Title: **Segment-based change detection for polarimetric SAR data**

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1. BACKGROUND

Change detection is a very important application of Earth observation data. A number of different applications relies on robust and accurate change detection from such data. Update of topographic maps is, for instance, a very important process for mapping agencies to be able to provide the most up-to-date map information to users. The update of topographic maps is an important and time consuming part of modern map production, and hence it is important to develop more robust and reliable methods to provide change detection information. Another example may be monitoring of larger land areas for environmental or security applications. In many cases high resolution optical data are used for this purpose. However, SAR has also shown a potential due to the reliable data acquisition (i.e. independent of clouds), and the polarimetric SAR may provide the additional information that is needed compared to single polarisation SAR to provide reliable and robust detection of changes. Polarimetric SAR data will be available from satellites in the near future, e.g. the Japanese ALOS, the Canadian Radarsat-2 and the German TerraSAR-X.

An appropriate way of representing multi-look fully polarimetric synthetic aperture radar (SAR) backscatter data is the so-called covariance matrix data format. For each pixel this consists of a 3×3 Hermitian, positive definite matrix which follows a complex Wishart distribution. Based on this distribution a test statistic for equality of two such matrices and an associated asymptotic probability for obtaining a smaller value of the test statistic have previously been derived by the authors and applied successfully to change detection in bi-temporal polarimetric SAR data. An intrinsic problem with SAR data is the speckle noise, and hence to obtain appropriate detection accuracy, reduction of the speckle is often necessary. This may be done by segmenting the images prior to change detection and then applying change detection to the segmented images.

A large number of segmentation algorithms for SAR images have been suggested in the literature. Most of these apply single-channel SAR images but multi-channel algorithms have also been described. Different approaches have been used for image segmentation. Edge detection combined with region growing is one approach, where segments are created by growing regions from a previously edge detected and edge thinned image. This method relies primarily on a robust edge detector, which preferably provides a constant false alarm rate. For single-channel SAR images this is fulfilled by the ratio edge detector, and for polarimetric SAR data, an edge detector based on the above mentioned test statistic fulfils this. Another approach is the region merging approach, where neighbouring segments are merged based on an equality criterion. Again, the ratio test statistic has been used for the single-channel SAR case. The authors have previously presented a new algorithm, where the region-merging scheme has been modified so that the equality criterion is based on the Wishart test statistic for fully polarimetric SAR data.

2. METHODOLOGY

In change detection applications, at least two images must be available and used in the change detection process. If these images are segmented independently, the segments in the different images will most likely differ. This will happen because the changes that have occurred may not only cause changes for the original objects, e.g. a crop may be harvested, or a forest area may be deforested, but is may also cause changes to the extent and shape of the objects themselves, e.g. an agricultural field may be split into a number of smaller fields, a building may be removed from or added to some area, hedgerows may be removed/added or other type of vegetated areas may be partly removed or added. In this case, ambiguities may arise when segments have changed shape and extent from one image to another, and it is not straightforward to decide if the segment from the first or the second image should be used or eventually some sort of combined segment. Therefore, in this paper an approach is used where the two images are segmented jointly. Hence,

only one set of segments exists, where the segmentation is based on the information in both images, and therefore the segments represent areas that are homogeneous in both images but not necessarily unchanged from the first acquisition to the next.

As mentioned above, the authors have previously presented a segmentation algorithm, where region-merging based on the Wishart test statistic for fully polarimetric SAR data has been used. In that case, single acquisition polarimetric SAR data were used. This approach can, however, be extended to cover bi-temporal polarimetric SAR data by combining the covariance matrices from the two acquisitions into a single covariance matrix structure. The Wishart test statistic is then used to detect possible changes within the segments between the two images.

3. RESULTS

Polarimetric SAR data from the Danish EMISAR system has been used in the study. The EMISAR system (an L- and C-band, fully polarimetric, airborne SAR) has in 1994 to 1999 acquired a lot of data over a Danish agricultural site. The data acquisitions were co-ordinated with ground surveys to obtain a detailed land cover map. The test area contains a large number of different land cover classes, such as more than 10 different crop types, deciduous and coniferous forest types, wetlands, lakes, and urban areas. Also, other test sites over for instance urban areas have been used to assess the improvement by the segment-based change detection method.

In the paper, results from pixel-based change detection, i.e. without segmentation, and from segment-based change detection, where the segments are computed from both single acquisitions and from the two acquisitions jointly, will be presented and compared.