

Impacts in Jupiter: Flashes & Fireballs

Tools & Science

Development team:

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² Amateur astronomers from SAAF

³ Spanish amateur astronomer

⁴ Hired at UPV/EHU for this project

Observers:

Overall community of amateur astronomers.

Some of them are very involved in this subject:

A. Wesley, C.Go, M. Delcroix,

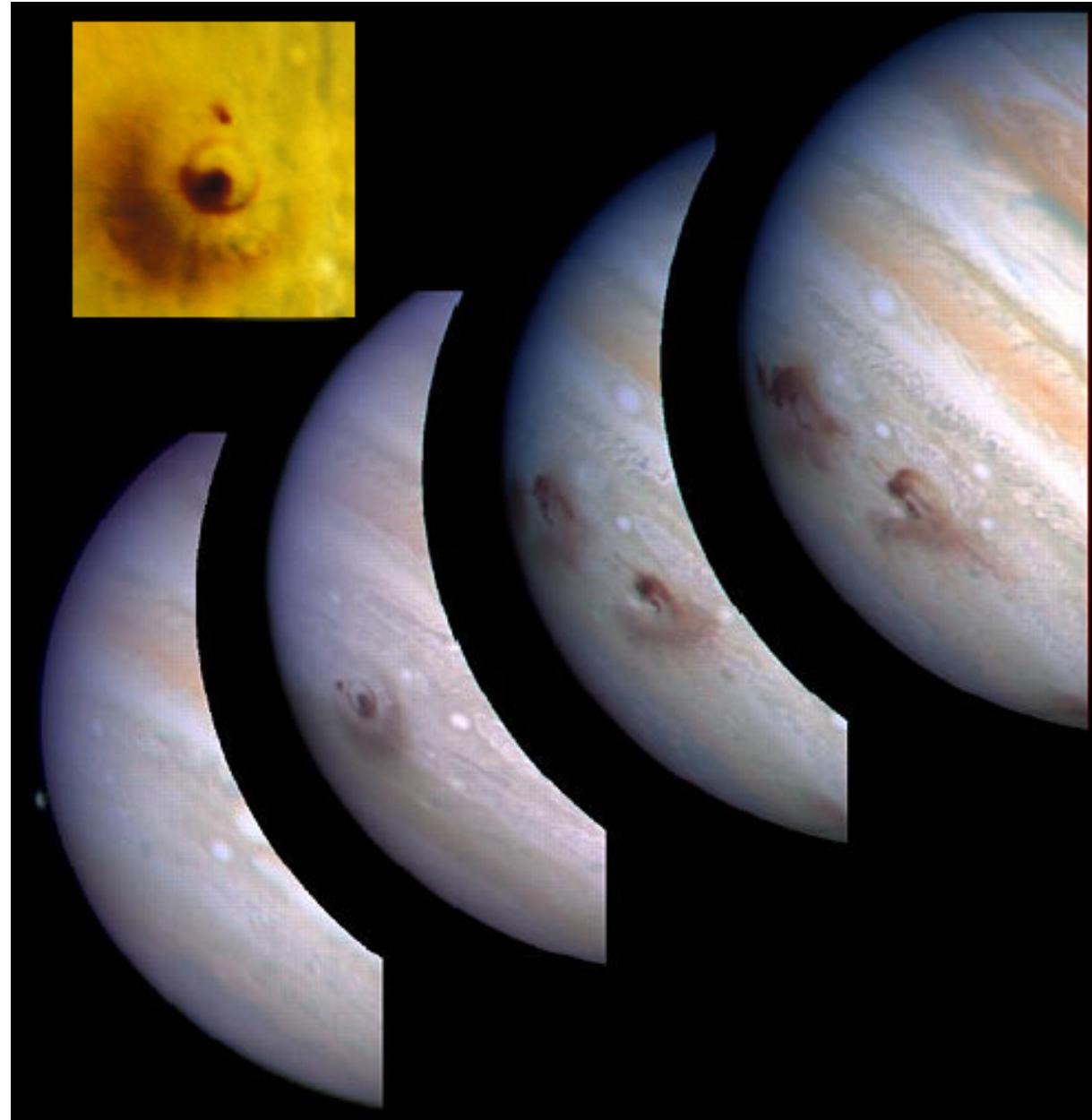


Large impacts in Jupiter

Shoemaker-Levy 9 July 1994

*At the time it was considered as
a "once in a lifetime event"*

*Jupiter Family Comet fragmented
by gravitational tides*



Large impacts in Jupiter

July 2009 Impact

Discovery images by A. Wesley

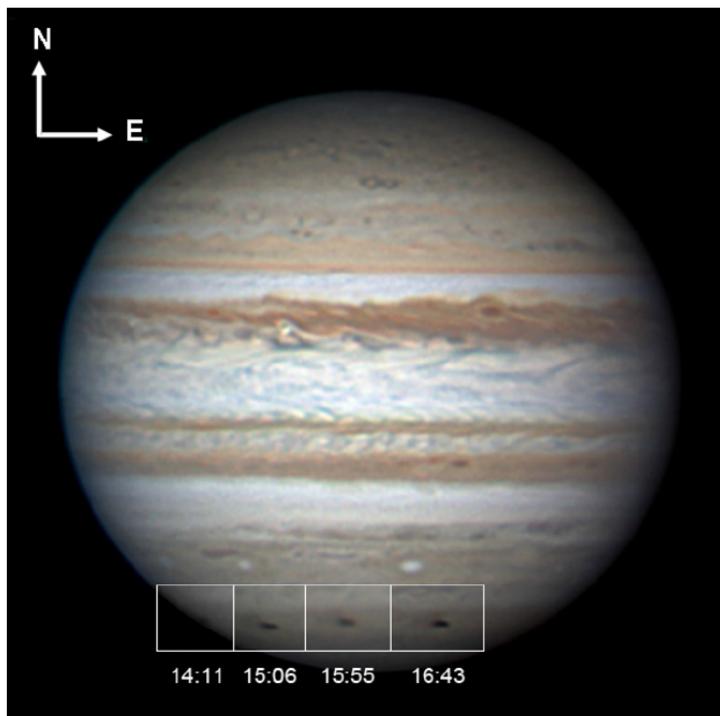
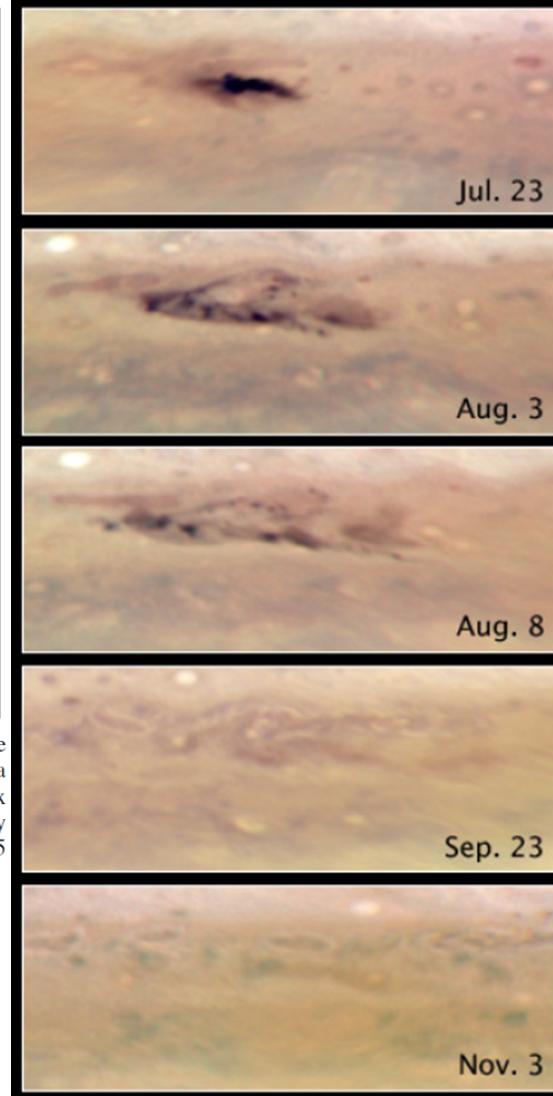


