AstroSurface for Dummies Version of document 1.0 / 20 December 2019

Warning

The title adopted for this manual is not intended to devalue the reader, but to compare itself with a well-known collection of books that addresses sometimes difficult areas to understand with inexperienced readers. AstroSurface is a software dedicated to image processing astronomical, and we'll only assume that the reader has some ideas about particularities of this treatment.

As on the other hand, not everyone is familiar with the English used by the software. (globalization requires . . .), we will give the translation of the words used.
Finally, it should be declared that it is not final and authoritative documentation, but a attempt to rule out the difficulties of accessing the software. The main reason for this is that it is still evolving and which all or part of this documentation may expire at each new version. So you're reading a provisional version that is probably not free. gaps and inaccuracies. Please do not attribute them to the author of the software. The editor of these lines is solely responsible for the nonsense and bad word games that enamel this manual, for the reason for which he stands in a cautious anonymity, for fear of reprisals.

The Editor.

AstroSurface is a free software developed by Lucien. For downloading and installation, see the official website http://astrosurface.com/. Copyright and licence are included in the distribution. In order to access it, simply click on About at the top in the menu bar. Then on link indicated. The manual was written on the basis of E-2 version 2019/11/03.

VIDEOS PRACTICES:

You will find on the site the possibility of viewing some very useful demonstration videos in addition to this manual.

The images and films used to illustrate this manual are for the most part the property of the editor. Who made them himself, but not all of them. It is therefore not recommended to consider these images as free of charge, even if they are ugly. And if they're ugly, it's to better illustrate the wonderful software capabilities that you're going to love.

Summary

AstroSurface functions not described here

In the methods described here, there are often additional possibilities that are not discussed, in order not to make this documentation too cumbersome. By looking at the displays in the text window or on the dialog window itself, there are often useful hints.
There are quite a few undescribed methods. And the software is constantly being modified.
Additional functions are regularly added.

Issues in the MathPix menu:

- - analysis of the movements of a target: for example, to control the movements a mount
- photometry and star finesse measurements (FWHM)
- measurement of apparent sizes and angles on an image,
- cutting intensities on an image,
- some computers for image data; sampling, focal length, etc.

In the Edit menu:

- copied/pasted on an image or between images,
- correction pad.

In the Convert/Export menu:

- Export of images or videos with various settings; size, intensity, Gain, etc.

I invite the reader to explore the various menus and launch the methods that are there for the experimenting. Some methods are inaccessible until one has loaded, i.e. an image, or a video (or a collection of files).

With the evolution of versions, it happens that sometimes certain methods are renamed, titles, the names of certain checkmarks too.

Some definitions.

What is a ROI?

Since the term is found almost everywhere in the software, and it designates a fundamental functionality, let's start with it.

ROI stands for "Region Of Interest" [1]. In AstroSurface, the term refers to a rectangular selection of a portion of the image.

Selection that you must make as a preliminary to a certain number of operations such as zooming or displaying the histogram of a small part of the image etc. (click, drag with the mouse in the image: a green frame appears on the selected region. It can turn red if this region is too large during certain operations). It is therefore not the software that will determine this region, it results from a drawing that you have made.

In some methods, when this ROI is required, you will find that almost everything is disabled in the operation's command palette, which can be quite confusing, as you wonder how to proceed further. If you find yourself in front of a disabled command, think ROI. A statement in the message area will tell you this, or in the method title bar, (use ROI) may be written.

One reason, but not the only one, is that many treatments are time-consuming, so applying them to the entire image can take a while, which is a drawback when you adjust with a slider trying to find a satisfactory setting. So the processing only occurs on this indicated ROI, which also has the advantage of allowing an immediate comparison between treated and untreated parts.

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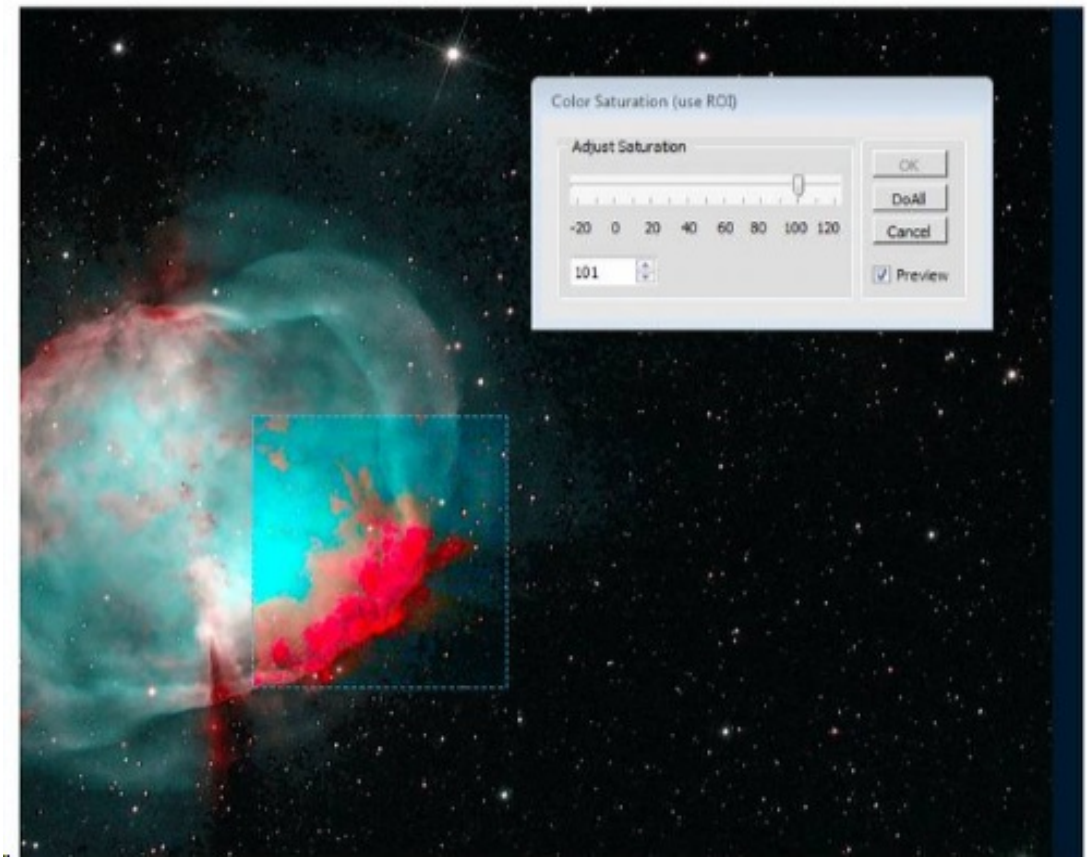
1 This is where we see that English is not very different: three quarters of the words come from French, more or less formed like region, rascal, scum. Expletives, curse words, that do not come from it do not deserve to be translated most of the time.

Once we are satisfied, we trigger the processing on the entire image using the "**Do All**" button that you will find in the relevant screens. The example below shows the ROI in action:



Here we have pushed the color saturation which only took place on the selected area. The mention "(**Use ROI**)" indicates that a selection is essential to make the operation work. [2] We can also see that the "**Do All**" button is activated as well as the "**Cancel**" button. Note that the "**Preview**" box is also active.

2 Contrary to what one might believe, this is neither a propitiatory mantra nor a war cry.

Processing of astronomical images

Let us briefly recall here the steps of astronomical image processing, at least to fix the terms. AstroSurface can process isolated images as general software does, but it is normally the last step of a processing that applies to a collection of images all representing the same portion of the sky, photographed repetitively with the same telescope. The goal being roughly to obtain a final image from the best of the images in the collection. Indeed, because of the various disturbances that can affect the shooting (especially atmospheric turbulence) and the faint light emitted by many celestial objects, a single photo will have a certain number of defects. Since these defects are random, they will compensate for each other to some extent if we combine a series of images. This collection can be presented as a series of files in a folder or a video file. These are called raw images.

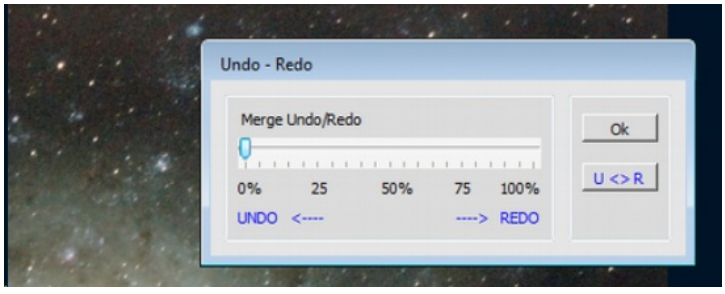
Standard processing involves the following steps:

1. Conversion: as a reminder, if AstroSurface does not recognize the file format produced by your sensor, you will need to find suitable conversion software.
2. Application of DOF (dark, offset, flat). These operations aim to limit the background noise generated by the electronic sensors as well as the defects of the telescope (vignetting, dust, etc.). This is called pre-processing
3. Analysis: this step aims to evaluate the quality of the images in the collection (fineness of details, similarity with the reference image) and to eliminate the worst ones.
4. Alignment: we align the images as exactly as possible on the reference image by a series of geometric transformations (translations and rotation, possibly other less simple things).
5. Stacking: The images are combined pixel by pixel. Roughly speaking, we make an average and eliminate the pixels that deviate too much from it.

Normally, all this ends up producing an image that is a little nicer than your raw images. But this image can be further improved by various very subtle operations. Note that you can skip to this final step directly if you have already done the processing in another software or if you have only taken one photo. In this case, you can skip the following section.

Random tips

In a number of cases, the "**Undo**" function, present in the "**Edit**" menu, is progressive. In other words, it returns to the original state in stages, which can be interesting to reduce overly intensive processing. The cursor allows you to adjust the proportion between the original and transformed image:



It should also be noted that all treatments have a "**Cancel**" button which returns directly to the original state.

In a number of screens, you will find small buttons labeled "**Load P**" = Load Parameters and "**Save P**" = Save Parameters. They allow you to save the settings of the different controls on these screens and therefore help to find them later.

Quick access buttons:

A number of unique image processing methods, among the most common, are accessible directly by buttons located at the top and left of the text window. This avoids having to go and pick them from the menu bar... In particular the Undo-R which corresponds to the Undo-Redo described above. It is also found in the Edit menu in the menu bar.

Context Menu

Right-clicking the mouse brings up a context menu that provides access to certain methods. These include:

- Center View: which allows, on large images, to center the display at the location of the mouse cursor (when clicking on Center View)
- Histogram: to display the histogram of the image or ROI,
- Save As: to save the image or ROI under a name to be specified. This can often be done during certain treatments, for example to save several versions,
- and other methods displaying Statistics or Information about the uploaded image or video.

Processing image and Video collections.

Conversion.

AstroSurface recognizes the .avi and .ser video formats. The first has the disadvantage of taking up a lot of disk space in the case of color videos. It also recognizes the most common image formats: **png, tiff**, **bmp, jpeg** as well as the **fits** format, the astronomy standard. If you need to convert your images, the **fits** format preferred which incorporates useful metadata for processing.[3] and in any case avoid the jpeg format which is perfect for artistic work, but introduces artifacts that can be accentuated by processing. The **png** format is often proposed by default for 8 or 16 bits.

Alert:

If you are converting RAW color images produced by digital cameras, for example, you also need to "debayerize" or dematrix them before opening them with AstroSurface. This operation consists of extracting the different RGB layers that are interlaced in the RAW files.[4]

Open a collection.

As you might expect, it's in the "**File**" menu that it happens.

- Open AVI or SER = open a video file (.avi, .ser)
- Open a File = open an isolated image (we will deal with this later).
- Open Files = open a collection of images. In the latter case, we make a multiple selection using the Shift and Ctrl keys as usual under MS Windows.

Videos are considered by AstroSurface as collections of images and vice versa.

When you open a video or a collection, you may come across this palette that invites you to decode the image by clicking on the right option of the Color Decoder' (Configure Menu). Don't panic, just try these mysterious options by checking the displayed image.
Does Jupiter really have to have this color?

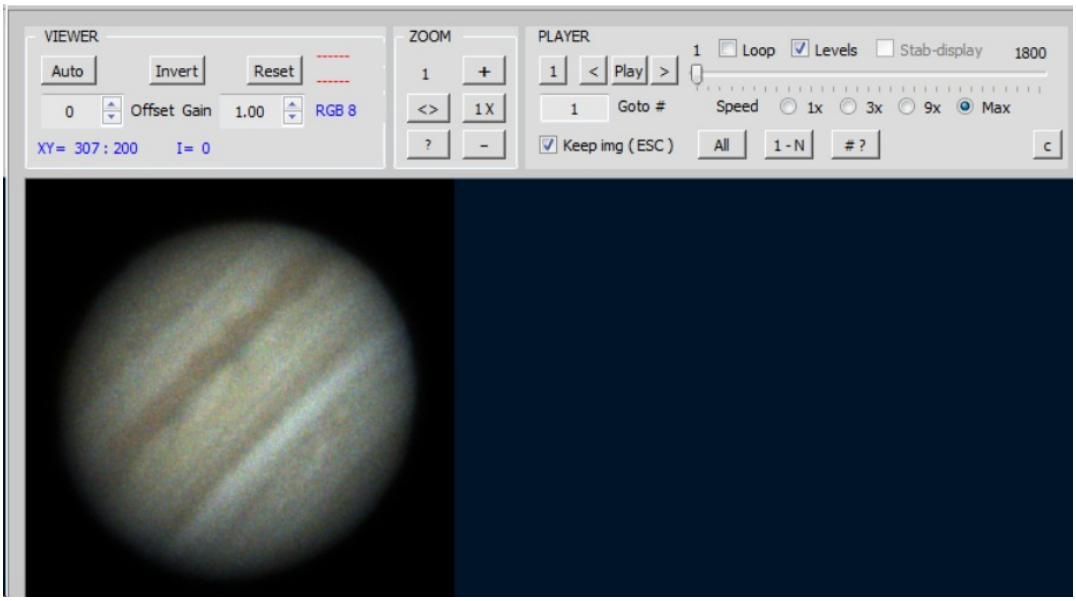
or rather this one?

3 Especially the Bayer matrix configuration when dealing with RAW type color images
4 For more details on this operation: https://fr.wikipedia.org/wiki/Dématriçage

You see, it's easy... And then, you can even show off on the forums by saying that your .SER have a GB-type Bayer matrix.
Then, you just have to click one of the buttons: "**OK**" , "**Abort**", "**File Dialog =** oops! This is not the file I wanted!", "**Register:** go directly to processing".

Visualization & Manual Selection

This step is not essential, but sometimes very useful in the case of difficult videos. It allows you to view your images and manually discard some of them for subsequent processing. Indeed, during your shots, it may happen that a cloud passes, that someone gets caught in all those wires hanging from your tube, that a patrol of cops arrives with their spotlights to see if you are not preparing a ground-to-air missile launch, in short one of those little impromptu events that make astrophotography so exciting. AstroSurface is naturally capable of sorting and discarding the worst images, but it is not a bad idea to make its task easier, especially if they are the first ones. Indeed, AstroSurface uses the first images to create a reference image. A number of images for this purpose is automatically proposed, and it is important for the success of the processing that these are not poor quality, especially the first one. The AstroSurface toolbar now looks like this:



A first frame called "**Viewer**" allows you to modify the display of images for you, such as:

- - Auto, is the automatic levels function: it allows you to adjust the histogram of the image over the entire available range.
- - Invert, inversion of colors or intensities.
- - Reset, cancellation of all settings.
- - Offset/Gain: if you have already clicked Auto, these two values are already set to the best, however, if the images have a very high dynamic range, it is possible that the darkest details do not appear. You can increase the gain and/or the offset (shift, displacement) to make them stand out, knowing that this will saturate the highlights.

None of these settings change the images, only their display.

Tip: These buttons and display settings are active even while viewing videos.
A second **"Zoom"** frame allows you to adjust the zoom on the image. It only changes the display.

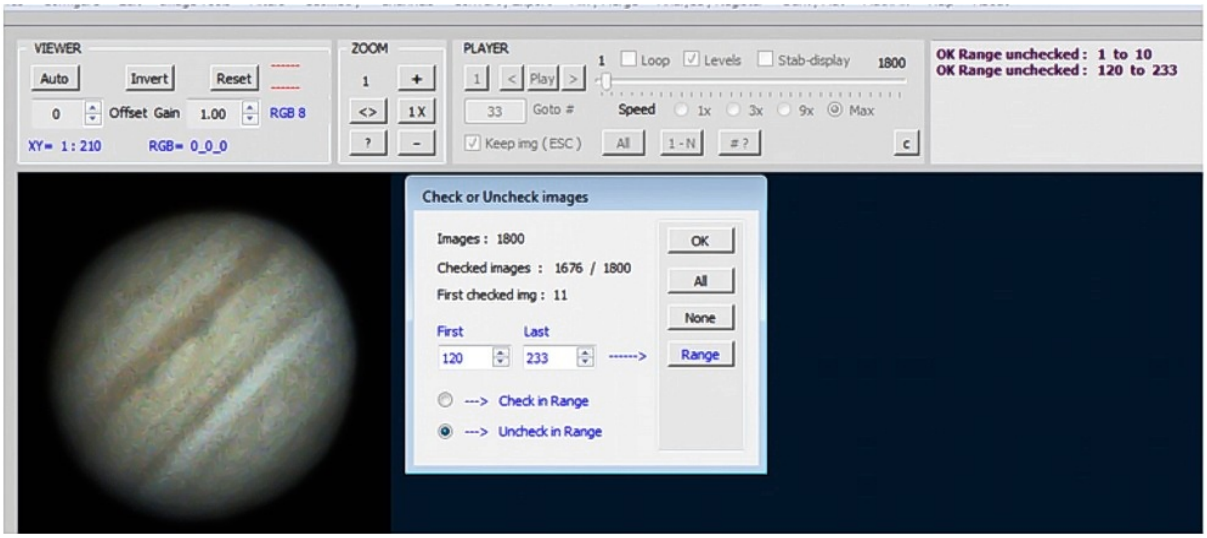
The button with the question mark in this area of the Zoom, shows you its keyboard shortcuts. And also how with "the little hand", to move the display on a large image.

A third frame called "**Player**" (only in Video mode) allows you to review the images: on the second line, a series of buttons:

- 1= return to the first image.
- < = previous image (on keyboard)
- **Play/Stop** : continuous playback and stop. Note that you can choose the scrolling (Speed) on the line below.
- > = next image (on keyboard) →
- A cursor allows you to quickly travel through the collection.
  On the line below, an input box gives the number of the displayed image. You can enter a value there to go directly to an image. (**Goto #** = go to number).

The last line allows you to discard frames (or re-add them) to the collection. Note that this does not erase the frames on disk or in the video, but they will simply be ignored by further processing:

- The "**Keep img (ESC)**" checkbox allows you to discard the current image. It also allows you to see if the current image has been previously disabled. The **Esc key** on the keyboard has the same effect.
- **All** allows you to activate all images (thus canceling all previous eliminations).
- **# ?** allows you to display (in the text box on the right) the number of remaining images (which are retained): for example **INFO: Images checked 1508 / 1800**
- The best for last: since it is obviously almost impossible to deactivate images one by one in a video where there can be thousands of them, the **1-N** button gives you access to a small dialog allowing you to activate or deactivate successive image sequences:



You are shown the total number of images, the number of images retained, and the number of the first image retained. Below, two input boxes where you can enter the number of the first (First) and the **(Last)** image of the sequence to be processed. The "**Check in range/Uncheck in range**" menu buttons allow you to choose the operation to be carried out, keep/discard. Finally, the "**Range**" button performs the operation.

