Quantifying the significance of the spatial and temporal scales of phytoplankton variability in the Subantarctic Ocean

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Southern Ocean chlorophyll-a concentrations are important for understanding the change in phytoplankton biomass in the surface waters and associated impacts on climate change through the uptake of atmospheric CO_2 via the biological carbon pump. Phytoplankton in the Subantarctic Southern Ocean have a distinct seasonal cycle (Arrigo et al. 2008), which is highly variable in both space and time (Thomalla et al. 2011). The seasonal and spatial distribution of chlorophyll-a can be attributed to the complex nature of the physical and biogeochemical factors controlling phytoplankton production (Swart et al. 2015, Thomalla et al. 2011). Continuous, high resolution glider data provides a novel way to assess phytoplankton variability at small time and space scales (submeso- to mesoscale) that are necessary for addressing climate related questions. Temporal variability of phytoplankton was investigated using Empirical Mode Decomposition of surface chlorophyll-a concentrations collected from a Seaglider over a period of 5.5 months (25 September 2012 to 15 February 2013). This study found that during spring, chlorophyll-a concentrations oscillate daily around the rising seasonal ramp due to increased light availability when the upper ocean stratifies through seasonal increase in heat flux. The phytoplankton blooms that form in spring do not occur at set temporal frequencies but are rather temporally sporadic. In summer phytoplankton blooms were found to occur at submeso- and mesoscales and modulated by synoptic time scales (4 to 9 days). This variability was found to be driven by storms varying the strength of the wind stress and consequently the mixed layer depth (that alters the nutrient and light environment). Spatial variability was investigated using daily MODIS ocean colour and sea surface temperature data. Spatial variability was characterised using a similar approach used by Mahadevan and Campbell (2002), where the spatial variance was calculated at different length scale. Spatial analysis found that compared to sea surface temperature, phytoplankton was patchier in both spring and summer at both large (266 km) and small (4 km) length scales. These dominant submeso- and mesoscale changes in chlorophyll-a at both temporal and spatial scales, highlights the need to sample phytoplankton at high spatial and temporal frequencies (<10 days) in order to accurately reflect phytoplankton seasonal variability and ultimately understand the impact of phytoplankton variability on carbon flux.

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