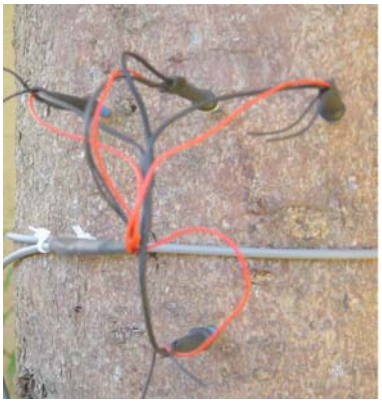
SF-L Sap Flow Sensor*



- Continuous monitoring of sap flow in trees
- Improved “well known” Granier Sap Flow Sensor
- Accurate measurement of night-time sap flow
- Enhanced accuracy and reliability
- Simplified data processing
- Complete installation tools

Introduction

The well known Granier sap flow sensor, i.e. thermal dissipation probe (Granier, 1985) uses heat as a tracer of sap flow. Due to its simplicity, reliability and affordability, several scientists have used the Granier technique all over the world. However, the technique has always had some shortcomings, which include:

1). Granier technique determines arbitrarily the sap flow to a zero value every night. This contravenes the possibility of nighttime transpiration (Granier, 1987) and the fact of refilling process of tree body during the night. (Do and Rocheteau, 2002).

2). The technique ignores the effect of natural temperature gradients of the sap-wood being measured, which range between +/- 1.5 ° C (fig. 1) and can cause considerable error in the results (DO and Rocheteau, 2002).

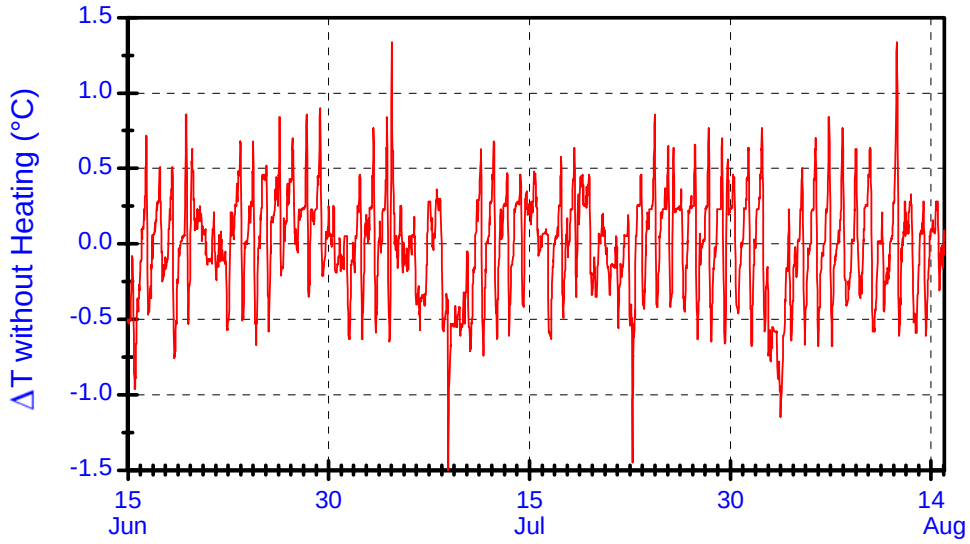


Fig.1 Vertical temperature gradients of a 40-year old spruce tree, measured with a Granier sensor without heating.

The SF-L Sensor

The SF-L sensor takes into consideration the variations of the natural temperature gradients of sapwood. The sensor uses two reference thermocouples to continuously record background temperature gradients (ΔT_{R1}, ΔT_{R2}) of the sapwood. During data processing, values of the temperature differences between the heated needle and the sapwood ambient temperature (ΔT) are corrected by the ΔT_{R1}, ΔT_{R2}.

* Patent pending

SF-L Sap Flow Sensor

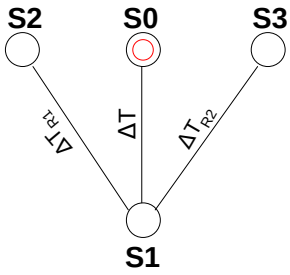


Fig. 2 Schematic diagram of the SF-L sensor

The new sensor therefore considerably enhances accuracy and reliability in sap flow measurements through continuous correction of natural temperature gradients of the sapwood. In contrast to Granier technique, SF-L sensor provides a very stable and more accurate ΔT_{max} value (temperature difference between the heated needle and the sapwood ambient temperature when sap flow=0). ΔT_{max} value is attained under conditions of zero transpiration and zero tree body refilling. This means 100% air humidity and zero tree diameter expanse. The diameter changes are detectable with high accuracy Ecomatik dendrometer (fig. 3).

Usually there is only one universal ΔT_{max} in a growth period of a tree. The ΔT values in the night are dependent on the refilling state of the tree and the transpiration demand and rarely attain ΔT_{max}. Correct determination ΔT_{max} value enables accurate measurements of the night sap flow. With the SF-L sensor, data processing is also highly simplified because it is no longer necessary to search for maximum temperature differences every night.

The SF-L sensor is easy to use. All necessary tools and spare parts are available at ECOMATIK.

