

Resolving Vertical Pressure Gradients Within a Mobile Sediment Bed

Melissa Marry and Diane Foster

Acknowledgments

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Spencer Marquardt, Savannah DeVoe, Corina Gudinas, Maggie Enderle, Jon Hunt, Garrett Forhman, Angela Sarni

Motivation

Previous work suggested the role of pressure gradients in the **momentary liquefaction** of the seabed, particularly with regards to underwater munitions

→ Need sediment bed pressure distribution

Pressure Stick:

- Measures vertical pressure gradient above and within the sediment bed
- Provides observations of momentary bed liquefaction at a fixed location
- Work in combination with previously developed mobile Pressure Mapping Munition (PMM)

Momentary Liquefaction

- Seabed instability caused by cyclic loads (e.g. waves, earthquakes)
- Occurs when the vertical effective stress of the soil vanishes
- Seabed loses its bearing capacity
- Material transforms from solid state into liquid state
- Mathematically, dp/dz changes sign

Deployments

October 26th-30th, 2020



- $0.3 \text{ m} \leq H_{\text{significant}} \leq 1.2 \text{ m}$
- Deployed along with the Nortek Vector and Aquadopp



First successful deployment of the Pressure Stick!

Wallis Sands Beach, Rye, NH

January 4th-5th, 2021



- New and quicker deployment strategy
- $1.5 \text{ m} \leq H_{\text{significant}} \leq 3.0 \text{ m}$ (high energy conditions)
- Pressure Mapped Munition (PMM)
- Pressure stick design improved!

