SEMINÁRIO NACIONAL SOBRE DINÂMICA DE FLORESTAS, CURITIBA, PARANÁ, BRAZIL, 24.06.2008

Poster abstract:

CONTINUOUS MONITORING OF TREE RADIAL GROWTH AND STEM HYDROLOGY WITH ELECTRONIC POINT DENDROMETERS - AN EXAMPLE FROM THE ATLANTIC RAIN FOREST, PARANÁ, BRAZIL

Hans-Peter Kahle, Jens Günther, Heinrich Spiecker,
Institute for Forest Growth, Albert-Ludwigs-University Freiburg, Germany
Hans-Peter.Kahle@iww.uni-freiburg.de

Renato Marques, Joemir Brüske
Departamento de Solos e Engenharia Agrícola, UFPR, Curitiba,
rmarques@ufpr.br

Monitoring of forest ecosystems is a means to assess the state of the ecosystems by providing information on its present conditions. Information from long-term monitoring is needed to judge whether a given state is close to or far from a reference state. In systems with long developmental cycles trends only become visible when looking on long-term dynamics. Conditions of forest ecosystems refer to different spatial and temporal scales as well as different hierarchical levels. Dendrometer data provide information on the short-term and seasonal dynamics of tree radial growth as well as on stem hydrology. Combining dendrometer data with data on environmental conditions, e.g. meteorological and soil conditions, gives insight into ecophysiological processes and biogeochemical cycles in the forest ecosystems. In the poster we show data and descriptive analysis results from the ecological field measurement station at Reserva Natural do Cachoeira, Antonina, Paraná, which demonstrate the substantial contribution dendrometer measurements can provide to the monitoring of forest ecosystems. Data for the period October 2006 and December 2007 are presented. Sample trees of four tree species were equipped with electronic point dendrometers: *Pera glabrata* (PG)*; Vochysia bifalcata* (VB)*; Tapiria guianensis* (TG), *Andira anthelmintica* (AA). In addition air temperature (TP), relative air humidity (RF) and soil moisture tension at 30 cm (Tens30) and 60 cm (Tens60) soil depth were measured inside the forest. The measurement interval was 5 minutes. The average daily stem radial increment (1/100 mm*day^{-1}) was 0.26 for PG, 1.03 for VB, 0.27 for TG, and 0.06 for AA. Stem radial growth mainly took place on cloudy days, whereas on sunny days average daily stem radial increment was either negative or small as compared to that on cloudy days. The daily cycle in stem radial changes is affected by stem hydrological changes and consists of a contraction and expansion phase. The average daily amplitude in stem radial dimension (1/100 mm*day^{-1}) was 4.14 for PG, 4.26 for VB, 7.04 for TG, and 3.42 for AA. Cross-correlation analysis reveals for all species a close relation between daily changes in tree radial displacement and the daily courses of RF, TP, Tens30 and Tens60. The response times of the tree stems' reactions, i.e. the lead and lag-times, differ among species, indicating species specific environmental controls of physiological processes.

Continuous Monitoring of Tree Radial Growth and Stem Hydrology with Electronic Point Dendrometers

- An example from the Reserva Natural do Cachoeira, Coastal Atlantic Rain Forest, Paraná, Brazil

Hans-Peter Kahle[1], Jens Günther[1], Heinrich Spiecker[1], Renato Marques[2], Joemir Brüske[2]

(1) Institute for Forest Growth, Albert-Ludwigs-University Freiburg, Germany; (2) Department of Soil Science, Federal University of Paraná, Curitiba, Brazil ; Contact: Hans-Peter.Kahle@iww.uni-freiburg.de

METHODOLOGY

Electronic point dendrometers (Fig. 1) provide data on the short-term and seasonal dynamics of tree radial growth and on changes in stem hydrological status. Stem growth is a significant component of the total ecosystem productivity. The seasonal dynamics of biomass growth is paralleled by the trees' phenological development, whereas the expansion and contraction of the tree stems is driven by changes in the stem hydrology due to transpiration.

Figure 2. Reserva Natural do Cachoeira.

At Reserva Natural do Cachoeira* (Fig. 2) 20 sample trees of four different species are equipped with point dendrometers: *Pera glabrata* (Tabo), *Vochysia bifalcata* (Guar), *Tapiria guianensis* (Cupi), *Andira anthelmintica* (Jaca). In addition to radial stem displacement, air temperature, relative air humidity and soil water tension (at 30 cm and 60 cm soil depth) was measured and registered every five minutes. Measurement period: Oct 18 2006 - Dec 31 2007.

*The support of the Society for Wildlife Research and Environmental Education (SPVS) is gratefully acknowledged.