The dialog does not close, which allows you to repeat the operation (on another sequence of course). Each time, the report of the operation carried out appears in the message area: you can read that I have eliminated the first ten images (I am not able to launch a video without shaking the whole thing), images 120 to 233 (passage of an exceptional convoy that made the walls shake).

I still have to remove the affectionate outbursts of my Newfoundland that I had forgotten to lock in his kennel (963-1024), and I can click **OK** and move on to serious things.
If I completely missed my shot, I can start over by clicking **All or None**.

NB: This marking of desirable/undesirable images is used by several methods.
Notably for the export of images or videos but not only.
It is thus easily possible to extract partial collections of images and/or to make partial videos.

Some tips:

To loop the video, there is a 'Loop' checkbox in the Player.

If you want to close the video and open the current image displayed, there is a method in the Files menu, "**Close Video --> Open Video image**".

Not a bad "Save As", right?

The image that is displayed can be saved on disk by the **Save As** on the Contextual menu (right click)
If you had previously drawn a ROI, the software then asks you if you saved the whole image or the ROI.
And if the Viewer was not at its default settings, the software asks you if the Viewer settings will be applied to the image to be saved: Offset, Gain, Inversion. That is to say, how the image is displayed.

Software Author's Note [5]:
I don't know if we'll ever be able to write a 100% complete manual.
Feel free to explore for yourself.

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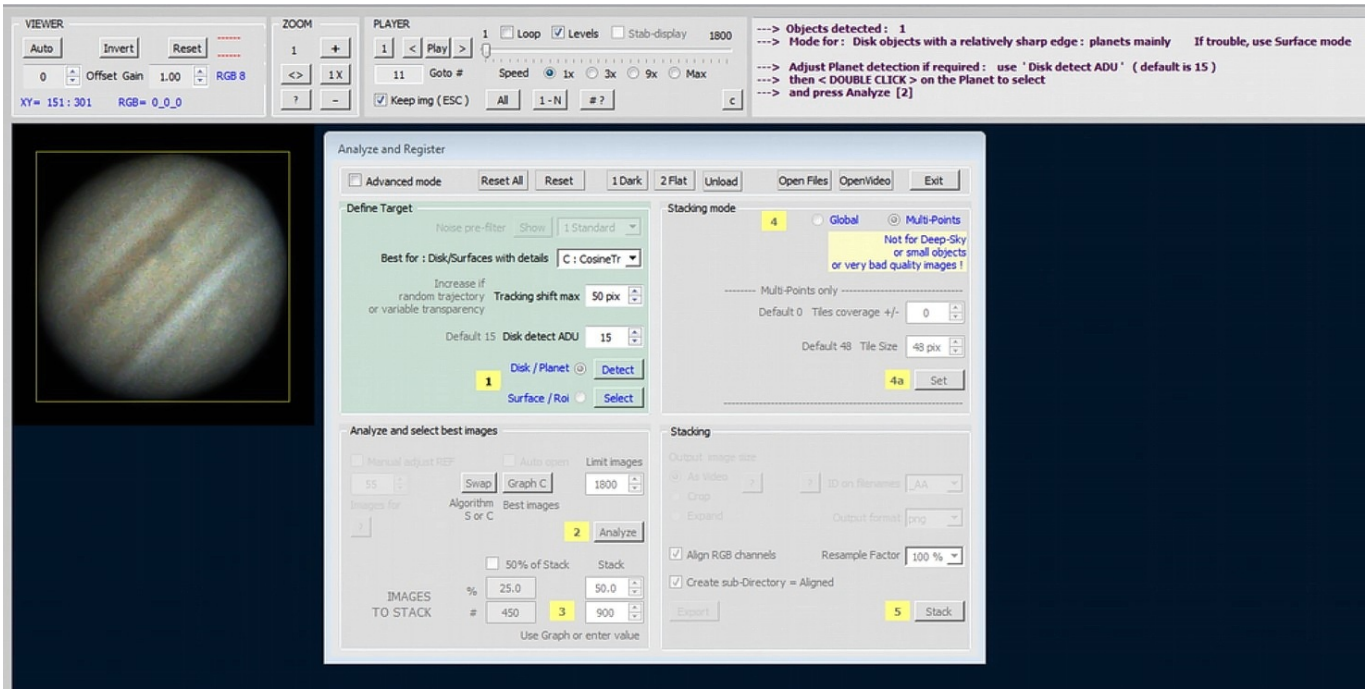
5 The editor disclaims all liability in advance.

Treatment.

We get there through the "**Analyze/Register: Project**" menu and we come across this magnificent screen which seems very complicated:



But everything is done to guide us step by step in the successive operations. As we are as modest as we are cautious, we will avoid clicking the "Advanced mode" box this time, which would not fail to plunge us into deep confusion by offering usa quantity of incomprehensible options. As on the other hand the treatment of planets and deep sky is quite different, we will start with the first ones (by pushing back the question of darks and flats to CP).

Treatment of the planets.

With our eyes irresistibly drawn to the little number 1 highlighted in yellow, we discover:

- **Disk/Planet Detect** (Disc/Planet Detection).
- **Surface/ROI Select**. (Surface/ROI Selection).

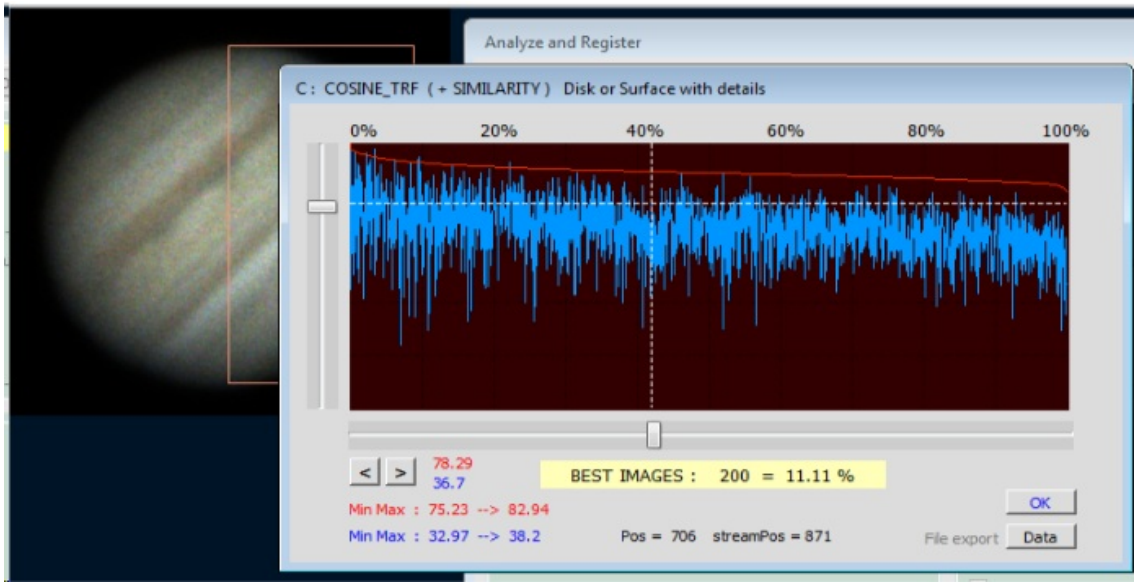
After having enjoyed the elegance of this British haiku, as the image obviously represents a planet, all that remains is to click on the corresponding button. We can see that this simple operation gets us out of trouble, not only because we see a yellow frame appear indicating that AstroSurface has found the planet, but also because the three options above have been automatically updated. It does not seem very prudent to touch them without having a good reason, however we can:

- Increase "**Tracking shift max**" which can be translated as maximum shift of images in pixels. Even if your tracking is almost impeccable, there is always a little shift between the images. If this shift exceeds the indicated value, AstroSurface will discard the image from the stack. Logically, the prior inspection of the images should have shown you if it is necessary to touch this setting.
- "**Disk detect ADU**" indicates the difference in brightness between the planet and the sky background, a value that AstroSurface uses to determine its outline. The yellow frame allows you to judge whether the selection encompasses the entire star.

The message area also has some useful information: first, that AstroSurface has found only one circular star in the photo. There could be several, indeed, and that is why it asks us to double-click on the chosen planet.
For the rest, AstroSurface warns us that the planets must have a fairly sharp edge to be detected, and that if that does not work, we can indeed adjust with "**Disk detect ADU**" and, in desperation, click the "**Surface/ROI Select**" button instead. [6]
This mode is made for full-frame or almost full-frame images: lunar, solar... Or for deep-sky images. In the latter case, for example, we can make a ROI on a small group of stars or a single one (!).
Important: When choosing this layout, we must ask ourselves: would I be able to recognize it very easily on the other images if it were shown to me alone?

And so, we can click on the "**Analyze**" button near the yellow number 2 that you had desperately clicked in vain until now. [7] The software calculates a little to estimate the quality of the images and then allows you to keep only a part of them for the rest of the operations. The "**Stack**" input box allows you to choose a percentage to keep and displays the number of corresponding images. This is the simplest and it is sufficient, but as we have a taste for risk, we will click the button marked "**Graph C**" (or Graph S depending on the algorithm used to classify in quality) which allows you to make a choice according to two different criteria:

- The quality score that represents the fineness of the details "cosine" [8].
- The quality score that represents the similarity with the reference image.



Here we see a 2D graph that represents the quality of the images according to both criteria at the same time. By sliding the sliders, we can select images that have satisfactory quality according to both criteria by favoring more or less one or the other. We also monitor the correct alignment of the images. When we are happy, we click **OK**.

NB: using the graph to limit stacking to the best images is not mandatory.
You can also simply enter either a percentage or a number of images to stack.
Enter in the boxes marked Stack: choose, percentage or number of images.

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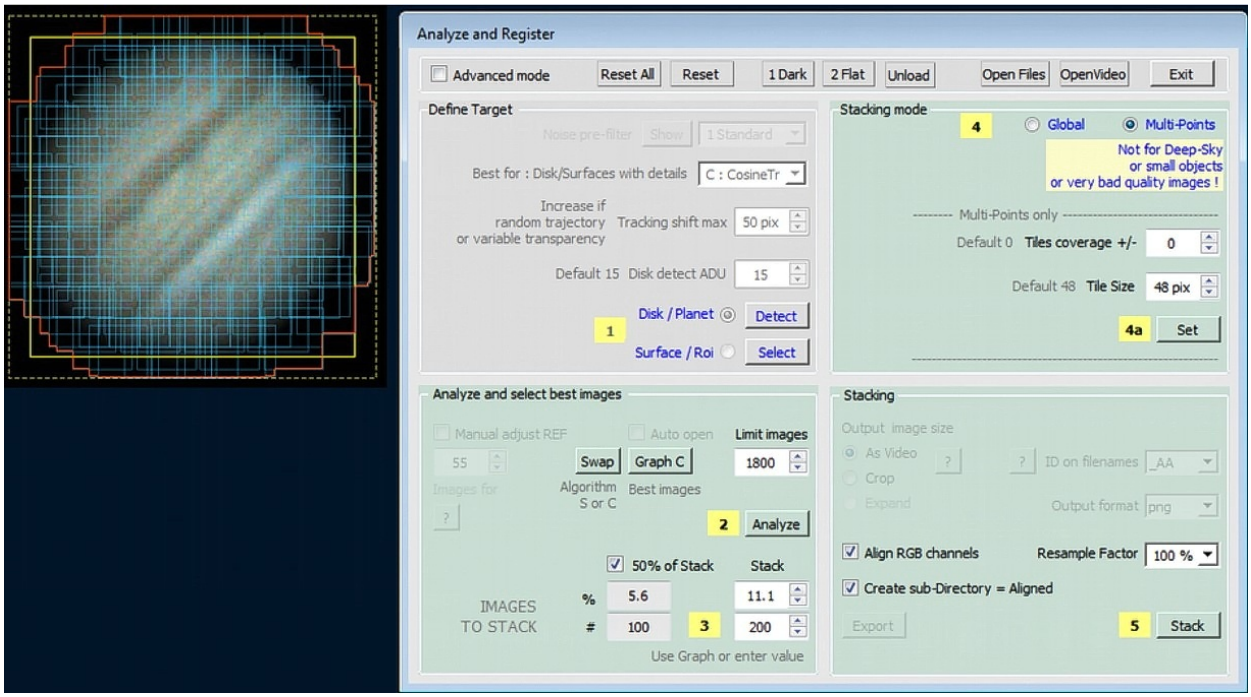
6 But in my humble opinion, it means that your images are so poor that you'd better give up.
7 Be honest... You tried...
8 In French "cosinus". Probably developed by the learned mathematician of the same name, which is a guarantee of quality.

NB: if we want to create a second stack that will be 50% of the images of the first, we simply click on the checkbox: "**50% of stack**". Which will ultimately create two images and not just one!

It is time to move on to the third part of the dialog. We are offered the choice between two stacking methods: global and multi-point. We are also told that the second is not suitable for processing images containing small objects (typically, the deep sky). We therefore choose multi-point [9], and, in accordance with our habits of caution, we do not touch the default values.

We click the "**Set**" button marked with a yellow **4a** and, before our dazzled eyes, the following result appears:



The message area warns us, however, that all this is not only intended to pleasantly tickle our retinas, but also to ensure that the entire planet is covered. If this is not the case, well, we adjust with the "**Tiles coverage** ± = covering by tiles" setting (and the Set button) until we obtain sufficient coverage (marked by the red outline).
"**Tile size** = size of the tiles" allows us to vary the size of the small blue squares (the tiles). It is recommended not to go below 48 pixels but we can enlarge them to see.

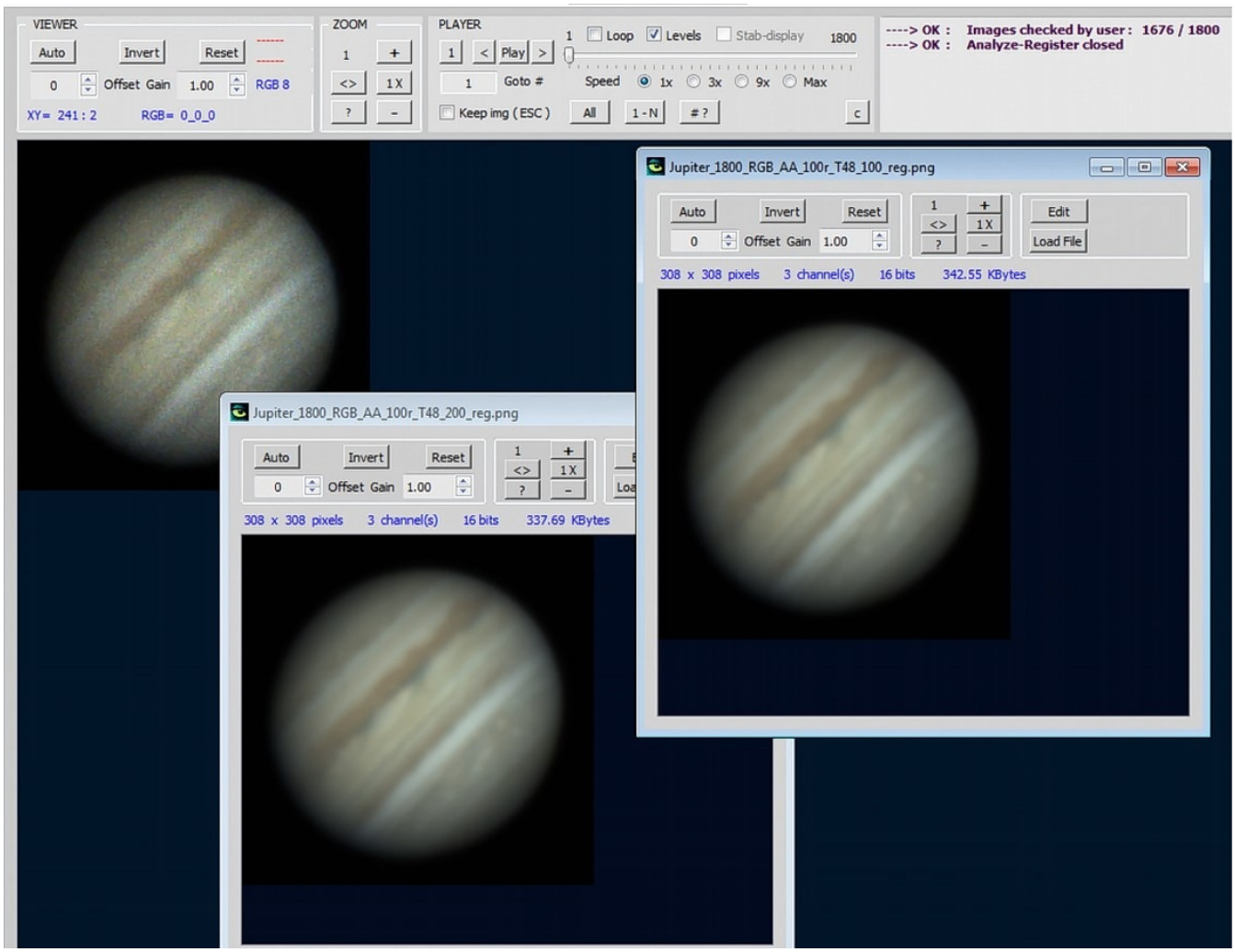
We have reached the end of our troubles. All that remains is to click the last "**Stack**" button and wait patiently for the result which is stored in a brand new image created on disk (in a subfolder named "**Aligned**" if you have checked the corresponding option). Here we even have two, and we will open them both together with the "**Files/File view open**" menu. The image is displayed in a separate window and can only be viewed, which gives us a comparison with the raw images that remained loaded [10]. We can see on the screenshot that the noise in the raw has disappeared, perhaps to the detriment of sharpness (but

9 Note that it is not impossible to choose the "Global" option for planetary images. Normally, "multi-point" gives better results, but it is up to you.

10 You can only load one video/collection/image for processing at a time, but you can load three for viewing only.

patience! AstroSurface hasn't said its last word!). There is hardly any difference between the two 100/200 images versions either, but the screenshot is not the best way to judge.

NB: the name of this or these two images is displayed in the text box. It is not obligatory to process immediately. You can redo settings and create other stacking images.