Figure 1. Discovery series of the impact debris obtained on 2009 July 19 at the indicated times (Newtonian telescope with a 368 mm diameter and a camera with a red–green–blue filter covering the spectral ranges 400–700 nm). Ninox software was used for cropping and presorting of the individual frames (Wesley 2009), with RegiStax software used for alignment and stacking (RegiStax 5 2009).

Quick Follow-up by HST



Discovered by **Anthony Wesley** (australian amateur astronomer) hours after the impact.

Described in:
Sánchez-Lavega et al. ApJL, (2010)
Hammel et al. ApJL (2010)

→Impact produced by a 0.5 km object
Observed only a few hours after the impact on the night-side of the planet

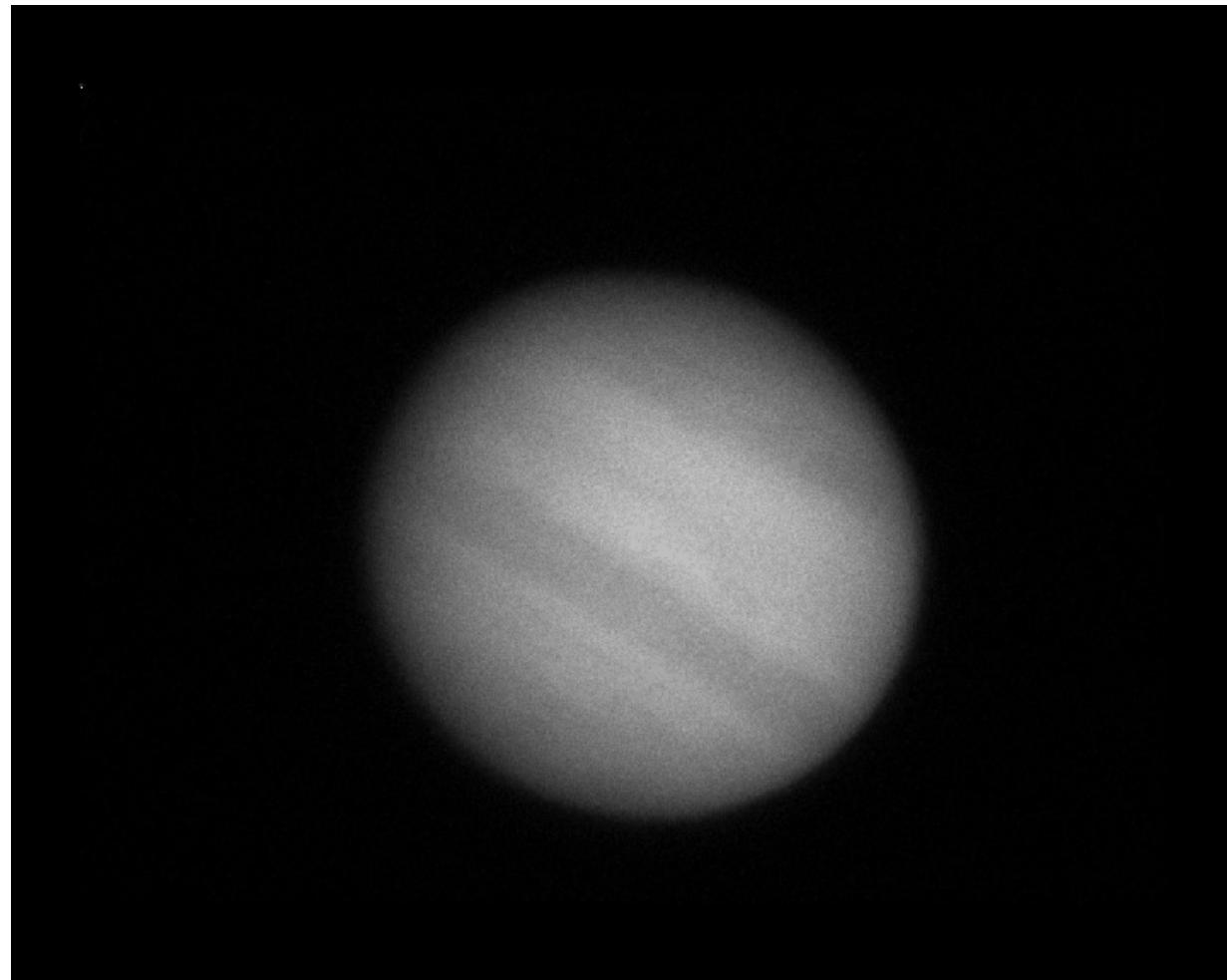
Debated asteroidal nature
Orton et al. Icarus (2011)

Small impacts in Jupiter: Flashes from superbolides (>10 m)

June 3 2010 Impact

Discovered by the same amateur (Anthony Wesley in New South Wales, Australia)

Data obtained during a normal Jupiter observing session on June 3, 2010 at 20:31:20 UT

