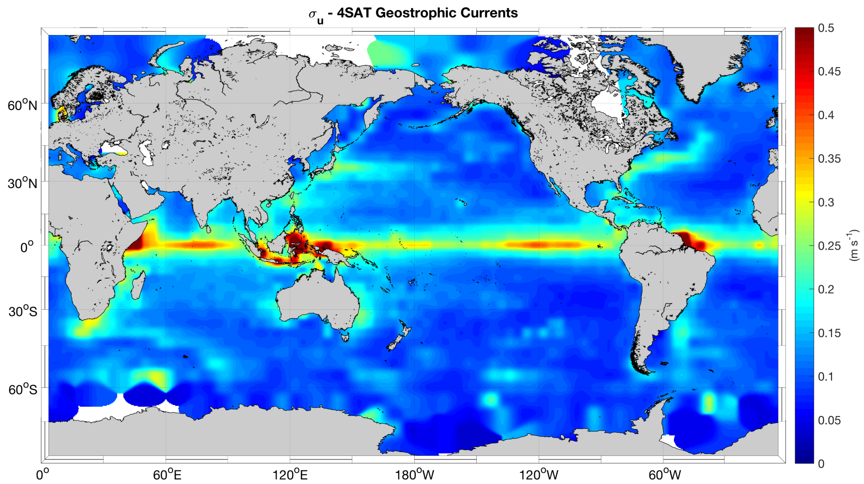
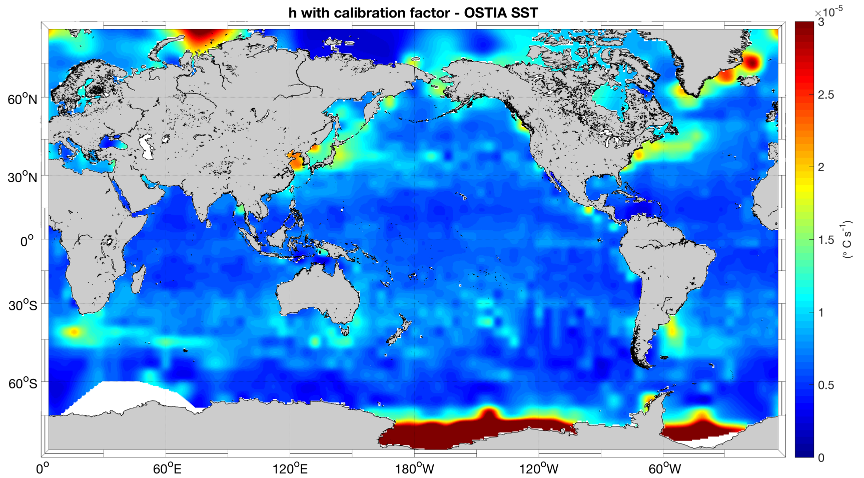
Improving the Altimeter-Derived Surface Currents Using Sea Surface Temperature (SST) Data: a sensitivity study to SST products

