The need for Professional-Amateur collaborations to the monitoring of the gaseous giant planets

Emmanuel Kardasis /Hellenic Amateur Astronomy Association (Athens,Greece)
Grigoris Maravelias /Hellenic Amateur Astronomy Association (Athens,Greece) /Physics Department,University of Crete (Heraklion,Greece)
Padma Yanamandra-Fisher /Space Science Institute (Rancho Cucomonga,CA,USA)
Glenn Orton /Jet Propulsion Laboratory,California Institute of Technology(Pasadena,CA,USA)
John H. Rogers /British Astronomical Association (London,UK) /JUPOS team
Michel Jacquesson /JUPOS team
Apostolos Christou /Armagh Observatory (Armagh,UK)
Marc Delcroix /Societe Astronomique de France (Paris,France)

abstract

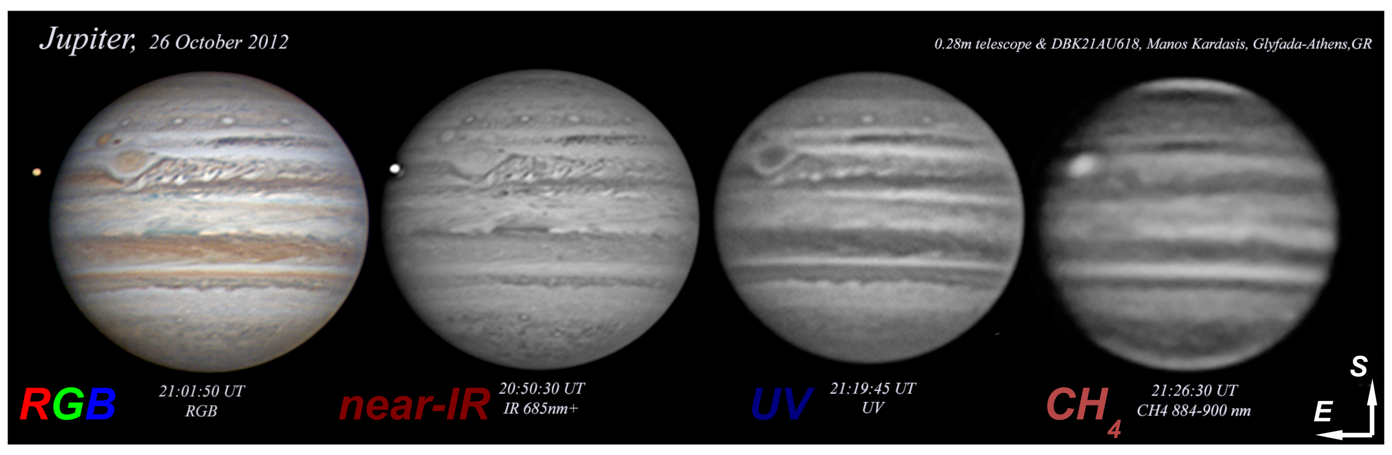
The observation of gaseous giant planets is of high scientific interest. Although they have been the targets of several space missions, the need for continuous ground-based observations still remains. As their atmospheres present fast dynamic environments on various time scales the time availability at professional telescopes is neither uniform nor sufficient duration to assess temporal changes. On the other hand, numerous amateurs with small telescopes (with typical apertures of 15-60 cm) and modern hardware and software equipment can monitor these changes daily (within the 360-900nm wavelength range). Amateur observers are able to trace the structure and the evolution of atmospheric features, such as major planetary scale disturbances, vortices, and storms. Photometric monitoring of stellar occultations by the planets can reveal spatial/temporal atmospheric variabilities. Their observations provide a continuous record and it is not uncommon to trigger professional observations in cases of important events, such as sudden onset of global changes, storms and celestial impacts. For example the continuous amateur monitoring has led to the discovery of fireballs in Jupiter's atmosphere, which provide information not only on Jupiter's gravitational influence but also on the properties of the impactors.