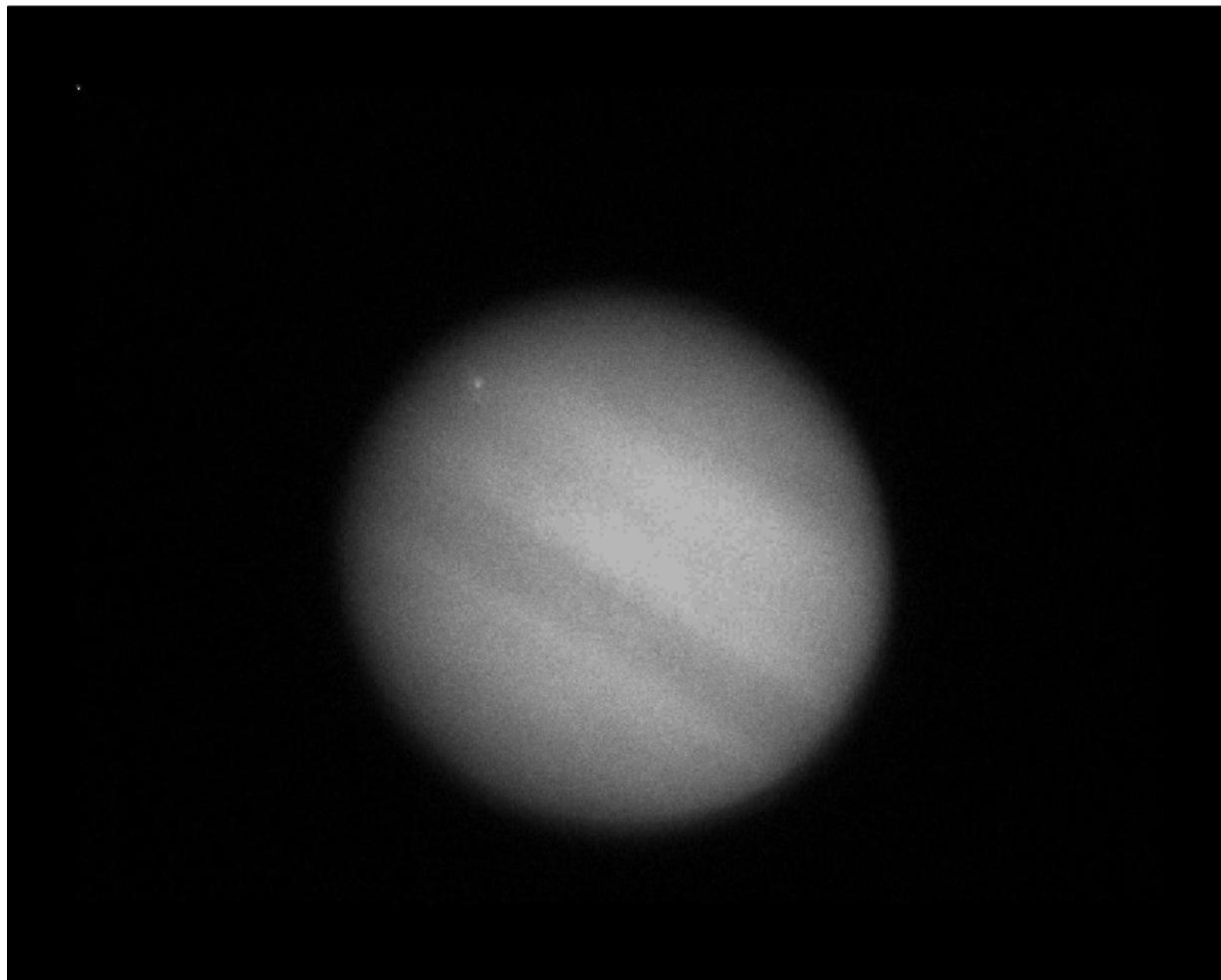


Small impacts in Jupiter: Flashes from superbolides (>10 m)

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Brightest frame:

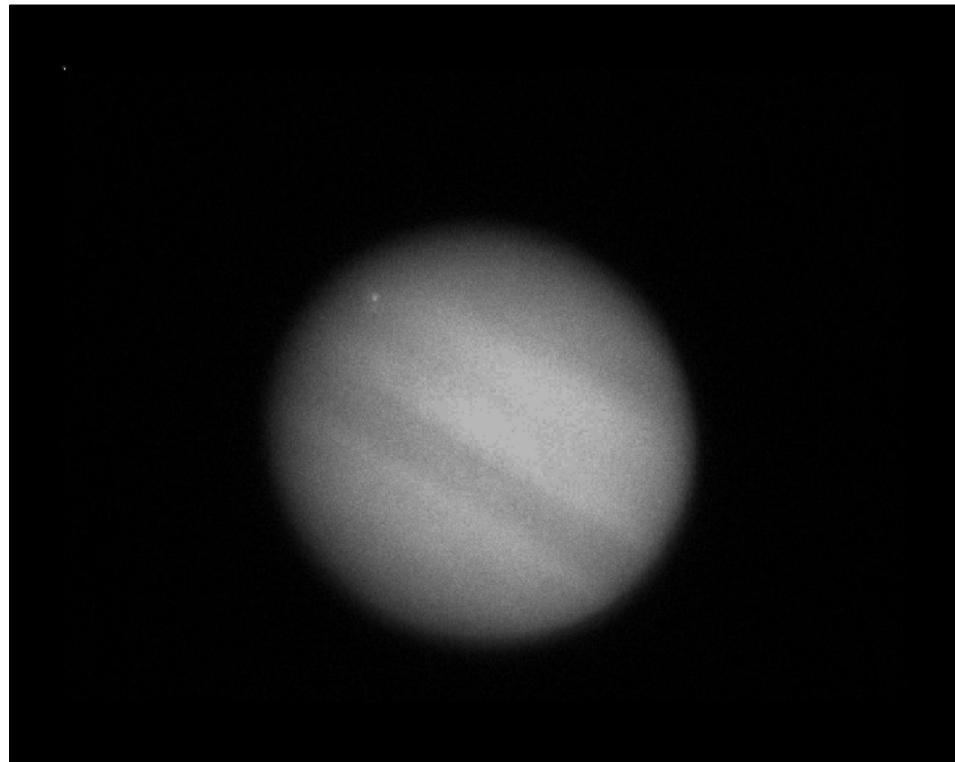
*Flash ~ 1/6000 Jupiter brightness
Equivalent to a +6.5 star*

