

Circumpolar assessment of the relationship between infrared vegetation indices and leaf area index in forest landscapes

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Leaf area index (LAI) is a key parameter governing atmosphere-vegetation interactions. The Global Climate Observing System (GCOS) has identified LAI as an essential climate variable to be mapped globally at 250m resolution at accuracies on the order of +/-0.5 unit. GCOS also identifies satellite remote sensing as the only current technology that can provide required coverage. However, the GCOS implementation document suggests that passive optical sensors have problems with LAI retrieval due to a) noise in understory variability and b) with saturation in the signal from passive optical sensors at LAI levels commonly found in forest biomes. These conclusions have been based predominantly on empirical and model based studies that attempt to relate LAI to spectral measurements in visible and near infrared wavelengths. Visible wavelengths are also problematic for operational LAI retrieval due to inherent uncertainties in atmospheric correction over low reflectance (e.g. dense forest) targets.

Satellite measurements in infrared wavelengths have reduced sensitivity to the atmosphere and should exhibit lower saturation than the visible due to higher leaf albedo. Little work has been performed to assess the usefulness of infrared vegetation indices for LAI retrieval over northern forests. We first make use of recently developed and validated radiative transfer models (5-Scale and MAC) to explore the theoretical sensitivity of infrared vegetation indices to LAI over discontinuous forest canopies. We then assemble a circumpolar dataset of in-situ LAI measurements from ten different regions in boreal and temperate forest biomes with Canada, Estonia, Finland, Russia, Sweden and the US to examine the relationship between LAI and spectral vegetation indices derived from coincident sensors on Landsat and SPOT platforms. Both modelling and empirical measurements suggest that infrared vegetation indices do not saturate in most northern forest landscapes at 100m resolution. Furthermore, infrared indices tend to reduce sensitivity of LAI algorithms to species or understory variability. Based on these findings we recommend a) the specification of 250m shortwave and near infrared bands on future polar orbiting sensors b) the use of shortwave infrared spectral information in future LAI retrieval algorithms over northern forest landscapes.