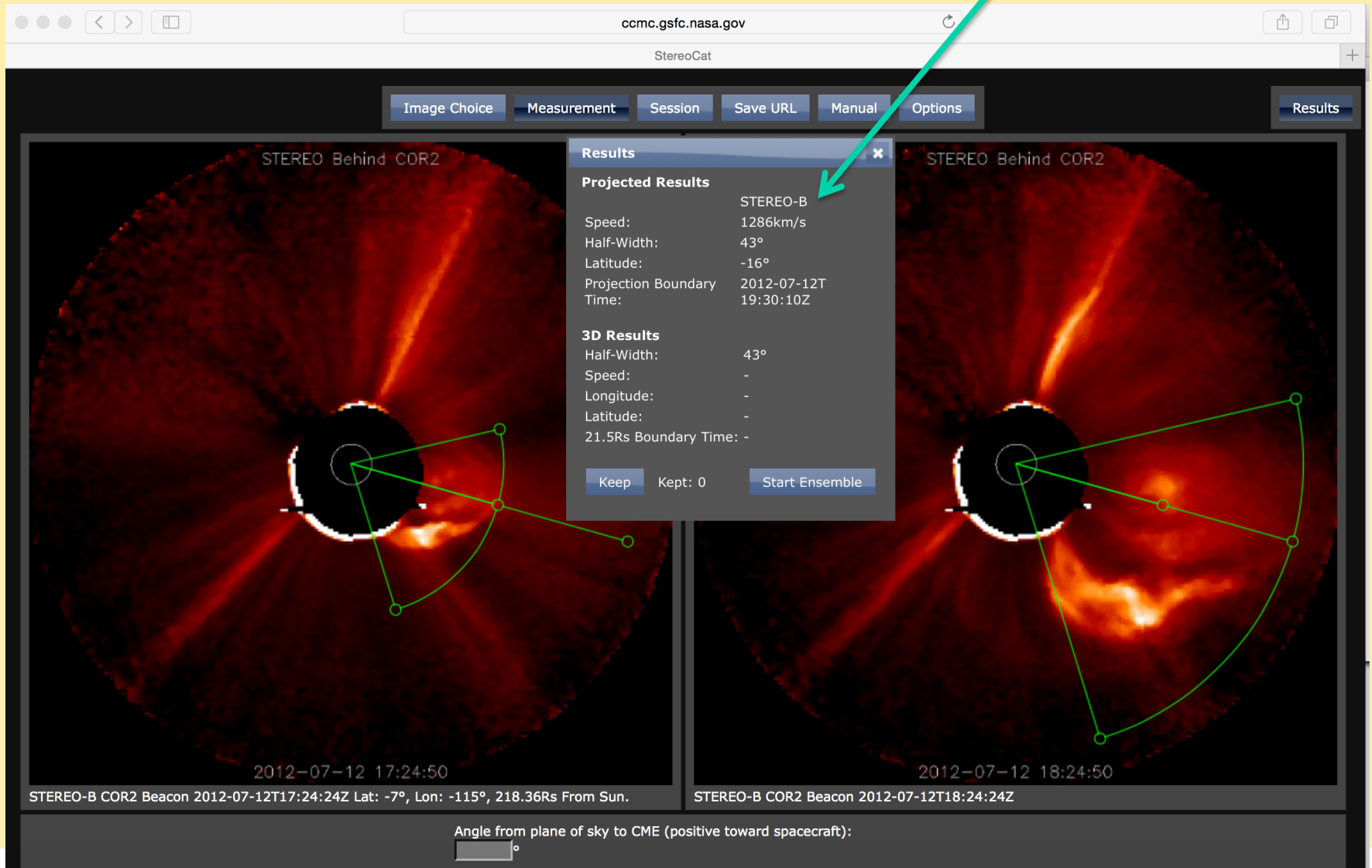
Event Type	Catalog	Data Level	Prime?	Long	Lat	Speed	Type	Half Width	Time 21.5	Note	WSA-ENLIL+Cone Result(s)	Submitted By
CME Analysis	SWRC_CATALOG	0	true	6.0	-13.0	1300.0	O	65.0	2012-07-12T19:29Z	remeasured using the GCS model	Not modeled	Leila Mays on 2015-06-01T19:02Z
CME Analysis	SWRC_CATALOG	0	false	-6.0	-17.0	1400.0	O	70.0	2012-07-12T19:35Z		1: Result 1 (2.0 AU) Earth = 2012-07-14T10:20Z (PE: -7.1 h) Mars = 2012-07-16T00:55Z MESSENGER = 2012-07-13T10:04Z Spitzer = 2012-07-14T13:56Z	Leila Mays on 2013-07-11T21:36Z
CME Analysis	SWRC_CATALOG	0	false	6.0	-9.0	1480.0	O	75.0	2012-07-12T19:31Z		1: Result 1 (2.0 AU) Earth = 2012-07-14T09:17Z (PE: -8.2 h) Mars = 2012-07-16T05:07Z MESSENGER = 2012-07-13T09:59Z Spitzer = 2012-07-14T15:06Z	Anthony Pritchard on 2013-08-08T20:48Z