Thus, co-ordination and communication between professionals and amateurs is important. We present examples of such collaborations that: (i) engage systematic multi-wavelength observations and databases, (ii) examine the variability of Jovian cloud features (JUPOS-Database for Object Positions on Jupiter) and Saturn cloud features, (iii) provide, by ground-based professional and mainly amateur observations, the necessary spatial and temporal resolution of features that will be sampled by the space mission Juno, (iv) investigate video observations of Jupiter to identify impacts of small objects (Jovian Impacts Detection-JID and DeTeCtion of bolides in Jupiter atmosphere -DeTeCt software), (v) carry out stellar occultation campaigns.

1. Systematic multi-wavelength observations and databases

archives: BAA [1], ALPO [2], ALPO-Japan [3], SAF [4] + databases: ALPO-Japan [3], IOPW-PVOL [5], JUPOS [6]

Amateur (AM) & *Professional (PRO)* international databases of multiwavelength observations.
JUPOS = historical & modern database of measurements on atmospheric features.

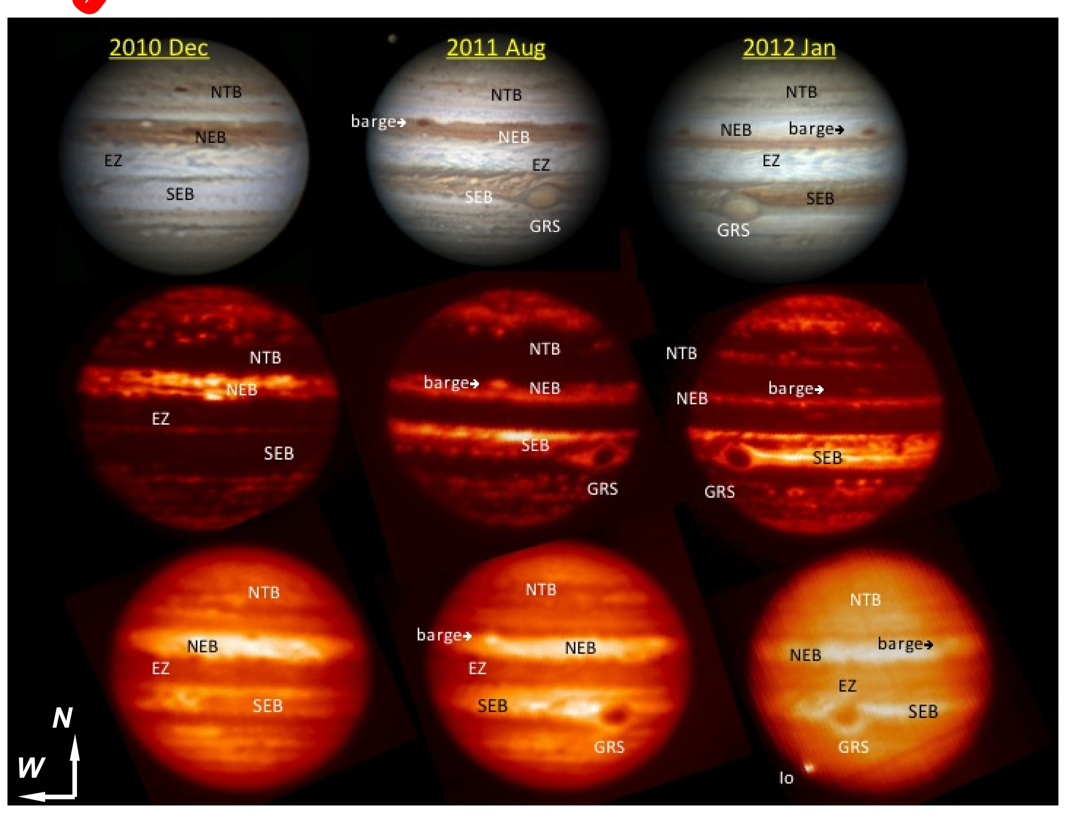


2. Ground-based space mission support

Problem: Failure of high-gain antenna deployment leading to reduced data rate. "Campaigns" on specific features which need accurate pointing and knowledge of their position beforehand.
Solution: > Monitoring of Jupiter in support of observations from NASA's Infrared Telescope Facility [7].
> Verification of these IR features so as to be used for predictions.

