Hydrographic controls on the inter-annual variability of chlorophyll-a concentration estimates in the Atlantic Sector of the Southern Ocean

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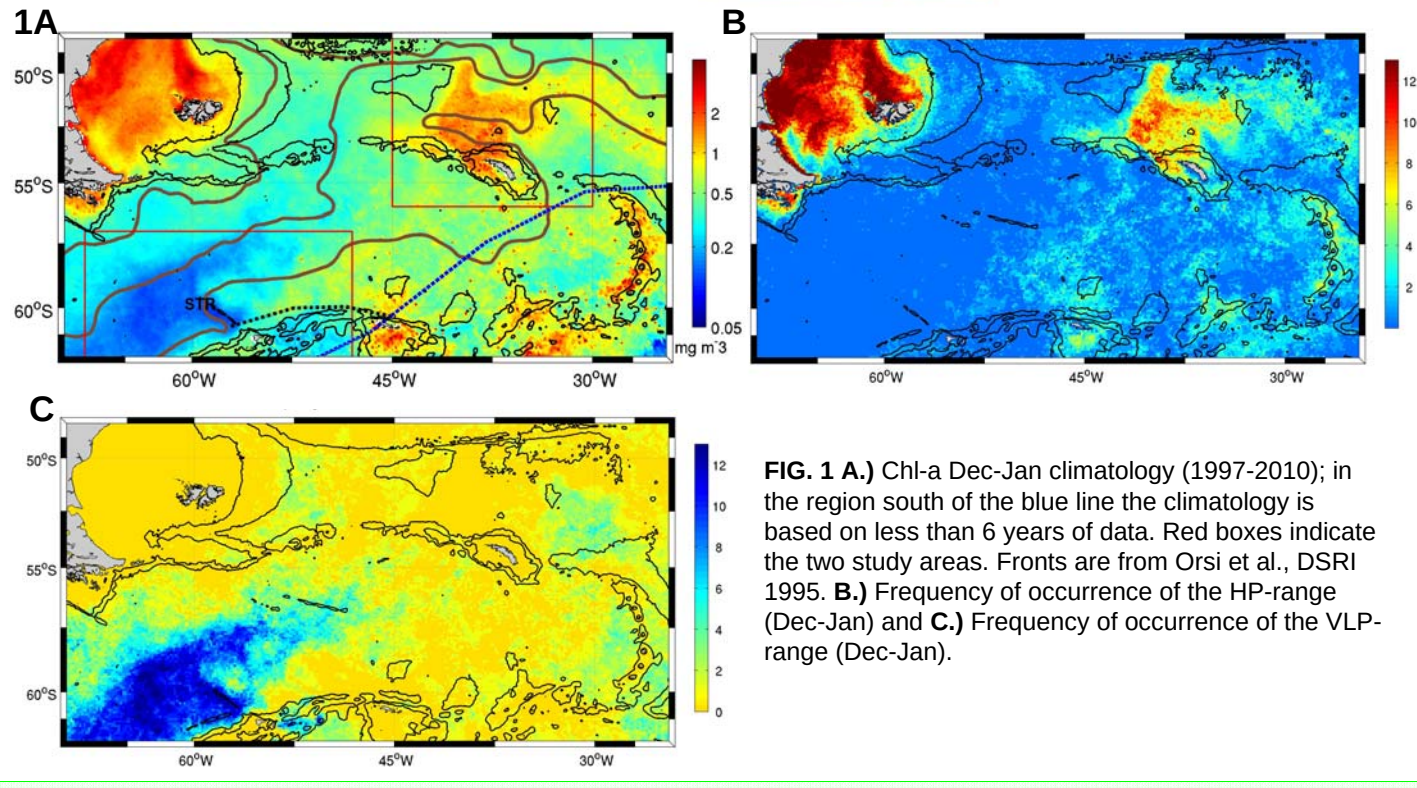


FIG. 1 A.) Chl-a Dec-Jan climatology (1997-2010); in the region south of the blue line the climatology is based on less than 6 years of data. Red boxes indicate the two study areas. Fronts are from Orsi et al., DSRI 1995. **B.)** Frequency of occurrence of the HP-range (Dec-Jan) and **C.)** Frequency of occurrence of the VLP-range (Dec-Jan).

Background

Despite high concentrations of inorganic nutrients, primary productivity in the Southern Ocean is believed to be mostly iron limited; highest chl-a are thus measured along coastal regions (i.e. Antarctic Peninsula), downstream from islands (i.e. Island of South Georgia) or along marginal ice zones, which are shown to be natural sources of bio-available iron. The intensity and recurrence of blooms is strongly dependant on bottom-up (i.e. nutrients inputs) or top-down controls (i.e. grazing), all of which may vary in time according to the physical and chemical environment.

