Guiding biogeochemical campaigns with high resolution altimetry: waiting for the SWOT mission

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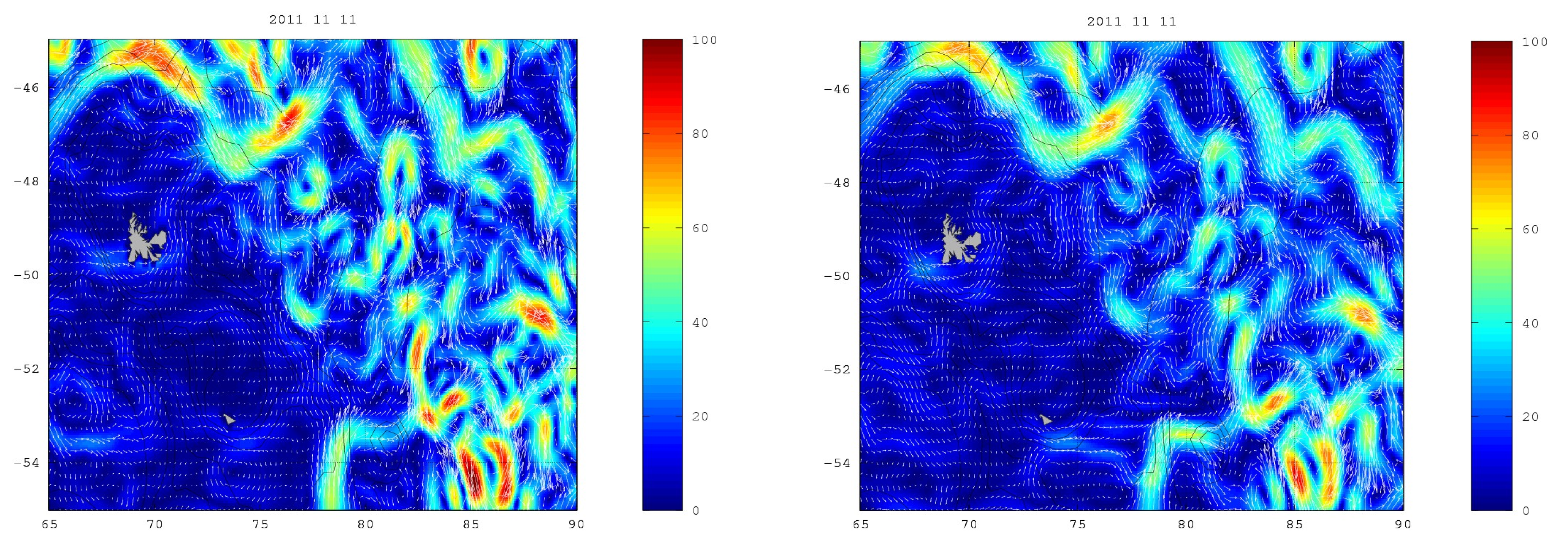
ABSTRACT

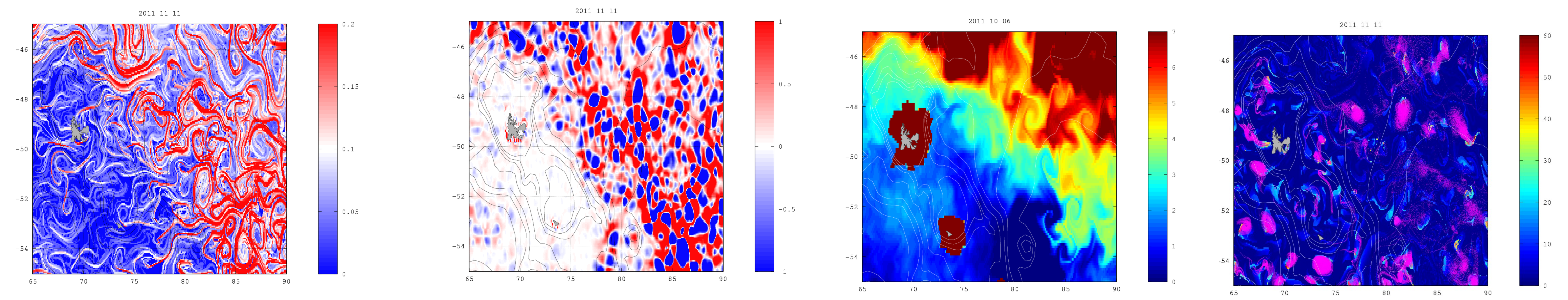
Biogeochemical processes in the ocean are strongly affected by the horizontal mesoscale (~10-100 km) and submesoscale (1-10 km) circulation. This variability has a direct effect on the biogeochemical budgets and provides a challenge to in situ studies, because sites few tens of kms or few weeks apart may be representative of very different situations. In order to overcome this problem, during the KEOPS2 campaign we have developed several diagnostics based on altimetry data which allowed us to map in real time possible physical structures of biogeochemical interest (like fronts, eddy cores, temperature filaments). This analysis has been perfomed on a specifically designed, high-resolution, regional altimetric product was produced by CLS (with support from CNES) which has been merged with other satellite data. The benefits of such analysis included the possibility of predicting in advance the region where the phytoplanktonic bloom would have occurred and of identifying possible different biogeochemical provinces. Such approach suggests the huge potential of incoming high resolution altimetry for biogeochemical in situ studies.

