# Setup

“Video Stage” folder is open, covering personal items on the desktop, containing:

* Application
* CmdLine folder
  + Command Line Version
  + Command line demo script
* One sample bias file
* Gathered files folder
  + All the bias I need
  + Some darks
* Masters output folder
* Incomplete set folder
* Set with different temperatures
* Manual is open in Reader and minimized
* Make sure
  + output directory is empty
  + Input directory doesn’t have files in a “completed” folder – all at root level
  + No cmdLineOutput directory exists
  + No other tabs are open in Adobe Reader

Make sure program defaults are set to Mean and No Grouping.

# Script

|  |  |
| --- | --- |
| Stage open, covering personal icons on desktop, nothing happening, voice only  PDF manual is open but minimized – will maximize to the screen being recorded, full-page mode | hello. This is a brief video introduction to the "master bias maker" application, a program used to help with astrophotography image calibration by combining multiple bias files into a single master bias.  If you're watching this you must have downloaded the program from my GitHub account. The source code is available but I'm going to assume that you have downloaded and are working with the prepackaged binaries, which are available for both Mac and Windows platforms. |
| Open the PDF manual and scroll through it. | You'll also find a PDF manual in GitHub, and I suggest you look through it. It explains the different combination algorithms in more detail, and goes into the many available options. But I’ll leave that for you to explore. |
| Close the manual |  |
| Point to sample bias file | If this program is used to combine bias files, what's a bias file?  Well, if you're using this program, you probably already know that. However, just as a review, |
| Semi-transparent white background overlaid on screen, with 3 builds that come up while speaking. | There are 3 kinds of calibration files involved in fully calibrating an astro image. Each of these removes a specific type of unwanted signal from your image.   * Bias frames represent the readout noise inherent in your camera, independent of exposure time. * Dark frames represent the noise contained in an exposure as long as the exposure time used for your main image. Longer exposures have more noise. * Flat frames represent the dust spots and other optical imperfections in your system.   Each of these involve taking a large number of frames and then combining them into a single master. And this series of applications has a program for each of those tasks. |
| Remove bullets and white background. | In this program, we’re doing that combination for our Bias frames. Here's a sample bias file. |
| Double-click bias file to open it. | This an image stored in FITS format. Let's **open it up** and have a look at the inside. |
| Displaying bias file in fits viewer. Stretch turned on. | Here we are. A bias file is an image taken of complete darkness – typically with the camera shutter closed or the lens cap covering the telescope – and with an exposure time of zero. So with those conditions you would expect the image to be all black, but clearly it isn't. So what you have here is a record of the noise produced by the electronics of the camera.  Don't panic - it's not as bad as it looks. That would be a terrible picture.  But the viewing software I'm using has stretched the image so that you can see some of the internal structure. |
| Move white point to right while speaking | Actually the picture *is* "almost" all-black if you were to look at it without the stretching. If I turn the stretching off, the screen goes all black at this resolution. Those non-black pixels have values of only a couple of hundred out of a possible 65,000. |
| Click STF to restore scaling | We’ll come back to the stretched view so you can see that, deep inside the dark end of the scale, there is some minor structure showing here. This is called "readout noise", and it's caused by the electronics in your camera. Obviously, since the shutter is closed, these data have nothing to do with the photograph you're trying to capture, so we would like to remove this noise from our final image.  The image processing software that you use will do that for you, subtracting the noise represented by the bias file from your image.  I should mention, though, that *where* and *when* to use Bias files is a little more complex than that, and there are different schools of thought on the question. Typically you don't apply them directly to your Astro images. You *will* definitely use *dark frames* to calibrate your Astro images and this readout noise is also included in the dark frames. You don't want to subtract it twice.  Many photographers don't use bias frames at all, others do. You will work out your own preferred workflow. In any case, they do have at least two uses:  First, you can subtract them from your dark frames so that your dark frames *don't* contain any camera readout noise. This makes the dark frames *scalable* to use with other exposure times than the ones with which they were captured.  It’s better to have dark frames taken at the same exposure time as the images you’re calibrating. But, if you don’t, scaling them works quite well.  Check whether the image calibration software you are using can scale dark frames and, if it can, you’ll want to use bias frames to make your darks scaleable. If you subtract your bias files from your dark files, then the readout noise would still be in your images, so you would also subtract the bias files from the image files.  Second, you can also use bias files to calibrate your flat frames. Ideally you calibrate your flat frames with dark frames of the same exposure length but since flat frames are usually very short exposures, bias frames are often good enough to calibrate them. There just isn’t that much difference between a half-second dark frame and a zero-second bias frame. |
