CCDBand-Aid

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CCDOPS is developed and maintained
By
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1. Introduction

CCDBand-Aid (CBA) is a program for removing the vertical bar pattern from images created with Kodak's KAI-11000M Series CCDs. By working with 32-bit floating-point FITS files, the program more effectively repairs the image than CCDOPS.

Program Highlights

- Using 32-bit floating-point data allows better repair of the vertical bars.
- The program works with bin modes 1 and 2.
- With PixInsight files, the default format is assumed... that is with pixel values from 0.0 to 1.0.
- With version 1.40, the program works with both full size and sub frames. This will be useful for users doing supernova searches or gathering variable star data.
- With version 1.40, CCDBand-Aid, includes command line execution, allowing execution by automation software.
- The corrected images provide better detail, especially in the faint background.
- CCDBand-Aid can process multiple images.
- The user may manually enter a predetermined correction amplitude for typically noisy narrow band images.
- Double clicking on the answer grid column sorts the data by the selected column.
- On startup, the program checks for updates and any special messages from the developer.

2. How CCDBand-Aid Works

CCDBand-Aid uses the phase of the vertical bar pattern to examine the image and calculate the amplitude of the pattern. CBA then adds the amplitude value to all the pixels in the dark bars and saves the image. By working with 32-bit floating-point images, CBA more effectively repairs the vertical bars.

The CCDOPS program only works with 16-bit unsigned images. If the computed amplitude of the bars is near an integer value, the program very effectively repairs the image. However, if the amplitude is near 0.5 or 1.50, CCDOPS rounds the correction up or down to an integer. This produces a corrected image with a final amplitude of ~ 0.5. A bar amplitude of 0.5 may seem trivial, but after stretching an image, to show faint background galaxies, the vertical bars can become visible.+

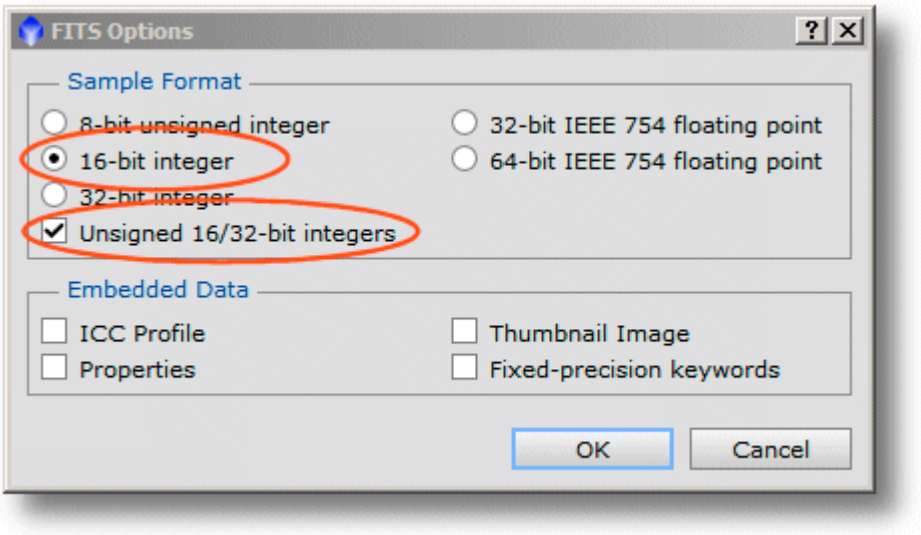
3. Initial Product Installation

Simply download the installation zip file from URL http://bf-astro.com/ccdBandAid/ccdBandAid.htm . Unzip the file in the folder of your choice and create a shortcut for CCDBand-Aid.exe.

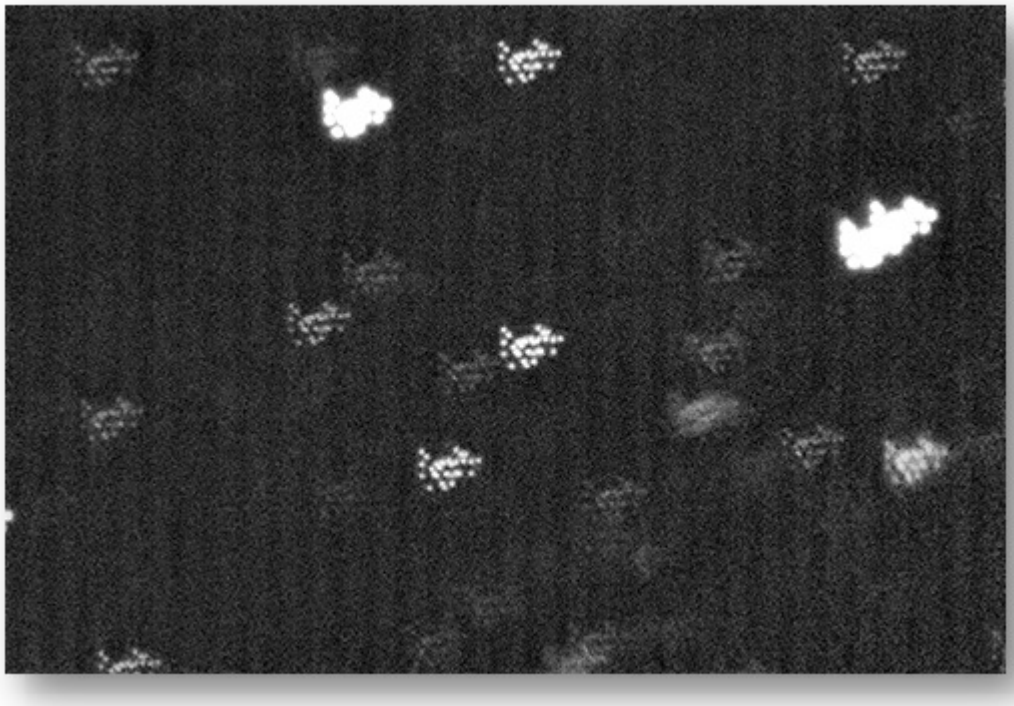
4. Determining the Vertical Bar Pattern Phase

The phase ranges from 0 to Period - 1 and represents the first column that is brighter than the one to the left due to the vertical bar pattern. The phase varies from camera to camera and with the subframe size. After establishing the phase, use it for correcting future images with that particular camera and frame size.

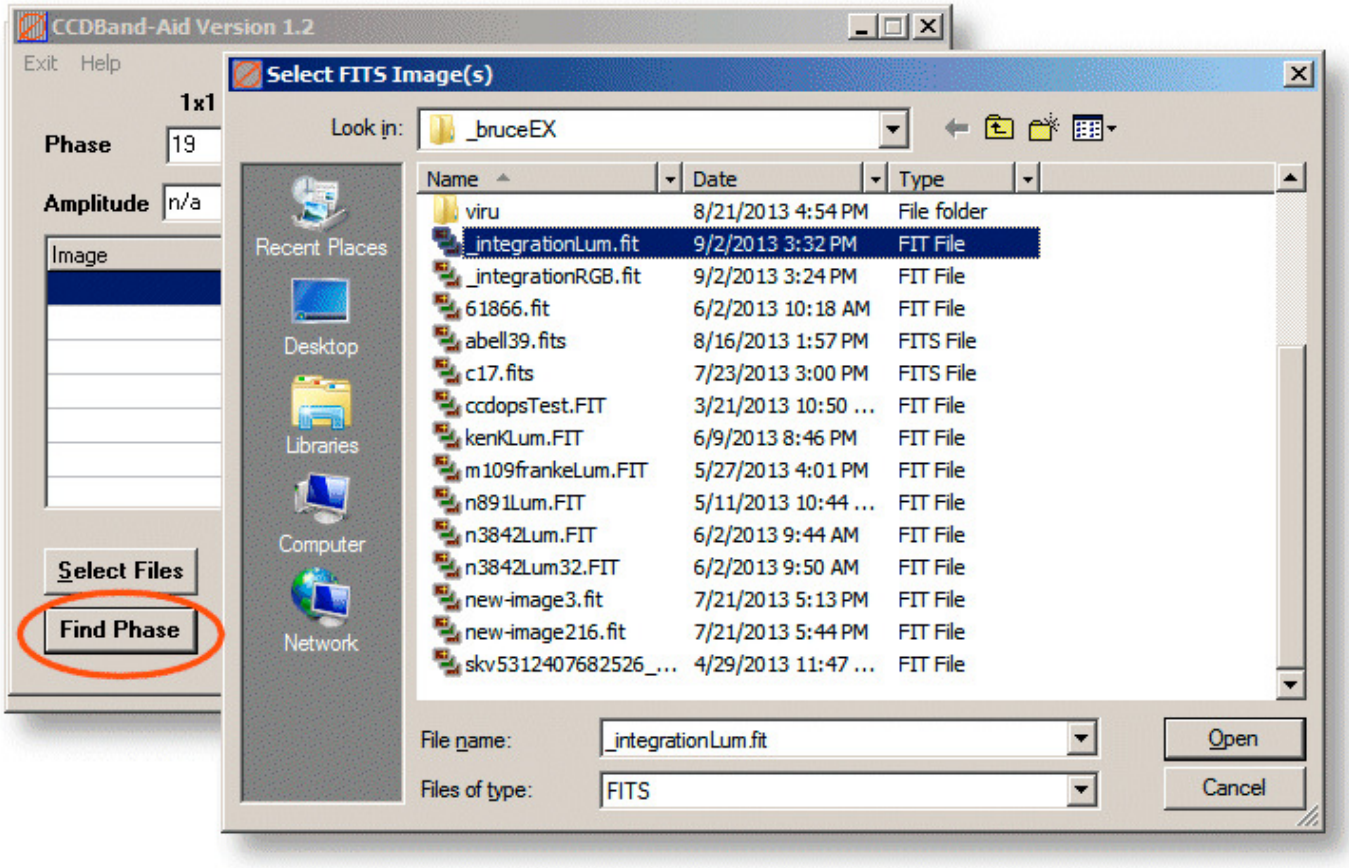
1. First, we must prepare an image to present data that are easy to analyze.
   - Use an image of a star field, away from the Milky Way, or a small galaxy. We want an image dominated with background.
   - Use images created with a low sensor temperature. As the CCD sensor temperature lowers the amplitude of the vertical bars increases, making phase analysis easier.
   - Use all of your calibrated sub exposures, the more the better, and do a mean combine. **Do Not** register the images. The below example uses 25 sub-exposures.
   - With RGB data, you may use all three color channels to increase the sub exposure count. If your software allows different weight schemes, use the average signal strength.
   - Finally, save the mean combined image as a 16 or 32-bit unsigned integer FITS.
     16-bit unsigned FITS for use with CCDOPS
     32-bit unsigned FITS for use with CCDBand-Aid
     For images saved with PixInsight, always use 16-bit unsigned FITS as shown below.



Here is a stretched partial view of a properly prepared image for phase analysis.

