J/Helioviewer Developers' Meeting
ESTEC, 2-3 July 2014

Daniel Müller

European Space Agency, ESTEC, The Netherlands

Daniel.Mueller@esa.int

Logistics

Day 1 (room at ESTEC: Aj030)

- Start: 14:00
- Coffee break: 16:15-16:45
- End: 18:00

Day 2 (room at ESTEC: Em106)

- Start: 09:30
- Lunch break: 12:30-14:00
- End: 18:00 (latest)

Goals of this Meeting

- *Who does what?*
  Provide overview of current Helioviewer Project Development (Helioviewer Project = Helioviewer.org, JHelioviewer and Helioviewer Server System)

- *Where are we going?*
  Coordinate future work

- *Helioviewer + Solar Orbiter*
  Discuss possible re-use and extension of Helioviewer software to serve as data visualization and browse tool for Solar Orbiter mission

Purpose of this Presentation

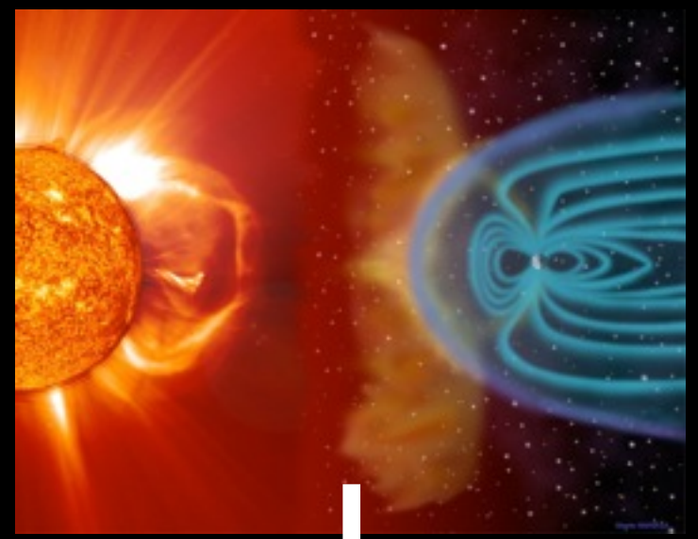
- Motivation: Visualizing and browsing large volumes of complex solar data
- JHelioviewer
  - Brief development history
  - Design choices

Visualizing Solar Image Data

Motivation

- Solar observatories generate huge amount of data

  SOHO (1995): 0.2 GB/day
  SDO (2010): 1.4 TB/day
  ATST (estimated average): ~12 TB/day
- Data covers wide ranges of length and time scales
- Many different data products available



Goals

- Enable efficient data browsing and visualization
- Link data to knowledge bases and automated feature recognition algorithms
- Support data-driven modeling

Large Data Volumes: The Challenge

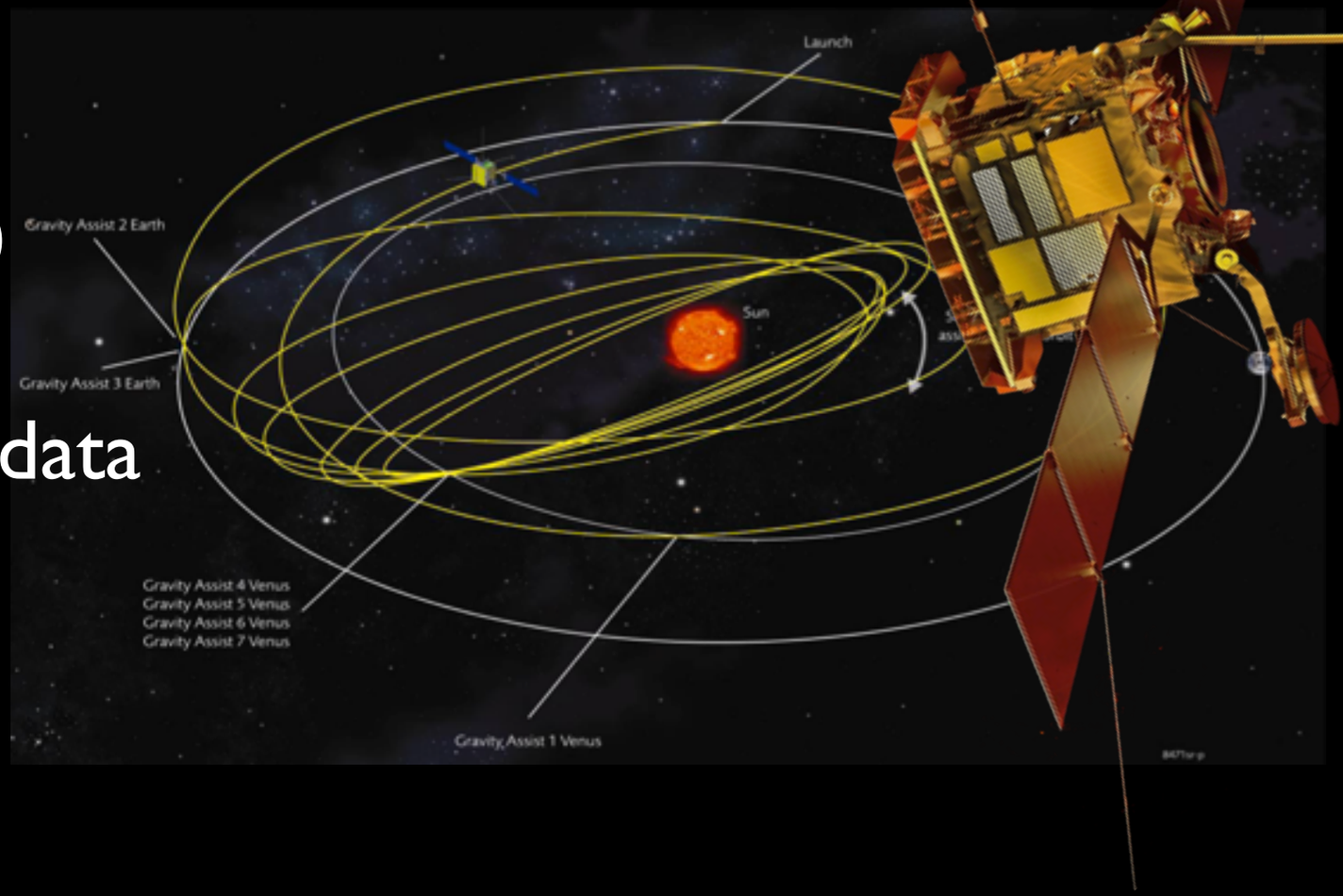
- Solar Dynamics Observatory:
  - ~4 PB for 5-year mission: costly to store
  - Equivalent to 2-3 TV channels
  - Can be delivered to <6 sites from JSOC

- DKIST/ATST Telescope (Haleakalā, 2019):
  - Data generation ~4.5 PB/year
  - VBI instrument after speckle processing: ~10^6 images/day (SDO/AIA: ~60,000 /day)
    (figures courtesy of K. Reardon)

Visualizing the Sun and Heliosphere in 3D

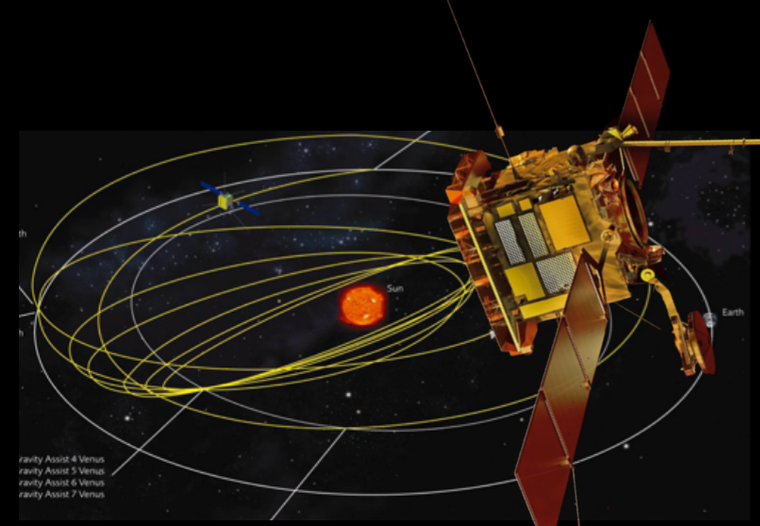
Motivation

- Solar Orbiter = Sun and Heliosphere in 3D
- Complex data products:
  - Multi-instrument
  - Multi-spacecraft (SO + SPP + near-Earth)
  - Wide range of scales
- Need models to interpret data



