Title

Sensitivity Assessment of Sentinel-1 SAR Closure Phase to Vegetation and Soil Moisture Dynamics: A Case Study for Regions in Southern France

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Date

2022-01-27

Abstract

From three coherent SAR images it is possible to estimate three interferograms. Combined in a circular way, the sum of the three interferometric phases is called the closure phase which necessarily adds up to zero on a single pixel level. However, if the interferograms are spatially averaged, phase consistency is not guaranteed. In most of the interferometric studies, those mismatches were assumed to be caused by decorrelation noise alone, and were either not considered or deemed negligible, eluding further investigations of its origin. However, recent publications have confirmed that inconsistent phase closures are systematic and not the exception, pointing to an underlying geophysical cause. Comparisons of the spatial signatures of phase closures with land cover maps suggest a spatial and temporal correlation that is related to the characteristics of different land cover types. Since interferometric measurements are sensitive to variations of the dielectric constant, those similarities have been attributed to dynamics in vegetation and soil moisture. A closure phase significance test developed at the Geoscience and Remote Sensing department at TU Delft aimed to increase the signal-to-noise ratio of this geophysical signal component by providing a significance ratio for phase closures. However, the sensitivity of (significant) phase closures to dynamics in vegetation and soil over different land cover types has not been assessed yet. Here we show that with enough averaging of the interferometric phase, the spatial and temporal characteristics of closure phase can be used to distinguish between different land cover types. We found that the degree of spatial averaging has a significant impact on both the phase closure values and its spatial and temporal consistency. The magnitudes of significant phase closures generally increased over low-vegetated land covers, suggesting that closure phases are most sensitive to soil moisture dynamics, whereas vegetation cover was associated with decreasing phase closure magnitudes and spatial inconsistency. Besides spatial averaging, significant differences were observed between closure phases from different polarizations. Furthermore, we found that amplitude backscatter and closure phase are spatially and temporally correlated, pointing to similar influencing mechanisms. Our results demonstrate the importance of applying a closure phase significance test and describe the effect of spatial averaging on the characteristics of phase closures with respect to different land cover types. We anticipate this study to provide useful steps towards using the closure phase for soil and vegetation monitoring in the future. For example, the findings could be used to further exploit potential synergies with amplitude backscatter for soil moisture retrieval from closure phase or develop more sophisticated methods for land cover mapping using InSAR. If not used for applications linked to land cover, vegetation or soil, being able to better predict the effect of those parameters on the interferometric phase and coherence, eventually enables to separate their contribution from other signals, such as deformation estimates. Additional research is needed to relate significant phase closures to moisture changes in vegetation.