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Persistent and highly contrasting biological patterns in the southwestern sector of the Atlantic Ocean: relating local circulation to phytoplankton pigment biomass

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Primary production in the Southern Ocean (SO) is believed to be mostly iron limited; despite the high macronutrient content of waters transported by the Antarctic Circumpolar Current, the SO is considered a High Nutrient Low Chlorophyll region. However, ocean color imagery shows a variable and patchy environment, where sharp chlorophyll concentration (chl-a) gradients separate highly productive regions, which are found mostly downstream from islands and along coastal shelves, from the less productive ones, where pigment biomass remains low. In the western sector of the Atlantic SO, an intense and long-lasting phytoplankton bloom is found northwest of the Island of South Georgia, while very low chl-a are persistently measured southwest of the Shackleton Transverse Ridge (STR), in the southern Drake Passage. In both cases, local circulation, which is steered by bottom topography, plays a major role in controlling biogeochemistry and thus the distribution and intensity of chl-a.
By combining surface drifter trajectories with satellite based measurements of sea surface height and ocean color, we relate local flow regimes to the observed pigment biomass patterns.
Basing our analysis on 13 years of SeaWiFS imagery, the intense and long-lasting phytoplankton bloom developing northwest of South Georgia appears to be recurrent in time with little inter-annual variability; furthermore, our results show how the bloom is clearly confined to the area enclosed by the cyclonic circulation flowing along the periphery of the South Georgia Basin (SGB). Here, current velocities appear to gradually decrease towards the center of the basin possibly favoring the accumulation of shelf-derived iron, and thus the growth of phytoplankton cells.
Southwest of the STR, the available ocean color time-series highlights an area with very low productivity values, which can be detected yearly and with little inter-annual variability. This region is adjacent to the more productive one found to the northeast of the ridge, above the Ona Basin. The former appears to be related to the intense Shackleton Jet flowing along the ridge, while the latter to the calmer cyclonic circulation located above the Ona Basin; just above the STR lies the area where maximum chl-a gradients can be measured.
Absolute dynamic topography values retrieved for the two regions together with surface drifter trajectories, suggest a clear spatial and temporal correspondence between local circulation patterns and those of surface chl-a; furthermore, the AVISO time-series confirms the low inter-annual variability of the two previously described flow patterns.
We argue how similarly above the STR and the SGB, the presence of the cyclonic circulation acts as a precondition to the observed higher chl-a. In both cases, nutrient (i.e. iron) rich waters may be entrained in the cyclone, and separated from those lying outside its borders. Similar observations have been made in the Crozet and the Kerguelen regions.