

HYDRAULIC CONDUCTIVITY: SHOULD WE PUSH OR SHOULD WE PULL?

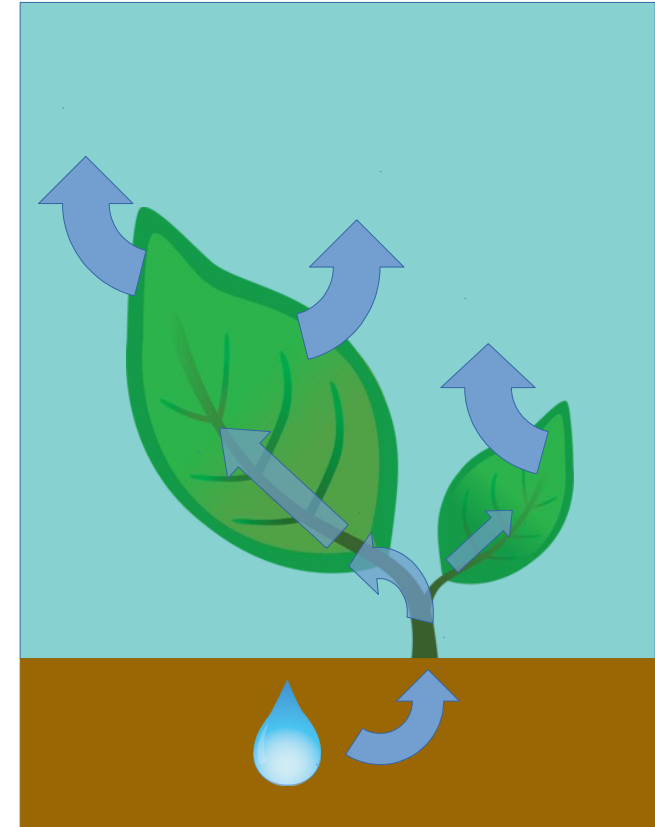
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WHY DO WE CARE ABOUT PLANT HYDRAULICS ?

- To take up CO₂ and transpire, plants need to transport water from soil to leaves
- Plant hydraulics explains plant water transport under tension
- Hydraulic failure assumed to cause drought stress and eventually plant death
- Different plant hydraulic traits enable plants to survive in different environments
 - By looking at all these traits, best plant functional types for given environment can be chosen



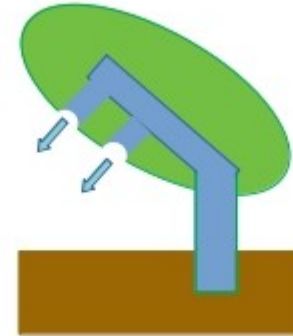
PLANT HYDRAULICS

COHESION-TENSION THEORY AND PLANT HYDRAULIC TRAITS

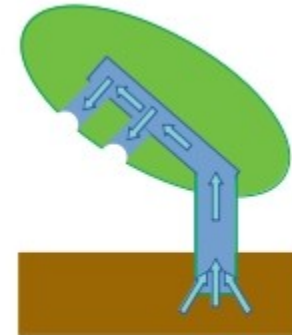
Water transpires from the leaves

- Generates a capillary force
- Reduces the pressure at the top of the plant
- Large enough pressure gradient between the leaves and the roots.

