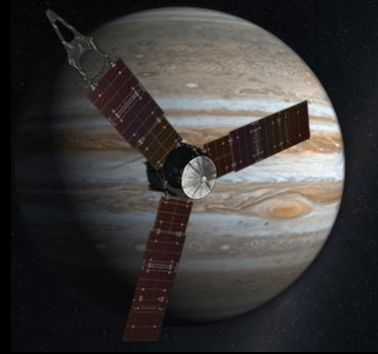


JunoCam and the Role of Amateur Astronomers

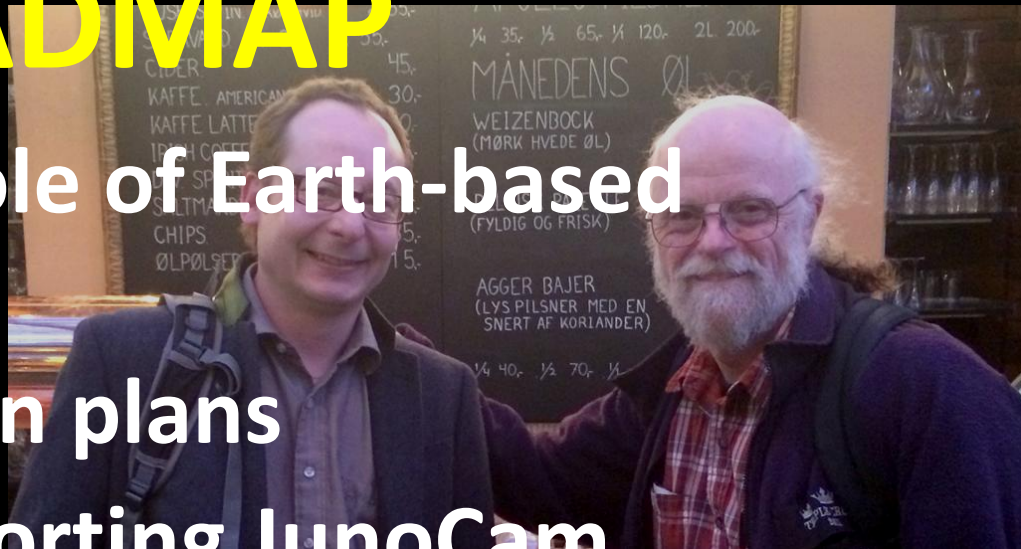
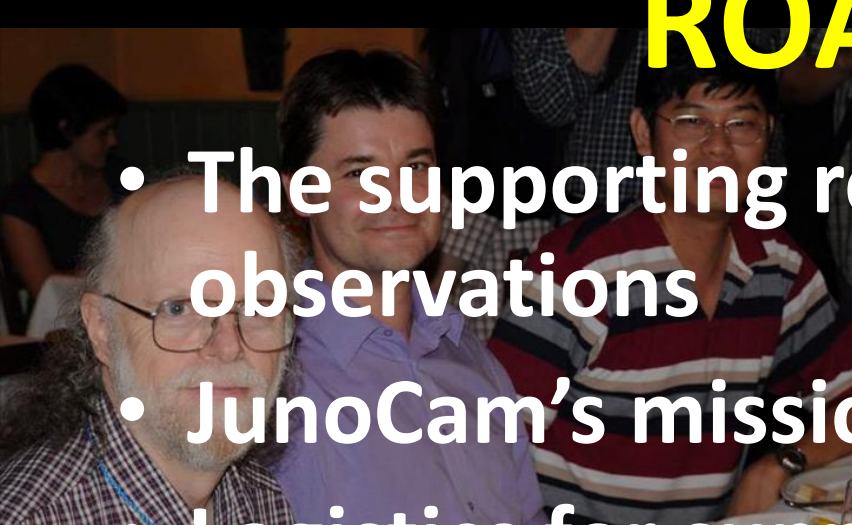
Glenn Orton

Jet Propulsion Laboratory
California Institute of Technology



ROADMAP

- The supporting role of Earth-based observations
- JunoCam's mission plans
- Logistics for supporting JunoCam
 - Uploading
 - Discussion
 - Voting!
 - Assembling your own JunoCam images



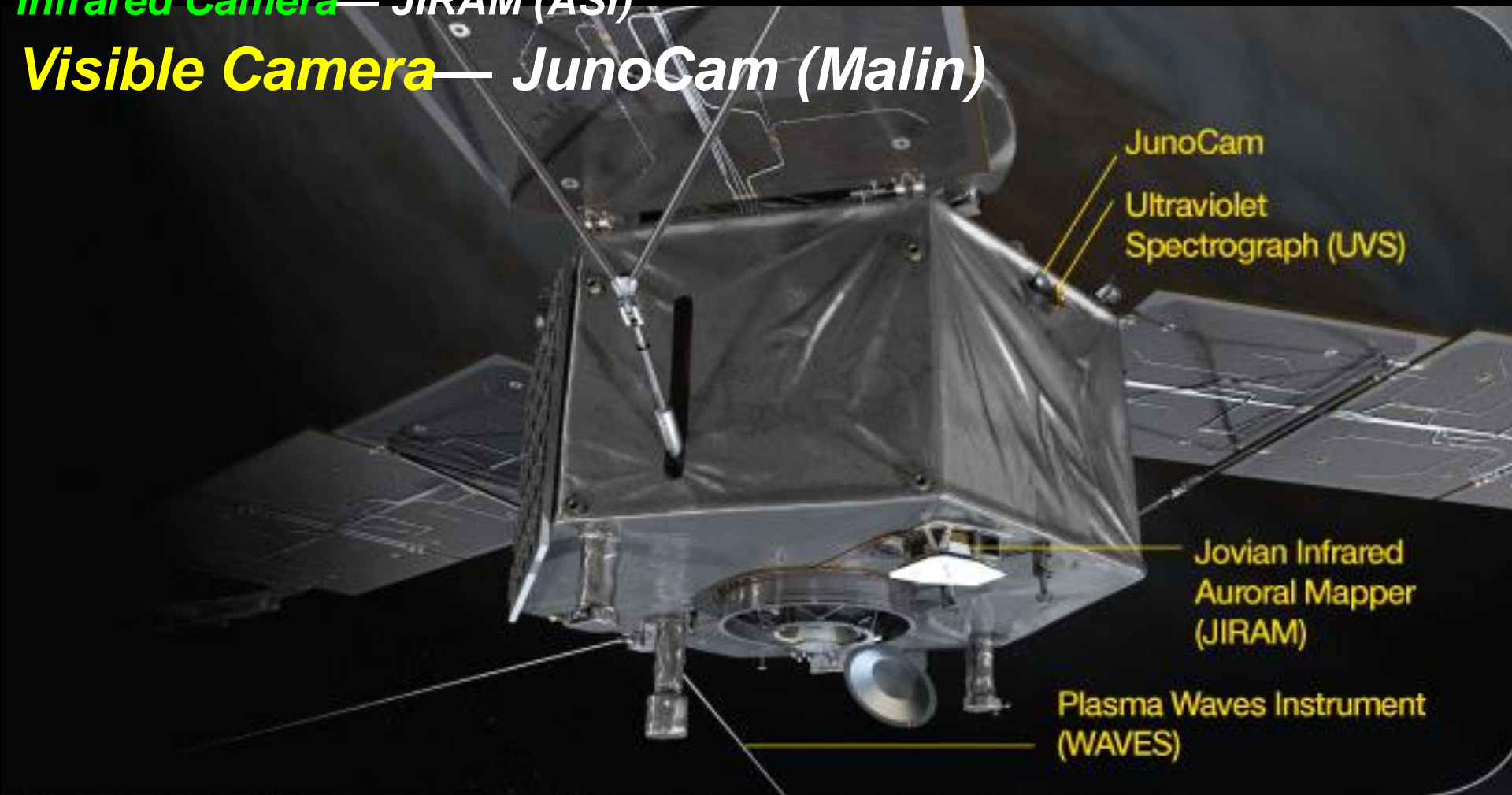
key remote-sensing instruments:

