Short Term Mobility (STM) 2017: Final Report

Title of the programme:

Development of Advanced DInSAR strategies for the cross-comparison analyses and up-to-dating of Earth's surface displacement time-series

Objectives:
The main purpose of my visit at Arizona State University (ASU) has been the realization of some common analyses (of mutual interest for ASU and CNR) on the area of San Andreas fault, U.S. In particular, the cross-comparison analysis between the products of differential synthetic aperture radar (DInSAR) techniques for the monitoring of the Earth's surface displacement over time has been carried out. To this aim, the Small Baseline Subset (SBAS) and the Wavelet-Based InSAR (WabInSAR) techniques have been considered.

Performed Activities
During my visit, I worked with prof. Manoochehr, on a joint project to benchmark WabInSAR time series code against the well-known SBAS algorithm. To this end, I processed a SAR dataset composed by 32 images acquired by Envisat satellite over the central creeping segment of the San Andreas Fault. A geocoded SAR image of the case-study area is shown in Figure 1.

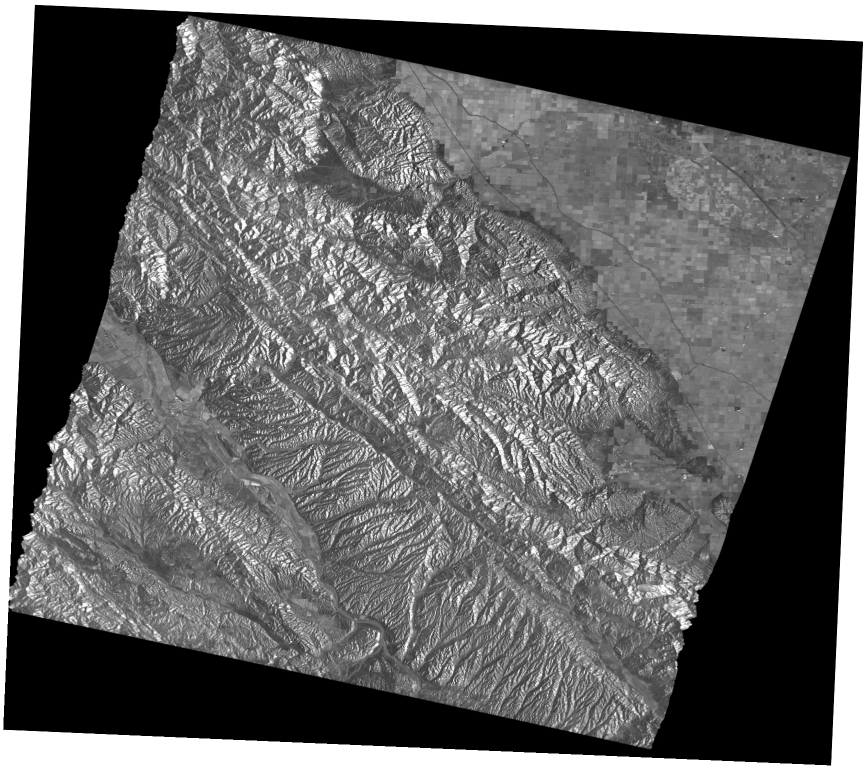


Figure 1: The temporal multilook image of the area of San Andreas Fault, representing the case-study of the analysis performed during the STM program at ASU.

The distribution of the available SAR data in the temporal/perpendicular baseline domain is shown in Figure 2.

