eXcalibrator User Documentation

by

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1. Introduction

What is eXcalibrator?

eXcalibrator provides an easy means to white balance astrophotos by computing RGB correction factors based on known star color. This method utilizes star color information from the NOMAD or Sloan Digital Sky Survey (SDSS) database. eXcalibrator uses data in the astrophotographer's final R, G and B FITS files!

Additionally, eXcalibrator is an excellent tool for calibrating RGB exposures for a given image-train. This is similar to the long-established G2V method. However, eXcalibrator produces more consistent night-to-night results. See section 6.

A Word on Other White Balance Methods:

The astrophotographer may choose several other options to determine color balance:

- Use G2V stars to calibrate the R, G & B exposures. Although popular, this method has two big drawbacks.
  1) Extinction for objects at low altitude causes a problem for all color channels... especially for the blue. The problem varies at different altitudes. This makes automatic adjustment difficult.
  2) Bad (variable) transparency: G2V calibration does not compensate for color shifts induced by bad transparency.
- Use the integrated light of a face-on spiral galaxy. This method shows a galaxy with its intrinsic color. However, if there is galactic or intergalactic extinction, the galaxy and foreground stars are too blue.
- Use the collective light of a star field.
  - Use this method with caution as the general star population is skewed towards the red end of the spectrum.
  - This technique can produce good results with globular clusters, if there is no galactic extinction.
- Simply set the background to a neutral gray. Of course, this will not work with an image completely dominated by a nebula.
- Just wing it by comparing to other images on the Internet.

The Underlying Idea:

Peter Riepe and Harald Tomsik, published in the German magazine 'VdS-Journal' base the idea behind the eXcalibrator approach on two articles. The goal is to make those G2 stars not affected by interstellar extinction, white.

Typical exposure times of object images often run so long that all nearby bright G2 stars become saturated and unusable for color calibration. The unsaturated G2 stars in the image are often faint and we have little or no information on these stars, so we usually cannot search for them successfully. With luck, we can identify a faint unsaturated G2 star, but then interstellar extinction may affect this star and ruin the color balance.

It makes sense to turn towards photometry. Several databases on the Internet catalog the flux of a huge number of faint stars measured through different broadband filters. The most important filter system is the Johnson UBVRI system; where U stands for Ultraviolet, B for Blue, V for Visual (Green), R for Red and I for infrared. For the purposes of color calibration, we focus only on the B, V and R data.

The difference between B and V gives us the “B-V color index," which characterizes the color of the star. A G2 star displays a B-V value of 0.65mag. Red stars show B-V values above 0.65, while blue star values range below 0.65. The difference between V and R builds a further color index. The typical value of V-R of a G2 star in the Johnson filter system is 0.52mag. The Johnson UBV filters are used with the Cousins RI filters rather than in combination with the Johnson RI filters. This usage leads to the Johnson-Cousins color index V-RC = 0.36mag of a G2 star.

For color balance purposes, all of this is useful information.

What eXcalibrator is Not

eXcalibrator is not a scientific astrometric tool. It is an aid for the amateur astrophotographer, to correct the color in "pretty pictures." This can be especially useful for those with color vision problems.

eXcalibrator Program Highlights

- Version 2.0 includes SExtractor for greater accuracy. See Section 4 for complete details.
- eXcalibrator selects many (~8-50) appropriate stars within your image to perform its calibration.
- Version 3.0 includes a Linear Regression routine that can use almost any color SDSS star. This greatly increases the number of useful stars and provides a more accurate calculation. For more information see URL... http://bf-astro.com/eXcalibrator/LinearRegressionApproach.pdf
- Version 4.0 is faster, easier and fully automatic.
- You may select a magnitude range to eliminate the impact of using over-saturated stars.
- eXcalibrator automatically adjusts the aperture size for each star, or the user may manually select a size to use with all stars.
- eXcalibrator normalizes the star's R, G & B flux values by subtracting the local background level.
- eXcalibrator excludes duplicate stars and stars with small separation from the calculation.
- When you exclude stars from the calculation the program automatically recalculates.
- A simple statistical analysis includes the Standard Deviation (StdDev) and RMS average.
- A single click removes statistical outliers... again with auto recalculation.
- A user-adjustable "dead zone" border eliminates stars without complete RGB data, due to dithering.
- The user can set the window position to "Always On Top," which makes the program always visible.
- If necessary, eXcalibrator provides a form for a manual calibration.
- On closing, the program saves the current settings.

2. Initial Product Installation

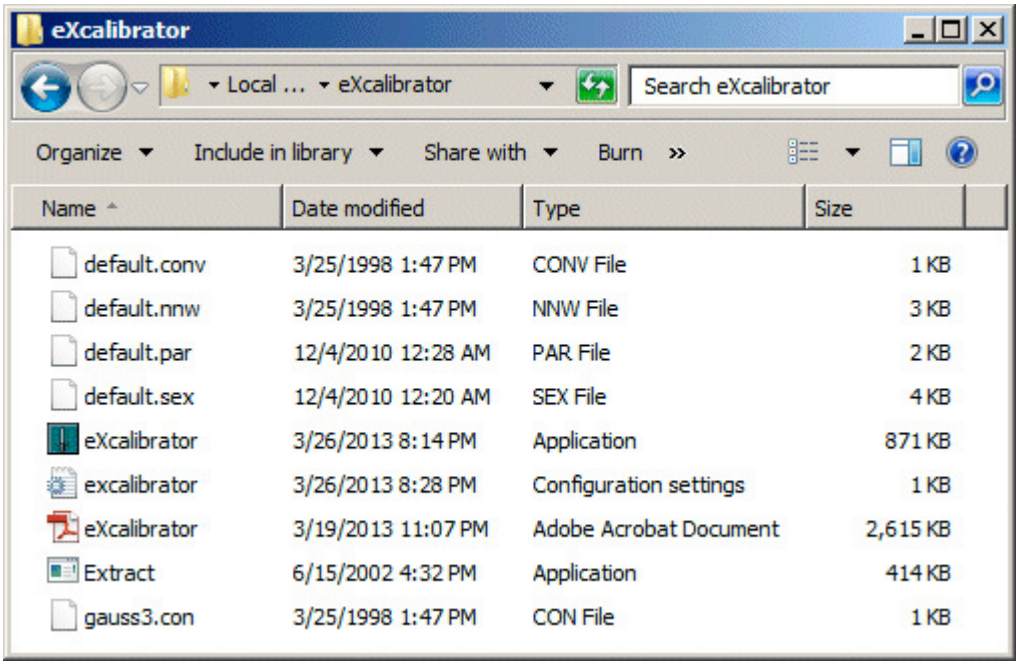
Current Limitations and Requirements

- This is a Windows XP (or higher) based program.
- Save the R, G and B FITS images in 16-bit signed, 16-bit unsigned, 32-bit float, or 32-bit integer formats. Subsequently, plate solve one of the Red, Green, Blue or Luminance channels, in order to insert World Coordinate System (WCS) data. The WCS data must include the following keywords in option A and or B...as shown below:
- With PixInsight, eXcalibrator requires 16-bit unsigned integer FITS files. You may continue to use the 32- or 64-bit floating-point files for PixInsight processing.

Option A	Option B
BITPIX	BITPIX
BZERO, BSCALE (16-bit only)	BZERO, BSCALE (16-bit only)
NAXIS1,NAXIS2	NAXIS1, NAXIS2
CRPIX1, CRPIX2	CRPIX1, CRPIX2
RPIX1, CRPIX2	CRPIX1, CRPIX2
CD1_1, CD1_2	CDELT1, CDELT2
CD2_1, CD2_2	CROTA1, CROTA2
CRVAL1, CRVAL2	CRVAL1, CRVAL2
CTYPE1, CTYPE2	CTYPE1, CTYPE2

eXcalibrator Program Installation

Simply download the eXcalibrator program from (http://www.bf-astro.com/eXcalibrator/eXcalibrator.htm), and unzip the contents into a folder of your choice.



If desired, right-click and drag on the “eXcalibrator.exe” icon to your Desktop or Quick Launch tray and choose the option to “Create Shortcuts Here.”

3. Performing an Image Calibration (Program Workflow)

First, a quick note about the use of the word "calibrate" in this document. "Calibrate" usually refers to the process of computing the white balance. Hence, the program name… eXcalibrator. Section 5 uses "calibrate" correctly.

Summary of Program Workflow

It is suggested to use eXcalibrator or G2V calibrated exposures or color-balanced filters. See section 5.

In summary, you will:

1. Save your registered R, G, and B images in either a 16- or 32-bit FITS format.
2. Do a plate solve on any one of the registered images, to add WCS data; and then resave the file to ensure saving the data into the FITS header.
3. Start eXcalibrator and select your R, G, B and WCS FITS files.
4. Set Your eXcalibrator Options
5. Click the “Calibrate Image” button to generate initial calibration factors.
6. Dealing with slow downloads.
7. Do Post-Calibration Adjustments (if necessary)
8. Enter the calibration values into your favorite image-processing program to perform color calibration.

Details of Program Workflow

i) Save Your Images

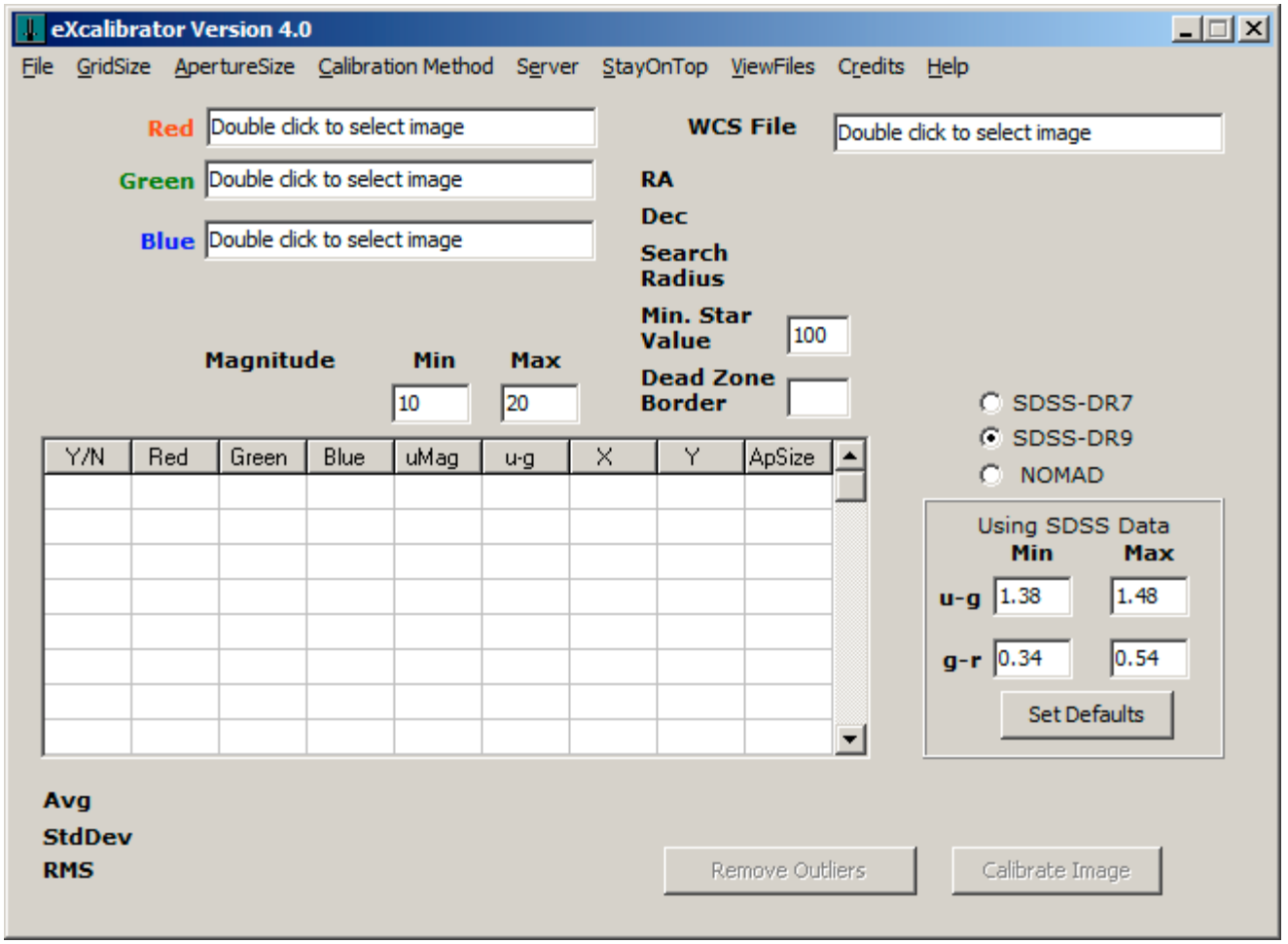
- Save your registered R, G, B images and WCS or Sum file in either a 16- or 32-bit FITS format.
- Save the three color files at the same bit level.
- The bit level of the WCS, or Sum File, may differ from the color files.
- With PixInsight, save a separate set of the red, green, blue and WCS files as 16-bit unsigned integer FITS. Use these files with eXcalibrator for determining the color balance. Then use the eXcalibrator color channel factors for creating the RGB image with the PixInsight 32- or 64-bit files.

ii) Plate Solve Your Image

- With CCDSoft and TheSky6, use any registered image to perform a WCS plate solve.
- In MaxIM DL, you can use the included PinPoint LE engine or the full version of PinPoint to accomplish the same thing.
- The PixInsight's (PI) plate solve script works fine. However, do not mix PixInsight files with those created by other software. PI modifies the data with a vertical flip. This is no problem if all the files are saved with PixInsight.
- The shareware program Astrometrica at URL http://www.astrometrica.at/ .
- The free online service at http://live.astrometry.net/ .

