Change Detection standalone software description: MADChange and WishartChange

Behnaz Pirzamanbein[1] and Allan A. Nielsen[1]

[1]Department of Applied Mathematics and Computer Science, Technical University of Denmark, Denmark

Contents

1 Introduction

This tutorial describes two standalone software which perform change detection analysis on multi-spectral optical and Synthetic Aperture Radar (SAR) images. MADchange uses Iteratively Reweighted Multivariate Alteration Detection (IRMAD) method to detect changes in optical images and WishartChange performs omnibus test statistics to detect changes in SAR images.

Both software are available in two versions: 1) Graphic user interface (GUI) app and command-line executable. These software support Windows, Linux and Mac operating systems.

2 Installation

To run the executable files users **first** need to download and install the MATLAB Runtime installer from

- MATLAB Website: `https://se.mathworks.com/products/compiler/matlab-runtime.html`, or
- Packaged_intaller folder

Thereafter users can install the app and run the commandline executable files. Note that Linux users have to make sure that the executable bit is set on both the command line and app files, i.e. MADChange_DataBio_Linux, run_MADChange_DataBio_Linux.sh, WishartChange_DataBio_Linux and run_WishartChange_DataBio_Linux.sh.

3 MADChange

MADChange detects changes over time in multi- or hyper-spectral data as acquired from space or airborne scanners covering the same geographical region. The MADchange also known as the iteratively reweighted multivariate alteration detection (IRMAD).

The method is based on a series of iterations maximizing the variance of the difference between the linear combination of these two data sets. In each iteration, the algorithm places the focus on no-change observations thus establishing an increasingly better background of no-change against which to detect change.

3.1 Command line

Executable file:

Windows MadChange_commandline.exe

Linux run_MADChange_commandline.sh

Mac

Input:

images_t1 a multispectral image (path and name) or a list containing different band of an image (path and name, the name contains name.band_name_t1.extension) at time one
Example in Windows:
C:\Download\image_t1.B1.tif,C:\Download\image_t1.B2.tif,C:\Download\image_t1.B4.tif,
C:\Download\ image_t1.B8.tif
the program support geotiff, envi and emi images/extensions

images_t2 a multispectral image (path and name) or a list containing different band of an image (path and name, the name contains name.band_name_t2.extension) at time two.

band_name_t1 list of image bands' name at time one

band_name_t2 list of image bands' name at time two

opts [PCs,epsln,size_image,flag_mask,low_value,dimWin,flag_roc,flag_save]

epsln epsilon for iterations. Insert 100 to apply 0 iterations, default value 0.01.

size_image an indicator; based on the dimension of the data set it is possible to select a different processing strategy:
0 - the whole data set is read and save in the workspace
1 - the data set is read line by line from files (less memory used but it takes more time)
default value = 0

flag_mask an indicator;
1 - to choose the mask threshold between the 1st and 2nd distribution
2 - to choose the mask threshold between the 2nd and 3rd distribution
3 - to use the principal component instead of the original data set

0 - no mask

default value = 0

low_value value in % to mask the low values of the histogram, 0 no mask

dimWin window dimension for the filter used in post-processing to perform a misregistration errors recovery

Example: 3 for a 3x3 window, 5 for a 5x5 window and 0 for no one.

default value = 0

flag_roc an indicator;

0 - to not perform the ROC (a ground truth is required)

1 - to perform the ROC

flag_save an indicator;

0 - to save the chi square files

1 - to save the chi square and the intermediate files

save_name name to be added to the saved files

path_name path where to save files

Output:

By default:

mads the MAD variates

chi2_irmad Chi-Square obtained by using cvs

On request:

ICMmask initial change mask (pre-processing)

cv1 canonical variates 1 unit variance

cv2 canonical variates 2 unit variance

Syntax:

- Windows

```
>cd␣\path\to\MADChange.exe
>MADchange.exe␣images_t1␣images_t2␣band_name_t1␣band_name_t2␣opts␣save_name␣path_name
```

- Linux

```
$cd␣/path/to/run_MADChange.sh
path/to/runfile$MADchange.sh␣path/to/MATLAB_Runtime/v94␣images_t1␣images_t2␣band_name_t1␣b
␣save_name␣path_name
```

- Mac

Example:

- Windows

```
C:\Users\path\to\MADChange.exe>MADChange.exe␣path\to\image_t1.B2.tif,
    path\to\image_t1.B3.tif,path\to\image_t1.B4.tif,path\to\image_t1.B8.
    tif path\to\image_t2.B2.tif,path\to\image_t2.B3.tif,path\to\image_t2
    .B4.tif,path\to\image_t2.B8.tif B2,B3,B4,B8 B2,B3,B4,B8
    0.01,0,0,0,0,0,1 test_result C:\Users\path\to\save
```

