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Scaling forest parameters using remote sensing and the implications for hydrological model error

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Evapotranspiration and interception in forested catchments is often modeled as a function of Leaf Area Index (LAI), which can be derived from remote sensing. Remotely sensed estimates of LAI have proven to be less than satisfactory when compared to ground truth data and this is believed to be due to a variety of reasons including saturation and background effects. "Spectral mixture analysis" and "adjustment" of spectral vegetation indices have provided some improvement in the spectral vegetation index relationship with LAI. However, there has been little investigation into how errors in remotely sensed estimates of LAI affect hydrological modeling at various scales.

In this study, linear spectral mixture analysis (LSMA) and adjustment of common spectral vegetation indices (NDVI, Simple Ratio and Moisture Stress Index) were used to determine LAI from a SPOT image (20 m resolution) in an area of montane forest with varying canopy densities in 10 plots of coniferous and 10 plots of deciduous stands. Insitu measurements using a TRAC Canopy analyzer and a FieldSpec PRO spectroradiometer were used to verify the remotely sensed estimates of LAI. LSMA led to excellent relationships between the shadow fraction and LAI in coniferous stands. However, LSMA worked poorly in deciduous stands. "Adjusted" Simple Ration incorporating the middle-infrared band worked moderately well for deciduous stands. Additional models of spectral vegetation indices were proposed tested.

Reducing model error and uncertainty involve efforts to minimize or at least quantify errors in individual parameters. The best LAI models from the first phase of research was used in a series of Monte Carlo simulations to determine the minimum sample size (equal to the smallest hydrological modeling unit, or subcatchment area, divided by the spatial resolution of the LAI values) for the greatest error reduction in models

that uses LAI. Even under conservative estimates of error in modeled LAI (20% of the mean), precision increased exponentially to provide errors as low as 2% for a sample size of 1000 pixels (or 0.4 km^2 when using SPOT data). The accuracy in LAI remained constant with sample size and increased exponentially with increasing variability in LAI. MODIS (500 m resolution) and Landsat (30 m resolution) were used to determine the scale invariance of LAI in a nearby 750km^2 forested catchment. LAI estimates varied substantially. Scaling evapotranspiration was further investigated by relating basal area, sapwood area and TDP measurements in the 20 plots to LAI.