

SiriL-GIMP Light Pollution Removal Workflow

by Vance C. Tyree

This workflow documents the procedure used to remove light pollution from deep sky images that are taken from urban locations with severe light pollution (Bortle 8). I have written workflows that involve using PixInsight and GIMP that use the Dynamic Background Extraction (DBE) tool in PixInsight and also a workflow that used only GIMP on the assumption that the deep sky images do not have light pollution gradients, which in “real” backyard settings is extremely rare. There are a number of new astrophotographers who are reluctant to spend \$270 for a PixInsight license. With that concern in mind, I have been looking for a free astro-image processing tools that can remove background light pollution as effectively as PixInsight does. I have recently become aware of SiriL from a posting on Facebook in Inner City Astronomy by Rob Tilson, who took a very nice M51 image in a Bortle 8 backyard – exactly the same light pollution environment that I have.

I started with an image of M31 image taken on 15 Nov. 2020. The procedure as described here will almost certainly change as I run background removal on many of my past images to refine the procedures to be more general than what was used on M31. As a test of this procedure using other images from my back yard, I also used the same workflow on M97, IC434, and NGC1499. Each of these images had a very different manifestation of light pollution gradient. I will speculate on these large variations in gradient later in this article.

Image Acquisition

I need to point out that all of my imaging is done with a one-shot color CMOS camera that is controlled by SharpCap 3.2 (most recent version). If you are using a monochrome camera with LRGB filters to acquire a color image then this procedure will still work if you process the images from each of the LRGB filtered exposures. Also, this workflow will work with a set of stacked images using a DSLR camera. There may be a few complications with the LRGB images because the light pollution gradient may be different in each color channel, but these problems can be managed by modifying my workflow to accommodate the changes in gradient.

My Workflow

Since this workflow contains my experience with only four different objects under varying light pollution gradients, this workflow may be changed as I gain more experience with different imaging situations.

Image Bit Depth Issues

I need to point out that your raw stacked images need to have as much dynamic range as possible to permit subtracting out a large light pollution signal and still have enough dynamic range to be able to use lots of histogram stretching to bring out the faint deep sky object. I use the 32-bits/channel FITS file from the Live Stacking tool in SharpCap 3.2. I strongly recommend that you use a 32-bit per

channel image as well. If your camera tools don't have a 32-bit per channel option then be sure to use 16-bits per channel. Anything less than 16-bits per channel will yield poor results in the final image. In the case of most DSLR cameras, the bit depth is commonly 14 bits/channel. However, that is not usually a problem because you will be stacking a number of sub-exposures from the camera and usually the stacking tool will output the stacked image in at least 16-bits/channel.

The Workflow

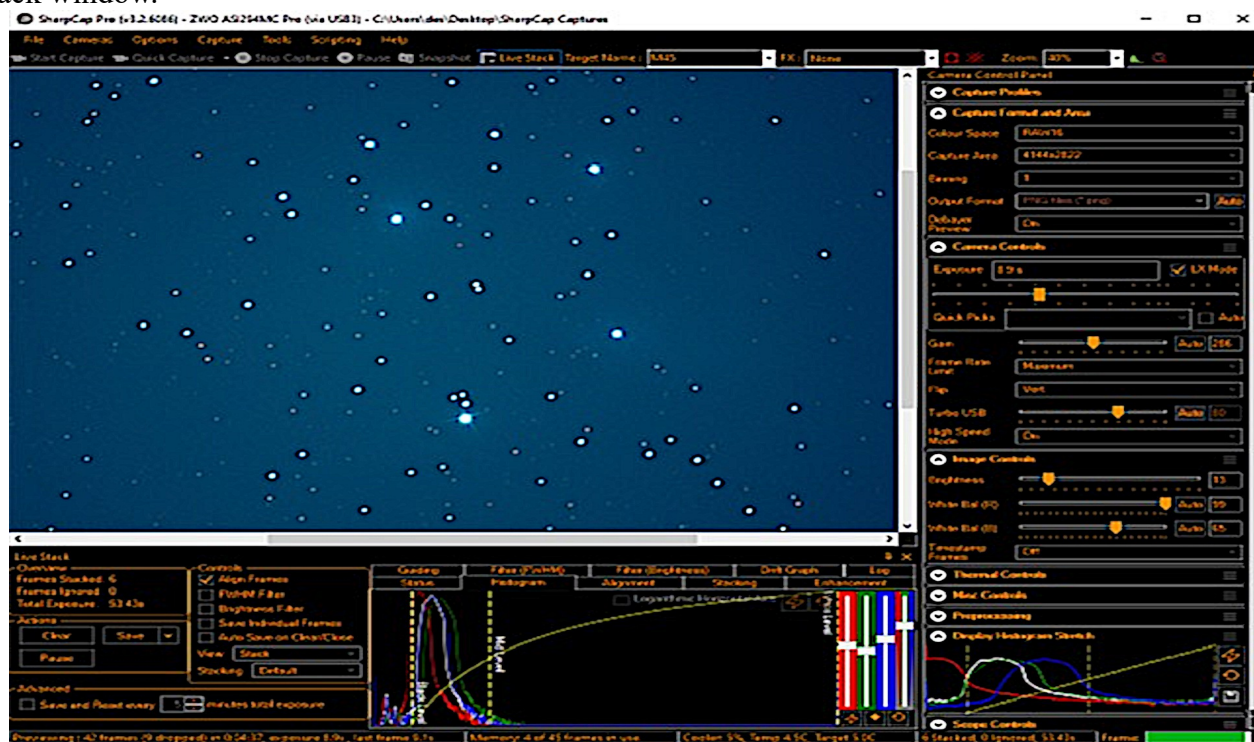
The SiriL software will be found in this web link to SiriL: <https://siril.org/>
The GIMP software will be found in this web link: <https://www.gimp.org/>

* First load the SharpCap Live Stacked 32-bits/channel FITS image into SiriL.

