Installation of MasTer

**(FOR Linux DISTROS)**

*Installation guide by:*

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## Preliminary information

**MasTer tool** is a set of mostly shell scripts aiming at processing automatically a large number of interferometric pairs and feeding and running the **MSBAS** processor [Samsonov and d’Oreye, 2012, 2017; Samsonov et al., 2017, 2020] in order to obtain the desired deformation maps and time series in vertical and horizontal components. Geocoded amplitude, coherence, interferometric phase and deformation maps are computed using the **MasTer Engine**, a command line InSAR processor derived from the Centre Spatial de Liege (CSL) InSAR Suite (CIS) [Derauw, 1999; Derauw et al, 2019].

This guide explains the installation procedure for **MasTer (MasTer tool, MasTer Engine, MSBAS)**, on a Mac computer. It does not replace the manual file provided with the software distribution (MassProcess\_notes\_Distro\_4.0.DOCX), but rather provide much more details to allow any user with less-advanced knowledge of the Mac environment to properly install the software suite.

The installation procedure has been last tested with the **MasTerEngine\_v20220929** package, msbasv3 (20190121), msbasv4 (20201009) and shell scripts dated from October 2022.

**Sources and codes** are available from Github at repositories by ndoreye. If accesses are private, ask [ndo@ecgs.lu](mailto:ndo@ecgs.lu) for being granted the access.

Gitkraken is a convenient interface for Github but is not mandatory.

**Download :**

* the documentation and manuals from ndoreye/DOCS
* the scripts from ndoreye/SCRIPTS\_OK repository
* the MSBAS sources from ndoreye/MSBAS (also available directely from S. Samsonov; see manual)
* the MasTerEngine sources from ndoreye/\_Sources\_ME (also available directly from D. Derauw; see manual)

This installation procedure as be tested on :

* **Ubuntu 22.0.4 LTS**

though former installations were operational.

**It is assumed that the user has the administrator rights** on the computer and can provide the root privilege when the “sudo” command is executed in the terminal.

In this installation guide, each command line that has to be written and executed in a terminal is written in *italic blue*. Files names are in blue. Paths are given in green.

Note that a script exists to assist you making the installation (at least for Debian OS). See …/SAR/MasTerToolbox/SCRIPTS\_OK/zz\_Utilities\_CIS/***MasTer\_install.sh***.

Read carefully all the text and questions displayed by the script.

For other type of Linux OS, you may need to adapt the script or proceed manually by adapting the procedure below.

Note that the ***MasTer\_install.sh*** installation script may be run several times (either to correct a problem during the installation or to perform an update of any element at any time). However, if some elements were installed manually (eg Gitkraken, Fiji or QGIS…), the script may not properly detect them as they may have been installed in an expected. This must not be a problem though.

**Kind reminder:** The software is provided for free. To help us carrying on with the development of the tool, we kindly ask you to cite the **MasTer Toolbox** in publications that contains results produced by the toolboxthanks to at least the most recent references from below:

*For MasTer Engine*

* Derauw, D., (1999). Phasimétrie par Radar à Synthèse d’Ouverture; théorie et applications. PhD Dissertation, University of Liège, 141 pages.
* Libert, L., Derauw, D., d’Oreye, N., Barbier, C., Orban, A., (2017). Split-band interferometry-assisted phase unwrapping for the phase ambiguities correction. Remote Sensing, 9(9), 879.

*For MSBAS*

* Samsonov, S., d’Oreye, N., (2012). Multidimensional time-series analysis of ground deformation from multiple InSAR data sets applied to Virunga Volcanic Province. Geophysical Journal International 191(3), 1095–1108. doi: 10.1111/j.1365-246X.2012.05669.x.
* Samsonov, S., d’Oreye, N., (2017). Multidimensional Small Baseline Subset (MSBAS) for two-dimensional deformation analysis: Case study Mexico City. Canadian Journal of Remote Sensing 82(6), 1–12. doi: 10.1080/07038992.2017.1344926
* Samsonov S., W. Feng, A. Peltier, H. Geirsson, N. d’Oreye, KK. F.Tiampo (2017). Multidimensional Small Baseline Subset (MSBAS) for volcano monitoring in two dimensions: opportunities and challenges. Case study Piton de la Fournaise volcano. Journal of Volcanology and Geothermal Research, Vol 344, 121-138, https://doi.org/10.1016/j.jvolgeores.2017.04.017
* Samsonov, S., A. Dille, O. Dewitte, F. Kervyn, and N. d'Oreye (2020). Satellite interferometry for mapping surface deformation time series in one, two and three dimensions: A new method illustrated on a slow-moving landslide. Engineering Geology, (266), 105471, doi:10.1016/j.enggeo.2019.105471.items

*For MasTer toolbox*

* Derauw, D., N. d’Oreye, M. Jaspard, A. Caselli, and S. Samsonov (2020), Ongoing automated ground deformation monitoring of Domuyo - Laguna del Maule area (Argentina) using Sentinel-1 MSBAS time series: Methodology description and first observations for the period 2015-2020.,   
  Journal of South American Earth Sciences, 104, 102850, doi:10.1016/j.jsames.2020.102850.
* d’Oreye N., Derauw, D., S. Samsonov, M. Jaspard, and D. Smittarello (2021), MasTer: a full automatic multi-satellite InSAR mass processing tool for rapid incremental 2D ground deformation time series. Proc. IEEE IGARSS21, Brussels, July 2021.
* d’Oreye N., Derauw, D., S. Samsonov, M. Jaspard, D. Smittarello, G. Celli (2022), MasTer: InSAR automated Mass processing Toolbox for Multidimensional time series. Instruction manual V4.0, Oct. 2022. 191 pp.

