DeTeCt 3.0: A software tool to detect impacts of small objects in video observations of Jupiter obtained by amateur astronomers

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Abstract: Impacts of small size objects (7-20 m in diameter) with Jupiter atmosphere result in **luminous superbolides that can be observed from the Earth with small size telescopes (12-40 cm)**. **Impacts of this kind have been observed five times** by amateur astronomers since July 2010. Although the probability of observing one of these events by an individual observer is very small, the accumulated probability of finding impacts by the large community of amateur astronomers is much higher. Amateur astronomers observe Jupiter using fast video cameras that record thousands of frames during a few minutes which combine into a single image that generally results in a high-resolution image. Flashes are brief, faint and often lost by image reconstruction software. We present major upgrades in a software tool DeTeCt and our current project to maximize the chances of detecting more of these impacts in Jupiter.

Fireballs in Jupiter atmosphere

On June 3, 2010 amateur astronomers Anthony Wesley from Murrumbateman, Australia and Christopher Go from Cebu, Philippines recorded a short flash of light on Jupiter while taking video observations of Jupiter. The observed **flash lasted about two seconds** and a scientific analysis of its light resulted in the conclusion that it was caused by an object of 8-13 meters impacting on Jupiter's atmosphere and producing a giant fireball in a superbolide event.

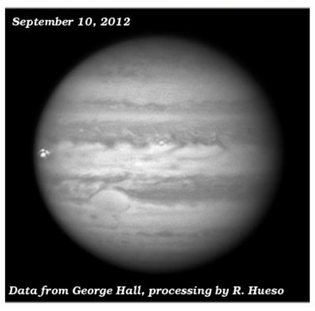
Other events have been found later with similar characteristics (see lower box). In all cases an observed raised the alarm to the amateur community after visually observing the impact flash on the video recording with later confirmations coming from observers who had been taking data at the right time but didn't see the flash when it produced. In all cases the regions suffering the impacts did not show any trace of the bolide material.

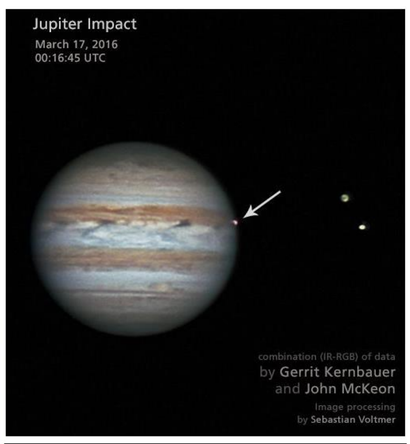
These events can therefore only be discovered if spotted on the few seconds each impact produces a bright fireball observable from ground-based telescopes but some of them are so faint that might be missing by an observer looking at its video data or not observing the video file while being acquired.

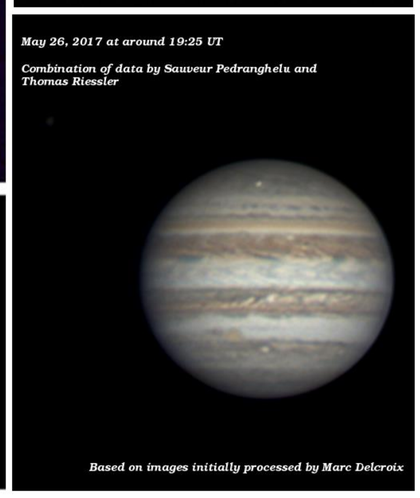
Fireball impacts

- **June 3, 2010**
  Observers: *Anthony Wesley (Australia) and Christopher Go (Philippines).*
  Possible characteristics: 4.7-18 m size object (105-780 Tn in mass; Energy 46-340 kTn)
- **August 22, 2010**
  Observers: *Masayuki Tachikawa, Kazuo Aoki, Masayuki Ishimaru (Japan).*
  Possible characteristics: 5.8-17 m size object (205-610 Tn in mass; Energy 88-260 kTn)
- **Sept. 10, 2012**
  Observers: *Dan Petersen (visual observation and alarm; USA) & George Hall (USA).*
  Possible characteristics: 7.8-19 m size object (500-950 Tn in mass; Energy 215-405 kTn)
- **March 17, 2016**
  Observers: *Gerrit Kernbauer (Austria) and John McKeon (Ireland).*
- **May 26, 2017**
  Observers: *Sauveur Pedranghelu (France), Thomas Riessler (Germany) & Andre Fleckstein (Germany).*

