EC-ESA Joint Earth System Science Initiative

22-24 November 2023| ESA-ESRIN, Frascati, Italy

Frontiers of science and opportunities

Bridging scales to improve projections of ocean health at the end of the century

Marina Lévy | LOCEAN-IPSL

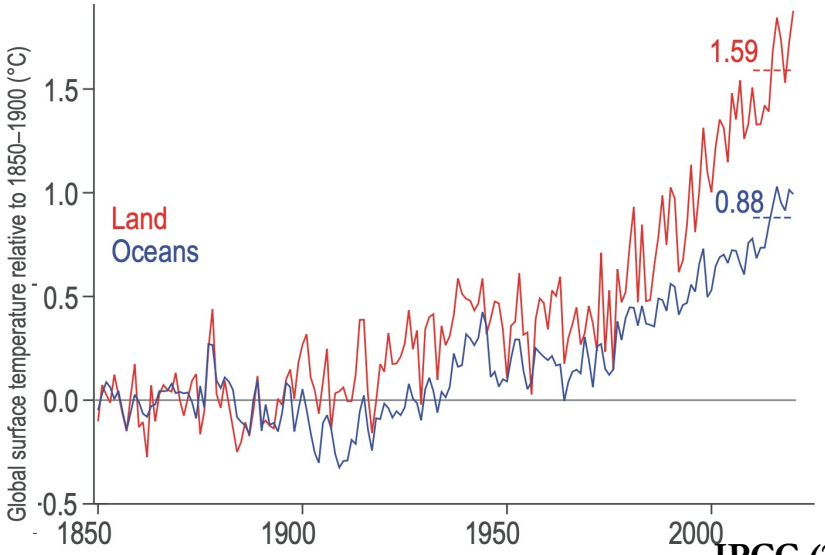
Deputy director Ocean department IRD

Phytoplankton bloom in the Gulf of Finland, Sentinel 2

The ocean is shielding us from Climate Change

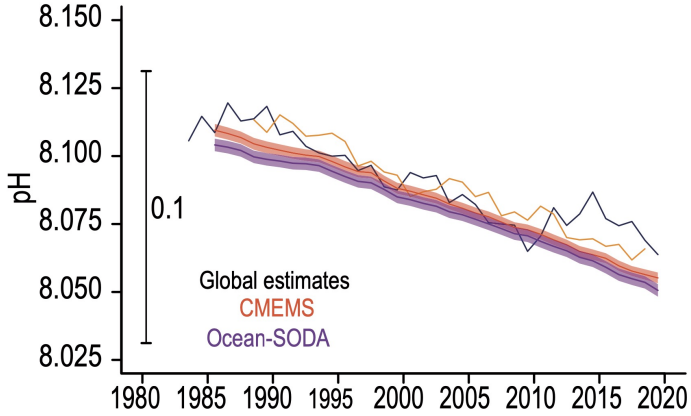
The ocean has absorbed 90% of excess heat and 25% of anthropogenic CO_2 emissions

Warming



IPCC (2021)

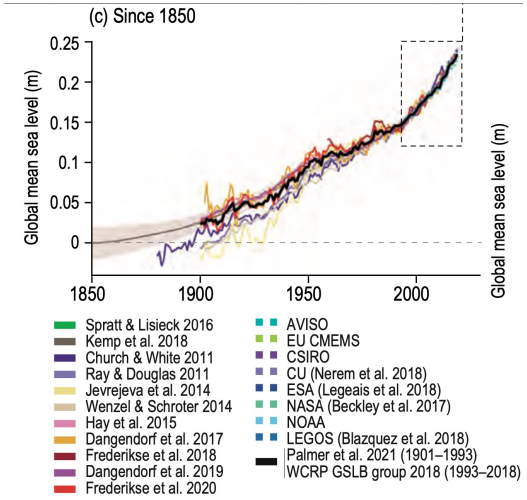
Acidification



IPCC (2021)

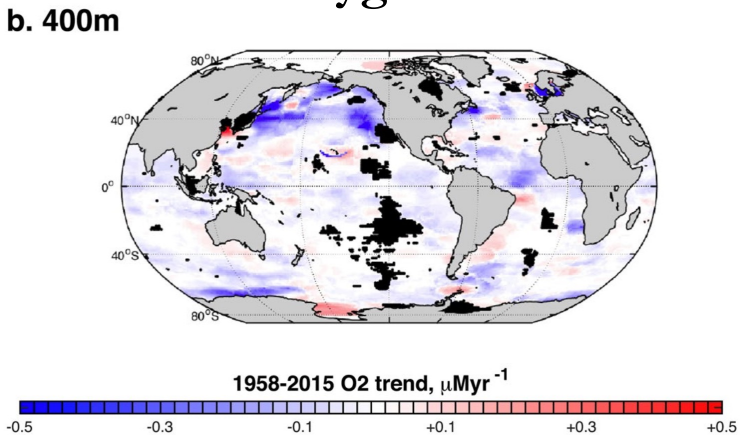
At a cost for the ocean health and for our well-being