*For DORIS*

* Kampes, B.M., Hanssen, R.F., Perski, Z., (2003). Radar interferometry with public domain tools. In: Third International Workshop on ERS SAR Interferometry, FRINGE03, Frascati, Italy, 1-5 Dec. 2003, 6 pages.

## 0) Prepare the work

The tools will need the following directories:

* /opt/local/bin
* $HOME/SAR/EXEC
* $HOME/SAR/MasTerToolbox/DOC
* $HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older
* $HOME/SAR/MasTerToolbox/MSBAS
* $HOME/SAR/MasTerToolbox/SCRIPTS\_OK

Where $HOME*/* is obviously your home directory.

It is also advised to source your **.barshrc** in your **.bash\_profile** as all the config will be set in **.bashrc.**

If you do not have these files, create them and ensure you can write and execute them.

## 1) Installing some external components

The following tools and apps are not all mandatory but experience shows that it may greatly help the user.

Note: if apt name or lib has changed, you can search by keyword the new name by typing at the Terminal:

* + *sudo apt-cache search <keyword>*

**Update installation:**

* If not done yet:
  + *sudo apt install make*
  + *sudo apt install gzip*
* To ensure update version of OS, type at terminal:
  + *sudo apt update*
  + *sudo apt upgrade*
* For old version of Ubuntu (<18):
  + *sudo apt install snapd*

**GitKraken :**

Although not mandatory, Gitkraken is a useful tool to sync with the last versions of MasTer Toolbox. It requires credentials to access MasTer private repositories on Github (contact ndo@ecgs.lu). GitKraken used to access private repositories requires a license though.

* Command line download (gitkraken-amd64.deb), and install by typing
  + *wget -c https://release.gitkraken.com/linux/gitkraken-amd64.deb*
  + *sudo apt install ./gitkraken-amd64.deb*
* In case of manual download (gitkraken-amd64.deb from web site), install by typing
  + *sudo dpkg -i gitkraken-amd64.deb*
* may also be done using snap:
  + *sudo snap install gitkraken --classic*
* Connect e.g. via Github
* Create profile in GitKraken (may need pay version for accessing private repositories)
* Launch GitKraken
* Clone Repo > Github.com :
  + Where to Clone: $HOME/SAR/MasTerToolbox
  + Repo to clone: DOC, MSBAS, SCRIPTS\_OK
* Clone Repo > Github.com :
  + Where to Clone: $HOME/SAR/MasTerToolbox/MasTerEngine
  + Repo to clone: \_Sources\_ME
* New tab > Open a Repo > select in Finder $HOME*/*SAR/MasTerToolbox /RepoYouWant

**To display raster figure: XnView, GIMP or Graphic Converter**

For instance, see <https://www.gimp.org/downloads/>

Or at Terminal :

* + *sudo add-apt-repository ppa:ubuntuhandbook1/gimp*
  + *sudo apt update*
  + *sudo apt install gimp*

**Editor :**

* Get a good text editor you like

**FTP:**

* Get a convenient ftp software that you like

**gnu fortran** (not mandatory):

* Get it from <http://fortran-lang.org/learn/os_setup/install_gfortran>
* install with:
  + *sudo apt-get install gfortran*

**GMT and GDAL:**

GMT, GDAL and some associated utilities are required for plots, images and GIS manipulations.

* At Terminal, type:
  + *sudo apt install gdal-bin*
  + *sudo apt install libgdal-dev*
  + *sudo apt install libgdal26*
  + check gdal by typing: *gdalinfo --version*
  + *sudo apt install libhdf5-dev*
  + *sudo apt install gmt*
  + *sudo apt install libnetcdf-dev*
  + *sudo apt install graphicsmagick ffmpeg*
  + *sudo apt install openjpeg* (optional I think)

**To display geocoded products: QGIS**

* Visit <https://qgis.org> and get it eg as follow:
* At Terminal type:
  + *sudo apt install gnupg software-properties-common*
  + *wget -qO - https://qgis.org/downloads/qgis-2021.gpg.key | sudo gpg --no-default-keyring --keyring gnupg-ring:/etc/apt/trusted.gpg.d/qgis-archive.gpg –import*
  + *sudo chmod a+r /etc/apt/trusted.gpg.d/qgis-archive.gpg*
  + *sudo add-apt-repository "deb https://qgis.org/ubuntu $(lsb\_release -c -s) main"*
  + *sudo apt update*
  + *sudo apt install qgis qgis-plugin-grass*
* note some interesting plugins are:
  + point sampling tool
  + PointConnetor
  + Profile tool
  + Qdraw
  + QuickMapServices
  + RasterDataPlotting (may require to install python first)
  + Serval
  + Temporal/Spectal Profile Tool
  + Value Tool

**For special characters if you keyboard sometimes plays it funny:**

* + Install Ubuntu package *Character Map*

## 2) Installing required tools

**MasTer** needs some pre-existing software and libraries to work properly. This is what we call the “dependencies”. So, we first need to install them. These installations are explained here, sorted by type of installation procedure.

