# Stack Tools

## Purpose

This module offers a set of functions for image stacks. These functions are:

* [Simple stacking](#_Stacking) of layers from multiple files into a single image stack
* [Unstacking](#_Unstacking) an image stack into its separate layers
* [Aggregate values](#Aggregate_Stack) in an image stack by location; supported aggregations are sum, mean, median, min and max
* [Stack statistics](#Stack_Statistics): calculates basic statistics by location; supported are sum, mean, standard deviation, coefficient of variation, min and max
* [Remove bias](#Bias_Removal) by taking the mean from a reference image stack by location and subtracting this mean from the mean of the target stack. The target stack is then corrected by subtracting the bias from all the individual layers
* [Zonal percentiles](#Zonal_Percentiles) calculates one or more percentiles spatially per zone; the result is stored in a table. Optionally for each percentile a raster image is created.
* [Zonal ranking](#_Zonal_Ranking) calculates the spatial percentile (rank) of each location per zone; the result is an image with the same dimensions as the input. The rank values range from 0-100%.

## Installation

Install the .sav files in the save\_add folder (see also [ENVI .sav files: Installation and configuration](http://www.itc.nl/personal/nieuwenh/installations.html).

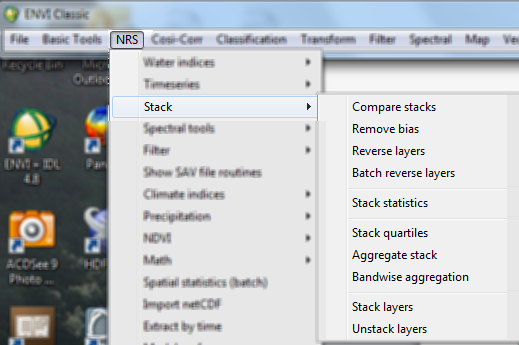
nrs\_Utils.sav Library with utility routines

nrs\_stack\_tools.sav The actual software

## Usage (gui)

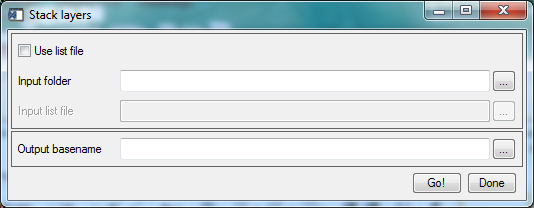
|  |  |
| --- | --- |
| NRS\_Stack\_gui | Start the user interface of the stacking. |
| NRS\_UnStack\_gui | Start the user interface of the unstacking. |
| NRS\_Aggregate\_gui | Start the user interface of the aggregation. |
| NRS\_Stack\_Statistics\_gui | Start the user interface of the stack statistics. |
| NRS\_Bias\_Removal\_gui | Start the user interface of the bias removal. |

Alternatively the commands can be started from the ENVI menu: ‘NRS | Stack’:



### Stacking

Menu option is ‘NRS | Stack | Stack layers’, the command line is ‘nrs\_stack\_gui’. This is a simpler function than the ENVI built-in layer stacking option. All input layers must have the same dimensions (rows and columns), the coordinate system is assumed to be the same (it is copied from the first layer to be stacked). The layers are simply stacked (in BSQ) without resampling. Below is the user interface.

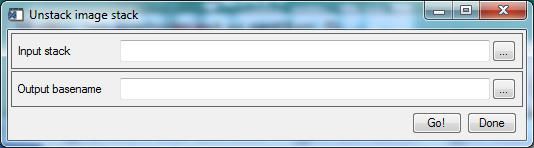


There are two options to initiate the stacking:

|  |  |
| --- | --- |
| Folder (Use file list not checked) | Select a folder: all ENVI files are scanned and used for stacking. The files are ordered alphabetically before the stacking, so the layer order is determined by this! |
| List file (Use file list checked) | Select a text file containing the layers to stack. The files are stacked in the order in which they appear in the list file. This gives more control to the user with respect to the order in which the layers are stacked. Also this option allows all image file recognized by ENVI as input. |

### Unstacking

Menu option is ‘NRS | Stack | Unstack layers’, the command line is ‘nrs\_unstack\_gui’. This is a simple command to extract all layers into separate files. Each file will be assigned the output base name with a number appended as the filename; the number increases for each file. No check is made on duplicate layer names. The layer name is copied to the output file as layer name. The output files are ENVI image files. Also the software creates a text file containing the names of the extracted layers. This can then for example be used as input for the above mentioned stacking command as the list file. This text file gets the base name of the output file.

