JUPITER IN 2007: FINAL NUMERICAL REPORT

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2008 December

<http://www.britastro.org/jupiter/2007reports.htm>

CONTENTS

(Six PDF files)

(Also, for higher-quality versions of charts, a separate GIF file for Fig.1, & separate ZIP file for the JUPOS figures [Fig.6, etc.])

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Part 1: Introduction

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Foreword

In 2007, Jupiter underwent a dramatic set of disturbances that had not been seen since 1990 or 1993, comprising a 'global upheaval'. These events were tracked in greater detail than ever before thanks to the high quality of modern amateur images and analysis. In order to make the results of this analysis available without delay, we present them here as a preliminary web publication. This is a complete report on the positions and motions of individual spots, derived from the JUPOS database.

This report represents the work of the JUPOS team: Hans-Joerg Mettig, Gianluigi Adamoli, Marco Vedovato, Michel Jacquesson. We are very grateful to all the observers **(Table 1)**, and to Grischa Hahn for his work on the WinJUPOS software.

This report does not aim to repeat material previously covered in interim reports, which include descriptions and image compilations of the major outbreaks, and discussion of the global upheaval. We have already published 19 interim reports, on this web site:
http://www.britastro.org/jupiter/2007reports.htm

--and three interim reports in the Journal of the BAA (vol.117, p.113, 2007 June; p.226, 2007 Oct.; vol.118, p.9, 2008 Feb.), which give an overall summary. They are also provided as PDFs on this web site:
http://www.britastro.org/jupiter/publications.htm [go to 'Interim reports...'].

However we include some image sets, to document newly-reported phenomena or to fill gaps in previous coverage. In particular the v-hi-res images from Damian Peach on Barbados were received after the early reports, and are incorporated here.

Several topics in the apparition remain to be completed, esp. an analysis of the multispectral images. Also, the present report does not attempt a complete discussion of the background to the phenomena mentioned, either from the literature, or from other recent apparitions (reduction of the JUPOS data for those since 2002 is still in progress). Apart from these matters, this set of reports now comprises a final report on the 'Local features and drifts' for this important apparition of 2007. We are publishing it on this web site (without finishing all of the formatting to publication standard) so that observers and scientists can access the results as soon as possible, and so that we can show more images and data than would be possible in a printed article. An edited summary will be prepared for publication as the final report in the JBAA in due course.

Summary

Jupiter's Global Upheaval in 2007:

Most of the major belts and zones had presented a fairly constant appearance from 1996 to 2006. Sometimes the planet presents a very different appearance, particularly during a 'global upheaval' (e.g. 1990) which involves planet-wide changes including coloration of the EZ, fading and vigorous revival of the SEB, and a super-fast outbreak on the NTB. At the start

of 2007, unexpected changes suggested a global upheaval was starting: exceptional darkening of the EZ, and quiescence of the SEB which, as predicted, soon led to fading.

Then in March, a super-fast NTB outbreak began, with brilliant white plumes initiating the turbulent revival of the belt. Meanwhile the SEB began to fade as we expected, leading to a violent outbreak initiating the SEB Revival. This started surprisingly early, on 2007 May 17. It generated dark spots in the rapidly retrograding SEBs jet-stream. Another novel feature of the apparition was a pair of South Tropical Disturbances (STrD's), and as the retrograding spots arrived at STrD-1, they performed a U-turn, one after the other, in a spectacular display of the 'Circulating Current' that had not been fully seen since the BAA Jupiter Section first described it in the 1920s and 1930s.

This was the first global upheaval since the advent of modern hi-res imaging by amateurs, so it was followed with far greater temporal and spatial resolution than any previous instance. It has enabled us to see a closer relationship between the key SEB and NTBs outbreaks than was previously appreciated. It now seems that they typically start within a few months of each other, presumably due to some unknown global predisposition; and they begin in a surprisingly similar manner, with a convective upsurge of clouds which can only rise up from a deep condensation level when special conditions prevail in the cloud-top layer. These topics are discussed in another interim report in 2008:
http://www.britastro.org/jupiter/2008report03.htm

