Regional climate model simulations for the Antarctic Peninsula: Comparing and contrasting with observed climate variability

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What do we look for with this project?

Generate information on climate projections for the Antarctic Peninsula and Chilean island territory through dynamical downscaling for the Antarctic Peninsula and statistical downscaling for the island territory (Rapa Nui and Juan Fernández Archipelago), which will be available on an interactive web platform. This project complements the reginal climate model simulations already carried out for the continental Chile (http://simulaciones.cr2.cl/).

For what?

In order to assess the vulnerability of the Antarctic Peninsula and Chilean island territory to climate change, and support the design of public policies and actions of the private sector, NGOs, and society.

Why do we want to carry out expert round tables and interviews?

To present the objectives of the project and know impressions and expectations about the climatic variables that are considered in the project.

1) Observed climate variability in the Antarctic Peninsula

- Temperature
- Precipitation
- Sea-ice
- Physical reasoning

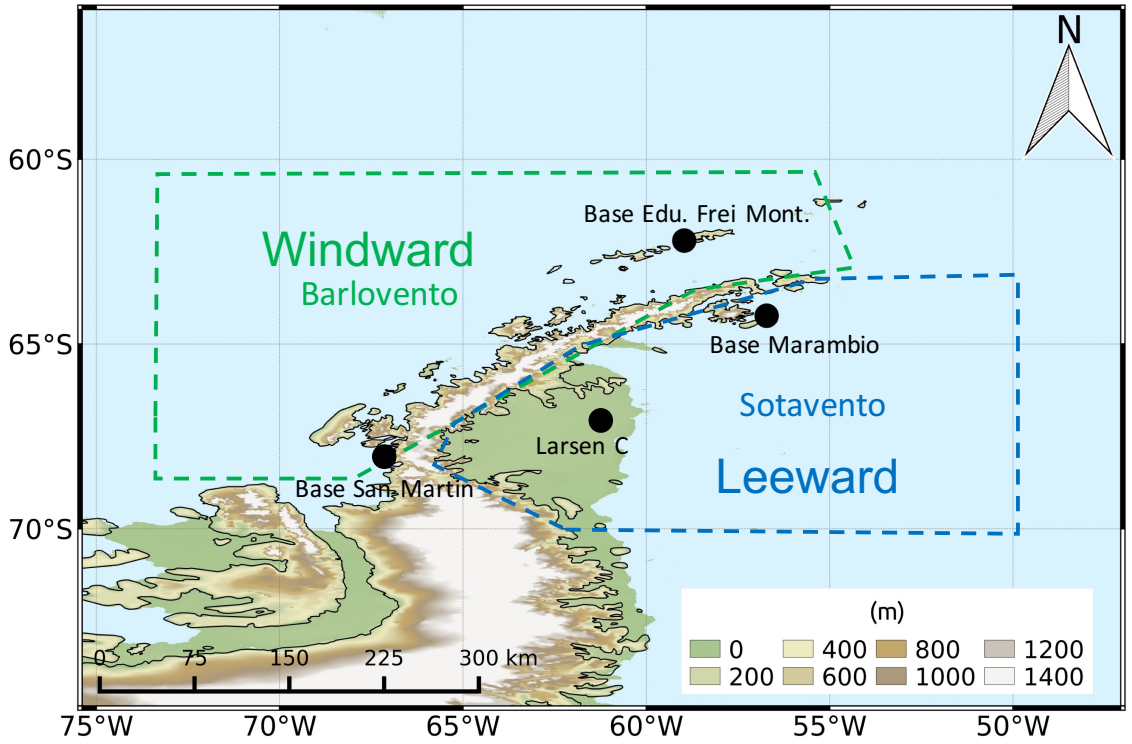
2) Evaluation of regional climate simulations

3) Climate projections in the Antarctic Peninsula

- Temperature
- Precipitation
- Sea-ice

4) **Visualization platform**

Observed climate variability in the Antarctic Peninsula



An analysis of the recent climate variability of the Antarctic Peninsula using meteorological stations, reanalyses and satellite products (1990-2015):

- Temperature
- Precipitation
- Sea ice

Data	Source	Variable	Temporal resolution	Spatial resolution
Stations	Chilean Meteorological Service, British Antarctic Survey and Global Historical Climate Network Daily	Precipitation, Temperature	Monthly	
ERA5	The European Centre for Medium-Range Weather Forecasts (ECMWF)	Precipitation, Temperature Sea level pressure, Zonal wind, specific humidity	Daily, Monthly	0.28x0.28 (~30 km)
ERA-Interim	The European Centre for Medium-Range Weather Forecasts (ECMWF)	Precipitation, Temperature	Daily, Monthly	0.75x0.75 (~80 km)
NOAA/NSIDC	NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 3	Sea ice concentration	Monthly	0.25x0.25 (~27 km)

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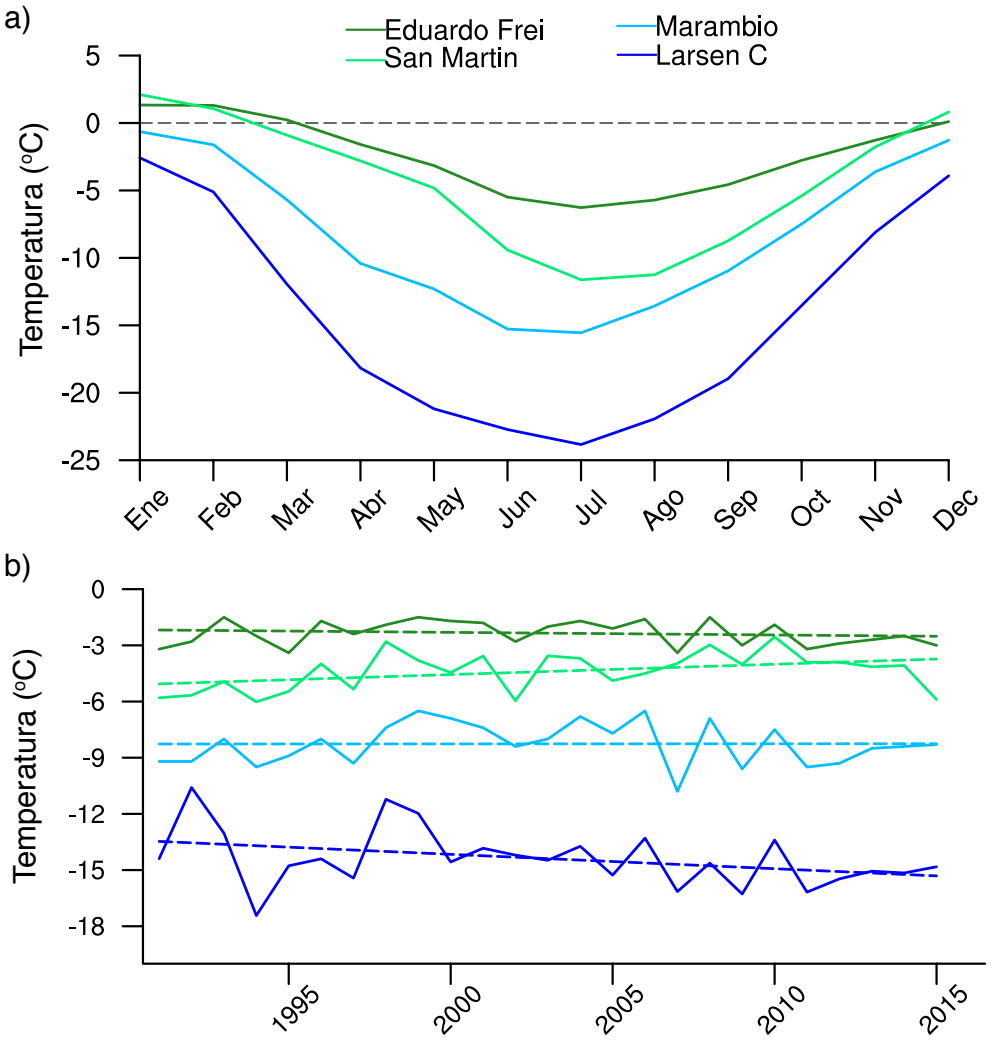
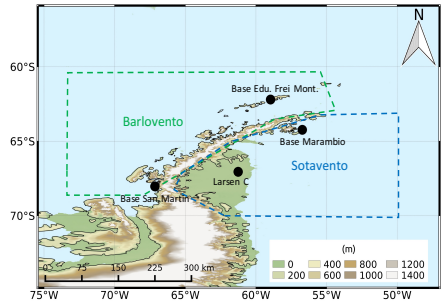
Observed climate variability in the Antarctic Peninsula

Temperature





- A cooling trend in the leeward part in the period 1991-2015 (-1.8°C in the station of Larsen C station).
- On the other hand, the central part of the windward peninsula shows a warming trend in the same period (+1.32°C at the San Martín station).

