MITIGATING TOPOGRAPHIC EFFECTS ON POLARIMETRIC SAR CLASSIFICATION

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1. INTRODUCTION

SAR polarimetric response depends, amongst other things, upon the relative orientation of the radar scatterer to the SAR system. The same target type can appear polarimetrically different depending on the underlying terrain. Thus the local topography influences the observed polarimetry. The best known topographic effect is the local incidence angle dependence of the radar cross section (RCS). Surfaces tilted toward the SAR show greater backscattered power than surfaces sloped away from the SAR system. However, terrain slopes generate several subtle polarimetric effects that change the relative strengths of the observed polarimetric channels. While we discuss the effects of range and azimuth slopes separately below, topography mixes these effects and requires simultaneous treatment of range and azimuth slopes.

2. TARGET ORIENTATION EFFECTS

The polarimetric orientation angle, the rotation about the radar look direction, generates non-zero, off-diagonal correlations in polarimetric covariance matrices between co-pol (HH & VV) and cross-pol (HV & VH) returns [1, 2]. These off-diagonal correlations provide estimates of the local terrain slopes in open areas that are dominated by rough surface scattering. Orientation angle effects also lead to classification confusion between volume scattering and double bounce scattering. This is the source of the misclassification of buildings, not aligned parallel to the SAR flight line, as vegetation by the standard Freeman-Durden and Wishart polarimetric classification algorithms. Compensating SAR imagery for orientation angle effects becomes difficult when the true underlying scattering mechanism is some mixture of, say, rough surface and volume scatter. While quad-pol imagery provides sufficient information to accurately measure target orientation angles, dual-pol imagery does not. When employing dual-pol SAR data, one can not always separate orientation angle effects from scattering mechanism effects.

3. LOCAL INCIDENCE ANGLE EFFECTS

Range and azimuth slopes affect the local incidence angle and therefore the total backscattered power. The RCS variations due to range slopes bias statistical classifiers, e.g. Wishart classifiers, when the more subtle polarimetric variations are dominated by large RCS changes. In addition to the RCS, range slopes may modify the character of scattering mechanisms. As an example for rough surface scattering, the value of the Cloude-Pottier average alpha parameter changes with the local incidence angle. This effect is most apparent in airborne SAR imagery where the nominal incidence angle may vary by ~30° across the image. Nonetheless, space borne imagery of terrain with significant relief will show similar effects.

4. MITIGATION APPROACHES

The three basic approaches that we pursue in this presentation are: 1) Estimating and then correcting the polarimetric covariance for the orientation angle, 2) Exploiting roll invariant polarimetric parameters, and 3) Compensating RCS variation by normalizing the polarimetric covariance by the span. Variants of these techniques have been employed by us and others, though not in combination and with the expressed purpose of mitigating topographic effects on SAR polarimetry. Explicit orientation angle correction requires quad-pol imagery in order to accurately determine the target orientation angle. Even then pixels that combine multiple scattering mechanisms complicate interpretation of the derived target orientation. Roll invariant parameters, e.g. the polarimetric entropy, avoid the orientation compensation entirely since they remain invariant under orientation angle rotations. However, roll invariant parameters provide only partial polarimetric information, which reduces scene classification capabilities. Neither of these two approaches corrects for local incidence effects, e.g. the RCS. A "first-order" correction is to normalize the polarimetric covariance matrices by their span, which essentially removes information of the total backscattered power from consideration. Compensating for polarimetric, rather than just RCS, effects arising from incidence angle variation requires prior modeling of the presumed underlying scattering mechanisms, which is beyond the scope of the present work.

5. SUMMARY

We apply these techniques to RadarSAT-2 and POLSAR dual- and quad-pol imagery of boreal forests and grasslands that have significant topography. We also generalize the basic approach to handle both dual- and quad-pol, repeat-pass imagery.

6. REFERENCES

[1] Lee, J.-S. and E. Pottier, *Polarimetric Radar Imaging: From Basics to Applications*, CRC Press, 2009.

[2] Cloude, S. R., *Polarisation: Applications in Remote Sensing*, Oxford University Press, 2010.