Data Analysis Challenges for Solar Orbiter

- Connect in-situ and remote-sensing data
  → 3D time-dependent data representation



- Assimilate data into models

- Combine Solar Orbiter data with data from other missions
  → Need to jointly display heterogeneous data from different viewpoints
  → Need to be able to transform between coordinate systems
  → Need coordinate information in metadata (WCS)
  (Thompson, *A&A 2006*, Thompson & Kei, *Sol. Phys.* 2010)

SDO Example: Why browse tools are essential

Example:

Long range magnetic couplings between solar flares and coronal mass ejections observed by SDO and STEREO
(C. Schrijver & A. Title, JGR 116, 2011)

- Shows that coupling of flares and eruptive events spans > 180° in longitude
- Data used for this study:
  - SDO/AIA+HMI, STEREO EUVI
- Data volume (compressed):
  - 800 GByte
- Download time @ 3 Mbit/s:
  - 25 days

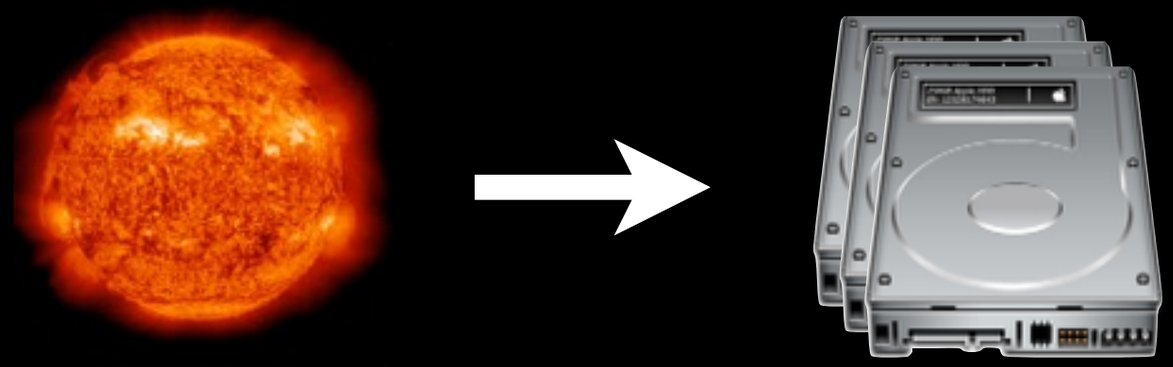
Need to know what's in the data before downloading in full science quality!

SDO Example: Why browse tools are essential

AIA takes 16MP images in 10 channels, every 12 sec, 24/7

Challenges:

- Data access & distribution
- Search
- Visualization



Solution:

- With JPEG 2000: Can compress 4k × 4k image to 1 MB
- 10 channels at 36 sec cadence → 24 GB/day = 8.8 TB/year
- Can keep comprehensive data set of browse data online for entire mission (science data: only few months)

What is JPEG 2000?

JPEG 2000 = wavelet-based compression standard

Advantages:

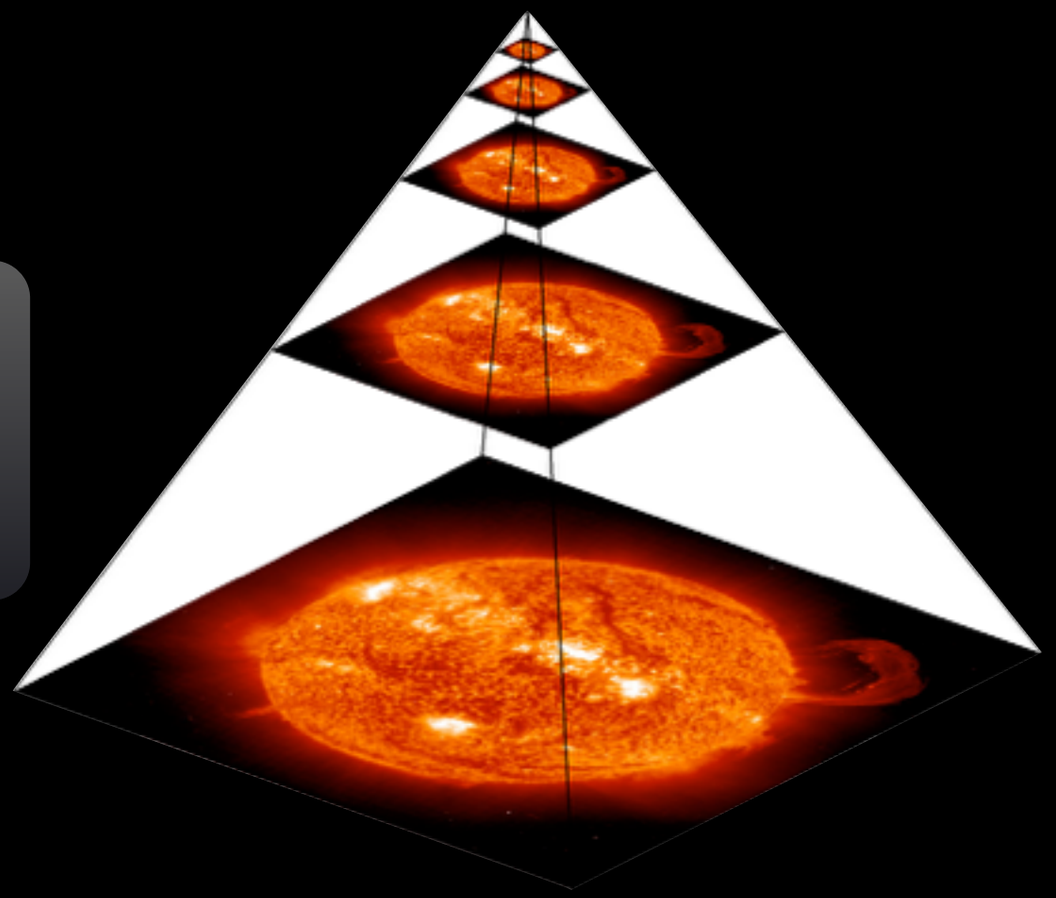
- **Multi-resolution**

  Images at different resolutions are automatically created during wavelet compression

- **Random image access**

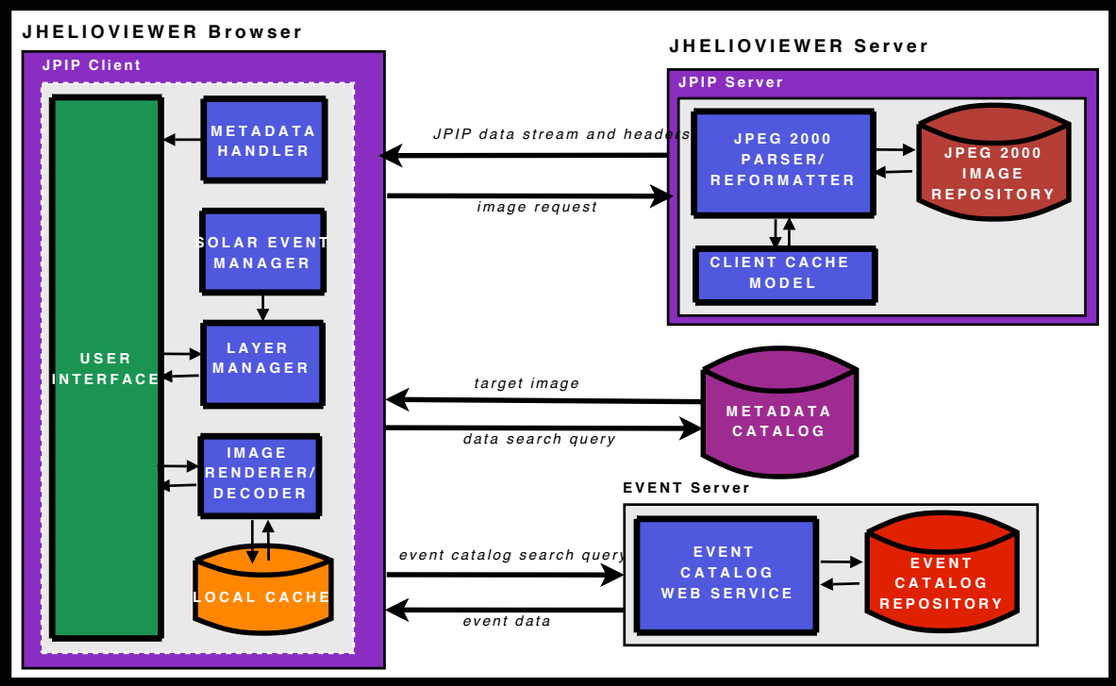
  Selected parts + quality layers can be accessed remotely

