Summarizing long-term changes in daily echogram patterns observed by moored echosounders in the U.S. Ocean Observatories Initiative network

Wu-Jung Lee[1] and Valentina Staneva[2]

[1]Applied Physics Laboratory and [2]eScience Institute, University of Washington

Funding:

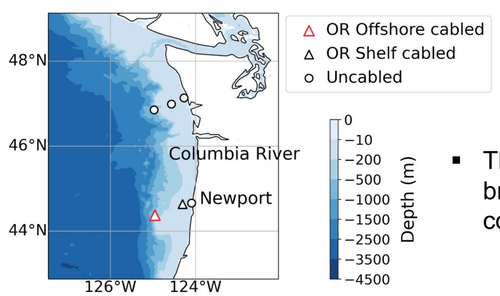
Lee & Staneva. 2020. Compact representation of temporal processes in echosounder time series via matrix decomposition. J. Acoust. Soc. Am. 148: 3429

1. Summary

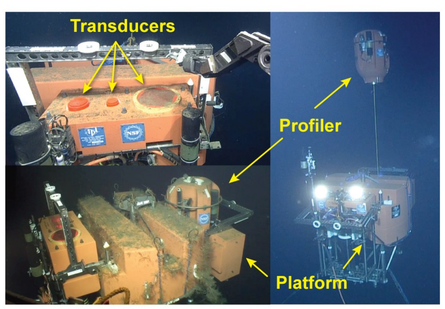
- **Context:** Recent explosion in the availability of echosounder data from diverse ocean platforms has created unprecedented opportunities to study marine ecosystems at broad scales
- **Challenge:** lack of computational methods to automatically discover and summarize prominent spatial-temporal echogram structures
- **Approach:** We use the long-term data collected by an OOI cabled echosounders as testbed to develop a data-driven methodology that builds compact representation of long-term echosounder time series using intrinsic features in the data
- **Outcome:** The compact representation provides biological information that is more tractable and interpretable than the original data, and is suitable for visualization and systematic analysis with other ocean variables
- **Significance:** This work forms the basis for constructing robust time series analytics for large-scale, acoustics-based biological observation in the ocean

2. Data source and location

- We used data collected by an upward-looking cabled echosounder mounted on the mid-water platform (200 m) of the Oregon Offshore Cabled Shallow Profiler Mooring (CE04OSPS)

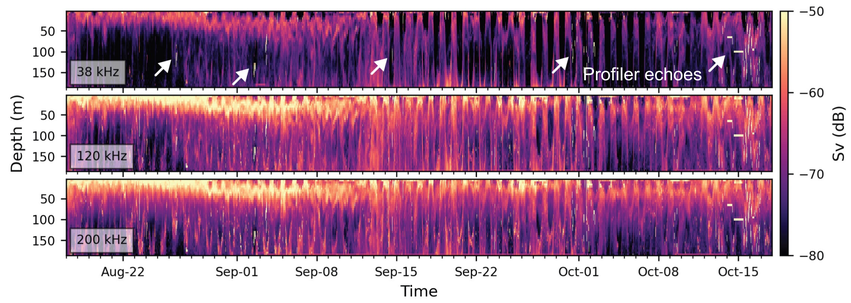


- The site is at the shelf break with a full water column depth of 580 m



- The echosounder contains 3 transducers transmitting at 38 kHz, 120 kHz, and 200 kHz

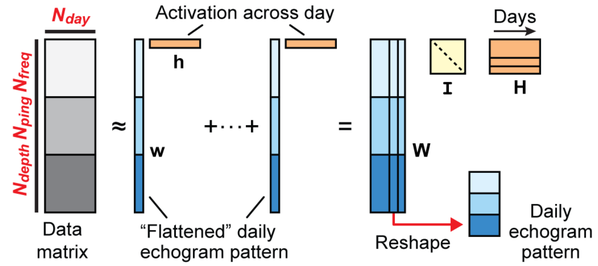
3. Echosounder data



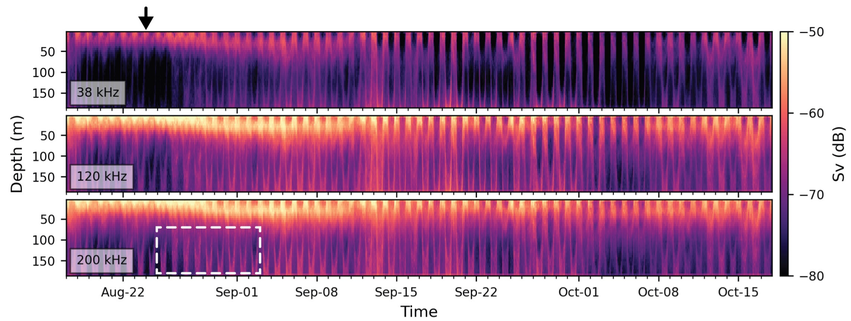
- The echogram contains multiple distinct patterns with varying strengths across the 2-month period and the 3 observation frequencies
- Echoes from the water column profiler collocated on the mid-water platform are noisy outliers needing removal

4. Methodology: matrix decomposition

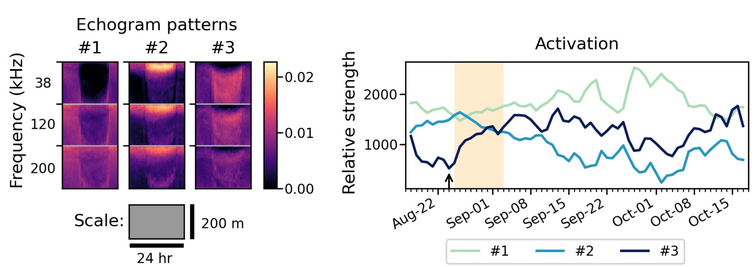
- We developed a two-stage approach:
  - Principal Component Pursuit (**PCP**) removes noisy outliers
  - Temporally smooth Nonnegative Matrix Factorization (**tsNMF**) discovers a small number of distinct daily echogram patterns, whose time-varying linear combination (activation) reconstructs the data



5. Decomposition results

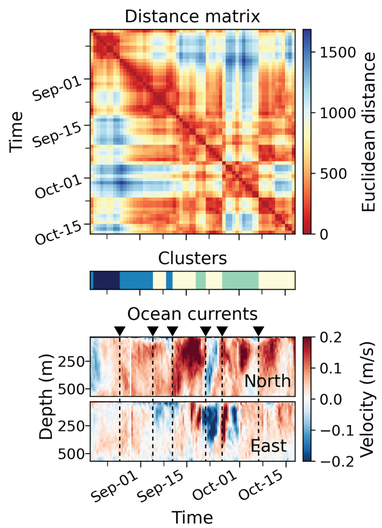


- PCP automatically removes noisy outliers from the data but retains high-level echogram structures



- tsNMF discovers biologically interpretable daily echogram patterns that are low-dimensional quantitative descriptors of the originally high-dimensional echogram

6. Temporal changes of echogram structure



- Temporal processes illuminated by the tsNMF component activations highlight echogram structural changes across the observation period
- Echogram temporal changes appear correlated with changes of direction and magnitude of ocean current

7. Outlook

- Compact representation derived from our methodology allows joint analysis with other ocean variables
- This unsupervised machine learning approach is well-suited for extracting information from data collected from unfamiliar or rapidly changing ecosystems