Workshop with MetServices

ASPECT

FACILITATING SEAMLESS CLIMATE ADAPTATION

WP1: Improving the production chain of seamless climate forecasts to address climate adaptation

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Introduction

Objectives:

- Production of improved seasonal-to-decadal predictions to meet user needs for the generation of seamless climate information
- Design forecast methodologies across temporal and spatial scales to leverage ongoing efforts in and contribute to operational modelling and monitoring activities

This presentation:

- Revision of the science behind climate predictions
- Rationale for exploring new protocols
- Update on progress and plans

Contributing institutions: BSC,CMCC,ECMWF, MetOffice, MPI

Existing systems

Seasonal Predictions

Decadal Predictions

Climate Projections

Climate information is associated mainly with Climate Projections

What is the reason for this perception?

- Seasonal initially conceived as initial value problem
- Decadal efforts put emphasis on “ “ “, e.g., predicting the internal variability of climate
- Projections were designed to explore the future climate change

But climate change is no longer exclusive to the future

Paradigm before 2020

Paradigm revisited

Bridging the gaps: exploring new protocoles

Seasonal Predictions

Decadal Predictions

Climate Projections

Bridge Seasonal-Decadal.
Forecasts up to 24-36 months

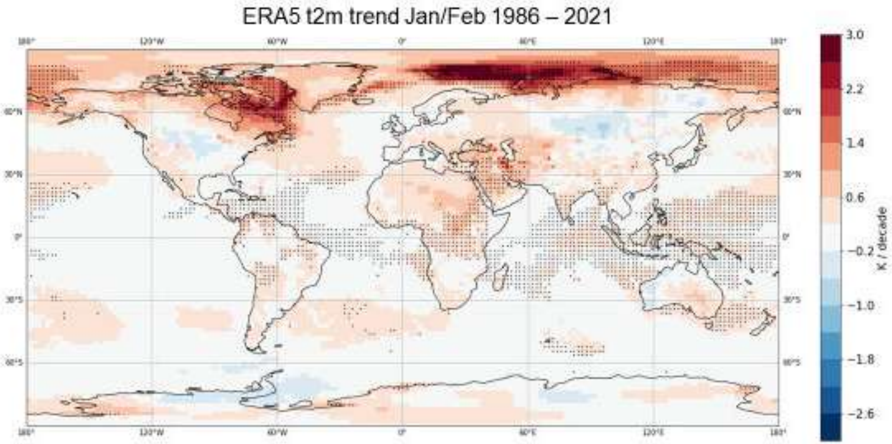
Bridge decadal-projections
Initialized climate outlooks to 20-30 years.
They allow high-resolution modelling and observations for provision of climate information

S2D bridge: Multi-year predictions (2-3 years)

Rationale:

- The climate is changing. Increased demand of information for adaptation (e.g. water management, agriculture)
- A changing climate does not only make climatology less informative, but can be an additional source of predictability and skill
- New science challenge: ensure that S2D prediction systems capture the force response