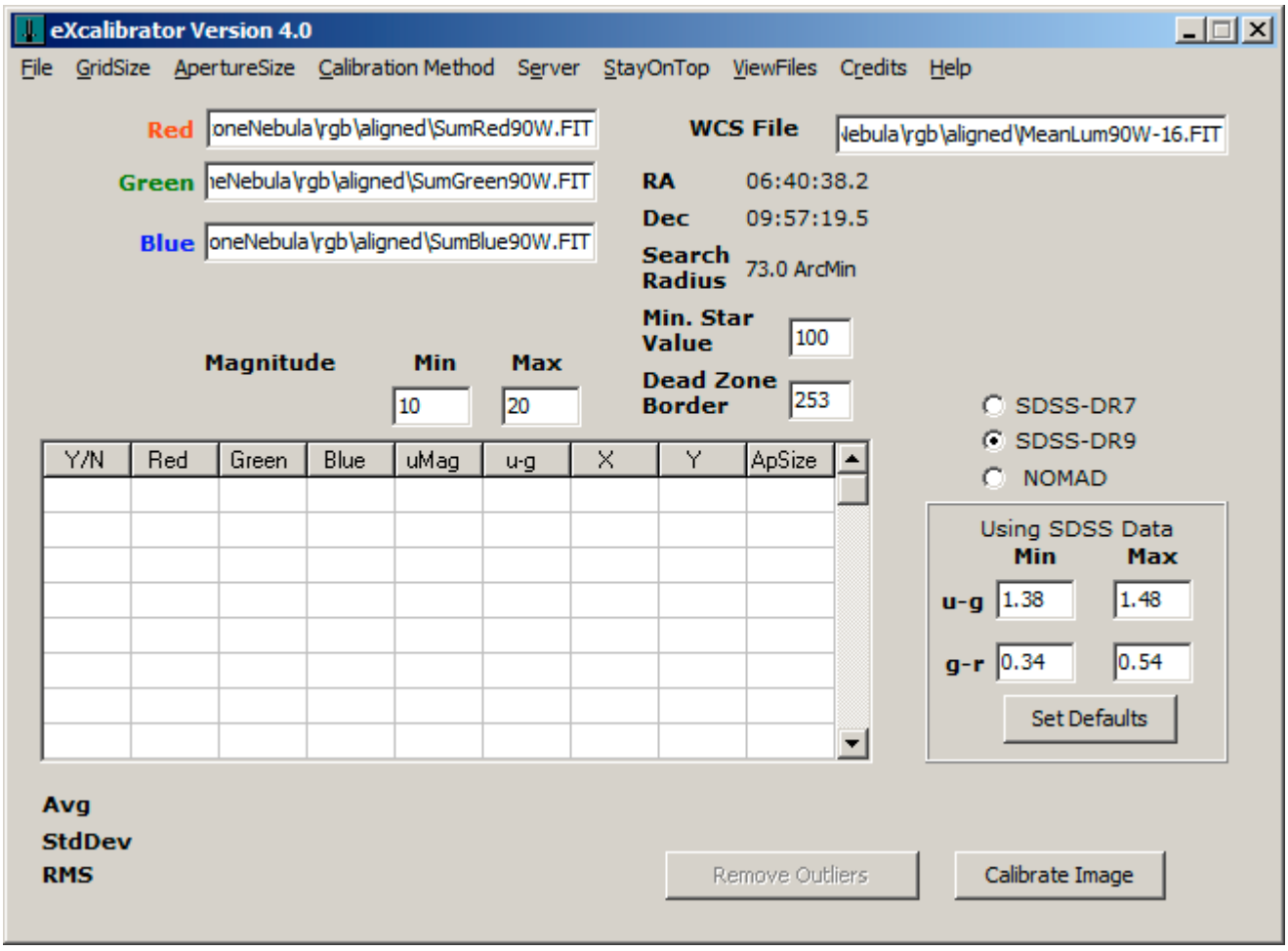
iii) Initial Data Input in eXcalibrator

- Execute or open eXcalibrator and you see the following screen:



- Double click on the WCS File text box and select the plate-solved file.
  - Use any file registered with the three RGB images. Load a luminance image, if you have one, as it is the easiest to plate solve.
  - Lower the bit level to 16, which may make plate solving easier. This way, a 16-bit file can be loaded in the WCS File text box, while using 32-bit files in the Red, Green and Blue boxes.
- Double click on the Red text box to select all three R, G & B files, (or you can do each individually). The File Open Dialogue window uses standard Window's file selection methods.
  - If you open all three images from the Red text box, the program uses the information in the FITS header to determine what filter is used and allocates each appropriately. (Opening the files from the Green or Blue text boxes does not do this... the user must make the correct color choice.)

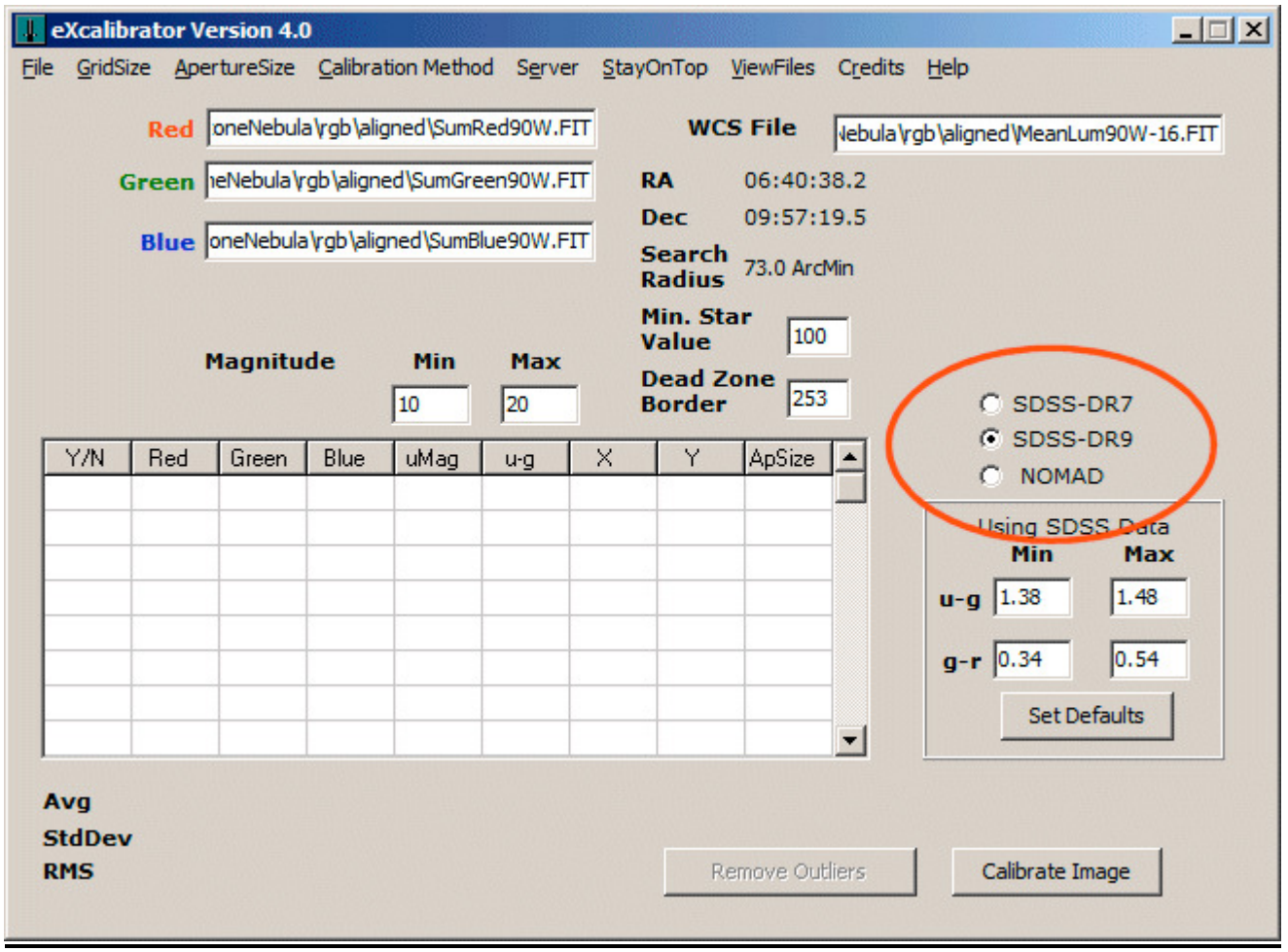
Here is the result:



iv) Set Your eXcalibrator Options

Select The Star Catalog

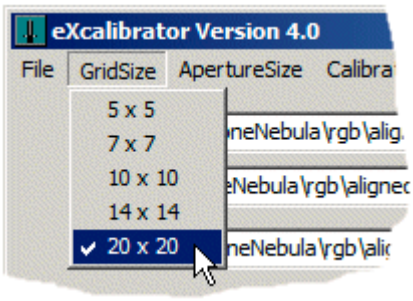
The SDSS-DR7 and DR9 databases are significantly more accurate than the NOMAD. Unfortunately, the SDSS data only cover 25% of the sky. Always try the SDSS-DR9 first and then the DR7. If both fail, the NOMAD catalog should always return data.



GridSize

This item sets the number of sections in the local background grid... 20x20 creates 400 sections. For cameras with small chips, 5x5 or 7x7 grids may work better.

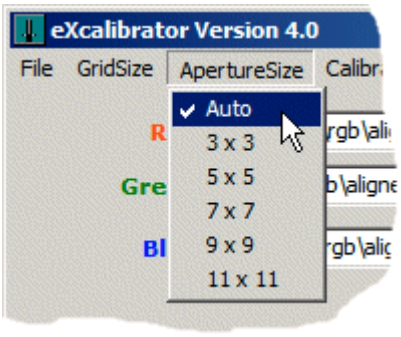
Using SExtractor disables GridSize selection.



ApertureSize

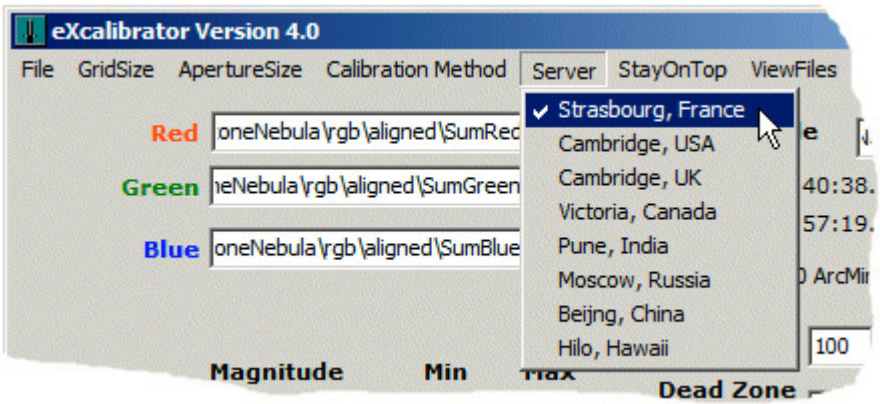
"ApertureSize" sets the size, in pixels, of the square grid used to compute the average flux for each star. eXcalibrator selects the best size for each star when the user selects "Auto." Otherwise, eXcalibrator applies the user's choice to all stars.