**GNU functions and utilities:**

Several commands might exist by default on Linux, but getting the gnu version again is wise.

To be sure to have the latest version of gnu tools, type at the Terminal:

* + *sudo apt install sed*
  + *sudo apt install gawk*
  + *sudo apt install* *coreutils* (i.e. for gdate, gstat)
  + *sudo apt install findutils* (i.e. for find)
  + *sudo apt install grep*(i.e. for ggrep)
  + *sudo apt install wget* (needed i.e. to download the S1 orbits)
  + *sudo snap install curl* and add the path to curl (e.g. /snap/bin) in your $PATH
* Check that all these gnu functions are stored in the /usr/bin directory. If not, move them there. That directory MUST be defined as ${PATHGNU} state variable in your .bashrc. At Terminal, type
  + *which sed*
  + *which gawk*
  + *which date*
  + *which stat*
  + *which find*
  + *which grep*

If answer to all these lines is not the same as echo ${PATHGNU}, edit your .bashrc and change ${PATHGNU} state variable. It must be something like   
export PATHGNU=/usr/bin

Don’t forget that a reboot (or source .bashrc) is required for changes in .bashrc to be taken into account.

* Just in case one of these functions would be called without its g-name in a script, it is recommended to have them in ${PATHGNU} with both names, that is with and without heading g (that is **sed** and g**sed**, **awk** and **gawk**, **grep** and **ggrep**, **date** and **gdate**, **stat** and **gstat**. This can be simply done with a link. In Terminal, type:
  + *cd* ${PATHGNU}
  + *sudo ln -s sed gsed*
  + *sudo ln -s gawk awk* (beware if *awk* already exist and would be a link pointing toward another version of *awk*. Replace it with our *gawk*)
  + *sudo ln -s date gdate*
  + *sudo ln -s stat gstat*
  + *sudo ln -s find gfind*

And to be sure…(I know it is overkill, but one never know…):

* + *sudo ln -s grep ggrep*
  + *sudo ln -s seq gseq*
  + *sudo ln -s uniq guniq*
  + *sudo ln -s readlink greadlink*
  + *sudo ln -s xargs gxargs*
  + *sudo ln -s du gdu*

Check also that *wget* is ${PATHGNU}

**Libraries & modules:**

* Install libraries and modules :
  + *sudo apt install clang*
  + *sudo apt install libfftw3-dev*
  + *sudo apt install libfftw3-long3*
  + *sudo apt install libfftw3-single3*
  + *sudo apt install libgeotiff-dev*
  + *sudo apt install libtiff-dev*
  + *sudo apt install libxml2*
  + *sudo apt install libxml2-dev*
  + *sudo apt install liblapack-dev*
  + *sudo apt install libomp-dev*
  + *sudo apt install libopenblas-dev*
  + *sudo apt install graphicsmagick-imagemagick-compat*
  + *sudo apt install imagemagick-6-common*
  + *sudo apt install imagemagick*
  + *sudo apt install g++*
  + *sudo apt-get espeak -y* (to make your computer talking during mass processing)
  + *sudo apt install parallel*

**Attention**: for *convert* function to operate properly **ps** and **eps** files, change permissions in /etc/ImageMagick/policy.xml (or /etc/ImageMagick-6/policy.xml)

and set (e.g. using nano as sudo):

*</policy domain=”coder” rights=”none” pattern=”PS” />*

as

*</policy domain=”coder” rights=”read|write” pattern=”PS” />*

(i.e. with pipe between read and write), and

*</policy domain=”coder” rights=”none” pattern=”EPS” />*

as

*</policy domain=”coder” rights=”read|write” pattern=”EPS” />*

Also, change as follow:

*</policy domain=”resource” name=”height” value=”16KP” />*

as

*</policy domain=”resource” name=” height” value=”32KP” />*

and

*</policy domain=”resource” name=”disk” value=”1GiB” />*

as

*</policy domain=”resource” name=”disk” value=”*8*GiB” />*

**For some plotting applications: Java (preferably installed before Fiji)**

Install it with :

* + *sudo apt install default-jdk*

or manually :

* + *see http://www.java.com*
  + follow instructions to install Java

Notes:

* if some scripts crash with the following message, re-install java and then re-install Fiji:   
  *The operation couldn’t be completed. Unable to locate a Java Runtime that supports (null).*
* One may need to define JAVA\_HOME state variable in the **.bashrc** for some application using it. Check where it is installed by typing:
  + *java -XshowSettings:properties -version 2>&1 > /dev/null | grep 'java.home'*

and update the **.bashrc** by adding a line with the answer of the line above:

* + *export JAVA\_HOME=PATH\_FROM\_LINE\_ABOVE*

**Fiji/ImageJ:** Do not install it with the terminal !!! You must use the stand-alone version.

* Download latest version from [*https://imagej.net/software/fiji/downloads*](https://imagej.net/software/fiji/downloads)
* Unzip the compressed file in $HOME*/*SAR/EXEC.
* Locate ImageJ-linux64 in your $HOME*/*SAR/EXEC/Fiji.app directory.
* Update $PATHFIJI in your .bashrc. It must be something like   
  export PATHFIJI=$HOME/SAR/EXEC/Fiji.app/
* Store the installed source e.g. in $HOME*/*SAR/EXEC/Sources\_Installed.