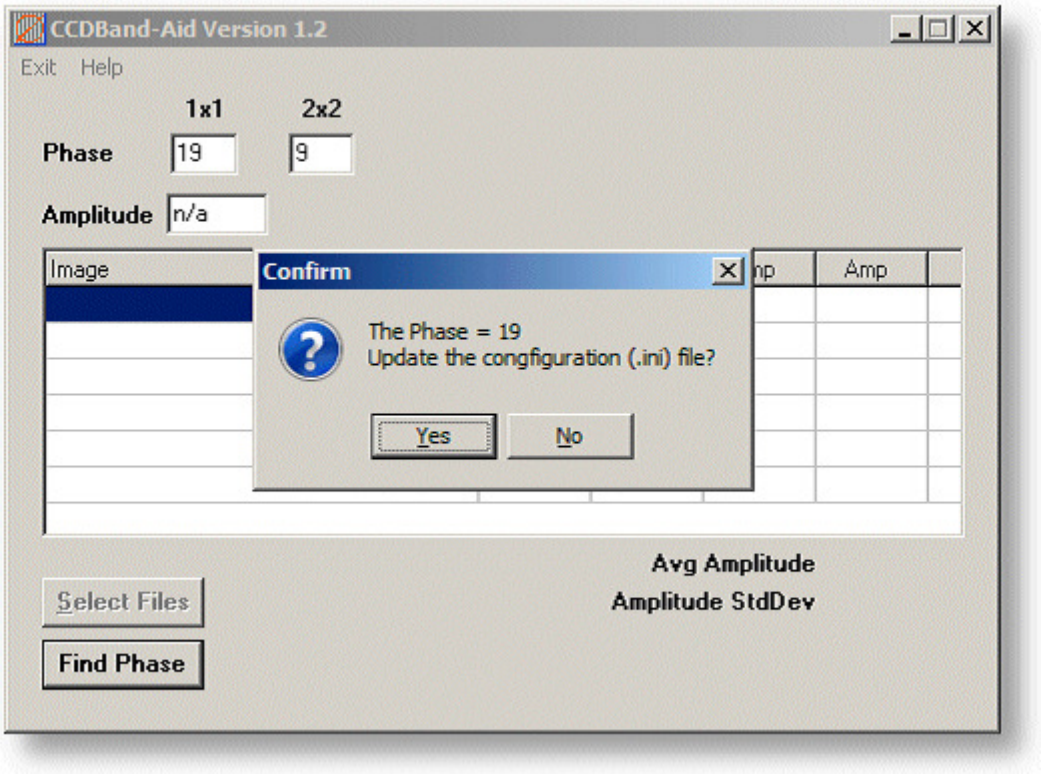


Execute CCDBand-Aid, click *Find Phase* and open the prepared mean combined image.



2. After a few seconds you should get a result similar to this. Click yes to update CCDBand-Aid's configuration file. It is suggested to repeat this process with two or three more images to confirm the result. The phase only needs to be determined once, so take the time to get it right.

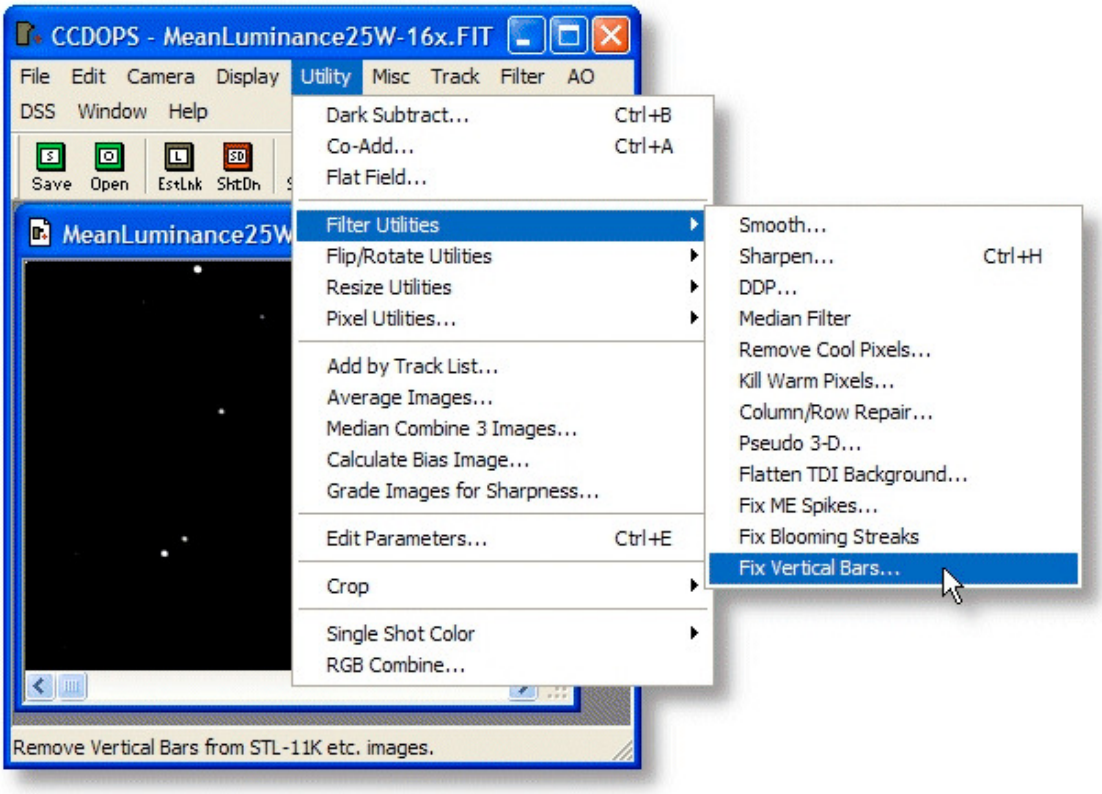
   For the Focal Pointe Observatory (FPO) camera, the phase is 19. Repeating the process with, a binned 2x2 image, gives a phase of 9. The two phase numbers vary from camera to camera, but remain constant for a given camera.



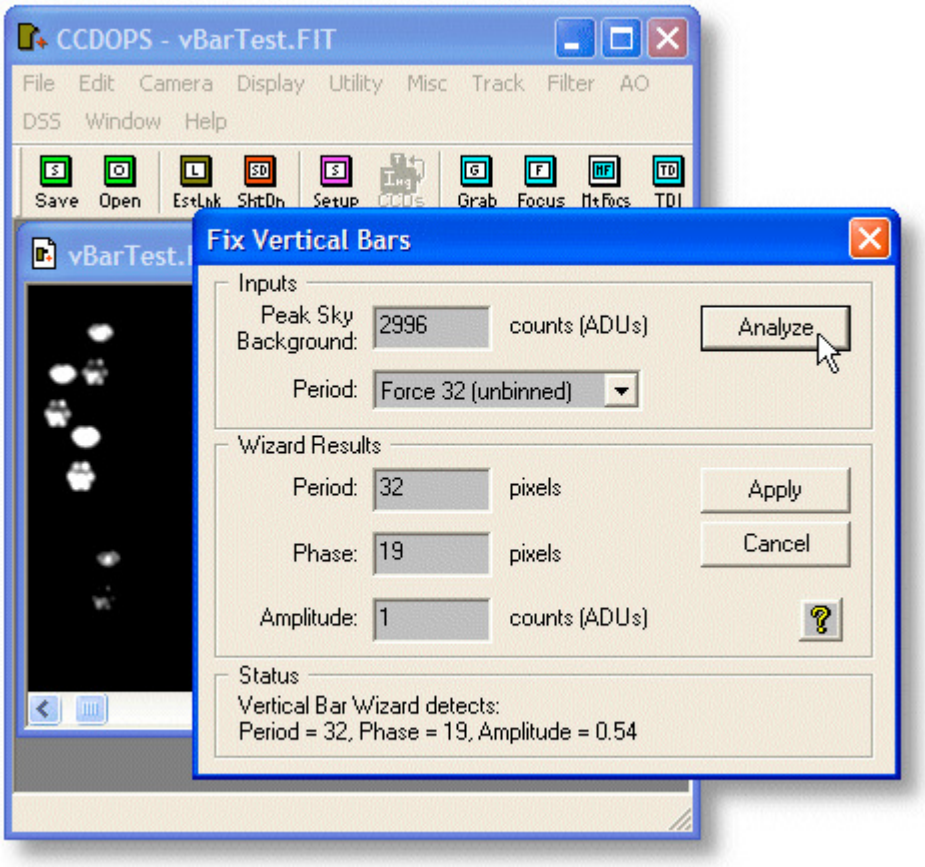
5. Using CCDOPS to Determine the Phase

Another option for phase determination is the program CCDOPS. This program has excellent routines and is useful to confirm the phase as determined by CCDBand-Aid.

1. Prepare an image as explained in section 4 and save it as a 16-bit unsigned FITS.
2. Execute CCDOPS, load the mean combined image and select *Fix Vertical Bars*.



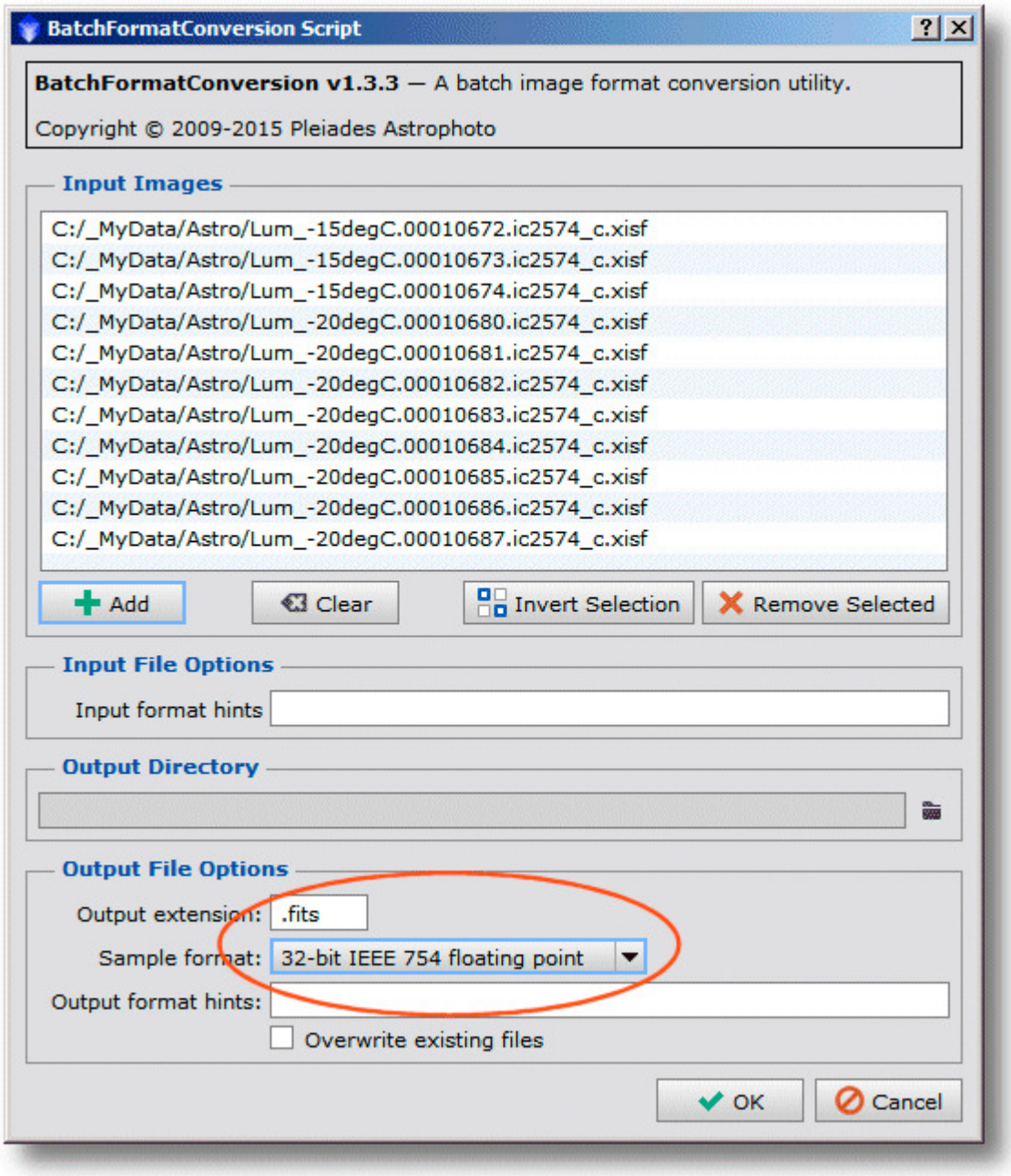
3. For unbinned images set the period to *Force 32 (unbinned)*. For binned images use *Force 16 (binned 2x2).* Do not use *Auto*, forcing the period gives better results. Finally, just click the *Analyze* button. Thanks to excellent programming, CCDOPS very quickly and accurately determines the phase of the bars. For the Focal Pointe Observatory camera, the phase is 19. Repeating the process with, a binned 2x2 image, gives a phase of 9. The two phase numbers vary from camera to camera. However, the phase remains constant for a given camera.