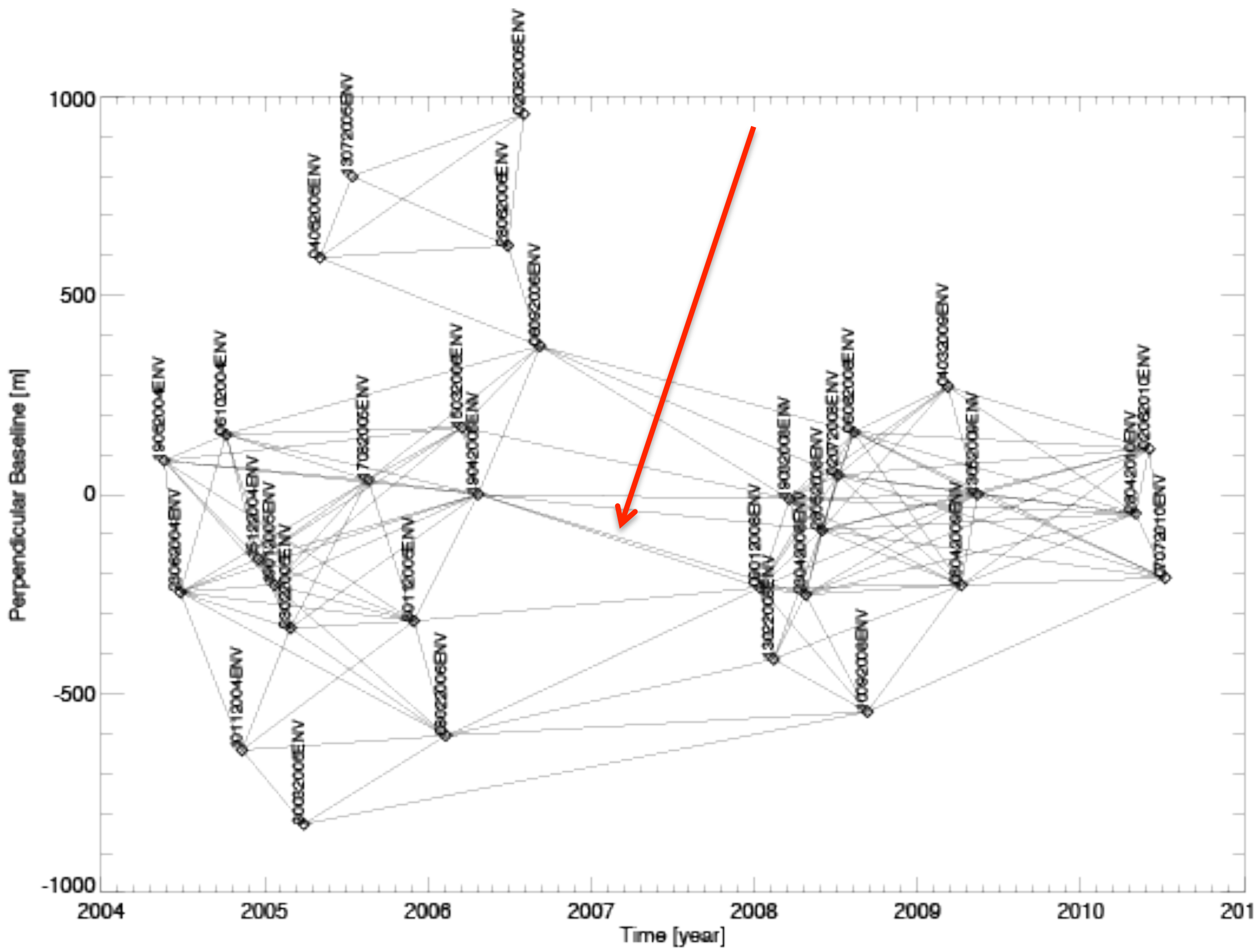
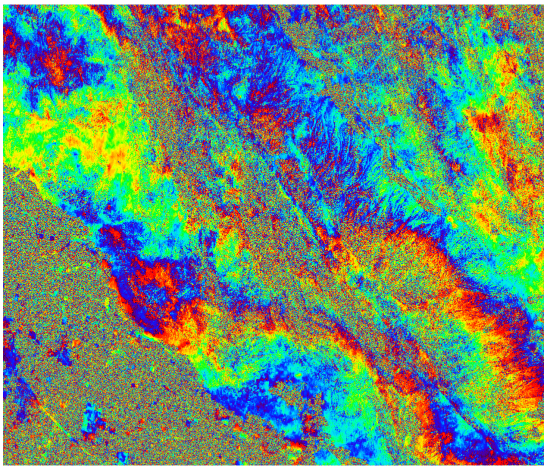
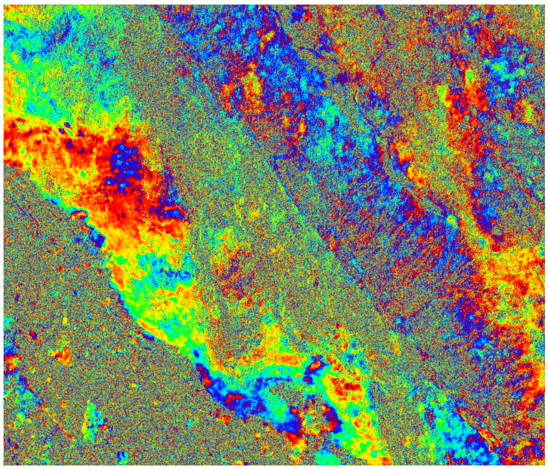


Figure 2: Distribution of the available SAR images in the Time/Perpendicular Baseline. As evident, there is a gap of about one year between 2006 and 2007. It implies that interferograms spanning that time interval (highlighted by the red arrow) are very noisy and difficult to be inverted. See also Figure 3.

