# 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 flat file
* Raw Inputs folder
  + All the flats I need
* Some dark files for calibration
* 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.

Turn of email and turn on do-not-disturb

# 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 flat maker" application, a program used to help with astrophotography image calibration by combining multiple flat frames into a single master flat.  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.  If you’re using Linux, download the source. It should build and run anywhere that Python 3.8 can run. You will need some 3rd-party packages, which you’ll find referenced in the source. |
| 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 flat file | If this program is used to combine flat frames, what's a flat frame?  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 Flat frames. Here's a sample flat file. |
| Double-click flat file to open it. | This an image stored in FITS format. Let's **open it up** and have a look at the inside. |
| Displaying flat file in fits viewer. Stretch turned on. | Here we are. A flat file is an image taken of a uniformly-lit flat surface. It might be the twilight sky (when it’s still light enough to not see stars), or a flat surface, or an artificial flat light source.  If you’re taking a picture of a uniformly-lit white surface, you’d expect the image to be all white, or all gray. Clearly it isn’t. What you have here is an image of the imperfections in your optical system. Vignetting around the corners, non-uniform transmission or CCD response and, most noticeable, “dust donuts”. These are dust spots on the lens or on the CCD chip, which show as donuts because they are out of focus. |
|  | These imperfections, especially the dust donuts, will show up quite visibly in any astro-images you take with this setup, so we’d like to subtract this signal from our actual images.  The image processing software that you use will do that for you, removing the noise represented by the flat frame from your image.  If you are doing monochrome imaging with coloured filters, the filters are part of the optical system, and can contribute dust donuts and other imperfections to the image. So, it is important to take flat frames with each filter you are using for your main images. |
|  | Ideally you'll take a large number of flat frames and then average them together in some way so you get a more realistic view of what the noise looks like. That "averaging together" is what this program is for. |
|  | By the way, if you are using TheSkyX Professional, another program you can get from my GitHub site, FlatCaptureNow, will manage the collection of flat files for you. |
| Close the FITS viewer |  |
| open 030 raw flat folder (shift-click for new window) | So here is the collection of flat frames we’re going to process. You see there are quite a few flat frames here – about 48 each binned 1x1, 2x2, and 3x3. For now we’ll use flats with just one filter. |
| Scroll down to darks | Notice there are also some dark files in this folder. That could happen if your image capture software was putting all the captured flat files into a single folder and you didn’t bother changing to a different folder when you captured your flat frames. 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 flat frames are processed. |
| Close raw flats 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 MasterFlatMaker menu 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 flat frames are combined into a single master. The files can be averaged together, or combined by median, or… |
| Point to M/M and Sigma | These last two options are more sophisticated combination algorithms that use different approaches to eliminate random noise in the data. The manual goes into the 4 methods in detail. |
| Point to precalibration section | Flat frames are actual images – just not of a very interesting subject. As real images, they need to be calibrated with dark frames. This section is where you specify how the calibration is done. |
| Point to grouping | We’ll also talk about these options in a moment. They allow multiple files to be combined into groups by size, filter, or CCD temperature. |
| Point to disposition | Finally, this section controls what is done with the flat 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 select some files to be processed. |
| 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, while the preferences are the defaults for all future sessions. There are also a couple more options. |
| Back to main window | Ok, let’s select the flat 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, command-O on a Mac or control-O on a PC. |
| 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 flat 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 stray frames won’t be a problem. |
|  | Selecting the files takes quite a while, because the program is actually *opening* and partially reading each file so its metadata can be displayed in the main window. |
| Showing populated files table. | Now the files we selected are in the files table here. |
| Demonstrate sort and leave sorted by name descending so Flats are visible at the top. | You can click on any column header to sort the table on that value. |
| Click on “Display ADUs” | Flat frames don’t have fixed exposure times. Instead, they will have whatever exposure time is needed to achieve a certain brightness. This brightness is measured as the “Average ADU” level in each frame, and you will have specified the target Average ADU value you want when you captured the flats.  This checkbox will add the Average ADU values to the file table.  The first time you turn it on it will be quite slow because it has to read all of the data from the files to calculate the ADUs. It is worth having a look to ensure that your flat capture process generated a fairly consistent ADU level.  Here you can see that my instructions to the capture software, to capture Flats at about 25,000 ADUs worked. |
| Scroll down to the dark frames | Notice that the Dark frames that we picked up are, indeed, dark. The Average ADU level is very small. |
| 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. |
| Sroll to top and sort by binning, with 1x1 at top. |  |
| 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 Bias boundary | First, what about those stray Dark files we picked up? 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 Flat 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 flat files selected, why is Combine disabled again?  It’s because there are 3 different sizes of flat 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 command-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. There are other reasons it might be disabled and it will always tell you what is wrong. |
| 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, I’m going to scroll down and use click and shift-click to select all the 1x1 files. |
| 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. That’s not a very good method, but I want to use it for a first demo to show you why it’s not very good. |
| 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 Flat file we just created is there. |
| Open the created file | We’ll double-click to open it in our FITS viewer and, sure enough, that’s a flat 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 flat 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. |
| Open “Hilighted-CR-hit PNG file in Preview” | It’s really easy to see random noise in Dark and Bias files. It’s quite difficult to see it in Flat files, so I saved an image of the one I found and I’ll open that saved image now.  This bright spot here is noise – it was visible in only one of the input files, where it was very bright. Probably a static discharge or a cosmic ray hit, or proof of alien visitors. |
|  | 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. |
