TERRAIN DEFORMATION MONITORING AND ATMOSPHERIC PHASE SCREEN ESTIMATION USING SENTINEL DATA

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ABSTRACT

Persistent Scatterer interferometry (PSI) is a group of advanced interferometric SAR techniques used to measure and monitor terrain deformation. In this poster the PSI processing chain implemented and used at the Geomatics division (PSIG) of CTTC is explained, using the Sentinel-1 data which has a wide area coverage, short revisiting cycle of Sentinel-1A, high image coherence, free of charge data availability etc. are certain characteristics, which makes Sentinel-1 data a great source for deformation monitoring. The atmospheric induced propagation delay correction is essential to avoid inaccurate height and deformation measurements. The main goal of the chain is to obtain a terrain deformation map with a set of selected points (Persistent/Dispersed Scatterer (PS/DS)) containing the information of the estimated annual velocity and the accumulated deformation at each image acquisition time.

OBJECTIVES

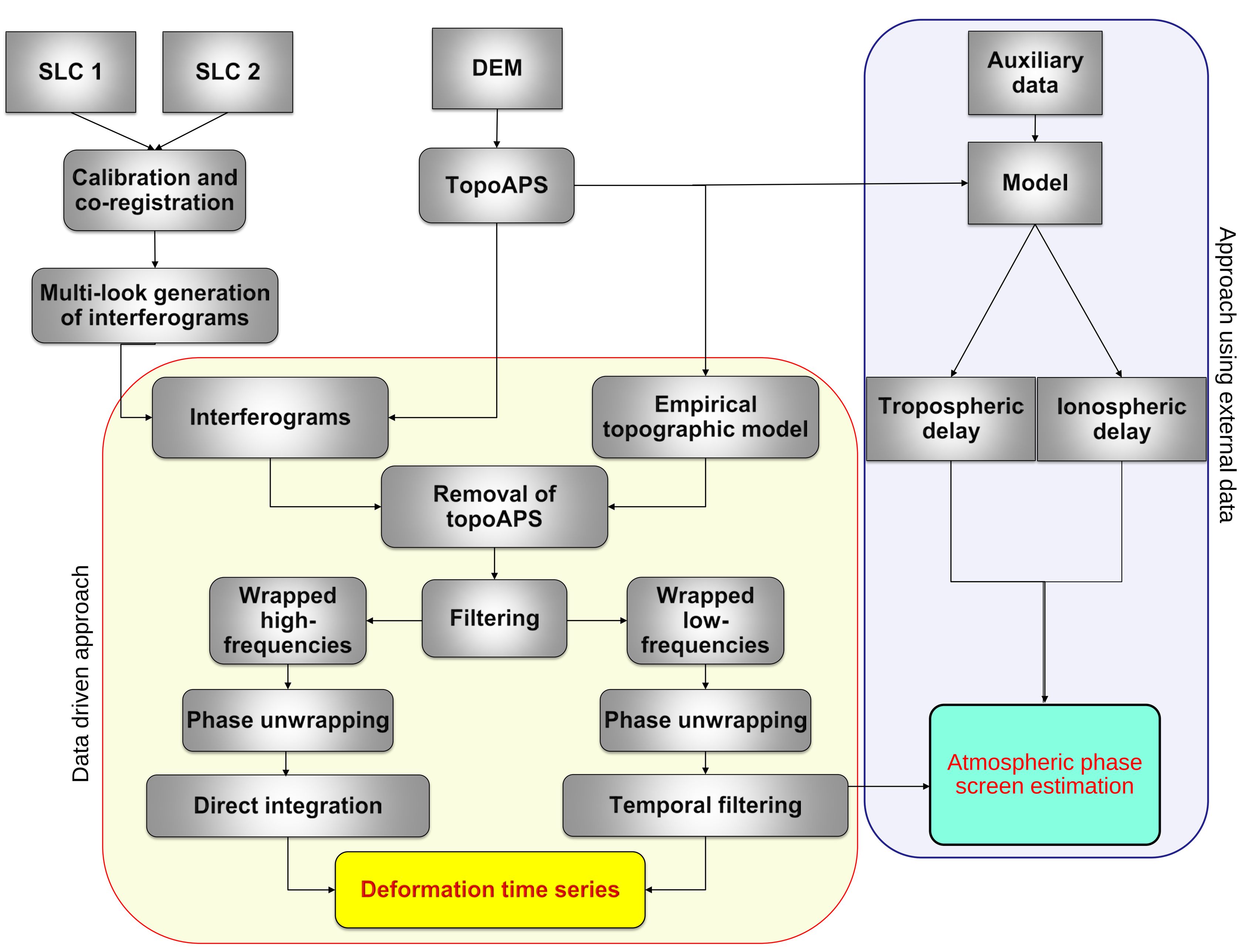
1. **Deformation monitoring using Sentinel-1 data.**