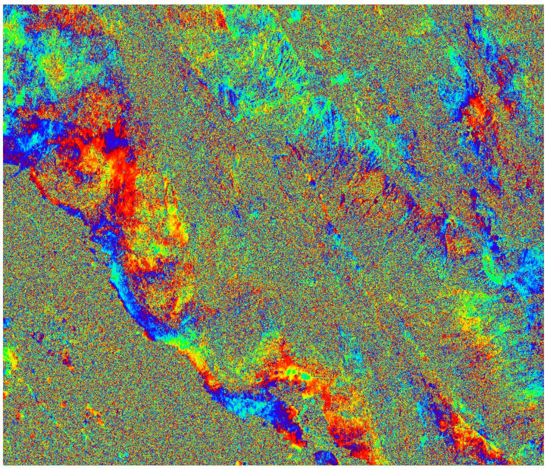
It is worth highlighting that the application of advanced Multi-temporal InSAR (MtInSAR) techniques for the generation of Earth's surface deformation, as SBAS and WabInSAR, requires the available images are properly co-registered with respect a reference image and the images are not far apart in the temporal/perpendicular baseline domain. Indeed, large baseline interferograms are more affected by noise and this limits the applicability of DInSAR techniques and the retrieval of geophysical parameters of the observed scene. Application of conventional SBAS technique revealed ineffective because most of the deformation was located in the area where the DInSAR interferograms were noisy. To circumvent this problem, I applied a modified version of the SBAS approach, consisting in estimating the mean deformation velocity of the area starting from a reduced set of very coherent interferograms, instead of using all selected short baseline interferograms shown in Figure 1.
Figure 3 shows some of the DInSAR interferograms used for the estimation of the mean deformation map of the area. The modified SBAS diagram block is also shown in Figure 4. As result, I generated deformation time-series of the area for the whole set of coherent/temporally coherent targets. The map of the mean surface deformation is depicted in Figure 5. As evident, a clear pattern of deformation is present across the fault, where a relative deformation of about 8 mm/year is captured.
The purpose of such activity was to cross-compare the results achieved with SBAS against those obtained with WabInSAR. To this aim, the same Envisat SAR dataset was indipendently processed by colleagues at ASU with WabInSAR. The obtained mean deformation velocity map of the area is shown in Figure 5



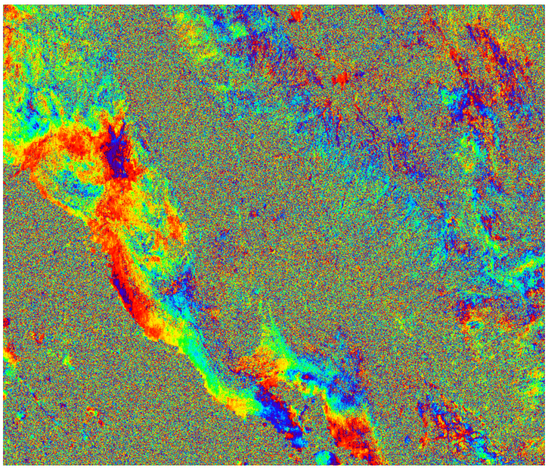
Aug. 6, 2008 – May 13, 2009



Apr. 23, 2008 – Apr. 8, 2009



Sept. 6, 2006 – Aug. 9,



Apr. 19, 2006 – July 2,

Figure 3. A selection of the DInSAR interferograms used for the experiments carried out at ASU.