DATA AND METHOD

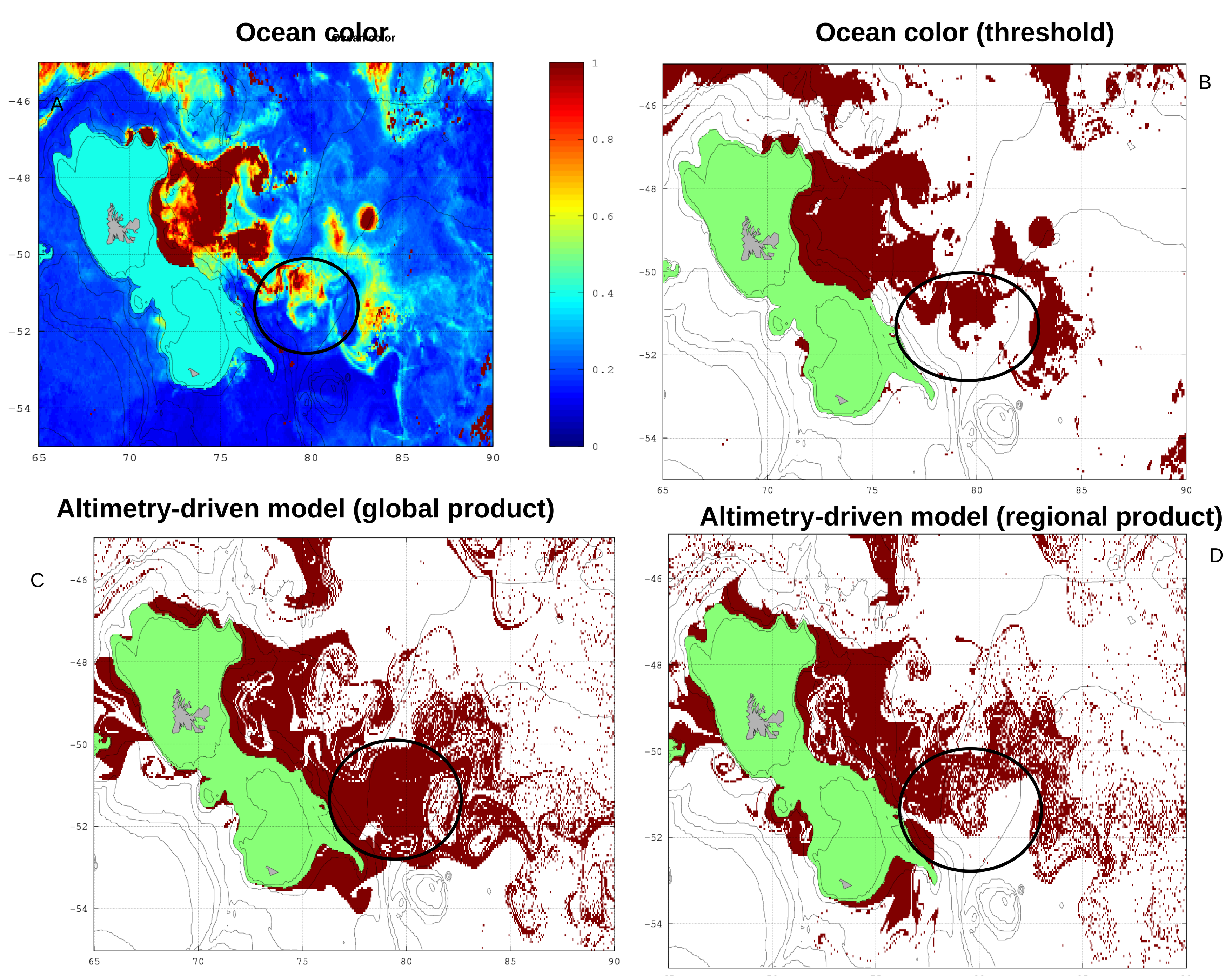
The multisatellite Kerguelen altimetric products have been produced by CLS (with support from CNES) using region-specific parameters for filtering, subsampling, and for computing the correlation radii and measurements errors needed for gridding. The NRT dataset used during the campaign has been extended in order to allow at least six months of Lagrangian backtrajectories. CLS also provided optimized multisatellite Chlorophyll images in real time and multisatellite infrared images in delayed time. The two images below show an example of the standard global product (left) and the optimized regional one (right). When inspecting the velocity field, differences appear to be minor. However, when integrated in a Lagrangian scheme, we found substantial improvements in predicting biogeochemical features like the extension of the bloom (see below). Details on the Lagrangian schemes can be found in the References below.