   Develop tools in order to exploit the wide area covering and the high coherence and temporal sampling provided by the Sentinel-1 satellites to allow mid and long-term monitoring of the deformations.

2. **Quantification of atmospheric phase delay**

   Analysis of the existing models to separate atmospheric phase contribution from the interferometric phase.

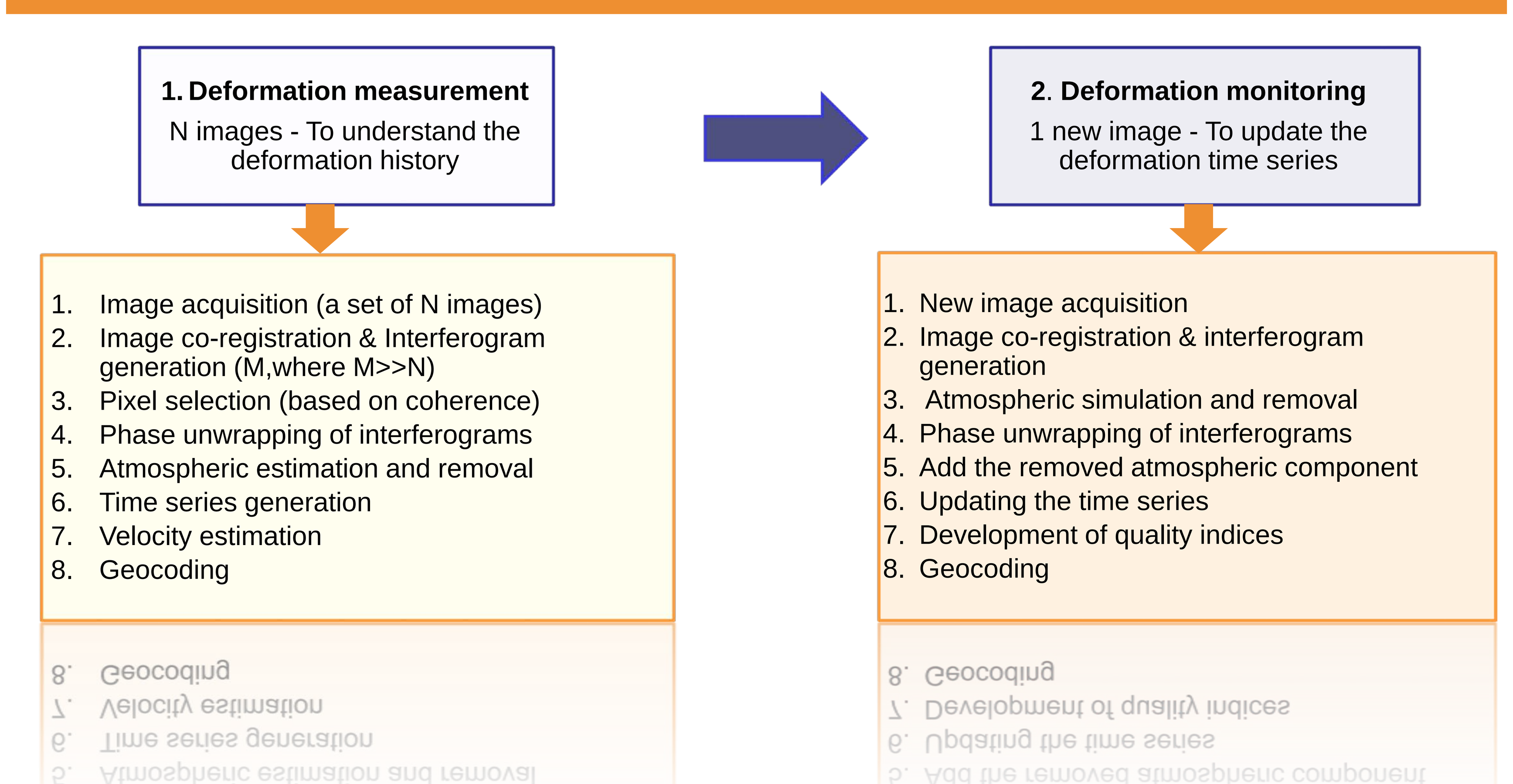
METHODOLOGY



$$\Delta\varphi_{int} = \Delta\varphi_{deformation} + \Delta\varphi_{atmosphere} + \Delta\varphi_{noise} + \Delta\varphi_{topography} + 2k\pi$$