Sea level rise



IPCC (2021)

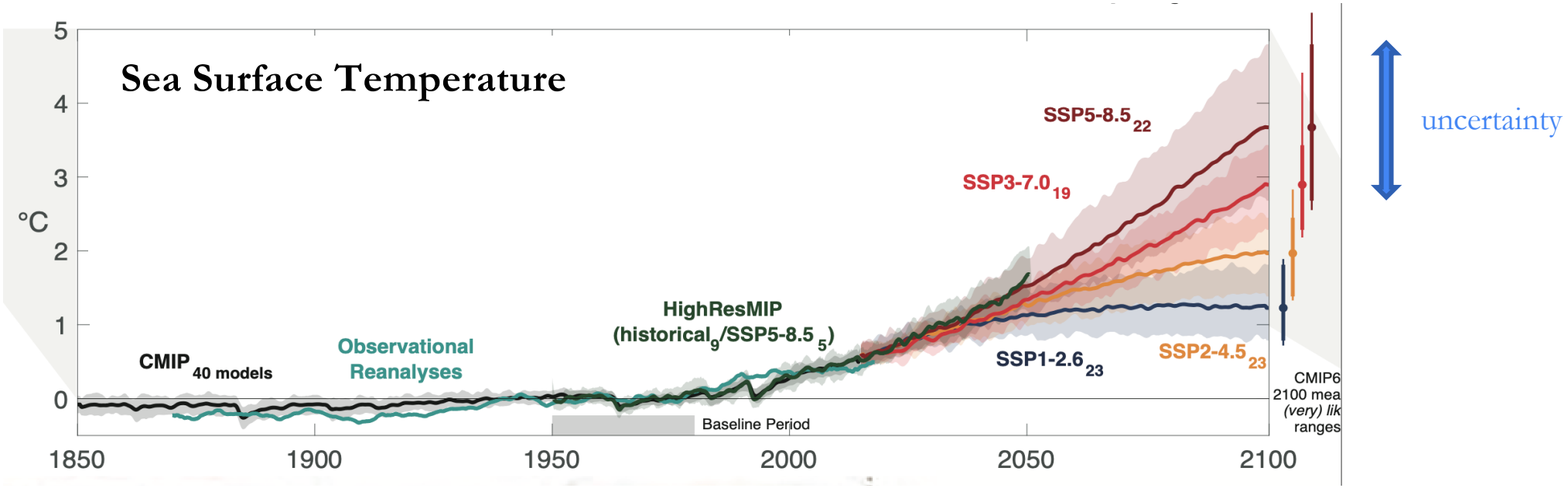
Deoxygenation



EMB (2023)

Domino effect on marine life and on ecosystem services provided by the ocean

Key question: projection of ocean stressors for 21st century



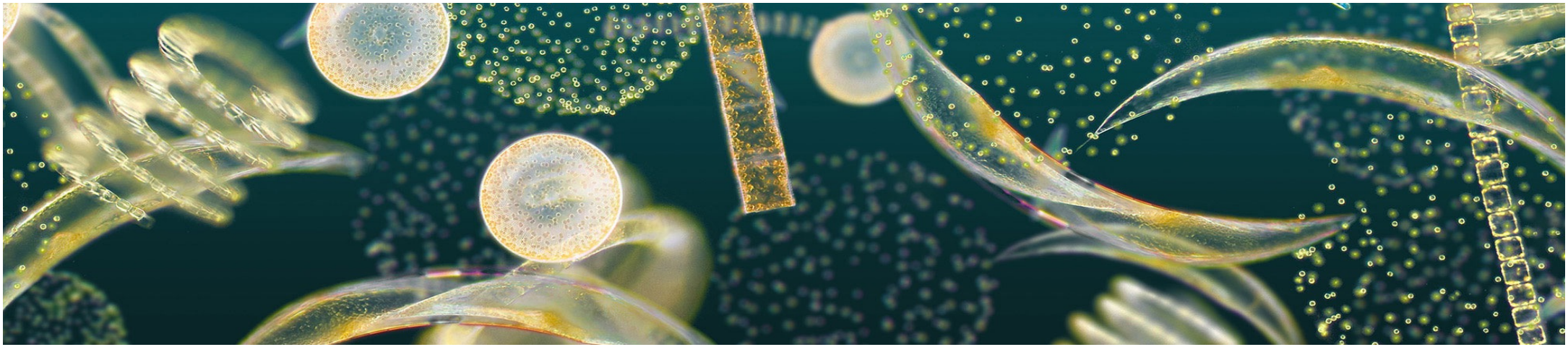
IPCC (2021)

