RegiStax 4

User Manual V1.0

written by

Peter Lloyd and Dave Nash

with help from

Cor Berrevoets

and Linux information by

Ken Hough

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RegiStax V4 Quick User Guide (*by* Cor Berrevoets)

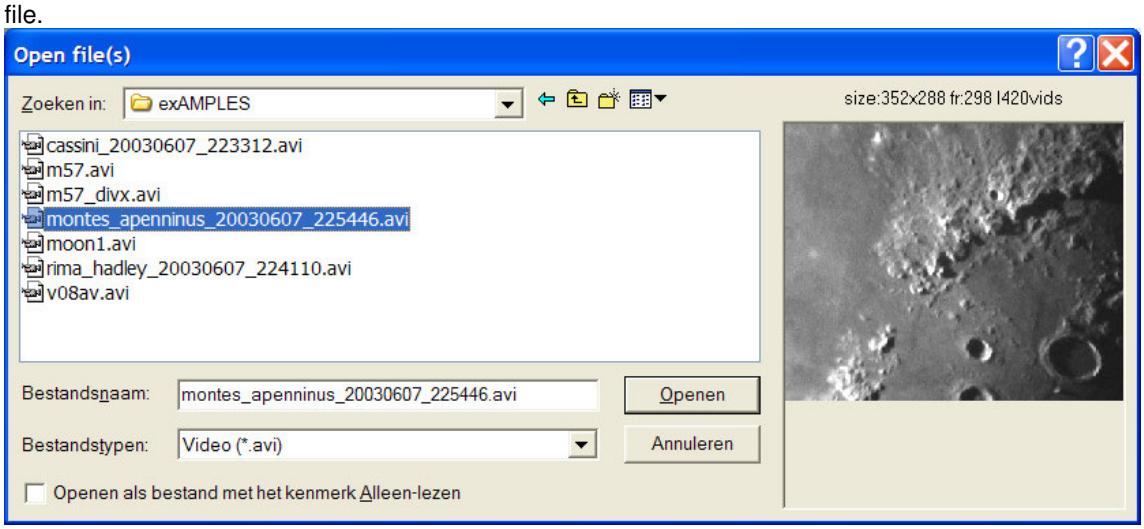
A fast processing run using Multiple points.

The following section is a simple tour for users to get used to the new multi-alignment options in RegiStax. It does not require much knowledge from previous version. Far more information can be read in the sections that follow this brief introduction.

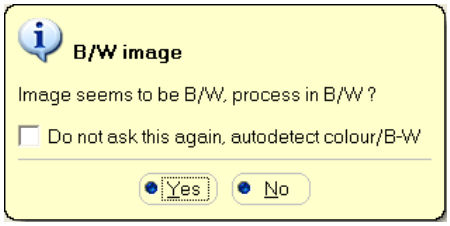
Initial Page

1. After startup you are presented with the intial screen of Registax.

2. Press the "Select" button on the top-left. A dialog will pop-up, choose the default filetype (avi) and select the directory where your files are located. When we select a file the previewscreen will show the 1st frame of that file.

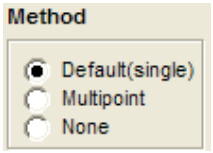


3. After we have selected the file we are planning to process (double-click the name) the file is loaded into RegiStax. If we load a B/W image and the RegiStax "colour" checkbox is "ON" you will get the following messagebox.

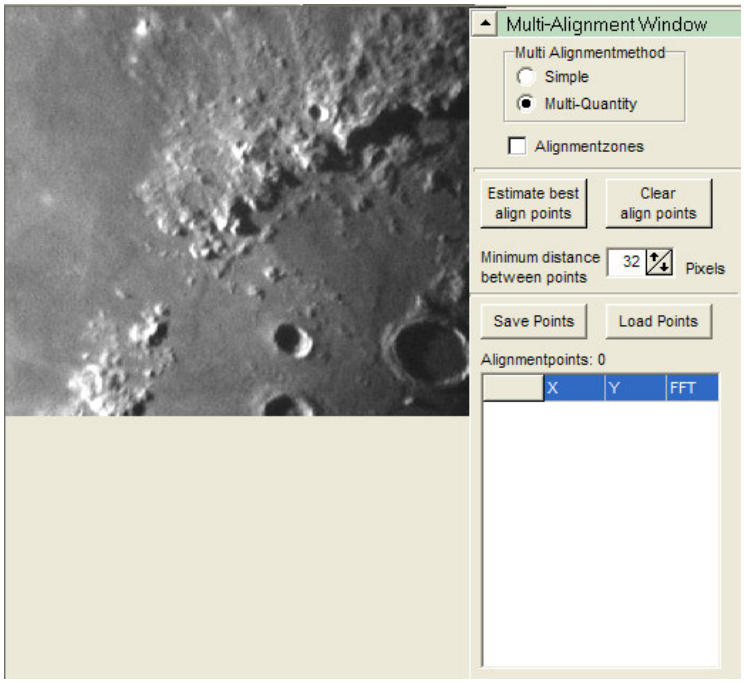


By checkmarking "Do not ask this again, autodetect colour/B-W" we will make RegiStax by default choose colour or B/W based on the file we enter.

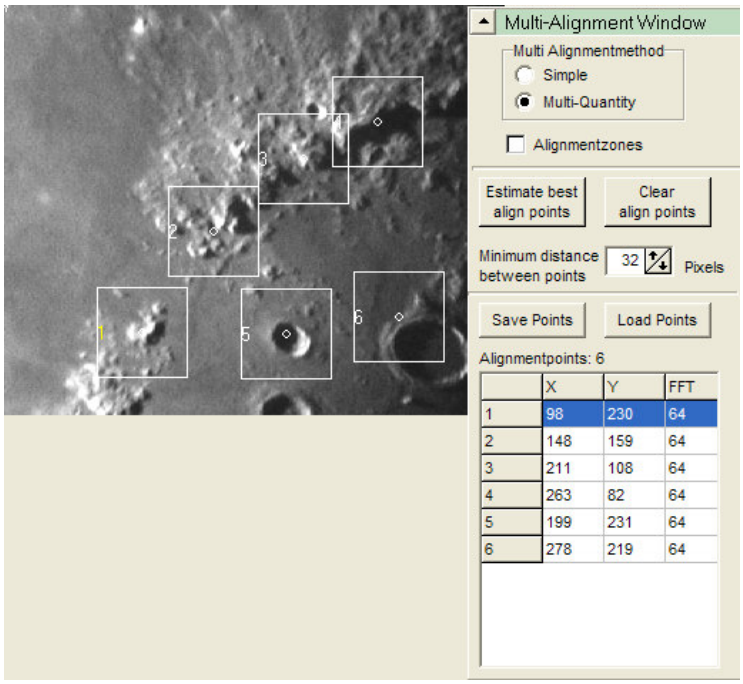
4. Now we have loaded the file the next step is to set RegiStax for multi-point alignment. We do this by setting the Method of the tab alignmentoptions to "Multipoint".



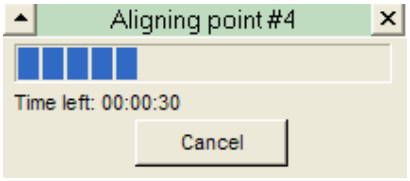
5. Now we are presented with the Multi-Alignment Window. This has several options but in this fast run we will not change any of them. After this search (using the slider below the image area) a good frame to use as a reference for the alignment.



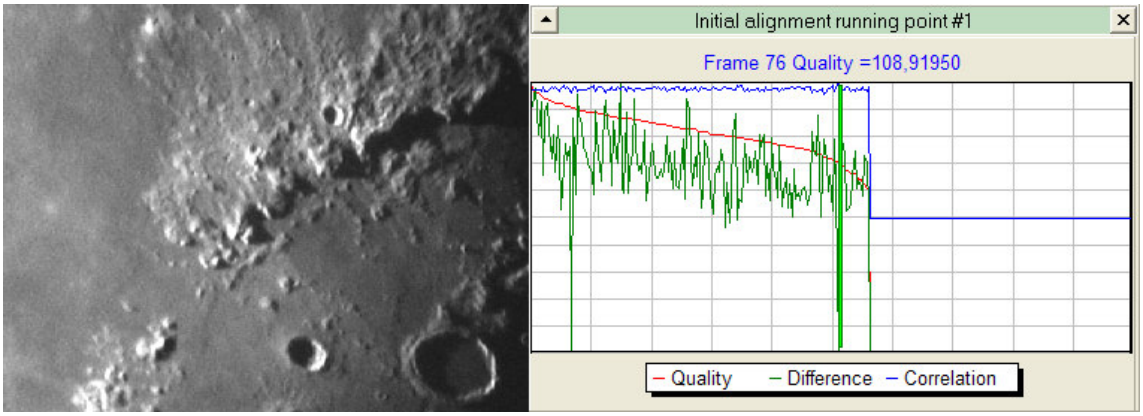
6. Our next step is to set the alignment boxes, first set the alignmentboxsize (Alignment options tab). Ive choosen to use 64x64 size boxes on this rather small image. Then start adding the alignmentpositions, you can do this by left-clicking at positions that look interesting and have rather high contrast. In lunar images these object are mostly craters/mountain chains. RegiStax will show in the Multi-Alignment Window the location of each point and the size of the alignmentbox (they are allowed to be different !). You can add up to 99 alignmentpoints. Deleting a point is easy, you can either use the delete-button on the list of alignmentpoints or right-click in an alignmentbox on the screen.



7. Using all the default settings (e.g. Quality-method = Gradient) we now are ready to process the image. Processing starts with Alignment. This will roughly (but often accurately) trace the position of each alignmentpoint in every frame. RegiStax will go through all the frames for every alignmentpoint and we will see a small window that (after processing the 1st alignment point) will tell us the estimated time that RegiStax still needs to process the other points.

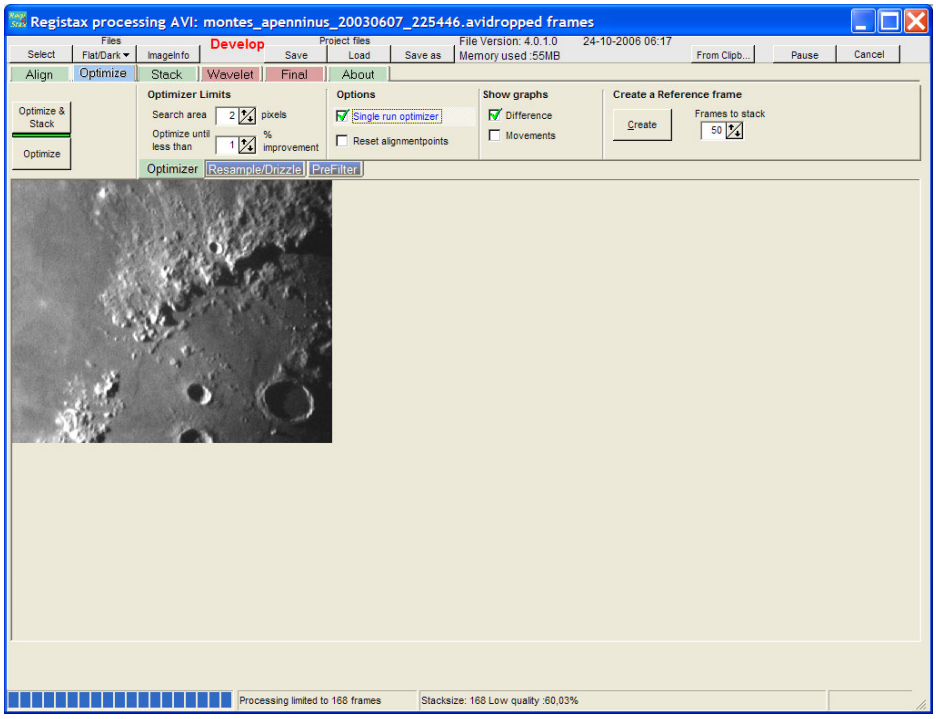


8. After processing we get a screen like this. A window marked “initial alignment running point #1” is presented (RegiStax works through the list of alignmentpoints in a descending direction ending with alignmentpoint #1). This window shows in red the estimated quality for alignmentpoint #1 for each frame (ordered by quality), in green the difference between this frame and the frame we choose as a reference and in blue the correlation between the reference and the frame. The slider is positioned at the location of the vertical greenbar we see and the image to the left is corresponding to this. Make sure that the image is good enough according to you to be used for further processing. If its not move the slider (on the bottom below the image area) further to the left to increase image quality or to the right if you think there are images that are probably still good enough to use. Notice that in this graph there is a sudden drop in imagequality and difference. This is due to the fact that the file I have processed here has “dropped frames”. These frames have been “dropped” during the recording of the avi and are therefore not useable for us. RegiStax shows this in the graphs as frames with quality zero and NO difference. The greenbar should NOT be positioned on the section with the dropped frames.

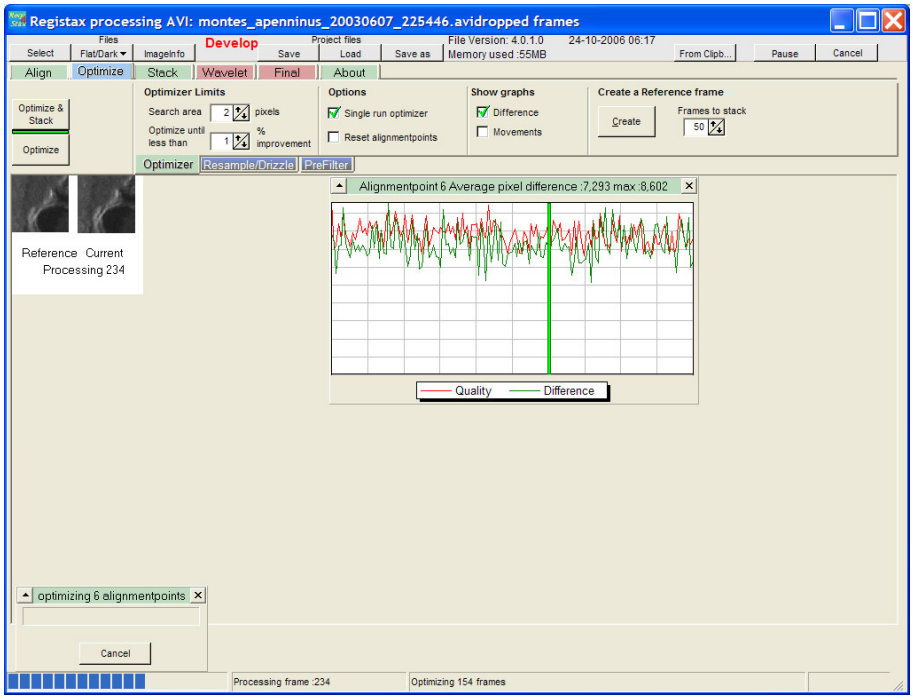


9. After we have made our choice for the “worst” image we still want to use press the “LIMIT” button which will make on the frames that are to the left of the green bar available for further processing.

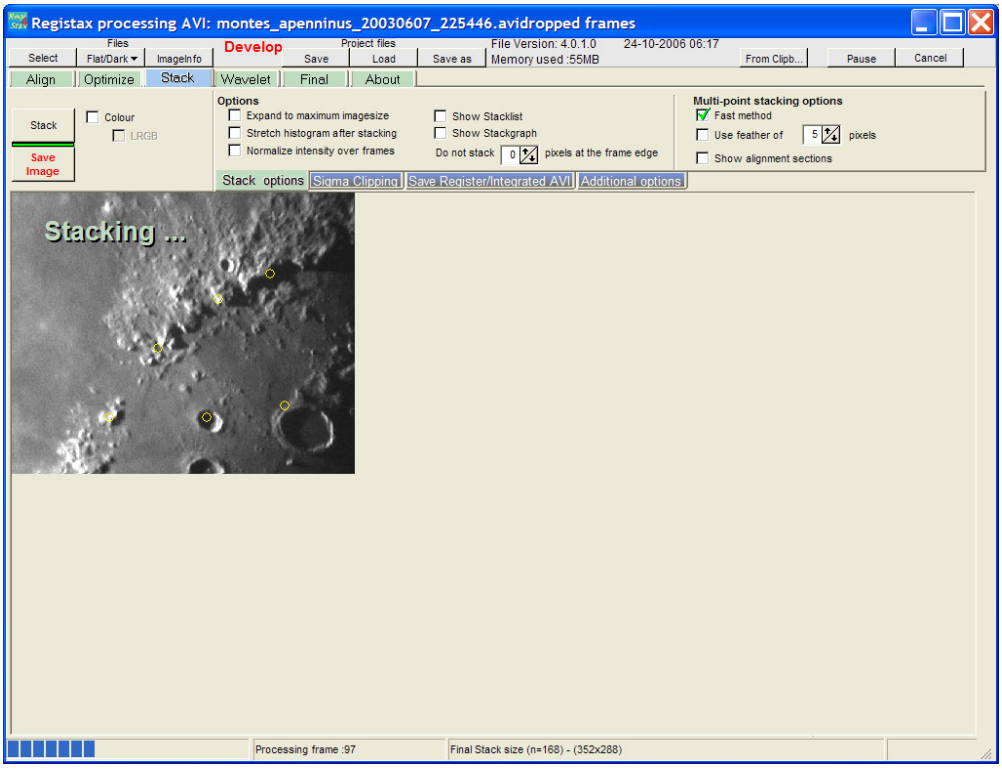
10. We are now in the optimize-stage of RegiStax. During this stage the initial alignment will be tested/improved using a routine that searches an area around the current estimates for the best alignmentpositions. In V3 we used a system that does a so-called full-matrix search for the best position that aligns the reference and the current frame, in V4 we have added a new function which is by default on : Single run optimizer. This function searches a larger area but does not do this in a full-matrix search fashion and therefore is as fast as the normal search of V3 for a smaller area. We keep this setting for our example. Since we are doing a simple processing run, we press Optimize & Stack.