Interesting results from the JUPOS analysis in this report include:
>> A white spot was rapidly prograding at 65ºS, further south than any spot previously tracked.
>> The spots retrograding in the SEBs jet and recirculating in the STBn jet displayed a clear gradient of speed with latitude and size, confirming that such spots 'roll' along the jet-streams, but also with some anomalies that may be unique to this outbreak.
>> At the source of the SEB Revival, not only did the first white spot erupt within a cyclonic 'mini-barge', but the next four white spots also erupted from exactly the same location.
>> The major NEBs projections belonged to two periodic systems with different speeds and spacings, which intersected and showed wave-like interference.
>> There was unusually extensive rift activity throughout the NEB.
>> There were three super-fast bright plumes in the NTBs outbreak, not just two, and they all broke up as they encountered the disturbance in the wake of the other plumes.
>> A previously unknown type of disturbance affected a localised sector spanning two high-latitude domains, from 45-54ºN.

We detect outbreaks of spots on five prograding jetstreams (S^3TBn, SSTBn, STBn, NTBs, and NNTBs), and on the retrograding jets on STBs and SEBs.

Finally, we present the first ground-based profile of speed versus latitude that is sufficiently detailed to show the regular alternating pattern of 'zonal winds' (i.e., the average speeds of winds blowing east or west) – a pattern which has previously been detectable only by spacecraft. This is shown in **Figure 1.** Thus we detect not only the specific jet-streams and the standard currents for major stable features, but also the gradients of wind speed with latitude across many of the domains, as revealed by smaller or more transient spots. Although we have detected these gradients in some domains before, the 2007 results show them in most domains from 60ºS to 55ºN. Comparing this profile with those from spacecraft, we confirm that at low latitudes, stable ovals tend to move more slowly than the ambient winds, but at high latitudes, all spots follow the zonal wind patterns. These results will be combined with data from 2003-2006 (in preparation) to give a more complete profile, to be discussed in a separate paper.

Observations, Analysis, & Acknowledgements

Opposition was on 2007 June 5d at 23h UT. Jupiter was in Ophiuchus, at declination 22ºS.

Amateur images and maps:
We are very grateful to all the observers; they are listed in **Table 1**. There were a few lo-res images in each month from 2006 Dec. to 2007 Dec., but imaging with moderate resolution and frequency extended from 2007 Jan. to Oct., and with high resolution and high frequency (some images every night) from late Feb. to early Sept.

With the planet so far south, observers in the tropics, Australia, and Brazil, were very important. Damian Peach took v-hi-res images from Barbados from May 23 to June 8. Australian observers were hampered by winter weather from July onwards, but fortunately Chris Go (Philippines) and Isao Miyazaki (Okinawa) produced numerous hi-res images. New observers began to contribute from southern Europe, and observers in Japan and the USA also managed to get decent images. Many of these were provided via the ALPO-Japan web site:

http://alpo-j.asahikawa-med.ac.jp/Latest

-- and via the (American) ALPO news-group, and we are grateful to the organisers of these groups.

Maps were routinely prepared by Yuichi Iga and by Marco Vedovato, from images on the ALPO-Japan web site. Damian Peach's map from his own images covering May 25-27 is the best ground-based map from the apparition. Hi-res maps were also made by Grischa Hahn from images taken by Chris Go, June 27 – July 21 [one was published in interim report in JBAA]. These maps are shown in **Figure 2.**

Several observers took images in multiple wavebands from UV to IR, esp. the methane band; these will be surveyed in a subsequent report.

Spacecraft images:
The New Horizons spacecraft took images at ≥ ground-based resolution on several dates in January (LORRI) and late February (LEISA).
The Hubble Space Telescope (HST) took images on March 8, March 25, May 11, and June 5.
Except where we specifically refer to spacecraft images for comparison, all the information in this report is from the ground-based amateur images.

Analysis:
Measurements of longitude (L1, L2) and latitude (zenographic) were done by the JUPOS project. The JUPOS database comprised 45,293 measurements of features on images during 2007. These were done by Gianluigi Adamoli, Michel Jacquesson, Hans-Joerg Mettig, and Marco Vedovato. The JUPOS team also provided charts showing all these spots in each latitude band: see <http://jupos.org>. For hi-res enlargement of individual spots, and latitude determination, selected portions of the JUPOS database were re-plotted in Excel. The typical scatter of measurements is ~0.3 to 0.6 deg (standard deviation, as quoted for latitudes in the tables). As there are numerous measurements for most spots, the standard errors of the mean are <0.1 deg (much less than the sizes of the spots). Therefore the uncertainties in drift rates are ~1 deg/mth (~0.5 m/s) for features tracked for one month, and less for those tracked for longer. For such long-lived features, intrinsic variations in speed are usually larger than the uncertainty in measurement.

