The Split-Band Interferometry Approach to Determine the Phase Unwrapping Offset

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Split-Band Interferometry

Split-Band Interferometry (SBInSAR) takes advantage of the large range bandwidth of recent sensors to split it into subbands and produce several subrange images of a same scene, with lower resolution and shifted frequencies. In a first time, the same spectral decomposition is applied to both master and slave images of a given pair. Then interferometry is applied to the subrange images of the pair, yielding a stack of subrange interferograms. Finally, the linear phase trend is explored through the stack of interferograms in order to provide **absolute phase measurements**. The issued phase is called the split-band phase (Figure 1).

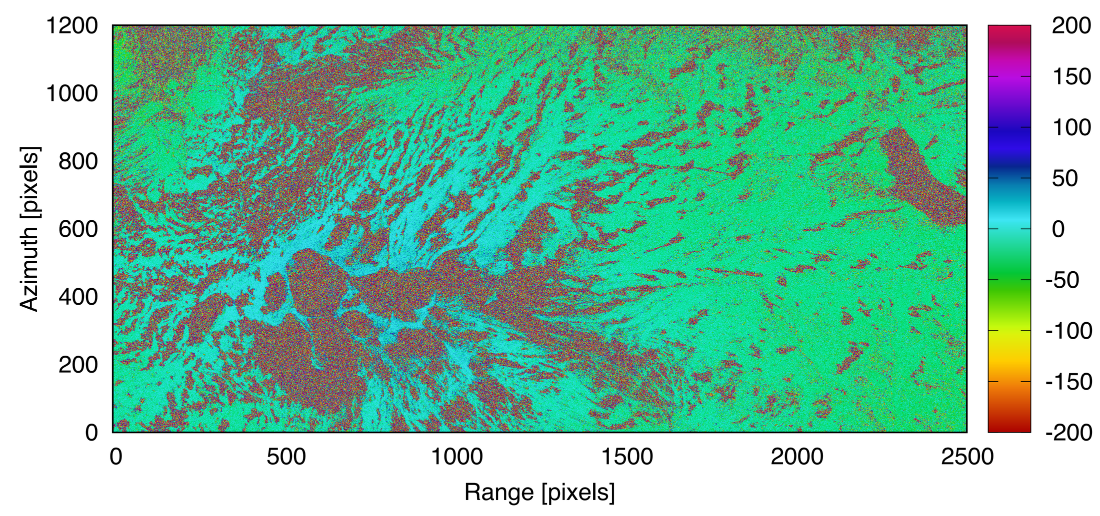

Figure 1. Split-Band Phase

Phase Ambiguities

Conventional phase unwrapping algorithms for InSAR processing perform a relative measurement of the phase, i.e. the phase is reconstructed for each pixel with respect its neighbours. In practice, this causes distinct phase unwrapping of regions separated by noncoherent patches and it introduces unknown phase-offsets that prevent from comparing the phase from one region to another (Figure 2). Since SBInSAR is supposed to provide absolute phase measurements, it can potentially **solve the phase ambiguities** and **reconnect the phase of separately unwrapped regions.**