Frontier: uncertainty for a given scenario

Phytoplankton : integrator of ocean stressors

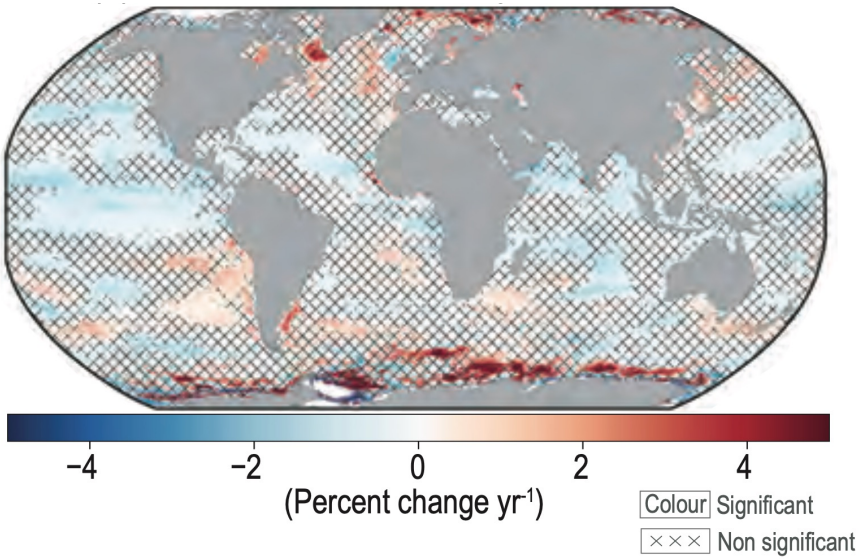
- Unseen majority: 90% of marine biomass, 50% of earth photosynthesis
- Sensitive to changes in temperature, pH, stratification, ice cover, currents
- Index of ocean health: recycles O_2 and CO_2, supports food web, supports biodiversity

Invisible to the naked eye but visible to satellites

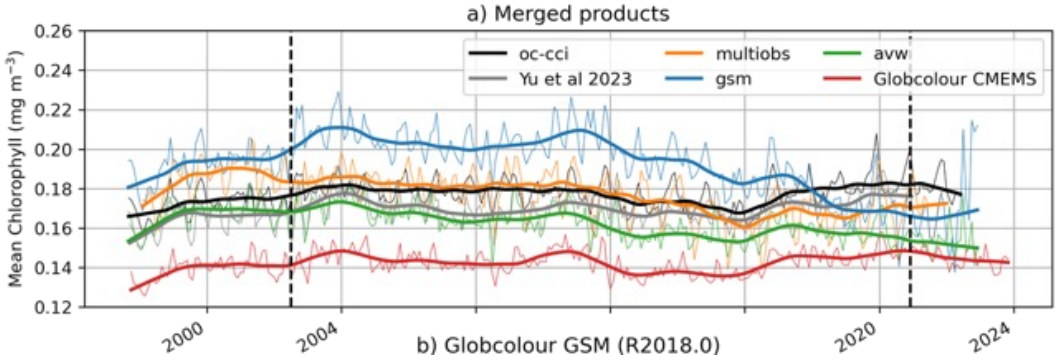


Phytoplankton global trend is difficult to detect

OC-CCI linear trend



IPCC(2021)