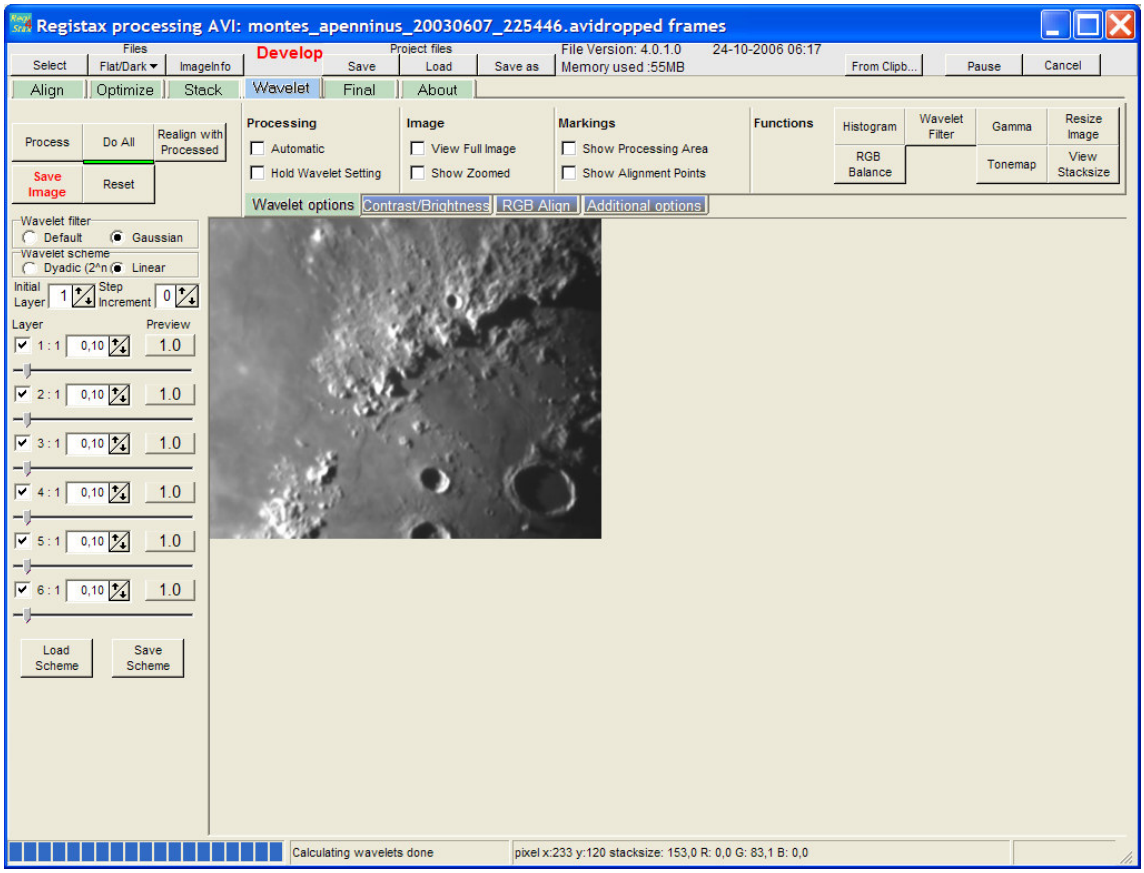
11. After starting the optimizer RegiStax will show a screen with the earlier recorded alignment information on quality and difference. This will be presented for every alignmentpoint and the multi-alignprogresswindow will again tell us how long
this will take.



12. After RegiStax has optimize all points it progresses (since we used optimize & stack) directly to the stacking phase. During this phase all frames and the recorded alignments are processed to form a stack image. This has for every position in the image the sum of the intensities of all frames that have been used to stack and were selected for a particular alignmentpoint (this is where multipoint differs greatly from single point processing). The progressbar below (in the statusbar) tells us how far we are with processing.



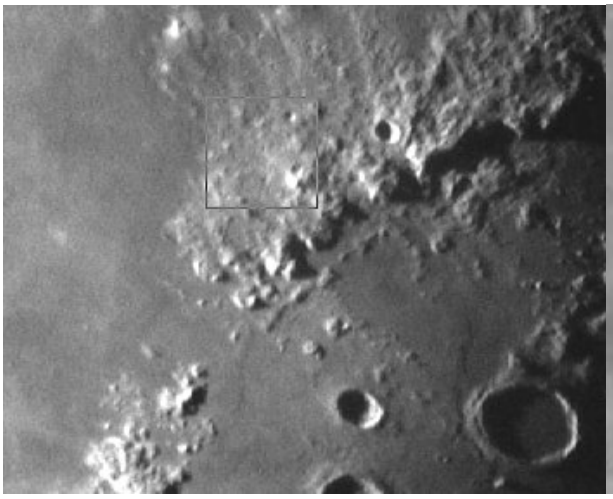
13. After stacking RegiStax progresses on to the waveletstage.



The power of RegiStax sits in the usage of Wavelets. This is a special filtering technique that is rather good in enhancing details in images. The waveletstage is where it all happens !

14. On the left you see 6 sliders that are numbered from 1 to 6. Now start by moving slider #1 to the right and watch the changes in the image when you release the slider. Move slider 1 back to its origin (or double-click it) and now move slider 2. Notice that this slider also changes the picture but in a slightly different fashion. Just try all the sliders to get a feel for the effect they have. As you will see the sliders with a larger number enhance details that are in general larger than the sliders with a lower number. There is no “best” position for these sliders since the nature of the method (wavelets) is so that the best position is depending fully on the quality and the amount of images used. You can also use several of the other image-processing feature like the histogram,gamma etc to enhance your image. When you are happy with the result you can save it in several formats.

This is the end of our short tour in RegiStax 4, the RegiStax manual will tell you more about most of the special functions that exist on the different stages. On the next page you can see the best raw image we had, the result of stacking and the result after using the wavelets.



The best raw frame

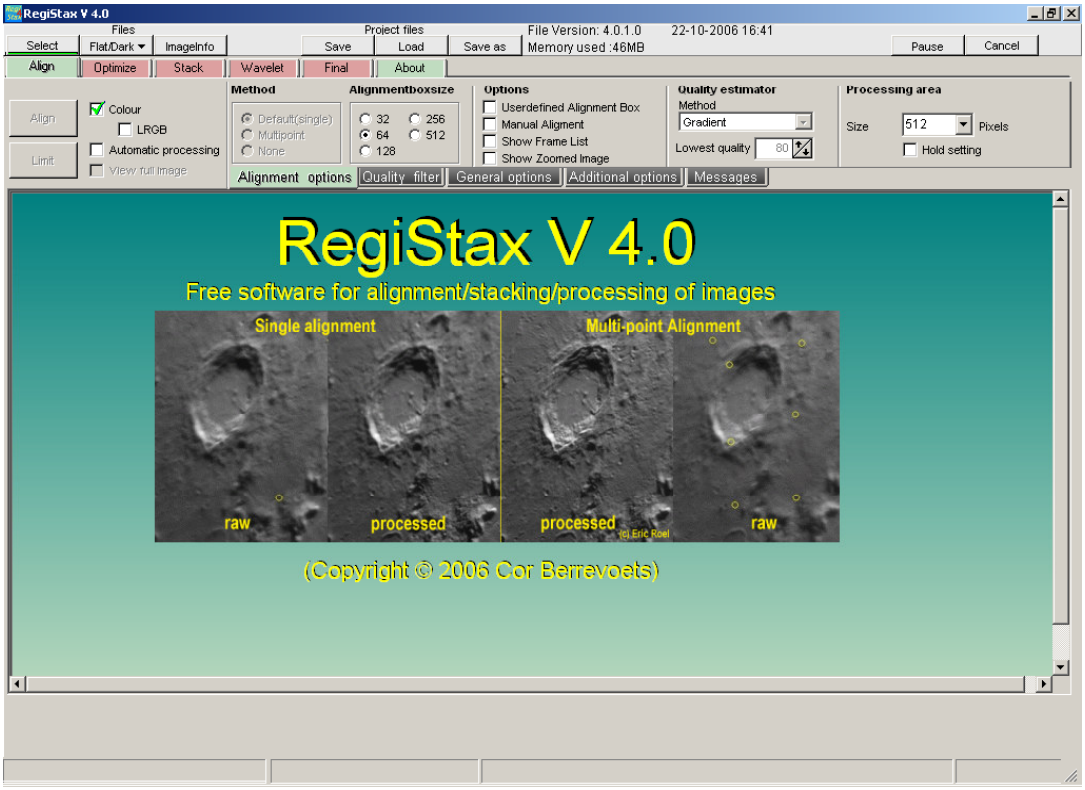
The result of stacking 150 frames

The final result after using wavelets

Introducing RegiStax version 4.0

RegiStax 4 is designed to allow you to process a set of images, typically combining them into a single composite image using the best of the set.

The RegiStax Window



General concepts

RegiStax processing is divided into several stages, each of which has a main screen of its own. Each stage has its own tab at the top of the RegiStax window, that when clicked causes the relevant screen to be shown.

Some stages cannot be used (and therefore you are prevented from clicking the tab) until others have been completed, for example you can't go to the wavelet processing screen to sharpen an image until you have either loaded an image or created one using the align and stack screens. For this reason processing in RegiStax is generally a more-or-less sequential affair, workflow progressing from one stage to the next in order. Tabs that you can click on are shown in green, while the current tab is shown in blue-green. Tabs that are unavailable (because the image being processed hasn't reached that stage yet) are shown red.

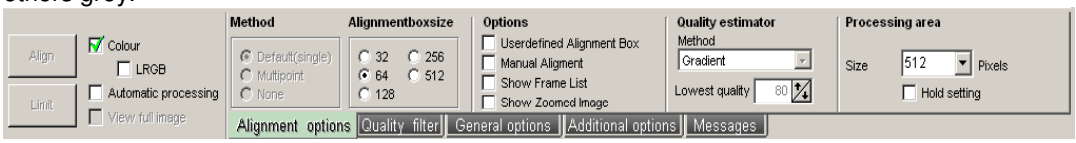
You can resize the RegiStax window in a few different ways and RegiStax will remember your preferred size/position of the window at the next startup. You can use the maximize button to fill the screen fully or increase/reduce the size of the window using the drag-icon at the bottom right of the window. Most of the important settings a user can make in RegiStax are saved for next time.

Note also that RegiStax takes the full size of a 1024x768 pixel screen. When RegiStax starts for the first time, the bottom status bar will be hidden underneath your Windows task bar. To see the status bar click the maximize/restore button on the RegiStax Window title bar.

When you start RegiStax you will see the program window shown above. Let's describe the main features:

- The main body is the image space. Initially it contains the RegiStax logo and copyright message. In use you will see images being processed here.

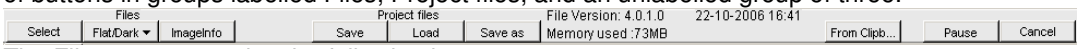
- Above that is the controls area (below). This part of the window holds the controls for the current RegiStax stage. You will see that the controls are loosely divided into groups, the first group (on the left) is fixed in place while the other controls shown depend on which option tab you have chosen. As you can see, the tabs shown here are "Alignment options", "Quality Filter", "General options", "Additional Options", and "Messages". Click each one now to see the different controls available. The currently selected tab is shown in Green, the others grey.



- Above the controls area are more tabs, these reflect the different stages of processing and the different facilities provided by RegiStax. They are displayed in the order in which you will use them, although you may jump stages at times. The stages are:
Align, Optimize, Stack, Wavelet, Final, and About

The Align, Optimize, and Stack tabs are all designed for combining multiple image frames into a single image. The Wavelet and Final tabs are for processing that single image, performing such operations as sharpening and colour balancing. In this manual we will use the term Tab, Screen, and Stage more-or-less interchangably, although generally the tab is the part at the top of the screen, which can be clicked, the screen is the display that appears as a consequence of clicking, and the stage is the conceptual stage of processing that the screen represents.

- Buttons: Working upwards again, the top line of controls, located just underneath the window title bar, is a set of buttons in groups labelled Files, Project files, and an unlabelled group of three.



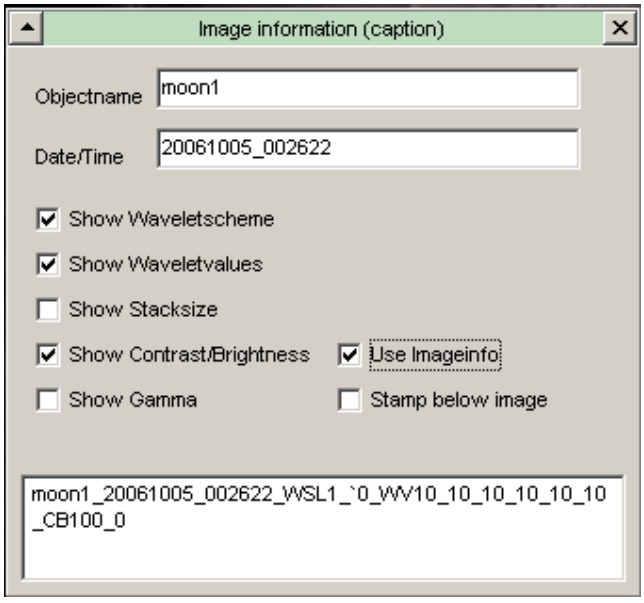
The Files group contains the following buttons:

Select Used to load new image files to begin a new processing session

Flat/Dark Used to create a dark or flat frame, or later to load such frames for use. This button opens a menu with four options:

- *Create Darkframe:* This creates a dark frame from the current set of images. It simply stacks all the images without aligning/registering. Afterwards save it and load your images for processing, then use Load Darkframe to use it
- *Create Flatfield:* This creates a flat frame based on the set of images. Again only a simple stacking routine will be used
- *Load Darkframe:* Select a dark frame for use with the current image set
- *Load Flatfield:* Select a flat field for use

ImageInfo Click to display information about the current image. Using this window you can control the file name during saving. Several processing settings are saved in the filename The user sets the object-name, the program suggests a datetime based upon the input files. Several parameters can be saved, Waveletscheme(WS), Waveletvalues(WV), Contrast& Brightness(CB), Stacksize(ST), Gamma (GA). When the USEIMAGEINFO checkbox is set the information will be used during saving. When the STAMP_BELOW_IMAGE is set, RegiStax will save the text in a separate text-section (white) below the image.



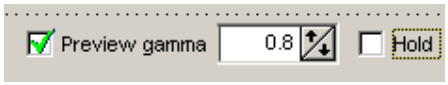
The Project files buttons are used to save the current state of the processing session, such that it can be resumed later. Click *Save* to store the session in a project file. After loading the original image file(s) with the Select button, click *Load* to restore the session. *Save As* is a special form of Save, which saves the project session like Save but renames the original image AVI to match the name of the project file.

The *From Clipboard* button loads an image from the Windows clipboard instead of file(s).

Finally, the *Pause* and *Cancel* buttons can be used to interrupt the processing session, of which more later.

In use, there are several pop-up tool-windows that you might see in RegiStax, such as the frame list. Such windows can be moved around by dragging them (select one by clicking its title bar). You can shrink the tool window by pressing the up-arrow-button on the left side of its title bar. This button also serves to unroll the full window after shrinking it. Several tool windows can be shown at the same time, when you select a tool window by clicking the title bar it will be shown in front of all others.

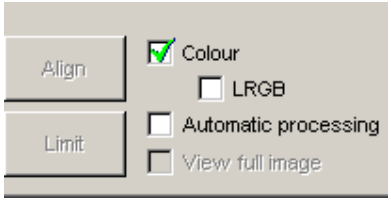
Loading Image Files



An image session will always begin by loading one or more image files. You can load one of more of the following single frame image file types:

- BMP, TIFF, FIT, JPG or PNG

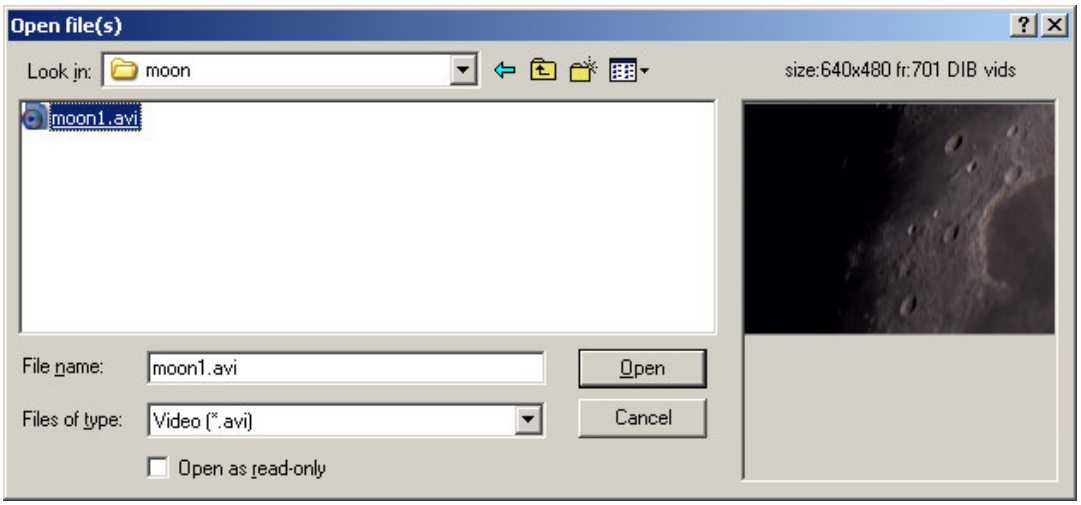
You can also load one or more AVI or SER files, which will load all frames from the files.



