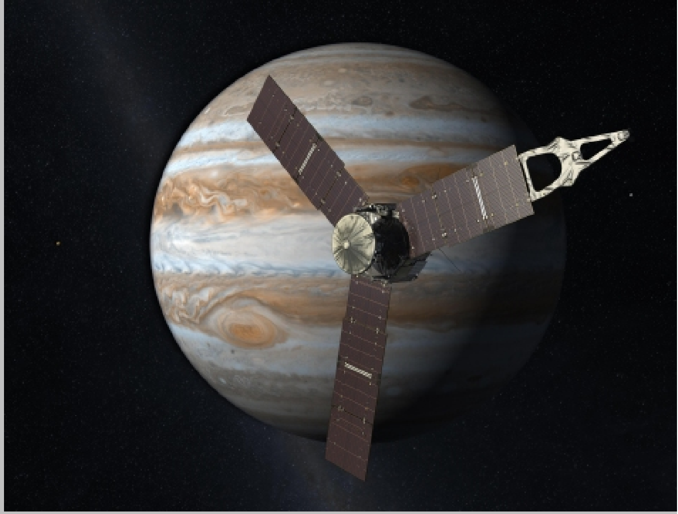
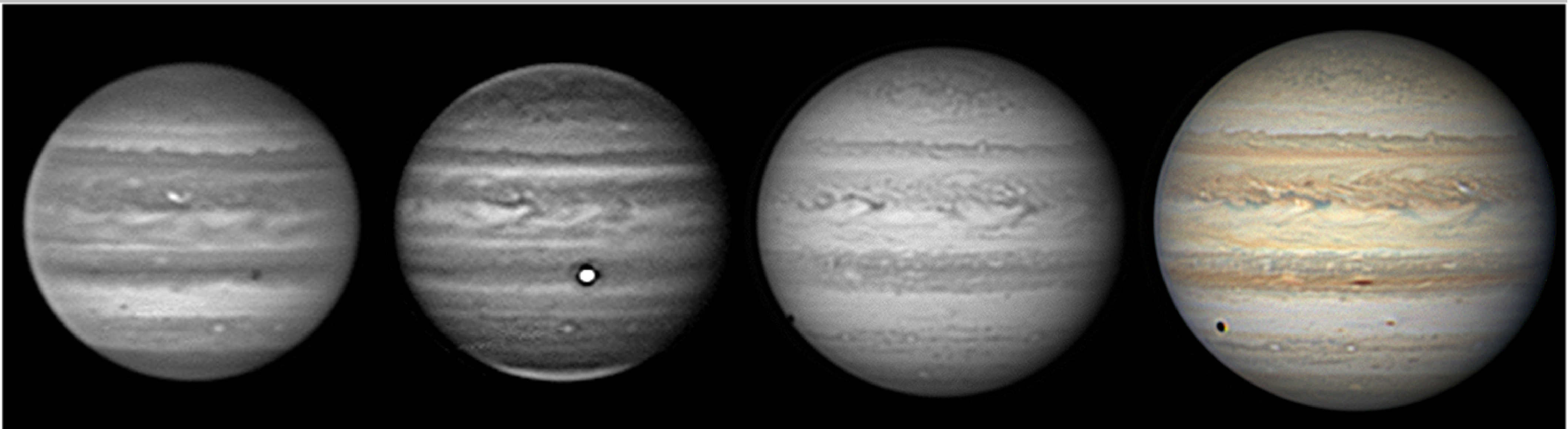
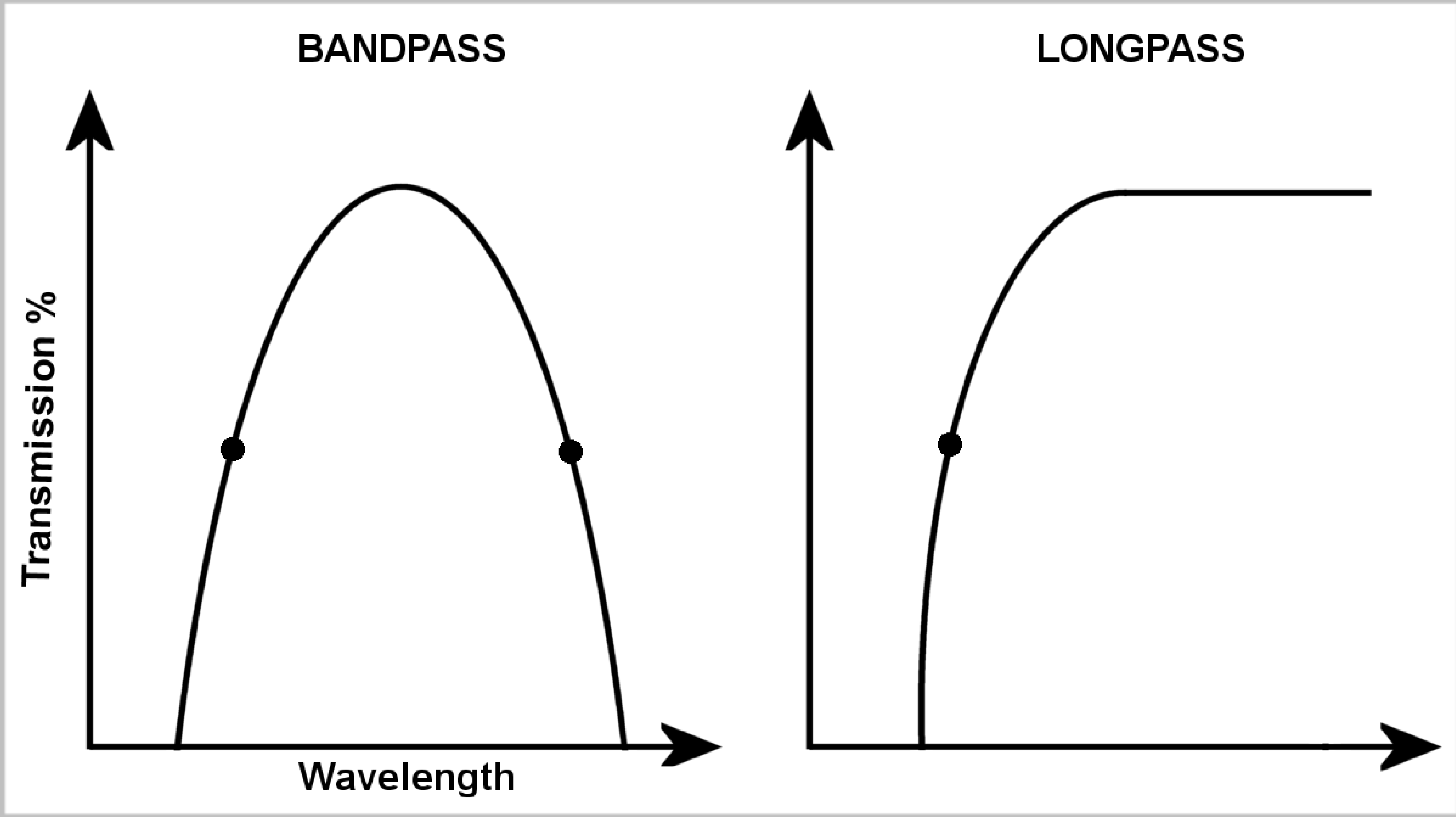