Sizes and energies from references [1&2]



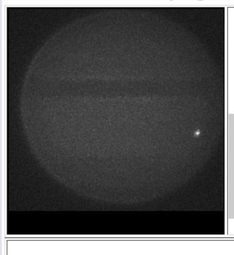




DeTeCt 2.1

DeTeCt is an open source Linux/Windows application developed by Marc Delcroix that allows to search for impacts in Jupiter videos. The software has been used regularly by dozens of observers examining data equivalent to about 76 days of observations distributed unevenly over the last few years. The software runs from the line command and produces log files that can be used to examine the statistics of non detections when comparing with the fortuitous detections of impacts. The software and statistical analysis of its results can be accessed at: http://www.astrosurf.com/planetessaf/doc/project_detect.shtml

DeTeCt2.1 webpage as of September 10, 2017



Impact flashes detection with DeTeCt software project/
Projet de détection de flash d'impacts avec le logiciel DeTeCt
by/*par* Marc Delcroix

Presentation of the project (EPSC2013, BAA workshop)

26/03/2017: NEW SOFTWARE VERSION 2.0.5 / *NOUVELLE VERSION 2.0.5 DU LOGICIEL*

Software download and tutorial for participating to the project
Téléchargement du logiciel et tutoriel pour participer au projet

NEW 26/03/2017 : Join the impact_detection Yahoo group for exchanges and support !

Jupiter
estimation of 4,4 impacts per year (0,4 per month)

Observer	Duration	Number of videos	Date range
Total : 71 observers	83.636 days	71196 videos	2004/02/29 - 2017/07/16
Michel Jacquesson (France)	11.350 days	6688	2014/03/12 - 2017/01/23
Paul Rolet (France)	9.914 days	7803	2012/09/07 - 2017/06/20
Zac Pujic (Australia)	9.579 days	4352	2005/02/22 - 2017/07/16
Manos Kardasis (Greece)	5.380 days	4212	2004/02/29 - 2017/04/08
Thomas Ashcraft (USA)	5.045 days	6282	2013/10/09 - 2016/11/30
Marc Delcroix (France)	3.561 days	2252	2006/04/13 - 2017/05/24
Bernd Gaehrken (Germany)	3.450 days	5157	2016/03/06 - 2017/06/17
Alan Coffelt (USA)	3.191 days	2315	2013/10/04 - 2017/04/26
Xavier Dupont (France)	2.166 days	1875	2012/08/16 - 2015/04/25
Grant Blair (USA)	2.108 days	2130	2013/08/20 - 2016/04/21
Trevor Barry (Australia)	1.625 day	2420	2009/07/06 - 2012/12/30
Christophe Pellier (France)	1.522 day	760	2012/02/20 - 2015/02/12
Pascal Bayle (France)	1.451 day	1802	2012/11/30 - 2015/05/10
David Domine (France)	1.450 day	907	2016/02/25 - 2017/04/10
Lammertus de Vries (Spain)	1.254 day	700	2009/08/03 - 2015/05/08
Torsten Mellenthin (Germany)	1.181 day	1495	2016/01/28 - 2017/06/24
Torsten Hansen (Germany)	1.181 day	436	2016/03/06 - 2016/03/31
Jocelyn Serot (France)	1.100 day	752	2014/01/10 - 2017/06/25
Agapios Elia (Cyprus)	1.039 day	963	2013/11/09 - 2016/06/12
Stephane Gonzales (France)	1.007 day	1194	2013/12/20 - 2015/04/14
Arnaud Claisse (France)	0.966 day	844	2014/01/19 - 2016/05/03
Matic Smrekar (Slovenia)	0.936 day	1631	2009/07/29 - 2016/06/10
Jean-Jacques Poupeau (France)	0.912 day	1274	2013/02/05 - 2016/03/23
Paul Jones (USA)	0.842 day	747	2011/08/29 - 2015/04/05
Pascal Lemaire (France)	0.801 day	834	2012/08/01 - 2016/02/10

Saturn
estimation of less than 32,1 impacts per year (2,7 per month)

