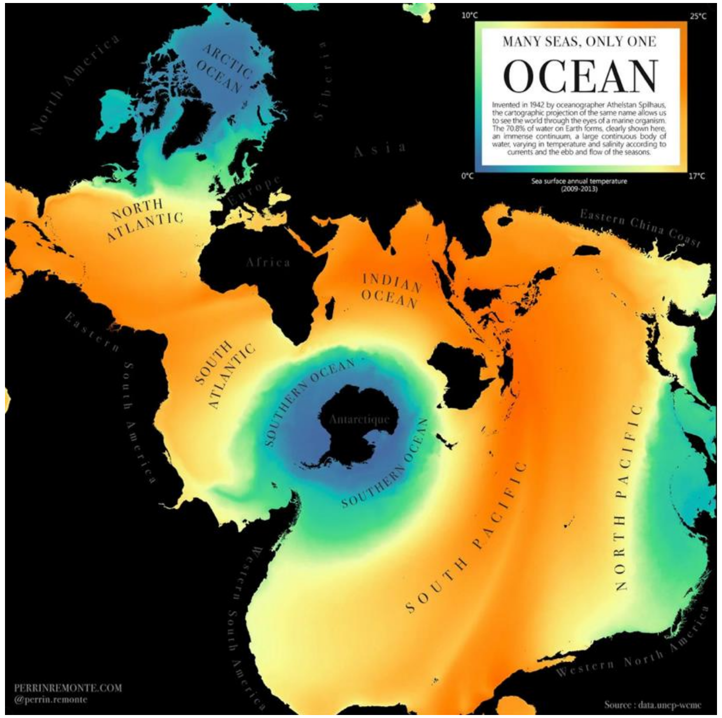
OCEAN ECVS

CLIMATE CHANGE INITIATIVE MID-TERM REVIEW

CLIMATE CHANGE INITIATIVE - OCEAN ECVS

4 ECVs based on a wide range of measurement techniques, covering 70% of the Earth Surface

ESA CCI program will be present at the 3rd UN Ocean Conference (Nice, France, 2025)



Sea Surface Temperature

infrared imagery + microwave radiometry

Ocean Color

optical imaging systems

Sea State

radar altimetry + Synthetic Aperture Radar

Sea Surface Salinity

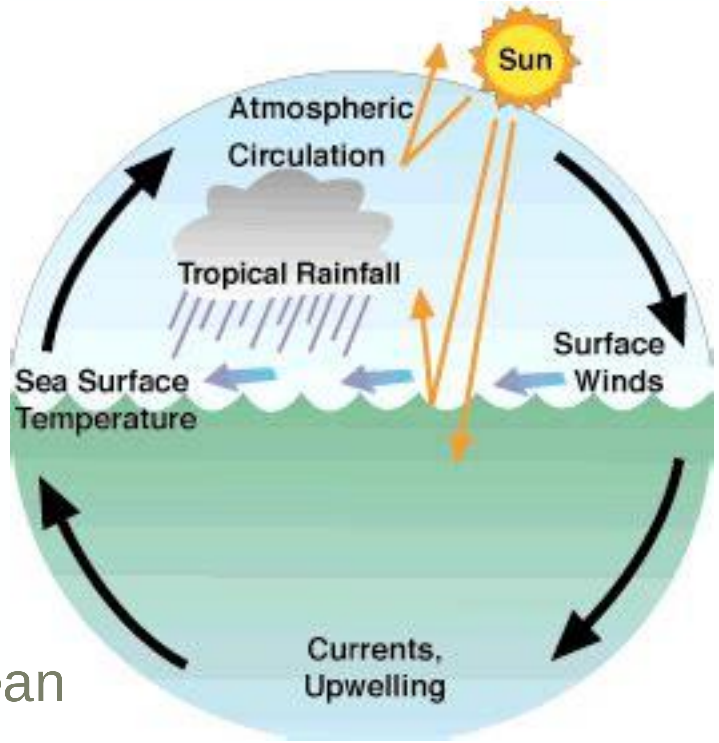
microwave radiometry

(other ocean activites in CCI: Sea Level, Sea Level Closure, Sea ice …)

SCIENCE QUESTIONS

The different ECVs are linked to different science and application questions:

- characterization of climate variability
- extreme events
- ocean – atmosphere exchanges

