Coronal Mass Ejection Forecasting User's Guide

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Version 1.0

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1.INTRODUCTION

1.1 Overview

The primary purpose of the Coronal Mass Ejection Forecasting software is to provide the capability to identify solar active regions with sigmoidal, S-shaped coronal structure. Sigmoidal structure is generally apparent hours to days before the occurrence of geoeffective events from the active region.

The purpose of the Coronal Mass Ejection Forecasting project is to identify sigmoidal regions using an automated, objective process.

The output from the process is the location of any sigmoidal region present in the solar corona.

The Coronal Mass Ejection Forecasting software provides the operator with the capability to identify sigmoidal regions in near-realtime, limited only by the availability of solar coronal images. The sigmoid identification can be derived from various spacecraft data; SOHO/EIT is the source at this time, with GOES/SXI available in the future.

1.2 Document Purpose

The purpose of this document is to provide for the user a description of the software components, a description the operation of the software, and to describe the options available.

2. OPERATION DESCRIPTION

2.1 Processing

The user can run the main execution script by typing:

run_sigmoid

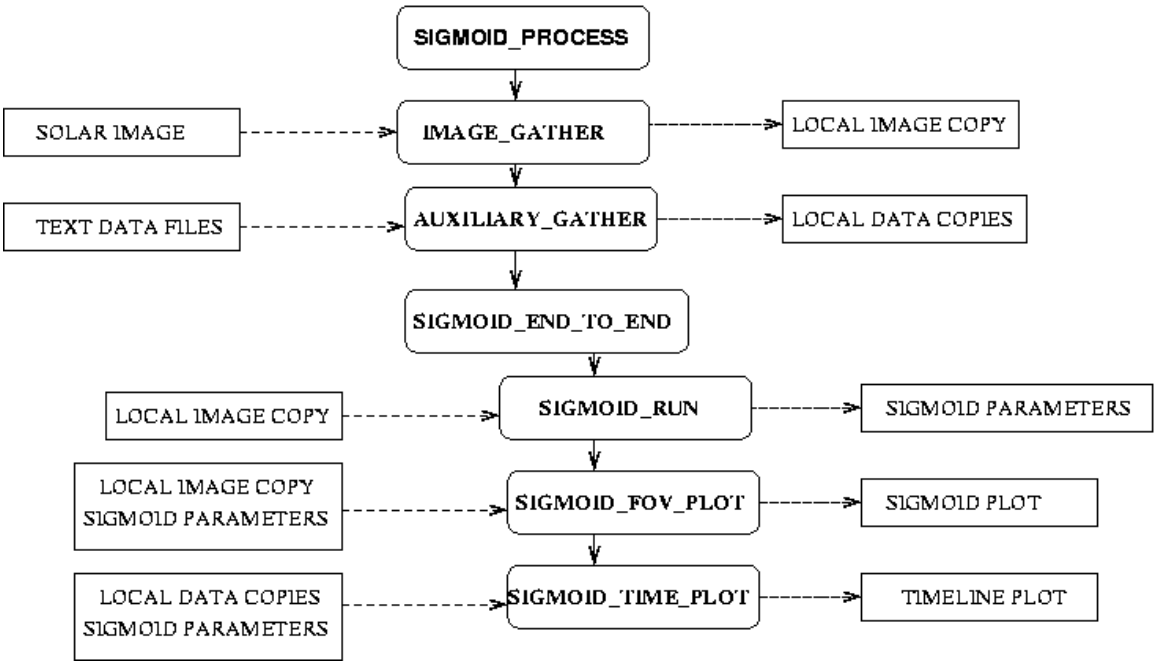
(which is located in the bin directory) with no parameters. (**NOTE:** The user must first edit the setup file *site_dependent* modifying $DIR_SIGMOID to point to the directory in which the software was installed. See Section 3.1 for a description of the setup file.)

This process will gather the necessary image and auxiliary data, search for sigmoids, and plot the results. The output can be viewed with any image viewer.

The processing is designed to run automatically, with the results of the most recent data available continuously.

2.2 Components

The Coronal Mass Ejection Forecasting software system consists of several scripts and procedures. The following diagram illustrates the data flow and processing order.



3. OPERATION

3.1 Site dependent parameters

The scripts depend on knowledge of a few site dependent parameters. These are listed in the ASCII file $DIR_SIGMOID/setup/site_dependent. They are defined as part of the environment to be accessible to all the sigmoid codes. These values must be altered based on the installation, using any Unix compatible editor.

