Regional scale evaluation of marine properties as simulated by CMIP6 Earth System models for contemporary climate conditions

CL3.1.4 – Climate change and other drivers of environmental change in Mediterranean-type and other climate regions, regional seas and coastal zones

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Rationale

Environmental changes related to climate hazards have significant implications at regional and coastal level

→ It is essential for a consolidated implementation of adaptation and mitigation strategies to understand, quantify and predict these impacts

Nevertheless: **information available on the environmental changes is often insufficient**

Extensive datasets from global projections (CMIP) provide a wealth of information including crucial estimates of uncertainty and likelihood but are mostly assessed at global or basin level delivering broad-scale information that is often less relevant or prone to large uncertainties at the regional service level.

Some regional information exists deriving from individual dynamically downscaled simulations, mostly driven by the effort of individual institutions => lack robust estimates of uncertainty and are prone to significant biases deriving from the applied boundary forcings, which are often chosen in an opportunistic manner.

→ Need for systematic approach for downscaling (Drenkard et al. 2021) based on thorough analysis of underlying global simulation

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Systematic Assessment of CMIP6 data

Based on climatologies for recent historical period (2000-2014)

Comparison of spatial patterns against observation based climatologies

Metrics: Bias, RMSD, Pearson Correlation, STD ratio

16 CMIP6 ESMs: ACCESS-ESM1-5 ,CanESM5, CanESM5-CanOE, CESM2, CESM2-WACCM, CMCC-ESM2, CNRM-ESM2-1, EC-Earth3-CC, GFDL-CM4, GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MPI-ESM1-2-LR, MRI-ESM2-0, NorESM2-LM, NorESM2-MM, UKESM1-0-LL

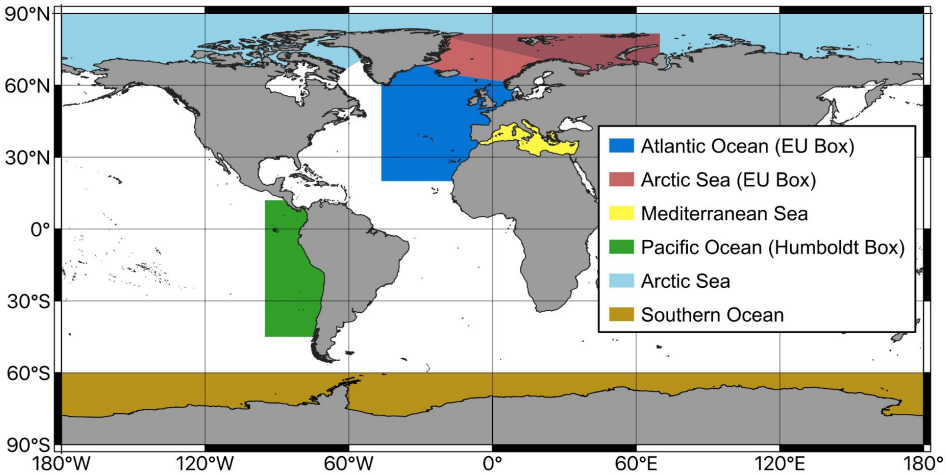
Assessment toolbox built on top of ESMValTool v2 (Eyring et al., 2021) to process and analyse CMIP6 historical data.

Overview of regional domains and variables

Marine biogeochemical quantities

- air-sea CO2 fluxes (fgco2)
- vertically integrated primary productivity (intpp)
- seawater temperature (thetao)
- seawater salinity (so)
- nitrate (no3)
- dissolved oxygen (o2)
- dissolved inorganic carbon (dissic)
- total alkalinity (talk)
- pH (ph)