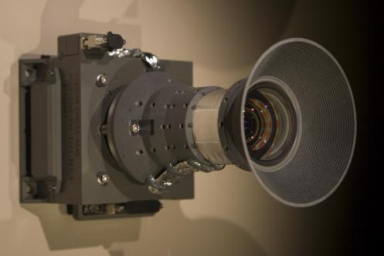
Microwave Radiometer— MWR (JPL)

UV Spectrometer— UVS (SwRI)

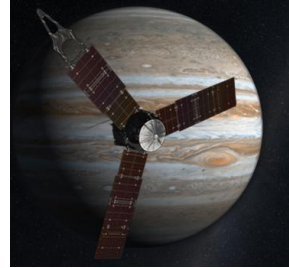
Infrared Camera— JIRAM (ASI)

Visible Camera— JunoCam (Malin)





JunoCam Observing Plans



- Approach
- Capture orbits
- Movies
- Prime Mission

Approach result: JunoCam's first image of Jupiter!



Jupiter was observed in every image acquired by JunoCam in jc059
This image acquired on 2016 Jan 26, ~57 million miles away, at 3x magnification

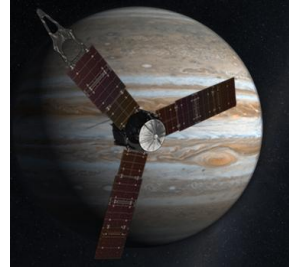
Perijove 1 (PJ1) Goals

Test everything we can!

- Polar images at lowest emission angle and closest range
- Teste different compression ratios
- Try out mid-latitude stereo pairs
- Image an entire rotation at 3 angles (from ring plane) to see if we can detect the rings
- Image Ganymede at 8/26 2100 at 473k km



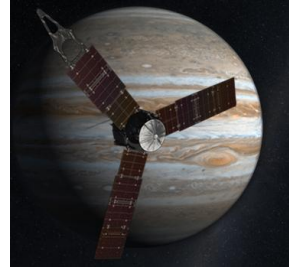
Pre-Prime Mission PJ2 and PJ3



- PJ2 has PRM, so no JunoCam images, at least not at perijove
- PJ3 has clean-up OTM with larger than normal uncertainties, so no public voting (but we will release the images for processing by the public)
 - > opportunity to repeat PJ1 tests
- “One-orbit” movie from PJ2+2days to PJ3

Movies

- **Approach** Movie
 - JOI-22 days to JOI-5 days
 - Low resolution on Jupiter, mostly just satellite movement
- **Marble** Movie
 - Some features distinguishable on Jupiter, but not much
 - JOI + 4 days to PJ1 -1 day
 - Plus next orbit to solar conjunction
 - Plus solar conjunction end to PJ2
- **One-orbit** Movie
 - PJ2 + 1 day to PJ3 +1 day
 - More features should be available
- After that we will start our nominal outreach ops