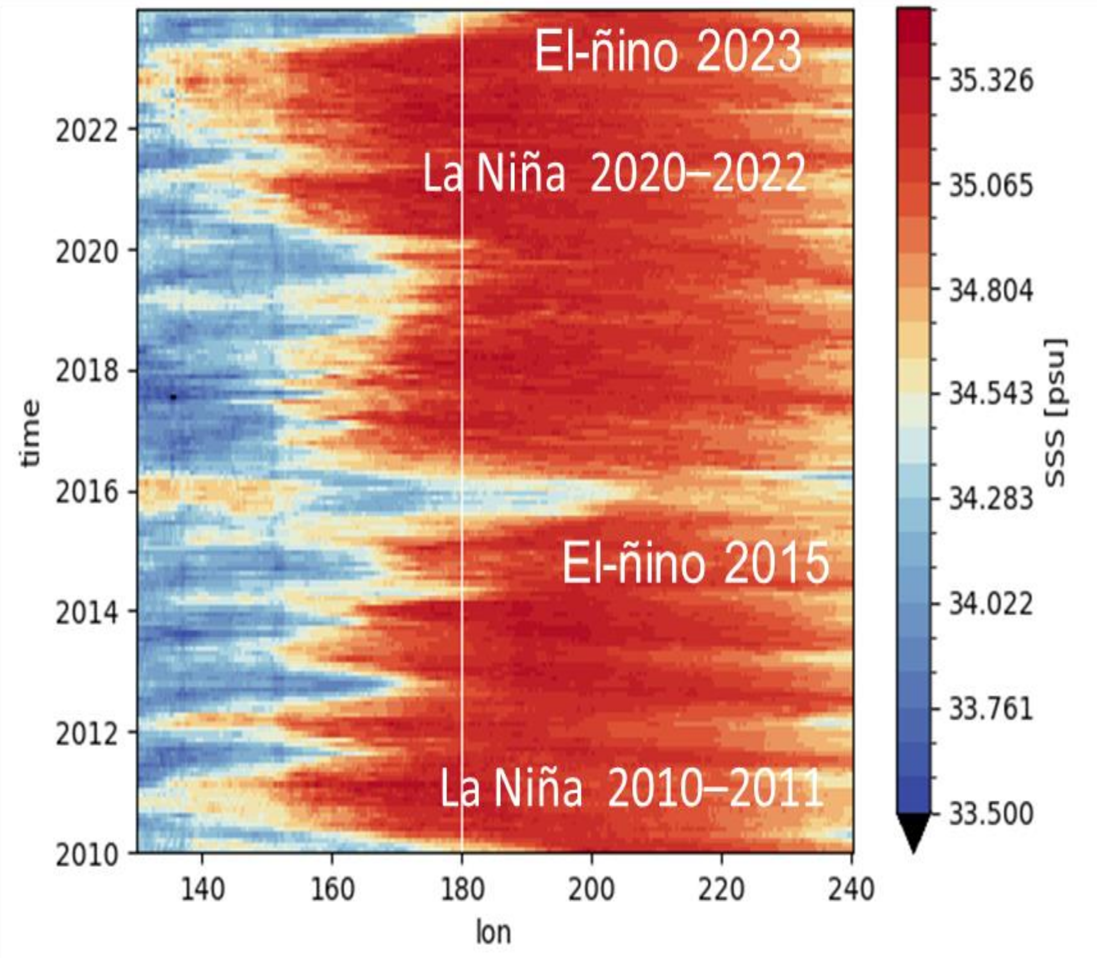


also:

cryosphere – ocean

land – ocean

example with Pacific surface salinity



Sea Surface Temperature – Owen Embury (Uni. Reading, UK)

Phase 1 – 2010 to 2013

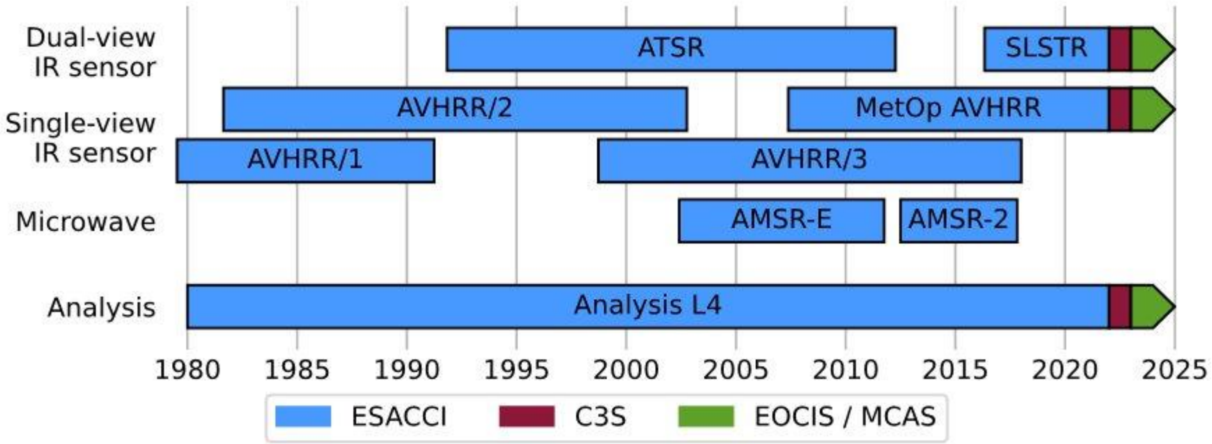
- CDR Version 1: Sept 1991 – Dec 2010 (19 years)

Phase 2 – 2014 to 2019

- CDR Version 2: Sept 1981 – Dec 2016 (35 years)
    - Plus ICDR extension to end-2022

Phase 3 – 2019 to 2023

- CDR Version 3: Jan 1980 – Dec 2021 (42 years)
    - Plus ongoing ICDR
- Improved AVHRR SST especially 1980s
    - Addition of AVHRR/1 from NOAA-6, 8, 10
    - Reduce desert-dust related biases
- Add SLSTR and full resolution MetOp AVHRR
- Passive microwave SST from AMSR-E and AMSR2