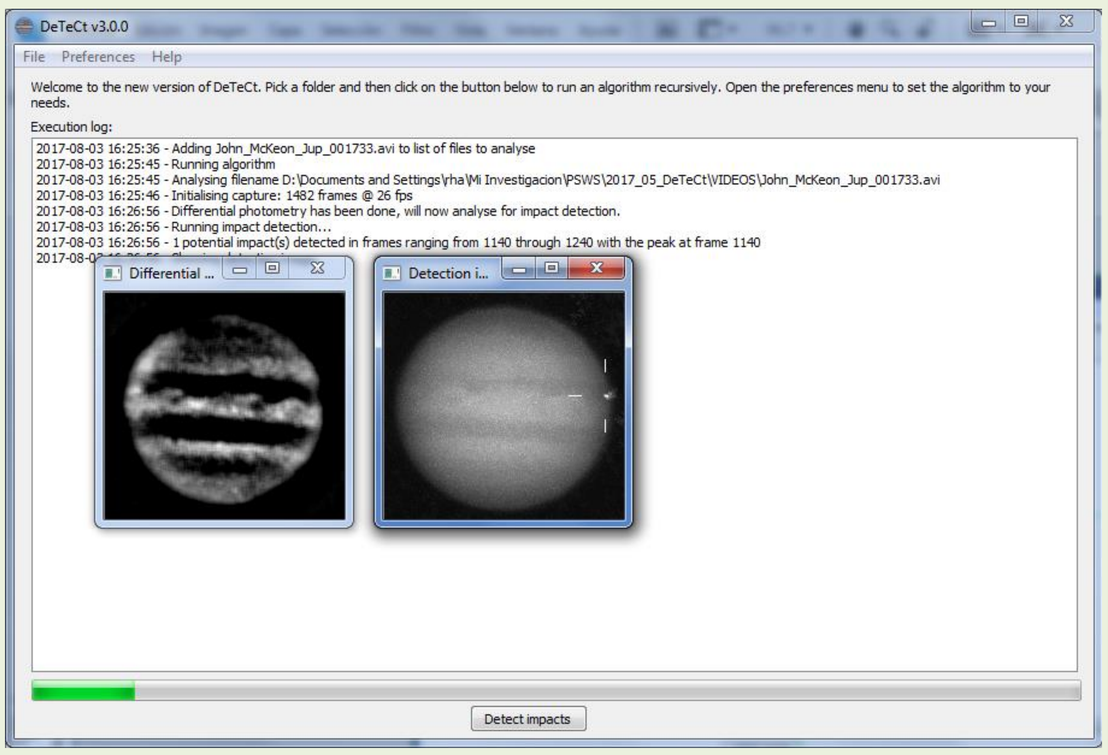
Observer	Duration	Number of videos	Date range
Total : 17 observers	11.381 days	4962 videos	1999/11/30 - 2017/09/04
Zac Pujic (Australia)	4.560 days	2059	2005/02/04 - 2017/09/04
Marc Delcroix (France)	2.054 days	930	2007/01/20 - 2016/07/24
Paul Rolet (France)	1.103 day	280	2015/05/12 - 2017/08/16
Manos Kardasis (Greece)	0.795 day	406	1999/11/30 - 2017/03/25
Grant Blair (USA)	0.456 day	255	2014/03/14 - 2016/04/24
Charles Galdies (Malta)	0.438 day	81	2014/06/08 - 2015/07/17
Arnaud Claisse (France)	0.405 day	63	2015/05/21 - 2016/05/04
Oleg Zaharciuc (Moldova)	0.382 day	186	2016/05/22 - 2016/08/09
Societe Astronomique de Touraine (France)	0.224 day	92	2014/03/14 - 2016/07/16
David Domine (France)	0.220 day	35	2016/04/23 - 2017/04/08
Stephane Gonzales (France)	0.198 day	104	2015/05/23 - 2017/06/05
Alan Coffelt (USA)	0.150 day	56	2015/05/03 - 2017/04/26
Pic du Midi (Delcroix/Dauvergne) (France)	0.145 day	221	2012/08/06 - 2016/08/08
Blake Estes (USA)	0.126 day	79	2016/05/08 - 2016/05/13
Matic Smrekar (Slovenia)	0.089 day	85	2011/06/27 - 2016/06/06
Adrien Marezac (France)	0.022 day	18	2017/06/11 - 2017/06/11
Torsten Mellenthin (Germany)	0.006 day	12	2017/04/01 - 2017/06/23