This tension generates water flow



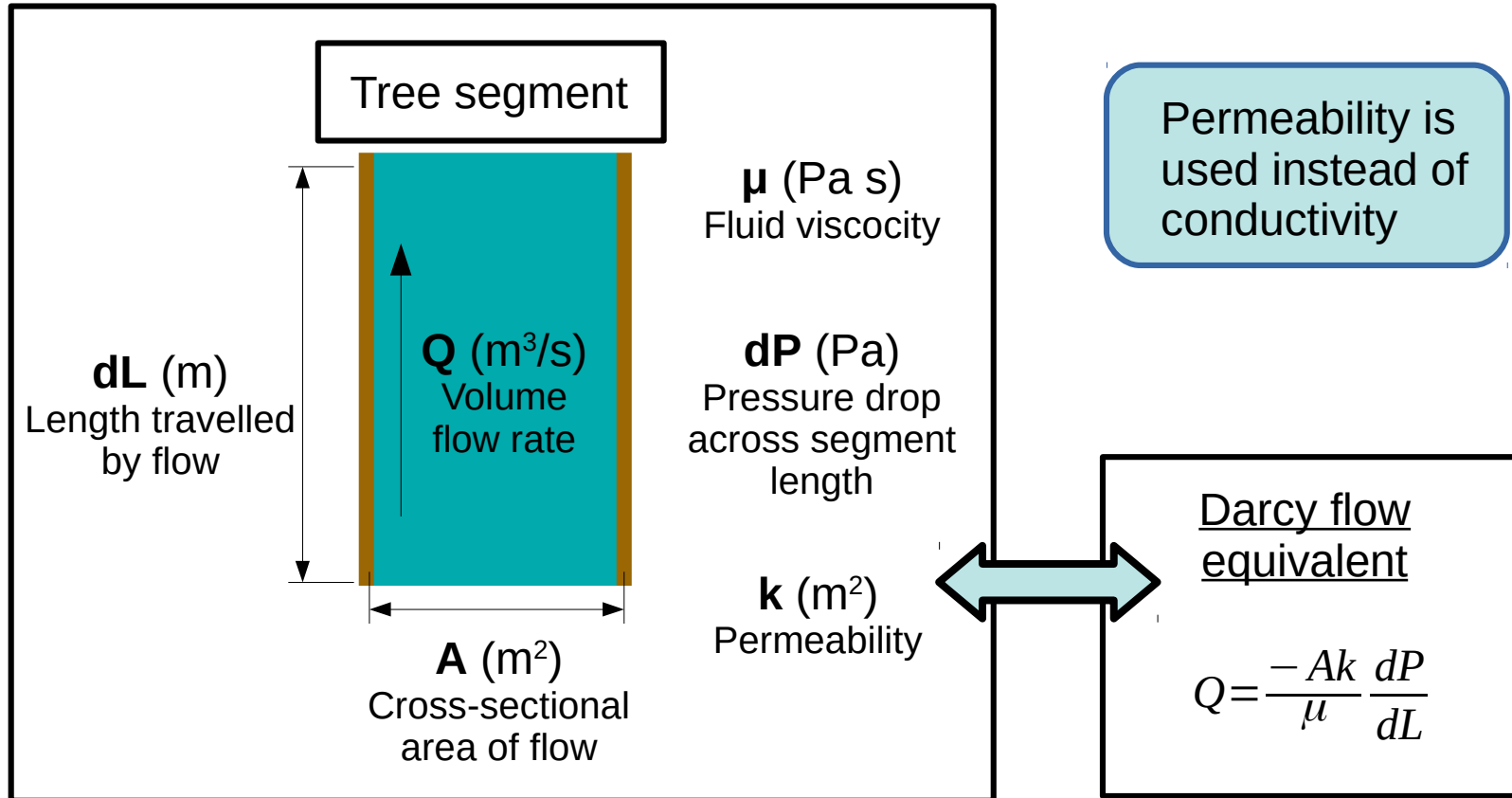
Transpiration



Cohesion-tension

PLANT HYDRAULICS

EQUATION USED



COMMON METHODS FOR MEASURING TWIG HYDRAULIC CONDUCTIVITY?

Method	Description	Pressure
Flow centrifuge	Small water head induces flow. Centrifugal forces lower pressures	Down to -10MPa
Sperry gravitational	Height difference induces positive pressure	+1 – 9 kPa
Pressure pump	Pressure tank induces positive pressure	Up to +500 kPa

Common traits are that:

- the pressure is controlled whereas flow is the dependent variable
- Water is pushed through samples

OBJECTIVES

- Develop a method to measure hydraulic conductivity at **controlled flow rate**
- Using this method, compare the effect of **pushing vs pulling** water through a twig sample