Interim-CDR (ICDR) provides ongoing extension:

- Funded by C3S to end-2022
- UK funded (EOCIS / UKMCAS) for 2023/24

Phase 4 – 2025 to 2026

- Further work to improve to early AVHRR
- Trial TIROS-N AVHRR for data in 1979, and MODIS
- Incorporate latest MetOp and SLSTR work

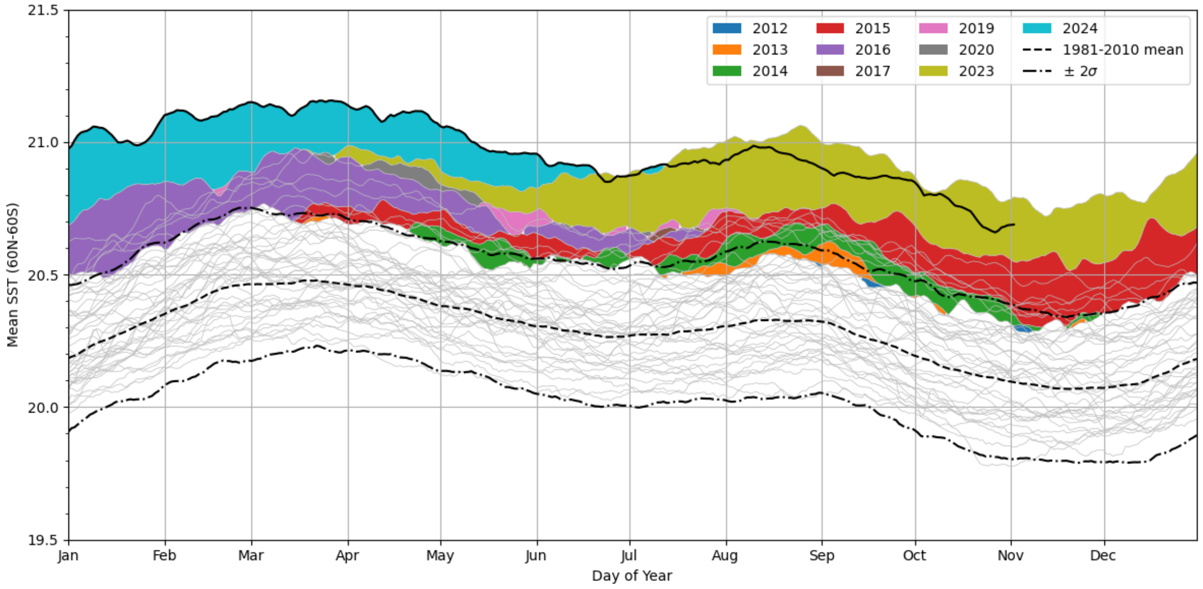
Exceptional Global Sea Surface Warming Driven by Earth's Energy Imbalance

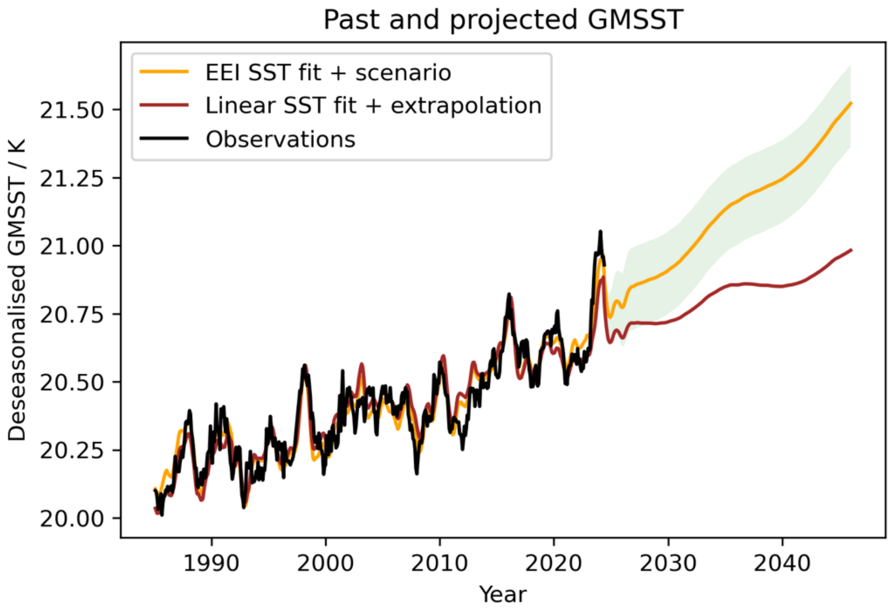
Record breaking global mean SST during 2023/24:

- Triggered by strong El Niño episode
- Can not be explained by ENSO variability alone
- Shows acceleration in multidecadal GMSST trend

Statistical model used to fit GMSST:

- ENSO, Volcanic, Solar, and long-term trend





Long-term trend physically linked to Earth's energy accumulation (EEA) but is often assumed to be linear.

