AGU Symbol and #

A comparison of calibrated sap flow and MAESTRA model simulation estimates of tree transpiration in a eucalyptus plantation

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Contextualization

Eucalyptus is the most hardwood planted genus in the world, providing an increasing share of wood supply for several purposes.

These plantations increased from 3 to 4.5 millions of hectares on the last decade in Brazil and are a significant component of the landscape. Investments in breeding programs and enhanced silvicultural practices led the Brazilian eucalyptus plantations to reach productivities > 40 $m^3ha^{-1}yr^{-1}$ (Stape et al. 2010).

Nevertheless, large wood production are closely related to elevated rates of resource use, raising questions regarding the effect of continuous forest plantations on hydrological cycle of the region. To address these questions, ecophysiological models are useful tools (Withehead & Beadle, 2004).

Objective

Our objective was to assess the ability of the MAESTRA model, a three dimensional model of individual tree crown radiation absorption and transpiration (Medlyn, 2004), to capture the seasonal and within-stand variability in tree water-use in fast-growing *Eucalyptus grandis* plantation in Southeastern Brazil (Fig. 1)

Material & Methods

MAESTRA was parameterized (i.e. canopy structural parameters such as tree leaf area, crown size and positions) by destructive sampling *in situ* after measurement period. Physiological parameters required for the stomatal conductance sub-model (Ball-Berry) were estimated from leaf-gas exchange measurements (For a complete description of the MAESTRA model visit www.XXXsite do maestra).

To capture within-stand variability in tree size, sap flow measurements were taken on 15 trees (Fig. 2) that spanned the range in aboveground biomass (16.3 - 346.2 kg) and leaf area (2.1 - 90.1 m^2) in a 6 year old southeast Brazil *Eucalyptus grandis* plantation. Transpiration simulation predictions were compared to estimates from sap flow measured by the thermal dissipation method (Granier probes) calibrated at the whole tree (potometer) and stand (eddy covariance) levels.

Figure 1. Partial view of the studied *Eucalyptus grandis* plantation stand, located on southeast of Brazil – 22º 58'04'' S / 48º 43'40'' W.

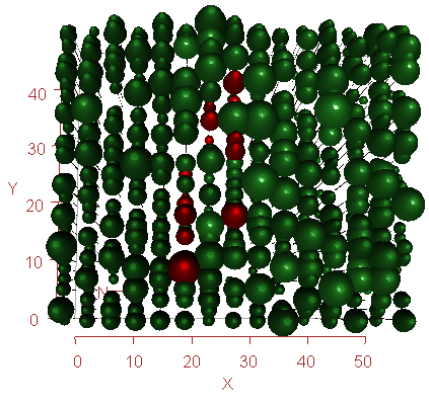

Figure 2. Graphical representation of the 15 trees studied (red crowns). To avoid overestimation of intercepted radiation and transpiration by the target trees, effect of shading provided by neighbors were accounted by accurate description of crown size and position of all trees on 5 lines surrounding target trees.

Results

Calculated transpiration showed a significant relationship to measured transpiration (R^2=0.79, p<0.0001, Figure 1).

During the study (from August 11th 2008 to May 5th 2009), measured and simulated transpiration rates ranged from 2.6 to 92.7 L day^{-1} and 2.1 to 110.4 L day^{-1}, respectively, whereas mean maximum and minimum temperature were 20.3, 33.2 and 16 ºC, respectively, and total precipitation was 1148mm.

Seasonal differences between measured and modeled maximum (46.5 versus 65.7 L day^{-1}), mean (30.7 versus 34.1 L day^{-1}) and minimum (17.6 versus 16.1 L day^{-1}) transpiration were small (Figure 2).

Specific to within-stand variability in tree size, MAESTRA underestimated the transpiration of small trees (aboveground biomass < 50 kg and leaf area < 15m^2) by 8% and overestimated large trees (aboveground biomass < 250 kg and leaf area > 45 m^2) by 9%.

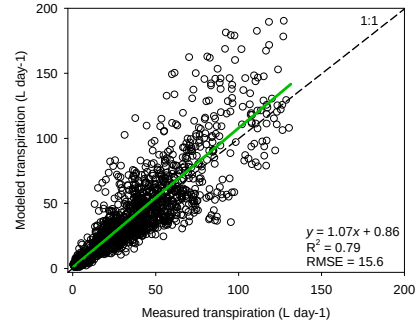

Figure 1. Relation between measured and modeled transpiration rates for all trees and days. Dashed line represents 1:1 line.

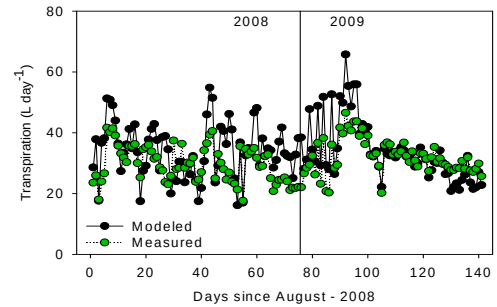

Figure 2. Measured and modeled transpiration rates over the period of measurement. Each point represents the average of the transpiration for all 15 trees for one day.

Conclusion

MAESTRA model showed to be a powerful tool to simulate seasonal patterns of daily transpiration for individual trees on stands of *Eucalyptus* spp. plantations in tropical regions and assess the effects of high levels of production on the hydrologic resources at landscape levels.

References: Stape et al. 2010. Forest Ecology and Management, 259, 9, XXX-XXX; Medlyn, B. 2004. A MAESTRO retrospective. In: Mencuccini, M. et al. (Eds.). Forests at the Land-Atmosphere Interface, 105-121, Whitehead & Beadle. 2004. Forest Ecology and Management, 193, 113-140.

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