Ocean physical-biogeochemical interactions in the CMIP6 and E3SM Earth System Models

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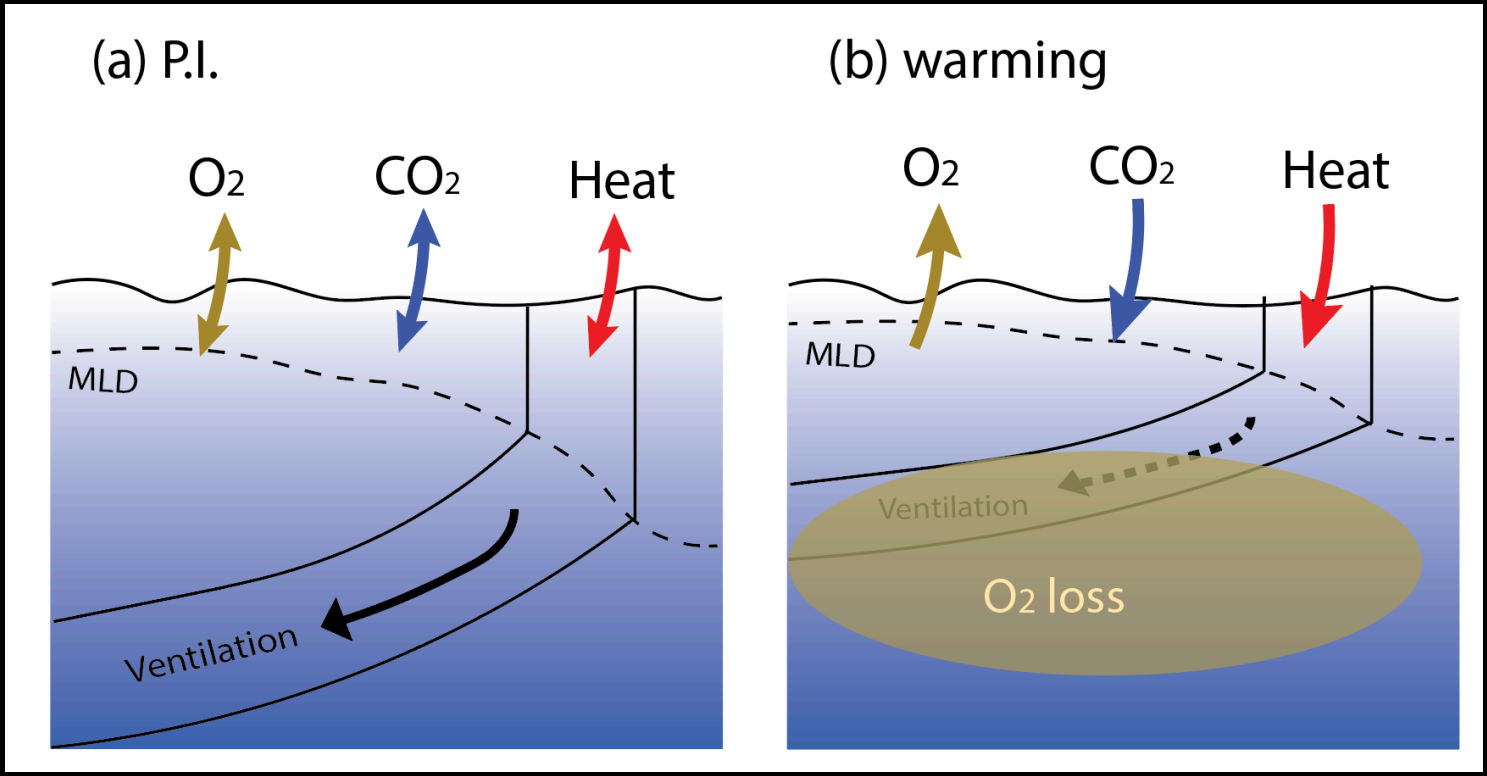
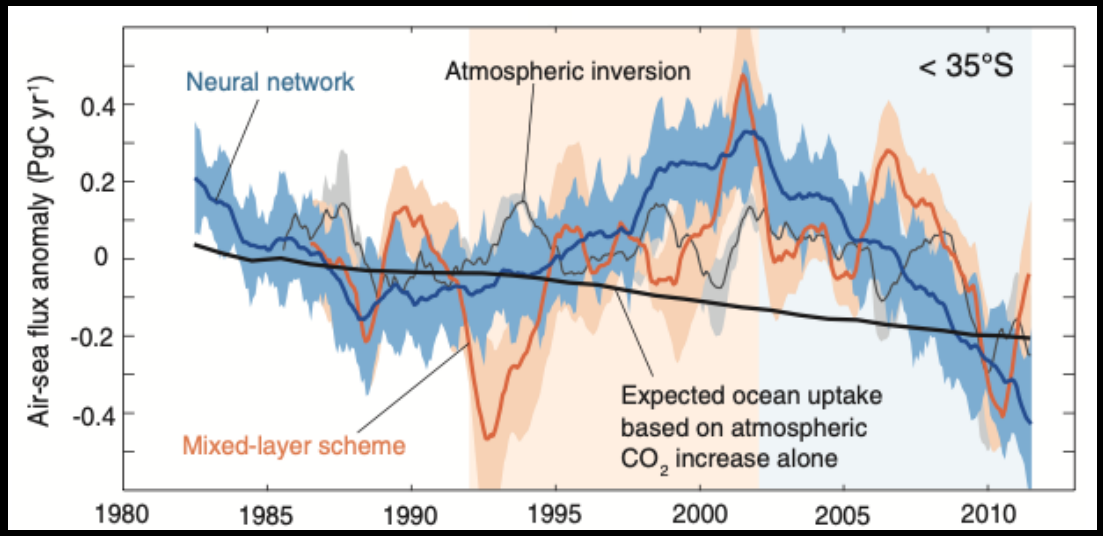
Motivation: the ocean exchange heat, carbon and oxygen with atmosphere