- **Flexible file format**
- **Well-suited for archives**



Remote Image Access via JPIP

- JPIP = JPEG 2000 Interactive Protocol
- Provides a client–server architecture for interactively transmitting image data over networks
- Can request arbitrary parts and quality levels of image series



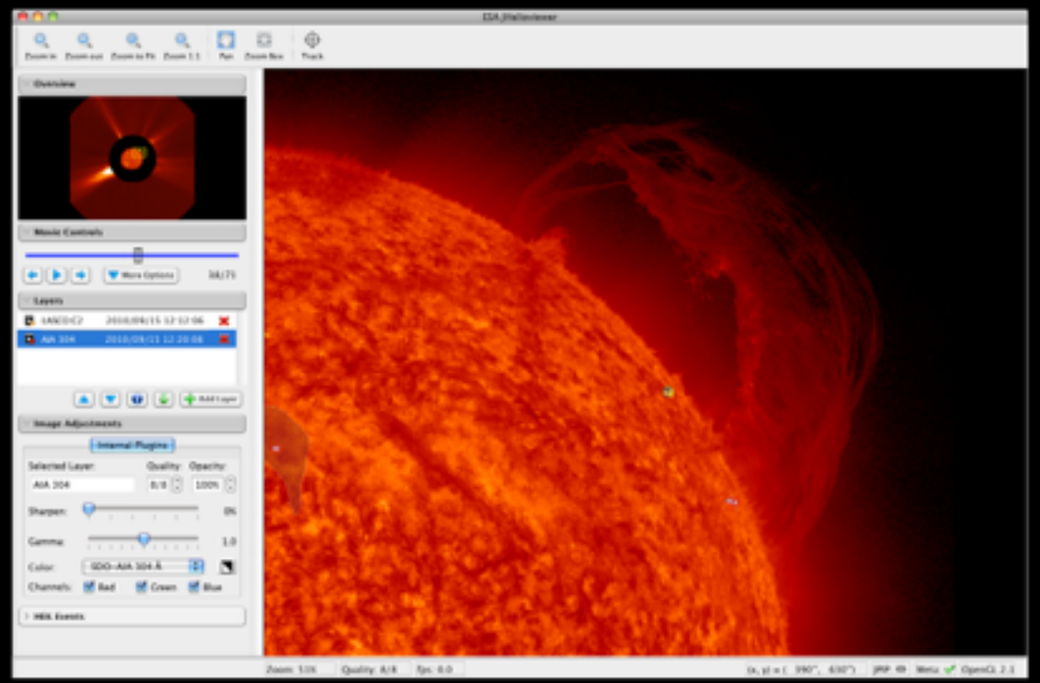
Müller et al.,
Computing in Science & Engineering (2009)

→ See Juan Pablo's presentation

The ESA/NASA Helioviewer Project

Front-Ends

- JHelioviewer - Java/OpenGL application
- Helioviewer.org - Web application

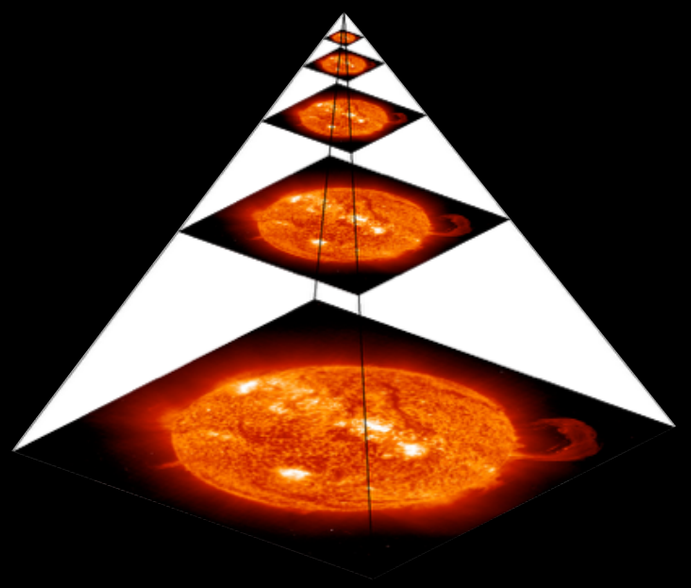


→ See Jack's presentation

Back-End

Helioviewer Server:

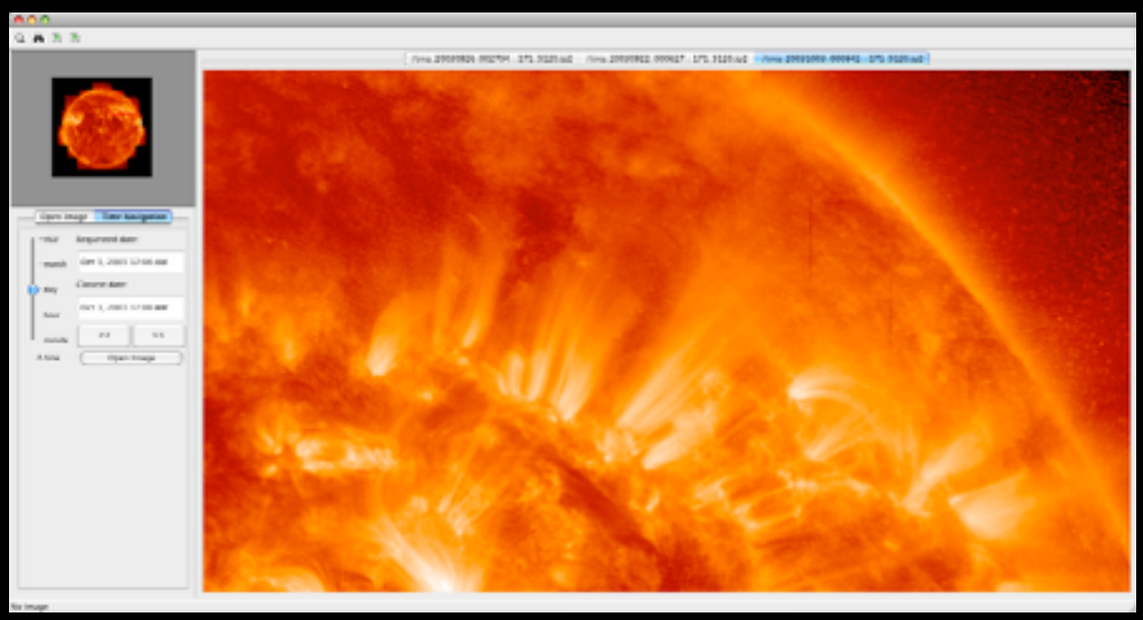
- JP2Gen - FITS-to-JPEG 2000 processing pipeline
- JPIP Server - JPEG 2000 Interactive Protocol streaming server → See Juan Pablo's presentation
- Dynamo - JPEG 2000 archive index, tiling engine, etc.



