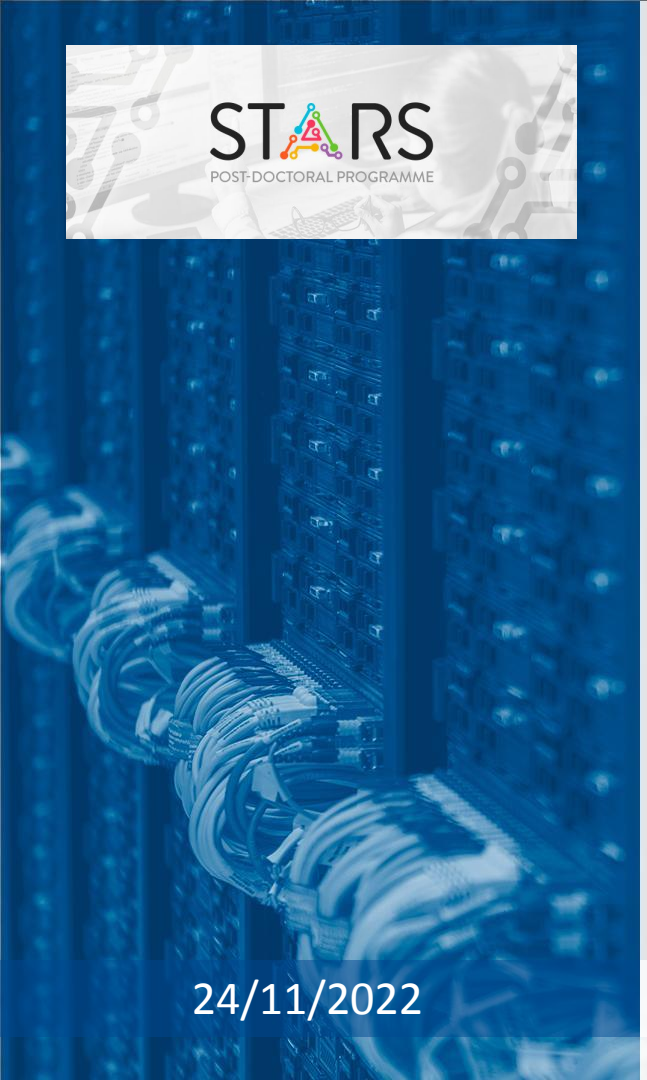
STARS
POST-DOCTORAL PROGRAMME



Barcelona Supercomputing Center
Centro Nacional de Supercomputación

On the (technical) path to a high-resolution decadal prediction system with EC-Earth3

Aude Carreric, P. Ortega, F. Doblas-Reyes, V. Lapin, M. Castrillo, E. Ferrer, S. Palomas, P.A. Bretonnière, C. Delgado, ... (BSC)

24/11/2022

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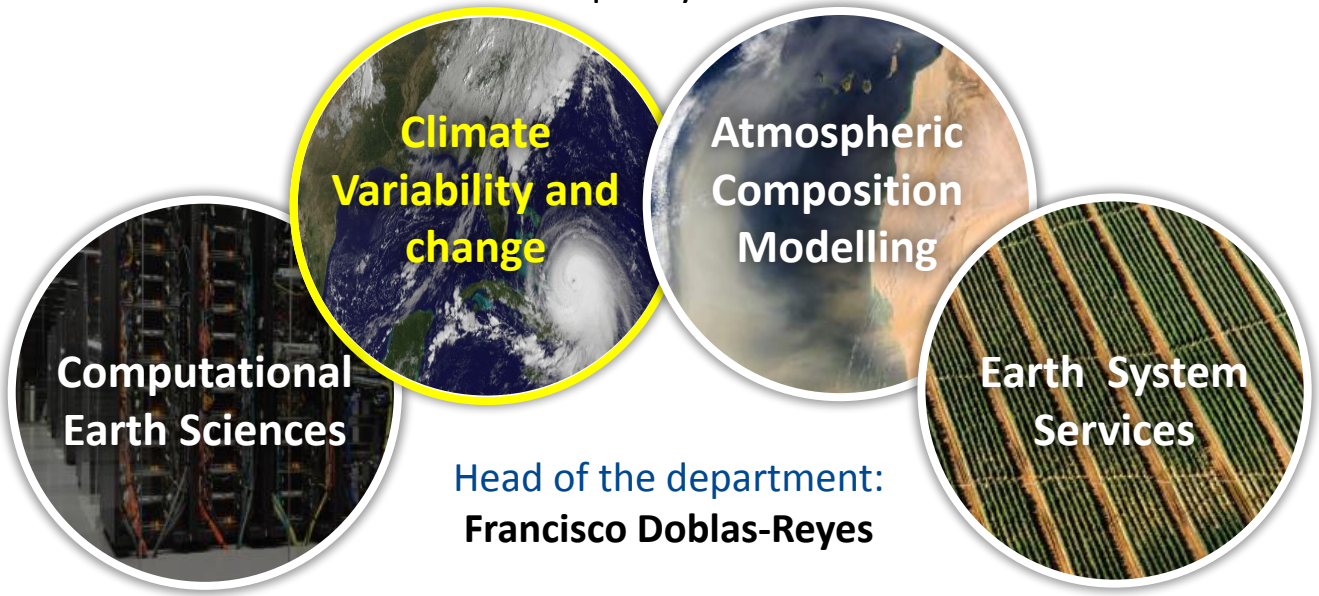
BSC- Earth Sciences Department

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality



Head of the department:
Francisco Doblas-Reyes

Context

- Decadal prediction:

Growing interest for decision-making purposes (agriculture, energy, water management)

Signal to Noise Paradox (Scaife and Smith, 2018; Hardiman et al. 2022)

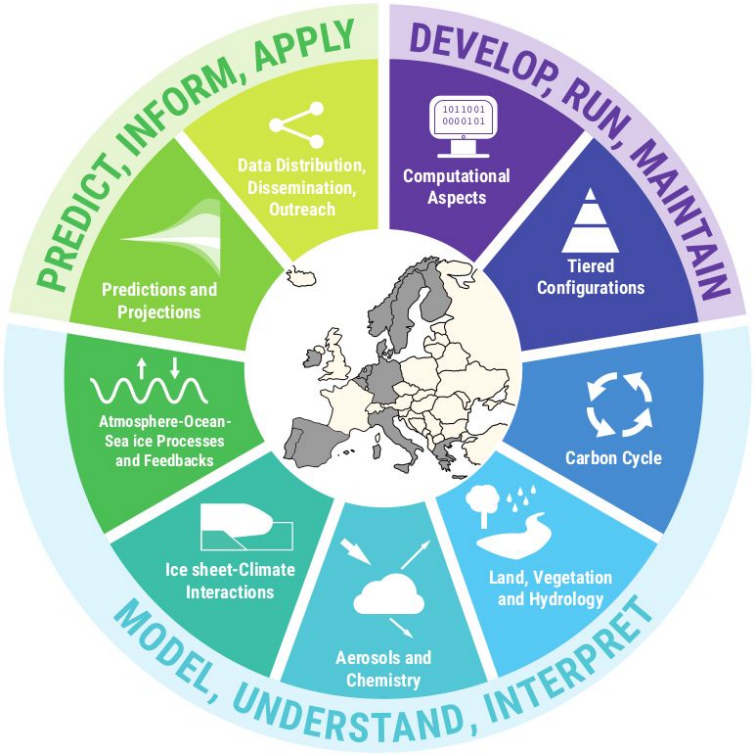
- High resolution: eddies permitting

Representation of previously unresolved processes (e.g. ocean eddies) that are important for **ocean-atmosphere interactions**

→ Expectation to better reproduce both climate mean state and variability

Seasonal forecasts: Prodhomme et al., 2016; Scaife et al., 2019; Kumar et al., 2022

