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 (22-40 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 Murrembateman, Australia and Christopher Go from Cebu, Philippines recorded a short flash of light on Jupiter while taking video observations of Jupiter. The observer **flashed last 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.

**Fireballs information**

- **June 3, 2010**
  - Observers: Anthony Wesley (Australia) and Christopher Go (Philippines).
  - Possible characteristics: 4.7-18 m size object (105-760 m in mass, Energy 49-540 kTn)
- **August 22, 2010**
  - Observers: Matsuyuki Tachikawa, Kazuo Aoki, Masayuki Ishimaru (Japan).
  - Possible characteristics: 5.8-17 m size object (105-610 m in mass, Energy 88-260 kTn)
- **Sept. 10, 2010**
  - Observers: Dan Petersen (visual observation and alarm USA) & George Hall (USA).
  - Possible characteristics: 7.8-19 m size object (500-950 m in mass, Energy 215-405 kTn)
- **March 17, 2016**
  - Observers: Gerrit Kernbauer (Austria) and John McKeon (Ireland).
- **May 26, 2017**
  - Observers: Sauveur Pedrinchelu (France), Thomas Plasser (Germany) & Andre Piackstein (Germany).

**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:


**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:


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 photometry image and the detection image**

DeTeCt3.0 has been used in the last three years to detect possible impacts on Jupiter with a statistical analysis of the results. The software main window shows a console view with text messages and a progress bar.

**Probability of finding an impact**

Based on the current detections, detectable impacts in Jupiter could be frequent (2-40 per year; reference 2) or very rare (4.5 per year, see Marc Delcroix talk on session A11 on Wednesday 15th). 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 (in cm) 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**


**Acknowledgements**

We are grateful to Emil Kraaijcamp and Nicolas Andrè for discussions on impact detection and detection algorithms. Part of this work has been developed in the framework of the Europlanet 2020 Ri. Europlanet 2020 Ri has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 654208. This work has also been supported by the Spanish MINECO project AYA2015-65841-P (MINECO/FEDER, UE). Grupos Gobierno Vasco IT-765-13.