35-year trends of boreal winter 2m temperature in ERA5

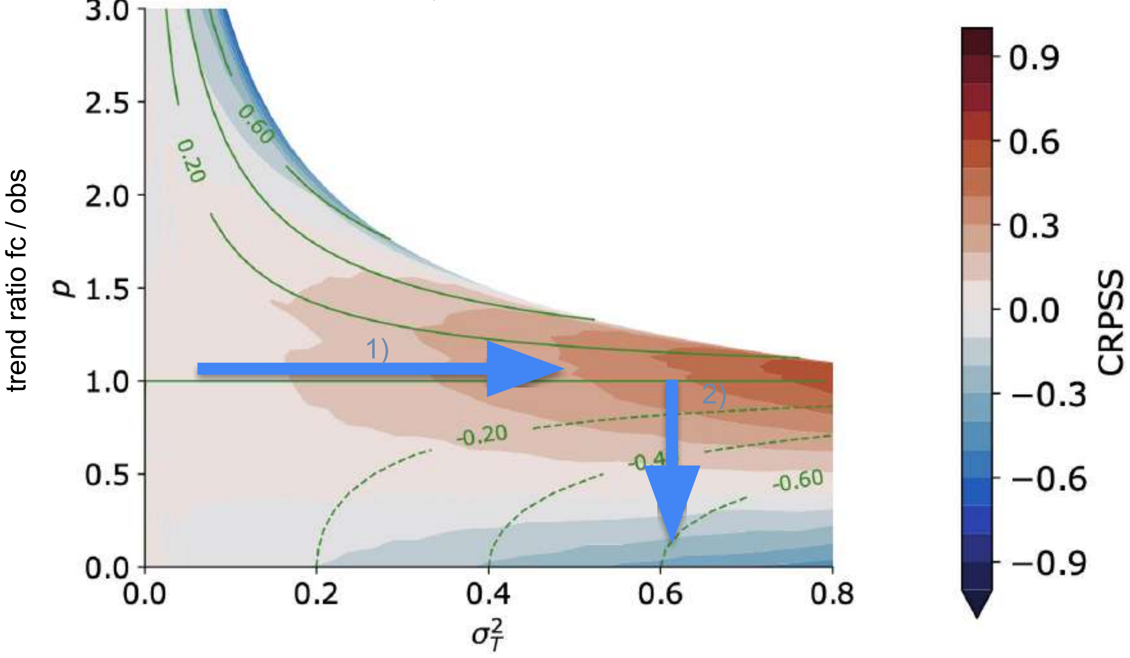


Stippling where trend is robustly non-zero and explains > 10% of total variance

Cp. Simmons, A. J.: Trends in the tropospheric general circulation from 1979 to 2022, Weather Clim. Dynam., 3, 777–809

Trend effects in diagnosed reforecast skill: what should we expect?

Wulff et al., QRMSE 2022



trend-explained fraction of variance

Toy model:

- Verification is white noise with trend
- Forecasts are AR-1 process with correlation α to verification and a different trend
- CRPSS change is w.r.t. verification after de-trending

1) Trends inflate reforecast scores
2) Getting trends wrong degrades reforecast scores

S2D bridge: 2-3 year predictions

Predictability drivers:

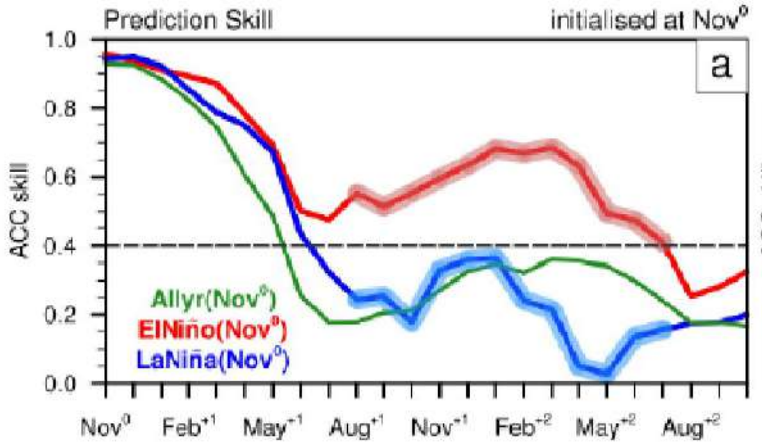
- **ENSO**: evidence of prediction skill beyond 1 year.

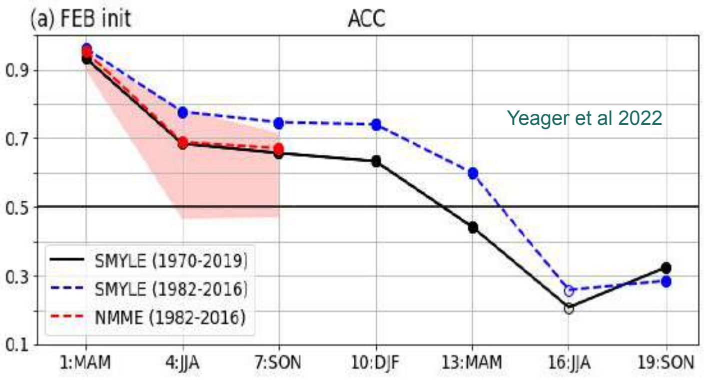
  Several systems show skill beyond 18 months for ENSO prediction.(Yeager et al 2022, Dunstone et al 2022, Sharmila et al 2023)

  In certain occasions that skill can go beyond (eg from El Nino to La Nina)

- **Radiative Forcing**
- **Stratospheric QBO**
- **Ocean thermal inertia**: upper ocean heat content worldwide
- **Atmospheric Angular Momentum** (Scaiffe et al 2024)