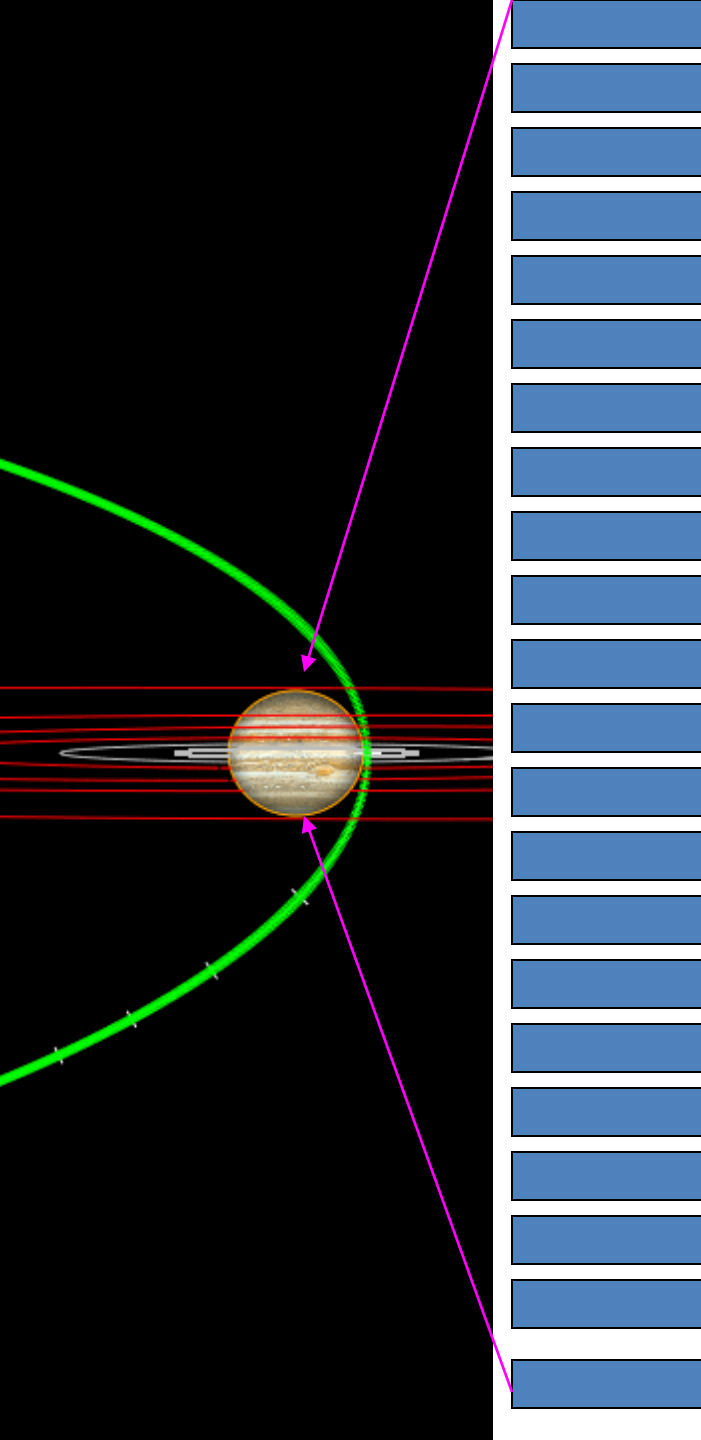


Prime Mission

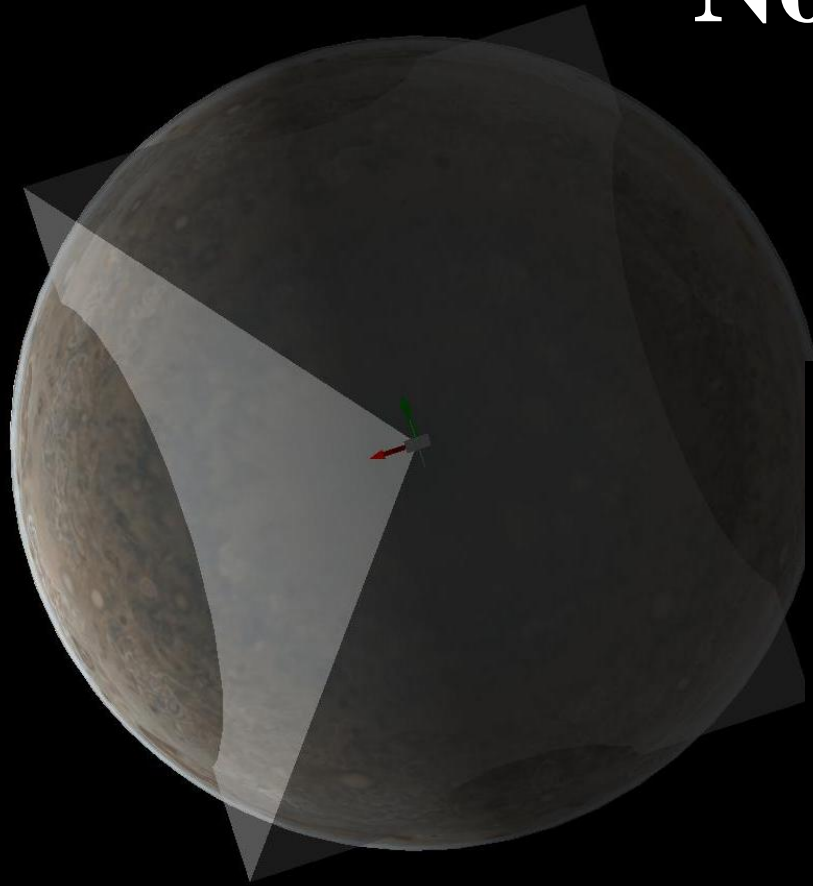
JunoCam Images

- Best image opportunities are from -1 hr to +1 hr
- Image opportunity frequency is ~1 image per minute, or 120 opportunities per perijove pass
- But data volume constraints will limit our total number of images in a perijove pass, so expect 10-12 “color” images at best
- Selection factors include
 - Where we are in the orbit
 - What features of interest are visible
 - Results of public voting
 - When we are in the mission (how much radiation damage has the camera experienced)

Notional image opportunities as a function of time
(imagine 60 of these for example)