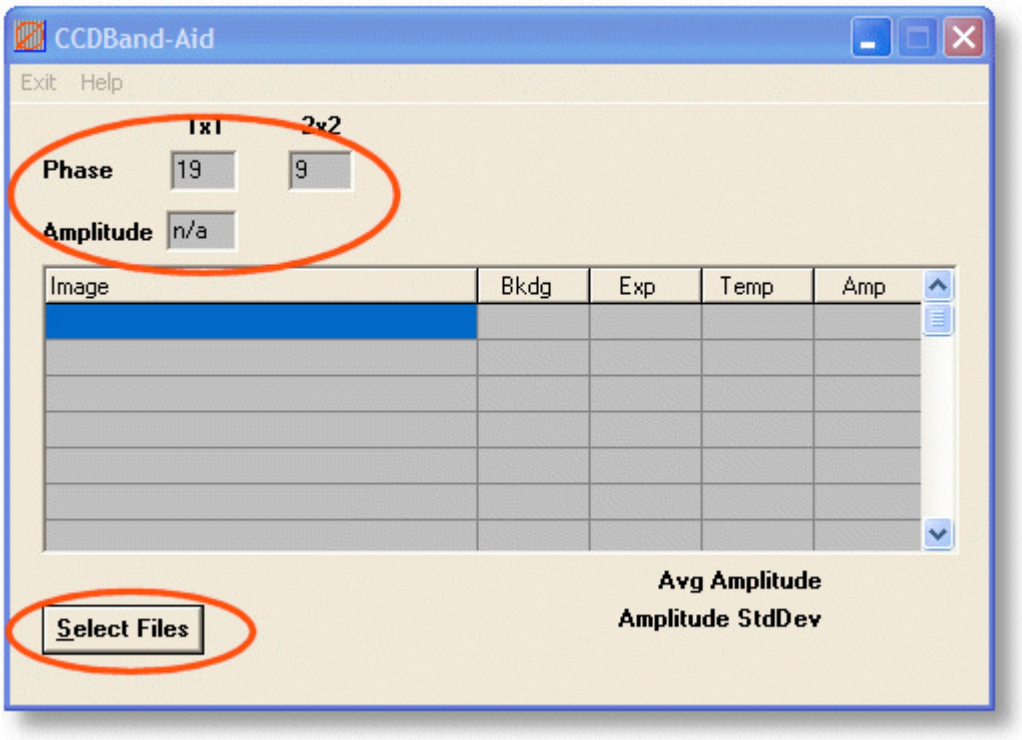
6. Using CCDBand-Aid

First, prepare your images. Calibrate and run any software for pixel clean up on all the sub-exposures. Do not register the images.

With PixInsight, use the BatchFormatConversion Script to convert the files to 32-bit floating point FITS.



Before using CCDBand-Aid the first time, determine the phase for unbinned and 2x2 binned images. See sections 4 and 5 for instructions. Then start CBA and enter the two phase numbers in their respective textboxes. If you are using narrow band images, enter a predetermined amplitude. Otherwise leave the *Amplitude* textbox empty or enter "n/a". Then click the *Select Files* button.



Fix out of Range Pixels

This option sets all pixels less than 0.0 to 0.0 and all pixels greater than 65535.0 to 65535.0.

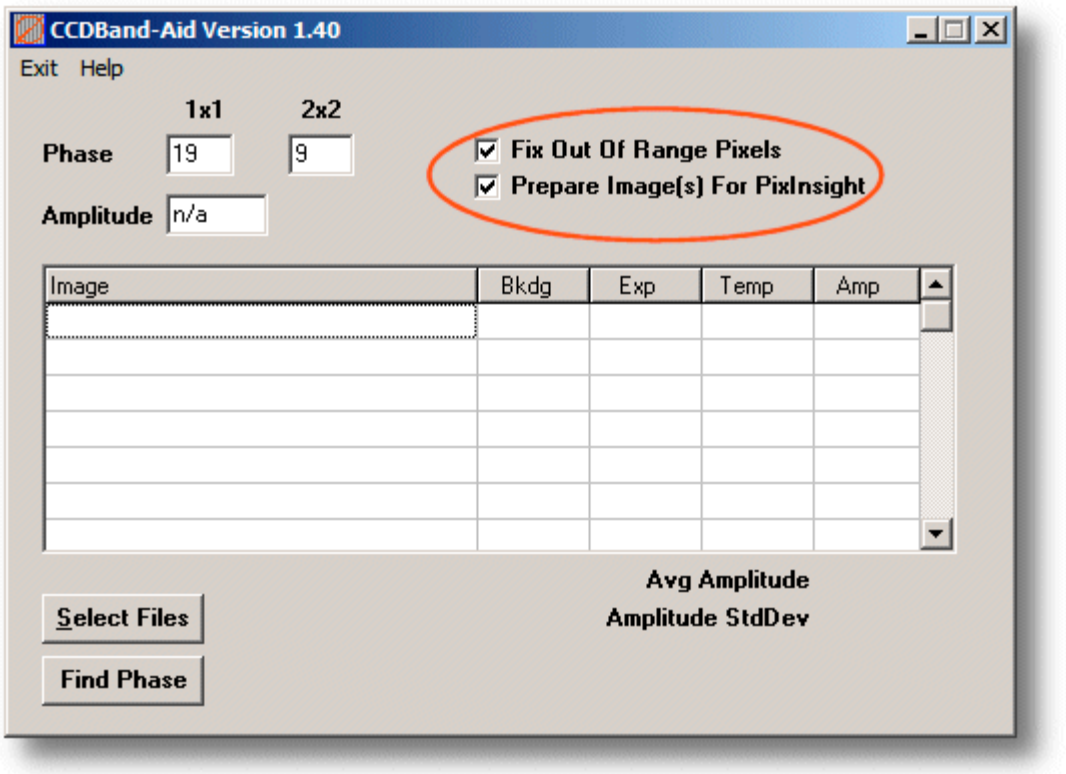
With PixInsight images, all pixels greater than 1.0 are set to to 1.0.

Prepare Image(s) for PixInsight

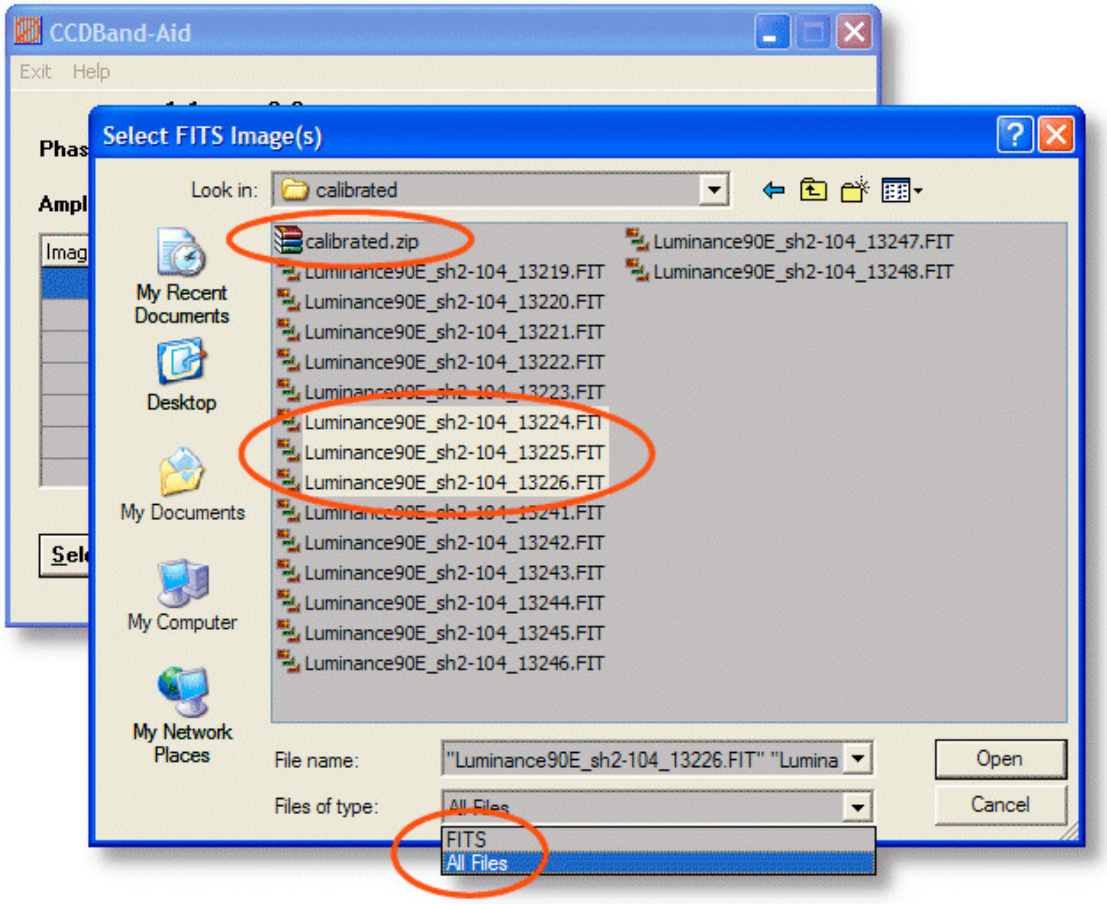
First, as above, all pixels are set to a range of 0.0 to 65535.0. Then the first pixel in the image is set to 0.0 and the next pixel to 65535.0.

With the PixInsight default settings, FITS images are rescaled to a range of 0.0 to 1.0. By setting one pixel 0.0 and one to 65535.0, PixInsight will not stretch or compress the data.

This is usually not a problem with monochrome images. There may be problems when working with color red, green and blue images. With some conditions the color balance may be significantly changed. The following URL explains the problem in detail.
http://bf-astro.com/tutorial/piColor.htm

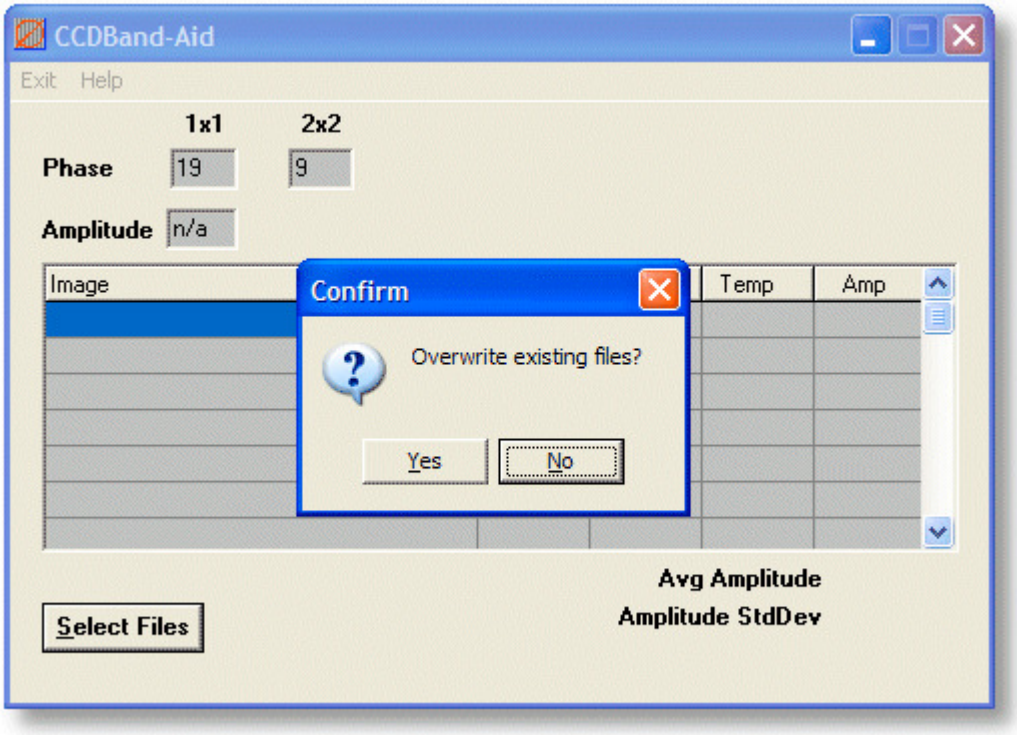


After clicking *Select Files*, CCDBand-Aid opens the Windows dialog box for selecting and opening files. This box has all the functions of Windows Explorer. You may choose file types, select files and even unzip an archive. Select the desired files and click the *Open* button.