When an interferogram is formed from two SAR images, and a Digital elevation Model (DEM) to simulate and remove phase changes due to topography$\Delta\varphi_{topography}$. Then $\Delta\varphi_{deformation}$ is the actual phase difference due to change in position of the point of interest which gives the displacement of the same, $\Delta\varphi_{atmosphere}$ is the difference in phase generated due to the change in atmospheric column between the first and second transition. These 2 phase differences is addressed in this thesis. The challenge is to separate the phase difference contribution from the total interferometric phase.

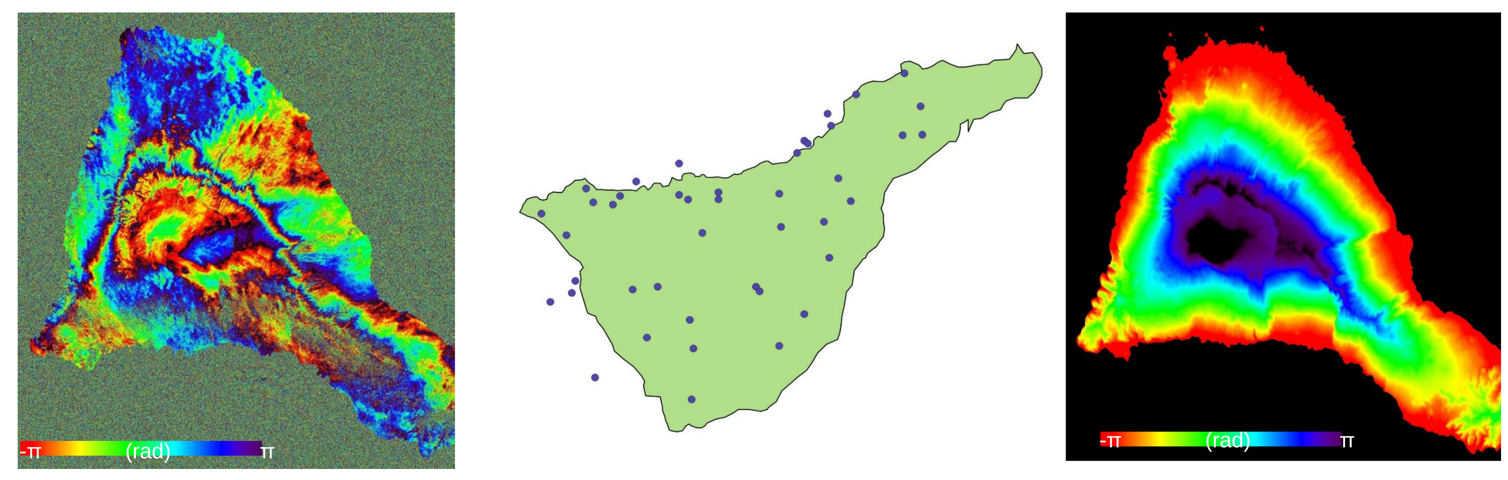
PSIG chain



The main objective of the PSI chain was to extend interferometric processing to wider areas using a unique, redundant and connected network of points and any type of interferometric SAR data. The generated maps consist in a set of selected points (Persistent/Dispersed Scatterer (PS/DS)) containing the information of the estimated annual velocity and the accumulated deformation at each image acquisition time.