USING FILTERS FOR JUPITER IMAGING

Christophe Pellier
JUNO WORKSHOP
Nice, May 12th, 2016



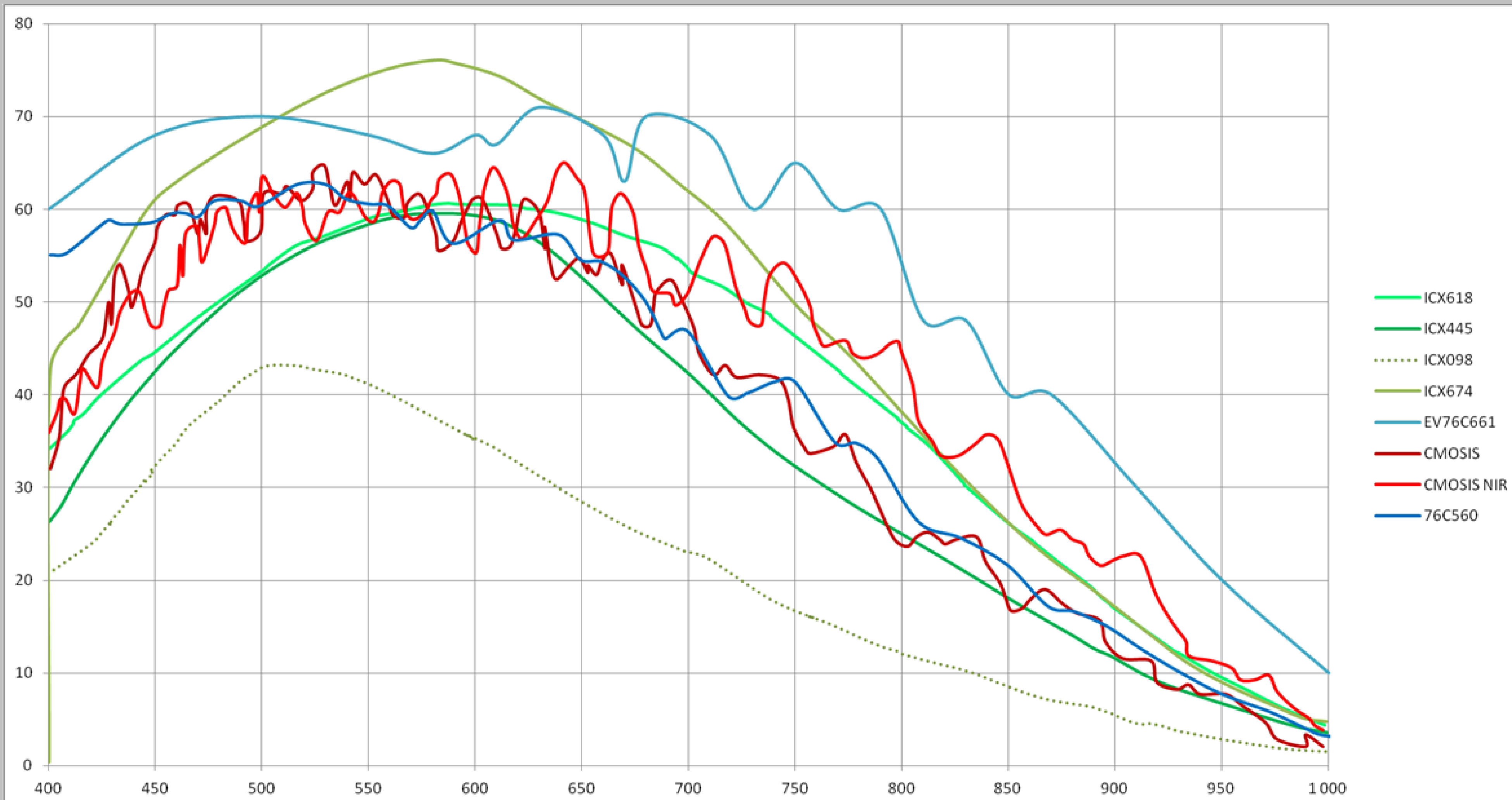
1. Understanding filters: the pass-band



A filter is a tool whose purpose is essentially to select information, blocking parts of the light spectrum while allowing some other parts to pass.

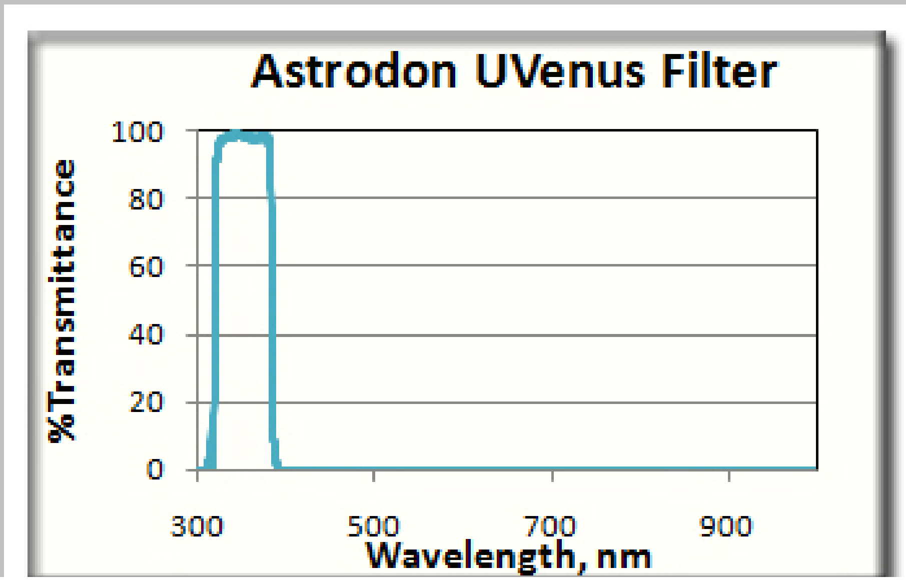
- ***Bandpass filters*** **have a cut-on (beginning of transmission) and a cut-off, transmission peak being in the middle.**
- ***Longpass filters*** **have a cut-on but no cut-off. They start passing light and when peak transmission is reached, it never drops.**

1. Understanding filters: camera sensitivity

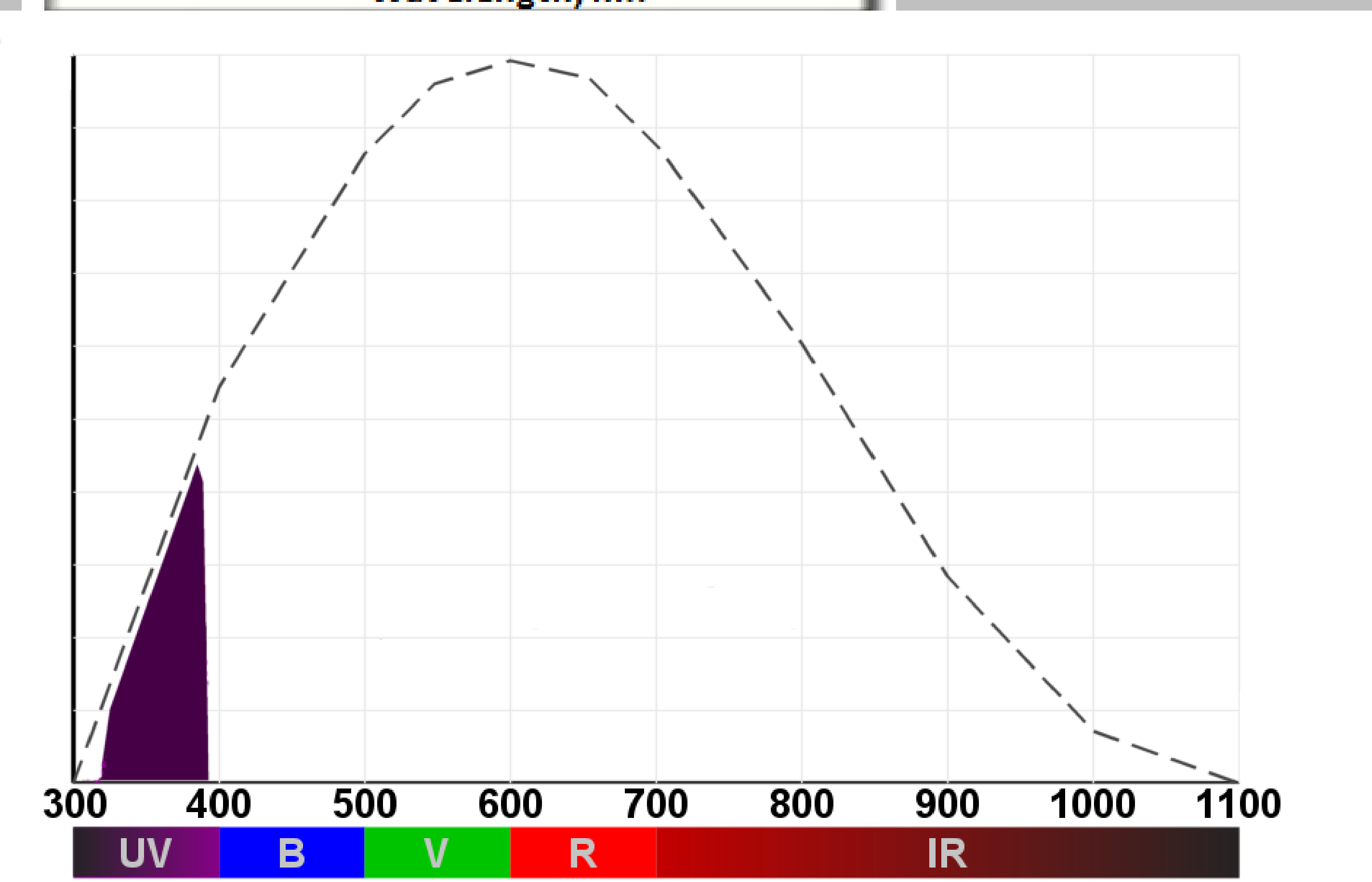


Cameras' sensitivity acts as a <u>second filter</u>. Its effects must be understood to anticipate the real effect of using glass filters.
In general CCD or CMOS sensitivity is excellent in visible light (400 to 700 nm), very good in near infrared (IR, 700 to 1000 nm) and low in near UV (300-400 nm).