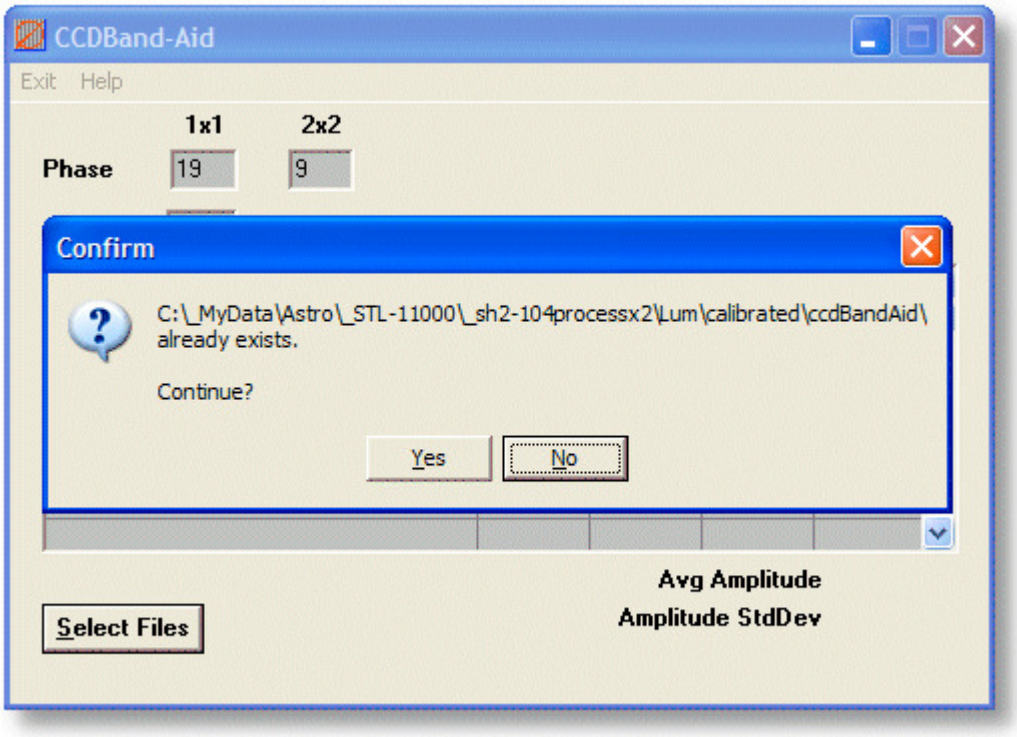


After selecting the files to process, CBA will ask one or two questions about over-writing files.

CBA first asks if you want to overwrite the selected files. Click *No* to tell CCDBand-Aid to create a new folder for the processed images.



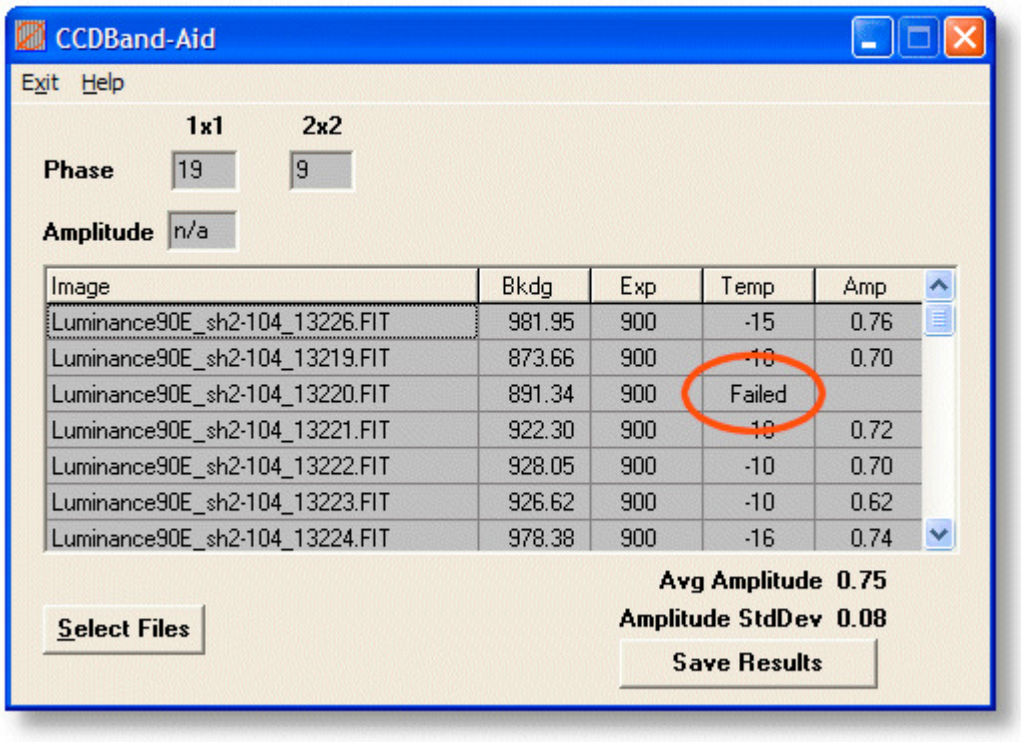
If a ccdBandAid sub-folder already exists, then CBA displays this message. Click *No* to stop the process.



After awhile, about 10 seconds per unbinned image, your CCDBand-Aid window should look as shown below.

Using a registered image is the usual reason for a failed repair with wide-band images.

Clicking the *Save Results* button appends the data to the ccdbandaid.csv file. This file is located in the same folder as ccdBandAid.exe. If you have Excel or OpenOffice Calc, double-clicking ccdbandaid.csv should load the file into a spreadsheet. If only one file is processed or the *Amplitude* textbox is used, the *Save Results* button remains hidden.



7. Command Line Execution

The command line has three input parameters.

The first parameter is an "F" or an "L". "F" indicates that the following parameter is the full path to a single FITS image. If the path has spaces, put everything in quotes. Do not add a trailing back slash for any folder or file name path.

If the first parameter is an "L", the following parameter is the full path to a text file list of images. Each text file line is the full path to an image.

The third input parameter indicates the output path. Simply enter a complete path without the training backslash. If the path does not exist, CCDBand-Aid creates it. And of course, use quotes if there are spaces. The output parameter can also be the single word... *subfolder*. In this case, the program creates a new subfolder where the FITS image lives. This works with both a single file or a list.

The program creates a log file (2018-10-25_CCDBand-Aid.log) in the same folder as the executable. The year, month and day are used for the file name prefix. Hopefully, it will just simply contain a line with the time and the message "No Errors". If there are problems, the time is noted with an error message. A couple of errors are fatal and processing stops immediately. Otherwise, the program goes on to the next file in the list.

Before running in batch mode, run the program manually to ensure that the phase is correctly set for 1x1 and 2x2 binning.

Text file example

```
C:\nova\Luminance180W_ngc 5907_01861.fit
C:\nova\Luminance180W_ngc 5907_01862.fit
C:\nova\Luminance180W_ngc 5907_01863.fit
```

Command line examples

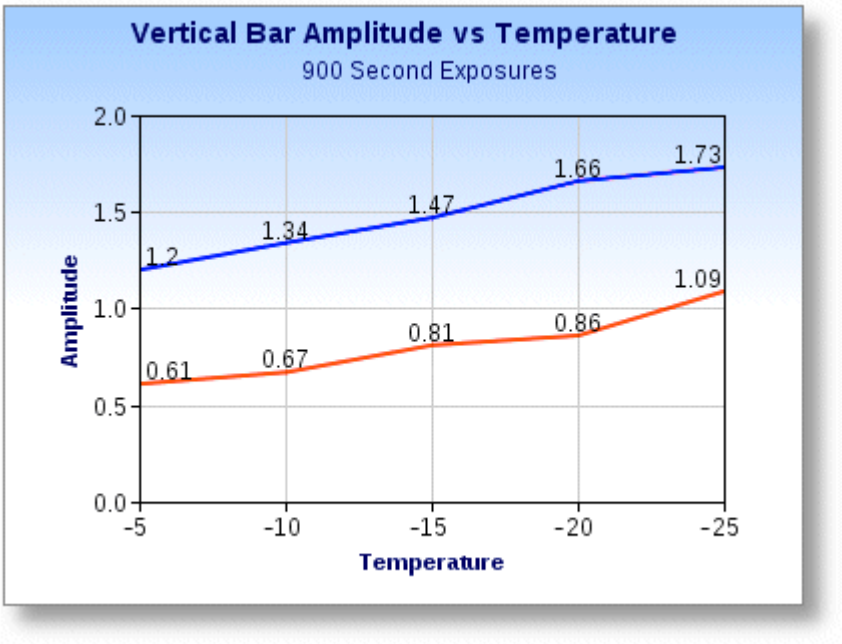
```
L C:\nova\supernova.txt "c:\nova\FTP the files"
F C:\nova\supernova.fit subfolder
```

8. Analyzing the Data

The Focal Pointe Observatory Data

The below graph reveals some interesting information about the nature of the vertical bars. The blue line is with 2x2 binning and the red is 1x1. The data source is nearly two years of exposures from the FPO, with over 1700 data points, saved to a CSV file with CCDBand-Aid.

The slope of the two lines is similar and the data are nearly linear. The 2x2 data are especially linear. Changing the -20 degree data-point to 1.61 makes the line almost perfectly straight. Individual cameras will have different band amplitudes. However, the relationship between 1x1 and 2x2 binning will probably be similar to the below graph.



The FPO data also suggest that shorter exposures produce images with lower band amplitudes. Unfortunately, there were not enough data points to attempt showing proof by plotting exposure vs. amplitude at a specific temperature. Dark and flat frames further support this assumption. Although darks are long exposures, light-wise they are an exposure of zero duration.

Why Analyze the Data?

Both CCDBand-Aid and CCDOPS usually fail to properly analyze and correct narrow-band (NB) images. Even with 30-minute exposures, NB images are noisy. This noise tends to mask over the low-level data, effectively hiding the bars from the software. This may also explain why the amplitude of the bars is lower at warmer CCD temperatures. The warmer the CCD, the more the noise.

With a good database of previously determined amplitudes, it is possible to make an intelligent estimate for repairing narrow-band images. For unbinned, -15 degree, 900-second exposures the FPO camera bar correction is about 0.81. This number may also work with 30-minute exposures.

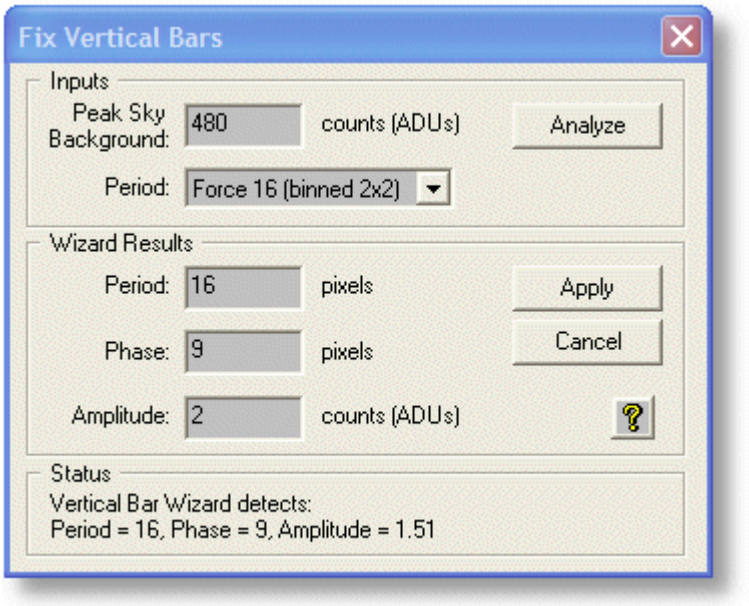
See Section 10 for a more complex and better way to work with narrowband or noisy images in general.

