The situation

Spatial interpolation of in situ and remote-sensing observations has been performed for decades in oceanography, with several applications:

- Simple visualisation
- Initialisation of numerical models
- Quality control of observations

We will present 3 tools designed for the interpolation of oceanographic data.

The problems

Observing the ocean is complex:
- Variety of processes and spatial scales
- Always changing conditions
- Presence of clouds that prevents satellite observations

Oceanographic data interpolation is complex:
- Uneven data coverage
- Large amount of data to process
- Presence of physical boundaries (coastlines, land)

We will show results of the three methods: DINEOF, DIVAnd and DINCAE.

1. The situation

2. The problems

3. Tool I: DINEOF

   **Method**
   - Empirical Orthogonal Function (EOF) based approach to fill in missing data from geophysical fields, typically because of the presence of clouds.

   **Applications**
   - Sea surface temperature (SST), sea surface salinity (SSS), chlorophyll concentration or suspended particulate matter (SPM)

   **New developments**
   - Detection and removal of cloud shadows in high-resolution images.
   - Combination of data from sensors with different spatial and temporal resolutions, for instance Sentinel-2, Sentinel-3 and SEVIRI.

4. Tool II: DIVAnd

   **Objective**
   - Generation of a gridded field using in situ measurements, in an arbitrary high dimensional space.

   **Method**
   - Minimisation of a cost function that takes into account the proximity to the observations, the smoothness of the interpolated field and the presence of coastlines.

   **Applications**
   - Chemistry interpolated maps
   - Climatologies

5. Tool III: DINCAE

   **Objective**
   - Reconstruction of the missing data based on the available cloud-free pixels in satellite images.

   **Method**
   - Neural network with the structure of a convolutional autoencoder.

   **Required a method to handle missing data (or data with variable accuracy) in the training phase.**

   The neural network is trained by maximizing the likelihood of the observed value.

   **Application**
   - Reconstruction of 25-year time-series of Advanced Very High Resolution Radiometer (AVHRR) SST data.

   **Results**
   - The reconstruction is obtained employing cross-validation and in situ observations from the World Ocean Database.
   - DINCAE results have lower error, while showing higher variability than the DINEOF reconstruction.

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4 T Tool II: DIVAnd

New developments

- Biological: interpolation of presence/absence data with DIVAnd coupled with a neural network.

- Physics: interpolation of sea surface velocity as measured by high-frequency radar.

- Biology: interpolation of abundance data for different species.

6. Code and publications

All the software tools are open source and the codes available on GitHub:

- [DINEOF](https://github.com/gher-ulg/DINEOF) (Python, Julia)
- [DIVAnd](https://github.com/gher-ulg/DIVAnd) (Fortran)
- [DINCAE](https://github.com/gher-ulg/DINCAE) (Julia)

**Publications**


7. About the authors

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