*Identified by the observer
(very experienced)*

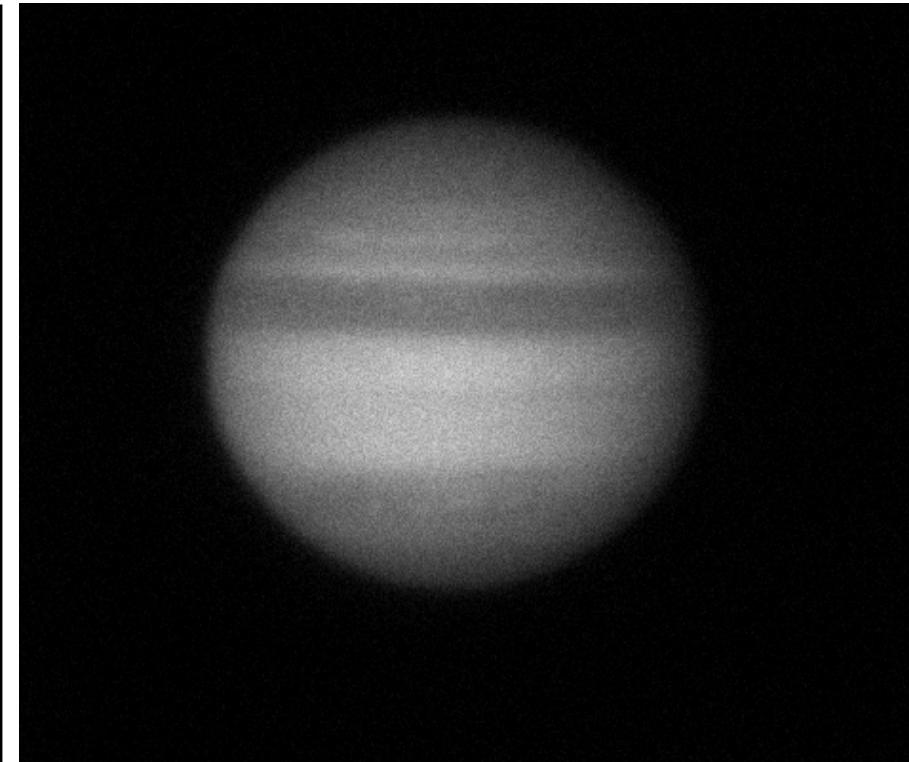
Small impacts in Jupiter: Flashes from superbolides (>10 m)

June 3 2010 Impact

Confirmed by Christopher Go (simultaneous observations from Phillipines)



RED Wavelength



BLUE Wavelength

Small impacts in Jupiter: Flashes from superbolides (>10 m)

A. Wesley image composite with added fireball



Jupiter + Fireball

Anthony Wesley, Broken Hill Australia

3 Jun 2010 20:31.6 Z CMI 299 CMII 33 CMIII 209

A. Wesley Equipment:

15" telescope (37 cm)

Point Grey Flea3 camera,
ICX618AQA chip

Red filter from Astrodon

60 fps

C. Go Equipment:

11" Celestron (28 cm)

Point Grey Flea3 camera,
ICX618AQA chip

Blue filter from Edmund Scientific.

55 fps

Hueso et al. ApJL (2010):

8-13 m impact

Small impacts in Jupiter: Flashes from superbolides (>10 m)

Further fireballs

August 20, 2010 18:21:56 UT



*Masayuki Tachikawa, 6" telescope
Kumamoto City (Japan)
Phillips Toucam (RGB webcam)*

*Kazuo Aoki, 9.25" telescope
Tokyo
Phillips Toucam (RGB webcam)*

*Masayuki Ichimaru, 6" telescope
Toyama (Japan)
Phillips Toucam (RGB webcam)*

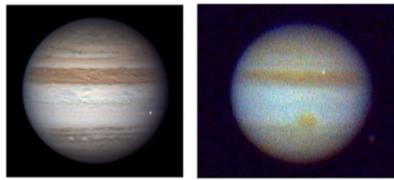
September 10, 2013
11:35:30 UT



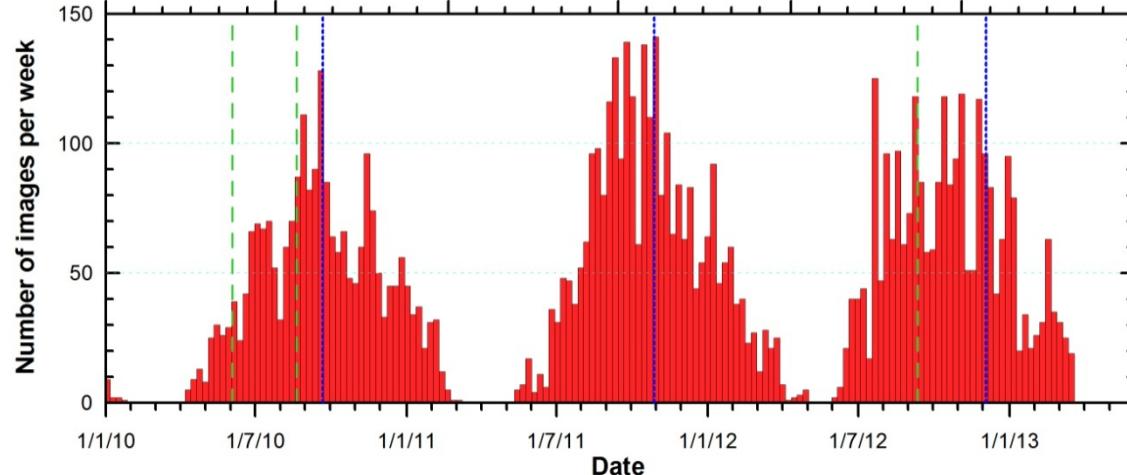
*Dan Petersen, 12" telescope
(Racine, Wisconsin)
visual observation
Estimation of magnitude +6.0*

*George Hall, 12" telescope
(Dallas, Texas)
Point Grey Flea3 camera
ICX618AQ chip
Red filter (Astronomik Type 2c)
15 fps*

Statistical significance

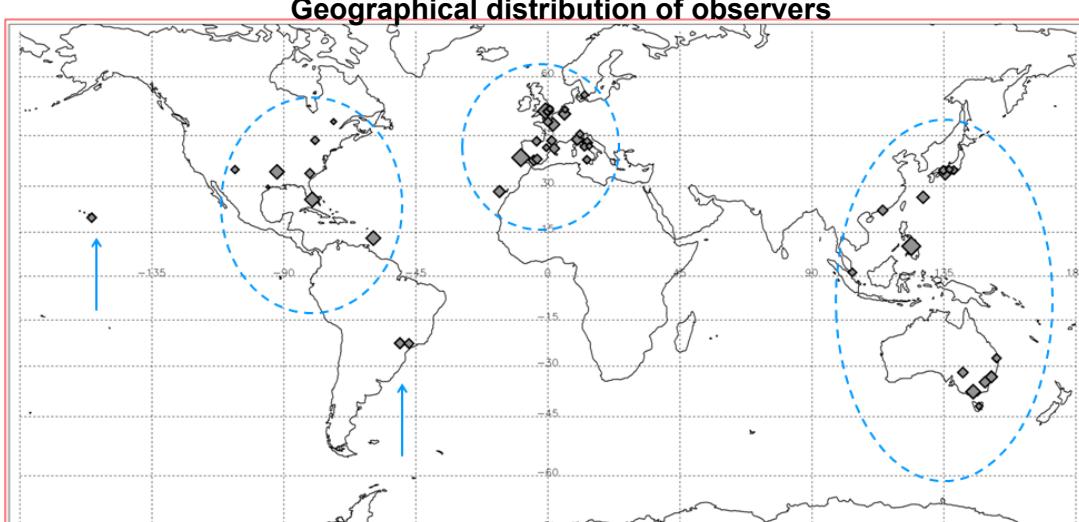


Jupiter's oppositions (blue) and dates of fireballs detected (green)