Data and methods

SeaWiFS Level 3 monthly composites at 9 Km resolution were retrieved from the distributed Active Archive Center, from Sept. 1997 to Mar. 2010 (13 full seasons). **AVISO** Mapped Absolute Dynamic Topography weekly "delayed time" products were averaged to form a climatology corresponding to the SeaWiFS dataset (bi-monthly averages of Dec-Jan. Surface drifter trajectories were also used.

Frequency plots: For each given month, ocean color pixels falling in one of 3 chosen ranges (very low productivity < 0.2 mg/m^3; low-medium productivity 0.2 - 1mg/m^3; high productivity/bloom chl-a >1mg/m^3) were flagged and counted. Results for the VLP-range and the HP-range are displayed in Figure 1.B and 1.C

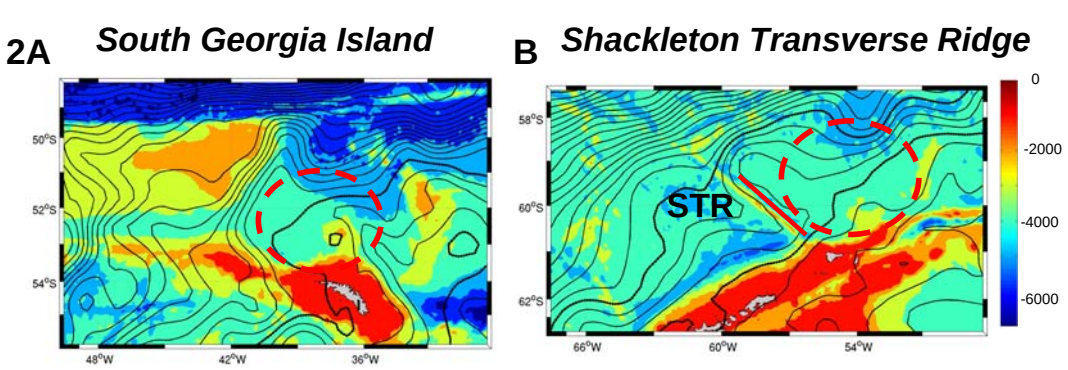


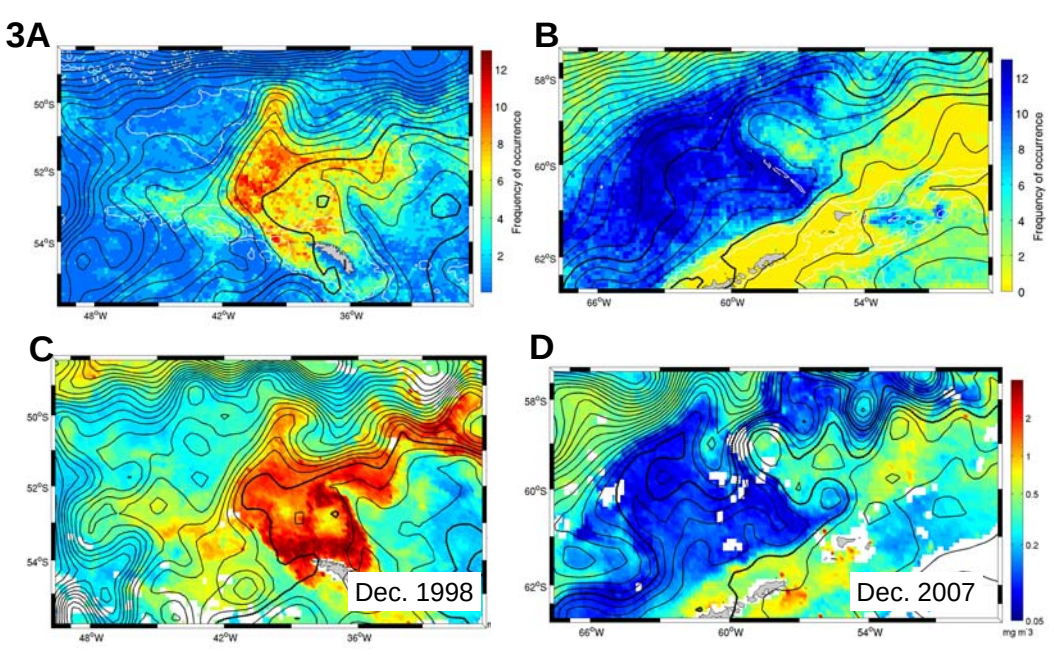
Fig. 2: Color-scale indicates bathymetry in the two study regions (in meters); black lines are ADT contours, values decrease from North to South and the -90cm and -110cm isolines are indicated in bold. **Fig. 3 A)** Frequency of occurrence of the HP-range and **B)** frequency of occurrence of the VLP-range and corresponding ADT contours; **C-D**) Chl-a (monthly) composites and corresponding ADT contours. **Fig. 4:** ADT contours (every 10cm) and chl-a for the Nov-Jan climatology around **(A)** Kerguelen, **(B)** Crozet and **(C)** South Georgia; **D)** three possible surface flow trajectories (from drifters) around South Georgia.