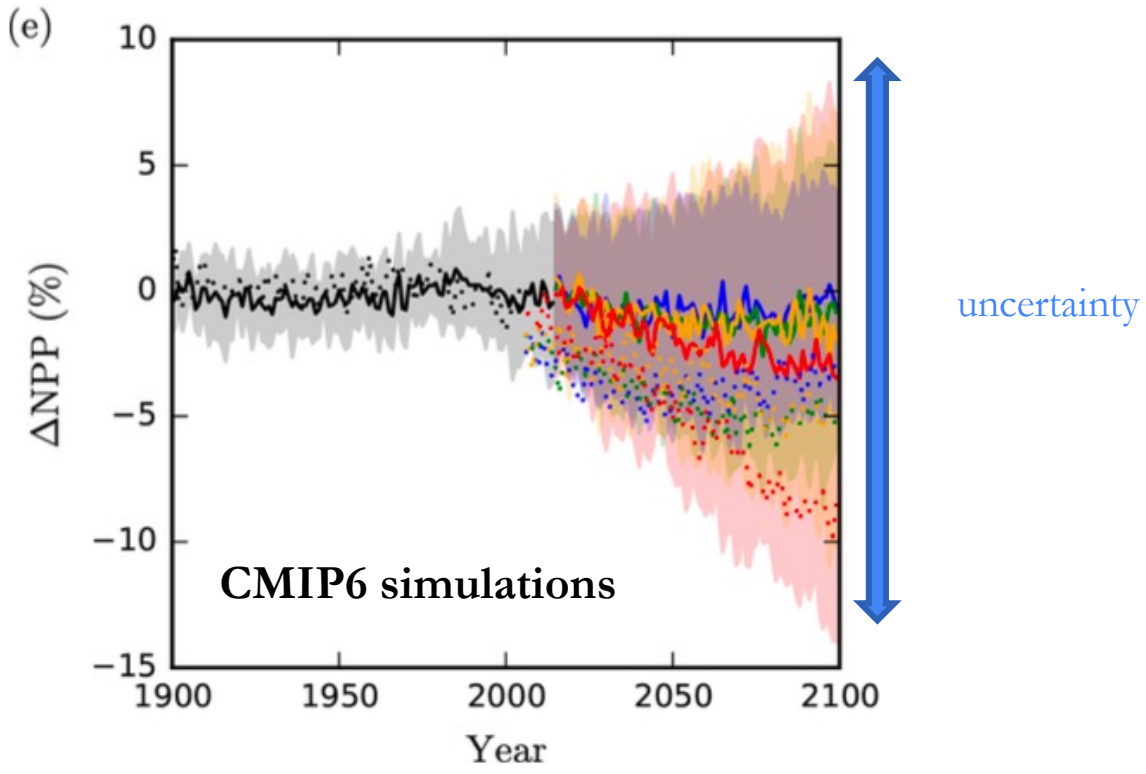


Pauthenet et al (pers. comm.)

- Non significant trend in many regions
- Opposed trends in different regions

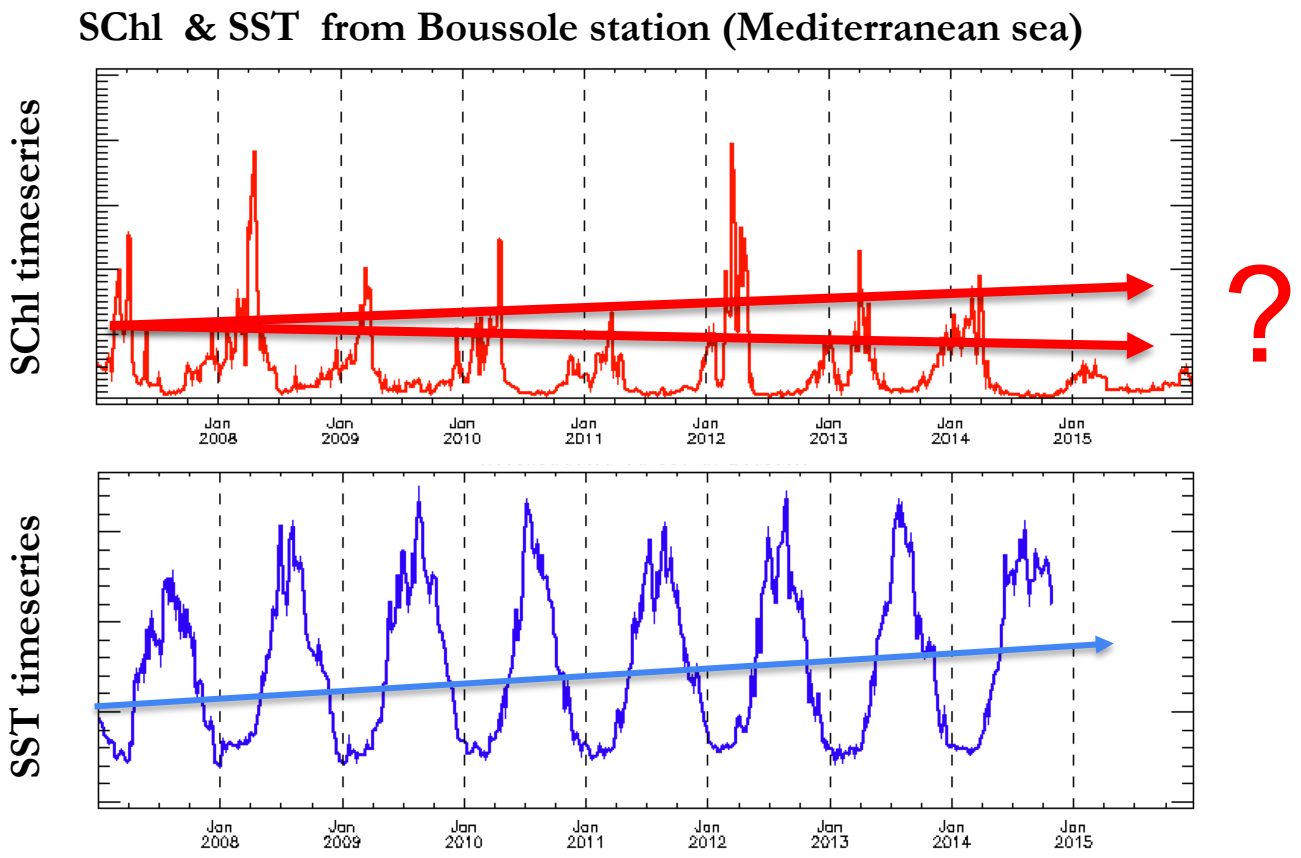
Phytoplankton future evolution is highly uncertain