|  | We’ll leave this file open for a moment and try a different algorithm. |
| Back to MasterFlatMaker, 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 6% of the data in all these files have been ignored as being probably outliers. The remaining 94% of the data are combined using Mean.  The theory behind the statistical technique we’re using says that with Threshold set to 2, about 5% of the data should be rejected – so 6% is pretty good performance. |
| 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 Flat. |
| Zoom in and arrange windows so both are showing the bottom left. | In the last master file, we had this artifact, but you can see that here, in the Sigma-combined file, it is not present. |
|  | So it worked – the SIGMA CLIP algorithm ignored the outlier data but kept all the good stuff. |
| Close FITS viewer |  |
| Back to main window, scroll to top, 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.  These files are all taken with the same filter, so we don’t need to worry about filter grouping right now. |
| 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 “20 files binned 1x1”, “20 files binned 2x2;”, “20 files binned 3x3” , “group combining complete”. |
| 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 two other grouping options, “group by filter” and “group by temperature”. You might have a folder full of files that were captured with different filters, like Luminance, Red, Green, and Blue; or with different CCD temperatures, like a bunch at 0 degrees, another bunch at -10 degrees, and so on. |
| Open “070 variety” folder and click Open | We’ll open a larger set of files that include a variety of filters and temperatures. |
| Scroll down and point out filters and temperatures | If we just scroll through this a bit, you can see there are a variety of filters – Red, green, Luminance…. And a variety of temperatures. 5 degrees, -1 degrees. |
| In options, Select Group by Exposure and Group by Temperature.  Exposure | We’ll select both of these options to see the grouping 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. |
| 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 the other grouping options are 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 filter and temp” |
| Click save |  |
| Monitor the console window | Now the console window is busier, because it is reporting the filter, temperature, and size grouping. |
| When console stops, scroll to top | We’ll scroll to the top and see what it was saying.  82 files binned 1x1  Within those, 20 files at temperature -15  Within those, 5 with blue filter, 5 with green, etc. |
| Close console, open output directory | And, if we go to the new output directory, here are all the files that were created – one for each combination of binning, exposure, and temperature that was in the original input file set. |
| 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. |
| Sort by binning. Select the 1x1 files | If I click on this first file and shift-click on this last 1x1 file, you see I have 20 1x1s. .  I also have 20 2x2s. |
| Select the 3x3 files | But you’ll note I only have 14 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 20.  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 dark files, and if I let my image capture software put them in the same raw files folder, 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. |
| Turn off Group by Exposure and Temperature | Oh, I’ll turn off “group by temperature” since these files are all at the same temperature, and “Group by Filter” since they are all luminance only. |
| 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: 14 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. |
| Options window, point to Pre-calibration | I left out precalibration until now to focus on the other program features. But Flat frames are images, so you really do need to calibrate them. Ideally with dark frames of about the same exposure time as the flats. |
| Select Fixed Dark File | So, let’s calibrate our flats with a dark.  So here we have said we’re going to calibrate our flats with a dark file, and we click “select file” to pick the dark file, which we already have on hand. This dark file has an exposure time of 5 seconds, because the flats are around 5 seconds exposures. |
| Select Mean combination | We’ll also go back to Mean combination because its faster and we’re not actually going to use the results anyway. |
| Turn off IGNORE GROUPS |  |
| Back to main window, open original Raw files | We’ll go back to our original set of data files |
| click Select All | We’ll click Select All and we notice the Combine button is enabled. We have files of multiple sizes selected, but we also have “group by size” turned on, so it’s willing to run. |
| Click Combine | Do you see the problem we’re about to have? Let’s click combine. |
| Give output directory | We’ll give it an output directory, and click Save. We’re going to get an error in a moment. |
| Point to error | It says “selected files can’t be combined, different sizes”.  What’s going on? We said “group by size”. |
| Close console window, go to Options tab, point to Dark file | It’s the dark file. We selected a fixed dark file, and it is binned 1x1. It can’t be used to calibrate 2x2 or 3x3 darks. |
| Back to main window, select just the 1x1 files | We’ll fix that in a moment but, for now, we’ll just select only the 1x1 Flat files. |
| Click Combine, give output directory | Now, since we’re processing only 1x1 files, the calibration with the 1x1 dark file will work.  Note the line in the console confirming we’re “calibrating with file DarkFile5Seconds.FIT” |
| Close console, open one of the created files. | Let’s open one of the created files. It still looks like a flat frame. We’d have to look at the pixel values to see that they are slightly smaller, because the dark file has been subtracted from the flats. |
| Back to Options, select Auto from Directory | Now let’s fix that problem with the wrong size dark file.  I’m selecting Auto from Directory. The idea is that I have a library of bias files, at different binning levels and at different temperatures. |
| Click Set Dir and select bias library | And we’ll click Set Dir and pick this directory which contains such an assortment of bias files. |
| Turn on Sub-Directories and Display Specs | I’ll turn on “sub-directories” so the bias library is searched in depth, and “display specs” so some additional information is displayed in the console. |
| Back to main window, select-all | We’ll go back to the main window and say “select all” |
| Click Combine, give directory | And click combine and give it an output location |
| Point out calibration line in console | For each flat file, it is searching the calibration library and finding the best dark file for calibration. “Best” means it has to have the correct binning and dimensions, and then among the remaining choices it picks the one closest to the same exposure time and temperature, with exposure time having much more weight than temperature.  The files in the calibration library I’m using here are all at the same temperature, so temperature will have no effect on what it picks. |
| 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 MasterFlatMaker. This is the same program, just extracted from the Mac package to make it easier to reach. I called it mclMFM for “Mac Command Line Master Flat Maker”.  And there is a shell script that we’ll get to in a moment. |
| Run mclMDM | 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  Auto calibration from a library directory, with the recursive option so subdirectories are searched.  Output directory  And the list of input files. Note that we have to use a pattern now to get just the flat files, since there is no GUI step that will filter out the darks. \*Flat\* 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 flat 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 MasterFlatMaker. Thanks for watching, and I hope you find the program useful. |