7800 Jupiter images in the International Outer Planets Watch PVOL database for 2010-2013 **equivalent to 5-20% of this period.**

Most of the observations are redundant
(obtained at the same time)
ESSENTIAL for this science



10-20% of observation efficiency is expected from the global distribution of frequent Jupiter observers

(6-12 hours every day over 6 months assuming good weather somewhere in the three big areas)

270 collaborators in 2010-2013

1/3 impacts discovered by “regular observers”

Objects properties

Results

June 3, 2010

$Energy \approx 4.0 - 15.0 \times 10^{14} J$

100 – 350 ktn

$Mass \approx 200 - 900 Tn$

Size (diameter) $D \approx 5.5 - 10.0 m$

$D \approx 8.7 - 16 m$

August 20, 2010

$Energy \approx 5.2 - 12.0 \times 10^{14} J$

120 – 300 ktn

$Mass \approx 300 - 700 Tn$

Size (diameter) $D \approx 6.5 - 9.0 m$

$D \approx 10 - 14 m$

September 10, 2012

$Energy \approx 12.0 - 32.0 \times 10^{14} J$

320 – 750 ktn

$Mass \approx 860 - 1500 Tn$

Size (diameter) $D \approx 9.0 - 12 m$

$D \approx 14 - 19 m$

Energy range: 100-750 ktn surrounding Chebyalinsk-like events [450 ktn] and 5-50 times less than Tunguska (3000-5000 ktn).

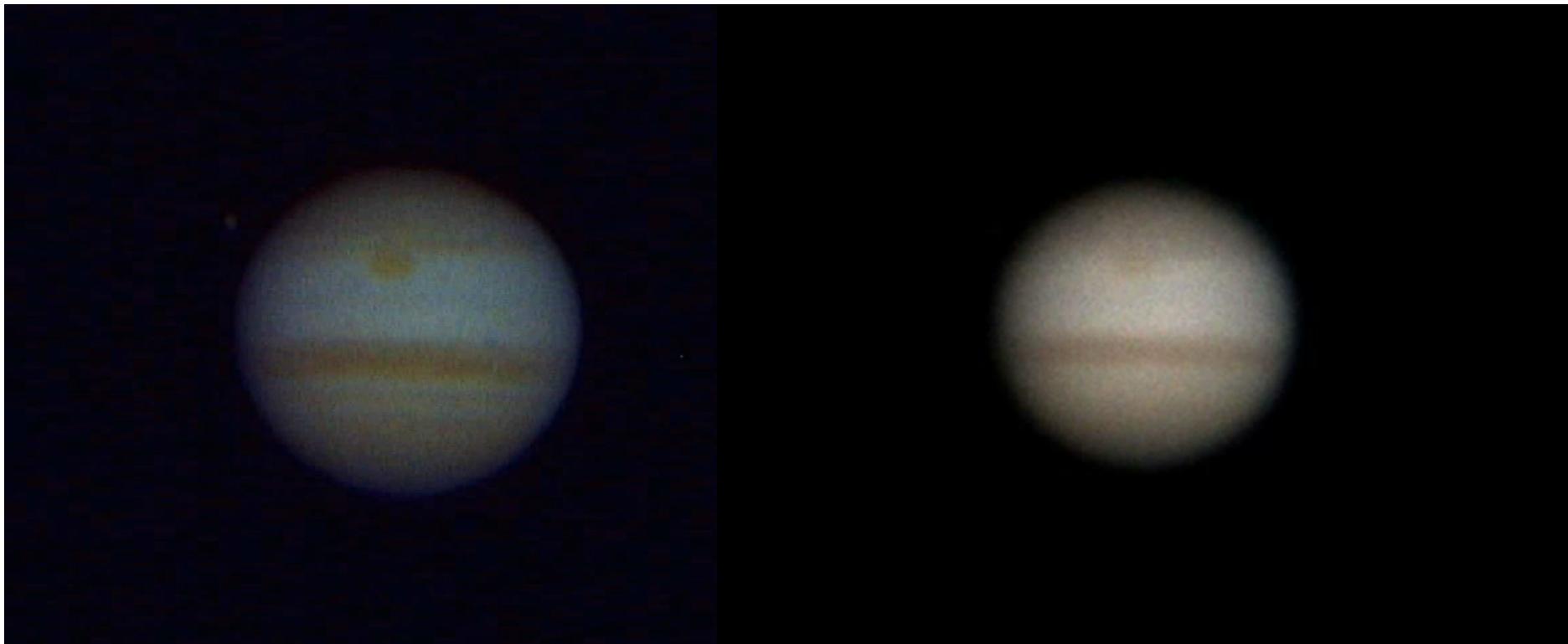
Published guess: 12-45 impacts of these sizes per year
Similar to some dynamical inferences 30-100 per year

Hueso et al. A&A, 2013

Unknown ability of amateurs to “recognize” an impact in their video observations. Difficulties to do it by eye at night in a long observing session
Hundredths of gigabytes of stored data by many individual amateurs

- Smaller impacts ($D \sim 4 m$) could be detected with 40cm telescopes in a good survey if we have good tools
- Large impacts ($D \sim 10-20 m$) could also be detectable in Saturn

Detecting impacts in non ideal cases



*Masayuki Tachikawa, 6'' telescope
Kumamoto City (Japan)
Phillips Toucam (RGB webcam)*