The PMM in Action

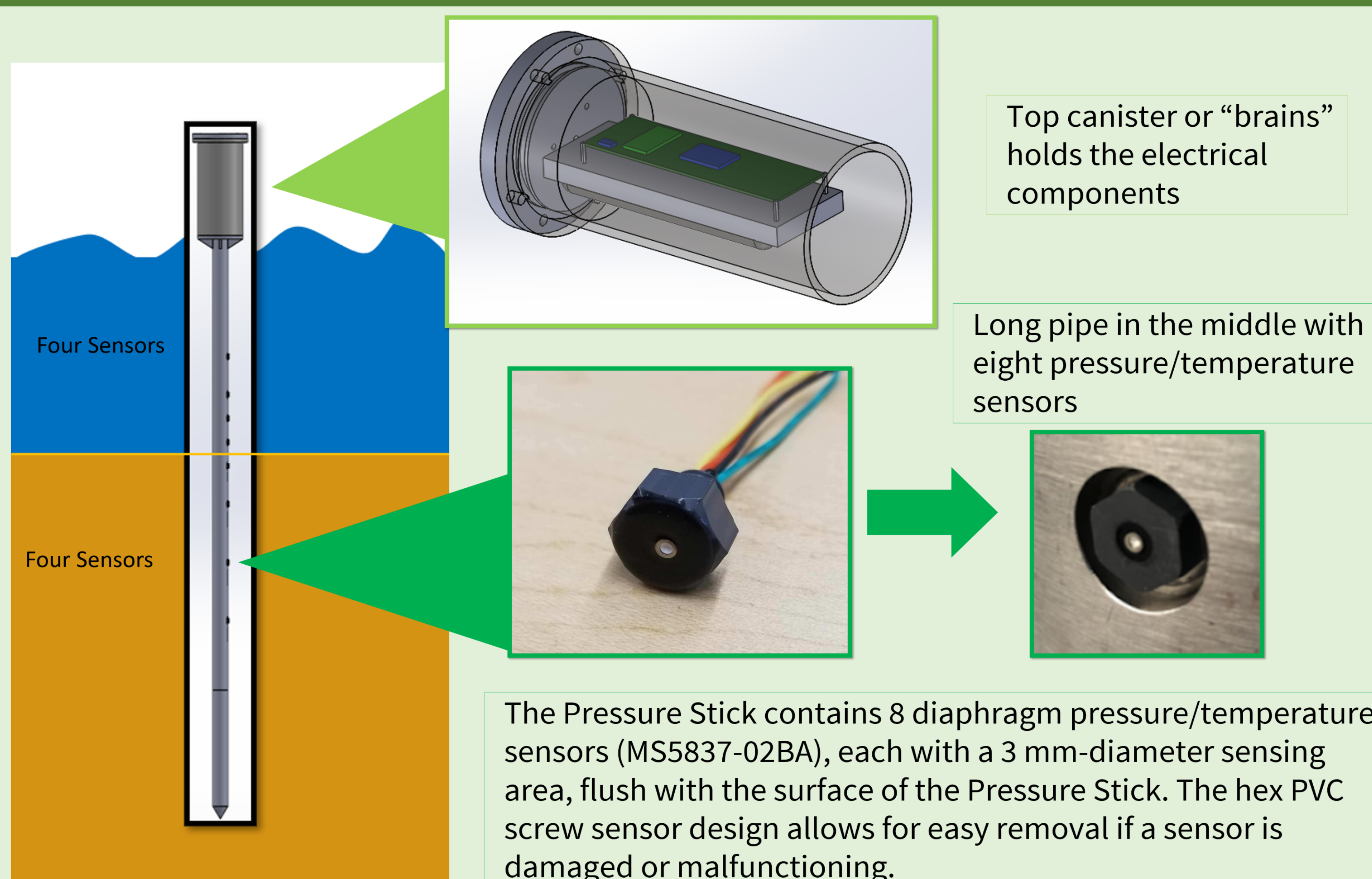


Fort Foster, Kittery, ME
9/10/2018



Wallis Sands Beach, Rye, NH
05/17/2019

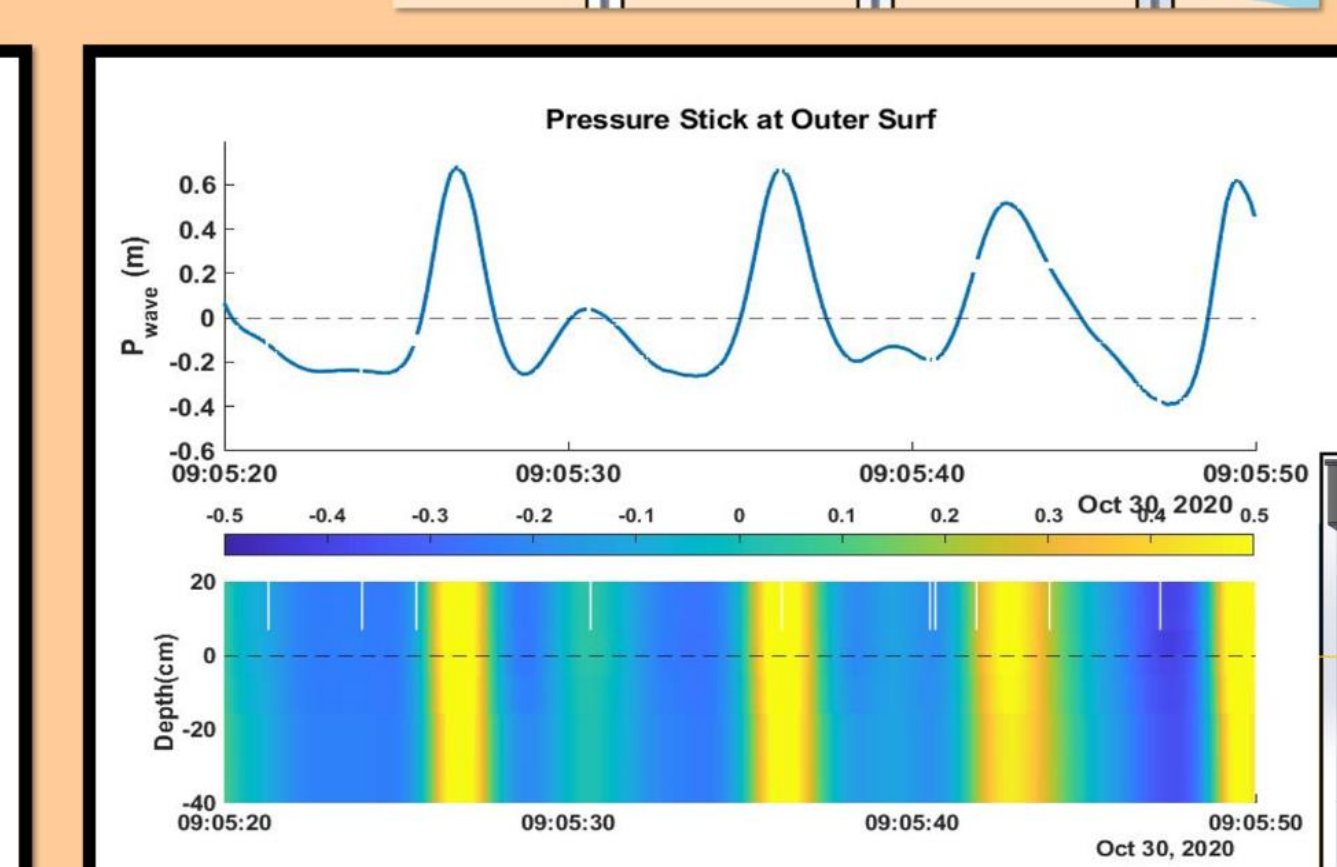
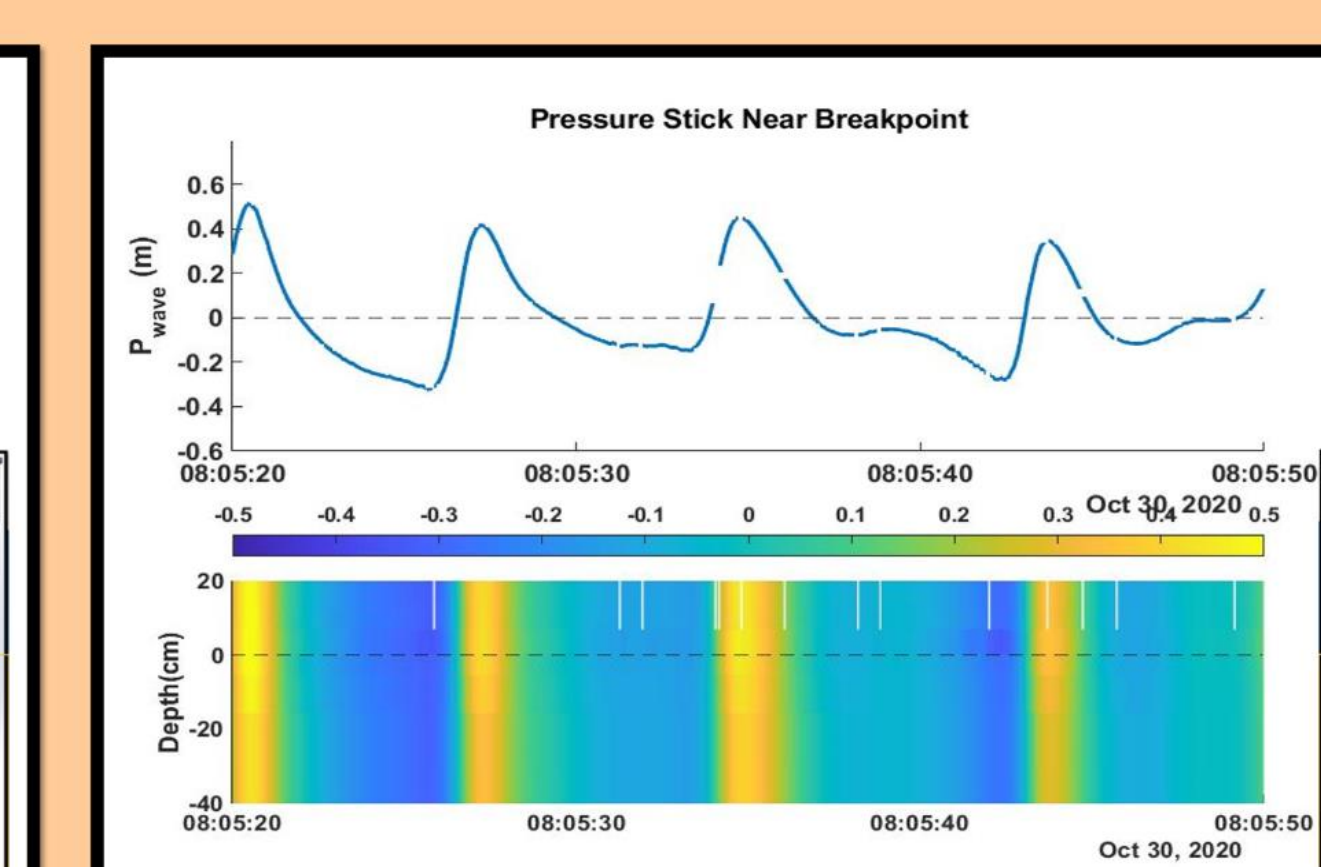
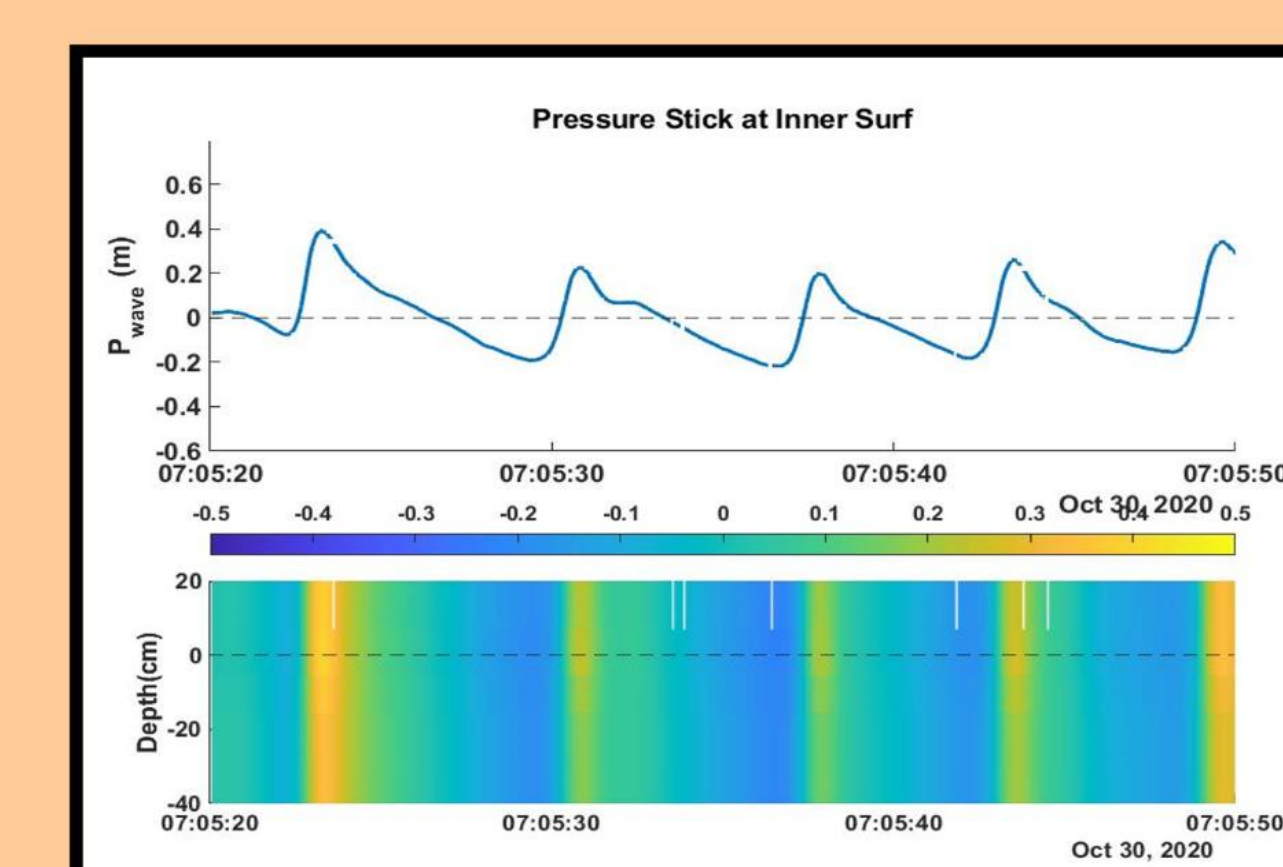
Pressure Stick Design