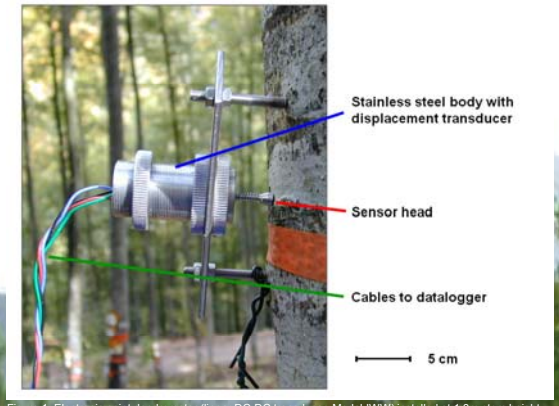

Figure 1. Electronic point dendrometer (linear DC-DC transducer, Model IWW) installed at 1.3m stem height.

RESULTS

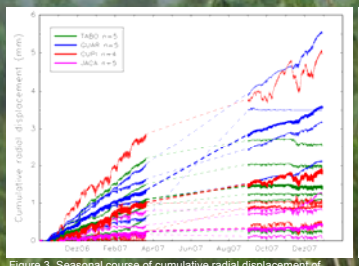

Figure 3. Seasonal course of cumulative radial displacement of individual trees (thin lines) and species averages (thick lines). Dashed lines: missing data due to failure malfunction (ant attack).

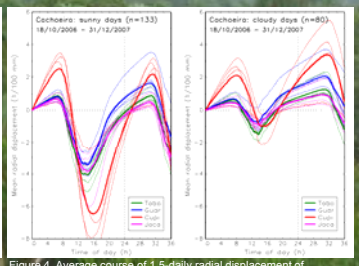

Figure 4. Average course of 1.5-daily radial displacement of individual trees (thin lines) and species averages (thick lines) on sunny (left) and cloudy days (right).

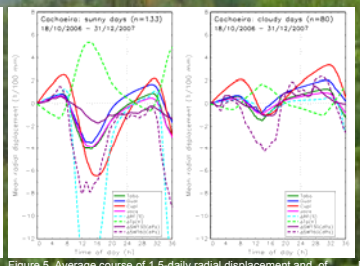

Figure 5. Average course of 1.5-daily radial displacement and of relative air humidity (ΔRF), air temperature (ΔTp) and soil water tension in 30 cm and 60 cm soil depth (ΔSWT30 and ΔSWT60) on sunny (left) and cloudy days (right).

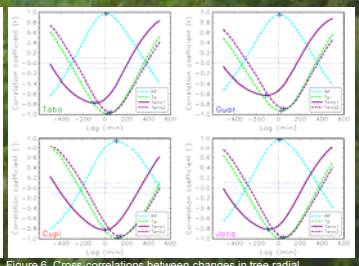

Figure 6. Cross-correlations between changes in tree radial displacement and changes in environmental conditions for sunny days. Extremal values of the correlation coefficients are indicated with cross symbols. Thin dotted lines: p=0.05 significance thresholds.

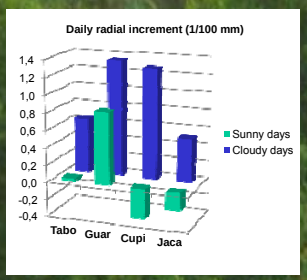

Figure 7. Average daily stem radial increment of the four species during sunny and cloudy days (10/2006-12/2007).

Stem radial dimension shows seasonal dynamics (Fig. 3) and diurnal rhythms of expansion (night) and contraction (day) (Fig. 4). The daily amplitude is significantly larger on sunny than on cloudy days (p<0.05) (Fig. 4). Growth mainly occurs during cloudy days (*i.e.* days during which daily amplitude in relative air humidity (RF) was smaller than the long-term average daily RF amplitude) (Fig. 4 and 5). The average daily stem radial increment (1/100mm·day^{-1}) was 0.26 for Tabo, 1.03 for Guar, 0.27 for Cupi, and 0.06 for Jaca (Fig. 7). On sunny days average daily stem radial increment was either negative (Cupi: -0.34, Jaca: -0.21) or small (Tabo: 0.04, Guar: 0.84) as compared to that on cloudy days. Cross-correlation analysis (Fig. 6) reveals for all species a close relation between daily changes in tree radial displacement and the daily courses of RF, Tp, Tens30 and Tens60 (p<0.05). The response times of the tree stems' reactions, *i.e.* the lead- and lag-times (negative and positive values on the x-axis of Fig. 6 respectively) differ among species and between sunny (Fig. 6) and cloudy days (not shown), indicating species specific environmental controls on physiological processes like water uptake by roots from different soil depths and transpiration dynamics.

CONCLUSIONS

Stem growth is a key process in forest ecosystem dynamics: (1) In conjunction with standard biometrical assessments, *e.g.* repeated diameter measurements, dendrometer data provide precise and most up-to-date data on tree growth and wood production in high time resolution, and (2) in combination with the monitoring of other forest ecosystem processes and structures dendrometer measurements link the tree-level with the soil and atmosphere compartments and thus provide the basis for the development of process-based tree growth and forest ecosystem models.

DEPARTAMENT OF SOIL SCIENCE
Curitiba, Brazil <www.ufpr.br>

INSTITUTE FOR FOREST GROWTH
Freiburg, Germany <www.iww.uni-freiburg.de>