StereoCAT is used to find CME Speed



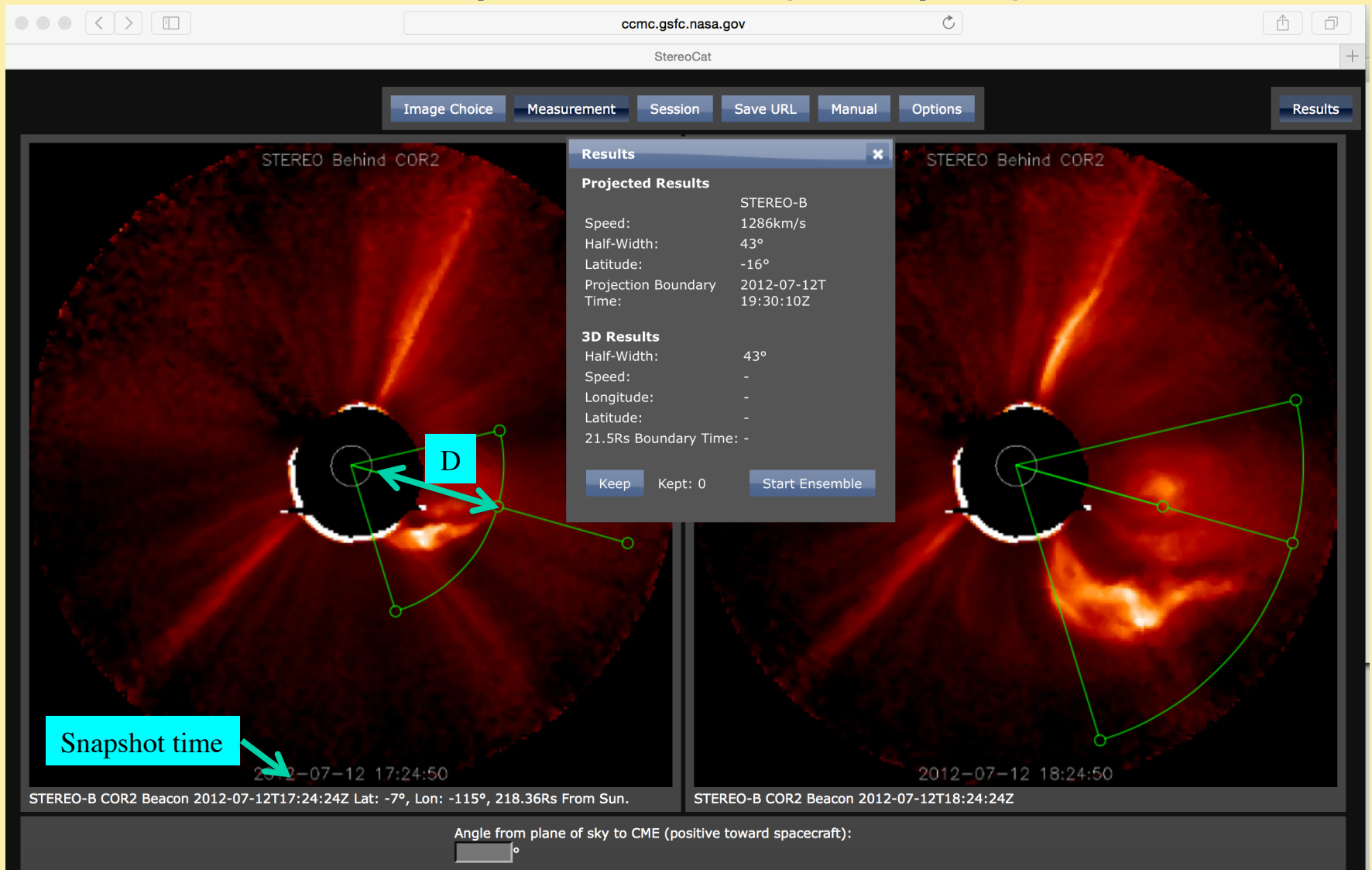
M StereoCAT (<http://ccmc.gsfc.nasa.gov/analysis/stereo/>) is developed at the CCMC. By tracing the CME front, we find CME Speed=1300km/s.