Before loading your file or files, notice the "Colour" and "LRGB" check-boxes. You should check "Colour" if your files contain colour images, and leave it unchecked for black-and-white processing. Additionally you can select LRGB to have RegiStax process colour files in a slightly different way: the Luminance (essentially brightness) is extracted from the colour data and recombined afterwards.
Note also that RegiStax will analyse the files (automatically if you enable “Autodetect Colour/B&W” in the “Messages” option tab) and if it seems that the Colour check-box is wrongly set for the type of image it will ask you if you want to change it.

There are two ways to load image files. Either Click the Select button described above and use the standard Windows file Load dialog, or open a Windows explorer window and drag&drop the files onto the main RegiStax window. Due to limitations in the windows operating system, you can experience limitations in selecting files via the Select button. If you are affected by this then use the other method, where the normal RegiStax limitation for frames (max 10000) exists.

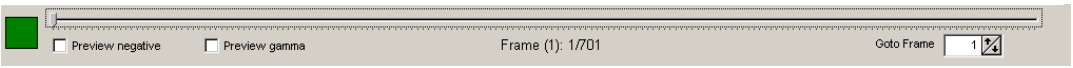
When you are in the Load dialog, you can use the standard Windows behaviour to select more than one file, that is, highlight them while pressing the SHIFT or CTRL key on your keyboard. RegiStax will display a preview of each file you highlight in the dialog box:



Once you have loaded more than one image frame, you are ready to begin processing at the Align tab. If however, you have loaded only one image frame then RegiStax will go directly to the Wavelet frame so that image can be enhanced.

The Align Stage

After you have loaded a set of image frames you will find yourself at the Align screen, with the Align Tab highlighted at the top of the window. The main image window will show the first frame in the list and you will see some new controls at the bottom of the window



These are:

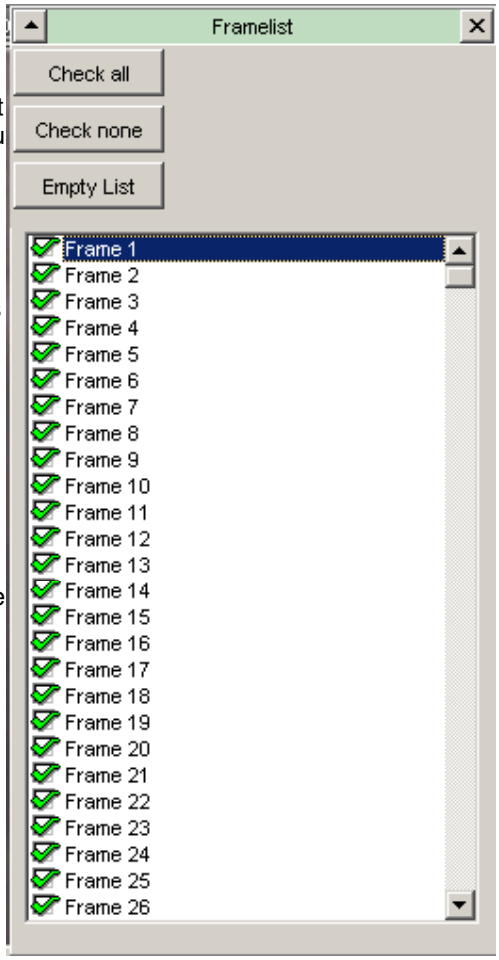
- Frame slider: slide the handle along to see the frames in the set. The current frame number will be shown in the status bar at the bottom of the window, and the image will change to show each frame as it is selected.
- Preview negative check box: For some image types it can be advantageous to see the alignment preview as a negative image. Check this box to enable such display.
- Preview gamma: Some images can be seen more easily by adjusting their gamma. Check this box to do so, and adjust the gamma in the numeric control that appears by the side. The adjusted images will be used during alignment, as it enables features to stand out more clearly. However the processed image will be composed of the original un-adjusted frames. Preview gamma and negative cannot be used at the same time.

If you enable Hold, the gamma setting will be remembered if you process another file.

- Goto Frame: Change the number in this box to jump directly to a frame number

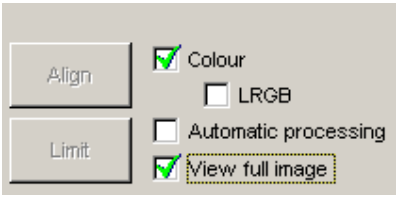
Another way to view the individual frames in the set is to check the "Show Framelist" box at the top. That will enable a pop-up window listing all the frames you have loaded.
You can view a frame by clicking on it in the frame list. The green "check mark" or tick by the side of each frame in the list shows that the frame is enabled for processing. To remove bad frames from processing you should remove the check mark. This can be done in several ways: By double-clicking the frame; By single-clicking the tick; or using the keyboard by pressing the Space bar. To disable or re-enable a whole block, highlight the first frame in the block by single-clicking its name, then press the shift key and with this key pressed double-click the last frame of the block.

You can also move between frames using the keyboard left and right arrow keys on the slider at the bottom. In that case the space bar also toggles frames between being enabled and disabled. The square on the left of the slider changes colour: Red for a disabled frame, and Green for a frame that is enabled for processing. A grey square is a so-called dropped frame (AVI only)



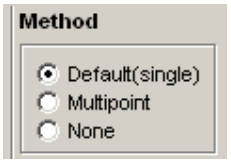
The main purpose of the align screen is to roughly align a set of frames with each other, such that they may be further processed, for example stacked into a composite image. Alignment is achieved by matching similar features between frames.

If the image is too big to fit on screen then scroll bars will be used, as is common in these cases, with which you can adjust the view of the current frame. However if you enable the check box "View full image", the image will be shrunk/enlarged so that the whole image can be seen in the window without any scrolling.



RegiStax has two methods for alignment processing:

- Single point
- Multiple point



Or you can select “none”, which allows you to proceed to the stacking-stage without alignment.

Traditionally, alignment has been done by identifying a point on the image and tracking it between all the frames. However the nature of astronomical images captured in typically less-than-perfect atmospheric seeing means that aligning on only one point results in a sharp final image around that point but less sharp areas in other parts of the final image. This can now be solved by aligning different parts of the image separately, each using its own alignment point. The parts of the image are combined during stacking resulting in an image with sharp details right across it.

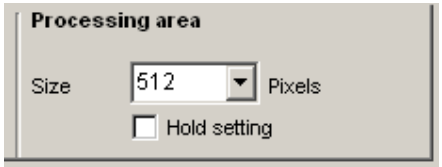
TIP: It is important that RegiStax can identify the alignment point(s) easily in the first frame, so before beginning alignment, move the frame slider until you find a clear frame in which the features are clear and well-defined.

You should choose the alignment method by clicking one of the buttons in the "Alignment Method" control. By default Single point alignment is selected. Click Multipoint to use multiple alignment points.

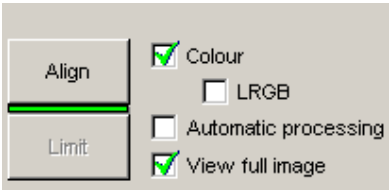
Next you must choose the size of the alignment box to use (the FFT size). This depends on the size of the feature you are going to align on. Move the cursor around the image and notice the box. If it covers the alignment feature well then it's a good size to use. If it is too small then click a larger size in the Alignmentbox control. If the alignment box is too big then processing may be slower, although larger alignment boxes can result in a better final image sometimes. When using multipoint alignment the boxes shouldn't be so big that they overlap.

For best performance choose one of the predefined alignment box sizes. Alternatively, check "Userdefined Alignment Box". In the latter case draw a box using the mouse with the left-button held (“dragging”) to define an area around your preferred feature that will be used for alignment.

Also on the Alignment options tab is the Processing Area. This sets the size of the area that will be automatically updated during wavelet processing. A larger area will demand a great deal more memory. It is recommended to leave the setting at the default of 512. At the wavelet-section the *Do All* button will process the full image so it can be saved. The *Hold* check box will make RegiStax remember this setting.

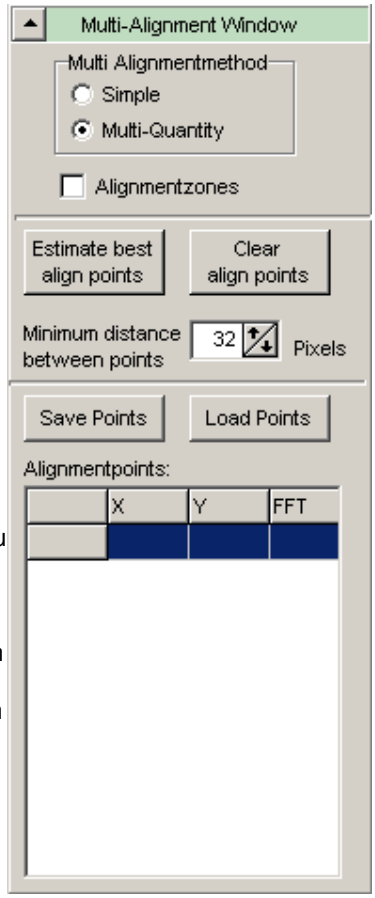


Single point alignment



When you have chosen the box size, click on the image on a well-defined feature, usually one with high contrast is a good choice. For single alignment you will see the FFT analysis window appear, and the Registration graph that tracks progress of the alignment process.
Here you can see another feature of RegiStax: The next logical processing step on the current screen is highlighted with a green bar. At this stage the Align button has a green bar which means that you should click that button to begin alignment (contrast this screenshot with the screenshot above).

Multi point alignment



If you enable multipoint alignment the multialignment window will pop-up.

The idea here is that you click on each feature in the image that you want to use for alignment. Each click will add an alignment point to the list in the multialignment window. If you make a mistake you can delete the currently selected alignment point by pressing the DEL key on your computer's keyboard.
Alternatively a rightclick of the mouse on an alignmentbox in the image will also remove the box from the list.

TIP: Change the currently selected alignment point by clicking in the X, Y, or FFT column of the multialignment window.

Alignment points need not be the same size. You can change the alignment box (FFT size) for the next point you add by clicking the size you want before adding the point.

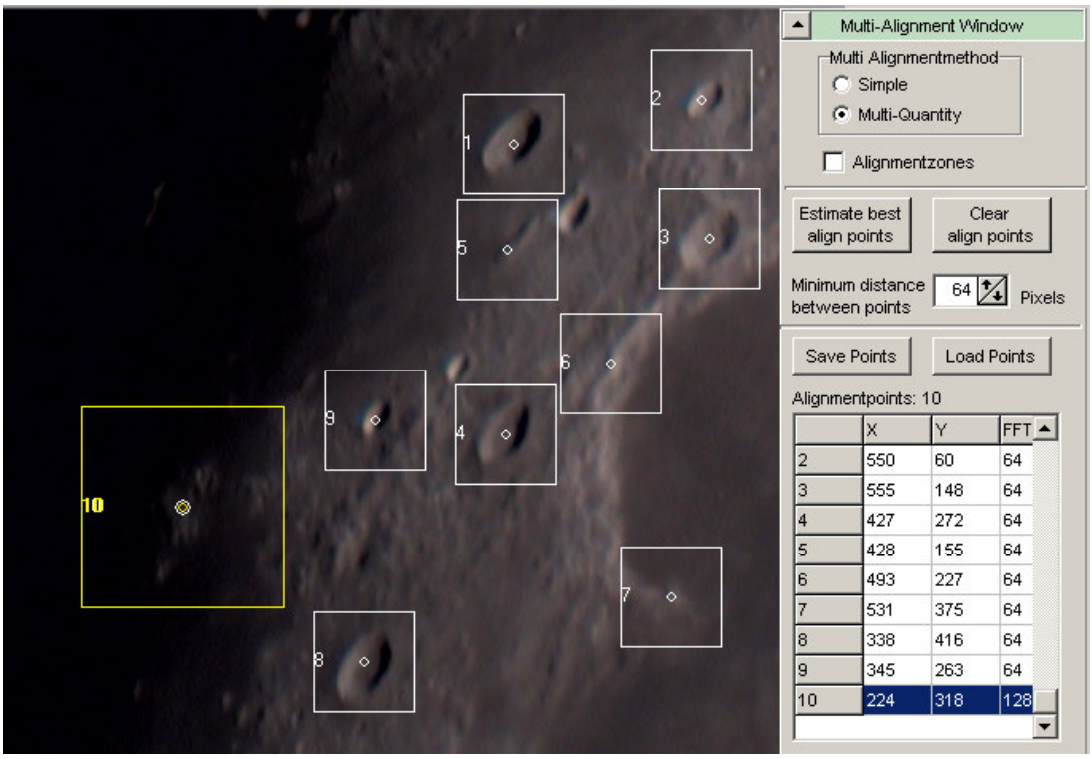
Alternatively, rather than manually choosing alignment points you can have RegiStax choose the points it estimates are the best. To initiate this click the Estimate best align points button. The number of points chosen by RegiStax will depend on the image itself, the size of the alignment box, and also the value entered in the "Minimum distance between points" control, whose purpose is hopefully self-explanatory. Note though that the points chosen are only an estimation and it may be better to choose points yourself or use the list as a starter.

To see more detail in the image when setting an alignment point click Show Zoomed Image which will show a pop-up box displaying an enlarged version of the area where the cursor is.

By default RegiStax will stack the same number of frames for each alignment point. This will usually give the most uniform appearance to a final image. However checking “Simple” in “Multi Alignmentmethod” will make RegiStax stack just those frames for each point, which meet the quality threshold.

If you want to see how the image will be divided up according to the alignment points you have defined, check the “Alignmentzones” box. This will cause the zones to be displayed in the main image area.

Finally, you can save or load alignment points, thereby saving yourself the trouble of entering the points again the next time you load a particular set of image files (for example to try a different way of processing, or because you want to start again).



Example lunar image showing 10 alignment points on prominent features.

Starting Alignment

To start the alignment process click the Align button. In the case of single-point alignment RegiStax will cycle through all frames in the set, attempting to track the alignment point through each frame. If you are using multipoint alignment it will perform this alignment for each point in turn.

If you have loaded more than one AVI file –and you have set “misalign warnings” under general options -, you will be prompted before alignment begins for each subsequent file, to point at the alignment point again. This is because there is likely to be drift between the end of one AVI and the beginning of the next, making it difficult for RegiStax to identify the same point between AVIs.

During alignment, if the alignment box moves off the image due to drift of the image, the results may be unpredictable. If you have significant drift between image frames, make sure alignment points are not too close to the edge of the image throughout the whole sequence. If the Alignment box moves partially off screen RegiStax cannot estimate image quality/shift properly and marks these images as no-quality.

Tracking options

There are some options that control the behaviour of RegiStax during alignment. They are shown in the General Options tab of the control section.

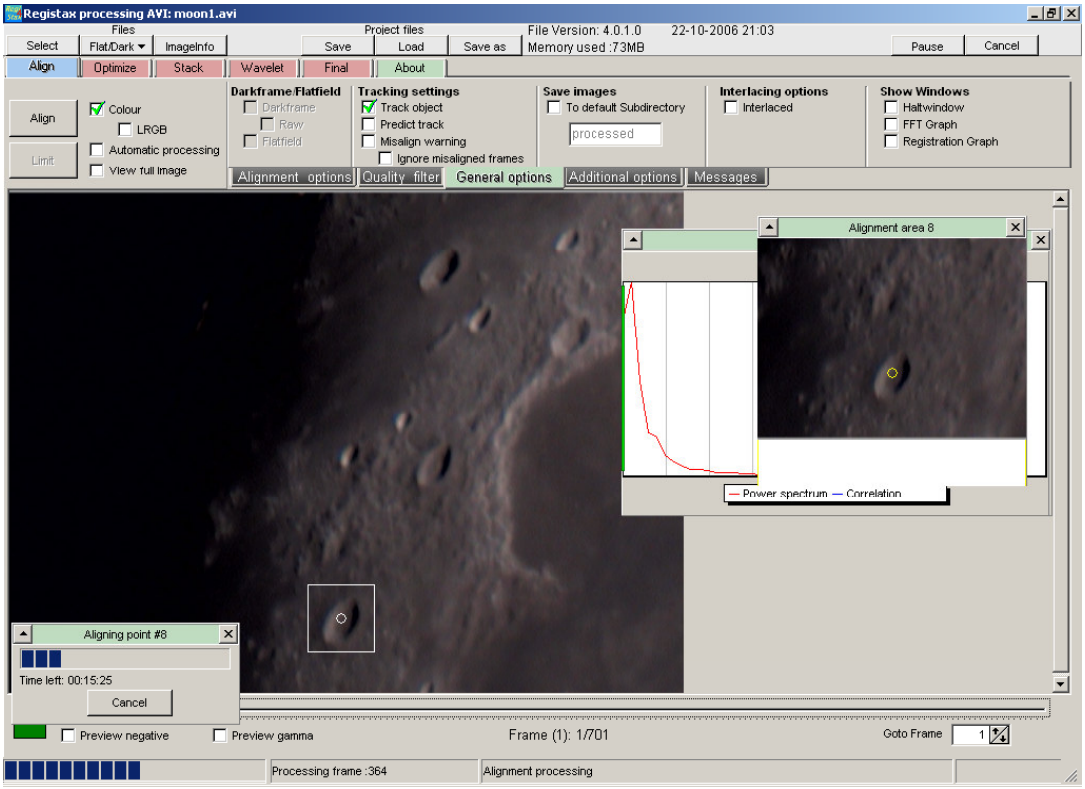
The options and their effects are listed below:

Track Object If this is enabled, RegiStax will attempt to track the alignment point between frames , Normally this should be enabled

Predict Track Enabling this options makes RegiStax predict the path taken by a drifting image feature. Use this option if the drift is predictable, otherwise (if the drift is more random) leave it turned off.

