Towards a comparison of European CMIP6 ESMs in the Southern Ocean

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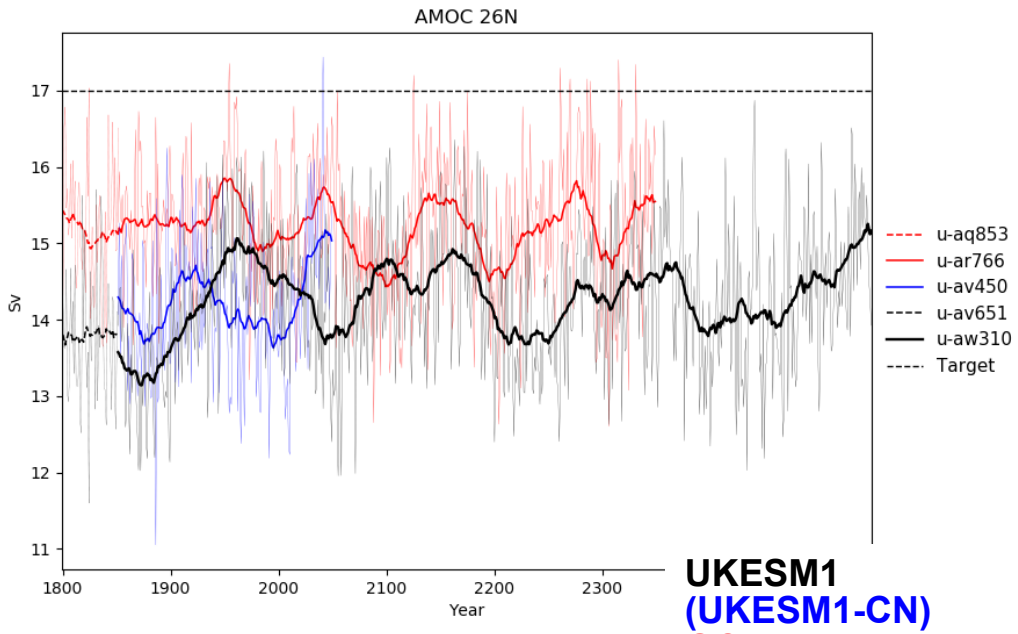
Outline

- UKESM1 is currently in production for CMIP6-DECKhist
- Here: focus on the pre-industrial control simulation (PI): large-scale ocean circulation and sea-ice cover
- Evaluation against observations and HadGEM3 GC3.1-LL (N96ORCA1)
- HadGEM3 GC3.1-LL is the physical core model of UKESM1 *(Kuhlbrodt et al., 2018, JAMES, under review)*
- A first plot with results from 3 CRESCENDO models (CNRM-ESM, IPSL-CM, UKESM1)

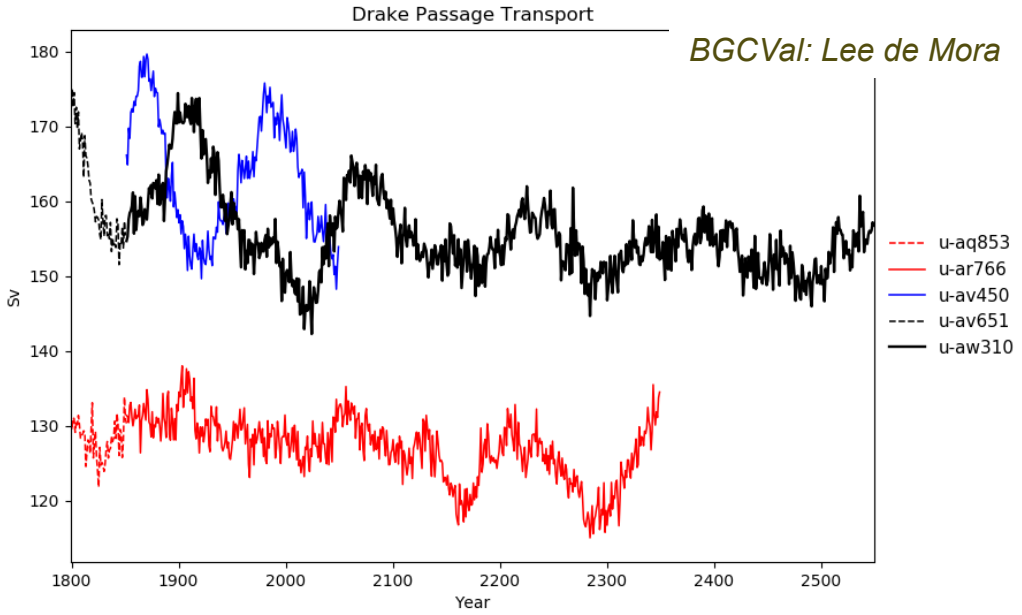
Large-scale ocean circulation

- Centennial variability in AMOC and ACC: anticorrelation?
- In the following figures: averages shown are 2100-2150 (years 250-300 of the simulations)

