Abstract—The Interferometric Permanent Scatterers techniques are providing accurate ground deformation mapping compared with standard interferometry based on one pair of Master/Slave scenes. This is because using a larger data set, it is possible to estimate and correct for additional phase error sources. The point targets detected as Permanent Scatterers are generally characterized by a stronger signal that provides more accurate phase information than the clutter present in the rest of the scene. This paper provides improved methods to obtain millimetres accuracy and to replace more expensive survey methods. At CCRS, these methods are applied to monitor several geo-hazard sites in difficult terrains.

Interferometric measurements – millimetres accuracy from SAR signal

Phase noise (degrees) Deformation noise (mm)

The measured SAR phase accuracy is a function of the Signal to Clutter Ratio and the type of the radar target (extended or point).

Point targets are more accurate than extended targets. Natural point targets can be easily found in cities but not in vegetated areas. Artificial point targets are easy to be designed and installed in vegetated areas.

Natural point targets, example from Frank slide, Alberta, Canada

Digital Elevation Map Radarsat image Natural Point Targets Height correction map Targets Deformation map One target profile Measurements geometry SAR Error Levels

Frank slide is a rock avalanche with good radar backscattered signal. A linear deformation model is fit through the data and temporal unwrapping is done using the linear model. Thousands of radar point targets are detected. An average deformation map is created.

A DEM is almost never perfectly accurate. Having more than 25 radar scenes, DEM height error corrections through regression analysis is possible.

Every target in the deformation map has a time-deformation profile. The deformation direction (up or down) has to be interpreted taking into account the measurement geometry. Sometimes, a downward movement could show up like an upward trend in the profile.

Artificial point targets, example from Little Smoky, Alberta

SRTM DEM Baselines (m) Multiple unwrapping solutions for deformation

Precise heights Wrapped profile using precise heights Height error: 25m Height search: 50m

Height error phase offsets Sub-pixel target position phase offsets Height error: ~ 5m Height error: + 5m

The SRTM DEM height errors are of the order of tens of metres. If not enough measurements, the regression process used to estimate the height errors will likely find multiple solutions by coincidence. Precise height knowledge will eliminate the need of estimating the height corrections through regression analysis.

For 500 metres baseline: 8 metres sub-pixel shift — 4 metres height error. Even if target height is precisely known, a ± 5 metres in height error space should be searched for a more accurate solution estimate.

Conclusions

A minimum number of scenes is needed for height correction and deformation model estimation. This number depends on the quality of the radar measurements. Precise heights knowledge is recommended for datasets containing less than the minimum number of scenes. For the same datasets, multiple deformation models and height corrections solutions are possible. Only one solution can be true, but which one? The larger the datasets, the better the estimates until only an unique solution will be found. It is generally accepted that a minimum number of 15 scenes is required for Permanent Scatterers monitoring. For the current SAR sensors this translates to a period of 360-525 days. In the future, SAR constellations will be available. The Radarsat constellation with a projected revisit period of 4 days will shorten the minimum acquisition time to 60 days.

References