SST CCI CDRv3 shows long-term trend is not linear

- Acceleration can be modelled using EEA from the last four decades
- Prediction of future GMSST warming is 0.6 K over the next two decades under a "mitigated" EEI scenario

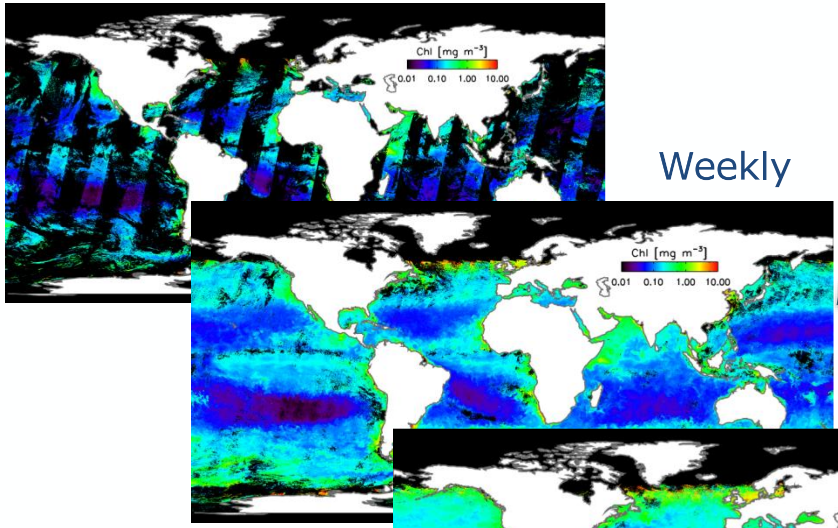
Ocean Color CCI – Shubha Sathyendranath (PML, UK)

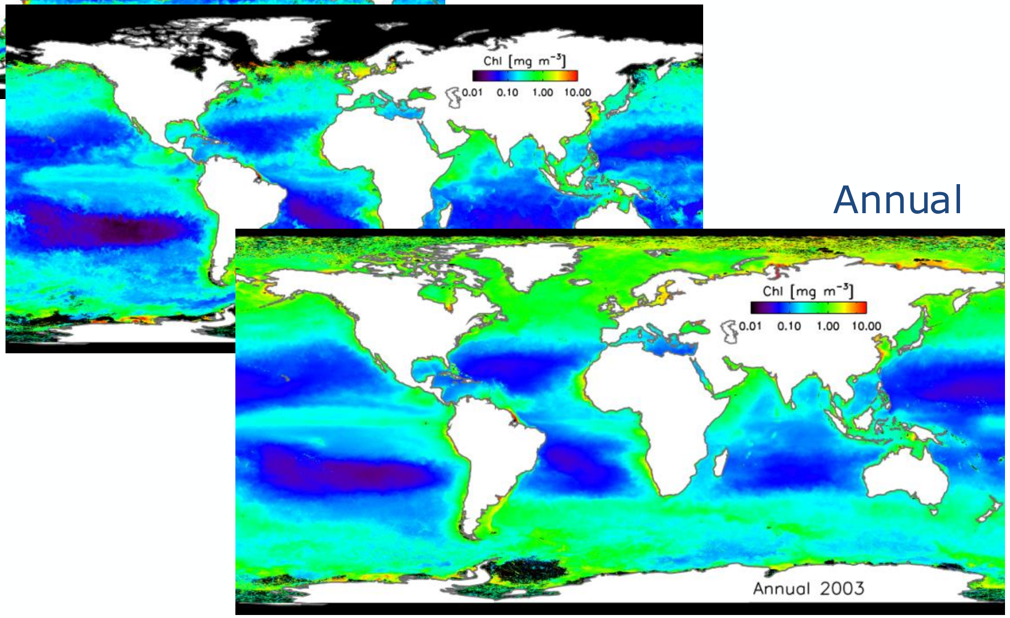
Daily

Weekly

Monthly

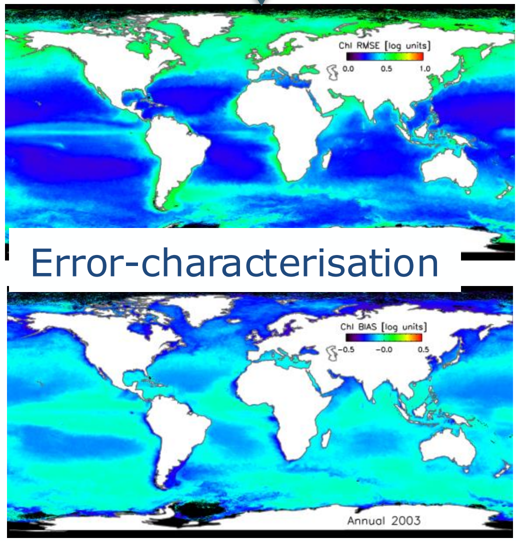
Annual





Improved spatial coverage, even at weekly scale

Error specification (RMSE and bias) based on comparison with match-up in situ data & extrapolation to global ocean



OC-CCI Products include:

- Remote-sensing reflectance values at reference wavelengths
- Chlorophyll-a
- Inherent Optical Properties
- Diffuse attenuation coefficient
- Per-pixel uncertainties
- Optical water classes
- Time series of 24 years

Ocean Color CCI – Shubha Sathyendranath (PML, UK)