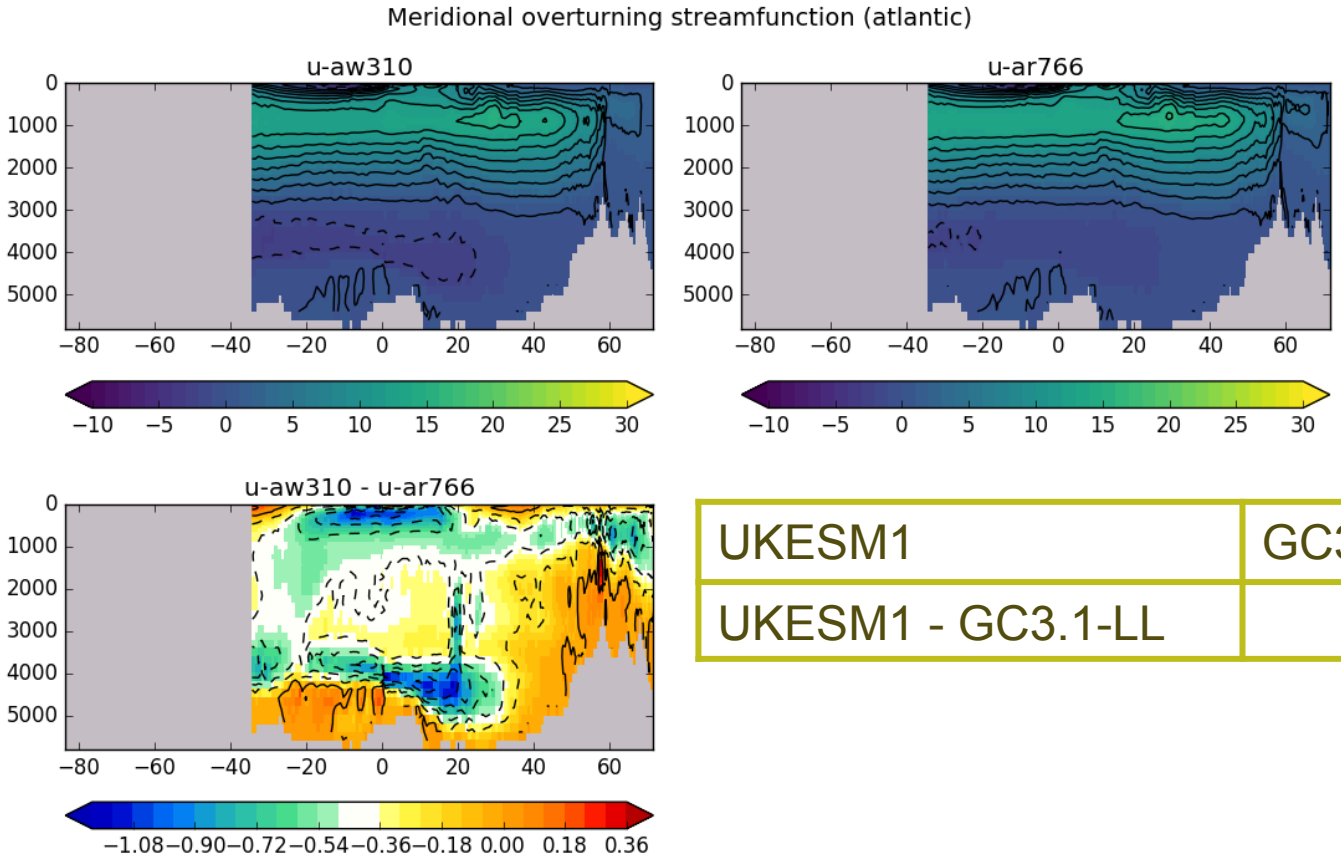


UKESM1
(UKESM1-CN)
GC3.1-LL

BGCVal: Lee de Mora



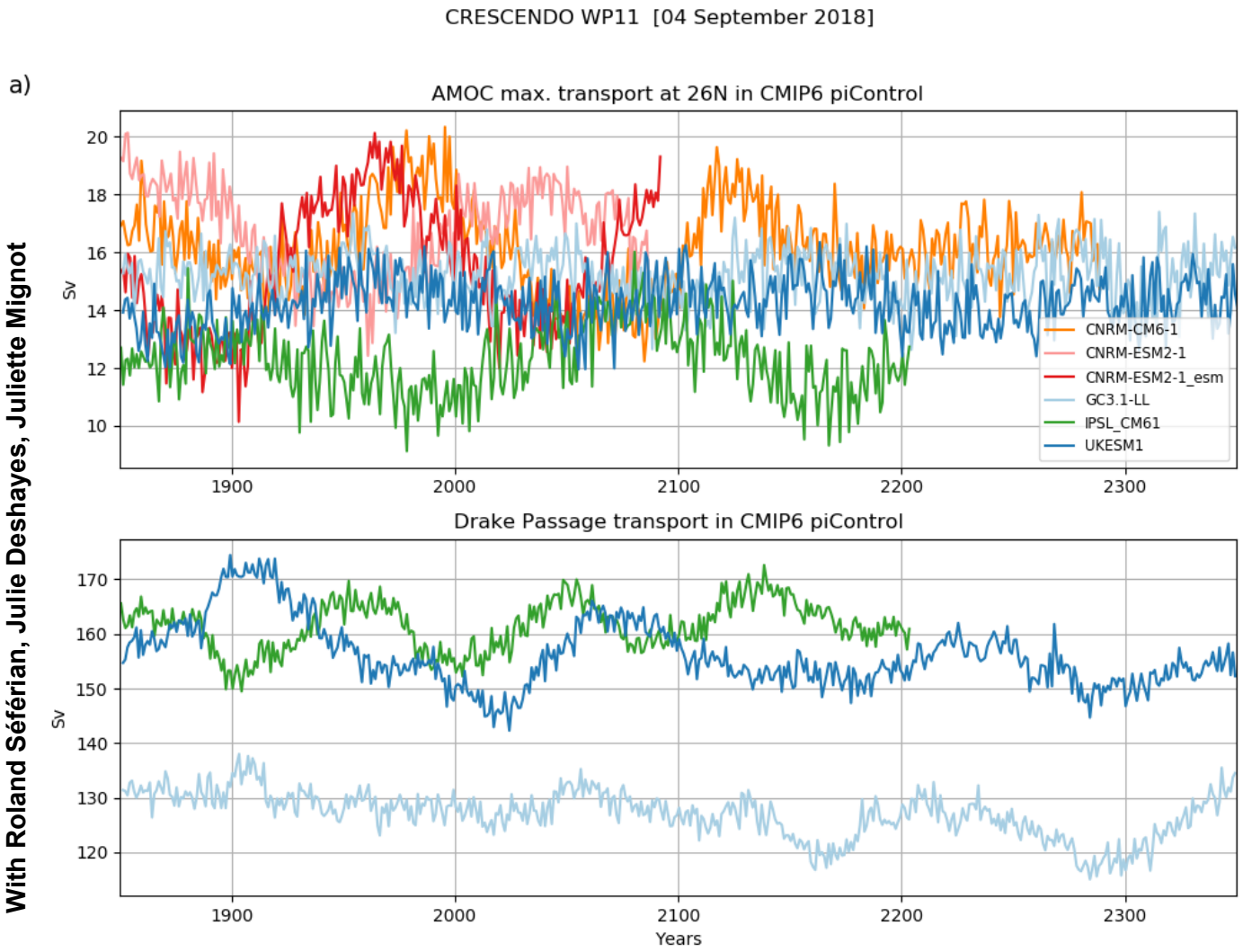
AMOC streamfunction



UKESM1	GC3.1-LL
UKESM1 - GC3.1-LL	

- More AABW in the deep North Atlantic in UKESM1

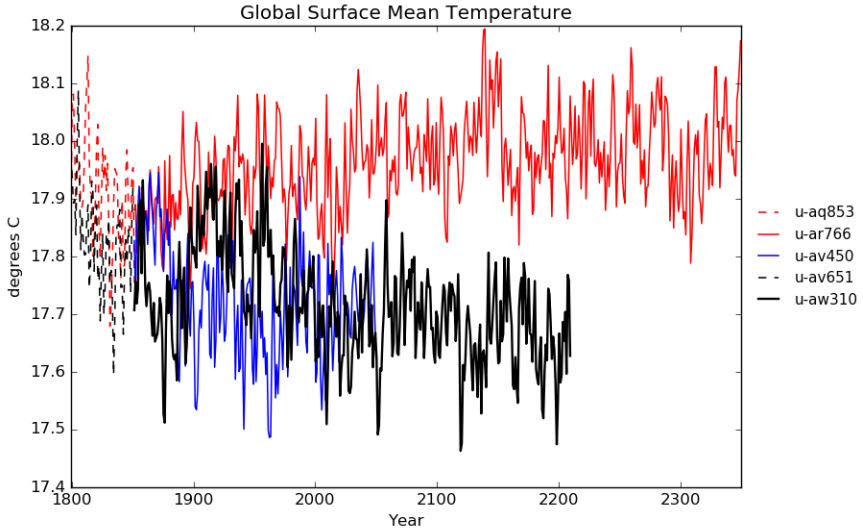
Three ESMs: AMOC and ACC

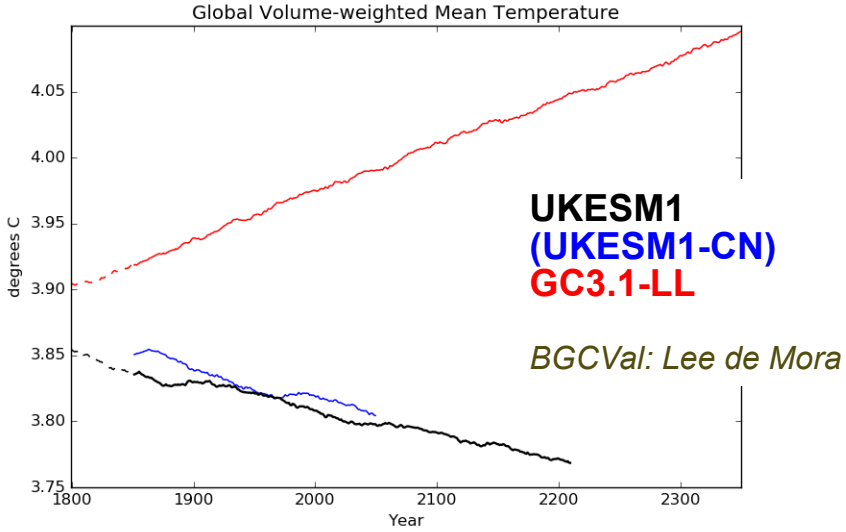