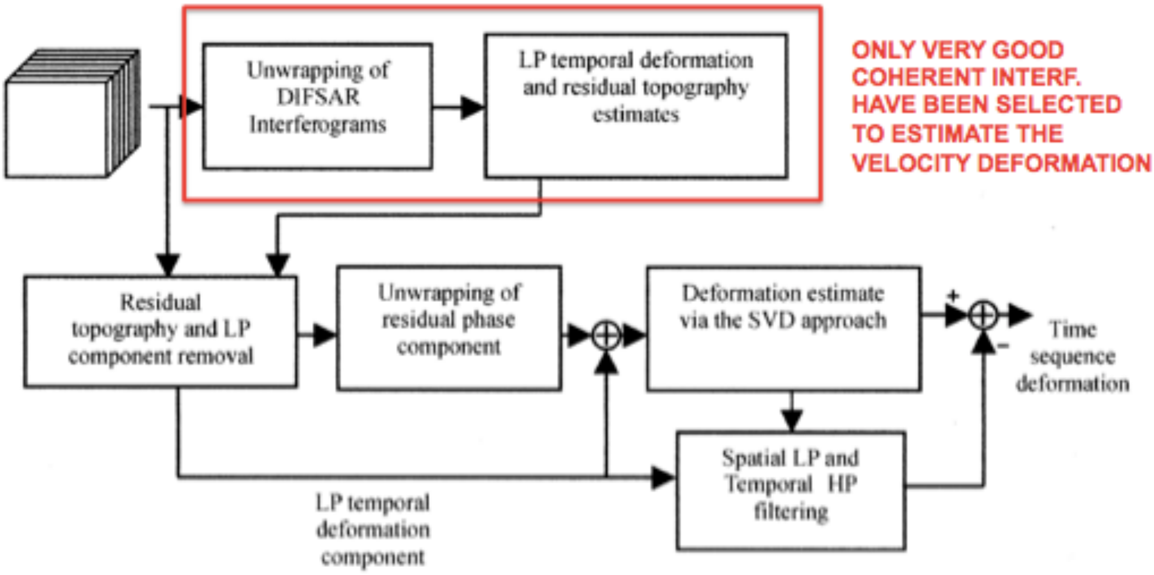


Figure 4. Modified SBAS processing chain.

