Assessing empirical vs. radiative transfer algorithms for seasonal monitoring of chlorophyll and N content in radiata pine using hyperspectral imagery

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In the southern hemisphere planted forests are dominated by introduced species and within New Zealand, South Africa, and Australia *Pinus radiata* D. Don is the most widely grown species. Fertilizer application with nitrogen (N) and phosphorus (P) is needed by forest growers, as growth rate is often constrained by nutritional deficiencies within plantations. Pigments such as chlorophyll *a*+*b* (C_{a+b}), carotenoids, anthocyanins and xanthophylls have been suggested as indicators of plant nutrition due to their direct link with N. Specifically, a decrease in C_{a+b} content is related to a reduction in photosynthesis, which makes C_{a+b} a proxy for N. Standard remote sensing methods have used narrow-band hyperspectral indices (NBHI) to predict C_{a+b} using non-linear relationships. However, these empirical models are seasonally dependent on growth and structural changes, and therefore affected when applied at different times across the growing season. Radiative transfer model (RTM) inversion methods can potentially account for the intrinsic complexity of forest canopies enabling the development of generally applicable models. In this study, we predicted C_{a+b} as a proxy for N in one-year-old *Pinus radiata* seedlings. We compared the precision and generality of NBHI empirical relationships vs. two RTMs, PRO4SAIL and PRO4SAIL2. These two RTMs couple the leaf PROSPECT-D to the canopy simulations through 4SAIL and 4SAIL2, respectively, with the latter adding improved representation of the tree clumping effects through incorporating a vertically projected crown cover fraction. Results showed that the C_{a+b} estimation using NBHI was successful but failed when applied to other dates across the season, and that PRO4SAIL2 was robust when used to independently estimate C_{a+b} across multiple dates.

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