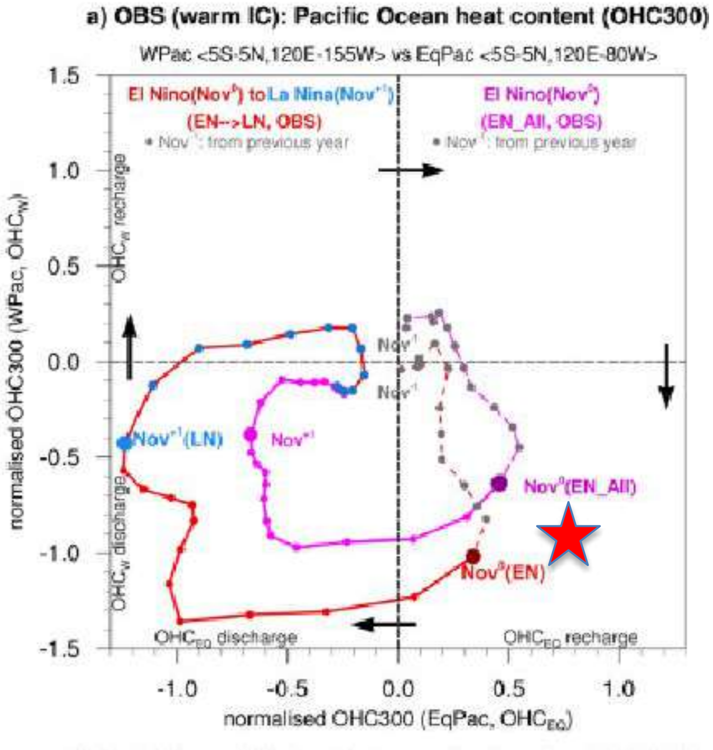
Skill beyond 1-years on ENSO forecasts





A look at the Eq OHC phase space to characterize ocean initial conditions

Composites from Analysis



From Sharmila et al 2023

Forecasts initialized during El Nino have high dynamical memory

Composites of Trajectories from CERA-20 in the OHC phase space illustrate the discharge-recharge mechanism associated to El Nino

Peak El Nino states is charged in Eastern/Central Pacific at expense of discharged in the Western Pacific.

During the subsequent year, the Eastern Pacific discharges, and the western Pacific starts recovering from the heat deficit.

El Nino events with largest Western Pacific discharge tend to be followed by La Nina events.

El Nino events with weaker Western Pacific discharge

The phase space orbits resemble those of a damped oscillator

ASPECT S2D: seasonal angle

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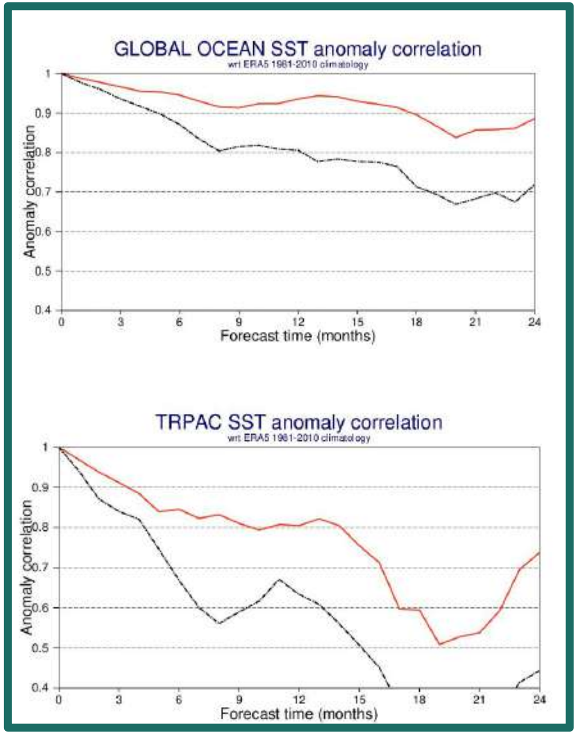
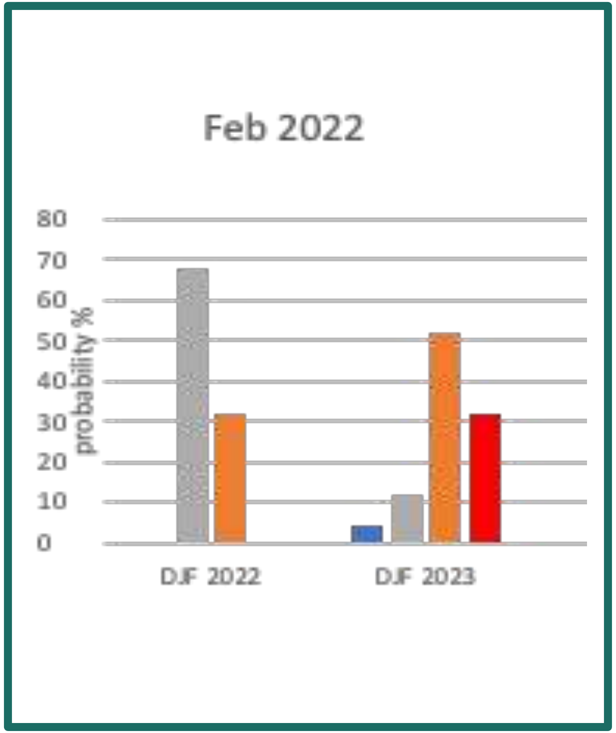
Global and regional
skill beyond one year



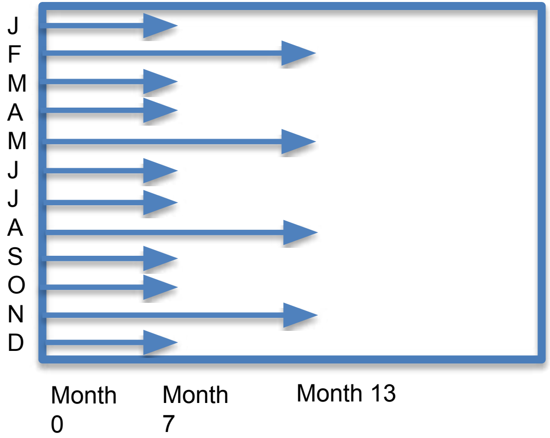
The 2023-4 El Niño was
predicted two-years ahead