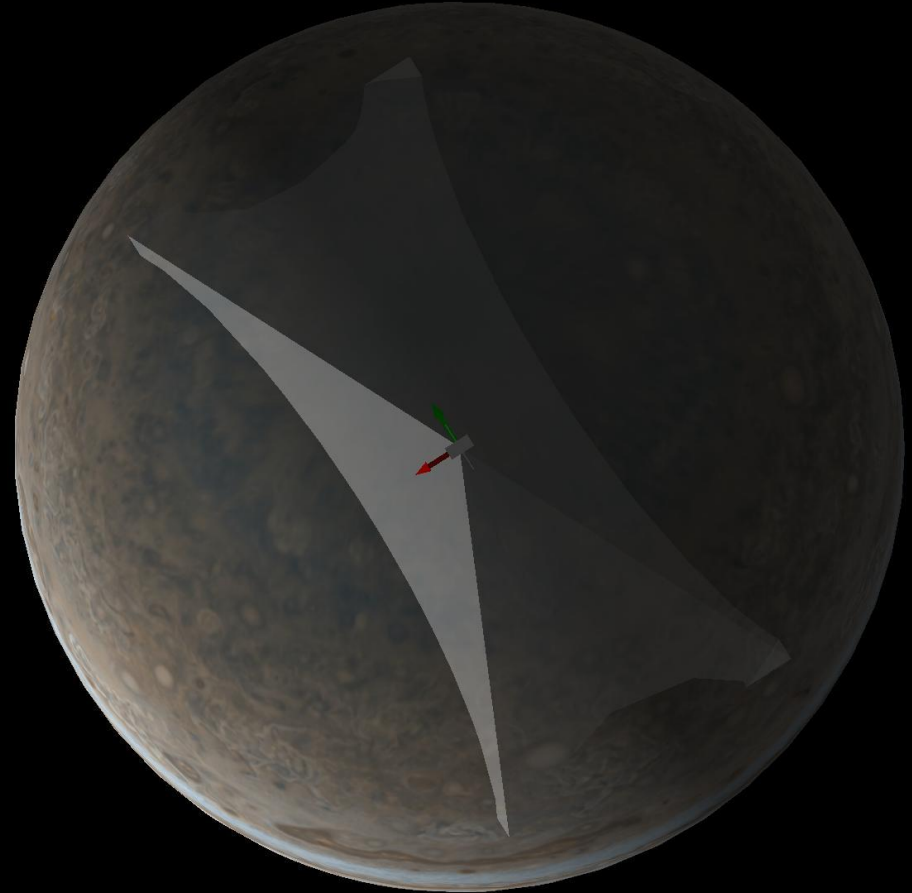


North Pole Images



Polar view on orbit 16

Polar view on orbit 33

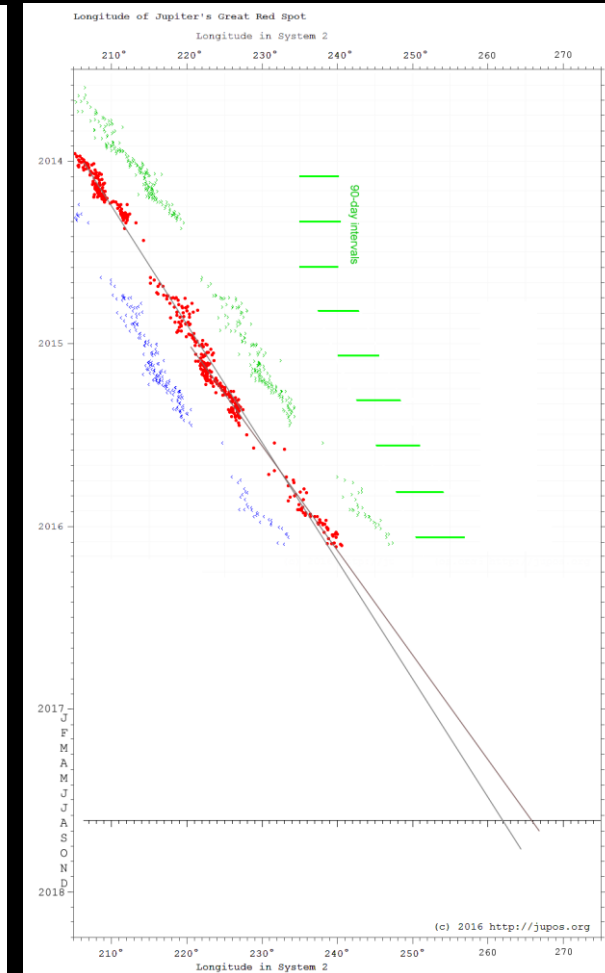
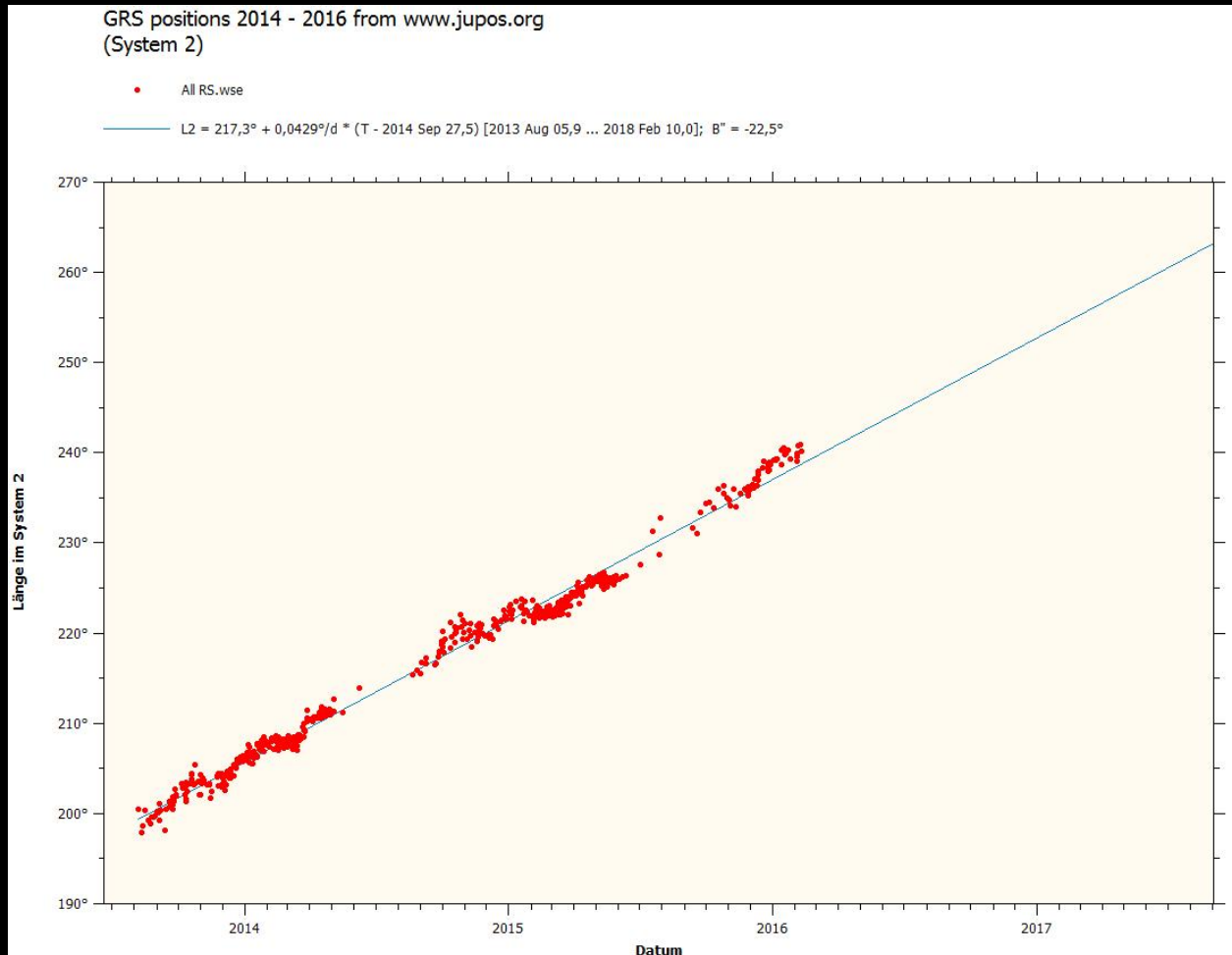


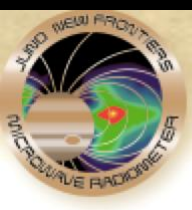
Amateur astronomers are members of JunoCam's virtual team

Images of the whole disk in **RGB** filters, plus additional filters as possible (e.g. 890 nm “**methane**” and other narrow filters)

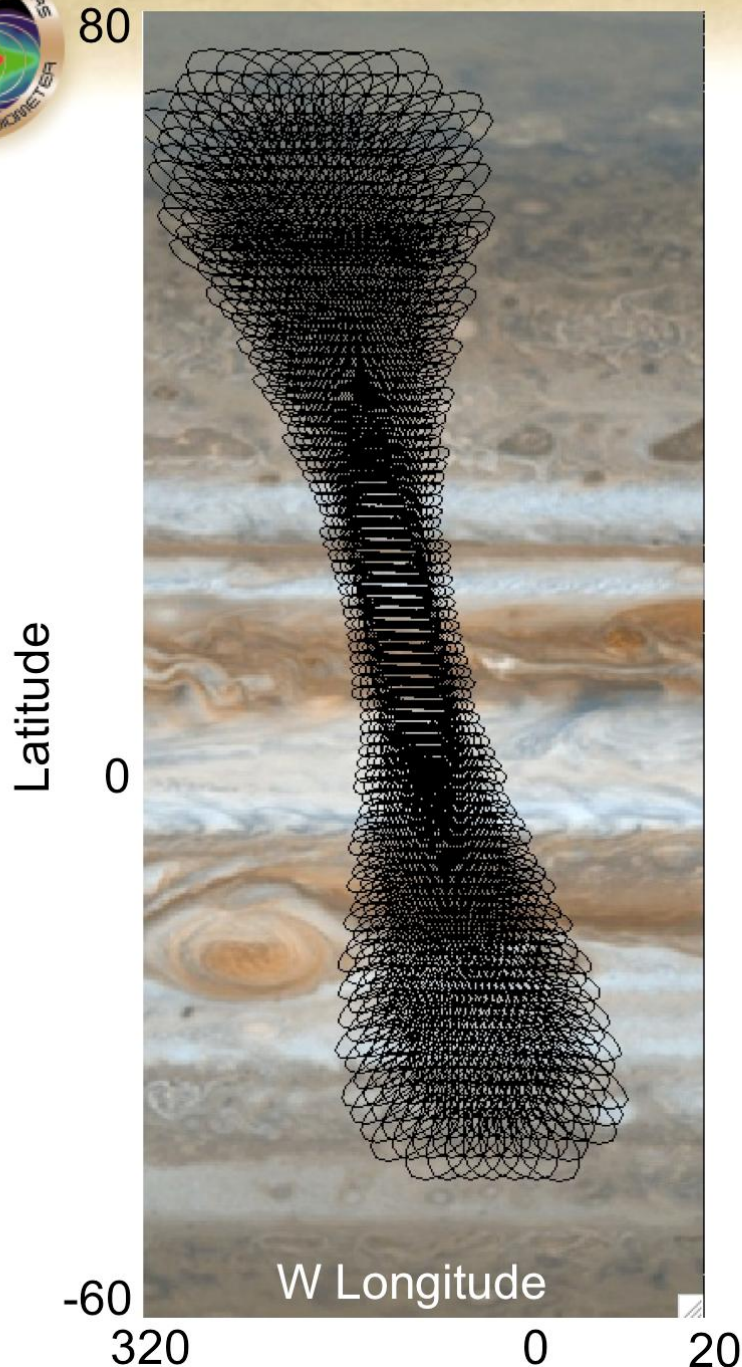
i. **Before**, to **predict** locations of features to help Juno in planning

JUPOS tracking of the GRS Position





MWR on during PRM?