We compare our drift rates with the zonal wind profiles measured from spacecraft. Profiles are now available from:
-- Voyager in 1979 [Limaye, 1986];
-- Hubble Space Telescope (HST) in 1995-98 [Garcia-Melendo & Sanchez-Lavega, 2001];
-- Cassini in 2000 [Porco et al., 2005, Science 299, 1541; numerical data kindly provided by A. Vasavada];
-- New Horizons in 2007 [Cheng et al., 2008, A.J. 135, 2446; numerical data kindly provided by A. Cheng & A. Simon-Miller].
We adopt the Cassini profile for reference as it is based on the most extensive and high-quality data. A more detailed comparison of these profiles with each other and with our ground-based data is in preparation.

NOTES:
In the following accounts:
-- All drifts (DL1, DL2) are in degrees longitude per 30 days, as usual.
-- AWO, anticyclonic white oval; GRS, Great Red Spot;
LRS, little red spot (anticyclonic reddish oval).
-- On the JUPOS charts: black = dark spots, red = bright spots, unless otherwise stated.

TABLE 1 & FIGURES ARE ON FOLLOWING PAGES.....

Table 1. Observers, 2007

Images

Observer	*Location*		*Telescope*
Adcock, Barry	Melbourne	Australia	360 mm Schiefspiegler
Adelaar, Jan	Arnhem	Netherlands	235 mm SC (C9.25)
Akutsu, Tomio	Cebu	Philippines	C8 or C11
Arditti, David	Edgware, Mdx	UK	C11 = 280 mm Sch-Cass.
Arditti, David	& Haute Provence	France	
Bertrand, Guillaume	St. Laurent sur Sevre	France	114-mm Newt.
Bosman, Richard		Netherlands	280 mm Sch-Cass.
Buda, Stefan	Melbourne	Australia	400 mm Dall-Kirkham
Carvalho, Fabio	Sao Carlos	Brazil	180 mm Newt.
Carvalho, Fabio		then	254 mm Newt.
Casquinha, Paulo	Setubal	Portugal	250 mm Newt.
Castella, Jaume	Badalona	Spain	280 mm Sch-Cass.
Chang, Daniel	Hong Kong	China	C8 or Mewlon-250
Chester, Geoff	* Alexandria	VA, USA	200 mm Sch-Cass.
Chester, Geoff	& US Naval Obs., Washington	DC, USA	305 mm OG
Colville, Brian	Cambray, Ontario	Canada	300 mm Sch-Cass.
Coombs, Arthur	Melbourne	Australia	250 mm Newt.
Cosenza, Riccardo	Palermo	Italy	C8 = 203 mm Sch-Cass.
Davidson, Jim	Fortaleza	Brazil	150 mm Sch-cass.
Delcroix, Marc	Tournefeuille	France	LX200 254 mm
Dickinson, Bill	* Glen Allen	VA, USA	C8 = 203 mm Sch-Cass.
Dupont, Xavier		France	180-mm Newt.
Edwards, Peter	W. Sussex	UK	C8 = 203 mm Sch-Cass.
Einaga, Hideo**	Kasai, Hyogo	Japan	250 mm Newt.
Fattinnanzi, Cristian**	Macerata	Italy	250 mm Newt.
Fattinnanzi, Cristian**		or	204 mm Sch-Cass.
Fernandez, Jose	Aralla, Leon	Spain	130 mm APM/TMB
Foulkes, Mike	Hitchin	UK	203 mm SC
Fukui, Hideto**	Fujieda	Japan	C14 = 356 mm Sch-Cass.
Ghomizadeh, Sadegh	Tehran	Iran	C11 = 280 mm Sch-Cass.
Go, Christopher	Cebu	Philippines	C11 = 280 mm Sch-Cass.
Grassmann, Guilherme**		Brazil	254 mm Sch-Cass.
Haese, Paul	Blackwood, S.	Australia	235 mm SC (C9.25)
Hancock, Ian	Canterbury	UK	254-mm Meade LX-200R
Hatton, Jason	Noordwijk	Netherlands	235 mm Sch-Cass.
Heffner, Robert**		Japan	C11 = 280 mm Sch-Cass.
Ikemura, Toshihiko	Nagoya	Japan	310 mm Newt.
Jacquesson, Michel	Sevigny-Waleppe	France	C8 = 203 mm Sch-Cass.
Jakiel, Richard	* Douglasville	GA, USA	305 mm LX200
Justice, Mark	Melbourne	Australia	254 mm Dall-Kirkham
Kardasis, Manos	Athens	Greece	254 mm Meade LX200
Kazanas, John	Melbourne	Australia	317 mm Newt.
Kolovos, Dimitrios	Athens	Greece	C11 = 280 mm Sch-Cass.
Kumamori, Teruaki**	Sakai, Osaka	Japan	200 mm Dall-Kirkham
Lawrence, Peter	Selsey	UK	C14 = 356 mm Sch-Cass.

