ValInSAR –Open source code- Instructions (v0)

Theory:

Our paper describes the theory behind Validation of DInSAR datasets (ValInSAR) methodology. See María I. Navarro-Hernández, Javier Valdes-Abellan, Roberto Tomás, Juan M. Lopez-Sanchez, Pablo Ezquerro, Guadalupe Bru, Roberta Bonì, Claudia Meisina, and Gerardo Herrera (2022). ValInSAR: A systematic approach for the validation of Differential SAR Interferometry in land subsidence areas. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. Under review.

1. Introduction

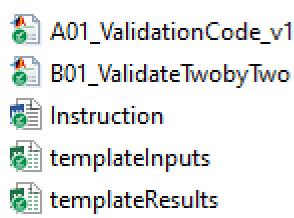
ValInSAR is a Matlab supported open source code developed by the University of Alicante aimed to validate Differential Synthetic Aperture Radar Interferometry (DInSAR) measurements with in-situ techniques to obtain reliable subsidence measurements.

2. Installation

You have to save the content of the "ValInSAR" folder in the current MATLAB folder. Then, you can execute the commands in the m-file by simply typing the filename at the MATLAB command window prompt.

3. Content

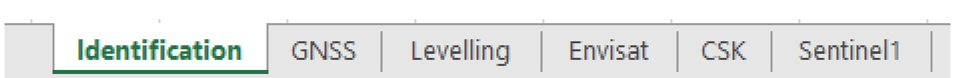
- In the "ValInSAR" folder the user will find the following files:



These files are described in detail in the following subsections:

- **TemplateInputs.xls:**

In this Excel file the user has to input all the information about the InSAR dataset (including different sensors) and the available In-situ information.



In the first sheet called "Identification", the users will input the ID, the name of the in situ data benchmarks (e.g. GNSS, Extensometer or Levelling) as well as the units used to measure the displacements (the code only accept m and cm).

ID	Name	Units
Loc1	LRCA	cm
Loc2	ORCA	cm
Loc3	LORC	cm

In the second, and the following, sheet the user will input the time series information for each in-situ technique. The number of these sheets will depend on the in-situ techniques used to perform the validation. The user should delete the sheets for which no in situ information is available. For example, in the case shown below, the user only has available information about GNSS and then, the sheet "Levelling" should be deleted.

Identification	**GNSS**	Levelling	Envisat	CSK	Sentinel1

The sheet should be filled in as shown in the following figure including the pairs of values of the time series (i.e. dates and displacements of the available in situ data). Note that in the example shown below the data are measured in the vertical direction, thus the value of the cell "angle" should be zero (i.e. 0 degrees), assuming that the technique measures in a vertical direction. Loc1, Loc2 and Loc3 corresponds to the ID labelled in the first sheet.

Angle	0				
Loc1		**Loc2**		**Loc3**	
Date	**Deformation**	**Date**	**Deformation**	**Date**	**Deformation**
03/12/2012	0.1744	17/04/2011	-0.4414	21/02/2016	0.6474
04/12/2012	0.1957	18/04/2011	-0.4596	22/02/2016	0.5313
05/12/2012	0.1349	19/04/2011	-0.3417	23/02/2016	0.5098
06/12/2012	0.0735	20/04/2011	-0.3145	24/02/2016	0.5699
07/12/2012	-0.0171	21/04/2011	-0.3429	25/02/2016	0.6032
08/12/2012	-0.0264	22/04/2011	-0.3338	26/02/2016	0.5548
09/12/2012	0.0155	23/04/2011	-0.3325	27/02/2016	0.5825
10/12/2012	0.0283	24/04/2011	-0.3551	28/02/2016	0.5978

Similar to the in-situ technique inputs, the number of sheets aimed to InSAR time series information will depend on the number of available sensors and orbits (ascending and descending).

Identification	GNSS	Levelling	**Envisat**	CSK	Sentinel1

For InSAR sheets, the incidence angle should be defined in the cell next to the cell "angle".