Supplementary Material S1



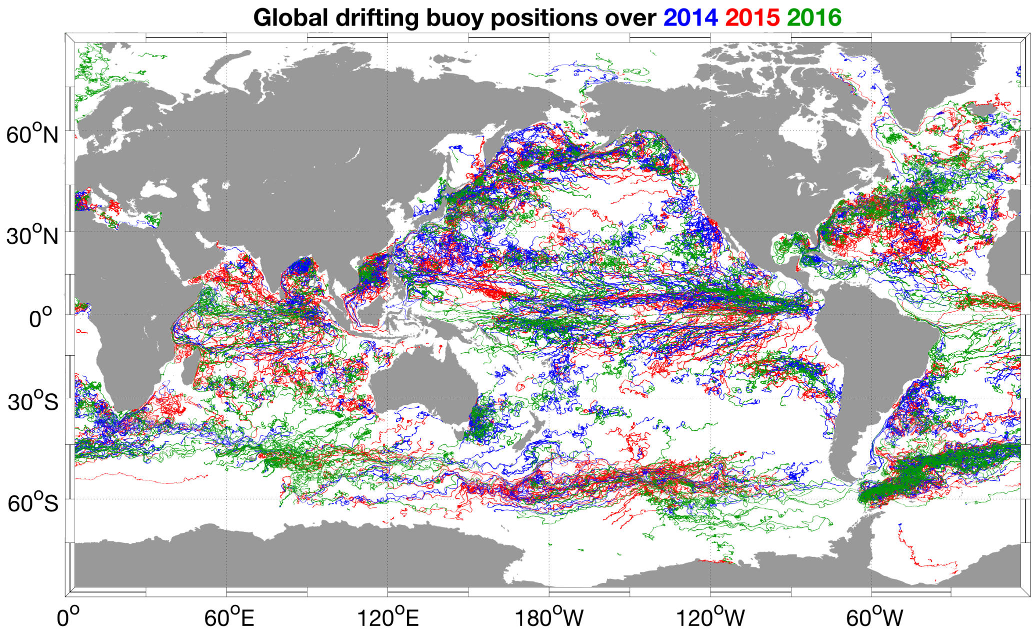


S1. Top: Example of uncertainty on the 4SAT zonal geostrophic currents (σ_u). This map is obtained interpolating the 4SAT zonal Altimeter currents along the trajectories of the drogued SVP drifters (in the 1993 to 2017 period). Then, σ_u is obtained as the Root Mean Square Error (RMSE) between the geostrophic and the in-situ measured currents have been computed on 4° x 4° boxes.

S1. Bottom: Example of uncertainty on the Forcing term F of the SST dynamical evolution equation (h). This is obtained computing an in-situ forcing term from in-situ, SVP-derived SSTs. The satellite-derived forcing term (computed with the OSTIA SST) is then interpolated along the trajectories of the drogued SVP drifters in the 2002 to 2017 period. Finally, h is given as the RMSE between the satellite-derived and the in-situ derived forcing term, computed in 4° x 4° boxes.

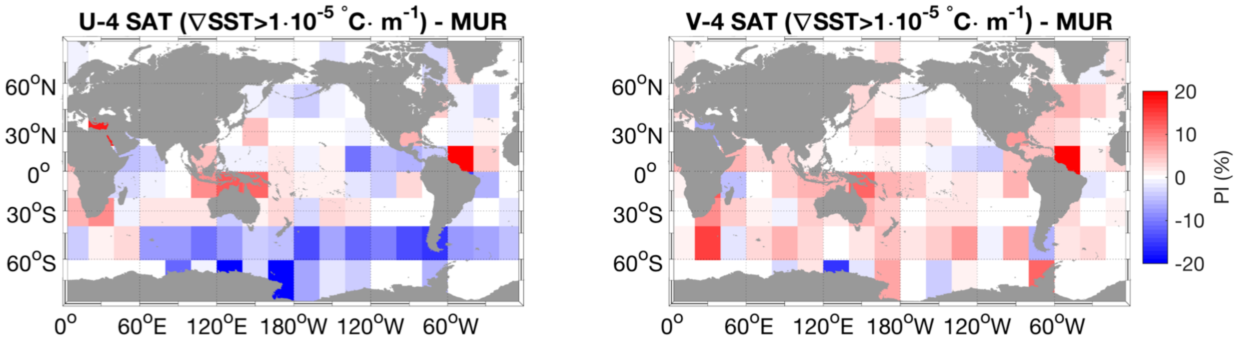
Both σ_u and h are low-pass filtered with 300 km cut-off wavelength in order to avoid sharp spatial variability due to the 4°x4° binning

