EPSC Abstracts
Vol. 11, EPSC2017-236-1, 2017
European Planetary Science Congress 2017

A simplified method to track long-term changes in Jupiter's belt/zone structure

Emmanuel (Manos) I. Kardasis (1)
(1) Hellenic Amateur Astronomy Association , Athens-Greece, astromanos2002@yahoo.gr / Tel.00306945335808)

Abstract

Jupiter atmosphere is extremely dynamic, showing a variety of phenomena generally organized in dark belts and bright zones which often change in color, width and latitude. It is not unusual that some disappear or reappear. Long-term changes (e.g annual) in this banded pattern need to be tracked by measuring the latitude of belts and zones and examining their coloring. Digital observations with planetary cameras in recent years have introduced many new ways of exploring the planets. In this work we present a methodology and some results of "Averaged Filtered Observations (AFO)", a simple way to measure the bands edges in order of latitude and view the overall contrast or color of the bands. A series of such AFO over several years would give a good record of the changes in latitude, the darkness/brightness/color of the bands, and their shift through time. This work may trigger average observations of this type by amateurs in different spectral bands and not only in Jupiter.

1. Introduction

Early astronomers, recorded the changing appearance of Jupiter's atmosphere. Historical accounts of banding changes can be found in [1,2, 3,4,5]. Amateur astronomers worldwide continue the observation by capturing hi-res images useful for professionals [6]. Moreover, many innovative techniques have been introduced with the use of modern technology and equipment [7,8]. In the following we will provide some information and results of a relatively simple imaging methodology we call "Averaged Filtered Observation (AFO)".

2. Methodology

The basic methods of planetary imaging are presented at [9] and for ~890nm imaging at [10]. Additionally, the AFO methodology, has the following workflow:

1. *Equipment*: typical planetary imaging setups are used, usually consisting of a 8'-20' telescope, a planetary camera and a PC.
2. *Filters:* all types of filters can be used depending on the spectrum we want to examine. In this work we mainly use a ~890nm methane absorption band filter that reveals the relative altitude of the bands. Furthermore the banding structure is better defined.
3. *Capturing:* a long series of videos in order to avoid distortion from discrete features in the band/zones. Longer duration will give a better, smoother average . A total duration capturing about 1/3 of the planet's globe is proposed. We should avoid the presence of the Great Red Spot in our view.
4. *Stacking* with Registax [11] or Autostakkert [12] is done on all individual videos without derotating the images [6].
5. *Processing.* Further image processing (e.g. applying wavelets, adjusting brightness-contrast) is then performed in these or other photo-processing programs like in normal planetary imaging.

3. Observations and results

All AFO's were obtained with small telescopes during latest Jupiter apparitions. Experiments were mainly made in the methane absorption band at ~890nm. Other filters can be used depending on the spectral band we want to investigate.

3.1 Jupiter AFO in the ~890nm band

In the ~890nm we captured the rotation of Jupiter for about 3h and 10min when the GRS was not visible. This produced about 164000 low resolution frames that were combined (stacked) without derotating them. After some smooth wavelet processing it resulted the image of Fig.1. All discrete features disappeared and a smooth average of the banding structure brightness is captured.

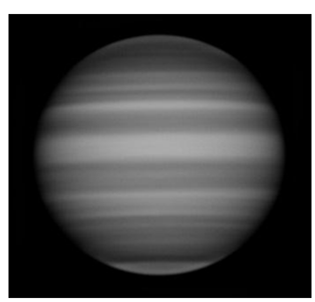

Figure 1. *The AFO result on Jupiter,15, April 2017, 18:20 - 21:30UT, Average brightness of Bands and Zones at ~890nm, (0.35m telescope, ASI290mm cam., Hutech BPF filter)[N is up], A calibrated version (presented at [13,14]) of this obs. could reveal the relative average height of each belt and zone.*

3.2 Comparing annual AFO's

The long term-variability of the banding structure and brightness can be tracked by comparing annual AFO's. The phase angle effect (PAE) must be considered when comparing average images at different epochs. So the planetary software WinJupos [15] was used (that calculates the PAE) to make two AFO maps from the latest apparitions of Jupiter that span 90 degrees in longitude [Fig.2].

