Mesoscale to Submesoscale variability during the OUTPACE cruise: Contrasting Biological and Physical regimes in the oligotrophic SW Pacific

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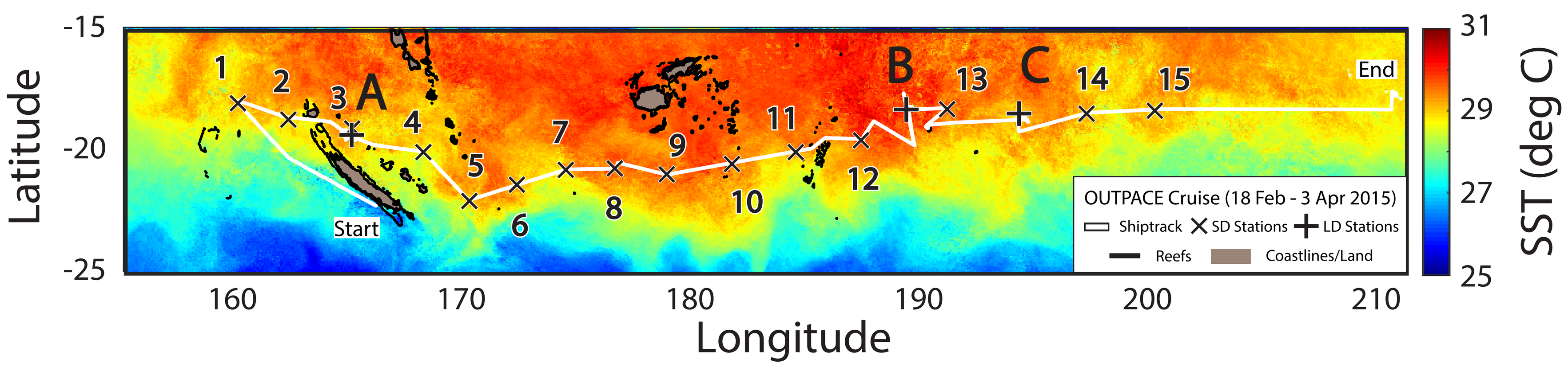
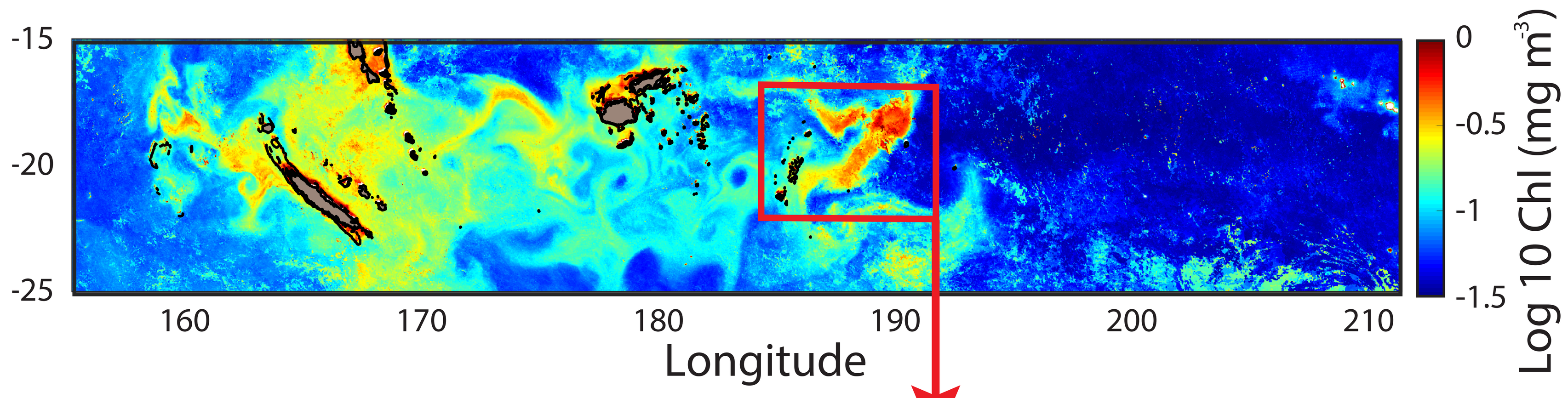
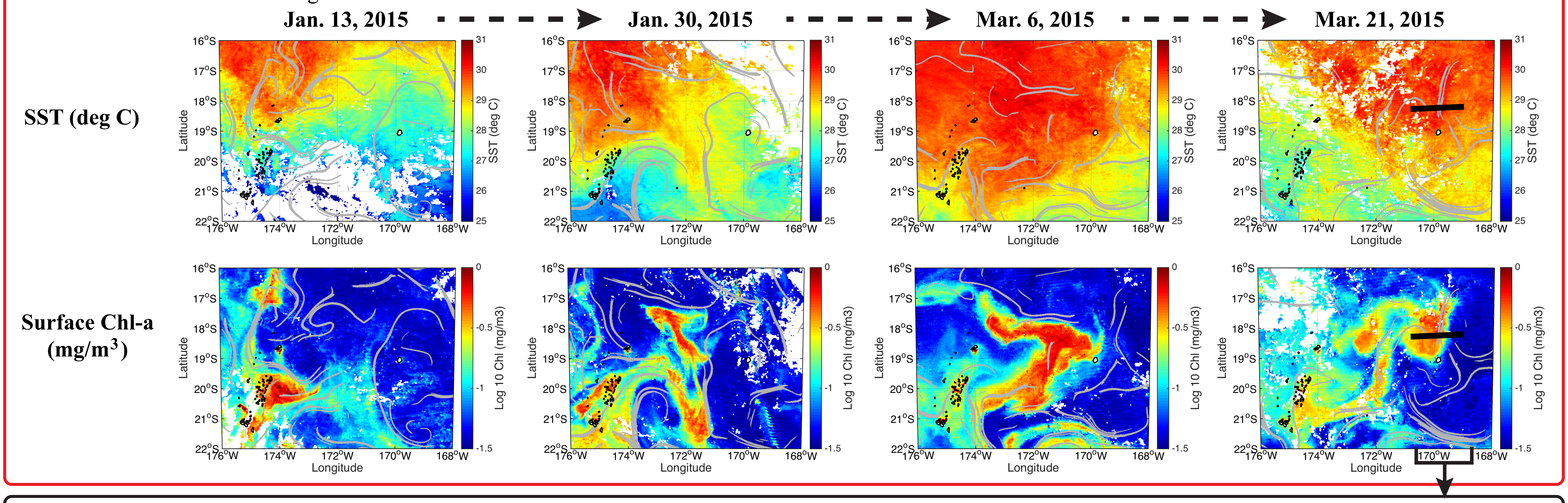
Main Objective: We present remote sensing and in situ data collected during the Oligotrophy to UlTra-oligotrophy PACific Experiment (OUTPACE) campaign, conducted from Feb. 18 to Apr. 3, 2015 in the SW Pacific. Proceeding from the regional, mesoscale, and finally submesoscale, we identify gradient regions of interest and determine to what extent mesoscale or submesoscale dynamics are responsible for the structures observed.