EC-Earth - European community Earth-System model

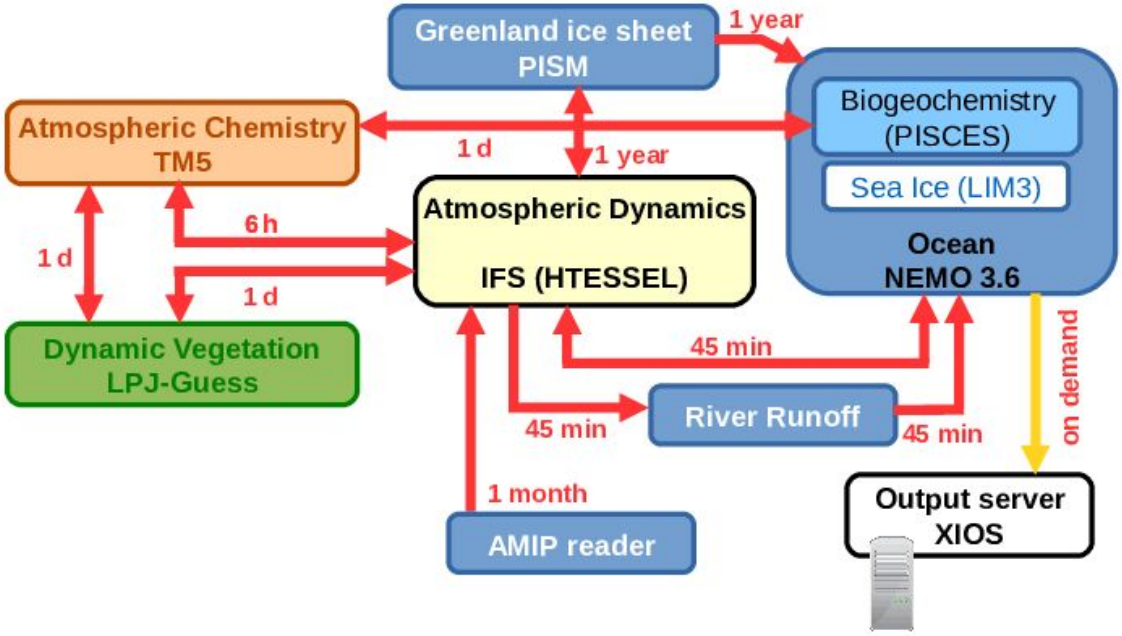


EC-Earth3 configuration	atmosphere	ocean	vegetation	atmospheric chemistry	marine biogeo-chemistry	land ice	CMIP6 MIP list in which the configuration participated
	IFS	NEMO	LPJ-GUESS	TM5	PISCES	PISM	
EC-Earth3	✔	✔					CMIP,DCPP,LS3MIP,PAMIP,RFMIP,ScenarioMIP,VolMIP,CORDEX,DynVarMIP,SIMIP,VIACSAB
EC-Earth3-LR	✔	✔					CMIP,PMIP
EC-Earth3-Veg	✔	✔	✔				CDRMIP,CMIP,LUMIP,LS3MIP,ScenarioMIP
EC-Earth3-Veg-LR	✔	✔	✔				CMIP,PMIP,ScenarioMIP
EC-Earth3-AerChem	✔	✔		✔			AerChemMIP,CMIP,RFMIP
EC-Earth3-CC	✔	✔	✔	✔	✔		C4MIP,DCPP,CDRMIP,CMIP,LUMIP,OMIP,ScenarioMIP
EC-Earth3-GrisIS	✔	✔				✔	CMIP,ISMIP6,PMIP
EC-Earth3-HR	✔	✔					CMIP,DCPP,HighResMIP

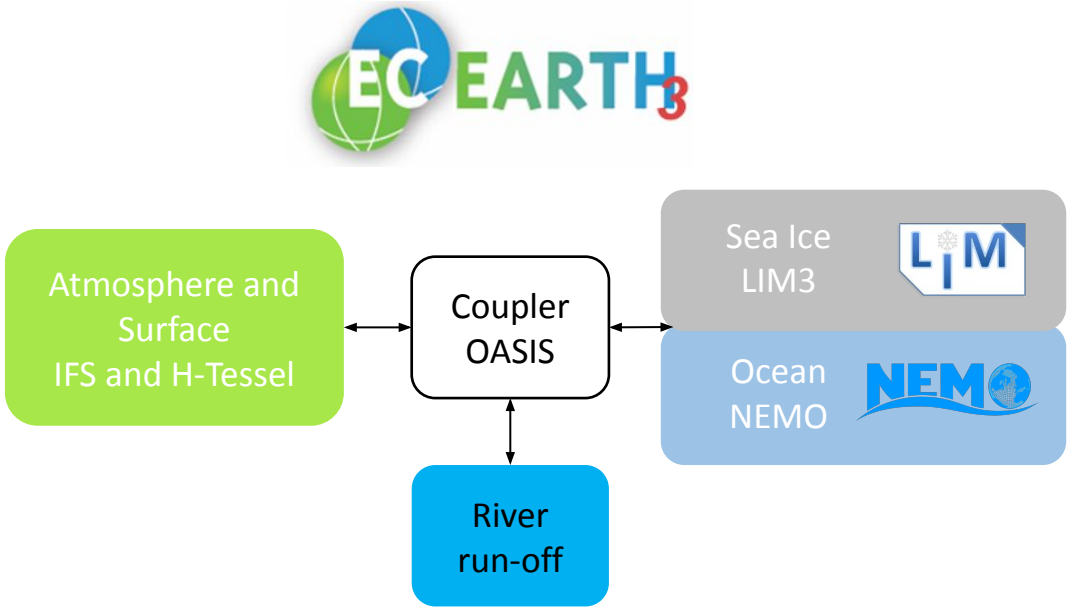
https://ec-earth.org/

Döscher *et al*. Geosci. Model Dev. (2022)

EC-Earth - European community Earth-System model



EC-Earth3.3 - AOGCM

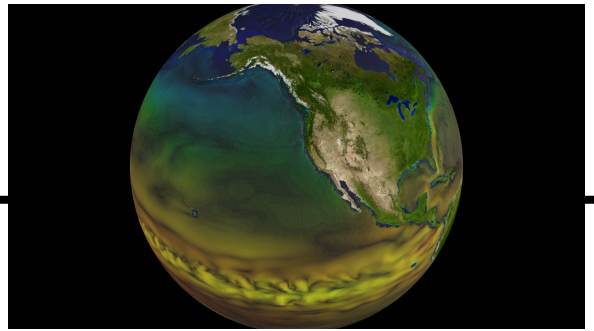


EC-Earth3.3 - Resolutions

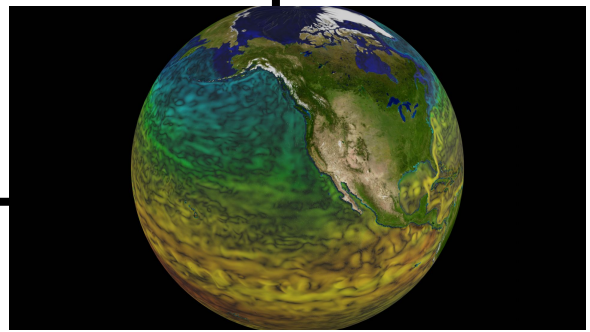
Model Components

	Standard Resolution (SR)	High Resolution (HR)
IFS (Atmospheric Model):	T255 ~80km L91 (top 0.01hPa) ~mesosphere *IFS-HTESSEL (Land Model)*	T511 ~40km
NEMO (Ocean Model):	Nominal 1°resolution L75 levels (thousands km deep)	Nominal 0.25°resolution
LIM (Sea-ice Model):	Multiple (5) ice category	