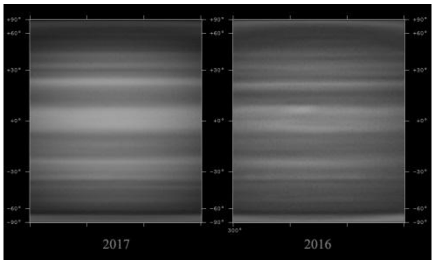

Figure 2. *A comparison of Jupiter's AFO made in the latest apparitions (left 2017/04/15 and right 2016/02/26-2016/03/20)*

3.3 Measurements of Belts/Zones Latitudes

The belts occur in almost the same latitudes in every apparition but sometimes their edges shift becoming narrower, broader or even disappear completely [2]. With the use of just one AFO image and the use of WinJupos software [15] we may measure the latitude of belt and polar hood edges. We measured the average latitudes in the AFO image of Fig.1 in 14-18 different positions of every edge. In the last column the typical Latitude of the belt is presented. By measuring annually with this method long term banding changes can be tracked.

Belt/Zone Region edge	No of Measured Positions	Average B"[°] (Jovigraphic latitude)	Standard Deviation (σ)	Typical B" [°]
SP hood	14	-67,09	0,56	
S3TBn	15	-41,50	0,31	-43
SSTBs	14	-39,47	0,32	
SSTBn	16	-34,90	0,34	-37..-36
(STZ)				
STBs	16	-32,26	0,40	-32
STBn	16	-25,32	0,37	-29..-27
STropZ				
SEBs	16	-21,39	0,35	-20
SEBn	16	-8,21	0,38	
EZ				
NEBs	16	8,28	0,57	
NEBn	16	21,30	0,33	17
NTropZ				
NTBs	16	24,68	0,25	24
NTBn	16	32,28	0,29	+31..+32
NTZ				
NNTBs	15	34,85	0,31	+35..+36
NNTBn	14	40,24	0,45	+39..+40
NNTZ				
N3TBs	18	42,96	0,35	43
NP hood	14	69,87	1,06	

Table 1. *Latitude measurements of main Belts and Polar hood edges from AFO image of Figure 1.*

3.4 The AFO method in the visual spectrum

The AFO can be used also to track colorization changes in the atmosphere of Jupiter

3.5 The AFO method in other planets

AFO can also be used in Saturn and possibly in Uranus and Neptune though for ice giants may be rather challenging. In Saturn it is not as useful as in Jupiter because Saturn presents very few discrete features, so the banding structure is much more uniform in simple planetary observation.

4. Summary and Conclusions

New technology and image processing techniques allow many new methods of planetary observations. We presented the AFO methodology and some preliminary results on Jupiter. Measurements of the belts and zones latitudes can be easily made in just one AFO image. A simple comparison of annual images made with AFO in the 890 nm wavelength range can easily show significant long-term changes in the belt/zone pattern. The use of AFO in the visual band can also reveal colour changes from year to year.

Acknowledgements

I would like to thank my wife Dimitra and my sons John & George, for their patience and support. Special thanks to John Rogers for making comments.

References

[1] Peek, B. M.,1958, The Planet Jupiter, Faber & Faber
[2] Rogers, J. H.,1995, The Giant Planet Jupiter,CUP
[3] Sanchez-Lavega, et al, 1991 , Icarus 94, 92–97.
[4] Sanchez-Lavega et al, Icarus 121, 1–17, 1996
[5] British Astr.Association, Jupiter section website
[6] Kardasis et al.2016, JBAA,126, 1-2016
[7] Pellier C. & Monachino G, EPSC2013-556
[8] Kardasis, E. , EPSC2013-795
[9] Salway M., Planet. Imaging and Image Proc., online
[10] Pellier, C., Taking CH4 images of Jupiter, online
[11] Registax, Image processing software, online
[12] Autostakkert, Image processing software, online
[13] GCP, Suppl. resources for Planet. Photom.,online
[14] Teifel,V.,1976,Soviet Astron.,vol.19-3, p. 373-377
[15] Hahn, G. 2019, WinJUPOS software, online