ALTIMETRY-BASED REAL-TIME MAPS



These are some of the altimetry-based diagnostics used for assisting the sampling strategy of the KEOPS2 campaign. From left to right: The Okubo-Weiss parameter identifies the eddy cores (blue spots) from the strain-dominated regions; the Lyapunov exponent calculation localizes the submesoscale frontal regions generated by the mesoscale turbulence; high resolution, cloud-free SST daily maps obtained by advecting microwave SST with altimetry data; eddy cores, identified by analyzing dispersion rates of Lagrangian particles.



Example of the improvement achieved thanks to the specific regional treatment of the Kerguelen altimetry produtc emplyed during the KEOPS2 cruise. Top: extension of the plume of Chlorophyll east of Kerguelen. Bottom: prediction of the plume extension by an altimetry-based model using the standard altimetry product (left) or the optimized regional one.

CONCLUSIONS

In contrast with past studies which focused on fixed stations, current campaigns have increasingly to rely on an adaptive sampling strategy, able to cope in real time with the spatiotemporal variability of the oceans. If such variability is not taken into account, it is very difficult or impossible to disentangle among different measurements which changes are due to the temporal evolution of a biogeochemical process and which changes are due to fact that different measurements were taken in different water masses. A typical biogeochemical campaign lasts nowadays for several weeks. In this time frame, the ocean upper layer is strongly affected by lateral stirring. A combination of altimetry-derived Lagrangian diagnostics and other satellite data permits to map some of this variability, so that frontal regions, intruding filaments, and isolated regions like eddy cores can be tracked during the ship cruise and taken into account in real time when choosing sampling sites. Nevertheless, a lot of structure of the ocean dynamics (notably, features below the ~50 km) are still invisible to altimetry and provide an important source of error for in situ biogeochemical time series analysis. The incoming observations from SWOT may fill this gap and help to reduce substantially this error.

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References

F. d'Ovidio, J. Isern-Fontanet, C. López, E. García-Ladona, E. Hernández-García, “Comparison between Eulerian diagnostics and the finite-size Lyapunov exponent computed from altimetry in the Algerian Basin”, Deep Sea Res. I, 56, 15-31 (2009).

F. d'Ovidio, S. De Monte, S. Alvain, Y. Danonneau, and M. Lévy, “Fluid dynamical niches of phytoplankton types”, PNAS, 107, 18366-18370 doi: 10.1073/pnas.1004620107 (2010).

F. Nencioli, d’Ovidio, F., Doglioli, A.M., Petrenko, A.A.,”Surface coastal circulation patterns by in-situ detection of Lagrangian Coherent Structures”. Geophys. Res. Lett. (38), L17604, doi:10.1029/2011GL048815 (2011).

V. Smetacek et al. “Deep carbon export from a Southern Ocean iron-fertilized diatom bloom”, Nature, 487, 313 (2012); see also News and Views on the same issue.