π-*RATE* (v3.1)

Poly-Interferogram Rate And Time-series Estimator

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Chapter 1

Introduction

π-RATE (Poly-Interferogram Rate And Time-series Estimator) is a Matlab-based software package that estimates displacement rate, time series and their associated uncertainties from a set of unwrapped InSAR images. It originated from the multi-interferogram method proposed by Juliet Biggs and her colleagues at the University of Oxford (Biggs et al., 2007). The method was then improved by John Elliott and his colleagues by adding topographically-correlated atmospheric delay corrections (Elliott et al., 2008). Based on Juliet Biggs's scripts, Hua Wang developed π-RATE through a one-year Royal Society International Incoming Fellowship supervised by Tim Wright since December 2007 (Wang et al., 2009). The function of time-series analysis was also added at this period of time. Some new algorithms, particularly variance-covariance matrix for large-scale interferograms, were developed during Hua Wang's visit at the University of Leeds in 2009 (Wang and Wright, 2012). The first formal version of π-RATE was tested within Tim Wright's InSAR group since then. Part of π-RATE was developed by Hua Wang at Guangdong University of Technology, China. Tim Wright developed some scripts, and led the whole period of π-RATE's development.

π-RATE can only be used for academic purpose, and **MUST NOT** be used as a part of any commercial package.

π-RATE is designed to work with data produced by ROI_PAC. For other InSAR software, we recommend to convert your data to ROI_PAC's RMG and RSC format. For all the scripts in π-RATE, you can type `help scriptname` for a brief description of its usage.

Throughout this manual, commands to be entered on the command line are in red, and the whole input/output arguments are in `light gray box`. The presence of >> before a command indicates that the command is a matlab script.

1.1 Major change history

- v3.1: Some new scripts were added so that it can estimate time series by combination of InSAR data from multiple tracks or satellites (Wang et al., 2012).
- v3.0: A new algorithm for time series analysis with multiple sudden events, e.g. coseismic deformation and volcano eruptions.
- v2.0: Major revisions for the time series analysis algorithms.
- v1.1: Data analysis and VCM evaluation for large data set. DEM error estimation.
- v1.0: First version of the software based on Juliet Biggs's scripts. Topographically-correlated atmospheric delay error correction was implemented. Some initial scripts for time series analysis were added.

Chapter 2

Installation

The first step is to download and install π-RATE on your own computer. To install π-RATE, you need create a folder, e.g. named pirate, under certain directory.

- Request π-RATE by filling the form at http://homepages.see.leeds.ac.uk/~earhw/contact/index.html.

- Uncompress the scripts

```
mkdir $HOME/pirate
cd $HOME/pirate
tar -xvf pirate_v3.1.tar
```

- Setup environment in your .cshrc file.

```
setenv PIRATEHOME $HOME/pirate/
set path = ($path $PIRATEHOME)
```

- To load π-RATE automatically when matlab starts up, update the environment of MATLABPATH in your .cshrc file.

```
setenv MATLABPATH $PIRATEHOME
```

Alternatively, you can add the path manually in Matlab command window.

```
>> addpath(genpath(getenv('PIRATEHOME')))
```

- Update .cshrc file.

```
source ~/.cshrc
```

Chapter 3

Input Files

To use π-RATE, you need create a folder for your project, e.g. track_334. And then make the following subdirectories for the InSAR observations, initial models (optional), synthetic data (optional), output data etc. Through the manual, all the following processing will be done in the subdirectory *track_334*.

```
mkdir track_334
cd track_334
mkdir obs fmodels sets out
```

3.1 InSAR data

```
cd obs
```

You are required to provide unwrapped InSAR images and their associated header files. The perpendicular baseline files are needed if you are going to estimate DEM errors. All these files can be either copied or linked to the subdirectory obs, and the filenames should be written into a text file. The shell scripts lnobs can make linkages for these files and create ifg.list which contains the filenames of the unwrapped InSAR data. Type the command to check its usages. *

3.2 DEM Data

DEM data are used to correct topographically-correlated tropospheric delay errors. The easiest way is to use the DEM for your InSAR processing. The pixel size can be smaller than that

*We link the incidence files for using VELMAP package following PIRATE. The perpendicular baselines are not generated by ROI_PAC automatically. You can contact Hua Wang for his Matlab code to do this.

of the interferograms. In this case, π-RATE will do multilook first. Please refer to the configure file for details.