Misalign Warning Sometimes RegiStax will lose track of the alignment feature it is tracking. If this option is enabled you will see a warning in that case. If the option is not enabled RegiStax will continue without warning you of the situation. Having misaligned frames is likely to lead to a poor result image, so it can be useful to have the warning. However see the next option below.
This option must be checked if you want to be prompted to re-select the alignment point when alignment begins for each AVI.

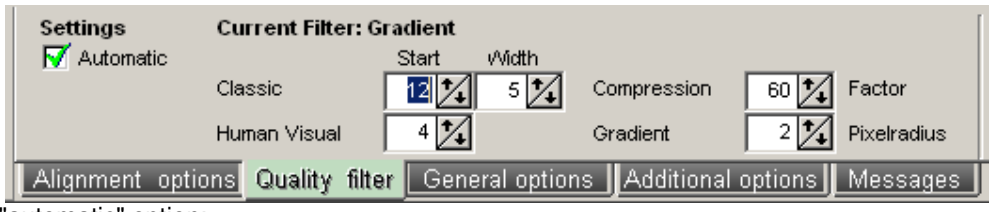
Ignore misaligned frames
If this option is enabled then RegiStax will automatically ignore those frames for which it loses track of the alignment point. If you don't choose this option then you will be prompted to click on the alignment feature again if the situation does occur.



This screenshot shows point 8 during the alignment processing.

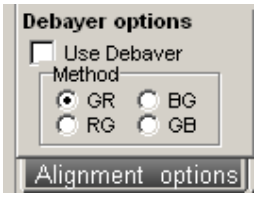
During Alignment you may click the "Cancel" button to interrupt alignment processing. This might be necessary if tracking of the alignment point is lost because of poor-quality input images, for example. It might take a couple of seconds for RegiStax to react to your click as alignment processing is very intensive for the computer. Once interrupted it is often best to restart RegiStax, as the internal state cannot be guaranteed and you may find problems if you attempt to continue.

Also, you can check the “Haltwindow” check box. That will enable a pop-up window with a button that can be used to halt the current alignment if tracking has been lost.
At the same time as alignment is going on, RegiStax is also estimating the quality of each frame, and sorting the frame set into order of quality. There are five different methods by which this can be done, and you can choose the method used before clicking the Align button. Of the five however, the best results are usually achieved with the "Gradient" method. It is also the simplest to use as no additional settings are required. You can choose the method used by selecting it from the drop-down list in the Quality Estimator section of the Alignment options tab.
If you choose Classic, Human, Compress, or Gradient, you can tune the parameters used by going to the General Options tab and adjusting the values found there. However, even in these cases there is an



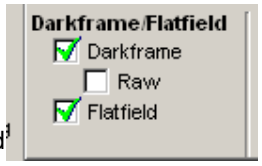
"automatic" option:

RAW colour images



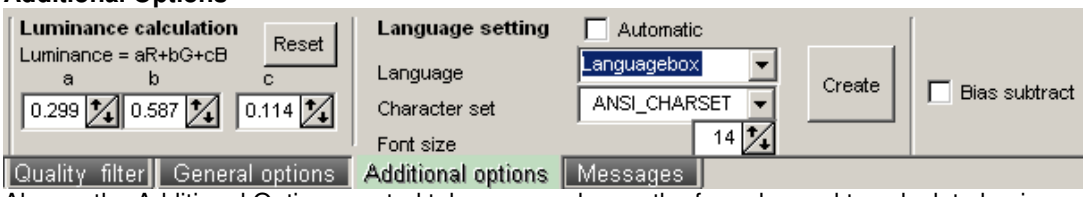
If your image frames have come from a webcam with the "RAW colour" firmware modification, you need to convert the image frames to correct RGB images before processing. This procedure is known as DeBayering. RegiStax can DeBayer the frames if you enable the option on the Additional Options control tab. There are four DeBayer methods: GR, BG, RG, and GB and the one that is right for your camera will vary. Click each to see which gives the best result. When using SER sequences RegiStax will automatically detect the debayer method from the file.

Dark/Flat frames



If you have created and loaded dark and/or flat frames for use with deep-sky images, the Darkframe and Flatfield check boxes will be enabled on the General Options tab. Make sure they are checked to use the dark and flat images you have loaded. If the Dark frame came from a Raw modified webcam click the Raw box too, to enable debayering.

Additional Options

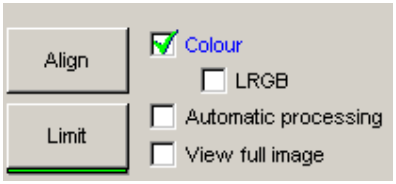


Also on the Additional Options control tab you can choose the formula used to calculate luminance. As stated earlier, the LRGB method means that the luminance image will be created and processed separately from the colour, and then reapplied to the colour when processing has finished. Luminance is normally calculated as 0.3xred + 0.5xgreen + 0.1xblue but expert users can change these factors here.

Language setting is on the Additional Options control tab and enables you to choose the language that RegiStax will use for controls. Users can define these translations themselves by pressing the create button. This will create a textfile (lang_XX1.txt) where XX stands for the current language. After translating all the texts in this textfile it should be saved as lang_XX.txt where XX stand for a shortcut of the language the translation is in. RegiStax will detect such files at startup. When your language of choice is translated properly just checkmark the “autolanguage” setting, the next time you start RegiStax it will be in your preferred language.

Finally on the Additional Options tab, is a Bias Subtract option. This is for those astronomical images that have a constant background value above zero. Check the box and you can enter a value that will be subtracted uniformly across all image frames. to remove the background offset.

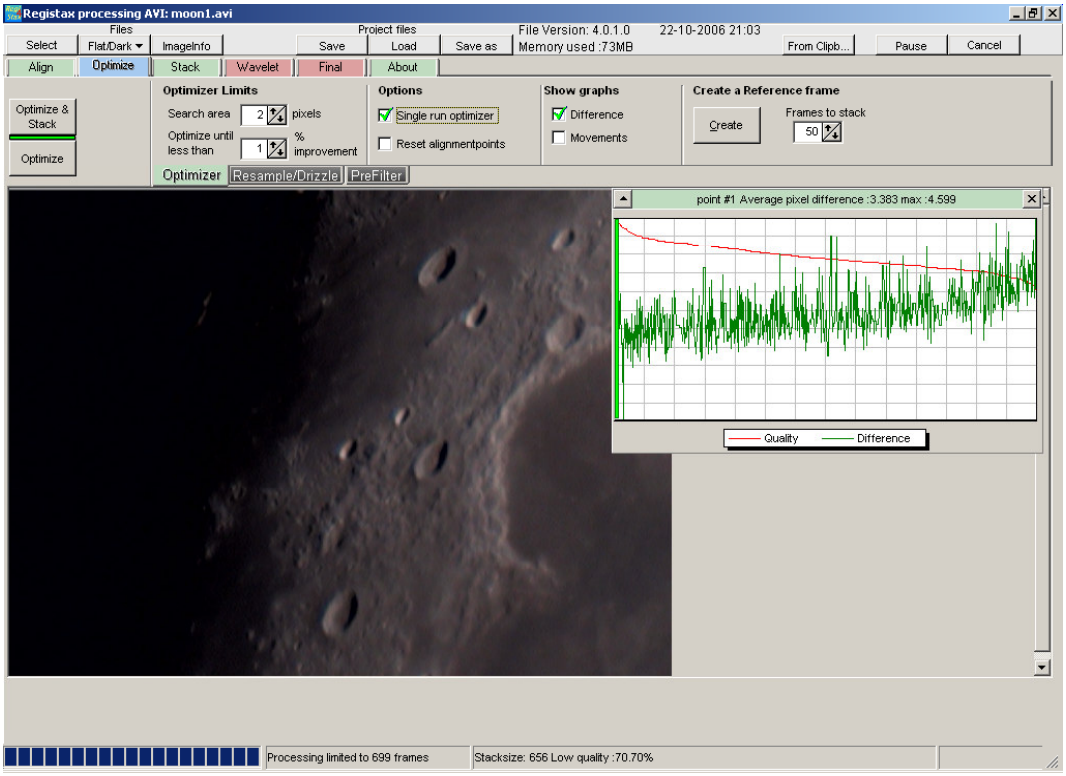
After Alignment



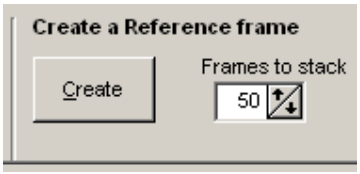
Once alignment has finished the worst-quality frames will be filtered out from the list and the best taken through to the next stage, Optimize. You should move to this stage by clicking the "Limit" button -- notice it now has a green line, indicating that you should press it to continue. The number of frames taken through to the Optimize stage depends on the position of the frame slider - Initially the slider is set at a point determined by the "Lowest quality" value. If that value is, say, 40%, then it means that frames with a quality estimate that is less than 40% of the best frame of the set are considered to be to low quality, and are not taken through to the Optimize stage.
Since the slider position indicates the lowest quality frame to take through to the Optimize screen, the screen might be showing a poor frame. You may move the slider left and right (higher-quality frames are on the left, lower-quality on the right) to find the worst-quality frame you would consider carrying along for processing. More frames will be filtered out later.
So, when this has been done, click "Limit" and you will see the Optimize screen appear.

The Optimize Stage

Once you have finished aligning the image frames the next stage is the optimizer, which looks at each frame in turn to fine-tune the alignment.



For this job it is important to have a good so-called "reference frame", in other words, the frame with which all others will be compared in order to determine their alignment and quality. By default, the reference frame will be the one you used to set the alignment points on the previous stage, but RegiStax has a mechanism for creating a better reference frame.



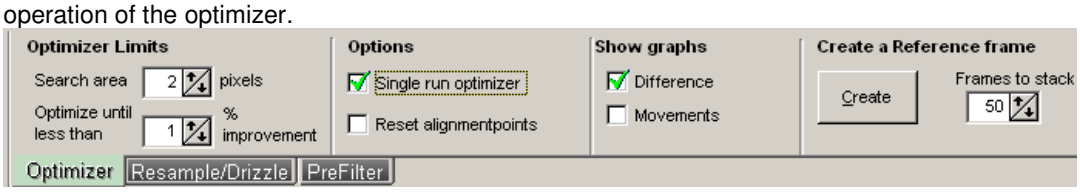
Click the *Create* button, and the program will run through the whole optimize-stack process automatically, for a small subset of frames (by default a maximum of 50 frames or half of the frames available for optimizing). These will by definition be the best frames, because the frame set has been ordered by quality. When the frames have been stacked automatically the Wavelet screen will be shown. The idea now is for you to enhance the quality of the image such that it will be improved and will be suitable for use as a reference frame when processing the rest of the frames. See the Wavelet stage for more details of how to enhance the image.

TIP: Don't over-enhance the image in the wavelets, only a slight sharpening will be helpful.

When you've improved the reference image you should click "Continue" on the wavelet screen, and the Optimize stage will be active again.

Optimizer controls

Besides the reference frame controls, there are some other controls to look at on this screen, which control the operation of the optimizer.



The first tab is labelled "Optimizer". The optimizer works by doing a fine-alignment of each alignment point. This tab is used for tuning the operation of this process. It has these controls:

Optimizer Limits

Search Area Sets the area around the alignment points that will be examined when searching for a better alignment. A higher number of pixels will most likely give the best after fewer runs, but will take more time. A small number of pixels will result in a faster search but more search runs will be necessary.

Optimize until After each alignment run, RegiStax calculates how much improvement the alignment shows compared to the previous run. If the improvement is higher than the number in this box (as a percentage), then the program will perform another run. In other words it keeps optimizing over and over until it can't make a significant improvement. This value determines what it considers to be "significant".

Options

Single Run Optimizer Notwithstanding the Optimize Until control mentioned above, if you check this box both the Search Area and the Optimize Until controls will be ignored and only a single optimizing run will be performed, using a larger predefined search area, with a different search algorithm. This can make your image processing significantly faster, but it is possible that quality will suffer since not all possible alignment shift positions are tested.

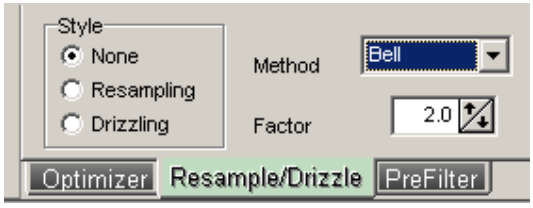
Reset Alignpoints Used in rare circumstances to reset the Optimizer's processing during multiple alignment, if one or more of the alignmentpoints shows excessive shifts due to a misalignment during processing. This option will start optimization for every alignmentpoint using the recorded shifts for alignmentpoint number 1.

Show Graphs

RegiStax can show graphs that display the quality and alignment of the frames being processed. The first graph is *Difference*, and has a red line indicating the relative quality of all frames (frames being along the horizontal axis of the graph), and a green line showing the difference between frames.

The *Movements* graph is actually a window showing the offset between all frames in the set, in other words it tells you how much drift you have in your images. The window shows a red dot for the position of the alignment point on each frame, shown relative to the centre of the graph (representing the position of the alignment point in the reference frame).

The next tab is Resample/Drizzle.



Resampling and Drizzling are alternative approaches to enlarging the image during processing. Use the *Style* selector to choose whether to resample, drizzle, or do neither. Both types of enlargement can help gain more accurate alignment between frames. Select the *Factor* to determine how big the enlarged image will be (the default is 2x).

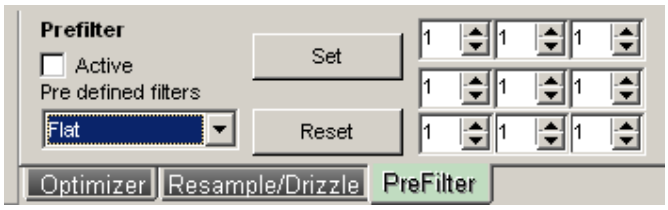
Resampling means making the image larger using a straightforward algorithm in which intermediate pixel values are interpolated from the original ones.

The enlargement method drop-down list shows the following algorithms:

Bell	Simple interpolation routine
BSpline	No sharp transitions, but it can cause blurring
Lanczos	More sharpening, but can cause “ringing” effect
Mitchell	No sharp transitions, often a good compromise between "ringing" and "blurring"

Drizzling is a different technique in which drift in the image is exploited to provide intermediate pixel values directly. This can give an effective increase in image resolution, on suitable images.

Next tab is Prefilter.



Enabling this feature will make RegiStax apply a filter to each frame before optimization.
Warning: most of the time this will blur the image, which is usually not what you want, but can be useful for noise-reduction or the like.