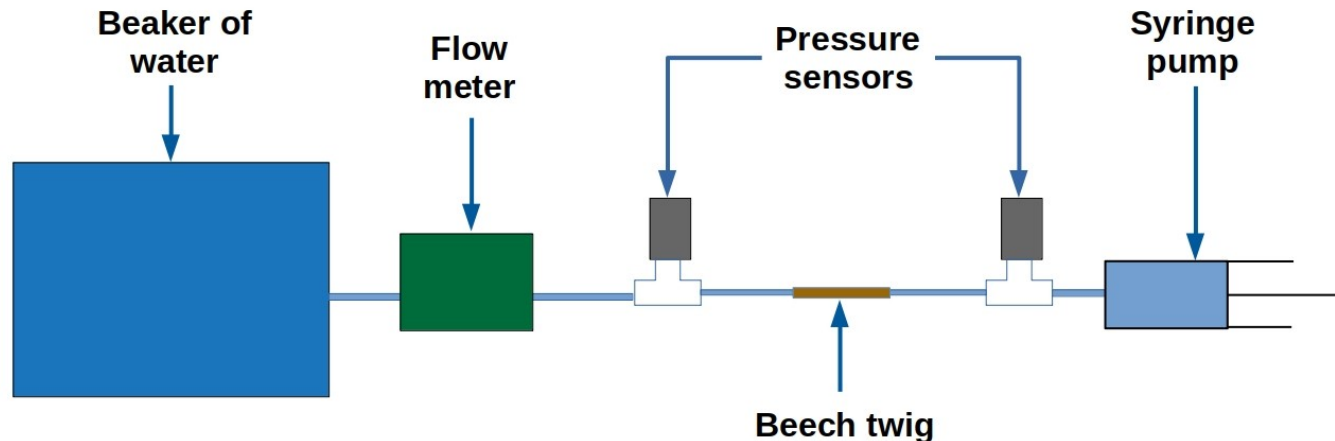
NEW SETUP

Experiment where **flow rate is controlled** by a syringe pump and the pressure is the dependent variable.

This is more similar to trees, where the transpiration rate is controlled by the leaf and the pressure changes as a result.

This setup allows for **rapid changes** to the experimental conditions with real time monitoring.

Flow is measured on both sides of the twig, with syringe pump and flow meter

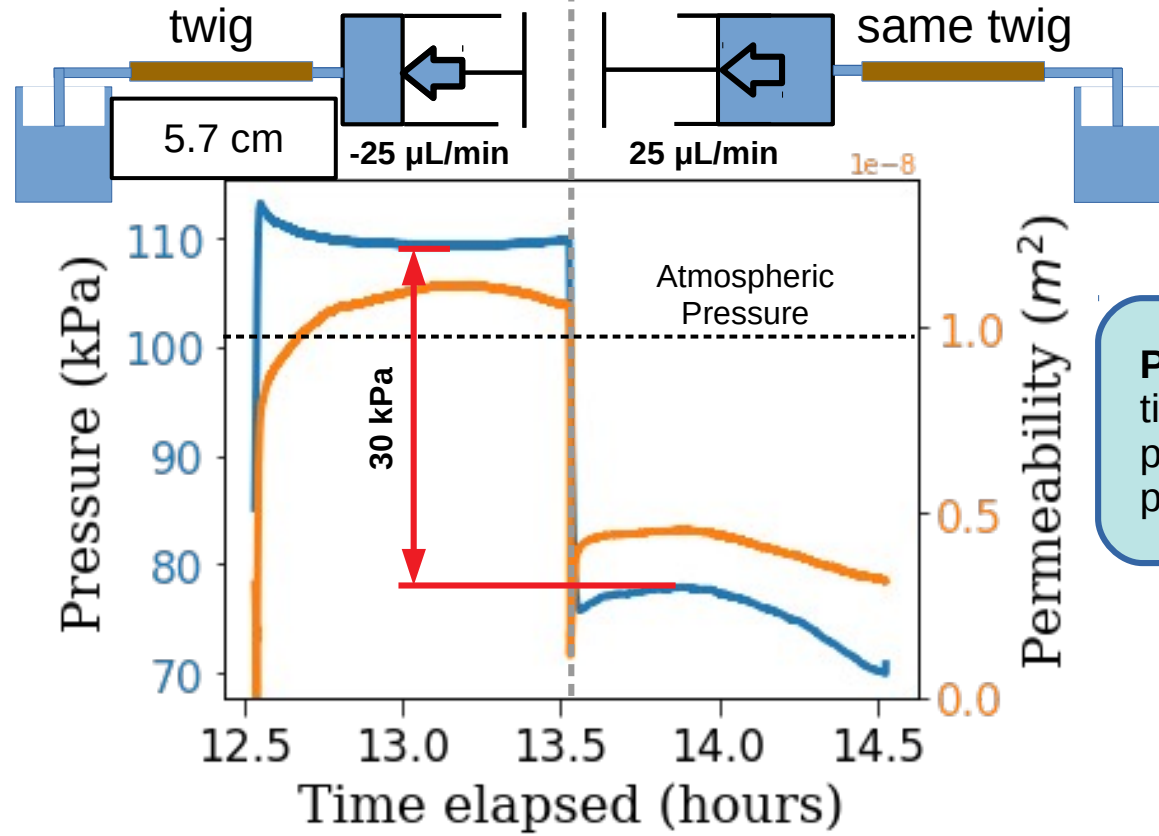


The next step to approach natural conditions is to pull water (suction) through the twig instead of pushing.

