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DOWNSCALING OF OCEAN FIELDS BY FUSION OF HETEROGENEOUS OBSERVATIONS USING DEEP LEARNING ALGORITHMS

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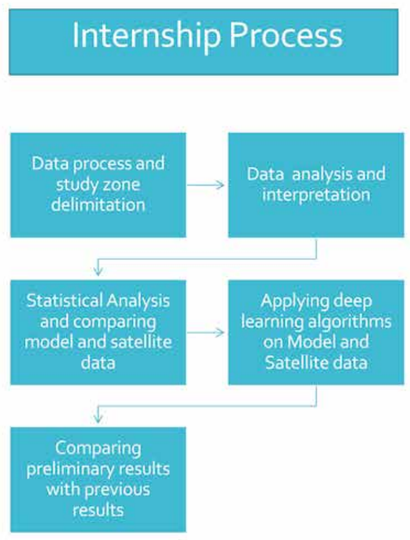
Abstract

The internship's prime focus is to exploit Deep learning algorithms to increase low resolution satellite data fields by merging them with high resolution data. Previous studies have been made on simulated ocean data in the Gulf Stream region given by the NATL60 model outputs and there have been successful results in increasing the accuracy of sea surface ocean currents

The main idea is to employ the same methods using satellite data this time provided by the Copernicus Climate Change Service to test the their viability. To have a coherent comparison, the study is being carried on the same region choosing the same temporal scale (one year). The resolution of the simulated data has been brought down to that of the satellite data as well to allow a correct analysis since the same phenomena is not always taken into consideration when the order of magnitude changes.

Internship Process



Data description

Satellite

- Merged satellite data provided by the Copernicus Marine Environment Monitoring Service
- We used the Sea Surface Height, Sea Surface Temperature and the horizontal velocity field (U,V)
- The velocity fields are derived from the Sea Surface Height (SSH), the Sea Surface Temperature (SST) was produced by running the Operational Sea Surface Ice Analysis

Model

- Simulated data provided by the output of NATL60 high resolution ocean model
- Similarly we used the Sea Surface Height (SSH), Sea Surface Temperature (SST) and the horizontal velocity field (U,V)
- The atmospheric forcing was issued from the ERA-interim reanalysis provided by the MERCATOR institute

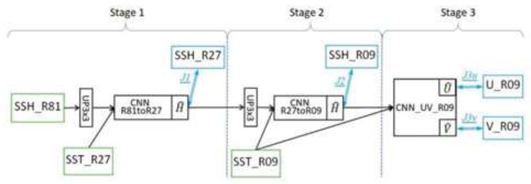
Resolution and Temporal Scale

- The resolution of both satellite and Model data has been adjusted to 0,25x0,25 degrees for all variables with a spatial coverage of (26°N, 45°N, 40°W, 65°W) the temporal scale is of one year spanning from October 2012 to September 2013 for both datasets as well

