Ocean – Atmosphere regional coupling to better resolve Sea Ice processes over the Antarctic

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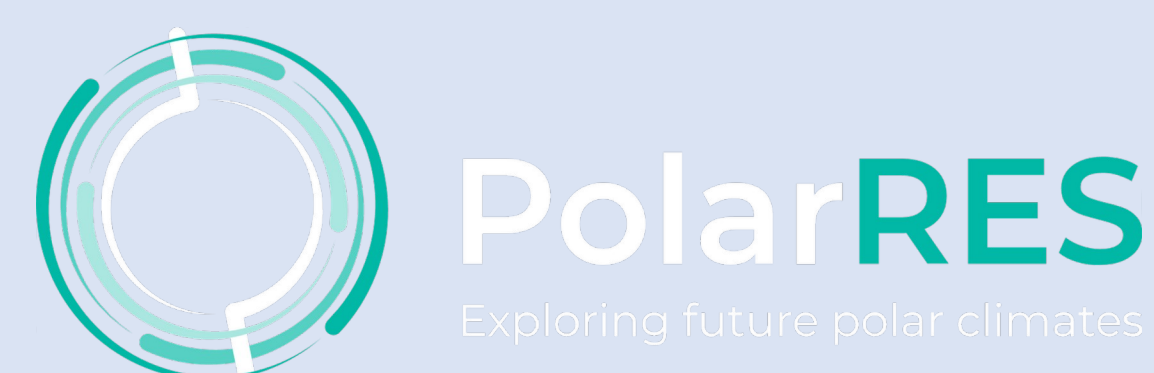
LIÈGE université   IGE Institut des géosciences de l'environnement   PolarRES

Abstract

Understanding the future evolution of the climate in Antarctica is crutial, as the continent holds the potential for a 3-meter rise in sea levels by 2300. However, the Antarctic climate is impacted by various processes and interactions, particularly at the ocean-atmosphere-sea ice interface, which are not fully implemented in Global Climate Models (GCMs). We are developing a high-resolution two-way coupling between the regional climate model MARv3.13 and ocean/sea-ice models NEMO4.2/SI3 to study these processes, such as blowing snow over sea-ice, and their potential impact on future polar climate scenarios selected by the PolarRES consortium. We evaluated the standalone models performance in simulating current climate conditions using various meteorological observations, satellite data, and ship observations. The results of this study are a first step to check the setup before moving to a fully coupled interface, and already show the importance of regional modeling to better resolve specific processes.

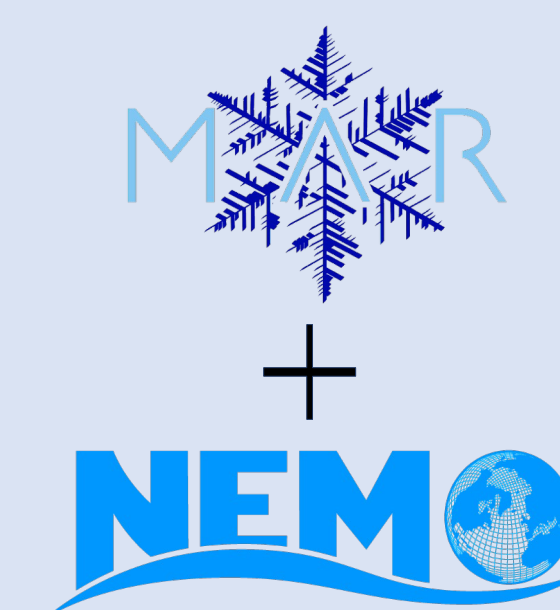## Coupled system simulations

NEMO
- Lastest NEMO 4.2 version
- 1/4° grid up to 55°S
- SI3 module for Sea-Ice dynamics

Oasis
Oasis 3-MCTv5.0 2 way coupling

Surface conditions / Sea Ice extent →

← Atmosphere conditions, Snow transport over Sea Ice

MAR
- Pan-Antarctic 25km resolution
- New 3.13 MAR version with improved radiative scheme