9. CCDBand-Aid vs. CCDOPS

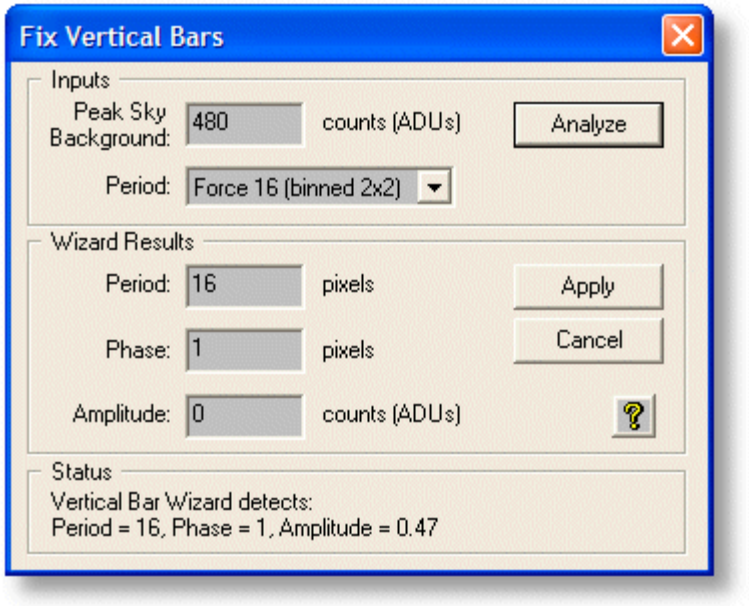
This section uses a group of nine dithered images, binned at 2x2.

CCDOPS Test

A mean combine, with no registration, produces this CCDOPS result. Note that CCDOPS rounded the 1.51 amplitude up to the integer 2.



After clicking *Apply*, saving and reloading CCDOPS gives the below analysis. CCDOPS reversed the phase... the light bars are now the dark. The amplitude is 0.47, nearly equal to (2 - 1.51). Subtracting 2 from the bright bars is an over correction of about 0.49.

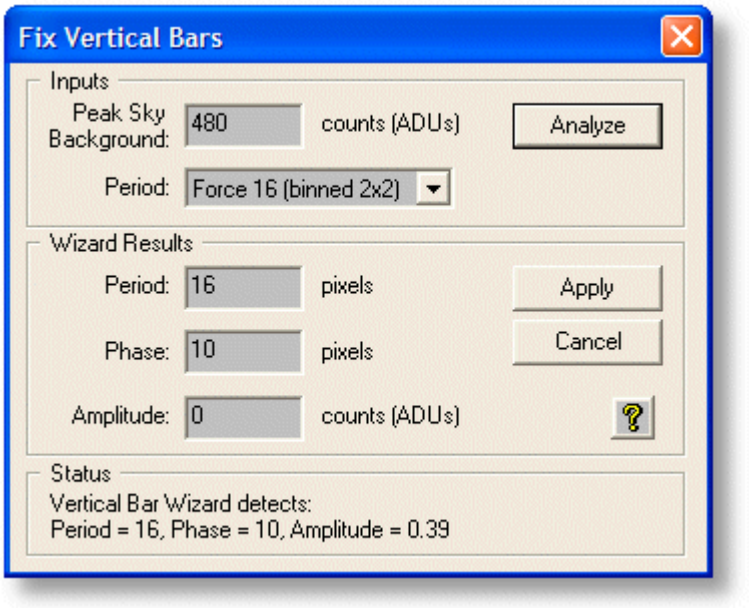


CCDBand-Aid Test

The 32-bit floating-point versions of the 9 sub-exposures were mean combined and repaired with CCDBand-Aid. The result was saved as a 16-bit unsigned FITS for CCDOPS analysis. The below image shows the CCDOPS result.

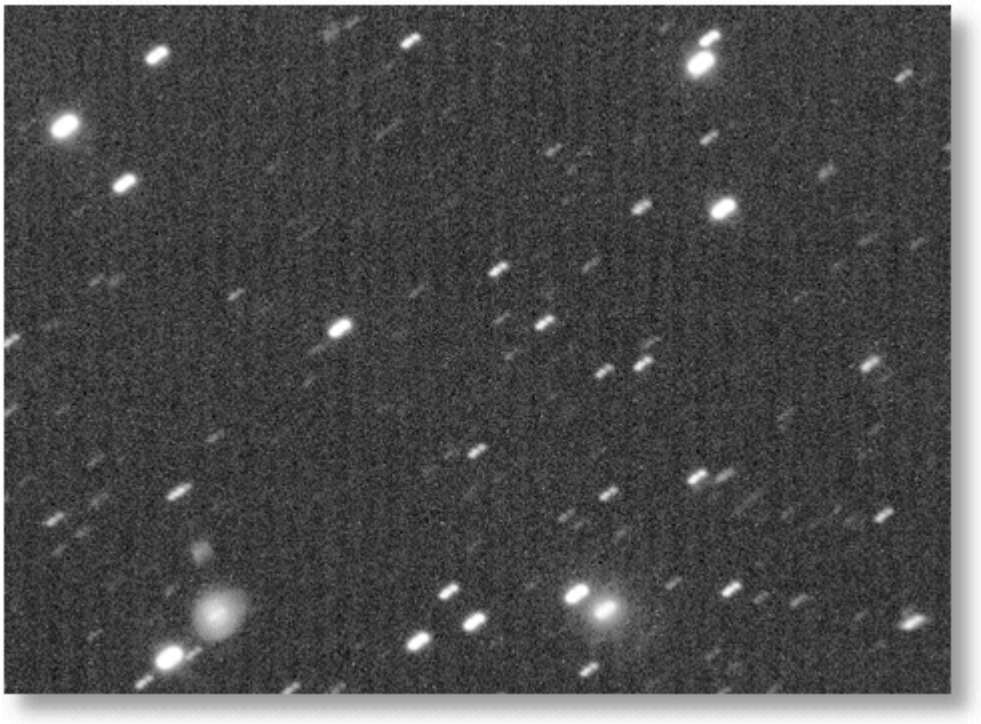
In this case, CCDBand-Aid and CCDOPS were unable to correctly determine the phase, making the amplitude answer invalid. The phase should be one or nine. Running the 32-bit version back through CCDBand-Aid shows amplitude of 0.0. CCDBand-Aid reduced the bands amplitude to a level that makes the bar phase undetermined or no longer correct..

Now, the only possible proof is in viewing the before and after images on the next page.

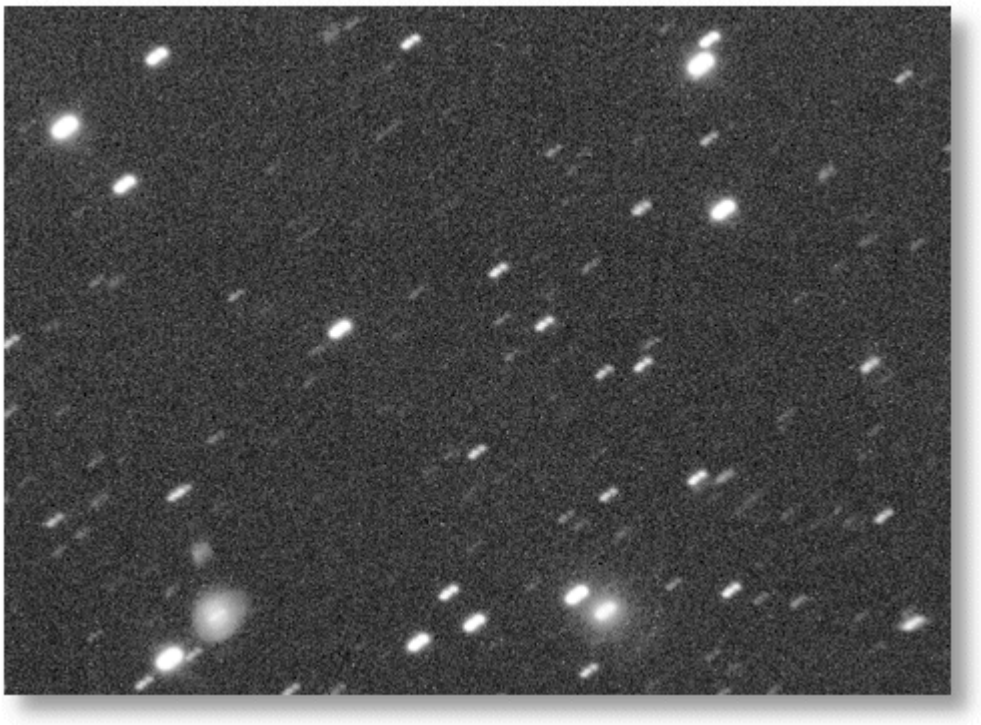


The processing for the following two images is identical.

Without CCDBand-Aid repair



With CCDBand-Aid repair



10. Working With Narrowband Images

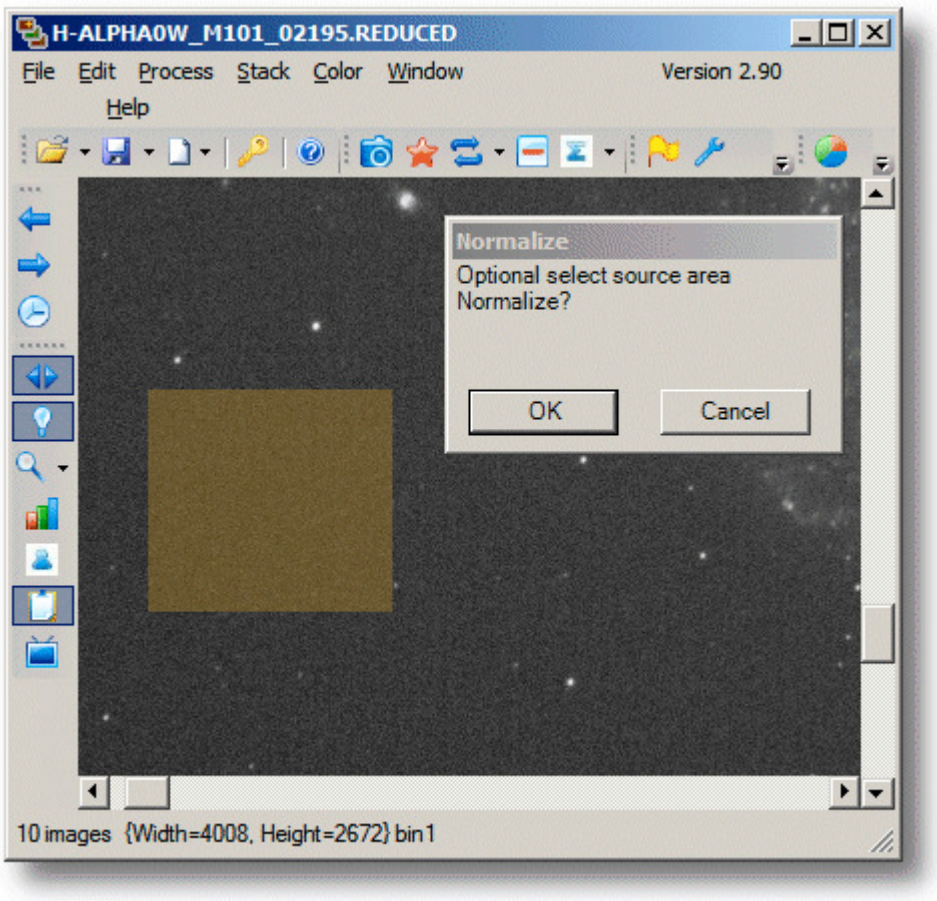
Both CCDBand-Aid and CCDOPS usually fail to properly analyze and correct narrow-band (NB) images. Even with 30-minute exposures, NB images are still noisy and difficult to process.