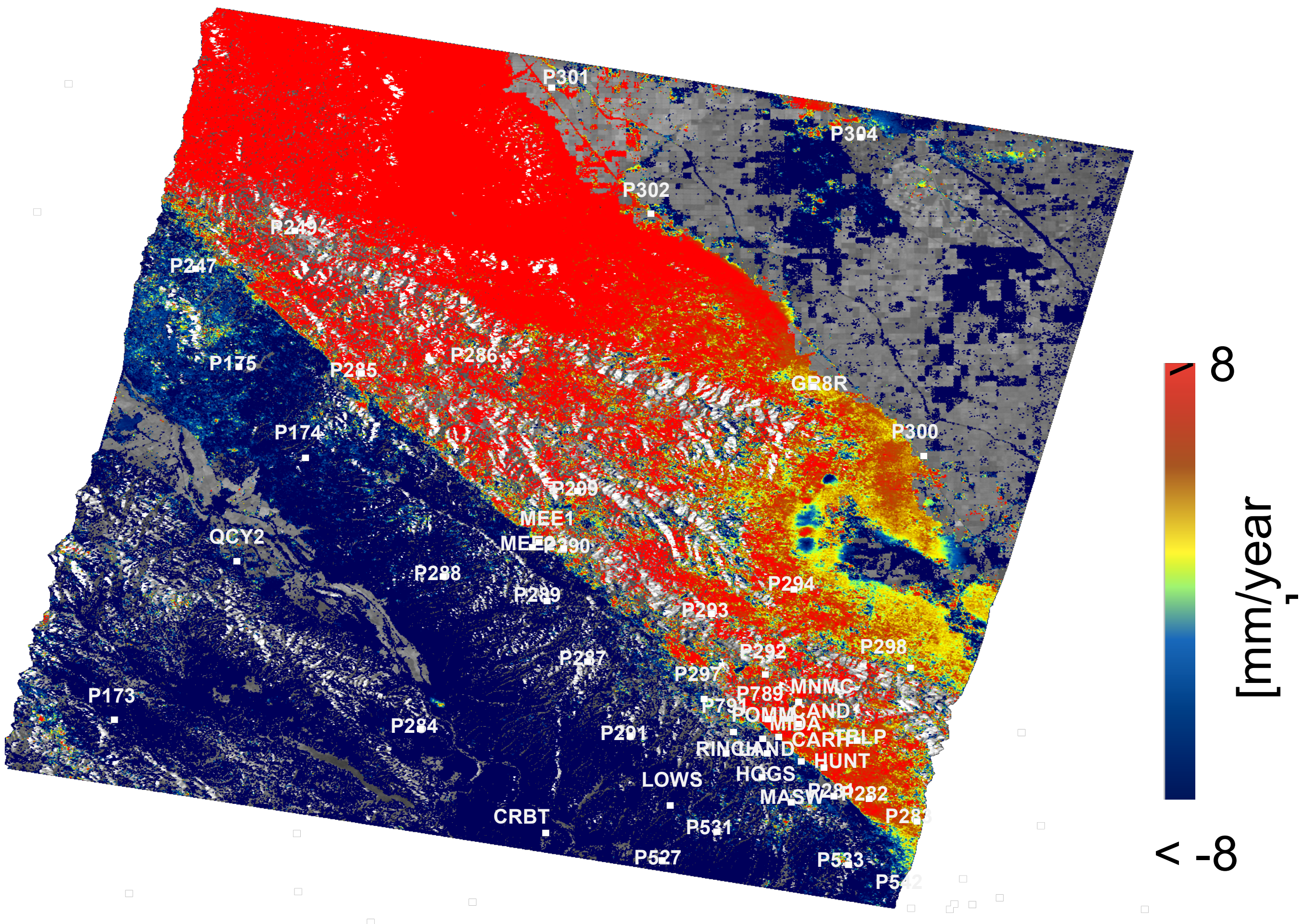


Figure 5. Mean displacement map of the San Andreas fault as revealed by applying the modified SBAS approach. Only the deformation of the very coherent pixels is portrayed. Location of GPS station is also highlighted.