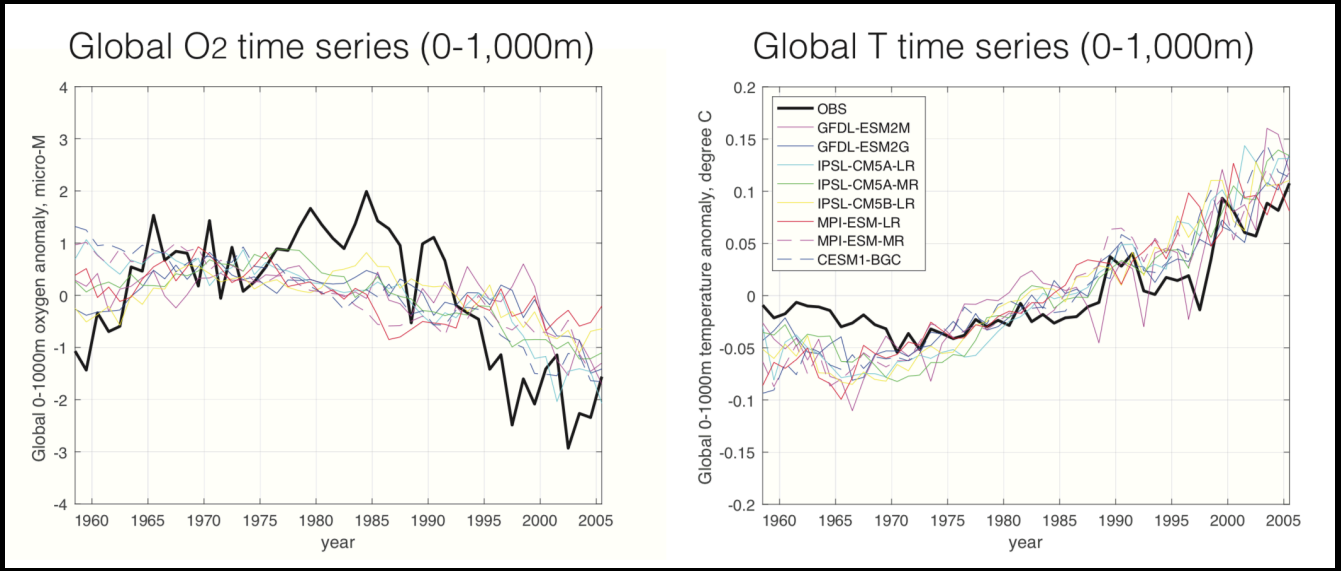


Motivation: simulated and observed biogeochemical trends/variability differ



Time-series of ocean carbon uptake south of 35°S from Landschützer et al (2015), exhibits much stronger IAV and DV than models (DeVries et al., 2019)