Supplementary material S2



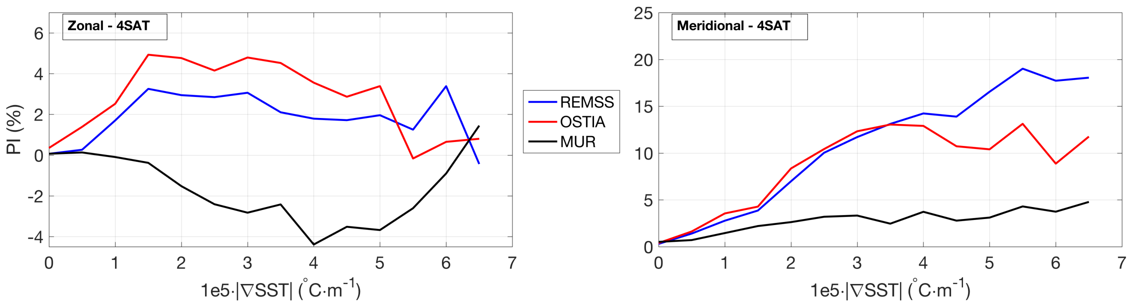
S2 . Drifting buoy trajectories over the 2014-2015-2016 period showing the validation sites for the Optimal currents assessment

Supplementary Material S3



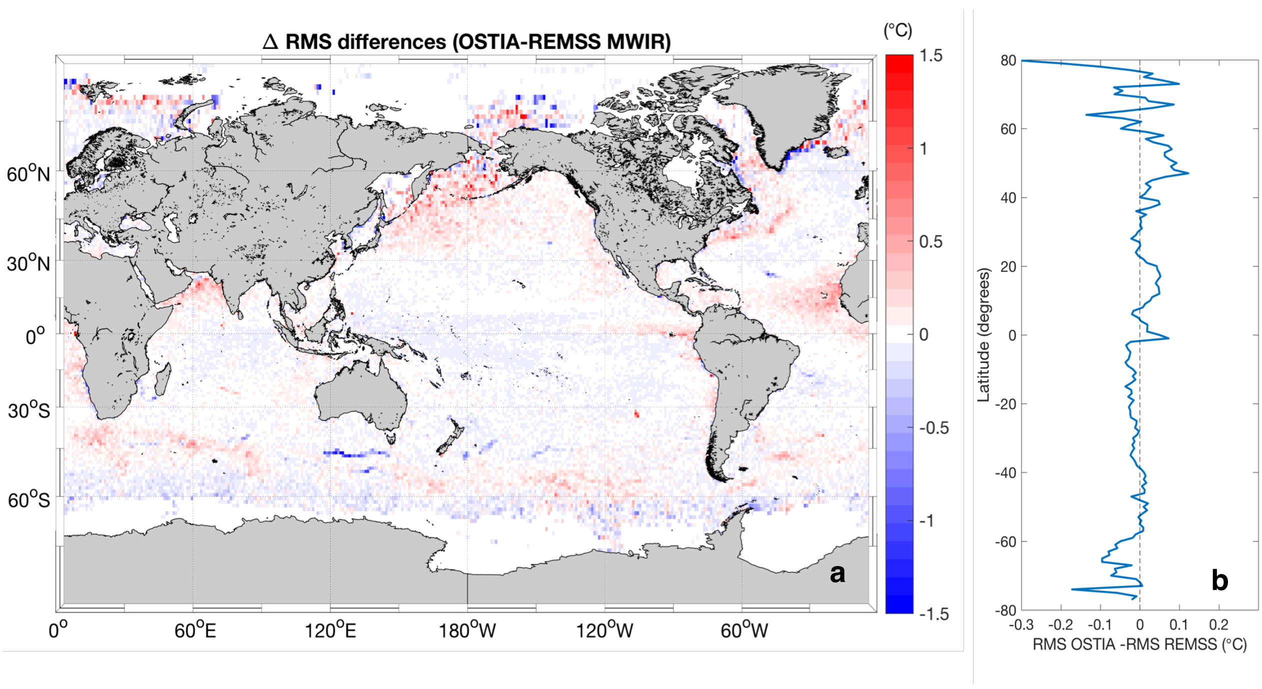
S3. Percentage if improvement (PI) for the OPC computed from the 4SAT Altimeter currents and the MUR SST (in the 2014-2016 period). Left) zonal flow, Right) meridional flow. The improvement is referred to the Altimeter currents and is computed using the in-situ measured drifting-buoys-derived surface currents as benchmark.

Supplementary material S4



S4. Percentage of improvement (PI) as a function of the local SST gradient magnitude. 4SAT Optimal Currents. Black, Reda and Blue lines stand for MUR, OSTIA and REMSS based optimal reconstructions, respectively.

