Achievements and Potential for Imaging Radar Systems for Africa

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Abstract: Imaging radar equipment has reached a high level of sophistcation, and has been deployed on spacecraft and aircraft, both manned and unmanned. More importantly, the interpretation of the image information has also reached a level of sophistication, making it very useful to a wide audience. In this paper we review some of the achievements of imaging radar internationally and in South Africa, and how the technology can make a contribution to African development. Interesting problems in electromagnetic modelling as an aid to image information extraction (inverse problems) remain.

INTRODUCTION

A sidelooking radar records range data as the platform moves, and using the known geometry between the platform trajectory and the surface being imaged, produces a high resolution image of the terrain, centred on the RF carrier frequency of the radar sensor. Modern computers allow reasonable resolution in real time, but most systems record data for postprocessing. Some radars transmit and receive all possible polarisation combinations (HH, VH, VV), allowing the full Stokes' Matrix for the image pixels to be assembled. The fully polarimetric nature of the image and the fact that the radar wavelengths have strong interaction with objects of similar scale size means that surface classification is possible for many applications, surpassing optical images in usefulness.

Since the image also holds the distance to the image surface, modulo the radar wavelength it is possible to use interferometry and images taken from displaced trajectories to measure terrain height. The foliage penetration capability of longer wavelengths (P Band) allow digital terrain models to be obtained, rather than digital surface models available from optical sensors, that include the height of vegetation cover. Interferometric images taken over long time periods allow for the monitoring of land motion of the order of millimetres, in relative terms.

AFRICAN CONTEXT

Many parts of Africa have not been mapped at all, or, not since colonial times. Radar offers the potential to rapidly acquire a sophisticated digital map infrasture to aid with development planning and environmental monitoring. Flood potential can be assessed, and low frequency radar will identify swamps and other waterlogged areas through vegetation. The ability to image through cloud is important for Central Africa, and will allow continuous monitoring of land use from space. In addition, crop type and yield can be inferred, which is very important for aid planning: this can be done rapidly and regularly independent of infrastructure.

CURRENT AND FUTURE MISSIONS

At present, only the Canadian RadarSat and the ESA ENVISAT are deployed in space. Both systems operate at 6cm wavelength. The relatively short wavelength has some limitations in highly vegetated areas. Germany is due to deploy the TerraSAR X system in the next two years. This system operates at 3cm wavelength, with good lateral resolution (metre). However, foliage penetration is problematic. A L Band system is planned by Germany (23cm) has more potential for interferometric mapping and vegetation monitoring.

A number of airborne sensors are operated by governments and private companies. There are too many to list here, but these systems mostly operate at short wavelength, and are aimed at mapping. Some do operate at P Band (68cm) and are suitable for digital terrain mapping and surface classifications. Fully polarimetric P Band has enormous potential for forest biomass estimation.

RESEARCH PROBLEMS

Most aspects of radar signal processing are well under control, with time domain processors becoming feasible and offering optimal processing i.e. fewer assumptions. Most research problems are related to inversion i.e. inferring surface parameters such as vegetation type from polarimetric information. Modelling offers some solutions, but good statistical methods for ensuring good clustering of classifications are still under development. Models need to be developed for the wide range of vegetation types found, and different radar wavelengths. Longer wavelengths (L Band and below) offer the most potential for dense vegetation classification, due to penetration and improved sampling of the structures involved.