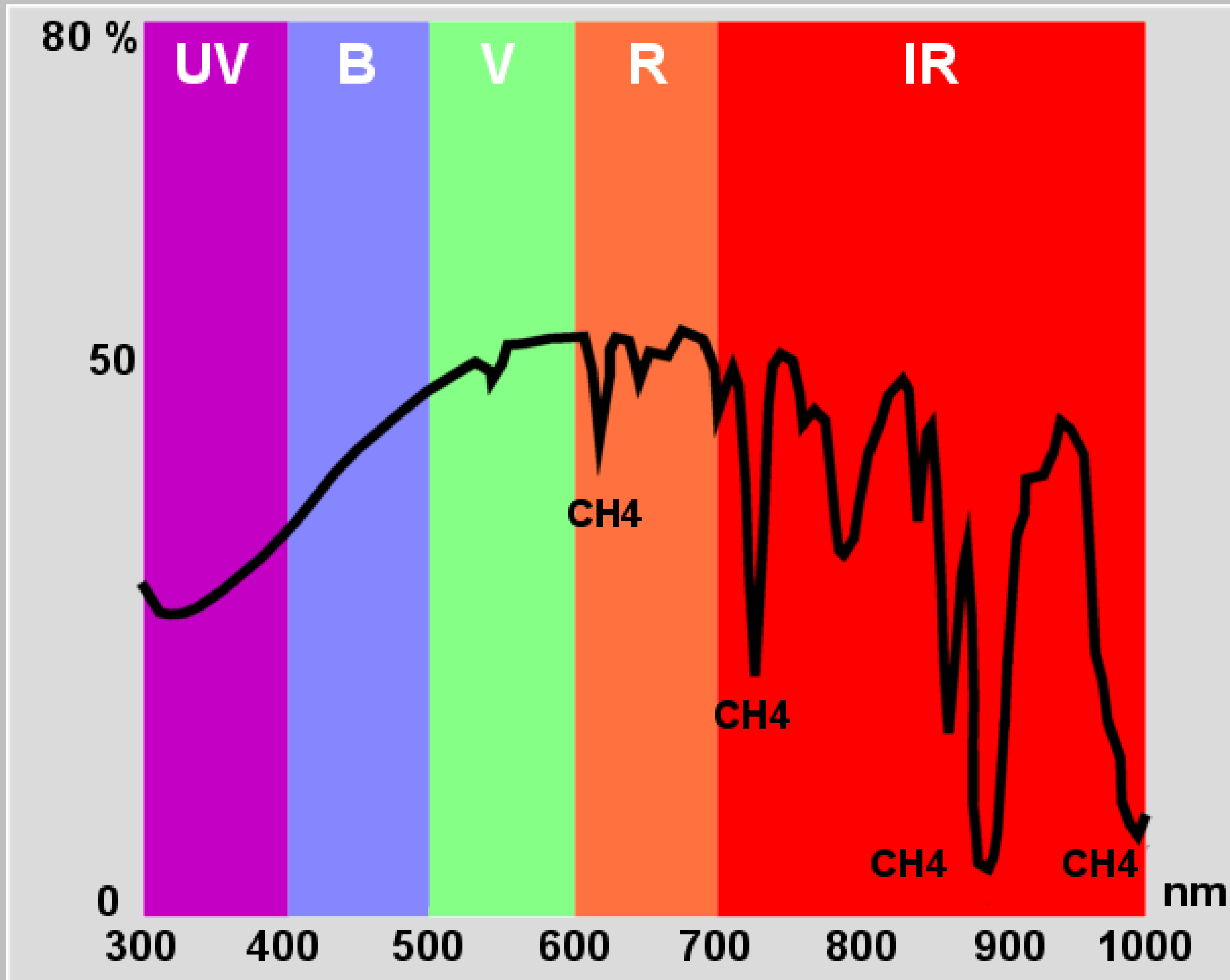
1. Understanding filters: camera sensitivity



Example of the influence of the second level of light filtering.



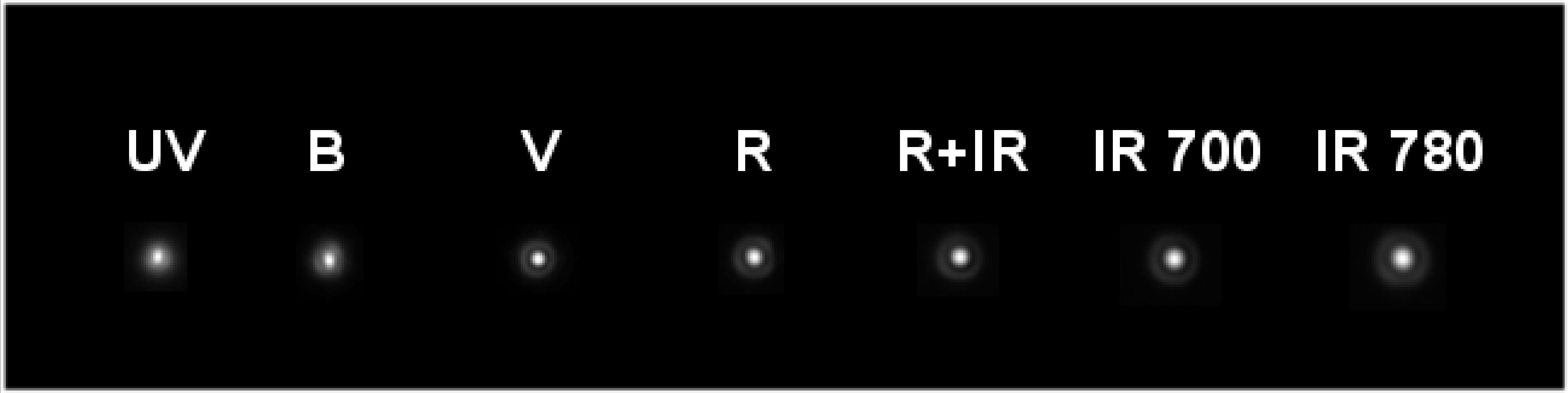
1. Understanding filters: Jupiter self light emission and absorption



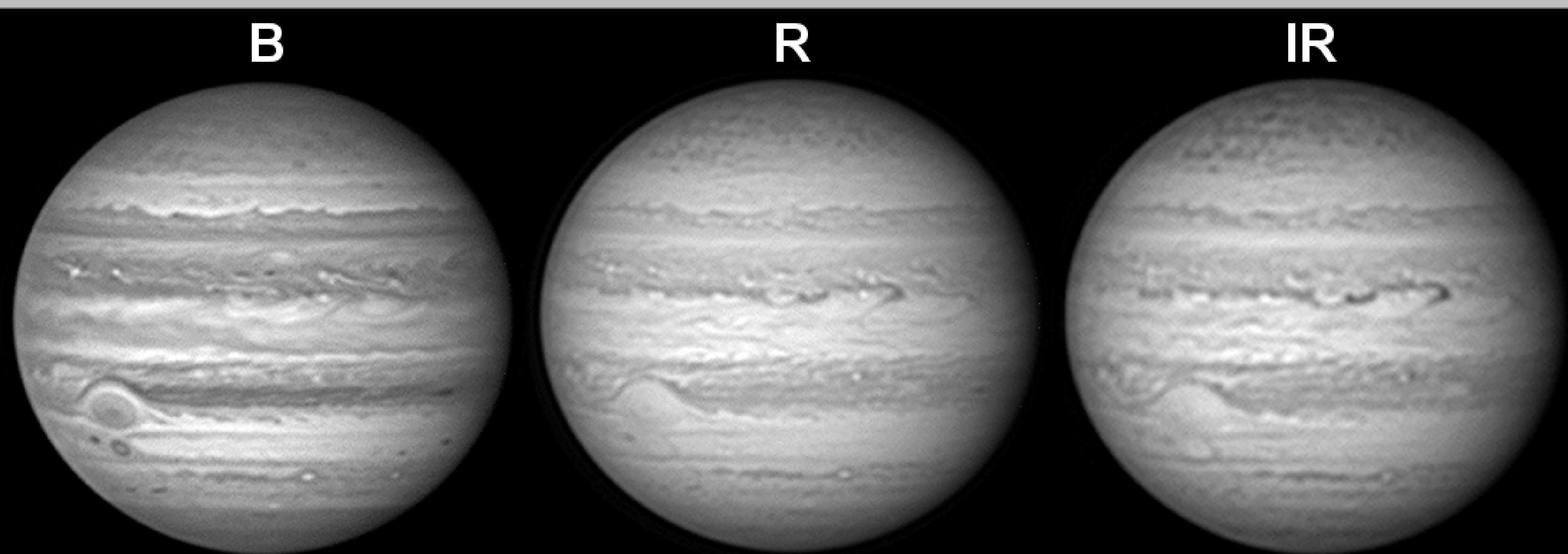
The planet's albedo acts as a <u>third level of light filtering</u>. Its must be added to the first two ones to anticipate completely the expected amount of gathered light.
Jupiter is globally yellow, with two large and shallow absorption bands in near UV and near IR, but with narrow and deep CH4 absorption bands.