RESULTS AND DICUSSION

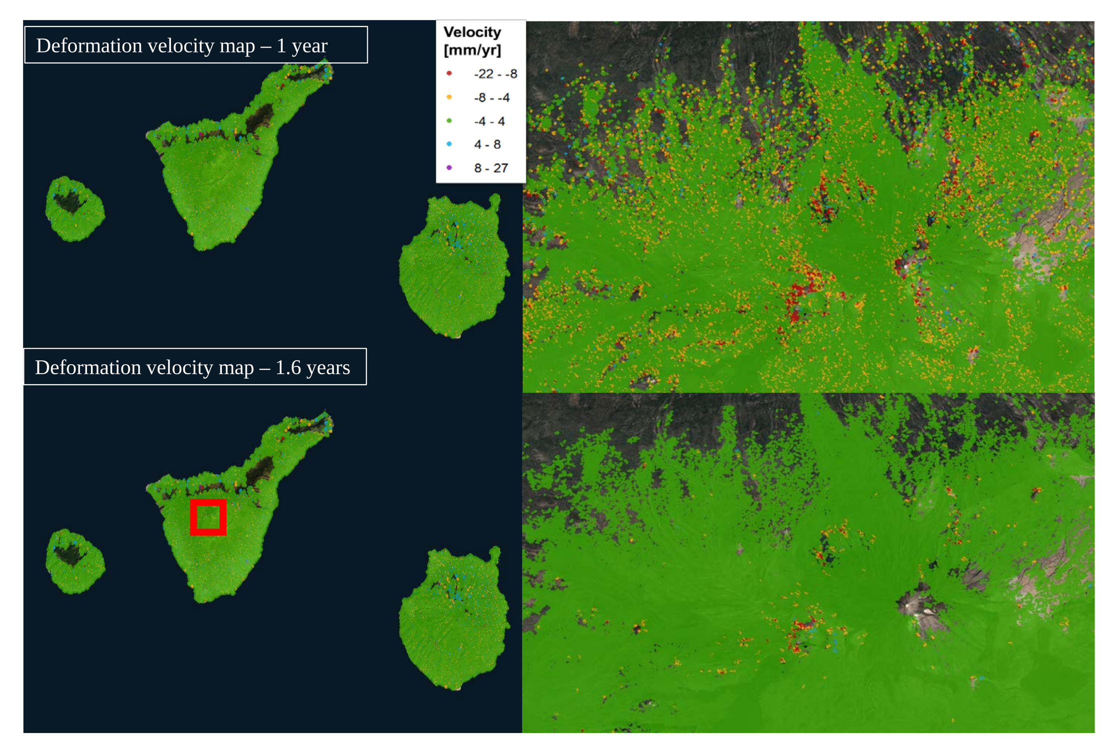
Atmospheric phase screen estimation from auxiliary data



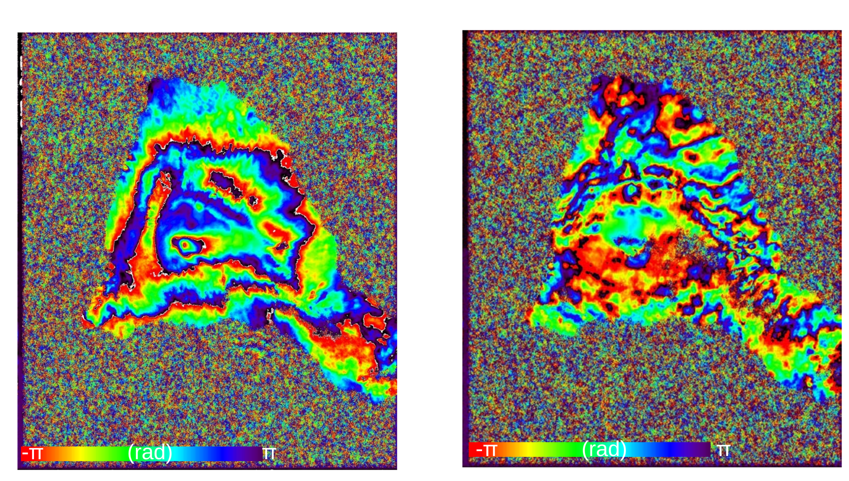
An attempt was made to capture the tropospheric effects using the Saastamoinen model with the ground level meteorological data from the Spanish Agencia Estatal de Meteorología (AEMET) as an input, acquired over the Canary islands lying within the latitude (30,25) and longitude(-20,-10). The figure above shows a sample interferogram of 6 days temporal baseline from 20.05.2017, the weather stations located in the island of Teneriffe and the modelled atmospheric phase delay. The modelled atmospheric phase delay was observed to be only topographically correlated thus not fully capturing the local turbulances and variations of the troposphere

Deformation time-series

The selection of the interferogram network is done by statistically evaluating the coherence of the study area. This analysis provides key inputs for the network like the temporal baseline to be used as well as the presence of periods characterized by low coherence. The increase in the time period of the network generation has resulted in a significant decrease of noise.