Brief History of JHelioviewer Development

The 'Goddard Years' (2008-2010)

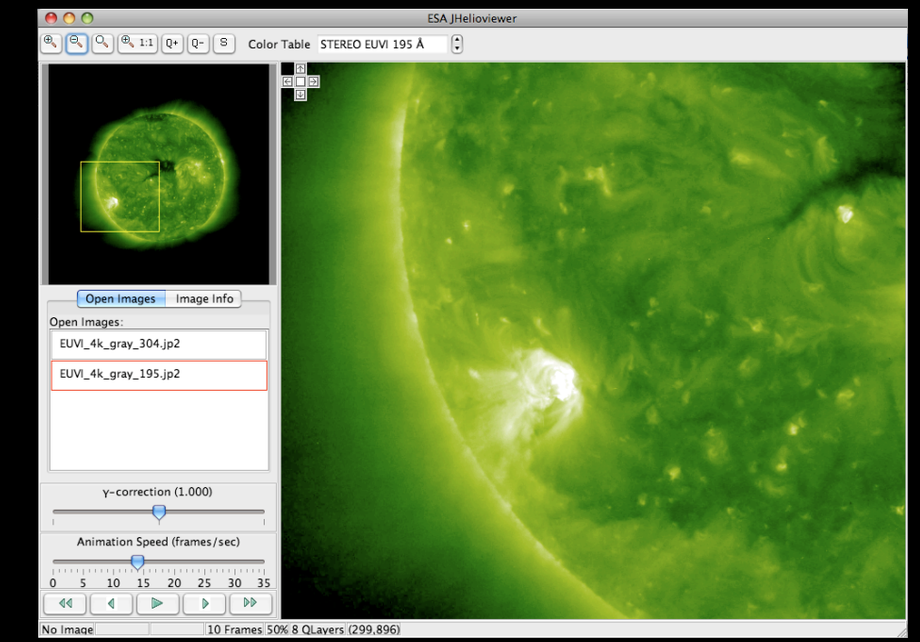
- 01/2008 - 05/2008:
  Ben Caplins (student at Hood College, MD, USA) starts working on a demo Java JPEG 2000 viewer for solar images, dubbed JHelioviewer
  - based on Juan Pablo Garcia Ortiz' GSoC JPIP server + viewer applet (open source + Kakadu software SDK)
  - as an experimental complement to Jack Ireland's SunViewer/HelioViewer web application
- *March 2008 - Milestone: Proof of Concept - Poster & Demo at SDO Science Team Meeting*



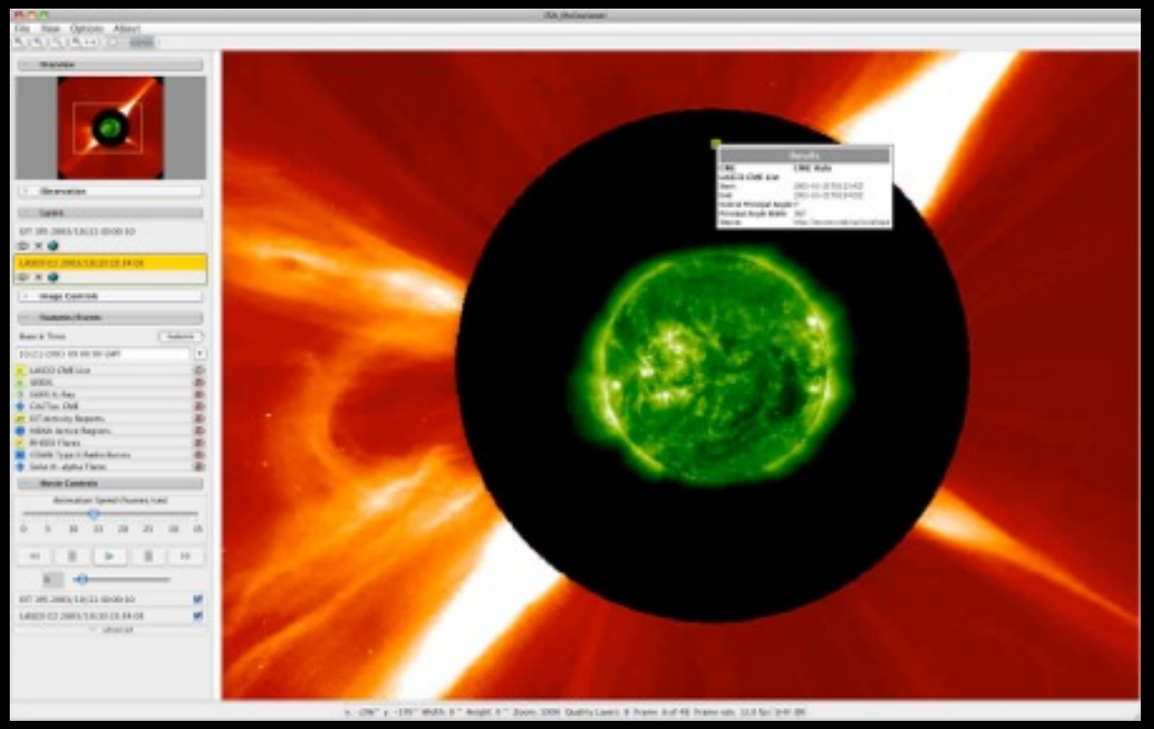
- Summer 2008:
  Alen Agheksanterian (math graduate student at Hood College) takes over

Brief History of JHelioviewer Development

- 09/2008-03/2009:
  Ben Wamsler (student at Ulm Univ., Germany) joins
- *Oct 2008 - Milestone: We can play JPEG 2000 movies! Demo at SIPWork IV + JHV publicly available online*



- *Summer 2009 - Milestone: JHelioviewer 1.0 released + paper in 'Petascale Computing' issue of CiSE*



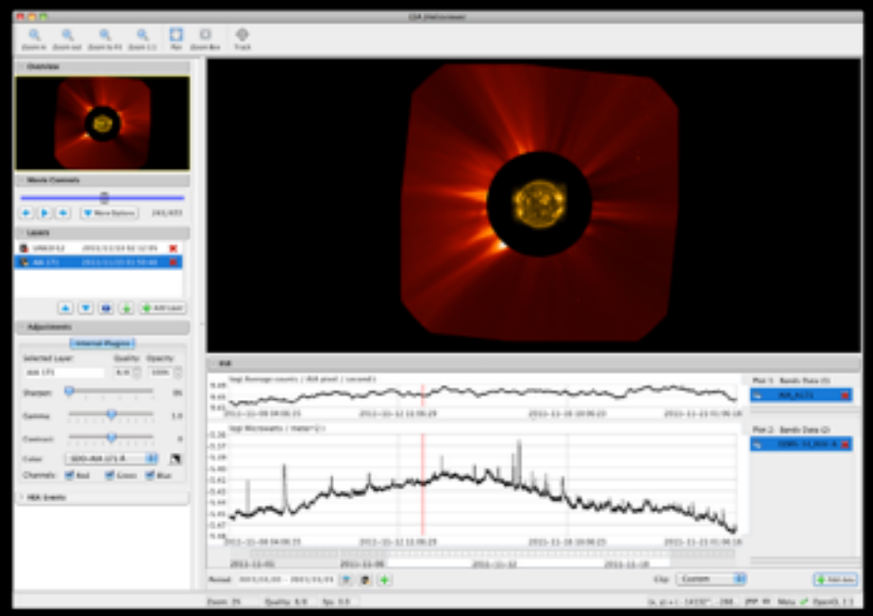
Brief History of JHelioviewer Development