**snaphu:**

* Download latest version (e.g. snaphu-v2.0.5.tar) from <https://web.stanford.edu/group/radar/softwareandlinks/sw/snaphu/>   
  and store it in in $HOME/SAR/EXEC.
* unzip it e.g. using *tar -zxvf*
* edit the Makefile in the /src directory to specify your compiler and the optimization flags. Ensure that makefile has no static option in following line  
   CFLAGS = -O3 # -D NO\_CS2
* compile: at Terminal in /src dir, type *make*   
  (it seems that you can ignore warnings; most recent compilers are more sensitive)
* Move compiled snaphu from /bin into $HOME/SAR/EXEC
* Download also the snaphu\_man1.txt if you need more info about snaphu and its configurations.
* Store the installed source e.g. in $HOME*/*SAR/EXEC/Sources\_Installed.

Note: this installation can also be made using install, but it might not be the latest version and path must be checked…

* + *sudo apt install snaphu*

**cpxfiddle:**

Not mandatory, but pretty convenient for creating raster files for quick looking at results.

* Download source from <https://github.com/TUDelftGeodesy/Doris/tree/master/sar_tools>
* Cut/paste source in new document with your favorite editor
* Save the file in $HOME*/SAR/EXEC/cpxfiddle.cc*
* Edit $HOME*/SAR/EXEC/cpxfiddle.cc* and replace line 1857:   
   if (argv[optind]=='\0')

by

if (argv[optind]==0 || argv[optind][0]=='\0')

* In Terminal:
  + *cd* $HOME*/SAR/EXEC*
  + *make -n cpxfiddle*
  + *g++ -O -c -ocpxfiddle.o cpxfiddle.cc*
  + *g++ -O cpxfiddle.o -o cpxfiddle*
* Clean sources in $HOME*/SAR/EXEC/*cpxfiddle.o
* Store the installed source cpxfiddle.cc e.g. in $HOME*/*SAR/EXEC/Sources\_Installed
* Update $PATHTOCPXFIDDLE in your .bashrc. It must be something like   
  export PATHTOCPXFIDDLE=/${HOME}/SAR/EXEC/

**gnuplot:** gnuplot is used e.g. to create time series figures or baseline plots.

* At Terminal:
  + *sudo apt install gnuplot-x11*
  + *which gnuplot*
* Ensure that the path provided by the former command displays the same path as $PATHGNU in your .bashrc, that is /usr/bin

**python:**

* At Terminal:
  + *sudo apt install python3*
  + *sudo apt install python3-opencv*
  + *sudo apt install python3-numpy*
  + *sudo apt install python3-scipy*
  + *sudo apt install python3-matplotlib*
  + *sudo apt install python3-gdal*
* Check which version is used:
  + at Terminal, type: *python -c 'import sys ; print(sys.path)'*
  + It must answer something like:   
    “['', '/usr/bin/python38.zip', '/usr/lib/python3.8', '/usr/lib/python3.8/lib-dynload', '/usr/local/lib/python3.8/dist-packages', '/usr/lib/python3/dist-packages']“
  + If a package such as numpy does not load, search where it is stored and check that it is in the same version as your python.

If versions differ, change the default python version with same command as above or try to install an appropriate version of the package.

* Link python to appropriate directory: It MUST be in /opt/local/bin/ as it is from there that it will be called by all the scripts:
  + *sudo mkdir -p /opt/local/bin*
  + *which python3* (To know where it is installed, e.g. */usr/bin*)
  + *sudo ln -s /usr/bin*/pyhton3 */opt/local/bin/python3*(To make this the default Python, providing that the path is indeed */usr/bin*)
  + *sudo ln -s /usr/bin*/pyhton3 */opt/local/bin/python*(Just in case… i.e. to be sure that it will be called either as python or python3)
* Install utm package, which is used eg. in ***\_LatLong2UTM.py*** script:
  + *pip install --upgrade pip*
  + *sudo apt install python3-pip*
  + *pip install utm*
* Install pyqt6 package, which is used eg. in ***MasterOrganizer.sh*** script:
  + */opt/local/bin/python -m pip install pyqt6*
* Add the path to python (*/opt/local/bin/*) in the $PATH in your bashrc. To avoid any risk of using another version of python if badly called, add it in the beginning of the $PATH.

**x-terminal-emulator:** A terminal emulator is required to open temrinal from command line (e.g. when splitting mass processing).

* Install it by typing at the terminal:
  + *sudo apt install deepin-terminal*

## 3) Installing MasTer

**MasTer** consists of several packages that need to be obtained or downloaded from different sources:

* **MasTerEngine** **(core parts: InSAR and MSBASTools)**:
  + To request the executables, contact: [dderauw@ecgs.lu](mailto:dderauw@ecgs.lu)
* **MasTer** **Tool** **(SCRIPTS\_OK: mass processing scripts)**:
  + To request the code, contact [ndo@ecgs.lu](mailto:ndo@ecgs.lu)
* **MSBAS (2D or 3D inversion time series)**:
  + Download from: <https://doi.org/10.4095/313749>
  + You can also request the code prepared with a make file adapted to Mac and Linux MasTer installation, contact [ndo@ecgs.lu](mailto:ndo@ecgs.lu)
  + In case of problem, contact sergey.samsonov@canada.ca