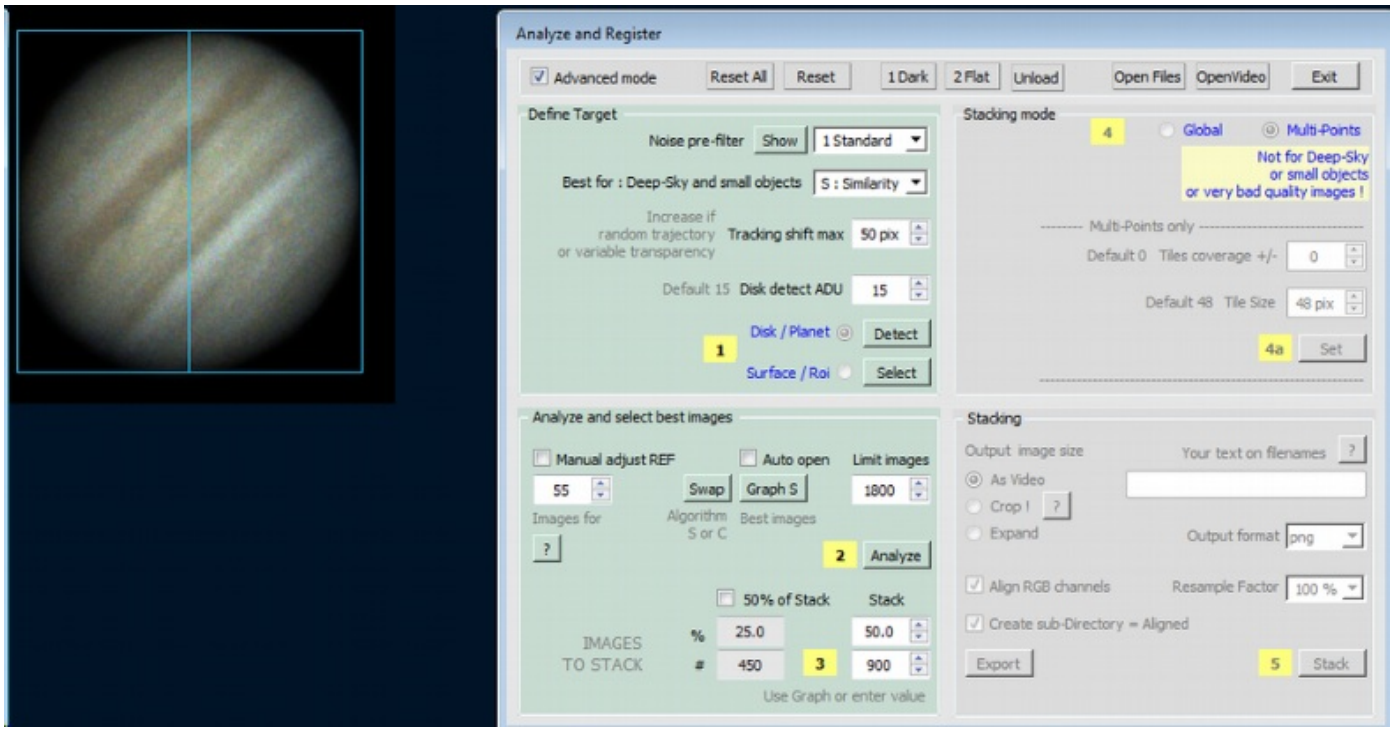
Reference image

As we said above, the images are aligned with each other during the analysis step. They can only be aligned with respect to one of the images in the collection. This is obvious. It is the one you double-clicked on or drew the ROI on at the very beginning. This very first image is very important because it is the one that serves as the geometric base for creating the reference image. Then AstroSurface creates a reference image by stacking a certain number of images from the collection. These images are not chosen at random: they are the first N of the collection not manually discarded.

This shows the importance of the manual sorting (or at least inspection) we recommended above. If everything goes well, there is no need to worry about the reference image, but if not, you can control what is happening by clicking "Advanced mode".

The check mark on “**Advanced Mode**” at the top left, allows you to show all possible options!

NB: in Limit Images, the number of images in the video normally appears.
You can reduce this number, for example to do quick tests or to not take into account the last images damaged by the arrival of clouds etc.



So click on "**Advanced mode**" and to see the very first of the N images that will constitute the reference image, just click on the "**?**".

The input box gives N the number of images stacked to create the reference. You can modify it, but it may not change much.

The "**Manual adjust REF**" checkbox will allow you, at the very beginning and during the analysis, to stop it automatically so that you can check and possibly make some manual adjustments on this reference image. Then you just have to restart the analysis, with or without modifications to this reference!

But you have to click on "**Analyze**" to see the corresponding dialog appear a little later, during the Image Analysis. And it will be possible at this time to inspect this reference image and possibly (but rarely) to modify it.

These operations are unnecessary in most cases, provided that the images are relatively stable and contain the ROI almost permanently. If, on the other hand, the final result is really unsatisfactory, we can investigate why. A good reference image is an essential condition for the rest.

Treatment of Planets II

This section shows how to process a planet image that does not contain a whole disk. It therefore mainly concerns the Moon or the Sun at high magnification [11]. The processing is not different from the previous one except that AstroSurface cannot detect a disk in the image since there is none. So, in step #1, you have to click the "**Select**" button and draw a ROI. It is better to choose for this a fairly contrasted region, presenting details and even possibly a part of the limb. As seen above, the ROI frame turns red if the selected region is too large. Then, the processing takes place as we have seen, using the multi-point option preferably.

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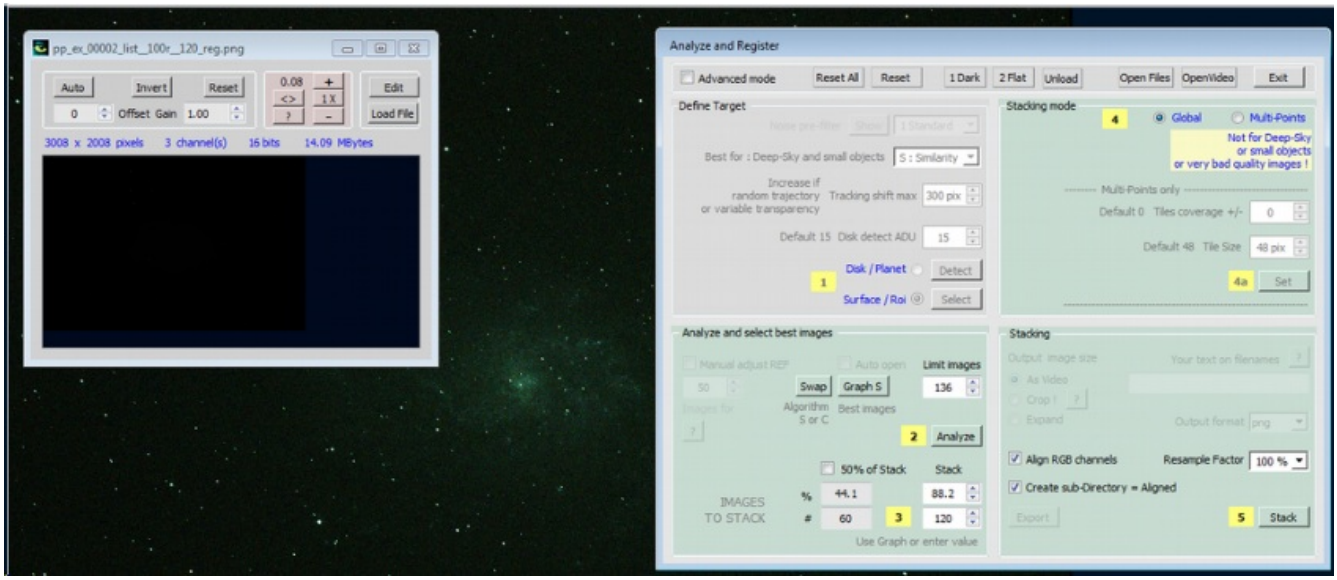
11 Otherwise you have a really big telescope or missed your framing.

Deep Sky Processing.

Deep sky image processing is not much different from what we have seen above. However:

- We will still use the "**Select**" button in step #1. Even if the stars also have a disk shape, "Disk/Planet" will not work. We will choose a ROI close to the center of the image and presenting characteristic and contrasted details.
- We will always use the "**Global**" option in step #3 because "**Multi-points**" does not work well in this case [12].

Here is a summary of the settings. At the end of processing, the stacked image appears in a separate window.



Offsets Darks and Flats.

As you probably know, these shots are intended to correct noise of electronic origin inherent in sensors as well as certain exposure defects (vignetting, etc.) The presentation of these techniques goes beyond the scope of this manual and we will simply explain their implementation.

- Two buttons **"1 Dark" "2 Flat"**, allow to incorporate respectively a master dark and a master flat in the course of the treatment. It is enough to choose the corresponding file that we will have previously made from a certain number of shots. Note that these images must be dematrixed and that the master offset must be subtracted from the master dark beforehand (reason why there is no "Offset" button).
- An **"Unload"** button allows to remove the use of master dark and flat in the subsequent treatments.

Making masters.

Astrosurface allows you to make the masters we just mentioned from collections of images taken under the same conditions. These functions reside in the **"Dark/Flat"** menu as you might expect. In all cases, you will start by loading the collection of images intended to create the master files.

- Make an offset = Create a master offset file. Click on the "**Calculate**" button and it's folded.

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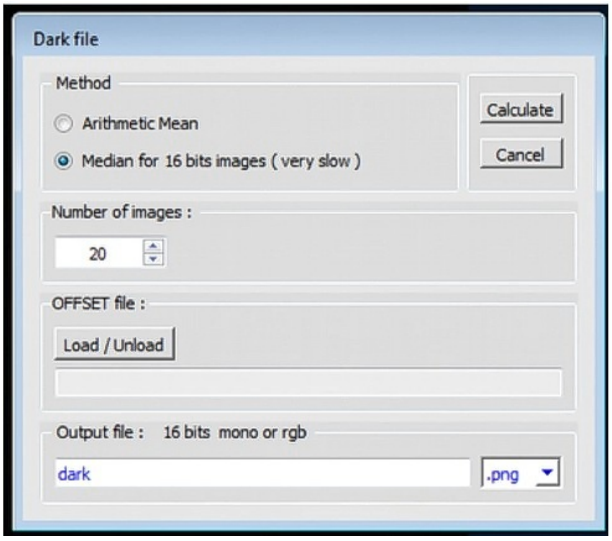
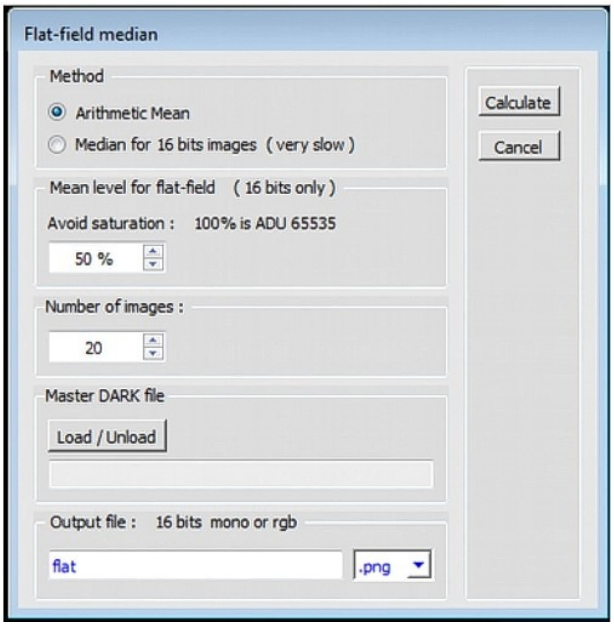
12 But you can always try if you are not convinced.

- **Make a Dark** = Create a Dark master file. It is not more complicated, except that we have the choice between two methods of calculation: "Arithmetic mean" = arithmetic mean and "Median for 16 bits images" = median for 16 bits images (which we are warned is very time-consuming). Note also that the **OFFSET File frame** allows us to incorporate a master offset file created by the previous function. Finally, the last frame allows us to choose the name of the file produced.



- Make a flat = create a flat master file.

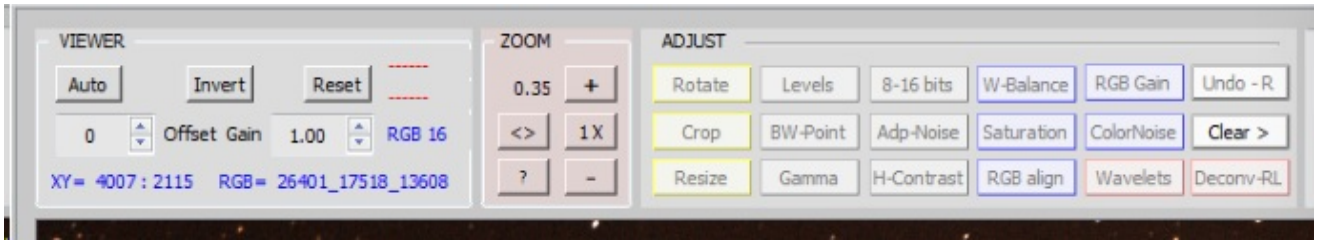
As above, two methods are proposed. In addition, we can choose the average exposure of the flat (Mean level for flat field): higher values will give lighter flats, but be careful with saturation.
Finally, we can apply a dark master to these flats:



Processing of individual images.

This processing is the logical continuation of the processing of a collection of images, but it can also be applied by directly opening an image using the **"Files/Open a File"** menu that we saw above.

The various functions are present in the **"Image tools"** and **"Filters"** menus that we will detail below. The most used ones are also accessible by the series of shortcut buttons of the same name located in the toolbar.



Let's point out in passing that the settings presented here are for the most part heavily exaggerated for the clarity of the exposition. Don't accept that these are recommended examples to follow.

Menu Image Tools

These functions are similar to those found in all image processing software and are therefore quite easy to understand.

Automatic Levels

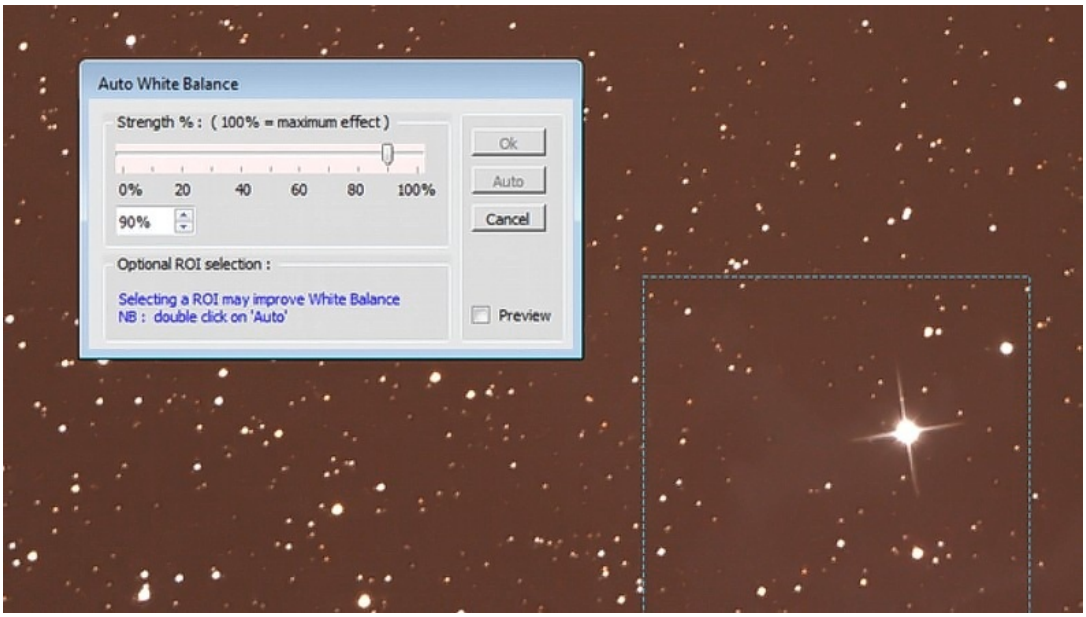
This function has the same behavior as the "Auto" button located in the left part of the toolbar. But it is the image that is modified and not just the display.

This is useful for images where a range of brightness is unused: for example, a very dark or very light image. The function distributes the pixels over the entire available range by modifying their brightness value. It can be adjusted manually, but in this case, there is a risk of saturating the highlights or overpowering the darkest parts.

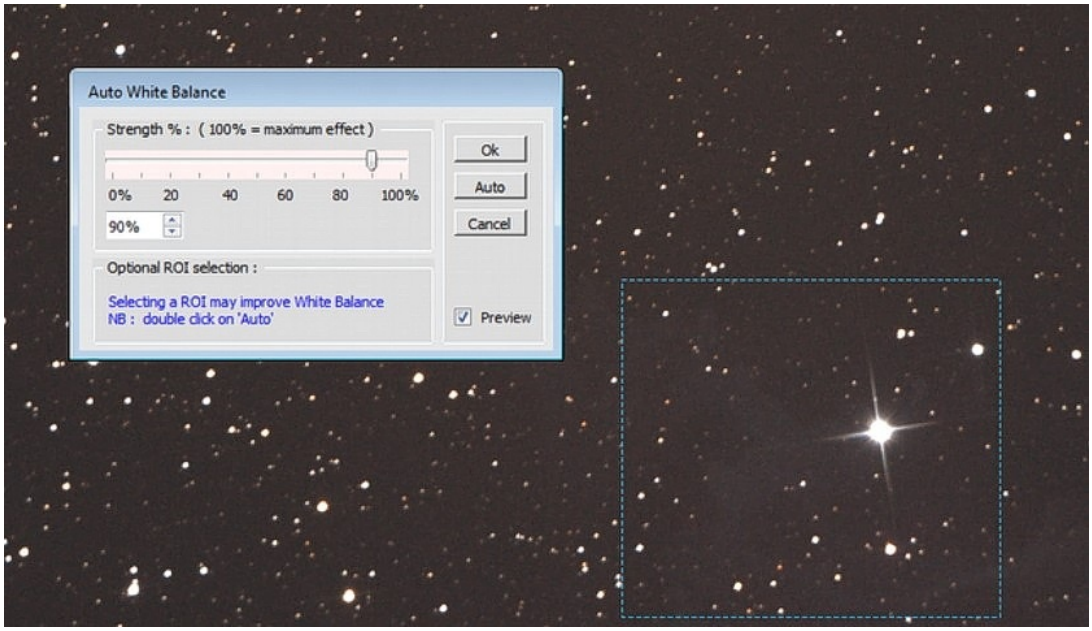
Black and White Settings.

These are color settings. **"Auto White Balance"** = Automatic white balance allows you to remove a dominant color in the image as below:

Before [13]



After [14]



The small blue text indicates that you can get better results by defining a ROI (which has been done here)

"Black and White levels" = White and black levels, gives you more control.
We start by selecting a portion of the image that should be black [15], then we click the **"Set Black"** button.

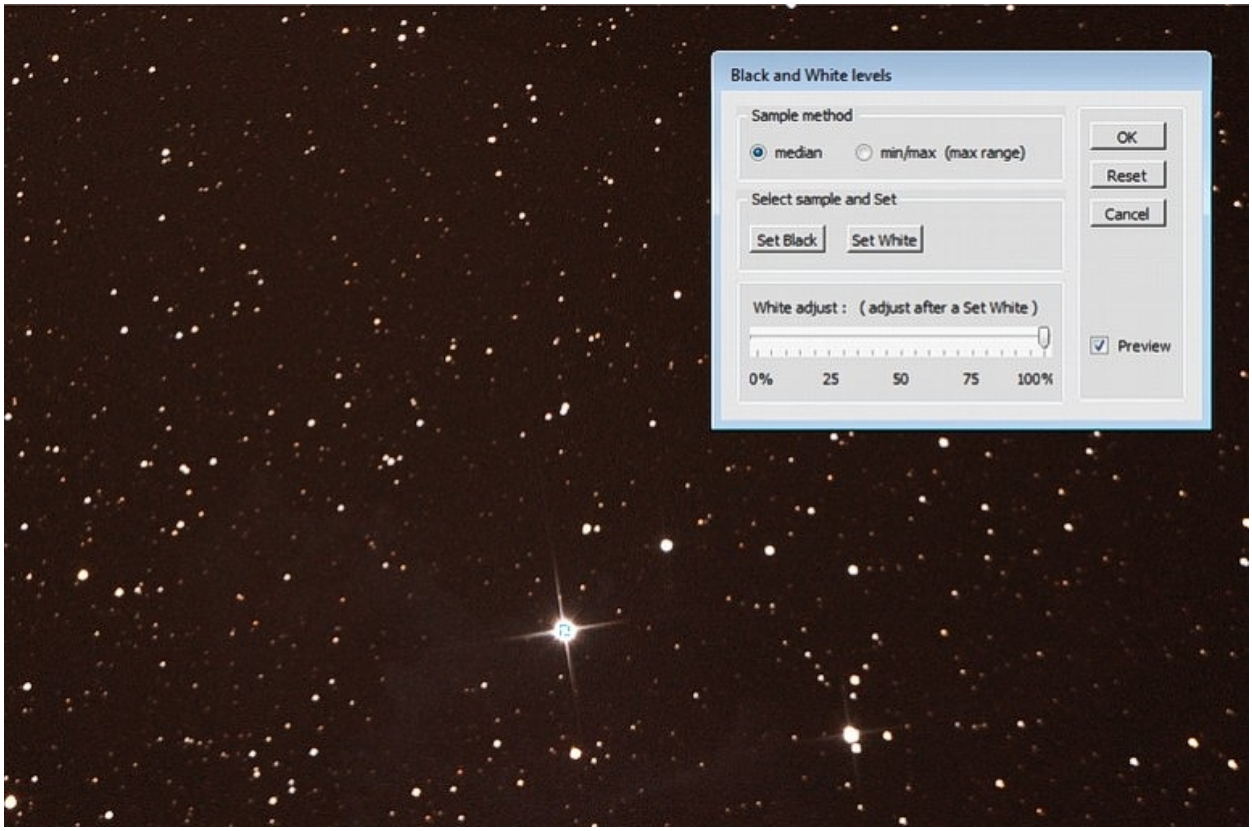
---

13 Yes, the image is very ugly, but that's on purpose. If it were successful, we wouldn't be able to admire what AstroSurface is capable of doing to save her.