Note as a reminder: our atmosphere is a fourth level of light filtering! (= less transparent in short wavelengths, B and UV)

1. Understanding filters: wavelenght and resolution

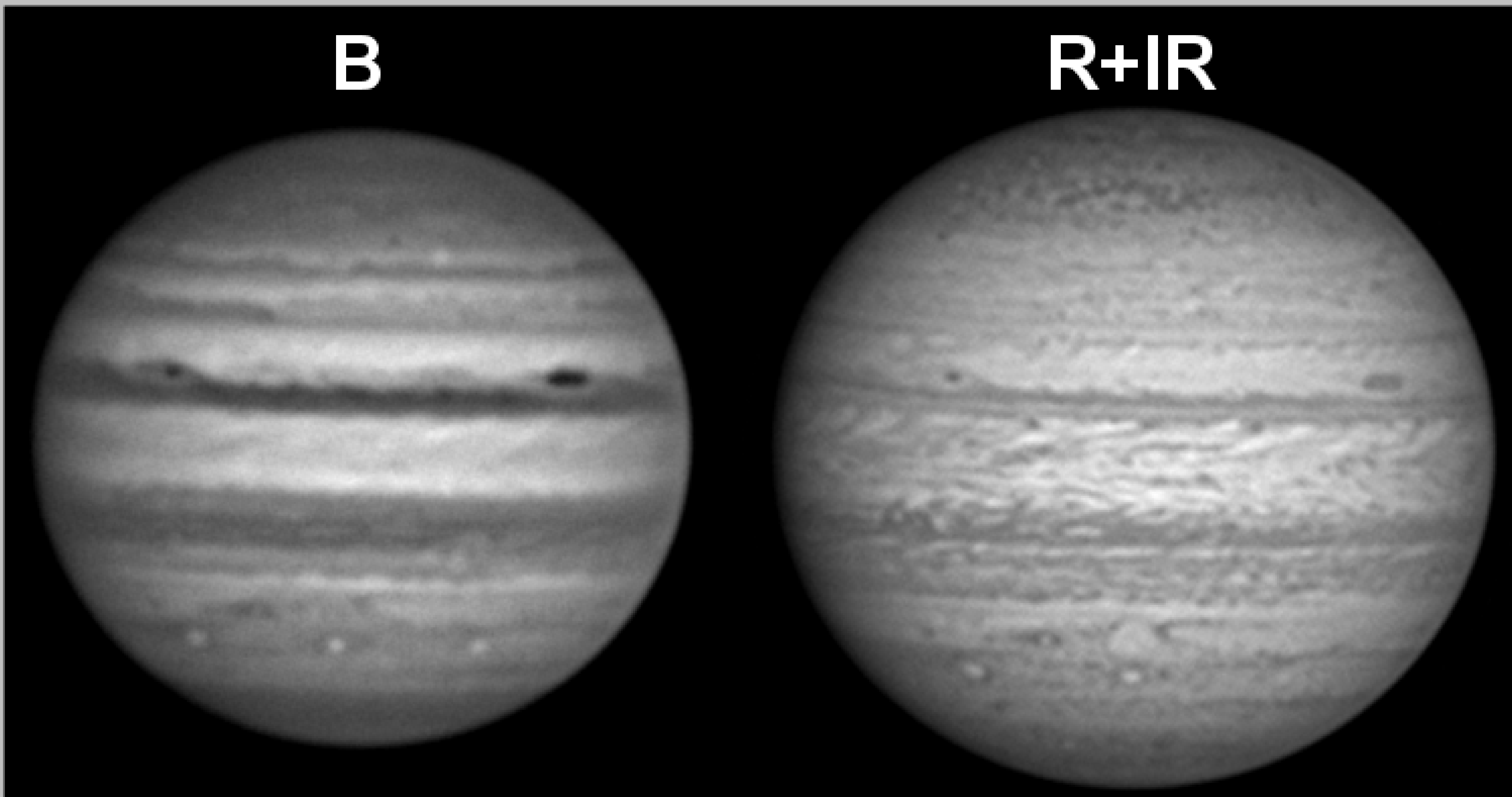


Optical resolution is correlated to the wavelength : Airy disk gets bigger as the wavelength increases : blue light achieves finer images than red if seeing is good and the instrument optically fine. IR is usually not as resolved as R.



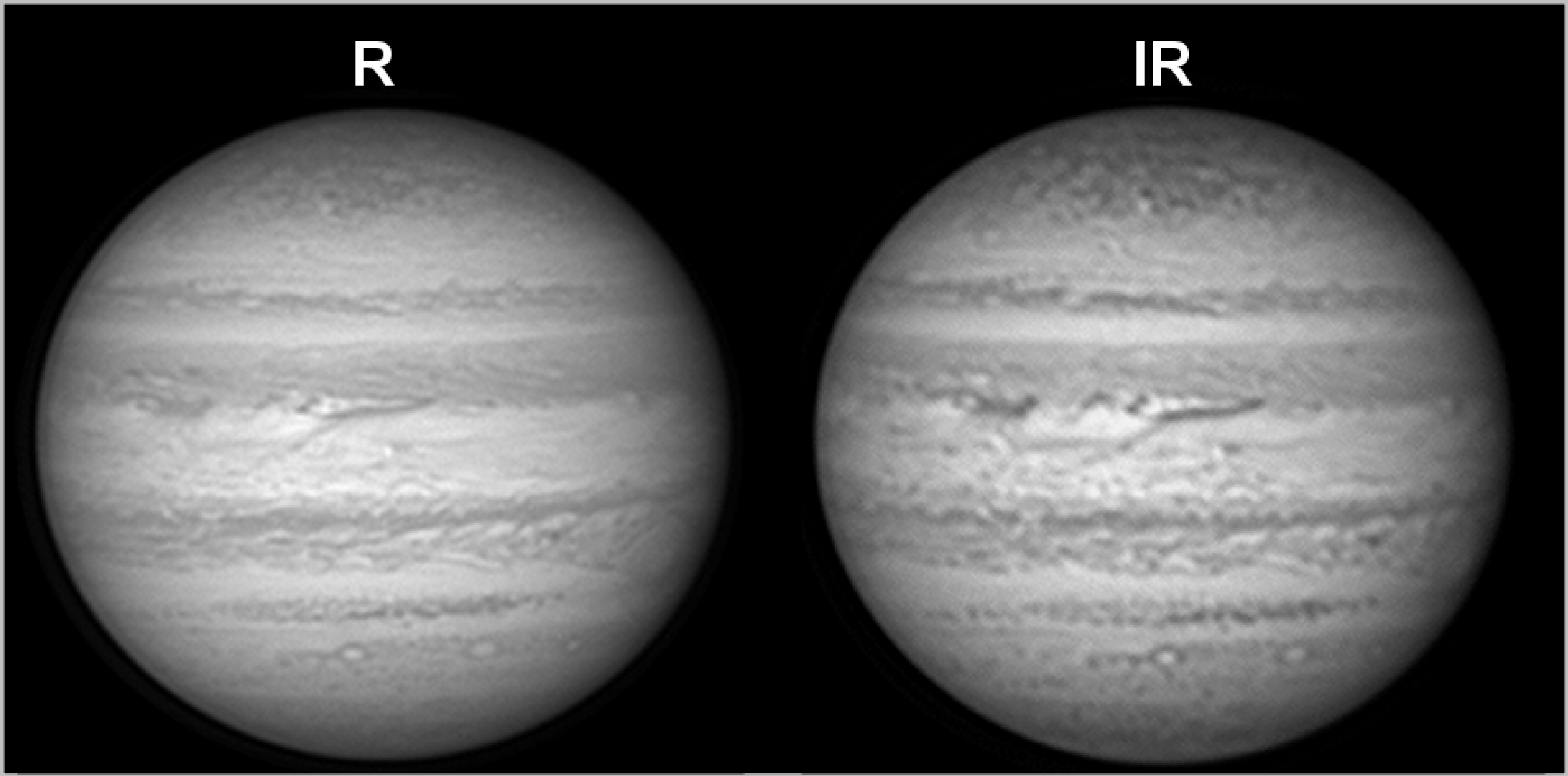
1. Understanding filters: seeing and resolution

Seeing and/or transparency conditions achieve an opposite behavior: the resolution is often better in long wavelengths (R/IR) than in visible light (RGB, B).
→ Long wavelengths are usually useful to get the best details under average conditions