Results

Sea Surface
Elevation

Observed
Pressure
Distribution
in the Bed



A closer look at the
inner surf zone...

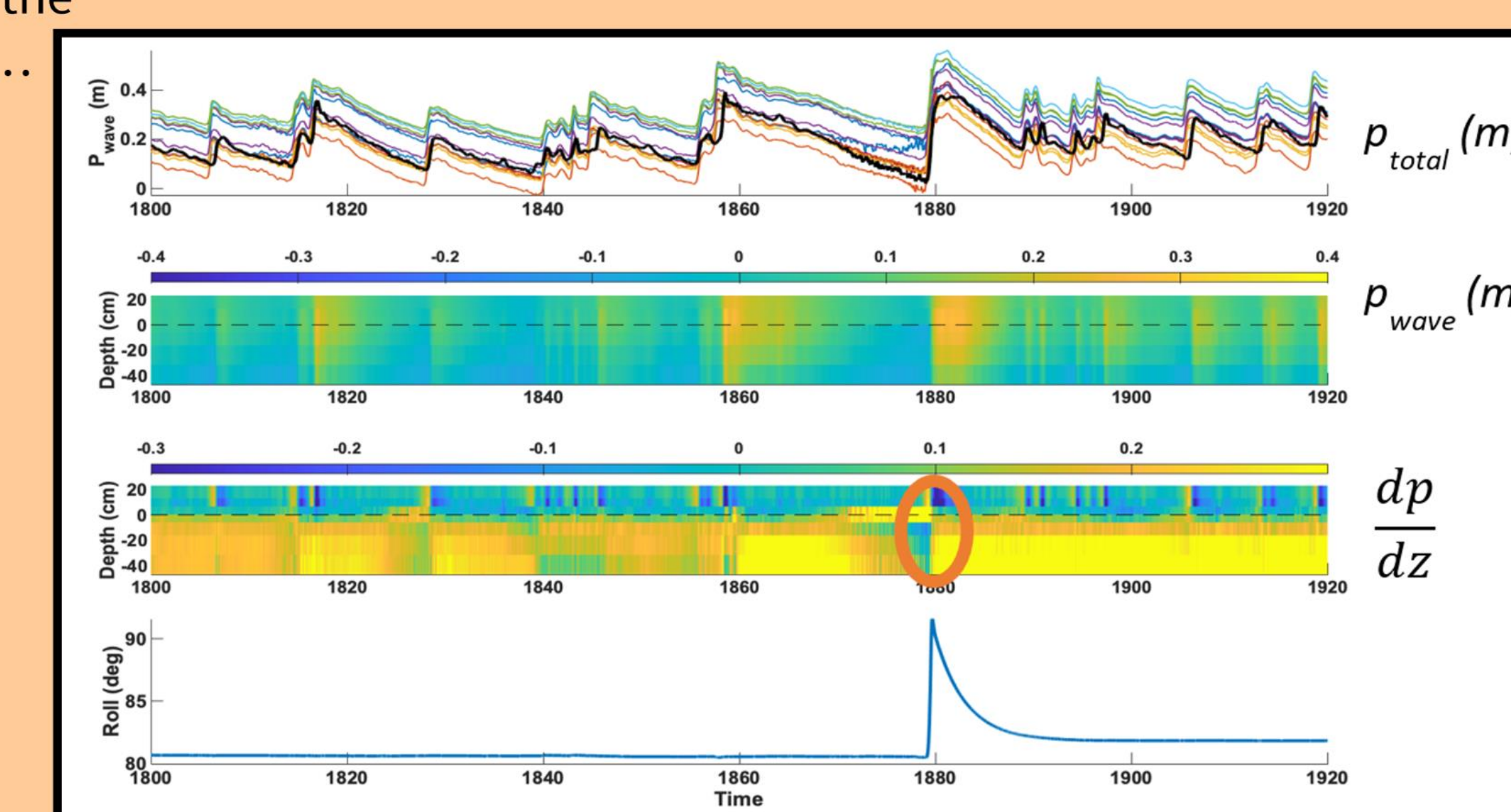
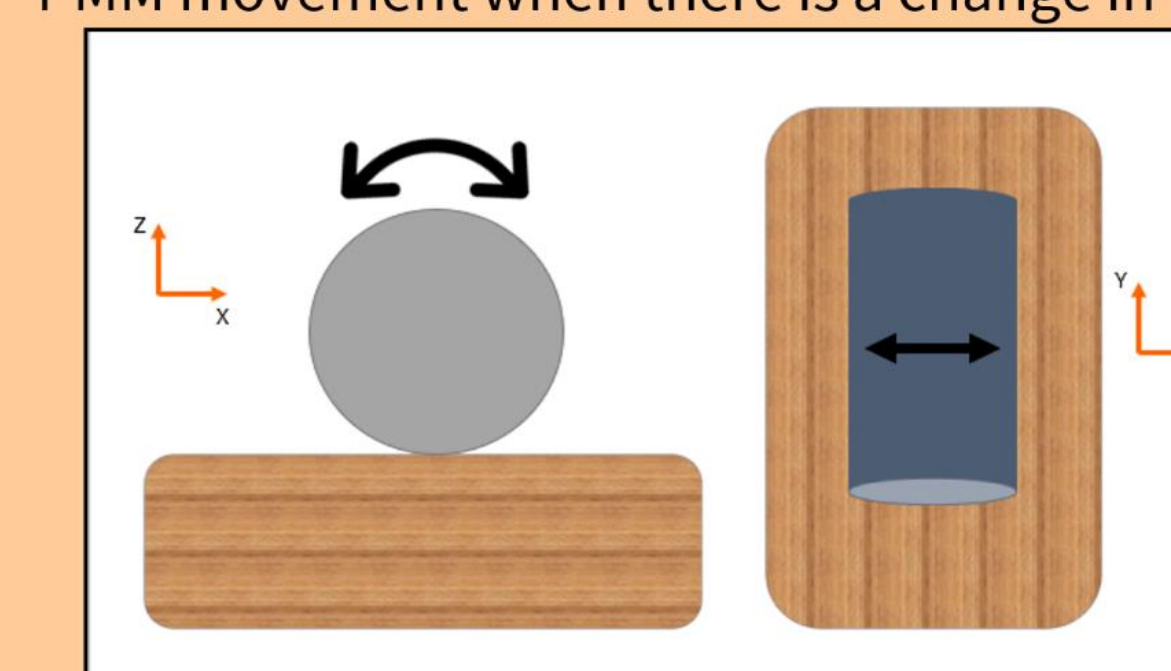