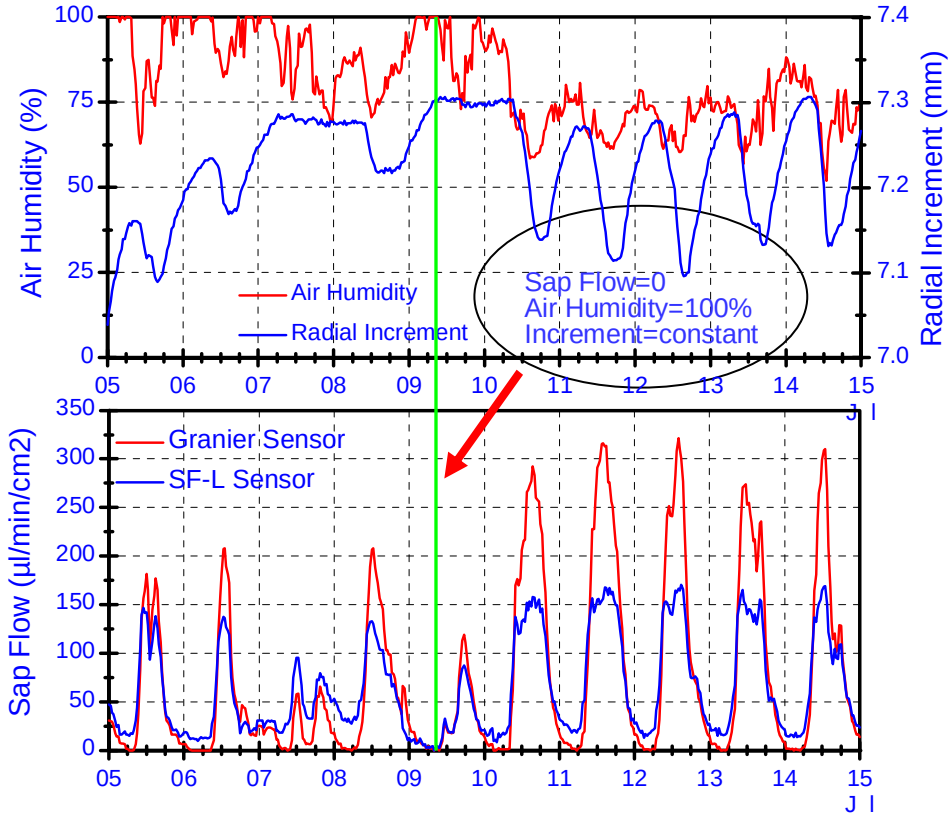


Fig. 3 Above: Air humidity and radial changes of a 40-year old spruce tree measured with an Ecomatik dendrometer type DD. Increase in diameter at night indicates that the tree continues to take up water even during nighttime hence sap flow is not zero.
Below: Comparison between sap flow measured with Granier sensor (red line) and with SF-L sensor (blue line). The Granier sensor shows zero sap flow every night while the SF-L detects zero value only on the night of 9. July, when air humidity reached 100% and the tree body fully saturated with water.

SF-L Sap Flow Sensor

Technical specification

Sensor	
Sensor composition	4 needles
Needle size	33 mm length, 1.5 mm diameter
Heating zone	20 mm from top of the needle
Cable length	0.7 m, extendable to 20 m
Tree size	Diameter>20 cm
Power consumption	0.2 W +/-5%, 84 mA DC, stabilized
Output	-100 µV to 1000 µV DC
Data Recording	3 differential channels required
Power supply	
Input	12 V DC
Output	84 mA stabilized, suitable for 1 to 3 SF-L sensors

Literature

Granier A (1985): Une nouvelle méthode pour la mesure du flux de sève brute dans le tronc des arbres, Ann. Sci. For., 1985, 42 (2), 193-200.

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Liu J C, Firsching B M, Payer H D (1995): Untersuchungen zur Wirkung von Stoffeinträgen, Trockenheit, Ernährung und Ozon auf die Fichtenerkrankung am Wank in den Kalkalpen. GSF-Bericht 18/95, 236 S.

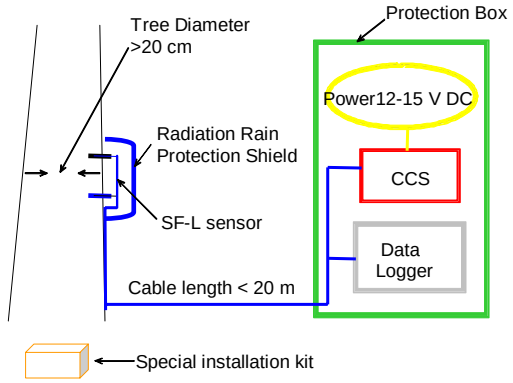
Do F and Rocheteau A (2002): Influence of natural temperature gradients on measurements of xylem sap flow with thermal dissipation probes. 1. Field observations and possible remedies. Tree Physiology 22, 641-648.

Do F and Rocheteau A (2002): Influence of natural temperature gradients on measurements of xylem sap flow with thermal dissipation probes. 2. Advantages and calibration of a non continuous heating system. Tree Physiology 22, 649-654.