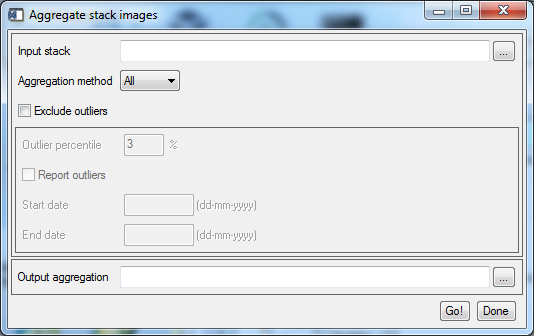


### Aggregate stack

Menu option is ‘NRS | Stack | Aggregate stack’, the command line is ‘nrs\_aggregate\_gui’. This command will on a per pixel basis aggregate the values in the stack. The output is an ENVI image with either a single layer (if one aggregation method is selected) or 5 layers (if the aggregation method ‘All’ is selected). The available aggregation methods are sum, mean, median, min and max, and the option ‘All’ to select them all at once.

The aggregation can be calculated by excluding outliers. The threshold for the outliers is set symmetrically at the lower and upper ends of the data values. So a percentile of 3 percent will only take into account the values ranging between the 3rd an 97th percentiles.

The position of the outliers in time and space can also be calculated. The size of the output cube is the same as the input: a value of 1 indicates an outlier. The name of the outlier data file is the name of the output aggregation appended with ‘***\_outlier***’.

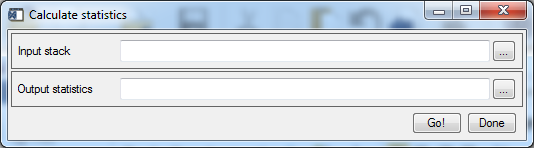


The output is an ENVI image. The layers get band names according to the aggregation method.

|  |  |
| --- | --- |
| Input stack | Select an image stack as input |
| Aggregation method | Select an aggregation method; currently supported: ***min***, ***max***, ***sum***, ***mean***, ***median***. If one of these is selected a single band image will be created. The option ***All*** will perform all aggregations at the same time. The output is a 5-band image; the band names indicate the aggregation method for the individual bands |
| Exclude outliers | Select this option if outliers should not be part of the calculation. |
| Outlier percentile | Define the threshold for the outliers values. The threshold is defined in terms of percentiles, it is applied both at the lower and at the upper ends of data values. |
| Report outliers | Select this option to generate an outlier report: this is a 3D-cube the same size as the input stack. For each location and date the value is set to one if the input value is an outlier with respect to the percentile thresholds |
| Start date | The date when the first band in the input stack was taken |
| End date | The date when the last band in the input stack was taken |
| Output aggregation | Define the output name of the result. By default the name is the name of the input post fixed with the aggregation method in case of a single aggregation, or post fixed with ‘*\_aggr*’ if the option ***All*** is selected. |

### Stack Statistics

Menu option is ‘NRS | Stack | Stack statistics’, the command line is ‘nrs\_stack\_statistics\_gui’. This command will on a per pixel basis calculate the statistics of the values in the stack. The output is an ENVI image with 5 layers, one for each of the statistics. The following statistics are calculated: mean, standard deviation, coefficient of variation, min and max. The layer names indicate the statistics value in that layer.



Explanation of the fields:

|  |  |
| --- | --- |
| Input stack | The input stack for the statistics calculation. |
| Output statistics | Name for the output statistics stack |

The statistics are calculated for each location (pixel).

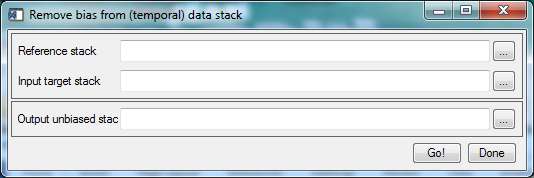
Mean:

Standard deviation:

Coefficient of variation:

### Bias removal

Menu option is ‘NRS | Stack | Bias removal’, the command line is ‘nrs\_bias\_removal\_gui’. This command will on a per pixel basis calculate the mean of the values in the reference stack. Again on a per pixel basis the bias value is then subtracted from all layers in the input target stack. The output is an ENVI image stack, with the same layer names as the target stack.