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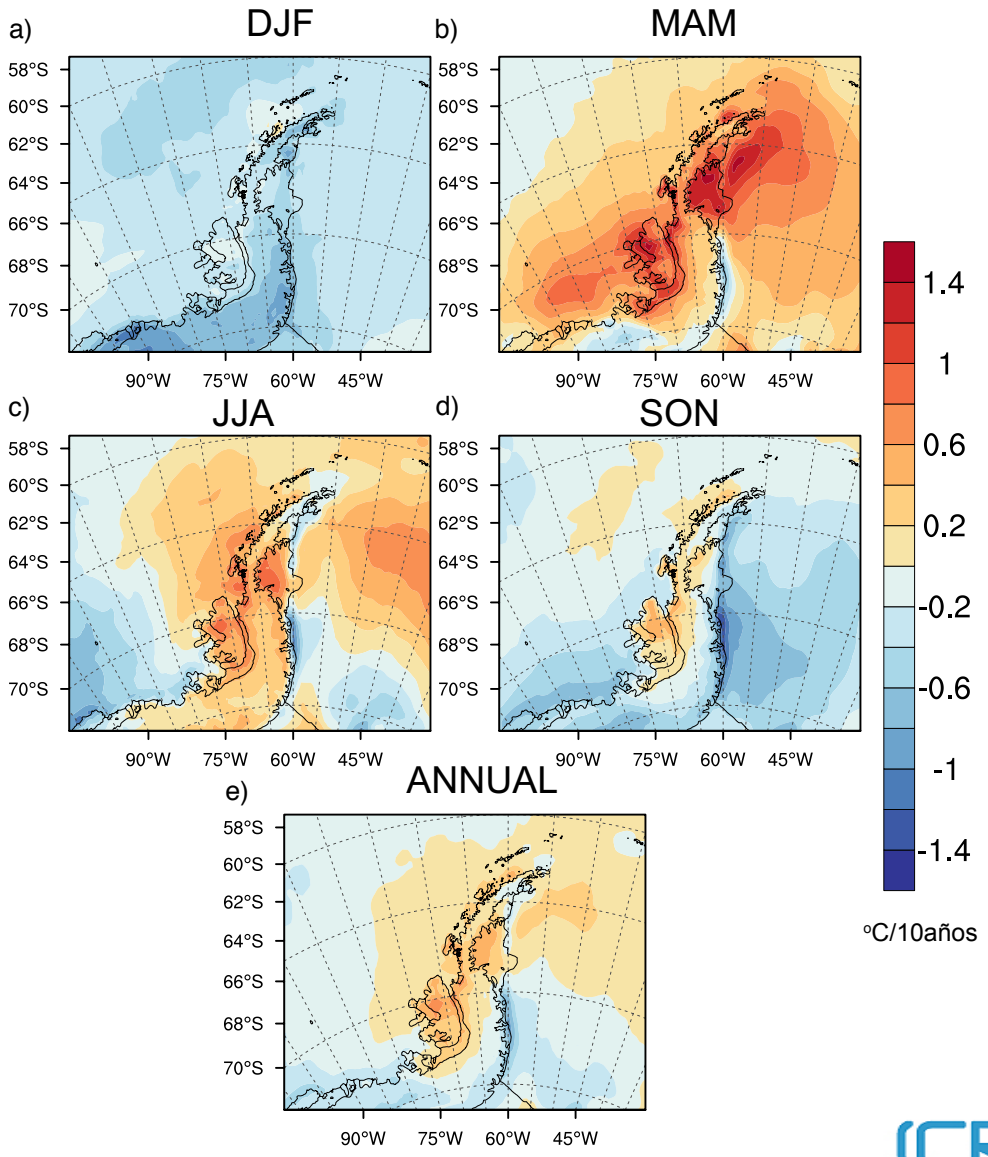
Observed climate variability in the Antarctic Peninsula

Temperature

ERA5

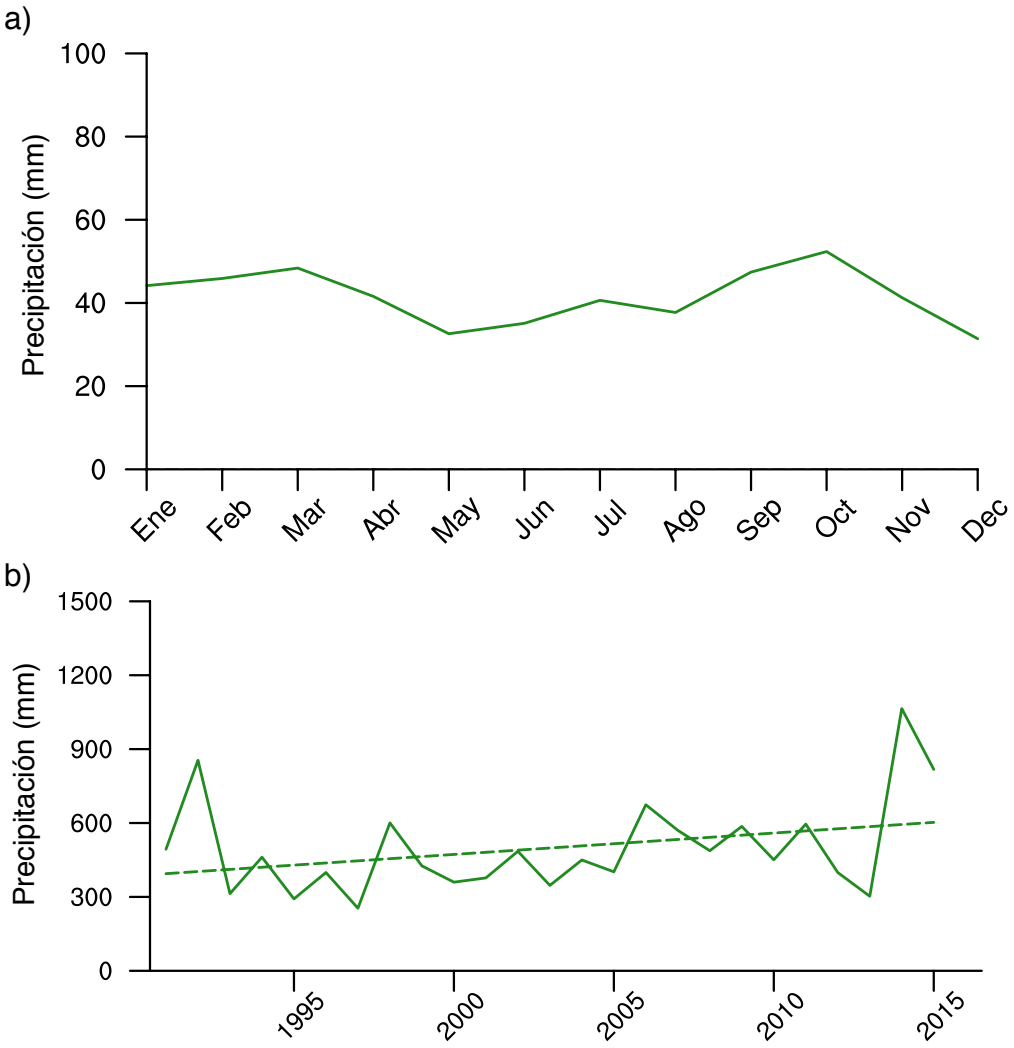


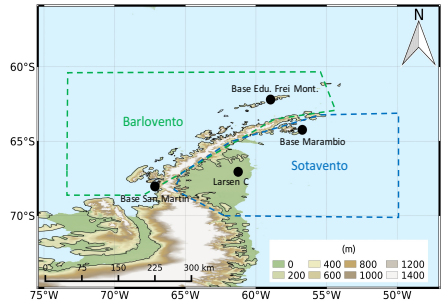
(1991-2015)

- In summer, almost the entire peninsula indicates a cooling trend (-0.2ºC to -0.6ºC / 10 years) while there is a marked warming trend in autumn, especially in the leeward part (+0.6ºC to +1.4ºC)/10 years).
- In winter, a general warming trend dominates over the windward part of the northern peninsula, in the same way, Larsen C, to leeward, also experiences a warming trend (~ +0.6ºC /10 years).

Observed climate variability in the Antarctic Peninsula

Precipitation



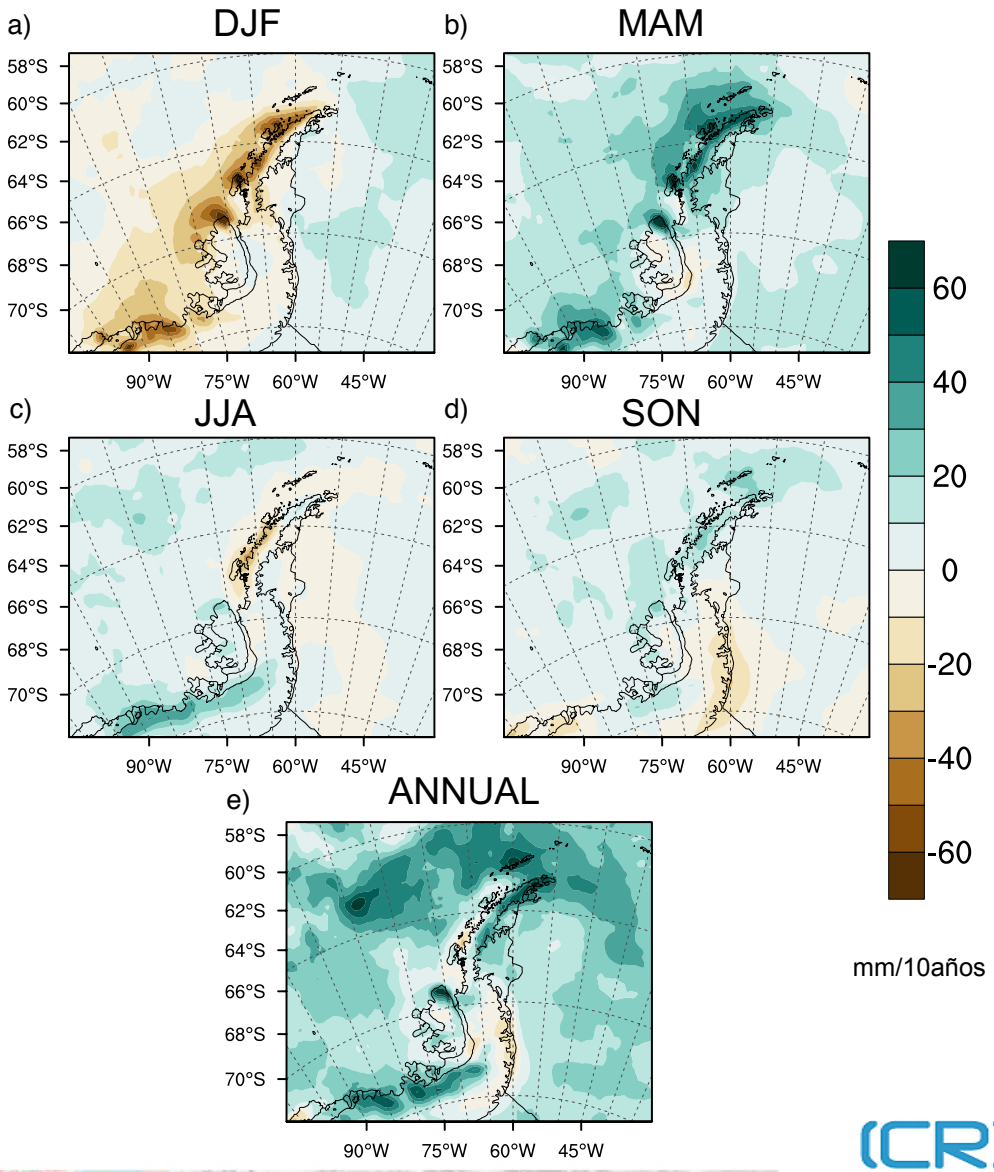


- The precipitation record at the Eduardo Frei Base indicates an increase in precipitation during the period 1991-2015 (~ +200 mm). This increase is more pronounced in recent years.