Using SExtractor disables the ApertureSize selection.



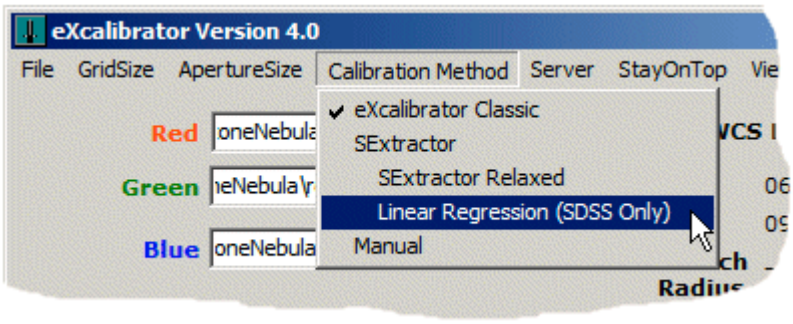
Server

Select the country of origin for the database server. Testing seems to indicate that the French server is generally the most reliable and fastest. The user may experience better results with a geographically closer server.



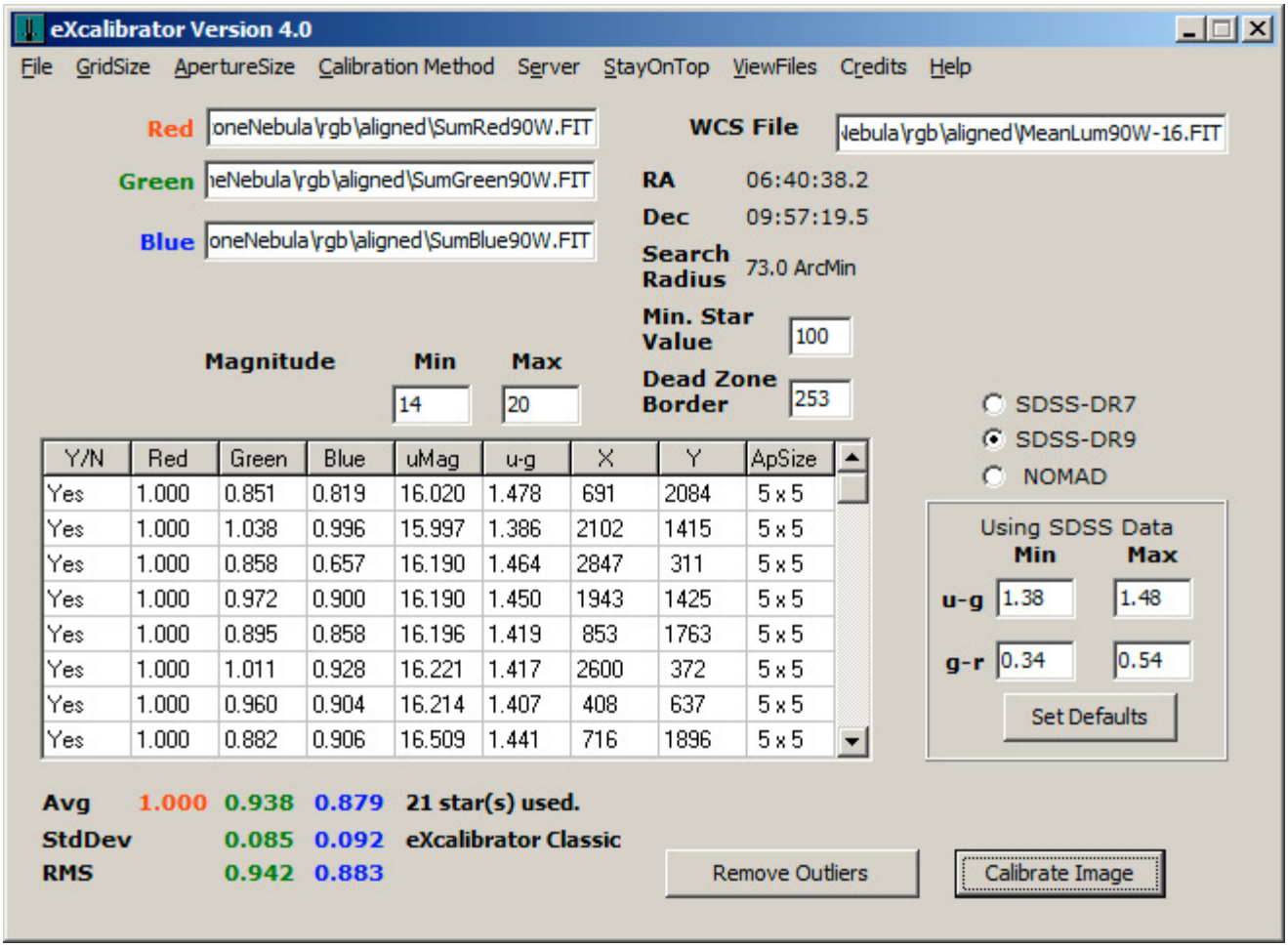
Calibration Method

- The ”eXcalibrator Classic” method uses the original program functions to compute the color ratio factors.
- “SExtractor” is an external program that very accurately locates and calculates light sources in the image. Although it is slightly slower than the eXcalibrator process, it is more accurate and only uses the highest-quality stars.
- “SExtractor Relaxed” finds more stars, as it accepts lower quality light sources.
- The "Linear Regression" routine uses cyan to white to orange SDSS stars.
  - The calculation is more accurate and may use hundreds of stars. This is particularly useful for systems with a small field of view.
  - This method also uses SExtractor.
  - For detailed information about the Linear Regression calculation see URL... http://bf-astro.com/eXcalibrator/LinearRegressionApproach.pdf
- Use the “Manual” process when a plate solve is not achieved.



v) Perform the Calibration Calculation

- Now click the "*Calibrate Image*" button.
- In about five to fifteen seconds, you should get a result similar to this. The calculation time is dependent on the field of view size and speed of the Internet connection.

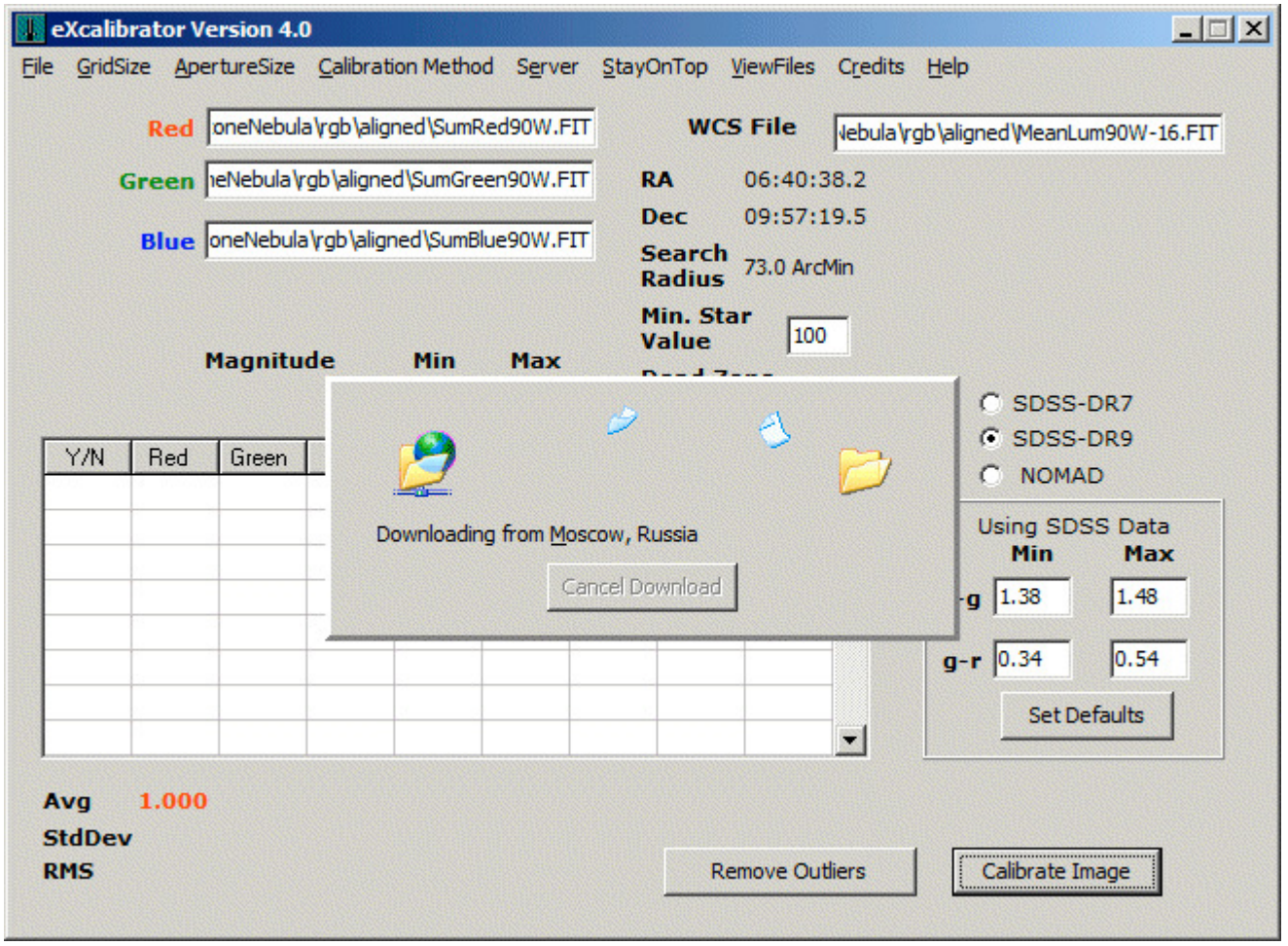


vi) Dealing With Slow Downloads

Several scenarios cause slow downloads. Most commonly, it is because the server is very busy or it is down for maintenance

After clicking "*Calibrated Image*," eXcalibrator displays the download animation box. This shows the server origin and the download progress. Initially, the cancel button is disabled. Unfortunately, eXcalibrator cannot allow download cancellation until the server actually responds. This usually takes one or two seconds and should be no longer than about thirty. If the server has not responded after 30 to 60 seconds, it may be necessary to stop eXcalibrator with the Task Manager.

Once the "*Cancel Download"* button is enabled, the user may decide to cancel the download and select another server.

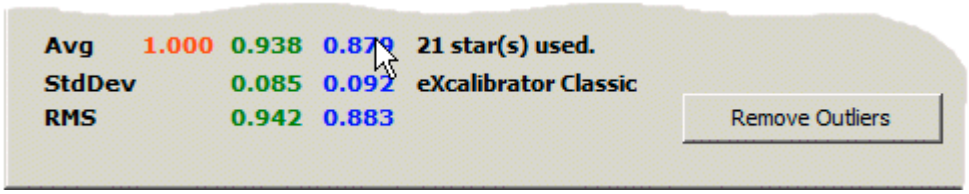


vii) Do Post-Calibration Adjustments

Change the Normalization for the RGB Factors (if required)

By default, eXcalibrator calculates the R, G and B color ratios relative to the red. Therefore, the factor for the red channel is always 1.00. Some programs, most notably PixInsight, require color ratios with a maximum value of 1.00. You may recalculate eXcalibrator's results by double-clicking on the desired text by color.

In the below example, double-clicking on the blue text, 0.879, changes the red, green and blue values to 1.138, 1.067 and 1.000. For PixInsight users, just double-click on the largest value in the "average" row.