To use this feature, check the *Active* box and choose one of the predefined filters, or - for advanced users - define your own by editing the numbers in the 3x3 matrix then pressing *Set* to enable it.
The matrix defines the filter as follows:
Each pixel in the result image depends on the value of nine pixels in the input image: the pixel which in the input image is in the same position as the output pixel under consideration, and the eight surrounding that input pixel. The value of each is multiplied by the weight (which can be negative) in the corresponding box in the matrix and the result is normalised to the dynamic range of the file being processed.
For example:
The "Flat" predefined filter assigns an equal weight to each pixel under consideration, resulting in a simple blur:

```
1  1  1
1  1  1
1  1  1
```

The "laplaceedge" filter assigns a high weight (8) to the central pixel and negative weights (-1) to those surrounding it. This results in a type of edge-detection:

```
-1  -1  -1
-1   8  -1
-1  -1  -1
```

A filter that represents unity, that is, the result is the same as the input, would be the following:

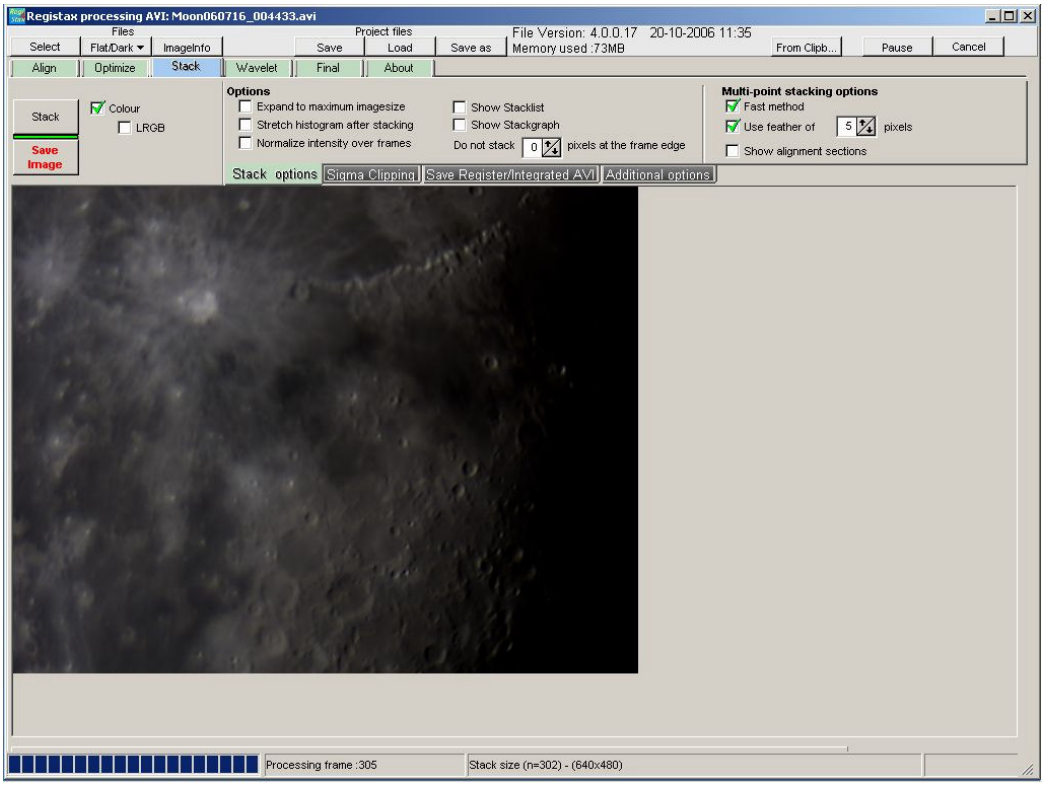
```
0  0  0
0  1  0
0  0  0
```

Where only the central pixel contributes to the same pixel on the output. Note however that due to the normalisation of values even this filter has the effect of "stretching" the histogram, ie. brightening the light sections and darkening dim ones evenly across the image.

To begin the optimization click the Optimize button, or the Optimize & Stack button. Use of the latter will cause RegiStax to move directly to the Stack screen after Optimization has finished, and will begin stacking the frames to create a composite.

If you are using multiple alignment points, each point will each be optimized in turn. Optimizing many points can take some time, especially if you haven't checked *Single Run Optimizer*, so wait until it has finished. Then you will be ready for the Stack Stage.

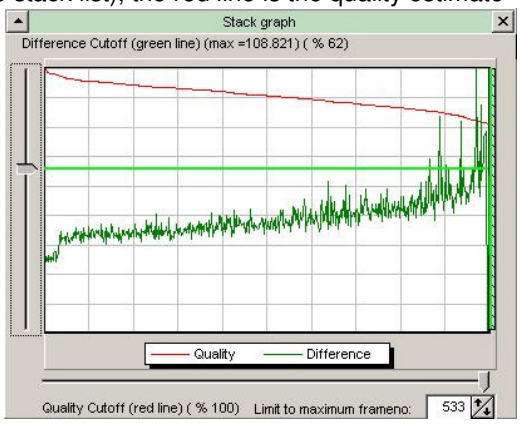
The Stack Stage



At this point all the images are aligned and optimized, and it is time to combine them into a single image. This process is called “stacking” and in effect we add all the images together. This process cancels out a lot of the random noise, and brings out some of the more subtle detail.

The first thing to do is to decide which frames you want to include in the stack. By default all of those processed so far will be included, but some may not be as well aligned as others, and some may not be of good enough quality. If you open the stack list by checking the **Show Stacklist** check box, you will see a list of all the frames in order of their quality judged by the criterion you chose on the Align page (for Align point 1 if you are using MAP[1] processing), the best at the top of the list, the worst at the bottom. If you click on the name of a frame, that frame will be shown in the image section. Look at the first and the last frame and you will get a feel about how variable your frames really are and this may help you decide if you want to remove all of the poorer frames. You can run up the list with the up-arrow key to see more of them. With MAP processing, however, be careful; a generally poor frame may have quite good quality close to one alignment point and rejecting it might eliminate good data for one alignment point.

Now open the Stack graphs by checking the **Show Stackgraph** check box. If you are doing single-point alignment you will see a single graph with two lines on it. If you are doing MAP processing, you will see two graphs, the upper one with a single red graph line, and a lower one with two lines and an edit box below it. In either case the horizontal axis is frames ranked in order (as in the stack list), the red line is the quality estimate and the green line is a plot of the differences in alignment between each frame and the reference frame.



You can now deselect frames that are poorly aligned or of poor quality. The lower graph (or the only one) has two sliders, one below and one to the left of the graph. The vertical slider may be move downwards and a green bar follows it. All frames whose differences fall above this line will be eliminated from the stack and therefore will not contribute to the final image. An example is shown on the right. Similarly, the horizontal slider may be moved to the left and an area of cross-hatching

[1] Multi Alignment Point

follows it. All frames in the cross-hatched area will be omitted from the stack. In the case of MAP processing, the upper graph has only the horizontal slider, and this can be used to eliminate the worst frames from all the alignment points in one setting. Alternatively you can just type the number of frames you want into the edit box. Corresponding cross-hatched areas appear in all the lower graphs automatically, but they can be moved on the lower graphs if you wish. There is one lower graph for each of the alignment points, selected by means of the edit box below it, so frames can be selected for each point separately. If you are tempted to remove significantly more frames for one alignment point than for others, this may not be a good idea because the section of the final picture derived from this point may be significantly noisier than the others and this may show on the final image. It is probably better to remove this alignment point altogether. The maximum number of frames finally remaining for the stack is shown in the status bar.

There are two schools of thought amongst astro-imagers concerning how big stacks should be. Some believe, correctly, that the more frames that are stacked the more the noise will be reduced and that it is better to stack lots of frames even if many of them are of poor quality. Others point out that reduction in noise is proportional to the square of the number of frames stacked so that a very great increase in the size of the stack is needed to reduce the noise very much. These workers prefer to cut out the poorer frames and accept a slightly noisier picture in return for a less blurred one. However, the final image obtained when poorer-quality frames are included can often be better than that obtained when these frames are excluded, especially when enhanced by wavelets. Thus the temptation to "weed out" poor quality and poorly aligned frames should be resisted until you are sure that a better final image results. Keep experimenting and see what produces the best result.

If you close the graph window and the stack-list window, if you still have it open, you can check a box labelled **Show alignment sections** which will show you how the picture will be divided up between the alignment points and also produce a table of the alignment points with a check mark beside each. Removing the check mark will remove that point and the divisions will be recalculated.

Two other controls may be important in MAP processing. Firstly **Use feather of *N* pixels**, where ***N*** is an edit box. Although unchecked by default, this is probably better checked. It causes the sections of the picture to be overlapped with soft edges and this reduces the likelihood that the joins will show in the final image. The second control that may be important is **Normalize intensity over frames** (under **Options**). The different sections of the picture in general use different frames in their stacks. If all the frames are not of the same general brightness (for instance maybe some light cloud moved over during the capture of the avi), then this difference may show in the final image. This control adjusts each frame to an average brightness before stacking to eliminate this problem.

On the left of the screen are two check boxes **Colour** and **LRGB**. Although these have been set earlier in the processing, they can be altered again here. If the **Colour** check mark is removed, a monochrome stack will be done and all colour information will be lost. If the check mark is inserted, the image will still be monochrome, but three identical layers will be produced, one for each colour, and these can be manipulated later.

There are a number of other options available which will probably only be used by the more experienced users. Refer to the **Reference** section below for a detailed description of these.

When you are satisfied that you have selected all the frames you want to contribute to the final picture, set up feathering and anything else you want involved, then press **Stack** and the stacking process will start. The word **Stacking** will appear on the image and the progress bar at the bottom of the screen will show you how it is getting on. When it has finished, the word **Stacking** will vanish and you can move on to the Wavelet phase.

Finally, you should not use the **Save Image** button until stacking is complete. It enables you to save the stacked image and its action when there isn't one is somewhat uncertain.

Reference.

This section attempts to document all features of the Stack page. It consists of two main buttons and a number of controls grouped onto four tabs.

Buttons.

Stack. Starts stacking.

Save Image. Saves the stacked image. Several file formats are available, 8-bit bmp and jpg, 16-bit png and tiff, and 32-bit fits. It should not be used before stacking is complete.

Check boxes

Colour. Normally already set, but can be changed here. It controls whether the images are stacked in colour or monochrome. If the earlier processing was done in monochrome and this box is checked to create a colour image, then the system crates three layers, one for each colour, but these will be identical. However they can be changed later to create, for example, an artificially coloured image. If the original was in colour and the check mark is removed from this box, then the system will create a monochrome image.

This function has a second value. If a set of three (or four) monochrome images are loaded whose names end in _R, _G, _B (and _L), then selecting Colour (and LRGB) at this stage will cause the program to treat these files as red, green, blue (and luminance) images and construct a colour image from them.

LRGB. If this box is checked then a luminance value for each pixel will be calculated for use on the Wavelet page. This has the advantage that wavelet processing only uses the luminance layer so that the colours will not be affected so much.

Control Tabs

1. Stack Options

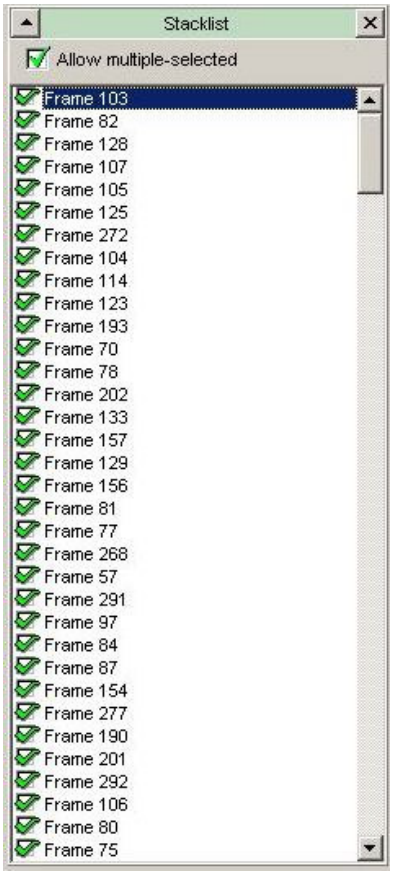
A Options

a. **Expand to maximum image size**. Normally the area of image to be stacked is that defined by the reference image. If this box is checked, the program will include all the pixels in all the frames into the final stack, thus creating the largest image possible.

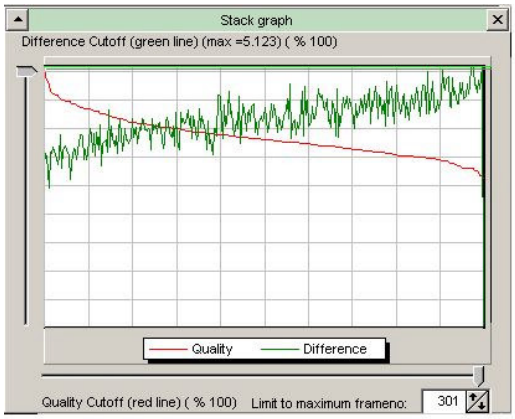
b. **Stretch histogram after stacking**. This was the default action under earlier versions of RegiStax but now it is optional. It results in the histogram of the final image being stretched automatically to fill the range 0.0 to 255.0 with 16-bit precision.

c. **Balance intensity over frames**. Different frames of the AVI may be of different brightness (caused perhaps by a thin cloud passing over). If multiple alignment points are being used, then the different areas may be formed by stacking different frames. It could happen that one such stack is noticeably darker than another and this would show in the final image. This option equalises the brightness of each frame before stacking to avoid this type of problem.

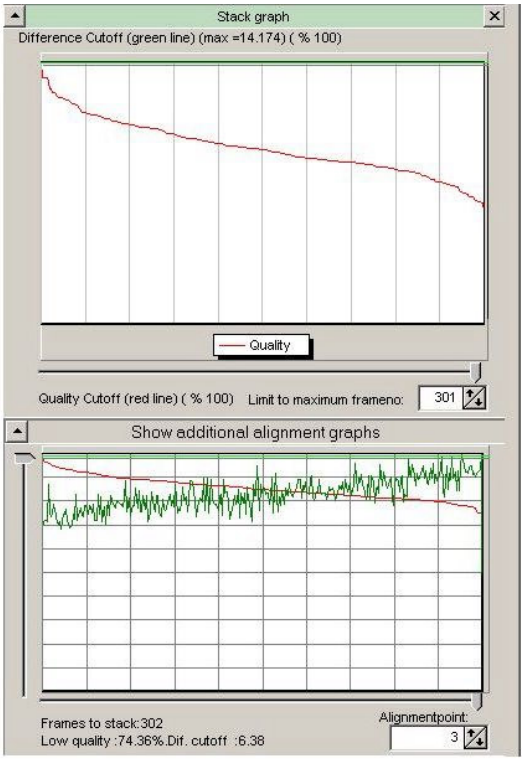
d. **Show Stacklist**. This opens a window displaying all frames in order of their quality (as judged from the first alignment point in multi-point alignments). The list can be used to deselect individual frames. During multi-point alignments, this feature must be used with great care because some frames may be used by some alignment points and not by others. Removing some of these might affect the overall quality of the final image.



e. **Show Stackgraph**. This displays a graph of quality (red) and the difference in alignment between each frame and the reference frame (green) plotted against the frames in order of quality. For single-point alignment a single graph appears and the quality (red) line is a smooth curve. For multi-point alignment two graphs appear; the upper one shows only a global quality graph based on the first alignment point, the lower one can be selected to show the quality and difference plots for each of the alignment points. The upper graph can be used to select the same number of frames for all the alignment points, the lower graphs can be used to select frames for each alignment point individually. It is wise to keep the number of frames for each alignment point nearly the same because large differences may result in noticeable differences in quality between the different areas in the final image.



Single-point



Multi-point

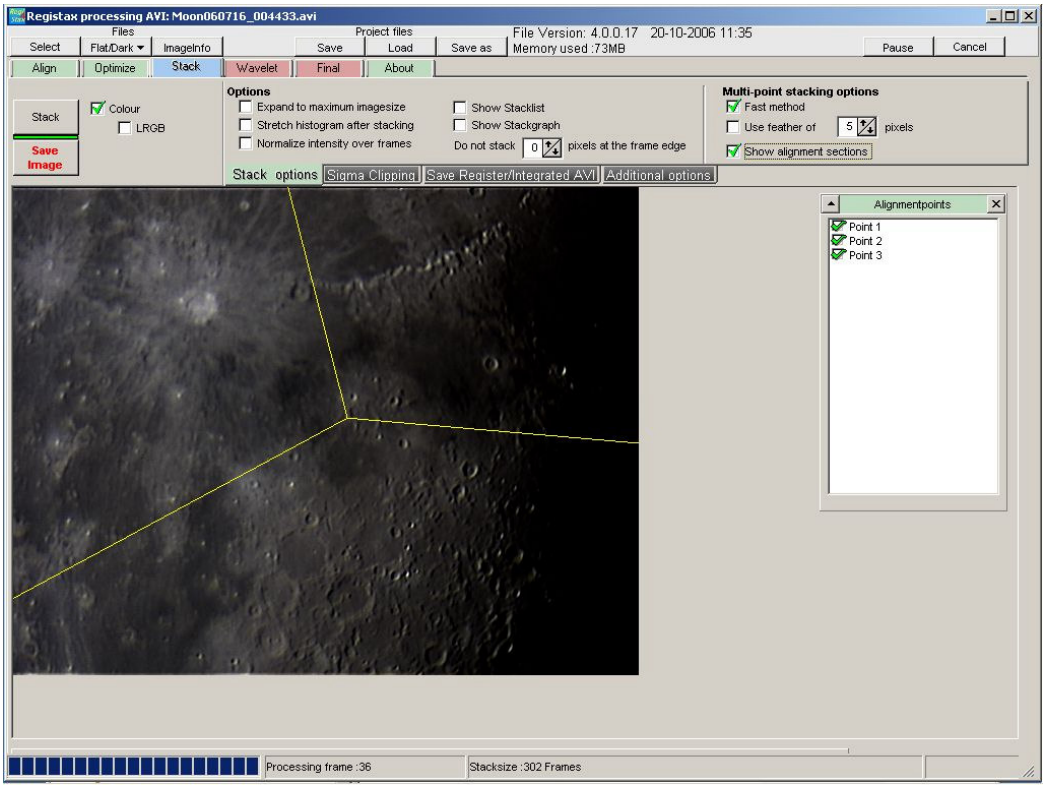
f. **Do not stack *N* pixels at the frame edge** (where *N* is selectable by an edit box). Sometimes the edges of the frames contain more noise than the rest of the frame and this can result in a poorer-quality image at the edges of the final picture. This control enables a zone round the edges of each frame to be omitted during stacking and therefore absent from the final image.