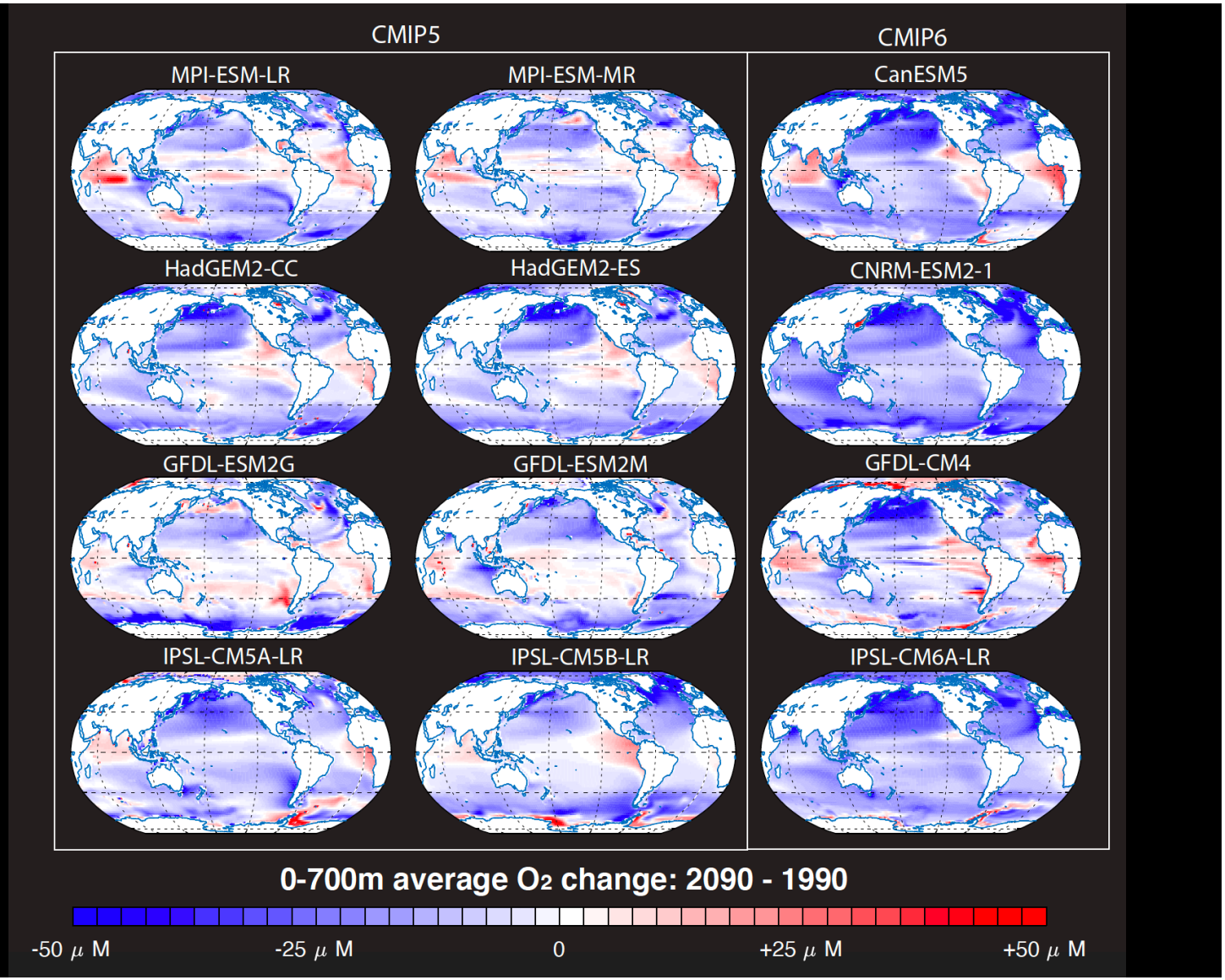
Motivation: simulated and observed biogeochemical trends/variability differ



CMIP5 models underestimate recent (1990-) acceleration of O_2 loss relative to observational estimates (Ito et al., 2017).

