Link between wind and temperature and sea condition in Estern Antarctic Peninsula

Liliana Margonari & Sebastian Marinsek
Universidad de Buenos Aires, FCEyN, Argentina. Instituto Antártico Argentino, Buenos Aires, Argentina
✉ *lilo.margonari@gmail.com*

ABSTRACT

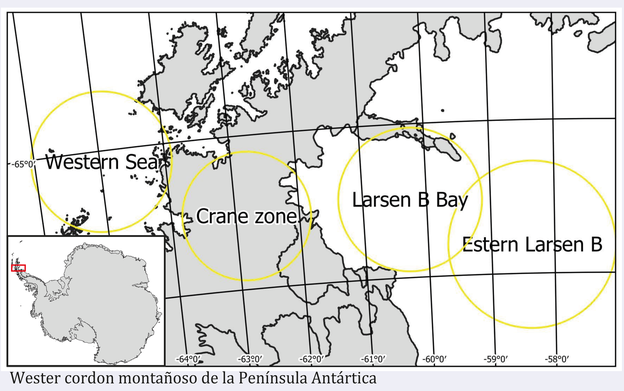
After the Larsen B collapsed in 2002, the landfast sea ice formation on shore of Larsen B Bay has been very variable. Between the summers of 2002 and 2012, the sea ice formation was variable. In the summers of 2004, 2005, 2006, 2007, 2009 and 2011, sea ice formed during the previous winters, fragmented and almost completely disappeared, while in the summers of 2003, 2008 and 2010 sea ice remained stable and in contact with the shore. During the summers of 2012 to 2021 inclusive, sea ice remained stable except for the formation of a water ponds on the sea ice during the summer of 2016. In January 2022 the sea ice breakup began, and although it was regenerated during April 2022, the sea ice was very unstable throughout 2022, and it was not regenerated again until end of April 2023. The surface atmospheric conditions from climate reanalysis ERA-5 developed by European Centre for Medium-Range Weather Forecasts and Temperatures and Positive Degree Days from Marambio Weather Station were analysed, and a good correlation was recognized between the presence of westerly winds and temperature increase in the eastern Antarctic Peninsula. Likewise, a direct relation was found between relatively warm years and the sea ice fragmentation. As a consequence of the sea ice break up the outlet glaciers have become more unstable, and retreated by calving, as well as their glacier fronts exposed to the sea waves. The sea ice condition is expected to continue in this context of climate change, with probably major implications in future freshwater reserves. nt weather

With global warming, Antarctic is warming. Ice shelves, sea ice and glacier are too susceptible to warm. Between 1990s and 2000s several ice shelves was collapsed. When ice shelves or landfast sea ice breakup occurs glacier destabilizes looking a new equilibrium.

The Intergovernmental Panel on Climate Change (IPCC, 2021) reported that anthropic activities, mainly through greenhouse gas emissions, caused an unequivocal increase in global average surface temperature of **1. °C** in 2011-2020 above the average during 1850-1900.

ZONA DE ESTUDIO

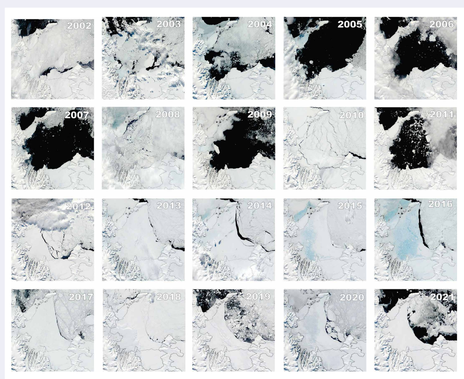
4 sectores fueron definidos para estudiar por sepado las condiciones atmosféricas



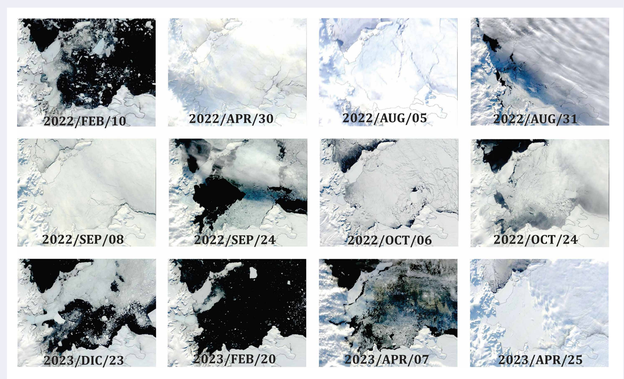
Wester cordon montañoso de la Península Antártica
Around Crane Glacier (actual glaciar en estudio a detalle)
Ensenada de Larsen B
Sector oriental de la ensenada de Larsen B