Courtesy of O. Tinto

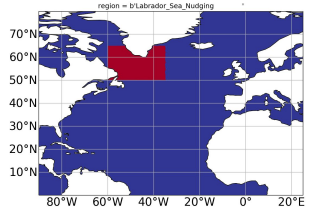


ORCA grid 1°

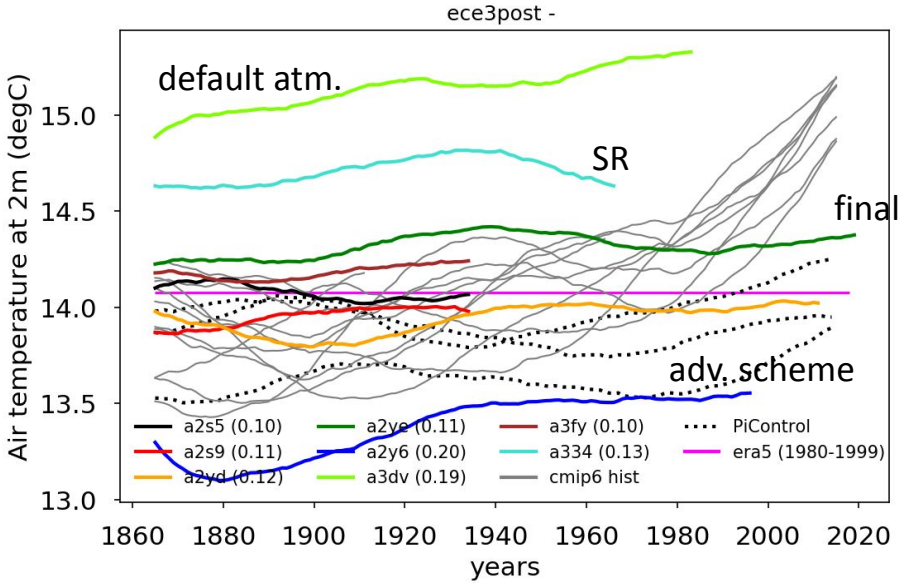


ORCA grid 0.25°

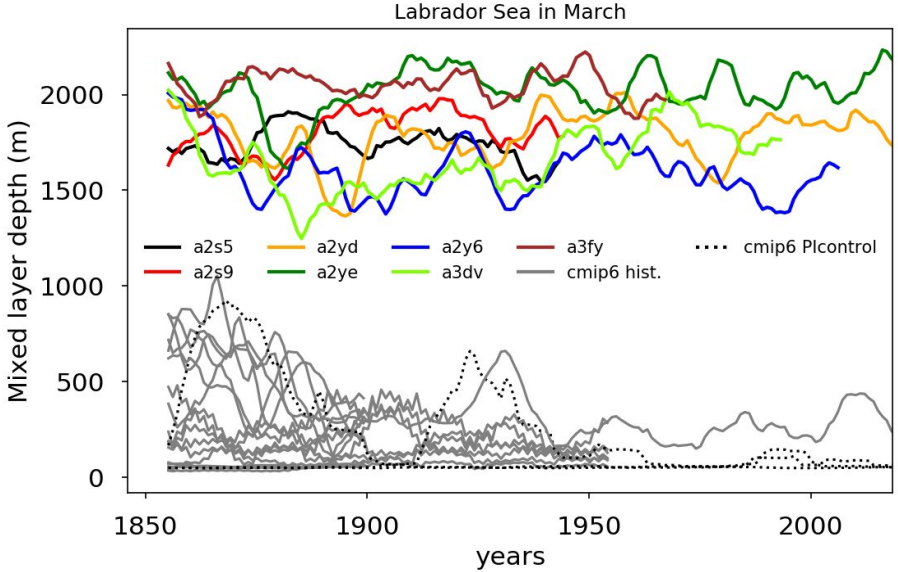
Tuning of the HR configuration



Surface air temperature



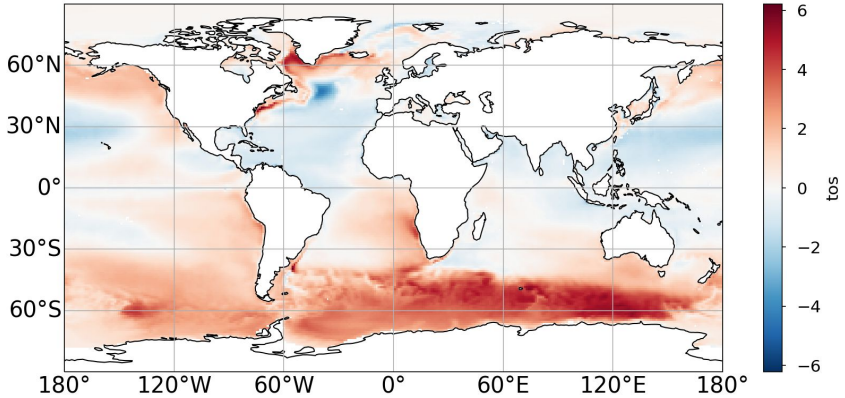
Mixed layer depth



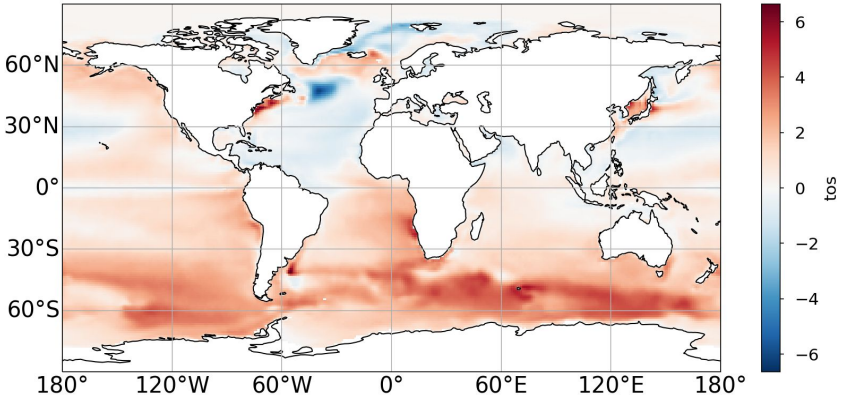
Rolling-mean 11 years

SST bias maps - tuned versions

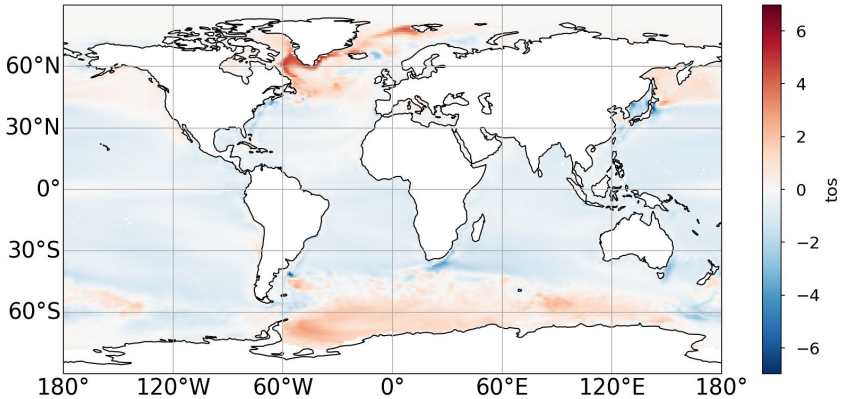
HR - OBS



SR - OBS



HR - SR



OBS: Hadisst (1980-1999)
EXP: last 70 years

HR slightly colder than SR overall but with regional differences.

Initial conditions of the forecast systems

Atmospheric Reanalysis
ERA5

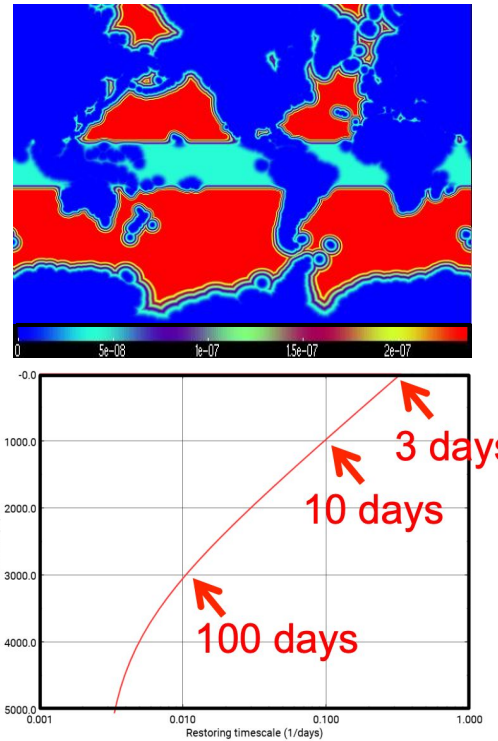
Ocean Reconstruction
- ERA5 surface fluxes
- ORAS5 restoring at the surface
- EN4 nudging in the subsurface