- Linux

```
path/to/runfile$ ./run_MADChange.sh /tmp/MATLAB/MATLAB_Runtime/v94 /
  path/to/image_t1.B2.tif,/path/to/image_t1.B3.tif,/path/to/image_t1.B4
  .tif,/path/to/image_t1.B8.tif /path/to/image_t2.B2.tif,/path/to/
  image_t2.B3.tif,/path/to/image_t2.B4.tif,/path/to/image_t2.B8.tif B2,
  B3,B4,B8 B2,B3,B4,B8 0.01,0,0,0,0,0,1 test_res /tmp/output
```

- Mac

3.2 App

Executable file:

Windows MadChange_app.exe

Linux run_MADChange_app_Linux.sh

Mac

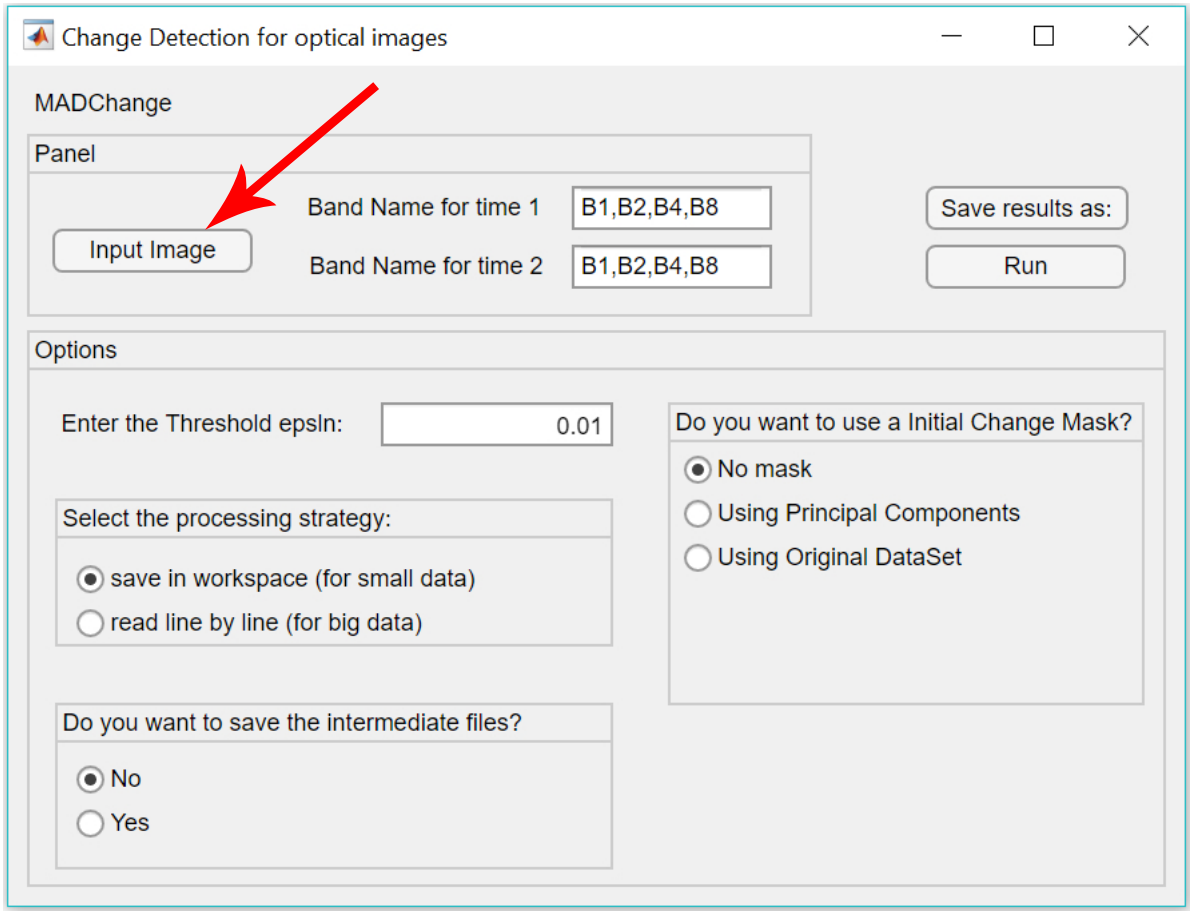

Figure 1: Graphical User Interface App

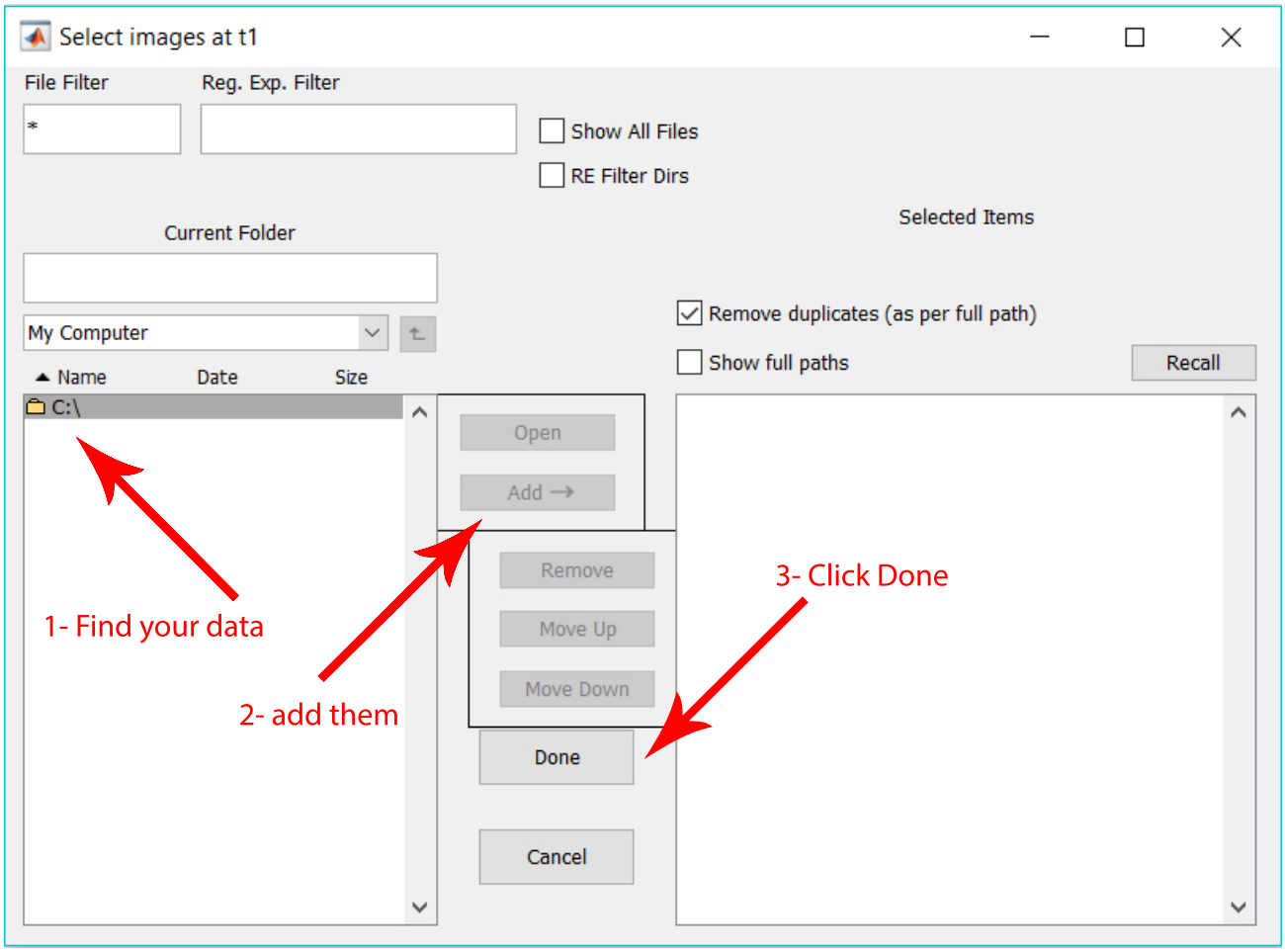

Figure 2: Input Windows

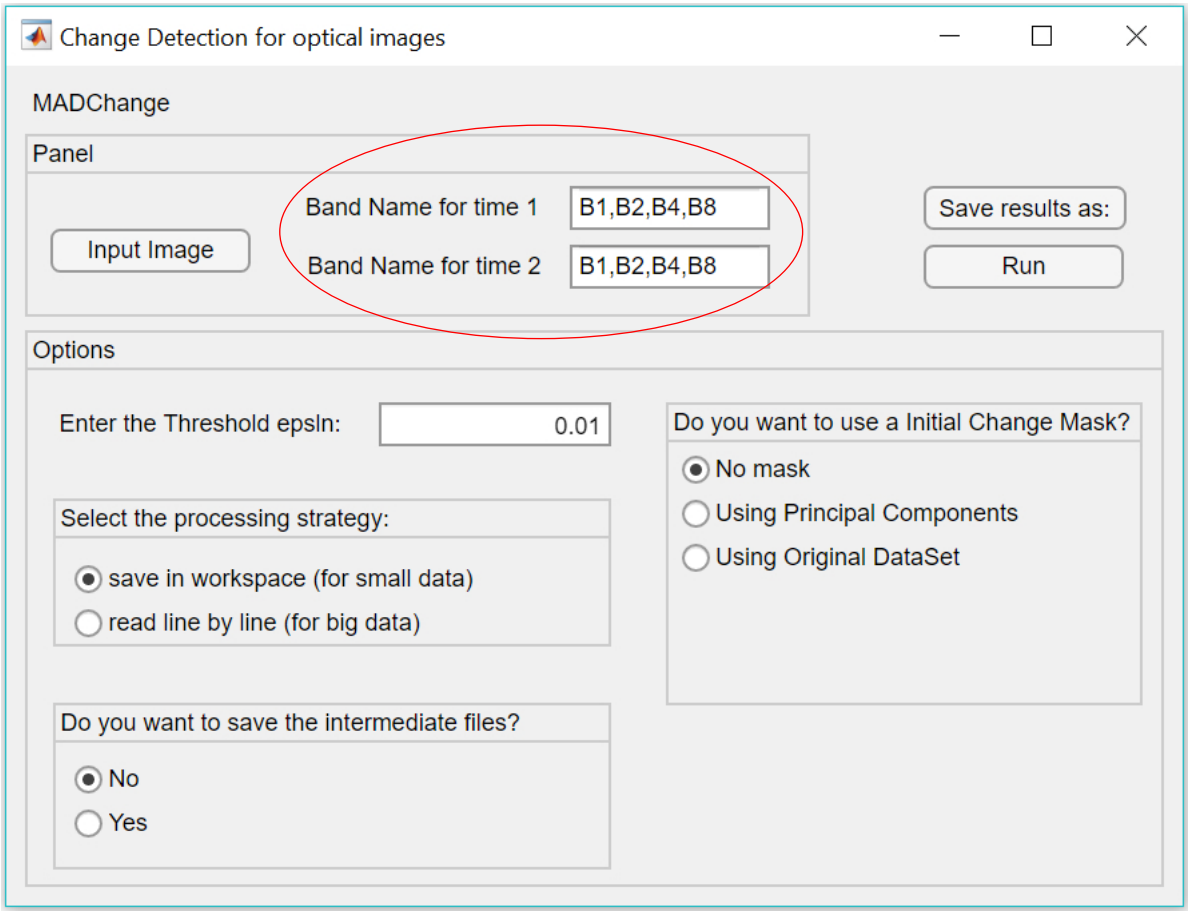

Figure 3: Add band names of the inserted images

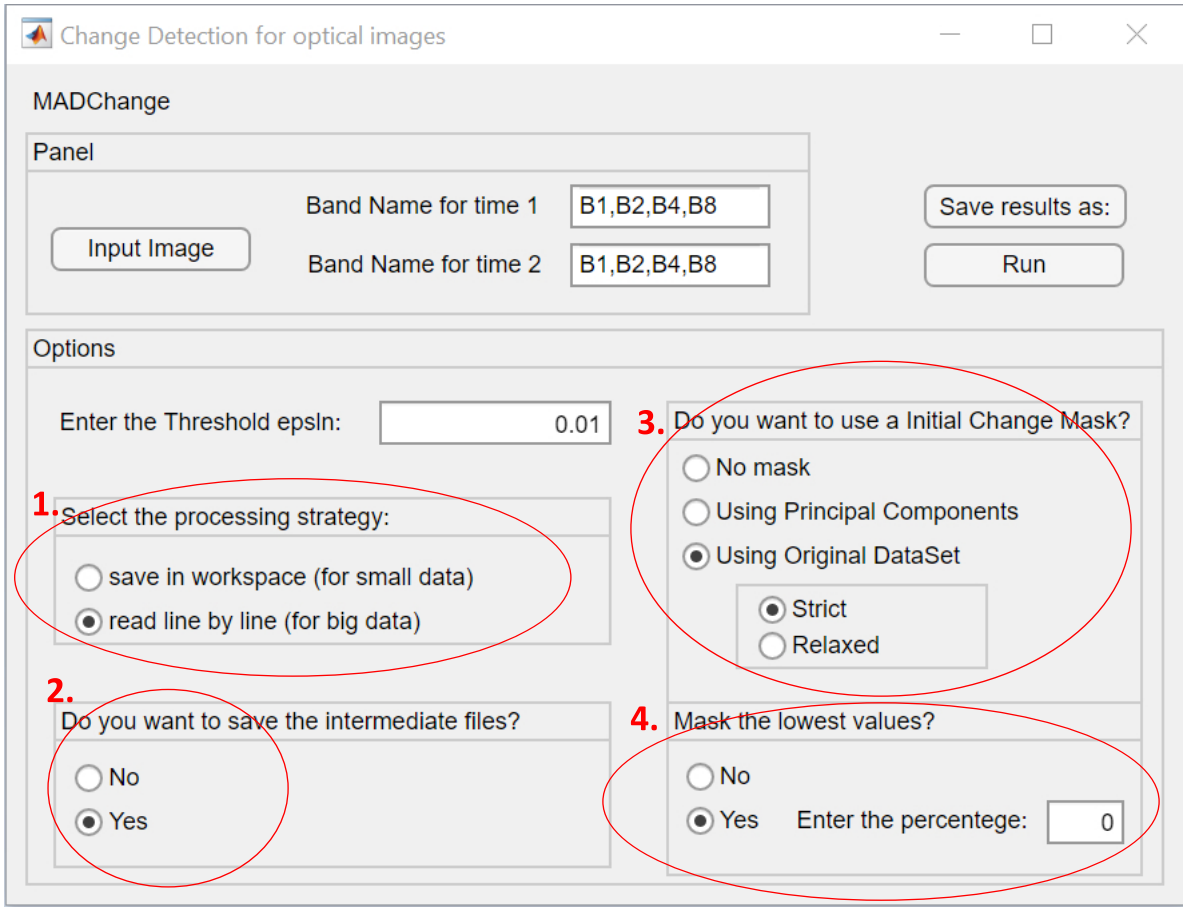

Figure 4: Options: 1. select the processing modality, for small data you can save the images on the workspace and for big data choose the "read the images line by line", 2. output all the files (see output section). Two preprocessing options: 3. Mask the strongest changes and 4. mask the lowest value related to dark regions and enter the percentage, e.g 5 means the 5% of the lowest value will be excluded from computation.