SEA ICE CONCENTRATIO (SIC) - LARSEN B BAY (LBB)

SIC Change
2002-2021 summers

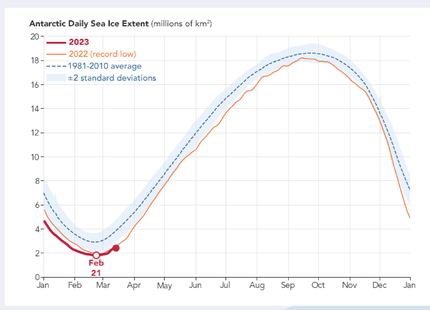


SIC Change
2022/FEB - 2023/APR



summer	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
min. SIC	[8/10]	[2/10]	[0/10]	[1/10]	[1/10]	[9/10]	[1/10]	[9/10]	[1/10]	[10/10]	[10/10]	[10/10]	[10/10]	[10/10]	[10/10]	[10/10]	[10/10]	[10/10]	[10/10]	[2/10]	[0/10]

- During 2001-2011 decade the SIC was highly variable.
- During 2012-2022 decade the SIC remained stable.
- In 2022 summer the sea ice was fragmented.
- Throughout 2022 the SIC was highly variable.
- The 2023 summer the sea ice was fragmented.

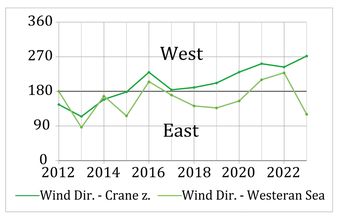


Source:
earth observatory, NASA.

2022 Feb.: Record SIC: 1.965 million km²
2023 Feb.: Record SIC: 1.790 million km²

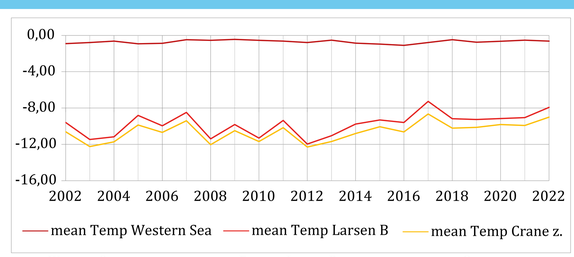
WIND DIRECTIONS

Foehn events imply warm winds (temperatures above 0 °C) coming from West, with a speed greater than 2.85 m/s and humidity below 79%..



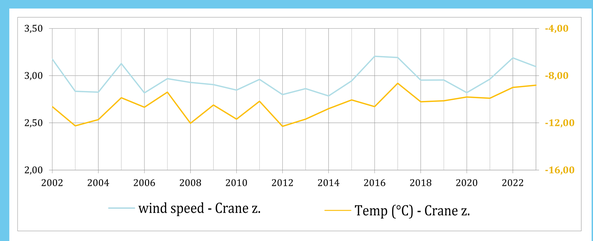
The winds trend to the Eastern AP is similar to Western. After 2021, a predominance of westerlies is maintained.

TEMPERATURES



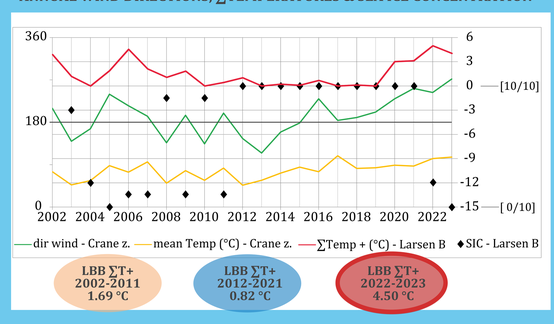
Western Sea	Eastern Larsen B:	Crane zone:
Mean Temp: -0.68 °C	Mean Temp: -9.65 °C	Mean Temp: -10.50 °C
Standar Deviation: 0.21 °C	Standar Deviation: 1.30 °C	Standar Deviation: 1.08 °C

