Partial-convolution-implemented generative adversarial network (GAN) for global oceanic data assimilation

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The oceanic data assimilation (DA) system, which interpolates the sparse observations to regular grids based on physical knowledge implemented in a numerical model, is indispensable to understand and forecast the global oceanic climate variabilities. Here we developed a deep-learning-based global oceanic DA system－DeepDA－by incorporating a partial convolutional neural network and a generative adversarial network (GAN). The partial convolution acts as an observation operator that projects the irregular observational information on gridded fields, and the GAN model brings in the observational information from previous time frames. Observing system simulation experiments showed that the analysis error in the DeepDA-produced three-dimensional temperature is systematically reduced compared to both the background and observed values. The DeepDA global temperature reanalysis for 1980-2020 successfully reconstructed the observed global climatological fields, seasonal cycle, and the dominant oceanic temperature variabilities. The DeepDA, which was formulated solely with a long-term control simulation, successfully lowers the technical barrier in obtaining global ocean reanalysis datasets using physical constraints in various numerical models, and thus, reduces the systematic uncertainties in estimating decades of global oceanic states using these models.

Key words: Oceanic data assimilation, deep learning, partial convolution, GAN, ocean reanalysis