DeTeCt 3.0

*As part of the "**Planetary and Space Weather Services**" Europlanet 2020-RI has funded the development of DeTeCt3.0 and further research on impacts in Giant planets. DeTeCt3.0 is an open-source software developed for Windows operative system and incorporates a graphic user interface and some characteristics to find faint impacts. The software main window shows a console view with text messages and a progress bar. The user can select to show the videos as they are processed with a variety of options including the differential photometry images. The software produces log files, allows visualization of the detection steps and finally builds detection images that the user can visually inspect. Batch mode is available for the analysis of large sets of videos.. The software is not yet fully tested and will continue to be developed with a formal release in February 2018.The current version of the software can be retrieved from: http://pvol2.ehu.eus/psws/jovian_impacts/*

***Please note** that you when you run the software you should send to Marc Delcroix (delcroix.marc@free.fr) the DeTeCt.log files for statistical analysis. Negative detections are also important to constraint the flux of impacts in Jupiter. If you have a positive detection please also send the detection image.*

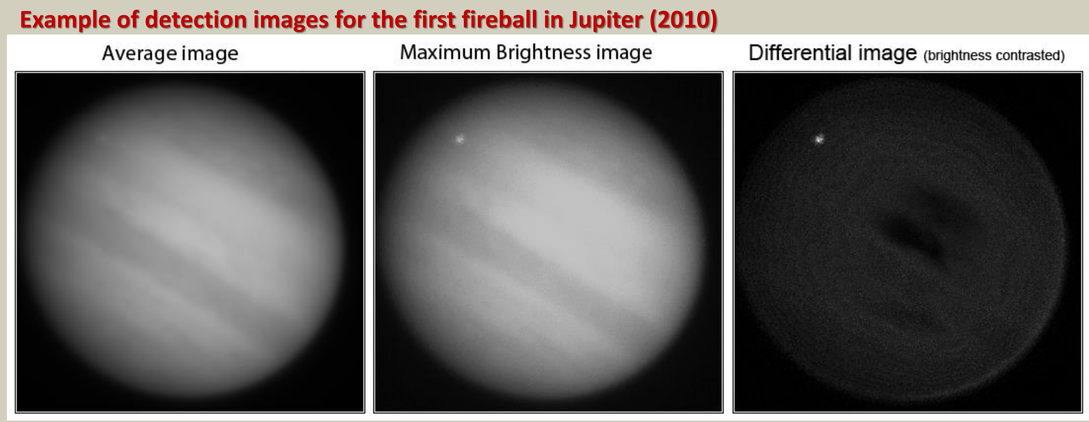
DeTeCt3.0 console view with a differential photometyr image and the detection image



DeTection images (DeTeCt2.1 & DeTeCt 3.0)

Besides automatic results both versions of DeTeCt incorporate the capability to build a "detection image". This image is computed from the maximum brightness minus the average brightness for each pixel in the planet and in many cases offers a very high potential for an instantaneous view of the impact. The detection image can filter-out spurious results at the limb of the planet from bad seeing or from flickering images of Jupiter's satellites.

Example of detection images for the first fireball in Jupiter (2010)



Probability of finding an impact

*Based on the current detections, detectable impacts in Jupiter could be **frequent (12-40 per year;** reference 2) or **very rare (4.5 per year, see Marc Delcroix talk on session AM1 on Wednesday 14:45**). However more detections are needed to explore this question. **Jupiter impacts have been found close to Jupiter opposition when the planet is more observed by amateurs**. We expect new impact detections as more explore their video observations of Jupiter and the planet's opposition moves towards summer in the north hemisphere where the highest density of observers live. Additionally, **frequent observations by larger telescopes (1-m) using filters where the planet is dark (blue or methane)** could seed light in the impact flux by finding more frequent impacts of smaller objects not observable with amateur means.*

References

[1] Hueso et al.: First Earth-based detection of a superbolide on Jupiter, *The Astrophysical Journal*, **721**, L129-L133, 2010.
[2] Hueso et al. Impact flux on Jupiter: From superbolides to large-scale collisions. *A&A*, **560**, A55, (2013).

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