(**Note:** When using SharpCap Live Stack you must save the 32-bit raw FITS file AND the stretched “as viewed” image. The “as viewed” image usually reveals the desired deep sky object along with the light pollution gradient. This “as viewed” image will be used later.)

SharpCap Live Stacking

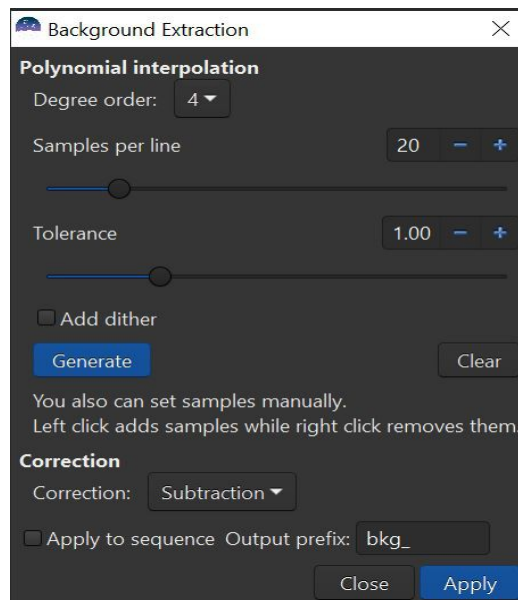
Let's briefly discuss origin of the “As Viewed” image. In SharpCap there is a tool that takes a sequence of camera images taken at a selected sub-exposure time and align their star images and average the images together to form an image that has lower noise in real time as you are watching. You accomplish this same task with individual DSLR images (not in real time) by taking a series of images and using a tool that aligns and stacks all of the images to produce a better, lower noise final image. The difference is SharpCap does this in real time. The SharpCap screen shot below shows the Live Stack window.



There are two graphs of the histogram of the image at the bottom of the window. The larger histogram controls the black point and the histogram stretch of the Live Stack image. The histogram on the lower right corner controls the black point and histogram stretch of the live image even when Live Stack has not been started. Both of these histogram tools are applied to the Live Stack image viewed in the main part of the Live Stack image. These two enhancement tools allow us to see a preview of the object being imaged along with the light pollution gradient. When the Live Stack has acquired the number of stacked sub-exposures that you want, you can save both the “As Viewed” image you see on the Live Stack window (as a PNG image) and the 32-bit/color image that is actually in memory (without histogram stretch as a FITS file). The “As Viewed” image will help me to know where nebulosity exists and what the light pollution gradient looks like as well as where moderately faint stars are located. This information will be used to help establish where the sample boxes should be placed and where the sample boxes should be removed, as you will see in the discussion below. It also previews where a sample box can be placed to generate a neutral background without any bright stars to interfere with the neutralization process.

You can build an equivalent “As Viewed” image using a DSLR stack by loading your stacked DSLR image into SiriL and adjust the black point and histogram stretch curve to reveal the desired object and the light pollution gradient. You can then save that image as a reference to serve the same function as the “As Viewed” image that I get from SharpCap Live Stack.

* Under the “Image Processing” dropdown list select “Background Extraction” This window will pop up:

