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Augmenting the sensor network around Helgoland using unsupervised machine learning methods

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A sensor network surrounds the island of Helgoland, supplying marine data centers with autonomous measurements of variables such as temperature, salinity, chlorophyll and oxygen saturation. The output is a data collection containing information about the complicated conditions around Helgoland, lying at the edge between coastal area and open sea. Spatio-temporal phenomena, such as passing river plumes and pollutant influx through flood events can be found in this data set. Through the data provided by the existing measurement network, these events can be detected and investigated.

Because of its important role in understanding the transition between coastal and sea conditions, plans are made to augment the sensor network around Helgoland with another underwater sensor station, an Underwater Node (UWN). The new node is supposed to optimally complement the existing sensor network. Therefore, it makes sense to place it in an area that is not yet represented well by other sensors. The exact spatial and temporal extent of the area of representativity around a sensor is hard to determine, but is assumed to have similar statistical conditions as the sensor measures. This is difficult to specify in the complex system around Helgoland and might change with both, space and time.

Using an unsupervised machine learning approach, I determine areas of representativity around Helgoland with the goal of finding an ideal placement for a new sensor node. The areas of representativity are identified by clustering a dataset containing time series of the existing sensor network and complementary model data for a period of several years. The computed areas of representativity are compared to the existing sensor placements to decide where to deploy the additional UWN to achieve a good coverage for further investigations on spatio-temporal phenomena.

A challenge that occurs during the clustering analysis is to determine whether the spatial areas of representativity remain stable enough over time to base the decision of long-term sensor placement on its results. I compare results across different periods of time and investigate how fast areas of representativity change spatially with time and if there are areas that remain stable over the course of several years. This also allows insights on the occurrence and behavior of spatio-temporal events around Helgoland in the long-term.

Whether spatial areas of representativity remain stable enough temporally to be taken into account for augmenting sensor networks, influences future network design decisions. This way, the extended sensor network can capture a greater variety of the spatio-temporal phenomena around Helgoland, as well as allow an overview on the long-term behavior of the marine system.