B Multi-point stacking options

a. **Fast method**. This implements a faster stacking algorithm. Generally this is as good as the slower version but in multi-point stacking it might sometimes cause the joins to show. If you see joins in the final image, removing this check mark might make them less visible.

b. **Use feather of *N* pixels**. The image is divided into parts around each alignment point. When these are reassembled into the full image, the joins may show. This control causes the edges to be merged over a number of pixels so that the joins do not show. Generally the default of 5 pixels works well, but it can be altered if need be. This feathering will apply to both sides of the join so that a feather of 5 pixels will create a feathered zone 10 pixels wide.

c. **Show alignment sections**. This control reveals the sections into which the picture has been divided during stacking. A window opens listing the alignment points and enables points to be removed; the divisions are then recalculated.



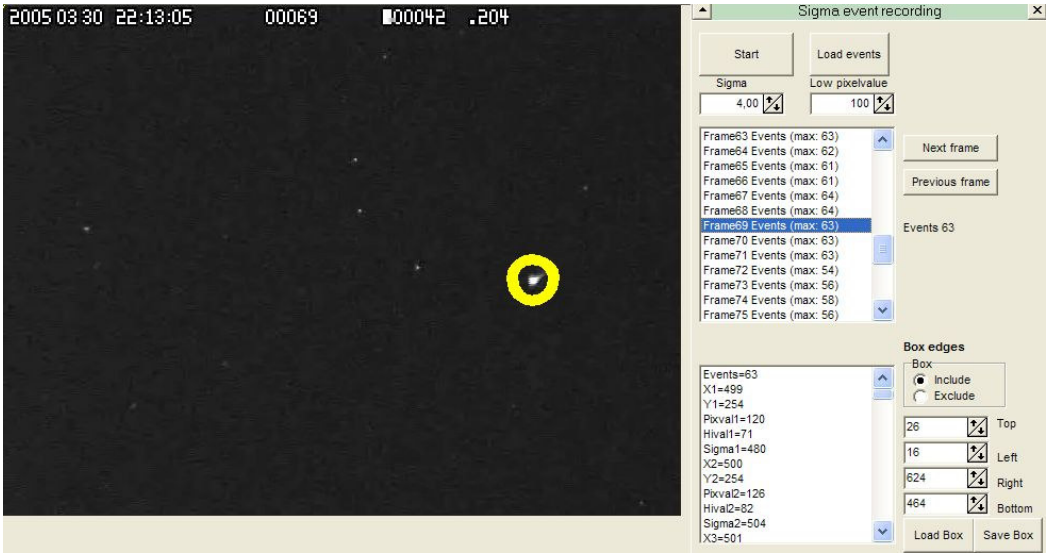
2. Sigma Clipping

a. This implements a scheme to eliminate outlying values amongst the pixels by eliminating any point more than so many (*N*) standard deviations[2] (sigma) from the mean for that pixel. 2 sigma will include about 95% of values. Check boxes allow for elimination of pixels having vales above the mean plus (*N* x sigma), below the mean minus (*N* x sigma), and the single highest pixel. This feature is useful if there are hot pixels in the image and no dark frame has been used. In that case use only **Cut pixels above sigma-high**. If dark pixels exist, use **Cut pixels below sigma-low**. Both options are checked by default.

b. **Search events**. This is a new feature to RegiStax 4 and is designed to help find transient flashes, such as meteor trails, in long AVIs. The picture below (courtesy of Roger Venable) illustrates this use. (Normally the yellow ring is much thinner than this; here there are 63 extreme pixels very close together.) The control opens a new window including a Start button, pressing which initiates the analysis and records outlying pixels in a file and displays the number in each frame in a text box. This list can then be examined to determine how many such pixels are in each frame. The data in the file

[2] The standard deviation (sigma) is a statistical measure of the width of a normal distribution. If this means nothing to you, ignore it, but know that generally 95% of observations fall inside 2 sigma, 98% inside 3 sigma. So you may lose a small number of normal pixels which look like outliers.

may be reloaded later by means of the “Load Events” button. Selecting a frame in this upper box causes the data concerning this frame to appear in the lower box and the outlying points are circled on the image. The search uses the value of sigma in the edit box inside this window and ignores that on the main page. The statistic that does this work is rather unhelpful if the mean value is too low, so pixels with mean values less than the entry in the **Low pixelvalue** edit box are ignored. You can also include or exclude the edges of the picture, adjustable with edit boxes, and displayed as a yellow box



on the picture. This is particularly useful if you have a timer display on every frame, for example. These settings can be saved to and recovered from a file. Having run the function, you may change the value of sigma upwards and the list of events is recalculated. However this does not happen if you reduce it, nor if you change the Low pixelvalue. The sigma and Low pixelvalue are remembered by the system.

3. Save Registered/Integrated AVI

A. Create registered AVI file
   a. **Save**. Saves an AVI of the aligned frames.
   b. **Image size**. You can select just the alignment area or the maximum area common to all frames.
B. Create integrated AVI file
   a. **Moving average**. The new AVI is created from the average of a selectable number of frames, *N*. The first frame will be the average of frames 1 to *N*, the next frames 2 to *N*+1, and so on.
   b. **Compressed**. Again a number of frames, *N*, can be selected. The system then stacks the original frames in groups of *N* and writes the result to a new AVI file. The first frame of the new AVI will be derived by stacking frames 1 to *N* of the original, the second from frames *N*+1 to 2*N*, and so on.

4. Additional Options

Prefilter.

Prefiltering can be use to filter noise from the frames before they are stacked. Please refer to the Optimize Section for a full description of how this works.

a. A choice of 10 prefiltering options and a check box to activate one.
b. A set of edit boxes which allow control of the filter matrix and buttons to set the filter or reset it to its default values (the flat filter).

Drizzling.

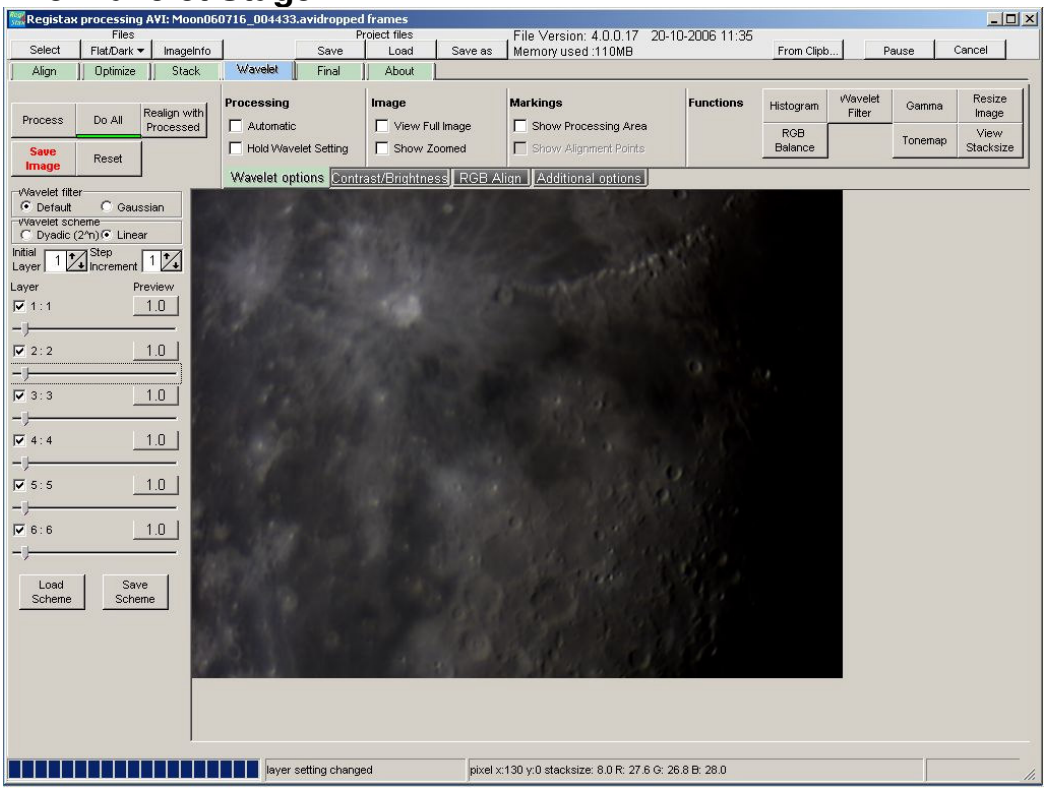
When an image is enlarged there are more pixels in the enlarged image than there are in the original, and some way has to be found to fill in the extra pixels. Resampling, used at the align stage, is one way and uses an algorithm to interpolate the missing pixels. Drizzling is very different; it does not use interpolation but uses only real data. The enlarged image is built up during stacking, but the option must also be selected at the optimize phase so that the required data can be accumulated. Any single frame provides one set of pixels. The next frame provides a second set which, in general, will not be exactly aligned with the first (they could, for example, be half the width of a pixel to the right) and can be used to start filling in the gaps. As more and more frames are stacked, more and more of the gaps are filled in. In addition, these new pixels need not be the same size as the old pixels and the user can decide how big they should be. The smaller the size of the new pixels, the more space there is to fill in and the more frames are needed[3]. The size of the new pixels is chosen with the **Relative pixelsize** edit box. The desired magnification is decided by the **Resizing Factor** edit box. It should also be understood that the number of frames needed by drizzling, for any given quality of image, is always greater than it is for resampling because not all the frames contribute to every pixel.

Interlace.

Some images are interlaced, that is the odd-numbered lines are transmitted first followed by the even-numbered lined (TV pictures are transmitted like this). Select the choice that suits your camera so that RegiStax can remove the interlacing and use only real data.

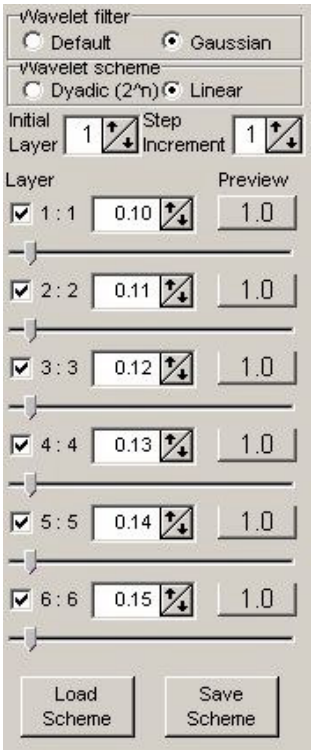
[3] For example, if the size of the pixels was set to 200%, and the drizzling factor set to 2x, we would simply get an enlarged image with enlarged pixels and no improvement in quality, but no interpolation would be involved. If the size is set too small there may be pixels in the enlarged image with no information in them giving rise to holes in the image.

The Wavelet Stage



All the frames have been stacked together and now is the time to enhance the image, to bring out the detail that is hiding in there and to control the colouring. This is largely a matter of personal preference, but some general guidance can be given. There are some actions better done before others, but there are no hard rules. A more formal description of the controls on this page is given below in the **Reference** section.

The controls do allow you to overdo processing to such a degree that you may create detail that was not really in the original. Wavelets are very powerful but have to be used with care, unless, of course, your object is to produce a dramatic image rather than a representation of reality.

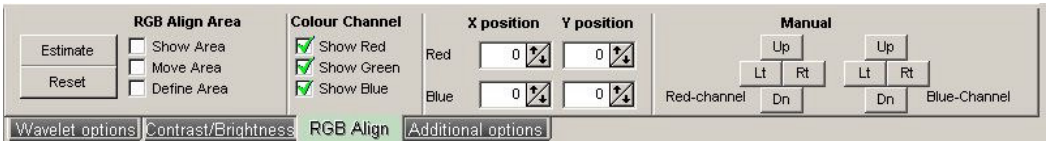


RegiStax provides at this stage a process called **Wavelets**. For a full description of what these are and how they work, see the Appendix 1. Suffice it to say at this point that there are six wavelets provided and that wavelet 1, at the top, contains the finest detail in the image and wavelet 6 the coarsest detail with the others in order in between. In the **Default** scheme each wavelet is provided with a check box, a slider, and a button. The check box enables the wavelet, the slider controls its enhancement, and the button shows the value of the wavelet and displays the effect the wavelet will have on the image. In the **default** scheme, the wavelets themselves are controlled by the **Initial Layer** and **Step Increment** controls. The **Initial Layer** is the width of the first wavelet; **Step** is the increment from wavelet to wavelet, a value of two makes the filter twice as wide as the first wavelet. A step of 0 gives the finest control which is the best for the best images, but for the run-of-the-mill image, a step of 1 is probably more useful.

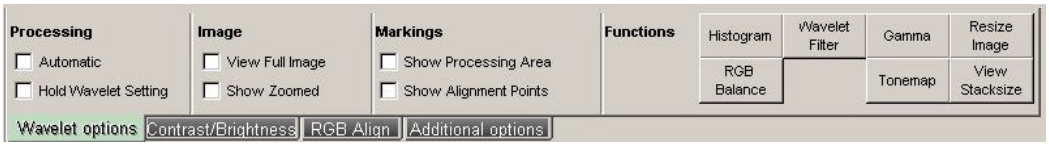
Gaussian is an alternative method of calculating the filters which uses a Gaussian curve. If this is chosen, a set of edit boxes appears, one for each wavelet. The entries in these boxes control the widths of the wavelet filters, so each can be set separately. The algorithm is more flexible than the default one (see **Reference** section below) and the ability to adjust each wavelet separately from the others makes this a very powerful technique.

Pressing a **Preview** button causes those places in the image where enhancing the wavelet will cause the image to brighten to be coloured green and the parts that will darken to be coloured red. This gives a good idea what that slider will do to the image. So, starting with the top slider, move it to the right to sharpen the small-scale details in the image, but be aware that the finest detail may be in the noise. The second slider will enhance slightly-coarser detail, and so on down. Increase each one carefully and observe the effect on the image. Moving the slider to the left reduces the influence of that wavelet and can even be made negative. Some people find this useful. Double-clicking anywhere on the slider control resets that wavelet to 1.0. Small adjustments can be made with the cursor controls on the keyboard, or by clicking on the slider control to one side of the slider itself.

Two schemes are available, **Linear**, which is the one described above, and **Dyadic** in which the wavelets widen in geometric progression, each being double the size of the previous one. This causes the blurring to increase rapidly so that the higher-numbered wavelets cause wide-spread effects; intended originally for nebulae, the results on other subjects can be interesting.



If your image was captured in colour, and especially if the object was low in the sky at the time, you will want to use the function **RGBAlign** behind the third tab. The atmosphere causes the three colours that compose a colour image to separate. This function puts them, back together again. The system estimates the required shift in a small area of the picture; check **Show Area** to reveal this area on the image. The size is the same as the alignment box used at the alignment stage, and it is placed on the first (or only) alignment point. If you prefer to use a different part of the image, check **Move Area** and, as you move the mouse over the image, a box follows the pointer and is placed by a click[4]. If you would prefer a different size or shape of box, use **Define Area** and drag out the box you want. This box can be moved with **Move Area**. Once you are satisfied that the box is where you want it to be, press **Estimate** and the system will calculate the best shifts to the red and blue images to line them up with the green image. Although this automatic estimation generally works very well, it very occasionally goes badly wrong especially with images very poor in one colour (such as blue in Mars). Always look at the shifts displayed in the four edit boxes; the lower one should be roughly the negative of the corresponding upper one (such as 2 and -2). A difference of 1 is not uncommon, but when things go wrong the numbers can differ by 10 or more showing that something is wrong. The adjustment can be done manually by putting numbers in the edit boxes or using the buttons on the right-hand side which move the colours one pixel at a time..



Returning to the **Wavelet Options** tab, the most useful controls are some of the buttons on the right-hand side. These buttons work like check boxes in that press them and a window opens, press them again and the widow closes.

Histogram opens the histogram display window. This is a plot of the number of pixels contributing to a given brightness within the image, plotted against the brightness on a scale of 0 to 255. The vertical scale can be converted to a logarithmic one, which stretches the lower part of the display, revealing areas with very few pixels. Move the sliders to cut off the outer parts of the histogram and press **Stretch** and the brightness in this range is stretched to 0 to 255. Any pixel cut off at the lower end with be black, and at the upper end will be white.

RGB Balance opens a window displaying the three histograms for the colours. The logarithmic function will follow that in the histogram display and, if the histogram has been stretched, that will be reflected here too. Three sliders and three edit boxes are provided. The sliders move the corresponding colour along the

[4] Occasionally a box will get left behind on the edge of the image. Ignore it—it is not real and will go away.

histogram (altering its brightness), the edit boxes adjust the intensity of the colour[5]. The **Autobalance** button causes the system to balance the colours as best it can, and the **Reset** button resets the sliders and the edit boxes to their starting positions.

Wavelet Filter opens a window containing the controls which control the wavelets. For a detailed description of this feature, see the **Reference** section.

Gamma is a function with has an effect a little like stretching the histogram but does not cause saturation at either end. A gamma of one is neutral, a higher value increases the contrast in the darker areas of the picture and decreases it in the brighter parts. A gamma less than one does the opposite. Generally gamma between 0.7 and 1.3 are sufficient for most purposes. Sigmoid and other shapes of curve can be designed by adding control points and dragging the curve as desired.