Default surface restoring coefficients

γ_T = -200 W/m^2/K

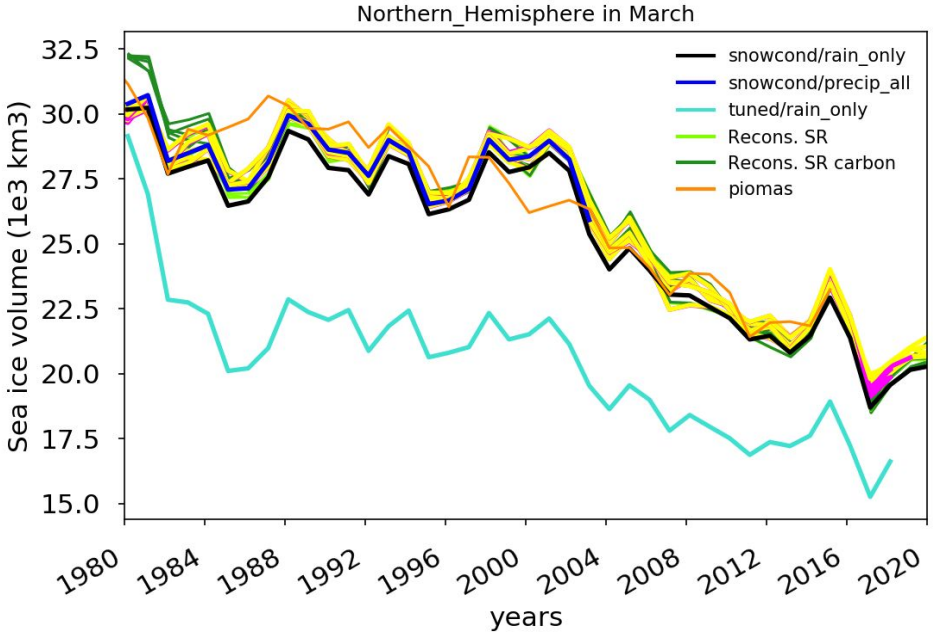
γ_S = -750 kg/m2/s/psu

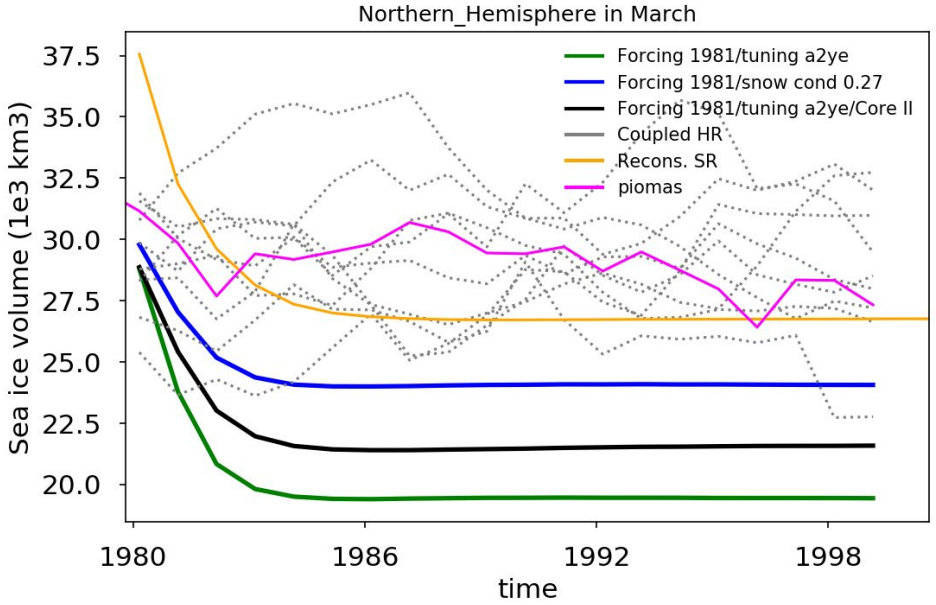
3D restoring timescales



Some issues encountered

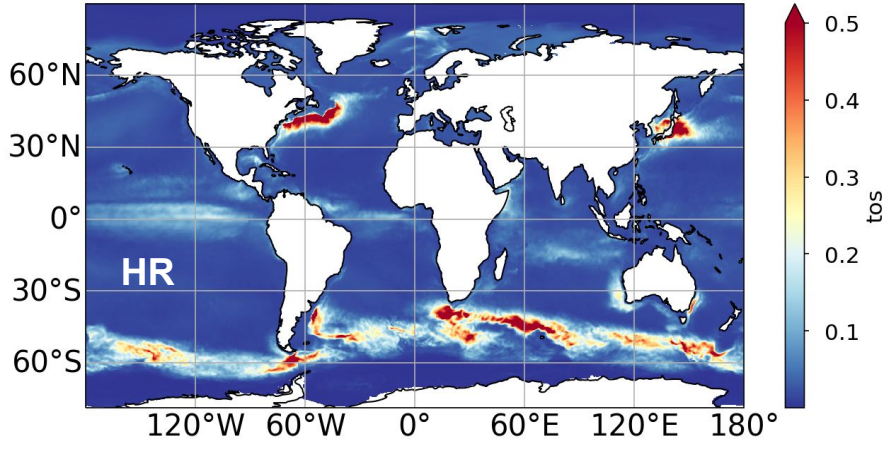
Impact of the snow conductivity value

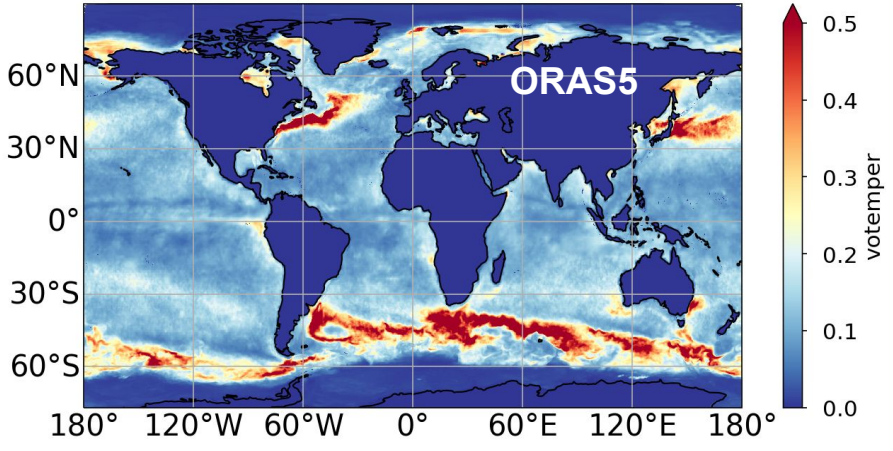


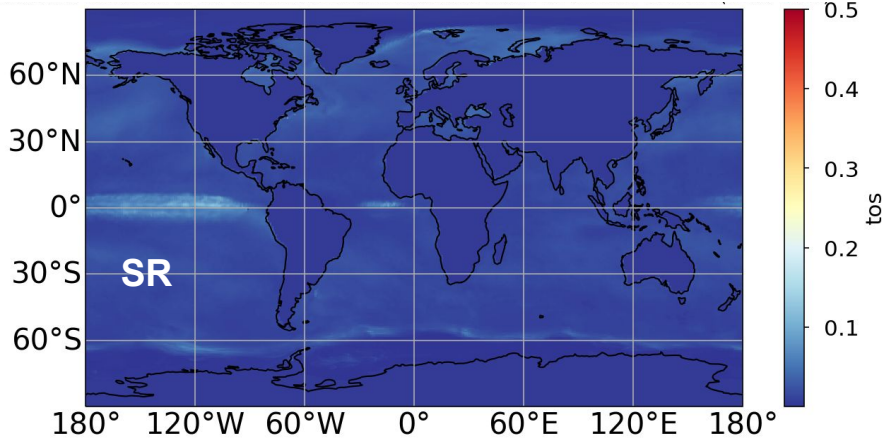


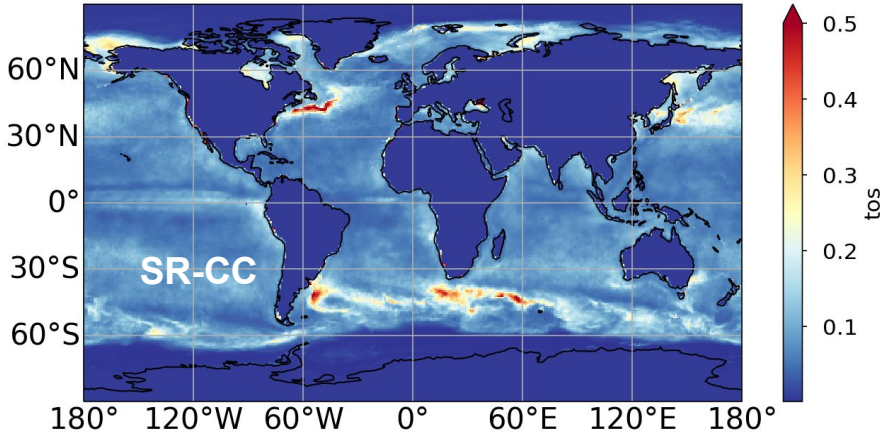
among others…

Low spread between members in SR