Pearcy R W, Ehleringer J, Mooney H A and Rundel P W (1989): Plant Physiological Ecology – Field Methods and Instrumentation. Chapman and Hall.

Ordering Information

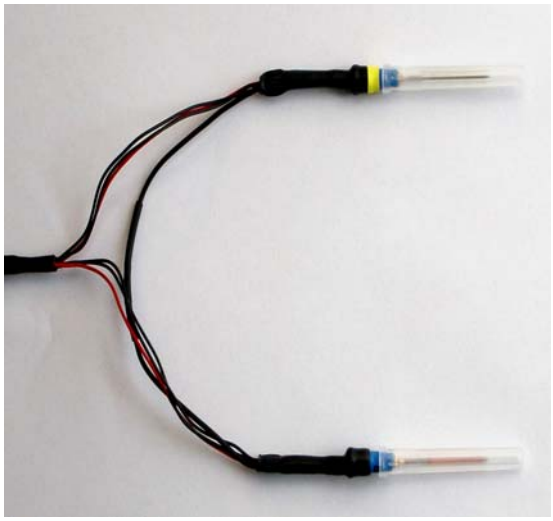
The SF-L sensor is suitable for trees with diameters larger than 20 cm. For its operation, special power supply, data logger and protection are required. The diagram below shows an overview of the necessary system components. All components are available at ECOMATIK. It is highly recommended to use the SF-L sensor with a dendrometer for monitoring the refilling status of the tree body.



Typical Arrangement of SF-L Sap flow measurement system

Parts No.	Components
SF-L-1 (Blue)	1 SF-L sensor with 0.7 m cable, 1 radiation, rain protection shield, 1 special adhesive tape, 1 silicon paste, 10 aluminum tubes
SF-L-2 (Red)	Constant current source (CCS)
SF-L-3 (Orange)	Installation kit incl. 1 hand drill, 2 drill bits with 2 mm diameter for drilling the holes into the wood, 1 drill bit with 8 mm diameter for removing the bark, special needle for inserting the aluminum tubes into the sap wood, 1 tube silicon-fat for improving the heat transmission from the heating into the wood.
SF-L-4 (Gray)	Data logger on request
SF-L-5 (Green)	Waterproof box
Cable extension	If required

SF-G Sap Flow Sensor



Introduction

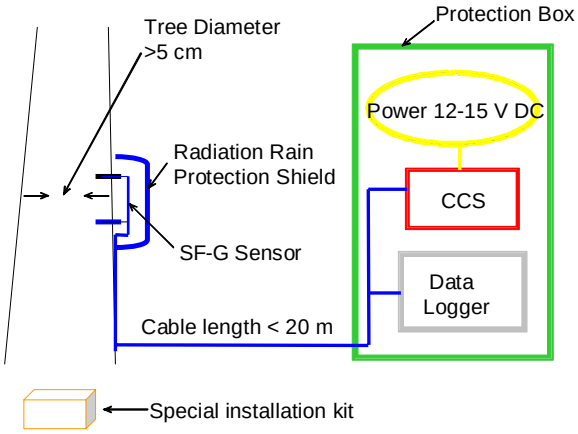
The SF-G is the well-known thermal dissipation probe (TDP) developed by Granier (1985) for measuring sap flow in trees. The sensor consists of two identical manufactured needles with copper-constantan thermocouples and a special heating wire. The two needles are inserted into the sapwood, one above the other 15 cm apart directly below. The top needle is heated with constant energy supply (=constant current source). The temperature difference between two needles ΔT resulted from the above heated and blow unheated needles correlates to the sap-flow-density.

Technical Specifications

Sensor composition	2 needles
Needle size	33 mm length, 1.5 mm diameter
Heating zone	20 mm from top of the needle
Cable length	0.7 m, extendable to 20 m
Tree size	Diameter>5 cm
Power consumption	0.2 W +/-5%, 84 mA DC, stabilized
Output	100 µV to 800 µV DC
Logger requirement	1 differential channels

Ordering Information

The SF-G is a sensor component of the sap flow measuring system. This means that SF-G must be installed into a tree and connected to a special power supply unit and a data logger. The diagram below gives you an overview of the whole sap flow measuring setup for outdoor purposes. All indicated components are available at ECOMATIK.



Typical Arrangement of SF-G Sap Flow measurement system

Parts No.	Components
SF-G-1 (Blue)	1 SF-G sensor with 5 m cable, 1 radiation, rain protection shield, 1 special adhesive tape, 1 silicon paste, 2 aluminum tubes
SF-G-2 (Red)	Constant current source (CCS), one CCS supplies 3 SF-G sensors
SF-G-3 (Orange)	Installation kit incl. 1 hand drill, 2 drill bits with 2 mm diameter for drilling the holes into the wood, 1 drill bit with 8 mm diameter for removing the bark, special needle for inserting the aluminum tubes into the sap wood, 1 tube silicon-fat for improving the heat transmission from the heating into the wood.
SF-G-4 (Gray)	Data logger
SF-G-5 (Green)	Protection box
Cable extension	On request