Angle	23					
Loc1		Loc2		Loc3		
Date	Deformation	Date	Deformation	Date	Deformation	D

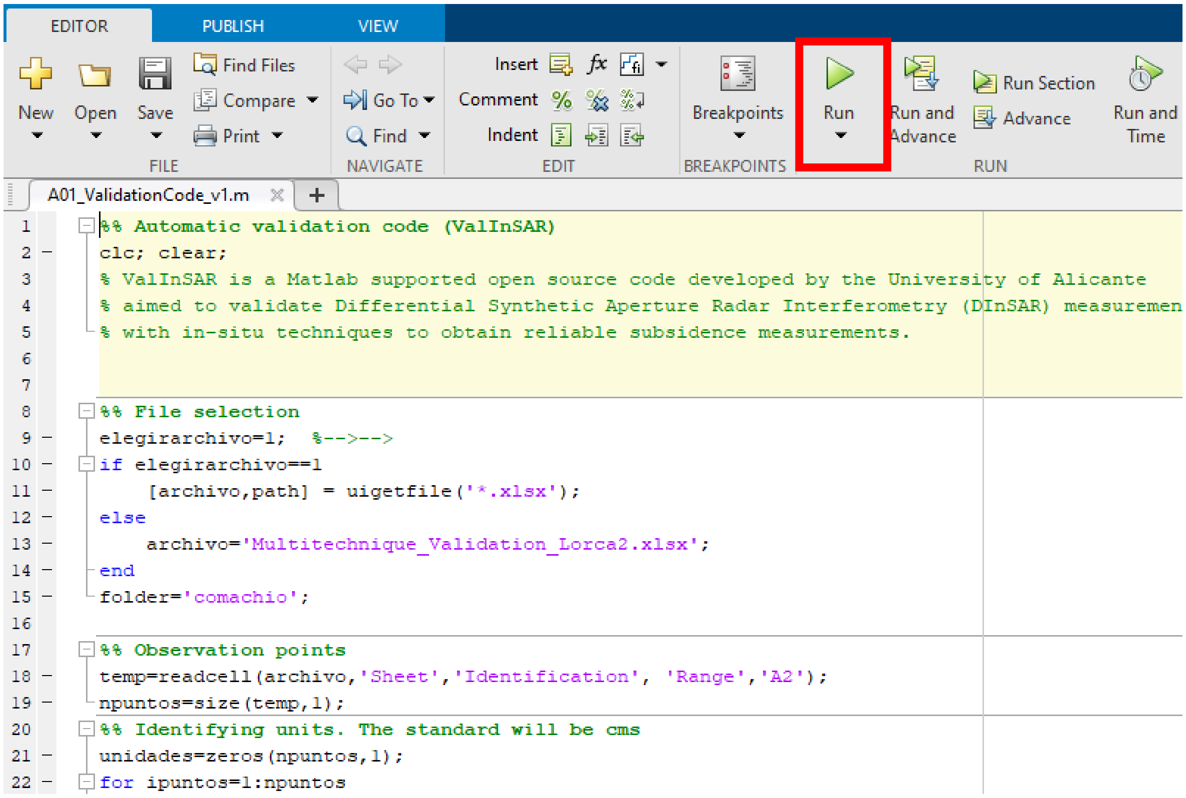
In columns Loc 1, Loc2 and Loc 3, the user will input the time series extracted. Note that according to the proposed methodology these time series correspond to the average time series of the PSs located within the buffer area around the in-situ benchmark defined in the first sheet. For example, for Loc1=LRCA GNSS we will consider the Envisat average time series of the PSs included within the buffer around LRCA location, as the following figure shows:

Angle	23				
Loc1		Loc2		Loc3	
Date	Deformation	Date	Deformation	Date	Deformation
02/06/2011	0.0000	02/06/2011	0.0000	02/06/2011	0.0000
18/06/2011	-0.2334	18/06/2011	-0.0749	18/06/2011	-0.2927
04/07/2011	-0.2069	04/07/2011	-0.4574	04/07/2011	-0.7080
17/07/2011	-0.4231	17/07/2011	-0.5082	17/07/2011	-0.8744
05/08/2011	-0.4563	05/08/2011	-0.8198	05/08/2011	-1.5523
21/08/2011	-0.5293	21/08/2011	-1.2228	21/08/2011	-1.7172
06/09/2011	-0.5235	06/09/2011	-1.4636	06/09/2011	-2.0134
22/09/2011	-0.8893	22/09/2011	-1.6124	22/09/2011	-2.4475
08/10/2011	-0.6994	08/10/2011	-2.0592	08/10/2011	-2.6390
24/10/2011	-0.9284	24/10/2011	-2.2253	24/10/2011	-2.9429
09/11/2011	-1.0633	09/11/2011	-2.5698	09/11/2011	-3.2534
25/11/2011	-1.1141	25/11/2011	-2.7803	25/11/2011	-3.5228

From this point the "TemplateInputs.xls" file is ready for be used by the ValInSAR code

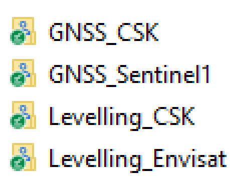
- **A01_ValidationCode_v1.m**

This is the MATLAB code to be run in the software, by pressing the "run" button it will appear a window asking for the input excel file (i.e. "TemplateInputs.xls"). The user selects the file, and the validation will start. More details about the validation appear in the script of the code.



- **TemplateResults.xls:**

The code automatically will create a folder with all the results. This folder contains all the possible combinations (pairs) formed by the available in-situ techniques as the available InSAR datasets. An example is shown in the next figure:



These folders contain all the images and result files named "validation_InsituSource_InSARSource", for example "Validation_GNSS_CSK". This file corresponds to the "TemplateResults.xls" Excel file and contains the ValInSAR statistic calculations.

The results file includes three sheets:

"Statis" correspond to the statistical results for velocity (it includes the statistical summary of all the benchmark for a type of in-situ technique (e.g. GNSS)).

It is worth noting that "sigmavel" and "sigmadef" cells are highlighted, since these values correspond to the standard deviation of the velocity and cumulative deformation from the InSAR dataset, and then should be manually introduced as an input in this file if the user is interested in calculate the NRMSE_A. Note that the statistical results used in the proposed validation methodology are highlighted in orange color (i.e. RMSE1, RMSE2 and R2).

	Vel
sigmavel	0.79
sigmadef	4.64
Range	6.3462
Points avarage	6.2581
Number of point	3.0000
percentil90	-2.5804
percentil10	-8.9267
RMSE	0.6241
NRMSE_A	0.7900
NRMSE_B	0.1648
NRMSE1	0.0983
NRMSE2	0.0997
NRMSE_C	1.0071
MD	0.6197
NMD1=MAPE	0.0404
NMD2	0.6197
NMD3	0.0976
NMD4	0.0990
R2	0.9994
m	0.9879
B	-0.6956

The meaning of the different statistical parameters is next:

- Sigmavel: this is the standard deviation of the InSAR velocity (1·σ). It is introduced by the user to calculate the NRMSE_A.
- Sigmadef: this is the standard deviation of the InSAR cumulative deformation (1·σ). It is introduced by the user to calculate the NRMSE_A.
- NRMSE_A: this is the RMSE normalized with sigmavel/sigmadef.
- NRMSE_B: this is the RMSE normalized with each observation.
- NRMSE1: this is the RMSE normalized with observed ranges.
- NRMSE2: this is the RMSE normalized with observed means.
- NRMSE_C: this is the RMSE normalized with the mean difference.
- MD: this Is the mean difference.
- NMD1: this is the MAPE value.
- NMD2: this is the MD normalized with sigmavel/sigmadef.
- NMD3: this is the MD normalized with observed ranges.
- NMD4: this is the MD normalized with observed means.