Here are the basic steps for working with narrowband images, followed by detailed instructions for CCDStack and PixInsight. This is similar to determining the band phase as documented in sections four and five

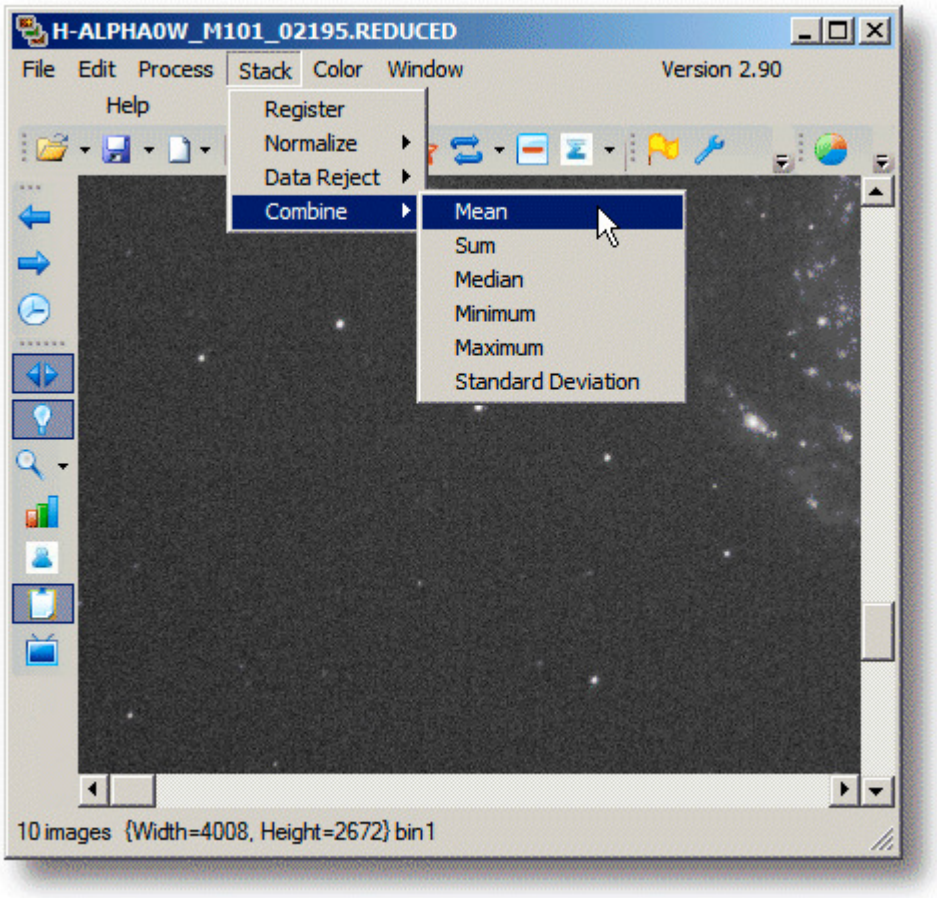
1. Group your sub exposures by temperature and length of exposure. Apply the following steps to each group.
2. Without registering the images, normalize the sub exposures. This creates a set of images with similar background levels.
3. Mean combine the group of exposures and save this and the normalized images as 32-bit floating point FITS.
4. Processes the mean combined image with CCDBand-Aid to get the band pattern amplitude.
5. Use the acquired amplitude to repair the vertical bands in the normalized images.

CCDStack Method

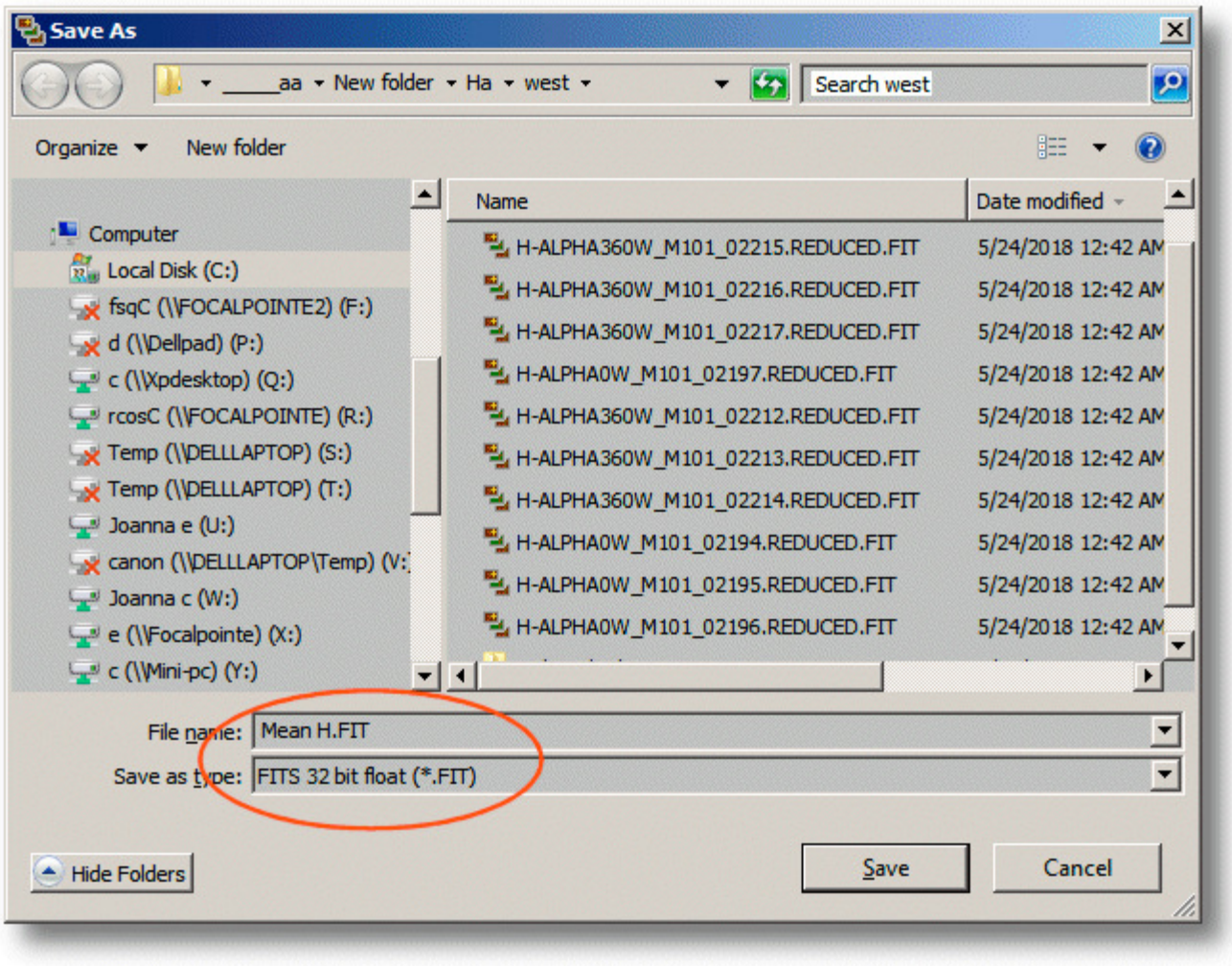
Because we are working with unregistered the images, you may have to use offset normalization. If you can do it, normalize the stack with both scalar and offset. In this example, auto normalization produced a good result. After normalization, all the images should have very similar background levels.



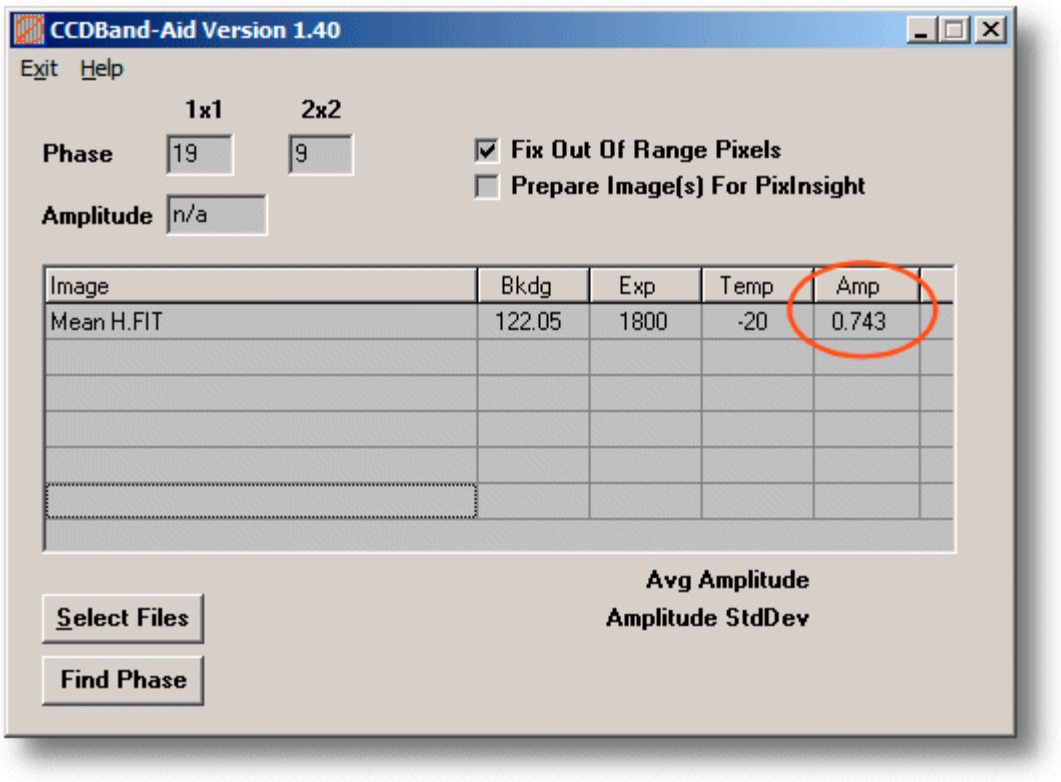
Then mean combine all of the normalized sub exposures. This produces an image with a stronger signal-to-noise ratio, allowing CCDBand-Aid to successfully determine the amplitude of the band pattern.



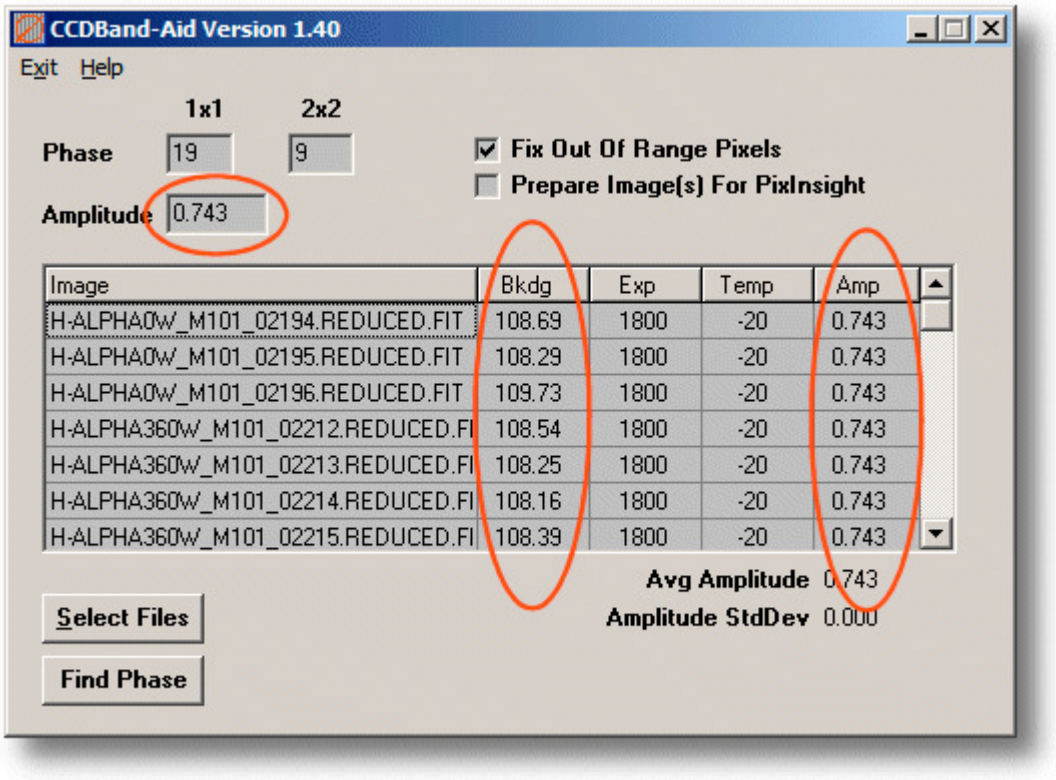
Save the mean combined image, and all of the normalized sub exposures, as 32-bit floating point FITS.



