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Observation-only learning of 4DVarNet neural schemes for the reconstruction of sea surface turbidity dynamics from gappy satellite images

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Optical remote sensing is increasingly used to assess various sea surface biogeochemical parameters (e.g., Chl-a, turbidity). If today's systems offer better spatiotemporal coverage, the space-time sampling depends on both the satellite orbit and the cloud cover. The resulting sea surface observations generally present large proportions of missing data, making their completion challenging.

Here, we explore neural interpolation schemes as an approach for image gap filling, and their training from observation-only datasets with large missing data rates (with a mean of 65% of missing data and up to 100% for the worst days of the time-series), i.e., when no reference gap-free data are available to run a classic supervised learning approach. We propose and assess different strategies based on real or simulated missing data patterns to discard parts of the available data for learning. We combine these learning strategies with 4DVarNet schemes, which are state-of-the-art neural interpolation schemes backed on a variational data assimilation formulation. The approach was tested in a turbidity reconstruction context, using a multi-modal satellite dataset (CMEMS product: `oceancolour_med_bgc_l3_my_009_143`) at 1 km spatial resolution with daily images from year 2019 to 2021, off the French coast in the western Mediterranean Sea.

Our learned variational algorithm significantly outperforms state-of-the-art interpolation techniques, including optimal interpolation and DINEOF, with a 37% gain in RMSE reached in preliminary tests.