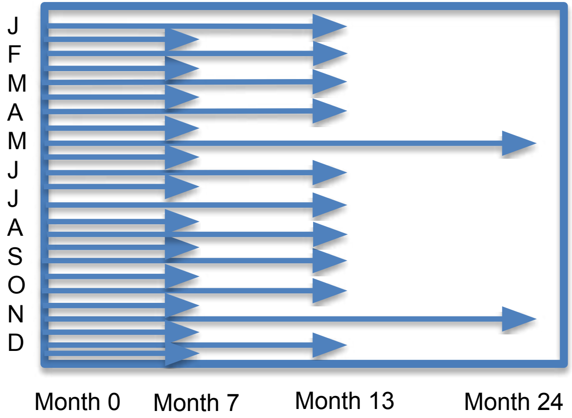
ECMWF

SEAS6 configuration (in 2025) will include 2-year forecasts

SEAS5



SEAS6



SEAS6 Real time forecasts

- 7m twice a monthly, 101 members
- 13m monthly, 33 members
- 25m twice a year 33 members

SEAS6 Reforecasts

A) Main set: 1993-2022

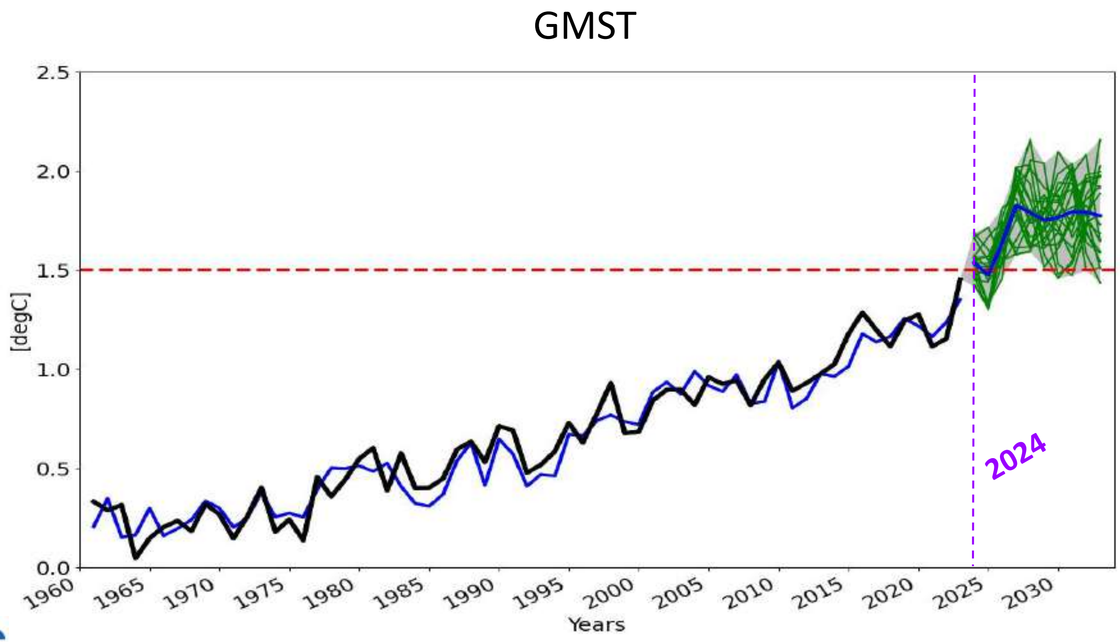
- 7m twice a monthly, 33 members
- 13m monthly, 22 members
- 24m twice a year 22 members

B) Supplementary set: back extension to 1961

- 7m quarterly: 55 members
- 13m, quarterly: 22 members
- 24m, twice a year: 22 members

ASPECT S2D: the decadal angle

Chances are that the coming decade will be the warmest on record and with most individual years exceeding the 1.5ºC threshold



Forecast initialised Nov 2023

Obs in black: HadCRUT 5.0.2.0

Reference period: pre-industrial; (HadCRUT updated to 2023/10).