StereoCAT finds CME Start time



M $CME\ start\ time = Snapshot\ Time - D / (CME\ speed) = 13:51$



The screenshot shows the StereoCAT web interface. At the top, there are navigation tabs: Image Choice, Measurement, Session, Save URL, Manual, Options, and Results. The Results panel is open, displaying the following data:

Projected Results	
STEREO-B	
Speed:	1286km/s
Half-Width:	43°
Latitude:	-16°
Projection Boundary Time:	2012-07-12T 19:30:10Z

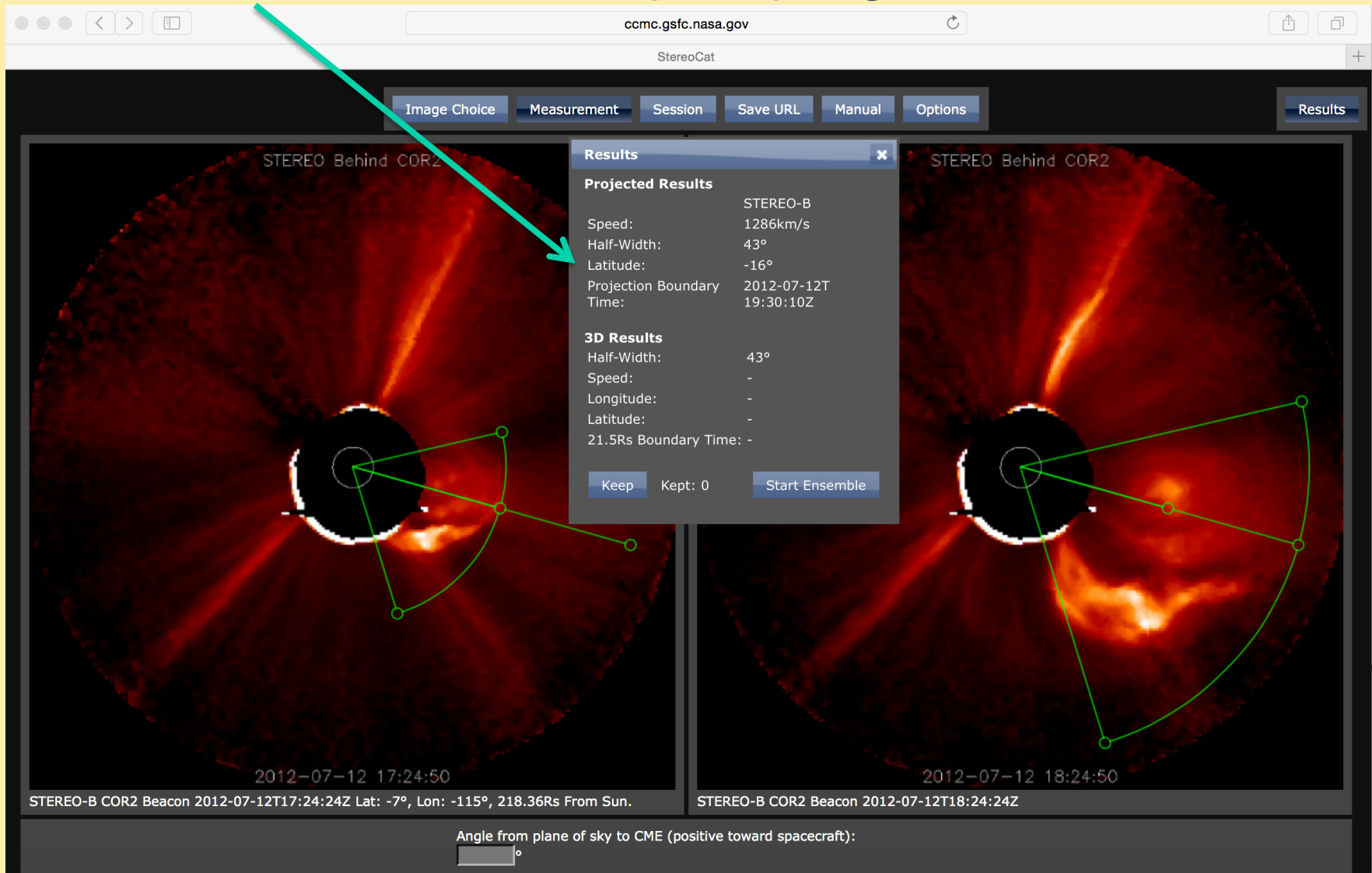
3D Results	
Half-Width:	43°
Speed:	-
Longitude:	-
Latitude:	-
21.5Rs Boundary Time:	-

