Manuscript title: Deep Learning for Super-Resolution of Mediterranean Sea Surface Temperature Fields
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REVIEWER #2

Reviewer: This study aims at reconstructing small scales SST from a low resolution SST field and provides a gap free L4 dataset resolving scales up to 5 km using deep learning algorithms. The super Resolution Convolution Network is learning using an ensemble of low resolution and high resolution SST images in the Mediterranean Sea. Results are shown for one snapshot and analyses are shown for cloud-free areas. Compared to the first guess at low resolution, the SST field has indeed been improved but this study needs further investigation and discussion of the results.

Response: The authors would like to thank the anonymous reviewer for their interest in reading our manuscript. We feel that the revised version of the manuscript is significantly enhanced as a result of the reviewer's feedback. Please find the detailed responses below with the reference to the modifications carried out in the re-submitted files (highlighted in yellow).

Reviewer: Comparison with other High resolution L4 products are required as the first guess is at very low resolution and does not reflect what is currently available (such as MUR product from JPL for example). Some SST products perform well when the cloud coverage is small but have a resolved spatial scale that varies a lot with the cloud cover. Comparison of the different SST products on a cloud-free event and on a cloudy day will show the potential of this new SST product much more homogeneous in time.

Response: First of all, thanks to the reviewer's comment, we realized that our objective and the super-resolution workflow within the CNR processing chain could be better introduced. In fact, CNR 1 km grid processing chain is based on a two step algorithm. The first step provides a low resolution field that is needed to obtain robust SST estimates below large cloudy areas, that is successively used as the background field for the application of a more local optimal interpolation algorithm. This background/first guess field is generally quite smooth even in cloud-free areas, and our objective is to improve its effective resolution and the intensity of the related gradients (it is thus an intermediate step in the processing chain). As such, the output of the network is not a new product itself, as clarified in Figure 1 of the revised version of the manuscript.
Then, we agree with the reviewer that it is quite useful and relevant to intercompare our original first-guess and the super-resolved one also with other products. Consequently, we performed a power spectral density analysis on different SST products available over the Mediterranean Sea (see Figure 9 and lines 278-291 of the revised version of the manuscript). The products used are the L4 NRT HR and the L4 NRT UHR provided by CNR for the Copernicus Marine Service, the GLOBAL OCEAN OSTIA product developed by the UK MET OFFICE, the Multi-scale Ultra-high Resolution (MUR) product provided by the NASA-JPL and the super-resolved SST field obtained by the application of the dADR-SR network developed in this work. We focus on cloudy areas and not on cloud-free events as this is where super-resolution is expected to provide an improvement.

Reviewer: From the snapshot with the SST gradient, One wonders if the method enables the reconstruction of smaller scales or is more of a gradient enhancement. It would be helpful to comment on that and illustrate if submesoscales are really generated in this SST reconstruction.

Response: The reviewer is absolutely right: this specific algorithm is mostly enhancing the gradients and it is in fact more conservative in the reconstruction of small scale features. Indeed, other methodologies (those based on Generative Adversarial Networks) have the potential to re-create small scale eddies/filaments which would be compatible with the learned features. However, single-image end-to-end approaches might not be the best choice to obtain accurate and dynamically consistent reconstructions (though surely looking quite "realistic"). Indeed, we are presently carrying out tests with GAN, but considering the time-frame and the amount of work still needed to get to (at least partly) conclusive results, those will necessarily need to be described in a successive paper.

Reviewer: The added value of this SST product is not clear from Table 1 and the spectrum figure (Fig.6). I would recommend adding other SST high resolution L4 products as discussed in point 4. Regarding the SSIM index, it may be interesting to also discuss the details of the decomposition between contrast / structures and luminance if the results prove to be relevant (the contrast and structure are expected to be much more improved than the luminance).

Response: As also explained above, to demonstrate how the super-resolved images reach an enhanced spatial resolution reconstructing SST fields under cloudy conditions, we performed a power spectral density analysis on different SST products available over the Mediterranean Sea. This is now fully documented in Figure 9 and lines 278-291 of the revised version of the manuscript. Given the fact that the SSIM index is not a common metric used in oceanography but it is mainly used in the computer vision field, we feel that is out of the goal of this paper to discuss the details of the single parts of this measure.

Reviewer: Finally, to really describe the effective resolution, the study of the ratio between the spectral content of the reconstructed data and the truth is more relevant than mere spectrum (as detailed in Ballarotta, et al 2019.). It should be included in a further analyses of this SST product to comment on the effective resolution of the SST product.

NB: Ballarota et al 2019: Ballarotta, M., Ubelmann, C., Pujol, M.-I., Taburet, G., Fournier, F., Legeais, J.-F., Faugère, Y., Delepoulle, A., Chelton, D., Dibarboure, G., and Picot, N.: On the resolutions of ocean altimetry maps, Ocean Sci., 15, 1091–1109, https://doi.org/10.5194/os-15-1091-2019, 2019.

Response: The reviewer is absolutely right.. We now added the computation and the analysis of the PSD ratio as defined in Ballarotta et al. (2019) in lines 273-277 and Figure 8 of the revised version of the manuscript.