14 She didn't lose ten kilos, but luckily, she can get a refund: it was a free trial.

15 ... in your mind. But you take responsibility for it.

We then do the same for white with the "**Set White**" button [16]. We also have the choice between two calculation methods: median or min/max (minimum/maximum range).

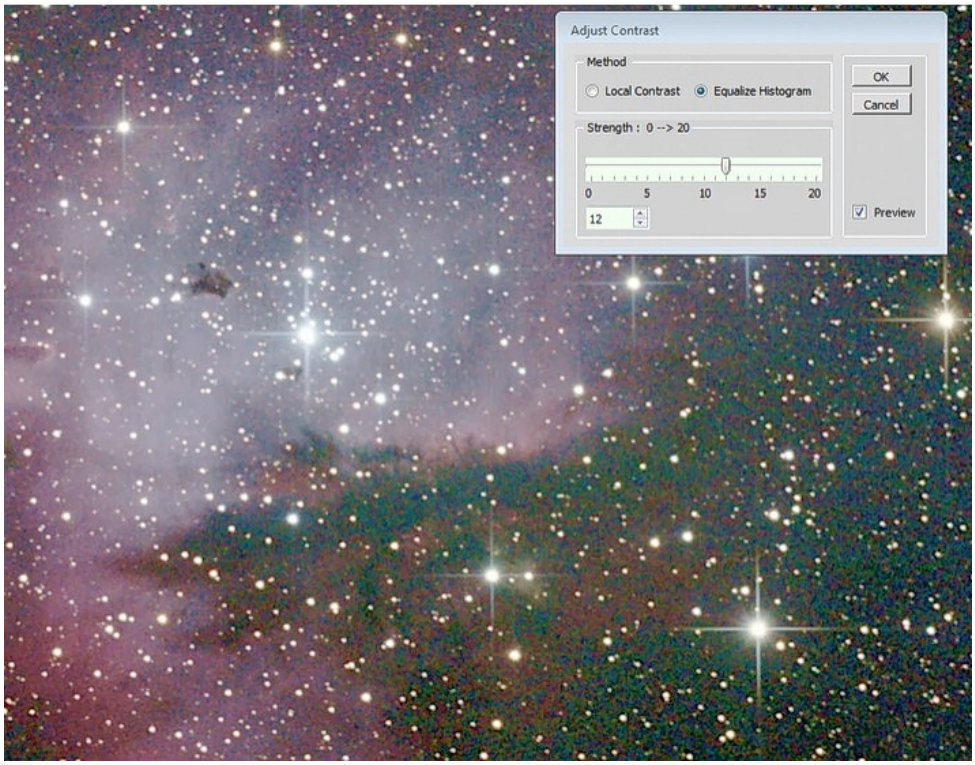


The image is still ugly, but we are beginning to discern the reddish clouds surrounding the flaming star. This is undoubtedly progress.

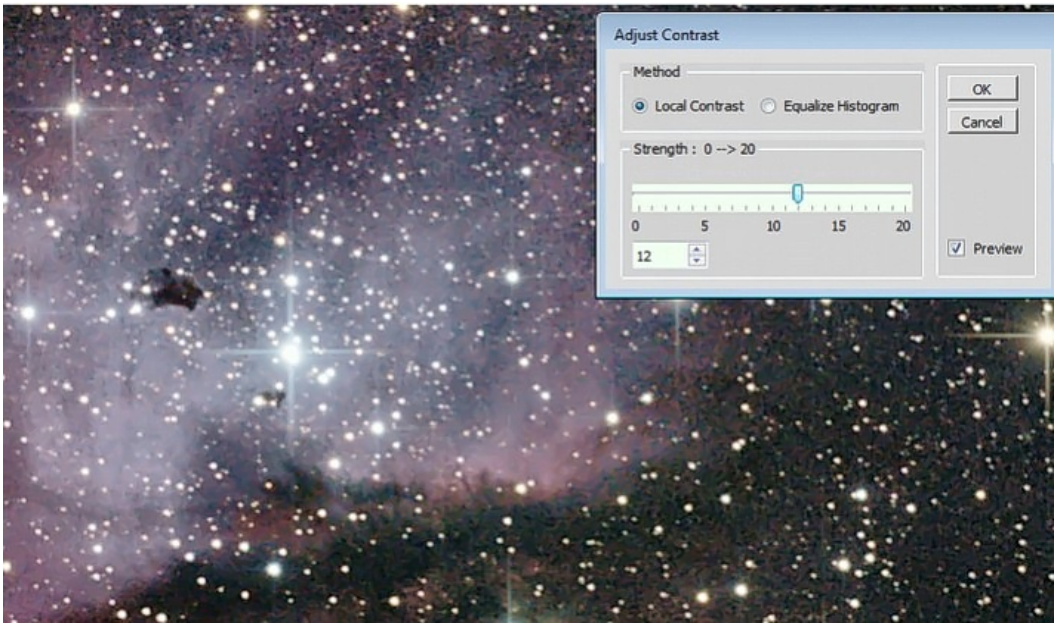
16 We can also be satisfied with one or the other. It's up to you

Adjusting Contrast

This is a contrast adjustment that can be quite classic in the "**Equalize histogram**" option. The operation applies indiscriminately to the entire image with the disadvantages that we see below:
increased noise in particular.

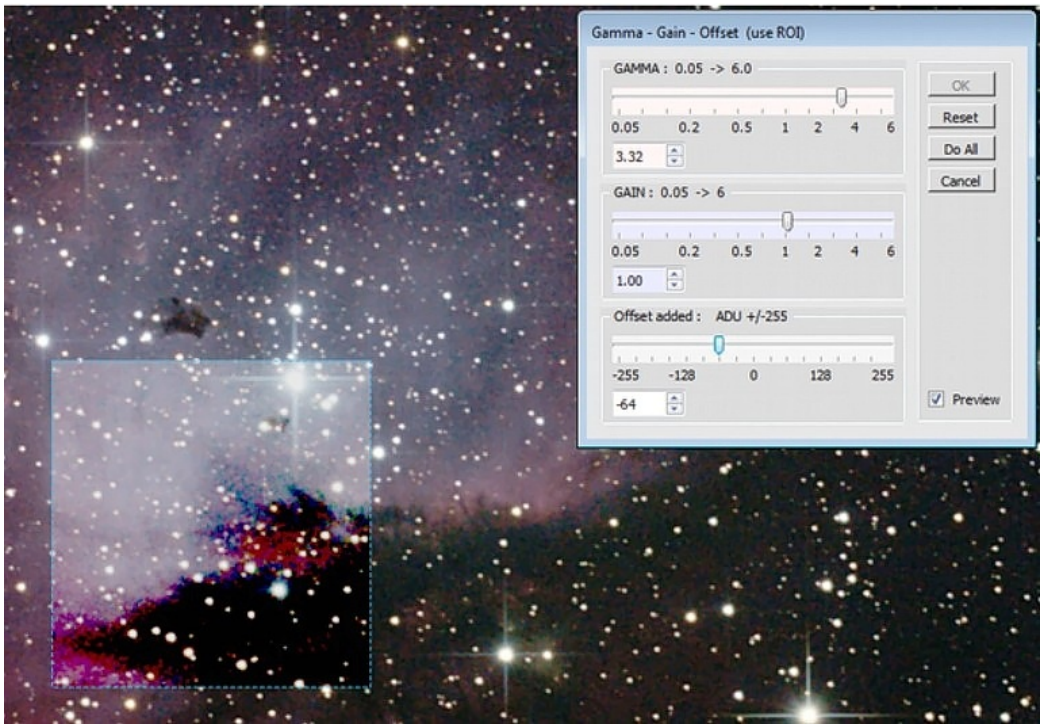


The second method (**Local contrast**) adjusts the contrast according to the environment, which largely avoids the excesses of the other method. It is particularly effective on planetary or lunar surfaces.



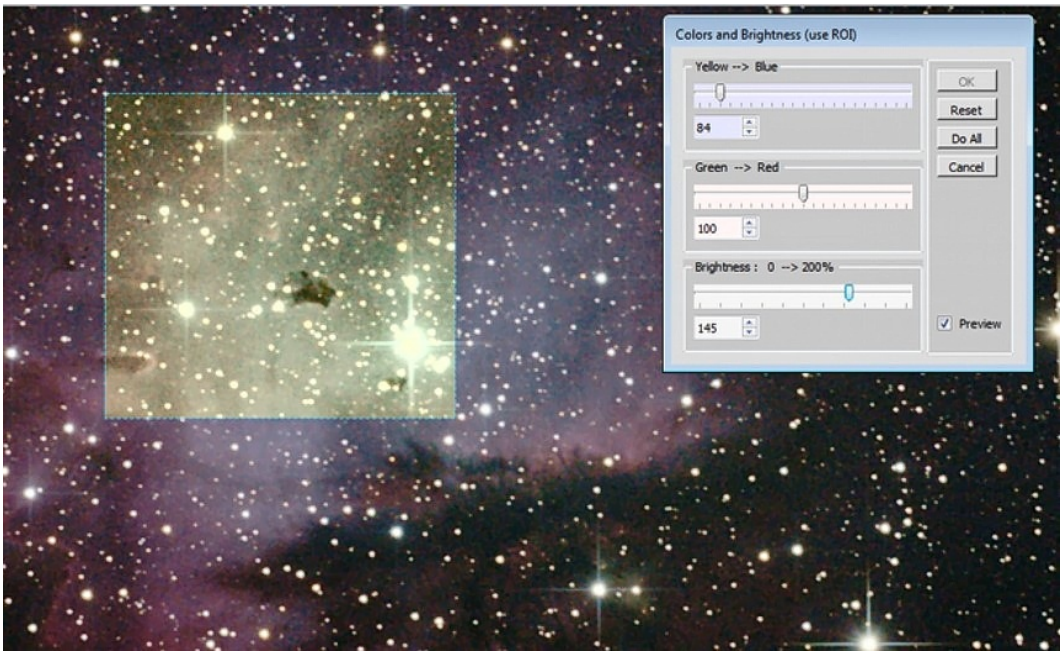
Exposure Gain Offset

The three settings are combined in the same palette. Apart from the gamma which affects the vividness of the colors, you can also adjust the gain, i.e. obtain more distinct colors and finally the offset which allows you to correct the brightness of the result by adding or subtracting a value from the brightness of all the pixels.



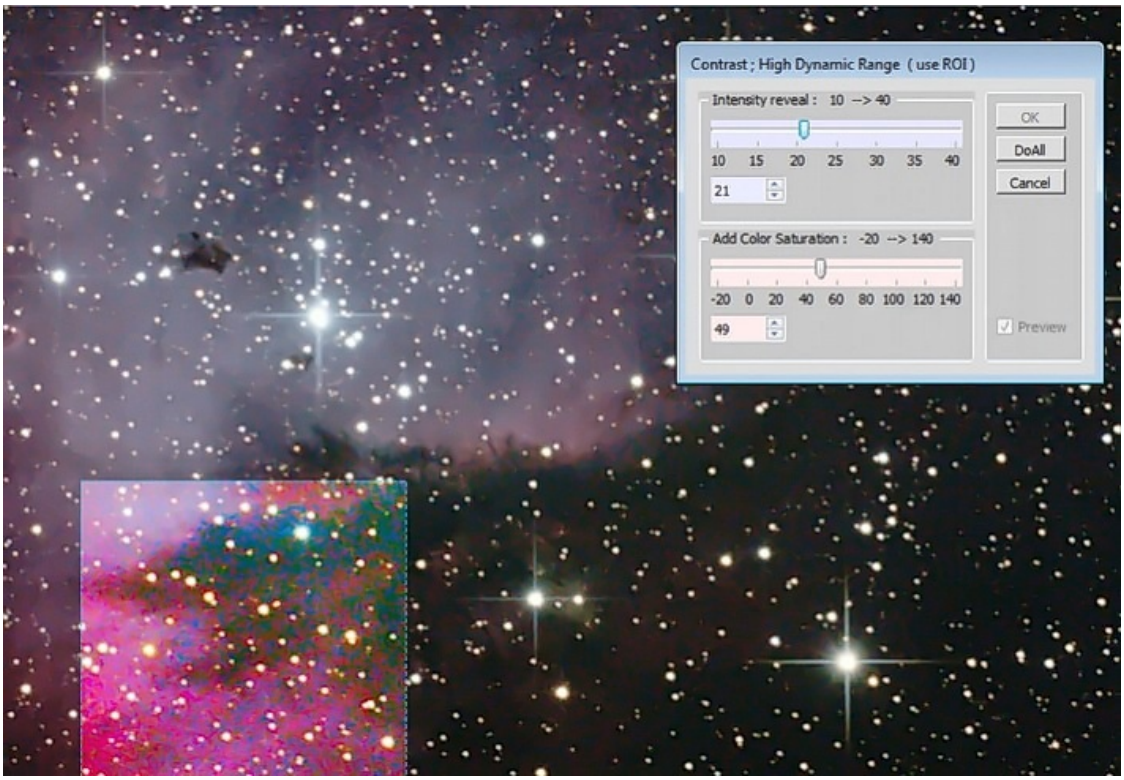
Colors and brightness

The overall tint of the image can be adjusted using the sliders:
"**Yellow → Blue** " , " **Green → Red** " and "**Brightness** ".

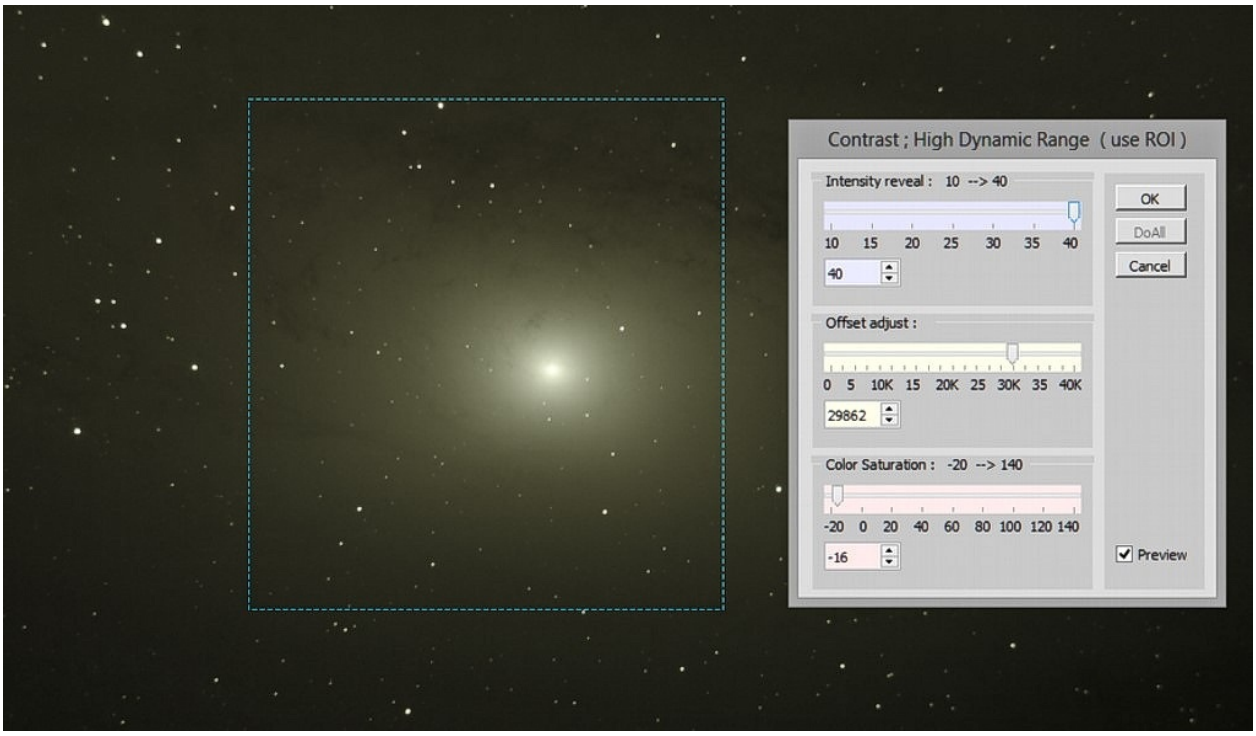


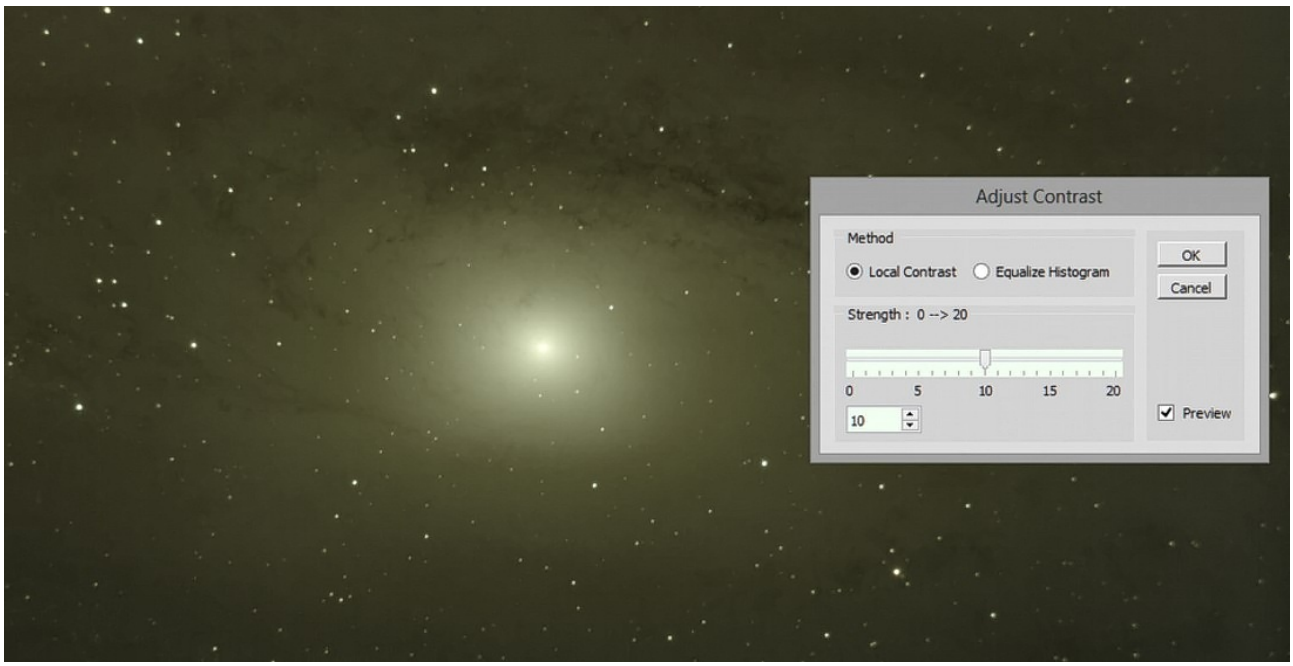
HDR Contrast Adjustment (HDR Contrast)