CMIP5/6 dissolved oxygen trend

Models generally agree in mid-high latitudes but disagree in tropics



Objectives:

- Evaluate E3SM and CMIP6 earth system models' ability to represent physical-biogeochemical variability

- Characterize patterns of physical and biogeochemical variability and their spatio-temporal linkages (both in observation and models)

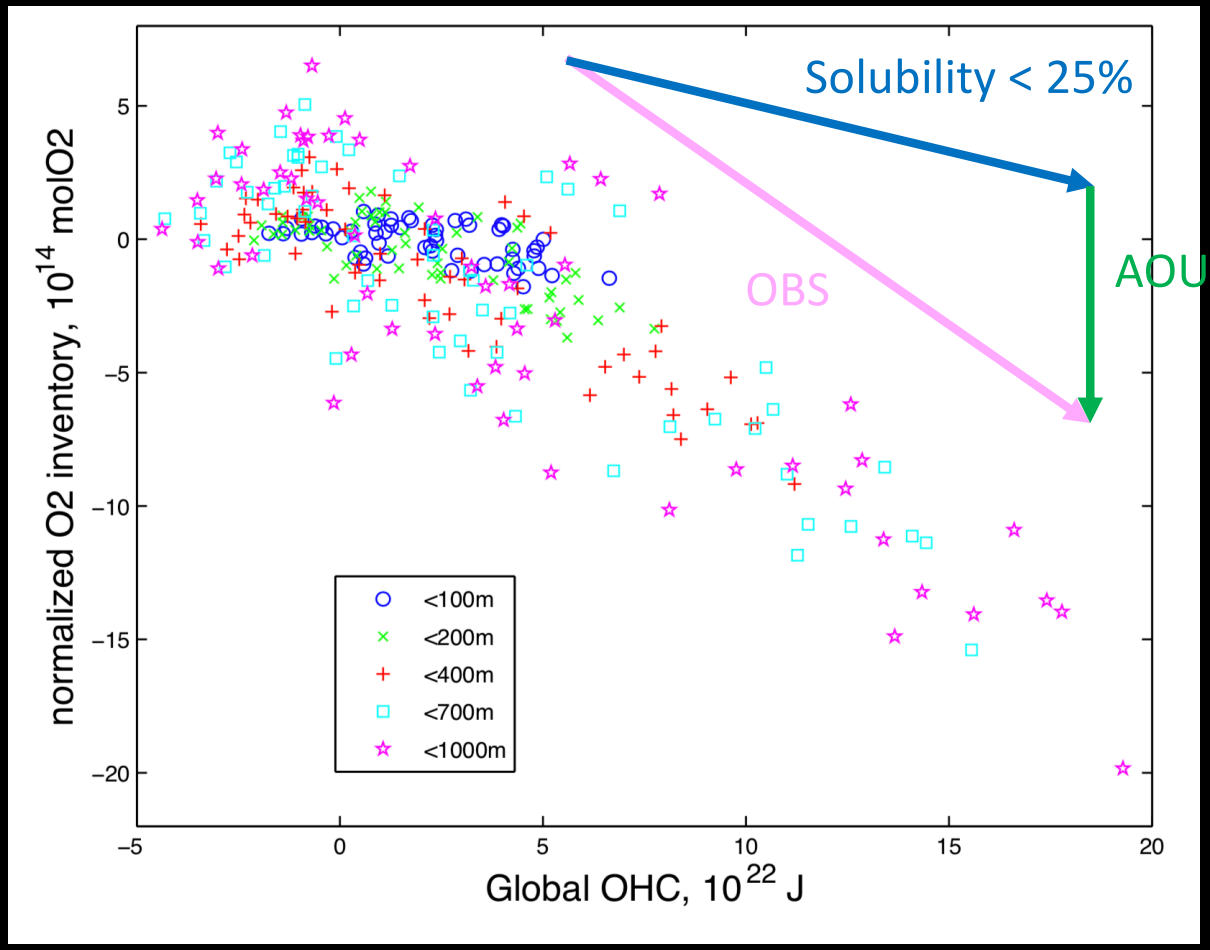
Hypothesis:

- Three key mechanisms: water mass distribution, ventilation, and biological production.