2. Using filters: red and infrared imaging

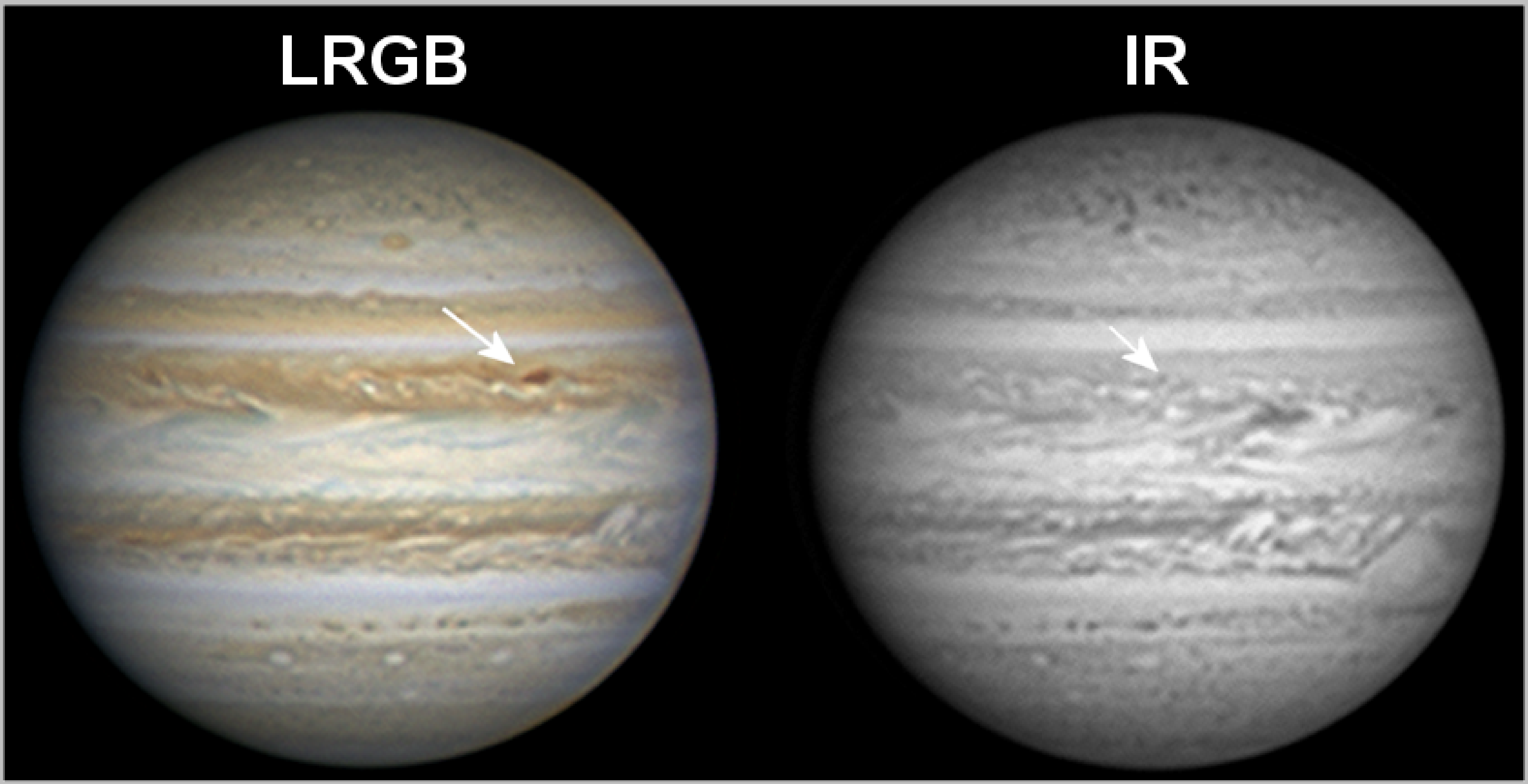
Apart of improving the seeing, the interest of R and IR filters is to provide a slight penetration inside the jovian atmosphere. Some higher hazes imaged in RGB are partially (red) or totally (?), infrared) eliminated.
Global contrast is weak, but the contrast of small structures is enhanced.
→ Excellent choice for general tracking of features and measurements under less than very good seeing (prefer color images)



Typical differences : better resolution in R, better contrast in IR (seeing better in IR)
Choose a large IR filter (around 700 nm cut-on like Baader 685 or Astronomik 742). No real interest to use deeper filter as resolution will continue to drop.

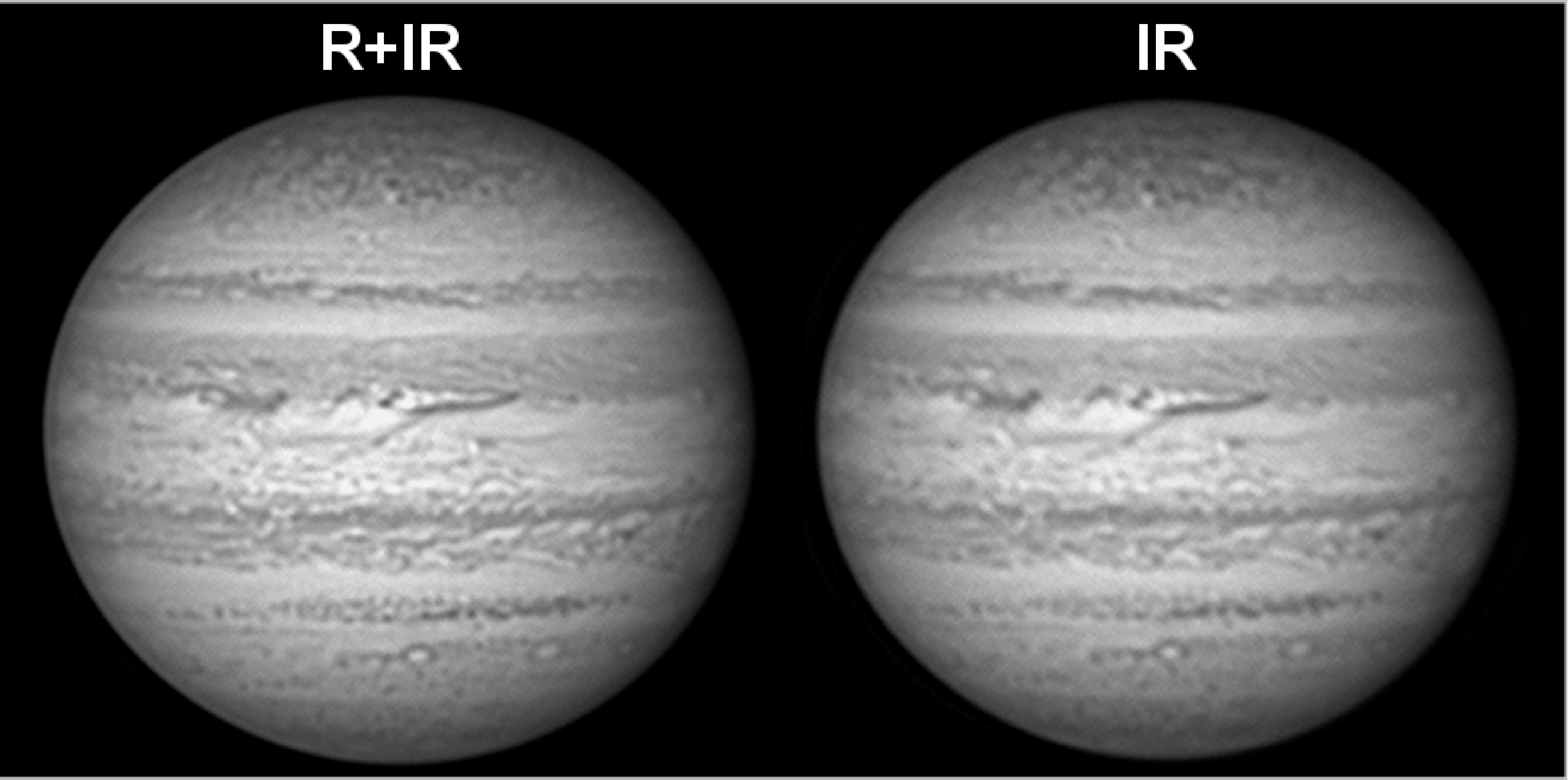
2. Using filters: red and infrared imaging

The only problem with pure IR imaging is that some superficial cyclonic brown structures are not visible : NEB barges and STB dark spots. Such structures can hardly be followed in IR so images welcome an accompanying RGB picture.
Pure red light do show those spots.