- 07-08/2009:
  Ludwig Schmidt (student at Cambridge Univ., UK): Substantial code redesign
  (e.g. introduction of view chain) - but not fully re-implemented yet
- 09/2009-02/2010:
  - Markus Langenberg (student at RWTH Aachen, Germany): OpenGL, view chain implementation
  - Stephan Pagel (student at Univ. of Applied Sciences, Berlin): UI improvements, events integration
- *Feb 2010 - Milestone (just in time for SDO launch!): JHV 2.0.3 released:*
  All previous functionality reimplemented using OpenGL, plus more
- 02-04/2010: Andreas Hölzl (student at LMU Munich, Germany): JUnit testing, GUI work
- 05-08/2010:
  - André Dau (student at TU Munich, Germany): Movie Export, logging framework, …
  - Malte Nuhn (student at RWTH Aachen, Germany): HEK integration/plug-in, new GUI
  - Helge Dietert (student at Cambridge Univ., UK): VSO plugin (beta), color tables, …
- *Nov 2010 - Milestone: JHV 2.1 released: SDO support, movie export, rot. tracking, new GUI*

Brief History of JHelioviewer Development

The 'Distributed Years' (2010-now)

- 08/2010: Daniel moves from GSFC to ESTEC → from now on, JHV development will have to be done by a geographically distributed team. Luckily, Stephan, André, Malte and Markus continue to be actively involved.
- 2011-2012: Stephan writes EVE plug-in to display 1D time series, and re-designs the plug-in manager

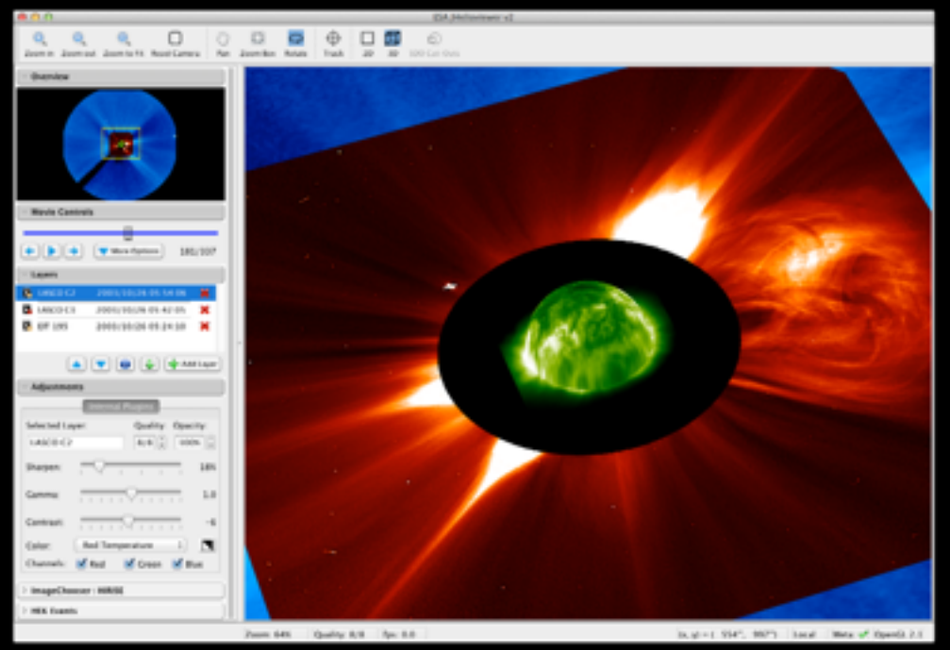


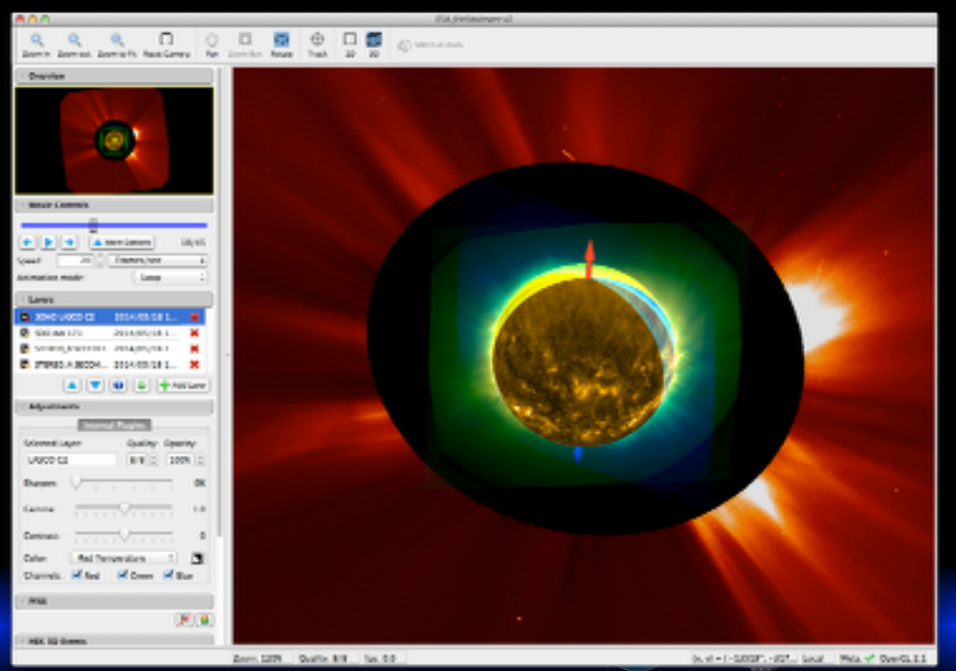
- 2010-2011: Development of open-source JPIP server, led by Juan Pablo Garcia Ortiz
- Spring 2011 - Milestone: Open-source JPIP server goes online (at GSFC)
- April 2012 - Milestone: JHV 2.2 released, incl. SDO Cut-Outs plug-in (by Carlos Martin)

Brief History of JHelioviewer Development

- 2011- now: University of Applied Sciences in Windisch, Switzerland, gets involved:
  - Rendering vector fields in 3D with JHV: B.Sc. thesis work by David Hostettler & Robin Oster
  - Simon Spörri: Development of first JHV '3D plug-in', implementation of WCS
  - May 2012 - Milestone: First beta version of JHV with 3D mode
  - Continuation and extension of this work by Simon Felix & Stefan Meier
  - June 2014 - Milestone: Beta release of JHV 3D

→ See Simon's presentation





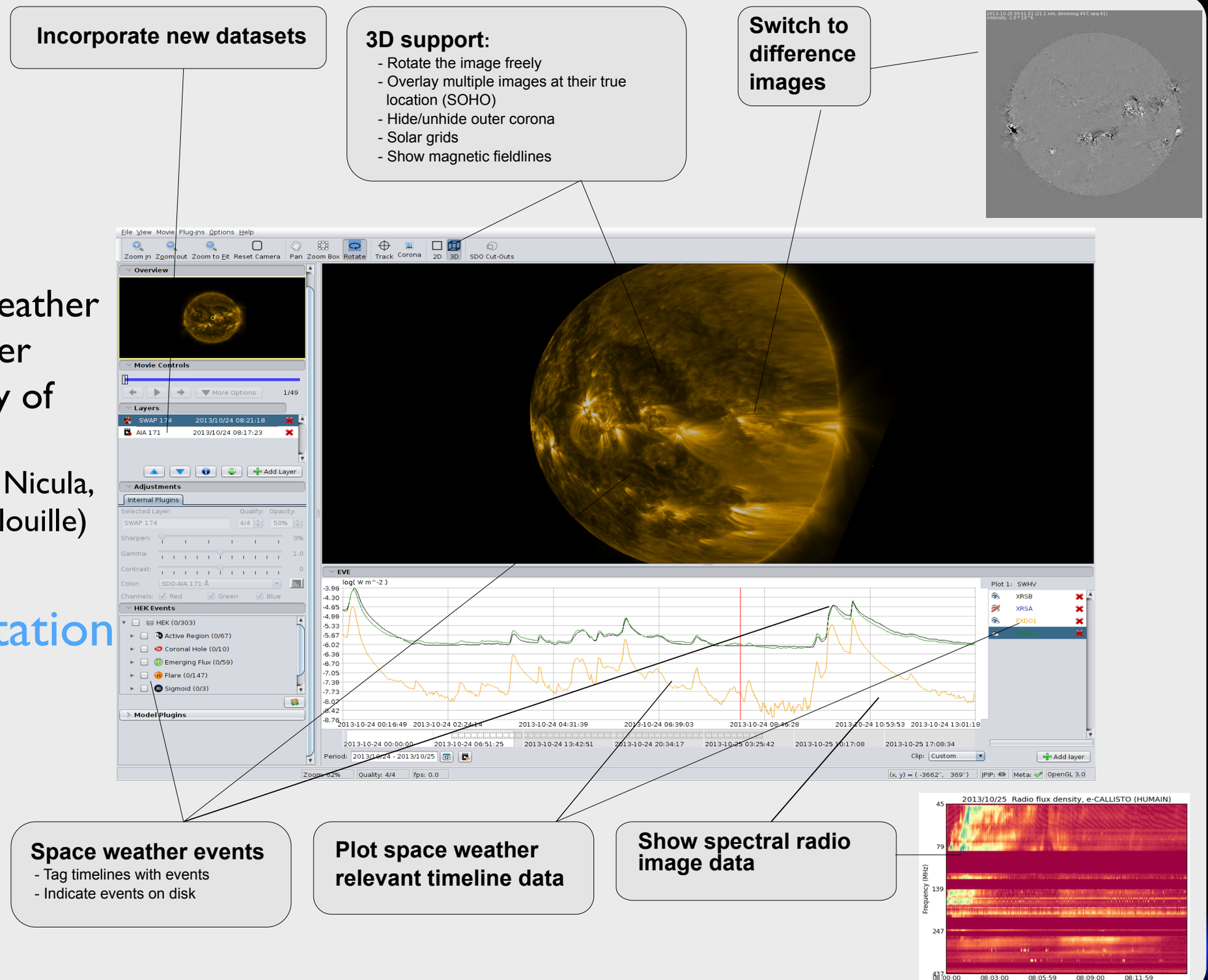
Brief History of JHelioviewer Development