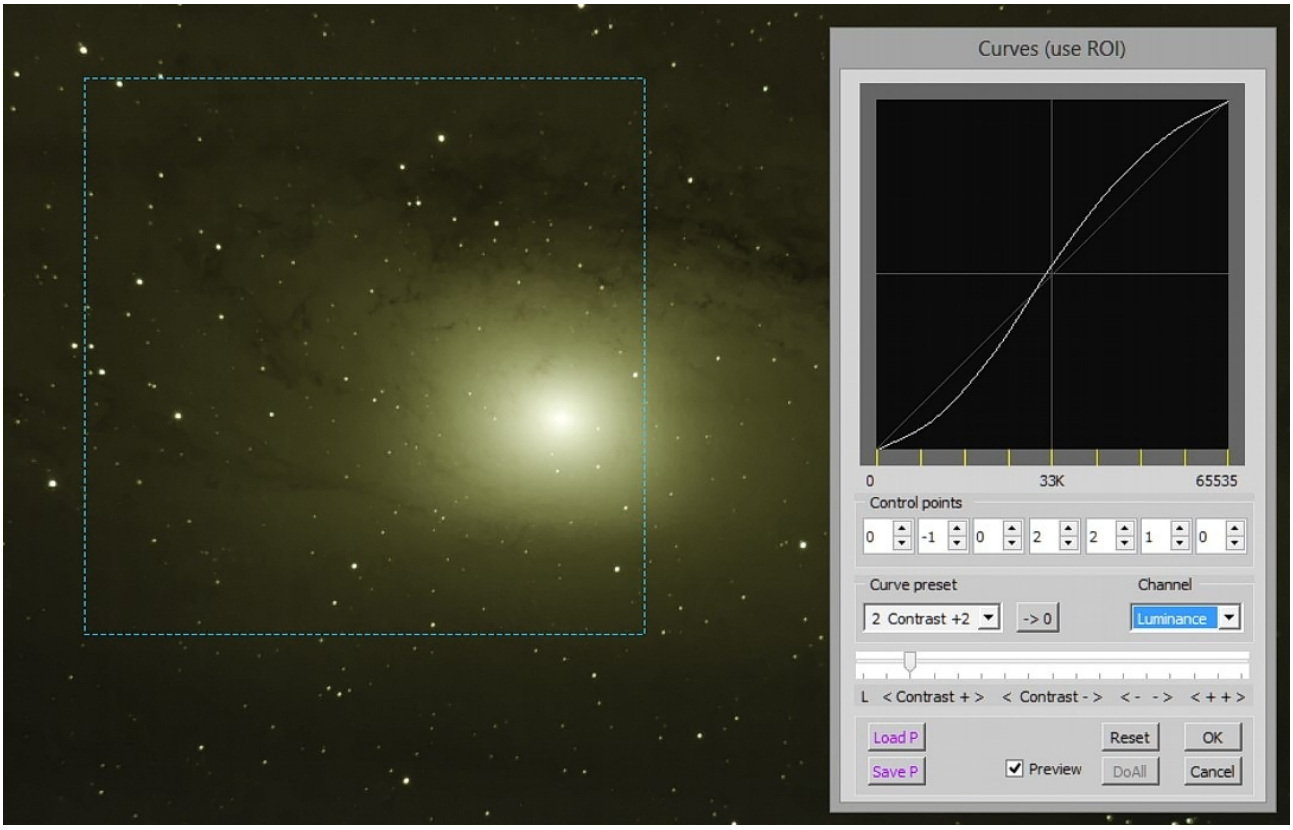
High Dynamic Range means large dynamic range. Characterizes images where there is a large difference in brightness between highlights and lowlights (very common in deep sky). This function is intended to bring out the latter without saturating the others, so the contrast applied is not linear as in the classic contrast setting. As a bonus, you can adjust the saturation.



Another more detailed example using local contrast to reveal details of this galaxy invisible in the original image without burning the core:

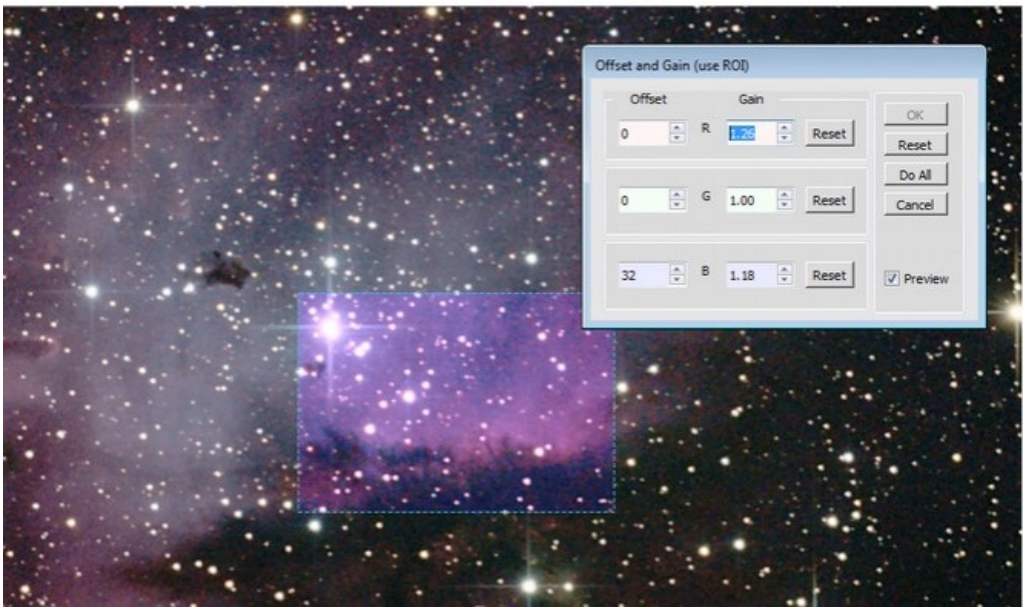



Adjust Contrast
Method
Local Contrast
Equalize Histogram
OK
Cancel
Strength : 0 --> 20
0
5
10
15
20
10
Preview


Curves (use ROI)
0
33K
65535
Control points
0
-1
0
2
2
1
0
Curve preset
2 Contrast +2
-> 0
Channel
Luminance
L < Contrast + > < Contrast - > < - - > < + + >
Load P
Save P
Preview
Reset
DoAll
OK
Cancel

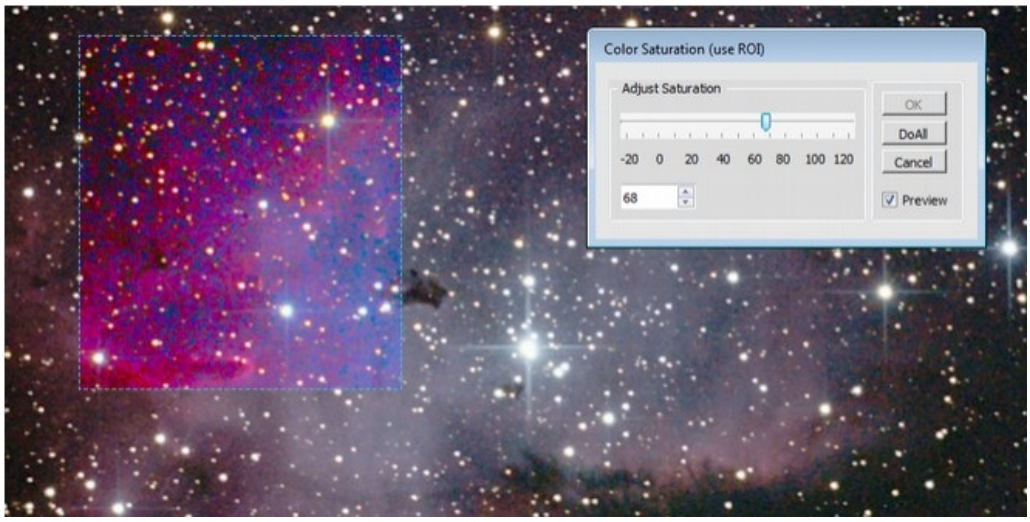
Color balance

Two values can be set separately on each of the fundamental colors: the gain which multiplies the color value of a pixel by the specified amount, and the offset which adds the specified amount. The "Reset" buttons allow you to return to the default values (1 and 0 = no change).



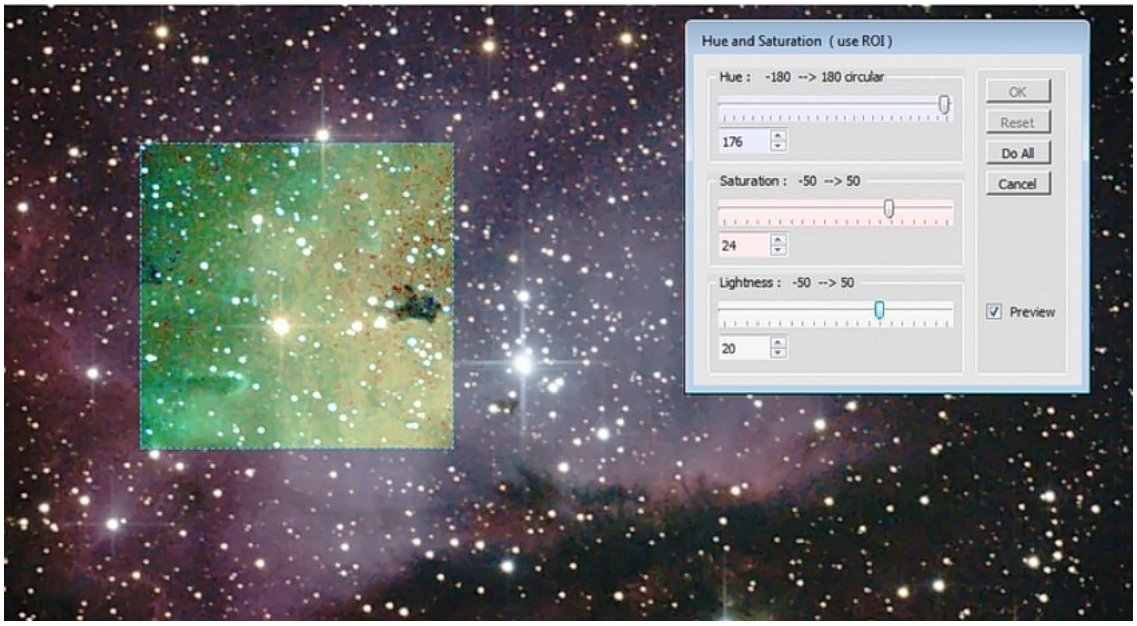
Color saturation

The classic saturation setting.



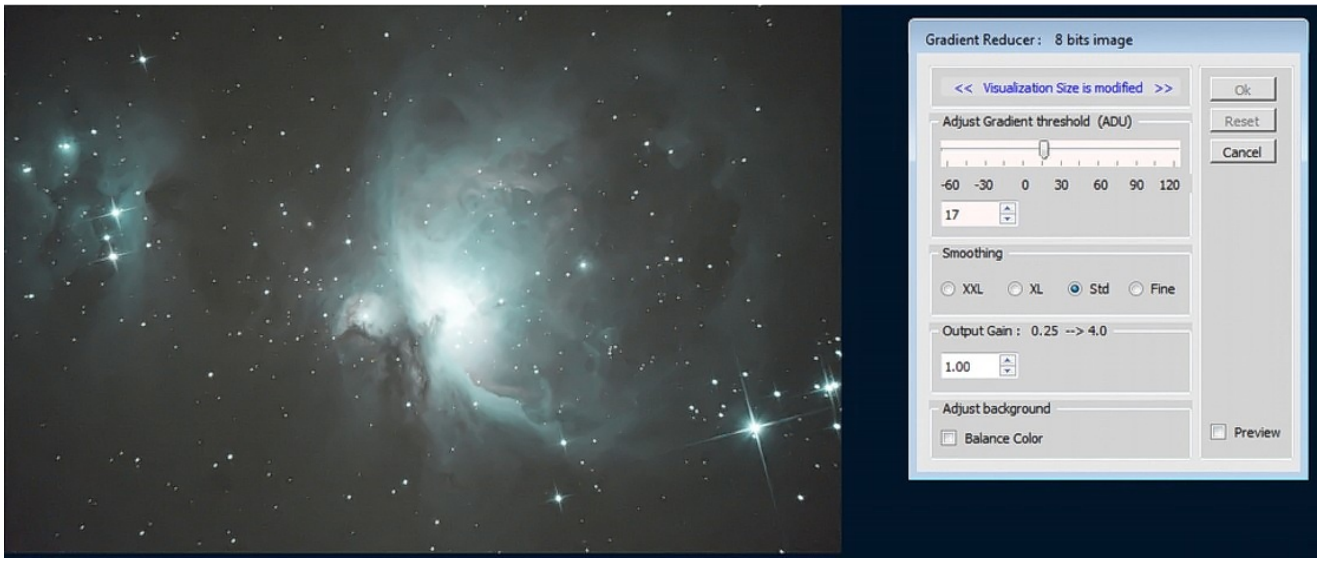
Hue and saturation

A combination of hue and saturation. The **Hue** slider shifts all colors in the RGB spectrum with looping (i.e. if you push to the right, deep purples will become red, and in the other direction, burgundy reds will become purple then blue). This way, you can give this photo a fake SHO look.
The last slider adjusts the brightness.



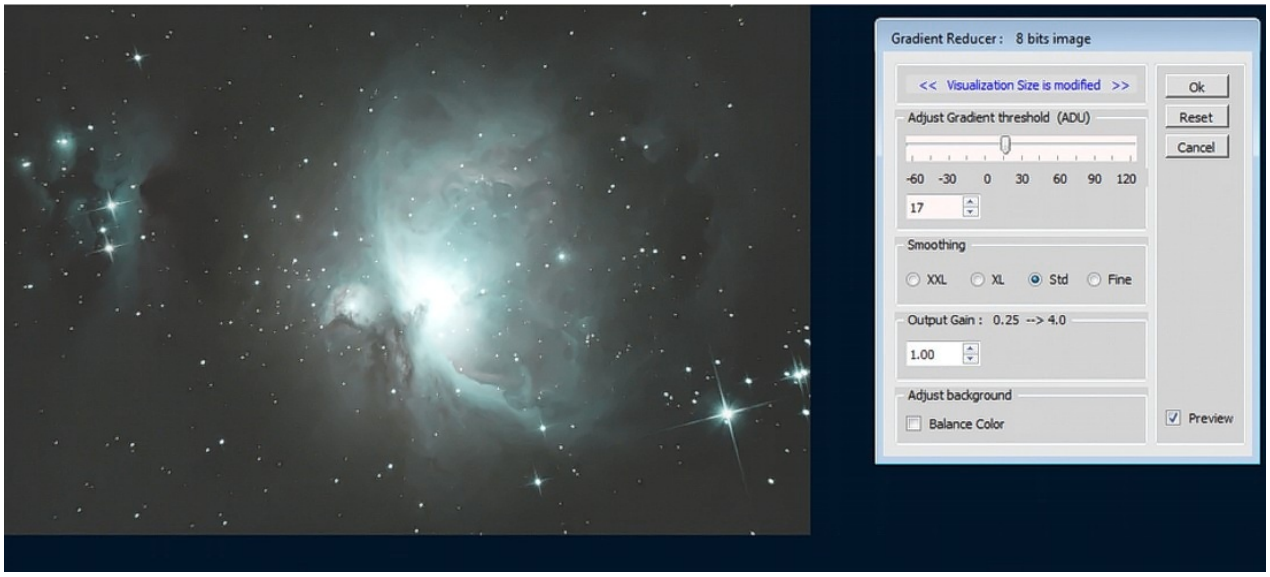
Gradient Removal

This feature is very useful for astronomical photos that often have defects due to optics (vignetting) or the environment (light pollution) that appear as gradients in the sky background. The photo below shows significantly darker corners, characteristic of vignetting:



The small blue text tells us that the size of the image on display is modified automatically, which is a good idea since it is to correct a defect that affects the entire image. **Gradient Threshold** means gradient threshold, in other words it is the value to adjust to remove the gradient as best as possible. **Smoothing** allows small irregularities to be ignored. Various values are possible, to try. **Output gain** allows

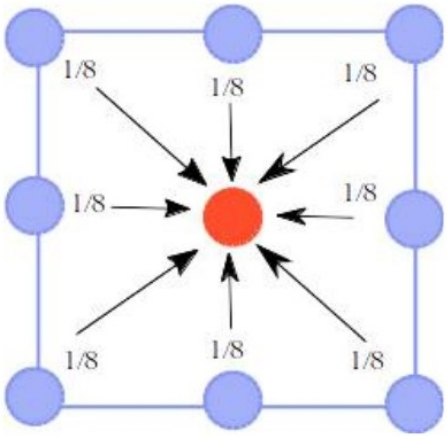
to adjust the brightness of the result. **Adjust Background Balance color** is an additional possibility that is of interest when the gradient is colored (light pollution for example). In this case the color balance is corrected to eliminate the dominant. We can see in the image below that the vignetting has been removed at the cost of a slight brightening of the sky background (which could have been removed with the output gain).



Filters Menu

What is a filter?

In computer image processing, this refers to a class of functions that has nothing to do with the ordinary notion of a filter. These functions modify the pixels of the image by taking into account their neighbors. Concretely, we define the neighborhood to be taken into account by a more or less large square of which the pixel to be modified is the center. All the others are assigned a function (or a simple coefficient) that will determine their contribution to the new value of the central pixel. This square is called a "kernel". To clarify the ideas, let's look at a very simple case: replace the color of a pixel by the average of the colors of the immediately neighboring pixels. The kernel will look like this:



The coefficients represent the contribution of each pixel to the final value of the color of the red point. By successively applying the operation to all the pixels of the image, we obtain a blur (which is not Gaussian), but nothing prevents us from assigning different coefficients to the neighbors or from working on larger kernels [17]. If we proceed randomly, the results are of no interest most of the time. This is why we build most filters by analogy with mathematical operations that have a physical meaning (the convolution product in particular). I say by analogy, because these operations are defined on continuous spaces, which is absolutely not the case for pixel arrays. So, it's a bit of voodoo, but since it works globally and since most programmers care about mathematical rigor as much as their first shirt...

The possibilities are almost endless, just open the "Filters" menu in Photoshop to realize it. Moreover, it is not difficult to imagine that these treatments that can be complicated are lengthy in execution time, especially when the kernels are large, because there are all the more operations to perform. AstroSurface only implements filters relevant for the processing of astro images. Also note that the filters do not all have the same efficiency on all types of images. That is why there are so many. Some can be efficient in deep sky and mediocre in planetary or vice versa. You have to try it out.

