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Correlations Between CO_2 Fluxes And High Spatial Resolution Reflectance Imagery

Current studies of the global carbon budget suggest the existence of a terrestrial sink for carbon in the midlatitudes of the Northern Hemisphere. A likely location of the net sink for carbon is considered to be in temperate and/or boreal forests, but the mechanisms involved and the spatial contributions to the sink are as yet unknown. Simulation of expected implications of the surface temperature changes associated with global warming requires a better understanding of the processes that control the carbon cycle to be able to predict and simulate the carbon dynamics within a region.

The present thesis, which takes advantage of data collected as part of the ***BOR**eal **E**cosystem **A**tmosphere **S**tudy* (BOREAS - NASA) project, studies the relationships between the high spatial and spectral CASI imagery and the CO_2 fluxes over heterogeneous boreal landscape. The *Compact Airborne Spectrographic Imager* (CASI) is an airborne push-broom imager which collects data in the visible and near infrared wavelength regions (400-950 nm). The sensor operates in a number of user-selectable modes which sample the CCD in up to 288 spectral channels and 512 spatial positions or pixels. In the *Spatial Mode* the imagery is obtained at full spatial resolution of 512 spatial pixels across the 35 deg swath, with the spatial resolution depending on the aircraft altitude, but usually ranging from 0.5 to 10 meters. Sixteen vegetation indices have been generated from the 3 m spatial resolution and 16 channel CASI data collected over the 16 x 16 km grid Modeling Sub-Area of the BOREAS *Southern Study Area*, Saskatchewan (Canada). CO_2 fluxes measured by *eddy correlation* from the Canadian *Twin Otter* aircraft *(Centre for Land and Biological Research, Agriculture Canada)* mapped the spatial variation in surface fluxes to explore the potential of relating airborne observations to the biological and ecological characteristics of the surface.

This study demonstrated that a near-linear relationship exists between most optical indices and the CO_2 fluxes, and that different relationships are found when the land cover type is considered. Deciduous and conifer stands in different stages, fen and mixed were the land cover classes studied. Good relationships between optical indices and CO_2 flux data are achieved using indices NDVI *(Normalized Difference Vegetation Index)*, SR *(Simple Ratio)*, MSR *(Modified Simple Ratio)*, G *(Greenness Index)* and LAI *(Leaf Area Index)*. Optical indices based on the chlorophyll degradation and pigments carotenoid/chlorophyll-*a* concentrations, such as NPI *(Normalized Phaeophytinization Index)*, SRPI *(Simple Ratio Pigment Index)* and PRI *(Photochemical Reflectance Index)* were tested, as well as fAPAR, Red Edge wavelength and PWI *(Plant Water Index)*. Combination indices were also tested, with correlations for PRI*LAI and σ(red edge)*LAI showing similar results to that for classical optical indices. A methodology based on a cubic convolution resampling model applied to the original 3 m CASI imagery followed by a Gaussian spatial transformation to the optical indices is presented. It demonstrates that the high spatial resolution of the CASI sensor captures the effect of detailed surface spatial patterns on the CO_2 flux distributions. The high spectral resolution enables the study of the relationship using several new optical indices.