|  | Ideally you'll take a large number of bias files and then average them together in some way so you get a more realistic view of what the readout noise looks like. That "averaging together" is what this program is for. |
| Close the FITS viewer |  |
| open raw bias folder (shift-click for new window) | So here is the collection of bias frames we’re going to process. You see there are quite a few bias frames here – about 32 each binned 1x1, 2x2, and 3x3. |
| Scroll down to darks | Notice there are also some Dark files in this folder. This can happen if your image capture software was putting all the captured bias files into a single folder and you didn’t bother changing to a different folder when you captured your darks. I left these ones in so you can see that they won’t be a problem – the program will filter them out so only the Bias files are processed. |
| Close raw bias folder |  |
| Point to and double-click the application | Let’s open the application by double-clicking the icon. This is the pre-packaged application bundle. I’m recording this on a Mac, and there is also a Windows version, identical except for Windows User Interface changes such as the location of the menu bar. |
| Program Opens | Here is the basic user interface for the program. Before we look around here, I suggest that, on your first use, you go into the Preferences window to look at the settings there. |
| Open Preferences | We’ll do that by selecting Preferences from the MasterBiasMaker application on the Mac, or the File menu on Windows. |
| Hover over a few items to see tool tips | The first thing to point out is that you can hover the mouse over any control in the program to get a brief tool tip. For more detailed help, refer to the supplied PDF manual. |
|  | The preferences are default settings that will be used the next time you run the program. They are also used as defaults for the command line version, which we’ll discuss later. |
| Point to the Combination Algorithm section | This section controls how the multiple bias files are combined into a single master. The files can be averaged together, or combined by median. |
| Point to M/M and Sigma | These last two options are more sophisticated combination algorithms that use different approaches to eliminate noise in the data. The manual goes into the 4 methods in detail. |
| Point to grouping | We’ll talk about these options in a moment. They allow multiple files to be combined into groups by size or CCD temperature. |
| Point to disposition | Finally, this section controls what is done with the bias files after they are processed. Again, we’ll come back to this. |
| Close preferences | Ok, enough about the preferences. Just remember they’re there, and set up defaults for the settings you use the most. |
| Displaying main window | Back here in the main window, there isn’t much to see until we open some files. |
| Switch to Options tab | So we’ll just have a quick look here, at the options tab. You’ll find all the same settings that were in the preferences, but these are set just for this session. And a couple more options. |
| Back to main window | Ok, let’s open the bias files to be processed. |
| Show Pick Files button then select Open from File menu | We can click “pick files” here, or we can select “Open” from the file menu or use its shortcut. |
| In the Open dialog, scroll to show all the files including some Dark files. | In the open dialog that results, we’ll navigate to the folder of raw bias files. I’ll scroll down so you can see there are a lot of them, and that there are also some stray Dark files in here. Feel free to just do command-A or control-a to select all the files in the folder, the Darks won’t be a problem. |
|  | Opening the files takes quite a while, because the program is actually opening each file to read its metadata so that it can be displayed in the main window. |
| Showing populated files table. | Now the files we selected are in the files table here. You can click on any column header to sort the table on that value. |
| Point to the disabled Combine button | Note the Combine button isn’t enabled. That’s because we need to select the files we want to process. |
| Click and shift-click to select 5 rows | For example, we could click this row and shift-click down here to select a group of rows. Now the Combine button is enabled. |
| Click Select All | Most of the time, of course, we’ll want to combine all the files we’ve just opened. We can use the Select All button for this. However, this raises two questions. |
| Scroll down to the Dark boundary | First, what about those Dark files? Well, if we scroll down you’ll see that they aren’t selected. I’ll deselect everything, and click select all, and you can see that only Bias files are selected. There is an option in the options tab to turn this restriction off, which you might need if the metadata in your FITs files is not correct. |
| Scroll to boundary between 1x1 and 2x2 bias files | Second, with all the bias files selected, why is Combine disabled again?  It’s because there are 3 different sizes of bias files here, binned 1x1, 2x2, and 3x3. Here, for example, is the boundary between the 1x1 and 2x2 files.  You can only combine files that are binned the same. |
| Deselect all, select the first file, scroll and select last file binned the same. | If I deselect everything, scroll to the top, and select the first 1x1 file, then scroll down and select the last 1x1 file, you’ll see Combine is enabled. |
| Shift-click to add one 2x2 file to the selection. | But if I shift click on this first 2x2 file to add it to the selection, I lose the Combine button since we can’t combine files binned differently. |
| Hover over the disabled combine button to show the tool tip | This is a good place to point out that we can hover the mouse over the disabled Combine button to get an explanation of why it’s disabled. Right now it’s saying that the files aren’t all binned the same. |