- Variability and mean strength of the AMOC and the ACC vary across models

With Roland Séférian, Julie Deshayes, Juliette Mignot

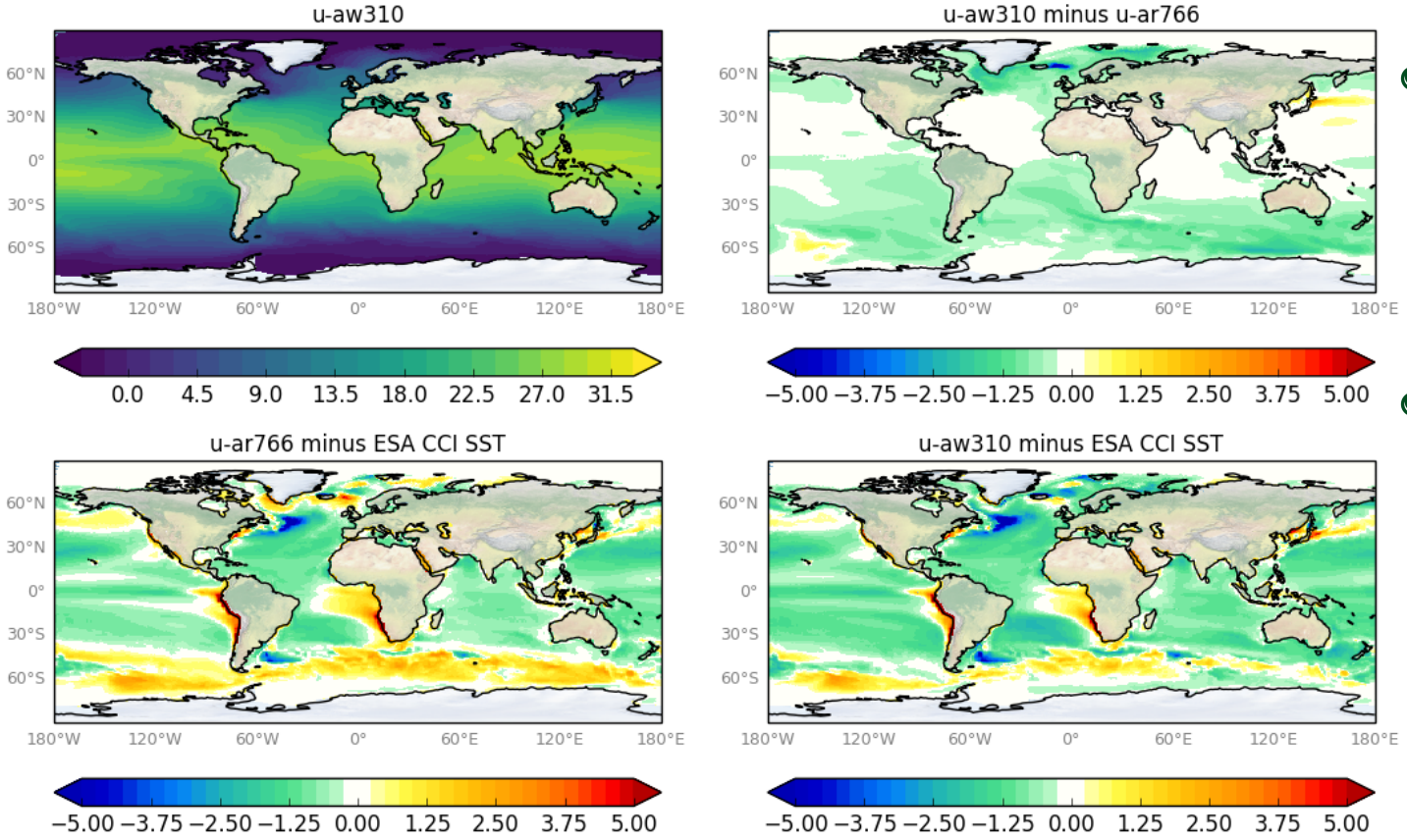
UKESM1: Ocean temperature drift





- Opposing drift in UKESM1 and GC3.1-LL
- Length of pre-industrial spin-up simulation: ~5,500 years for UKESM1; ~600 years for GC3.1-LL

