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The limitations of in situ data for validating satellite-derived spatio-temporal ocean products.

Rory Scarrott, Fiona Cawkwell, Mark Jessopp, and Caroline Cusack
Department of Geography, University College Cork, Environmental Research Institute, Beaufort Building, Ringaskiddy, County Cork, Ireland

The Ocean-surface Heterogeneity MApping (OHMA) algorithm is an objective, replicable approach to map the spatio-temporal heterogeneity of ocean surface waters. It is used to processes hypertemporal, satellite-derived data and produces a single-image surface heterogeneity (SH) dataset for the selected parameter of interest. The product separates regions of dissimilar temporal characteristics. Data validation is challenging because it requires In-situ observations at spatial and temporal resolutions comparable to the hyper-temporal inputs. Validating this spatio-temporal product highlighted the need to optimise existing vessel-based data collection efforts, to maximise exploitation of the rapidly-growing hyper-temporal data resource.

For this study, the SH was created using hyper-temporal 1km resolution satellite derived Sea Surface Temperature (SST) data acquired in 2011. Underway ship observations of near surface temperature collected on multiple scientific surveys off the Irish coast in 2011 were used to validate the results. The most suitable underway ship SST data were identified in ocean areas sampled multiple times and with representative measurements across all seasons.

A 3-stage bias reduction approach was applied to identify suitable ocean areas. The first bias reduction addressed temporal bias, i.e., the temporal spread of available In-situ ship transect data across each satellite image pixel. Only pixels for which In-situ data were obtained at least once in each season were selected; resulting in 14 SH image pixels deemed suitable out of a total of 3,677 SH image pixels with available In-situ data. The second bias reduction addressed spatial bias, to reduce the influence of over-sampled areas in an image pixel with a sub-pixel approach. Statistical dispersion measures and statistical shape measures were calculated for each of the sets of sub-pixel values. This gave heterogeneity estimates for each cruise transit of a pixel area. The third bias reduction addressed bias of temporally oversampled seasons. For each transit-derived heterogeneity measure, the values within each season were averaged, before the annual average value was derived across all four seasons in 2011.

Significant associations were identified between satellite SST-derived SH values, and In-situ heterogeneity measures related to shape; absolute skewness (Spearman's Rank, $n=14$, $\rho[12]= +0.5755$, $P<0.05$), and kurtosis (Spearman's Rank, $n=14$, $\rho[12] = 0.5446$, $P < 0.05$). These are a consequence of (i) locally-extreme measurements, and/or (ii) increased presence of sharp transitions detected spatially by In-situ data. However, the number and location of suitable In-situ validation sites precluded a robust validation of the SH dataset (14 pixels located in Irish waters, for a dataset spanning the North Atlantic). This requires more targeted data. The approach would have benefited from more samples over the winter season, which would have enabled more offshore validation sites to be incorporated into the analysis. This is a challenge that faces satellite product developers, who want to deliver spatio-temporal information to new markets. There is a significant opportunity for dedicated, transit-measured (e.g. Ferry box data), validation sites to be established. These could potentially synergise with key nodes in global shipping routes to maximise data collected by vessels of opportunity, and ensure consistent data are collected over the same area at regular intervals.