- Juno is scanning cross track during the Period Reduction Maneuver
- We looked at possibility of obtaining a 3-D mapping
- Conclusions
 - Fully sampled map
 - Covers $10^{\circ}+$ in longitude with emission angle $< 60^{\circ}$
 - Resolution ~ 0.7 deg (900 km) at equator
 - Uniquely valuable, complementary, exciting science

Notes:

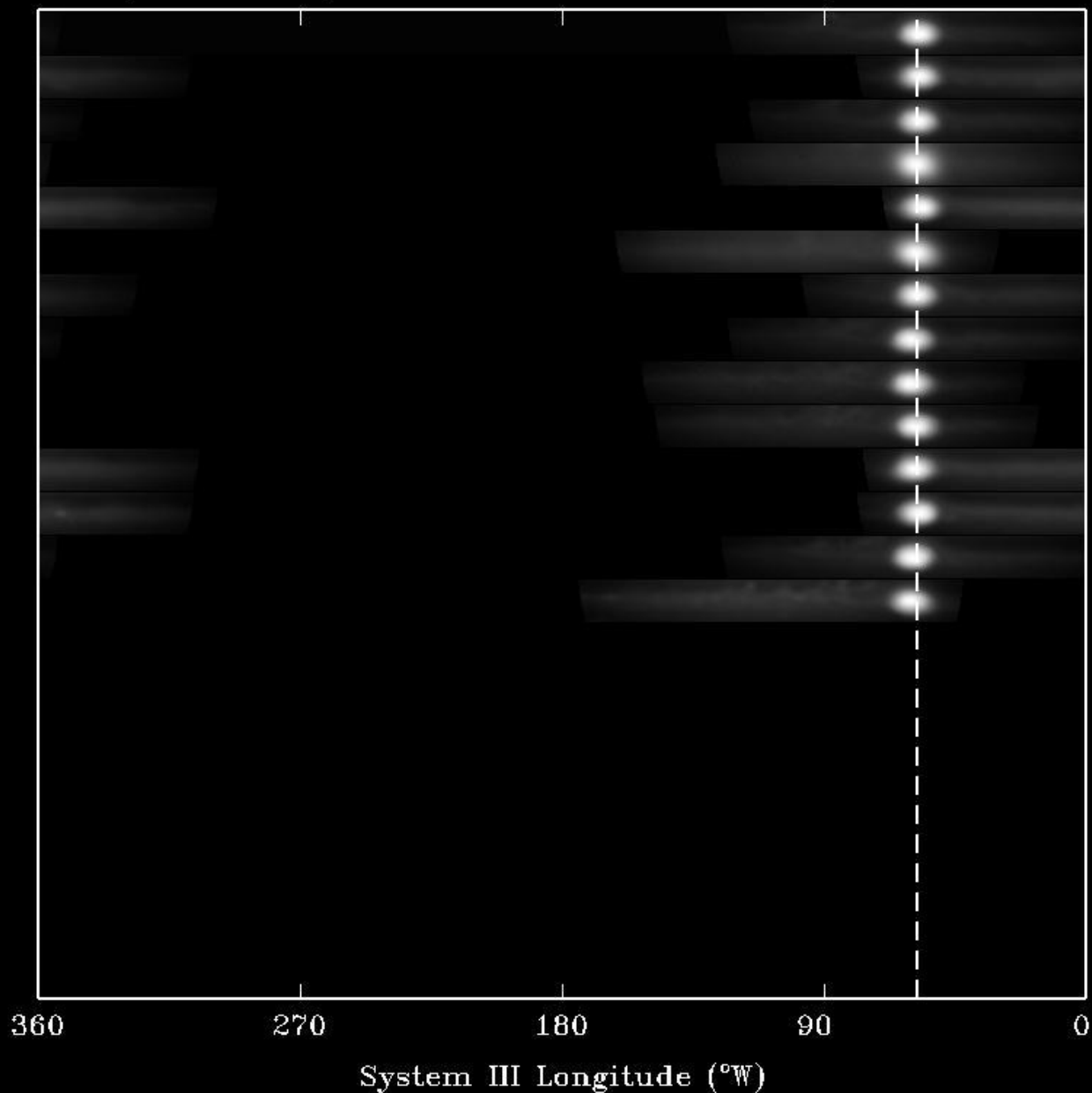
A3 - A6 footprints shown (12° diameter)

Every footprint of every other scan is shown

Longitude of background Jupiter image is arbitrary

Predicted system III longitude for 2017 Aug 9 0.550000 UT
Assuming zonal mean speed of -4.0500 m/s
Cylindrical maps of latitude $-20.0 \pm 7^\circ$ at $2.16 \mu\text{m}$

2015 Nov 21
2015 Nov 23
2015 Nov 28
2015 Dec 10
2015 Dec 12
2015 Dec 27
2015 Dec 29
2016 Jan 27
2016 Jan 27
2016 Jan 28
2016 Jan 30
2016 Feb 23
2016 Feb 28
2016 Mar 2



Amateur astronomers are members of JunoCam's virtual team

Images of the whole disk in **RGB** filters, plus additional filters as possible (e.g. 890 nm “**methane**” and other narrow filters)



- i. **Before**, to **predict** locations of features to help Juno in planning
- ii. At the **same time as the orbit perijoves** for global **context**
- iii. **In between**, to detect **short-term time changes** of atmospheric features, creation of movies
- iv. **After**, to follow up **evolution** of features.

This is also needed for **building cylindrical maps** of Jupiter for the **voting** of the public on which features to target with JunoCam.

Known Variability

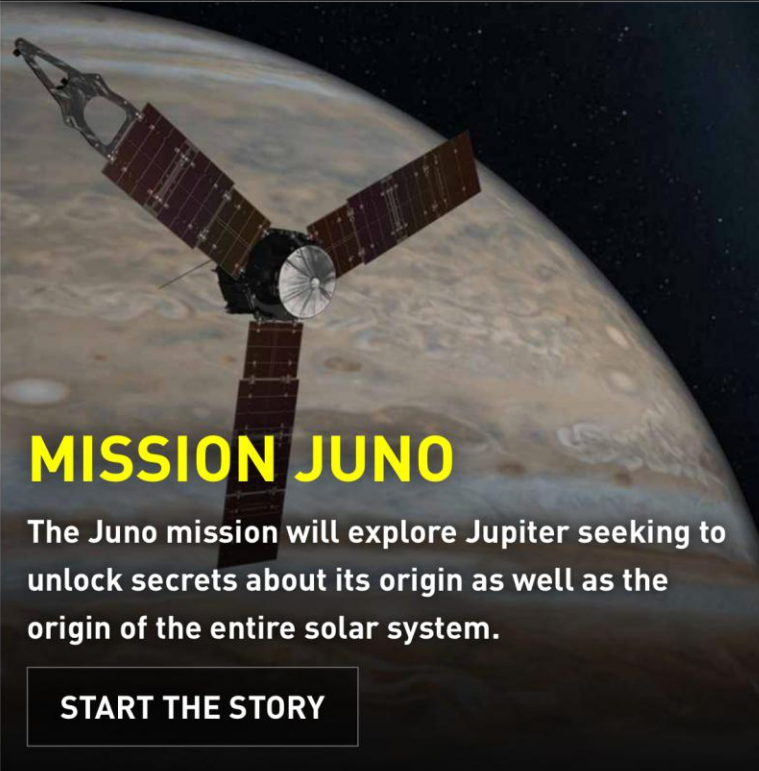
- Longitudinal shrinking of the GRS
- SEB Fade-Revival Cycles
- Reddening of Oval BA
- “Pinkening”/”whitening” of Oval Z
- Unexpected upwelling events
- Contraction/expansion of NEB
- Other unexpected phenomena

- Bookmarks Menu
 - Get Bookmark Add-ons
 - Mozilla Firefox
 - JPL
 - Microsoft Exchange - Ou...
 - NBS New Business Syst...
 - SSC:Proposal Kit: Curre...
 - JPL Student Safety Haza...
 - Unlimited Release System
 - HORIZONS Web-Interface
 - BEACON Library, Archiv...
 - Integrated Business Man...
 - Foreign Travel
 - Domestic Heavily-Atten...
 - Visitor Request Form
 - Quick Searches
 - Firefox and Mozilla Links
 - Google
 - Cars
 - Road Runner
 - AF Volunteers - Login
 - Observatories
 - CAT del IAC - Access...
- Edit



MENU


PROFILE: GLENN




MISSION JUNO

The Juno mission will explore Jupiter seeking to unlock secrets about its origin as well as the origin of the entire solar system.