Observed climate variability in the Antarctic Peninsula

Precipitation

ERA5



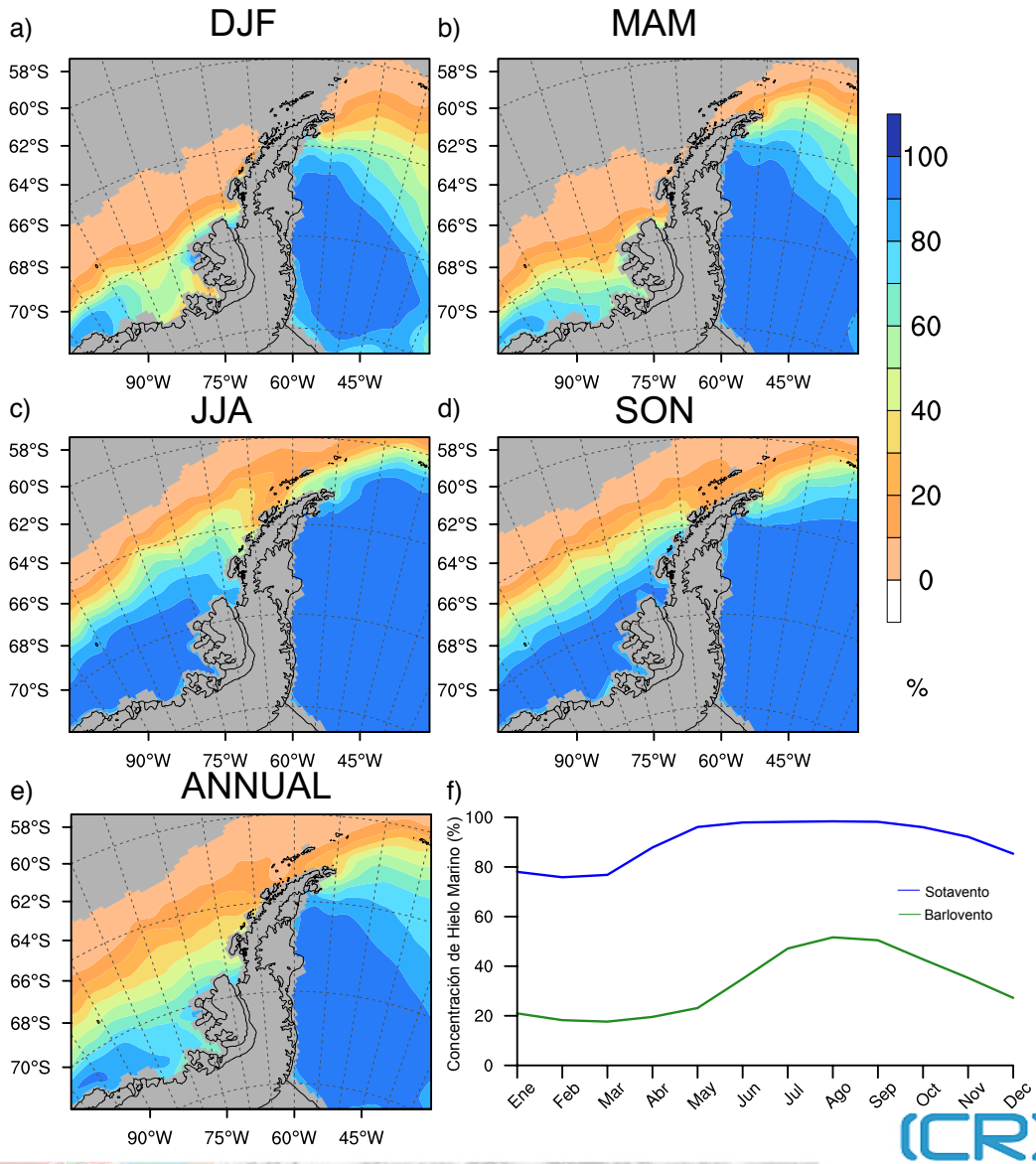
(1991-2015)

- The most notable differences in the precipitation trend occurs in summer and autumn.
- In summer, there is a marked decrease in precipitation along the windward side of the peninsula (-40 mm to -60 mm/10 years).
- On the other hand, in autumn, precipitation tends to increase in almost the entire domain, particularly in the north of the peninsula (+40 to +60 mm/10 years).

Observed climate variability in the Antarctic Peninsula

Sea ice

NOAA/NSIDC



- The maximum concentration of sea ice is reached during the period from May to September (~ 90%), whereas the month of February is the lowest one that registers a minimum of sea ice (~ 75 %) on the leeward slope.
- The windward slope reaches its maximum concentration values in August (~ 50%), while March has the lowest values of sea ice concentration (~ 20%) on the windward slope.

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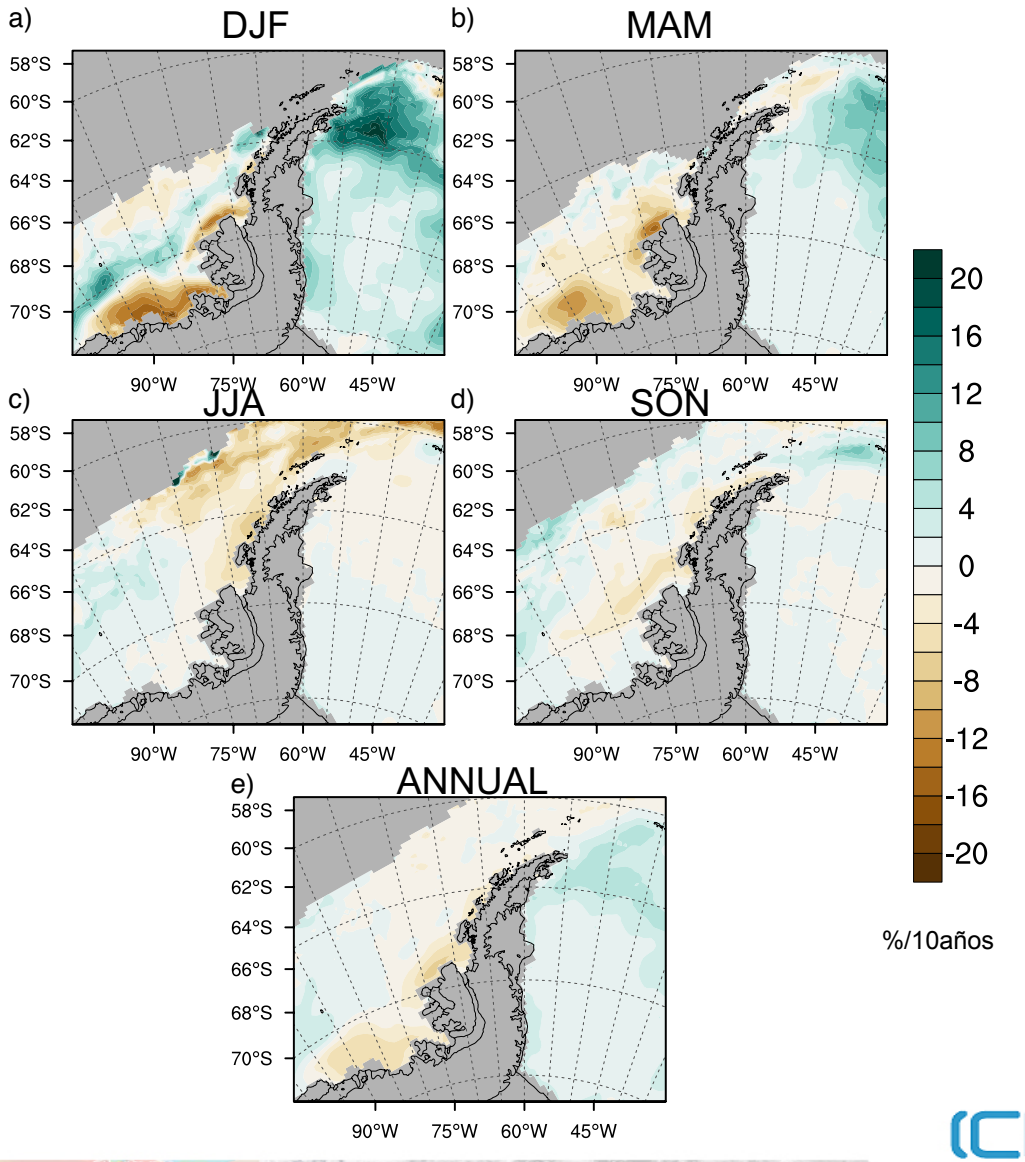
Observed climate variability in the Antarctic Peninsula