| Deselect the 2x2 | We’ll see, in a moment, a way to process all the files, even with different binnings, in one go. But for now, let’s just command-click to deselect this offending 2x2 file. And you can that the Combine button is enabled again. |
| Go to Options tab and show Mean method is selected | We’ll quickly pop over to the Options tab and note that the selected combination method is Mean. |
| Back to main window and click Combine. | Now back to the main window and we’ll click Combine to combine the selected files using the Mean algorithm. |
| In save dialog, navigate to output folder and point out file name. | We’re prompted for the name and location of the combined file that will be created. We’ll navigate to our output folder. Notice that it has suggested a file name, which we’ll keep. |
| Click Save | We click Save to begin the processing. |
| Console appears. Wait for processing. | A console window appears telling us what’s going on. It says combining by Mean. We wait for the processing… and it says combination complete. |
| Close console window |  |
| Open output folder | Now if we go to the output folder, we can see the master Bias file we just created is there. |
| Open the created file | Double-click to open it in our FITS viewer and, sure enough, that’s a bias file. |
| Open meta data | If we look at the file’s meta data, we see it is the correct binning, and that a comment has been added saying “Master bias MEAN combined”. |
| Zoom in on the bottom left corner | Now, let’s see why we might use those other combination algorithms. I’m going to zoom in all the way so we can see the individual pixels. |
| Point to a cosmic ray blip. | I happen to know, from checking in advance, that this spot here is noise. It’s a cosmic ray blip or some other artifact. It is absent from all but one of the input files, but in that one input file it’s very bright.  This is the problem with Mean combination. Mean is an average of all the files, so the bright spot in one file affected the average and it’s visible here. |
| Leave that file open, move window over a bit | We’ll leave this file open for a moment and try a different algorithm. |
| Back to MasterBiasMaker, Switch to Options and select Sigma | All the other combination algorithms here are various ways to ignore outlier data like that. They are explained in detail in the manual. Let’s try the best of them, which is Sigma Clip. We’ll leave this setting, “Z limit”, as “2.0”. See the manual for what that’s about. |
| Back to main window, run Combine again. | Back to the main window, the files are still selected, so we can just click Combine again. |
| Save Dialog | Again, we’ll tell it where to put the output file, and note it is suggesting a pretty good file name. |
| Show console window | Again, a console window opens. The messages are different, with information coming out of the Sigma Clip algorithm. |
| Show the % dropped figure | This algorithm uses statistical techniques to eliminate data that are probably outliers. You see here that about 5% of the data in all these files have been ignored as being probably outliers. The remaining 95% of the data are combined using Mean. |
| Close console |  |
| Open output directory | Here’s the new file we just created, see that it says “Sigma Clip” in the name. |
| Open the new fits file | If we double click to open it, here is another Master Bias. |
| Zoom in and arrange windows so we can see both. Point to several artifacts. | In the last master file, we had these artifacts, but you can see that here, in the Sigma-combined file, those artifacts are not present. So it worked – it ignored the outlier data but kept all the good stuff. |
| Close FITS viewer |  |
| Back to main window, click Select All | Now let’s see that ability to handle all the files at once. I’ll click Select All, and we lose the Combine button, because these files are not all the same size. |
| Move to Options tab and select “group by size” | But, over here in the options tab, I can select the “group by size” checkbox. |
| Back to main window | And, back in the main window, Combine is now enabled again. It’s going to process all the selected files in groups, producing 3 output files for the 3 different sizes we have selected. one binned 1x1, another binned 2x2, and another binned 3x3. |
| Click Combine, save dialog appears | We click Combine. Now this dialog is not asking us for the name of an output file, and hasn’t suggested one. That’s because it’s going to produce 3 output files. It’s asking us for the name and location of a directory to receive those files. |
| Give a directory name and click Save | So we’ll call the directory “size grouped” and click Save. |
| Tour the console window | Now in the console window, it indicates that it is grouping by size, and produces messages for each of the size groups. Here it says “32 files binned 1x1”, “32 files binned 2x2;”, “32 files binned 3x3” , “combination finished”. |
| Shift-Open the output directory | And, if we open the “size grouped” directory, here are our 3 output files. Note the binning level is part of the file name.  So normally we would do “select all”, with “group by size” selected, and just let it do its thing. |
| Back to program, options window. | You might have noticed another grouping option, “group by temperature”. You might have a folder full of files that were captured with different CCD temperatures, like a bunch at 0 degrees, another bunch at -10 degrees, and so on. |
| Select Group by Temperature. | We’ll select this option to see this work (and we’re leaving group by size on too). This “width” parameter is part of the statistical algorithm that finds the grouping – technically called “clustering”. This means that we’ll group together files whose temperature doesn’t vary by more than about 1 degree from the centre of the group. |
| Back to main window, show temperature column. | Unfortunately these files are all the same temperature, so are not much of a demo. |