START THE STORY




JUNOCAM




WHY WITH NYE



NEWS



FEATURES

**@NASAJUNO**

6 MAY
Register now for a chance to be at the @NASAJPL #NASASocial when I arrive at Jupiter in July
<https://t.co/LftuhUEBaz>
<https://t.co/tYAD4KSjqg>

THE TEAM

Learn about the team behind Mission Juno

MEDIA GALLERY

All of our viewable content in one place

LEGACY

Explore the legacy of discovery, which laid the groundwork for the Juno mission

- Bookmarks Menu
 - Get Bookmark Add-ons
 - Mozilla Firefox
 - JPL
 - Microsoft Exchange - Ou...
 - NBS New Business Syst...
 - SSC:Proposal Kit: Curre...
 - JPL Student Safety Haza...
 - Unlimited Release System
 - HORIZONS Web-Interface
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 - Visitor Request Form
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 - Cars
 - Road Runner
 - AF Volunteers - Login
 - Observatories
 - CAT del IAC - Access
- Edit



MENU

PROFILE: GLENN



JUNOCAM

Upload your images of Jupiter, comment on the images, and vote on which pictures JunoCam will take when it reaches Jupiter.

PLANNING

Upload your telescopic images and data of Jupiter to help the team plan the mission

[GO TO PLANNING](#)

DISCUSSION

Create and comment on points of interest in Jupiter's atmosphere

[GO TO DISCUSSION](#)

VOTING

Vote on points of interest for JunoCam to capture during its orbit of Jupiter

[COMING IN 2016](#)

PROCESSING

Browse other users' processed images from JunoCam or download, process, and submit your own images.

[COMING IN 2016](#)



PLANNING

We're calling all amateur astronomers to upload their telescopic images and data of Jupiter. These uploads are critical for the upcoming Discussion section (now live!) and will help NASA successfully plan the future of the mission.

If you're a veteran astrophotographer or if you're just getting started with your first telescope, we highly recommend you read our

Mac OS X dock with various application icons including Safari, Mail, and Finder.

- Bookmarks Menu
 - Get Bookmark Add-ons
 - Mozilla Firefox
 - JPL
 - Microsoft Exchange - Ou...
 - NBS New Business Syst...
 - SSC:Proposal Kit: Curre...
 - JPL Student Safety Haza...
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MENU

PROFILE: GLENN

JUNOCAM

PLANNING

DISCUSSION

VOTING


PROCESSING


+ UPLOAD DATA


FILTERS


1/132


NEXT >


Ceres-00
04 May 2016 12:05 UT

Ceres-00
04 May 2016 11:59 UT

Ceres-00
04 May 2016 11:53 UT

Ceres-00
03 May 2016 11:08 UT

Ceres-00
03 May 2016 10:44 UT

Ceres-00

WELCOME TO PLANNING

Upload your data and images using the **UPLOAD DATA** button above!

(Please read our [Submission Guidelines \[PDF\]](#) before uploading an image.)

Also in this section you can browse through submitted images and data of Jupiter.

Follow this link for **professional Earth-based support observations** schedules or **CONTACT** us for more information.

< Select an image to the left to view data.

input / upload page

Deleted or Relaxed Suggestions for Formatting

- Do not stretch the images or change the linearity
 - Turn OFF the histogram stretching before registering and stacking the images
- Save in FITS, PNG or TIFF formats
 - Ask for highest-depth option
 - This preserves linearity, which JPEG and GIF destroy
- IMS text file with each image
 - Generated within WinJUPOS
 - Who made the image, where, what time, which filter
- ~~• Send a “sharpened” image if you want, but send something has not been subject to a wavelet or an unsharp masking procedure.~~
- Cylindrical maps flattened by Lambertian law
 - This is an option within WinJUPOS
- Compress results (zip file)
- Now this is an automatic option within WinJUPOS.

Example Contribution

12 Jun 2015 10:38 UT

TITLE

2015-06-12-1038_4w

WAVELENGTH

R+G+B (RGB)