Sea ice

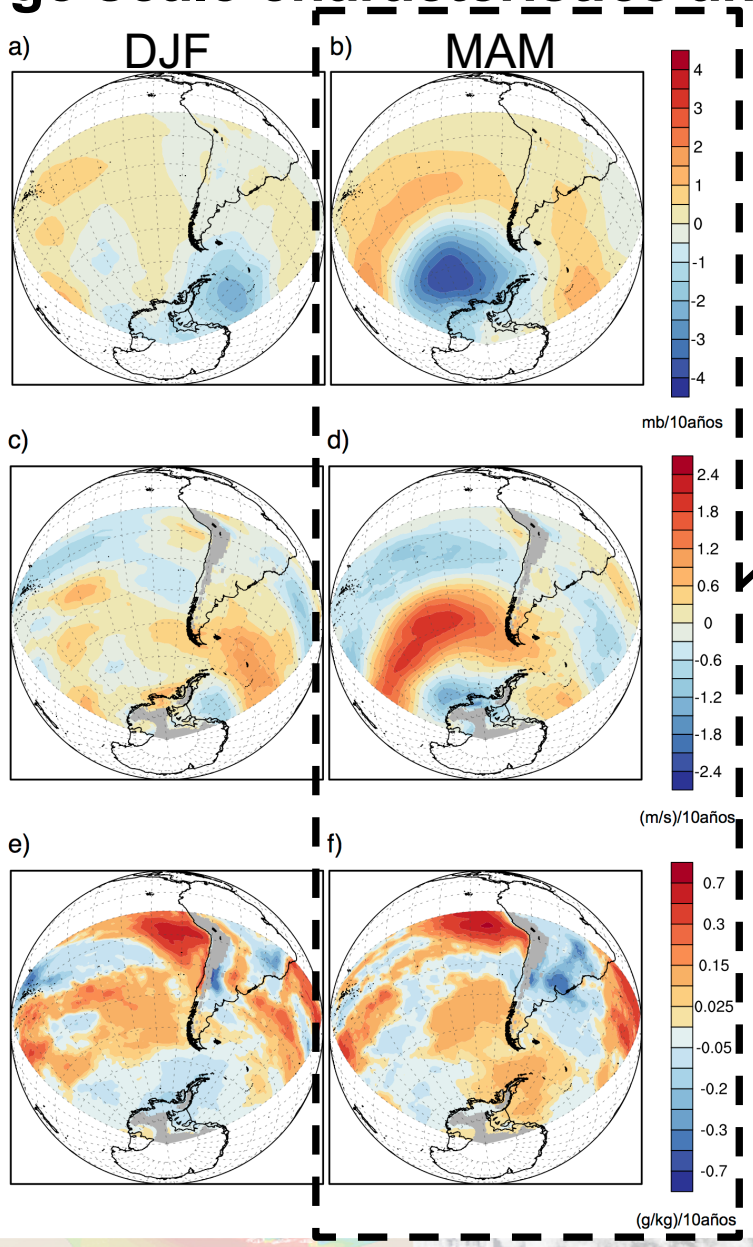
NOAA/NSIDC

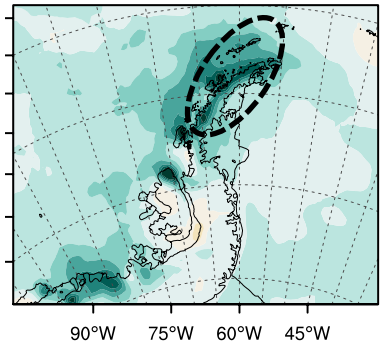


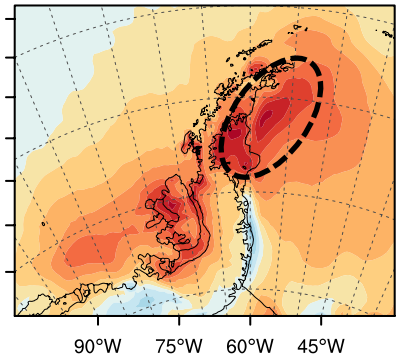
(1991-2015)

- An increase in each season, except in winter. In particular, in summer, the concentration of sea ice tends to increase notably off the leeward coasts of northern peninsula (+20%10 years)
- The windward slope, on the other hand, shows a general downward trend that is more pronounced in autumn and winter

Large scale characteristics and physical reasoning of the observed changes







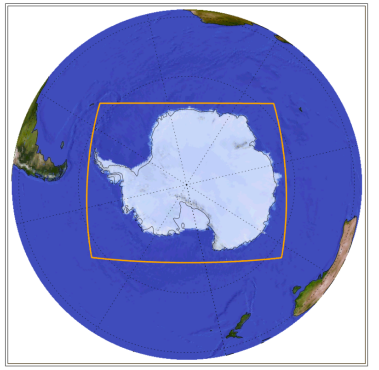
Foehn type warming?

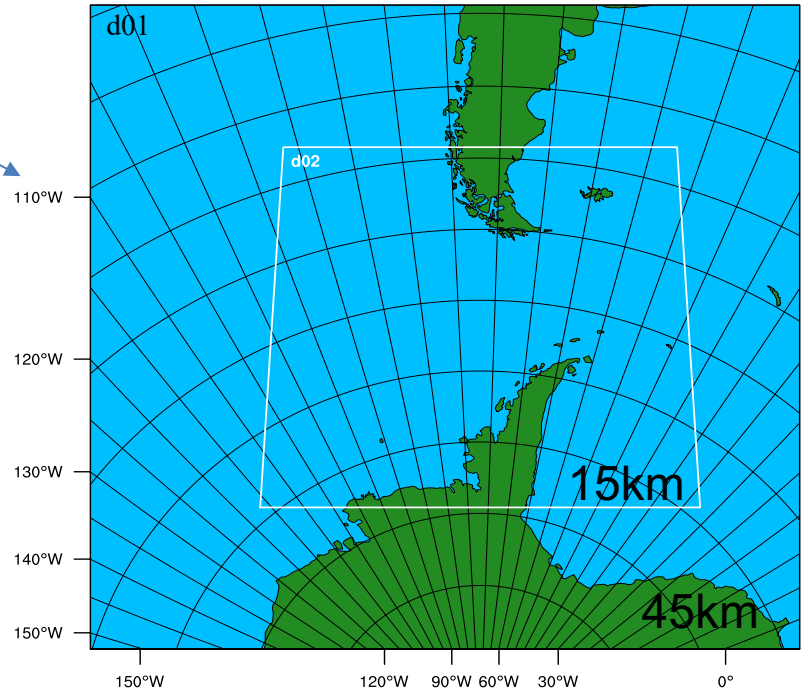
It is likely that these observed changes are associated with changes in large-scale circulation patterns. In particular, low-pressure centers at sea level in the Amundsen / Ross Sea sector and in the Weddell Sea sector tend to have an important role in the trends observed in the peninsula.

Evaluation of regional climate simulations

- Temperature
- Precipitation
- Sea ice

Simulation	Border Conditions	Spatial Resolution	Period
CORDEX (KNMI-RACMO21P-ERAINT)	ECMWF-ERAINT	0.44 ° x 0.44 ° (~50 km)	1979-2012 (1991-2012 for the evaluation)
PWRF-ERAINT	ECMWF-ERAINT	0.4 ° x 0.4 ° (~45 km) 0.13 ° x 0.13 ° (~15 km)	1989-2015 (1991-2012 for the evaluation)





PWRF

Microphysics	Morrison
Radiation	RRTMG
Land Surface	Noah-MP
Planetary Boundary Layer	MYJ
Cumulus	Grell-Freitas

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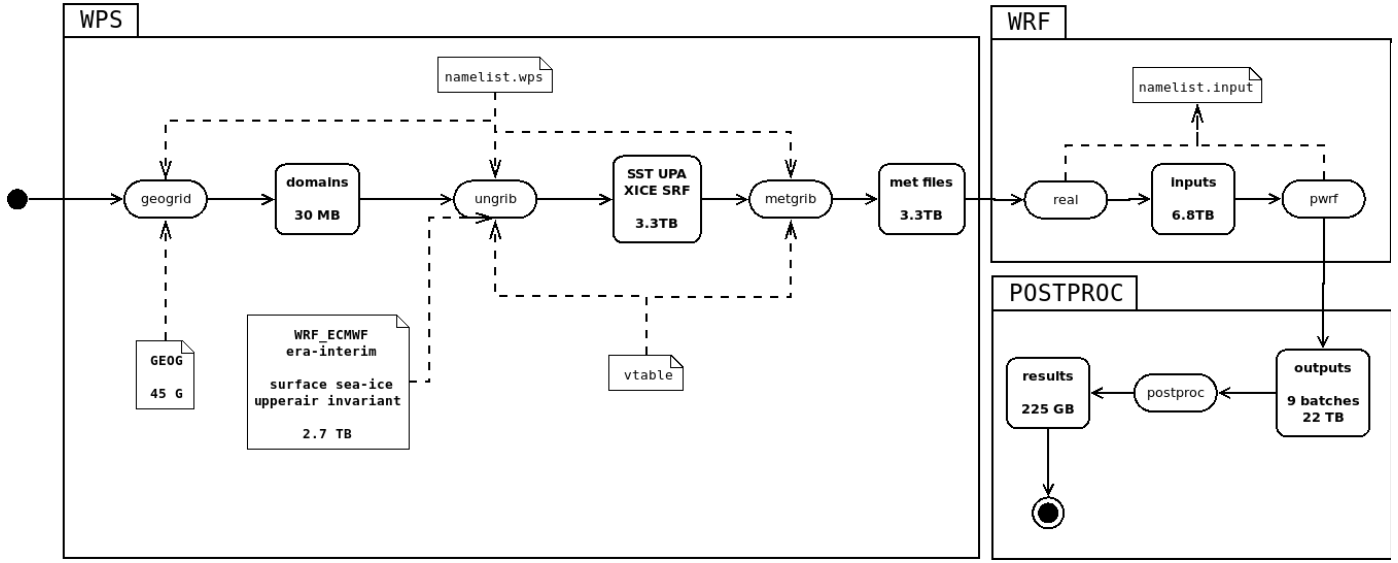
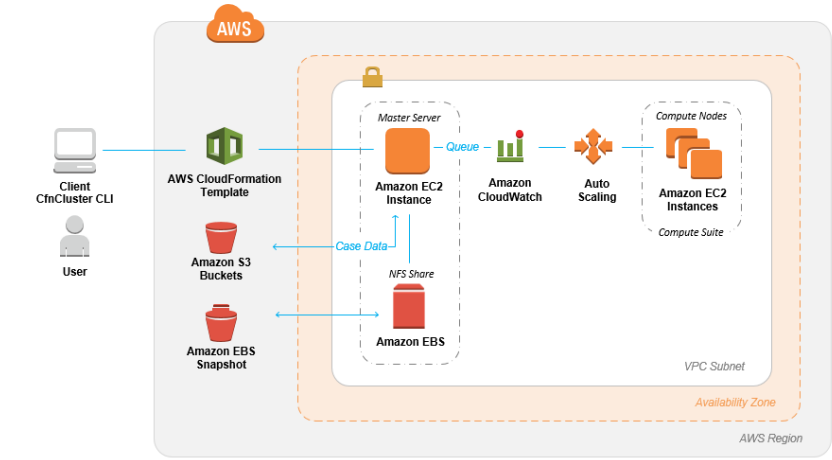
Evaluation of regional climate simulations

