Variability in Antarctic wind speed during the 20th Century and related subsurface warming in the Southern Ocean

Natália Silva, Ilana Wainer and Marcos Tonelli

University of São Paulo - SP, Brazil

natalia3.silva@usp.br

Context

Changes to Antarctic winds have already been addressed, usually related to the positive polarity of SAM (Marshall, 2003; Sen Gupta & England, 2006). It is believed that these winds could impact on ocean temperatures along the coastline of Antarctica (Hall & Visback, 2002; Spence et al., 2014). Therefore we address, using reanalysis data, changes in Wind Speed since 1900 and how the SO temperature varies in function of wind.

Data and Methods

- Spanning 1900 to 2010 & Lat < 55°S;

	NOAA 20CR V2 (atm & ocn)	ECMWF ERA 20C (atm & ocn)	ECMWF ORA s4 (ocn)
Spanning	1851 - 2014	1900 - 2010	1958 - 2013
Hor. resolution	2°	1°	
Input Data	SLP, SP, SST, sea-ice concentration	SLP, SP, and surface marine winds	Θ & S profiles, Δη, SST and sea ice

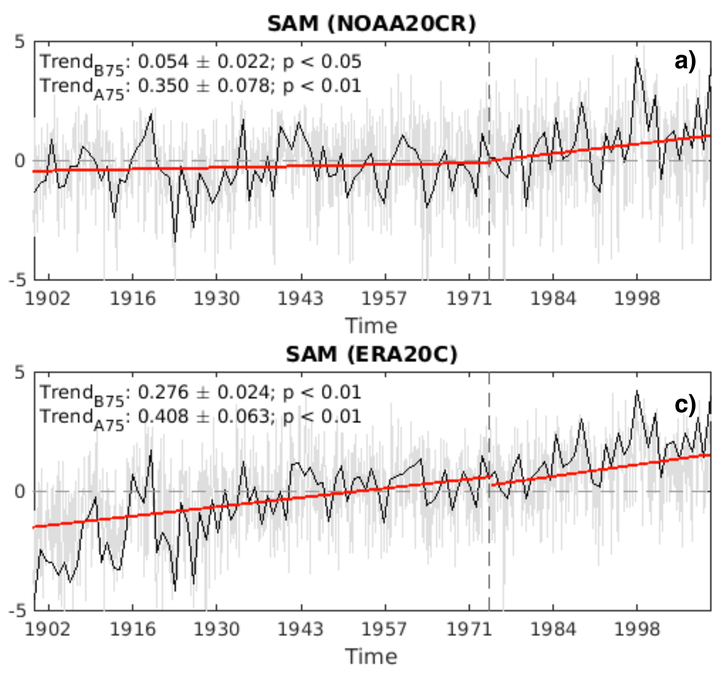
$\Delta WS = 20L_{mean} - 20F_{mean}$

$\Delta\Theta = \Theta_{After1975} - \Theta_{Before1975}$ (Θ = Potential Temperature)

$SAM_{index} = P^*_{40°S} - P^*_{65°S}$ (Gong et al. 1999); P* normalised SLP

- Trends: LSQ Method (Holland & Welsch, 1977);
- Correlation: Pearson correlation coefficient (Fisher, 1958).

Results



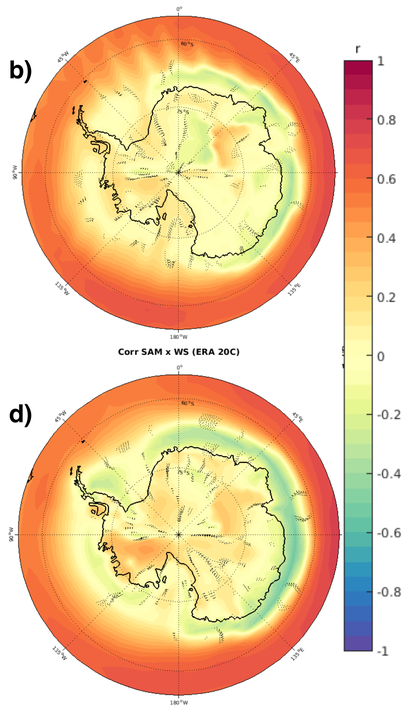


Fig 1: SAM_{index} time series and trends (a, c), along with correlation maps between SAM and WS (b, d) for NOAA20CR (superior) and ERA20C (inferior). Dashed lines in a and c represent the year of 1975 when SAM_{index} became positive and the trends almost doubled. Black dots overlaid on b and d represents where p_value < 0.01.