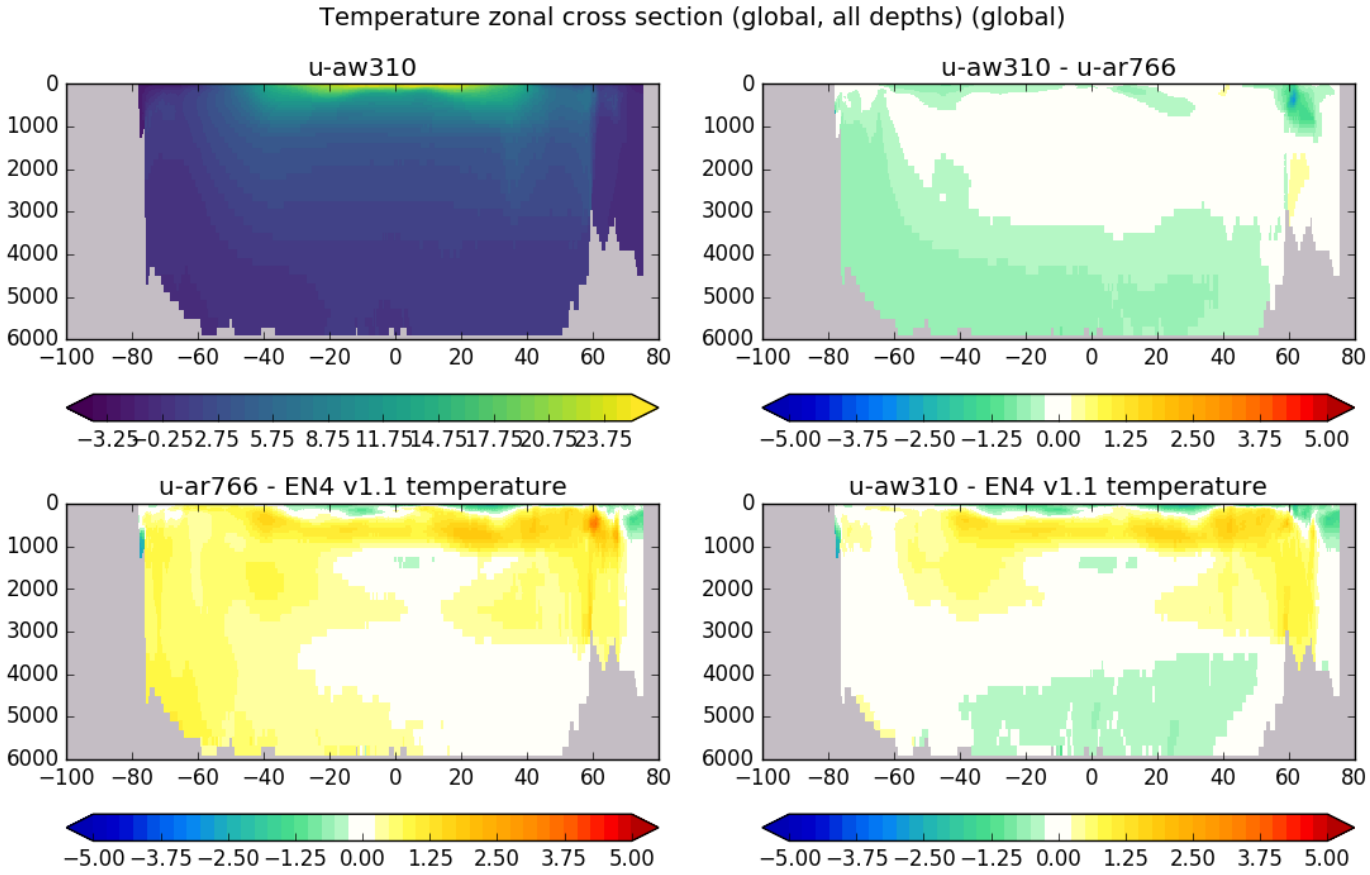
Sea surface temperature



- UKESM1 globally about 0.35K colder than GC3.1
- Most of the cooling in the Southern Hemisphere

UKESM1	UKESM1 - GC3.1-LL
GC3.1 - obs	UKESM1 - obs

Ocean warming in control simulations

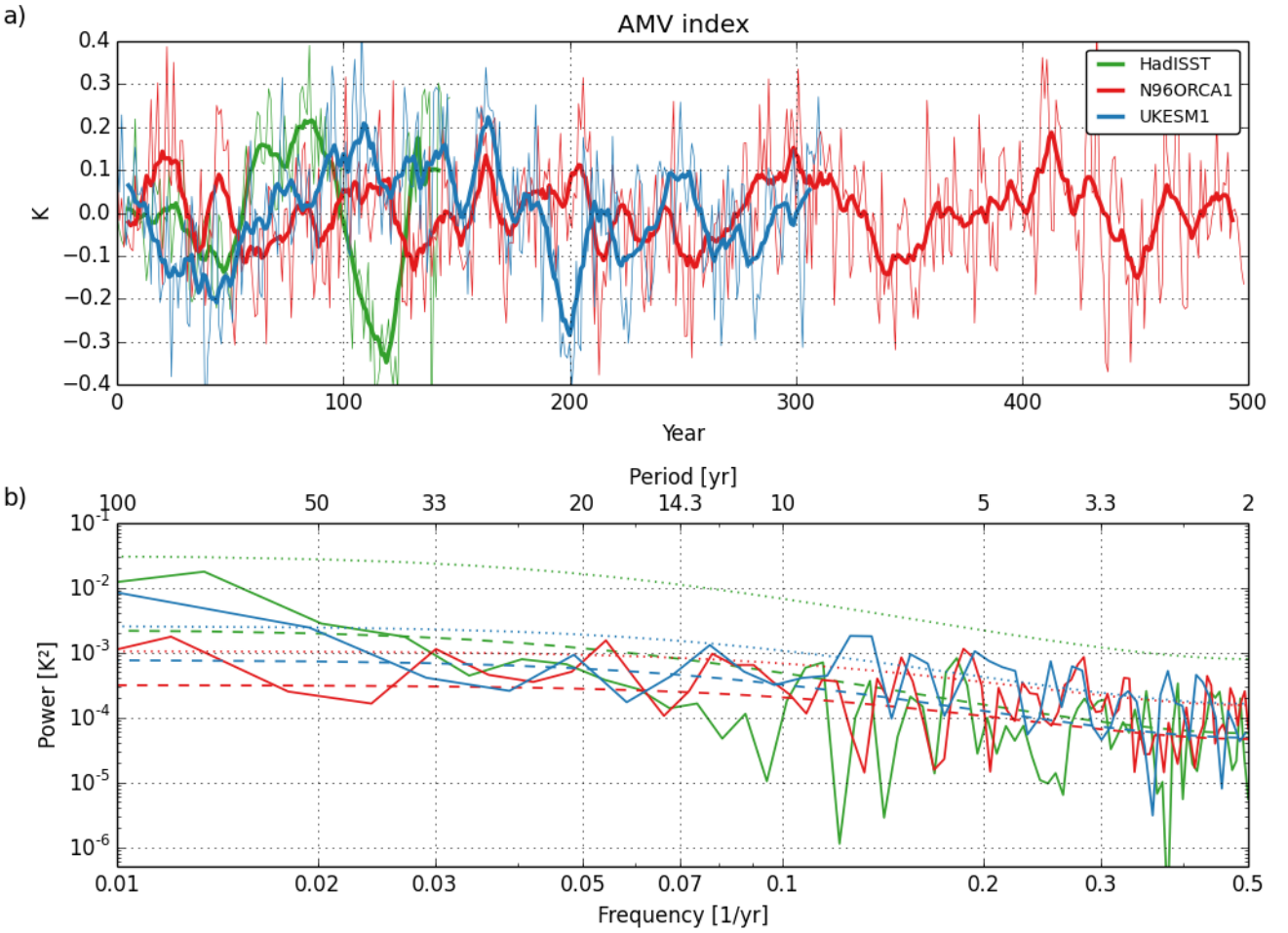


- UKESM1 captures temperature throughout high-latitude Southern Ocean well
- Subsurface warm bias underneath cold surface

UKESM1	UKESM1 - GC3.1-LL
GC3.1 - obs	UKESM1 - obs

Atlantic meridional variability

- UKESM1 piControl has more variance on interdecadal time scales >50yr
- Observations have even more variance on interdecadal time scales, but this includes the forced variability



Summary: UKESM1 piControl

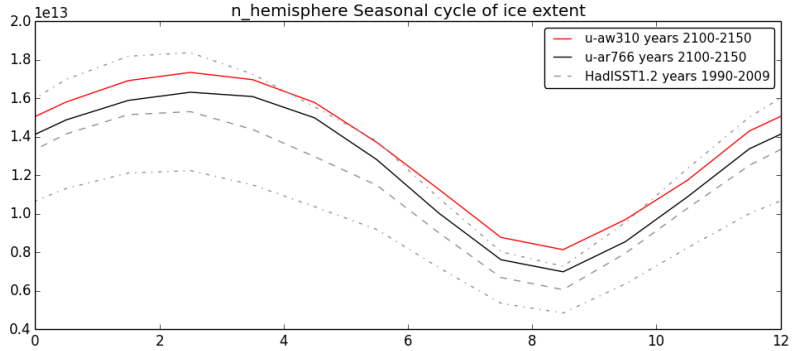
- UKESM1 ocean is colder than GC3.1 – beneficial in the Southern Ocean at all depths, and for the ACC
- AMOC is somewhat to weak in UKESM
- Decadal and centennial variability in large-scale ocean circulation
  ⇨ more detailed analysis planned in WP11, including further CRESCENDO models
- UKESM1 has thicker Arctic sea ice – probably not an issue