NEMO domain (colored, average SIC) along with MAR domain (solid line)
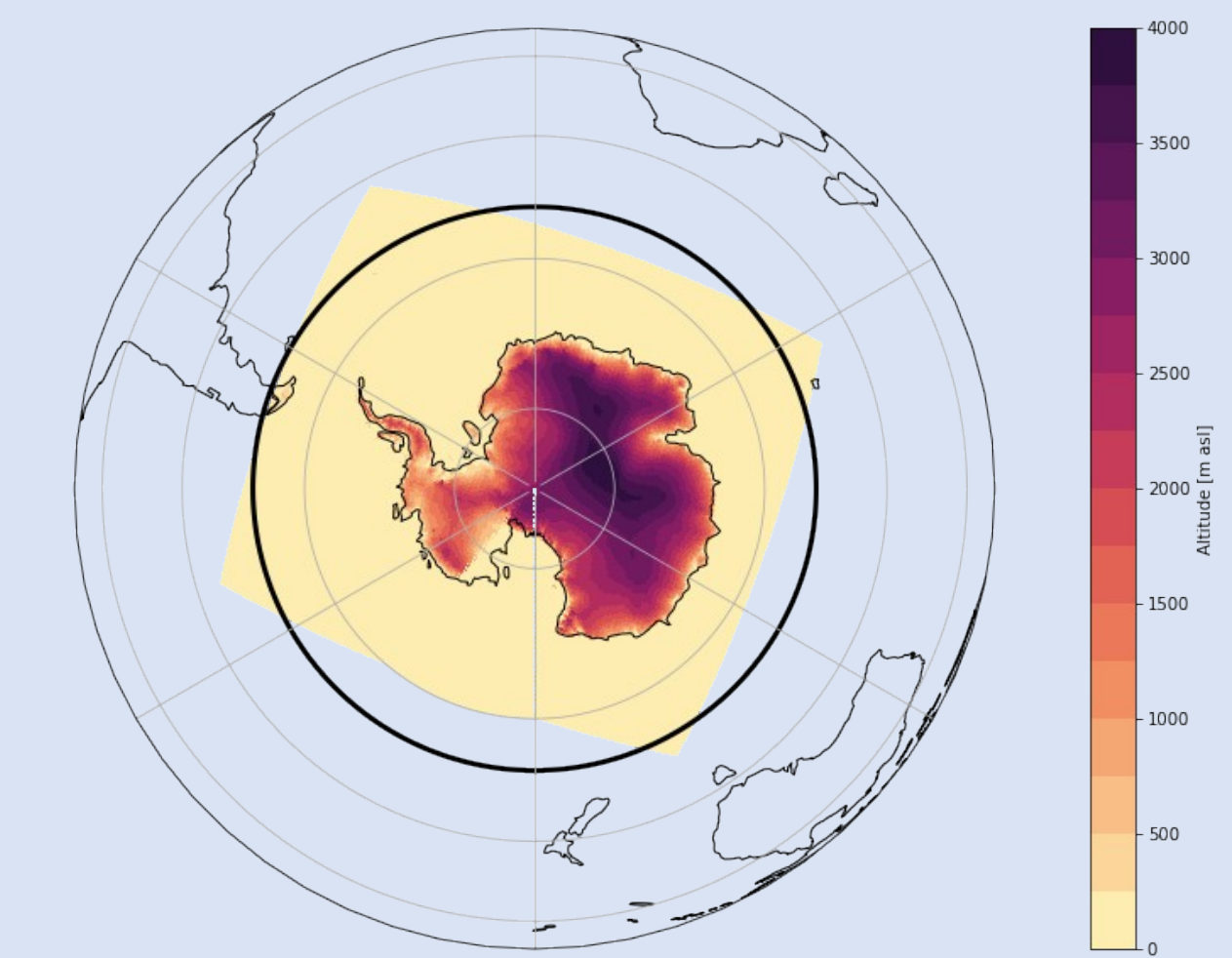
MAR Pan-Antarctic domain (colored, surface height) along with NEMO domain (solid line)

Standalone Models Evaluation

NEMO → 40 years run forced by eORCA025

Weddell Gyre (Sv) · Ross Gyre (Sv) · ACC transport (Sv)
Mean bot. sal. WWED (PSU) · Mean bot. sal. WROSS (PSU)
Mean bot. temp. EWED (C) · Mean bot. temp. EROSS (C) · Mean bot. temp. AMU (C)