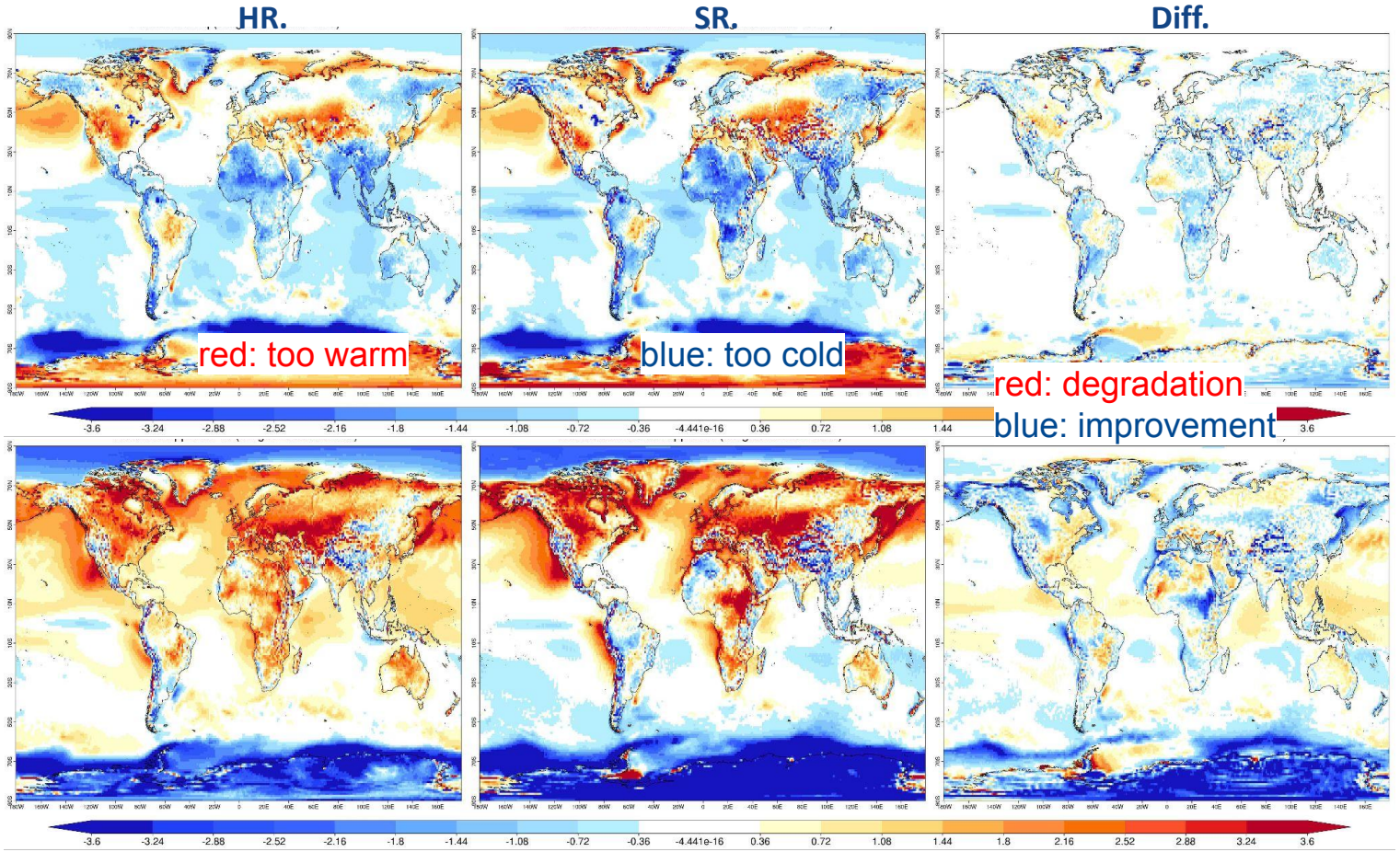


Seasonal forecast systems

Model	Forecast start-dates and length	Number of members	Atmospheric initialisation	Oceanic initialisation
EC-Earth3.3-SR EC-Earth3.3-HR	1990-2015 8 months	20	ERA5	in-house reconstructions ORCA1 ORCA25
CNRM-CM6.1 ~Sys7	1993-2014 6 months	30	ERA-interim	Glorys 2v4 Glorys 12v1

2 initialisations: May and November

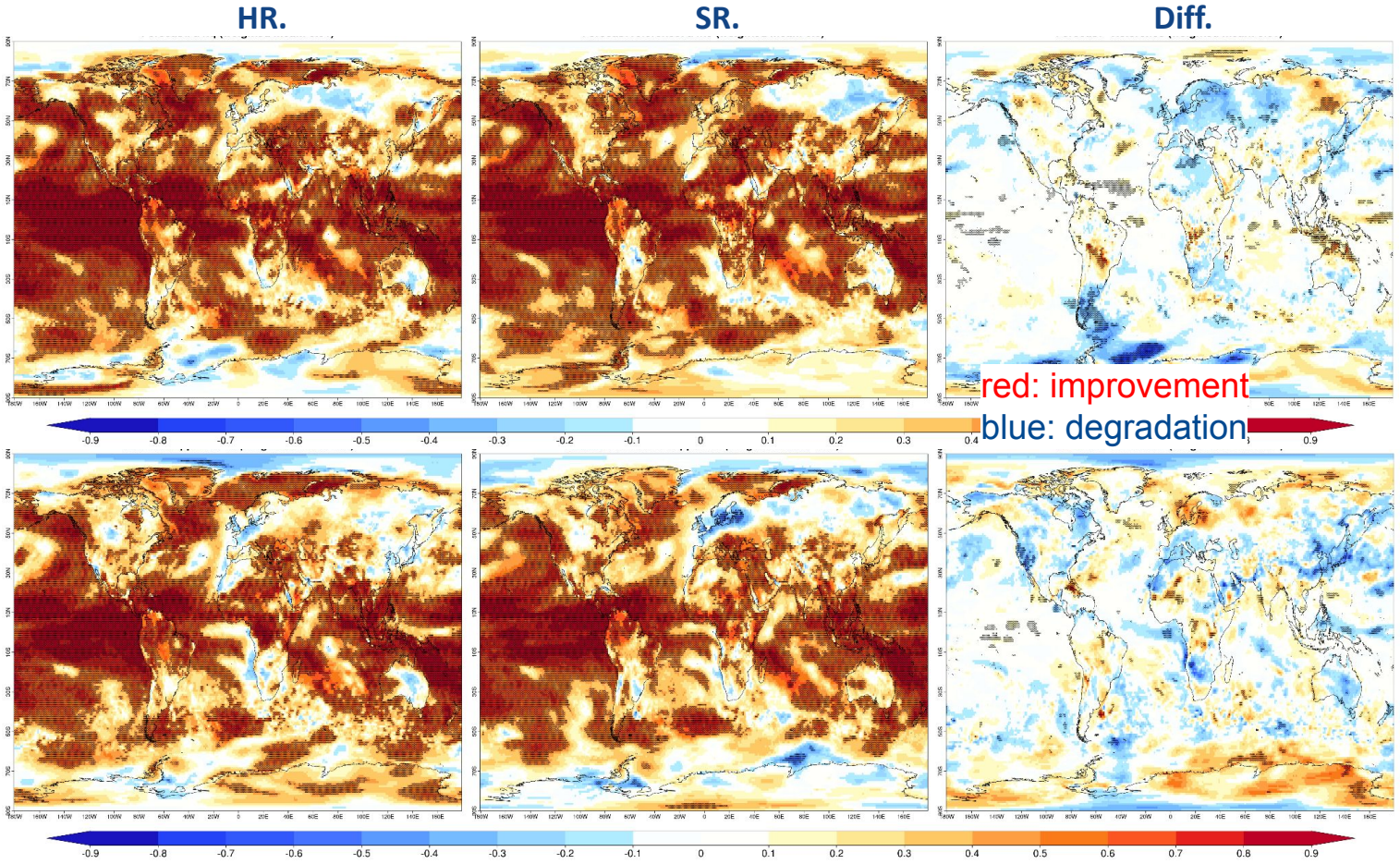
Maps of bias: TAS - Init. in May, JJA mean