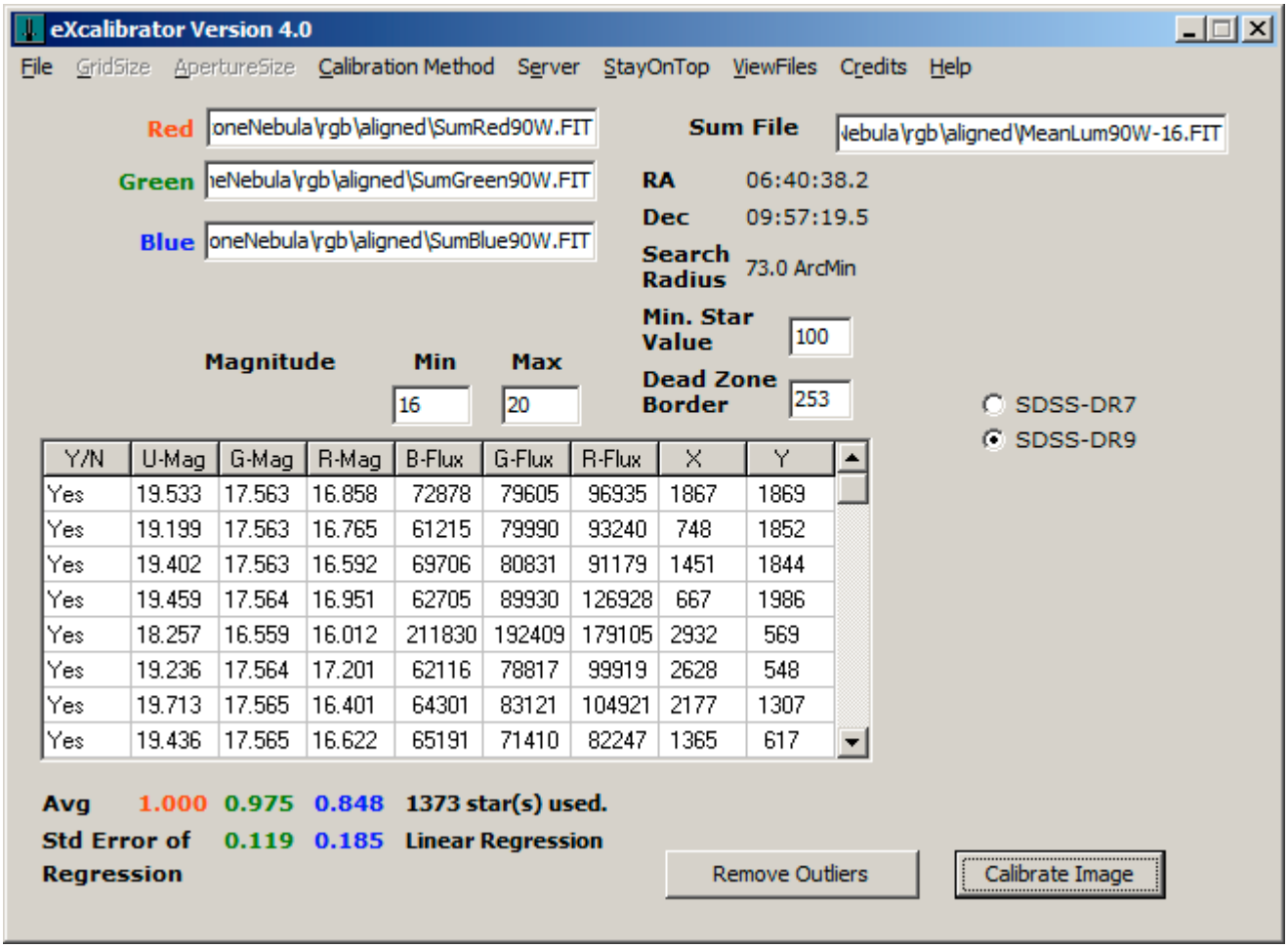


Star Selection:

- If you did not get enough calibration stars, you may...
  - Change the Min and/or Max Magnitude values and click "*Calibrate Image*" again.
  - Increase the usable image area by reducing the size of the "Dead Zone Border."
  - Increase the range of the (b-v), (v-r) or (u-g), (g-r) values. A small change has little affect on the final color ratios. Try plus and minus 0.05. If you have SDSS coverage, the "Linear Regression" routine will usually provide an ample star count.
- Experience shows, when using SDSS data, magnitudes of Min=15 and Max=20, usually give good results.
- The unsuccessful attempt to use the linear regression routine with NOMAD data provided useful information.
  - Comparing about 8,000 NOMAD stars to SDSS data showed a linear relationship from magnitudes 14 to 18.
  - This also confirmed the need for adjusting the NOMAD calculation. The data suggest using adjustment constants of (Green x 0.96) and (Blue x 0.85).
  - Although less accurate than the SDSS data, the NOMAD stars can give reasonable color balance when using white stars. Higher star counts will average the errors and give better results.
- To use more centrally located stars, increase the size of the "Dead Zone Border."
- Double click in the "Y/N" column to include or exclude individual stars. To aid the decision-making process, double click the desired column to sort the grid.

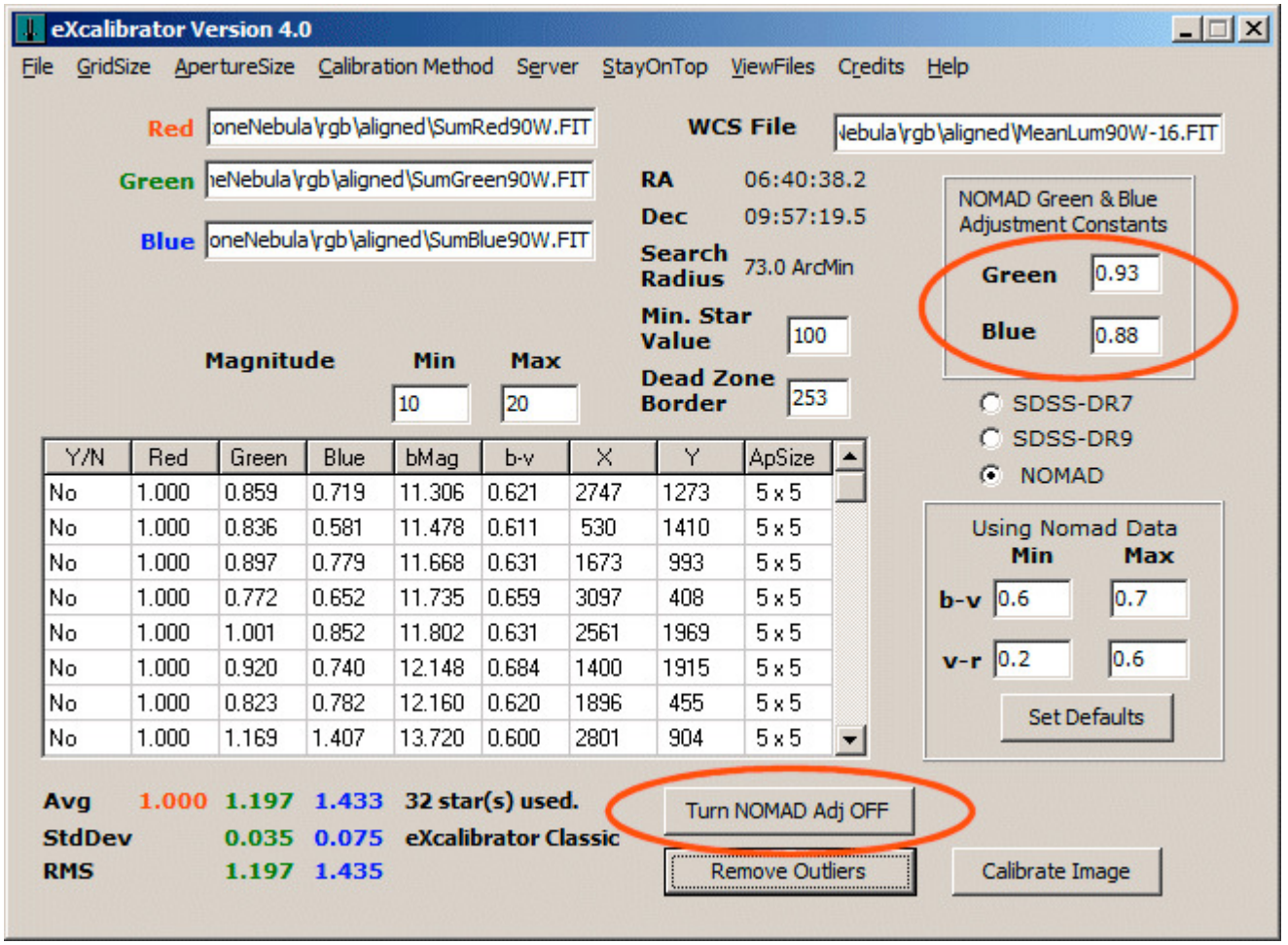
Improving the Variability of the Data:

- In the example below, the values for the Standard Error of Regression, or StdDev, for the Green (0.119) and Blue (0.185) data are slightly high. Reduce this variability by removing stars where the green or blue results fall outside the current StdDev values.
- One click of the "*Remove Outliers*" button lowers the star count to 890, and reduces the Green and Blue StdDev values to 0.060 and 0.093 respectively. Using a StdDev less than 0.10 is suggested.
- A second click on the "*Remove Outliers*" button further reduces the star count to 436 and the green and blue StdDev values to 0.031 and 0.049, respectively. It is up to the user to determine if removing outliers more than once is statistically valid.



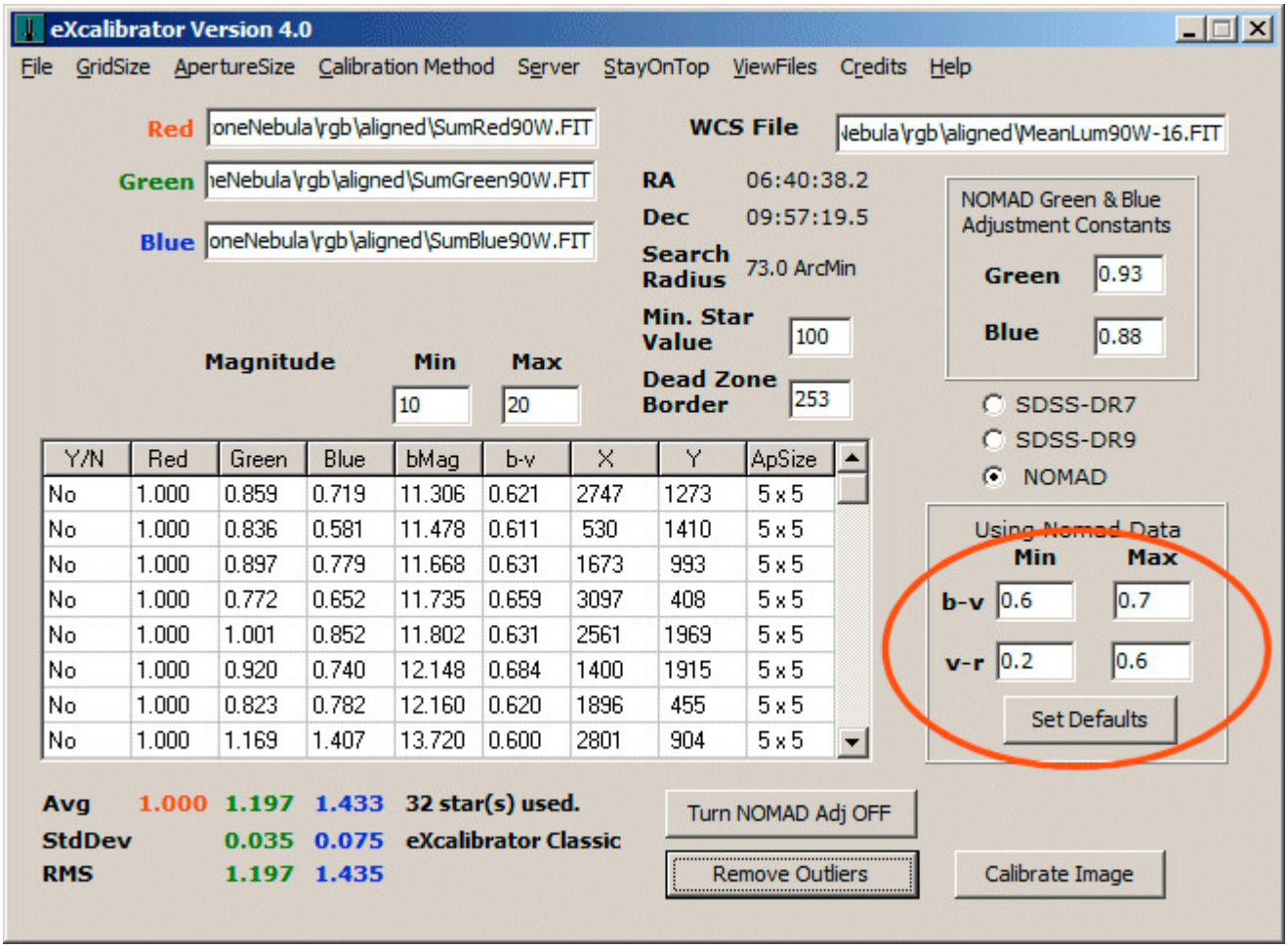
Adjusting for NOMAD Accuracy:

- The NOMAD data, a collection of several catalogs, does not have the accuracy of the more modern and strictly digital Sloan survey (SDSS). Color balancing with the NOMAD data often yields a too-blue image. Typically, reduce eXcalibrator's green correction factor by 5 to 10% and the blue correction factor by 10 to 15%.
    - The first time the program runs, it puts 0.93 and 0.88 in the NOMAD Adjustment Constant text boxes. After that, eXcalibrator saves and reloads whatever was last used.
    - Any time the user recalculates the data, the Averages, RMS and Std. Dev. values are adjusted with the user-entered Green and Blue NOMAD factors.
    - The program has a button to toggle the NOMAD adjustment on and off.
    - The grid numbers do not change with or without the NOMAD adjustment.
    - Using SDSS data hides the NOMAD Adjustment Constant text boxes and the toggle button. The SDSS data need no adjustments. Unfortunately, the Sloan survey data cover only 25% of the sky.