At the bottom of the interface, there is a text input field for the angle from the plane of sky to the CME, currently set to 0 degrees.

StereoCAT guesses CME place of birth



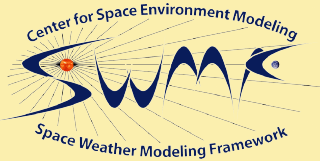
M Latitude is -20° . Estimates for (HEEQ) longitude are $\pm 6^\circ$



The screenshot shows the StereoCAT web interface at ccmc.gsfc.nasa.gov. The interface includes a navigation bar with buttons for "Image Choice", "Measurement", "Session", "Save URL", "Manual", "Options", and "Results". Two COR2 images are displayed side-by-side, labeled "STEREO Behind COR2". The left image is from 2012-07-12 17:24:50, and the right image is from 2012-07-12 18:24:50. A "Results" popup window is open, displaying the following data:

Projected Results	
STEREO-B	
Speed:	1286km/s
Half-Width:	43°
Latitude:	-16°
Projection Boundary Time:	2012-07-12T 19:30:10Z
3D Results	
Half-Width:	43°
Speed:	-
Longitude:	-
Latitude:	-
21.5Rs Boundary Time:	-

At the bottom of the interface, there is a text input field for "Angle from plane of sky to CME (positive toward spacecraft):" with a value of °.



Newly Developed EEGGL tool



M The new tool, EEGGL (Eruptive Event Generator using Gibson-Low configuration – see Splash page

<http://ccmc.gsfc.nasa.gov/analysis/EEGGLInfo/EEGGL.html>

and the tool itself: <http://ccmc.gsfc.nasa.gov/analysis/EEGGL/>) has been recently developed at the CCMC (Goddard Space Flight Center) in collaboration with the University of Michigan.

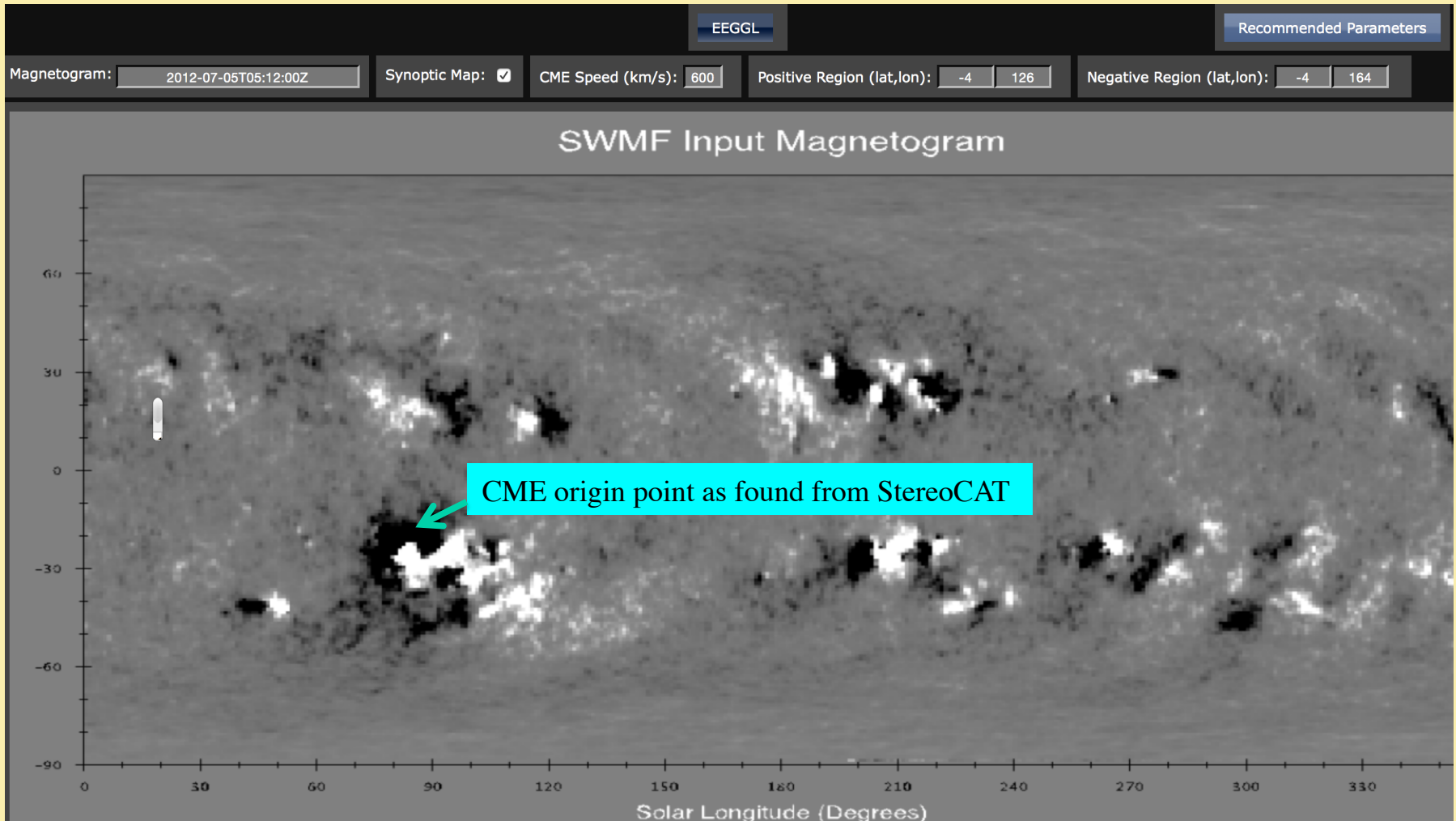
M Based on the magnetogram and evaluation of the CME initial location, speed, and start time the user may