- Wide use of OC CCI data in publications
- In 2023 total of 82 peer-reviewed publications including three PhD theses in a variety of journals

nature climate change

Article https://doi.org/10.1038/s41558-022-01479-2

Global decline of pelagic fauna in a warmer ocean

Received: 19 April 2022

Accepted: 19 August 2022

Published online: 29 September 2022

Check for updates

Alejandro Ariza[1], Matthieu Lengaigne[2], Christophe Menkes[2], Anne Lebourges-Dhaussy[3], Aurore Receveur[4], Thomas Gorgues[5], Jérémie Habasque[3], Mariano Gutiérrez[6], Olivier Maury[1] and Arnaud Bertrand[1]

Pelagic fauna is expected to be impacted under climate change according to ecosystem simulations. However, the direction and magnitude of the impact is still uncertain and still not corroborated by observation-based statistical studies. Here we compile a global underwater sonar database and 20 ocean climate projections to predict the future distribution of sound-scattering fauna around the world's oceans. We show that global pelagic fauna will be seriously compromised by the end of the twenty-first century if we continue under the current greenhouse emission scenario. Low and mid latitudes are expected to lose from 3% to 22% of animal biomass due to the expansion of low-productive systems, while higher latitudes would be populated by present-day temperate fauna, supporting results from ecosystem simulations. We further show that strong mitigation measures to contain global warming below 2 °C would reduce these impacts to less than half.

communications earth & environment

ARTICLE

Check for updates

https://doi.org/10.1038/s43247-023-00791-9 OPEN

Phytoplankton abundance in the Barents Sea is predictable up to five years in advance

Filippa Fransner[1✉], Are Olsen[1], Marius Årthun[1], François Counillon[1,2], Jerry Tjiputra[3], Annette Samuelsen[2] & Noel Keenlyside[1,2]

nature climate change

Article https://doi.org/10.1038/s41558-023-01768-4

Widespread changes in Southern Ocean phytoplankton blooms linked to climate drivers

Received: 5 October 2022

Accepted: 18 July 2023

Published online: 28 August 2023

Check for updates

Sandy J. Thomalla[1,2✉], Sarah-Anne Nicholson[1], Thomas J. Ryan-Keogh[1] & Marié E. Smith[3,4]

Climate change is expected to elicit widespread alterations to nutrient and light supply, which interact to influence phytoplankton growth and their

Remote Sensing of Environment 286 (2023) 113404

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journal homepage: www.elsevier.com/locate/rse

ELSEVIER

Dominant timescales of variability in global satellite chlorophyll and SST revealed with a MOving Standard deviation Saturation (MOSS) approach

Bror F. Jönsson[a,*], Joseph Salisbury[b], Elizabeth C. Atwood[a], Shubha Sathyendranath[a], Amala Mahadevan[c]

[a] Plymouth Marine Laboratory, UK
[b] University of New Hampshire, USA
[c] Woods Hole Oceanographic Institution, USA

ARTICLE INFO

Keywords:
Satellite oceanography
Timescales
Biological production
Chlorophyll
Sea surface temperature
Variability

ABSTRACT

Satellite-derived sea surface temperature (SST) and chlorophyll (Chl) datasets have been invaluable for estimating the oceanic primary production, air-sea heat exchange, and the spatial and seasonal patterns in their variability. However, data gaps, resulting from clouds and other factors, reduce coverage unevenly (to just about 20%) and make it difficult to analyze the temporal variability of Chl and SST on sub-seasonal time scales. Here, we present a MOving Standard deviation Saturation (MOSS) method to enable the analysis of sparse time series (with as little as 10% of the data). We apply the method to identify the dominating (sub-annual) timescales of variability, τ_d, for SST and Chl in every region. We find that τ_d values for Chl and SST are not consistent or correlated with each other over large areas, and in general, SST varies on longer timescales than Chl, i.e. τ_d(SST) $>\tau_d$(Chl). There is a threefold variability in τ_d for SST and Chl even within regions that are traditionally considered to be biogeographically homogeneous. The largest τ_d for Chl is generally found on the equatorial side of the trade wind belts, whereas the smallest τ_d are found in the tropical Pacific and near coasts, especially where upwelling is common. If the temporal variability in Chl and SST were driven largely by ocean dynamics or advection by the flow, regional patterns of τ_d for SST and Chl should co-vary. This is seen in coastal upwelling zones, but more broadly, the lack of coherence between τ_d(Chl) and τ_d(SST) suggests that biological processes, such as phytoplankton growth and loss, decouple the timescales of Chl variability from those of SST and generate shorter term variability in Chl.