PLATE SCALE

0.2

CM3

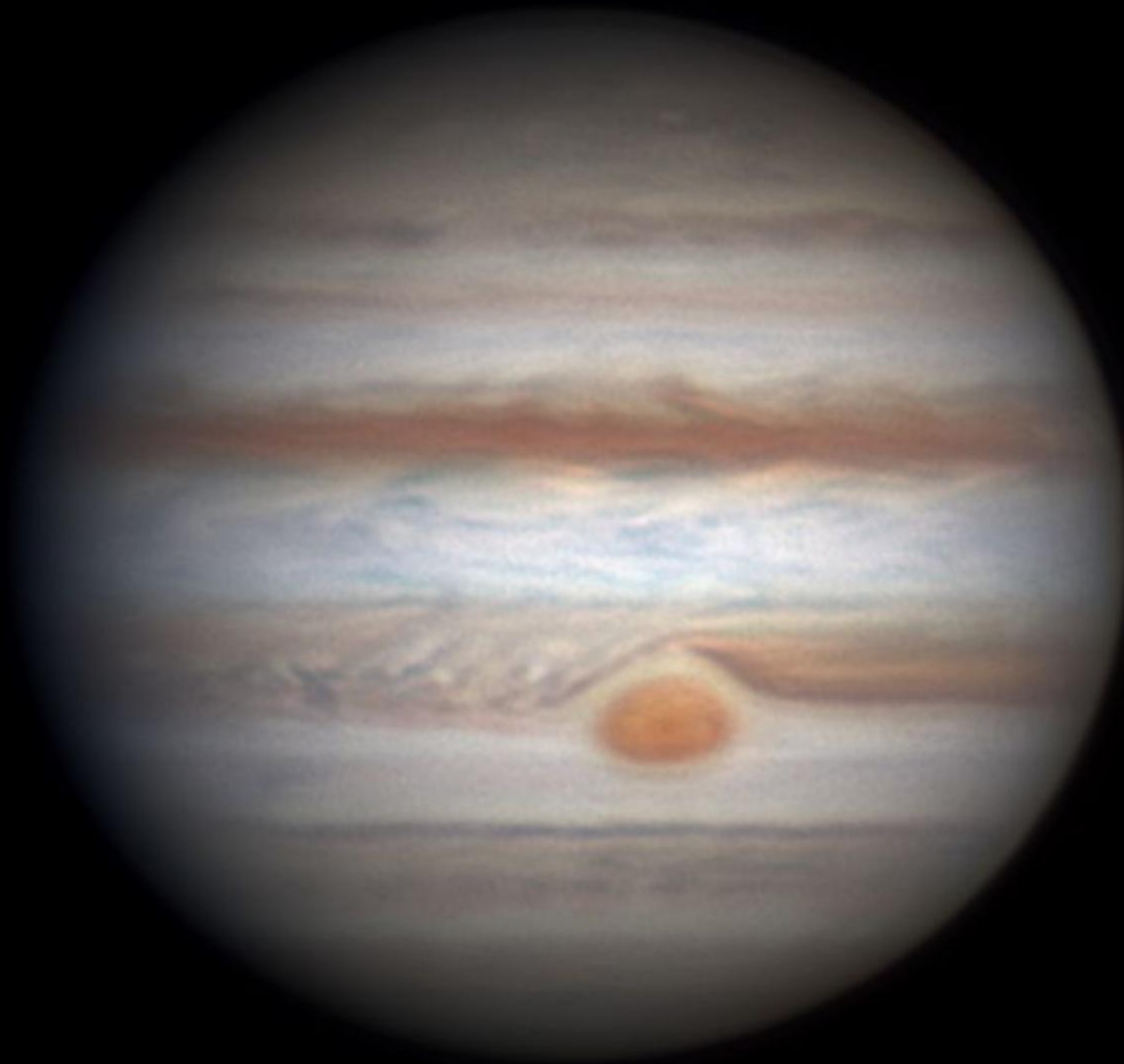
180.34°

DOWNLOAD

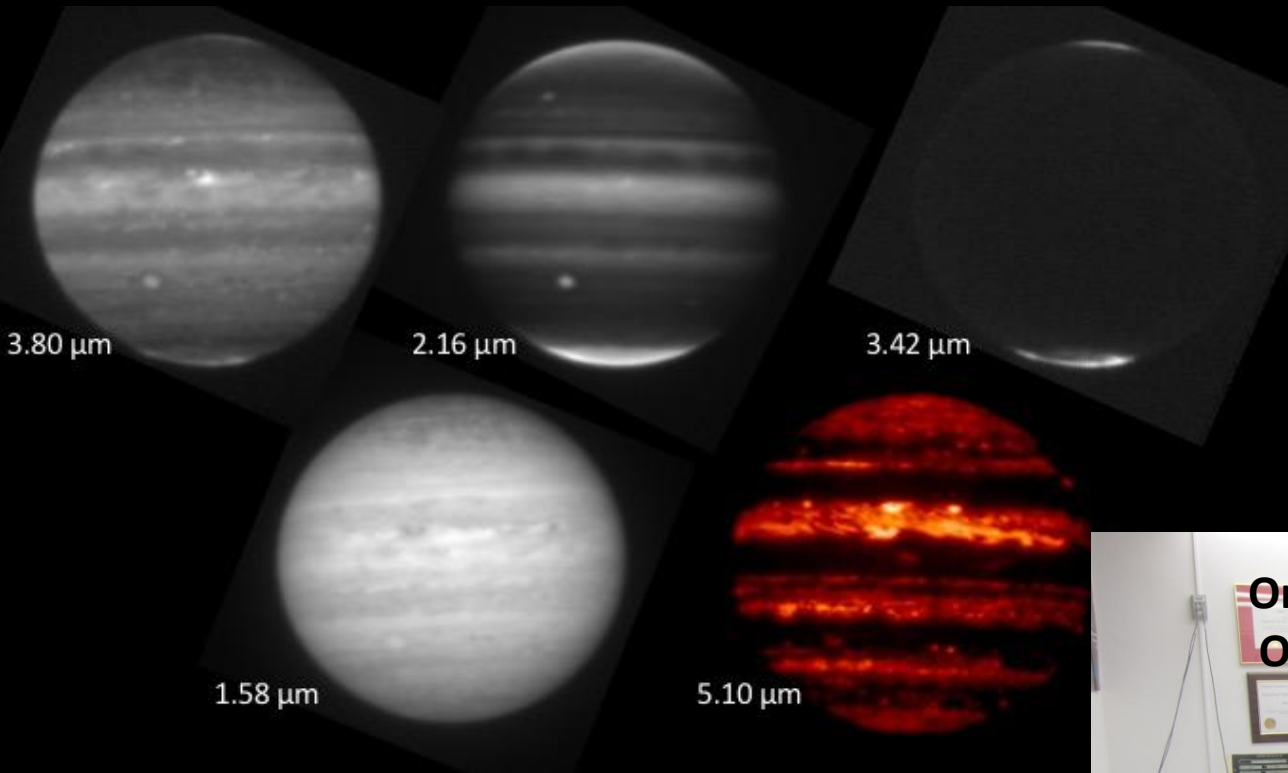
[THUMBNAIL](#) / [ORIGINAL](#)

LINK

</junocam/planning?id=51>



Discontinued uploading of our near-IR images:
working instead to get them on another server

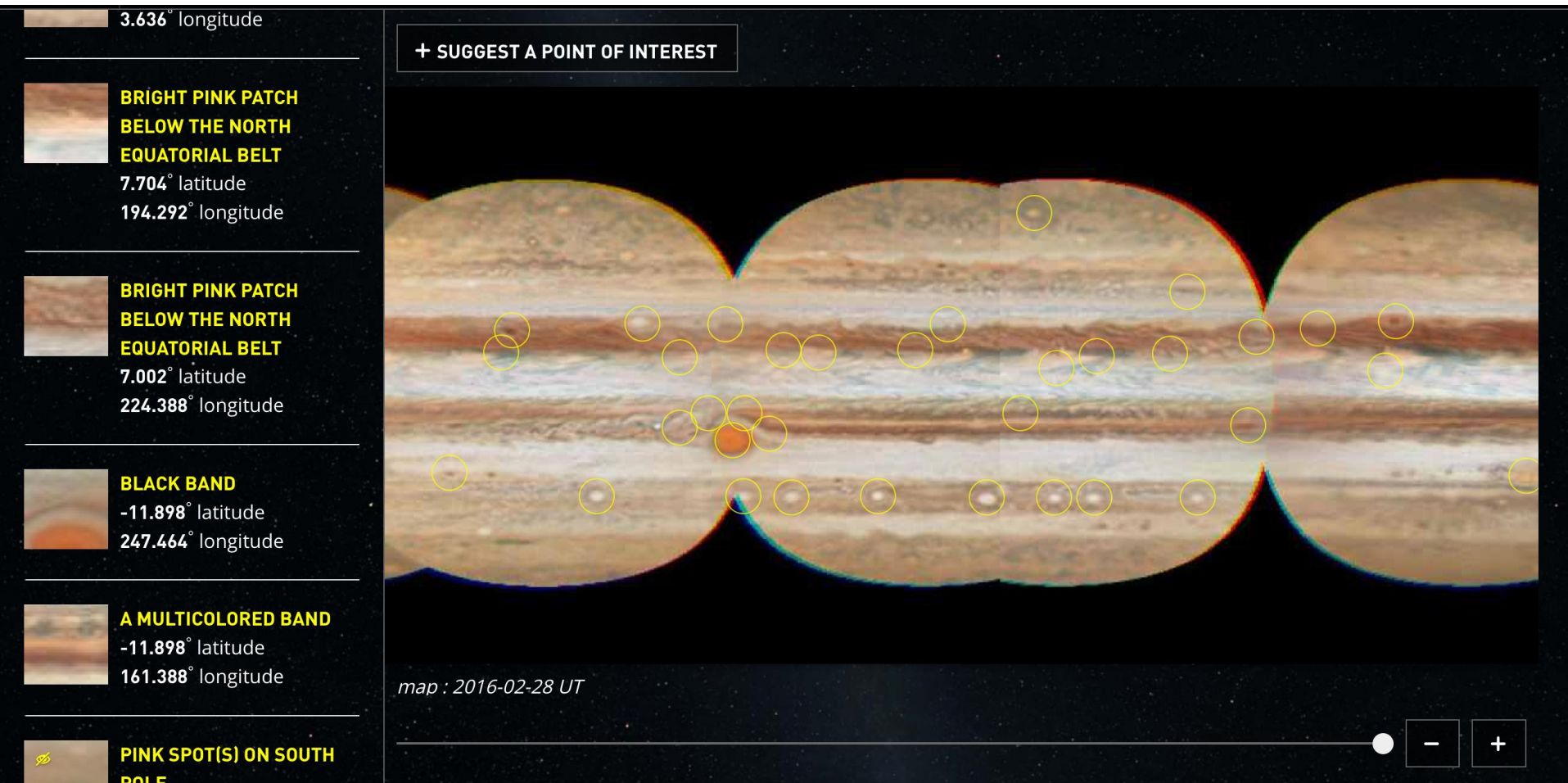


**Orton, Momary, Cecconi in
Orton's office (2016 April 21)**

Discussion Page

- On the discussion page members of the public identify “Points of Interest” (POI’ s)
- The POI is selected on the cylindrical map
- All previous cylindrical maps are available and the user can move backward to look at the history
- When a POI is selected the suggester gives it a name and a description of why it is interesting
- This initiates a thread of conversation
- ***We now have a place for discussion of regional activity and Jupiter in general!***
 - ***It is getting rapidly populated! ☺***