Seasonal forecast system
20 members
23 startdates (1993-2014)

Reference: ERA5 - TAS

Maps of ACC: TAS - Init. in May, JJA mean

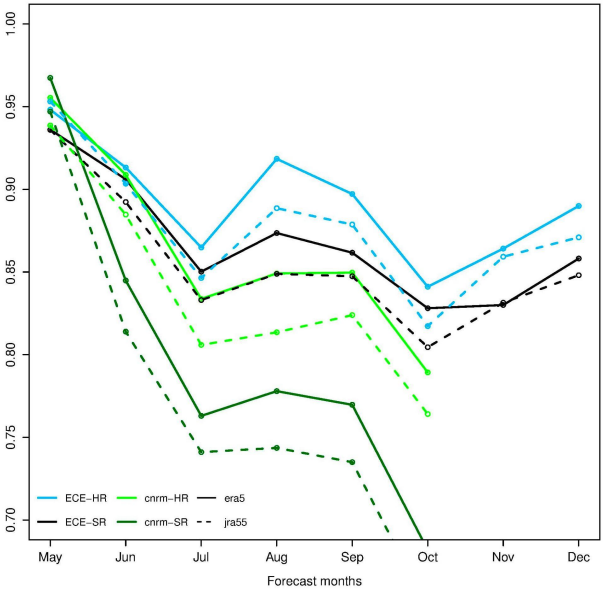


Seasonal forecast system
20 members
23 startdates (1993-2014)

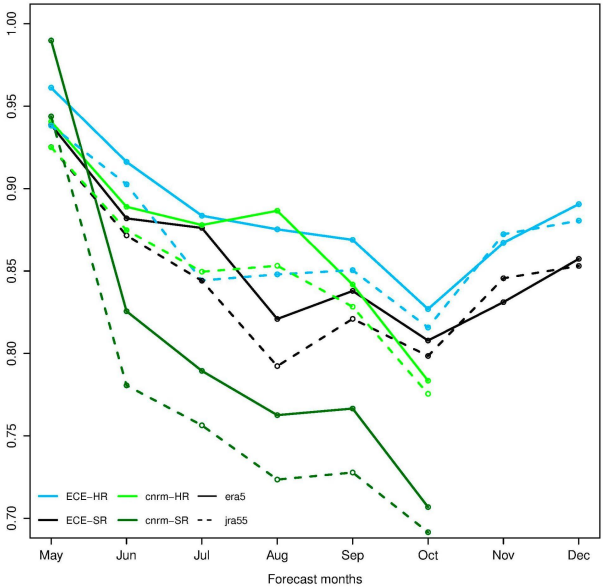
Reference: ERA5 - TAS

Anomaly Correlation Coefficients in Nino regions

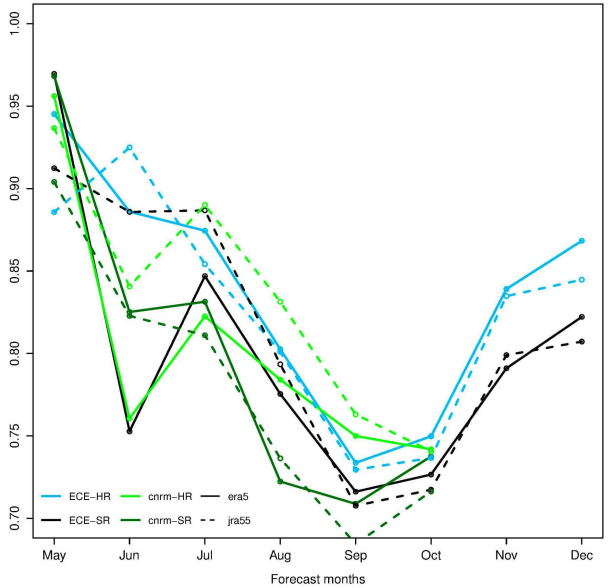
Nino3



Nino3.4



Nino4



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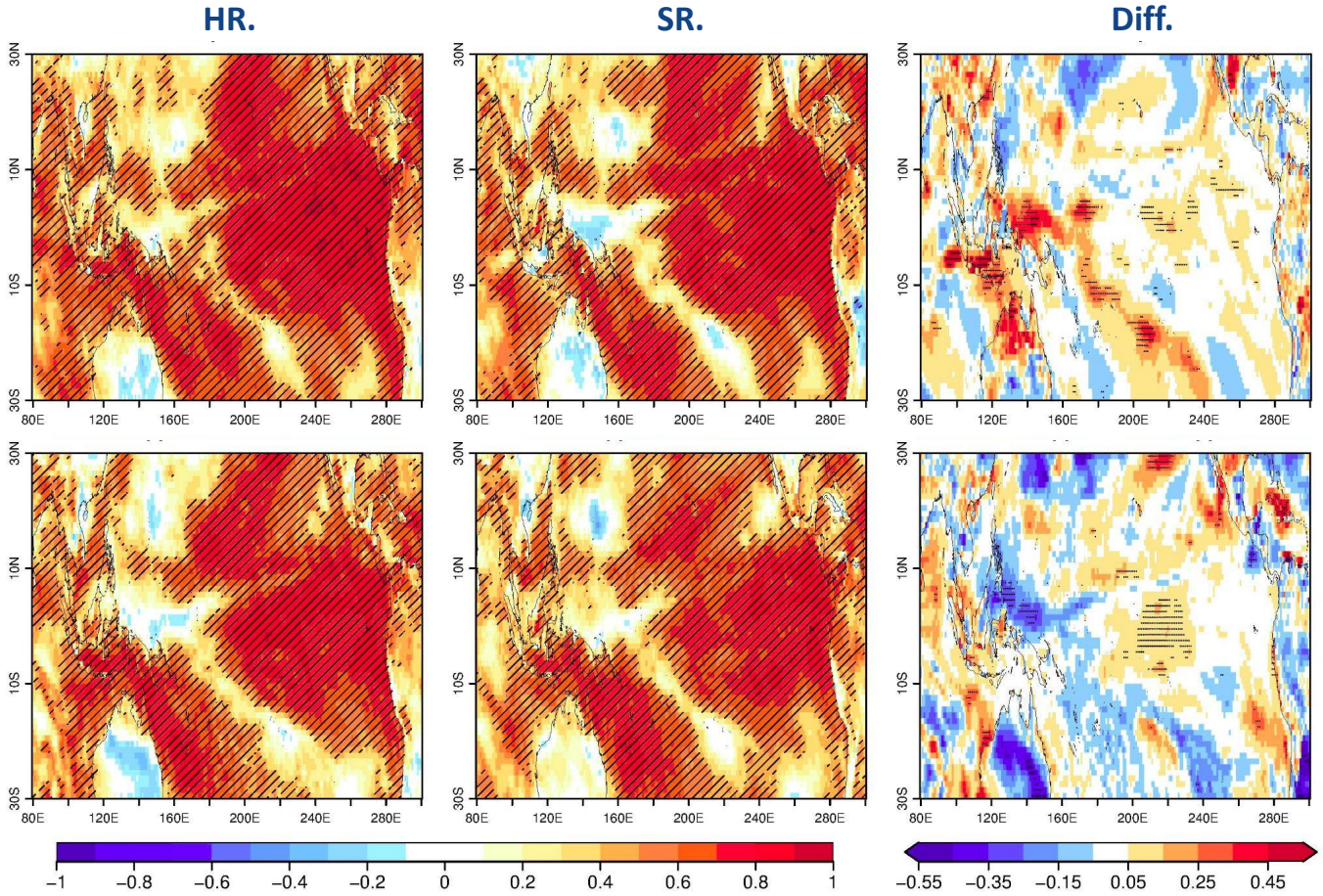
Reference: TAS
ERA5
JRA55