Lazzarotti, Paolo		Massa & Mt. Giogo	Italy	315 mm Dall-Kirkham (own Gladius)
Lewis, Martin		Herts.	UK	222 mm Newt.
Lomeli, Ed	*	Sacramento	CA, USA	235 mm SC
Maxson, Paul	*	Surprise	Arizona, USA	250 mm Mewlon
Medina Manzano, Gabriel				178 mm Mak-Cass.
Medugno, Antonello		Capua	Italy	356 mm Sch-Cass.
Mishina, T.**		Yokohama	Japan	200 mm Newt.
Miyazaki, Isao		Okinawa	Japan	400 mm Newt.
Moore, David M.		Phoenix	Arizona, USA	362 mm Cass.(new)
Morisan, Richard			France?	Meade LX50 (200 mm)
Ng, Eric, et al.		Hong Kong	China	320 mm Newt.
Olivetti, Tiziano		Bangkok	Thailand	275 mm Newt.
Ortega, Jordi		Barcelona	Spain	
Ortega, Jordi	&	Javalambre, Teruel	Spain	Mewlon 210
Owens, Larry		Alpharetta	Georgia, USA	C14 = 356 mm Sch-Cass.
Parker, Donald C.		Coral Gables	FL, USA	406 mm Newt.
Parker, Donald C.			or	254-mm Mewlon
Peach, Damian		Barbados	Barbados	C14 = 356 mm Sch-Cass.
Pellier, Christophe		Versailles	France	250 mm Cass.
Phillips, Jim		Charleston	SC, USA	TMB 8" or 10"
Phillips, Michael*		Swift Creek	NC, USA	C8 = 203 mm Sch-Cass.
Pretorius, David		Launceston, Tasmania	Australia	254 mm Newt.
Prost, Jean-Pierre		Antibes	France	Takahashi-CN212 (Cass.)
Pujic, Zac		Brisbane	Australia	310 mm Newt.
Salway, Mike		NSW	Australia	12" Newt.
Sanchez, Jesus R.		Cordoba	Spain	250 mm Klevtsov-Cass.
Sherrod, Clay			AK, USA	
Soldevilla, Jose A.		Canyelles, Barcelona	Spain	250 mm Newt.
Todd, Larry		Dunedin	New Zealand	200 mm [OMC200]
Tyler, Dave		High Wycombe, Bucks.	UK	C14 = 356 mm Sch-Cass.
Valimberti, Maurice		Melbourne	Australia	C14 = 356 mm Sch-Cass.
Vandebergh, Ralf		?	Netherlands	250 mm Newt.
Walker, Sean		Chester	NH, USA	317 mm Newt.
Warren, Joel	*	Amarillo	TX, USA	200 mm Sch-Cass.
Watson, Matt		Canberra	Australia	
Wesley, Anthony		Murrumbateman, NSW	Australia	333 mm Newt.
Yunoki, Kenkichi**		Sakai, Osaka	Japan	260 mm Newt.
Zannelli, Carmelo		Palermo	Italy	280 mm Sch-Cass.

NOTES: * via ALPO (USA).