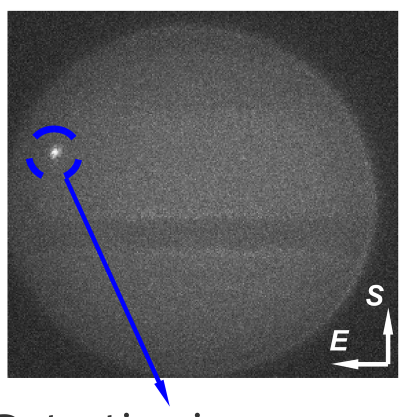
Problem: Cannot point everywhere at the same time.
Solution: Amateur alerts about rapidly evolving features, e.g. the link between a radio-signal burst and a bright cloud associated with an upwelling, which signaled the very beginning of the great storm of 2010-2011 [8].

Amateurs monitor Jupiter to provide contextual spatial and temporal information of atmospheric features [9].
**G. Orton serves as the point of contact.*



AM RGB image (Up) and **PRO** near-IR images at 5μm (middle) and 8.7μm (bottom), during phases of the SEB revival or the NEB fade. The 5μm filter is sensitive to cloud all the way down to the 2-3 bar pressure levels. The 8.7 μm filter offers a spectral "window" between methane emission and ammonia absorption lines, transparent to higher clouds of ~1-bar level, sensitive to maybe just ammonia-condensation [10].

3. Investigation of impacts on Jupiter's atmosphere



Detection image generated by DeTeCt for the June 3, 2010, impact flash (C. Go;[12]).

- First impact: 21 P/Shoemaker-Levy 9 (1994) by **PRO**
- 4 more impacts (2009, two in 2010, 2012) by **AM**

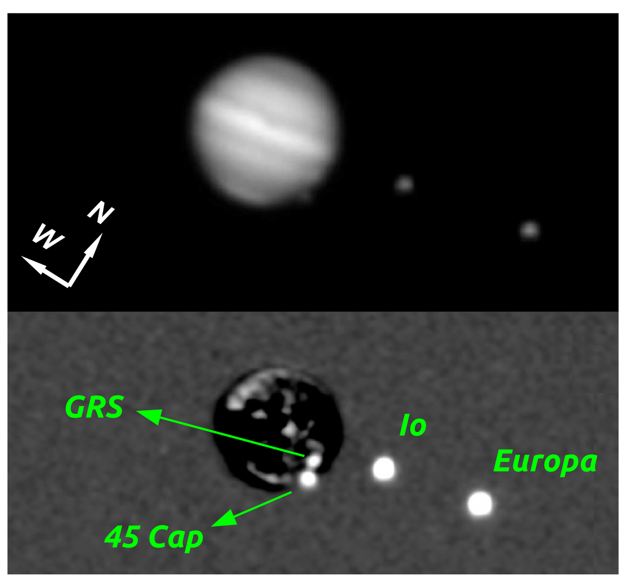
are there more ? how many ? — **JID & DeTeCt** software