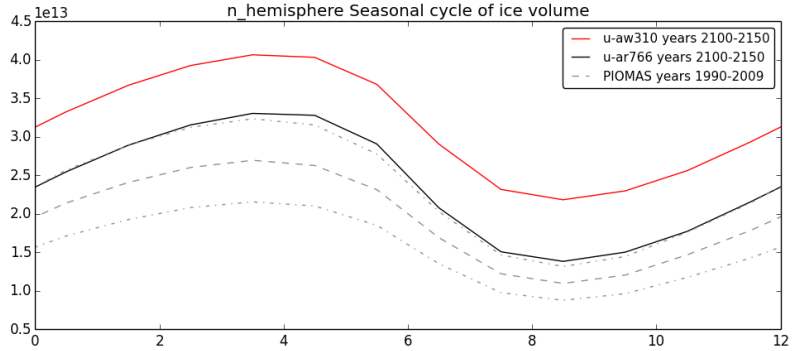
Sea ice: seasonal cycle

Ice extent

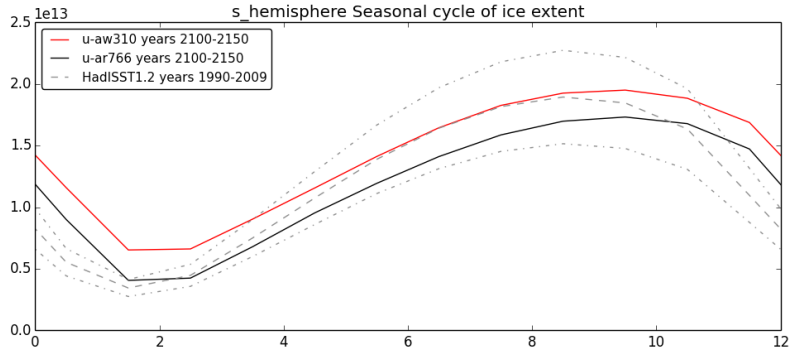
Ice volume

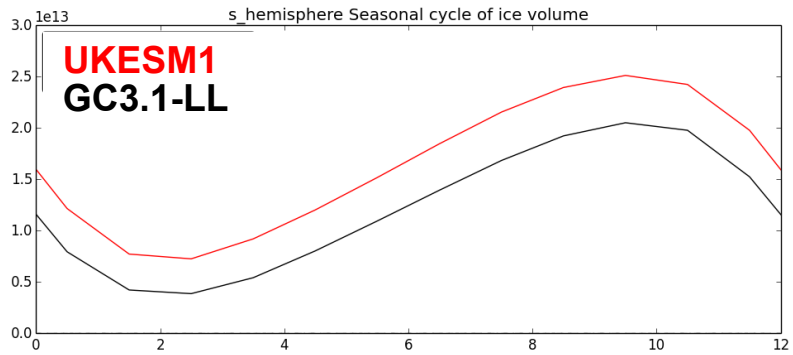
Arctic





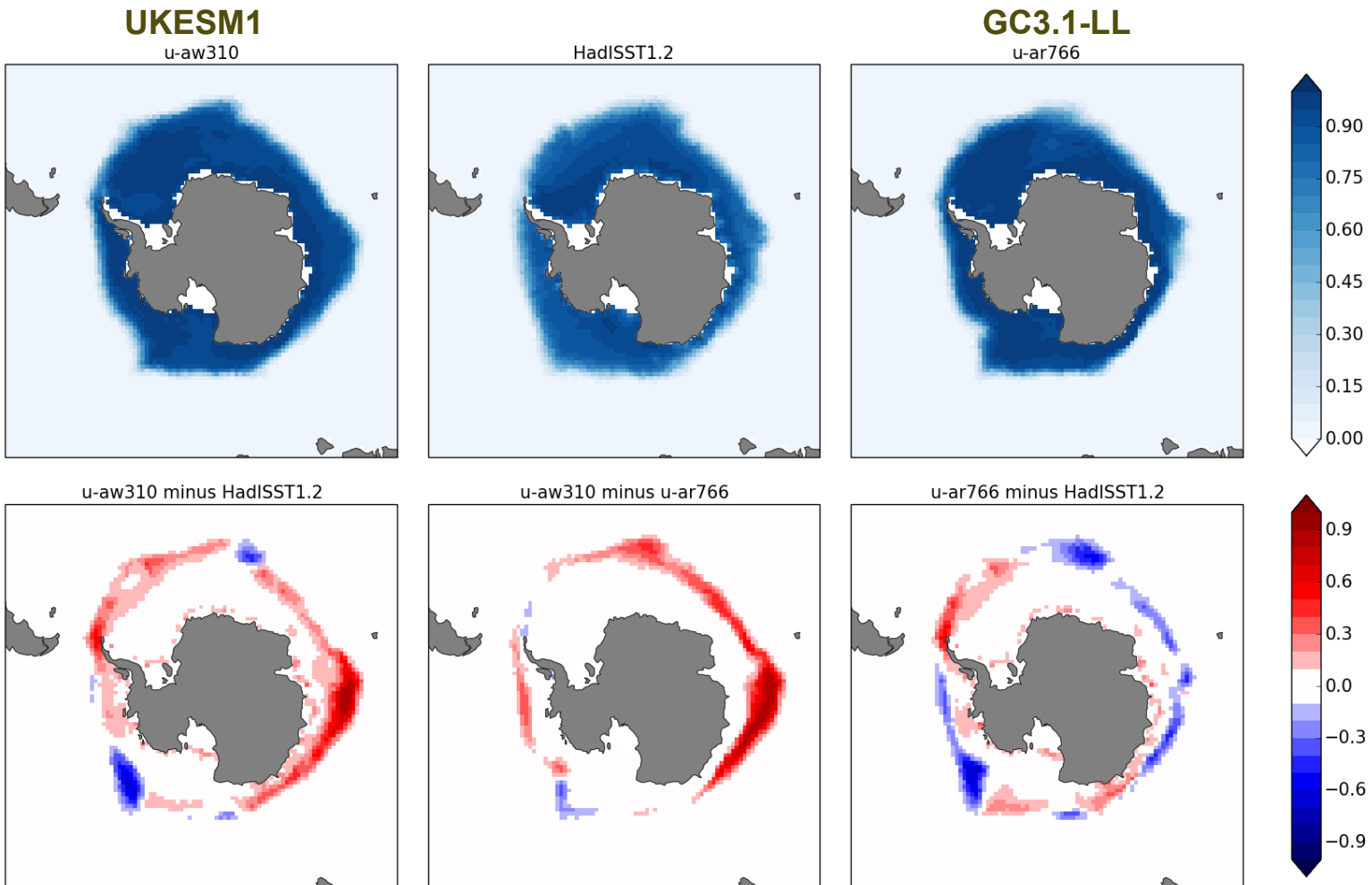
Southern Ocean



