IMS_VASC

User Manual

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IMS_VASC

International **M**onitoring **S**ystem **V**olcano **A**coustic **S**ource location and asso**C**iation.

Combined infrasound signal association and source location using a brute-force, grid-search, cross-bearings approach.

About

IMS_VASC combines infrasound signal association and source location using a brute-force, grid-search, cross-bearings approach. Written by Robin S. Matoza, University of California, Santa Barbara.

If you use this software, please cite:

Matoza, R.S., D.N. Green, A. Le Pichon, P.M. Shearer, D. Fee, P. Mialle, and L. Ceranna (2017), Automated detection and cataloging of global explosive volcanism using the International Monitoring System infrasound network, *J. Geophys. Res. Solid Earth*, **122**, 2946–2971, doi:10.1002/2016JB013356

The methodology and motivation for the approach are described in the above reference.

License

Acknowledgement

The Progressive Multichannel Correlation (PMCC) bulletin files provided as example input files were produced using the PMCC software (*Cansi*, 1995). The PMCC software is developed and maintained by the CEA. This work was made possible by the Virtual Data Exploitation Centre (vDEC - https://www.ctbto.org/specials/vdec/) platform of the CTBTO that allows access to IMS data for civil and scientific applications.

The views presented in this work are those of the authors and do not necessarily represent the views of the CTBTO or any other institution mentioned herein.

Cansi, Y. (1995), An automatic seismic event processing for detection and location: The P.M.C.C. method, *Geophys. Res. Lett.*, **22(9)**, 1021Ð1024.

1 Installation and dependencies

These programs are written in Fortran 90 and require a Fortran 90 compiler. The programs have been tested with the `gfortran` and `ifort` (intel) compilers. The example plotting script `plot_sarychev_map_gmt4.sh` or `plot_sarychev_map_gmt5.sh` uses Generic Mapping Tools, either version 4 (GMT4) or 5 (GMT5). However, GMT is not required to run `ims_vasc` and associated routines.

To install:

```
cd src
make all
```

this will place executables in the local `bin` directory of this distribution (modify the `Makefile` variable `BINDIR` to change this).

2 Quickstart

2.1 Overview

The workflow is as follows:

1. Generate the during grid $\mathbf{G^d}$ (e.g., a grid corresponding to a 2-day time interval) by running `ims_vasc`
2. Generate the prior grid $\mathbf{G^p}$ (e.g., a grid corresponding to a prior 10-day time interval) with a separate run of `ims_vasc`
3. Generate the cleaned grid $\mathbf{G^c}$ (eqn. 1 of *Matoza et al.*, 2017) and masked grid $\mathbf{G^m}$ (eqn. 2 of *Matoza et al.*, 2017) by running `ims_gridproc`

The outputs of the above programs are Fortran binary files. The utility programs `readwrite_imsvascbin_basic` and `readwrite_imsvascbin_gridproc` will read the Fortran binary output files and produce ascii files for plotting.

2.2 Example run: June 2009 Sarychev Peak eruption

An example run is provided in the `examp` directory for the June 2009 eruption of Sarychev Peak as a series of `tcsh` scripts. To run the example:

```
cd examp
./step01_ims_vasc_during.tcsh
./step02_ims_vasc_prior.tcsh
./step03_gridproc.tcsh
./step04_exportascii_during.tcsh
./step05_exportascii_prior.tcsh
cd PLOT
./plot_sarychev_map_gmt4.sh
```

which should produce Figure 1. All required input files are in the `examp/IN` directory. Output files are placed in `examp/OUT`. Note that a GMT5 version of the plotting script `plot_sarychev_map_gmt5.sh` is also provided.

3 Input parameters

In the following, we use the syntax:

```
Description of parameter :: Parameter value in the example script
```

Using the `step01_ims_vasc_during.tcsh` run as an example, the input parameters to `ims_vasc` are as follows:

```
Station list file :: IN/stationlist.txt
Latitude min, max, and spacing for grid search area (trial source nodes) [deg] :: 30. 60. 0.1
Longitude min, max, and spacing for grid search area (trial source nodes) [deg] :: 120. 170. 0.1
Allowed azimuth deviation [deg] :: 2.
Association celerity [km/s] :: 0.33
Association max distance [km] :: 5000.
Min, max, mean frequency [Hz], (enter 0 0 0 for all frequencies) :: 0.1 5.0 2.0
```