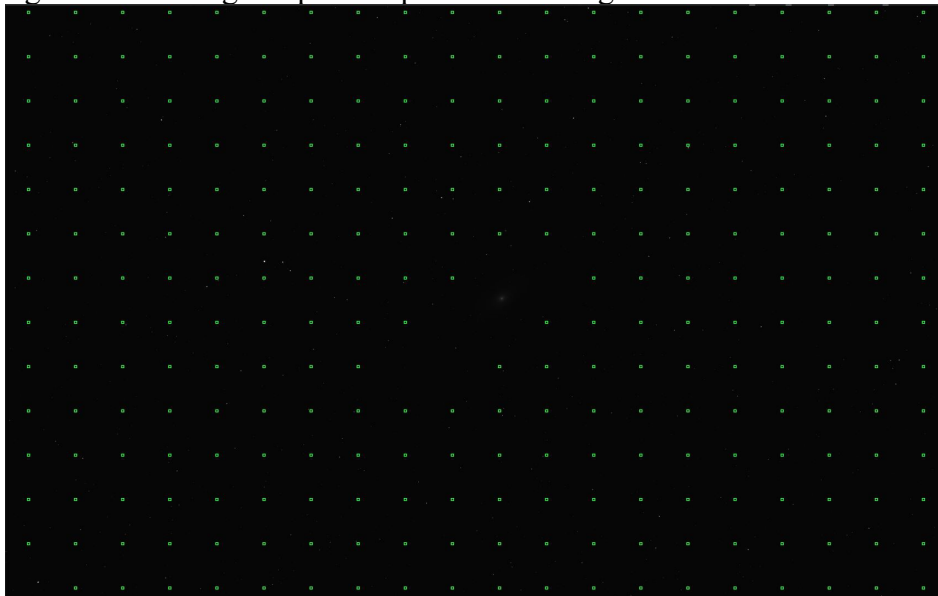


Move the “Tolerance” slider as far to the left as possible to 0.01. This tolerance slider will allow you to establish what minimum tolerance is needed to place sample boxes over the image frame but not cover nebulosity in the image. Click “Generate” to see where sample boxes are placed. If the sample boxes don't cover to the edge of the image frame then move the Tolerance to the right a little and click “Generate” again. This procedure was repeated until I reached Tolerance of 1.01 in the M31 image. You will find that the final “Tolerance” can be very different with different images from the same backyard at different times during the same night and on different dates of an imaging session. I have found that

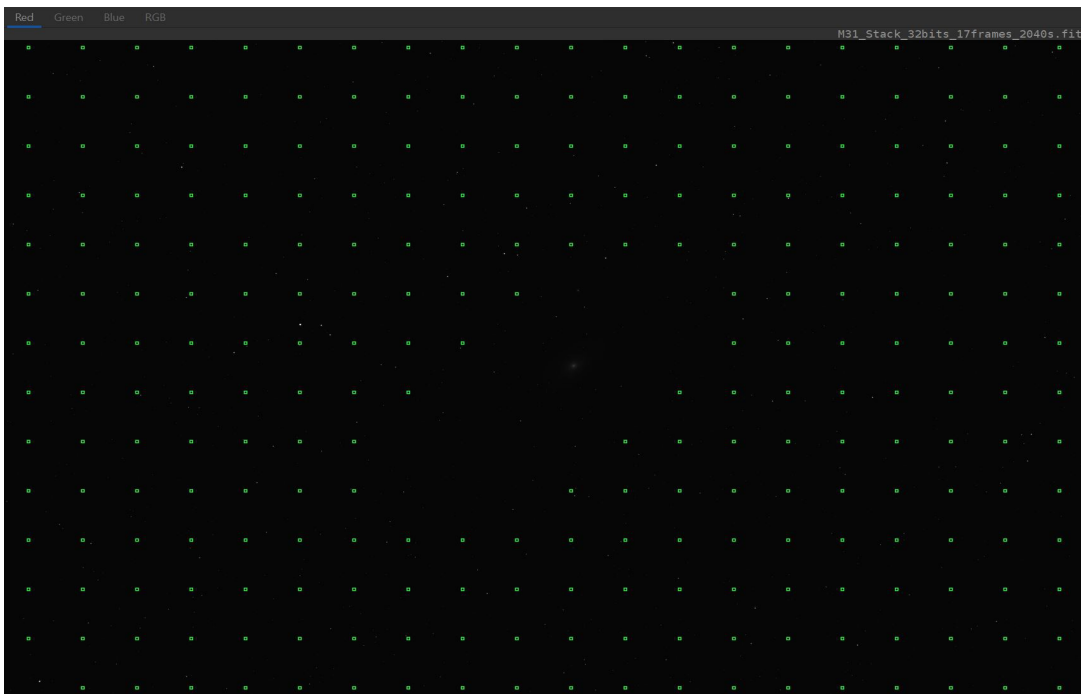
the variation appears to be due to what outdoor lights the nearby neighbors are using and when they turn them on or off. Further, I have noticed that the shape of the light pollution gradient can vary as more sub-exposures are added to the Live Stacking. I have also noticed that there can be a definite greenish cast to the background light pollution. I think some of this greenish cast this may be due to the fact that some outdoor lights are pointed up into trees. Another theory I have is that many outdoor lights may be pointed downward (hopefully to avoid lighting up a neighbor's house) but the reflection of the light off a lawn will be green.

Another observation I had is that in my Bortle 8 sky the interference caused by a partial moon is insignificant as long as the moon is not much more than about quarter phase and is more than 45 degrees away from the object being imaged. As you image closer to the moon the light gradient becomes more complex. Even with this situation, I have found that the light pollution gradient from the urban sky and the moon is still manageable. So, the plus side of urban imaging is that you can get more imaging time per month because the moon's interference is manageable.

After you get the generated sample points over the image frame, it is time to examine where sample boxes are missing. The following sample box placement was generated for the M31 image:



You will see that there is an elliptical blank space that contains the bright portions of M31 and a single sample box missing from the lower left corner. This missing box in the lower left corner is present because I know that this region has a bit of spurious light caused by a light leak in the optical system used in the imaging, so I chose to ignore its absence. The elliptical region has no boxes because M31 is bright enough to exceed the “tolerance” threshold, which is the reason that we incrementally increase “tolerance” level. One of the functions the “As Viewed” image provides is to show where the nebulosity is located. If the nebulosity is fairly bright (as with M31) then check to make sure that no sample boxes are placed on the nebula to prevent including the desired object in the background removal process.



Now, select the Red channel in the upper right above the image. Remove the boxes around the peripheral of the image ellipse by right-clicking the boxes to create a guard band around the image. This box removal will automatically occur in the Green and Blue channels.