PWRF-ERA-Int



AWS High Performance Computing

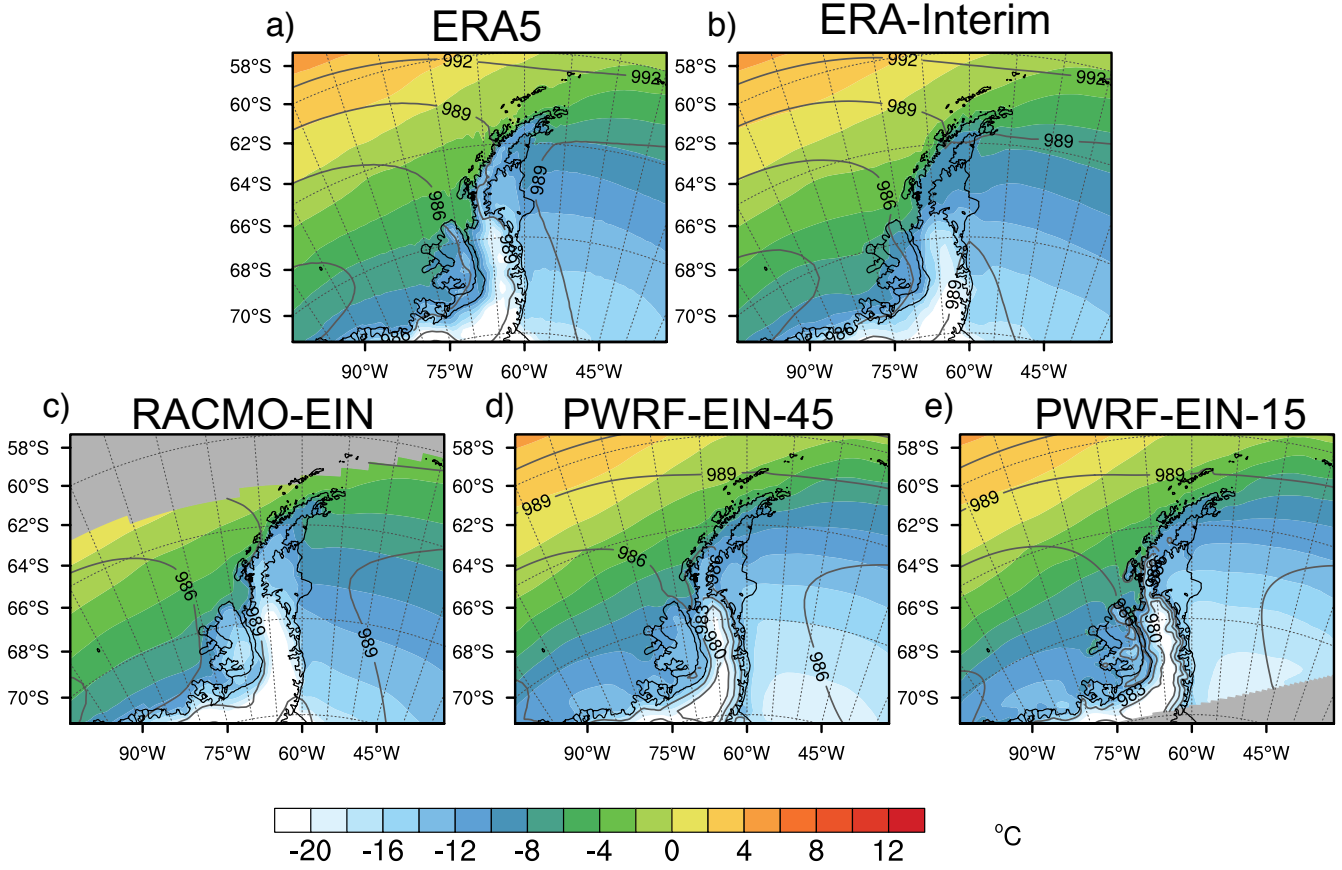


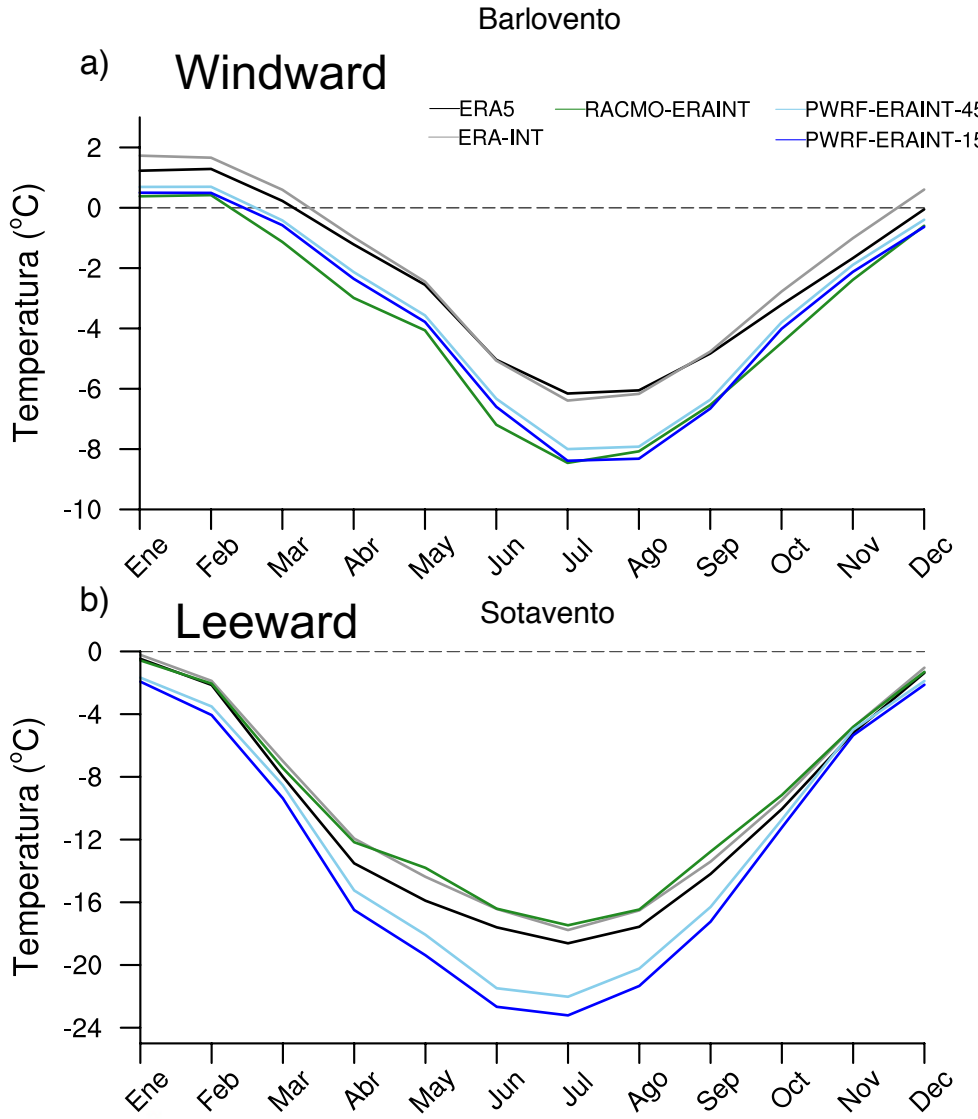
AWS Reference Architectures

- Elastic Compute Cloud (EC2), c5n.18xlarge
- 3 Elastic Block Storages (EBS, 16 TB each)
- 360 cores (10 computing nodes of 36 cores each)
- 3 years of batches (~5.5 days, 2.4 TB), in total, 9 batches generated 22 TB of data, which were reduced to 225 GB of final results.

