

Implexx Sap Flow Sensor

versus

Granier or Thermal Dissipation Probes (TDP)

Summary Table of Features:

Feature	Implexx Sap Flow Sensor	Granier or TDP
Accuracy	±3%	Underestimates sap flow by 60% (Steppe et al 2010)
Sap flux density measurement range	-100 to +2000 cm ³ cm ⁻² hr ⁻¹	+10 to +2000 cm ³ cm ⁻² hr ⁻¹
Measures stem water content?	YES	NO
Measures reverse flow or hydraulic redistribution?	YES	NO
Multiple measurement points?	YES	NO
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	NO
Easy to manage in the field?	YES	NO
Theoretically derived method?	YES	NO

Details:

The Implexx Sap Flow Sensor is different to the Granier, or thermal dissipation probe (TDP), method with the following features:

- The Implexx sensor has a unique calibration equation which can be applied to many woody species for accurate estimations of sap flow. The Granier or TDP sensor is known to have an inaccuracy of up to 60% and must be calibrated for every installation. This makes the TDP sensor very difficult to use.
- 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, the Granier or TDP sensor is an old, analog sensor technology that requires large and expensive data loggers, with multiplexers, and complex programming and support.
- The Implexx sensor can measure sap flux density, sap flow, transpiration and stem water content simultaneously. The Granier sensor only measures sap flux density.

- 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. The Granier or TDP sensor only outputs temperature difference which is must be calibrated for an accurate sap flow measurement.
- The Implexx sensor has a short, 3 second heat pulse whereas the Granier sensor needs constant and continuous heat, 24 hours a day, 7 days a week. The Granier applies continuous heat to the plant which, in some cases, can potentially cook and damage the plant.
- The Implexx sensor requires small power supplies whereas the Granier or TDP requires large power supply. This is because the Implexx Sap Flow Sensor operates off a heat pulse whereas the Granier sensors must have continuous heat supplied. With the Implexx sensor, it is possible to support up to 12 sap flow sensors with a small, 20W solar panel and battery. With the Granier or TDP, you will need at least and 80 Watt solar panel, or more, plus large marine grade batteries. Not only is this expensive, but the additional solar panels and batteries are extremely difficult to manage under field conditions.
- The Granier or TDP technique is inaccurate at measuring slow or zero rates of flow and cannot measure reverse flow. Therefore, the TDP method is unreliable at night-time, during cooler weather such as winter, early spring and late autumn.
- Many studies have found the Granier or TDP technique to have errors as large as 60% (for example, see attached paper by Steppe et al 2010). In contrast, the Implexx sensor has a scientifically demonstrated accuracy of less than 3%.
- The Granier method assumes there is zero sap flow during the night. This is critical for the Granier method to accurately determine correction factors which are used in the calculation of sap flow. However, sap flow is nearly always above zero at night and is typically around 12% of total daily flow. Night-time sap flow is particularly high in desert, sub-tropical, tropical and savannah style biomes where night-time sap flow can be as high as 40%. Any night-time sap flow means the Granier or TDP sensor cannot accurately estimate sap flow.
- The Granier probes can only measure at one depth in the sapwood whereas the Implexx sensor can measure at multiple depths. This is extremely important as many students have demonstrated that sap flow varies across the radial profile of the tree. That is, sap flow is usually higher towards the outside of the tree and lower towards the inside of the tree. The Implexx Sap Flow Sensor can measure this variation for an accurate overall measurement of tree sap flow. The Granier probe cannot measure this and can lead to significant errors in tree sap flow measurements.