

# Solar physics data analysis software and data visualization via the Helioviewer Project

Jack Ireland  
SDAC/VSO Project Scientist

# SolarSoftWare (SSW)

- A set of integrated software libraries, data bases, and system utilities which provide a common programming and data analysis environment for solar physics.
- Built from Yohkoh, SOHO, SDAC and Astronomy libraries; primarily an IDL based system, although some instrument teams integrate executables written in other languages.
- Many data analysis and instrument science operation packages are written in SSW
- Provides a consistent look and feel at widely distributed co-investigator institutions to facilitate data exchange and to stimulate coordinated analysis.

# SSW

- Handles much current and older solar physics data.
  - *Science data is accessible.*
  - *Ground, space and virtual observatories.*
- In continuous development since the 1980's.
  - *Accumulated knowledge and experience.*
  - *IDL is a simple language to pick up.*
- Easy to get started to do the science you want.
  - *SSW is probably already installed somewhere at your institution.*
  - *Supported by a profit-motivated company.*

# SSW

- No central development authority or review
  - *Can lead to wheel re-invention, functionality duplication (mission/instrument stove-piping)*
  - *Software written in many different styles (differing documentation, code legibility)*
  - *Version control not enforced across all of SSW*
- IDL
  - *IDL has a single namespace - you always get the first module in the search path that has the requested name, which might not be the one you want.*
  - *Licensing (fees, changing license terms).*
- Very few tests verifying performance
  - *Harder to track down bugs.*
- Feature and bug reporting
  - *Some functions have an email of someone to contact, some don't.*



# The SunPy Project

- Python-based solar physics data analysis software
- Allows users to access the broadening range of Python scientific data analysis software
- Free and community supported.



# Functional Scope

- Includes:
  - data search and download (VSO, JSOC, HEK, HELIO, etc)
  - coordinate frames and transformations
  - high level data objects to hold data (Map, TimeSeries)
  - visualization of data objects
  - solar properties, e.g. differential rotation



# Organization

- Governed by a board
  - directs the development of the SunPy project
  - two-year terms for (most) board members
- Member of NumFOCUS
  - promotes open practices in research, data, and scientific computing by serving as a fiscal sponsor for open source projects and organizing community-driven educational programs
  - includes AstroPy, NumPy, matplotlib, Julia and many others



# Development Scope

- Use accepted software development practices to design and implement functionality
  - distributed version control (git)
  - continuous integration
  - code is reviewed before acceptance
  - code has tests
  - code must be documented
  - code follows common Python standards
    - SunPy adds extra requirements, for example, public facing API only accepts inputs with physical units.



# Development Scope

- Try not to reinvent the wheel
  - heavy use of Astropy library (units, time, coordinates and frames) and project structure
  - example: scikit-image functionality used to do cross-correlation of images.
- All input is good and should be easy to do - bug reports, adding to docs, examples, new functionality, bug fixes, tests, etc.



# Helioviewer Project

- Goal is to enable exploration of the Sun and the inner heliosphere for everyone, everywhere via intuitive interfaces and novel technology.
- Based on the JPEG2000 image standard
  - Streaming protocol (JPIP)
  - Arbitrary metadata (FITS)



# helioviewer.org

helioviewer.org/#

x: -1109 " y: 721 "

Parker Solar Probe

CH SPoCA 30721

AR SPoCA 23143

Coronal Hole: SPoCA 30766

Start Time: 2019-09-01 23:21:53 UTC  
End Time: 2019-09-02 03:21:53 UTC  
SPoCA Identifier: SPoCA 30766

View HEK data  
Make movie using event times and current field of view  
Copy start / end times to data download