RESULTS

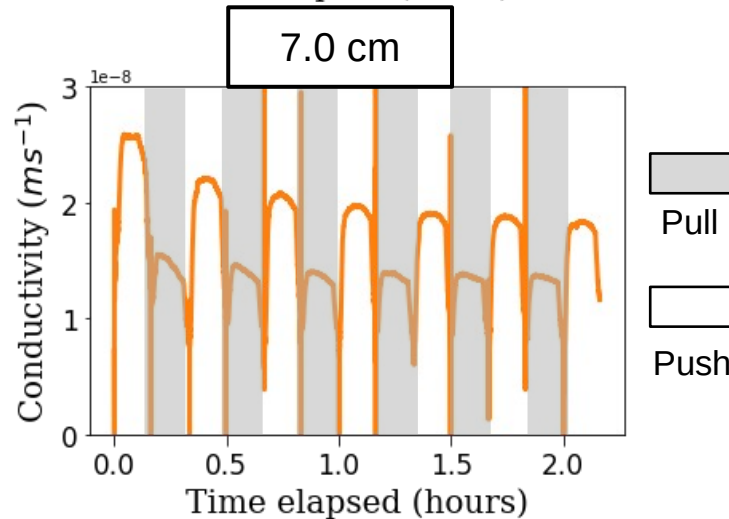
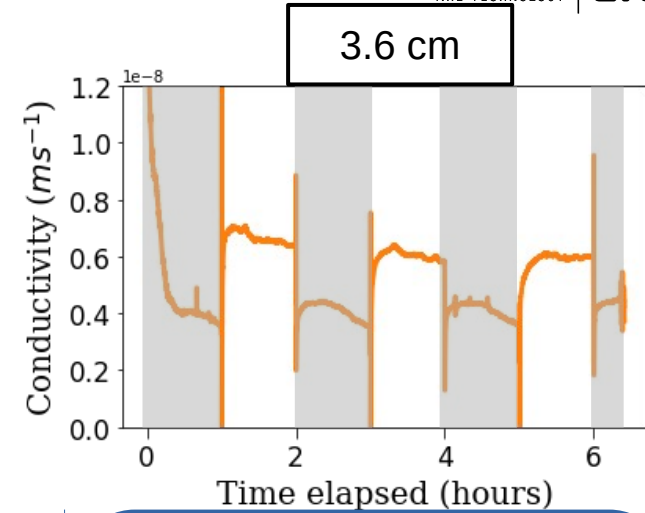
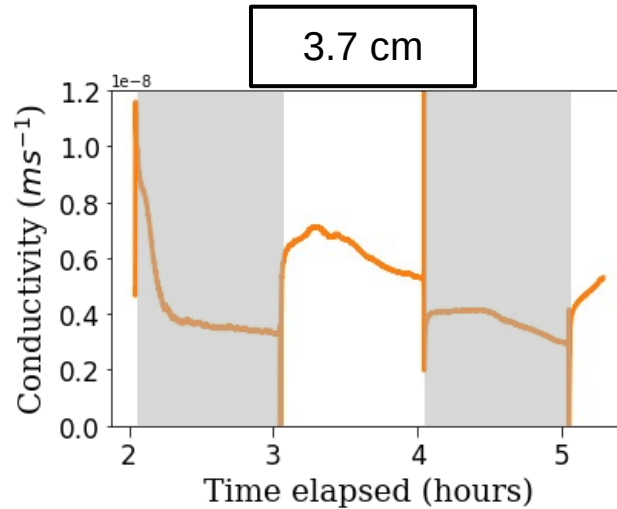
Water **pushed** through with
resulting ΔP similar to current
methods