Sea state CCI – Fabrice Ardhuin (LOPS, France)

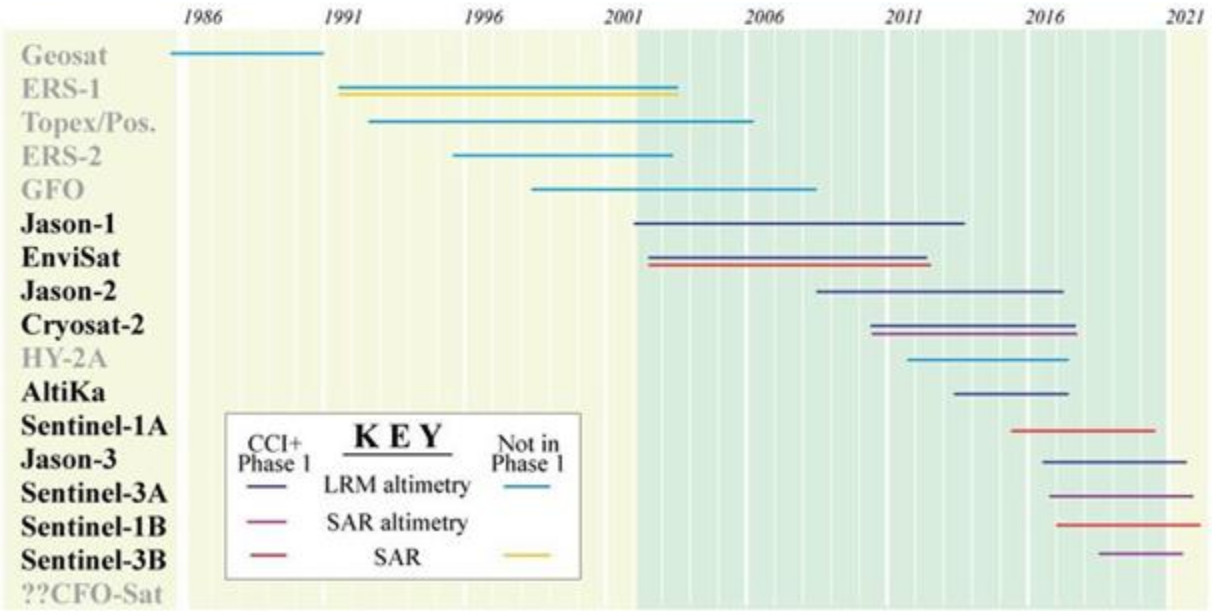
Phase 1 – 2010 to 2013

- CDR Version 1: Sept 1991 – Dec 2018 (27 years), uses GDR alti. data with denoising & intercalibration
- CDR Version 3: 2002- 2022: retracked altimeter data (lower noise), and SAR-derived parameters

(NB: Great to see Sentinel 1C up!)

Phase 2 – 2023 to 2026

- CDR Version 4: coming out in 2024, includes extension to recent years, new uncertainty estimates
- CDR Version 5: will have as much retracked data as possible (ERS-2, maybe CFOSAT & Sentinel 6 …)
- ongoing ICDR as part of CMEMS



Phase 3 ?

Under discussion with CMEMS / C3S

Sea state CCI – Fabrice Ardhuin (LOPS, France)

Sea state CCI team is currently extending and merging V1 and V3 data sets into a single V4.

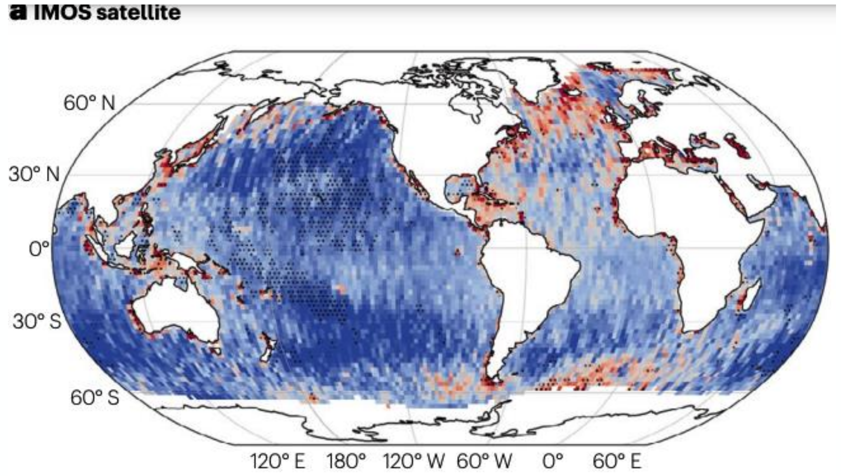
Main difficulty : strong variability and poor sampling with nadir altimetry alone.

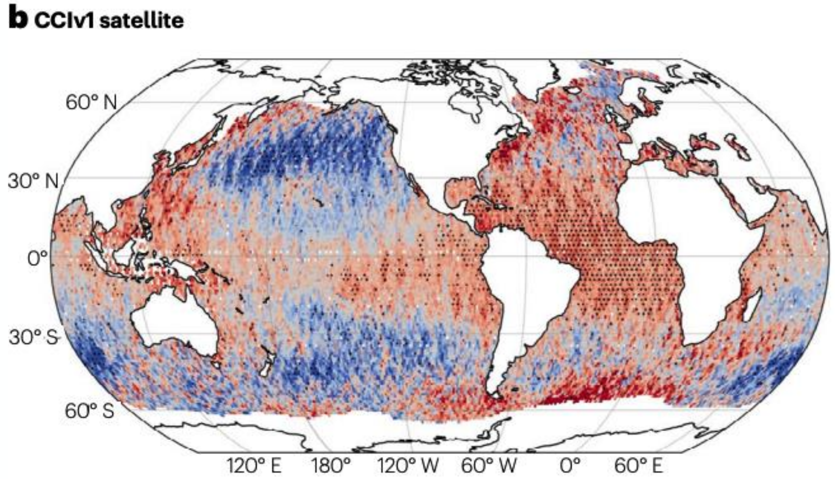
e.g.: “time of emergence” is around 2050 for North Atlantic

