A semi-automated process to identify turbidity currents within the Cascadia Subduction Zone in Barkley Canyon

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INTRODUCTION

WORKING ASSUMPTION: Seismic hazard estimates for the Cascadia Subduction zone are based primarily on moment rates determined from geologic observations, including turbidites identified within offshore sediment cores. This **assumes that submarine landslides and turbidity currents are triggered by strong shaking from large local earthquakes. However, there are few quantitative estimates on what level of shaking remobilizes sediment, and no direct observations of shaking-generated turbidity currents in Cascadia, limiting our ability to constrain magnitude and source properties**. This affects the current method of interpreting sediment records to estimate seismic hazards (Talling, 2021; Walton et al., 2021).

QUESTION: Using cabled arrays with colocated seismic and oceanographic sensors, can we identify causative links between small to moderate regional shaking, and turbidity currents in Cascadia?

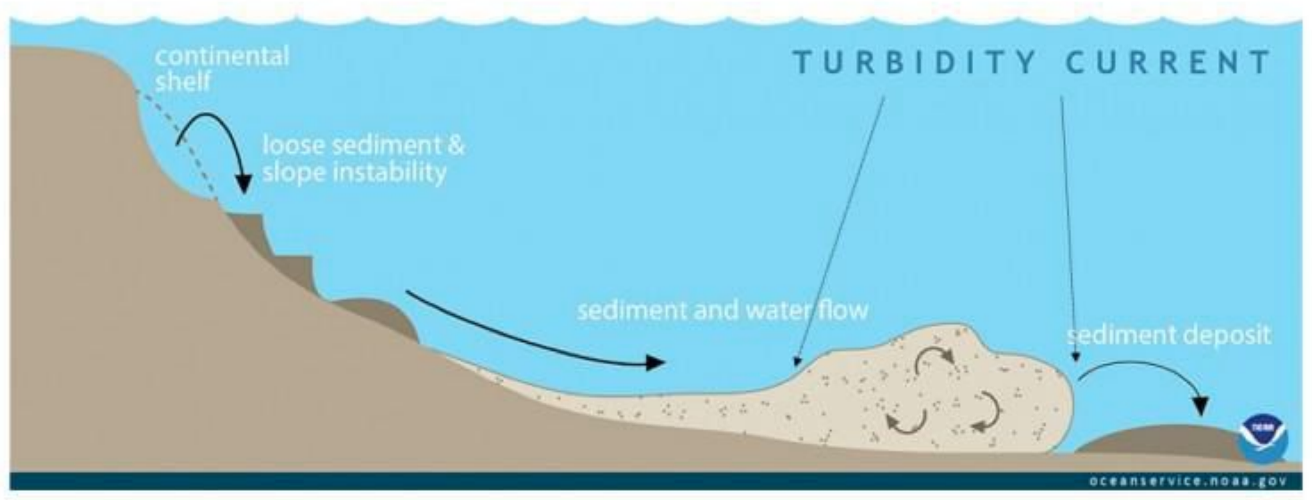
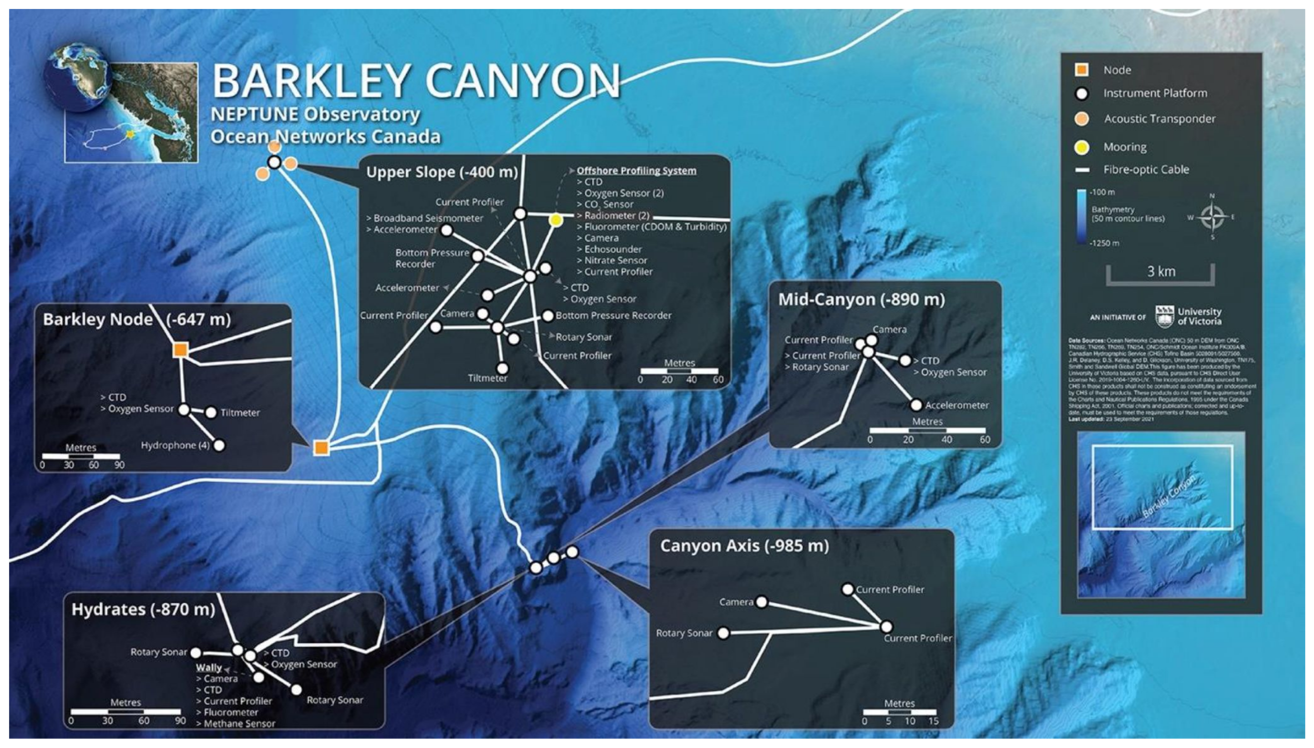
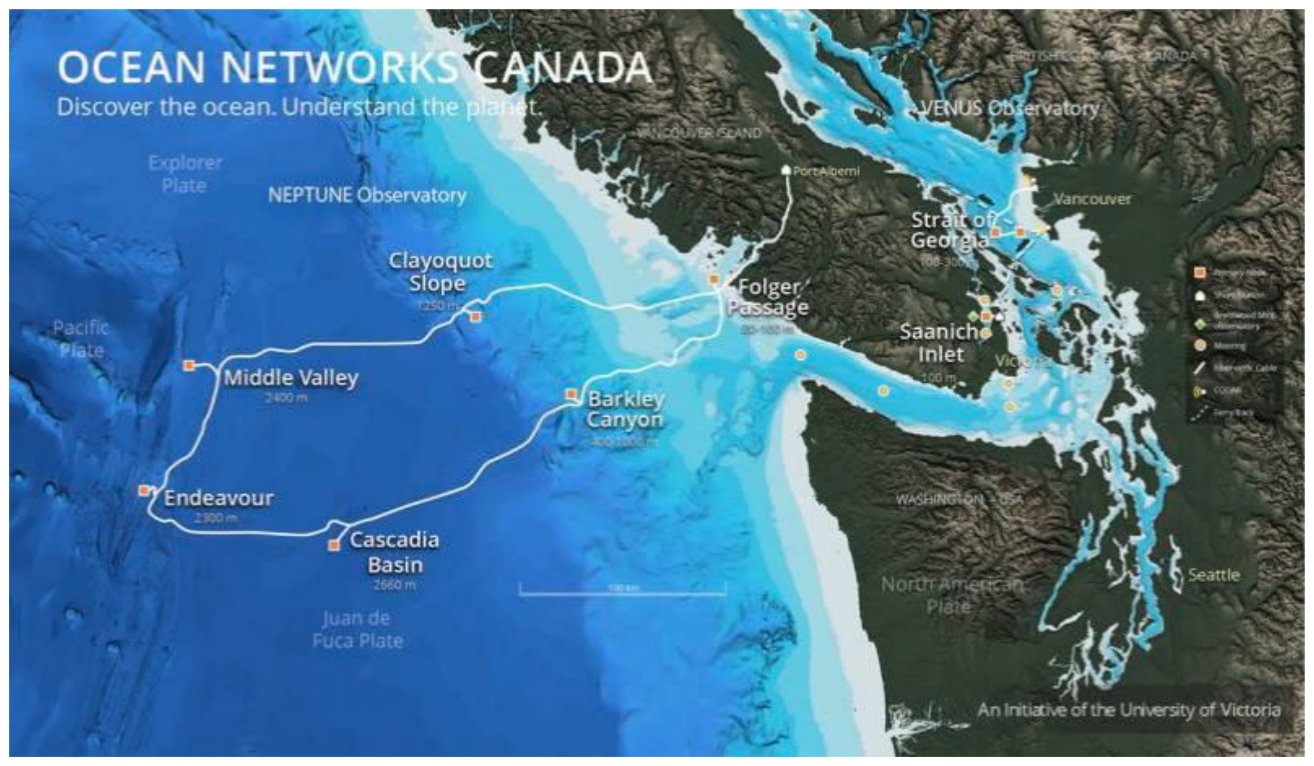
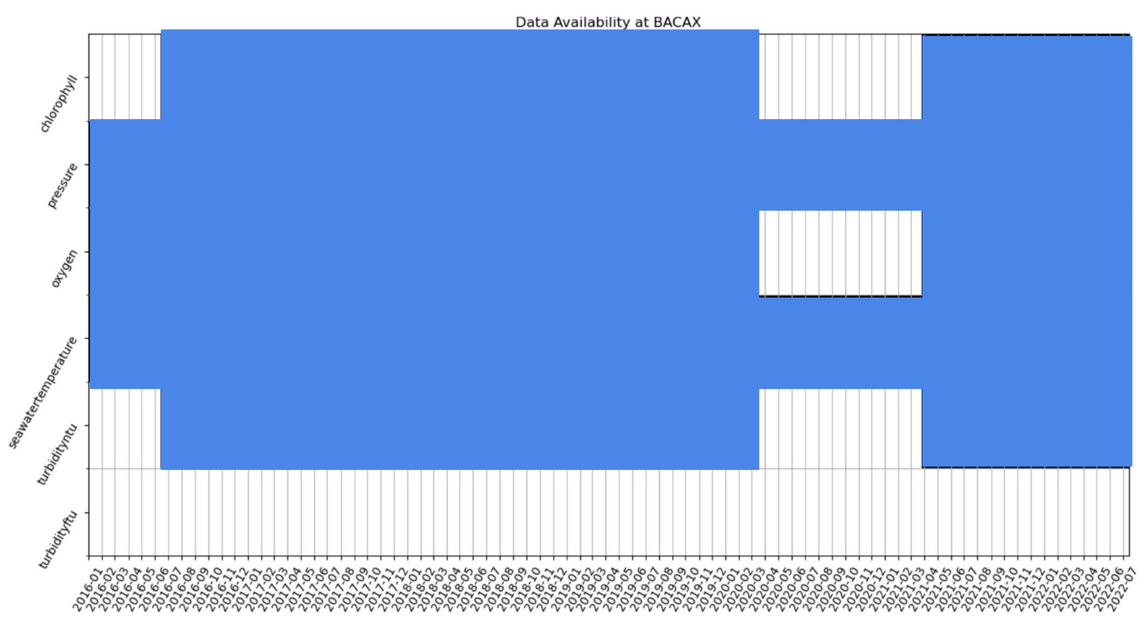