**3.1 Compile MasTerEngine:**

If executable files were provided (zip file),

* simply unzip it and copy the binaries in $HOME/SAR/MasTerToolbox/MasTerEngine
* then store the zipped file in   
  $HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older/V*mostrecent*\_MasterEngine  
  where*mostrecent* is the date of the last version, which is in the name of the zip file. This date must be as YYYYMMDD and will be used by some scripts to track (and log) the version used during processing.
* Update $PATH in your .bashrc. It must be something like PATH=$PATH:/$HOME/SAR/MasTerToolbox/MasTerEngine

If you were provided with the source code (zip file), simply unzip it in   
$HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older/V*mostrecent*\_MasterEngine

where*mostrecent* is the date of the last version, which is in the name of the zip file. This date must be as YYYYMMDD and will be used by some scripts to track (and log) the version used during processing. Then,

* In Terminal, in   
  $HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older/V*mostrecent*\_MasterEngine/MasterEngineYYYYMMDD/InSAR/sources   
  type: *make*
* Move all files from

$HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older/V*mostrecent*\_MasterEngine/MasterEngineYYYYMMDD/InSAR/bin

in $HOME/SAR/MasTerToolbox/MasTerEngine

* In Terminal, in   
  $HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older/V*mostrecent*\_MasterEngine/MasterEngineYYYYMMDD/MSBASTools/sources   
  type: *make*
* Move all files from

$HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older/V*mostrecent*\_MasterEngine/MasterEngineYYYYMMDD/MSBASTools /bin

in $HOME/SAR/MasTerToolbox/MasTerEngine

* Clean (delete) the decompressed directories; keep only the zip file in:  
  $HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Older/V*mostrecent*\_MasterEngine
* Update $PATH in your .bashrc. It must be something like PATH=$PATH:/$HOME/SAR/MasTerToolbox/MasTerEngine

Note that if you are provided with an updated version of MasTer Engine (either as source code or executable binaries), you can simply update it by copying the zipped file it in $HOME/SAR/EXEC and run the script

/$HOME/SAR/MasTerToolbox/SCRIPTS\_OK/zz\_Utilities\_CIS\_Ndo/***UpdateMasterEngine.sh***

**3.2 Compile MSBAS:**

* In Terminal, in $HOME/SAR/MasTerToolbox/MSBAS/3Dsbas\_Archives/msbasv4

decompress msbas\_20201009\_wExtract\_Unified\_20220919\_Optimized\_v1\_Gilles.zip

* In   
  $HOME/SAR/MasTerToolbox/MSBAS/3Dsbas\_Archives/msbasv4/msbas\_20201009\_wExtract\_Unified\_20220919\_Optimized\_v1\_Gilles

type: *make all*

(it seems that you can ignore warnings; most recent compilers are more sensitive)

* Move *msbasv4* in: $HOME/SAR/MasTerToolbox/MSBAS
* In   
  $HOME/SAR/MasTerToolbox/MSBAS/3Dsbas\_Archives/msbasv4/msbas\_20201009\_wExtract\_Unified\_20220919\_Optimized\_v1\_Gilles/msbas\_extract

type: *make all*

* Move *msbas\_extract* in: $HOME/SAR/MasTerToolbox/MSBAS
* Clean (delete) the decompressed directories ; keep the sources in   
  $HOME/SAR/MasTerToolbox/EXEC/Sources\_Installed
* Update $PATH in your .bashrc. It must be something like   
  PATH=$PATH:$HOME/SAR/MasTerToolbox/MSBAS

**3.3 Get the MasTer** **Toolbox** **scripts at the right place:**

* Ensure that the scripts (obtained from Github or from unzipped file) are stored at the right place:   
  $HOME/SAR/MasTerToolbox/SCRIPTS\_OK
* Update $PATH in your .bashrc. It must be something like

PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS\_OK

PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS\_OK/zz\_Utilities\_CIS

PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS\_OK/zz\_Utilities\_CIS\_NdO

PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS\_OK/\_cron\_scripts

PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS\_OK/MasterOrganizer

* If scripts were receiver from a zipped file, it can be stored in   
  $HOME/SAR/MasTerToolbox/EXEC/Sources\_Installed

**3.4 Define the environmental variables:**

MasTerEngine, MSBAS and MasTer Toolbox requires environmental variables that will be called from the scripts. These are :

PATH\_SCRIPTS=/${HOME}/SAR/MasTerToolbox : path to SCRIPTS\_OK

(i.e. the directory containing all the scripts)

PATHGNU=/usr/bin : path to where the gnu utilities are stored   
(Note: in case you have several versions of the gnu utilities, it is highly recommended to have the path to /usr/bin defined first in your $PATH)

PATHFIJI=/Applications/Fiji.app/Contents/MacOS/: path to where Fiji application is

PATHCONV=/usr/bin : path to where the convert command is (from ImageMagick)

PATHTOCPXFIDDLE=/${HOME}/SAR/EXEC/ : path to where the cpxfiddle command is (from TU Delft)

The path to some disks where data, intermediate results and final results will be stored must also be defined by state variable. At least 5 variables must be defined, that is:

PATH\_1650, PATH\_3600, PATH\_3601, PATH\_3602 and PATH\_DataSAR.