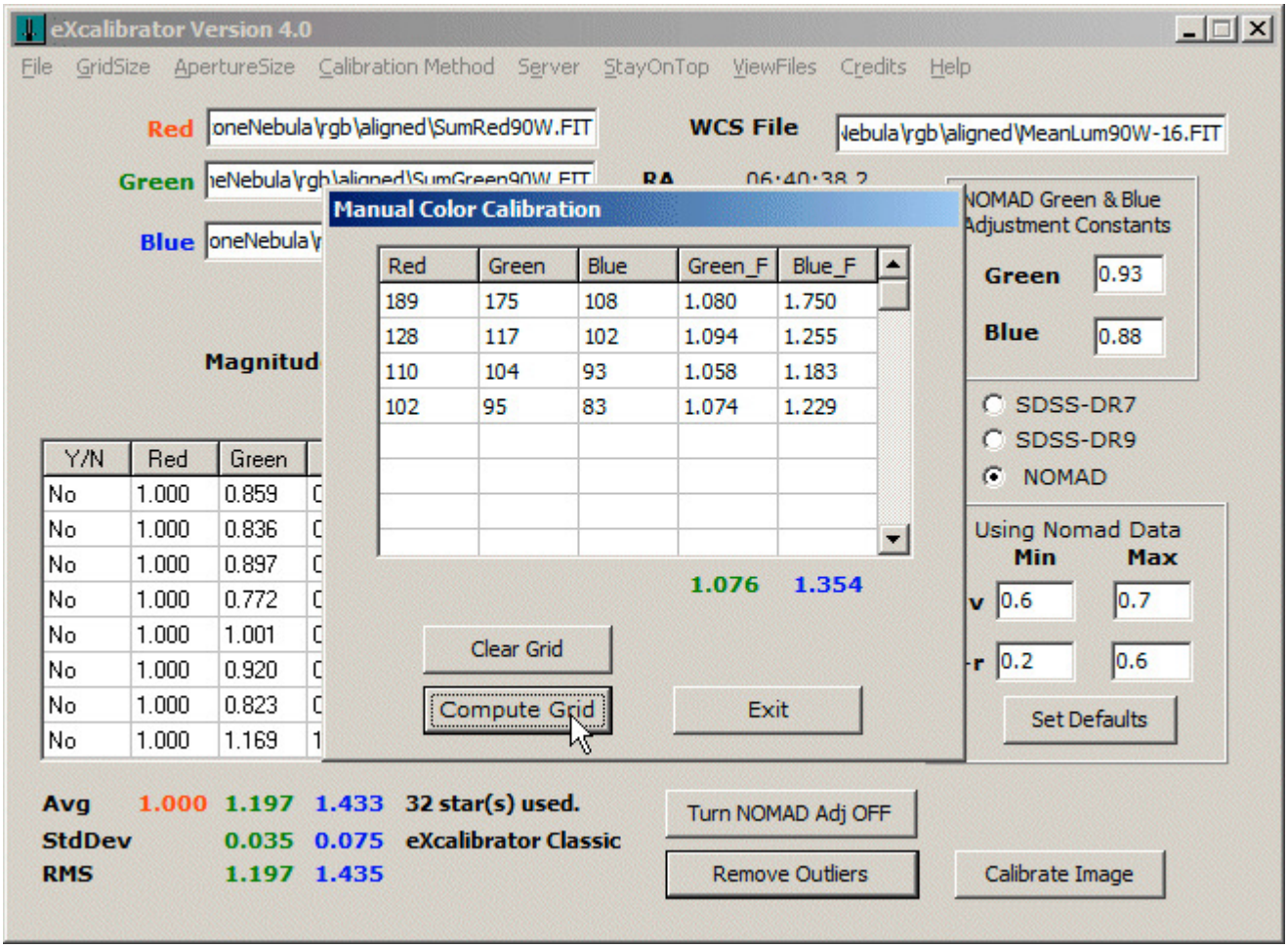
Further Fine Tuning:

- For further fine-tuning, modify the Min and Max (u-g), (g-r) or (b-v), (v-r) result values for the SDSS or NOMAD filter subtractions. However, it is suggested you use the default values. You are strictly on your own here.



viii) Doing a Manual Calibration

- If eXcalibrator produces incorrect color, the program provides the Manual Color Calibration (MCC) form. Use the x- and y-column data in the Result Grid to locate calibration stars in your RGB image. Then use your favorite image processor to measure the R, G and B values for the stars and enter the data into the first three columns of the MCC form. The MCC form can take data for ten stars, but four or five should do the job. Then click "Compute Grid" to calculate the average green and blue correction factors, shown just below the grid.
- eXcalibrator usually provides very good results with SDSS data and less consistent results with NOMAD. A manual calculation helps verify the result.



4. Using SExtractor

What is SExtractor?

SExtractor is a program that builds a catalog of objects from an astronomical image. The program was written by Emmanuel Bertin and S. Arnouts at the Institut d'Astrophysique de Paris. Back in the early nineties, the purpose of SExtractor was to find a compromise between refinement in both detection and measurements, and computational speed. By today's standards, SExtractor would be more accurately described as a "quick-and-dirty" tool. However, it is very good at extracting accurate photometry data.

How eXcalibrator Uses SExtractor

eXcalibrator runs SExtractor in a hidden window and uses the "double-image mode." Image1 (the Sum File) supplies light source centroids, and image2 provides flux measurements. For image1, use any of the R, G, B images or the luminance. Also, for image1, use a plate-solved image. The "double-image mode" insures measuring the flux of the three RGB images at the exact same place and in the same manner.

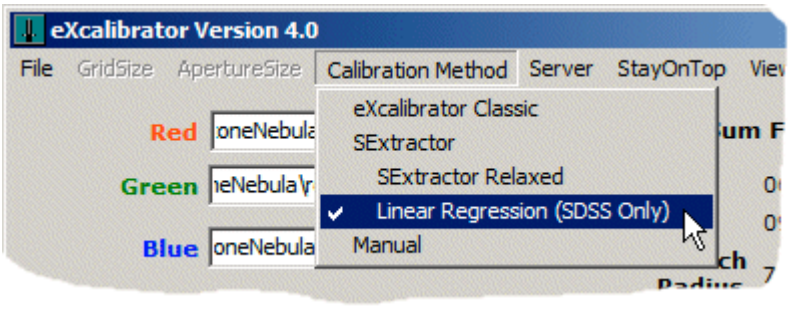
SExtractor reverses the eXcalibrator calculation process.

- SExtractor creates catalogs of all the high quality light sources, in the R, G and B images, and writes the data to simple, formatted, text files. The process is somewhat slow because SExtractor searches the entire image. The standard eXcalibrator process is faster because it only looks for the stars in the downloaded data.
- eXcalibrator then loads the SExtractor catalogs and looks up the matching entries in the downloaded NOMAD or SDSS data.
- Finally, eXcalibrator computes the RGB correction factors, in the usual manner.

The SExtractor Workflow

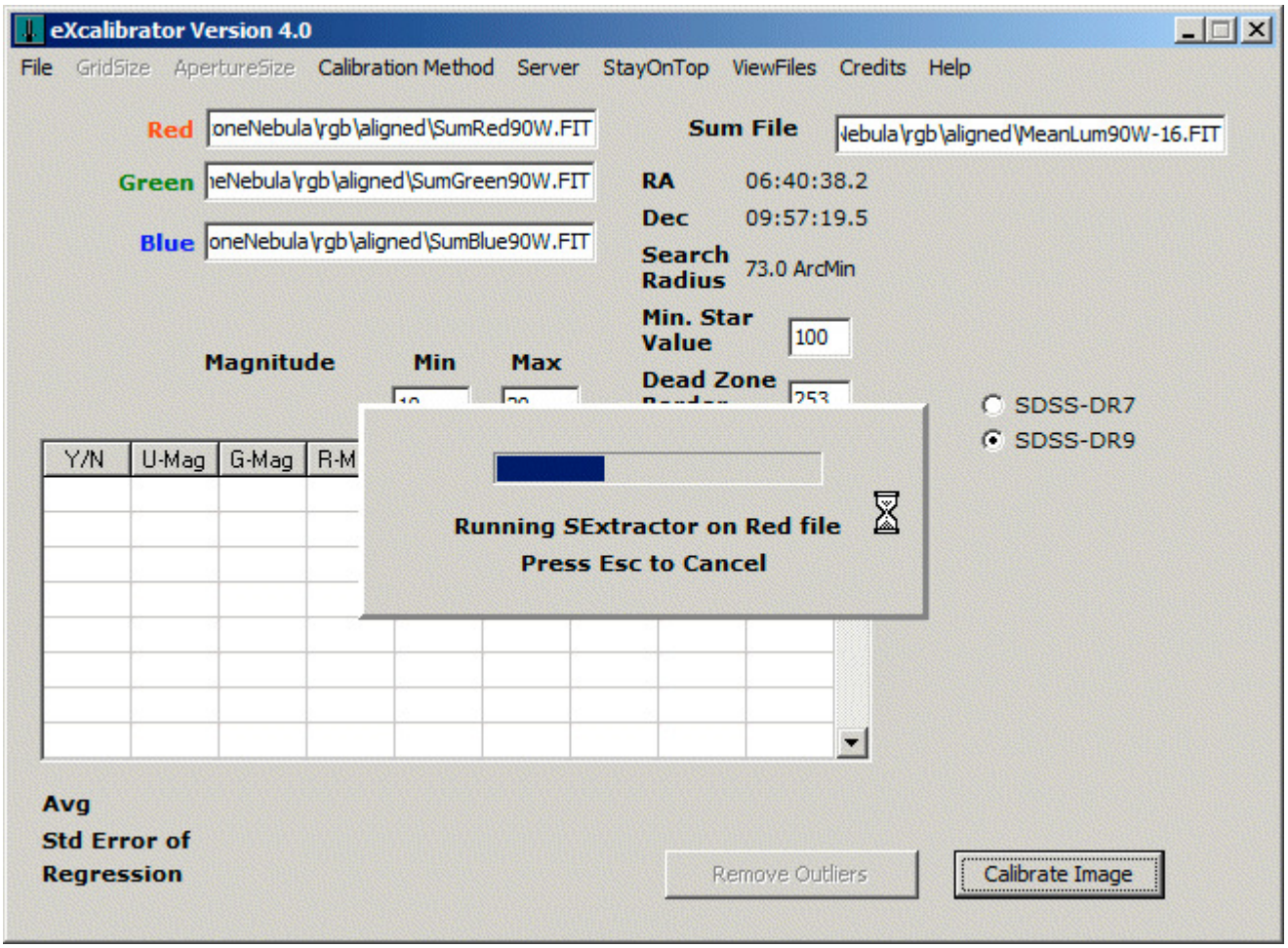
The source extractor workflow is the same as eXcalibrator Classic. Simply select one of the three SExtractor calculation methods.

- "SExtractor" is an external program that very accurately locates and calculates light sources in the image. Although slower than the "eXcalibrator Classic" process, it is more accurate and only uses the highest-quality stars in the image.
- "SExtractor Relaxed" finds more stars, as it accepts lower-quality light sources.
- "Linear Regression" uses high-quality SDSS stars with an expanded color range.



