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Processing and performance of large scale deformation monitoring with InSAR stacks

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SAR interferometry is a powerful tool for monitoring large scale deformation of the Earth's surface. The performance of the deformation product depends on a number of crucial factors, among which the quality and quantity of the original SAR data, the corrections applied, and the processing algorithms. Disparity in these factors can yield results that are significantly different using different tools and approaches.

The tropospheric delays, if not corrected, can amount to many cm of extra delays at distances of hundreds of kilometers, e.g. typical Sentinel-1 scenes. Significant effects are also cause in conjunction to large topographic variations. According to our experience, by correcting the tropospheric delay using the ECMWF models for atmospheric pressure, humidity and temperature, on can abate the residual errors to 1 or a few centimeters, depending essentially on the geographical location.

The ionospheric phase delays are often very significant in L-band interferograms. We have shown that in most cases it is possible to reduce them down to the centimeter level on a grid sampled at 1 km using split-spectrum techniques. Without corrections the ionospheric errors can often reach many decimeters or several meters at L-band. At C-band the impact is smaller, but large scale errors in the order of 5-50 cm are not unusual, which indicates that this error might be a performance bottleneck once the tropospheric corrections are applied.

Processing is also an important but neglected topic. One problem is that there exist many methods/flavors for interferometric stack processing and the derivation of deformation rates but no clear discussion on the merits of each. Persistent / permanent scatter techniques are normally rather robust; here the crucial point might be to avoid a propagation of integration errors in the space direction. For techniques that used multi-looked interferograms (i.e. interferograms averaged spatially to reduce noise) a very important point, not often discussed, is avoiding integration errors in the time direction. In fact we have shown that almost any dataset is affected by phase inconsistencies (non-zero phase closures, typically related to moisture variations in the imaged target), which is equivalent to saying that the final integrated deformation history is path dependent. In particular several approaches tend to rely heavily on short term interferograms, because of coherence, but they ignore that short-term interferograms tend to be biased. If the bias in not corrected it will be reflected in the final deformation rate product. We estimate errors in the order of several mm/year for naïve integration approaches.

Our message is that only when all these aspects are addressed it is possible to attain performances of say 1 mm / year for deformation rates for long wavelengths of the motion (100's km).