Names are inherited from architecture at ECGS and will be called throughout the processing.

For security reason, it is a good practice to have them pointing to different physical drives, if possible, but this is not mandatory; they can also point toward directories instead of disks, e.g.:

PATH\_1650=/mnt/hp-1650-Data\_Share1 (disk or dir where data or results will be stored)

PATH\_3600=/mnt/hp-D3600-Data\_Share1 (disk or dir where data or results will be stored)

PATH\_3601=/mnt/hp-D3601-Data\_RAID6 (disk or dir where data or results will be stored)

PATH\_3602=/mnt/hp-D3602-Data\_RAID5 (disk or dir where data or results will be stored)

PATH\_DataSAR=/mnt/DataSAR/ (disk or dir where auxiliary data will be automatically

stored such as orbits, geoid etc… in a dir named SAR\_AUX\_FILES)

Note also that more disks can be defined and used e.g. for sharing the computation through several disks when intensive computation is required.

When processing ENVISAT or Sentinel 1 data, MasTerEngine will require orbital information. It will usually pick them for you and store them automatically in dedicated directories where it will get them when required. These directories must be defined by the following state variable names:

S1\_ORBITS\_DIR=${PATH\_DataSAR}/SAR\_AUX\_FILES/ORBITS/S1\_ORB

ENVISAT\_PRECISES\_ORBITS\_DIR=${PATH\_DataSAR}/SAR\_AUX\_FILES/ORBITS/ENV\_ORB/vor\_gdr\_d

To create DEM corrected from geoid height, the following state variable must be defined:

EARTH\_GRAVITATIONAL\_MODELS\_DIR=$PATH\_DataSAR/SAR\_AUX\_FILES/EGM  
A directory named EGM96 must exist in that directory and it must contain the geoid file WW15MGH.DAC. It can be downloaded from (link checked 05 10 2022):

<https://web.archive.org/web/20130314064801/http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm96/binary/WW15MGH.DAC>

## 4) Directory structure for data, auxiliary data and results

In addition to the structure of the installation directories, it is important to store your data, auxiliary data (DEM, masks, kml, orbits, geoid, parameters files…), intermediate results and final results in a structure as described below.

MasTer toolbox expects a directory structure similar as what is shown below. Most of the directories where the intermediate and final results are stored will be created by the scripts based on the information provided in the LaunchParameters.txt file.

For those which must be created by the user (in full or based on name provided in the LaunchParameters.txt file), it is required to follow the following architecture and directories naming.

In *italic green* is the information that must be adapted to your satellite(s), orbital mode(s) and region(s). These directories can be located in the disk(s) you want.

Note that, for safety reasons, it is advised to store e.g. raw data and data in csl format (i.e. from MasTerEngine) on different hard drives, or the mass processed results and the msbas results on different hard drives etc….

Names in red are mandatory.

Disk 1 (i.e. PATH\_1650):

PATH\_1650/kml : where to store kml for cropping, or for coherence check

PATH\_1650/ Param\_files\_SuperMaster : where to store your LaunchParametersFiles.txt by */SAT/TRK*….

PATH\_1650/SAR\_CSL/*SAT/TRK*/NoCrop : where data in csl format are stored (incl. crops)

PATH\_1650/SAR\_SM/AMPLITUDES/*SAT/TRK/Region* : where amplitudes gif will be computed

PATH\_1650/SAR\_SM/MSBAS/*Region* : where compatible pairs for msbas are computed

PATH\_1650/SAR\_SM/RESAMPLED/*SAT/TRK* : where data resampled on Super Master are saved

Disk 2 (i.e. PATH\_3600):

PATH\_3600/SAR\_DATA/*SAT/…* : where raw data are stored (safer to keep them on a different hard drive than 1650)

Disk 3 (i.e. PATH\_3601):

PATH\_3601/SAR\_MASSPROCESS/*SAT/TRK/Crop* : where directories with each pair computation details and results are stored

PATH\_3601/SAR\_MASSPROCESS/*SAT/TRK/Crop*/Geocoded : where geocoded maps are stored in sub dir Amp, Coh, Defo etc…

PATH\_3601/SAR\_MASSPROCESS/*SAT/TRK/Crop*/GeocodedRasters : where rasters of geocoded maps (for quick look) are stored

Disk 4 (i.e. PATH\_3602):

PATH\_3602/MSBAS\_RESULTS/*Region* : where msbas series are computed

Maybe in one of these disks, or somewhere else where enough storage room is available:

$PATH\_DataSAR/SAR\_AUX\_FILES/DEM : where DEMs are stored

$PATH\_DataSAR/SAR\_AUX\_FILES/EGM96 : where geoid is stored

$PATH\_DataSAR/SAR\_AUX\_FILES/MASKS/*SAT/TRK* : where coherence masks are computed

$PATH\_DataSAR/SAR\_AUX\_FILES/ORBITS/*SAT* : where orbits are stored

Note that $PATH\_DataSAR is the state variable defined in .bashrc !!