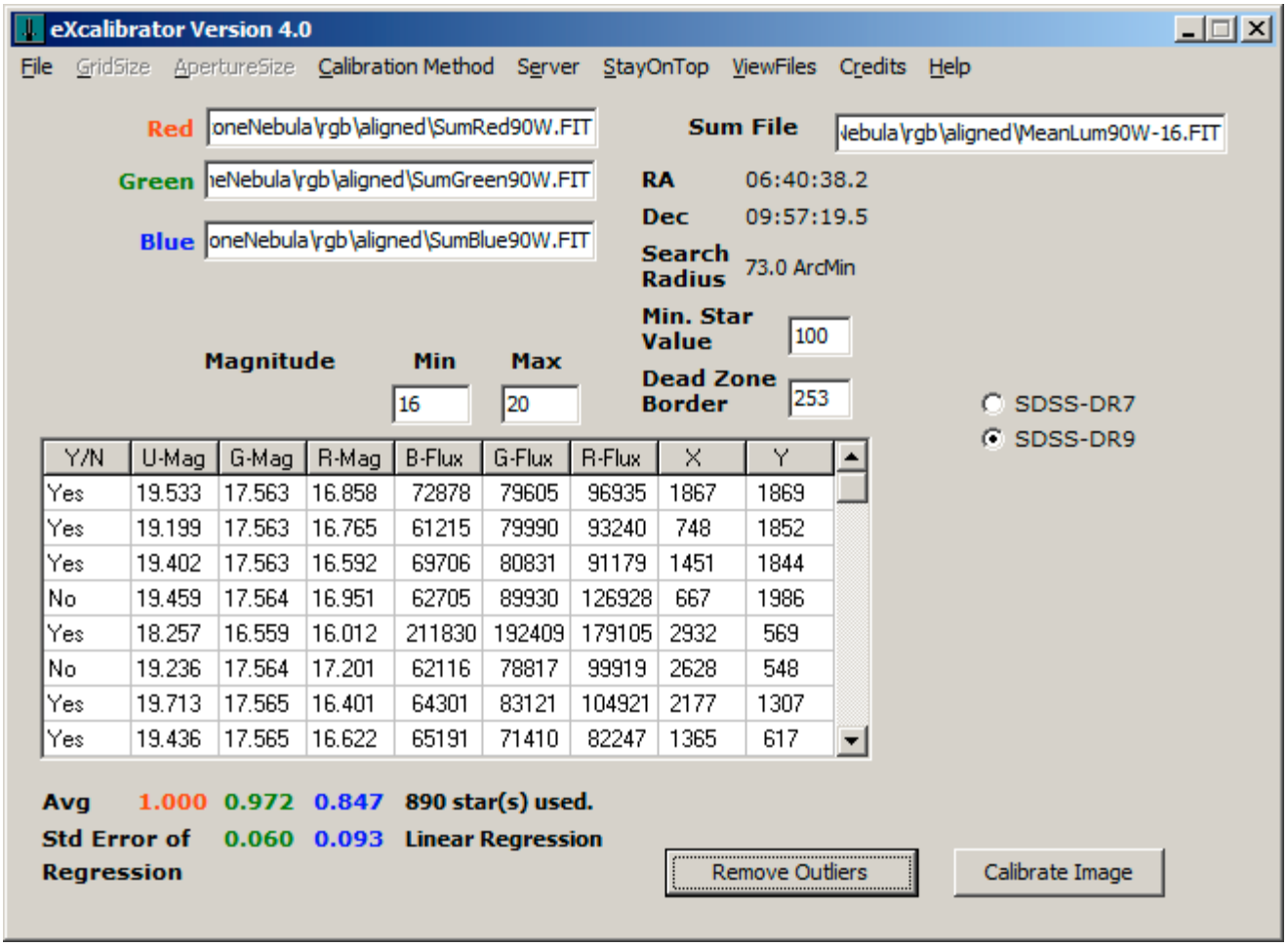
After clicking "*calibrate image*," eXcalibrator adds an additional step to the process. eXcalibrator runs SExtractor with the three RGB images. This creates text files in eXcalibrator's home folder, named r.txt, g.txt and b.txt. This process takes about ten seconds. eXcalibrator does not repeat the SExtractor analysis unless one of the image files changes.

Here is a screenshot of eXcalibrator while SExtractor analyzes the images.



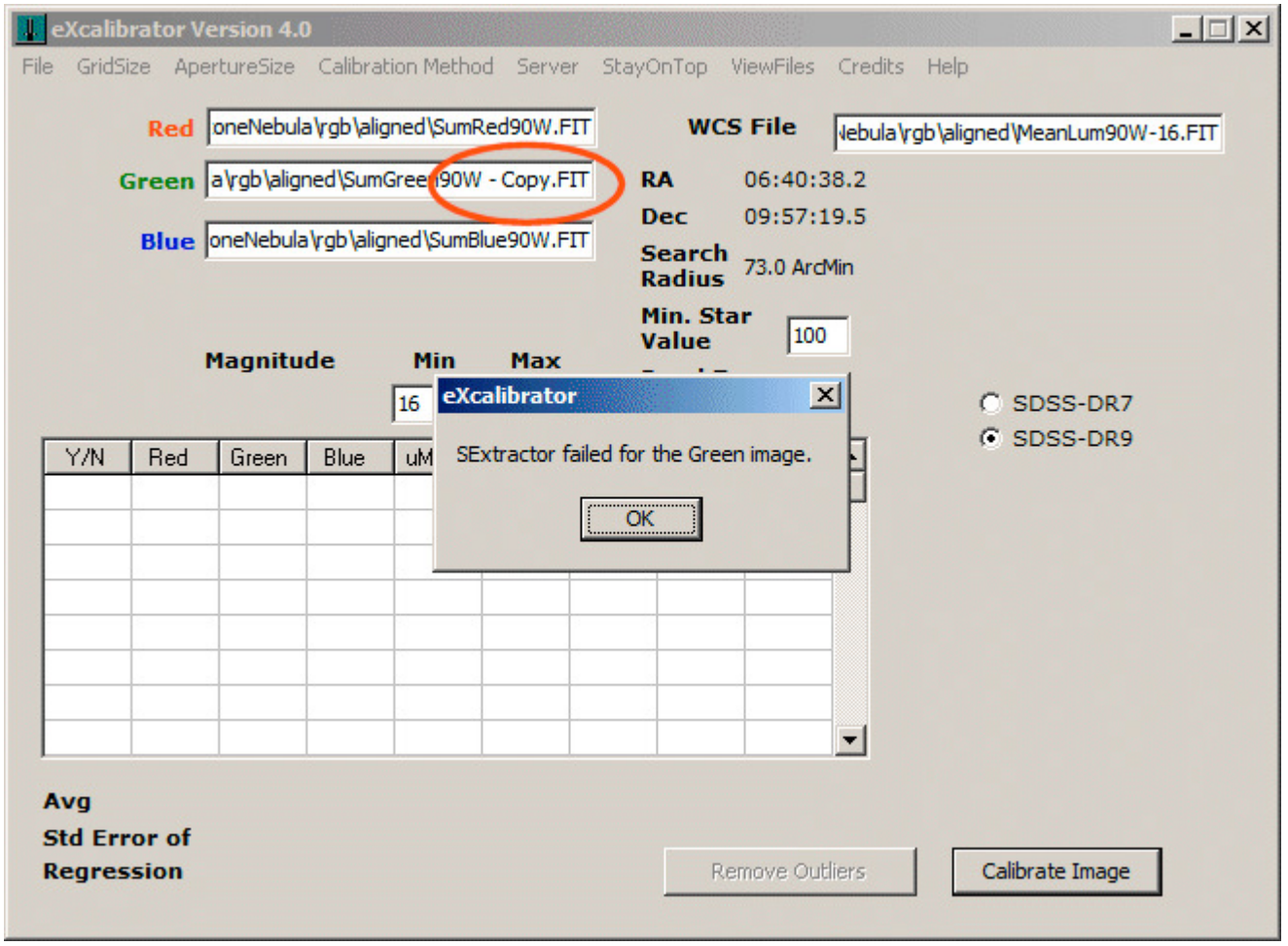
After SExtractor finishes, eXcalibrator immediately starts the rest of the calibration process.

Here is a typical Linear Regression result with a wide field of view.



Do Post-Calibration Adjustments (see pages 13 - 16)

If the SExtractor analysis fails, eXcalibrator displays a messages similar to this:



SExtractor is an older DOS program that can accept long file names, but spaces are a problem. The program perceives spaces as delimiters for input parameters. Unfortunately, there is no list of allowable characters. Avoid spaces and special characters in file paths and names.

SExtractor excepts the underscore "_" and dash "– " characters. Other special characters probably also work. The user will simply have to experiment.

5. Calibrating The Initial RGB Exposures

Why Calibrate?

Quality color images require an equal balance in the signal-to-noise ratio between the three color channels. Let us consider an image-train that requires a 50% increase with the blue filter and the astrophotographer uses equal length red, green and blue exposures. With image processing, it is possible to multiply the blue data by 1.5 and produce an image with good color. However, the signal-to-noise ratio, in the blue channel, will be less than the other two. This may produce noticeable noise and reduced detail in the blue areas of the image.

How to Make Corrections

There are two ways to correct the color. One can use equal length R, G and B subexposures and take 50% more with the blue filter. Alternately, the astrophotographer can use equal subexposure counts and take 50% longer exposures with the blue filter. With both methods, mean combine the subexposures.

The first method is preferred, as it requires just one set of dark frames. When creating the RGB image, multiply the blue data by 1.5. This gives the color correction. The extra blue subexposures maintain the equal SNR between color channels.

In the second case, simply create the RGB image with red, blue and green ratios of 1:1:1. The longer blue exposures supply the color balance and equalization of the signal-to-noise ratios. Unfortunately, this method requires extra sets of dark frames or scaled darks.

Enter eXcalibrator

So, how do we determine the correct RGB ratios for a given image-train? The long-established method is to use G2V stars. Our sun is a G2V star and we perceive its light as white. The goal is to adjust the exposures so that a G2V star appears white in our images. eXcalibrator offers an alternative method, although the goal is the same. The G2V method uses exposures of a single star. eXcalibrator can use hundreds of stars from a single field of view. By using a much larger sample, eXcalibrator produces more consistent results.

The eXcalibrator Image-Train Calibration Work Flow

- First, pick a very clear night.
- Identify a field of view, near the zenith, and covered by the Sloan Digital Sky Survey. This is important, do not use the NOMAD stars.
- For each filter, take a five-minute guided exposure with no dithering.
- Apply dark and flat frames in the normal manner.
- It may not be necessary to register the images. If so, use a Nearest Neighbor alignment routine.
- Run the red, green and blue images through the eXcalibrator process... as described in sections 3 and 4.

Example Results

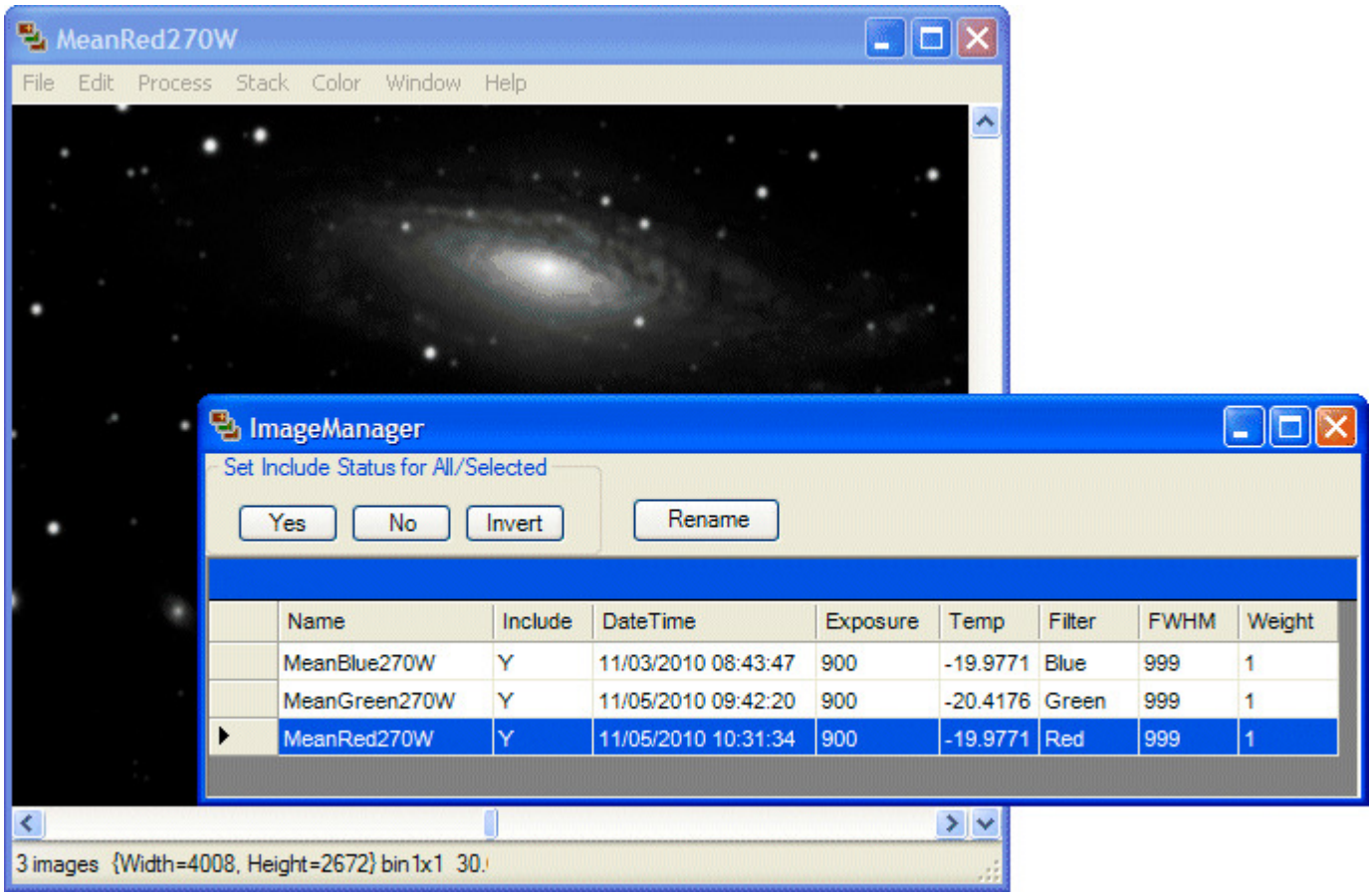
With the author's RCOS scope and STL–11000 camera, using AstroDon filters, the red, green and blue eXcalibrator ratios are 1.00, 0.95 and 1.05. This is close enough to 1,1,1 to allow equal length exposures. After stacking the subexposures, for the final R, G and B images, eXcalibrator determines a final adjustment. If there were no problems with variable seeing conditions, this is usually a minor fix.