Maps of ACC: TAS - (Init. in May) August



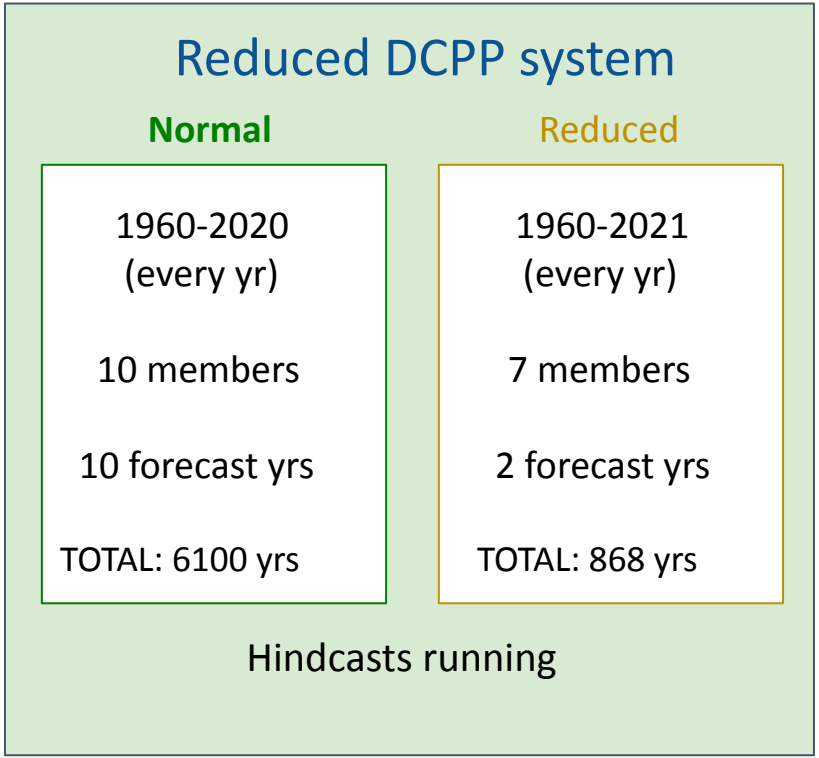
Seasonal forecast system
20 members
23 startdates (1993-2014)

Reference: ERA5 - TAS

Next steps

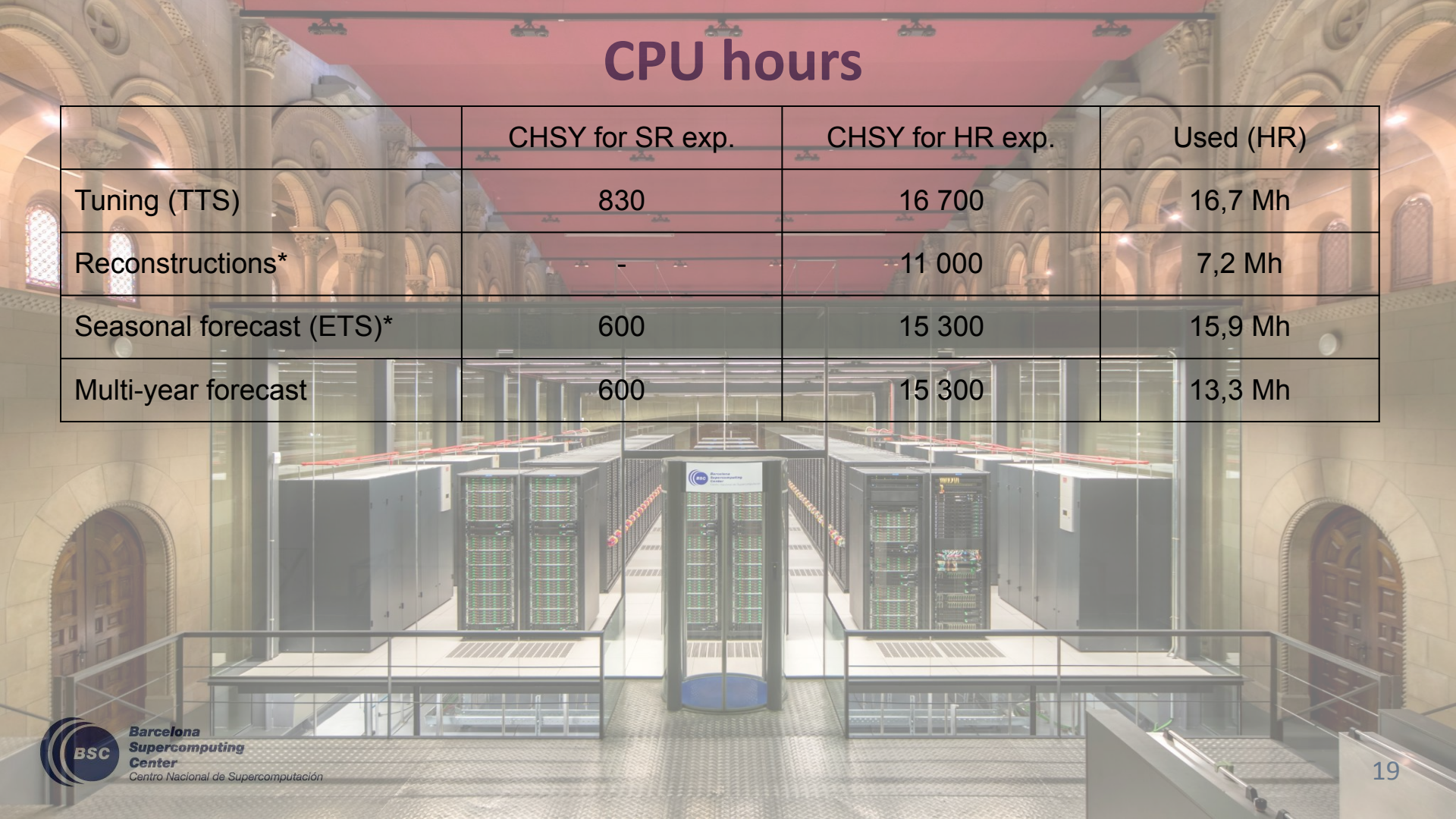
- retrieving CNRM data
- analysis in the tropics:
  - mixed layer depth, heat content, winds, etc
  - composites analysis
- Initialization in November
- Paper

- Monitoring the multi-year forecast system currently running



CPU hours

	CHSY for SR exp.	CHSY for HR exp.	Used (HR)
Tuning (TTS)	830	16 700	16,7 Mh
Reconstructions*	-	11 000	7,2 Mh
Seasonal forecast (ETS)*	600	15 300	15,9 Mh
Multi-year forecast	600	15 300	13,3 Mh



Tuning parameters

Parameters:

- nn_etau: penetration of tke below the mixed layer due to internal & inertial waves
- rn_lc: coef. associated to Langmuir cells
- rn_cdsn: thermal conductivity of snow
- rn_alb_smlt: melting snow albedo
- rn_alb_sdry: dry snow albedo
- rn_aht_0: horiz. diffusion parameter