Forecast:

ensemble mean in blue;

individual members in green

Forcings:

ssp2-rcp4.5 (CMIP6 compliant)

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S2D: decadal angle

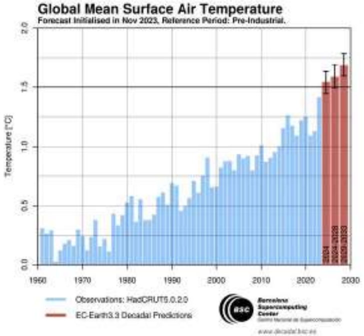
BSC predicts that global-mean temperature could reach the 1.5ºC warming level threshold in 2024

16 January 2024

Annual global mean surface temperatures in 2024 will likely exceed the 1.5ºC threshold for the first time, according to the prediction carried out by the Climate Variability and Change group at the Barcelona Supercomputing Center

Combining the past 10 years of observations and the 10
2014-2033 is 1.41±0.05ºC, indicating that we are on the brink

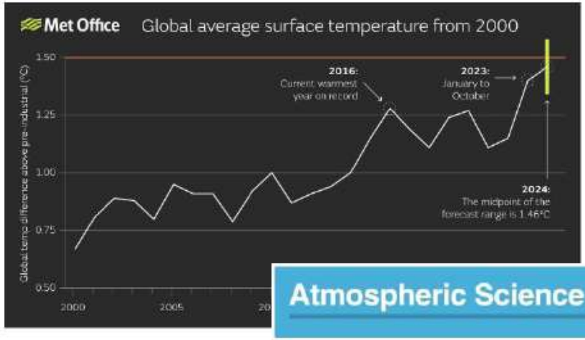
The BSC is a world-renowned decadal prediction centre that a



2024: First chance of 1.5 °C year

Author: Grahame Madge
00:01 (UTC) on Fri 8 Dec 2023

The Met Office outlook for global temperature suggests 2024 will be a further record-breaking year, expected to exceed 2023, which is itself almost certain to be the warmest year on record.



Atmospheric Science Letters Open Access RMetS

RESEARCH ARTICLE | Open Access

Will 2024 be the first year that global temperature exceeds 1.5°C?

Nick J. Dunstone, Doug M. Smith, Chris Atkinson, Andrew Colman, Chris Folland, Leon Hermanson, Sarah Ineson, Rachel Killick, Colin Morice, Nick Rayner, Melissa Seabrook, Adam A. Scaife

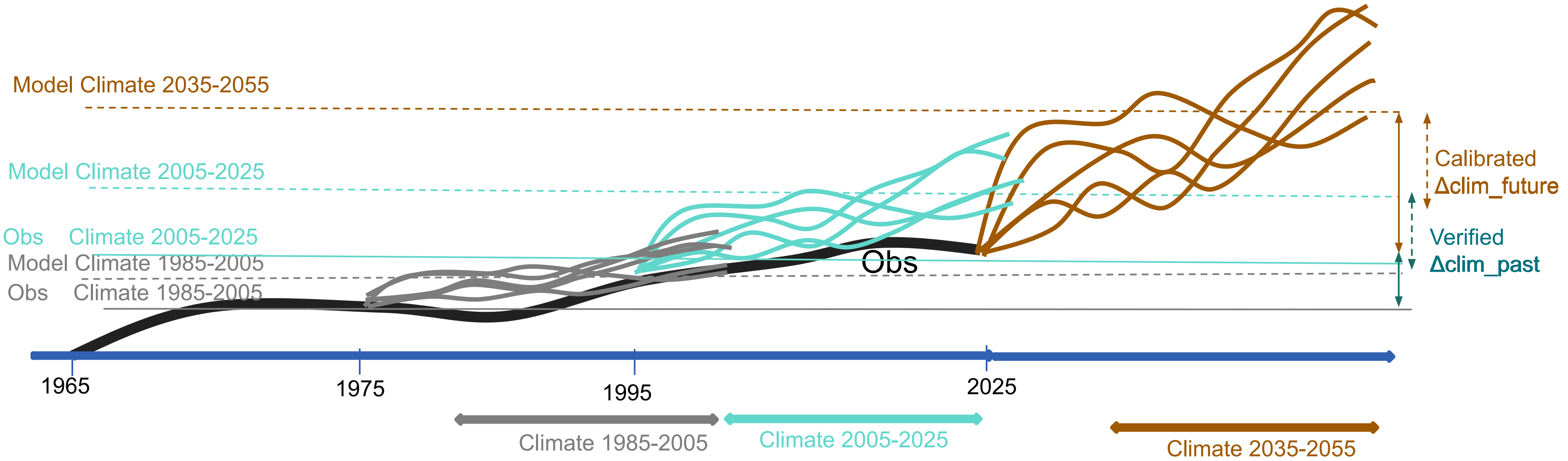
First published: 13 June 2024 | https://doi.org/10.1002/asl.1254

Paper just published

Extended seasonal

Institute	Model/system	Ensemble size	Forecast length	Res. (atmo)	Notes
BSC	EC-Earth3 (std)	20	36 months	~100 km	
BSC	EC-Earth3 (high)	15	36 months	~30 km	Finishes 2021.
CMCC	CMCC-CM2-SR5	10 (15 soon)	28 months	~100 km	(10 members→15)
ECMWF	SEAS5	25	24 months	~35 km	
MPI	MPI-ESM-HR	30	24 months	~100 km	
Met Office	DePreSys3	40	17 (Nov) 11 (May)	~60 km	Shorter forecasts.
JMA	SINTEX-F2	12	28 months	~100 km	Starts 1982.
ECCC	CanCM4i	10	28 months	~500 km	Lower resolution.
ECCC	CanESM5	10	28 months	~500 km	Lower resolution.
NCAR	CESM2	20	24 months	~100 km	
8 institutes	**10 systems**	**192 (max)**	**~24+ months**	**~30-500 km**	

S2P bridge: Initialized 30 year outlooks
how will climate have changed by the middle of the century?