— eORCA   — eANT-ctrl   — eANT-ctrl94   - - - eANT-sic95   - - - eANT-sic94
eORCA = eORCA025.L121-OPM026   eANT-ctrl = eANT025.L121-ctrl   eANT-ctrl94 = eANT025.L121-ctrl94   eANT-sic95 = eANT025.L121-sic95   eANT-sic94 = eANT025.L121-sic94

Currents, salinity and temperature evaluation made by taking the global eORCA025 simulations as a reference (grey line). Green lines (resp. blues) are results with the maximum SIC set at 94% (resp 95%). Dashed lines are spinup results (to build up circulation). Solid lines are simulations with a restarting state from the last year (2020) of the spinup simulations.

MAR → 20 years run forced by ERA5
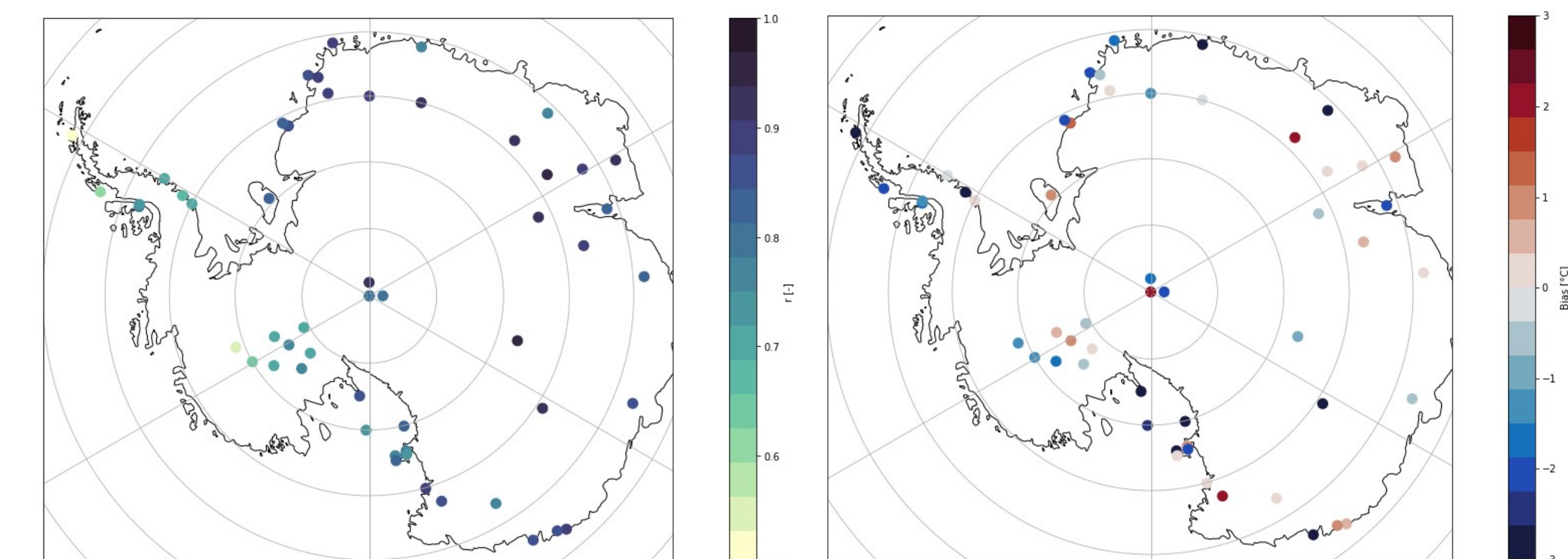
		r	Bias	Mean Obs	CRMSE
P2m [hPa]	Annual	0.97	-1.58	871.78	2.53
	Summer	0.97	-2.04	865.35	2.07
	Winter	0.98	-1.12	874.55	2.04
T2m [°C]	Annual	0.94	0.87	-26.03	3.56
	Summer	0.81	-0.79	-14.52	2.5
	Winter	0.88	2.2	-33.85	3.46

MAR evaluation made using automatic weather stations around the continent. Maps show AWS summer surface temperature correlation (top) and summer bias (bottom) between model and observations, for the 2000-2020 period.