Followed by **pull** at same flow rate



Permeability is 2-3
times higher when
pushing compared to
pulling

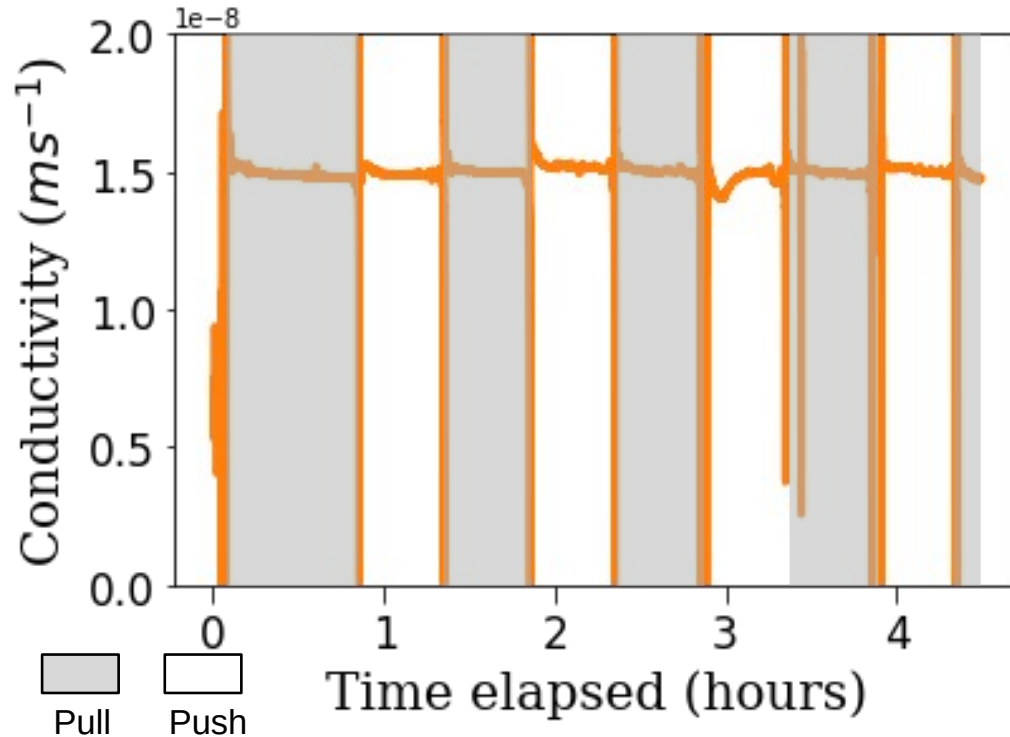
RESULTS REPRODUCIBLE



The experiment was repeated several times, each with a different twig

The increased permeability has been **reproduced consistently**

NOT AN ARTIFACT



The same experiment was run with a **capillary** that has a similar permeability

No significant variation in permeability compared to experiment with twigs

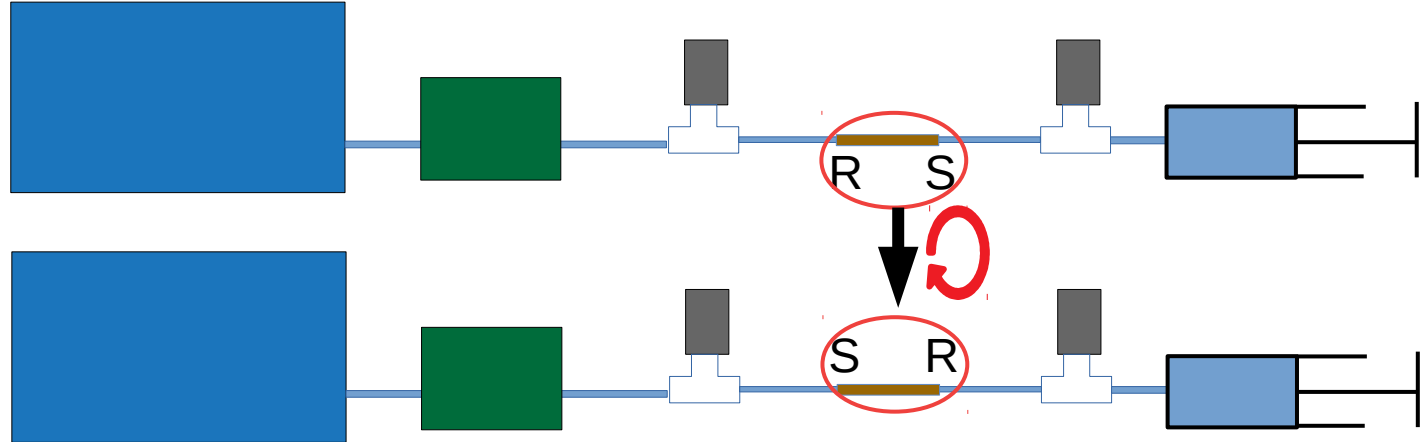
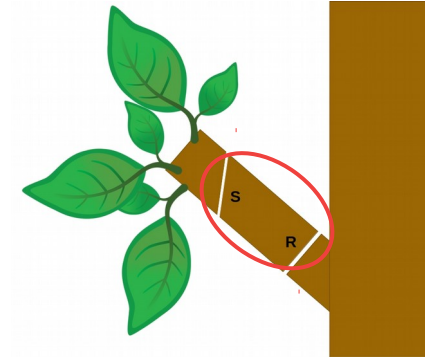
Conclusion