Discussion Page



(2) Discussion Page went live mid-December

- Over 50 POIs identified to-date
- Some no longer visible

Voting Page

MENU

JunoCam Home

Planning

Discussion

Voting

Processing

Sign Up or Login

Vote on this POI

WELCOME TO VOTING ROUND: ROUND NAME

Close in: 1 days 13 hrs

lorem ipsum dolor sit amet, consectetur adipiscing elit. In accumsan, nibh lacinia suscipit malesuada.

Your 3 Votes

BLACK SPOT
13.878 latitude / 320.112 longitude

You haven't Use this vote

You haven't used this vote

POINT OF INTEREST NAME
13.878 latitude
320.112 longitude

Vote

POINT OF INTEREST NAME
13.878 latitude
320.112 longitude

Vote

POINT OF INTEREST NAME
13.878 latitude
320.112 longitude

Vote

POINT OF INTEREST NAME
13.878 latitude
320.112 longitude

Vote

POINT OF INTEREST NAME
13.878 latitude
320.112 longitude

Vote

POINT OF INTEREST NAME
13.878 latitude

Vote

Vote Leaderboard [show](#)

FLATTENED IMAGE OF JUPITER
(cropped to longitudinal path of current orbit)

122 COMMENTS

Add Image

Submit

- Instructions from PI Candace Hansen (strategy and constraints) and Atmospheres Working Group chair Andrew Ingersoll (science)

- Public and scientist discussion

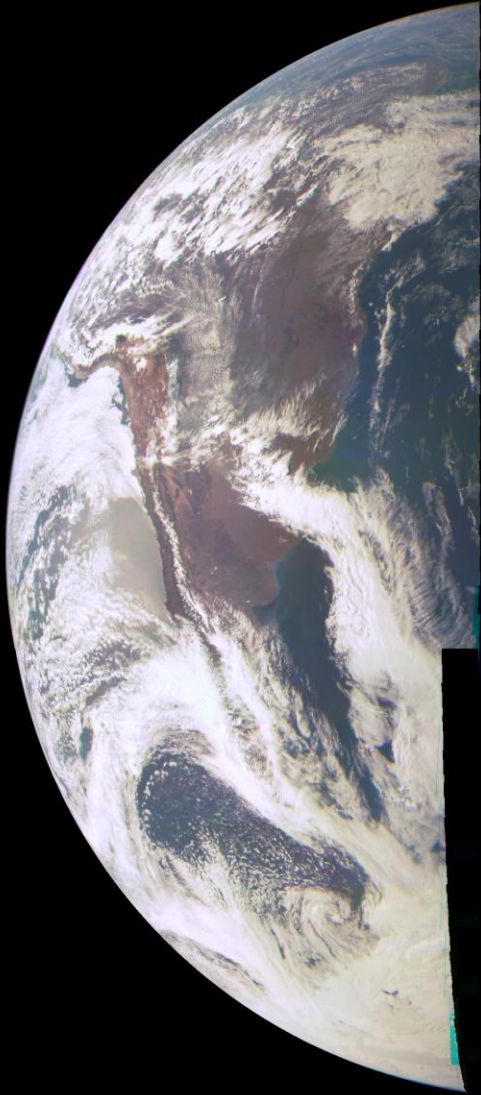
Voting Timeline – Map Updates

Juno Orbital Data (150326 Reference Trajectory)			PJ-to-PJ Orbit Duration (days)	Voting?	Voting Opens	Voting Closes	Comment		
Perijove (PJ)									
#	Type	Time (UTC/SCET)							
0	JOI	07/05/2016 02:47:38	53.419						
1	C Orbit	08/27/2016 12:51:20	53.222	No			First JunoCam high resolution images for gallery		
2	PRM	10/19/2016 18:11:07	13.987	No					
3	Cleanup	11/02/2016 17:52:29	13.960	No					
4	MWR	11/16/2016 16:54:46	13.957	Yes	4-Nov	9-Nov	Voting opens the Friday before the Wednesday before PJ		
5	GRAV	11/30/2016 15:52:21	13.957	Yes	18-Nov	23-Nov	Voting closes the Wednesday before perijove		
6	MWR	12/14/2016 14:49:58	13.957	Yes	2-Dec	7-Dec			
7	MWR	12/28/2016 13:47:35	14.008	Yes	16-Dec	21-Dec			
8	MWR Tilt	01/11/2017 13:59:37	13.957	Yes	30-Dec	4-Jan	Cylindrical Map update one day prior to voting opening		
9	MWR	01/25/2017 12:57:12	13.957	Yes	13-Jan	18-Jan			
10	GRAV	02/08/2017 11:54:47	13.957	Yes	27-Jan	1-Feb			
11	GRAV	02/22/2017 10:52:21	13.931	Yes	10-Feb	15-Feb			
12	GRAV	03/08/2017 09:12:44	13.957	Yes	24-Feb	1-Mar			
13	GRAV	03/22/2017 08:10:19	13.957	Yes	10-Mar	15-Mar			
14	MWR Tilt	04/05/2017 07:07:53	13.957	Yes	24-Mar	29-Mar			
15	GRAV	04/19/2017 06:05:27	14.008	Yes	7-Apr	12-Apr			
16	GRAV	05/03/2017 06:17:26	13.957	Yes	21-Apr	26-Apr			
17	GRAV	05/17/2017 05:14:57	13.957	Yes	5-May	10-May			
18	GRAV	05/31/2017 04:12:29	13.957	Yes	19-May	24-May			
19	GRAV	06/14/2017 03:10:03	14.021	Yes	2-Jun	7-Jun			
20	GRAV	06/28/2017 03:40:40	13.957	Yes	16-Jun	21-Jun			
21	GRAV	07/12/2017 02:38:12	13.957	Yes	30-Jun	5-Jul			
22	GRAV	07/26/2017 01:35:46	13.957	Yes	14-Jul	19-Jul			
23	MWR Tilt	08/09/2017 00:33:19	13.982	Yes	28-Jul	2-Aug			
24	GRAV	08/23/2017 00:08:07	13.957	Yes	11-Aug	16-Aug			
25	GRAV	09/05/2017 23:05:44	13.957	Yes	25-Aug	30-Aug	Perijove now on Tuesday GMT		
26	GRAV	09/19/2017 22:03:21	13.957	Yes	8-Sep	13-Sep			

Cylindrical Map
update one
day prior to
voting
opening

Earth Jupiter Image Staging at MSSS

- Images will be posted on the MSSS JunoCam website
- Accompanied by detailed image description
- Nice FAQ page



Spectroscopy

- CCD spectroscopic measurements by the amateur community have begun
- These are welcome contributions
 - In particular, spatially resolved observations of features that are evolving
- Issues: calibration, formatting
- Points of discussion later in the session, so for now...



glenn.orton@jpl.nasa.gov

...let's buckle up
and get started!



Thanks!

Supplemental Information