Figure credit: Diane Foster

- Waves go from sinusoidal shaped in the outer surf to peakier/asymmetrical near the breakpoint to sawtooth in the inner surf zone
- Decay of wave induced pressure into the sediment bed

PMM movement when there is a change in roll



Some Extras

Some More Extras

Future Work

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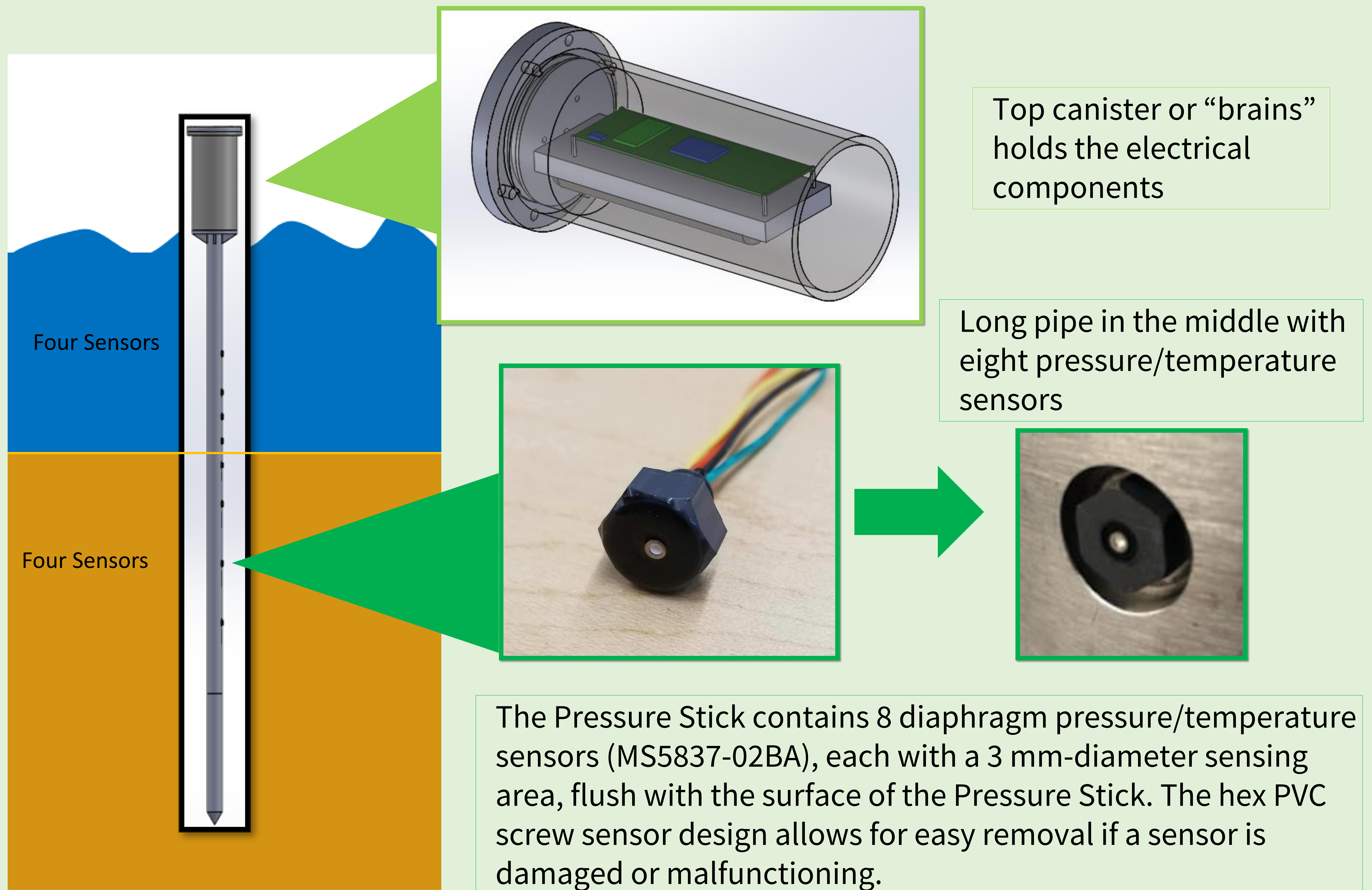
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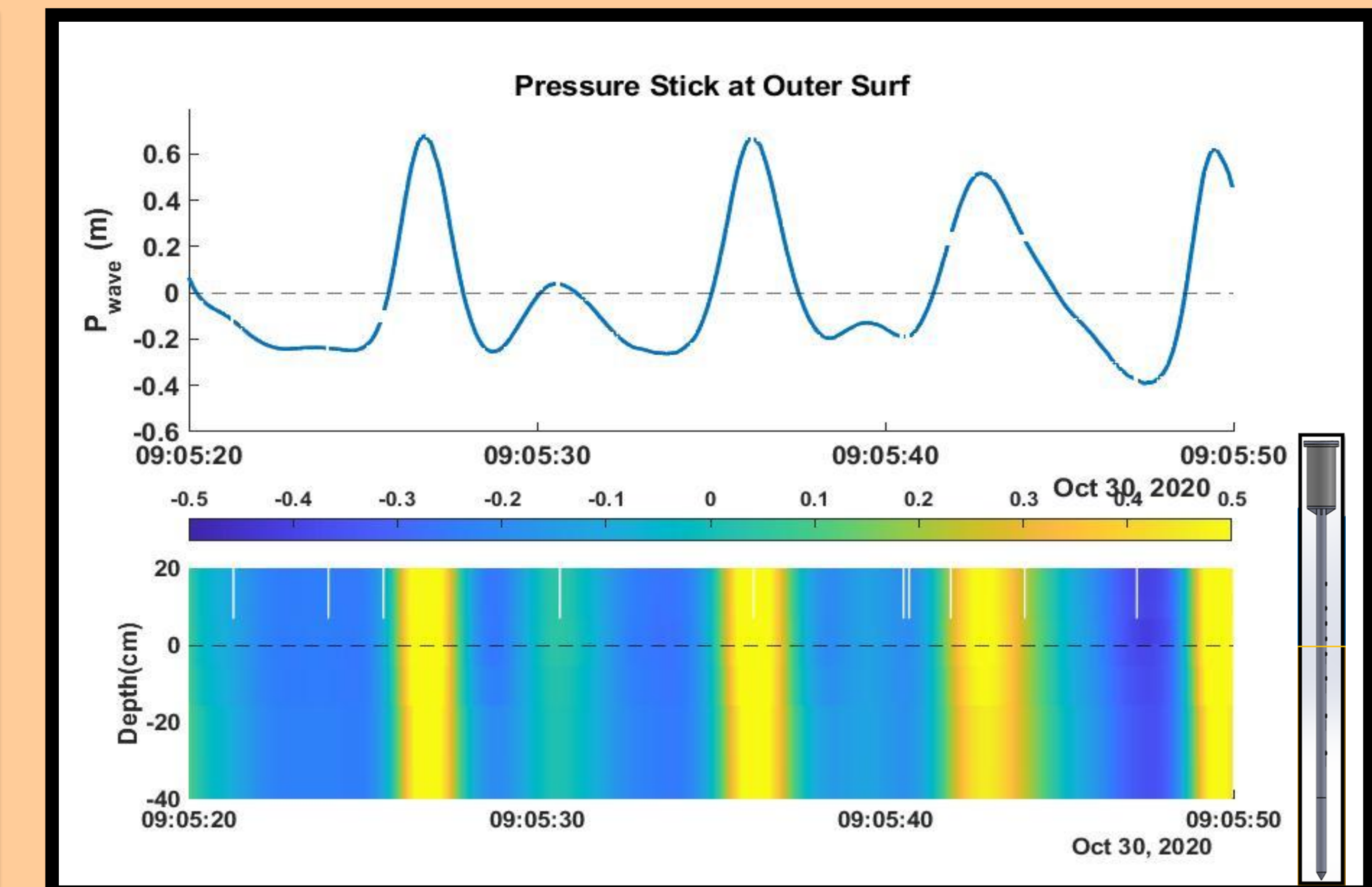
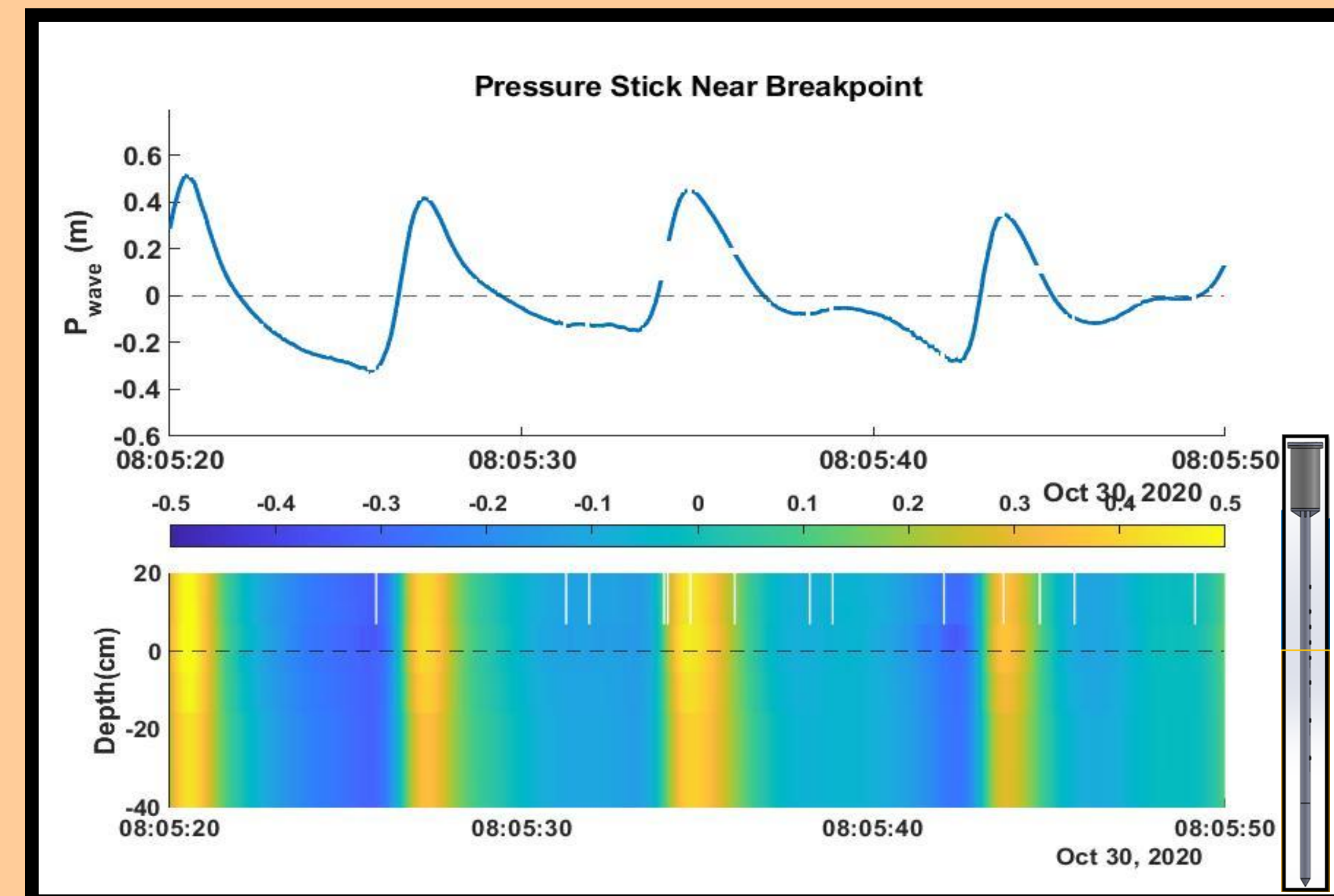
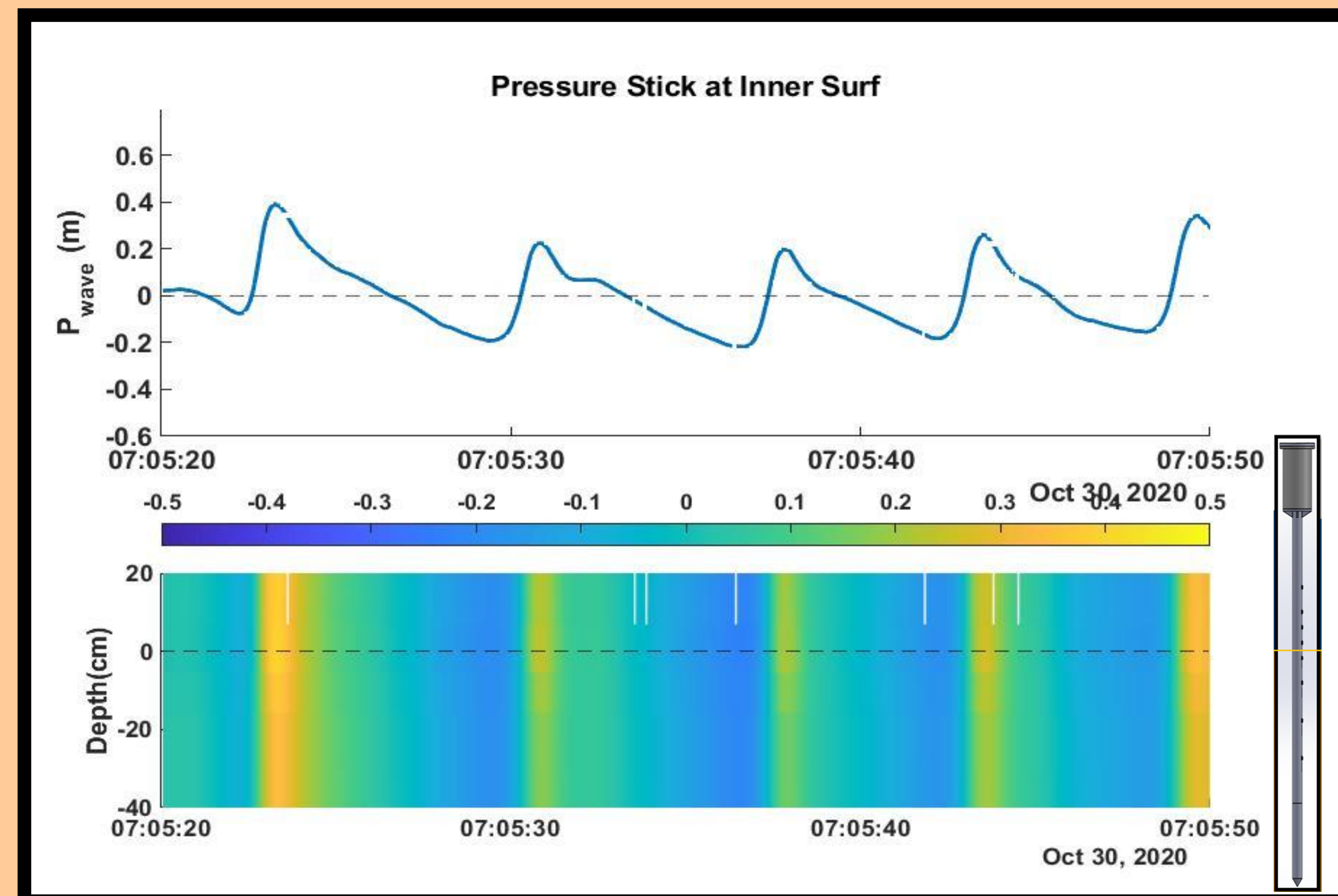
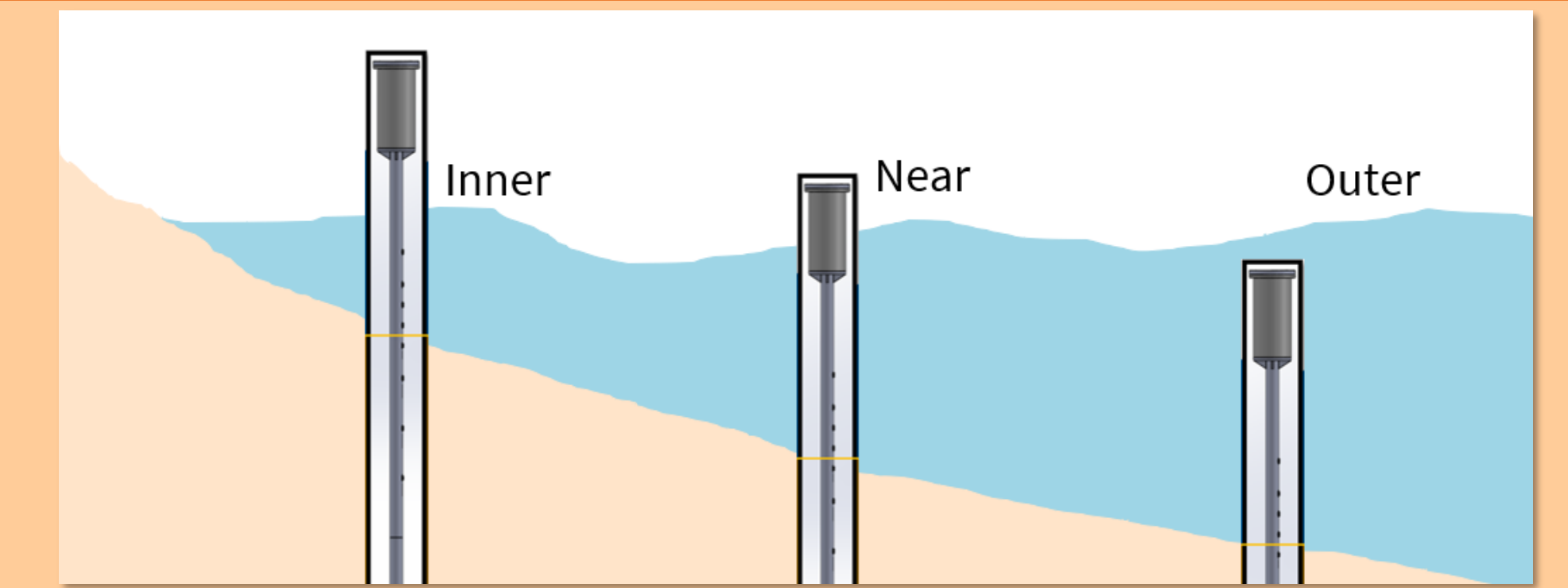