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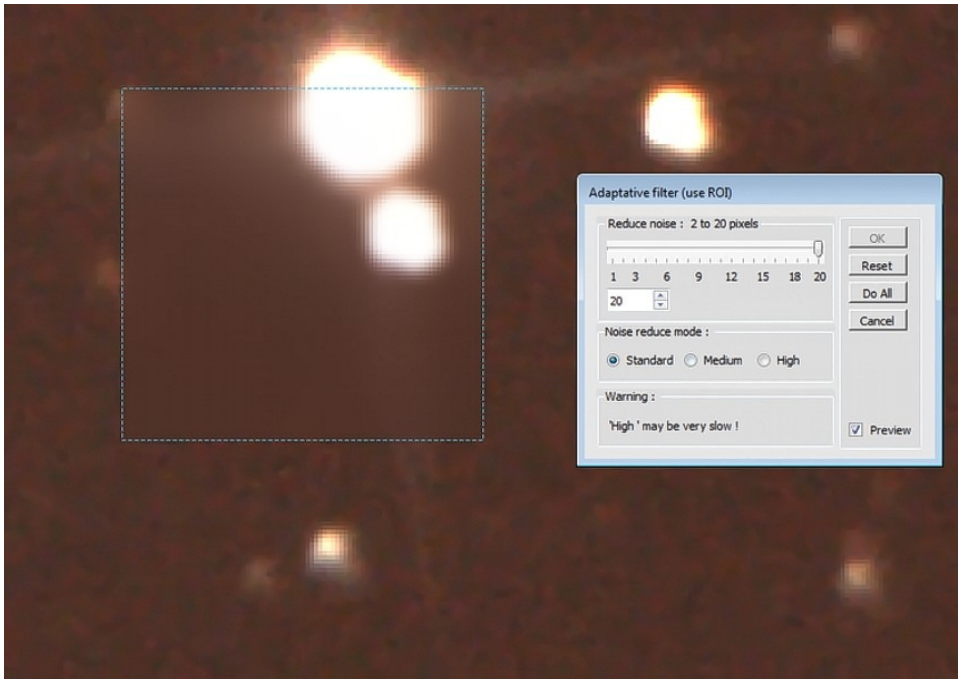
17 If you want to play with this, AstroSurface allows you to define your own kernels and apply them to an image, and you will find the same functionality in Photoshop and Gimp.

Gaussian Blur

A great classic. It introduces a more or less significant blur in the image. It can be used to soften the edges of an overly sharp image [18] or to limit noise, but the following filters are more effective in the latter case.

Adaptive noise reduction (Adaptive filter)

We're not going to rack our brains trying to figure out why it's called that. As you can see, it reduces noise very effectively, but it also comes at the expense of sharpness and the smallest details (you can see that the edge of the biggest star, which was already not very sharp, disappears completely). Unfortunately, this is more or less the case with all noise reduction filters.



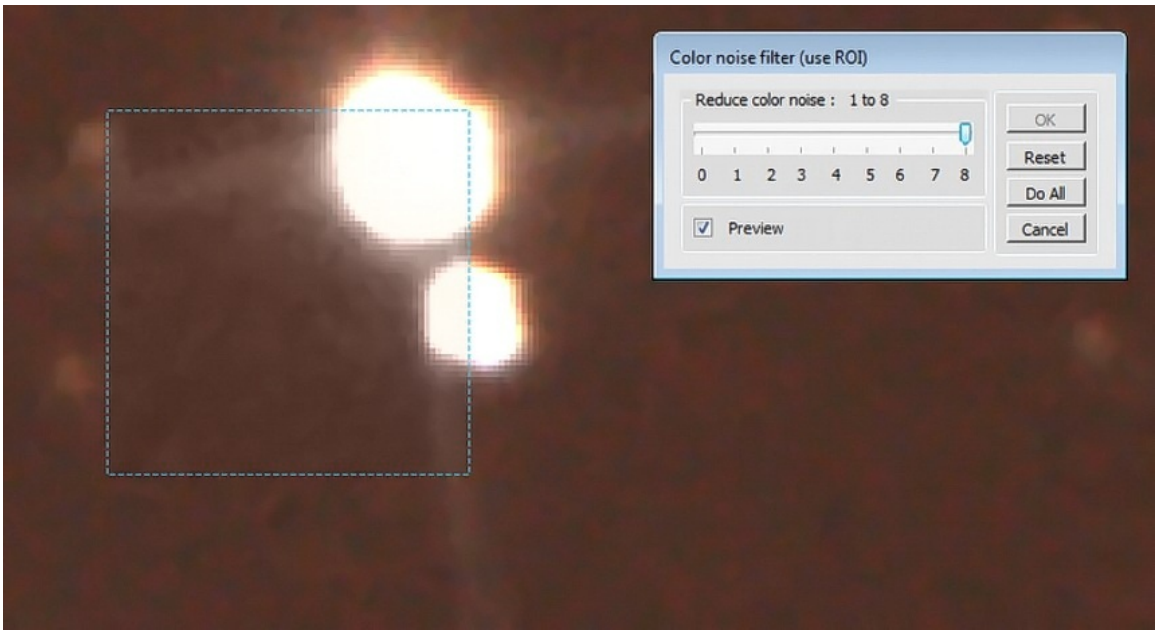
Reduce noise = noise reduction. The slider allows you to adjust… well the size of the kernel! The bigger it is, the smoother it will be. **Noise reduce mode** offers three distinct modes. If the standard is not enough, try the others (the **High** mode can be very slow).

---

18 Overly sharp astronomical images are probably as rare as five-legged sheep in my opinion, but after all, it's a matter of taste.

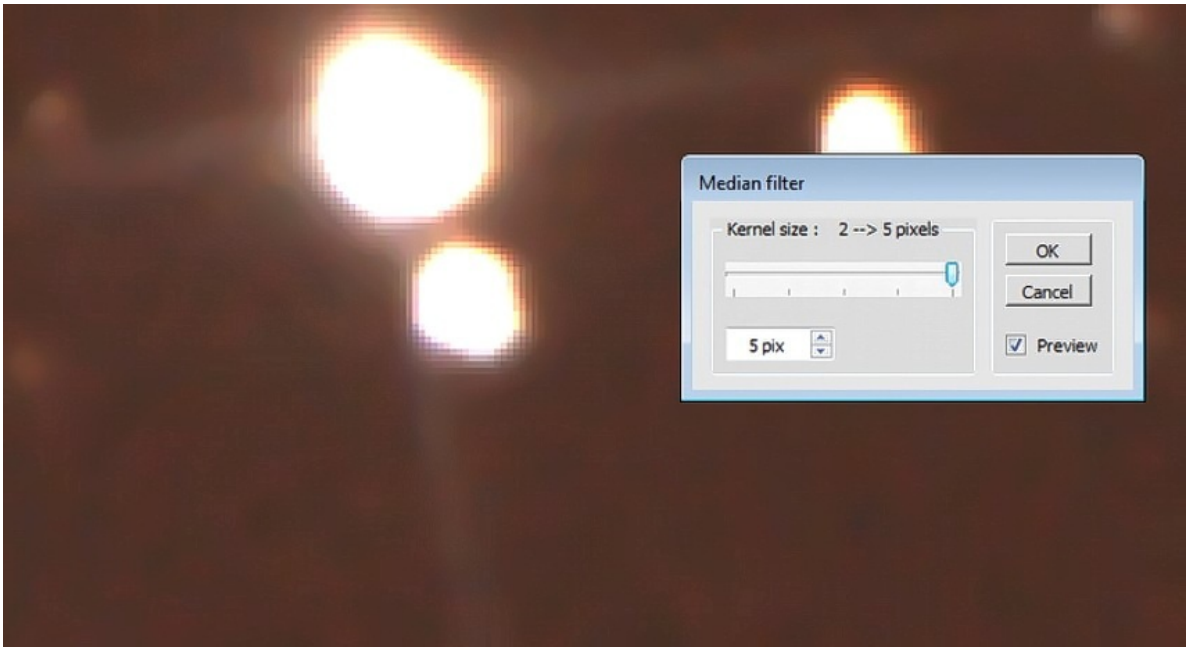
Color noise reduction

Noise often appears as a somewhat random coloring of low-light pixels. This filter reduces this color disparity a bit like desaturation. Unlike the previous one, this filter barely affects sharpness:



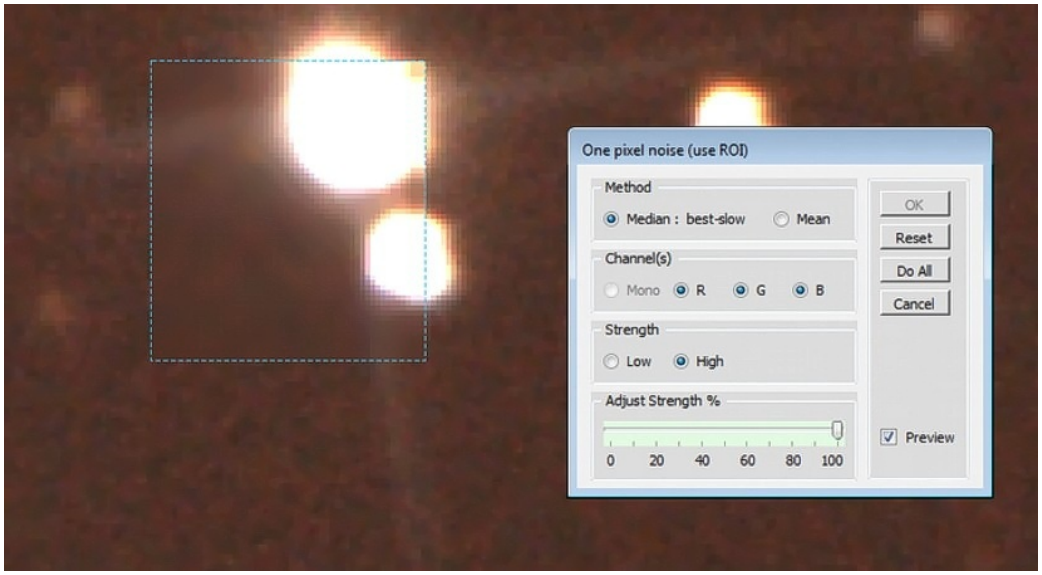
Median filter

Another filter for noise reduction. Like the others, it tries to reduce noise while losing as little detail and sharpness as possible.



Impulse noise

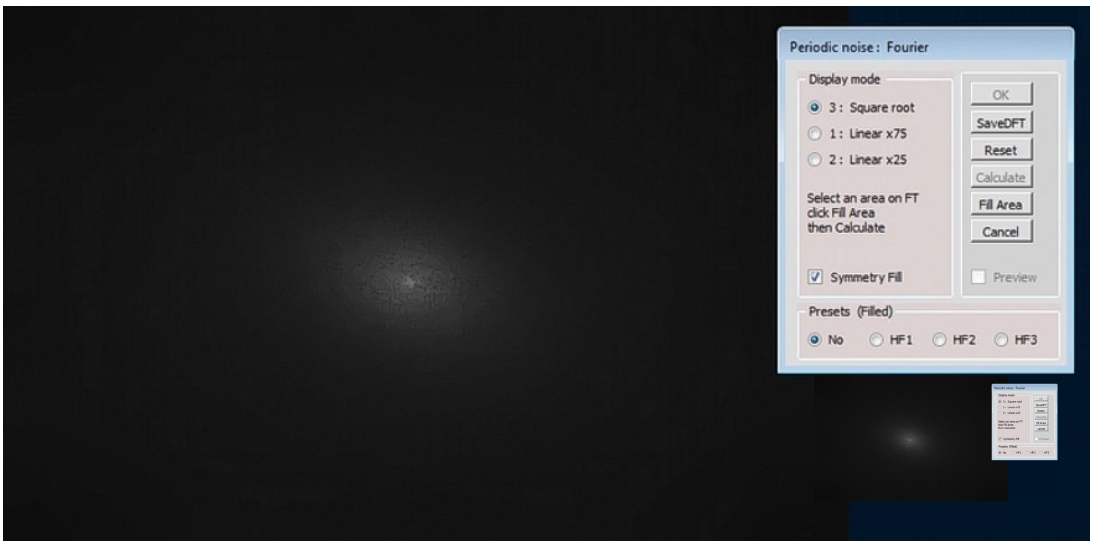
Another noise reduction filter. There are two methods: median best-slow (best but slow), average. Strength = strength to adjust to your liking: Low = weak High = high, plus the slider.



Fourier transform noise reduction.

A noise reduction based on the Fourier transform. This transform is a mathematical operation that is as useful as it is incomprehensible to ordinary mortals (see: https://fr.wikipedia.org/wiki/Transformation_de_Fourier).

To try to give an idea, let's say that an image is transformed into a cloud of points, each of which represents a detail of a given dimension (whatever its shape and position in the image). The position of this point in the figure is a function of the dimension of these details and its brightness a function of the number of similar details. And that gives this:

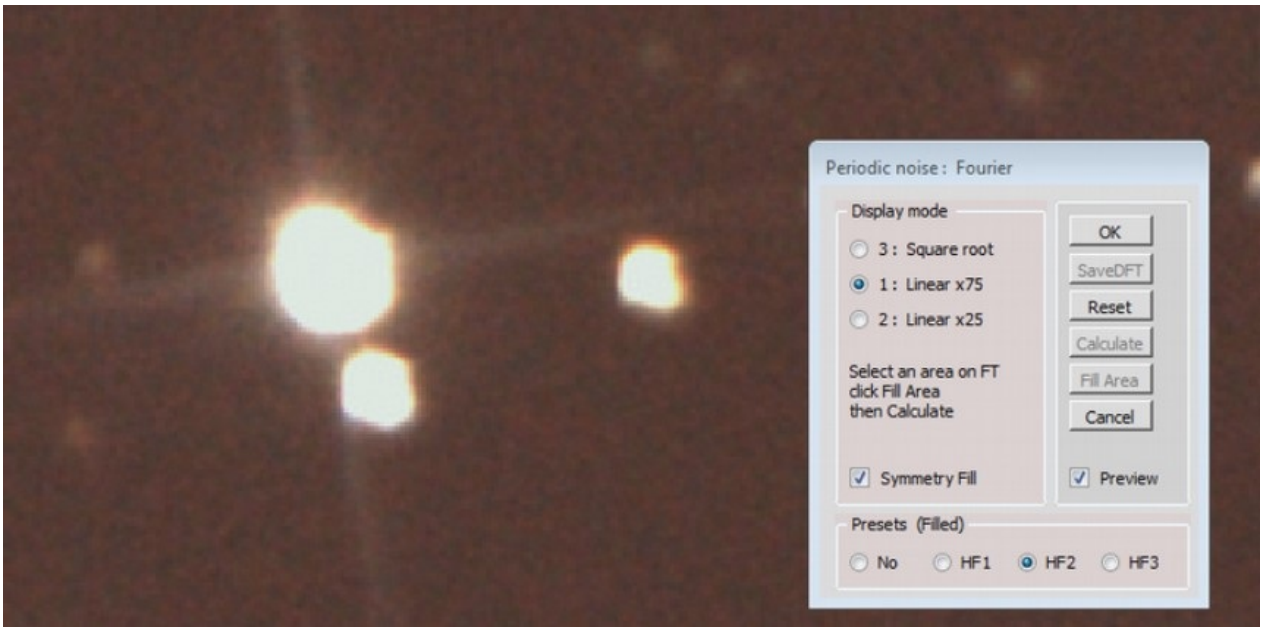


Nothing to do with our beautiful image![19] The trick is that the Fourier transform has an inverse that allows you to return to the original image. Not very interesting, except that you can modify the transformed image before applying the inverse transformation, which will allow you to act

---

19 In fact it is very ugly, but I think I have already said that.

on details of a given dimension. Noise is one of them, since these are very small details. If I erase all the points that correspond to this small dimension in the transform, they will disappear as if by magic on return [20].
This is what the command screen allows you to do: you can select an area, click on the "**Fill area**" button = fill the area (in fact you erase it, but it doesn't matter), repeat the operation if necessary, then finally on the "**Calculate**" button and get something like this:



You're going to tell me that you don't know what to delete [21]. So to help you, small Presets = predefined menu buttons are there to delete areas that are likely to give an interesting result (you can directly click "**Calculate**" without using "**Fill area**" in this case). If you start filling by hand, you can take inspiration from the shape of these areas: it is essential that they are symmetrical if we want to avoid the appearance of artifacts, but you are warned: in pure manual mode, this is a very difficult function to master.

Wavelets

The wavelet technique comes from the same idea as the Fourier transform. A transformation is applied to the image that separates it into different levels corresponding to details of greater or lesser size [22]. These levels correspond to coefficients that can be modified before performing the inverse transformation, which allows you to reinforce or, on the contrary, attenuate the details of an image based on their size. Imagine a landscape of hills and valleys that you would transform in this way. By reinforcing the low spatial frequencies, you could transform the hills into mountains and the valleys into canyons, but without changing the size of the rocks and other stones scattered there. Conversely, by acting on the high spatial frequencies, you would make these stones grow without affecting the overall relief. Very often, we reinforce the low-dimensional details (but not the first level which contains mostly noise) in order to improve the general sharpness. And as one can imagine, having too heavy a hand leads to creating artifacts.

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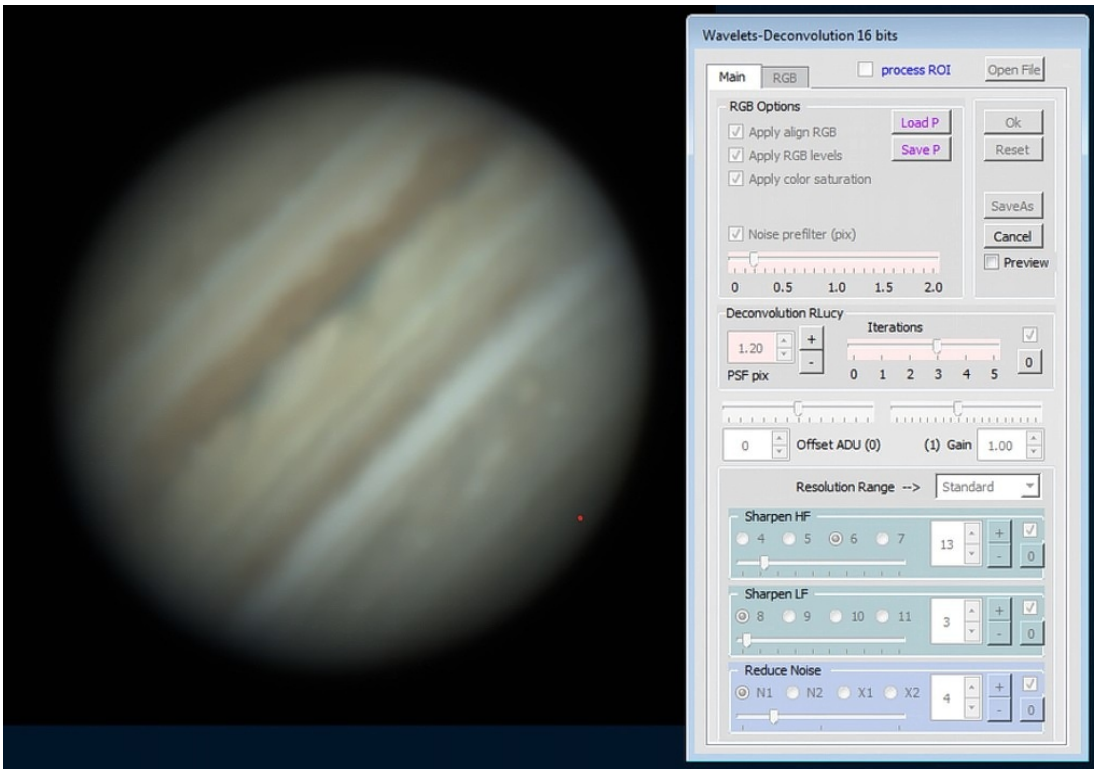
20 Well, that's the theory, but don't dream.

21 And you're not the only one.

22 If you really want to know more, you can consult https://fr.wikipedia.org/wiki/Ondelette. But we warned you, it requires some mathematical knowledge. If you don't understand the first line, there's no point in continuing.