Explanation of the fields:

|  |  |
| --- | --- |
| Reference stack | The stack to calculation the bias from |
| Input target stack | The input stack to apply the bias correction to. |
| Output statistics | Name for the output stack |

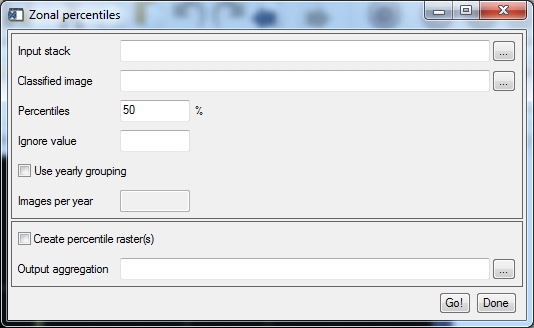
The statistics are calculated for each location (pixel).

Bias (mean of reference):

Output:

### Zonal Percentiles

Menu option is ‘NRS | Stack | Zonal percentiles’, the command line is ‘nrs\_zonal\_percentiles\_gui’. This command will calculate one or more percentiles per zone for each location.



Explanation of the fields:

|  |  |
| --- | --- |
| Input stack | The input stack (usually a time series) |
| Classified image | The raster image containing the different zones. This is usually a classified image |
| Percentiles | A comma separated list with one or more percentiles. The values should be specified as values between 0 and 100. |
| Ignore value | The value in the input to ignore (optional) |
| Use yearly grouping | Check this to allow the percentiles to be calculated per year (in case of multi-year stacks) |
| Images per year | If the ‘*Use yearly grouping*’ specify the number of images per year |
| Create percentile raster(s) | Check this to calculate raster images for each of the percentiles |
| Output aggregation | Name for the output percentile table |

The output table is a text table (CSV formatted) with a number of columns equal to the number of bands in the input stack plus 2.

Column one (Percentile) contains the user specified percentile(s), here 25% and 40%. Column two contains the zone (Class) from the classified image, here classes 1 to 5. Column one and column two are the primary key of the table.

The remainder of the columns match the bands in the input stack, here Band\_1 to Band\_7. The values indicate the percentile value in a band for each zone.

A small sample:

Percentile,Class,Band\_1,Band\_2,Band\_3,Band\_4,Band\_5,Band\_6,Band\_7

25,1,96,97,98,98,100,101,103

25,2,90,88,86,81,77,76,78

25,3,88,87,87,86,86,85,86

25,4,98,99,99,98,99,98,98

25,5,109,110,113,115,118,120,122

40,1,99,100,101,102,104,106,108

40,2,96,94,92,86,82,81,83

40,3,92,91,91,91,90,89,90

40,4,102,103,103,103,103,103,103

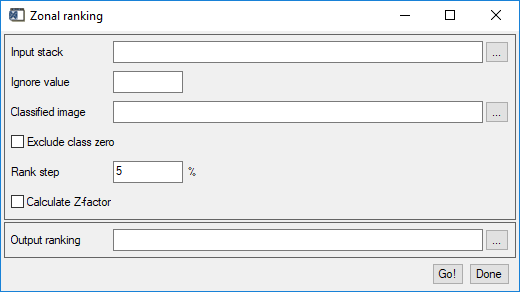
40,5,113,115,118,121,124,127,129

…

### Zonal Ranking

Menu option is ‘NRS | Stack | Zonal ranking, the command line is ‘nrs\_zonal\_ranking\_gui’. This command will calculate the temporal percentile rank per band and zone for each location. This is done by processing each zone over all bands in the input stack as one dataset:

* Per zone (class) extract the values from all input bands
* Using a histogram sort the extracted values into as many bins as specified by the resolution step (5% gives 100% / 5% = 20 bins);
* Each bin contains the original locations of all the values in the bin.
* Each bin represents exactly one rank.
* Assign the rank of the bin to all original locations collected within the bin.



Explanation of the fields:

|  |  |
| --- | --- |
| Input stack | The input stack (usually a time series) |
| Ignore value | The value in the input to ignore (optional) |
| Classified image | The raster image containing the different zones. This is usually a classified image |
| Exclude class zero | Exclude value zero in the class image (optional); this is useful for non-ENVI classified images, where class zero is the no data value. For ENVI classified images this option is disabled (because not needed) |
| Rank step | The minimum rank step. The value should be specified as a value between 5 and 100. |
| Calculate Z-factor | For each of the classes determine the Z-factor |
| Output ranking | Name for the output raster stack; if not specified the software defines it as the name of the input image with ‘\_rank’ appended to the basename |

The rank step determines the minimum ranking resolution of the ranking.

The Z-factor is calculated for each zone as (from <https://en.wikipedia.org/wiki/Standard_score>):

Z-factor =

Where:

x: the image values in the selected zone over the entire stack

: the average of x

σ: the standard deviation of x

The Z-factor is stored in a separate image with the same dimensions as the ranking. The filename of the Z-factor image is the name of the ranking with ‘\_zfact’ appended to the basename