Tone Map is a new feature of Version 4 of RegiStax. It is a complex function controlled by a simple graphical format that is described in more detail in the **Reference** section.

Resize Image opens a new window which gives an option of seven degrees of magnification from 10% to 200% and four different interpolation algorithms. Choose the algorithm that best suits your image. A button, **Original**, returns the magnification to 100% and another, **Save**, enables the resized image to be saved, in bmp or jpg formats only.

View Stacksize causes the image to change to areas of grey which reflect the size of the stack for that area. Moving the mouse pointer over an area causes the size of the stack to be displayed in the status bar.

Reference

RegiStax uses a system called “Wavelets”. Using the default settings Wavelet 1 contains information on the finest detail in the image, wavelet 2 contains information on slightly coarser detail and so on. So enhancement of wavelet 1 sharpens the finest detail in the image, enhancing wavelet 6 emphasises the coarser details. The page also includes a variety of other ways of enhancing the image.

In order to use the full power of wavelets it is helpful to understand how they work. A detailed description is given in Appendix 1.

Moving the mouse pointer over the image at any time displays, in the status bar at the bottom of the window, the x and y co-ordinates of the pixel at the pointer along with the number of frames contributing to that pixel (stacksize) and the averaged intensities of the red, green, and blue components of the pixel.

The page contains a set of buttons, the controls for the wavelets, and more controls on four tabs. Some of these functions do not work when using LRGB processing.

Buttons

Process. Under certain circumstances the wavelet functions have to be recalculated. This button does that.
Do All. To save time, functions initially are only applied to a Processing Area which is often less than the whole image. (Its size is set on the Alignment page.) Pressing this button forces the functions to be applied to the whole image. It is important to use this button prior to saving the image.
Realign with Processed. This returns you to the optimize page with the current image as the reference image.
Save Image. This saves the current image. A number of different formats are available, and the program will remember the last format that you used. **Do All** should always be used prior to **Save**—RegiStax may warn you if you haven’t but it may not.
Reset. This resets all wavelets to 1.0 and step to 0.

[5] The graphs may appear to do the opposite to what might be expected. This is caused by the scaling routine that plots the curves; the real effect can be seen on the image.

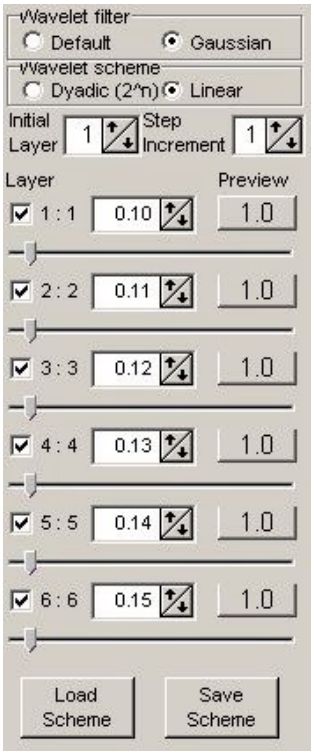
Wavelet Controls

Filter

Wavelets depend on a series of filters (for details see Appendix 1) and the program provides two ways of calculating these filters.

Default is the original version that will be familiar to users of the earliest versions of RegiStax. It makes use of a user-defined matrix available from the Wavelet Filter button.

Gaussian uses a Gaussian function to derive the filter. The user has control of the basic parameters of this filter available from the Wavelet Filter button, but can also control them directly here by means of the edit boxes for each wavelet. This filter has big advantages over the default filter; it is a finer filter, not restricted to a 5x5 pixel area and allows finer control over the layers.



Scheme

Linear. The wavelets increase in a linear fashion, that is each wavelet has a size which is **Step** bigger than the previous wavelet.

Dyadic. The wavelets increase in a geometric progression, that is the second wavelet is twice the first, the third is 4 times the first, the fourth 8 times the first and so on (2 to the power of the (number of the wavelet – 1)). This setting is mainly useful for large-scale objects such as nebulae, but linear and Gaussian probably give better control. Dyadic is a "left over" from previous versions of RegiStax.

Wavelets

Initial Layer. This edit box sets the starting point for the sizes of the wavelet filters.

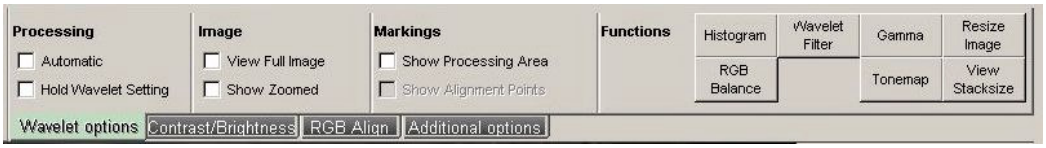
Step Increment. This controls the intervals between wavelets.

Layer. Six sets of a slider, a button, a check box, and for Gaussian an edit box, one for each wavelet. The enhancement factor for the wavelet can be changed by sliding the slider, or clicking on one side or the other of the slider, or with the cursor-control keys, which increase or decrease the value by 0.1. The factor is displayed on the button. Pressing the button shows on the image the effect that that wavelet will have by colouring green the areas which will increase, and red the areas which will decrease when the wavelet is enhanced. Double-clicking anywhere on the slider will reset the value to 1.0. Finally a check box can be used to disable the visible effect of the wavelet completely.

A button enables a wavelet scheme to be recorded in a file and another loads a scheme back again. This is useful if you want to set the wavelets the same for several images.

Tabs

1. **Wavelet Options**



A. **Processing**. Two check boxes

a. **Automatic**. Causes Process to be implemented automatically whenever it is needed. This will slow the system down and you may find moving the sliders somewhat more tricky with this set.

b. **Hold Wavelet Setting**. Normally when you start processing a new file, all the wavelet settings are returned to 1.0. Checking this box prevents that so that the last-used setting is retained. It does not prevent you from altering them manually but the system will always hold the last values you used.

B. **Image**. Two check boxes.

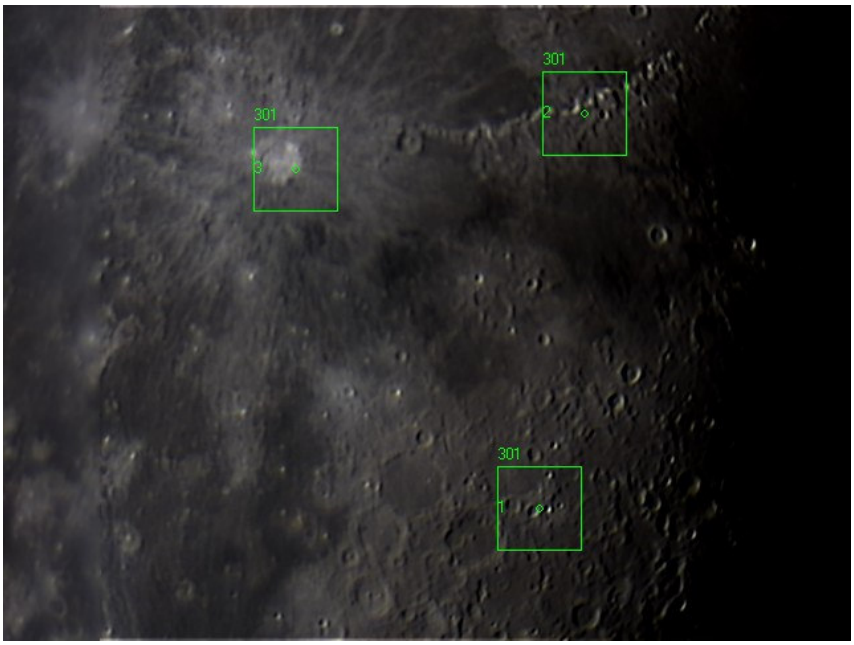
a. **View full image**. Large pictures are shrunk to fit the window, and small images are enlarged. Removing this check mark shows the image at its natural size.

b. **Show zoomed**. This opens an extra window showing an enlarged image of part of the main picture. It is controlled by pressing CTRL and moving the mouse over the picture until the right part of the picture is shown in the zoom window and then releasing CTRL. This enables you to see details of processing even if you have a very large image not all of which is on the screen because you have **View full image** selected.

C. **Markings**. Two check boxes.

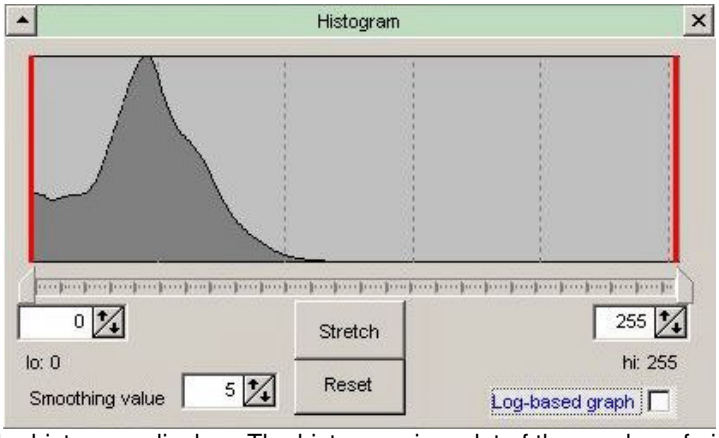
a. **Show Processing Area**. Not all the image may be processed when changes on this page are made if the processing area (set on the Alignment page) is smaller than the image. This control indicates the corners of the processing area. Removing the checkmark does not always remove the marks completely but **Do All** removes the remnants.

b. **Show Alignment Points**. This not only reveals the points themselves but also the alignment boxes. Each is numbered and also shows the number of frames stacked for that point.



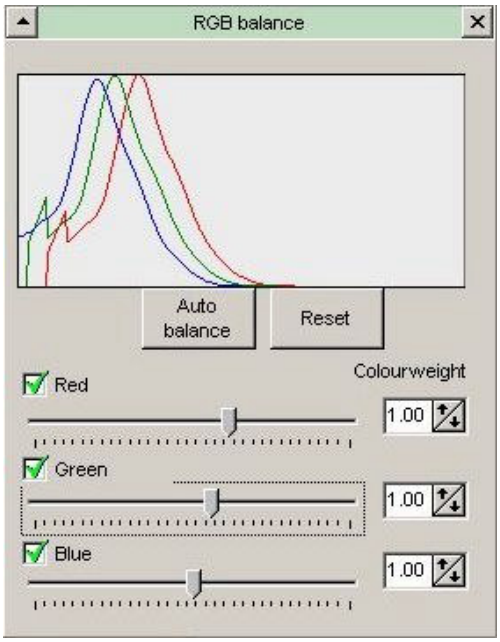
D. **Functions**. Six buttons which toggle extra windows. They work the same way as check boxes do, press the button and the window appears, press it again and the window vanishes.

a. **Histogram**.

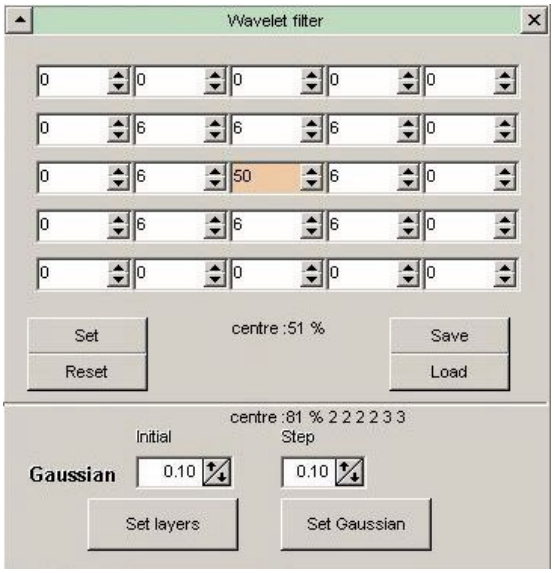


This opens the histogram display. The histogram is a plot of the number of pixels with a given value plotted against that value on a scale of 0 – 255. A checkbox enables the plot to be displayed on a logarithmic scale, which stretches the lower part of the display. This can be very useful if there is a big range of values, but must be treated with care. The range of the histogram can be altered in two ways, there are sliders that can be moved inwards, or numbers may be inserted into two edit boxes. The two are linked; change one and the other changes to match. The edit boxes will only display or accept integers. The Stretch button stretches the histogram to the limits indicated. The reset button resets it back to full width. Finally an edit box called "Smoothing value" controls the smoothing of the displayed curve by averaging the values over the number of positions either side.

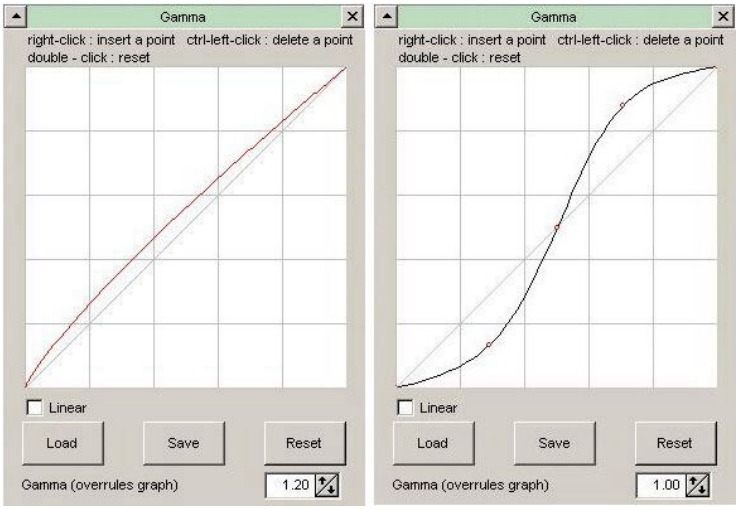
b. **RGB Balance**.
This used to be part of the histogram window in earlier versions of RegiStax. It has been separated out in this version so that the windows can be smaller. On colour images it shows the histograms for each colour and provides sliders and edit boxes for each colour which enable the histograms to be moved and scaled to balance up the colours if needed. This can be useful, for example, for colour images of the Moon where the colours are very subtle and only show up clearly with later enhancement. The sliders move the histogram left or right relative to the others (changing the brightness of the colour), the edit boxes control a scaling factor to increase or decrease the amount of the colour in the image (a bit like contrast) which also has an effect on the displayed histogram for that colour. **Auto balance** causes the program to try to align the peaks in the three histograms. Generally this works well but can give strange-looking results on some pictures, so use with care. **Reset** resets everything to their default positions. Stretching the histogram in the histogram window, or selecting log-based display there, affects these graphs also.



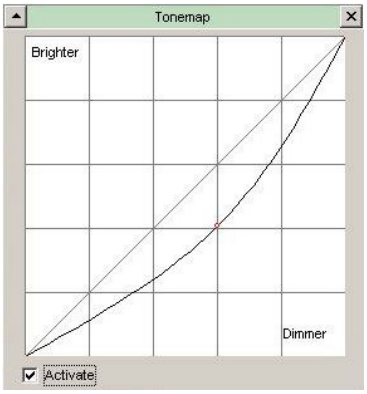
c. **Wavelet Filter**. This enables the form of the wavelet function to be modified, both for the default form and for the Gaussian form. (See Appendix 1 for details.) Changing the Gaussian parameters causes Gaussian to be selected as the active filter. Unlike the default filter the Gaussian filters can also be controlled from the wavelet slider section.



d. **Gamma**. The gamma curve is the relationship between the input intensity and the output intensity. The value can be changed using the edit box at the bottom and increased values cause the curve to move upwards making it concave to the X-axis. This increases the contrast in the darker parts of the picture and reduces it in the brighter parts. Values below 1.0 do the reverse. This very powerful function is made even more so by the ability to drag the curve into any shape one wants. To do this, control points are introduced onto the curve by clicking the right-hand button on the mouse and then dragging it using the left-hand button. As many such control points as desired can be inserted and so can control the curve to be any desired shape. In this way, sigmoid curves, for example, can be created which emphasise contrast in the middle of the intensity range whilst de-emphasising it in the brightest and darkest parts. Normally the program calculates a smooth curve through the control points but a check box, **Linear**, makes it draw straight lines between the control points. The curves can be saved or loaded using the corresponding button.



e. **Tonemap**.



Real images, both terrestrial and astronomical, have a dynamic range (the difference between the lightest and the darkest parts) which is greater than can be displayed on a monitor or printed on paper. Tone Mapping is an attempt to preserve detail whilst compressing the dynamic range and to allow for the fact that the human visual system sees colours differently depending on their surroundings. There are many algorithms to do this, none of which is perfect but all of which can do a good job in limited circumstances. RegiStax V4 provides a first attempt to incorporate one of these, packaged in a very simple-to-use graphical format. As far as the user is concerned, manipulating this graph is very much the same as manipulating the gamma curve—right click to add a control point, ctrl-left click to remove one. In this case one central point and two extreme ones are already defined and can be dragged about with the mouse. Generally dragging the central point downwards to the right will make the image darker, and dragging it up and to the left will make it lighter. The transformation routines acting behind the scenes use histogram-equalising routines and so there is no point where the image in unaffected. The checkbox **Activate** must be checked to implement the algorithms. The changes that occur are reflected in the histograms, both the general and the colour ones.

f. **Resize Image**. This opens a new window which shows a resized image. A choice of seven size factors from 10% to 200% is provided along with a choice of four interpolation algorithms. Choose

the one that seems to work best for you (RegiStax remembers this for next time). The widow provides a button (**Save**) to save the image, in either bmp or jpg format only, and another (**Original**) to resize to 100%. If the resize ratio is greater than 75%, the window expands to accommodate the image until it becomes too large for the screen when scroll bars appear.