Analysis similar to projections: Changes in mean, variability, trends, extremes

The first set of integrations allows calibration (similar to projections)

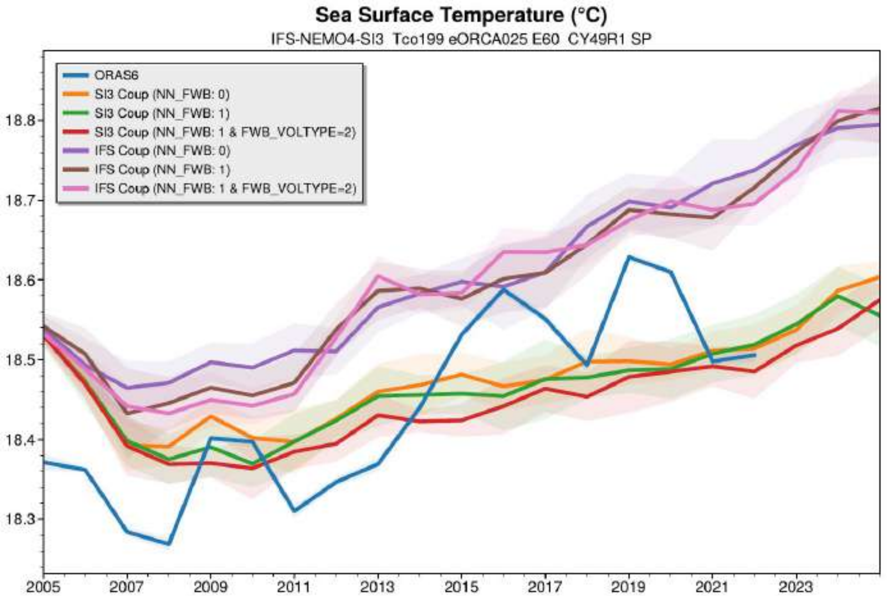
The second set of integrations allows verification (similar to decadal)

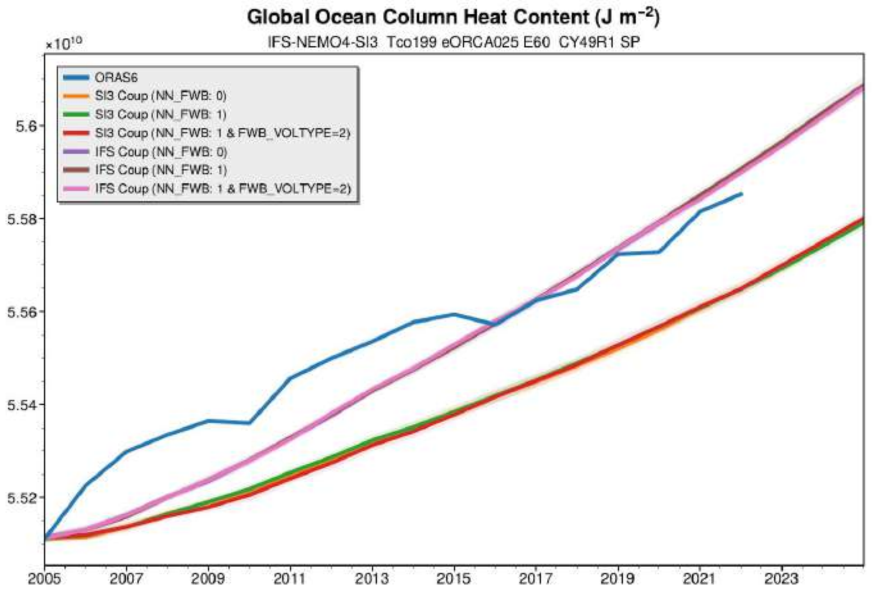
Further sets of integrations will remove uncertainty in the calibration.
The more the better. But how many more are needed?

Note: We take only the last 20-years of the integrations to eliminate impact of initialization

30-years initialized outlooks (II)

Testing the impact of albedo (SI3 versus Clim from IFS) and Fresh-water closure on heat uptake





The solution is sensitive to the Sea-Ice albedo settings.
Fresh-water closures have very little impact on Ocean heat uptake