** via ALPO-Japan web site.

Cameras used are not listed here, as during the 2007 apparition, most observers who had previously used Philips ToUcam or Lumenera Lu075M cameras switched to DMK21AF04 or Lumenera SKYnyx 2-0M.

Table 1 (continued):

Additional observers via JUPOS:

	[Italian observers per Marco Vedovato]	
Bortolotti, Michele	Verona	Italy
Botallo, D.	Palermo	Italy
Cardin, Marco		Italy
Cellini, C.	San Romualdo, RA	Italy
Comolli, L.		Italy
Di Nasso, Riccardo	Pisa	Italy
Di Stazio, A.	Roma	Italy
Fabrizio, Michele	Isernia	Italy
Mancini, Riccardo	Cerreto Guidi (FI)	Italy
Mingo, Mauro	Cupramontana (AN)	Italy
Placenti, C.	Gela (CL)	Italy
Ravagnin, Alessandro	Chirignago (VE)	Italy
Rhodes, Jason V.	Albenga (SV)	Italy
Saltamonti, S.		Italy
Tonon, A.	Torino	Italy
	[French observers per Michel Jacquesson]	
Lecleire, Jean-Marc	Paris	France
Poupeau, Jean-Jacques		France
Rieugnie, Marc	Toulouse	France

Visual observers:

Observer	*Location*		*Telescope*
Abel, Paul	Leicester	UK	200 mm Newt.
Adamoli, Gianluigi	Verona	Italy	
Cicognani, Massimo	Collina, FO	Italy	
Colombo, Emilio	Gambarana, Cambio	Italy	150 mm Newt.
Heath, Alan	Nottingham	UK	C8 = 203 mm Sch-Cass.
Hernandez,Carlos		FL, USA	230 mm Mak-Cass.
Horikawa, Kuniaki	Yokohama	Japan	160 mm Newt.
McKim, Richard	Upper Benefield, Notts.	UK	410 mm Dall-Kirkham-Cass.
Mosch, Joerg	Meissen	Germany	
Siliprandi, Paolo	Vimercate, MI	Italy	

Figure 1 [below]: Global zonal wind profile. JUPOS/BAA data in 2007 (this report) are compared with Cassini data in 2000 [Porco et al.(2005) Science 299, 1541; numerical data kindly provided by A. Vasavada]. Data from the subsequent tables in this report are grouped as follows: *(Large dark green points:)* Large spots or groups of spots: these are the kinds of features which would have been recorded in historical visual reports, defining the major currents; they often interrupt the zonal wind pattern.
(Small brown points:) Smaller spots and rifts: these tend to follow the zonal wind gradient even where larger spots do not, although they do not reach the peak speeds in many of the jets.
(Small light green points:) Exceptional spots in the SEB and Circulating Current, as described in this report.
High-latitude prograde jets are abbreviated in the form S3 for S^3TBn, N3 for N^3TBs, etc.; this will provide a simpler nomenclature in future now that these jets are observed up into the polar regions.
[See separate GIF file for higher-quality version.]