Next, click “Apply”. You will not see any visible change in the image because SiriL has moved the black point to remove the “light pollution glow” in the background in the screen view only. The original image has not been modified yet. However, the gradient and associated light pollution colors remains in the screen view image. When you click “Apply” SiriL removes the gradient and the overall light pollution in the image.

Click “Close” on the “Background Extraction” window.

Wait!! Isn't there a simpler way to remove the light pollution background? Yes! Instead of incrementally optimizing the “tolerance” setting, you can simply accept the default “tolerance” value (1.0) and click “Generate” to place sample boxes on the image and do the background removal as described above. My experience so far has found that incrementally finding the optimum “tolerance” setting usually ends up with a value near 1.0. There is nothing wrong with doing a simple background extraction for your first attempts at background extraction. The results will probably be OK, but be aware that you may some point in time encounter an image that requires incremental tolerance optimization. **Just follow the steps below to remove the light pollution color bias, because if you don't your image will carry the light bias and make the image a bit off in color.**

Before we continue, I need to point out that SiriL removes the light pollution and its associated gradient in each of the three color (Red, Green, Blue) channels independently. There is a color bias that must be removed before doing any aggressive histogram stretching. If this light pollution color bias is not removed it will cause strong color shifts in the deep sky image. We will remove this light pollution color bias by selecting an area in the image where there are no bright stars and use this selected area as a reference for producing a neutral dark sky background.

Now open the “Histogram Transformation” tool – under the “Image Processing” list. You will see the histogram of the image in the extreme left hand edge. Apply some curvature by dragging the middle slider to the left. Click “Apply”. DO NOT make the curvature too steep, because we are trying to reveal enough stars to select an area for the background color reference. Now the curve is replaced by a line. Move the curve slider again and click “Apply”, repeating this process until you are just barely able to see a residual background color from the light pollution and most of the bright and the not so bright stars. You may or may not see the desired deep sky object yet.

The next step is to neutralize the background color.

Close the “Histogram Transformation” tool.

Open the “Color Calibration” tool.

Select the Red channel on the upper left of the image and place a small sample box around a region of background that appears devoid of stars (Note: almost certainly there are faint stars in that selected region, but don't worry about this). This box will be used in the other two channels as well. While still in the Red channel and then click “Use Current Selection” (repeat “Use Current Selection” to use the same selection box for the Green and Blue Channels), click RGB to view the full color screen image and then click “Background Neutralization”. The sky background turns neutral gray.

Close the “Color Calibration” tool.

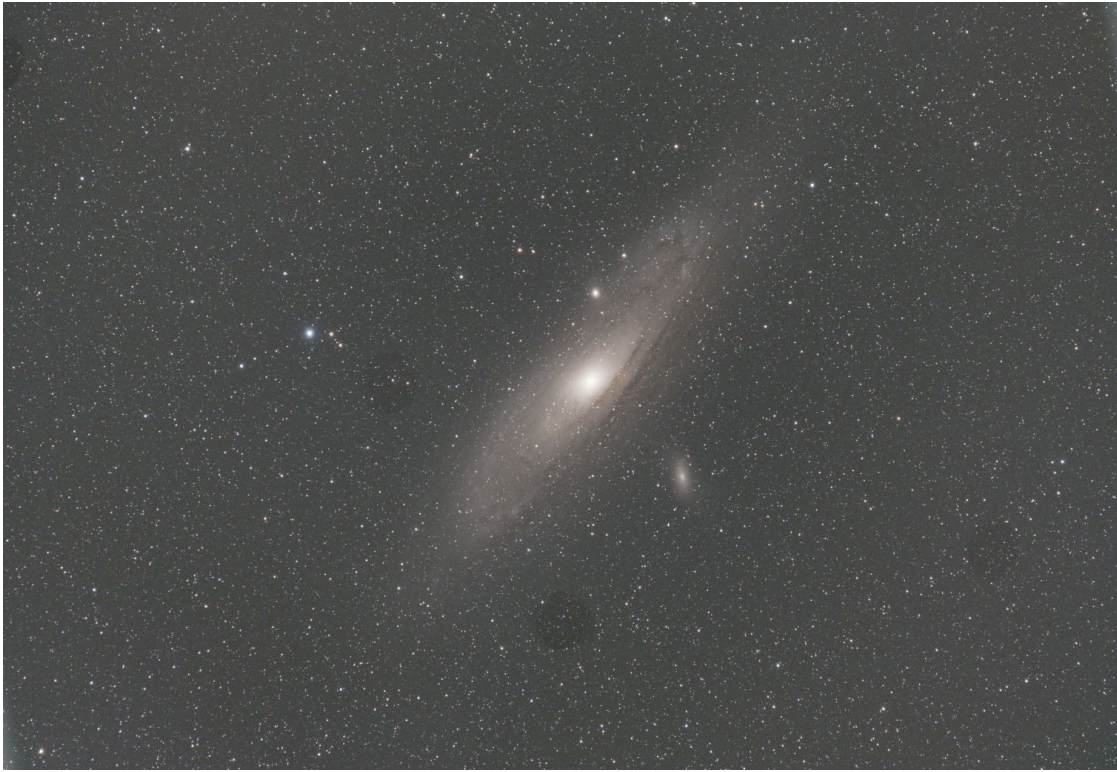
Open the “Histogram Transformation” tool.