Extended decadal prediction

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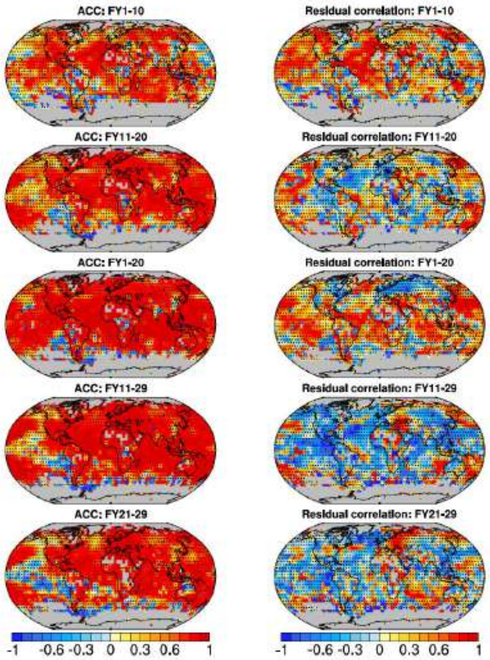
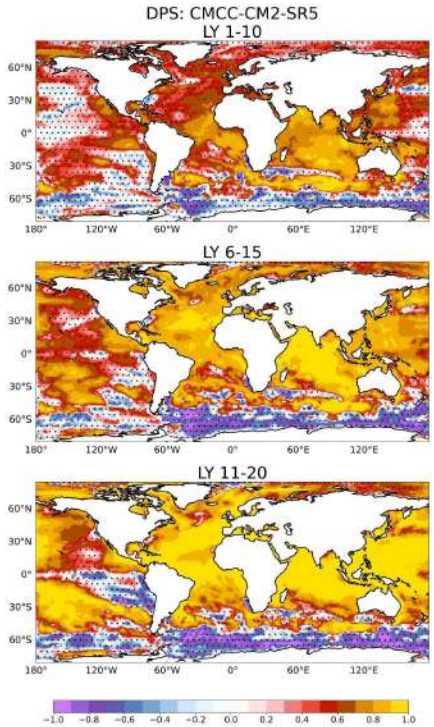
SST correlation for EC-Earth3.3 30-year forecasts (start every five years 1960-2000)



Simulations for the start dates up to 2020 are also available

SST correlation for CMCC-DPS 20-year forecasts (start every five years 1960-2000)



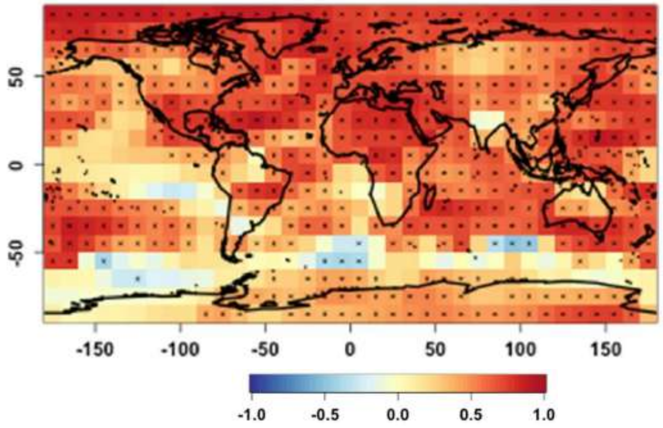
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

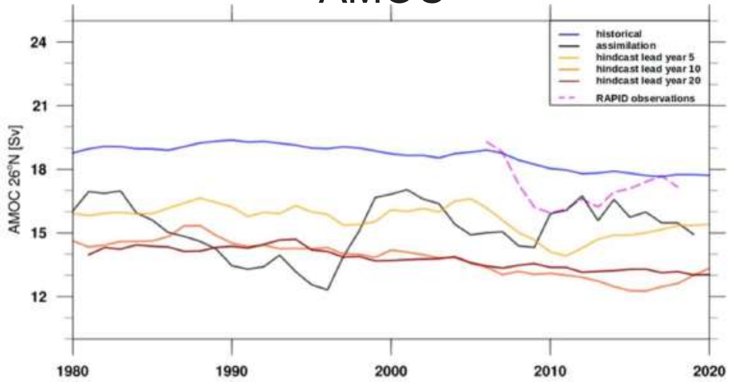
Extended decadal prediction

20-year forecasts with MPI-ESM-LR, start every year 1960-2019 (1st of Nov), surface air temperature (SAT) and Atlantic Meridional Overturning (AMOC); Düsterhus and Brune (2023)

SAT correlation: Forecast time: 18-20 yrs



AMOC



The effect of the initialisation persists for longer than 10 years and the AMOC drifts towards a state different from both the initial state and the state of the historical simulations