→ Both models run the present climate well
→ NEMO configurations needs small improvements (Ross and Weddell gyres remain weak)
→ MAR domain to be compared over the same domain a 12.5km to asses resolution impact

Motivations

PolarRES — Exploring future polar climates

High resolution modeling over the poles

→ WP3: Long term climate projections

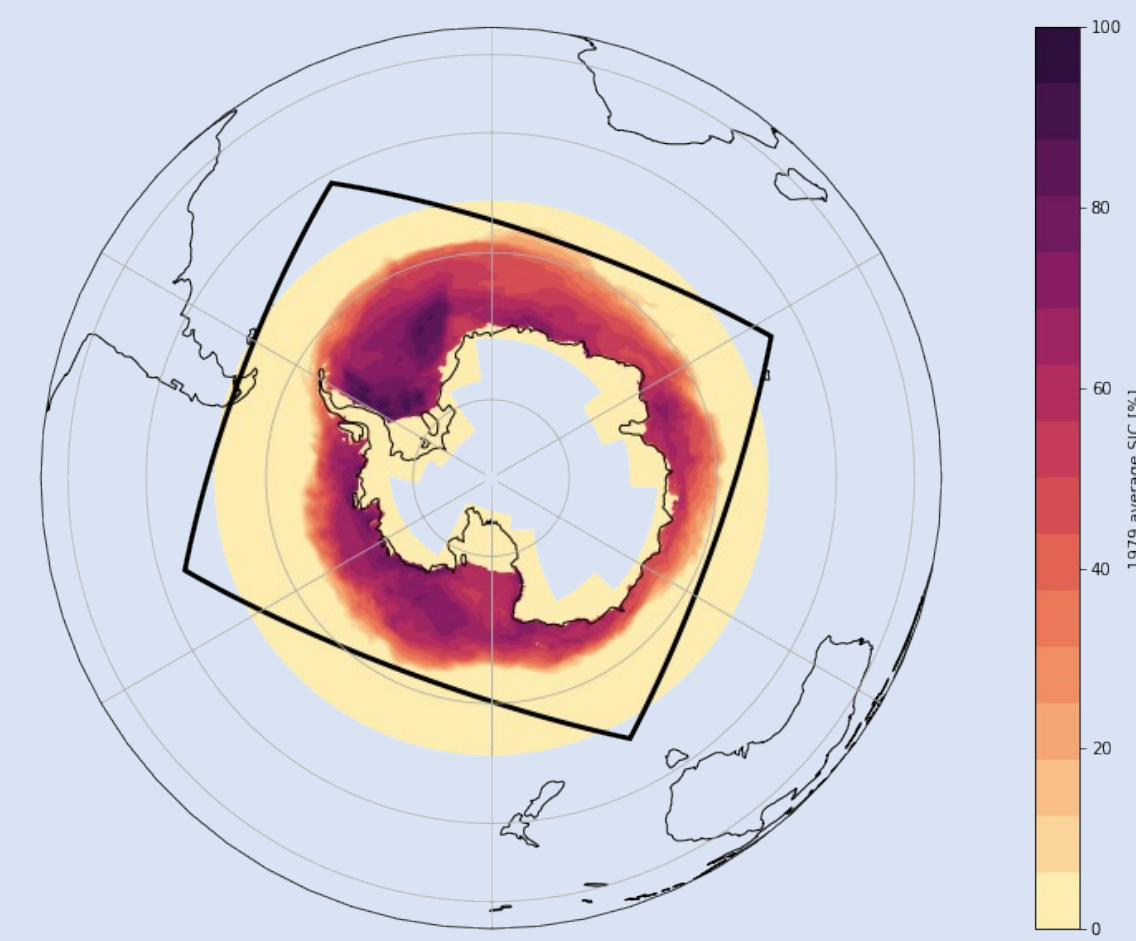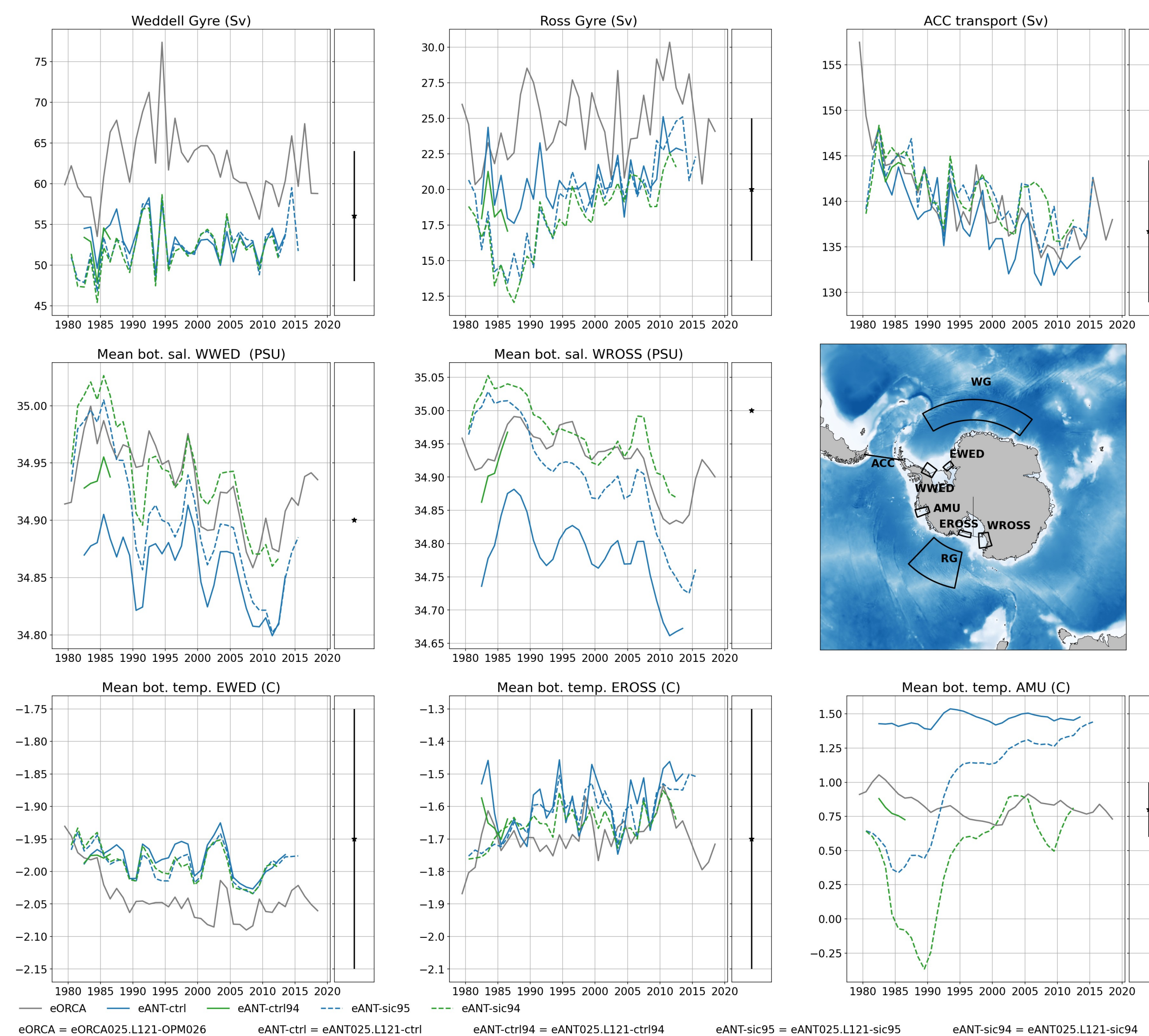→ WP5: improvement of AOI interactions processes understanding

→ Coupled system simulations (MAR + NEMO)

Study Status

- Domains definition, models configuration
- Atmospheric AWS data collection
- Antarctic Ocean observations collection:
  • Satellite Surface conditions
  • Ship / Boeys data
- Standalone evaluations
- Coupling interface developpement
- Coupled system evaluation
- Projections using CMIP6 data
- Process studies over present

Timeline

Current state