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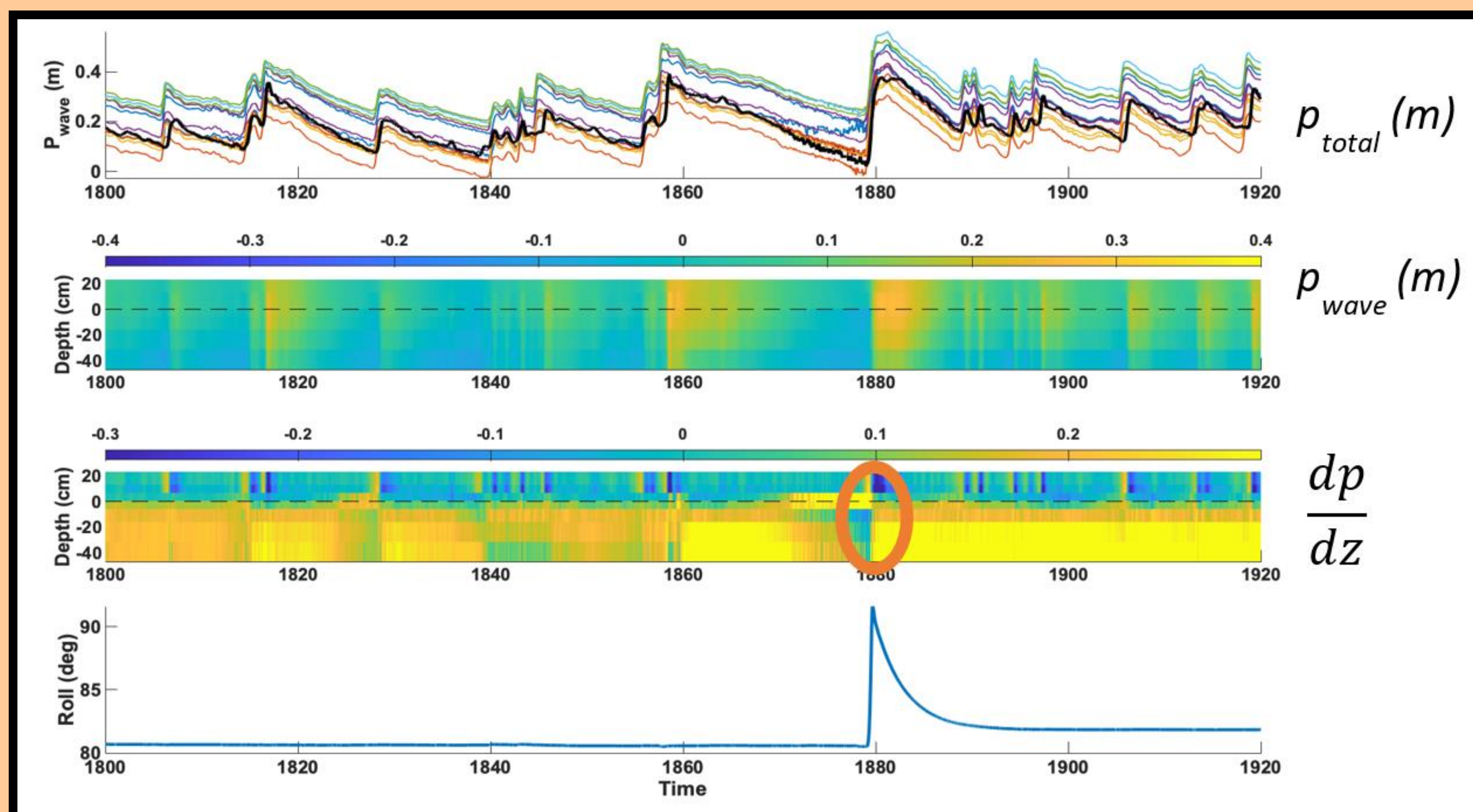
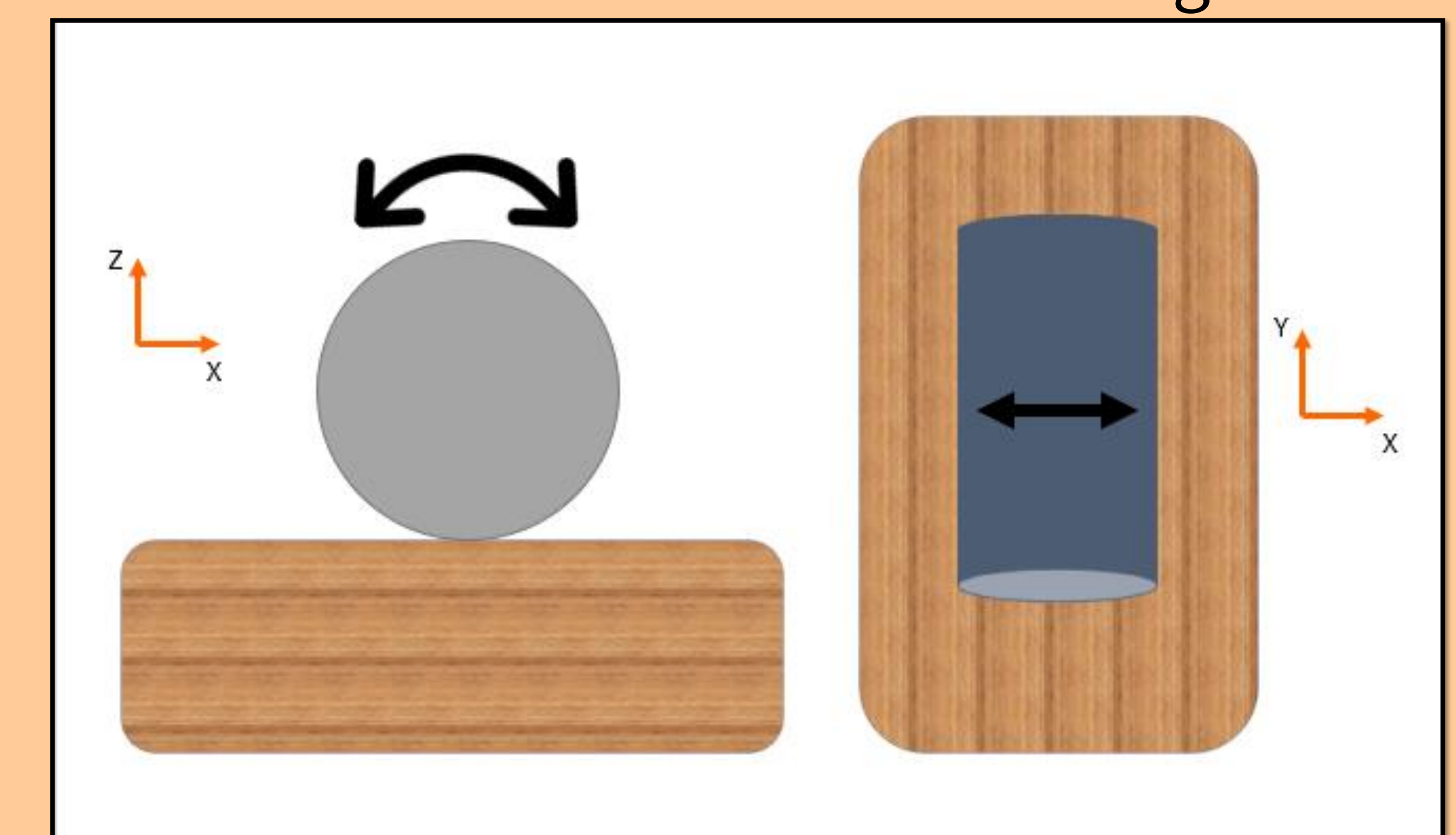