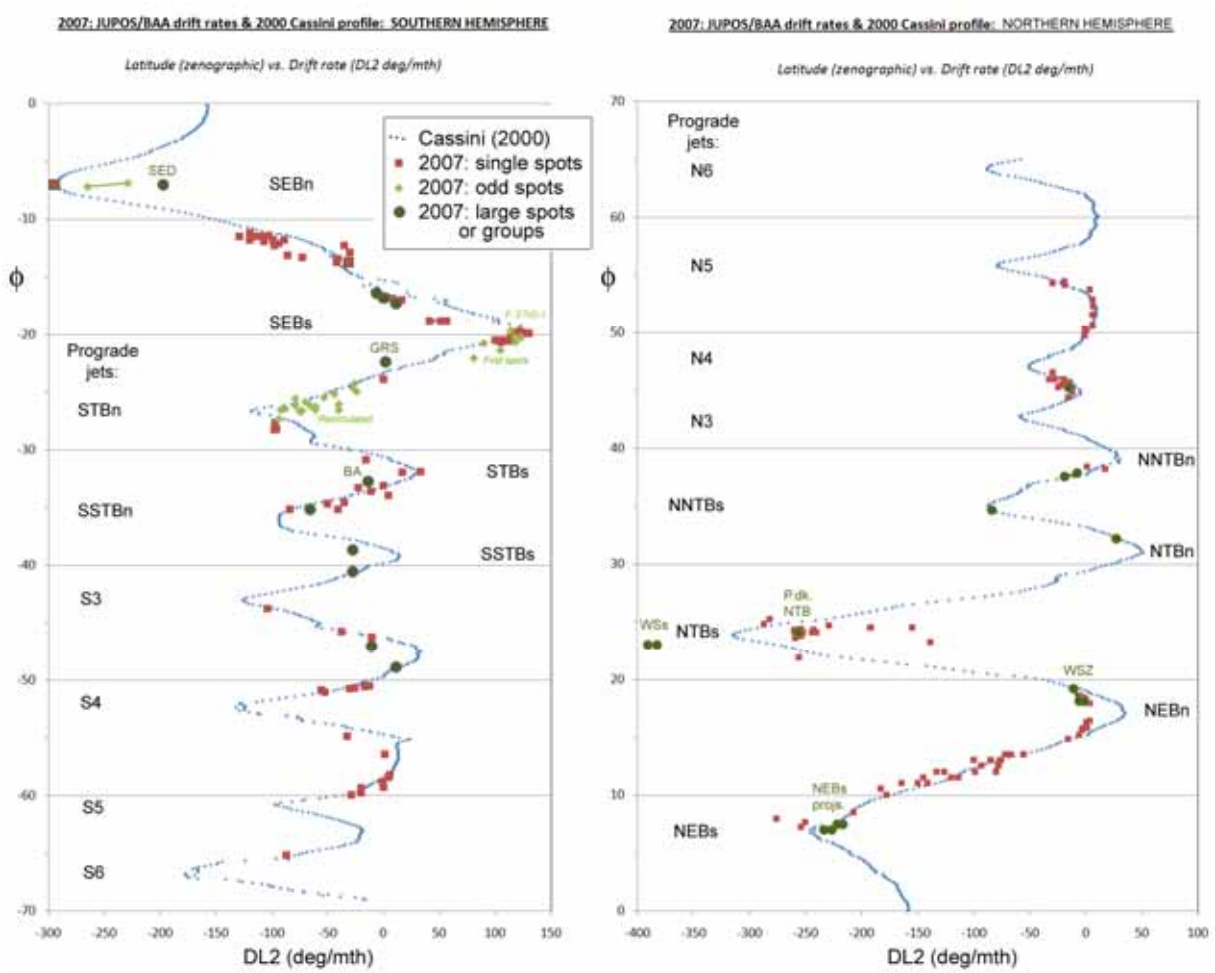
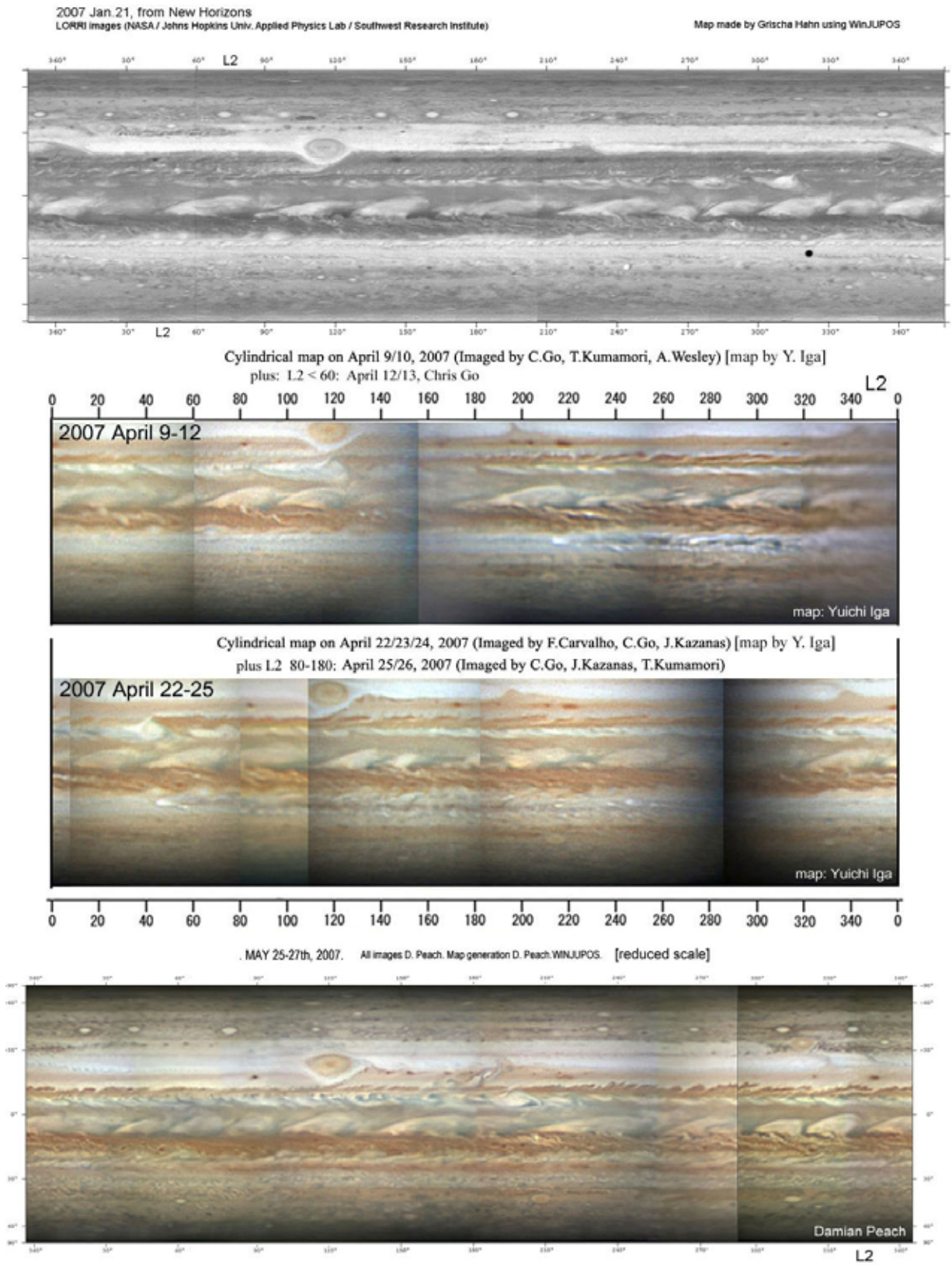
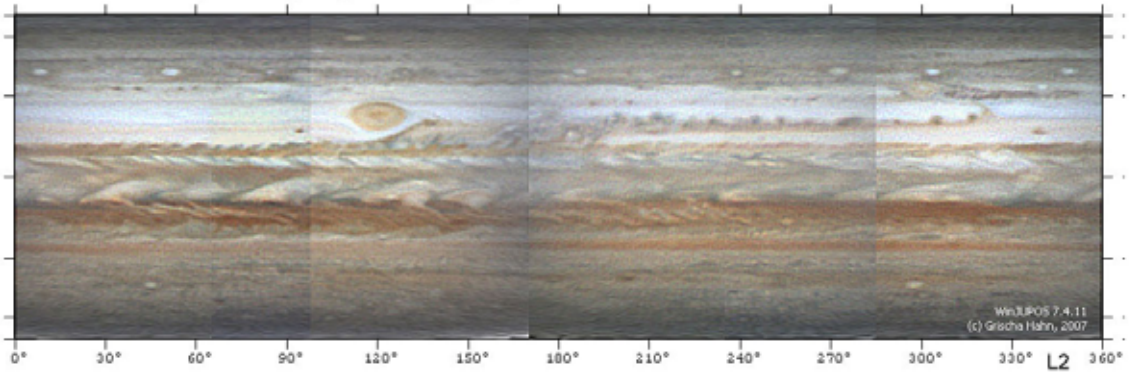


Figure 2 [below]: Global maps. Six cylindrical projection maps from 2007, including one from New Horizons images. See the rest of this report for portions of these with features labelled. South is up in these maps (and in all images in this report).



2007 June 27 -- July 3 Images by Chris Go, Map by Grischa Hahn



2007 July 19-21 Images by Chris Go, Map by Grischa Hahn