Process the mean combined image with CCDBand-Aid to determine the amplitude of the band pattern.



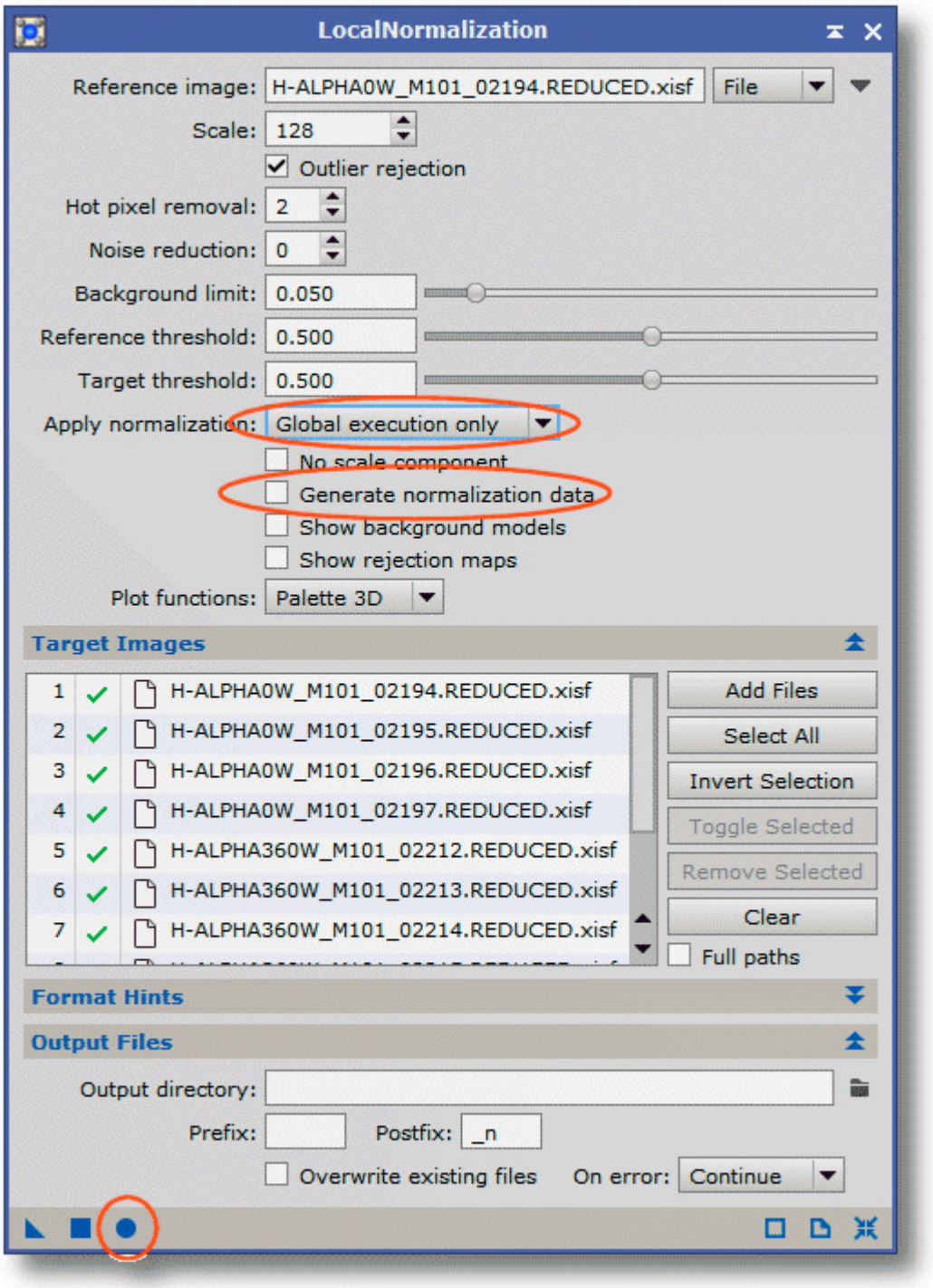
Enter the amplitude, from the previous step, and select the normalized FITS images. Below, we can see that CCDBand-Aid used the predetermined amplitude with all images. Also, note that the CCDStack automatic normalization worked well with these images. The background levels are all nearly identical. Now you can stack the sub exposures and produce a narrowband result with no vertical bars.



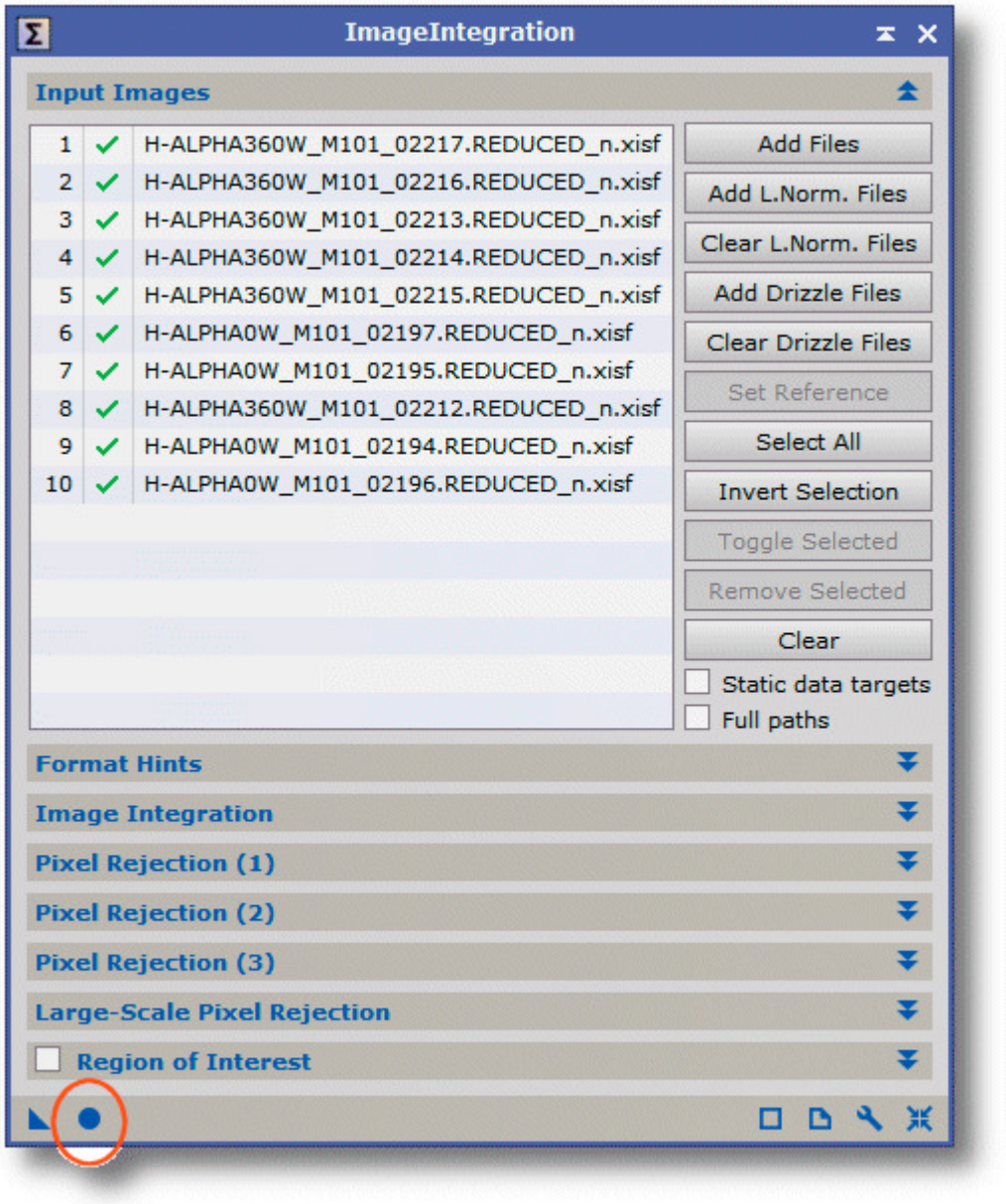
PixInsight Method

In PixInsight, open the LocalNormalization dialogue and click the X on the lower right hand corner to select the default settings. For *Applied normalization*, select "Global execution only". Then uncheck *Generate normalization data*. Click *Add Files*, select the images to normalize and Click *Apply Global*. With this example, the images are saved in the same folder with "_n" added as the postfix.

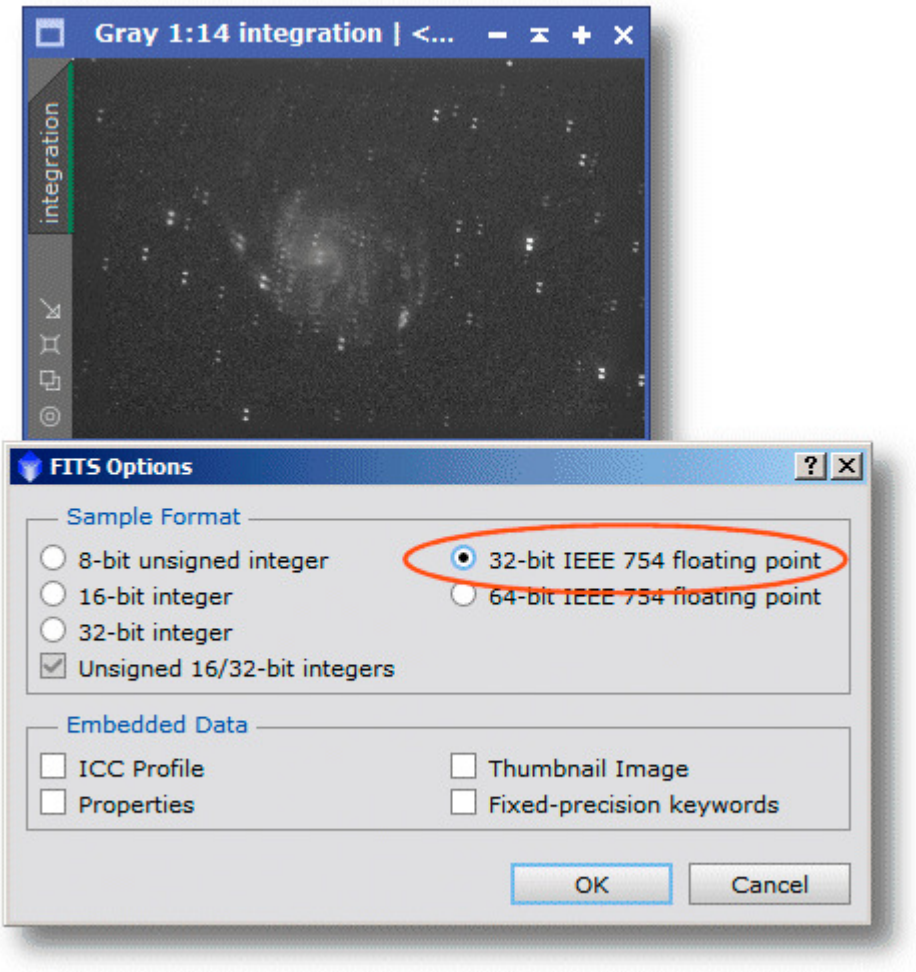
The default settings seem to do a decent job of normalizing the images. Experimentation will no doubt produce better results.