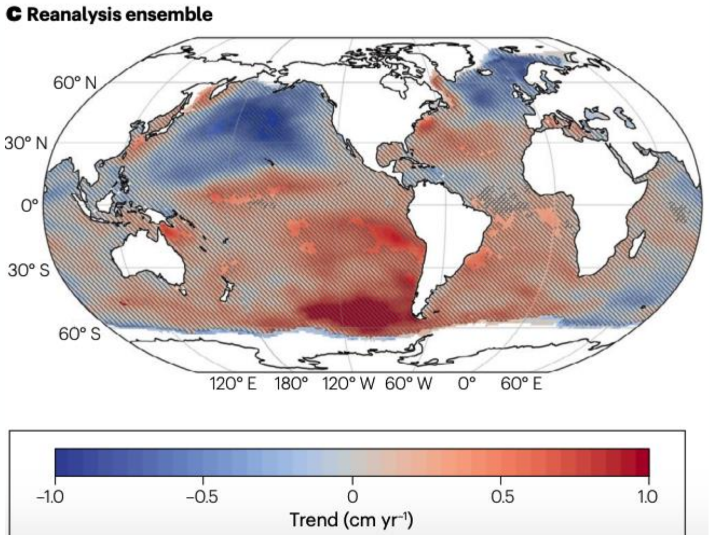
(Hochet et al. GRL 2021)

NB: V4 will also contain

Sentinel 1 IW mode data







Casas-Prat et al. Nature Rev. Earth & Env, 2024)

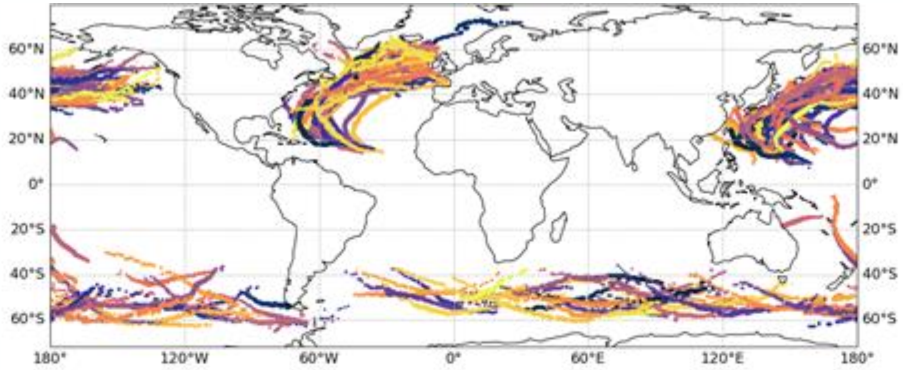
Sea state CCI – Fabrice Ardhuin (LOPS, France)

One particular area of interest are extremes:

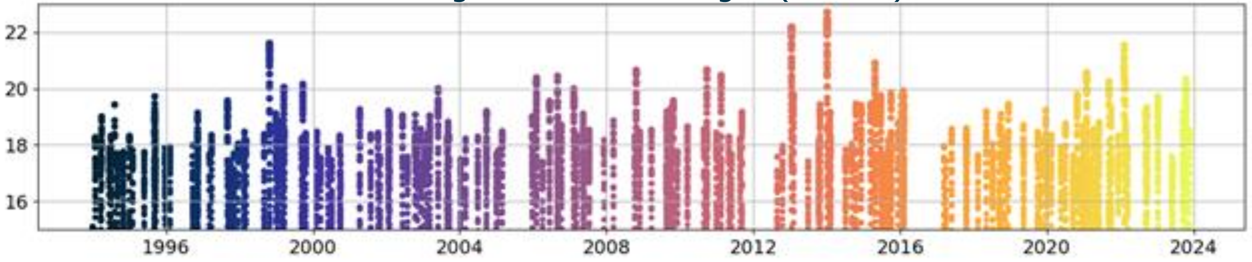
- how good are satellites in capturing wave extremes?
- can we find any trend globally or per basin?
- Can we link satellite record with longer term proxies?