Supplementary Material S5



S5.1 a) RMS differences between the OSTIA, REMSS L4 daily SST and the in-situ SST measurements provided by the Global Drifter Program. b) same as “a”, zonal averages.

In order to further investigate the accuracy of the REMSS and OSTIA L4 SST products used in our study, we created a match up database collocating each satellite SST daily map with in-situ SST observations in the period 2002 to 2017 (to guarantee a common observations period in both SST datasets). The satellite-derived REMSS (Microwave plus Infrared observations) and OSTIA

SST have been matched up with SST observations from the Global Drifter Program (drogued plus undrogued drifter measurements)[1], as depicted in S5.2.

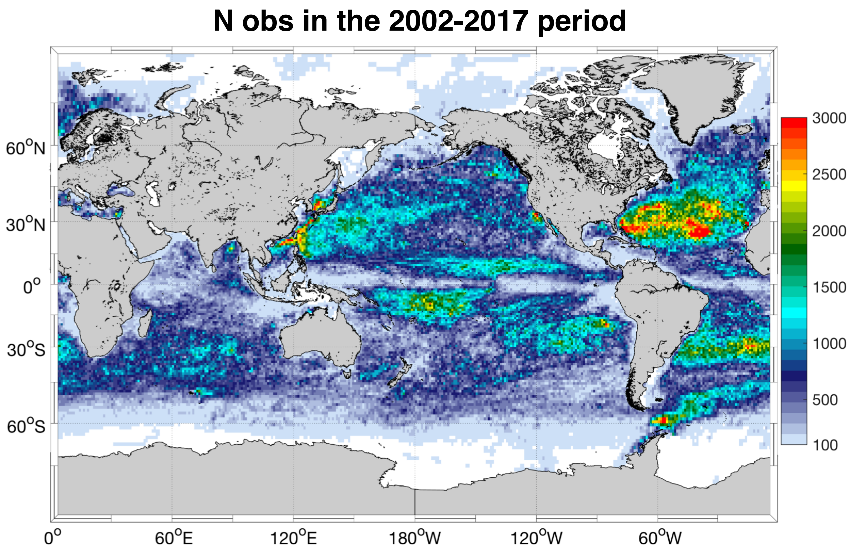
In what follows, we are aware that the OSTIA L4 SSTs include in-situ measured SST in their optimal interpolation scheme and that the results shown at point a) and b) are expected. The analyses only want to assess the effect of not including in-situ SST observations in a L4 prodcut (as in the REMSS SST).

The two panels reported in S5.1 respectively represent:

a) The map of differences between the Root Mean Square errors (RMS) of the OSTIA and REMSS SST evaluated using the in-situ SST as ground truth (binned in 1°x1°). For instance, the blue areas in the map are indicating a smaller RMS, hence, a higher accuracy for the OSTIA SST according to our analysis. (the total number of observations is reported below)

As a general comment, the REMSS SSTs show better performances in correspondence of the major current systems. Most likely, this is due to the effective higher resolution of this SST product compared to the OSTIA database. Here, the SST signature of the meandering or eddy-like features is captured with more accuracy. Elsewhere, and in particular in the Southern Ocean from 50°S onward, the OSTIA SSTs are the dataset more in agreement with the actual SST field.

b) this panel emphasizes the comments provided at point "a". It represents the zonal averages of the quantity shown in panel "a" for each latitude (the meridional step is 1°). According to this analysis, the REMSS and OSTIA SST have comparable averaged behaviour at mid-latitudes. On the other hand, at the high latitudes, where the satellite-based SST retrieval is more critical, the OSTIA SST have a clear reduced RMS compared to the in-situ measurements. This additional analysis is provided in support of section 4 of our study.



S5.2 number of in-situ SST match-up observations in the 2012-2017 period (binned in 1°x1° boxes).

[1] Lumpkin, R.; Özgökmen, T.; Centurioni, L. Advances in the application of surface drifters. *Annual Review of Marine Science* **2017**, *9*, 59–81.