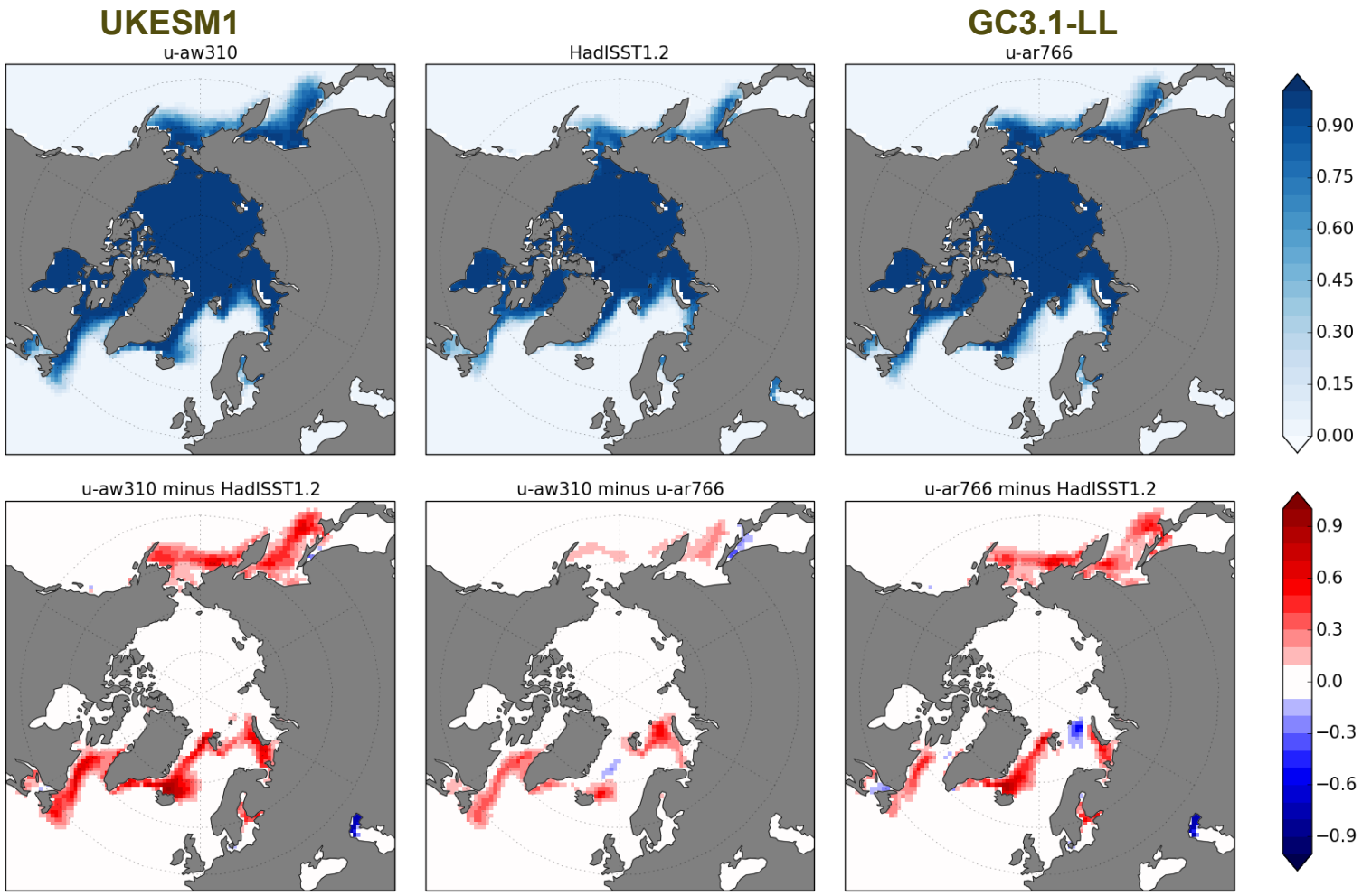


- UKESM1 has more sea ice cover, and thicker sea ice than GC3.1-LL
- Simulated pre-industrial sea ice is thicker than present-day observed – that's expected

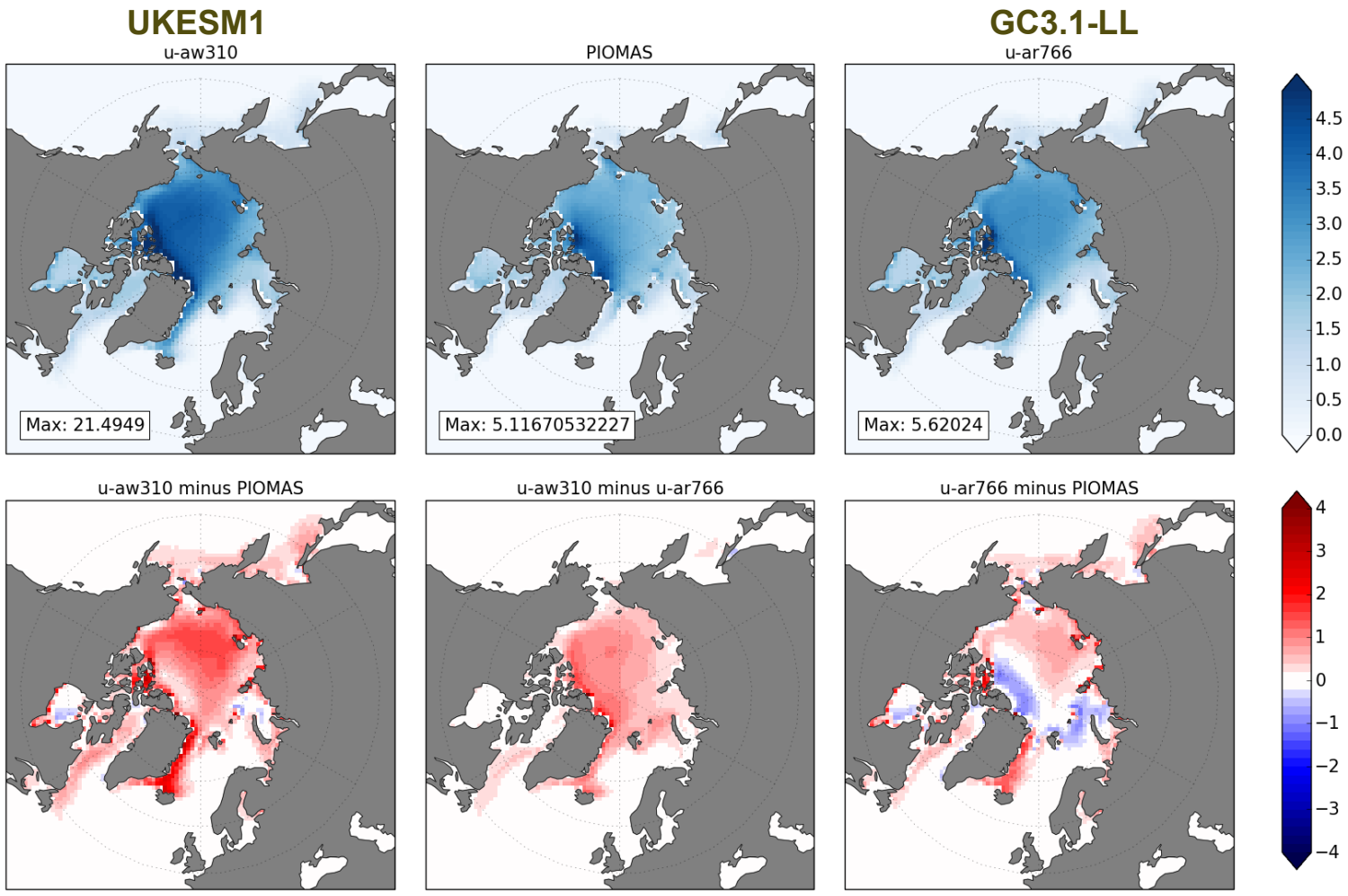
Sea ice: extent in Southern Ocean winter