Areas

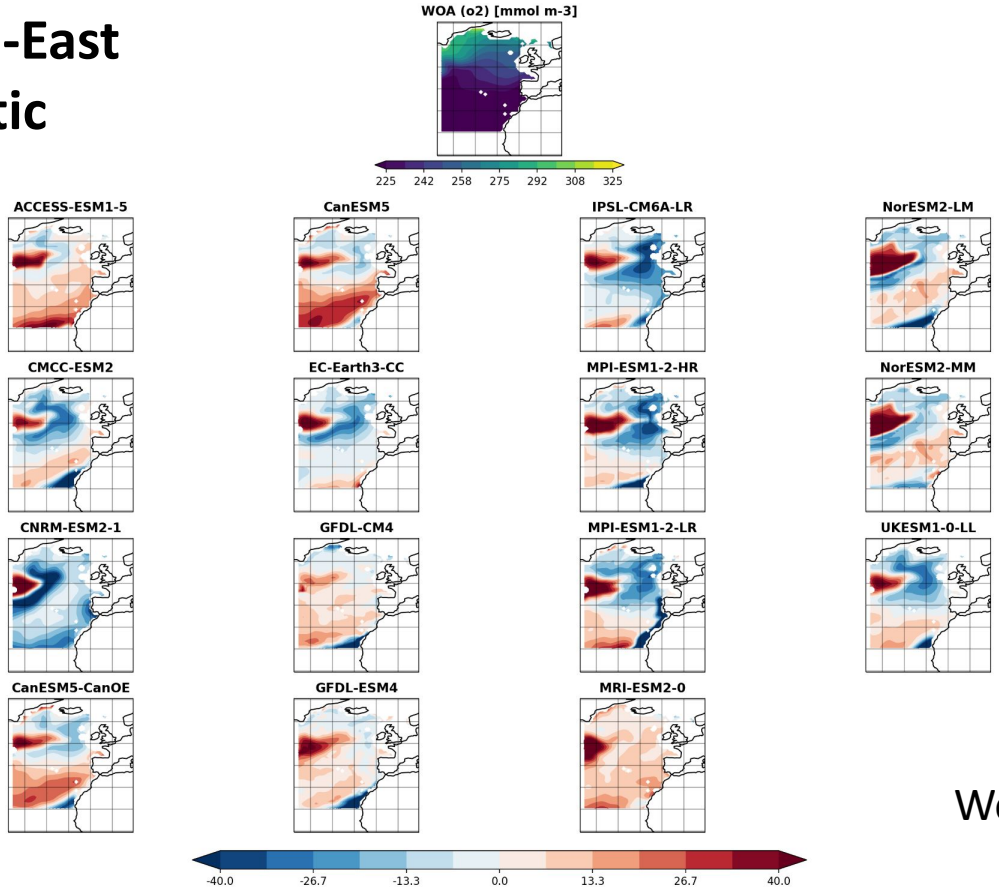


Marine regions considered in the evaluation of CMIP6 ESMs historical simulations.

Depth layers (m): near-surface, 100, 250, 500, 1000

Examples - Bias maps

North-East Atlantic



Dissolved Oxygen @ 250m

Model climatology

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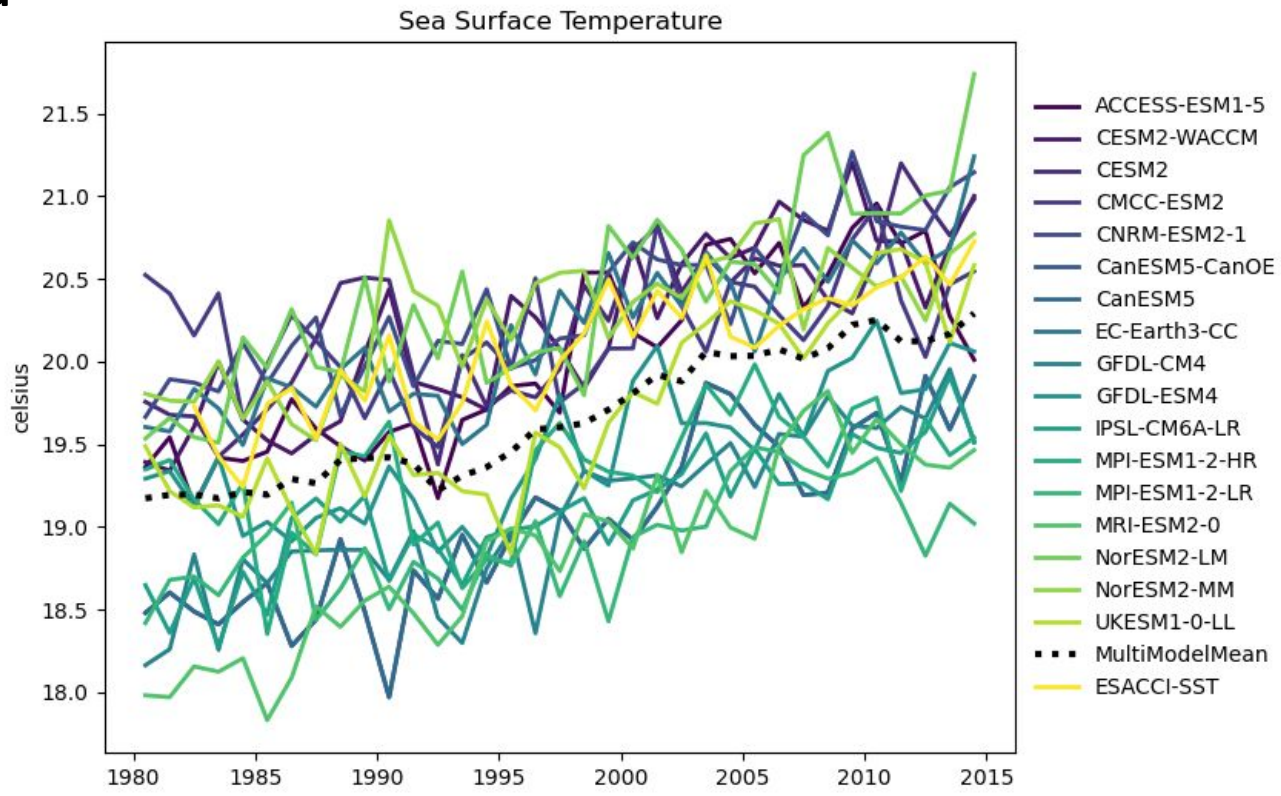
WOA climatology