| Open “different temperatures” folder and select all | So I’ll get some different data. We’ll say File/Open and navigate to this other folder where I have some bias files that were captured with different temperature and binning. Select all and Open. |
| Scroll through new window. | Note that there is now an assortment of temperatures here. |
| Select All | I can say Select All and the Combine button is still enabled, |
| Options tab | because I left “group by size” turned on. And “group by temperature” is still on too. |
| Back to main window, click Combine | So, if I click Combine, I’m again asked for the name of a directory to receive the files. |
| Give it a different directory name | This time we’ll call it “size and temp” |
| Click save |  |
| Monitor the console window | Now the console window is busier, because it is reporting the temperature grouping and the size grouping. |
| Close console, open output directory | And, if we go to the new output directory, here are all the files that were created. You can see the temperature and binning information in the file names. |
| Back to program | There’s a final workflow scenario that the program can help you with. Suppose you aren’t finished gathering all your raw files yet, but you want to process the complete sets that you have gathered, while leaving the others. |
| Open “Incomplete Set” | For example, let’s do a File/Open and navigate to this folder called “Incomplete Set”. Select All and Open. |
| Select the 1x1 files | If I click on this first file and shift-click on this last 1x1 file, you see I have 32 1x1s. That’s the number I usually gather.  I also have 32 2x2s. |
| Select the 3x3 files | But you’ll note I only have 25 3x3 files. I’m not finished collecting those yet. |
| Options tab, select “ignore fewer than 32” | Over here in the options tab I can select “Ignore groups with fewer than” and set this value to 32.  Now the program will process the 1x1 and the 2x2 groups, but not the 3x3 group. |
| Select “Move to” | That’s not a complete solution yet. If I come back to this situation tomorrow, after I have gathered the rest of my bias files, how do I remember which ones I have processed already?  To solve that, I can also select “move to” here in the section called “disposition of input files”. This will cause processed files to be moved to a sub-folder. Let’s see this in action.  Oh, I’ll turn off “group by temperature” since these files are all at the same temperature. |
| Back to main window, select all, combine. | Back here in the main window, I’ll select all the files and click combine. |
| New output folder | Again I’m prompted for an output folder, and I’ll give it a name, “completed masters” |
| Observe console | Here is the grouping by size happening, but see that it is only doing the 1x1 and 2x2 files. Here is a message saying “Ignoring one size group: 25 files” |
| Open the output directory | Looking in the output directory, we see the two files that were produced, for 1x1 and 2x2. |
| Open the input directory | And, if we look in the input directory, we see a new subfolder has been created. The files we processed are in there. The files we didn’t process are still where they originally were. |
| Back to program | That completes our demo of the GUI version of the program. This is enough to get you started.  If you’re interested, stay with me and we’ll have a look at how you can use the program from the command line. |
| Quit GUI |  |
| Open Terminal | On the Mac, you do command line things from the Terminal program. On a PC you’d use Windows Powershell. |
| Drag Command Line folder for a cd | We’ll do a Change Directory to this Command Line demonstration folder. |
| Ls the folder | I put two files in here. One is the command-line version of MasterBiasMaker. This is the same program, just extracted from the Mac package to make it easier to reach. I called it mclMBM for “Mac Command Line Master Bias Maker”.  And there is a shell script that we’ll get to in a moment. |
| Run mclMBM | To demonstrate that this is, in fact, the same program, let’s run it all by itself with no parameters. |
| GUI window opens | If we do that, the GUI window opens and we’re looking at the program we’re already familiar with. |
| Run with -h option | But if we run it from the command line with any additional arguments, it stays in command line mode. Here we’ll use the traditional “dash h” option to call up the help…  And we get a summary of all the available command line arguments.  Every option you saw in the GUI version is available as a command line option.  That’s a lot of options and, as with most complex command line programs, you really should put the invocation command in a shell script so you can tune the parameters. |
| Open run.sh | Here’s a shell script I’ve prepared for this demo. |
| Walk thru options | Notice the “backslash” line continuation on each line, so this is actually a single line.  Sigma combine with threshold of 2  Group by size  Output directory  And the list of input files. Note that we have to use a pattern now to get just the bias files, since there is no GUI step that will filter out the darks. \*BIAS\* does that. |
| Back to terminal, clear |  |
| Run “run.sh” | We’ll run the program, and we get the same output that appeared in the console window in the GUI, now coming out in the standard output of the command line. |
| Close terminal |  |
| Open output directory | Here is the output directory we just created, with the 3 master bias files. |
|  | You probably noticed that the command line version was considerably faster than the GUI version. That’s because it didn’t have to pre-open all the files to display their metadata in the GUI, and because it did less error checking.  So if you’re comfortable with Terminal and process many files very often, it’s worth making up a script to use the program this way. But start with the GUI, and stick with it for infrequent use. |
| Close output directory | That completes our tour of MasterBiasMaker. Thanks for watching. |