The “TemplateResults.xls” summarizes the statistical results for all the time series ordered by columns. Each column contains the results corresponding to each location:

	Vel	loc1	loc2	loc3
sigmavel	0.79			
sigmadef	4.64			
Range	6.3462	13.0745	42.8815	7.2576
Points avarage	6.2581	9.9228	22.0715	47.9036
Number of point	3.0000	84.0000	114.0000	14.0000
percentil90	-2.5804	-5.9075	-5.1454	-45.6113
percentil10	-8.9267	-13.7780	-36.8643	-51.5260
RMSE	0.6241	1.6552	1.0001	0.5242
NRMSE_A	0.7900	0.3567	0.2155	0.1130
NRMSE_B	0.1648	0.1423	0.0482	0.0109
NRMSE1	0.0983	0.1266	0.0233	0.0722
NRMSE2	0.0997	0.1668	0.0453	0.0109
NRMSE_C	1.0071	1.1415	1.3452	1.2523
MD	0.6197	1.4500	0.7435	0.4186
NMD1=MAPE	0.0404	0.0134	0.0043	0.0002
NMD2	0.6197	1.4500	0.7435	0.4186
NMD3	0.0976	0.1109	0.0173	0.0577
NMD4	0.0990	0.1461	0.0337	0.0087
R2	0.9994	0.9969	0.9989	0.9745
m	0.9879	1.2664	1.0676	1.0511
B	-0.6956	1.1939	0.9917	2.0778

The second sheet labelled "velocity" summarizes the calculation of the velocity for each location in the overlapped period for both techniques (i.e. in-situ and InSAR in this example).

Loc	GNSS	CSK
1	-2.5804	-3.2684
2	-7.2673	-7.7841
3	-8.9267	-9.5808

The third sheet, labelled "Deformation", contains the interpolated time series for each location:

	Time	GNSS	CSK	Time	GNSS	CSK	Time	GNSS	CSK	Time	GNSS	CSK	Time	GNSS
Loc	1	1	1	2	2	2	3	3	3	4	4	4	5	5
Data	13/12/2012	-5.12	-5.12	02/06/2011	-1.57	-1.57	28/02/2016	-45.48	-45.48	00/01/1900	0.00	0.00	00/01/1900	0.00
	29/12/2012	-5.34	-5.39	18/06/2011	-2.17	-1.67	08/03/2016	-45.63	-45.56	00/01/1900	0.00	0.00	00/01/1900	0.00
	18/01/2013	-5.20	-5.41	04/07/2011	-2.34	-2.17	11/03/2016	-45.78	-45.67	00/01/1900	0.00	0.00	00/01/1900	0.00
	03/02/2013	-5.35	-5.62	17/07/2011	-2.56	-2.24	12/04/2016	-46.59	-46.43	00/01/1900	0.00	0.00	00/01/1900	0.00
	11/02/2013	-5.34	-5.79	05/08/2011	-3.11	-2.66	28/04/2016	-46.59	-46.85	00/01/1900	0.00	0.00	00/01/1900	0.00
	19/02/2013	-5.12	-5.76	21/08/2011	-3.38	-3.19	11/05/2016	-46.91	-47.15	00/01/1900	0.00	0.00	00/01/1900	0.00
	03/03/2013	-5.38	-5.89	06/09/2011	-3.98	-3.51	30/05/2016	-46.91	-47.81	00/01/1900	0.00	0.00	00/01/1900	0.00
	23/03/2013	-5.67	-6.19	22/09/2011	-4.50	-3.71	15/06/2016	-47.41	-48.14	00/01/1900	0.00	0.00	00/01/1900	0.00
	08/04/2013	-5.93	-6.17	08/10/2011	-4.64	-4.30	01/07/2016	-48.03	-48.75	00/01/1900	0.00	0.00	00/01/1900	0.00
	03/05/2013	-5.97	-6.37	24/10/2011	-4.86	-4.52	30/07/2016	-48.68	-49.50	00/01/1900	0.00	0.00	00/01/1900	0.00
	22/05/2013	-6.18	-6.54	09/11/2011	-4.77	-4.98	14/08/2016	-49.04	-49.75	00/01/1900	0.00	0.00	00/01/1900	0.00
	07/06/2013	-6.40	-6.73	25/11/2011	-5.18	-5.26	31/08/2016	-49.53	-50.22	00/01/1900	0.00	0.00	00/01/1900	0.00
	23/06/2013	-6.43	-6.93	11/12/2011	-5.78	-5.69	03/11/2016	-51.40	-51.81	00/01/1900	0.00	0.00	00/01/1900	0.00