- choose the active region from which the CME originates;
- then the EEGGL tool provides the parameters of the Gibson-Low magnetic configuration to parameterize the CME;
- the recommended parameters may be used then to drive the CME propagation from the low solar corona to 1 AU using the global code for simulating the solar corona and inner heliosphere. To achieve this, the EEGGL has a link to the run submission web page, which helps the user to fill in the request form for a simulation run.

EEGGL tool (historic events): chose AR



M For a start time, 2012-07-12.13:51 calculate CR number 2125 and Carrington longitude 83. Find AR in the synoptic magnetic map for CR2125 near the point with longitude $83 \pm 6^\circ$ and latitude -20°



Find Parameters for GL configuration



M Choose and mark bipolar configuration of solar spots in this AR

The screenshot shows the ccmc.gsfc.nasa.gov web interface. At the top, there are navigation buttons and a search bar. Below that, there are tabs for 'EEGGL' and 'Recommended Parameters'. The main content area displays a magnetogram titled 'SWMF Input Magnetogram' for the date 2012-07-05T05:12:00Z. The magnetogram shows a bipolar configuration of solar spots. A yellow box highlights a positive spot, and a blue box highlights a negative spot. A dialog box titled 'Recommended Parameters' is open, showing the following parameters:

Recommended Parameters	
GL Flux Rope Parameters	
Longitude:	85.00°
Latitude:	-23.00°
Orientation:	208.17°
Radius[Rs]:	0.94
Bstrength[Gs]:	4.30
Grid Refinement Parameters	
R_Start[Rs]:	1.10
Longitude_Start:	45.00°
Latitude_Start:	-43.00°
R_End[Rs]:	20.00
Longitude_End:	125.00°
Latitude_End:	-3.00°

At the bottom of the dialog box, there is a link: 'Request SWMF Run Using Parameters Above'. A red arrow points from the 'Recommended Parameters' button in the top right to the dialog box. A red arrow points from the highlighted spots in the magnetogram to a text box at the bottom.