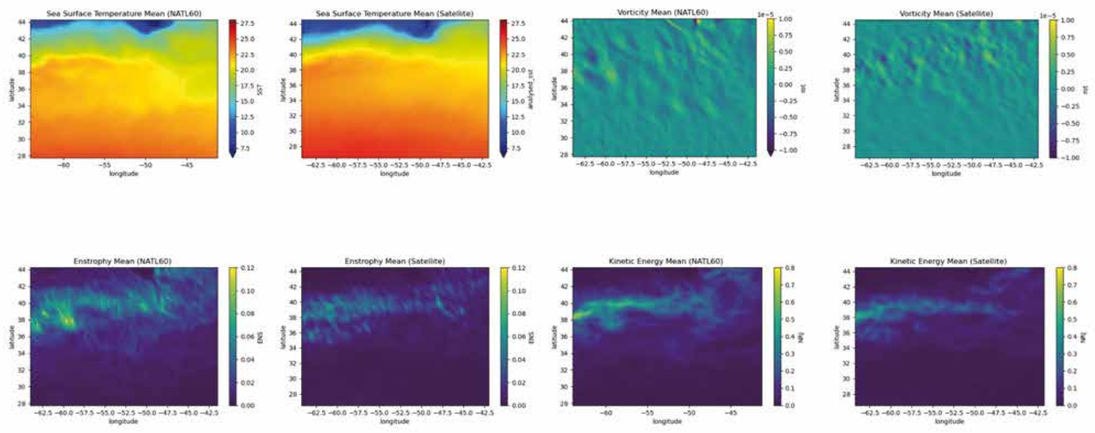
Methodology

- The principle of the methodology : Improving the resolution of the ocean current field given by low resolution satellite altimeters observations with high resolution Sea surface temperature data
- The scheme below represent the architecture used which is similar to RESAC Neural Network (1) , the inputs are in green while the desired outputs are in blue, the data resolution used is that of the satellite unlike in NATL60 simulated data used in RESAC (check the table below)
- Our data of 366 images is divided into 3 sets : learning set (256 images), validation set and test set (55 images) each
- The four cost functions are J1, J2, J3u, J3v. UP3x3 stands for the UPsampling procedure that increases the input size by a factor 3X3 in order to reach the higher resolution of the next image.
- $\hat{H}$ is the estimated SSH at R27 and R09 respectively, $\hat{U}$ and $\hat{V}$ are the estimated current values.

Data or grid	Pixel coverage (1/100 deg.)	Resolution km at equator
NATL60	1.3 x 1.7	1.5 x 1.9
SST (sat)	5 x 5	5.6 x 5.6
R09	12.0 x 15.0	13 x 17
SSH, U, V (sat)	25 x 25	28 x 28
R27	36.1 x 45.1	40 x 50
R81	108.2 x 135.3	120 x 150



Data visualization & Comparison



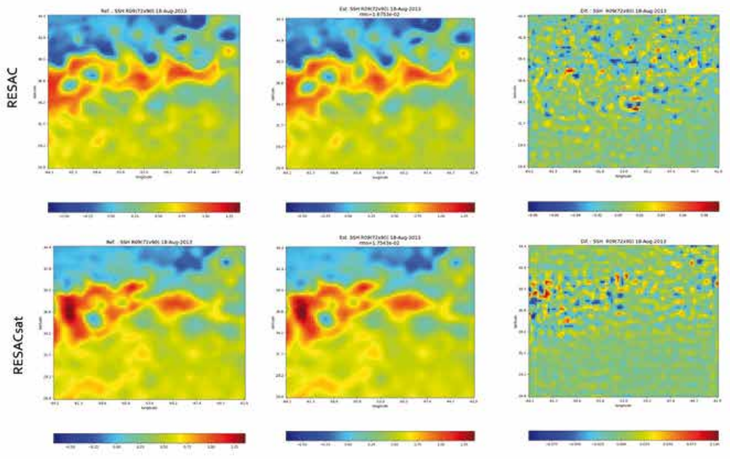
RESAC (RESACsat) are Deep Learning Architecture learned with NATL60 (resp :Satellite Data)

RESAC and RESACsat results: Satellite vs NATL60

The comparison between the reconstituted Sea Surface Height for the RESAC and RESACsat at R09 resolution.

The simulated NATL60 data and the Satellite observations are plotted in the first and second rows respectively.

The first column represents the reference, the second one the estimated data, while the third column contains the difference between the two.

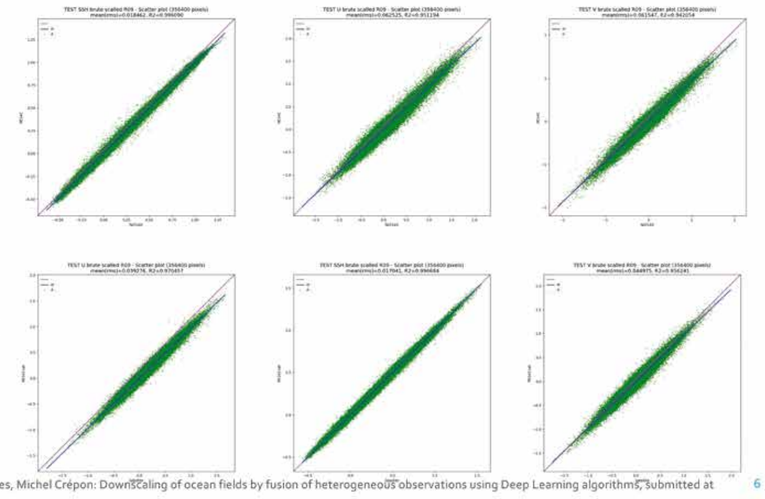


RESAC and RESACsat Satellite vs NATL60

The scatterplots of the SSH, U and V respectively from the left to the right for the test set.

We have in the first row the scatterplots for the three downscaled variables , NATL60 in x-axis versus RESAC in y-axis .

We have in the second row the scatterplots for the same variables, Satellite in x-axis versus RESACsat in y-axis.



(1)Sylvie Thiria , Charles Sorror , Carlos Mejia, Jean-Marc Molines, Michel Crépon: Downscaling of ocean fields by fusion of heterogeneous observations using Deep Learning algorithms, submitted at GMD (2021)