Evolution of phytoplanton production



Kwiatkowski et al (2020)

Entangling of scales in phytoplankton time series

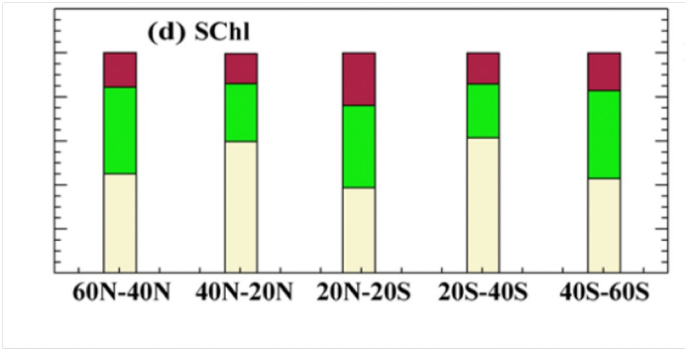


ESA CCI products

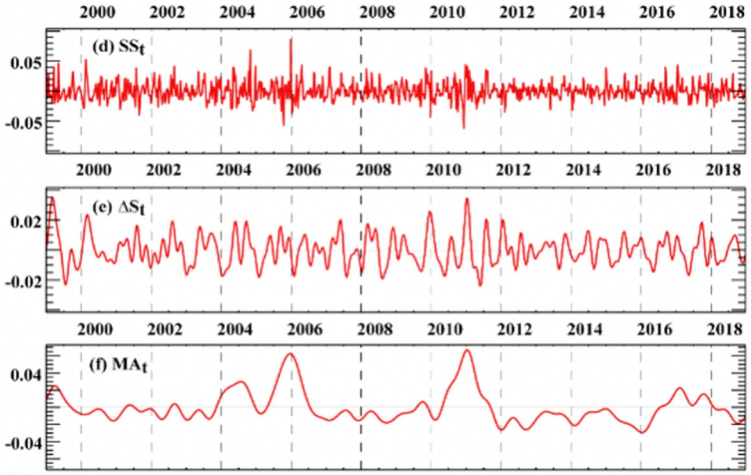
1/3 of phytoplankton variance due to finescales

Decomposition into:

Finescales	**20-100 km**
Seasonal	>> 100 km
Long-term	>> 100 km



Finescales
< 1 month



Finescales

Seasonal

Long-term

nature geoscience

Article

https://doi.org/10.1038/s41561-022-01057-3

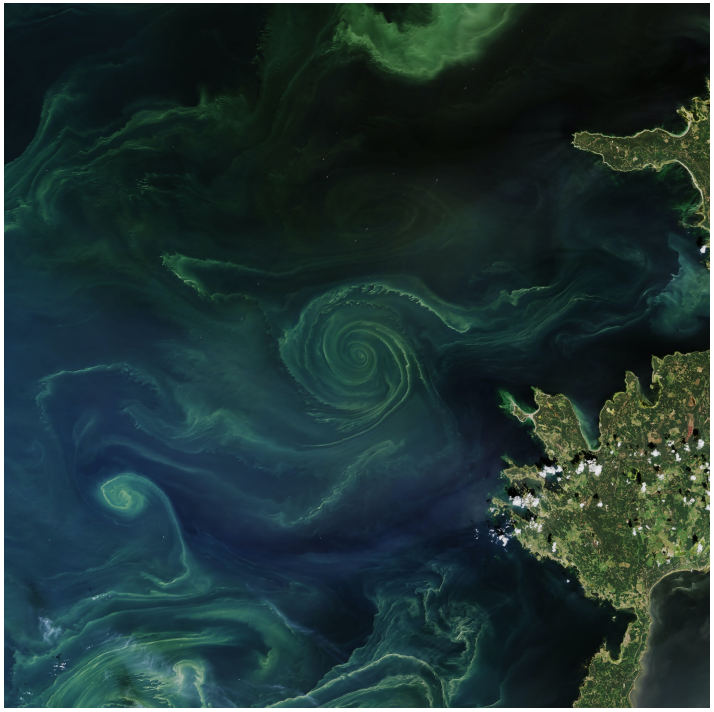
Annual variations in phytoplankton biomass driven by small-scale physical processes