Evaluation of regional climate simulations

Temperature





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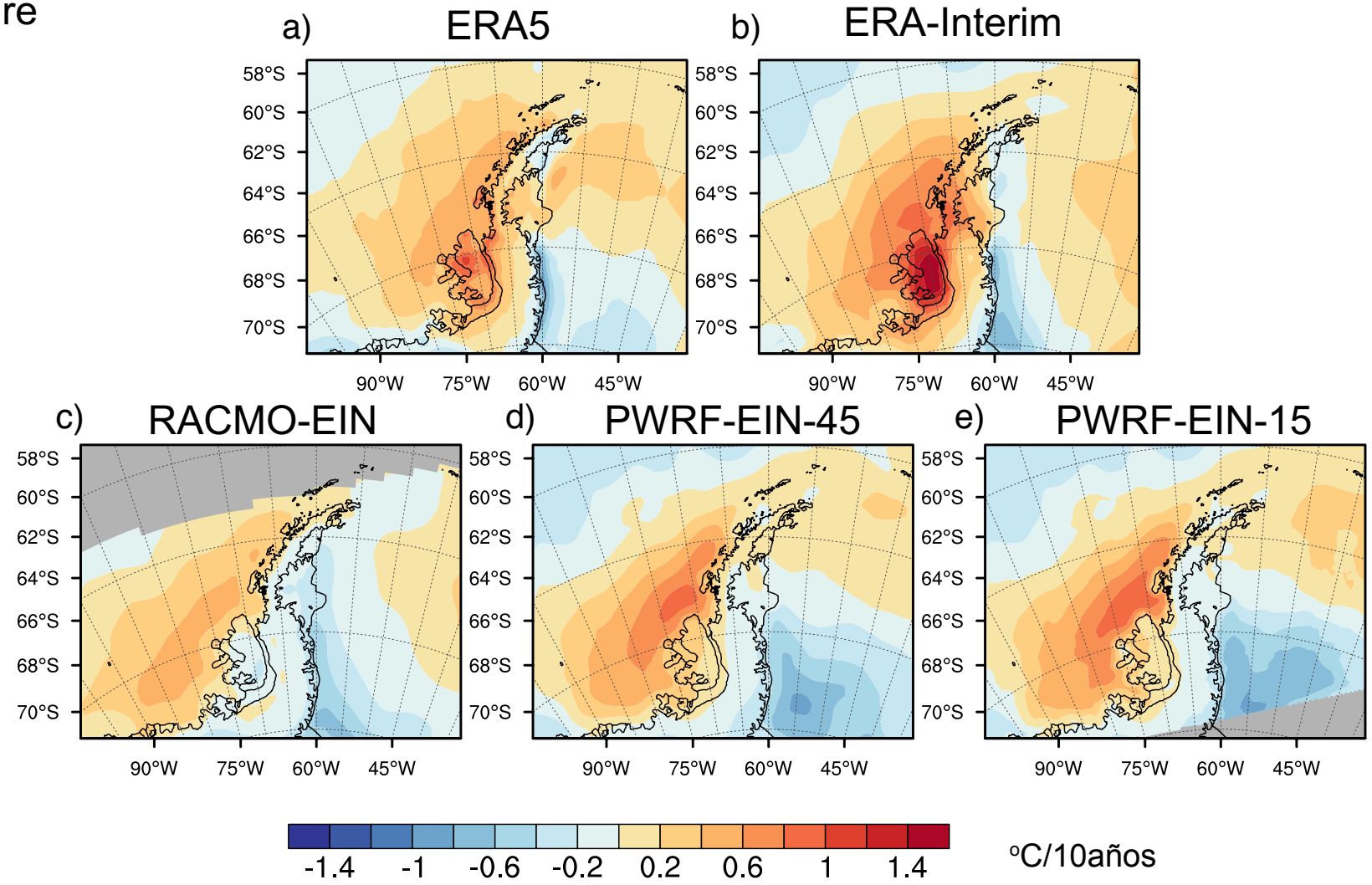
Evaluation of regional climate simulations

Temperature



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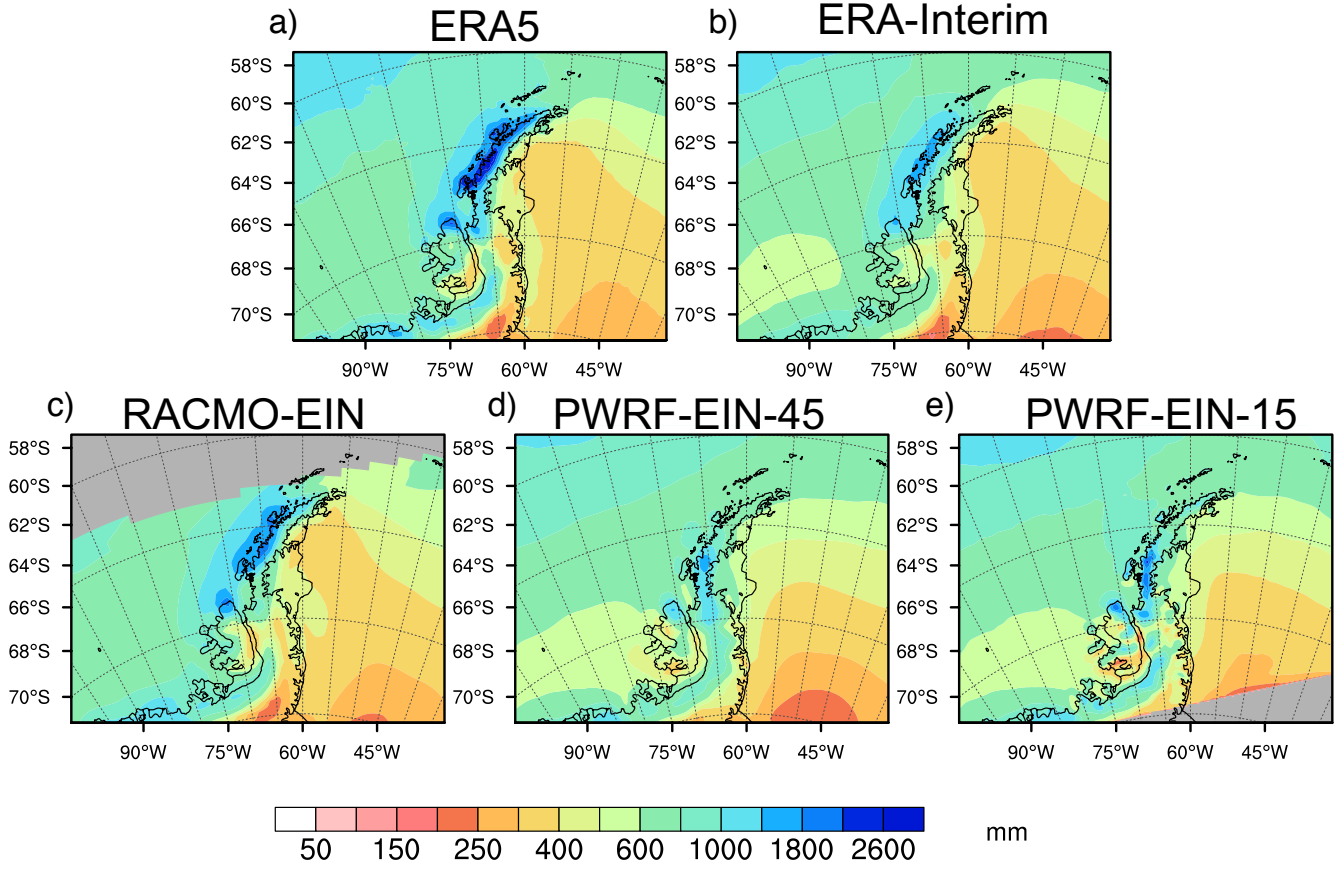
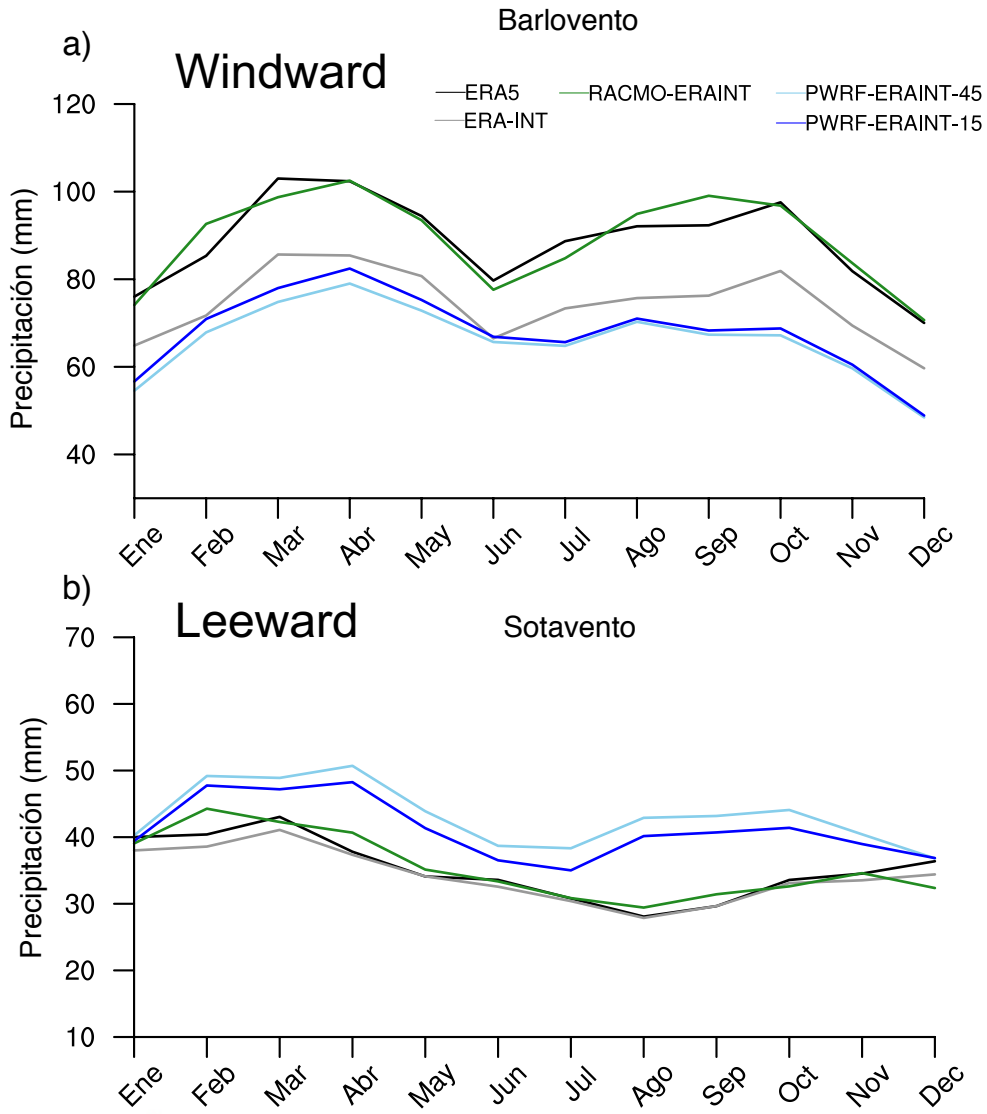
Precipitation