Metric:

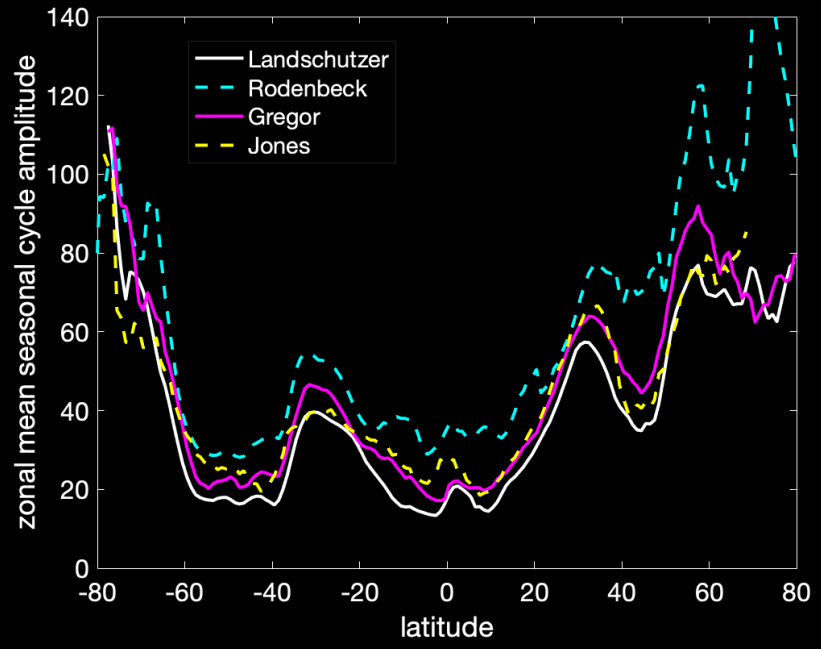
O_2:T ratio

Ocean O_2 Content

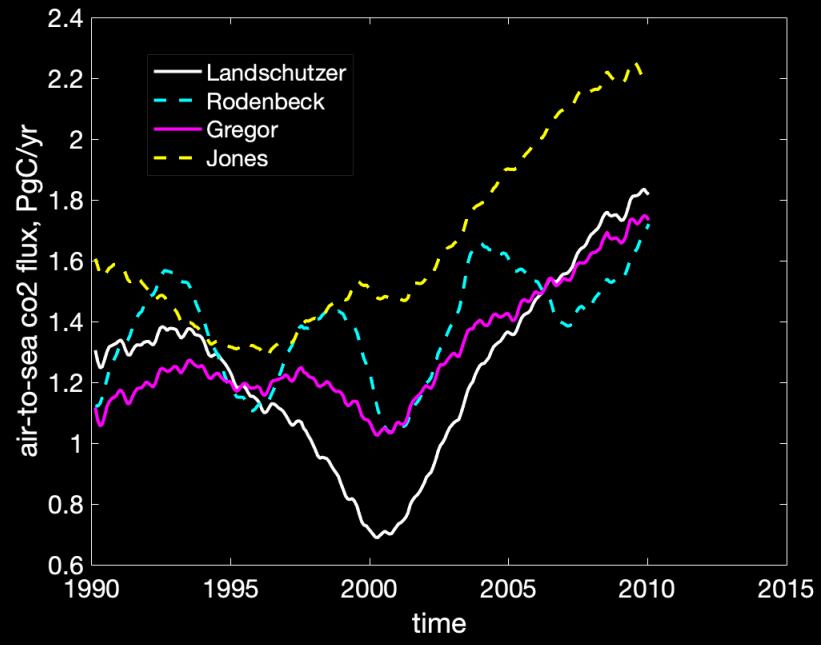


Ocean Heat Content (ORAS4)

pCO_2 seasonal cycle amplitude (zonal mean)



