

## Implexx Sap Flow Sensor

versus

## Heat Ratio Method

### Summary Table of Features:

Feature	Implexx Sap Flow Sensor	Heat Ratio Method
Accuracy	±3%	Underestimates sap flow by ~15% (Flo et al 2019)
Measurement range	-10 to +1000 cm/hr	-10 to +15 cm/hr
Measures stem water content?	YES	NO
Affected by ambient temperature?	NO	NO
Measures reverse flow or hydraulic redistribution?	YES	YES
Multiple measurement points?	YES	YES
SDI-12 digital output?	YES	NO
Supports low cost loggers?	YES	NO
Supports internet enabled devices such as LoRaWAN and NB-IoT?	YES	NO
Outputs multiple parameters?	YES	NO
Calibrated?	YES	NO
Requires low or small power supply?	YES	YES
Theoretically derived method?	YES	YES

### Details:

The Implexx Sap Flow Sensor uses the Dual Method Approach (DMA) method to measure sap flow. The DMA is a combination of the Heat Ratio Method (HRM) and Tmax methods. Therefore, the Implexx Sap Flow Sensor outputs DMA, HRM and Tmax methods. Therefore, the Implexx Sap Flow Sensor can also be an HRM sensor.

The DMA is different to the HRM method because:

- Accuracy and calibration: the Implexx sensor has a unique calibration equation which can be applied to many woody species for accurate estimations of sap flow. The HRM sensors are typically not calibrated, and they can potentially underestimate sap flow by ~15% (Flo et al 2019).
- Measurement range: the DMA is the only sap flow method that can measure the entire observable range of heat velocity in plants. Heat velocity ranges between -10 to +1000 cm/hr and the DMA can measure this range. The HRM can only measure slow velocities within the range between -10 to +15 cm/hr.

- Accuracy: the DMA is more accurate than the HRM because it can resolve the entire measurement range. The HRM cannot measure higher sap flow therefore it cannot accurately measure daytime sap flow.
- SDI-12: the Implexx sensor has SDI-12 digital output which means many sensors can potentially be connected to a small, low cost data logger. In contrast, other commercially available HRM sensors have a dedicated data logger or require complex wiring and programming.
- Outputs: the Implexx sensor can measure sap flux density, sap flow, transpiration and stem water content simultaneously. HRM sensors typically output heat velocity or require expensive software to convert heat velocity to sap flow.
- The Implexx sensor outputs multiple parameters that are extremely important for plant physiology and plant water use research. These parameters include total tree sap flow, outer and inner sapwood sap flow, stem temperature, stem water content, and sapwood thermal properties.