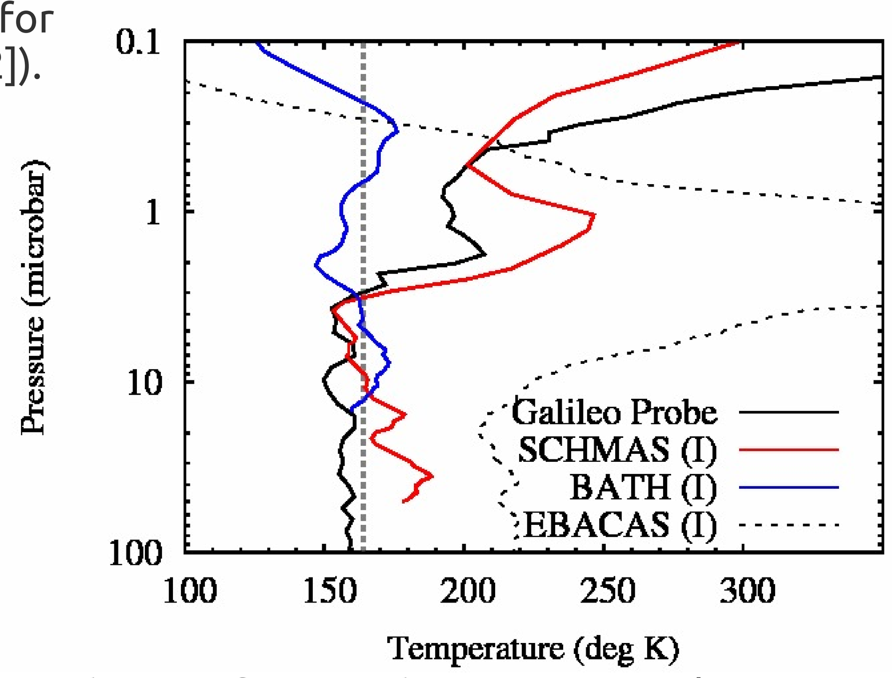
> Campaign to detect impacts in existing videos
> Constrain the rate of observable Jovian impacts

out of ~ 6d 6h 40m video time (July 2013)
Jovian impact rate < 6 /year [11]

4. Stellar occultations events

Goal: Ground-based observations to measure starlight attenuated by the intervening atmosphere due to differential refraction > determine structure and variability of planetary/satellite atmospheres.