Note: In Linux, to mount external drive, you must

1. Define the mounting point of your disks, e.g for a disk named “syno\_sar”:

sudo mkdir /mnt/*syno\_sar*  
sudo chown *yourlogin* /mnt/*syno\_sar*

1. Add them in the /etc/fstab. Example below shows the mounting of a Windows server and a Synology server:

# EG FOR A WINDOWS STORAGE SERVER

# IMPORTANT: Leave "cache=none" to avoid issues with 10Gbit Ethernet-Network on eno1

//*hp-storeeasy.ecgs.welter/hp-1650-Data\_Share1* /mnt/*1650* cifs comment=systemd.automount,username=*YOURUSRNAME*,password=*YOURPWD*,uid=*YOURID*,gid=users,noatime,iocharset=utf8,rw,mfsymlinks,cache=strict,vers=3.1.1,soft,noserverino,nobrl,nounix 0 0

# EG FOR SYNOLOGY STORAGE

//*syno-sar.ecgs.welter/DataSAR* /mnt/*syno\_sar* cifs comment=systemd.automount,username=*YOURUSRNAME*,password=*YOURPWD*,uid=*YOURID*,gid=1001,iocharset=utf8,file\_mode=0777,dir\_mode=0777,noatime,rw,mfsymlinks,soft,nounix 0 0

## 5) Check installation

**5.1 The directory structure**

At the end, you should have MasTer installed in a folder named “SAR” as shown in **Fig. 1**.

*/$HOME/SAR/EXEC*

*|--Executables…*

*|--Sources\_Installed*

*/$HOME/SAR/MasTerToolbox*

*|--****DOC***

*| |----Biblio*

*| |----MasTerEngine*

*| |----MasTer\_Toolbox*

*| |----MSBAS*

*|*

*|--****MasTerEngine***

*| |--\_Sources\_ME/Older*

*| | |--[several sources of old versions]*

*| | |--V20220929\_MasTerEngine*

*| |--Executables…*

*|*

*|--****MSBAS***

*| |----3Dsbas\_Archives*

*| | |--msbasv4*

*| |--Executables…*

*|*

*|--* ***SCRIPTS\_OK***

*| |--* *\_cron\_scripts*

*| |--* *MasTerOrganizer*

*| |--* *TSCombiFiles*

*| |--* *zz\_Utilities\_CIS*

*| |--* *zz\_Utilities\_CIS\_Ndo*

*| A lot of scripts…*

**Figure 1 – Directory structure required for the proper usage of MasTer Toolbox.**

Notes:

1 ) The folders /$HOME/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME/Olderis used to store the archives and the most recent sources of both components of MasTerEngine, that is InSAR and MSBASTools.

Their latest executable version, when compiled, must be moved to   
/$HOME/SAR/MasTerToolbox/MasTerEngine/.

Hence, when a new version of these packages is available, no need to change the paths of the environmental variables.

2) Similarly, the folders /$HOME/SAR/MasTerToolbox/MSBAS/\_3Dsbas\_Archivesis used to store the archives and the most recent sources of both components of MSBAS, that is MSBAS\_EXTRACT and MSBASv*i* (where *i* stands for the version). Their latest executable version, when compiled, must be moved to /$HOME/SAR/MasTerToolbox/MSBAS/.

Hence, when a new version of these packages is available, no need to change the paths of the environmental variables.

1. You can use the script ***Check\_Installation.sh*** to check your installation. See script and manual.

You should also have auxiliary files stored in a folder named “SAR\_AUX\_FILES” in DataSAR as shown in **Fig. 2**.

*$PATH\_DataSAR/SAR\_AUX\_FILES/*

*|--****DEM***

*|*

*|--****EGM96***

*| |----*WW15MGH.DAC

*|*

*|--****Masks***

*|*

*|--****ORBITS***

*|----ENV\_ORB*

*|----S1\_ORB*

**Figure 2 – Directory structure required for the storage of**

**auxiliary files required by MasTer Toolbox.**

Notes:

1 ) The folders /$PATH\_DataSAR/SAR\_AUX\_FILES/DEM/is used to store the DEM. It may be associated to a state variable $EXTERNAL\_DEMS\_DIR used automatically by MasTer Engine. However, for the automation with MasTer Toolbox, to avoid possible confusion, the path to the DEM for each run is rather given in the LaunchParameters.txt file.

2) The folders /$PATH\_DataSAR/SAR\_AUX\_FILES/EGM must contain the geoid file in EGM96/WW15MGH.DAC.

3) The folders /$PATH\_DataSAR/SAR\_AUX\_FILES/MASK is not mandatory, but it is a convenient place to store the mask you would build and used during your processing.

3) The folders /$PATH\_DataSAR/SAR\_AUX\_FILES/ORBITS must contain the orbits for ENVISAT (if required) or Sentinel 1 (if required). These directories must be associated to the state variable $ENVISAT\_PRECISES\_ORBITS\_DIR and $S1\_ORBITS\_DIR respectively.

