Interferometric closure phase: observation of polarimetric modulation, seasonal effects, and wavelength dependencies

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Introduction

Closure phase deviations are fundamental phase inconsistencies arising in SAR interferometric stacks when multi-looking is applied to the interferograms. Besides challenging simple interpretation and retrieval of the interferometric phase history, they seem to contain information on the propagation in semi-transparent dielectrics which could find application in moisture monitoring and vegetation growth. In general phase inconsistencies signal the presence of two or more scattering mechanisms with different phase evolutions. Satisfactory and sound physical interpretation of the observation of closure phases remains a research subject.

In order to shed more light into this poorly understood effect, we are currently investigating different datasets at the phenomenological level. In this work, we collect evidence to show possible polarimetric effects, seasonal effects, and wavelength dependencies. ALOS-2 and Sentinel-1 are ideal tools to explore closure-phase effects, in particular to their high coherence over vegetated targets.

Dependencies with polarimetry

Preliminary results demonstrate that changing the polarimetric basis can have a modulatory effect on the closure phase. This is observed in an L-band dataset acquired by ALOS-2 over Japan. These first results indicate that the Pauli 3 component is more subject to closure phase deviations relative to the Pauli 1 component, suggesting an influence of vegetation. Polarimetry shows thus some capability in separating the mechanisms that generate phase inconsistencies, though no polarization will in general yield perfect consistency. The relation with polarimetric entropy is under investigation.

Dependency with season

Seasonal observations are now possible with Sentinel-1 data, since many stacks have now reached two year temporal span. Clear seasonal dependencies are observed in a Sentinel-1 dataset over Mexico, where dry winters and wet summers clearly show up in the average closure phase for consecutive acquisitions. These observations support the idea that water status is the main driver for closure phase, especially in modern datasets where the baseline component is kept under strict control, and rule out pure volumetric-geometric effects.

Analysis of the discrepancy between 12 day and 24 day interferograms reveal that the potential reconstruction drift in the phase history is in the order of >1 cm/year: a relevant limitation to InSAR analyses over distributed targets.

Dependency with wavelength

In general phase closures have been observed at frequencies ranging from P to X-band, but for entirely different datasets. We now plan to compare different frequencies over the same area and time span, by analyzing Sentinel-1 data and ALOS-2 data together. Depending on the coupling between propagation and attenuation of the electromagnetic wave, closure phases are expected to show more or less wavelength dependency.

Modelling closure phase evolution

A key parameter to characterize dielectrics is the tangent loss, i.e. the ratio between the imaginary part and the real part of the dielectric constant. Assuming that the tangent loss is constant while the moisture content of soils or woods varies, a small tangent loss allows for large phase evolution with a small change in the power balance between different scattering mechanisms or scattering surfaces. Large tangent losses instead cause a rapid change in the attenuation and consequently fast decorrelation, as different scatterers or surfaces suddenly appear or disappear. Values of the tangent loss appropriate for wood are compatible with the observations, though it has not been possible yet to invert a physical model.

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Additional material and references

Some figures showing sesonal effects and polarimetric effects on closure phases are to be found in the attached pdf.

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