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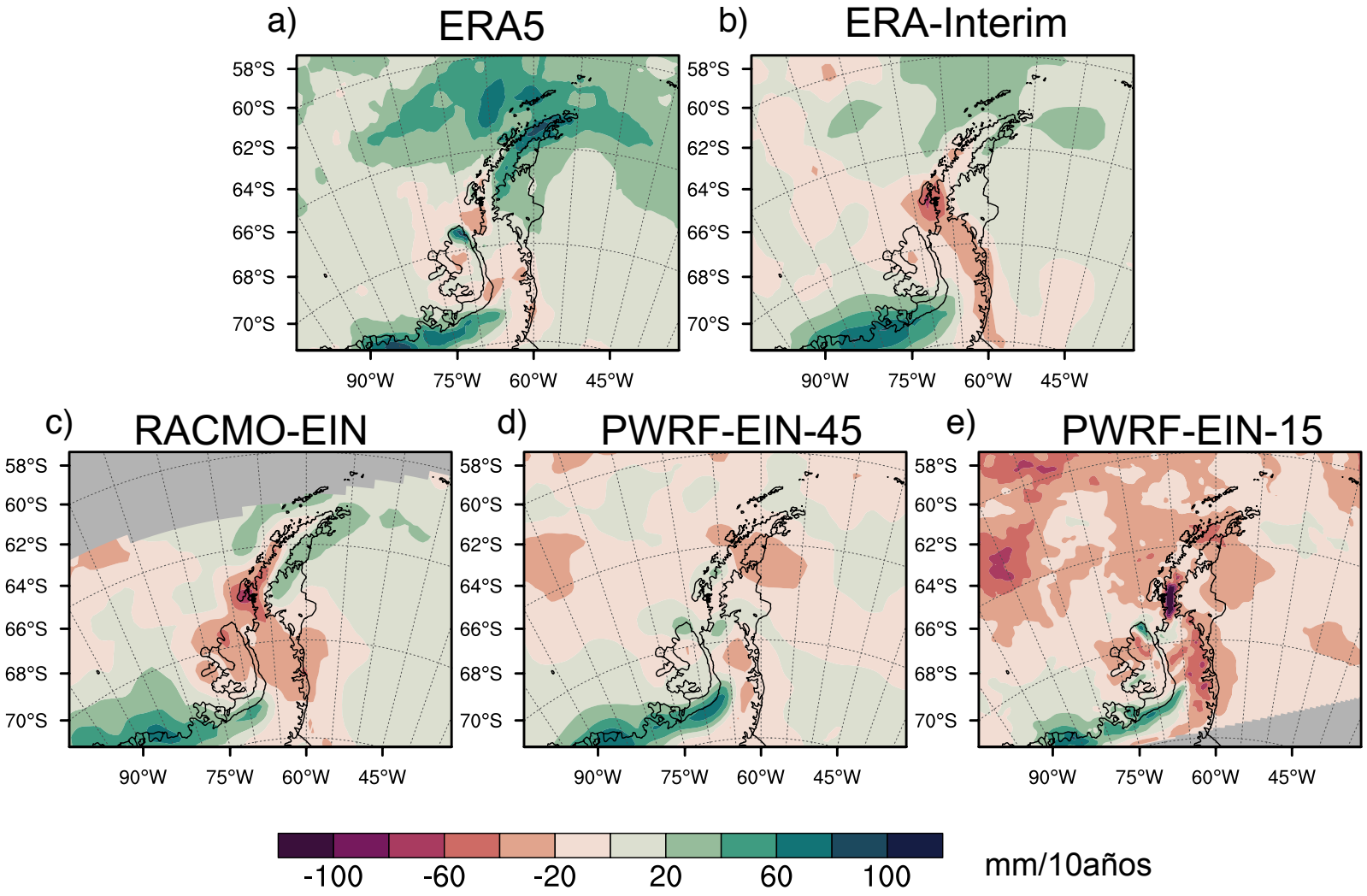
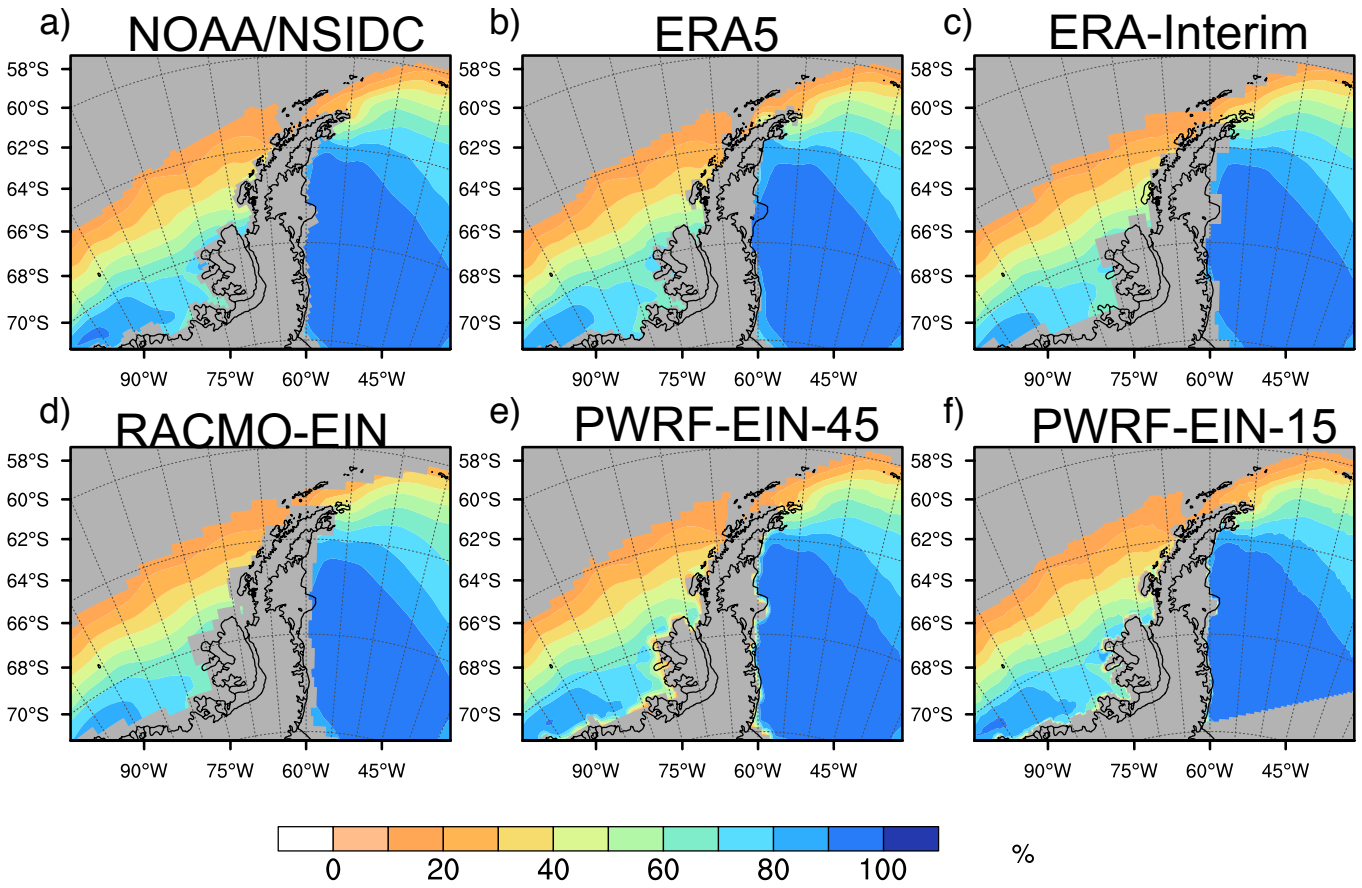
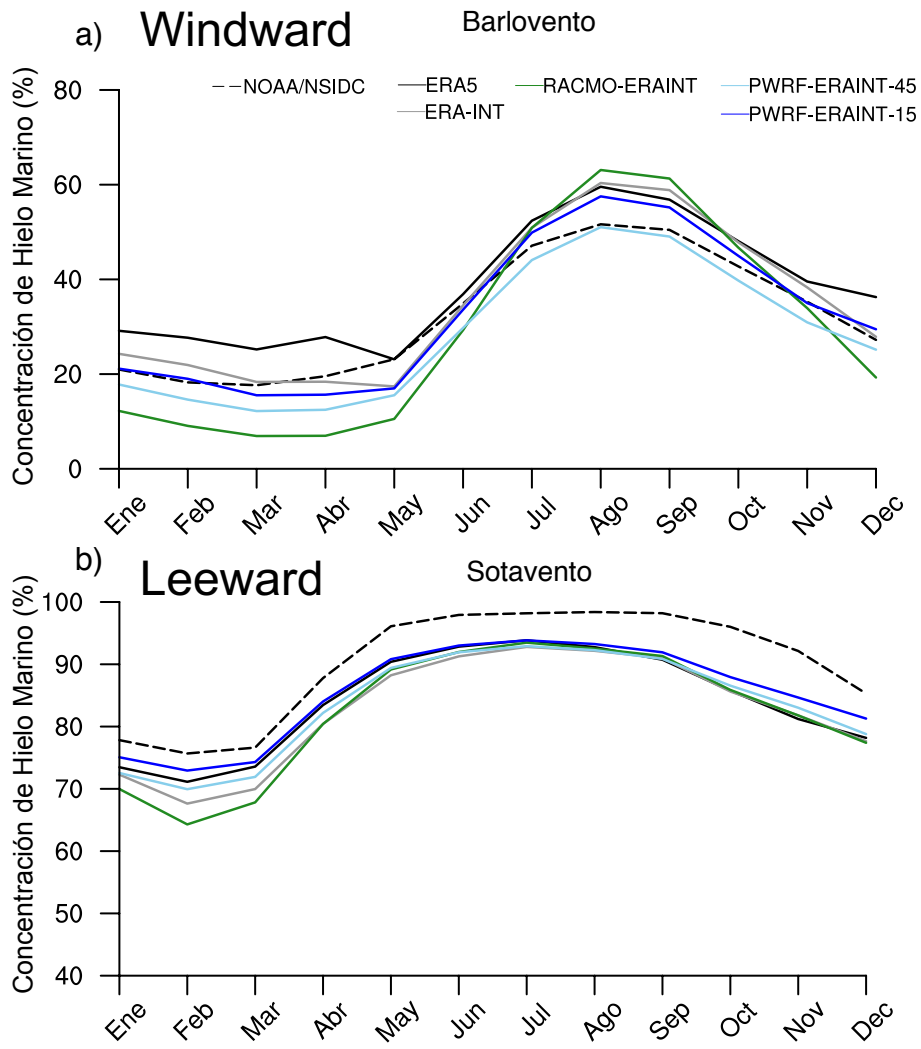