Global air-sea CO_2 flux time series (36 mon running mean)



Methodology

Traditional statistics + dynamical system theory + **complex network**

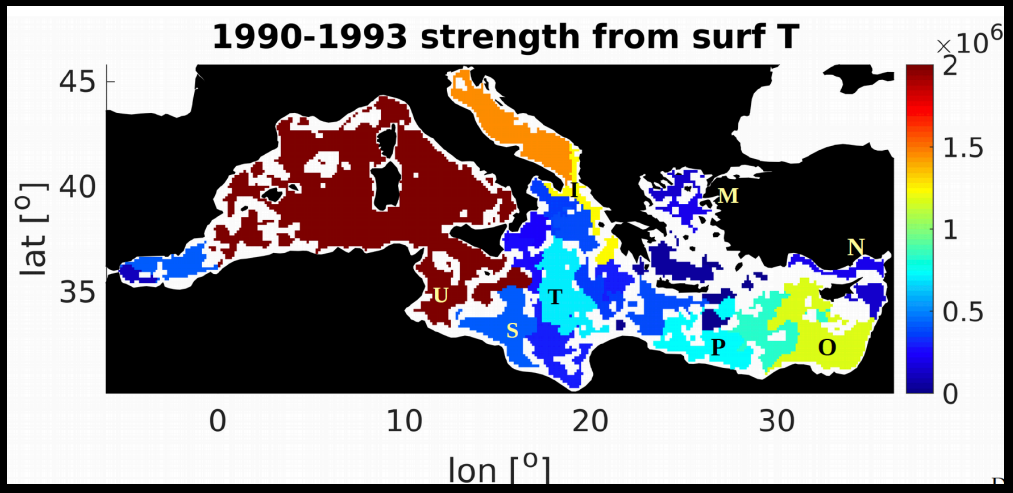
δ-MAPS: a ML tool to analyze spatio-temporal linkages

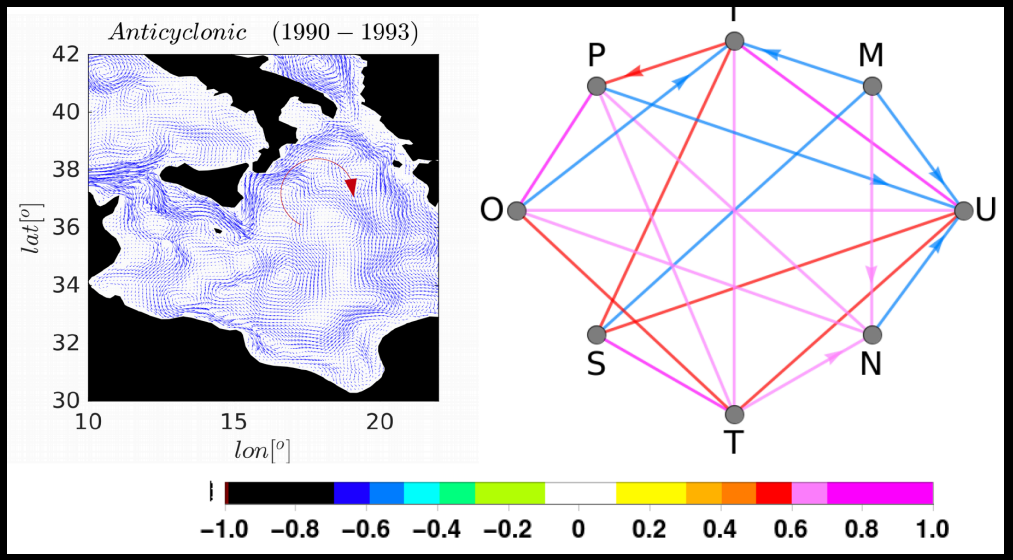
- Domain: spatially contiguous components of a climate field (T, S, O_2, pCO_2, etc)
- Causal network analysis: calculate lagged functional relationships between different domains

δ-MAPS application: Mediterranean ecoregions.