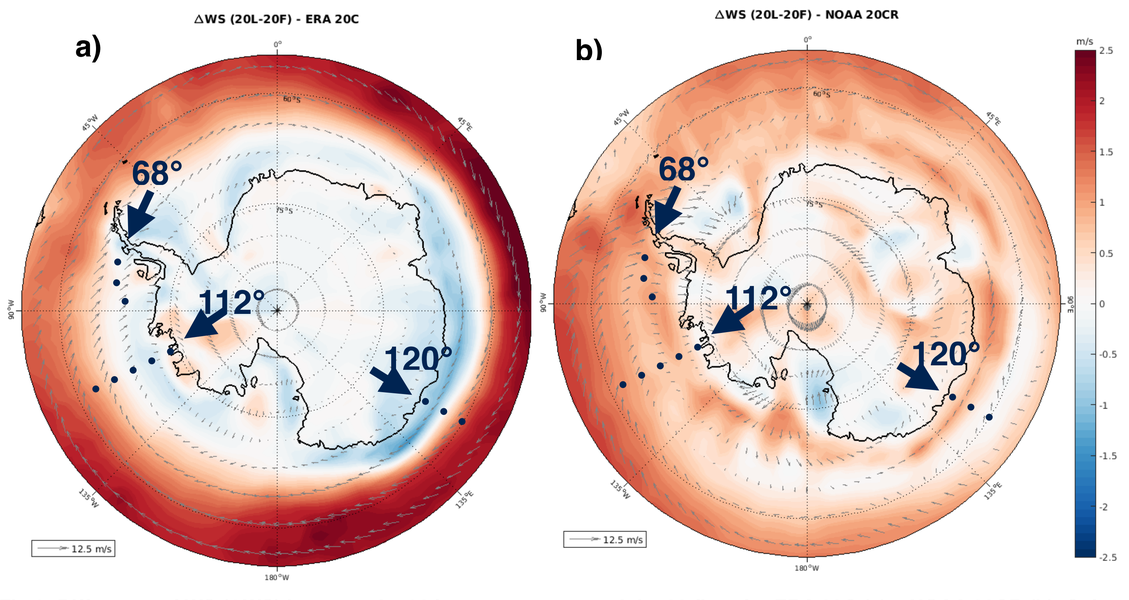


Fig 2: Difference of WS (ΔWS) between the 20 last years mean and the 20 first, for ERA 20C (a) e NOAA 20CR (b). Color shading represents the WS norm difference and overlaid, the wind difference vectors. Arrows and dotted lines in navy blue show the location of the vertical profiles for Fig 3.