With the authors FSQ–106 scope and STF–8300 camera, using Baader filters, the R, G and B exposure ratios are 1.00, 1.20 and 1.43. This image-train uses equal-length exposures with subframe counts of 10, 12 and 14. After stacking and mean combining subexposures, eXcalibrator determines the color channel ratios for the final RGB image. These ratios are usually similar to the previously determined image-train calibration.

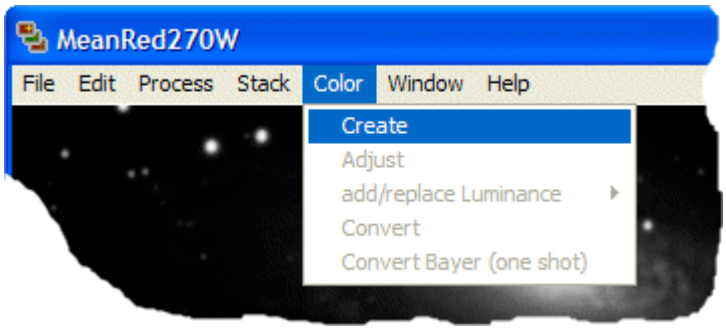
6. Creating an RGB Image With eXcalibrator (Program Workflow)

Note: For illustration purposes, the process below utilizes CCDWare's CCDStack. You may, of course, use whatever image-processing program you desire!

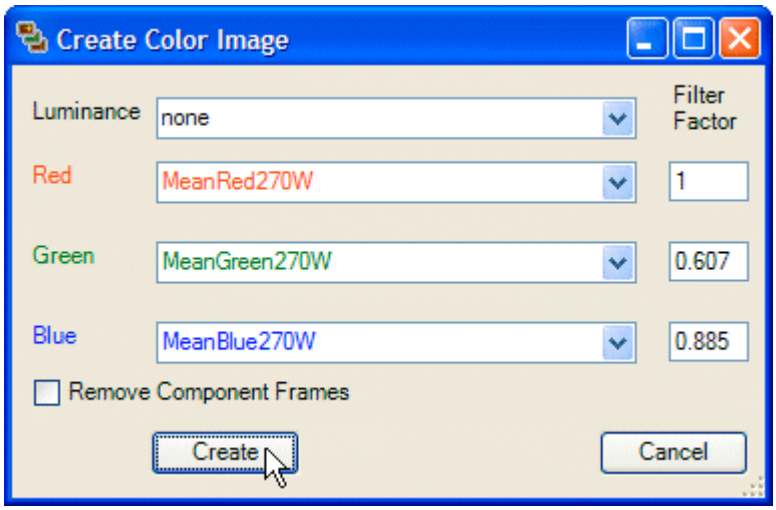
- First, load your three master channel combines into the program:



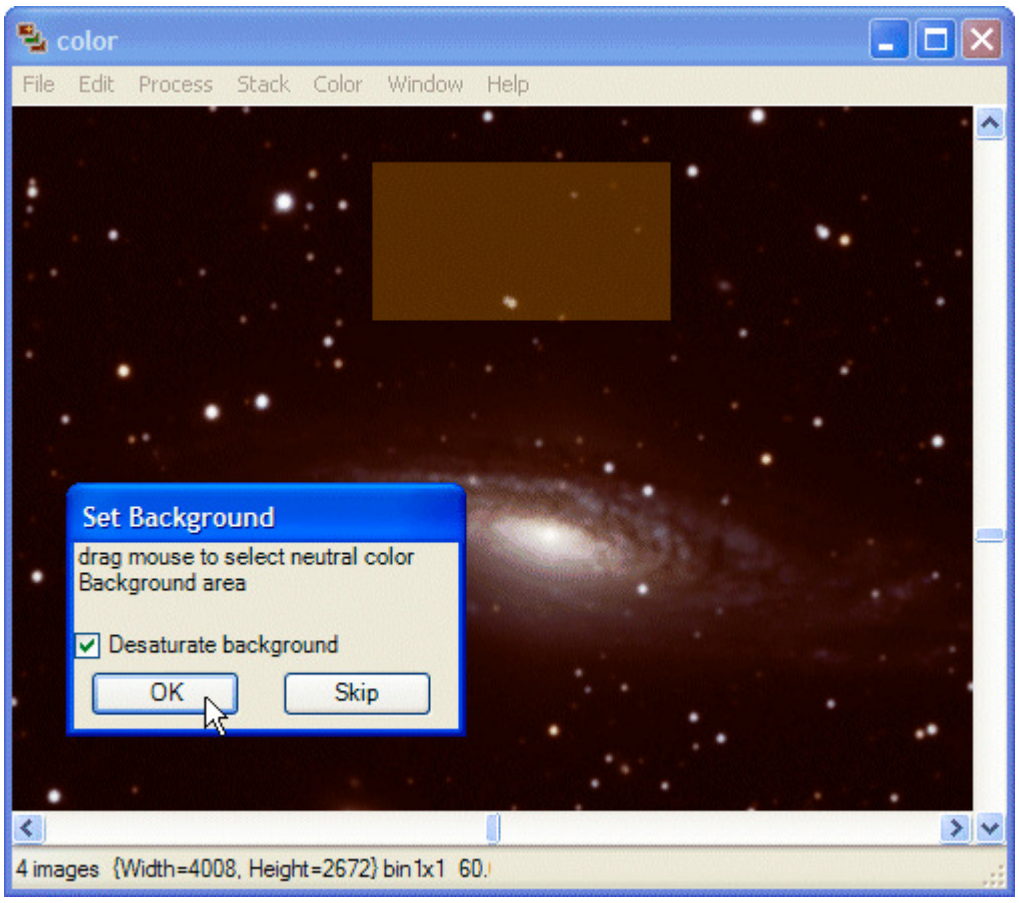
- Then, select the option to “Create” a color image:



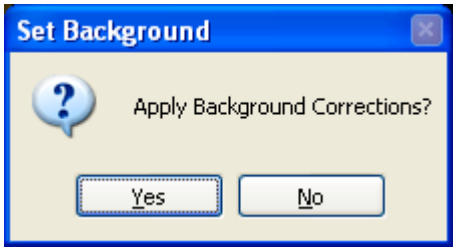
- Enter the ratios provided by eXcalibrator, and click the “Create” button:



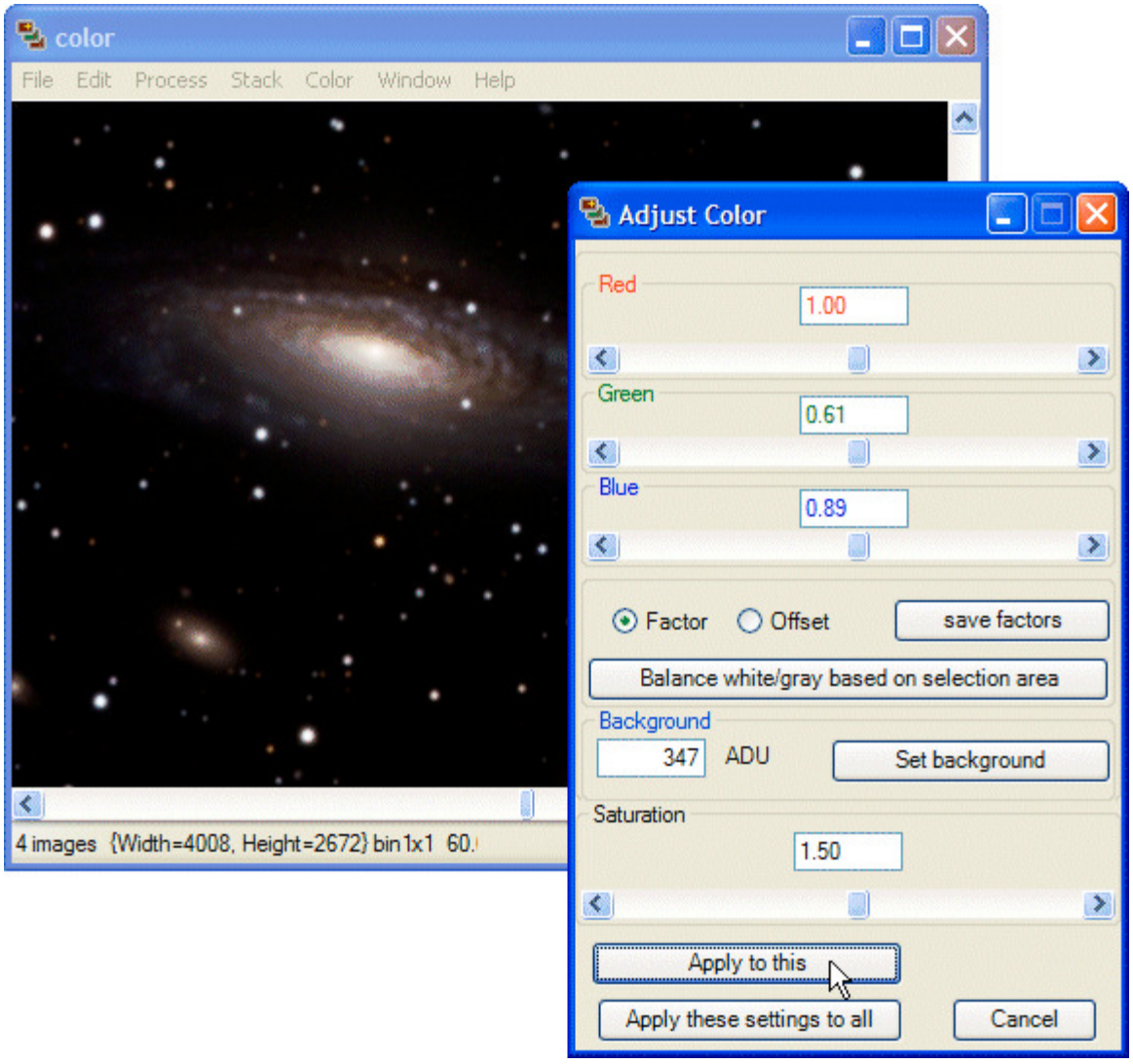
- Once the initial combine is done, select an area of the image that represents dark sky background. With a gradient, select the brightest area of the background. Click "OK."