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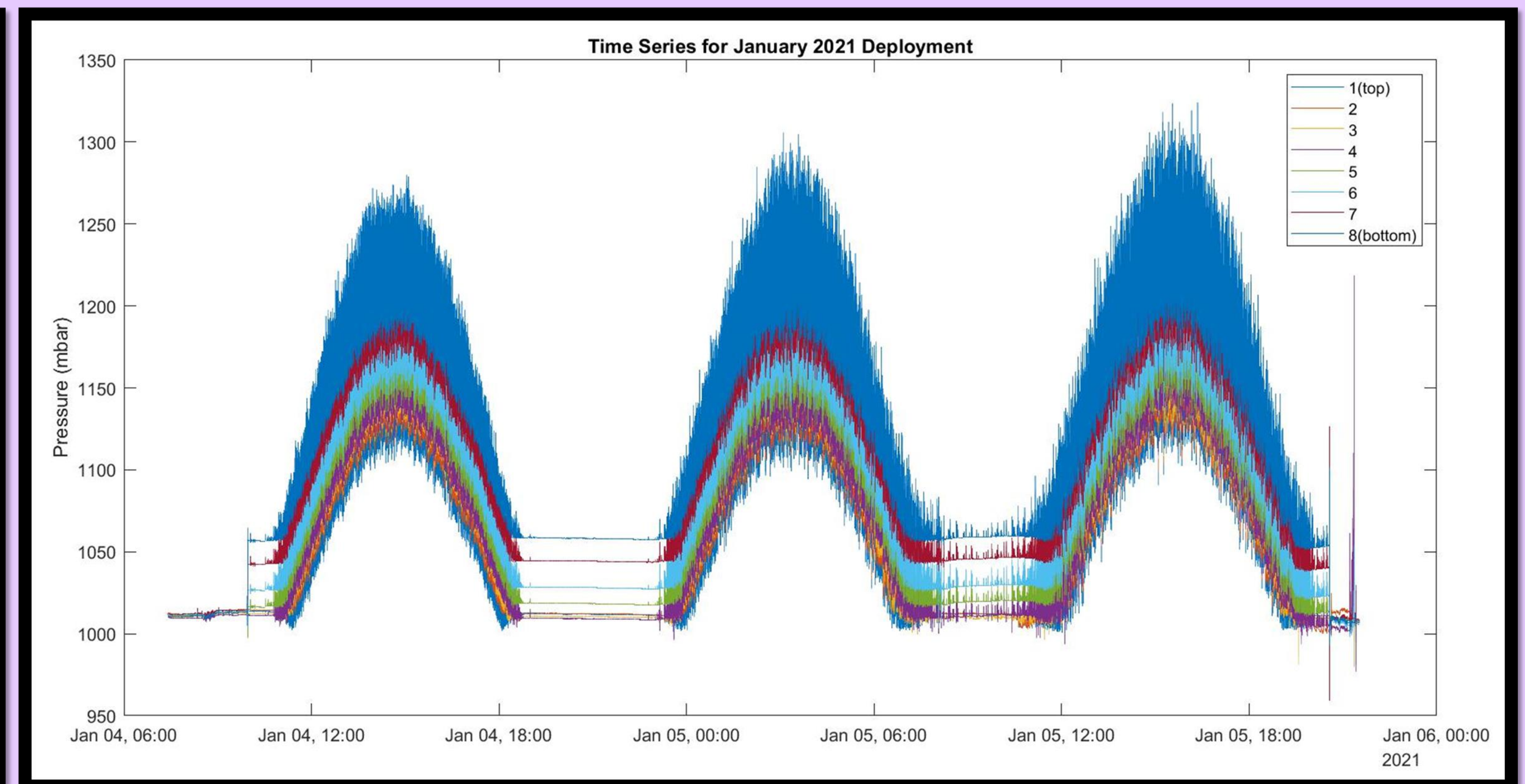
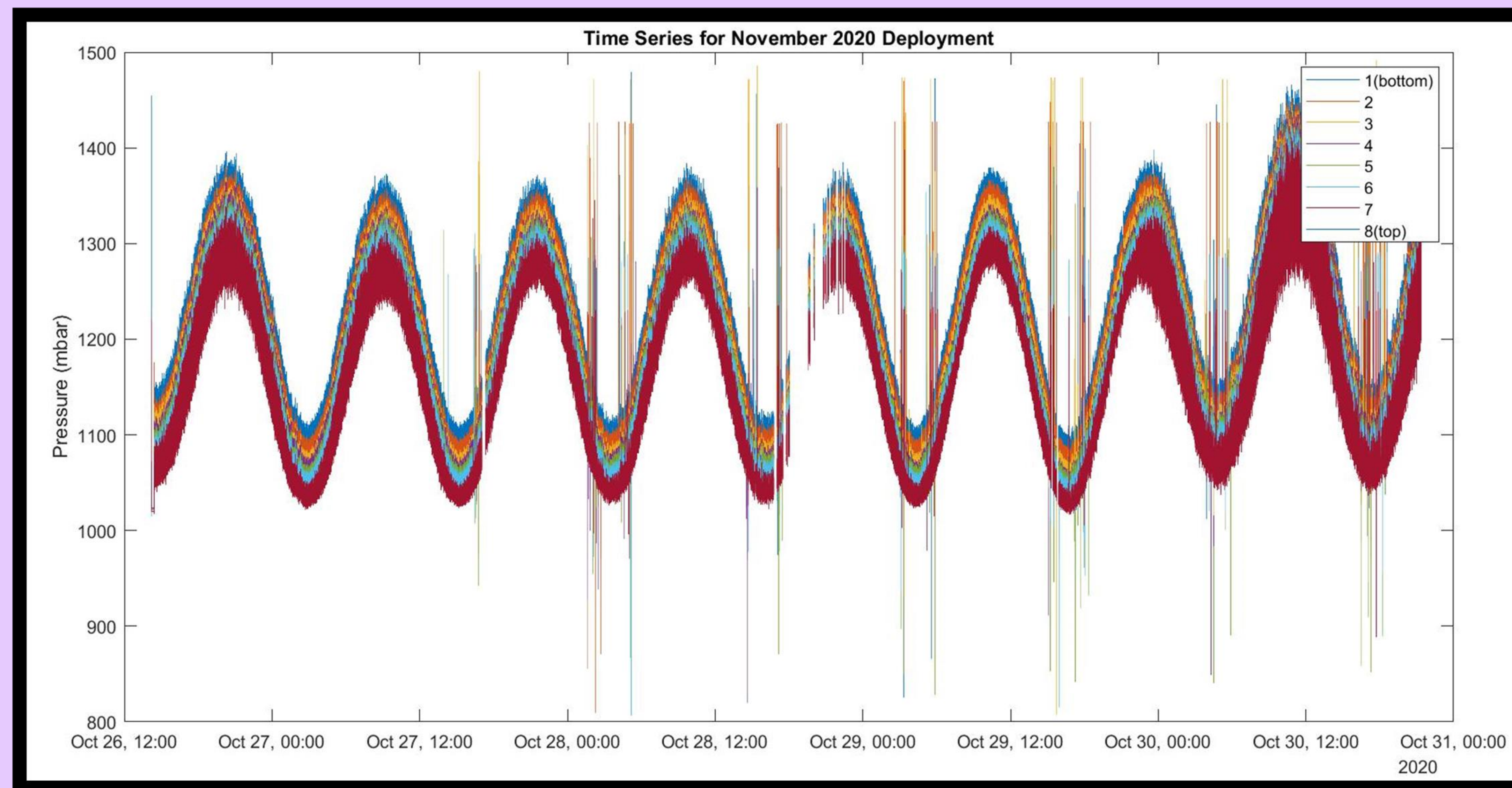
Future Work

