Wind-modulation of upwelling at the shelf-break front off Patagonia: Observational evidence

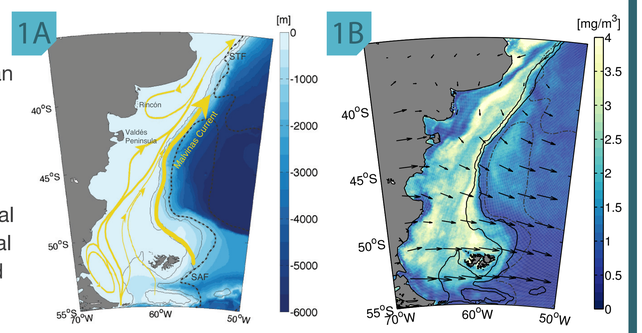
Carranza MM[(1)], Gille ST[(1)], Piola AR[(2,3)], Charo M[(2)] & Romero SI[(2,3)]

(1) Scripps Institution of Oceanography-UCSD, La Jolla, CA, USA; (2) Servicio de Hidrografía Naval, Buenos Aires, Argentina;
(3) Facultad de Ciencias Exactas y Naturales-Universidad de Buenos Aires, Argentina. maucarranza@ucsd.edu

MOTIVATION

The Patagonian shelf is the largest chlorophyll-a (Chl-a) hot spot in Southern Ocean color images. Phytoplankton production is responsible for net CO_2 uptake. The 1500-km long shelf-break front (SBF) that tightly follows the 200-m isobath, is characterized by persistently high satellite Chl-a concentrations indicative of upwelling.

FIGURE 1. (1A) Bathymetry of the Patagonian shelf with schematic of mean circulation. (1B) Satellite Chl-a amplitude (annual maximum-annual minimum) based on 12 years of monthly means (2000–2011), with mean summer wind vectors overlaid. Solid black contours indicate the 200 and 1000 m isobaths. The Sub-Antarctic Front (SAF) and Sub-Tropical Front (STF) from Orsi et al. [1995] are shown by dashed black lines.



OBJECTIVE

To explore wind-related physical forcing on atmospheric synoptic scales as a possible driver of Chl-a variability and upwelling at the SBF

Composites of Chl-a by wind direction

Northerly winds linked to higher Chl-a offshore of the SBF
Southerly winds linked to higher Chl-a onshore of the SBF

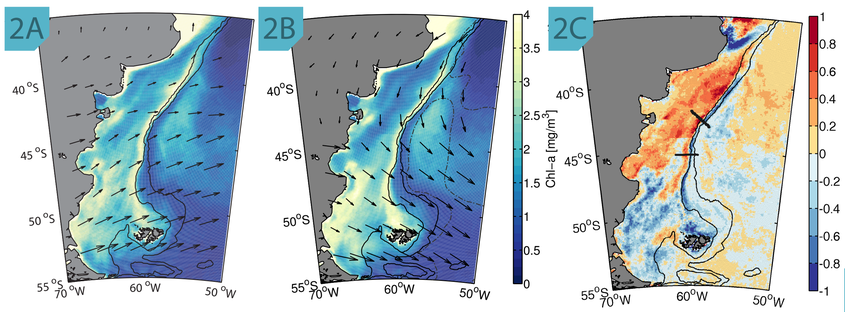


FIGURE 2 Composites of 4-day Chl-a for (2A) southerly winds and (2B) northerly winds for the summer. (2C) Difference between 2A and 2B. (2D) Mean summer satellite Chl-a for southerly winds (red), northerly winds (blue), and all summer cases (green) for the southern transect across the shelf-break front shown in 2C.

Do along-front winds modify upwelling at the SBF?

Along-front winds can influence the tilt of isopycnals at the SBF (*Siedlecki et al., 2011, JGR*). Due to Ekman transport, isopycnals verticalize in response to southerly winds, and horizontalize in response to northerly winds. As winds oscillate, nutrients are pumped from the bottom Ekman layer to the surface.

Isopycnal Tilting and In Situ Chl-a: Synoptic Evidence

FIGURE 4. Satellite Chl-a and surface winds (left), vertical structure of Chl-a fluorescence (right, color bar) with density contours overlaid in white, for two transects across the shelf break. (4A) northerly winds, and (4B) southerly winds. Wind roses showthe relative frequency of wind directions by wind speed ranges (in m/s) for each transect, based on hourly shipboard winds.