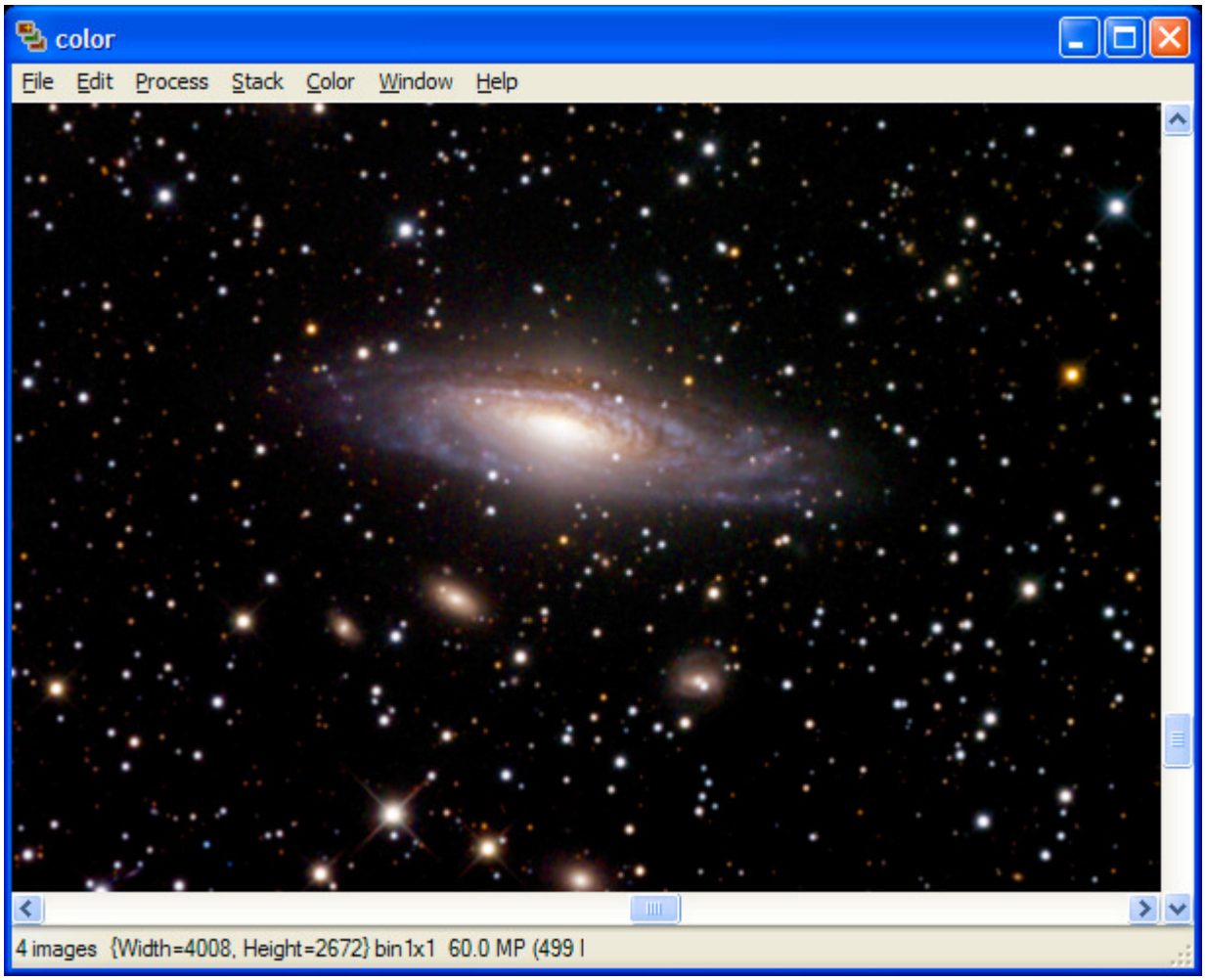
- Click “Yes” when asked if you want to “Apply Background Corrections.”



- Adjust the saturation, as desired, and click “Apply to this.”



- Your initial color combine is finished!



7. Troubleshooting

What to do with an Invalid Calibration

As mentioned earlier, eXcalibrator occasionally produces an invalid result. However, the program still provides useful information to make a manual calibration much easier... especially with rotated images. Use the Manual Color Calibration, described above, to obtain green and blue channel correction factors.

The x, y Locations Are Not Dead Center on the Stars

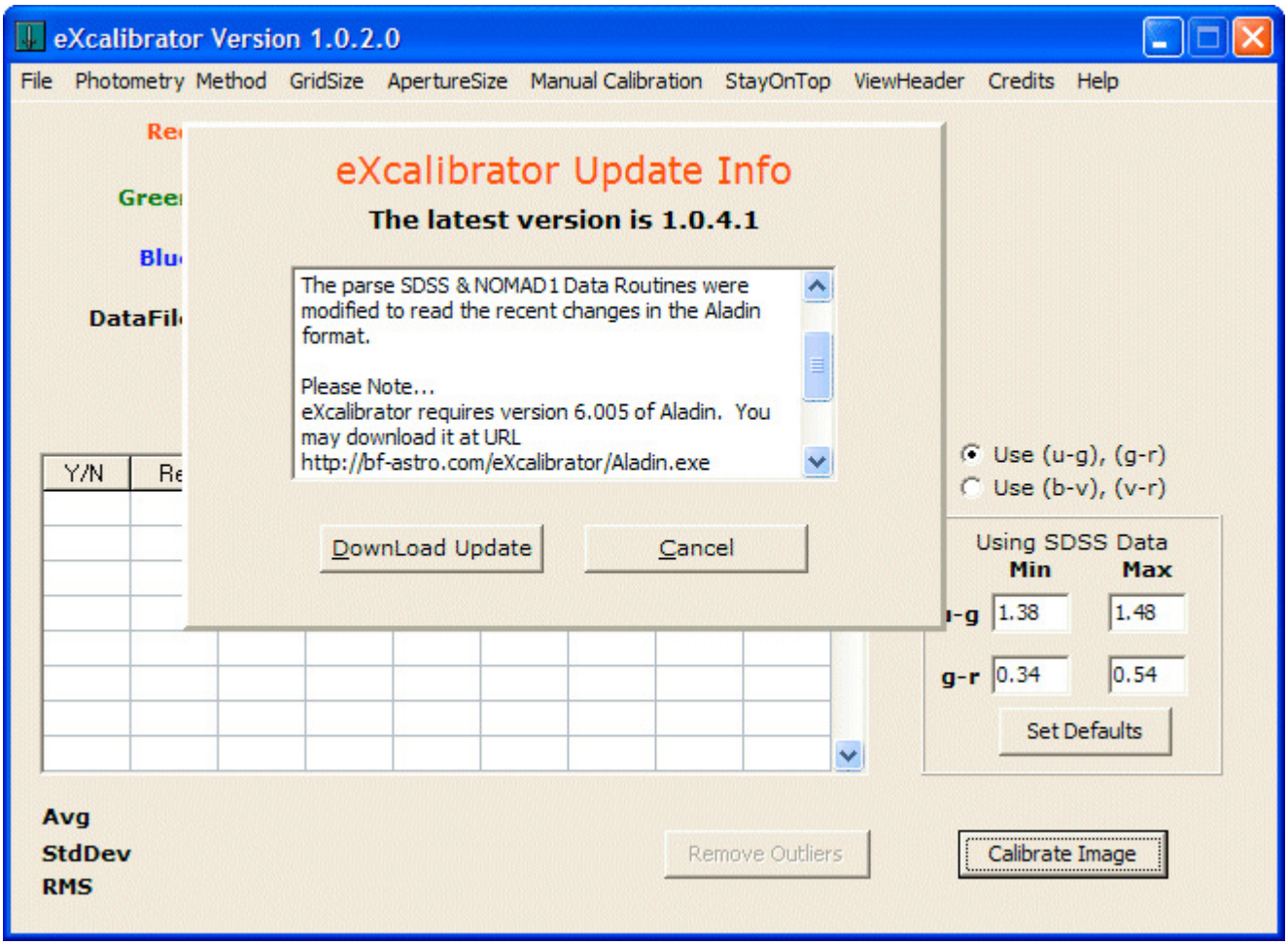
When doing a manual calibration, the user may notice that the x, y pixel locations are not always at exact star centers. If the R, G and B images are properly registered, the eXcalibrator calculation is still valid. To account for hot and cold pixels, the program uses the average of a 3x3 to 11x11 pixel array, to determine the color values.

Suggestions and Bug Reporting

Send an email to bfranke@bf-astro.com, with the subject line starting with “eXcalibrator.” The program has a link, under the Help menu, to start an email for you, with the recipient already filled in and the subject line started.

8. Ongoing Program Maintenance

Program Updates



On startup, eXcalibrator downloads a small text file with update information. The program displays an update panel, if a new version is available. After downloading, close eXcalibrator to unzip and install the new executable.

If necessary, go to the eXcalibrator web page to download a new documentation (PDF) file.
See URL: http://bf-astro.com/eXcalibrator/eXcalibrator.htm

9. Revision History

Version 4.0 April 6, 2013

- Improvement... eXcalibrator no longer requires manual downloading of NOMAD or SDSS data. The program now automatically downloads the required information.
- Improvement… The calculated R, G and B factors may be normalized to any of the three colors. This is especially useful for PixInsight users.
- Bug fix… eXcalibrator now allows processing a new set of images without the need to reload the program.

Version 3.2 Feb 24, 2013

- Bug Fix... The parse SDSS Data Routine is modified to read the recent changes in the Aladin SDSS-DR7 format.
- Improvement... eXcalibrator no longer downloads update info and general messages to the hard disk. They now load directly into memory.

Version 3.1 May 29, 2012

Bug Fix... Fixed a divide by zero error in the getBackGroundLevel function.

Version 3.0 2nd Qtr. 2012

- Added the Linear Regression calculation... for use with SDSS stars.
- A new Aladin filter is included.
- In Aladin, the Excel format is now use for copying data to the clipboard.
- A faster version of SExtractor is included.
- Error messages are improved.

Version 2.06 Jan. 22, 2012

New Feature... A message display system is added. This allows the broadcast of emergency information to the user when eXcalibrator executes. The message will display at program startup until the noted problem is repaired.

Version 2.05 2July 27, 2011

Bug Fix... eXcalibrator was not correctly checking for the absence of the FITS keywords CROTA1 and CROTA2.eXcalibrator now allows 16-bit signed FITS files.

Version 1.0.4.1 Feb. 5, 2011

Bug Fix... The parse SDSS & NOMAD1 Data Routines are modified, again, to read the recent changes in the Aladin format.

Version 1.0.4.0 Oct. 14, 2010

- Bug Fix... The parse SDSS Data Routine is modified to read the recent changes in the Aladin format.
- Improvement... The program can now use any registered image to obtain the WCS data.
- Improvement... eXcalibrator now automatically applies the NOMAD1 adjustment factors.
- Special Note... See Appendix A for documentation on the above changes. This is currently only available in the English version.

Version 1.0.3.0 Mar 22, 2010

- Bug Fix... When using the "Use Local Background" photometry method, the program sometimes found no usable stars, resulting in a later floating-point error. An added error message now suggests input changes to find more stars.
- Improvement... Added more error messages.

Version 1.0.2.0 ***Mar 13, 2010***

No software changes... just added the French translation for the documentation. Thanks go to Thierry Serieys for this work.

Version 1.0.2.0 ***Feb 10, 2010***

No software changes... just an organizational rewrite of the documentation into clearer setup and workflow sections. An added example workflow shows how to use eXcalibrator's results in an image-processing program. Thanks go to Neil Fleming for his work on this rewrite.

Version 1.0.2.0 ***Sept. 1, 2009***

- On startup, eXcalibrator now informs the user if a program update is available. After downloading, it is necessary to exit the program to unzip and install the new executable. It may be necessary to go to the web page to download a new documentation (PDF) file.
- Bug Fix... To avoid divide-by-zero errors, a Minimum Star Value is added. The brightness for red, green and blue must all be above this value to include the star in the calibration.

Version 1.0.1.0 ***Sept. 1, 2009***

With 16-bit images, some programs placed the value, 32767, in the FITS header for the keyword BZERO. eXcalibrator now looks for 32767 and 32768.

10. Thanks, Disclaimers, and Copyright

I'd like to thank...

- Bernhard Hubl for providing background information on the underlying process.
- Mischa Schirmer for design information and GUI assistance.
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- Bruce Waddington for developing the Linear Regression Algorithm.
- Chris Abissi for the original beta testing and software design contributions.
- Alan Klotz, for compiling V2.2 of SExtractor as an executable that can run on the Windows O.S.
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- ST-ECF, for publishing the code for their Footprintfinder program as freeware.
- Centre de Donnees astronomiques de Strasbourg (CDS) for providing the VizieR Catalogue Service .
- Thierry Serieys for the documentation French translation.
- Felipe Largo for the documentation Spanish translation.
- Herbert Walter for the documentation German translation.

…Bob Franke

End of Document