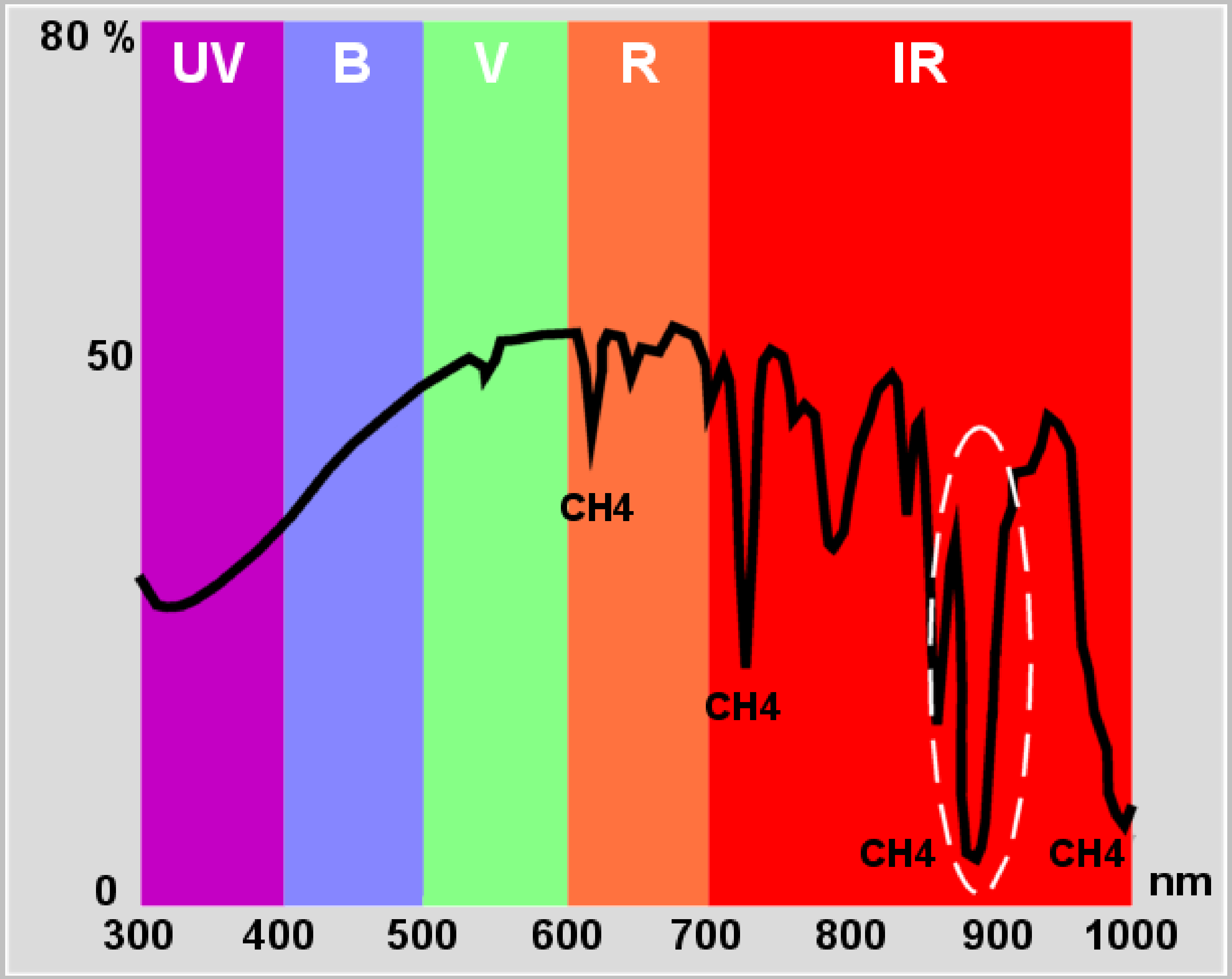
2. Using filters: red and infrared imaging

So called "R+IR" filters are an interesting compromise : excellent light gathering, better contrast than in red light, and better resolution than in IR (however seeing is less good than in IR)
Filters are cheap but performant: Baader RG 610, even Wratten 23 & 25



2. Using filters: methane band imaging

At 890 nm is a deep absorption band due to the presence of methane in the jovian atmosphere. The image do not represent the color (=albedo) of the clouds, as with any other filter, but their relative height : bright is higher, dark is deeper.
Band is less than 20 nm wide (some 10 times less than bandpass filter) and the absorption is strong: expect a very low amount of gathered light.
In the meantime CH4 is located in near IR and so it shares the other characteristics of IR light : good seeing, but low resolution.

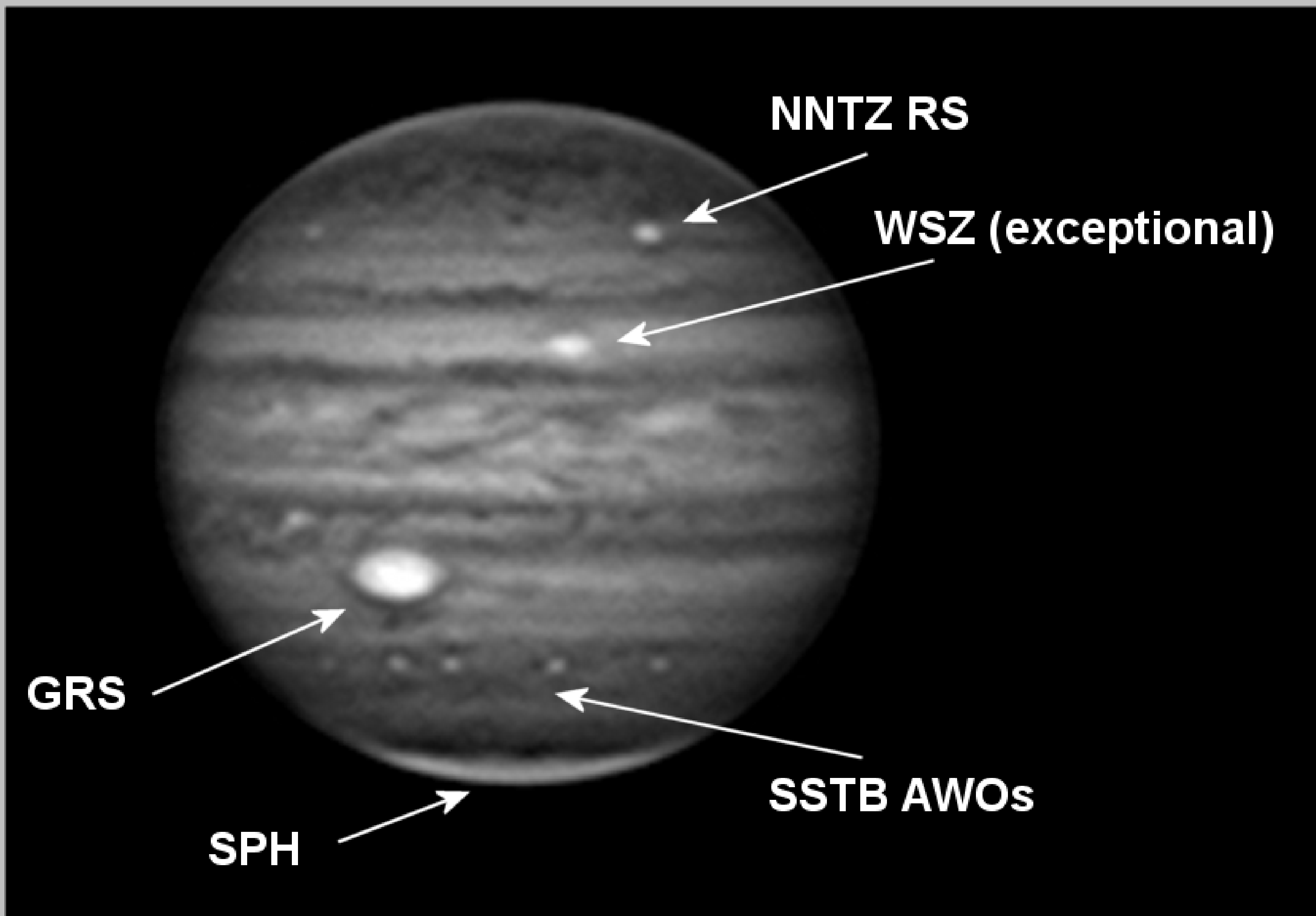


2. Using filters: methane band imaging

General features:

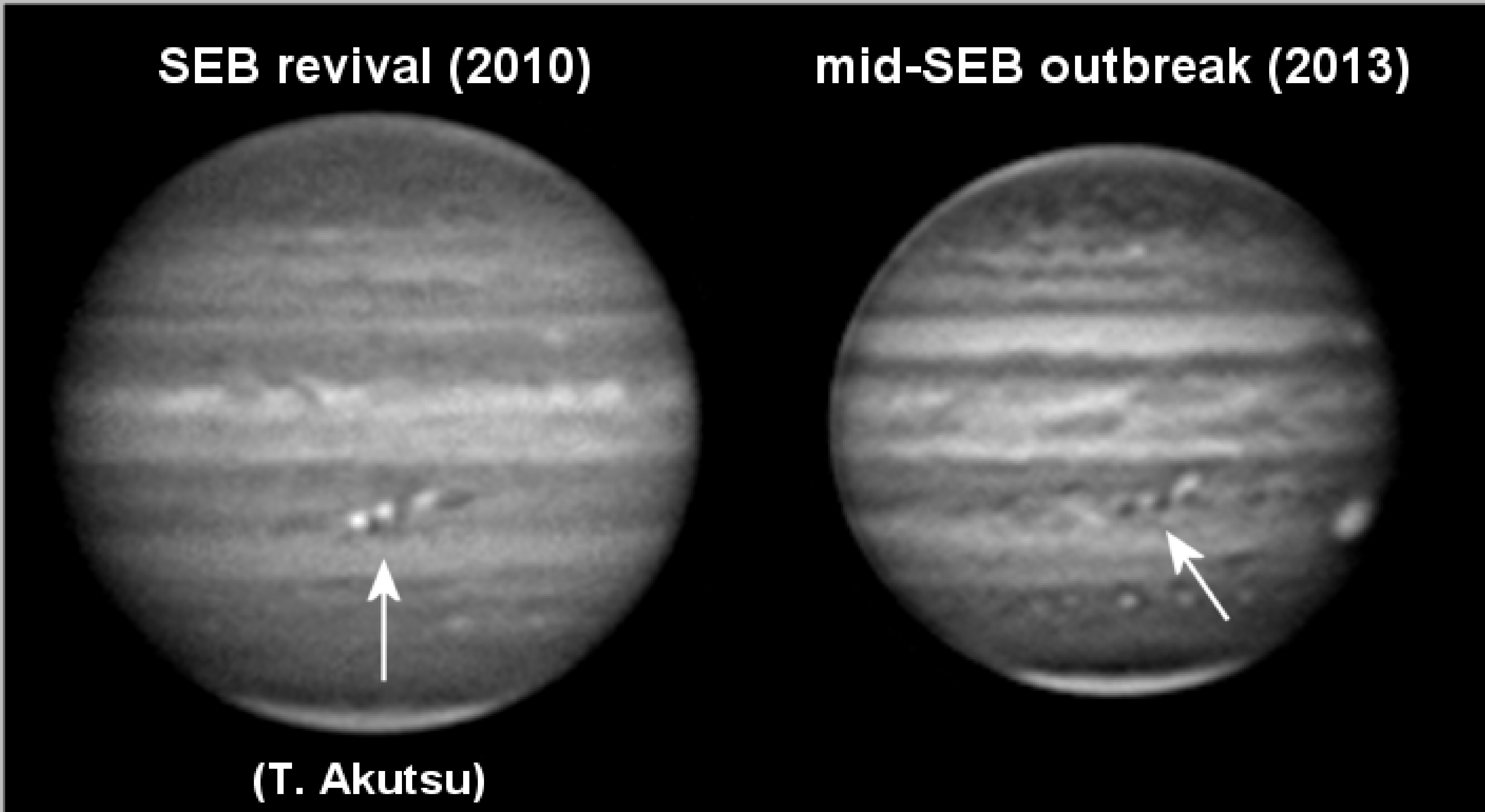
- Zones are bright, being the siege of ammonia cloud condensation at high altitude (ascending part of the Hadley cell)
- Band (belts) are dark: descending dry winds, less clouds
- Anticyclones are bright with notable exception (NTrZ AWOs are usually not)
- Low pressures are dark

