

# 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/#

Helioviewer.org x: -1109 " y: 721 "

Observation Date  
Date: 2019/09/02 01:08:40 UTC NEWEST  
Jump: 1 Day

Images Add Layer

Features and Events

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

☒ 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
- ☒ Sigmoids
- ☒ Spray Surges
- ☒ Sunspots

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](#)

Virtual Solar Observatory

Request Viewport Images from VSO

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

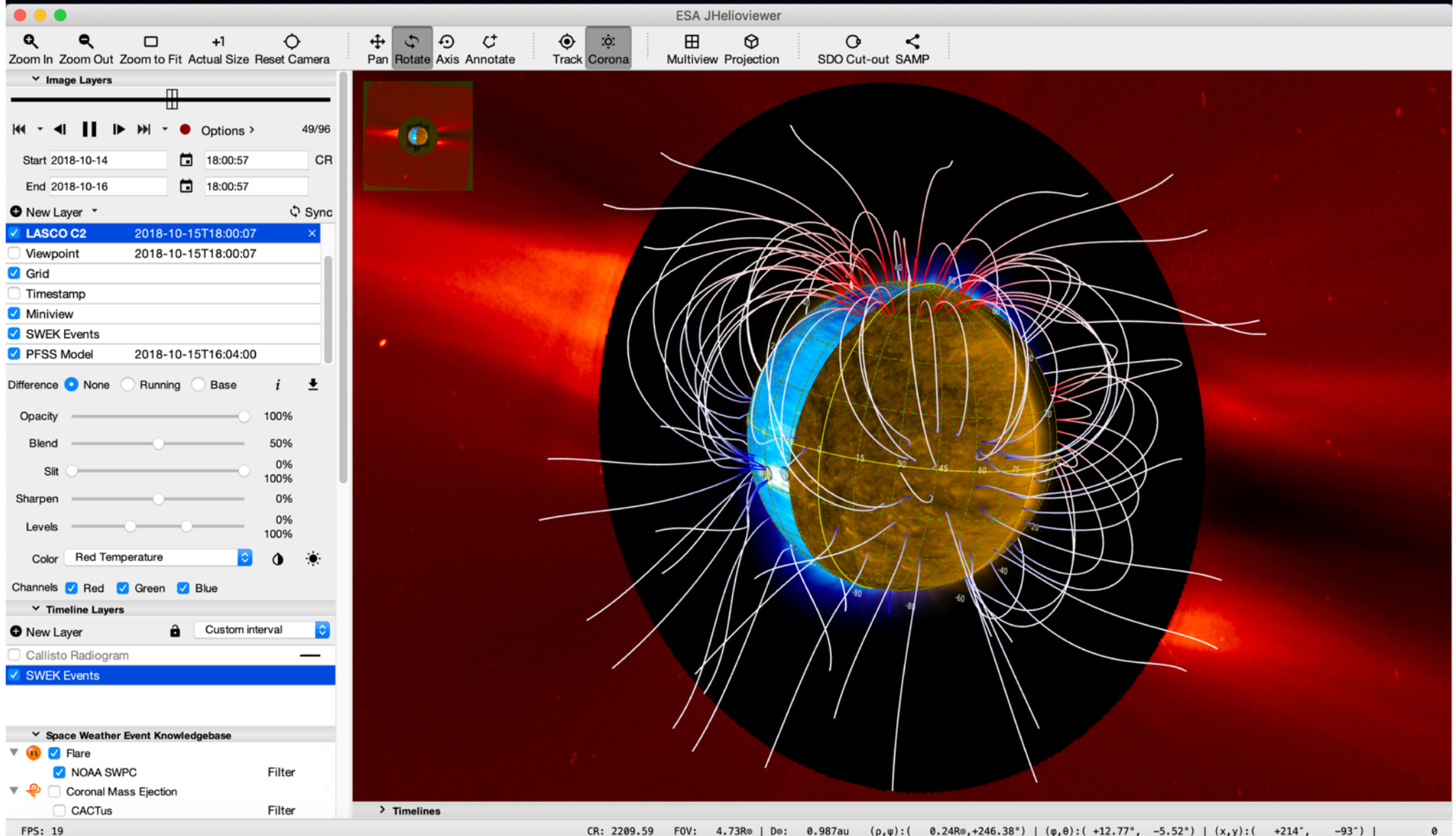
[SSW Script](#) [VSO Website](#)

SDO AIA/HMI Cut-out Service

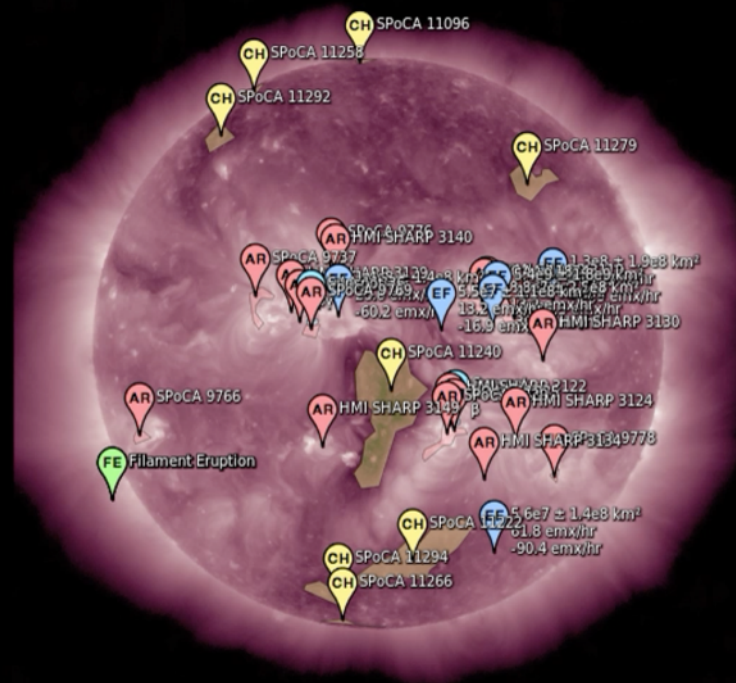
Image Timeline Events Timeline



# 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
    - *Browser-based*
    - *Development based at GSFC*
  - 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