1) Introduction

The ionosphere is a dispersive medium for radar waves and the introduced propagation delay is one of the most relevant error sources in interferograms from low-frequency spaceborne Synthetic Aperture Radar (SAR), e.g., L-band SAR (Fig. 1). In our study we use a split-band method to estimate this delay and to correct L-band interferograms. For the first time we use such corrected data in an earthquake source analysis. We compare this physically-informed phase correction with the commonly used simple deramping of interferograms.

We use ALOS L-band data of the non-complex rupture of the M6.8 2011 Tarlay earthquake in Myanmar to demonstrate the applicability of the method. We further show that the fault model results by either correction method differ, not much, but notably.

2) Split-band method vs deramping

The ionosphere advances the radar carrier phase \( \varphi_c \), depending on the total electron content (TEC) (Eq. 1, \( c \) is speed of light, \( K \) is 20.28 m\(^3\)s\(^{-2}\)). The ionospheric phase shift \( \Delta \varphi_{ios} \) is frequency dependent and because the radar pulse has a frequency bandwidth in the MHz range around \( f_0 \), we can separate the returned signal into a low and high frequency band. The non-dispersive parts \( \Delta \varphi_{ramp,l} \) in \( \Delta \varphi_l \) and \( \Delta \varphi_{ramp,h} \) are equal in both bands (Eq. 2).

\[
\begin{align*}
\varphi_c &= \frac{2\pi}{\lambda} \cdot BC \cdot TEC \\
\Delta \varphi_{ramp,l} &= \Delta \varphi_{ramp,h} = \frac{4\pi}{\lambda} \cdot f_0^2 \cdot TEC \\
\Delta \varphi_{ios} &= \Delta \varphi_{ramp,l} + \Delta \varphi_{ramp,h} = 2\pi \cdot f_0 \cdot TEC
\end{align*}
\]

The ionospheric contributions \( \Delta \varphi_{ios} \) differ and can be extracted to get \( \Delta \varphi_{ramp,h} \).

Without any knowledge of the ionospheric phase delay we usually deramp the data (Eq. 3, \( \varphi_{residual} \)). In our study we use a split-band correction for the analysis of larger earthquakes, where deramping becomes problematic.

3) Application to earthquake fault modelling

The M6.8 Tarlay earthquake occurred on March 24 in 2011 in the so-called Golden Triangle region of Indochina (Fig. 3). It ruptured the left-lateral strike-slip Niem Ma fault producing a surface displacement of more than 1 m (Tun et al., 2014). Our fault modelling includes all first-order fault parameters without knowledge of any specific site and external information.

The predicted surface displacements from our optimum fault model fit the InSAR-measured surface displacements generally very well (Fig. 4). This model gives, however, a systematic over-estimation of the azimuth SAR pixel offsets.

In our model comparison we find similarly to other reported fault models of the 2011 Tarlay earthquake that the results of the simply deramped data give a spurious oblique mechanism. The split-band method corrected data models suggest pure strike-slip on a vertical fault plane (Fig. 5).

4) Conclusions

The split-band method for ionospheric phase correction of L-band InSAR data gives excellent results and proved very useful in our fault modelling.

Data deramping can introduce a notable bias to the fault modelling results already for moderate-sized displacement signals of moderate extent of some tens of kilometers.

Our results suggest a larger importance of physically-informed ionospheric correction for the analysis of larger earthquakes, where deramping becomes problematic.

Acknowledgements & References

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Figure 1. Sensor-ground geometry.

Figure 2. Left: ALOS L-band interferograms spanning the 2011 Tarlay earthquake are heavily affected by ionospheric phase delays. Middle: Using the split-band methods separated ionospheric phase. Right: Corrected interferograms.

Figure 3. Regional tectonic overview of Indochina (map after Lacassin et al., 1998) and teleseismic earthquake location and mechanism (source: USGS) as well as mapped rupture trace after Tun et al. (2014).

Figure 4. Optimum model using a rectangular dislocation with uniform slip in an elastic half-space and the split-band method corrected data. The modelled surface trace is outlined in blue (middle) and the mapped surface is dotted in white (middle) or black (right).

Figure 5. Comparison of fault model parameter statistics from Bayesian data error pre-estimation (Sudhaus & Jönnson, 2009) for split-band method corrected InSAR data (dark red) and deramped InSAR data (orange).