Slide the Black point slider to the right a bit to darken the image background a bit – then add some curvature until M31 appears a little more then click “Apply”.

After the stretch is done the line will appear again in the graph. Repeat the above procedure with the “Histogram Transformation” adding a little more curvature with black point adjustment – **DO NOT** attempt a high level of stretch at each adjustment before clicking “Apply”. Repeat the process several times, as needed, until a nice image of M31 is achieved.

Now Close the “Histogram Transformation tool”.

We are going to save this image as a TIFF file with 16-bits per channel for further processing in GIMP. There is a small icon to the right of the “Save” button allows saving the file to another file name. **DO NOT click SAVE because it will overwrite the original FITS file.** Be aware that SiriL wants to save images to the Windows Pictures folder, so be sure to specify the exact path to where you want to save the partially processed image file. So, we are now at this stage with the M31 image as seen below:



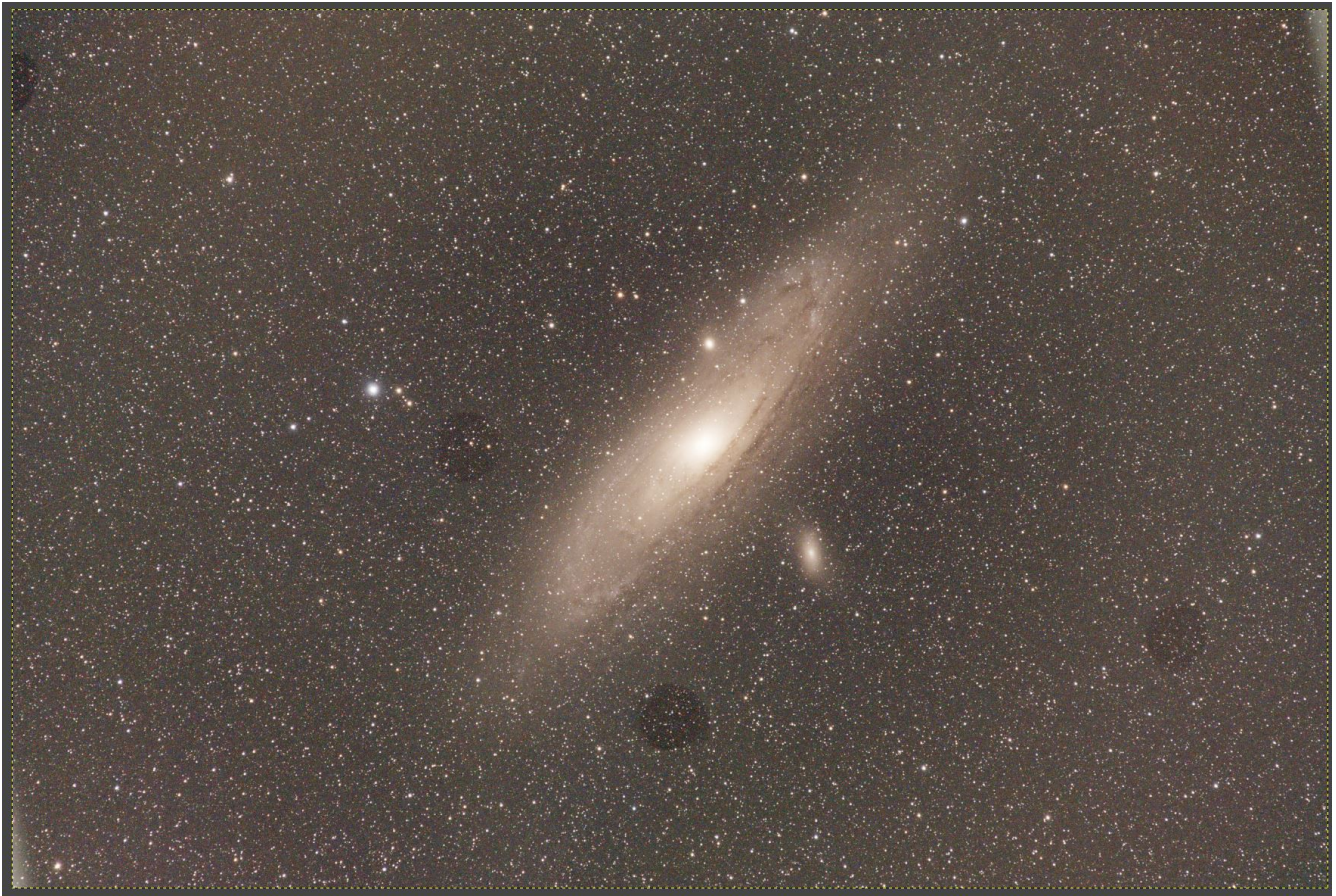
As you can see, this stage of processing has M31 well defined and with a bit of light pollution glow remaining. The final processing can be done in GIMP or some other general image processing tool of your choosing. Just be sure that your image processing tool has a “Curves” tool similar to what is described below

GIMP processing will be done with a little more Curves stretch/black point and Color Saturation to produce a nice pleasing image the way you want to present it. What follows is a description of what I did on the M31 image using GIMP, but it will work essentially the same way using Curves in Photoshop or any other image processing tool that has a “Curves” tool similar to Photoshop.