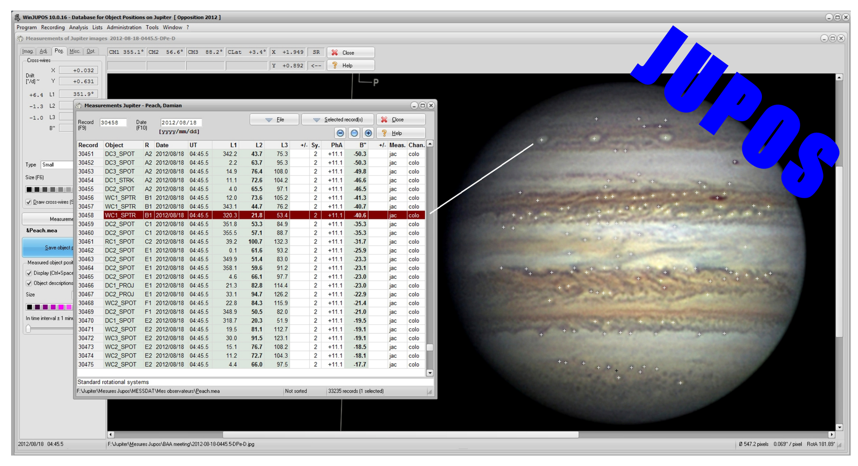




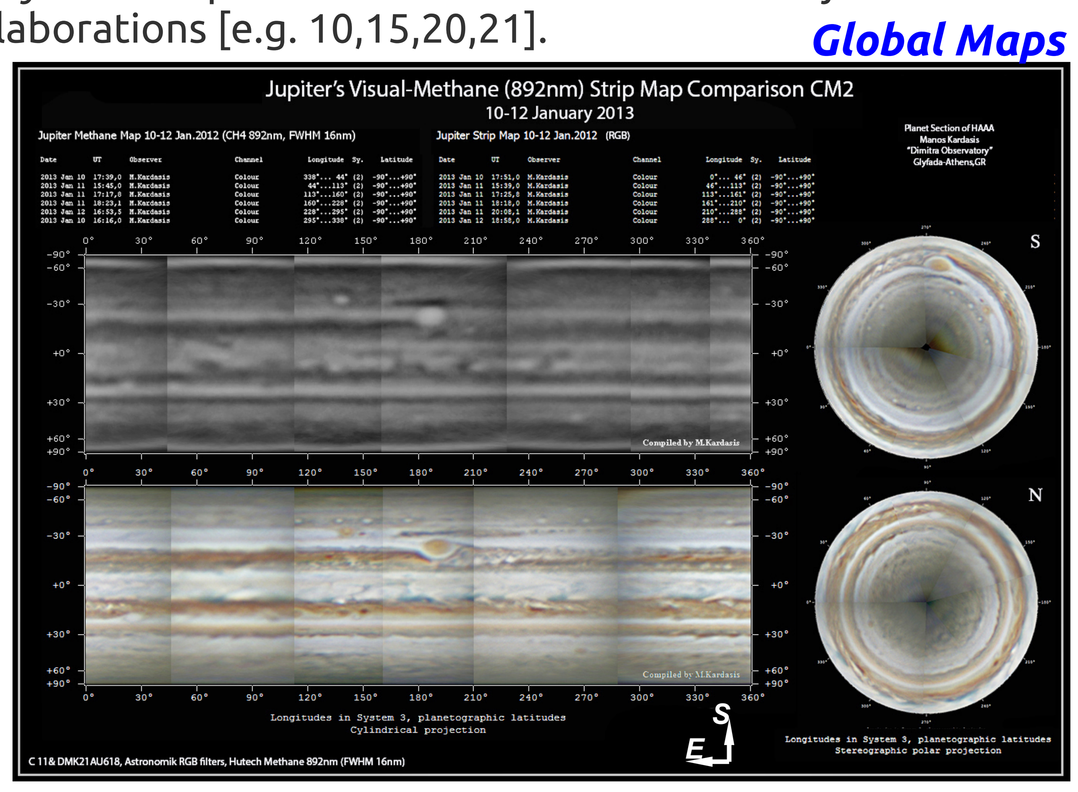
Left: Occultation of 45 Cap by Jupiter on 3/4 August 2009: CH_4 filtered Sabadell observations before (top) and after (bottom) template subtraction.
Top: Atmospheric profile derived in this work compared with in situ data from the Galileo Probe ASI investigation. Ingress profiles from data acquired by both **PRO** and **AM** observers at Teide (SCHMAS), Calar Alto (EBACAS) and Hakos (BATH) [13].

5. Examination of the cloud features variability

PRO cons: Rapidly-varying atmospheric features (e.g. Jupiter). Large-scale climatic cycles of several years. Limited time availability on professional telescopes
AM pros: Continuous monitoring over many years.
Results: Unveiling peak speeds and variability of major jets [14,15]. Monitoring the evolution of major events like fading or narrowing and subsequent violent revivals of South/North Equatorial & North Temperature Belts [10,14,16]. Track of changes in the Great Red Spot like its rotational period [17,18,19,20]. Monitoring of shape, color and speed of vortices [21] and other disturbances, waves, small scale and ephemeral events such as impacts [16,22].
Many of the phenomena have been the subject of **PRO-AM** collaborations [e.g. 10,15,20,21].