Brightest regions: GRS, Oval BA, South polar hood, EZ.



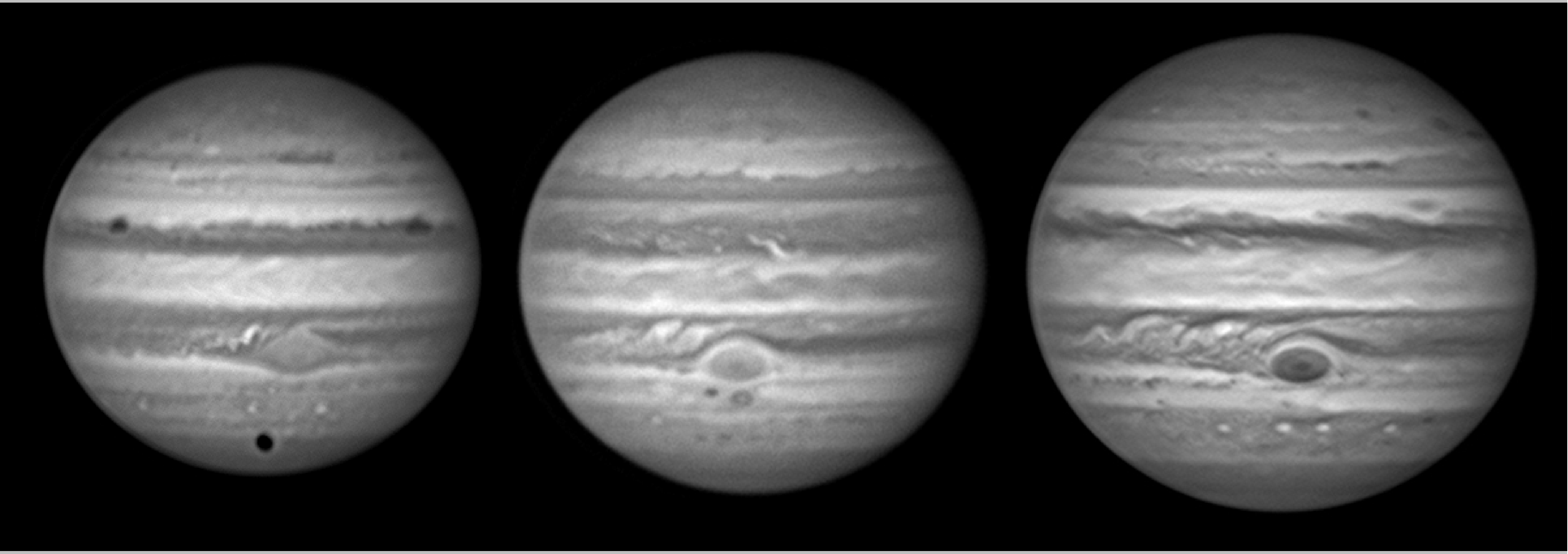
2. Using filters: methane band imaging

Following of oubreaks is nicely done with CH4 filter.
Both images show alternative dark and bright spots, evidences for the existence of convection (ascending currents are bright, downwelling ones are dark)
(true as well for EZn plumes and festoons)



2. Using filters: analyzing colors in blue light

Jupiter is largely a warm-colors planets (yellow, brown, orange), absorbed by blue light. A blue filter can bring objectivity to color changes studies if needed. RGB comparisons are more sensitive to personal processing equations among amateurs.
Below: profund changes of albedo in 2011, 2012, 2013



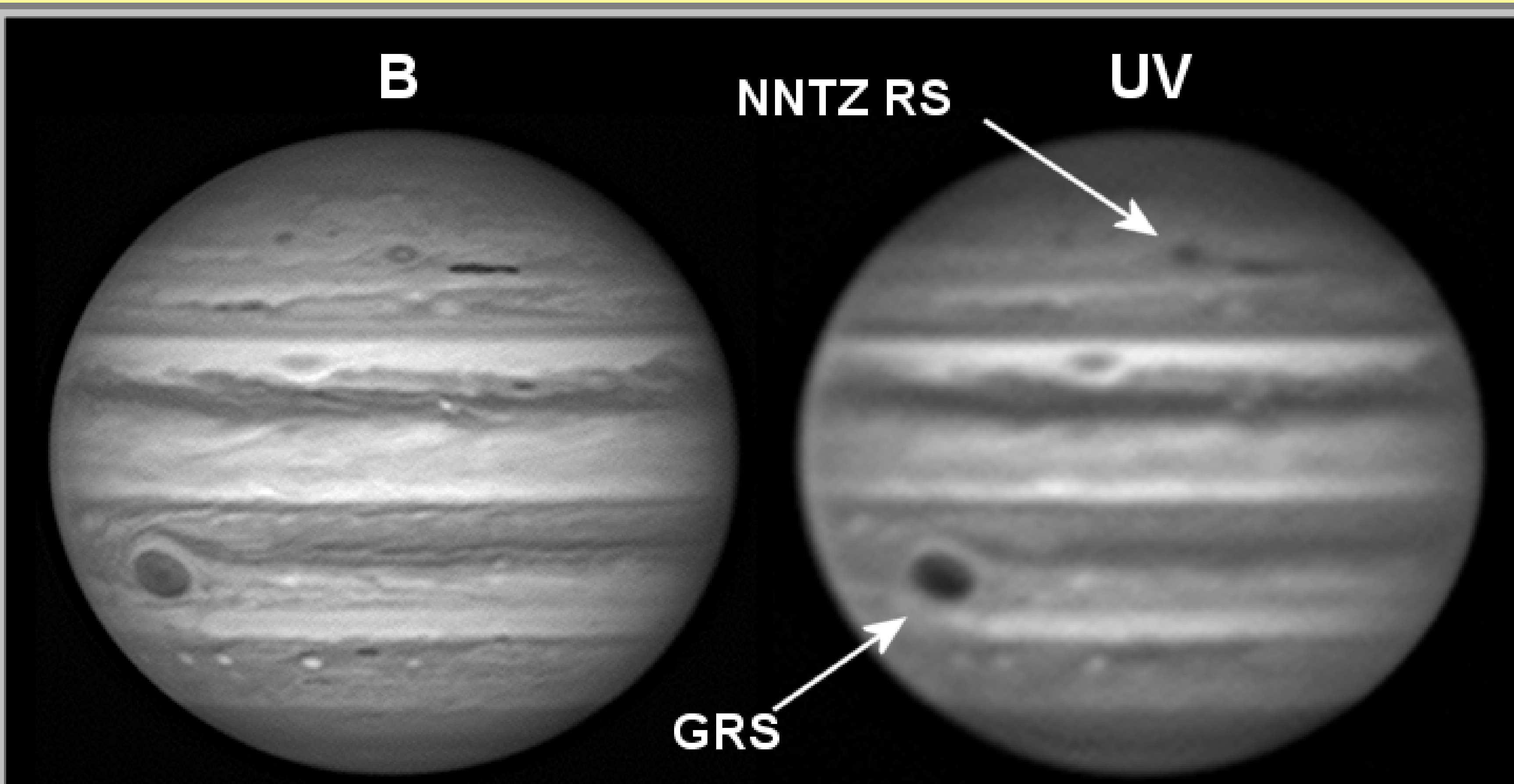
2. Using filters: UV imaging

Jupiter is strongly absorbing light in UV – imaging difficulty is very similar to CH4. The clouds appear to be observed through a high altitude haze that transforms albedos in some particular ways – although absorption is strong, UV is not a "super B" image.