4 WishartChange

WishartChange is a method to detect changes in a time-series of (polarimetric) synthetic aperture radar (SAR) images. SAR data often come from on-board instruments such as, Sentinel-1, Radarsat-2, TerraSAR-X and etc. Applying this method on SAR data, for example Sentinel-1 data with a revisit time of six days to the same site, is useful in forestry and agricultural applications where the day-and-night, all-weather capability of radar is needed, and where a spatial resolution of 20m is sufficient.

Each pixel in SAR images is represented by a 3 by 3 (quad or full polarization) or a 2 by 2 (dual polarization) covariance matrix. For each pixel, WishartChange carries out a series of statistical tests to quantify the equality of these matrices over time. Rejection of the hypothesis of equality is interpreted as a change. Moreover, the method computes different aspect of changes such as, number of time changes occur per pixel, the time of the occurrence of the first change and the time of occurrence of the last change occur.

4.1 Command line

Executable file:

Winodws WishartChange_commandline.exe

Linux run_WishartChange_commandline_Linux.sh

Mac

Input:

images a list of images (path and name) where name contains name.pols_names_times_name.extension
Example for Windows users:
C:\Download\image.VV_0.tif,C:\Download\image.VV_1.tif, C:\Download\image.VH_0.tif,
C:\Download\image.VH_1.tif
and so on, the program support geotiff, envi and emi images/extension

npols a number represent the polarization type i.e.
$9 = 3 \times 3$ full polarization
5 = azimuthal symmetry
$4 = 2 \times 2$ dual polarimetry
3 = full Diagonal
2 = dual diagonal

1 = single

Note: the covariance matrix is symmetric and of form

$$\begin{pmatrix} \text{HHHH (real)} & \text{HHHV (complex)} & \text{HHVV (complex)} \\ & \text{HVHV (real)} & \text{HVVV (complex)} \\ & & \text{VVVV (real)} \end{pmatrix}$$

pols_name a list containing the name of polarizations

Example: VV,VH

times_name a sequence of number 0,1,2,3,4 or a list of personalize numbers such as 062,064,067

Nol Number of looks

Pvalue a significant threshold for p-test

times Number of times

flag_size an indicator; if 0 save the file in workspace if 1 read line by line

flag_area an indicator; if 1 read the whole area of the image, if 0 read the region of interest (ROI)

file_figure name of the figure to be saved

file_table name of the table to be saved

shape_file the function accept either 0 for the case of choosing the ROI interactively or (path and name) of the shape file to be read as ROI

output:

By default:

P-value table of p-values in .csv format

changes map plot of first and last changes plus frequency of the change both as .pdf and 3 bands geotiff

Syntax:

- Windows

```
>cd␣\path\to\WishartChange.exe
>WishartChange.exe␣images␣pols_name␣times_name␣Nol␣Pvalue␣times␣strategy
whole␣opt␣file_figure␣file_table␣shape_file
```

- Linux

  ```
  $cd␣/path/to/run_WishartChange.sh
  path/to/runfile$Wishartchange.sh␣path/to/MATLAB_Runtime/v94␣images␣pols_name
  times_name␣Nol␣Pvalue␣times␣strategy␣whole␣opt␣file_figure␣file_table␣shape_file
  ```

- Mac

Example:

- Windows

```
C:\Users\path\to\WishartChange.exe>WishartChange.exe$\color{white}_\
    sqcup$path\to\image.VH_0.tif,path\to\image.VH_1.tif,path\to\image.
    VH_2.tif,path\to\image.VH_3.tif,path\to\image.VH_4.tif,path\to\image
    .VH_5.tif,path\to\image.VH_6.tif,path\to\image.VH_7.tif,path\to\
    image.VH_8.tif,path\to\image.VH_9.tif,path\to\image.VV_0.tif,path\to
    \image.VV_1.tif,path\to\image.VV_2.tif,path\to\image.VV_3.tif,path\
    to\image.VV_4.tif,path\to\image.VV_5.tif,path\to\image.VV_6.tif,path
    \to\image.VV_7.tif,path\to\image.VV_8.tif,path\to\image.VV_9.tif 2
    VH,VV 0,1,2,3,4,5,6,7,8,9 4.9 0.9999 10 1 1 test test 0
```

- Linux

```
path/to/runfile$ ./run_WishartChange.sh /tmp/MATLAB/MATLAB_Runtime/v94
  /path/to/image.VH_0.tif,/path/to/image.VH_1.tif,/path/to/image.VH_2.
  tif,/path/to/image.VH_3.tif,/path/to/image.VH_4.tif,/path/to/image.
  VH_6.tif,/path/to/image.VH_7.tif,/path/to/image.VH_8.tif,/path/to/
  image.VH_9.tif,/path/to/image.VV_0.tif,/path/to/image.VV_2.tif,/path/
  to/image.VV_3.tif,/path/to/image.VV_4.tif,/path/to/image.VV_5.tif,/
  path/to/image.VV_6.tif,/path/to/image.VV_8.tif,/path/to/image.VV_9.
  tif,/path/to/image.VH_5.tif,/path/to/image.VV_1.tif,/path/to/image.
  VV_7.tif 2 VH,VV 0,1,2,3,4,5,6,7,8,9 4.9 0.9999 10 1 1 test test 0
```

- Mac

4.2 App

Executable file:

Windows WishartChange_app

Linux run_WishartChange_app_Linux.sh

Mac

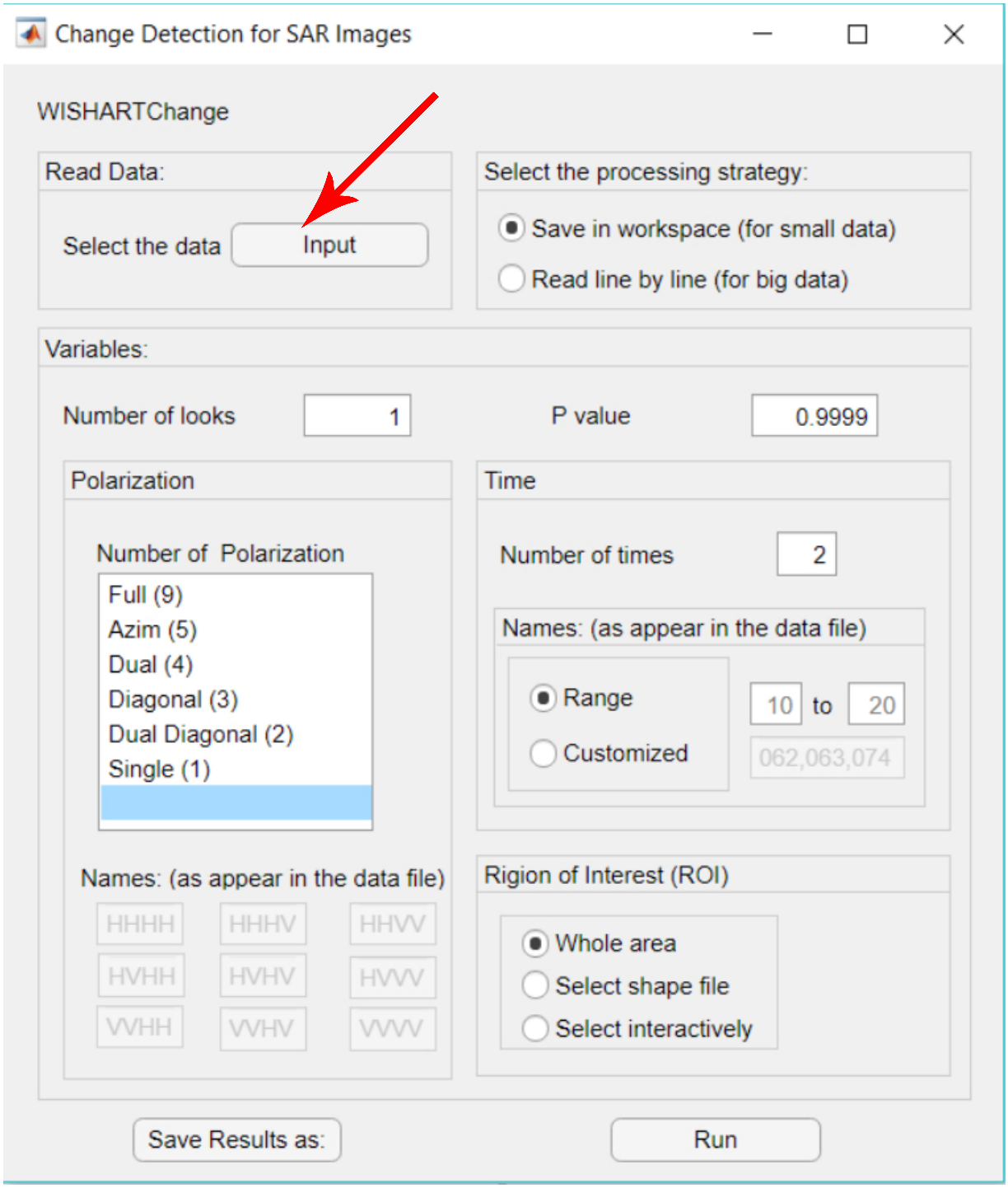

Figure 5: App User Interface

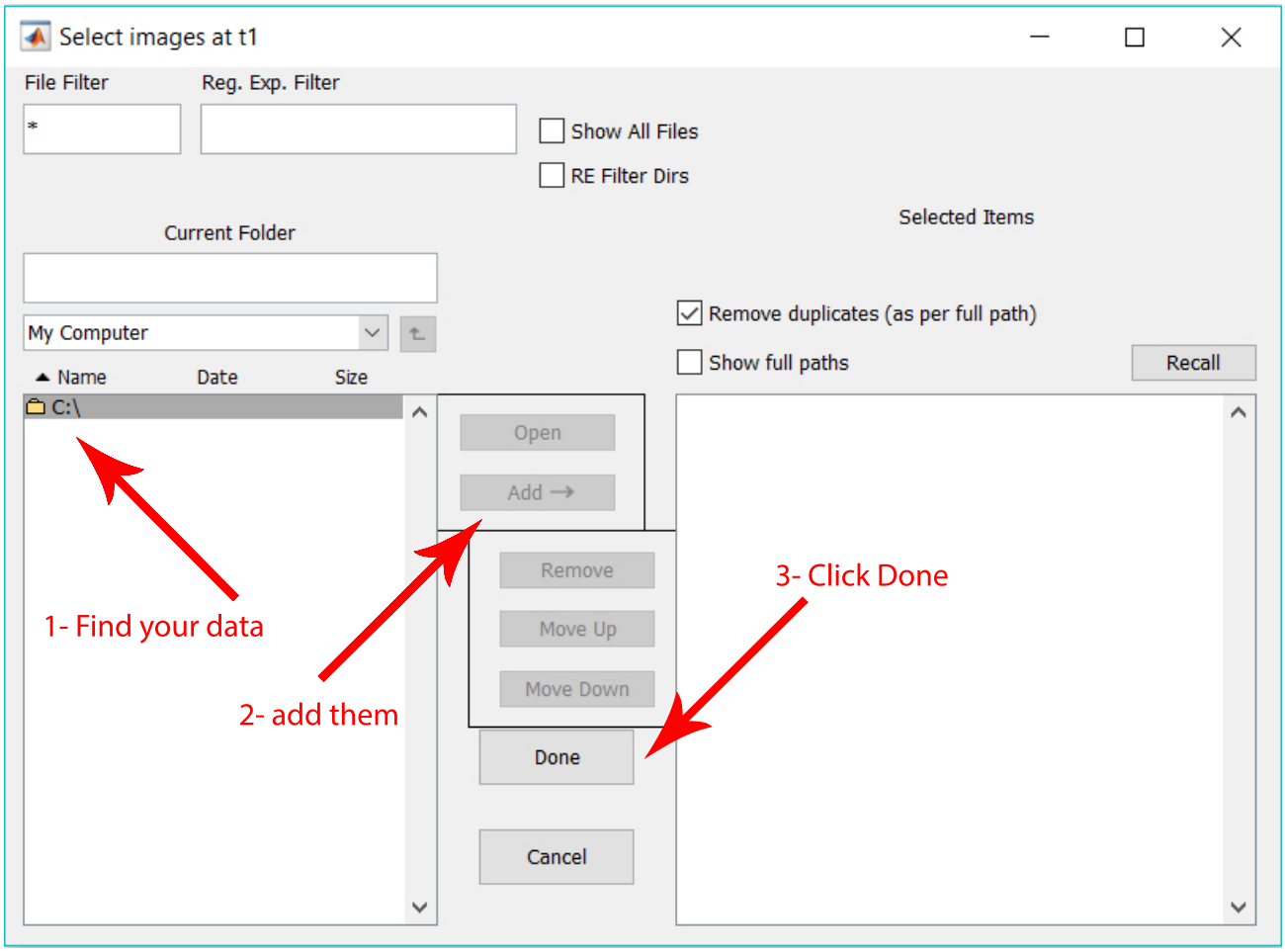

Figure 6: Input Windows

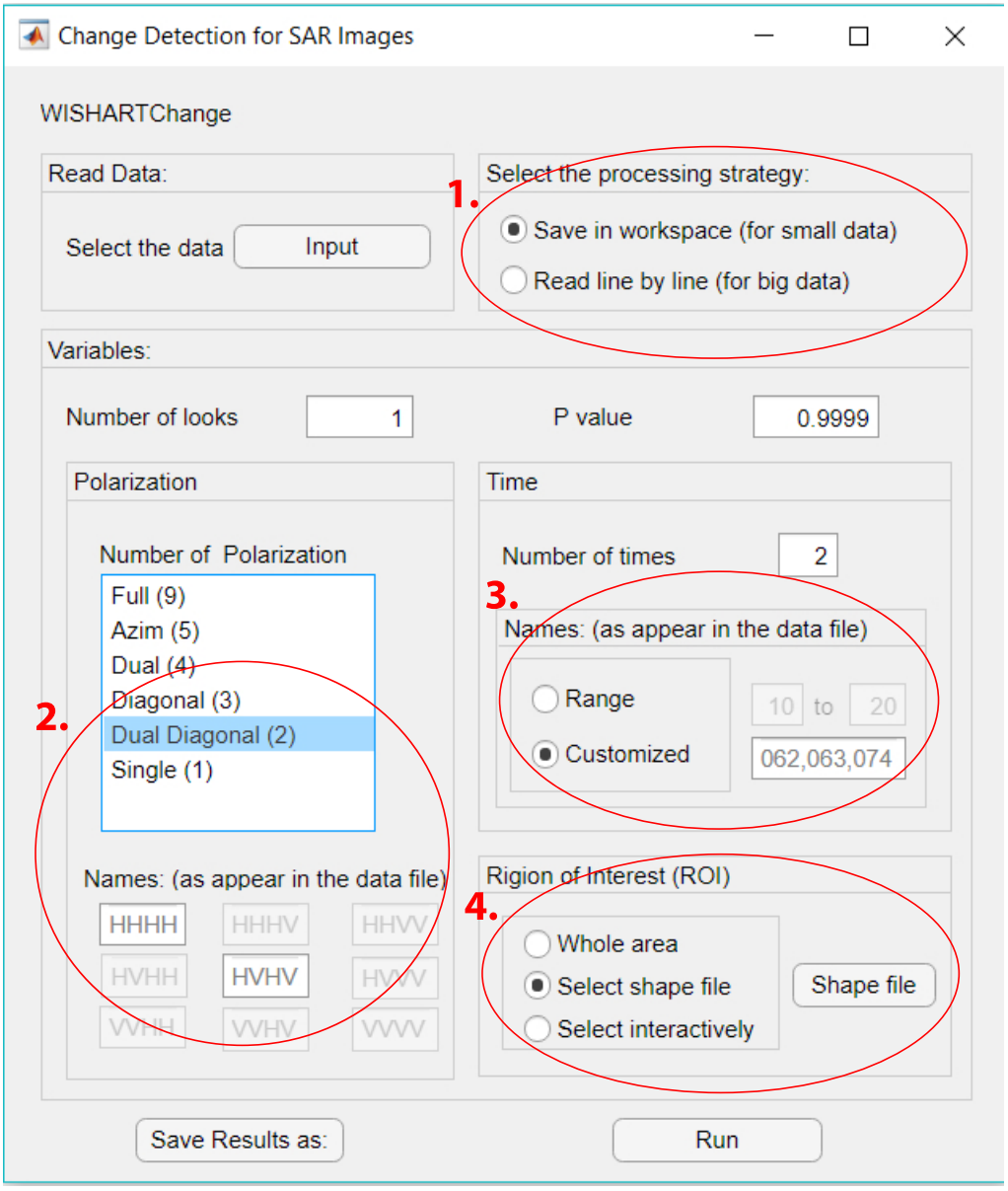

Figure 7: Options: 1. select the strategy, for small data it will save the images on the workspace and for big data it read the images line by line, 2. enter the right polarization and the name of it as appear in the file name, 3. names of the different time as appear in the file name, e.g. if it is a sequence use 0 and 10 and if its customized name use 062,063,064 4. choose the region of interest, for example if there is a shape file add that or if users want to interactively choose an area from the last changed map.

5 Acknowledgement

This work is funded by, DataBio, the European Unions Horizon 2020 research and innovation programme under grant agreement No 732064.