2. Contrast/Brightness.

The panel contains the contrast and brightness adjusters. Each has a slider and an edit box, either of which can be used to adjust the contrast and brightness of the image. The up- and down-arrows in the edit boxes increment the contrast by ±5 or the brightness by ±2; increments of ±1 can be made by clicking on the control to one or other side of the slider (or with the cursor-control keys), and bigger changes by sliding the slider itself. A **Reset** button is provided to reset the contrast to 100 and the brightness to zero (the default settings). There is also a check box, **Hold Settings**. Normally when you start working on a new image, these controls are reset to their default settings. Checking this box holds the settings until RegiStax is reloaded. Checking this box does not prevent you from altering the settings; they will stay where you leave them.

3. RGB Align

Atmospheric refraction can cause the three colours of which the image is composed to be out of registration with each other. This function enables you to re-align them. Everything is done relative to the green channel, so only the red and the blue channels can be adjusted. The panel contains a number of buttons, check boxes, and edit boxes.

A. Check boxes.

a. **Show Area**. Alignment of colours takes place in a small area within the image. This control reveals this area as two coloured boxes. The system initially searches the larger area (yellow box) and refines its estimates in the inner area (green box) to find the best solution.
b. **Move RGB Align Area**. This enables you to move the mouse and see the align area move and place it where you want it. Sometimes the moving boxes leave a copy behind on the edge of the image. This has no function and can be ignored.
c. **Define RGB Align Area**. The default align area is the size of the original alignment area selected on the Align page. If this is not suitable, this control enables you to define your own by pressing the left button and dragging out a suitable rectangle. This defines the green box. This box can be moved just like the default box. Be aware, however, that if you do this you cannot reset the original default box, but you can define one similar to it of course.
d. **Show Red, Show Green, Show Blue**. These control the visible image and enable you to see each colour separately or in combinations by removing the check marks.

B. Buttons

a. **Estimate**. This automatically estimates the shifts necessary to bring the colours into alignment and the offsets are shown in the four edit boxes.
b. **Reset**. This resets the offsets to zero.
c. Eight buttons on the right-hand side which will move the colours one pixel up, down, left, or right and enable fine adjustments by hand if need be.

C. Edit Boxes

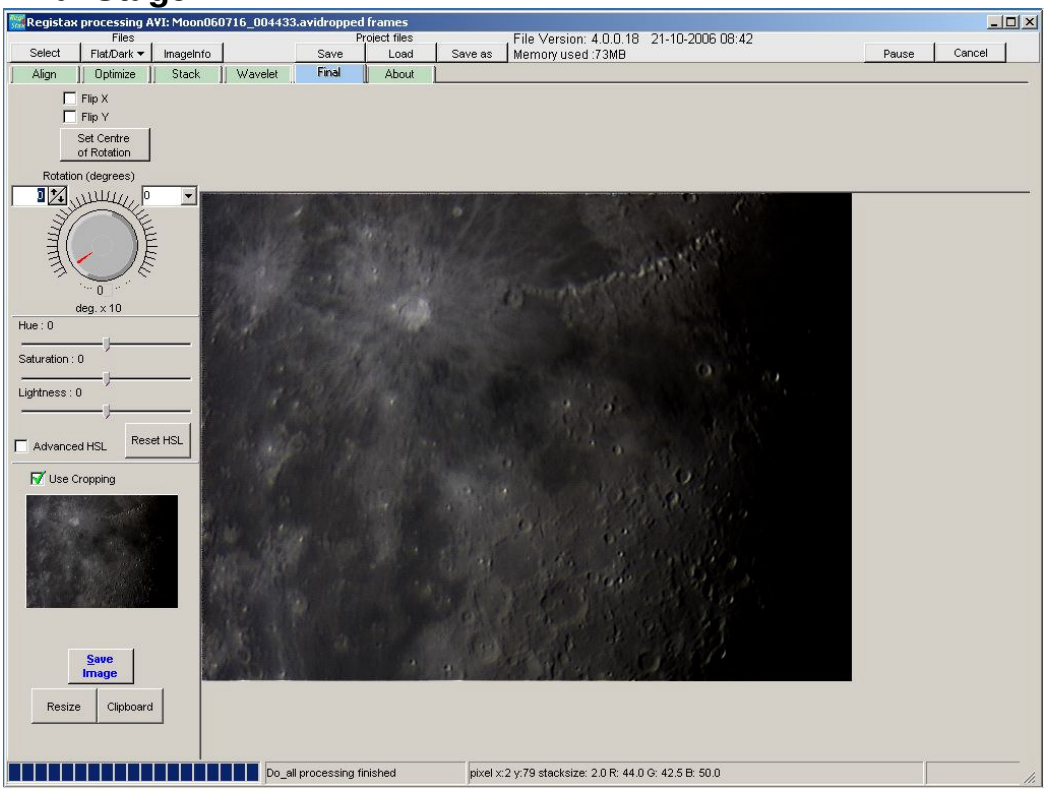
Four edit boxes contain the shifts in the red and blue channels and can be adjusted manually if necessary.

4. Additional Options. Three buttons and two radio buttons.

a. **Copy to Clipboard**. Copies the current image to the clipboard.
b. **Difference with Clipboard**. Pressing this displays the difference between the current image and that on the clipboard. Red indicates that the intensity is less, green that it is more (like when a wavelet Preview button is pressed). Do not expect this button to toggle; pressing it a second time does a second comparison—it does not revert to the original. To revert to the original, either press Do All or select a different Toggle button (see below).

c. **Toggle**
Current Image. Display the current image.
Clipboard Image. Display the image on the clipboard.
d. **View Stack Size**. This shows the alignment areas in tones of grey to indicate the size of the stack for each area. The actual size is displayed in the status bar at the bottom of the screen as the mouse pointer is moved over the area. Note that the joins for MAP processing will show up as brighter lines if feathering has been used.

The Final Stage



Finally a page which provides the ability to do some simple transformations on the final image, flipping, rotation, clipping, and sizing, and a powerful ability to modify the colours.

A. Flipping

Two check boxes enable the image to be reversed left-to-right (**Flip X**) or top-to-bottom (**Flip Y**). Checking both achieves a 180° rotation about the middle of the image. These functions are useful for pictures taken through telescopes with an odd number of mirrors.

B. Rotation

The centre of rotation can be selected by pressing the button **Set Centre of Rotation** and clicking on the image at the required point. Three controls are provided to control the rotation, two edit boxes and a rotary control. The first edit box, on the left, enables the degree of rotation to be set to any integer value. The second box gives a selection of values in 15° intervals. Finally a rotary control enables the degree of rotation to be set in intervals of 10°. Unfortunately when you use the **Save Image** button to save the image, if you choose bmp or jpg formats you will only save the image as you see it on the screen, and if you use any of the other formats, you will get the full picture but it will not be rotated.

C. Cropping

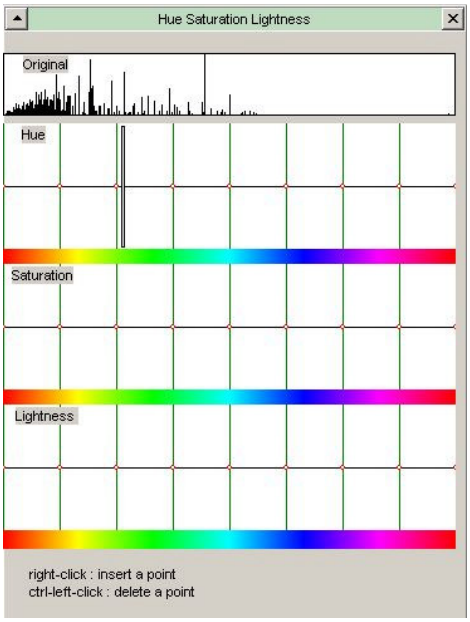
The mouse can be used to drag out a rectangular box on the image causing the **Use Cropping** checkbox to be checked, Then the image saved from here (in bmp or jpg formats only) or sent to the clipboard will be restricted to that rectangle. Removing the check mark will cause the box to disappear and the full image will be saved. Checking the box again will reactivate the same box even though it is not shown.

D. Sizing

A button, **Resize**, copies the button on the wavelet page. Resized images can only be saved in bmp or jpg formats.

E. HSL

Three sliders control the Hue, the Saturation and the Lightness of the colours throughout the image, and a button, **Reset HSL,** to reset them to their mid positions. A check box, **Advanced HSL**, opens another window which gives access to very powerful colour-modifying controls. The window is divided into four sections; the top section shows a histogram of the colours within the picture, and the other three concern the three HSL components. If the mouse pointer is moved over the image, a bar appears in the Hue area indicating where on the histogram above it the pixel at the pointer contributes. On entry, the lower areas may be blank, in which case drag the mouse across one and a grid appears on which are control points between which the program constructs a smooth curve. These control points can be dragged to produce any shaped curve and so control the hue, saturation and lightness of bands of colour. The two control points at the extreme edges are the same point so the function is circular. Take care not to drag a control point under a label; you may not be able to pick it up again. But **Reset HSL** will recover it.



F. Remaining Controls

Save Image saves the image but see the restrictions above concerning resized and rotated images. If the **Use Cropping** checkbox is checked, the image will be cropped before saving if, and only if, the format is bmp or jpg.

Clipboard sends the image to the clipboard. If **Use Cropping** is checked, the image is cropped before saving on the clipboard. This clipboard image cannot be viewed via the Additional Option on the wavelet page. If the image has been rotated, the image sent to the clipboard is exactly as seen on the screen.

Appendix 1 A detailed explanation of wavelets.

The system uses a series of filters which slightly blur the image. The first wavelet is created by multiplying the original image by the filter and then subtracting the original image from it. For the second wavelet, the filtered image from the first stage is substituted for the original image and the second filter is applied, the first-filtered image is subtracted and this gives the second wavelet. This process continues through to create the 6th wavelet leaving behind a very-highly filtered image. This may be summarised mathematically as:

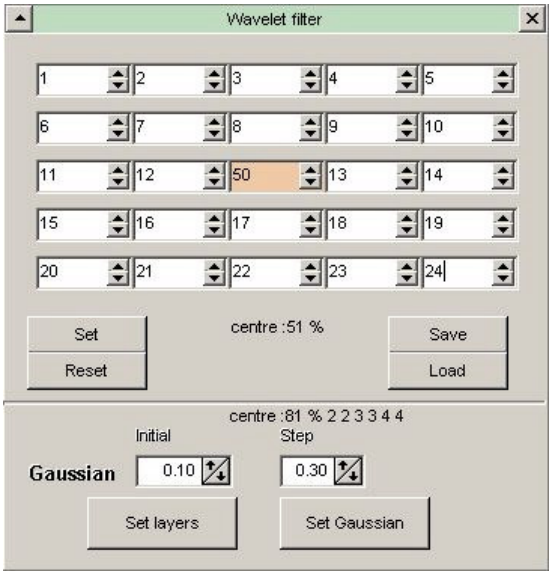
$$(\text{Filtered Image})_1 = (\text{Original Image}) \times (\text{Filter})_1$$
$$(\text{Filtered Image})_n = (\text{Filtered Image})_{n-1} \times (\text{Filter})_n \; (n=2\ldots6)$$
$$(\text{Layer})_n = (\text{Filtered Image})_n - (\text{Filtered Image})_{n-1}$$

The result of this is six images (or layers) and a heavily filtered image which will, when added together, recreate the original image. The net effect of all this is that the first layer, derived from the first wavelet, contains the finest detail of the image, and the successive layers contain coarser and coarser detail. Each layer is then multiplied by the factor set by the wavelet sliders before being added together to provide the final image. Thus enhancing the smallest wavelet will emphasise the finest detail in the image, the largest wavelet the coarsest detail. The effects of each layer can be displayed by pressing the **Preview** button.

Filters.

a. Default.

The filter is created by using the 5x5 matrix shown in Wavelet Filters. For the purpose of this explanation only, the numbers in the figure have all been made different. For a filter of value 1, these numbers are used to multiply the values of 25 pixels surrounding and including the pixel being treated. Thus this central pixel is multiplied by the central number (50, in the shaded box) and the surrounding ones are multiplied by the corresponding entry, i.e. the pixel above the central one is multiplied by 8, the one above that by 3, the one below the central pixel by 17 and so on. These numbers are then added and divided by the sum of the numbers in the matrix (350 in this case) and this is the value assigned to this pixel.



For the next wavelet, the value of the filter is 2 and a 9x9 matrix is created by using numbers in the above matrix twice. This the central, vertical column would read 3 3 8 8 50 17 17 22 22. For the wavelet of value 3, each cell is used three times to create a 15 x 15 matrix, and so on. Below the edit boxes is some text which indicates what proportion of the filter is contributed by the central pixel, 51% in the example above.

b. Gaussian

A Gaussian curve is a symmetrical, bell-shaped curve with a formal mathematical definition controlled by two parameters, the central value and a measure of the width. For the purpose of a wavelet filter, the curve is centred on the pixel under consideration and the width is specified by the entries in the two edit boxes at the bottom of the wavelet-filter window. This filter, therefore, allows the user a wide range of accurate filters because a Gaussian filter is not limited to a 5x5 matrix. The Initial entry is the width of the first wavelet, and the Step is the increment from one wavelet to the next. The actual step is the product of the two numbers, so that in the example above the actual step will be 0.03. These widths can be set independently by means of the edit boxes that appear on the main window above the sliders when Gaussian is selected. This ability to set the widths independently is an important power of the **Gaussian** scheme. Above the edit boxes is a string of numbers. These tell us that with this setting the central pixel provides 81% of the final value so there is only 19% contributed from surrounding pixels. The other numbers indicate the radii of the successive filters. In this example the first filter is five pixels wide (2*2 plus the central pixel) and the last is 9 pixels wide (2*4+1).

An example of something you can do with Gaussian filters that you cannot do with the default filter is the “trapping” of noise. To do it proceed as follows. Remove the check mark from the first wavelet. Move the slider of the second wavelet upwards until noise becomes apparent in the image. Now increase the size of the first filter slowly by increasing the value in the edit box using the up-arrow button until the noise disappears. All the noise is now trapped in the first wavelet which is disabled and hence does not contribute to the final image. If you increase the second wavelet later you may have to repeat the adjustment of the first.

Appendix 2: RegiStax running under Linux

RegiStax has been written and compiled to run under Microsoft Windows, but Linux users need not be denied the opportunity to use it. **RegiStax** can be run via **wine** (a recursive name standing for 'Wine Is not an Emulator').
wine provides an MS Windows API under Linux so that many MS Windows applications can function correctly while running under the Linux operating system. On a recent and correctly installed version of Linux, all that is necessary to run **RegiStax** is to click on the desktop icon that is generated when **RegiStax** is installed.
The notes below refer to observations made while installing and running **RegiStax** under SuSE Linux v10.1, using the KDE v3.5.1 desktop manager with **wine** version 0.9.11. **RegiStax** will also run under other desktop managers. On relatively slow PCs, it might be preferable to use a 'lightweight' desktop manager such as **fvwm**, **icewm** or **windowmaker**.
Not all Linux distros include **wine**, but it can be downloaded from:
<http://www.winehq.com/>
Installation/running of RegiStax on a Linux system:
1.If this is the first time that **wine** is to be used, make sure that it has been installed (for SuSE Linux use YAST), then as a normal user (ie. not as root) run the command **winecfg**. This will take a few minutes to generate local directories, files and font metrics (residing under the hidden directory ~/.wine). Subsequent use of **winecfg** will immediately display the **winecfg** configuration terminal.
2.To install **RegiStax**, move into the directory containing the 'installregistax??.exe' file and enter the command: 'wine ./installregistax??.exe'.
RegiStax will be installed under '~/.wine/drive_c/Program Files'
3.RegiStax v3 will load and will run, but some components of the GUI will be displaced, making it impossible use this version under **wine**.
RegiStax V2 and the upcoming **RegiStax V4** are displayed correctly and can be run as intended.
4.In order to get fonts to display correctly, it is necessary to copy the normal MS Windows .ttf font files to the ~/.wine/drive_c/windows/fonts directory. In the absence of these files RegiStax is usable, but GUI text items such as labels may not be optimally sized.
Under MS Windows 98, these .ttf files can be found in the directory C:\windows\fonts
5. Wine will automatically map MS Windows drive and directory locations (as shown by RegiStax and other MS Windows apps) to locations on a Linux system. These locations are shown and can be modified under the **winecfg** configuration terminal.
That's all! Quite simple, really.
Although recent versions of **wine** can be configured via **winecfg**, there should be no need to change anything from the default settings in order to run **RegiStax**. It is generally recommended that unless a specific version of MS Windows must be emulated, then **wine** should be configured to emulate Windows 98, which is OK in this case.
RegiStax is designed to run on a 1024 x 768 pixel screen and will not resize to fit larger (or smaller) screens. The Linux desktop screen display must therefore be set to at least 1024 x 768 pixels. There is no point in setting **wine** to emulate a virtual desktop.
There is no need to add any native MS Windows DLL files to the **wine** system.
Have fun!
K. Hough