Figure. Depiction of the temporal progression of a turbidity current. Image from: https://www.washington.edu/news/2017/06/27/distant-earthquakes-can-cause-underwaterlandslides/

DATA: Ocean Networks Canada



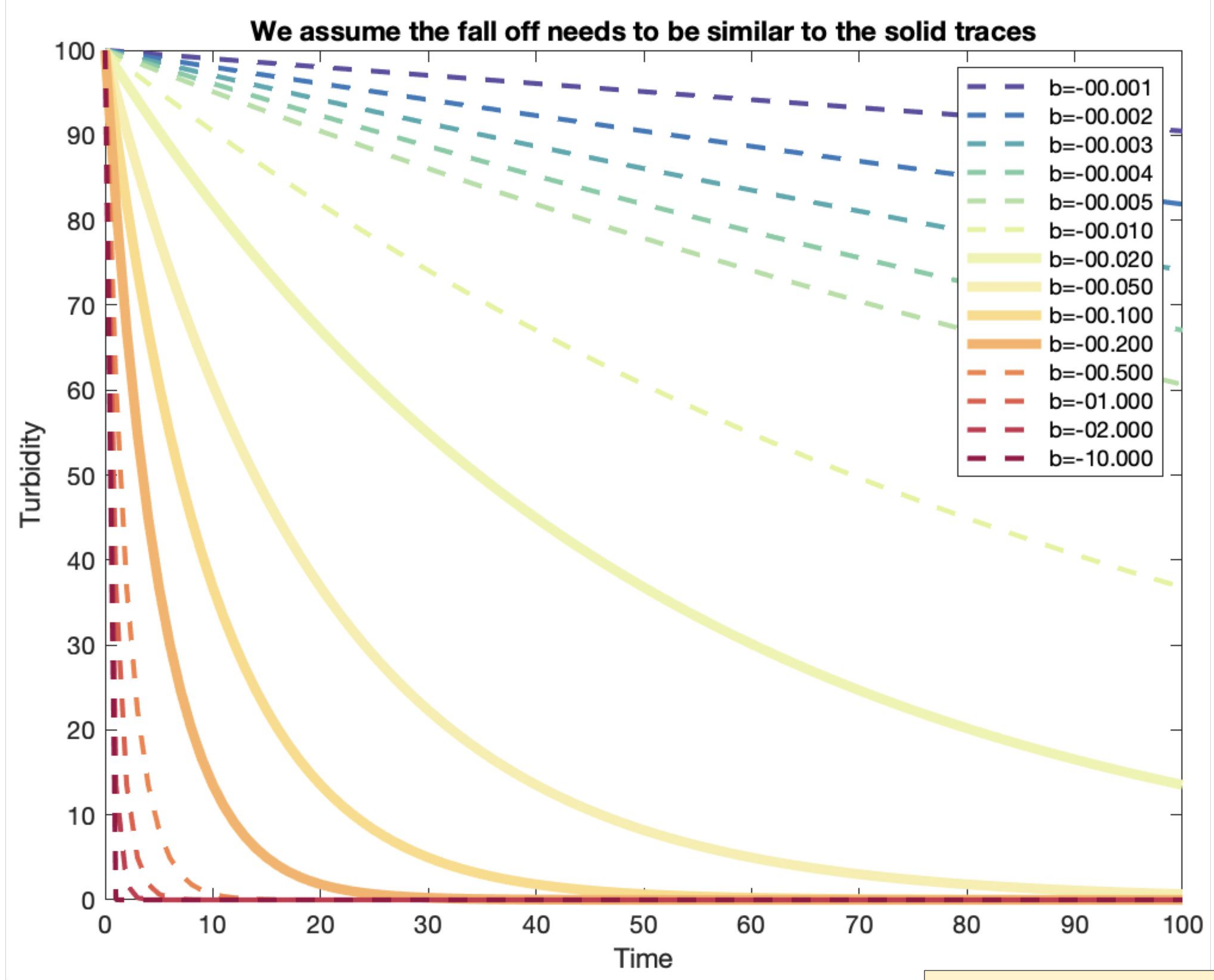




Ideally we would like to explore time periods that contain multiple data types.

METHOD

To assess correlations between strong shaking from earthquakes and turbidity currents requires a robust turbidity catalog. Here, we **explore ways to semi-automatically create turbidity catalogs.** We find that the identification of turbidite signals is much easier than identification of seismic waves (P-wave and S-waves) and requires minimal tools.



Step 1. Identify when signal is above the noise floor (trigger)
- ➢ De-spike the data using a moving median
- ➢ STA/LTA (1 min/3 min)
- ➢ Triggering threshold = mean + 2•sigma (each month)
- ➢ Trigger off when STA/LTA ratio drops below 0.5

Step 2. Require exponential decay signature
- ➢ For each trigger, identify time of the maximum value within 50 time steps after initial trigger
- ➢ If max occurs at index 40-50, reject. Otherwise, if max is at or above mean +2•sigma continue.
- ➢ Fit an exponential decay to 50 time steps, starting with the max value, forcing the 'a' and 'b' values to be max(y) and - 1, respectively
- ➢ Keep triggers with -0.2 < b < -0.02 (see above figure)