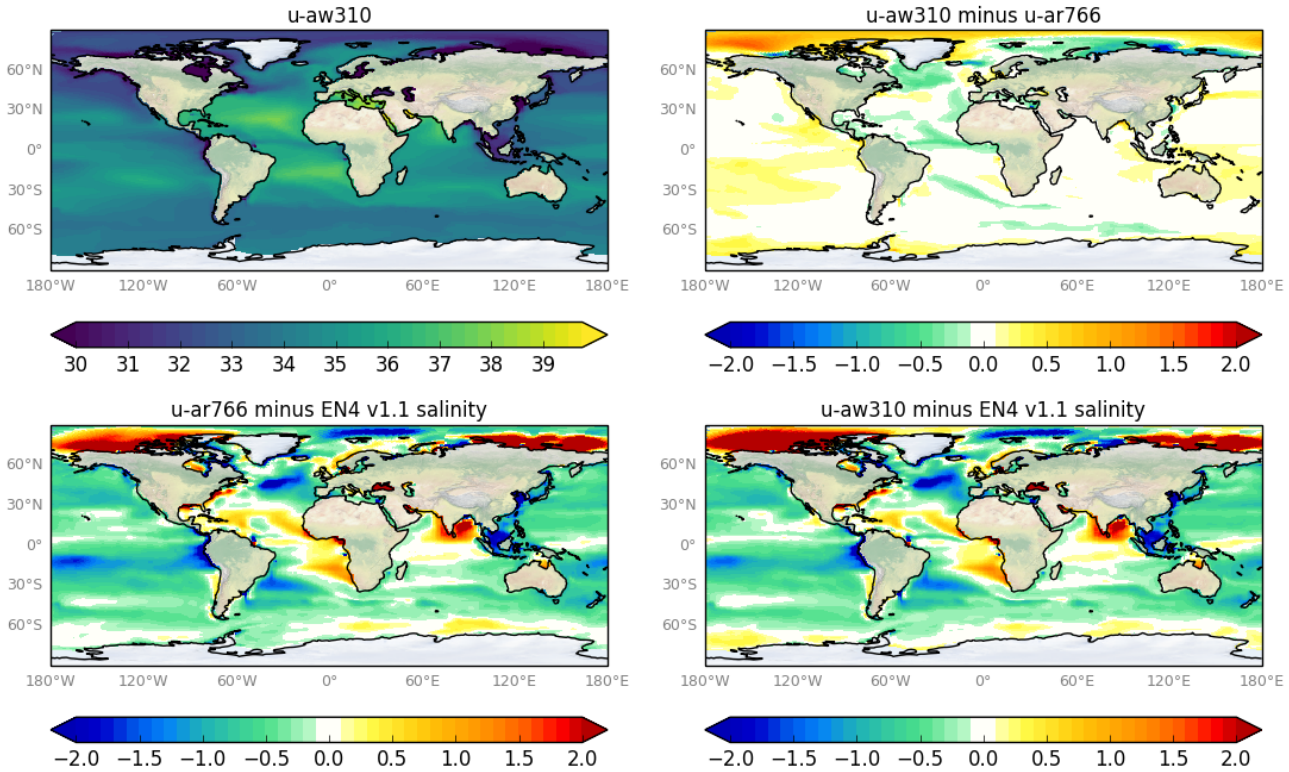
Sea ice: extent in Arctic winter



Sea ice: thickness in Arctic winter



Sea surface salinity



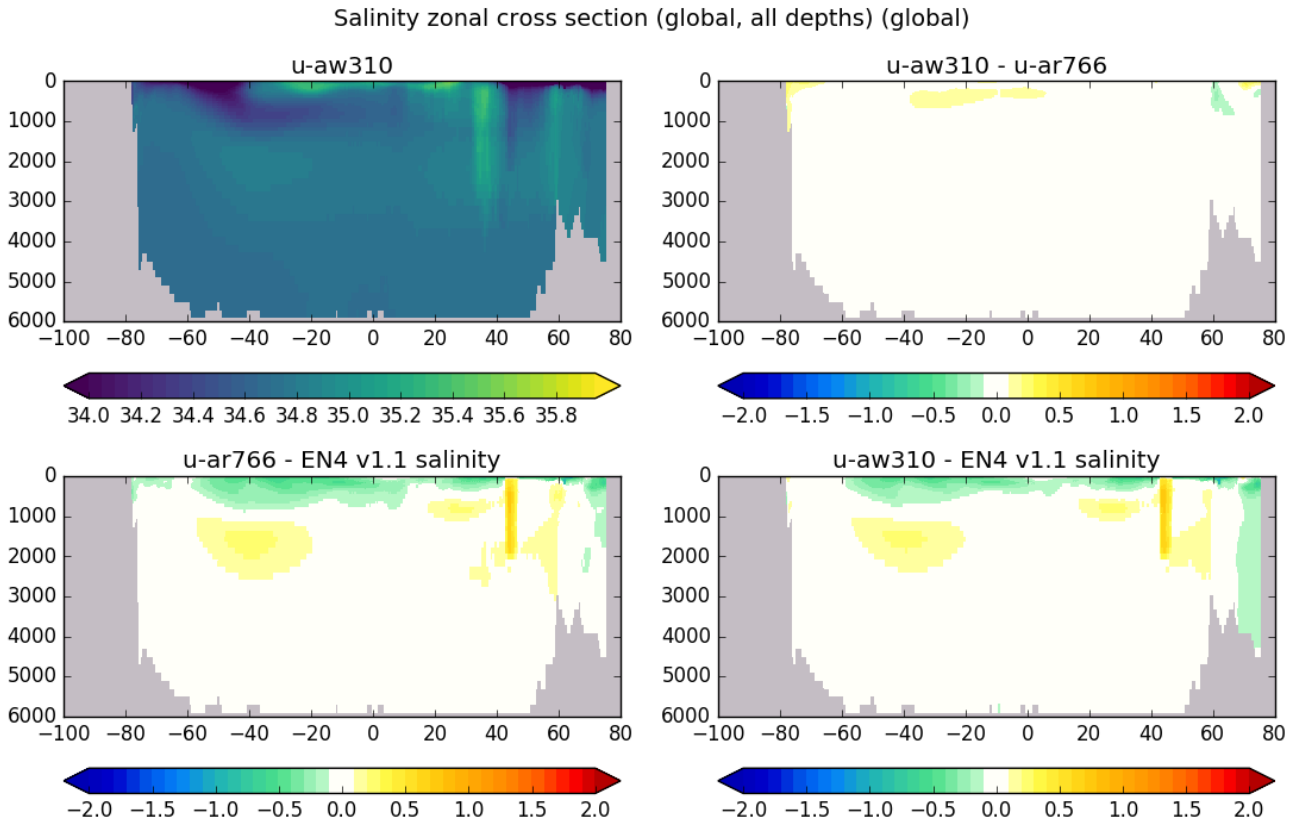
UKESM1	UKESM1 - GC3.1-LL
GC3.1 - obs	UKESM1 - obs