Received: 14 September 2021

Accepted: 22 September 2022

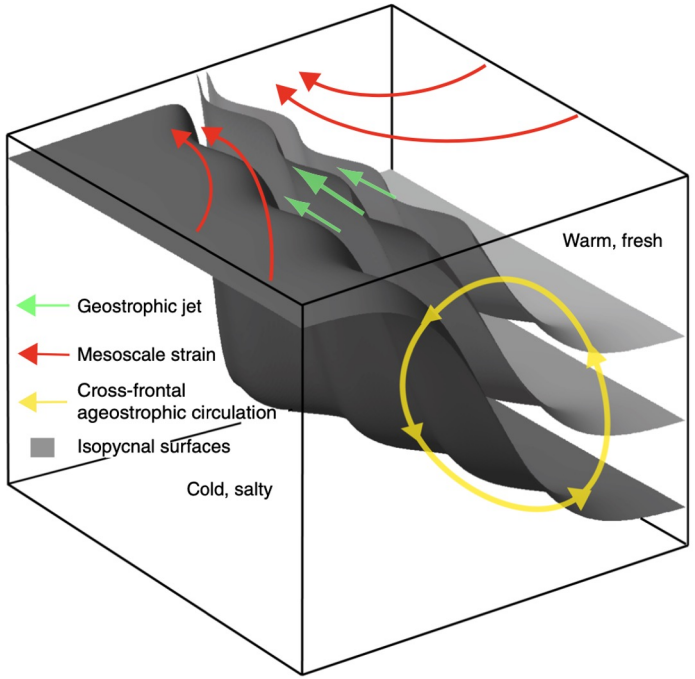
M. G. Keerthi[1], C. J. Prend[2], O. Aumont[1] & M. Lévy[1]

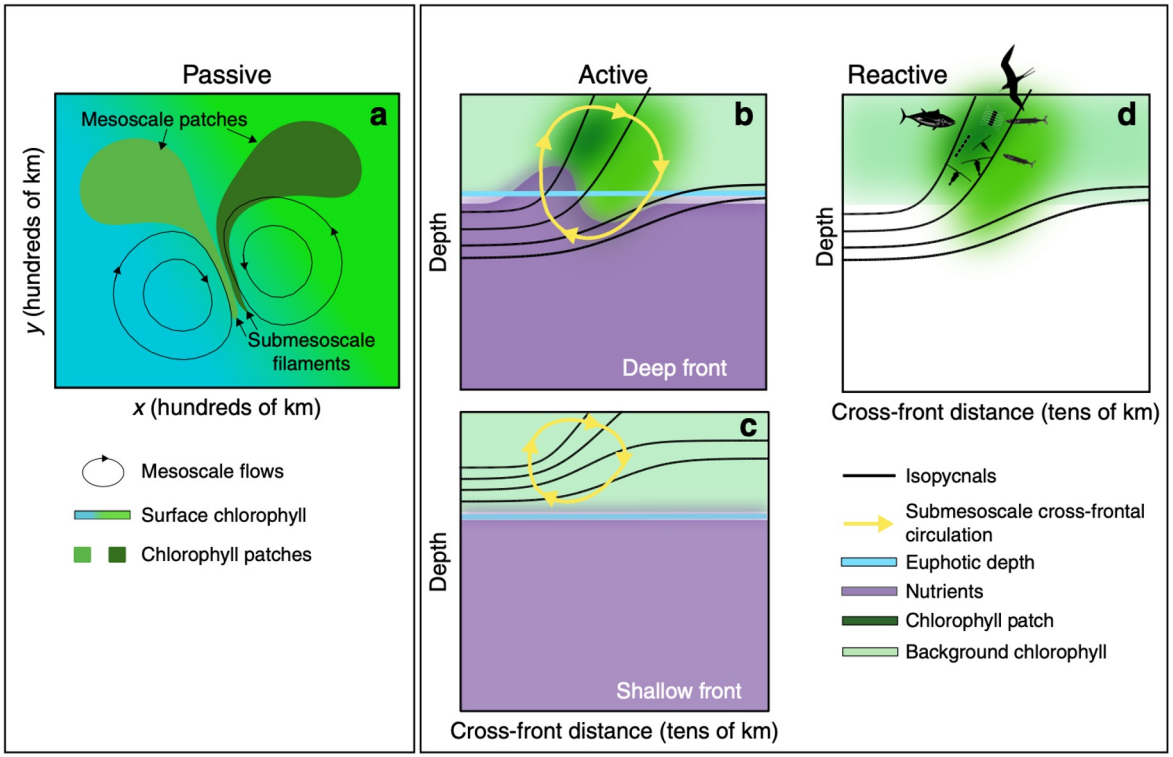
Does the response of plankton to climate change depend on finescale processes ?