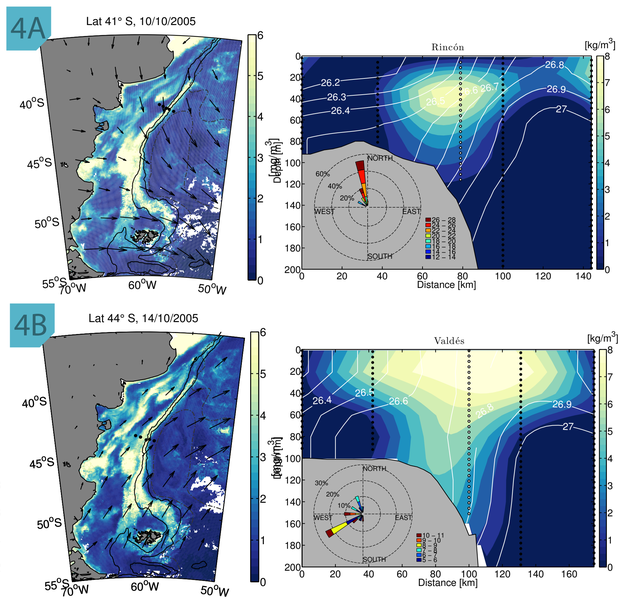
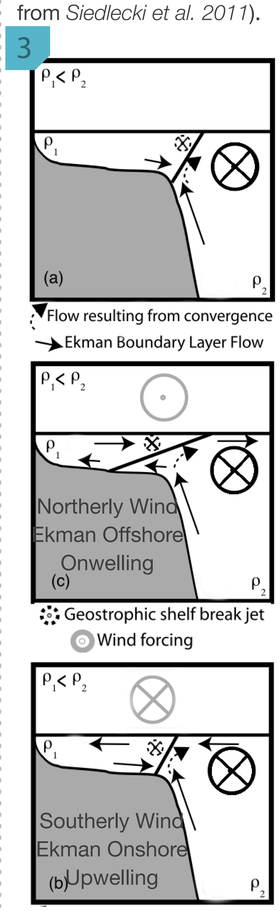


FIGURE 3. Shelf-break upwelling due to along-front winds (adapted for the SH, from *Siedlecki et al. 2011*).



Water-Column Response to Along-Front Winds

Along-front winds are correlated with temperature through the water column. Temperature responds to changes in the winds with a lag of ~2-4 days.

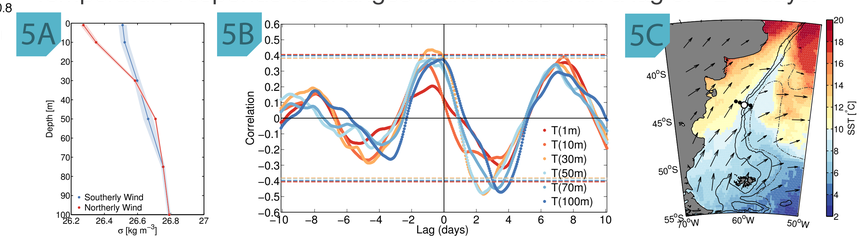


FIGURE 5. (5A) Mean density profiles segregated by along-front wind direction, and (5B) cross-correlations between meridional winds and water column temperature. Hourly wind and temperature data come from a GEF2 mooring at the SBF (white dot in 5C).

CONCLUSIONS

- Satellite Chl-a composites segregated by wind direction suggest that along-front winds modulate shelf-break upwelling
- In situ hydrographic observations show isopycnal tilting and changes in stratification that are consistent with Ekman dynamics
- Subsurface Chl-a fluorescence provides further evidence of the influence of along-front winds on Chl-a concentrations at the front

Isopycnal Tilting and Stratification Changes: Statistical Significance

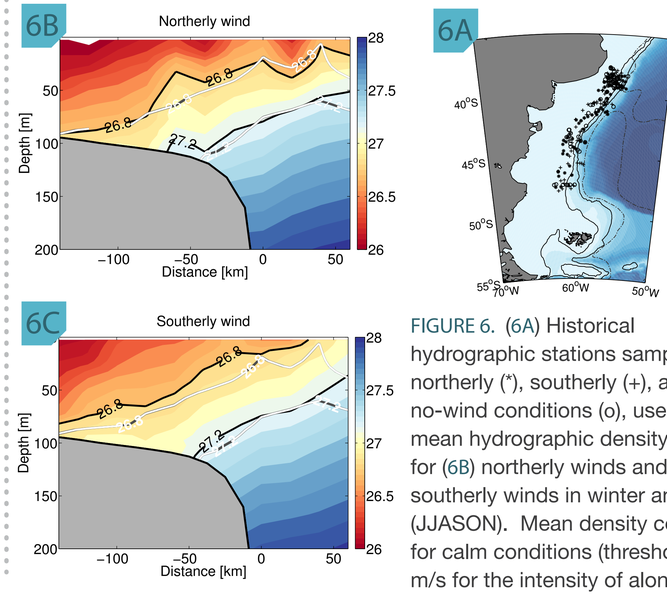


FIGURE 6. (6A) Historical hydrographic stations sampled with northerly (*), southerly (+), and no-wind conditions (o), used in mean hydrographic density sections for (6B) northerly winds and (6C) southerly winds in winter and spring (JJASON). Mean density contours for calm conditions (threshold of 2 m/s for the intensity of along-front winds) are overlaid in white.

REFERENCES

- Carranza et al. (2017), Wind modulation of upwelling at the shelf-break front off Patagonia: Observational evidence, J. Geophys. Res. Oceans, 122.
- Siedlecki et al. (2011), Nutrient exchange and ventilation of benthic gases across the continental shelf break, J. Geophys. Res., 116, C06023.

ACKNOWLEDGEMENTS

NASA Physical Oceanography Program (NASA NNX08AI82G) and NESSF Fellowship (NESSF NNX12AN41H). Data processing workgroups from REMSS and Mati Kahru for satellite data. Servicio de Hidrografía Naval (SHN) in Argentina and the Inter-American Inst. Global Change Res. CRN3070 (US NSF GEO-1128040) for in-situ data.

Ocean Carbon Hot Spots (2017), Monterey CA