Observational field:
World Ocean Atlas 2018 Climatology

Examples - Time Series

Mediterranean Sea

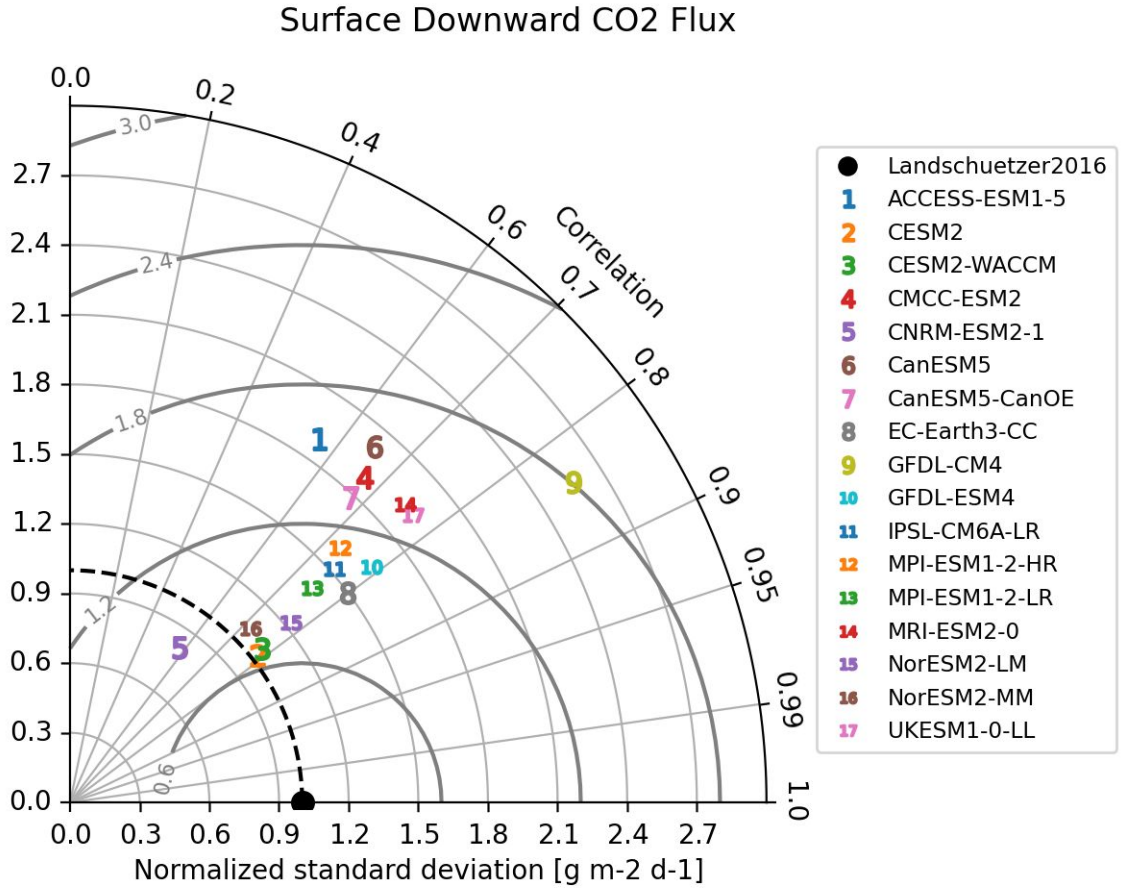
Observational field:
ESACCI-SST
(yellow line)