Environment Variable	Purpose
DIR_SIGMOID	Directory path to the location of the sigmoid tree.
SIGMOID_IMAGE_TYPE	Instrument acronym of the source of solar coronal images.
SSW_INSTR	List of SolarSoft packages to include

solar	Directory path to one level above the location of the SolarSoft software
SSW	Set to $solar/ssw to locate the SolarSoft software
SSWDB	Set to $solar/sswdb to locate of the SolarSoft database
HESSI_PATH	Set to $SSW/hessi to locate the HESSI package
ssw_quiet	Set to 1 to eliminate unneeded messages
sswidl	Set to $SSW/gen/setup/setup.ssw to locate the SolarSoft executable

The choice for SIGMOID_IMAGE TYPE is presently SXI. It should be changed if SXI fails and an alternate data source is placed into operation. A sample of the above-mentioned setup file can be found in Appendix B.

3.2 Outputs

When the process is executed, it outputs a timeline of solar, heliospheric, and geomagnetic activity. If any new coronal images are available and contain a sigmoidal active region, the image with sigmoid overplotted is also output. The output images are viewed with any image viewer. Samples of the output images are shown in Appendix C.

APPENDICES

A. Acronyms and Abbreviations

AACGM	Attitude Adjusted Corrected Geomagnetic
ACE	Advanced Composition Explorer
AFCCC	Air Force Combat Climatology Center
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AFSCN	Air Force Satellite Control Network
AFSPACECOM	Air Force Space Command
AFSWC	Air Force Space Weather Center
AFWA	Air Force Weather Agency
AFWIN	Air Force Weather Information Network
AF/XOW	Air Force Director of Weather
APL	Applied Physics Laboratory of Johns Hopkins University
ASCII	American Standard Code for Information Interchange
ASPAM	Atmospheric Slant Path Analysis Model
AVHRR	Advanced Very High Resolution Radiometer
AVN	Aviation Model
AVO	Alaska Volcano Observatory
BATS	Biosphere-Atmosphere Transfer Scheme
CARMA	Community Aerosol Research Model from Ames/NASA
CLASS	Canadian Land Surface Scheme
CME	Coronal Mass Ejections
COE	Common Operating Environment
DII	Defense Information Infrastructure
DMSP	Defense Meteorological Satellite Program
Dst	Disturbance, storm
ECMWF	European Center for Medium-Range Weather Forecasts
EIT	Extreme Ultraviolet Imaging Telescope
EVA	Extravehicular Activities
FAC	Field Aligned Currents
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FSL	Forecast Systems Laboratory
FTP	File Transfer Protocol
GI	Geophysical Institute
GIC	Ground Induced Currents
GIF	Graphic Interchange Format
GIT	Georgia Institute of Technology
GMT	Generic Mapping Tools
GOLD	Geophysical On-Line Data
GOES	Geostationary Operational Environment Satellite
GRIB	Gridded Binary
GSE	Geocentric Solar-Ecliptic

GSFC	Goddard Space Flight Center
HLBL	High Latitude Boundary Layer
IDL	Interactive Data Language
IMF	Interplanetary Magnetic Field
ISS	International Space Station
JHU	Johns Hopkins University
Kp	Planetary Index of Geomagnetic Activity
LAN	Local Area Network
LAPS	Local Analysis and Prediction System
LASCO	Large Angle Spectroscope Coronagraph
LEO	Low-attitude Earth Orbit
LSM	Land Surface Model
MATCH	Model of Atmospheric Transport and Chemistry
MeV	Million Electron Volts
MM5	Fifth Generation Mesoscale Model
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
netCDF	Network Common Data Form
NGDC	National Geophysical Data Center
NGM	Nested Grid Forecast Model
NOAA	National Oceanic and Atmospheric Administration
NOGAPS	Navy Operational Global Atmospheric Prediction System
NRL	Naval Research Laboratory
NWP	Numerical Weather Prediction
OWS	Operational Weather Squadron
PACE	Polar Anglo-American Conjugate Experiment
PBL	Planetary Boundary Layer
PCA	Polar Cap Absorption
PFRR	Poker Flat Research Range
PNG	Portable Network Graphics
RBE	Radiation Belt Environment
SAA	South Atlantic Anomaly
SABER	Sounding of the Atmosphere using Broadband Emission Radiometry
SD	Space Department of the Applied Physics Laboratory
SDFM	Surface Dust Flux Model
SDP	Software Development Plan
SEC	Space Environment Center
SEE	Solar EUV Experiment
SEON	Solar Electro-optical Observing Network
SEP	Solar Energetic Particles
SFOC	Space flight Operations Center
SOHO	Solar and Heliospheric Observatory
SPE	Solar Particle Event
STP	Solar Terrestrial Physics