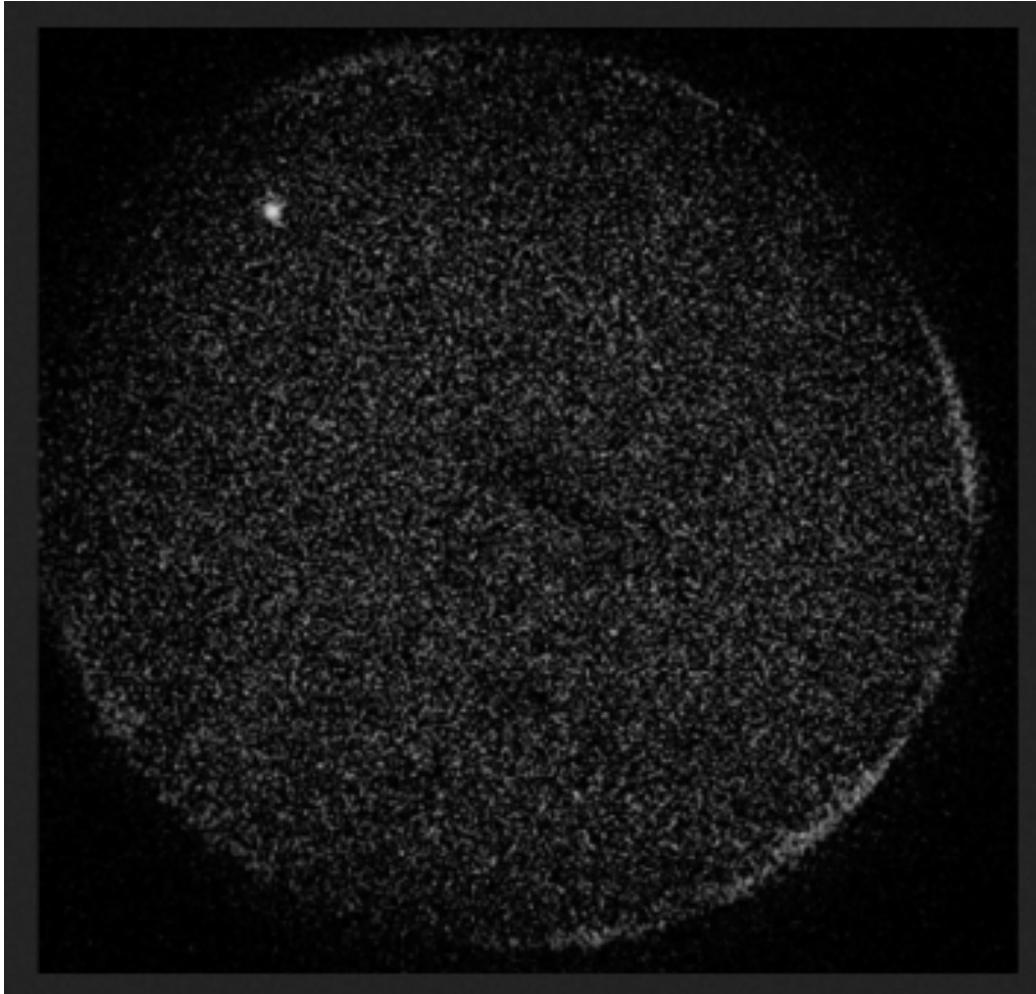
*Kazuo Aoki, 9.25'' telescope
Tokyo
Phillips Toucam (RGB webcam)*

*Masayuki Ichimaru, 6'' telescope
Toyama (Japan)
Phillips Toucam (RGB webcam)*

Events last ~2 s in videos that sometimes can be minutes long.
If telescopes are small and impacts faint they last shorter.

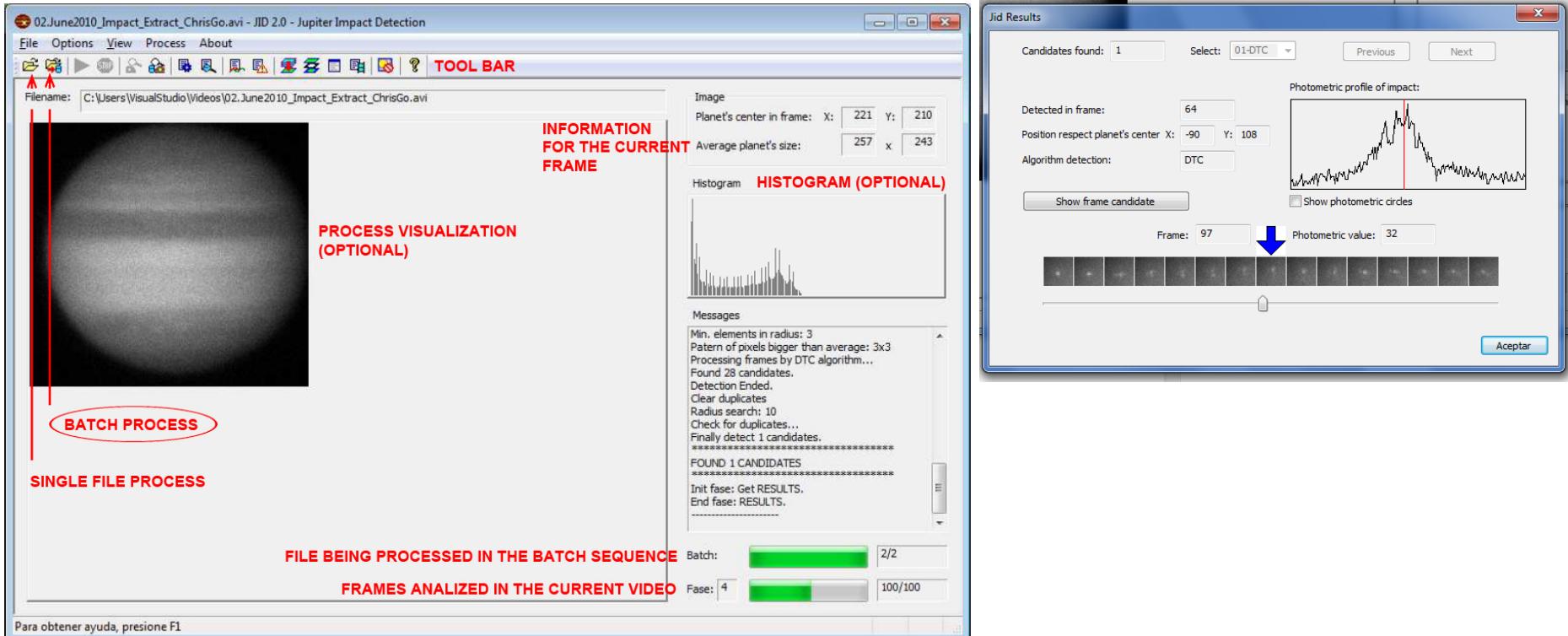
Detecting impacts tools

*Currently there are two software packages for analyzing amateur video observations of Jupiter
Both are based on differential photometry of full images
A reference image is computed and updated as the video proceeds*



Detecting impacts tools

1- UPV/EHU software developed by Juan Carlos Moreno (amateur)



Available on: <http://www.pvol.ehu.es/dtc>

Open Source, multiplataform, supporting most video formats and batch mode

- ✓ Automatic impact detection and light-curve extraction
- ✓ List of candidates easy to review

Not widely used. A few bugs remain (video codecs).