The GIMP procedure is as follows:

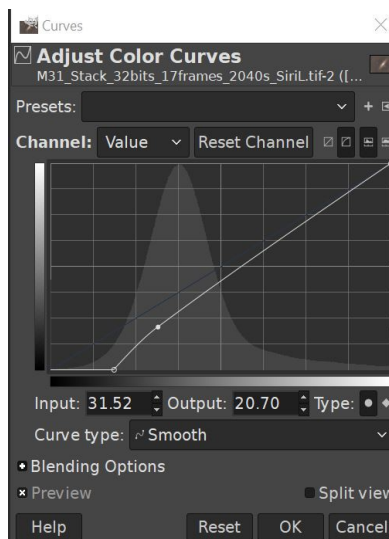
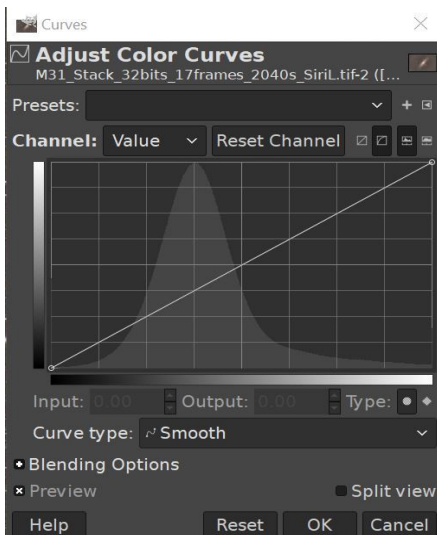
Open the SiriL processed image (M31 in this case):

The first thing you will notice is that there is a fair amount of light pollution glow remaining in the image. I have applied several cycles of histogram stretch with black point adjustment to get the brightness of M31 nearly to the level I want for the final image. The next step is to use Curves in GIMP to remove the light pollution. Here is the M31 image I loaded into GIMP:

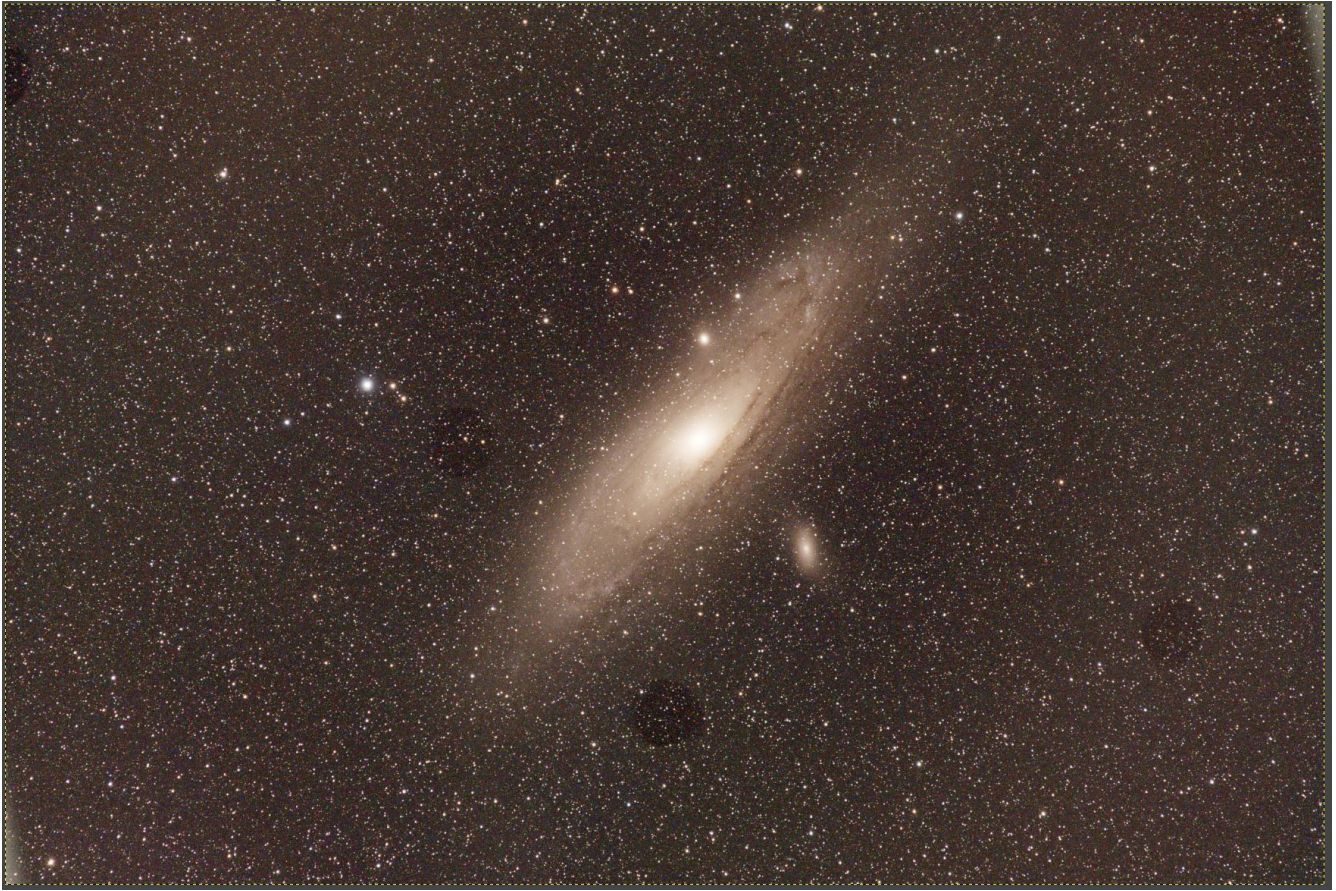


Now Open the Colors > Curves tool.