AstroSurface stands out from other software by offering a composite function that combines wavelet processing with other operations. The reason is that these operations are complementary and are best performed together [23]. Let's take a closer look:



As you can see, this screen combines a number of functions, the first ones concern colors and allow you to apply the adjustable options in the RGB tab:

- Alignment of RGB channels
- Color balance
- Color saturation

As these operations have been described elsewhere, we will not return to them.
Then comes a noise attenuation, adjustable using the slider, then a Richardson-Lucy deconvolution, an adjustment of the offset and the gain (brightness/contrast), then the wavelets themselves and finally a final noise reduction, to be used as a last resort! Note that all these cascade operations can be disabled one by one using a checkbox, without having to return to the default settings (which do not make any changes).

Finally, note that at the very top, the "**process ROI**" checkbox allows you to restrict the processing to a ROI, even if the software does not ask you for it; in the case of small images.
This allows, for example, to process only one area: a satellite only.

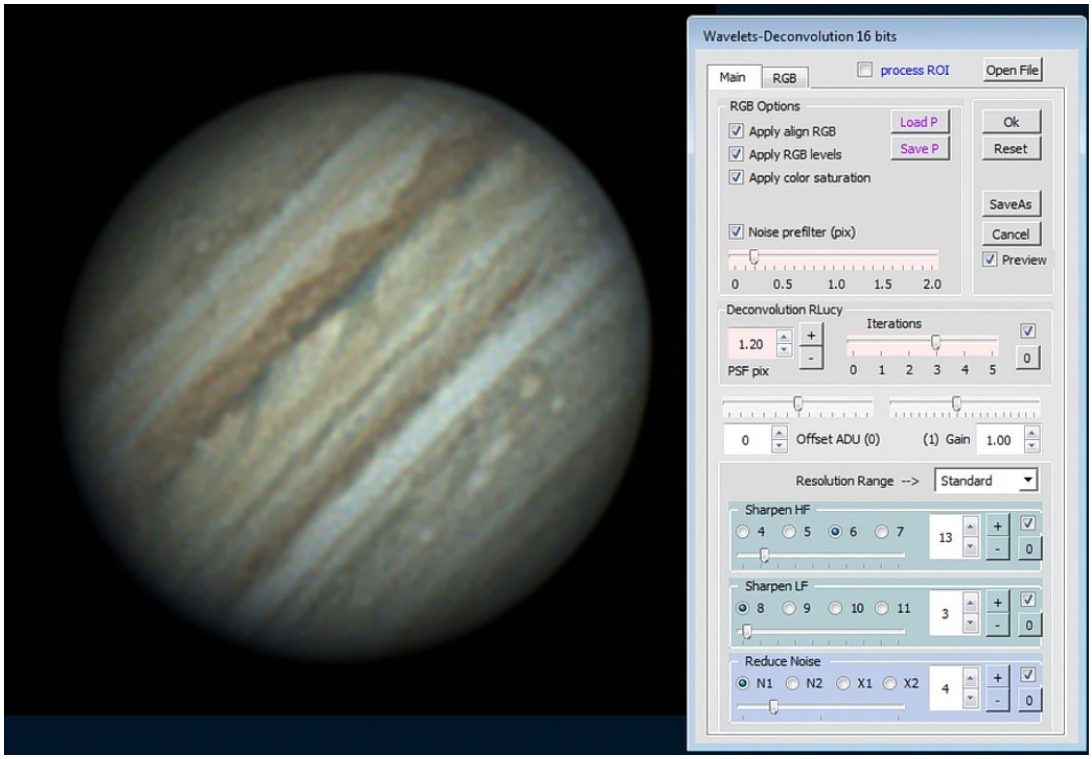
Rather than clicking around, the author's recommendation is to start by setting the "**Sharpen HF**" slider = Emphasize high spatial frequencies (i.e. fine details). Try the various menu buttons to find the best setting, while controlling the noise boost with the "**Noise Prefilter**".
Second, set the "**Sharpen LF**" slider = Emphasize low spatial frequencies (i.e. larger details). In general, you emphasize much less.

---

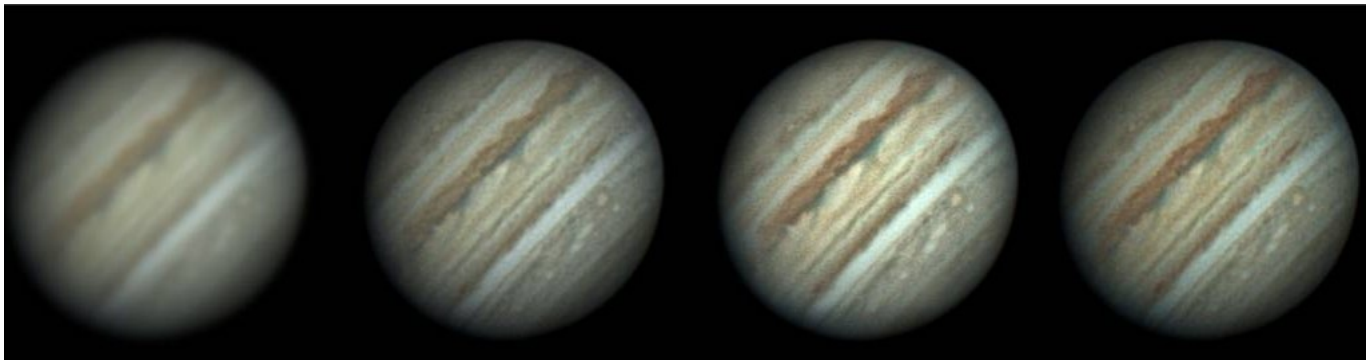
23 Let not the critics find a pretext to get upset: it is not because the author of the software was too lazy to create separate screens.

When we feel close to the optimum, we can activate the RL deconvolution which really only has an effect here on an image already optimized by the wavelets.

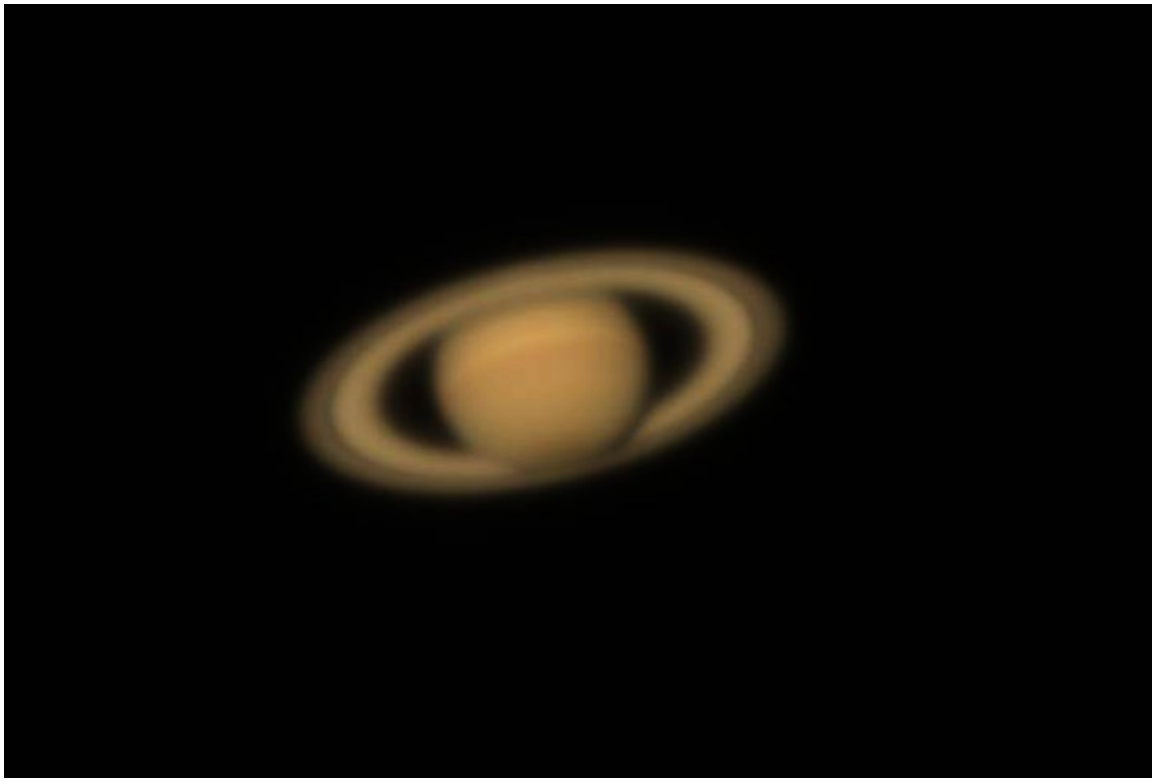
Finally, we can reduce the noise using the "Reduce noise" frame located at the very bottom, but it is recommended to use it last, just like the offset and the gain.
And it gives this:



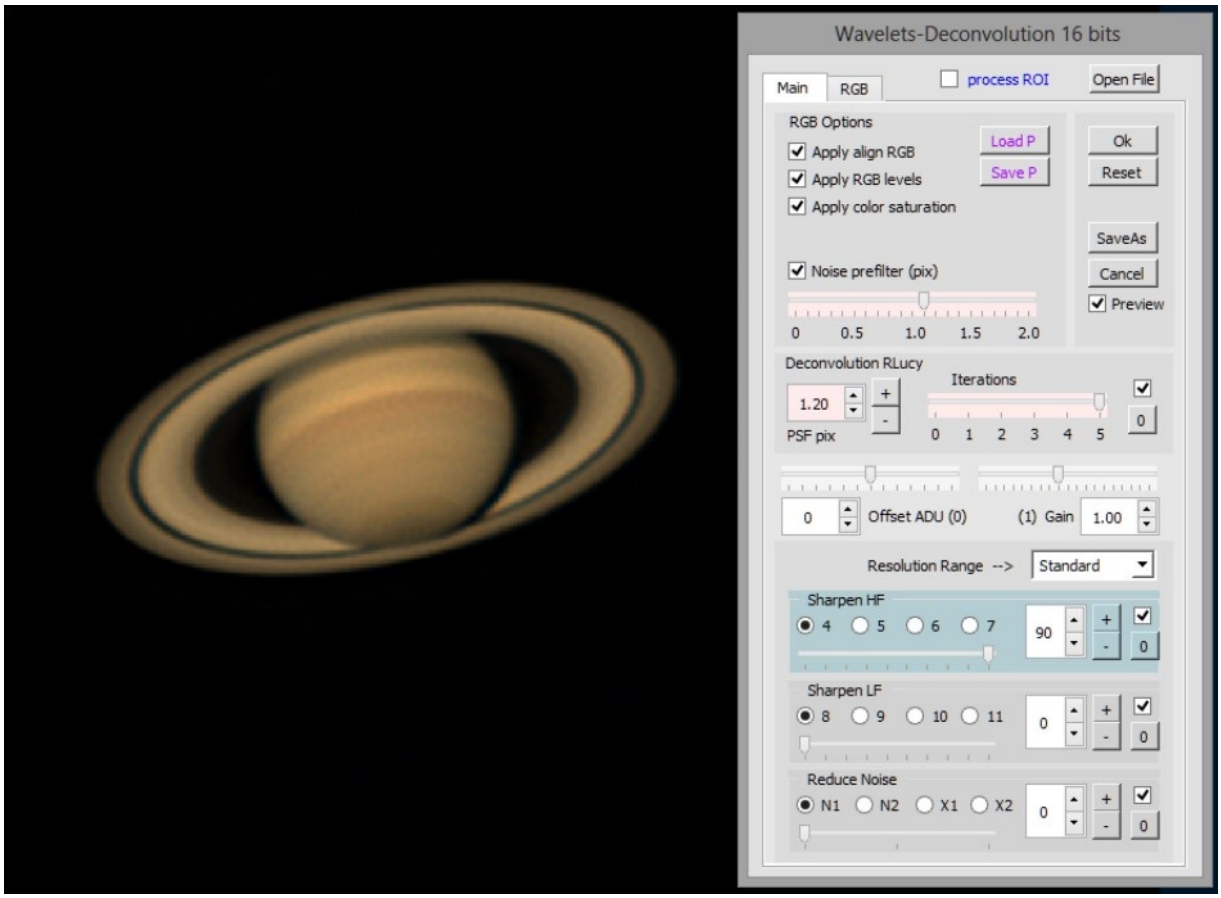
Undoubtedly, there is no comparison.
Finally, let us point out that the "**Resolution range**" options box contains the options "**Very fine**", "**Standard**", and "**Medium**". This is to be used in cases where the standard does not allow the desired improvements, either because we cannot accentuate the finest details, or because we cannot accentuate the largest ones.

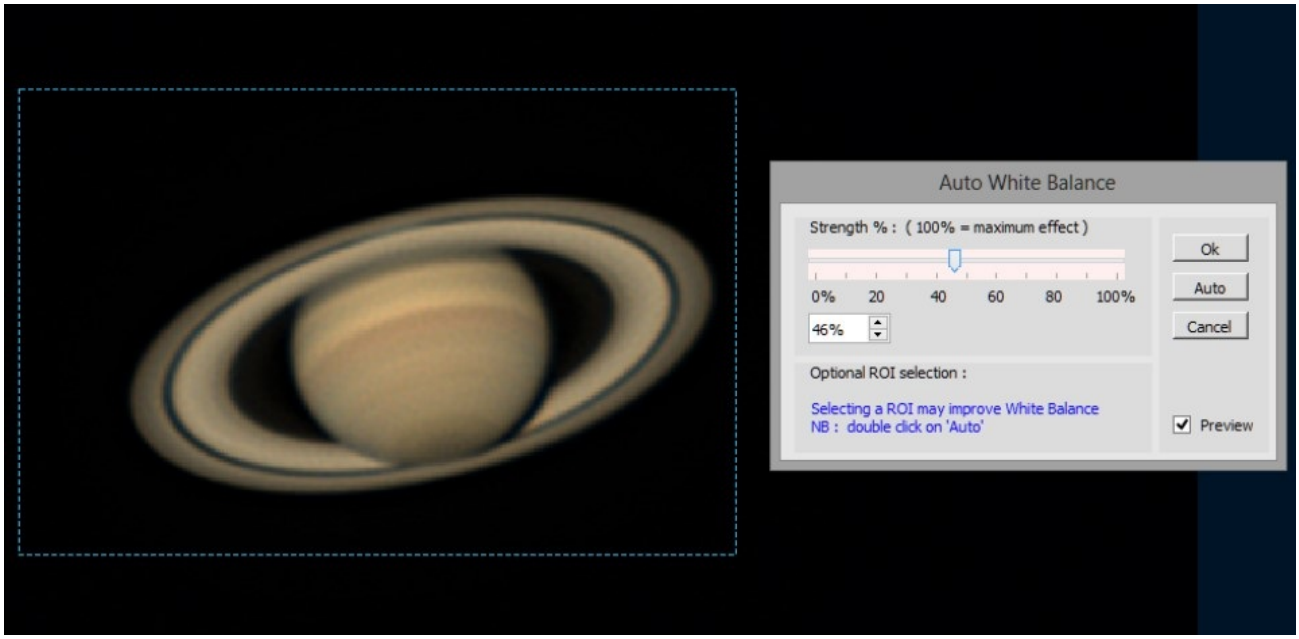


Some processing tests on Jupiter by wavelets and sharpness. On the left the raw stacking image. The color balance has also been retouched.
Another example on Saturn:



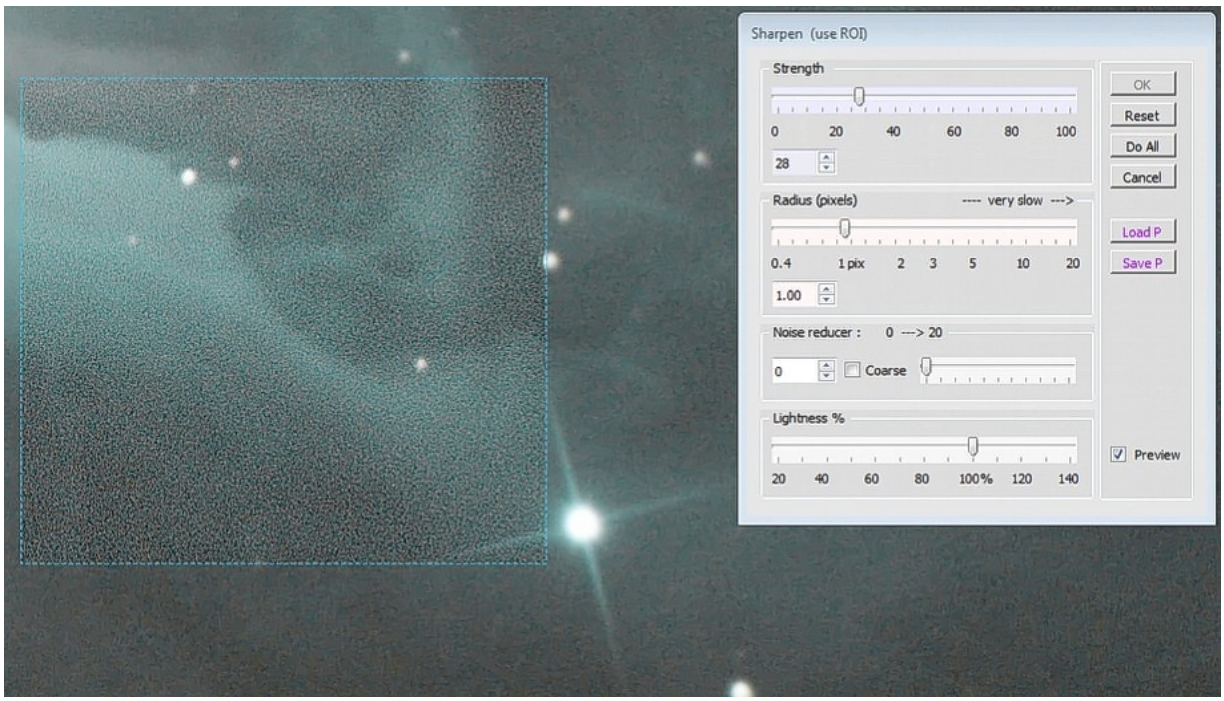
original raw stack image.





Sharpen

This filter sharpens the image. But as the example below shows, it also brings out the noise. Hence the "**Noise reducer**" option. As we have seen a number of times, the "**Strength**" slider determines the processing energy and **Radius** = radius the kernel size. But let's not dream: noise reduction is the adversary of sharpness. At most, we can find a compromise.



Motion blur reducer, to do

Convolution (and deconvolution)

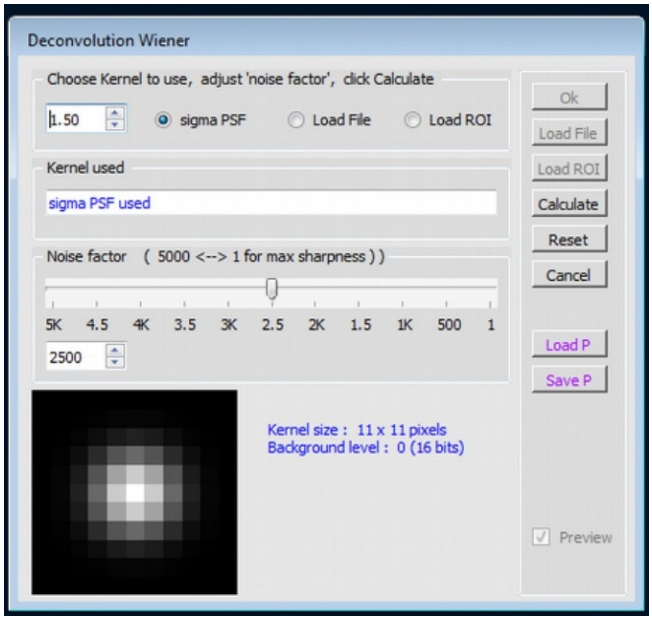
This is the function that allows you to apply a previously created filter. See kernel generation. Otherwise, applying a filter, as we saw above, can more or less correctly represent the mathematical operation called convolution product. Apart from enriching your general knowledge, this notion has a certain interest. In physics, it allows you to represent a situation that is dear to us: the beautiful, clean signal coming from the stars is in some degree obscured by the atmosphere (turbulence, dispersion) then by our telescope (diffraction) to finally give this imperfect image recovered by our sensor. We can improve all this by a convolution product between a function representing the signal, another representing the influence of the atmosphere and yet another representing our telescope. But since these operations are reversible, we can wonder, knowing these disturbing functions, if we could go back to the clean signal by applying them in reverse [24] .