- The presence of the translucide haze is in general revealed by limb brightening (opposite to all other wavelengths).

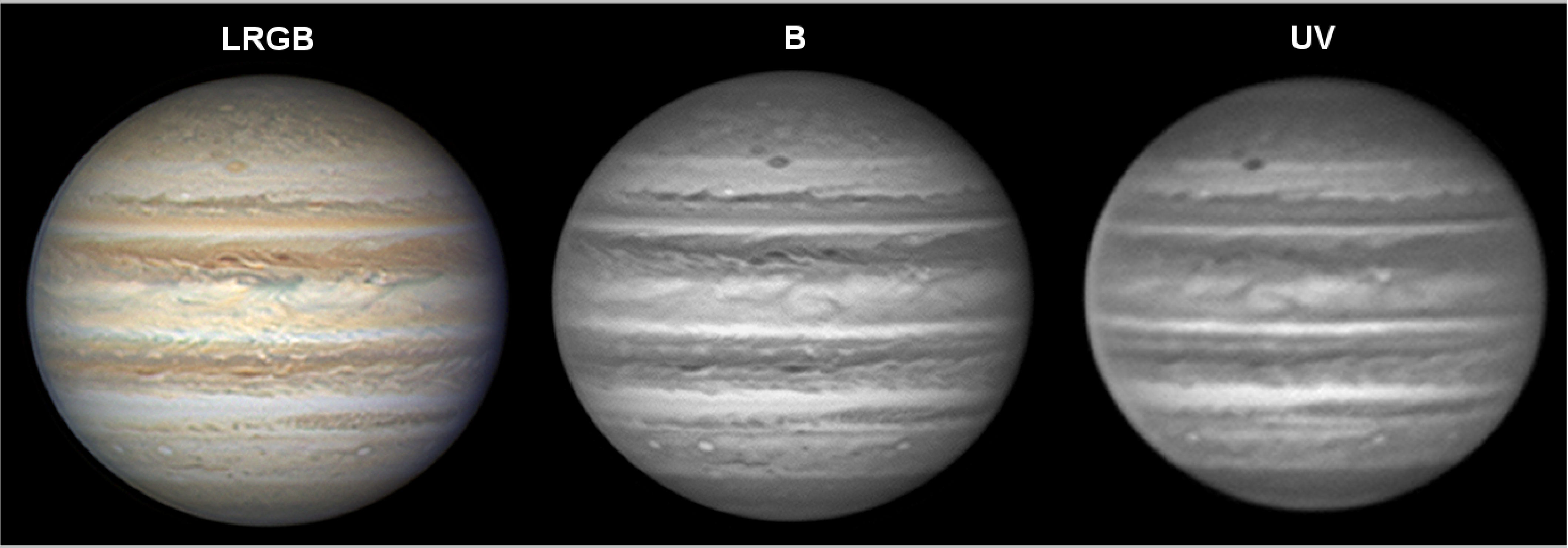
- Increased absorption is noticed if strong yellow or orange coloration is observed in zones (typically: EZ but not only)

- Strongly increased absorption is generally noticed on anticyclonic red spots (GRS, BA, NNTZ RS...) to the point that it appears as a propriety of this class of jovian objects.

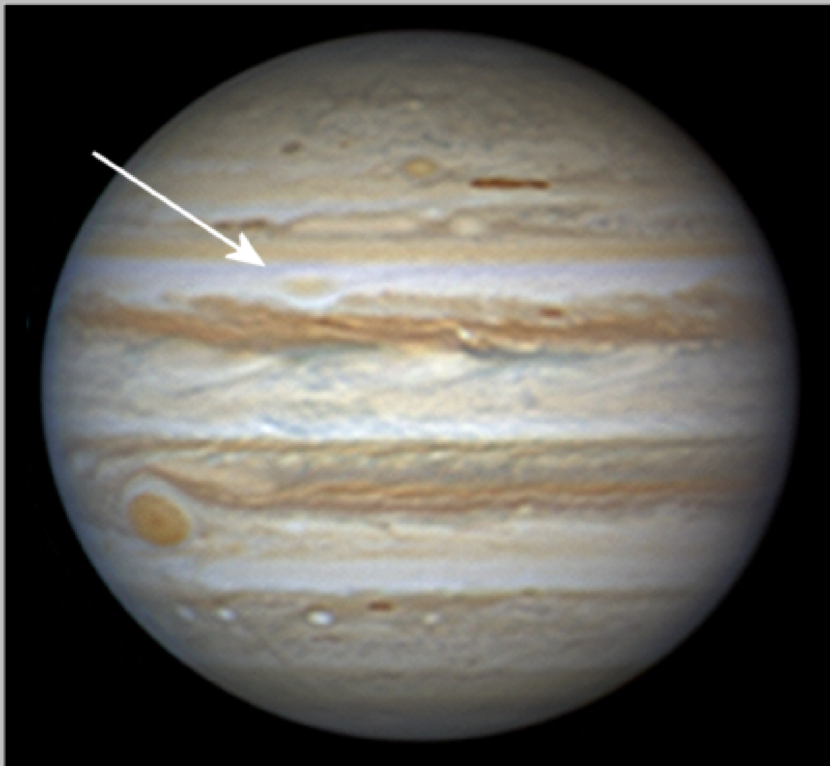


2. Using filters: UV imaging

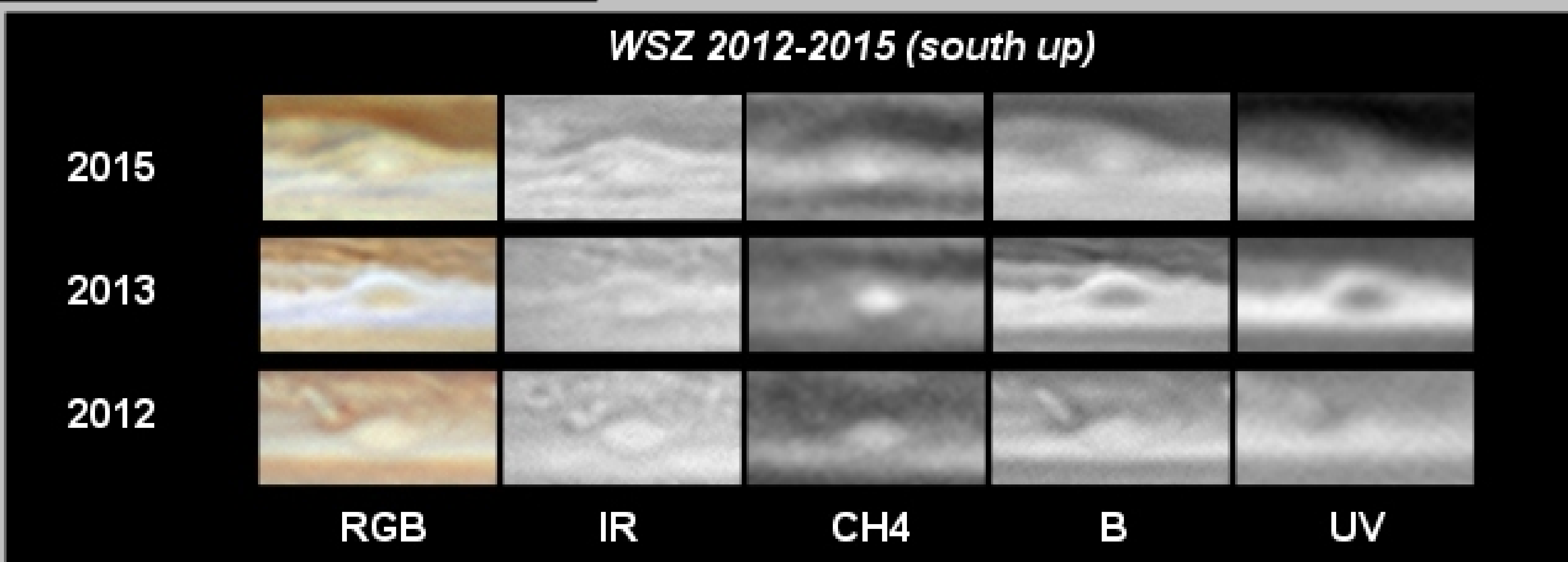
EZ Coloration event in 2012. Almost back to normal in late October, but the absorption lingers in UV light for several weeks.



3. Example of the interest of getting regular multispectral imaging: The ephemere red spot -state of WSZ in 2013



"White spot Z" is a several decades old anticyclonic white spot in the North tropical zone.
In the fall of 2013 it turned orange during several monthes and looked like a fourth or fifth red spot (after GRS, BA, NNTZ RS and SPR RS). Do other band confirm the change ?



4. Protocole of filters use for Jupiter

While true color imaging remains the more useful way to study Jupiter, it can be sustained by filters under certain situations:

- R, IR, R+IR imaging : do often, at least when seeing is less than very good (especially interesting when it can achieve better resolution than in RGB)

- CH4 imaging : do always, if possible, especially when special transitory events are underway (outbreaks, upheavals)

- B imaging : sometimes interesting to show if conditions are good

- UV imaging: interesting only to show special coloration events – do only if seeing is at least good