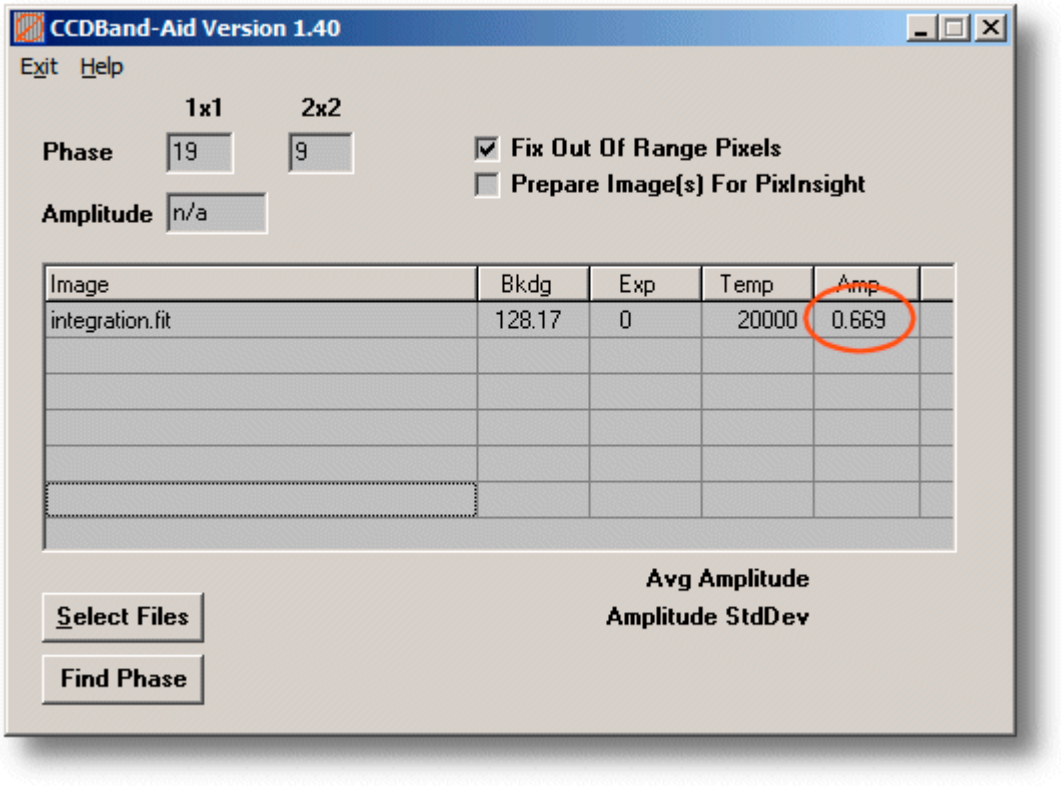
Open the ImageIntegration dialogue and again select the default settings. Click *Add Files* and select all the normalized images. Finally, click *Apply Global* to create the mean combined image. This image has a stronger signal-to-noise ratio, allowing CCDBand-Aid to successfully determine the amplitude of the band pattern.



Save the integrated (mean combined) image, as 32-bit floating point FITS.

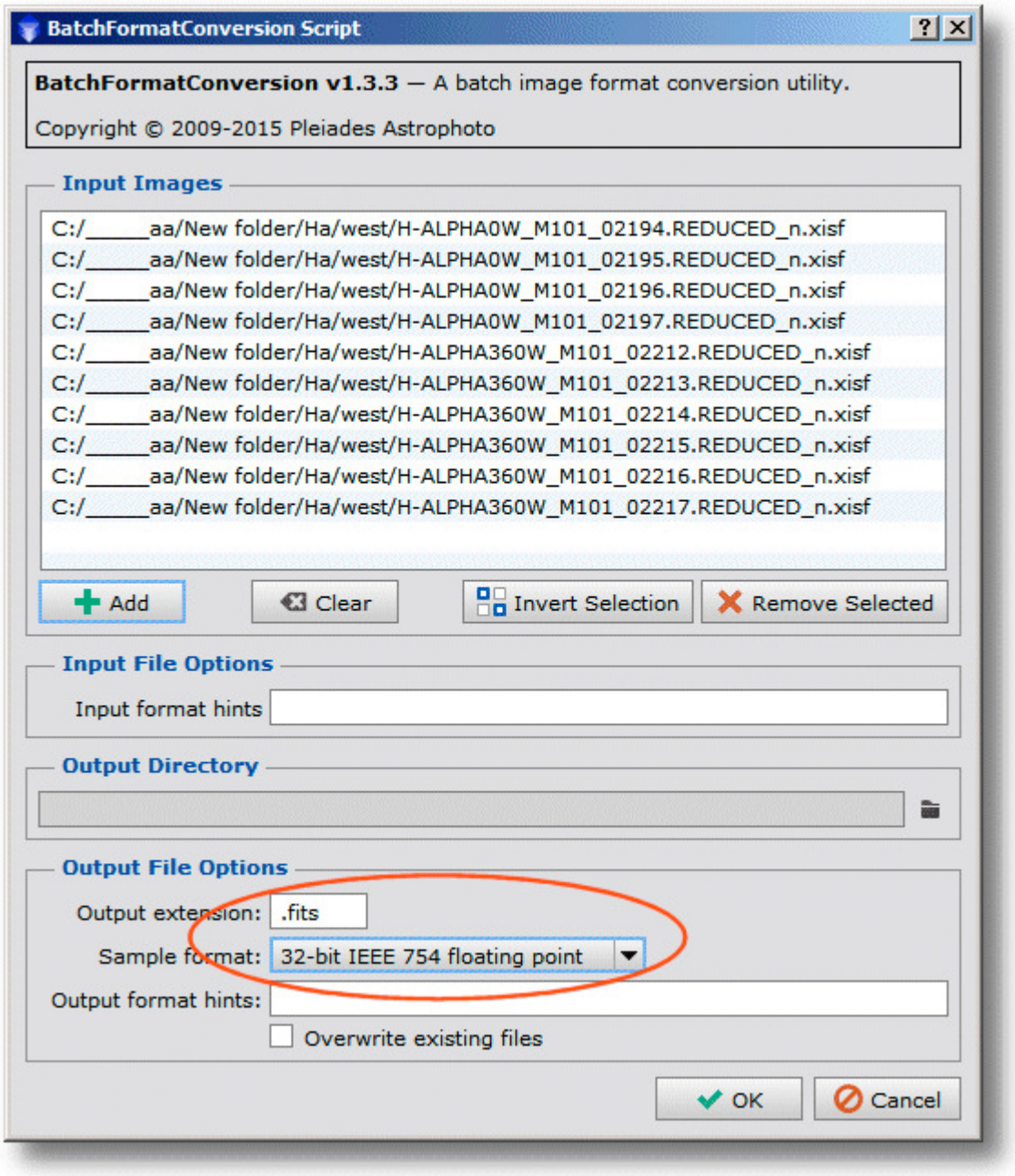


Process the mean combined image with CCDBand-Aid to determine the band pattern amplitude. Do not be concerned with the very high value for the amplitude. CCDBand-Aid internally multiplies PixInsight data by 65535 and then divides by 65535 when the processed FITS image is saved.

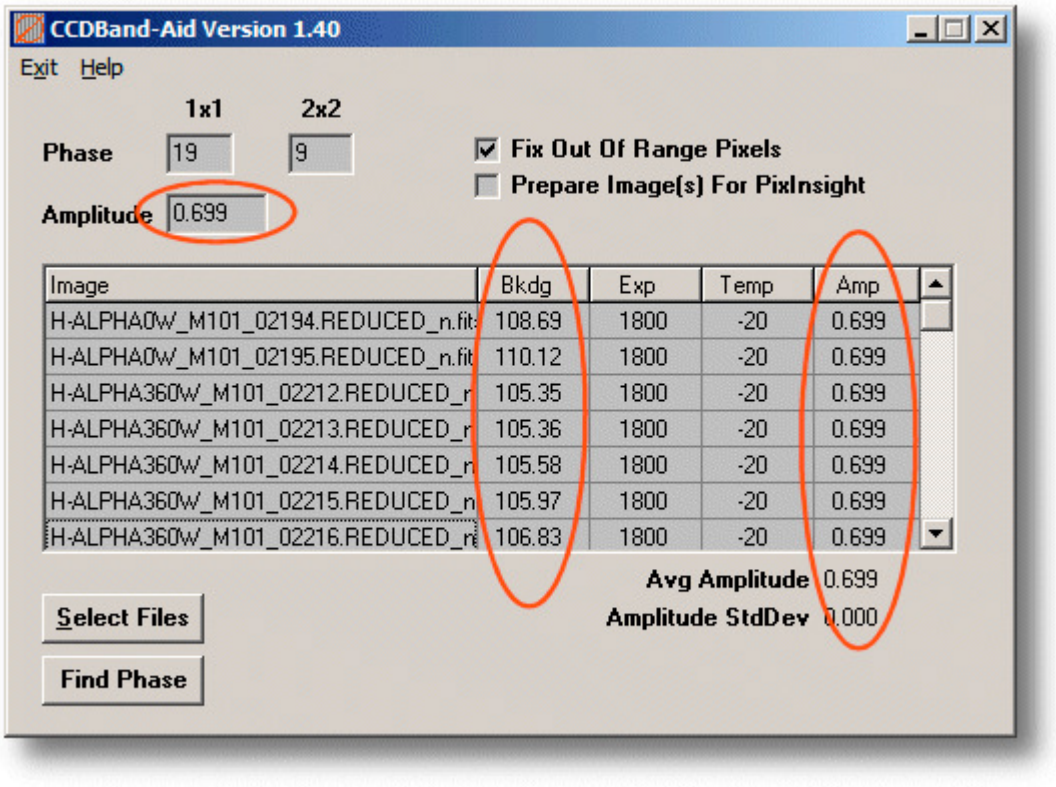


CCDBand-Aid only repairs vertical bar patterns in 32-bit floating point FITS images.

Execute the PixInsight BatchFormatConversion script and add all of the normalized .xisf images. Clear the *Input format hints* option. For the *Output extension* enter ".fits" and for the *Sample format* select 32-bit IEEE 754 floating point. Click OK and now you have a set of images suitable for processing with CCDBand-Aid.



In CCDBand-Aid, enter the previously determined amplitude and select the normalized FITS images. Below, we can see that CCDBand-Aid used the predetermined amplitude with all images. Also, note that the PixInsight default normalization values worked well with these images. The background levels are all very similar. Now you can stack the normalized sub exposures and produce a narrowband result with no vertical bars.



11. Revision History

***Version 1.40* Jan. 14, 2019**

- New Feature... CCDBand-Aid, includes command line execution, allowing execution by automation software.
- Bug Fix... PixInsight, version 1.8.6, introduced Astrometry Integration. By default, this appends 40K of data to plate solved images saved in the FITS format. CCDBand-Aid erroneously interpreted these as pixel data. This caused the program to incorrectly determine that some pixel values are greater than 1.0.
- New Feature... the program works with both full size and sub frames. This is useful for users doing supernova searches or gathering variable star data.
- New Feature... A function is added to repair out of range pixels.
- New Feature... The function is Added to prepare the images for better use with PixInsight.

***Version 1.35* May 22, 2017**

Bug Fix... If the band-phase was less the 1/2 the band-width, the program calculated a negative number for first image column.

***Version 1.25* Sept. 23, 2013**

Bug Fix... The PixInsight algorithm is revised to avoid divide by zero errors.

***Version 1.2* Sept. 14, 2013**

- The program now has a routine to determine the vertical bar phase.
- CCD Band-Aid can now process PixInsight 32-bit floating-point files. The default format is assumed... that is with pixel values from 0.0 to 1.0.

***Version 1.1* June 2, 2013**

The program is now considered for use with any manufacturer's camera. The camera may use the Effective or Active pixel array. That is 4032 x 2688 or 4008 x 2672 pixels respectively.

12. Disclaimers, and Copyright

…Bob Franke

end of doc