WIND SPEED AND TEMPERATURES



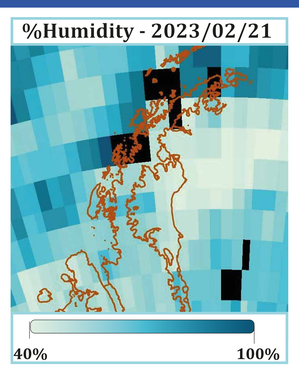
Correlation, $R^2 = 0.4$

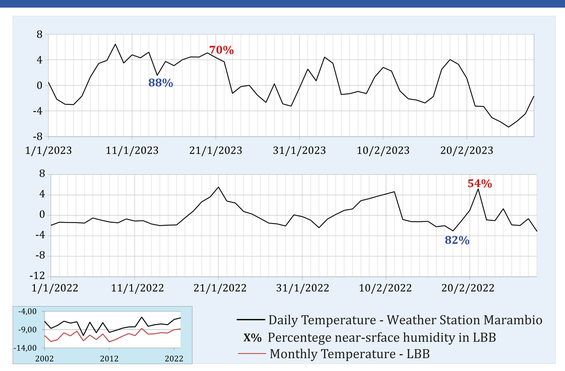
ANNUAL WIND DIRECTIONS, ∑TEMPERATURES & SEA ICE CONCENTRATION



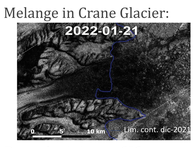
LBB ∑T+ 2002-2011 1.69 °C
LBB ∑T+ 2012-2021 0.82 °C
LBB ∑T+ 2022-2023 4.50 °C

TEMPERATURE & HUMIDITY

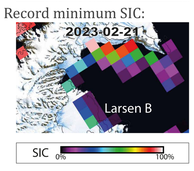




Melange in Crane Glacier:

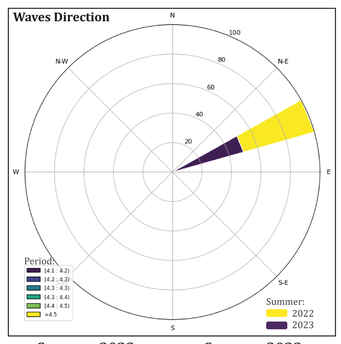


Record minimum SIC:



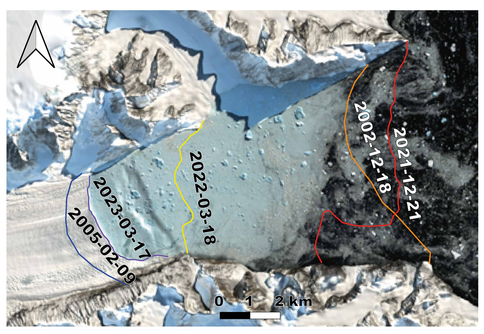
Moist air rises over the western Antartic Peninsula mountain range and then dry and warm air descend down leeward slope heating the eastern Antarctic Peninsula

WAVES



Summer 2022
Direction: 70°
Período: 3,6 a 5 s.

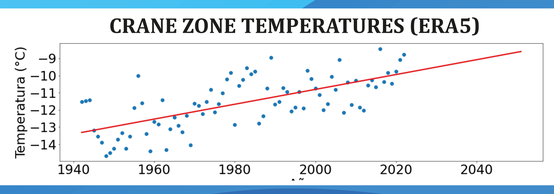
Summer 2023
Direction: 67°
Período: 3 a 5,1 s.



Retroceso del Crane:

From summer 2012 and until January 17th 2022, sea ice remained in Larsen B Bay and Crane Glacier became stable. After that the front glacier receded rapidly.
The sea ice lack implies exposure to eastern swells.
Between 2021-dec and 2022-mar retreat 7km.
Between 2022-mar and 2023-mar retreat 3km.

CRANE ZONE TEMPERATURES (ERA5)



Mean T °C 1942-1962 -12.9
Mean T °C 2002-2022 -10.5
Predicted T °C 2050 -8.5

The warming evidence is clear; the IPCC reported an increase of 1.1 °C in the decadal average of 2011-2020 compared to 1950-1900. We recorded an increase of 2.4 °C in the bidecadal average from 2002-2022 compared to 1942-1962. While the IPCC (using complex models) predicts a 1.5°C rise by 2050, we predict a 2°C rise for the eastern Antarctic Peninsula by taking the linear trend in mean annual temperatures between 1942 and 2022.

CONCLUSION

In Larsen B Bay, east of the Antarctic Peninsula, from the analysis of various remote data, was obtained a relationbetween the front Crane Glacier position and sea ice condition, registering periods of glacial retreat when the landfast sea ice is fragmented and glacier advance when the sea ice formed in winters remains stable. Was obtained a relation between the partial or total disintegration of the landfast sea ice with the positive temperature sum, recognizing that high positive temperature sum generated a greater percentage (or thickness) of sea ice disintegration. On the other hand, we recognized the foen winds appearance generates higher temperature conditions to the eastern PA, promoting the sea ice disintegration, leaving the glaciers front exposed to sea waves and ablation by calving, generating larger retreats of the glacial fronts, which implies losses of the freshwater reservoir, changes in the bay salinity and possible changes in the relative sea level.
We infer, if the climatic conditions continue their current course, there will not only be consequences for the glacial masses, also negative consequences for other surrounding environments and ecosystems could will occur.