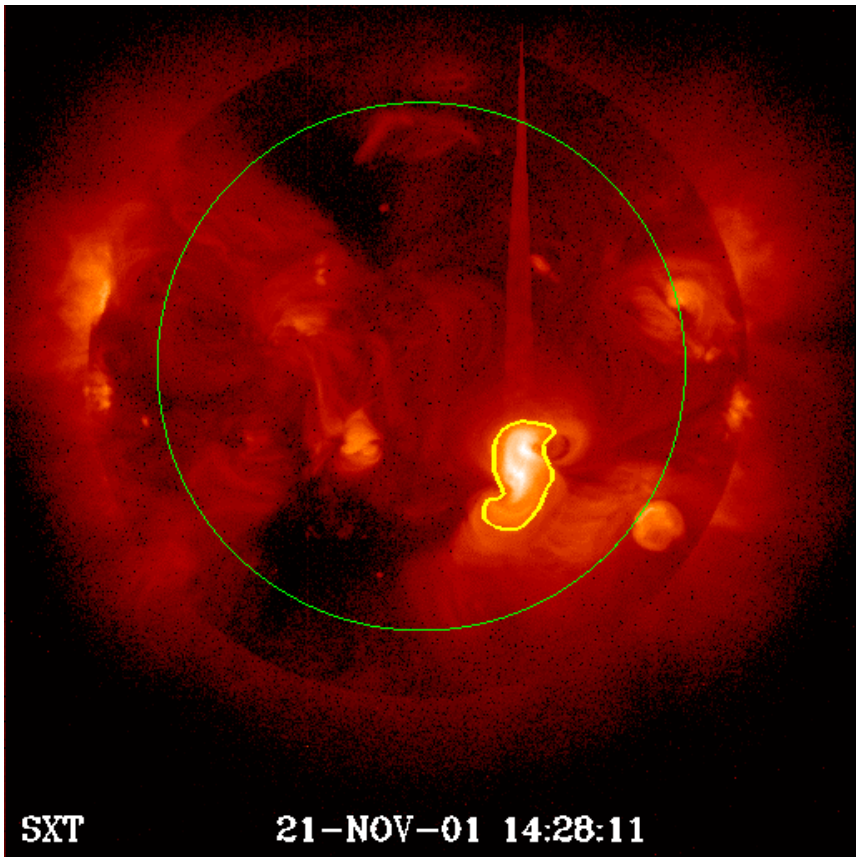
SWOC	Space Weather Operations Center (Offutt)
SWXS	Space Weather Squadron
SXI	Soft X-ray Imager
Tcl	Tool Command Language
Tk	Toolkit
Tix	Tk Interface Extension
UAF	University of Alaska, Fairbanks
UCAR	University Corporation for Atmospheric Research
UCB	University of Colorado, Boulder
UPOS	University Partnering for Operational Support
UTC	Coordinated Universal Time
WDC	World Data Center
WF	Weather Flight
WMO	World Meteorological Organization
XDR	External Data Representation

B. Setup File

```
setenv DIR_SIGMOID          /project/upos/dev/hasselm1/CME_TEST
setenv SIGMOID_IMAGE_TYPE   SXI
setenv SSW_INSTR "eit lasco mdi sxt bcs hxt wbs trace hessi stereo binaries"
setenv solar /project/upos/software
setenv SSW $solar/ssw
setenv SSWDB $solar/sswdb
setenv HESSI_PATH $SSW/hessi
setenv ssw_quiet 1
source $SSW/gen/setup/setup.ssw
setenv sswidl $SSW/gen/setup/ssw_idl
```

C. Sample images

The following solar coronal image was received from the Yohkoh/SXT instrument. A sigmoid was found, and the image shows the sigmoid overplotted onto the solar image. The green circle is the limit of the region on the Sun where sigmoids can be detected. Sigmoids too close to the limb (edge) of the Sun are distorted and cannot be identified automatically.



The following timeline plot shows the time interval of the sigmoid seen in the previous image. The sigmoid detected on 21 November 2001 in active region 9704 was followed on 22 November by two M-class X-ray flares, each associated with a halo CME and a Type II (shock wave) radio burst. The energetic particles from those events arrived promptly, and the geomagnetic disturbance occurred on 24 November.