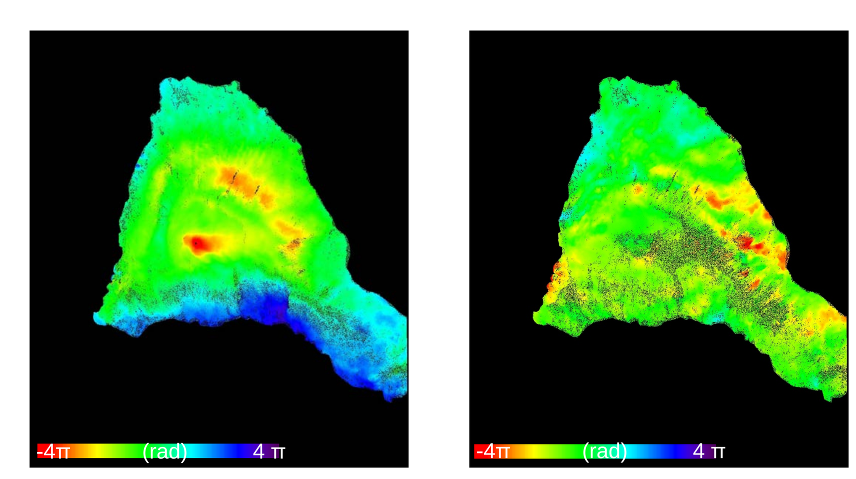


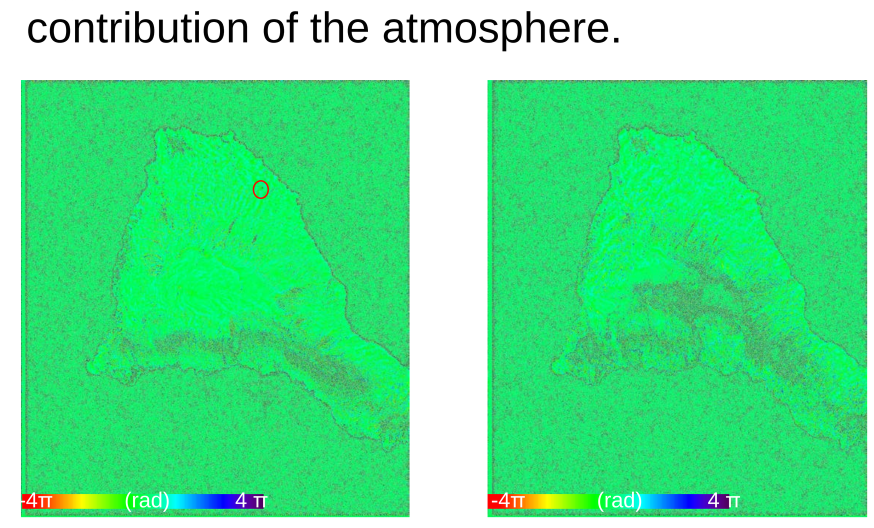
Atmospheric phase screen estimation from the data-driven approach



An example of the phase due to the low frequencies of the interferograms 20170923_20170929 and 20180202_20180208, after removing the phase correlated with topography from the respective interferograms using Fourier transforms.