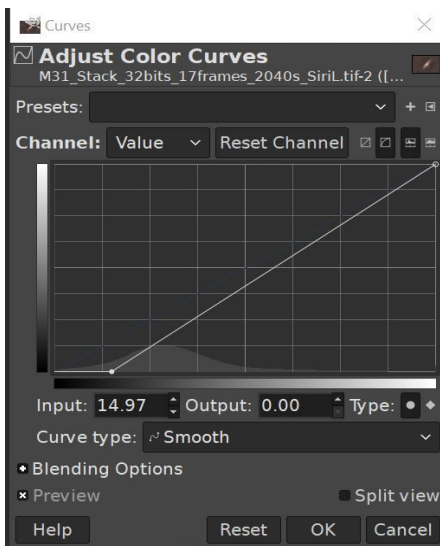
You will see the histogram of the M31 image as shown below left. The screen shot on the right shows the adjustment of the Black point to the right into the left edge of the histogram to remove most of the remaining light pollution. Also, there has been a small curvature added to the line to enhance M31 a little more before adding any more Black point adjustment.



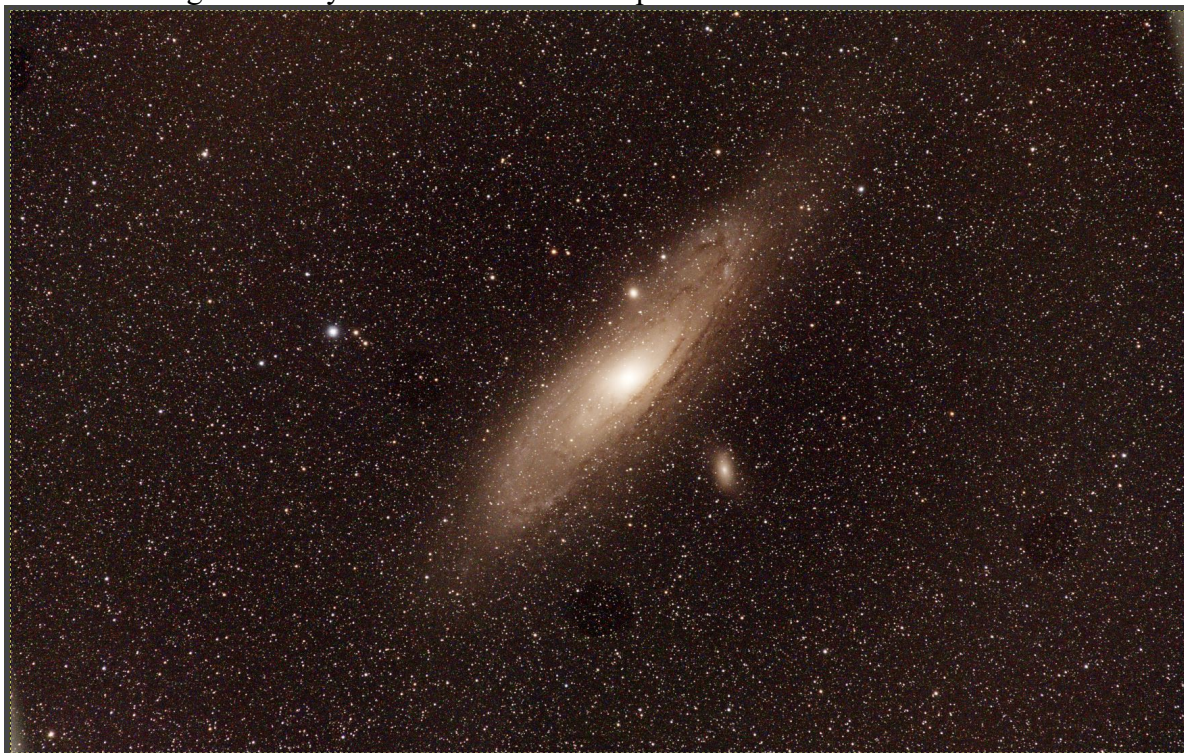
The result of these adjustments is shown below:



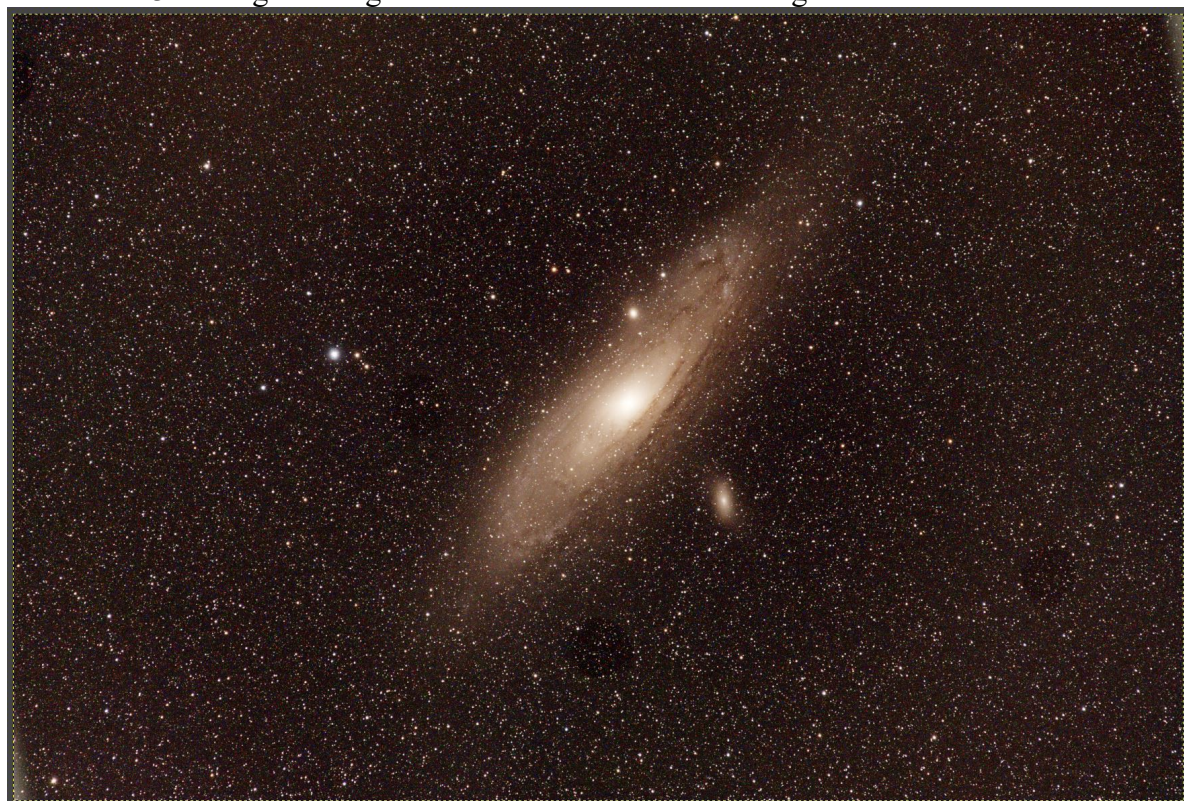
You can see the background is darker and M31 is a little brighter. Now, I am going to do another “Curves” adjustment to darken the background more. I have only moved the Black point to darken the image.



M31 is now showing a dark sky and a well defined shape and detail as shown below:



If I darken the M31 background again then I will have the following:



You can be the judge if the darker version is better than the lighter version. I prefer the darker version even though some of the more faint outer portions of M31 are lost because the background sky is darker. You can boost the color saturation if you want to strengthen the distinct color of M31. At this point it becomes a matter of aesthetics as determined by your preferences.

I will make one final comparison of M31 using only the black point and histogram stretch tool in the ShaprCap Live Stack tool. The diagonal bluish light pollution gradient on the lower left is clearly visible.

The “As Viewed” image of M31 from the Live Stacking run reveals what the light pollution gradient was.



SiriL did a good job of removing the light pollution gradient and the color associated with the light pollution.

Now, let's take a look at a few more examples to see how well SiriL can remove light pollution gradients along with their associated color. These next examples will be shown in small format side by side to show the light pollution gradient before and after light pollution removal. Keep in mind that all of the following images were taken from my back yard at different dates and times. They show just how much light pollution can change over time and at different places in the sky. It clearly shows that intelligent light pollution gradient removal using SiriL is a very powerful tool that, in my experience, does as well as PixInsight.



IC434 showing the LP Gradient from upper left to lower right



IC434 after SiriL and GIMP Processing



NGC1499 showing the LP Gradient roughly horizontal



NGC1499 after SiriL and GIMP Processing



M97 showing the LP with a green cast roughly uniformly over the image



M97 after SiriL and GIMP Processing

These images of M97 were taken using a ZWO ASI6200MC camera and a Canon 400mm f/5.6 lens, which is a rather poor choice for an object with an angular size of about 3 arc-minutes. However, the large field of view of this camera/lens captures M108 (to the lower right below center). Just to see what I actually got, I cropped the image to show M97 and M108 in the same frame, below:



Not too bad for only a 32 minute stack time with 240 second sub-exposures. I also need to point out that the telescope drive is an iOptron CEM25EC, which contains a precision encoder that enables real-time removal of RA periodic error. This M97 image was also part of another experiment to see if the real-time periodic error removal was sufficiently accurate to allow a 240 second sub-exposure without auto-guiding. This cropped image is evidence that it is possible to not auto-guide with 240 seconds exposures. However, the Live Stacking tool in SharpCap 3.2 is capable of correcting any atmospheric drift that occurs while stacking many sub-exposures. I'm not sure if this will work with much longer telescope focal lengths, but that is the subject of future experiments.