INTEGRATION OF RADARSAT-2, TERRASAR-X and ALOS PALSAR DATA FOR IN-SEASON CROP ACREAGE ESTIMATES: A CANADIAN EXAMPLE

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ABSTRACT

Annual information on agricultural land use (crop inventory) is needed by both government and private organizations. Mapping crops and estimating crop acreages, particularly when these data are tied to the landscape, supports numerous program requirements within the Government of Canada. To meet this operational requirement, Agriculture and Agri-Food Canada (AAFC) has carried out a multi-year (2004 – 2007), multi-sensor (Landsat TM, SPOT, RADARSAT-1, ASAR), and multi-site (five provinces: Ontario, Saskatchewan, Alberta, Manitoba, P.E.I.) research activity to develop a robust methodology to inventory crops across Canada's large and diverse agricultural landscapes. Results clearly demonstrated that multi-temporal satellite data can successfully classify crops for a variety of cropping systems across Canada. Overall accuracies of at least 85% were achieved (McNairn et al., 2009a). When available, multi-temporal (2 to 3 scenes acquired at different growth stages) optical data are ideal for crop classification. However due to cloud and haze interference, good optical data are not always obtainable. A SAR-optical combination offers a good alternative. When only one optical image is available, the addition of two ASAR images acquired in VV/VH polarization provides acceptable accuracies.

Although an integrated optical-radar approach can consistently discriminate crops, the continued dependency on optical data, particularly in cloud-prone regions, is less than ideal for operational delivery of crop information. A radar-only approach to crop discrimination and acreage estimation would provide an operational advantage. However for the most part, SAR data alone have not been able to match the accuracies achieved with optical data, primarily because of the availability of radar data with only limited dimensionality. Single frequencies, and for some sensors single polarizations, do not provide enough information for accurate discrimination even when multi-temporal acquisitions are exploited (Shang et al, 2006 and 2008).

The availability of multi-polarization radar, and in particular polarimetric modes on satellites such as RADARSAT-2 and ALOS PALSAR, does offer increased information content that will assist in crop separation and improved classification accuracies for end-of-season (early September) crop inventories (McNairn et al., 2009b; Shang et al., 2009). However when in-season (before the end of July) crop information is needed, multi-frequency SAR data acquired at multi-polarizations are required. Radar backscatter is strongly dependent upon crop canopy architecture. Differences in canopy penetration due to radar frequency mean that structural differences within the canopy profile can be exploited to assist with crop discrimination. Major crop classes have differing structures, both with respect to the total biomass and the size and shape of these canopy components. Consequently, canopies appearing to be similar at one frequency might have contrasting backscatters at another frequency. Thus it is expected that integrating SAR data acquired at multiple frequencies (L-, C-, and X-band) will provide improved classification accuracies. This study has found that larger biomass crops such as corn were well classified using the L-band PALSAR data. Lower biomass crops (cereals) were well classified using shorter wavelength X-band SAR (TerraSAR-X). For other crops C-Band SAR (RADARSAT-2) SAR data are needed.

In 2008 and 2009, AAFC conducted a two-year multi-frequency (X-, C- and L-band), multi-temporal SAR campaign. Two sites from Canada were selected to capture different cropping systems, one in eastern Ontario and one in Manitoba. The eastern Ontario site is located in Casselman (45°15'N; 75°00'W), 50 km east of Ottawa where the cropping system consists of pasture-forage, small grains (wheat, barley and oats), corn and soybeans. During the growing season, over 300 fields were surveyed. The Manitoba site is located in Carman (49.35°N; 97.96°W), 50 km south of Winnipeg where the main crops are canola, wheat, soybean, corn, flaxseed, sunflower and potato. For this site, over 500 fields were surveyed. Half of the surveyed fields were used for training the classifier and half for validating the classification results. An overall classification accuracy of 85% for the Carman site was achieved and for the less complex cropping system of Casselman, 90% accuracy was reached. The detailed campaign design and results will be reported in this paper.

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