Different shaconemo configurations: IPSL vs UKESM1

Examples of differences:

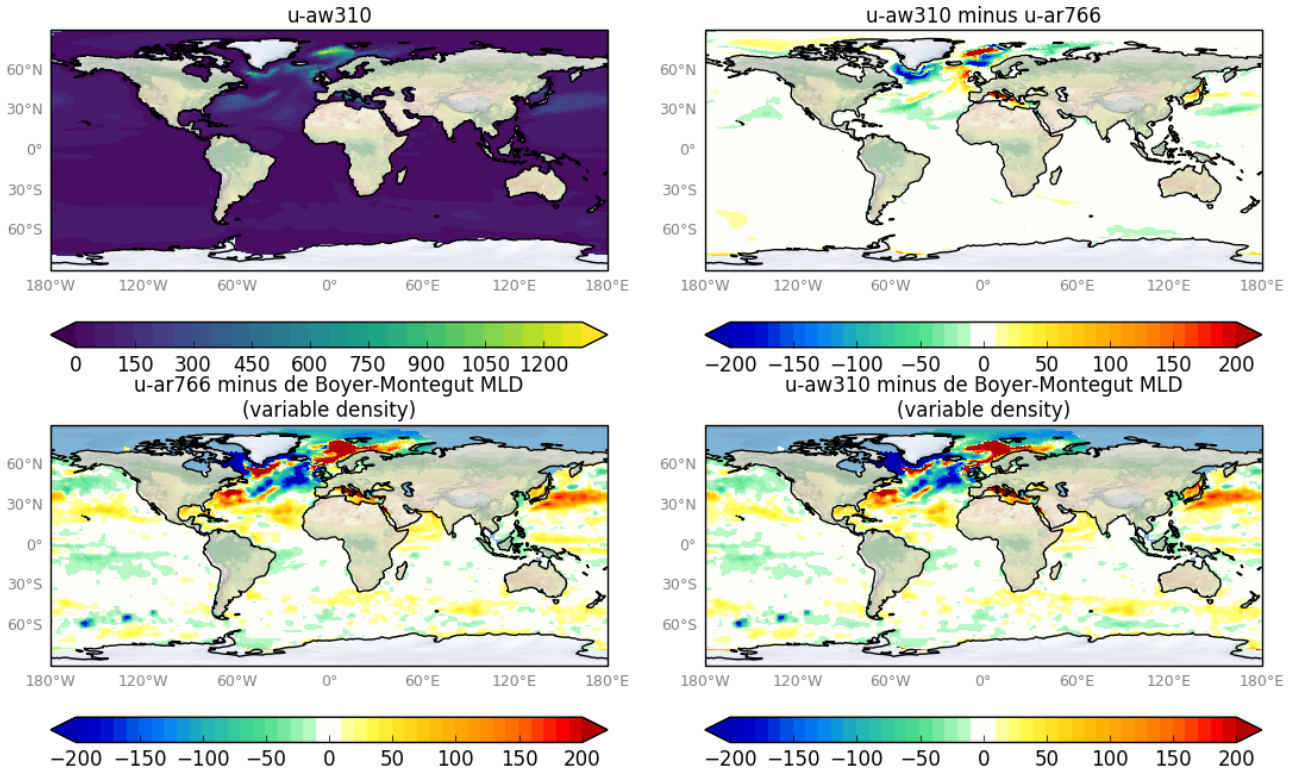
- UKESM1 has interactive icebergs, IPSL doesn't
- IPSL uses zdftmx, UKSEM1 doesn't
- nn_htau=4 in UKESM1, nn_htau=1 in IPSL (profile of vertical mixing …)
- Coupling frequency to atmosphere is 3h in UKESM1 while 1.5h in IPSL
- Bathymetries are not identical, including minimum depth (11m in UKESM1, 20m in IPSL
- … and so on

Zonal mean salinity

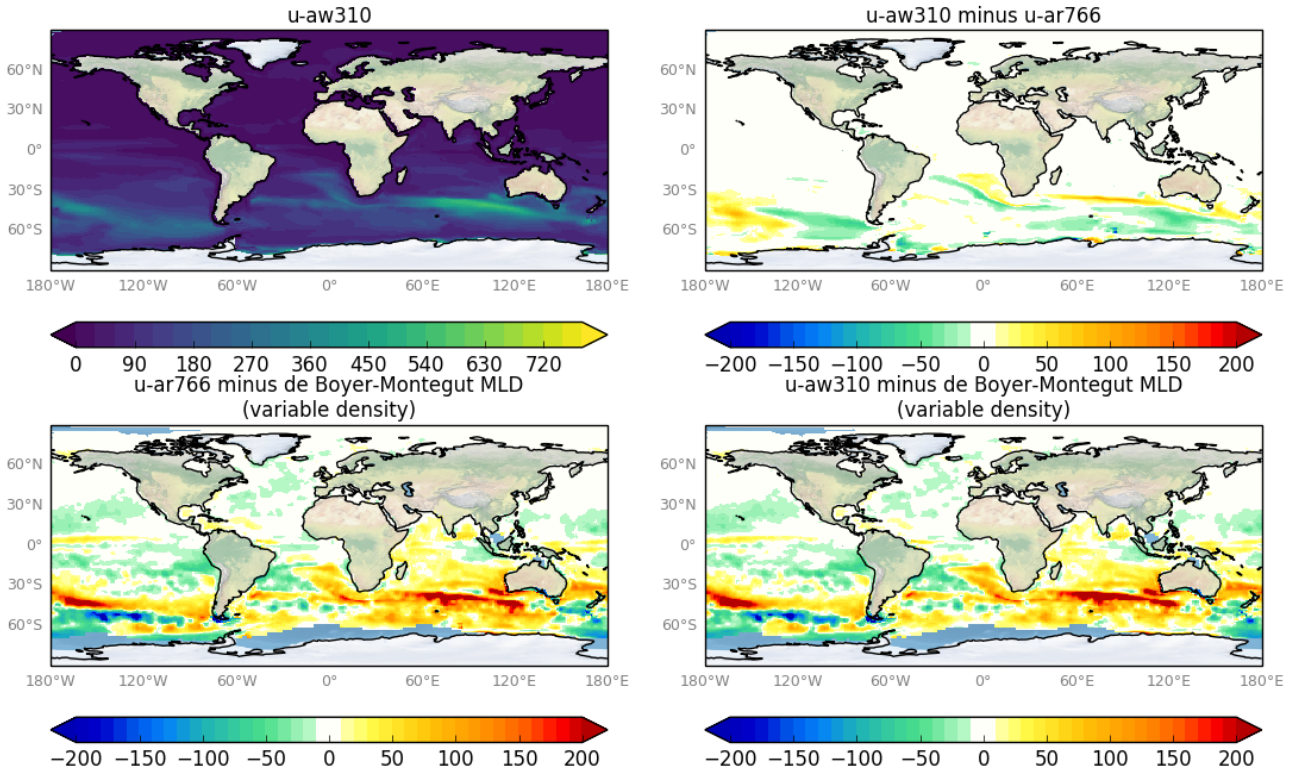


UKESM1	UKESM1 - GC3.1-LL
GC3.1 - obs	UKESM1 - obs

Mixed layer depth: March



Mixed layer depth: September



UKESM1	UKESM1 - GC3.1-LL
GC3.1 - obs	UKESM1 - obs