AIA 171 2019/09/02 01:08:33 UTC  
LASCO C3 2019/08/27 23:30:07 UTC

Request Image Sequence from VSO

Start Date: 2019/08/27 23:30:07 UTC  
End Date: 2019/09/02 01:08:33 UTC

AIA 171

LASCO C3

SSW Script VSO Website

SDO AIA/HMI Cut-out Service

Observation Date

Date: 2019/09/02 01:08:40 UTC

Jump: 1 Day

Images

Add Layer

Features and Events

HEK

check all check none

Active Regions (2)  
NOAA SWPC Observer (1)  
SPoCA (1)

Coronal Cavities

Coronal Dimmings

Coronal Holes (2)  
SPoCA (2)

Coronal Jets

CMEs

Coronal Rains

Coronal Waves

Emerging Fluxes

Eruptions

Filaments

Filament Activations

Filament Eruptions

Flares

Loops

Oscillations

Plages

Sigmoid

Spray Surges

Sunspots

Data Sources

Image Timeline Events Timeline

Virtual Solar Observatory

Request Viewport Images from VSO

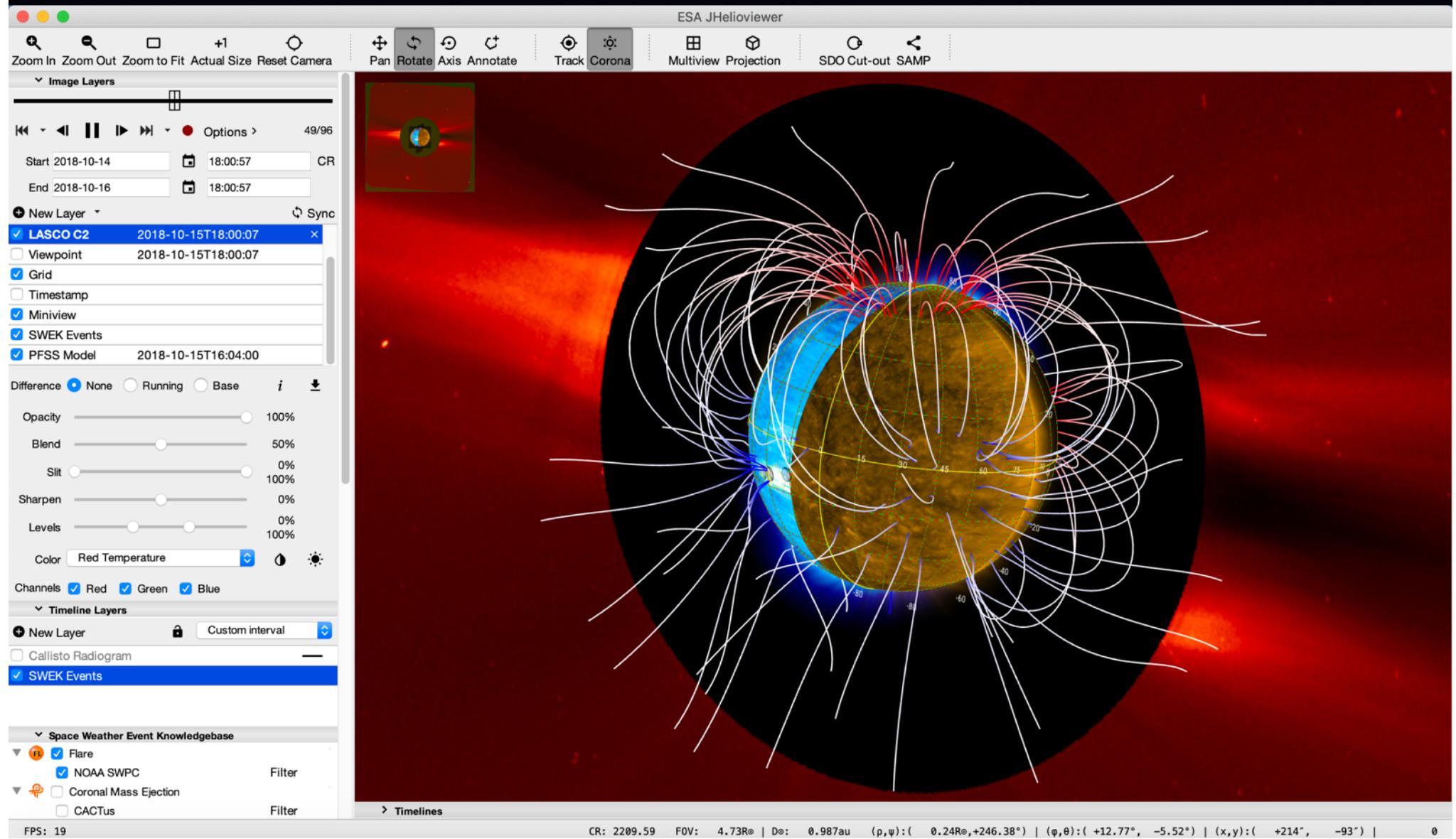
Request Image Sequence from VSO

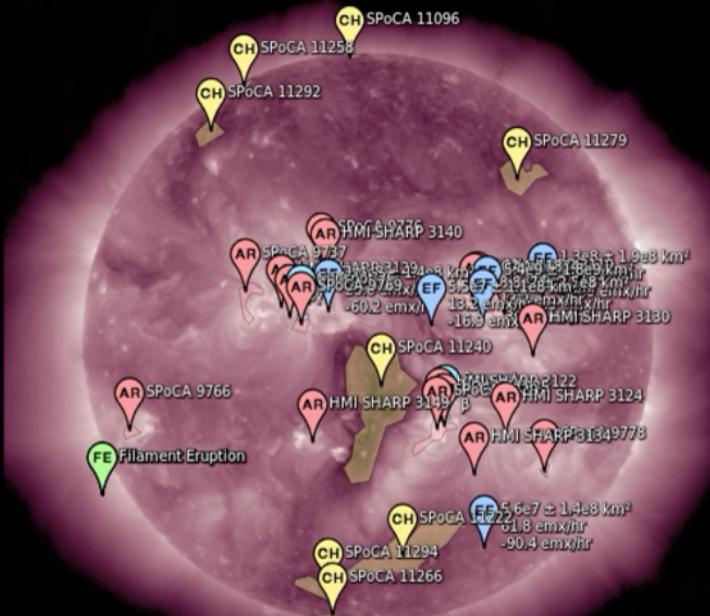
SDO AIA/HMI Cut-out Service

SSW Script VSO Website



# jhelioviewer.org





LASCO C2  
AIA 211

2013-09-01 05:12:05  
2013-09-01 05:17:11

[www.helioviewer.org](http://www.helioviewer.org) 



# Helioviewer Project

- Three operational Helioviewer servers
  - *GSFC, Royal Observatory of Belgium, Institut d'Astrophysique Spatiale*
- Two main clients
  - [helioviewer.org](http://helioviewer.org)
    - *Browser-based*
    - *Development based at GSFC*
  - [jhelioviewer.org](http://jhelioviewer.org)
    - *Downloadable Java-based client*
    - *Development based at ROB*

# Next...

- Data analysis environment is changing
  - SSW developers are retiring
    - *who will maintain the heritage of SSW?*
  - Python-based analysis is growing
    - *how do we support all aspects of a more heterogeneous data analysis environment?*
  - New analysis techniques (ML) and new questions (cross-disciplinary)
    - *typically requires lots of data and compute - how can we support these new science questions?*

# Next...

- Extensions to Helioviewer to support PSP and Solar Orbiter
  - Three dimensional reprojection from arbitrary viewpoints
    - *Already implemented in JHelioviewer client but will be implemented server-side (using SunPy) and in helioviewer.org*
  - Better connection to data
    - *Recent NASA funding opportunity provides support for additional datasets that are useful for PSP science.*
- Server side changes
  - Faster movie creation on helioviewer.org
  - Move to cloud architecture & explore micro-services approach

End