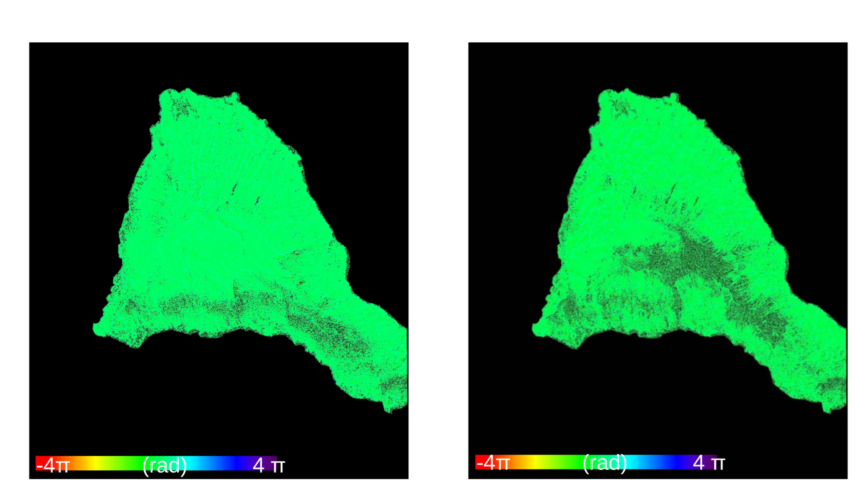
The unwrapped phase from the low frequency signals are shown in the figure for the same interferograms. The separation of low and high frequencies shows a significant improvement in the phase unwrapping. The low frequency signals in this work is assumed to be a contribution of the atmosphere.

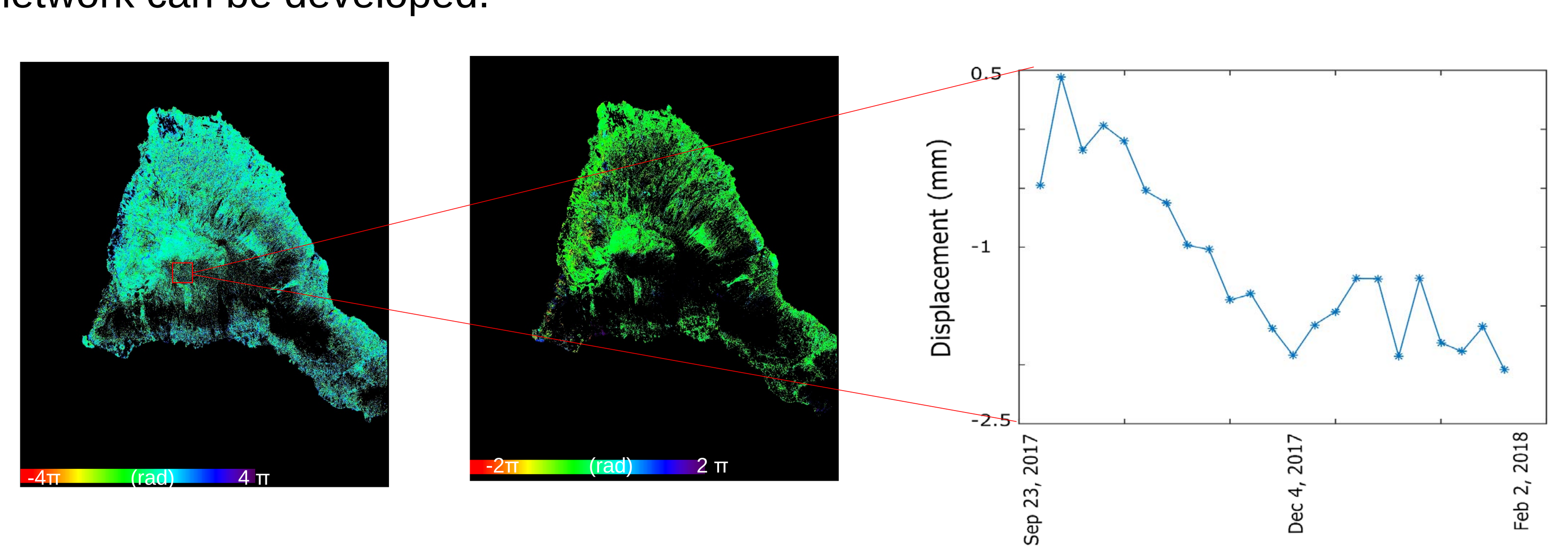




The phase of the residuals after of filtering the low frequency signals is shown in the figure. By preliminary qualitative analysis, it was observed that most of the deformations or movements existing in the given area was retained in the image

The unwrapped phase from the high frequency signals are shown in the figure for the same interferograms. It is worthy to notice that unresolvable phase unwrapping errors are not present in this. By considering the temporal filtering of the accumulated low-frequencies a method to remove the APS from the interferogram network can be developed.





The figure above shows the accumulated deformation using the filtering and the standard PSIG chain. It shows a significant improvement in the spatial coverage of PSs and reduction in phase unwrapping errors. Also an example of the time series of a stable point is shown in the figure.