## iLOVE: integrating Long-term Observation & Virtual Evaluation

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Deep Learning (DL) helps identifying patterns, interactions and trends among biological communities – an important asset to discern temporal dynamics across ecological and environmental gradients.

Project iLOVE, funded by the AWI DataHub program, will establish a comprehensive analytic framework tailored to heterogeneous, multiannual data; based on data from the FRAM Observatory. This ecological timeseries continuously records biodiversity and their environmental drivers in Fram Strait, the major gateway between the Arctic and Atlantic Oceans. Specifically, iLOVE will apply the following modules to bacterial sequence data and contextual abiotic parameters:

**Analytical Modules:** Co-Occurrence Networks (discerning ecological interactions via bacterial amplicons and metagenomes); Convergent Cross Mapping (empiric dynamic modeling to understand causal relationships); Energy Landscape Algorithm (identifying stable states and transitions within the ecological landscape);

**DL Modules:** Graph-based Neural Networks (capturing complex relationships); Variational Autoencoders (generative models for feature extraction and representation), and Transformers (sequential dependencies).

The resulting, complementary findings on ecological dynamics, network relationships and temporal changes will be integrated with e.g. zooplankton imaging data to identify temporal connectivity across trophic levels. These insights into ecosystem functioning are essential to assess the current and future Arctic Ocean.

iLOVE will deliver (i) a Python package to allow application of the analytic framework to any time-series dataset; and (ii) an easily accessible Web interface to visualize trends in time-series data. iLOVE closely cooperates with related Helmholtz projects; developing DL methods for deep-sea monitoring (MANIDE) and promoting data interoperability across Helmholtz and beyond (HARMONise). By applying the outcomes to ongoing AWI and GEOMAR collaborations, we foster quantitative time-series analyses across Helmholtz; with a strong emphasis on FAIR science.

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