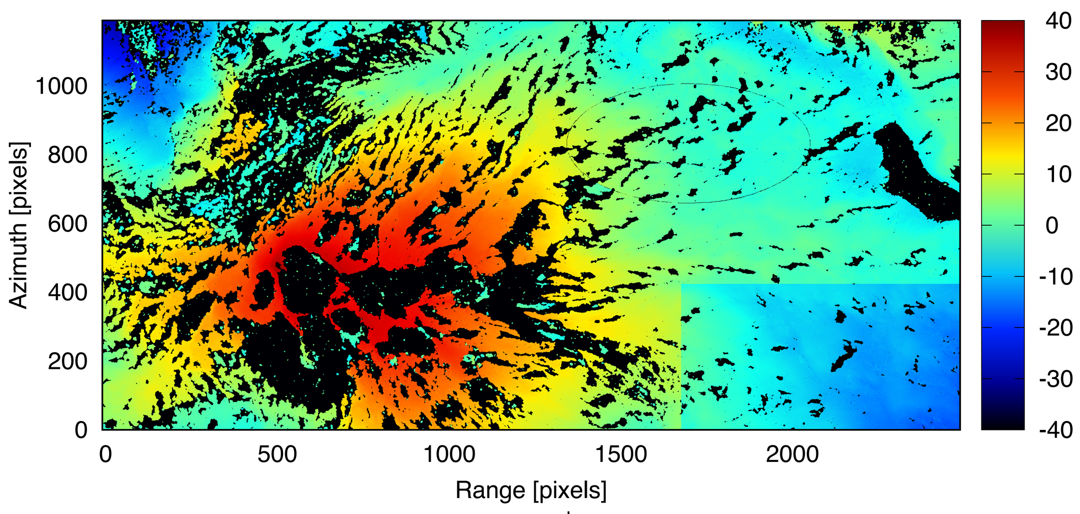

Figure 2. Unwrapped Phase

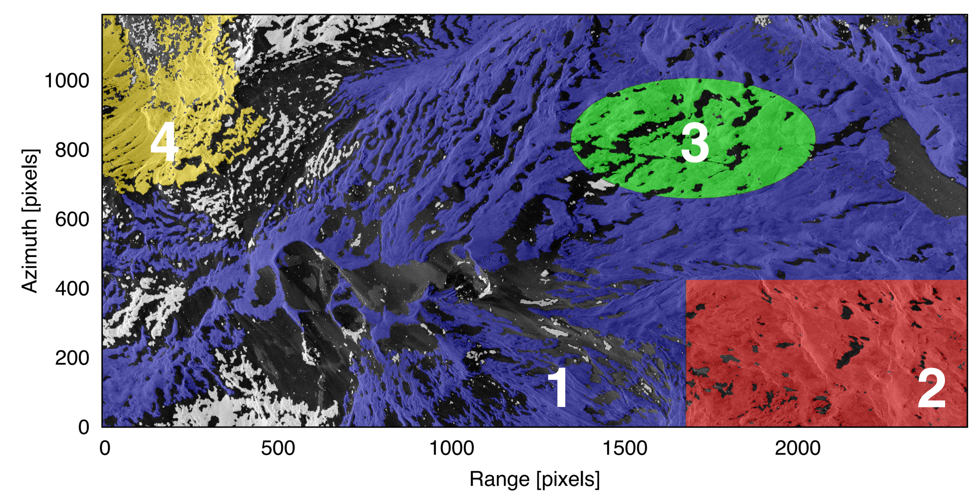

Figure 3. Map of the Manually Disconnected Regions

In this study, we propose to use SBInSAR to assist the phase unwrapping and reconnect separately unwrapped areas. We consider the general case where the phase ambiguity is an unknown number of cycles $2\pi n$, with n being an integer. This phase ambiguity has the same value for all the points through a given region of continuously unwrapped phase.

Frequency-Persistent Scatterers

Targets with a stable response across the spectral domain are called **frequency-persistent scatterers (PS_f)**. The spectral stability of a PS_f ensures the linear behaviour of the phase with the frequency and therefore the accuracy of the split-band phase. Consequently, absolute and spatially independent measurements are possible using SBInSAR at these points only. We propose two criteria to select PS_f assuming a one-cycle accuracy of the split-band phase: first, the **standard deviation of the slope** of the linear regression; second, **the stability of the phase variance** throughout the subrange interferograms.

SBInSAR-Assisted Phase Unwrapping

In a first time, the **SBInSAR-assisted phase unwrapping** selects the PS_f of a given region based on one criterion or the other. Then it computes the difference in cycles between the split-band phase and the unwrapped phase for each selected PS_f. The value of the phase offset with the highest number of occurrences, i.e. the **mode** of the distribution, is assumed to be the correction that must be applied to the unwrapped area.