1. Mark positive and negative spots
2. Click "Recommended parameters"

Fill in Form to Request Simulation Run



With the found parameters for GL configuration request a run.

ccmc.gsfc.nasa.gov

EEGGL View Space Weather Activity

EEGGL Recommended Parameters

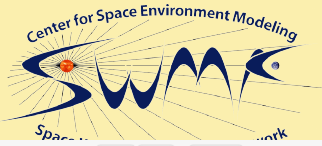
Magnetogram: 2012-07-05T05:12:00Z Synoptic Map: CME Speed (km/s): 1300 Positive Region (lat,lon): -27 95 Negative Region (lat,lon): -19 84

SWMF Input Magnetogram

Recommended Parameters
GL Flux Rope Parameters
Longitude: 85.00°
Latitude: -23.00°
Orientation: 208.17°
Radius[Rs]: 0.94
Bstrength[Gs]: 4.30
Grid Refinement Parameters
R_Start[Rs]: 1.10
Longitude_Start: 45.00°
Latitude_Start: -43.00°
R_End[Rs]: 20.00
Longitude_End: 125.00°
Latitude_End: -3.00°
[Request SWMF Run Using Parameters Above](#)

1. Parameters are found
2. Request SWMF run

Solar Longitude (Degrees)



Submit Your Run and Wait



ccmc.gsfc.nasa.gov

SWMF AWSoM_R run submission

View Space Weather Activity

-START TIME-

Year: 2012
Mon: 07
Day: 12
Hour: 13
Min: 51

**-GL FLUX ROPE
PARAMETERS-**

Longitude: 85
Latitude: -23
Orientation: 208.17
Radius: 0.94
B Strength: 4.30

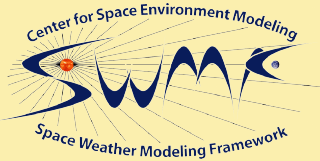
-Cone Opening Angle-

Longitude: 40
Latitude: 20

Special Request:

BACK

CONFIRM



SWMF Run-On-Request with EEGGL



- M Simulates Solar Corona (SC) in spherical coordinates (about 3 million cells) and Inner Heliosphere (IH) in Cartesian coordinates, on AMR grid (about 35 million cells) with an improved resolution within the cone in which the CME propagates.**
- M Superimpose the Gibson-Low configuration with the observationally constrained parameters, to simulate CME**
- M Steady-state simulation of the state prior to eruption takes approximately 17 hours at 120 CPUs with the CCMC cluster hilo.**
- M Simulation of 4-10 hours of the CME evolution in the SC and then about 3 days of its evolution in the IH takes approximately 16 hours at 120 CPUs.**

The only relevant slide.

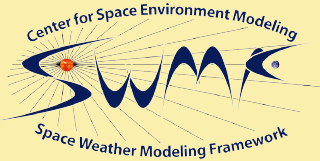


M Transitioning the EEGGL to the CCMC. Problems:

- EEGGL in the CCMC is the web application and the UofM team cannot handle the web application at the CCMC by multiple reasons (classification, network security)
- EEGGL in the CCMC is the web application while the code development in the UofM is done in languages (f95, C++, IDL) not suited for web application at all.
- This results in an excessive labor needs when the CCMC has to reshape new versions of the code to get them work at the CCMC

M Solution of the problems:

- Algorithms are implemented in Python. At the CCMC this part of the code one-to-one converts to the server side (“back-end”) of the EEGGL
- The emulator is implemented in Python/IDL/Fortran-executable. This emulator both allows us (UofM) to keep using/developing the EEGGL as standing-alone code and describes, how the browser side (“front-end”) of the EEGGL at the CCMC may look like.



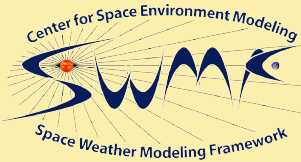
Future Work



- M We will add a capability to simulate real-time CMEs based on the existing automated real-time simulation system .**
- M We will add a capability to superimpose the Titov-Demouline flux rope.**

Acknowledgement

- M The collaboration between the CCMC and University of Michigan is supported by the NSF SHINE grant 1257519 (PI Aleksandre Taktakishvili). The work performed at the University of Michigan was partially supported by National Science Foundation grants AGS-1322543 and PHY-1513379, NASA grant NNX13AG25G, the European Union's Horizon 2020 research and innovation program under grant agreement No 637302 PROGRESS. We would also like to acknowledge high-performance computing support from: (1) Yellowstone ([ark:/85065/d7wd3xhc](https://www.nsls.gov/)) provided by NCAR's Computational and Information Systems Laboratory, sponsored by the National Science Foundation, and (2) Pleiades operated by NASA's Advanced Supercomputing Division**