3.3 Initial Models (optional)

The initial models will be removed before orbital correction, and added back before making rate map. The method to make the initial models depends on the data you are analyzing. The pixel size can be smaller than that of the output rate map, but their dimensions should not be smaller. The direction of the displacement rate is consistent with the input unwrapped InSAR data, i.e. in line-of-sight direction. A rsc file is required for each model, thus π-RATE can extract the same region as the rate map.

3.4 Fault Data in GMT Format (optional)

Fault data are only used to interactively extract profiles perpendicular to the fault trace. It should be in GMT format, and π-RATE will convert it to MATLAB format.

3.5 Profile Parameters (optional)

A file containing the parameters of the profiles is required if you are going to make profiles after rate map estimation. Following is an example of the file named profdef.dat. If π-RATE can not find such a file, it will ask you to extract profiles interactively if you set make_prof=1 in the configure file.

```
1 1 76.558460 35.222000 77.570460 36.050000 0.000000 0.100000 kf1
2 2 76.613660 35.074800 77.644060 35.902800 0.000000 0.100000 kf2
```

3.6 Earthquake list for masking (optional)

The list file is used to mask some regions for orbital and atmospheric delay errors estimation. Usually you need make a mask for active area (earthquakes, volcanos and subsidence), large atmospheric delay changes (e.g. ATF) etc. Once this file is provided, π-RATE will automatically select proper interferogams to let you make masks. An example of the list file is as followed.

```
1 20030101 0 1
2 20041022 0 0
```

```
20050926 0 0
20060617 0 0
20060725 0 0
20060910 0 0
20080331 0 0
20080709 0 0
20081017 0 0
20090211 0 0
20090617 1 0
```

Chapter 4

Configure File

4.1 Create configure file

There are two scripts to make the configure file, i.e. setparsbrief and setparsfull. The first one will create a configure file which contains the most important parameters. All the other parameters will be set as default values. The last one will create a configure file containing all the parameters. You can edit the generated configure file for your own study.

To create the configure file, run one of the following commands in Matlab command window. Please use help command to find the usage of these two functions.

```
>> setparsfull('pirate.conf',1)
>> setparsbrief('pirate.conf',1)
```

4.2 Run π-RATE

After making configure, run π-RATE using the following command.

```
>> pirate('pirate.conf')
```

Chapter 5

Tools

5.1 plot tools

- plotifg: a Matlab script to plot an image.
- plotifgs: a Matlab script to plot a set of images.
- plotrmg: a shell script to plot transparent amplitude and/or phase data using GTM software.
- plotts: a shell script to plot a set of transparent amplitude and/or phase data using GMT software.

Plotifg and plotifgs are useful to check the results step by step. Type help in Matlab command window for their usages. Plotrmg and plotts are useful to make the final plots. Type the command to check their usages.

5.2 profiles

There are three functions to extract profiles in π-RATE: extractprof, profdefine, and make_prof.

Extractprof will interactively extract the coordinates of a set of profiles and save them in a file named profdef.dat. The usage of extractprof is as following:

1. open the target figure using plotifg
2. left click to select a start point
3. left click to test end points

4. right click to select end point
5. redo 2-4 for multiple profiles
6. middle click to stop

Profdefine will read profdef.dat generated either by extractprof or manually. Extractfaultonprof allows users to select the fault location on the profile that is helpful for plot, e.g. using GMT. The displacements along and across the profiles will finally be made by make_prof.

5.3 removearea

The function is borrowed from Carolina Pagli. It will make a mask for an image. Again, you need plotifg to display an image first, and then run removearea to make a mask.

5.4 cor2amp

Calibrate and calculate mean amplitude image using the corresponding band in the geocoded cor (or unw) files.

5.5 caldemcoef

The function is outside π-RATE to calculate coefficient for the conversion from height to phase. The output can be used for DEM error estimation in π-RATE.

5.6 SARVIEW

SARVIEW is a program designed for phase unwrapping correction outside π-RATE. It can also be used to view binary images like rate map and time series. The software is available at http://homepages.see.leeds.ac.uk/~earhw/software/sarview/index.html.

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