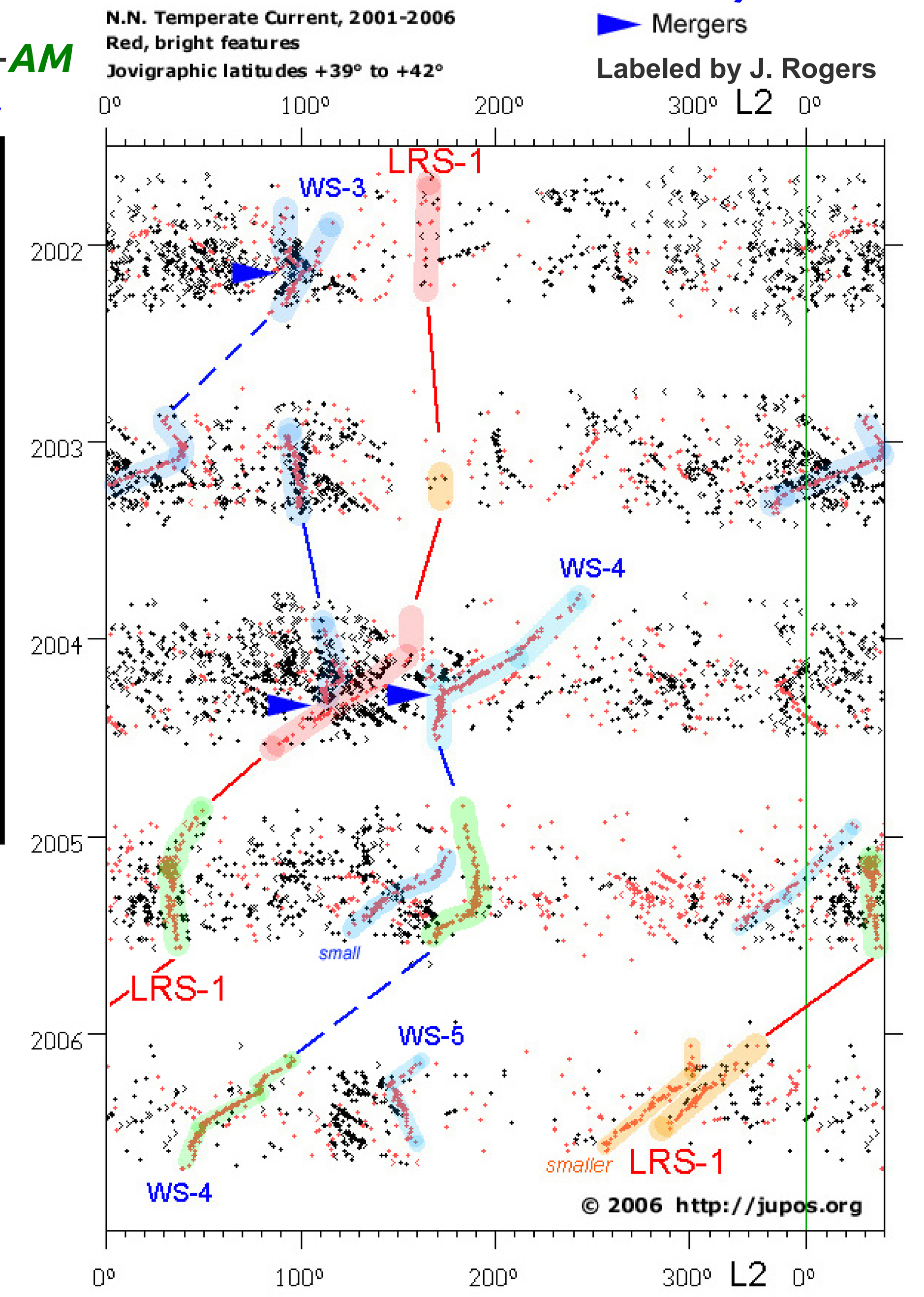


Global Maps

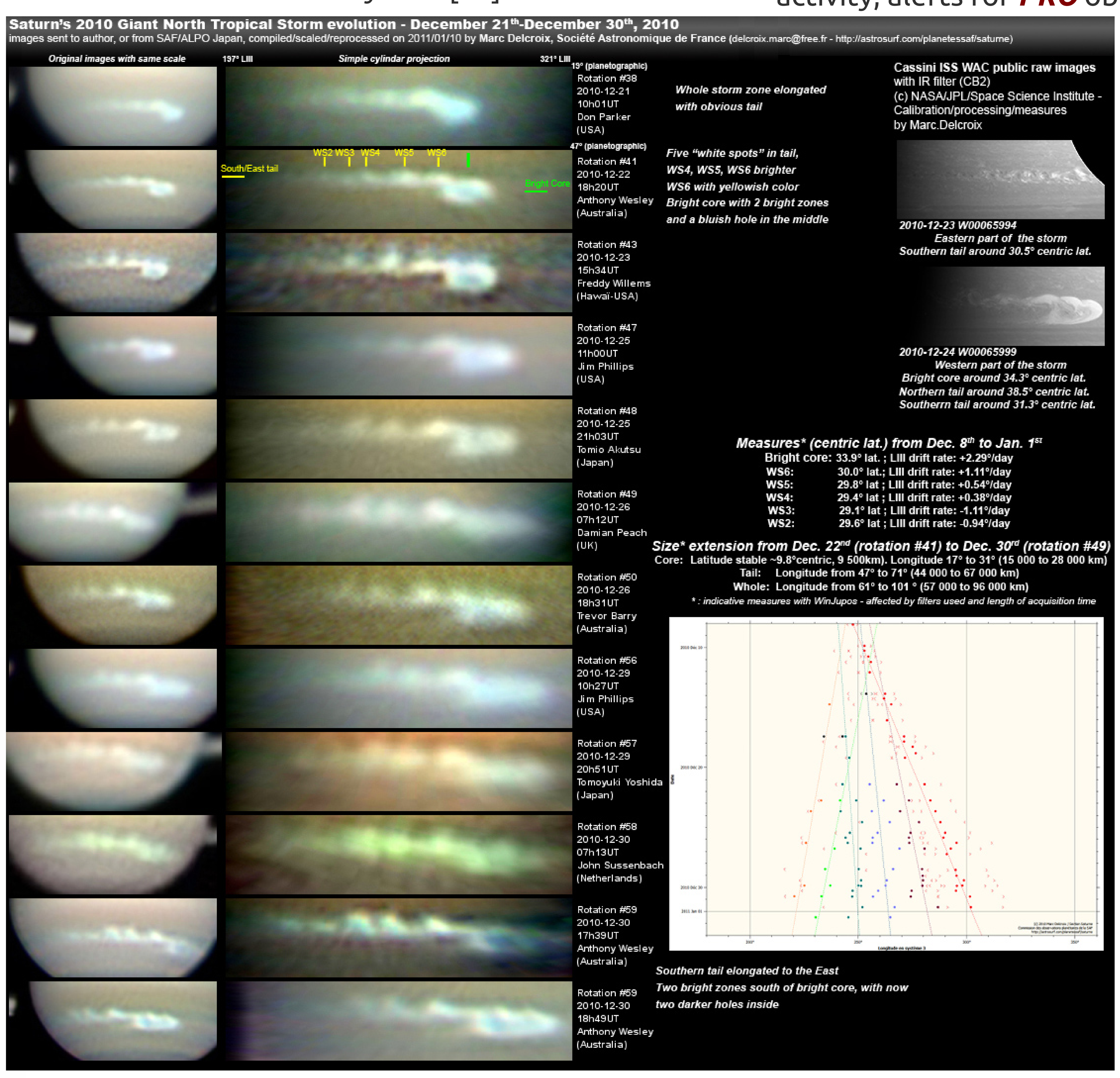


Top: Maps of Jupiter during January 10-12, 2013, in the CH_4 filter (brighter areas means higher altitude formations; top left), and in a color RGB image (bottom left). The South (top right) and North (bottom right) polar projections of the planet in the RGB filters (E. Kardasis).
Right: Drift chart of anticyclonic ovals in the NN Temperate Current (+39° to +42°). The red oval LRS-1 was found to be a persistent feature for more than 15 years, with changes in appearance and drift rate which would remain undetected by the infrequent professional observations. White ovals (WS) were also tracked over several years [23].

Drift charts



Reports: description of world-wide observations, analysis of events and their evolution, discovery of new features, predictions of activity, alerts for **PRO** observations [16].



PRO cons: Limited resolution of *Cassini*'s Radio and Plasma Wave Science instrument (observing Saturn Electrostatic Discharges – SEDs – radio signatures of lightnings).
AM pros: Amateur imaging in the optical wavelengths locates the white spots that are the sources of the SEDs. Increasing quality and systematic coverage over many years provide the ability to calculate the drift rates and follow the shape evolutions of the visible white spots [24,25]. E.g. the evolution of the Great White Spot (GWS) eruption of December 2010 [26,27], and the analysis of around 100 spots contributing to the study of Saturn's wind profile over all latitude range of the GWS [28].

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