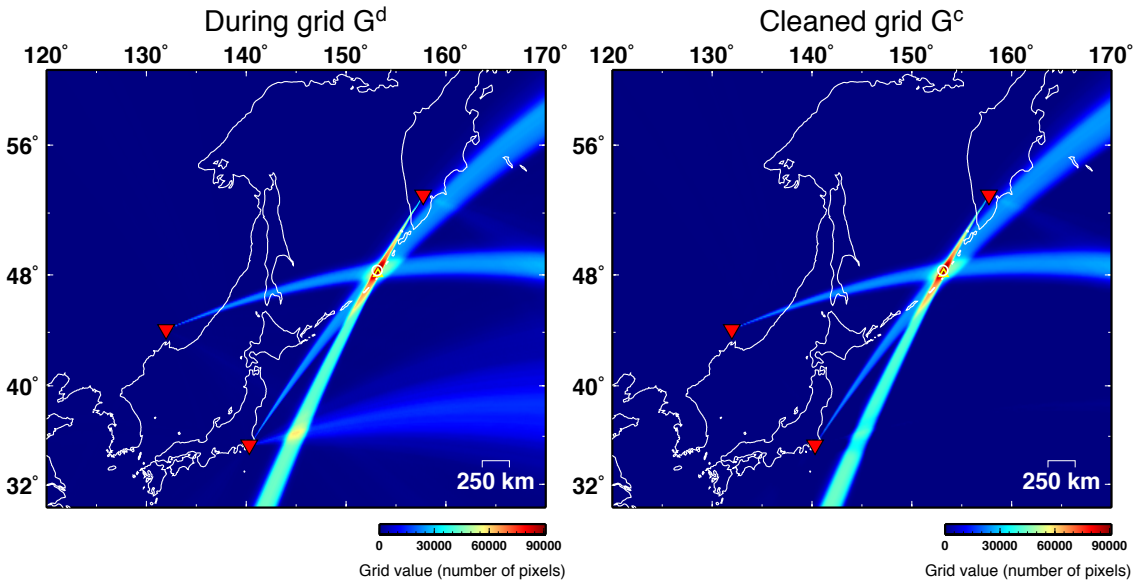

Figure 1: During grid $\mathbf{G}^{\mathbf{d}}$ and cleaned grid $\mathbf{G}^{\mathbf{c}}$ for the June 2009 eruption of Sarychev Peak, Kuriles. The three example infrasound arrays (IS44, IS45, IS30) are shown as red triangles; coastlines in white. The grid value corresponds to the number of PMCC pixels.

```
Min number of pixels to count a station in intersection (m) :: 500
Number of nearest stations that must detect (e.g., 2) (enter 0 to not use this option) :: 0
File containing list of PMCC bulletin input files :: IN/bullfilelist_during.txt
Grid stacking start time [yr, mon, dy, hr, mn, sec] :: 2009 06 11 00 00 0.0
Grid stacking stop time [yr, mon, dy, hr, mn, sec] :: 2009 06 13 00 00 0.0
Binary output filename :: OUT/OUT_DURING/out.dur.2009.0611.0613
```

Using the `step03_gridproc.tcsh` run as an example, the input parameters to `ims_gridproc` are as follows:

```
Binary input filename (during grid) :: OUT/OUT_DURING/out.dur.2009.0611.0613.dat
Binary input filename (prior grid) :: OUT/OUT_PRIOR/out.pri.2009.0601.0611.dat
Duration of during grid [days] :: 2.
Duration of prior grid [days] :: 10.
Alpha, background rate exceed ratio (eqn. 1) :: 2.
Minimum number of interesecting stations :: 0
Maximum azimuthal gap [deg] (enter a value greater than 360 to not use this option) :: 400.
Binary output filename containing cleaned and masked grid :: OUT/OUT_CLEAN/out.cln.2009.0611.0613.dat
Number of pixels threshold for detection :: 500
Volcano list file (Smithsonian Institution GVP database) :: IN/volcano_list_gvp.txt
Event detection (catalog) file :: OUT/OUT_ICAT/icat.2009.0611.0613.dat
```

4 File format descriptions

4.1 Station list file

The station list file (e.g., `IN/stationlist.txt`) is a 3-column file, with columns: station latitude, station longitude, station name. Enter as many lines in this file as there are stations with data to consider. e.g.,

```
35.30775 140.31377 IS30
53.10580 157.71390 IS44
44.19990 131.97729 IS45
```

e.g., station IS30 has latitude 35.30775 deg and longitude 140.31377 deg. This run considers only three stations.

4.2 Bulletin list file

The bulletin list input file (e.g., `IN/bullfilelist_during.txt`) is a 2-column file, with columns: station name, PMCC bulletin file name for the station. e.g.,

```
IS30 IN/BULLFILE/DURING/IS30_2009_162to165_bull.txt
IS44 IN/BULLFILE/DURING/IS44_2009_162to165_bull.txt
IS45 IN/BULLFILE/DURING/IS45_2009_162to165_bull.txt
```

In each case, the station name is given, followed by the absolute or relative path of the PMCC bulletin file. Note that the station names must match between the bulletin list and station list files.

4.3 PMCC bulletin files

The main data input files to `ims_vasc` are ascii files containing array processing detection lists. This program has been developed and tested using array processing detection lists that are output from the Progressive Multichannel Correlation (PMCC) method; however, the program should work with any array processing detection algorithm. PMCC or an alternative array processing program is not included with this distribution. The PMCC bulletin files are modified and cleaned slightly from those produced directly by the PMCC program. Columns are as follows:

```
Column 1: year
Column 2: month
Column 3: day
Column 4: hour
Column 5: minute
Column 6: second
Column 7: minimum frequency
Column 8: maximum frequency
Column 9: azimuth
Column 10: apparent velocity
Column 11: root-mean-square (r.m.s.) amplitude
Column 12: number of pixels
Column 13: mean frequency
```

Important: the number of pixels (column 12) is a parameter specific to PMCC. `ims_vasc` counts the number of pixels associated to a particular trial source grid node. If you use a different array processing method, or otherwise wish to weight all detections equally, set column 12 to value 1 for all lines in the input bulletin file.