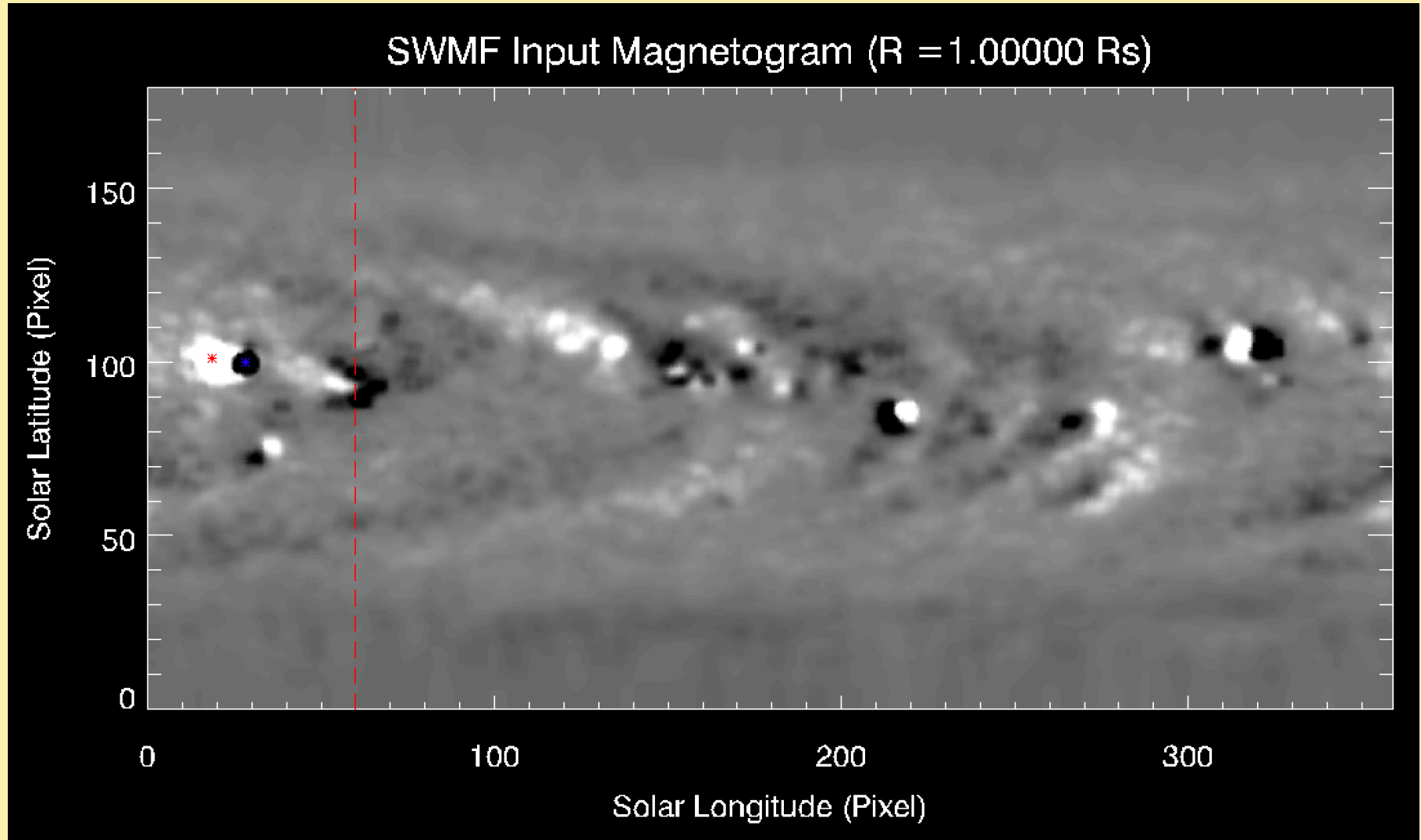


Today's Experience. 1. Start the EEGGL script with the today's noon magnetogram

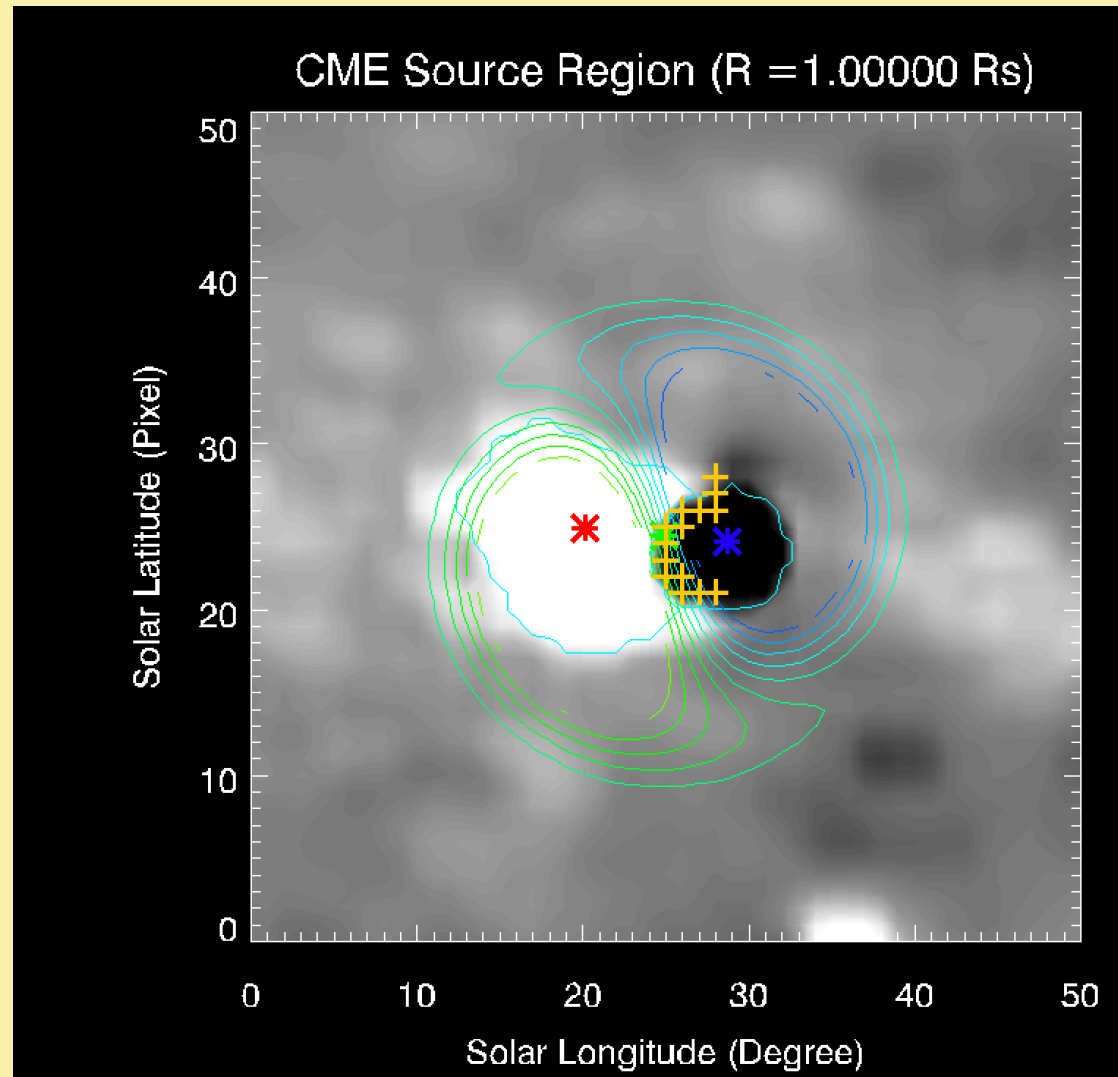


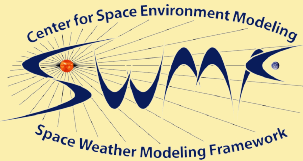
```
LOADCT: Loading table Rainbow + white
Program caused arithmetic error: Floating illegal operand
Compiled module: GLSETUP2.
Compiled module: READ_MAGNETOGRAM.
LOADCT: Loading table B-W LINEAR
LOADCT: Loading table Rainbow + white
LOADCT: Loading table B-W LINEAR
LOADCT: Loading table Rainbow + white
srblap2015-0085;util/DATAREAD/srcMagnetogram>./GLSETUP.py GNG2176_317.fits -Out=remap -nSmooth=5 -CMESpeed=1000.0[
```


Today's Experience. 2. Choose an active region



Today's Experience. 3. Enjoy result (zoom)





Today's Experience. 4. CME parameters.



M #CME

M T UseCme

M T DoAddFluxRope

M 342.50 LongitudeCme

M 10.50 LatitudeCme

M 0.87 OrientationCme

M GL TypeCme

M 0.60 Stretch

M 1.80 Distance

M 0.49 Radius

M -10.15 BStrength

M 0.0 Density

M 1.0 ModulationRho

M 1.0 ModulationP