- Redeploy Pressure Stick and PMM at an overwash site
- Resolving where the sediment bed is located
- Pressure Stick version 2.0 – more sensors, more battery power

References

- Sarni, Angela., 2020. Measurement of Dynamic Pressure Gradients on the Surface of Short Cylinders. University of New Hampshire.
- Wen, F., Wang, J.-H., Chen, J.-J., 2018. Qualitative Estimation of Momentary Liquefaction in a Sandy Seabed Based on Pore Water Pressure. International Journal of Offshore and Polar Engineering 28, 303–311.. doi:10.17736/ijope.2018.cl07

Some Extras

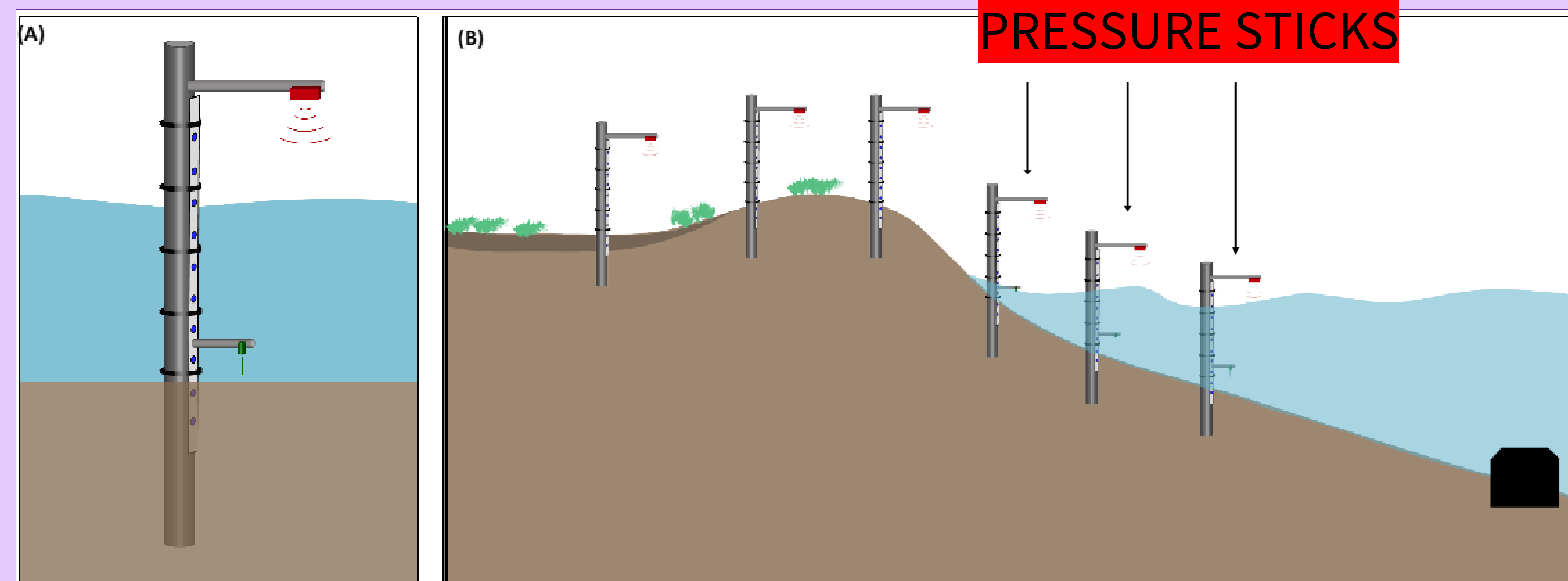


Connection to NHSeaGrant:

Diane Foster's Overwash Project

Plan to deploy instrument sticks measuring wave pressure and velocity to help understand the role of dune overtopping and sediment overwash in coastal areas.

The Pressure Stick can be used for this!



Some More Extras

- Animation showing the role of dynamic surface pressure on the PMM
- The circles on the PMM represent each pressure sensor and their size/color changes according to the value of the pressure
- Bigger circles \rightarrow greater magnitude
- Warmer colors \rightarrow positive pressure
- Cooler colors \rightarrow negative pressure