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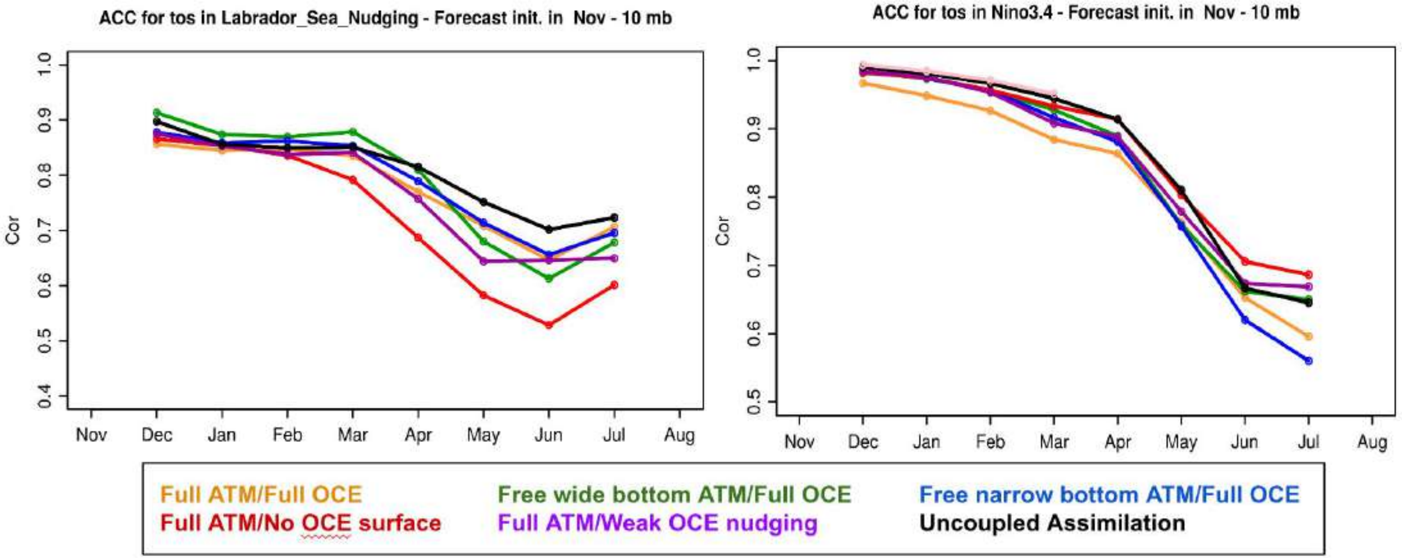
Initialisation

Model initialisation is a key WP1 activity. This aspect requires expensive experiments.

Correlation of the ensemble mean, area-averaged SST from EC-Earth3.3 predictions started from different sets of initial conditions.



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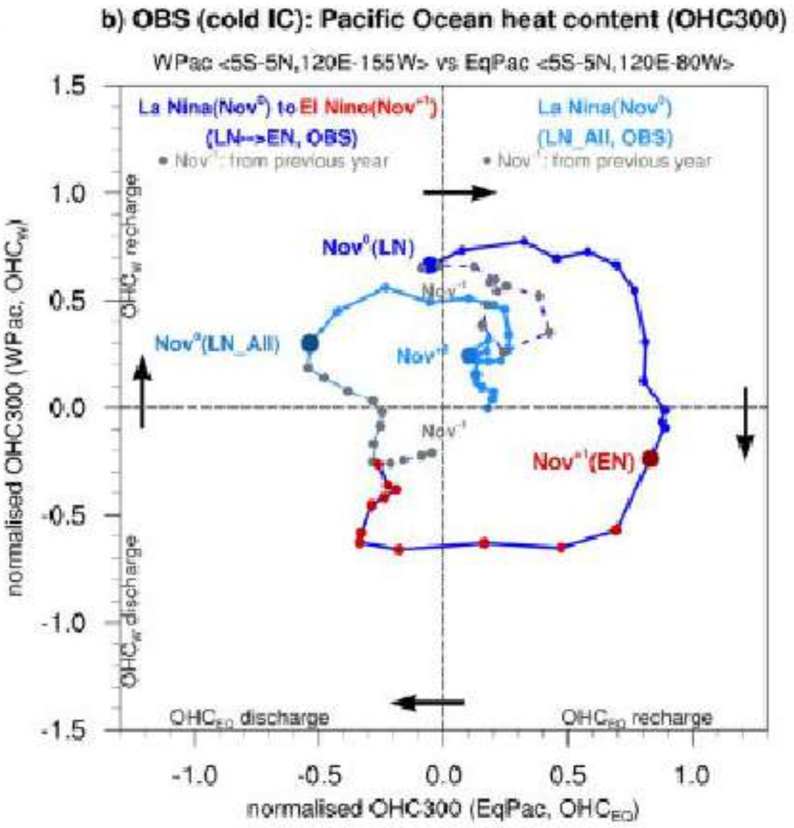
OHC phase space for trajectories starting

Composites from Analysis



La Nina conditions transitioning to El Nino start with a recharged OHC in Western Pacific, and <u>neutral or recharged Eastern/Central Pacific.</u>

The amplitude of the generic La Nina composites (LN->ALL) decays fast when the trajectory goes to the upper-right quadrant, when going throw the boreal spring.

The forecast composites for La Nina initial conditions also captures the differences between LN->ALL and LN->EN, but the orbits decay faster than when initialized with El Nino conditions.

The boreal spring predictability barrier seems to affect more the forecasts from La Nina to El Nino than from La Nina to El Nino