Finescale processes are a large part of the uncertainty

Mecanistic understanding of the local impact of finescale processes





REVIEW ARTICLE

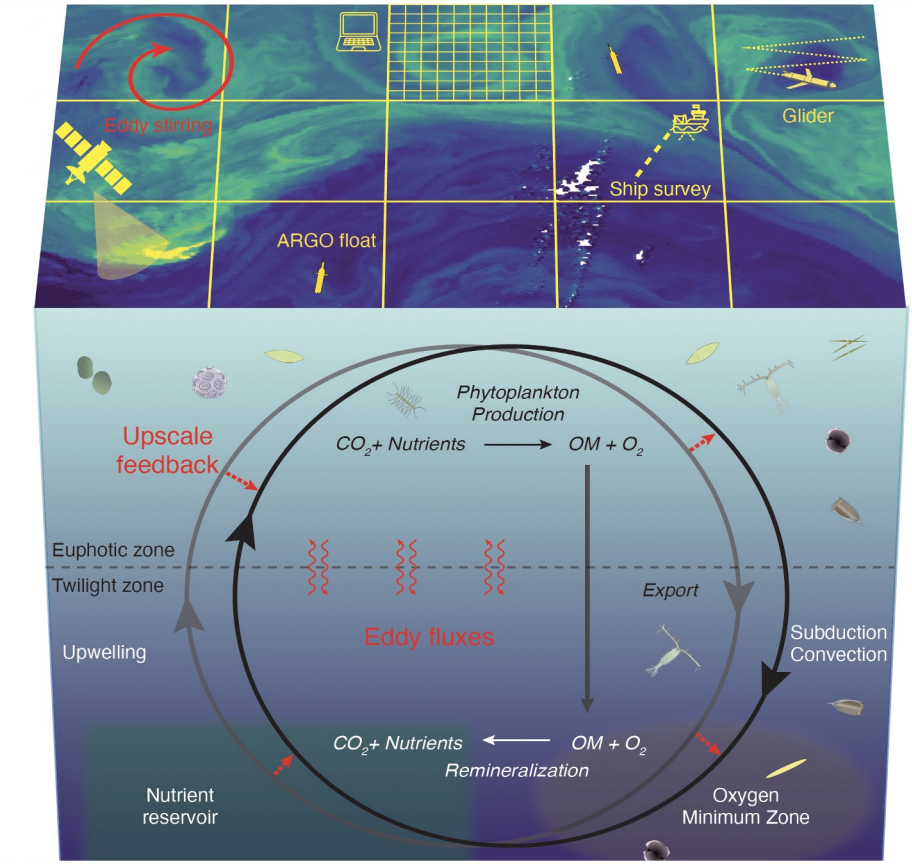
DOI: 10.1038/s41467-018-07059-3 OPEN

The role of submesoscale currents in structuring marine ecosystems

Marina Lévy[1], Peter J.S. Franks[2] & K. Shafer Smith[3,4]

Levy et al, 2018

Challenge: Bridge the gap between finescales and large scales

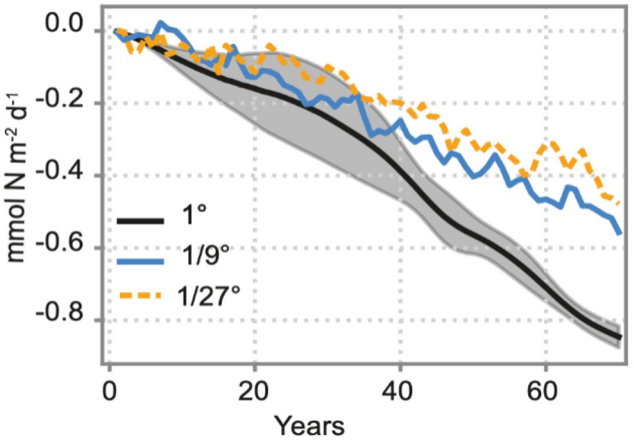


Levy et al, 2024

Problem: conventional tools pushed to their limits

Evidence of importance of finescales on response to warming

Decrease in phytoplankton production in response to warming in a toy ocean model



Damping of climate change impact on phytoplankton when finescales are accounted for

Oceanic primary production decline halved in eddy-resolving simulations of global warming

Damien Couespel[1], Marina Lévy[1], and Laurent Bopp[2]

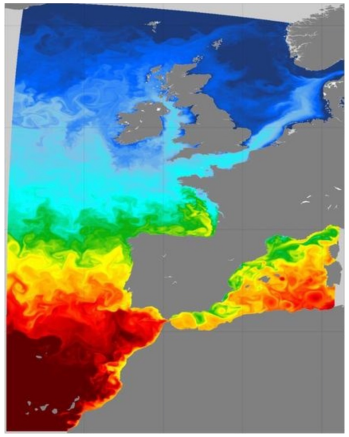
Summary

- Past efforts on understanding finescales have focussed on local eddy-effects
- Climate projections are very sensitive to the way finescales are treated
- Taking finescales into account has gone from a curiosity to a necessity

Future efforts must incorporate the understanding of finescales
for climate monitoring and for climate projection