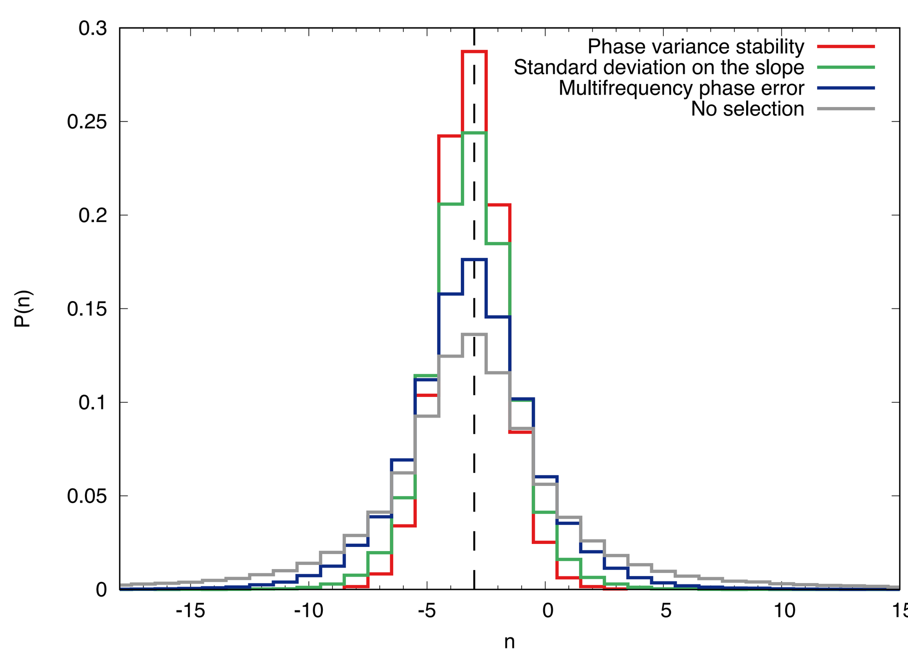

Figure 4. Normalized Distributions of the Difference in Cycles between the Split-Band Phase and the Unwrapped Phase at the PS_f Selected for Region 3

Test Case

SBInSAR-assisted phase unwrapping was tested on a pair of Spotlight images acquired by TerraSAR-X over **Copahue Volcano** on December 15 and 26, 2014. A spectral decomposition into 5 nonoverlapping subbands of 60 MHz was applied. In order to validate our results, we artificially disconnected regions of the unwrapped phase (Figure 3). This approach enables a **validation based on the relative values** of the phase-offsets.

Results

When applied to the test case, the method provides the expected phase ambiguities for the artificially disconnected areas, whatever the selection criterion. However, the distribution shows less dispersion when the phase variance stability is used (Figure 4). Moreover, the procedure has been tested on both artificially and naturally disconnected areas and we observed that the percentage of PS_f contributing to the mode of the distribution stabilizes around 25-35% when the region contains more than 30 PS_f. This amount is considered to be the minimum number of PS_f to have a **statisticallly significant population** (Figure 5).

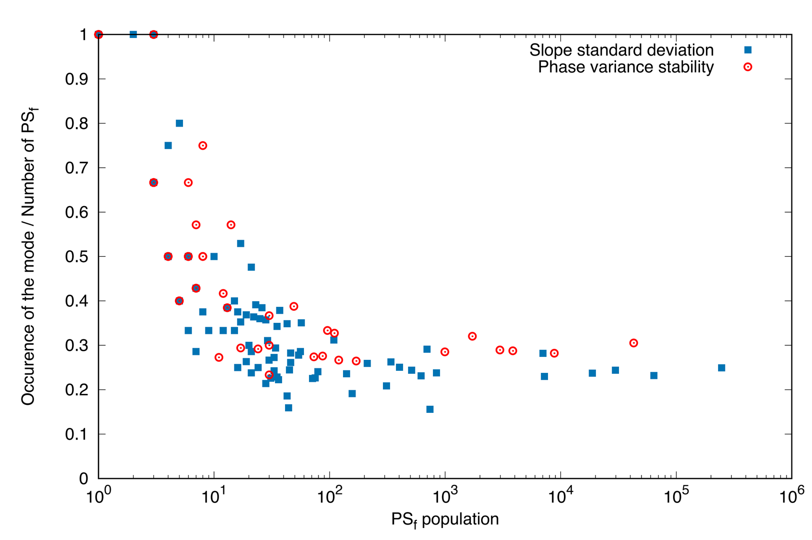

Figure 5. Percentage of Mode Occurrences for all Distinct Regions

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