ExpID	Atm Parameters	Ocean Parameters	Sea Ice Parameters	Advection scheme	Diffusion Parameters
a2s5	SMHI's namelist	nn_etau = 0, rn_lc = 0.2	rn_cdsn=0.15, rn_alb_smlt=0.72, rn_alb_sdry=0.85	TDV scheme	rn_aht_0 = 300
t0dt	SMHI's namelist	**nn_etau = 1, rn_lc = 0.15**	rn_cdsn=0.15, rn_alb_smlt=0.72, rn_alb_sdry=0.85	TDV scheme	rn_aht_0 = 300
t0dz	SMHI's namelist	nn_etau = 0, rn_lc = 0.2	**rn_cdsn=0.25**, rn_alb_smlt=0.72, rn_alb_sdry=0.85	TDV scheme	rn_aht_0 = 300
t0e0	SMHI's namelist	nn_etau = 0, rn_lc = 0.2	rn_cdsn=0.15, **rn_alb_smlt=0.76**, rn_alb_sdry=0.85	TDV scheme	rn_aht_0 = 300
a2s9	SMHI's namelist	nn_etau = 0, rn_lc = 0.2	rn_cdsn=0.15, rn_alb_smlt=0.72, **rn_alb_sdry=0.88**	TDV scheme	rn_aht_0 = 300
a2y6	SMHI's namelist	nn_etau = 0, rn_lc = 0.2	rn_cdsn=0.15, rn_alb_smlt=0.72, rn_alb_sdry=0.85	**UBS scheme**	rn_aht_0 = 300
a2yd	SMHI's namelist	**nn_etau = 2**, rn_lc = 0.2	**rn_cdsn=0.27**, rn_alb_smlt=0.72, rn_alb_sdry=0.85	TDV scheme	rn_aht_0 = 300
a2ye	SMHI's namelist	nn_etau = 0, rn_lc = 0.2	rn_cdsn=0.15, rn_alb_smlt=0.72, rn_alb_sdry=0.85	TDV scheme	**rn_aht_0 = 1000**
a3dv	**default parameters**	nn_etau = 0, rn_lc = 0.2	**rn_cdsn=0.20**, rn_alb_smlt=0.72, rn_alb_sdry=0.85	TDV scheme	**rn_aht_0 = 1000**
a3fy	SMHI's namelist	nn_etau = 0, rn_lc = 0.2	**rn_cdsn=0.20**, rn_alb_smlt=0.72, rn_alb_sdry=0.85	TDV scheme	**rn_aht_0 = 1000**
------	------	------	------	------	------
a334	default values	nn_etau = 0, rn_lc = 0.20	rn_cdsn=0.27, rn_alb_smlt=0.75, rn_alb_sdry=0.85	TDV_ZTS scheme	rn_aht_0 = 1000

Summary

We retained the parameters of the `a2ye` experiment as tuned parameters for the coupled HR model:

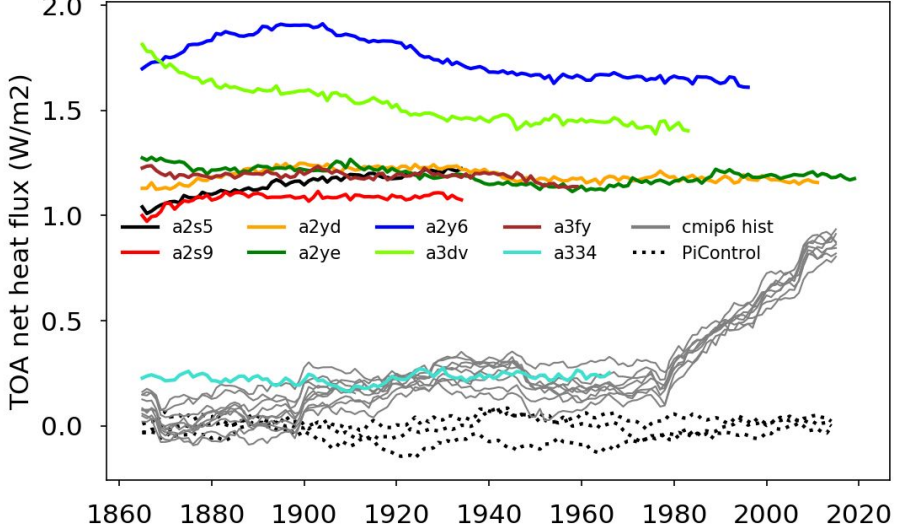
Atmospheric parameters

RPRCON	1.34E-3
RVICE	0.137
RLCRITSNOW	4.0E-5
RSNOWLIN2	0.035
ENTRORG	1.70E-4
DETRPEN	0.75E-4
ENTRDD	3.0E-4
RMFDEPS	0.3
RCLDIFF	3.E-6
RCLDIFFC	5.0
RLCRIT_UPHYS	0.875E-5

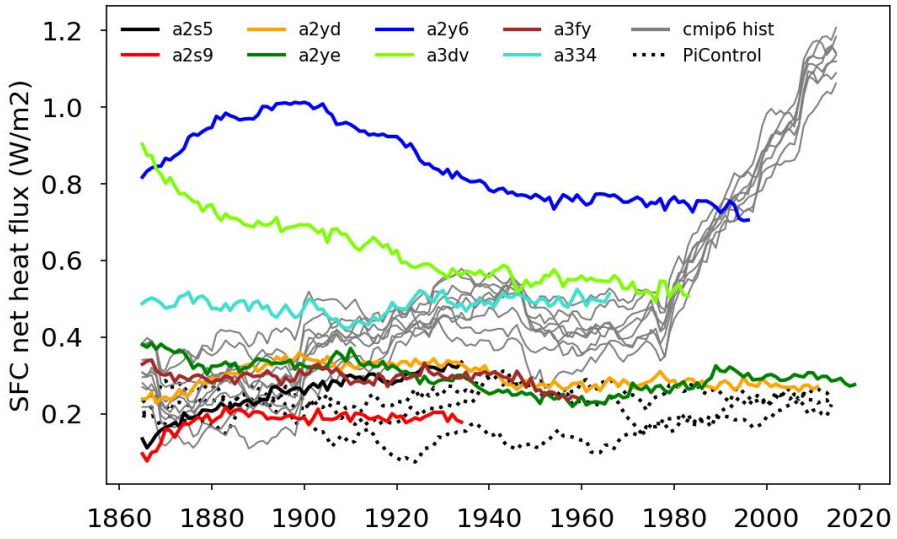
Oceanic and sea ice parameters

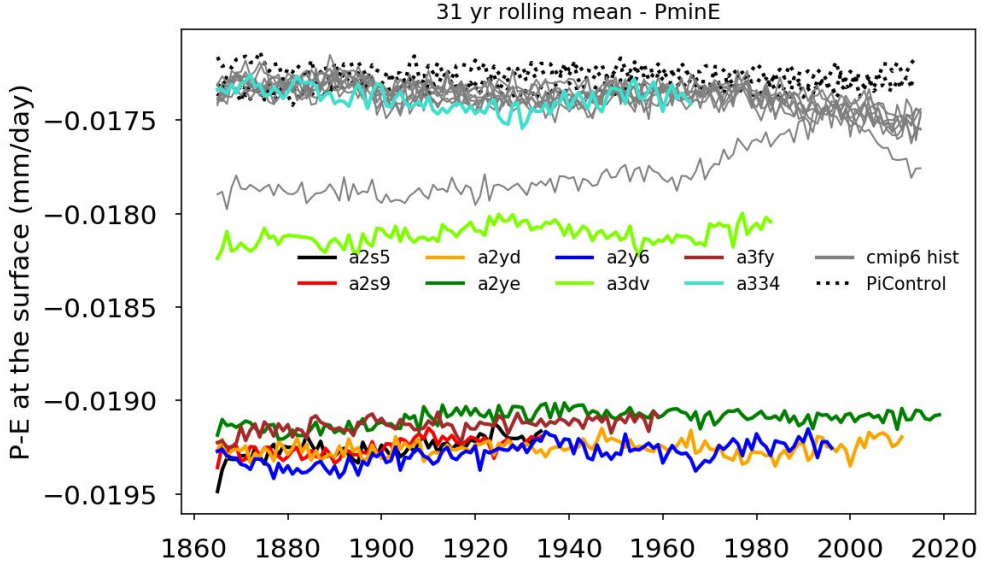
nn_etau	0
rn_lc	0.2
rn_cdsn	0.15
rn_alb_smlt	0.72
rn_alb_sdry	0.85
rn_aht_0	1000
advection scheme	TDV scheme

Radiation budget



	Net TOA	Net SFC (with snowfall)	TOA - SFC	P-E (mm/day)
a2s5	1.19	0.29	0.89	-0.0192
a2s9	1.09	0.19	0.90	-0.0193
a2yd	1.17	0.28	0.89	-0.0192
a2ye	1.18	0.28	0.90	-0.0191
a2y6	1.64	0.74	0.90	-0.0192
a3dv	1.44	0.54	0.90	-0.0181
a3fy	1.19	0.29	0.90	-0.0191
a334	0.24	0.50	-0.26	-0.0174





Forecast systems

Seasonal Hincasts

Hindcast period: 1990-2015

Ensemble: 20 members

Forecast range:

8 forecasted months

from May to December

from November to June

TOTAL: 694 yrs

Reduced DCPP system

Normal	Reduced
1960-2020 (every yr)	1960-2021 (every yr)
10 members	7 members
10 forecast yrs	2 forecast yrs
TOTAL: 6100 yrs	TOTAL: 868 yrs

Hindcasts running