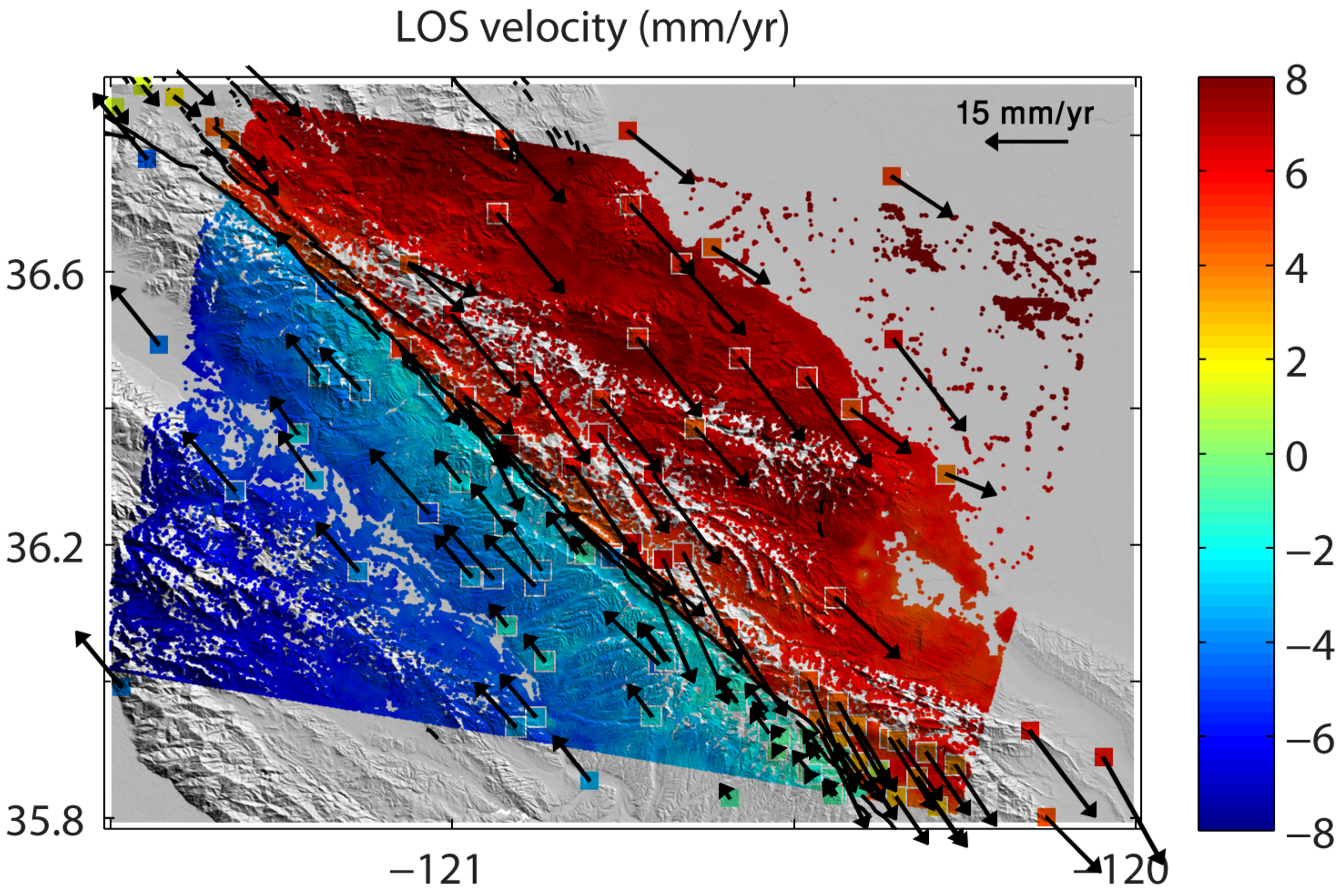


Figure 6. Same as Figure 5 but by using the WabInSAR method.

Some preliminary results of the cross-comparison analysis are provided in Figure 7, where the deformation time-series of some selected targets located in the vicinity of relevant GPS stations are presented. Location of GPS stations is highlighted in Figure 5. The root mean square error of the difference between GPS and DInSAR-driven measurements is also indicated in the presented plots. Globally, the agreement between GPS and SBAS results is good with RMSE values ranging from 1 mm to 5 mm, and an average value of about 2.5 mm.

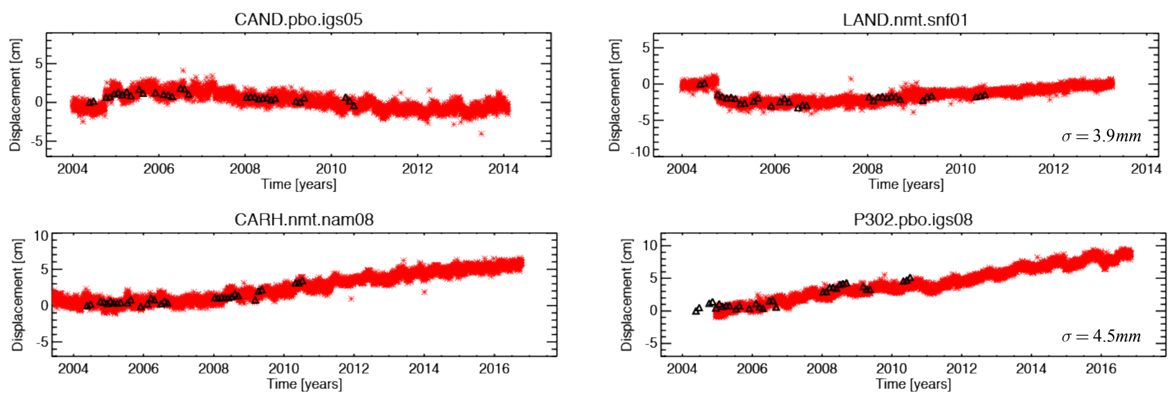


Figure 7. Comparison between GPS and SBAS-driven deformation time-series in correspondence of some selected GPS stations. Standard deviation of the difference between InSAR-derived and GPS data is also indicated.

In cooperation with the ASU's colleagues, I count to extend this preliminary analysis and provide a more accurate cross-comparison among GPS measurements, SBAS and WabInSAR deformation time-series in a publication. We are working these days to write a full paper and we count to submit it by the end of this year.

Outcomes and Further cooperation between CNR and ASU

During my stay at ASU, we further discussed my involvement in the NASA sea level change team, which resulted in developing a proposal submitted to ASI to acquire CSK imageries over several key coastal cities in California. I will assist us in processing these data sets and contribute to data interpretations. We have also discussed long-term collaborations between Arizona State University (ASU) and IREA-CNR, regarding conducting joint projects and exchanging researchers, which will benefit both parties.

Currently, as said, we are working together for drafting some papers to be submitted for publication on peer-review journals in 2019.

Date Signature

Antonio Pepe

October 23, 2018