Linking physical and biological variability to investigate connectivity patterns and their variability from SSTa

Novi et al., in prep





δ-MAPS application: Mediterranean ecoregions.

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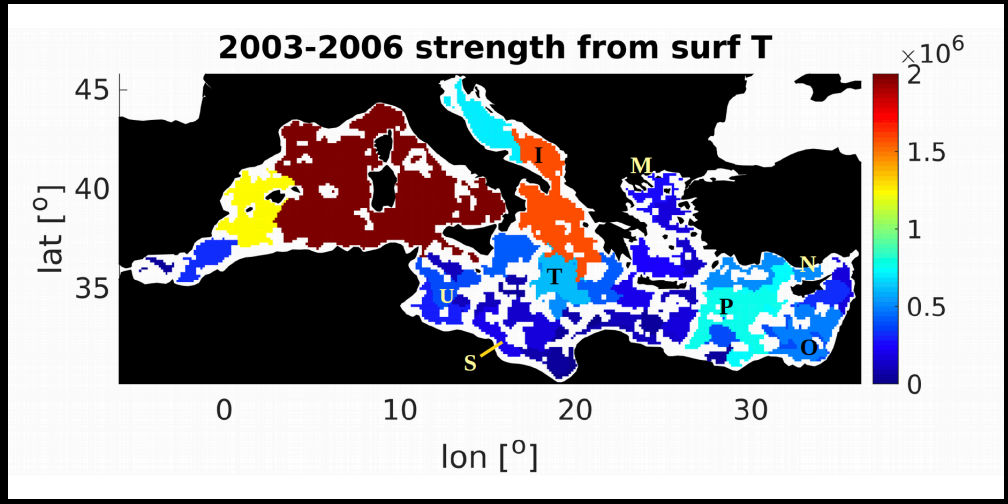

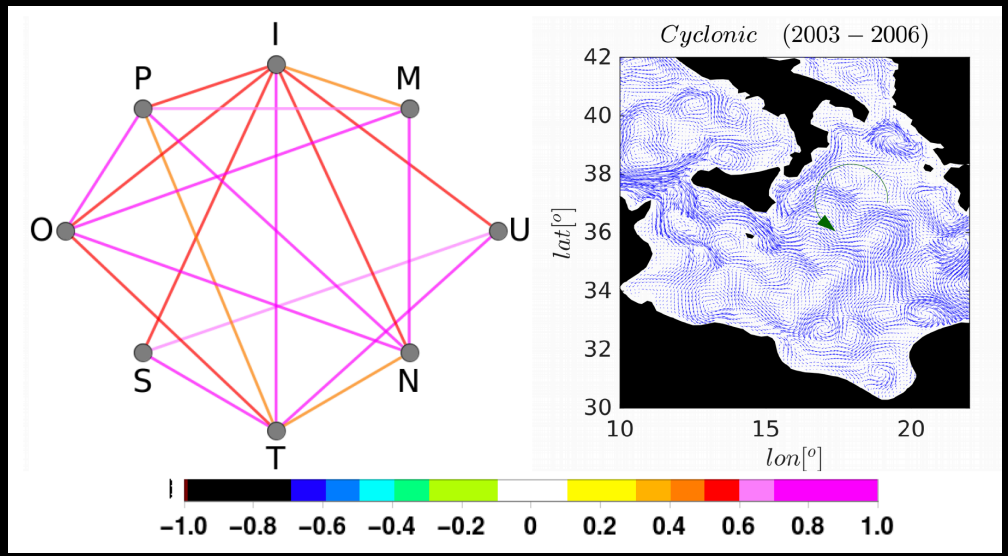

Project plans:

Project period: 9/2020 – 9/2023

- Application of δ-MAPS – *a new way to analyze and compare ESM outputs between models and with observations*

- Observational analysis (benchmarking, uncertainties, δ-MAPS)
- Analyzing CMIP6 and E3SM historical simulation and future projections
- Testing hypothesis about mechanisms behind biogeochemical variability