A COMBINED MULTI-TEMPORAL INSAR METHOD INCORPORATING PERSISTENT SCATTERER AND SMALL BASELINE APPROACHES

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ABSTRACT

InSAR techniques that process data from multiple acquisitions in time enable both the extraction of deformation time series and a reduction of error terms present in single interferograms. There are currently two broad categories of methods that deal with multi-temporal images: persistent scatterer (PS) methods and small baseline (SB) methods. As they are optimized for different scattering models, the two approaches are complementary. Here, a new algorithm is presented that combines both PS and SB approaches. Combination of the two data sets increases both the number of pixels with useable signal and also increases the SNR for pixels selected by both methods. The new algorithm is applied to ERS data acquired over Eyjafjallajökull volcano in Iceland, which experienced intrusive episodes during 1994 and 1999–2000.

Key words: PSI; SBAS; MT-InSAR.

1. INTRODUCTION

Spaceborne synthetic aperture radar interferometry (InSAR) is a useful tool for measuring surface deformation because of the high spatial resolution achieved and the ability to acquire the data remotely. However, problems due to changes in scattering properties of the Earth's surface with time and look direction limit the applicability of this technique. Where measurement is possible, signal due to displacement of the ground is obscured by variation in atmospheric properties and inaccuracy in satellite orbit and surface elevation determination. *Multi-temporal InSAR* (MT-InSAR) techniques, which involve the processing of multiple acquisitions in time, provide one way to address these issues. Currently, there are two broad categories of MT-InSAR techniques, *persistent scatterer* (PS) methods including those that identify pixels based primarily on their phase variation in time [e.g., 1, 2] and those that use primarily correlation of their phase in space [e.g. 3, 4], and *small baseline* (SB) methods [e.g., 5, 6]. The naming of the categories is inconsistent in that "persistent scatterer" refers to the type of pixel that is identified by the method whereas "small baseline" refers to the methodology of interferogram formation. However, as the names are already well-established, I use them throughout this paper.

In a synthetic aperture radar image, the value for each pixel is the coherent sum of contributions from all scatterers within the associated ground resolution element. Relative movement of these scatterers or change in look or squint angle causes the scatterer contributions to sum differently, an effect known as decorrelation [7]. For ground resolution elements containing a persistent dominant scatterer the phase due to decorrelation varies little with time even if the dimmer scatterers move with respect to the dominant scatterer. Furthermore, the variation is also small when viewed from different look and squint angles. This is the principle behind a PS pixel. For resolution elements containing no dominant scatterer, on the other hand, phase variation due to decorrelation is often large enough to obscure the underlying signal. However, by forming interferograms only between images separated by a short time interval the decorrelation in time is minimized, and for some resolution elements may be small enough that the underlying signal is still detectable. Furthermore, if the difference in look and squint angle between each pair of images is also not too large, the corresponding geometric and rotational decorrelation can be reduced by band-pass filtering in range and azimuth [8]. Pixels whose phase when filtered decorrelates little over short time intervals, which I refer to as slow-varying filtered phase (SFP) pixels, are the targets of SB methods. Note that for pixels dominated by a single scatterer, the effect of range and azimuth filtering may be to increase decorrelation due to the coarsening of the resolution. Nevertheless, the decorrelation is often still low enough for some PS pixels that they also qualify as SFP pixels. Thus SFP pixels and PS pixels form two distinct, but overlapping, sets of pixels.

There has been some debate about the relative merits of PS and SB approaches. However, as they are optimized for different models of ground scattering, the two approaches are in fact complementary, at least in the usual case where a data set contains pixels with a range of scattering characteristics. Here I present a new algorithm that combines both PS and SB approaches to maximize the spatial coverage of useable signal. Improvement of the spatial coverage is important not only because it increases the resolution of any deformation signal, but also because it allows for more reliable estimation of integer