Requires interaction with the user.

Needs further developments

Detecting impacts tools

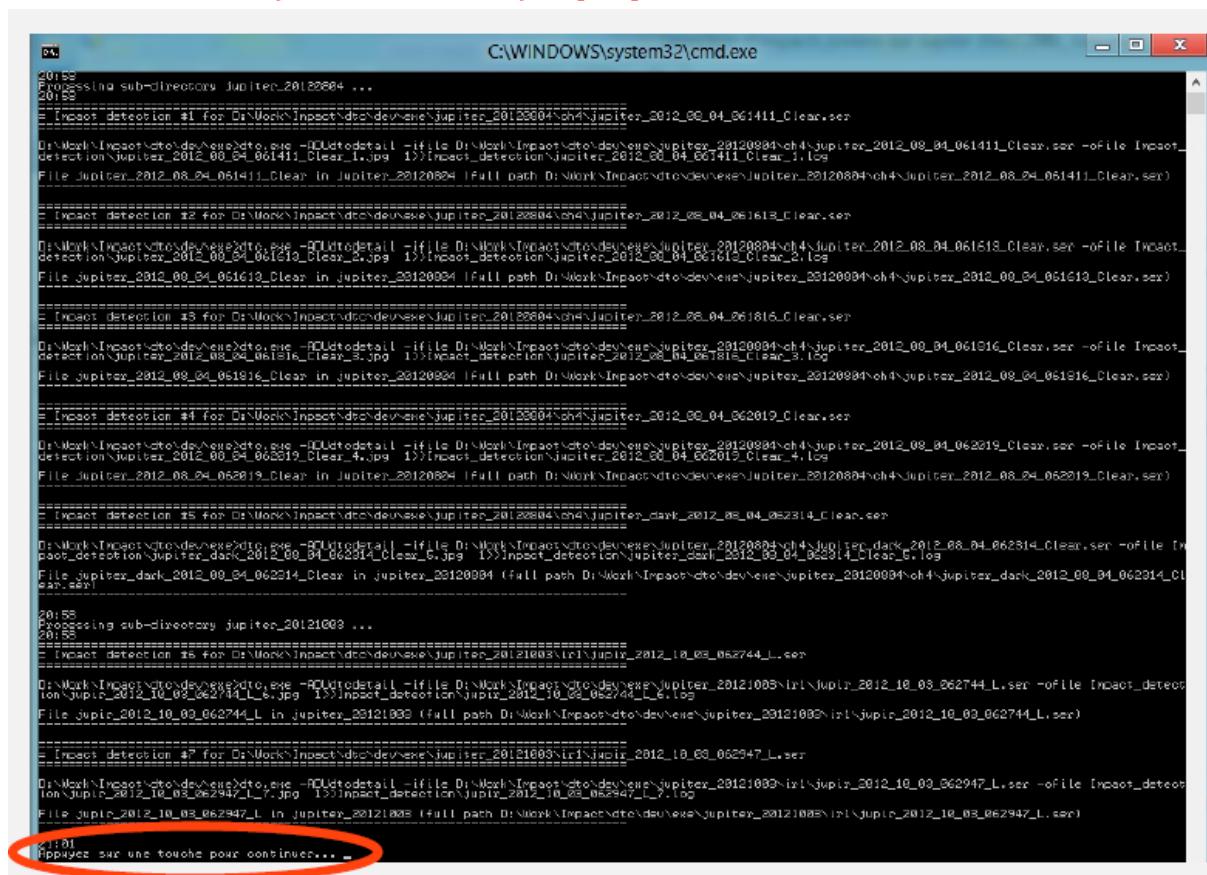
2- Marc Delcroix's software (amateur astromer & professional programmer in Toulouse)

Very similar or same detection algorithm

Very different approach → Batch Mode only & Statistics

Much more used than the JID software from UPV/EHU

Interface may not be very “popular”