- 2013- now: ROB gets involved:

Space Weather Helioviewer

- 2-year ESA GSTP Project (2013-15) to add space weather capabilities to J/Helioviewer
- Led by Royal Observatory of Belgium
  (F. Verstringe, B. Bourgoignie, B. Nicula, D. Berghmans, C. Marqué, V. Delouille)

→ See ROB's presentation



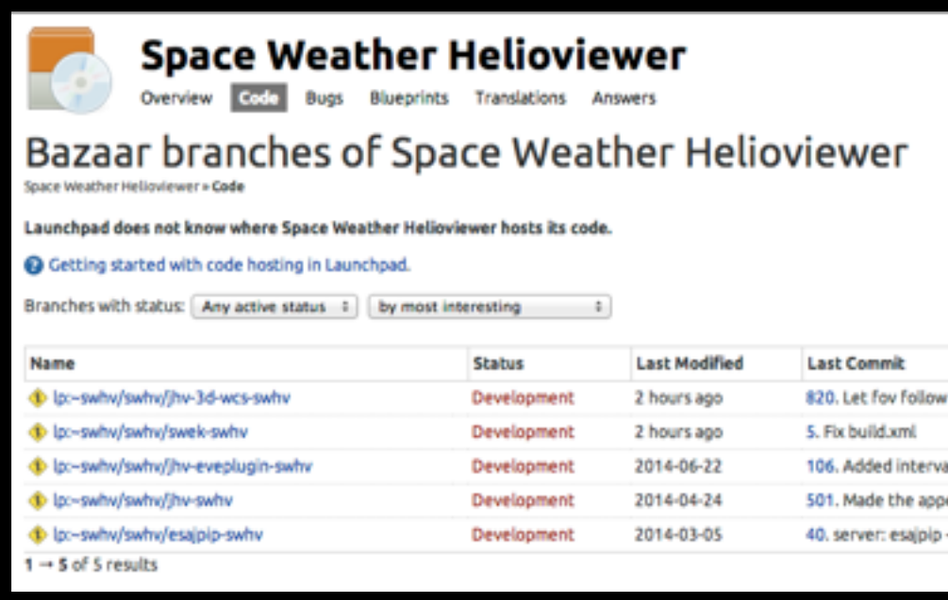
Links

Launchpad main page: https://launchpad.net/jhelioviewer

JHV trunk:
https://code.launchpad.net/jhelioviewer

FHNW's JHV-3D-WCS branch:
https://code.launchpad.net/~jhelioviewer-dev/jhelioviewer/jhv-3d-wcs

ROB's Space Weather Helioviewer main page:
https://launchpad.net/swhv



Usage

- Helioviewer software is very popular in the solar physics community and beyond and has become a standard tool for interactively browsing data from solar space missions. The Solar Orbiter community is interested in using it, too.

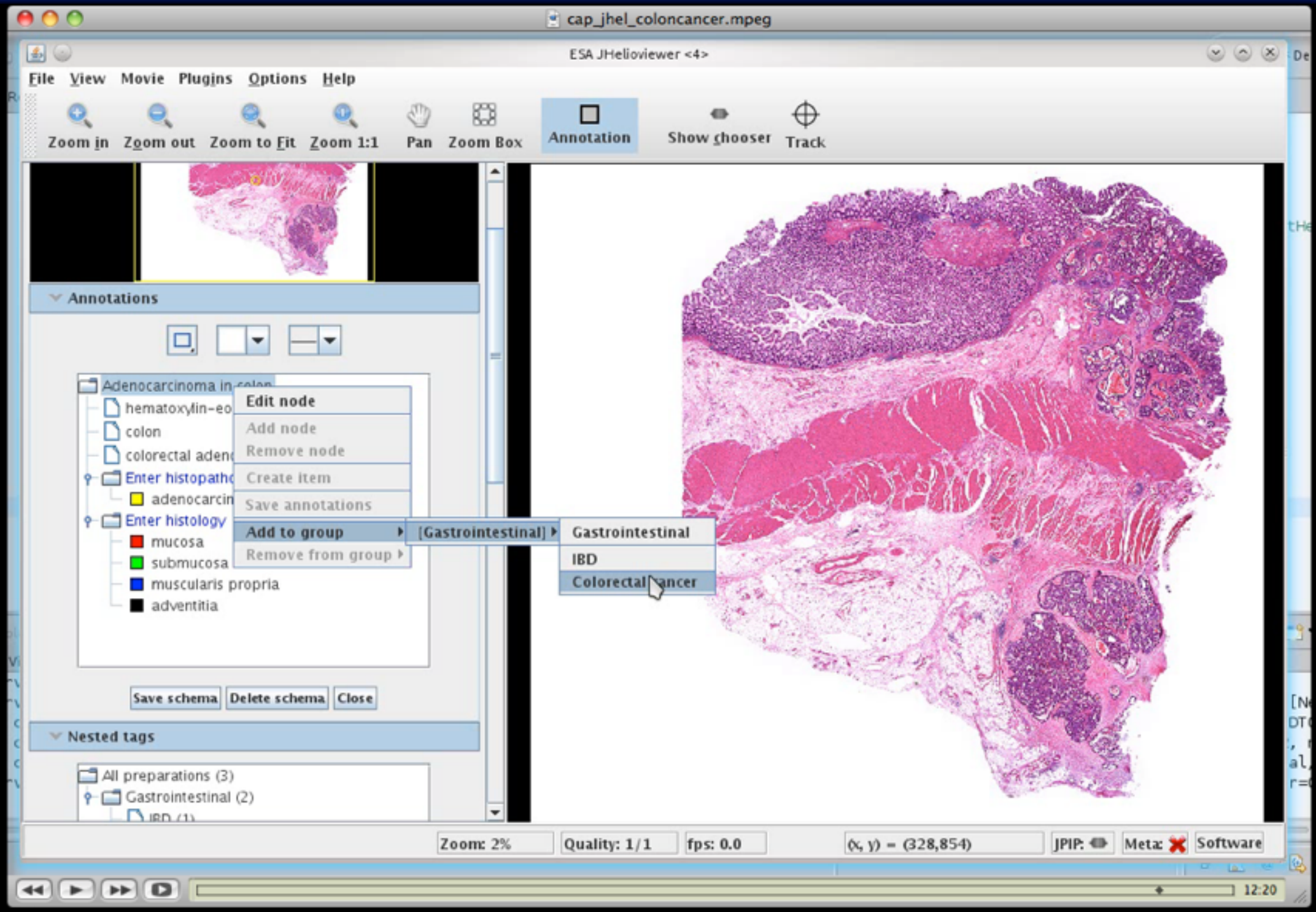
- Traffic: The near-Sun passage of Comet ISON generated an unprecedented amount of traffic to the Helioviewer servers: > 2.5 million images and > 50,000 user-generated movies in one week.