Evaluation of regional climate simulations

Sea ice





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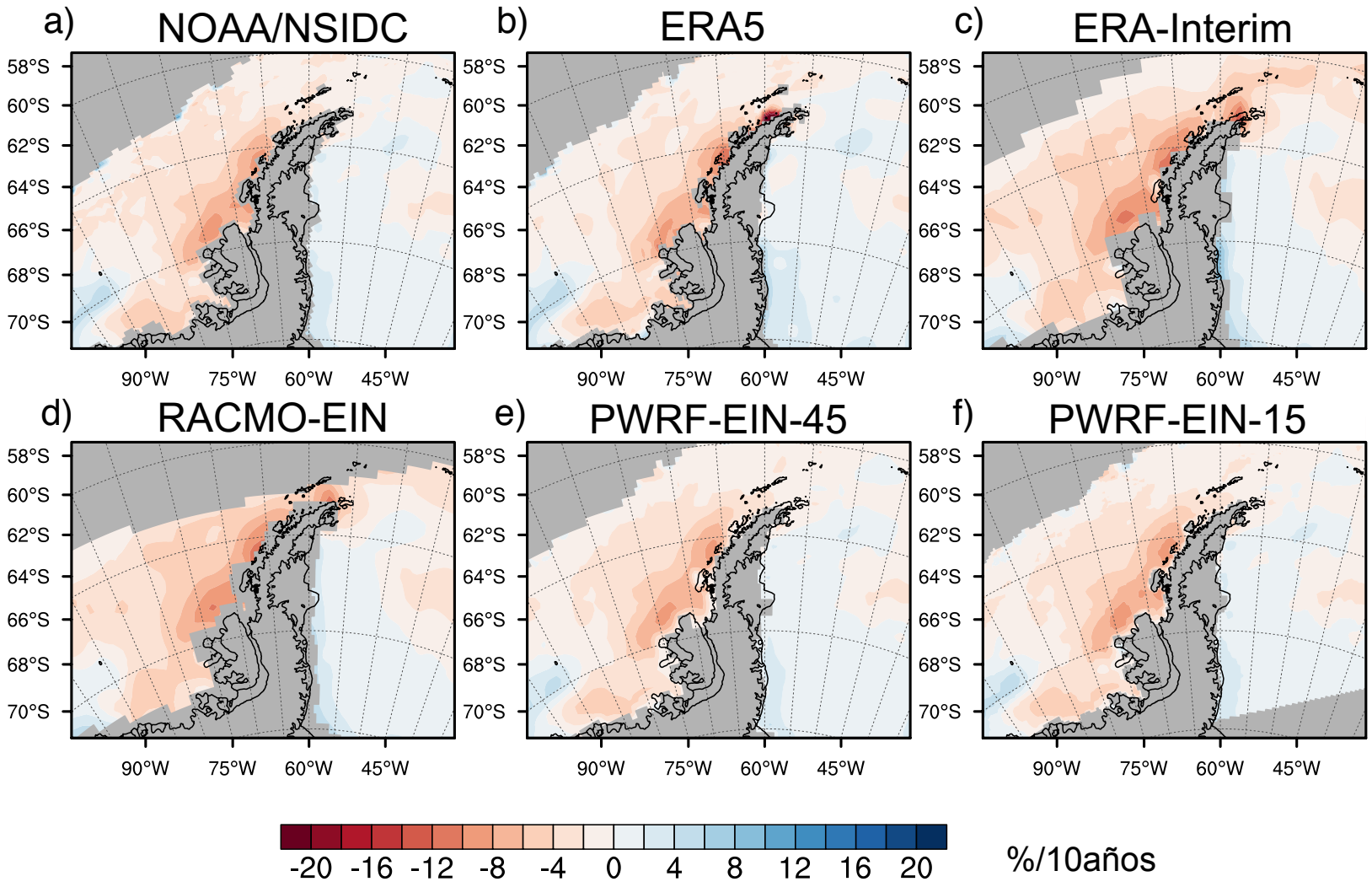


Summary and some discussions

- There are different seasonal trends in temperature, precipitation and sea ice. Particularly, summer and autumn seasons show important differences.

- Central parts of the windward peninsula show a marked warming trend and decreased sea ice concentrations.

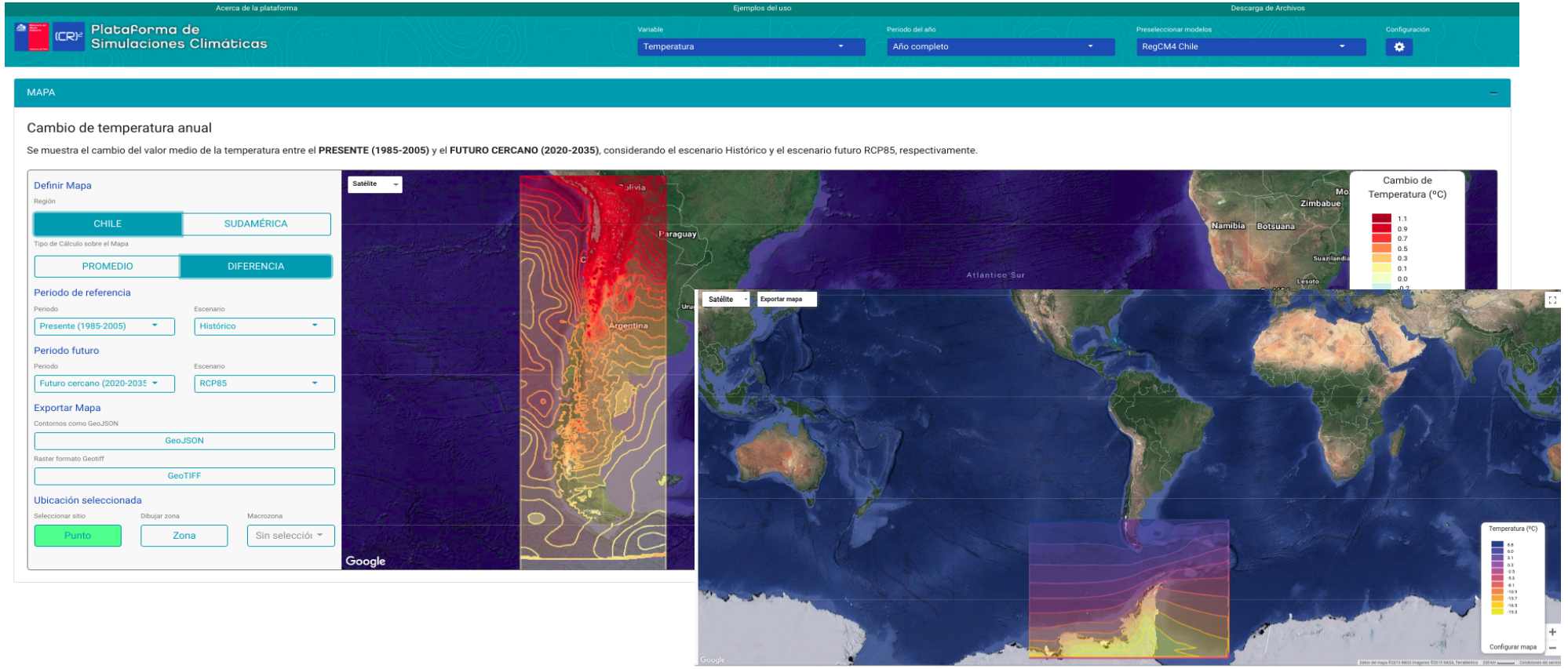
- The synoptic conditioning over the western Antarctica (Amundsen-Bellingshausen Sea Low) and thus, warm and moist air advection towards the Antarctic Peninsula can result in episodic moisture transport and warm air advection events over the Antarctic Peninsula, which eventually cause a warming trend.

- It is likely that seasonal contrasts in the observed trends are dependent on the strengthening phases of the Amundsen-Bellingshausen Sea Low and Weddell Sea Low.

- The observed trend and the climatic characteristics of the peninsula are generally captured by the regional climate simulations (RCMs). However, RCMs show a persistent cooling trend on the leeward side. Furthermore, there are marked differences between the RCMs and reanalyses in representing precipitation trend.

Visualization platform

- Projection: Mercator
- Allows you to see maps of the areas of interest
- Allows analysis of the simulations available for different points and areas



http://simulaciones.cr2.cl

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Ongoing simulations

Experiments	Period	Border Conditions
PWRF-HIST	1976-2005 (Historical)	NCAR-CESM1 (Bias corrected)
PWRF-RCP8.5	2006-2050 (Projections)	NCAR-CESM1 (Bias corrected)

Acknowledgements

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Fitz Roy Massif, El Chaltén, Argentine Patagonia