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Processing sub-directory Jupiter_20120804 ...
201208
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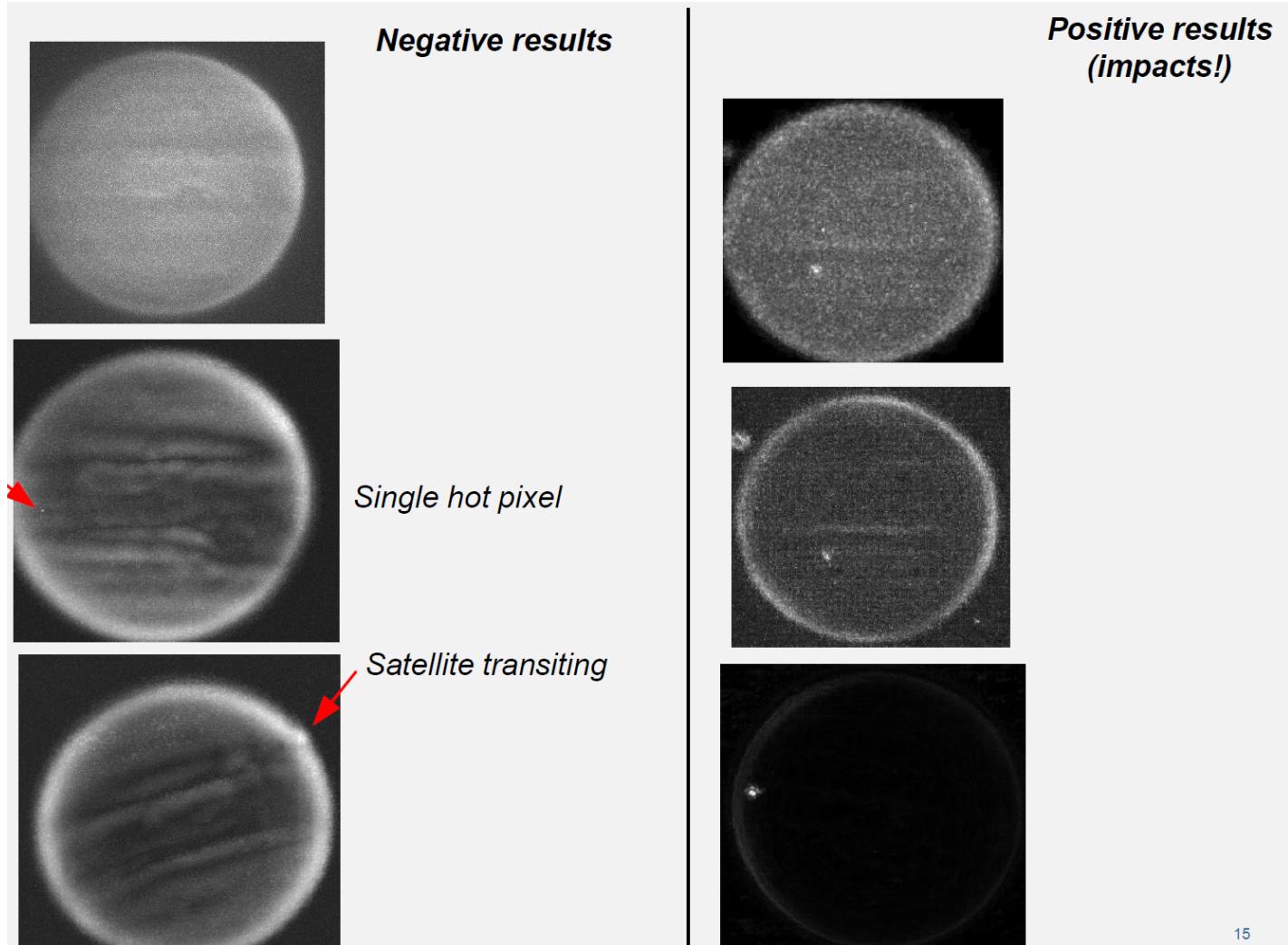
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X:100
Appuyez sur une touche pour continuer...
```

Detecting impacts tools

2- Marc Delcroix's software (amateur astromer & professional programmer in Toulouse)

Well documented



Detecting impacts tools

2- Marc Delcroix's software (amateur astromer & professional programmer in Toulouse)

Very interesting results from ongoing analysis

Jupiter
estimation of less than 9 impacts per year

Observer	Duration	Number of videos	Date range
Total : 47 observers	43.772 days	43022 videos	2004/02/29 - 2016/03/05
Paul Rolet (France)	6.470 days	5428	2012/09/07 - 2016/02/29
Michel Jacquesson (France)	6.194 days	4485	2014/03/12 - 2016/01/18
Thomas Ashcraft (USA)	4.239 days	5139	2013/10/09 - 2016/01/22
Manos Kardasis (Greece)	4.227 days	3369	2004/02/29 - 2016/02/28
Xavier Dupont (France)	2.060 days	1877	2012/08/16 - 2015/04/25
Alan Coffelt (USA)	1.878 day	1357	2013/10/04 - 2015/12/09
Marc Delcroix (France)	1.854 day	2115	2006/04/14 - 2016/02/04
Trevor Barry (Australia)	1.613 day	2424	2009/07/07 - 2012/12/30
Christophe Pelliier (France)	1.523 day	796	2012/02/20 - 2015/02/12
Pascal Bayle (France)	1.389 day	1802	2012/11/30 - 2015/05/10
Lammertus de Vries (Spain)	1.168 day	700	2009/08/03 - 2015/05/08
Grant Blair (USA)	1.088 day	994	2013/08/20 - 2014/12/04
Stéphane Gonzales (France)	1.006 day	1196	2013/12/20 - 2015/04/14
Paul Jones (USA)	0.828 day	757	2011/08/29 - 2015/04/05
Pascal Lemaire (France)	0.733 day	834	2012/08/01 - 2016/02/10
Jocelyn Serot (France)	0.711 day	549	2014/01/10 - 2015/12/14
Jean-Jacques Poupeau (France)	0.688 day	1275	2013/02/05 - 2014/12/29
Steve Hill (United Kingdom)	0.639 day	841	2005/03/26 - 2014/03/10
Matic Smrekar (Slovenia)	0.562 day	859	2009/07/29 - 2015/06/05
Agapios Elia (Cyprus)	0.528 day	478	2013/11/10 - 2016/01/29
Arnaud Claisse (France)	0.483 day	387	2014/01/19 - 2015/05/17
Pic du Midi observatory (Delcroix/Dauvergne) (France)	0.402 day	854	2010/09/29 - 2014/10/04
Vincent Moreau (France)	0.377 day	450	2007/06/10 - 2014/12/23
Flavius Isac (France)	0.324 day	546	2011/08/12 - 2013/02/17
Phil Miles (Australia)	0.312 day	425	2013/12/03 - 2014/01/17
Fred Locklear (USA)	0.295 day	211	2013/10/09 - 2013/12/01
Franklin Marek (USA)	0.269 day	263	2014/01/03 - 2015/02/20

Saturn
estimation of less than 101 impacts per year

Observer	Duration	Number of videos	Date range
Total : 11 observers			
Marc Delcroix (France)	3.649 days	1802 videos	2007/01/20 - 2015/08/29
Manos Kardasis (Greece)	1.816 day	890	2007/01/20 - 2015/07/15
Paul Rolet (France)	0.645 day	293	2008/03/10 - 2015/08/20
Société Astronomique de Touraine (France)	0.433 day	144	2015/05/12 - 2015/06/12
Arnaud Claisse (France)	0.212 day	83	2014/03/14 - 2015/08/29
Stéphane Gonzales (France)	0.166 day	44	2015/05/21 - 2015/06/19
Pic du Midi observatory (Delcroix/Dauvergne) (France)	0.105 day	60	2015/05/23 - 2015/05/25
Charles Galdies (Malta)	0.087 day	167	2012/08/06 - 2014/03/09
Alan Coffelt (USA)	0.077 day	81	2014/06/08 - 2015/07/17
Matic Smrekar (Slovenia)	0.073 day	28	2015/05/03 - 2015/05/07
Grant Blair (USA)	0.020 day	8	2011/06/27 - 2011/08/05
	0.011 day	4	2014/03/14 - 2014/03/14

Probably requires some external validation (how does seeing affects the results, telescope size, filter, etc...)

The last years have had Jupiter oppositions in winter (North)

We really need to find more fireballs to make any clear conclusion

Current situation

We need an easier software and more effort to reach the community

SOFTWARE TO BE DEVELOPED UNDER PSWS

Jon Juaristi jon.juaristic@ehu.eus

Hired under EPN2020-RI from February 2016

VESPA/PVOL developer at UPV/EHU

Will attend the VESPA workshop in Toulouse next week

Will start working on this problem after VESPA/PVOL first version released
(Summer 2016)

PLAN: Use existing codes & integrates these efforts.

Probably within VESPA/PVOL. Collaborate with Marc Delcroix.

We need more observers & observations

Juno arrives at Jupiter 4th July 2016

Large involvement of amateurs in supporting Juno

Pro/Amateur workshop in Nice organized by EPN-2020 RI May 2016

http://www.ajax.ehu.es/Juno_amateur_workshop/