Step 3. Human review of identified signals

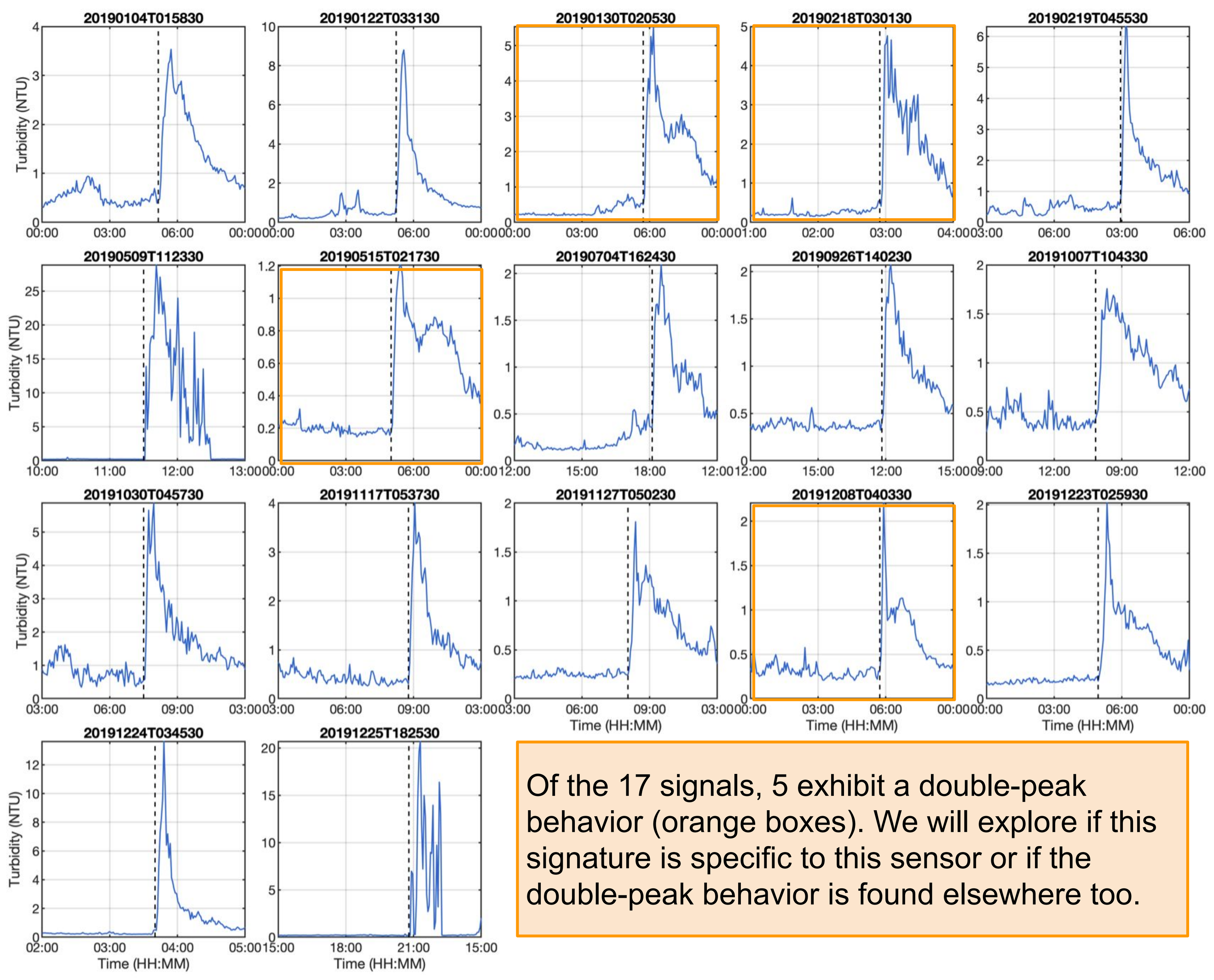
2019 Data

Step 1 ~14,000 triggers

Step 2 39 triggers

Step 3 17 triggers

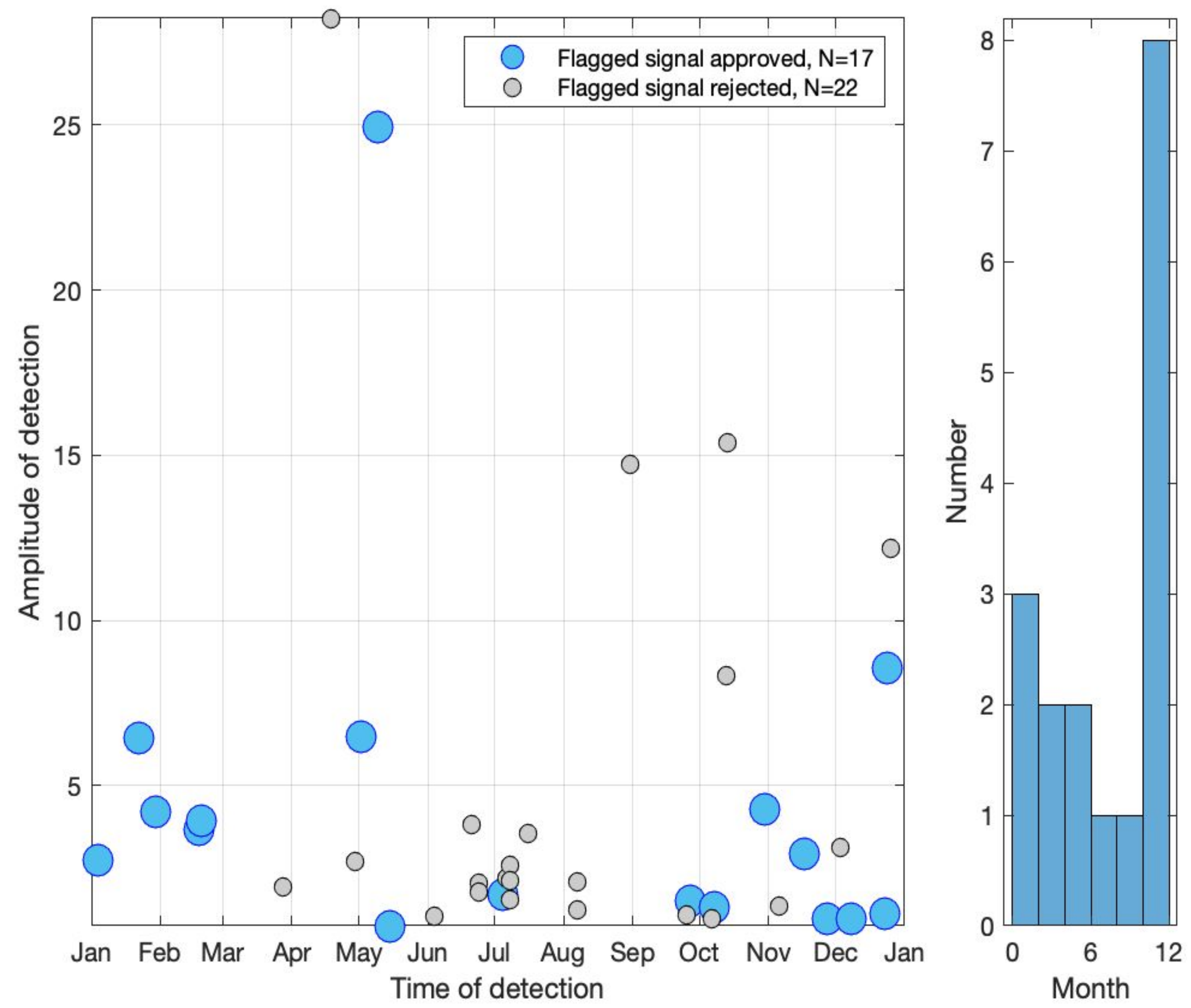
RESULTS: BACAX 2019 data, 17 signals identified



Of the 17 signals, 5 exhibit a double-peak behavior (orange boxes). We will explore if this signature is specific to this sensor or if the double-peak behavior is found elsewhere too.

Our simple detection method is **successful at identifying turbidity signals** within the continuous data stream from station BACAX.

SEASONAL OBSERVATIONS



The 2019 data indicate that **turbidity currents are more prevalent in the winter months (October - February).**

TAKE HOME

- ➢ Our very basic method that uses STA/LTA to first identify signals above the noise floor, and then requires an exponential fall off signature in the data is successful at reducing the number of triggers from ~14000 to 39. A final human review of the signals reduces the number of identified turbidity signals to 17.
- ➢ At station BACAX we find 5 out of the 17 signals have a double-peak behavior.
- ➢ Initial work suggests a seasonal effect in that more turbidity activity is found in the months October through February. This seasonal effect should be accounted for when assessing correlations between large regional and local earthquakes and turbidity behavior.
- ➢ At shallower depths (<400 meters, Upper Slope), seasonality is clearly attributed to sediment resuspension by more frequent storms during late-fall/winter months (Arjona-Camas et al 2022). But here at 1000 it may be triggered by intense downwelling processing transporting down sediments and organic matter (Thomsen et al 2017).

Next Steps

- ➢ Our method successfully identified turbidity currents that are above the noise floor, however it is possible that additional turbidity currents exist within these data that have not yet been identified.
- ➢ To construct a more robust catalog we use the identified turbidity currents as templates in a the "eqcorrscan" template matching codes to search for additional signals.
- ➢ After construction of a fuller turbidity catalog we can
  - ○ Determine if other data types have distinctive features (see plot below)
  - ○ Assess if there is any correlation between large local, regional or global earthquakes and the turbidity signals.
- ➢ In initial tests we look for immediate triggering, but delayed triggering will also be explored.