**5.2 The environmental variables in .bashrc**

At the end, your ./bashrc must look like:

# ~/.bashrc: executed by bash(1) for non-login shells.

# see /usr/share/doc/bash/examples/startup-files (in the package bash-doc)

# for examples

# If not running interactively, don't do anything

#case $- in

# \*i\*) ;;

# \*) return;;

#esac

[…]

PATH=/opt/local/bin:$PATH

PATH=/usr/bin:$PATH

PATH="/usr/local/bin:/bin:/usr/sbin:/sbin:/snap/bin/"

# trick to avoid error at usage of say function

alias say='echo | espeak -s 120 2>/dev/null'

# MasTer PATHS

##################

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/MasTerEngine/\_Sources\_ME

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK/MasTerOrganizer

PATH=$PATH:/usr/local/tigervnc/bin/

PATH=$PATH:/home/nicolas/SAR/EXEC

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/MSBAS

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/MasTerEngine

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK/zz\_Utilities\_CIS\_Ndo

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK/zz\_Utilities\_CIS

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK/\_cron\_scripts

PATH=$PATH:/home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK

# MasTer VARIABLES

##################

export OPENBLAS\_NUM\_THREADS=1

export JAVA\_HOME="/usr/lib/jvm/java-11-openjdk-amd64"

export PATH\_HOMEDATA=/mnt/dell3raid5/

export PATH\_SynoData=/mnt/syno\_data/

export PATH\_3602=/mnt/3602/

export PATH\_3601=/mnt/3601/

export PATH\_3600=/mnt/3600/

export PATH\_1650=/mnt/1650/

export PATH\_DataSAR=/mnt/syno\_sar/

export EARTH\_GRAVITATIONAL\_MODELS\_DIR=${PATH\_DataSAR}/SAR\_AUX\_FILES/EGM

export ENVISAT\_PRECISES\_ORBITS\_DIR=${PATH\_DataSAR}/SAR\_AUX\_FILES/ORBITS/ENV\_ORB

export S1\_ORBITS\_DIR=${PATH\_DataSAR}/SAR\_AUX\_FILES/ORBITS/S1\_ORB

export PATH\_SCRIPTS=/home/nicolas/SAR/MasTerToolbox

export PATHCONV=/usr/bin

export PATHFIJI=/home/nicolas/SAR/EXEC/Fiji.app/

export PATHGNU=/usr/bin

export PATHTOCPXFIDDLE=/home/nicolas/SAR/EXEC/

export PATH=$PATH

#export OMP\_NUM\_THREADS=10,8,4

#export OMP\_NUM\_THREADS=4,3,2

# Trick to avoid error at usage of say function

alias say='echo | espeak -s 120 2>/dev/null'

# Trick to solve possible ImageJ issues. In case of prblm opening Terminal windows from command line,

# check you DISPLAY value using the command

# who (shows all displays) or who -m (shows your current display) and change below accordingly

export DISPLAY=:0.0

## 6) Operating with cron jobs

If you want to operate **MasTer** toolbox from cron jobs, pay attention to the following:

* All variable environments are defined here in the .***bashrc*** which is designed for interactive shell. Whatever you do, it won’t be sources from scripts if it starts with the following lines (as by default in at least Ubuntu 18.04 and later):

# ~/.bashrc: executed by bash(1) for non-login shells.

# see /usr/share/doc/bash/examples/startup-files (in the package bash-doc)

# for examples

# If not running interactively, don't do anything

case $- in

\*i\*) ;;

\*) return;;

esac

* It is advised to source the .***bashrc*** from the ***.bash\_profile***
* It is advised to define all your state variables at the beginning of your bashrc
* It is advised to launch scripts by redirecting the messages to /dev/null to avoid filling up the mailbox by ending the command line with:

> /dev/null 2>&1

* You can launch your commands in the crontab as follow (supposing that the path to your bash in /bin):

mm hh \* \* \* exec /bin/bash -l /path/to/script arg1 arg2 … > /dev/null 2>&1

Example of crontab:

# Edit this file to introduce tasks to be run by cron.

# m h dom mon dow command

SHELL=/bin/bash

BASH\_ENV=~/.bashrc

PATH\_1650=/mnt/1650

PATH\_3600=/mnt/3600

PATH\_3601=/mnt/3601

PATH\_3602=/mnt/3602

PATH\_SynoData=/mnt/syno\_data

PATH\_DataSAR="/mnt/syno\_sar"

PATH\_HOMEDATA="/mnt/dell3raid5"

PATH\_SCRIPTS=/home/nicolas/SAR/MasTerToolbox

S1\_ORBITS\_DIR=${PATH\_DataSAR}/SAR\_AUX\_FILES/ORBITS/S1\_ORB

ENVISAT\_PRECISES\_ORBITS\_DIR=/mnt/syno\_sar/SAR\_AUX\_FILES/ORBITS/ENV\_ORB

EARTH\_GRAVITATIONAL\_MODELS\_DIR=$PATH\_DataSAR/SAR\_AUX\_FILES/EGM

PATHGNU=/usr/bin

PATHCONV=/usr/bin

PATHFIJI=$HOME/SAR/EXEC/Fiji.app/

PATHTOCPXFIDDLE=/${HOME}/SAR/EXEC/

# # # # # Domuyo 03h05; 5h35; 17h30

05 03 \* \* \* cd /home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK/\_cron\_scripts/; bash -l -c './Domuyo\_S1\_Step1\_Read\_SMCoreg\_Pairs.sh'

35 05 \* \* \* cd /home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK/\_cron\_scripts/; bash -l -c './Domuyo\_S1\_Step2\_MassProc.sh'

30 17 \* \* \* cd /home/nicolas/SAR/MasTerToolbox/SCRIPTS\_OK/\_cron\_scripts/; bash -l -c './Domuyo\_S1\_Step3\_MSBAS.sh'

## 7) Updates in this manual

V 4.1 (October 26 2022):

- add installation of gnu parallel

- add chapter “7) Updates in this manual”