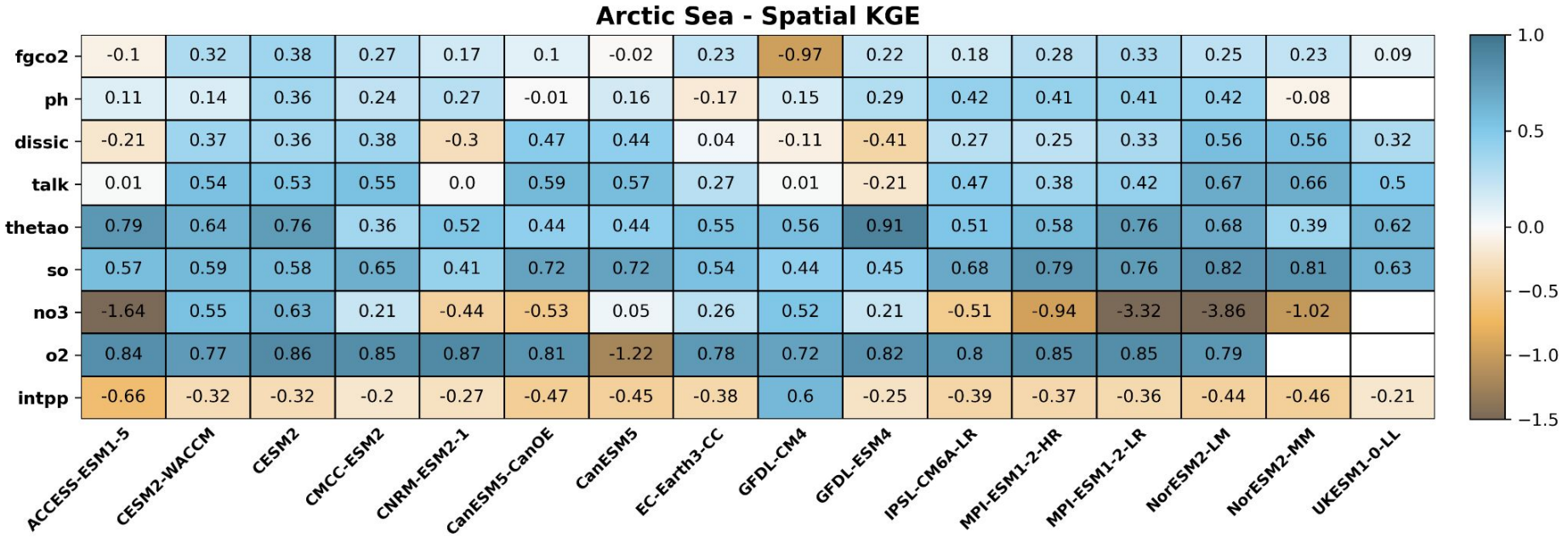
Examples - Taylor Diagrams

North-East Atlantic

Observational field:
Landschuetzer et al. (2016)



Examples - Summary Tables



Kling-Gupta efficiency (KGE) combines Pearson's correlation, variability bias ($\sigma_{sim}/\sigma_{obs}$) and mean bias ($\mu_{sim}/\mu_{obs}$) (Gupta et al., 2009). A value of 1 indicate a perfect representation of data.

Emerging messages

- Valuable information highlighting the increased uncertainty in CMIP6 projections at regional level and the spread of model performances
- Highly relevant information for statistical or dynamic downscaling efforts
- No single fit-for-purpose models for downscaling across regions and ocean pressures

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