Now that's a good idea, and on paper, it works perfectly! The problem is that we don't know this perturbing function very well, which to make matters worse, varies over time. So we can't solve the question rigorously, but we can try to get close to it.

Hence the multiplicity of deconvolution algorithms that are distinguished among other things by the hypothesis that is made on the shape of the perturbing function [25]. If they do not work very well, it is not because they are bad, but because their hypothesis does not fit very well with your shooting conditions. Therefore we will try another one.

Wiener Deconvolution

One of the usable deconvolutions. The control panel looks like this:



We are not going to start using an alternative kernel so the two settings that we can make are the kernel size (in the input box at the top left) and the processing energy (called noise factor here, don't ask me why). You have to click the "Calculate" button each time you change a setting. The kernel size can be adapted to the image size. So reduce it if the image is small. In the best cases, we can expect this:

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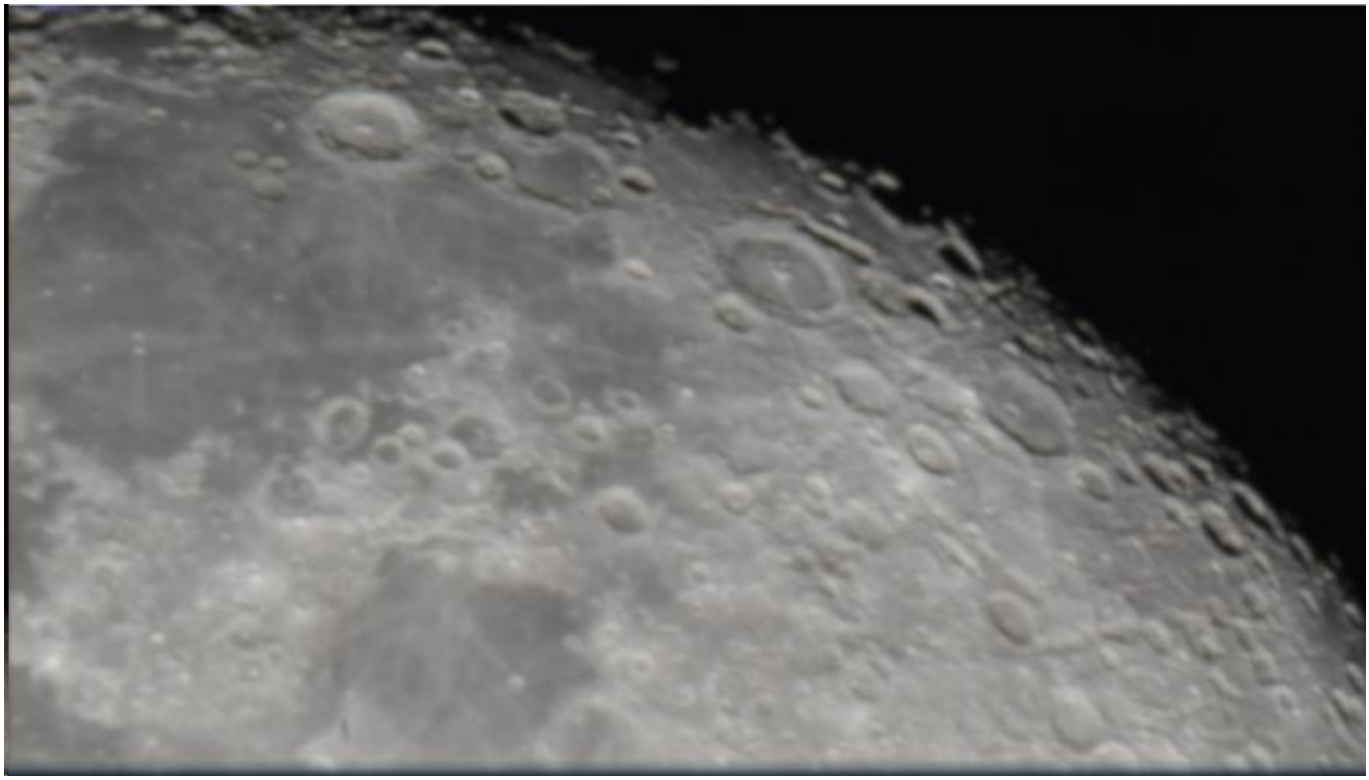
24 Which, you guessed it, is called deconvolution.

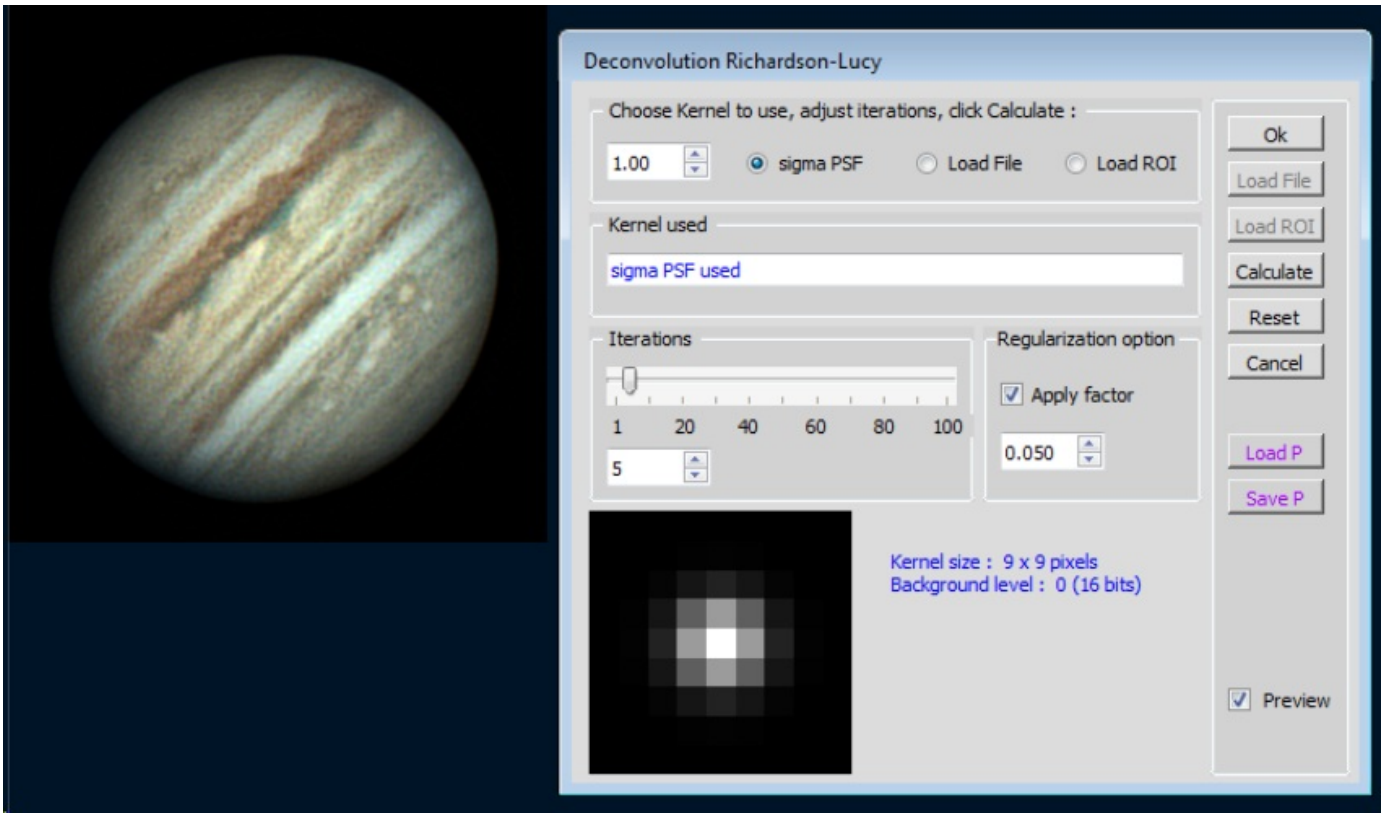
25 Except for the so-called blind deconvolution, which is supposed to be able to sort things out without any hypothesis, but which I have not yet seen implemented in an astro software

Before :



After… Impressive, right?

Lucy-Richardson Deconvolution [26]



Like the previous one, we apply a filter of adjustable dimension a certain number of times. We first set the number of iterations [27]. The "**Calculate**" button allows to perform the operation and to activate the "**Preview**" box.

Let us point out in passing that the last two items in the menu: Generation of a PSF kernel (Kernel PSF generate), and Generation of a line kernel (Kernel Line generate), are intended to create kernels that can be used by filters (in particular deconvolutions), but we will refrain from discussing this somewhat esoteric subject.

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26 Alas Lucy Richardson is not the brilliant astrophysicist who inspired the song "Lucy in the sky..."

27 In English "iterations" where we see that these lazy English people were not even able to copy an accent

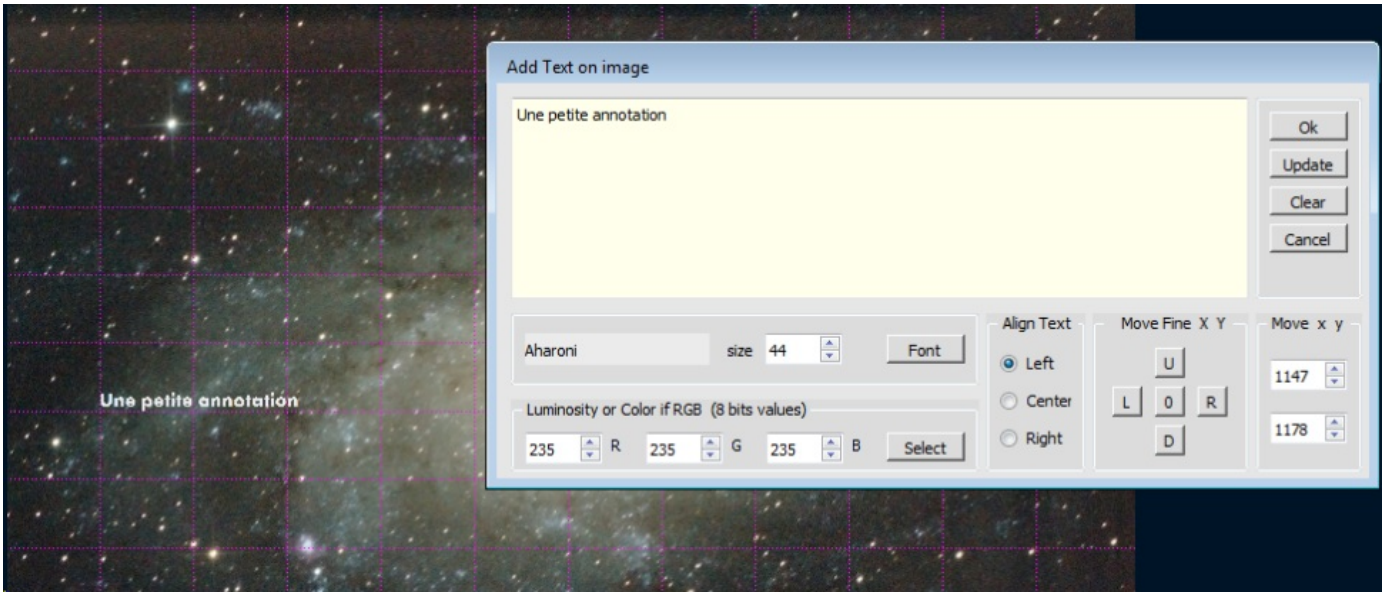
Other menus

We are not going to insult you by explaining the really obvious functions like those of the "Geometry" menu and we will be content to present the most interesting or original ones.

Edit menu

"**Drawing**" allows you to annotate your image with circles, lines or points.
In English, arrow is called Arrow, so the bottom frame allows you to draw arrows.

"**Add Text**" = Add text is the complement of the previous one. We start by double-clicking on the image to determine the position of the text. Then everything is done in the dialog window:



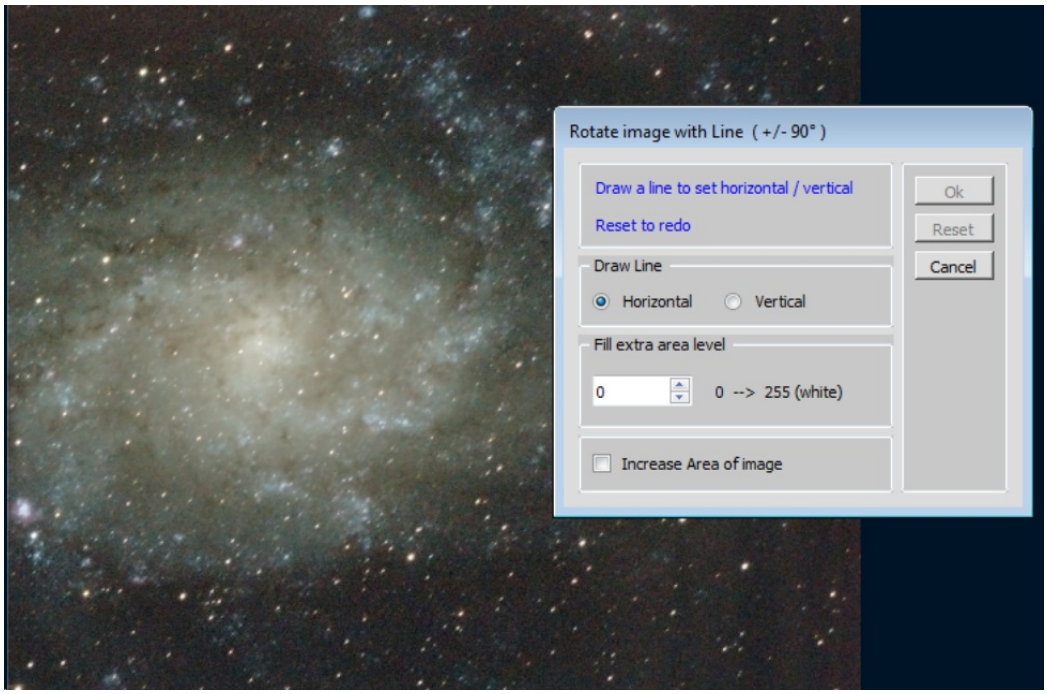
You enter your text in the frame (by deleting the default text). You choose the font, its size and its color if necessary, and click on the "Update" button. Note that these operations can be done several times and that you can correct the text once entered. Simply click "**Update**" for the changes to be taken into account.
You can also change the position of the text in the "**Move Fine X Y**" frame = fine movements in X Y, or by declaring coordinates in the "**Move X Y**" frame or by double-clicking again elsewhere on the image.
When everything is in place, click "**OK**" or "**Cancel**" to cancel everything.

"**Add Photo Borders**" = draws a frame in the image.

Geometry Menu

Translation ("**Translate**"), Rotation ("**Rotate**"), Crop ("**Crop**") and Resize ("**Resize**") are no mystery and work like in a drawing software. Let's mention some less ordinary functions:

"**Rotate with line**" = rotation by alignment. We draw a line on the image (for example between two stars) and the software calculates the rotation necessary so that the pixels of this line are aligned vertically or horizontally, as desired:



In the "**Fill extra area level**" frame, you can choose the color (gray level) of the fill to use for the corners of the image that will be empty due to the rotation. Similarly, "**Increase area of image**" resizes the image so that all the pixels of the original image fit in it.

Binning [28] or Mean

This is a reduction of the image by an integer factor (2 by default and most often). In other words, the pixels forming a square whose side is equal to the factor are compacted into a single pixel. But unlike the Resize function which tinkers in a rather mysterious way, here you can choose the operation used for compaction:

Binning: the pixels are summed. The result will obviously be a much brighter image. This function is the analogue of the binning option of cameras where the signal recorded by several photosites arranged in a square is summed to give a single pixel.

Average: it is the average of the different pixels that will determine the resulting pixel.

Mix/Merge Menu

The functions in this menu allow you to compose images. "**Merge 2 images**" = mix two images is the simplest function.

"**Align/Rotate 2 images**" = Align two images. Allows you to superimpose two offset images (with possible rotation), thus creating mosaics.

The next two are intended to combine images from monochrome sensors used with colored or selective filters in general.

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28 Sorry, but everyone talks about binning, even in French.

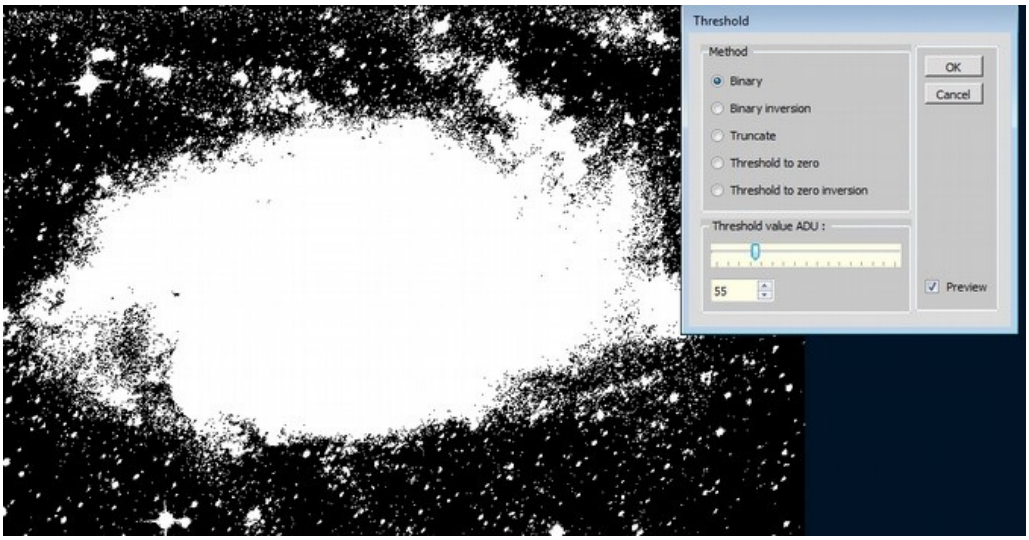
"**L + R.G.B RGB→** " : composition of four images: luminance, Red, Green, Blue to give a single RGB image.

"**L + Color RGB→** " : combines two images: luminance and RGB color.

Math/Pix Menu

This menu mainly contains image analysis functions: trajectories, magnitudes, fineness FWHM, intensity cut in particular.
The calculator is useful for performing common mathematical calculations in amateur astronomy: the sampling value for example.

Let's mention the "**Threshold**" function. This is a function designed to create masks to be able to process different parts of an image separately. The simplest option (**Binary**) transforms into pure white all pixels whose brightness is higher than the threshold adjustable by the slider. The others are transformed into pure black. Here we see that all bright objects can be easily distinguished from the sky background.



AstroSurface does not currently have any functionality to use these masks [29], but they can be exported to Photoshop or GIMP.

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29 But it's planned... Stay tuned!