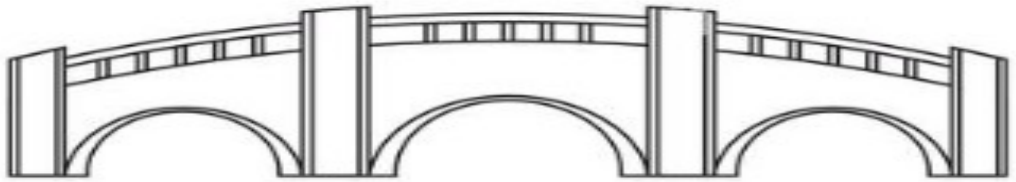
And now : consolidate bridges to achieve this

Today's bulletin from MOI



Ocean community
DTO Digital Twin
CMEMS
SWOT
SeaStar

Calling for high-resolution



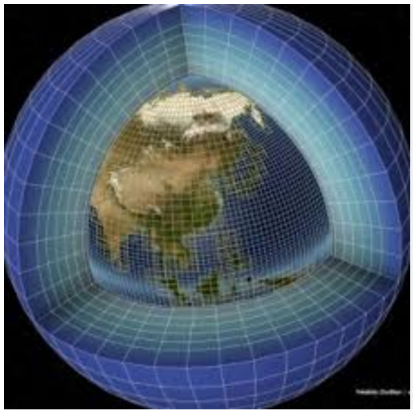
OC-CCI : HR, nearly global and nearly 25 yrs

Entangle the role of finescales in climate analysis

Have in mind the big picture when working on finescales

Artificial Intelligence / Deep Learning
- Combine data of different resolutions
- Advance parametrizations of finescales

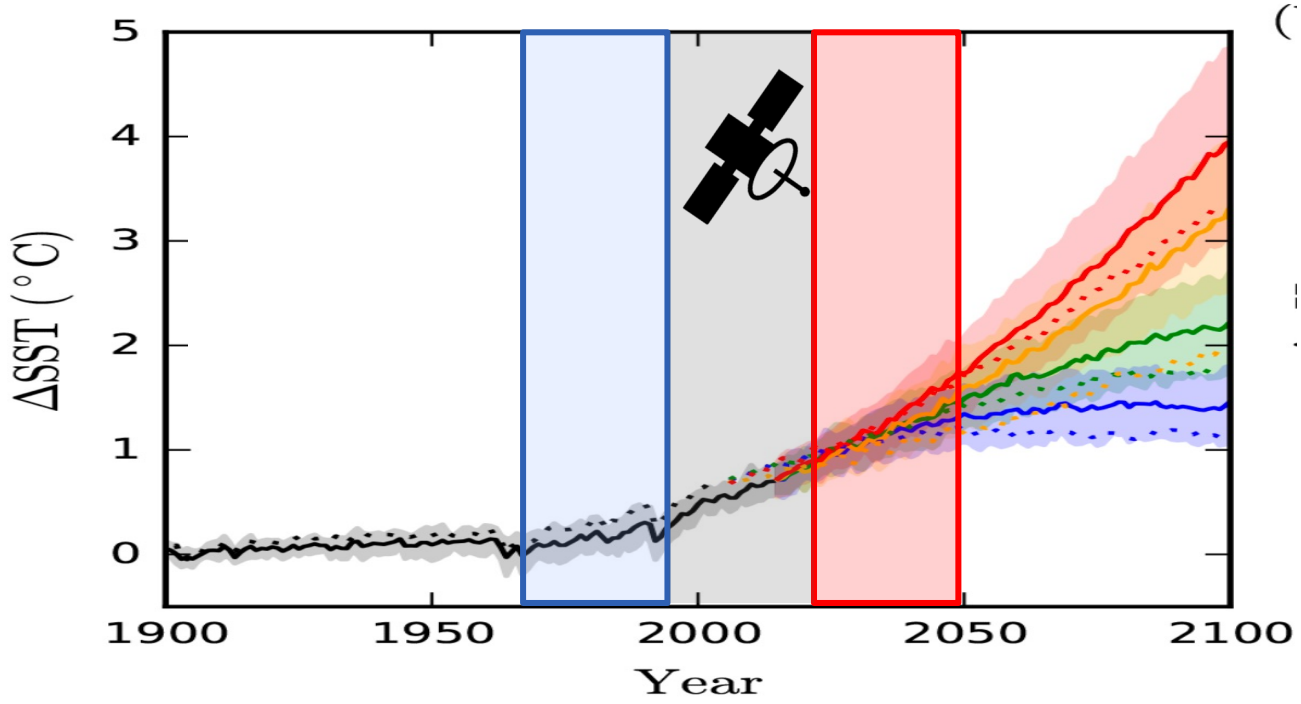
IPSL ESM used for CMIP6



Climate community
Coarse resolution
CMIP
CCI

Calling for long lasting time series

Epilogue



1. Solution oriented science : sustainability science
2. Be coherent with our messages and reduce the carbon footprint of our activities