Results

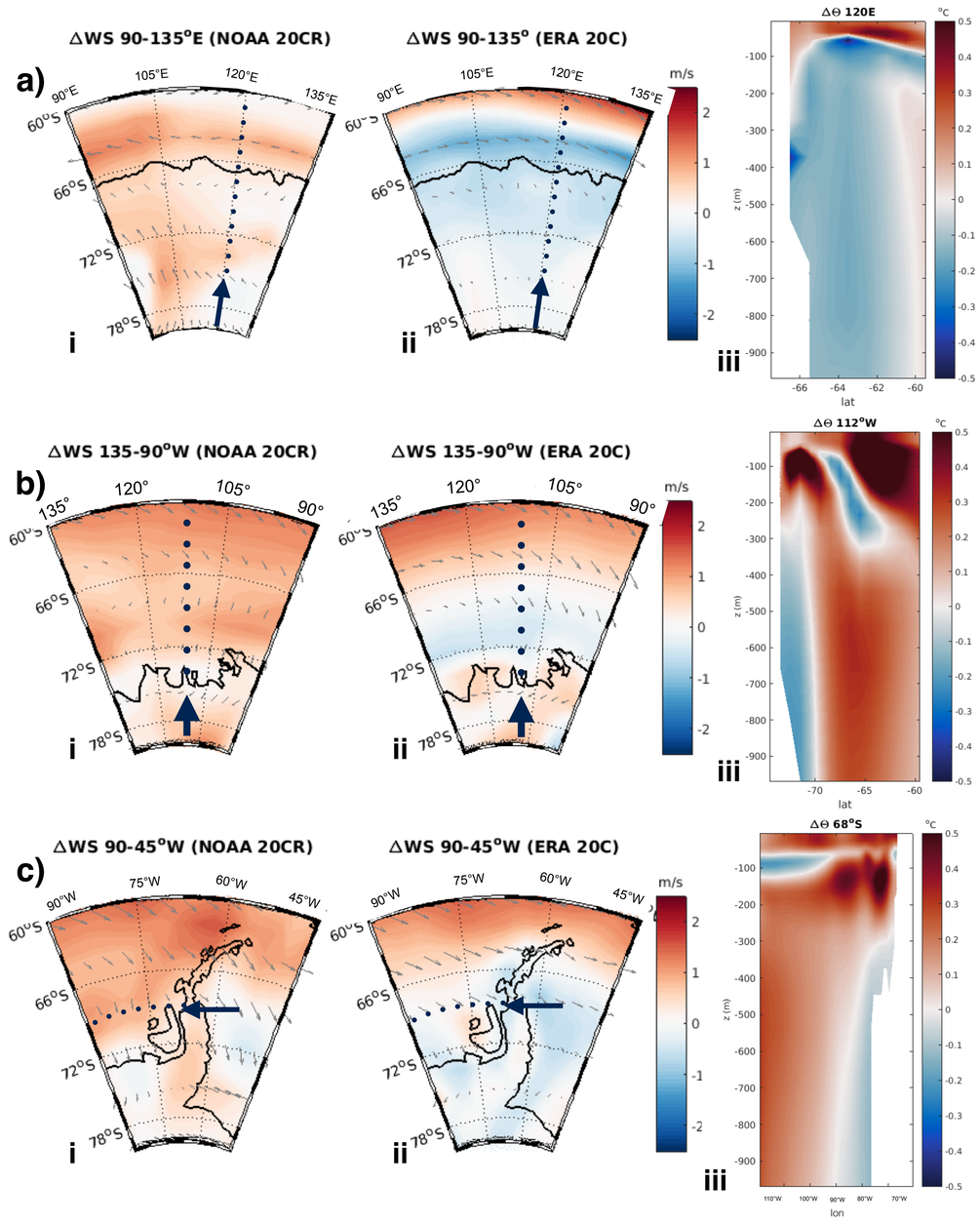


Fig 3: Regional ΔWS for NOAA 20CR (i) and ERA 20C (ii) , along with Θ vertical profiles (iii) at Wilkes Glaciers (120°E) (a), Amundsen Sea (112°W) (b) and Western Antarctic Peninsula (68°S) (c). Places are the same as those studied by Spence et al. (2014). Overlaid on (i) and (ii) are ΔWS in grey vectors, plus arrows and dotted lines in navy blue show the location of the vertical profiles (Fig 2 also shows these locations).

Summary

- SAM_{index} has shown positive trends during the 20th Century, especially after 1975;
- ΔWS is different between the reanalysis, but both show an increase in WS at latitudes northwards of 60°S. According to SAMxWS correlation, ERA20C seems to represent better the pattern expected;
- The potential temperature at 120°E is increasing at the surface and the inverse deeper than 100m;
- At the Amundsen Sea and Western Antarctic Peninsula, the ocean is warming resultant to (Spence et a., 2014):

ANTHROPOGENIC INFLUENCES
↓
SAM_{index} ++
↓
Westerlies winds ~60°S ++
Easterlies coastal winds --
↓
Ekman transport --
Ekman pumping ++ (“upwelling”)
↓
Antarctic Slop Front shoals
↓
Advection of warm waters in subsurface

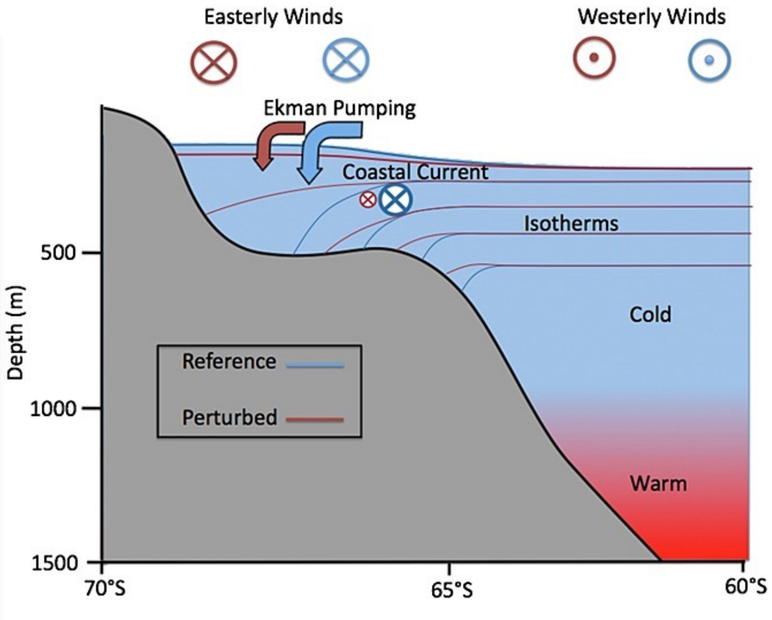


Fig 4: Schematic subsurface warming due to wind speed changes related to SAM_{index} increase. From Spence et al., 2014.

Acknowledgments

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References

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