Regional Scale: Below are the 45-day weighted mean SST and Chl-a for OUTPACE, using the ship's changing distance in time to each pixel as the weight. SST shows a dominant meriodional gradient, with little zonal variability. Surface Chl-a observations, by contrast, indicate an overall zonal gradient where high concentrations in the west, near archipelagos, decrease to the east in the subtropical gyre. Surface Chl-a also demonstrates an abrupt maximum near the gyre boundary. Why does this maximum occur? This region, sampled during LD Station B (March 14-21), is the focus of the mesoscale and submesoscale discussion to follow.

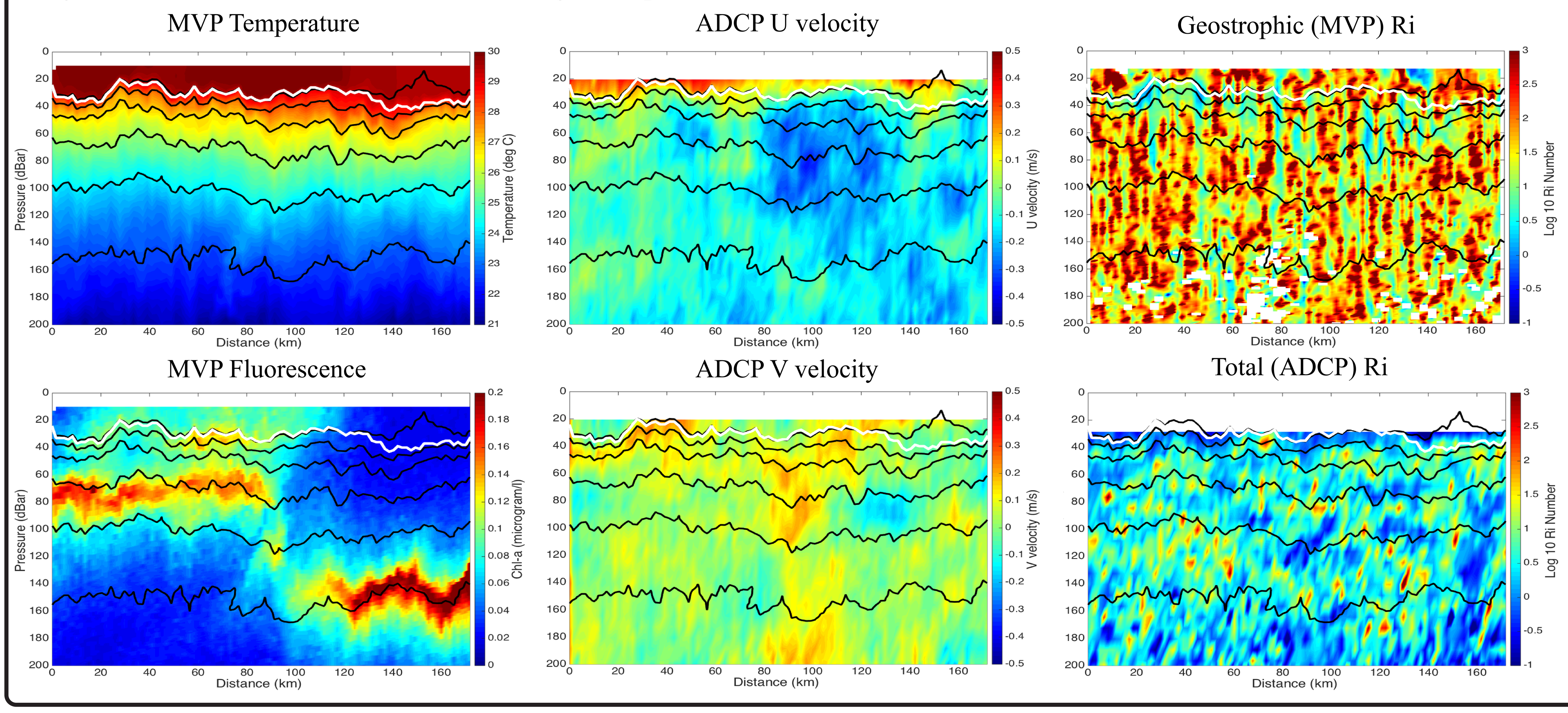




Mesoscale: Finite scale Lyapunov exponents (FSLE, d'Ovidio et al., 2004) are computed from AVISO altimetry-derived geostrophic currents, with an initial particle separation of 0.01 degrees and 30 days integration time. Exponents 0.1 day^{-1} or more are shown in gray to show shear in the mesoscale circulation. The temporal evolution of SST and Chl-a patch structure is shown over two months, Jan 2015 to Mar 2015. On Mar 21, a Moving Vessel Profiler (MVP) transect was conducted, shown in black in the latest figure.



Submesoscale: Data from the Mar 21 MVP transect and shipboard ADCP measurements over 11 hours are shown. A sharp gradient is present in Chl-a fluorescence which is not found in temperature or density (isopycnals in black for 1022 kg m^{-3} and above in intervals of 0.5, mixed layer depth in white calculated as density 0.03 kg m^{-3} greater than nearest surface value). The geostrophic (Thomas et al., 2013) and total Richardson numbers are calculated from MVP and ADCP data, respectively.



Geostrophic (MVP) $Ri = \frac{f^2 N^2}{|\nabla_h b|^2}$

Total (ADCP) $Ri = \frac{N^2}{(\partial \mathbf{u} / \partial z)^2}$

Submesoscale flows occur in the regime of Ri ~O(1), or 0 in the log plots shown. Geostrophic (MVP) Ri values observed in this transect are mostly larger than this, indicating that geostrophic shear in this region is not of the magnitude typical of submesoscale flows. By contrast, Total (ADCP) Ri values are reduced relative to the geostrophic Ri. As a result, most of the observed vertical velocity shear is not attributable to geostrophy, but to other phenomena present within the dataset.

Conclusions: Remote sensing data suggest that the mesoscale circulation is responsible for the horizontal gradient present in surface Chl-a at the submesoscale during OUTPACE. In situ data provide little support for balanced, buoyancy-driven circulation at the submesoscale, although there is significant observed velocity shear. Gradients in biogeochemical tracers and processes, including phytoplankton, nutrients, and remineralization, can be produced by mesoscale stirring. Studies focusing on submesoscale bio-physical interactions should consider resolving these gradientgenerating mechanisms, such as in Lévy et al. (2012).

References: *d'Ovidio et al. (2004) Geophys. Res. Let., 31(17)   Thomas et al., (2013) Deep Sea Res. II, 91, 96-110   Lévy et al., (2012) Ocean Modelling, 43, 77-93*

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