- In May 2013, The 1 millionth user-generated movie was served by the Helioviewer servers.

- The current version of JHV (2.2) has been downloaded > 27,000 times.

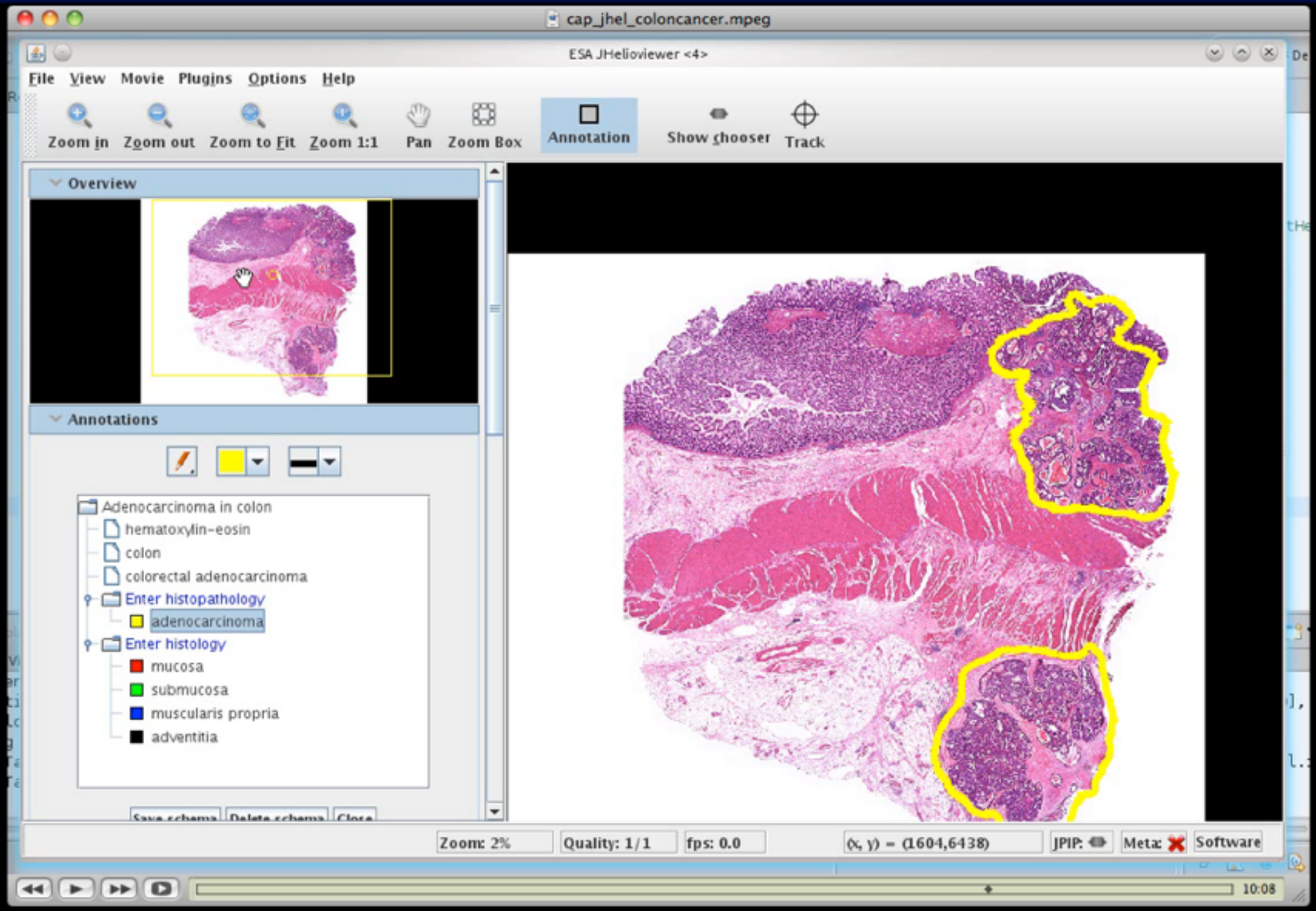
Additional Slides

Spin-Offs: JHelioviewer in Medical Research



Courtesy C. Moro, Karolinska University Hospital, Stockholm

Spin-Offs: JHelioviewer in Medical Research

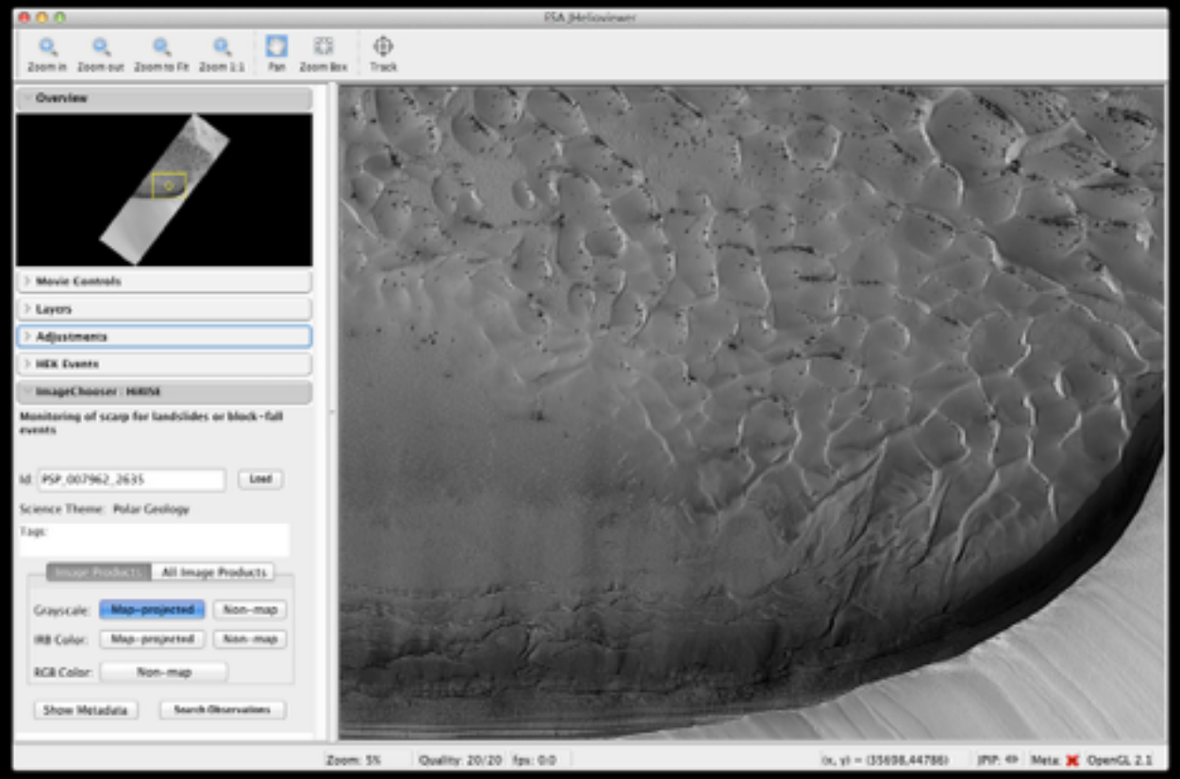


Courtesy C. Moro, Karolinska University Hospital, Stockholm

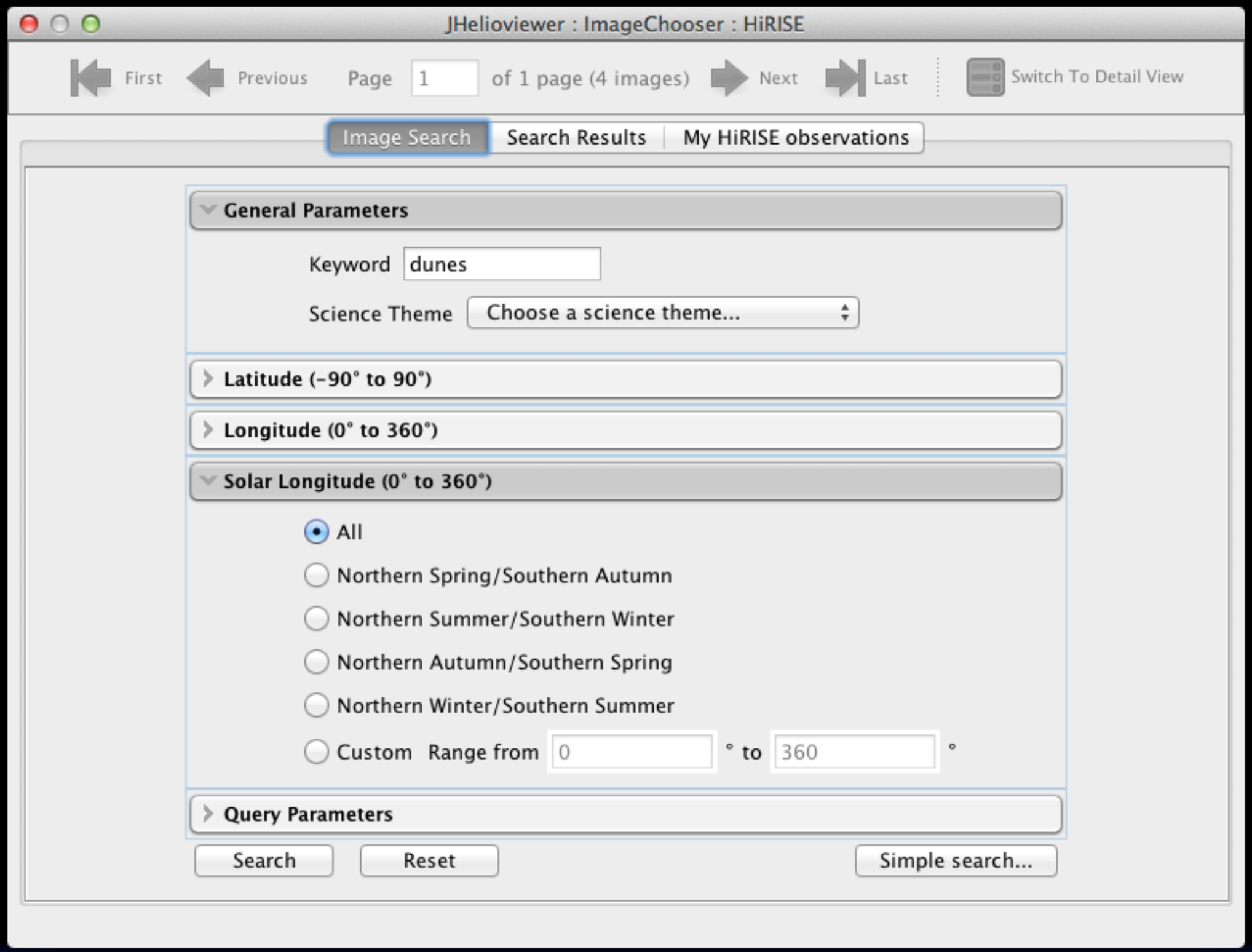
Spin-Offs: JHiRISEViewer - A plugin for Mars