The variation is due to the twig itself and not the experimental method

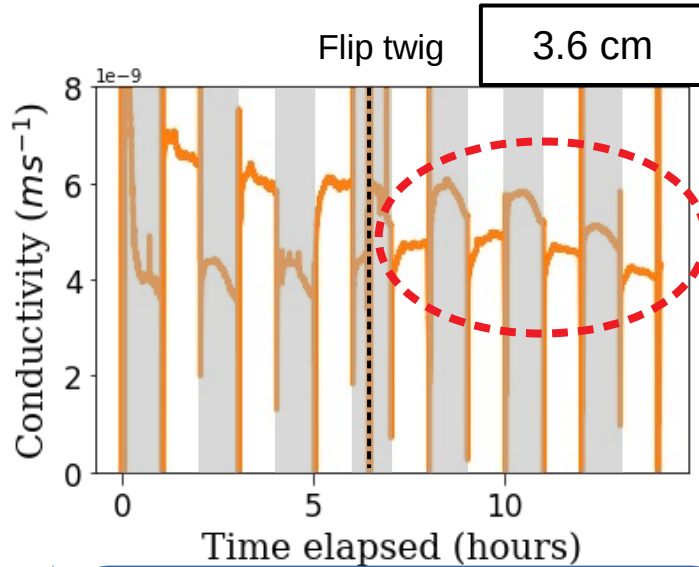
DIRECTIONALITY VS PRESSURE

The twig's direction is noted when placing it into the setup

Twig's direction is flipped to see if results are due to pressure or direction of flow in twig

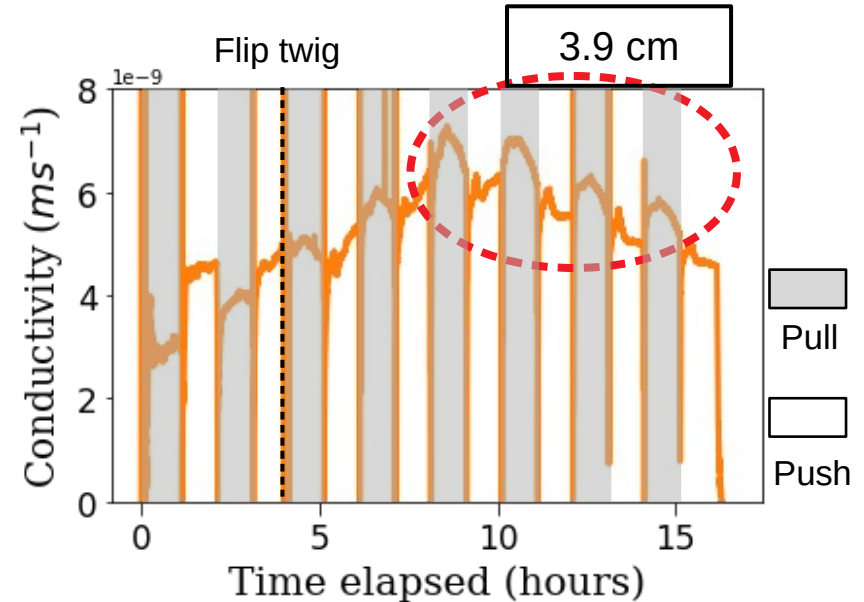


FLIPPING TWIG DIRECTION DURING PUSH-PULL SEQUENCE



After flipping, the pattern is now inverted, where pulling produces the higher k.

Reproduced in separate experiment



Difference is due to:

- Different pressures
- Flow direction

- Twig permeability is **systematically increased** when water is pushed through the twig, compared to pulling as in a living plant
- It is **not an artifact** of experiments as a capillary does not produce the same results
- The results suggest that flow direction through twigs matter
- However I am working at much lower suction than would be found in trees