Observations

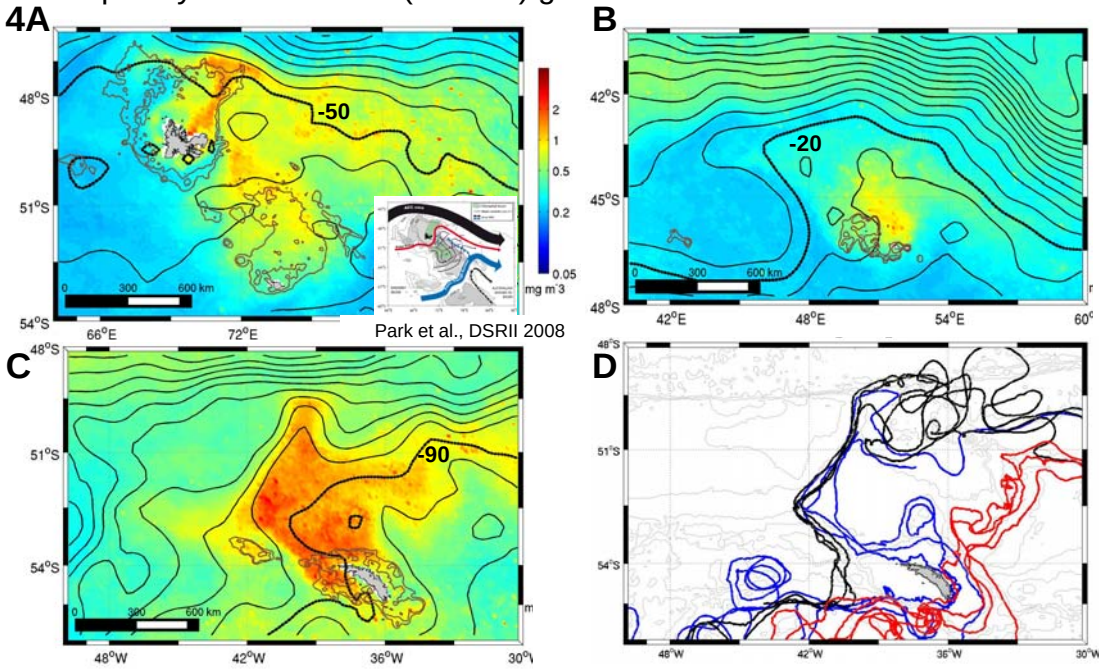
1. Stability of chl-a patterns - Figure 1: After obtaining frequency plots for each of the selected chl-a range we observe that the region north of South Georgia and around the STR exhibit very little spatial and inter-annual variability.

2. Topographic steering of the currents - Figure 2: Both in the region adjacent the South Georgia Island and the STR, ADT contours appear to follow tightly bathymetric features, giving evidence for topographically steered circulation.

3. Surface circulation controls chl-a patterns – Figure 3: Combining ocean color frequency plots and ADT contours, we find a clear geometrical match (also at shorter timescales – Fig. 3 C-D). The location of ADT gradients often corresponds to the location of maximum frequency of occurrence (or chl-a) gradients.



4. Stable meanders confine more productive waters – Figure 3: Red circles in Figure 2, highlight a cyclonic circulation, which embraces calmer waters. Here enclosed waters (carrying nutrients and phytoplankton cells) may be spatially confined by the faster flows found at the periphery. Similar conditions have been observed also in the Kerguelen (Fig.5a) and Crozet (Fig.5b) regions.



5. The South Georgia island mass effect appears stronger than elsewhere – Figure 4: Circulation patterns downstream from South Georgia (Fig. 4C) confine productive waters to a much larger area than the one found downstream from Kerguelen islands. Albeit the much smaller shelf area, chl-a downstream from South Georgia may reach higher values and larger extension than elsewhere.