JHiRISEViewer Plugin

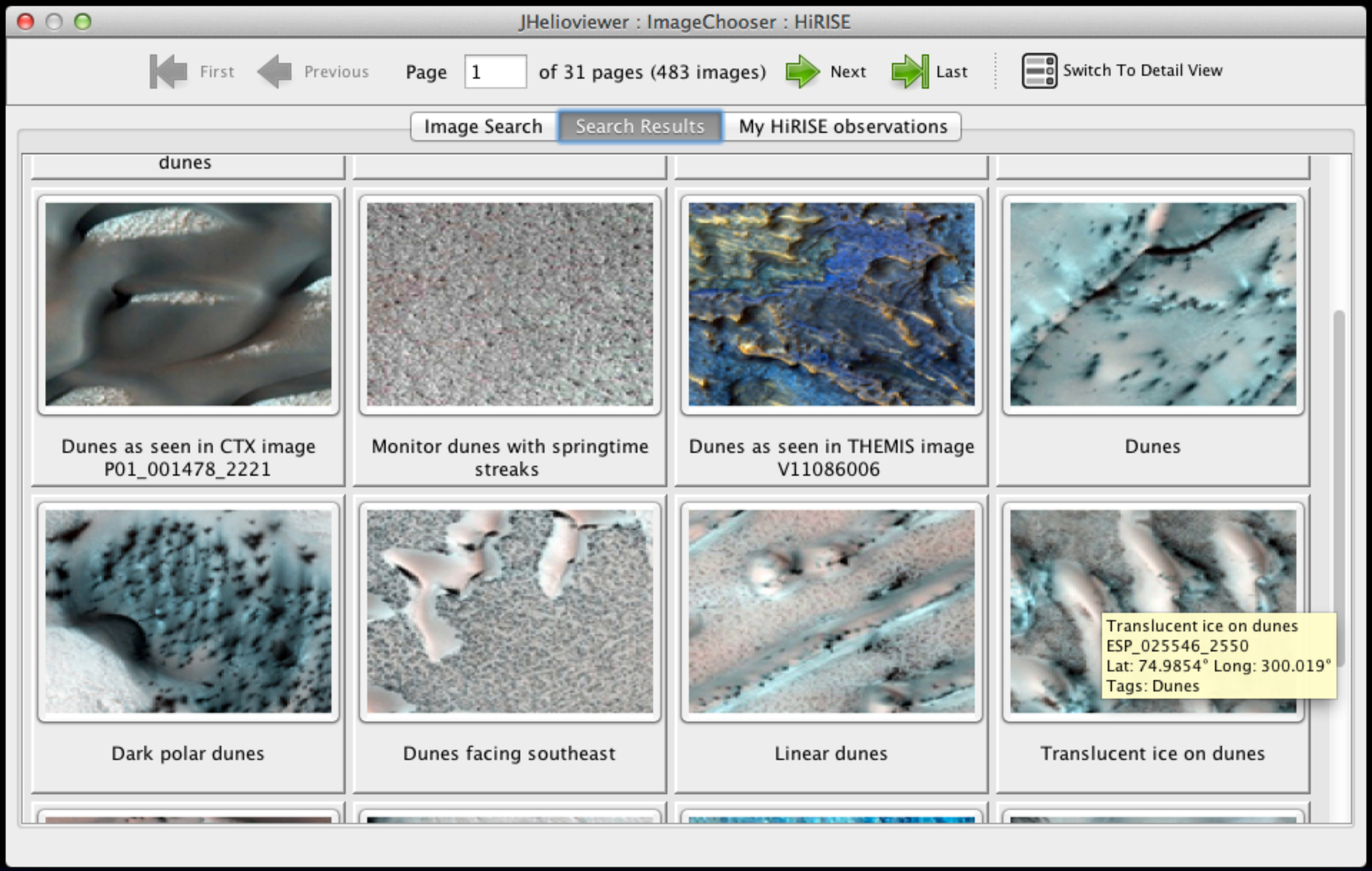
- NASA Mars Reconnaissance Orbiter/HiRISE:
  - 0.5m optical telescope, resolution down to 30cm on Martian surface
  - 20k pixel wide CCD (red), typical images: 20k x 126k = 2.5 GPix
  - JHelioviewer can display the entire HiRISE catalogue (> 22,000 images)
- Developer: Carlos Moro, Karolinska University Hospital, Stockholm



Spin-Offs: JHiRISEViewer - A plugin for Mars



Spin-Offs: JHiRISEViewer - A plugin for Mars



Spin-Offs: JHiRISEViewer - A plugin for Mars