Applications:

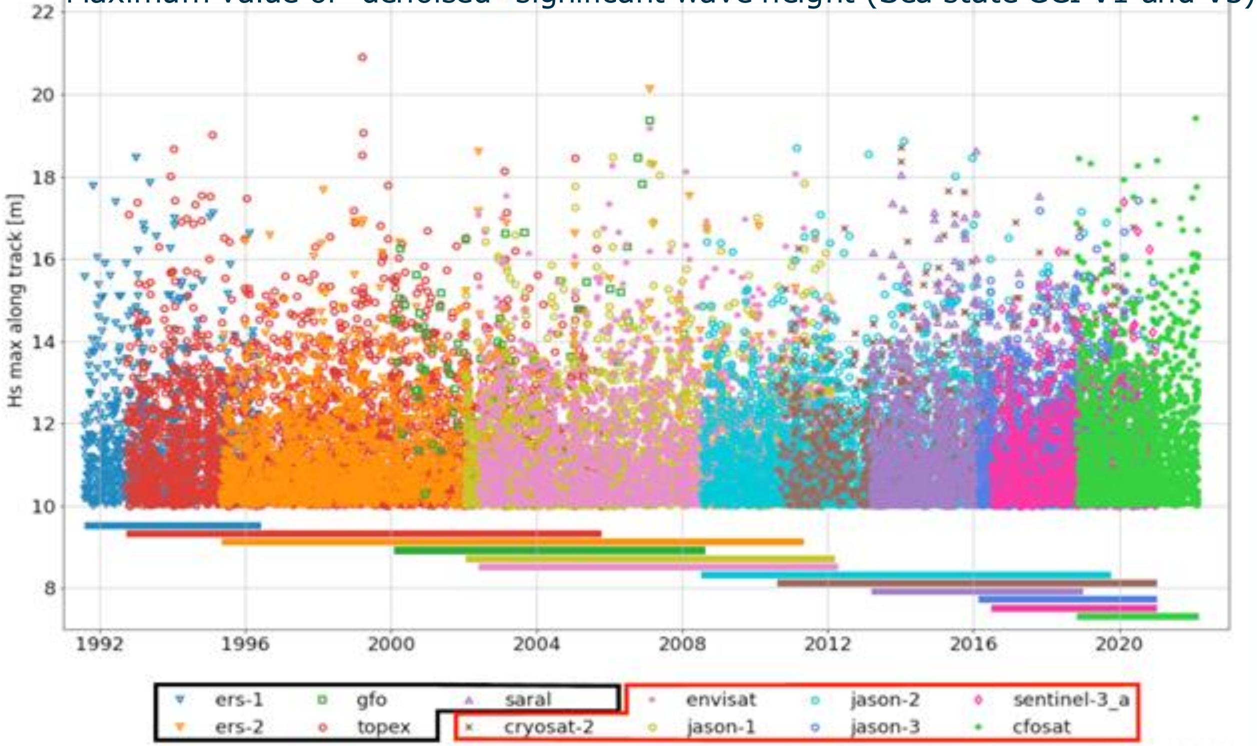
- coastal and marine engineering
- marine energy (infrastructure, maintenance)
- interactions with sea ice, SST, SSS …



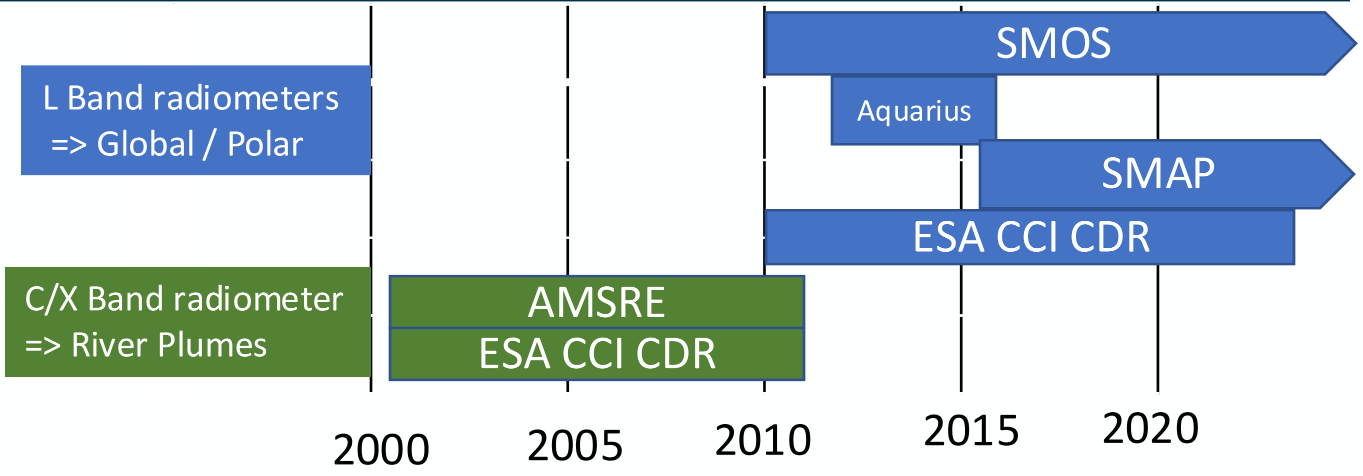
Maximum value of modeled significant wave height (meters)



Maximum value of "denoised" significant wave height (Sea state CCI V1 and V3)



Sea Surface Salinity – J.Boutin & N.Reul (LOCEAN & IFREMER, Fr)



Phase 1 – 2020 to 2022

Global products:

- CDR Version 1/2/3: Jan 2010 – Nov 2018
- CDR Version 2: Jan 2010 – Dec 2019
- CDR Version 3: Jan 2010 - Sep 2020

Phase 2 – 2023 to 2025

Global + Polar products:

- CDR Version 4: Jan 2010 – Oct 2021
  - Improved polar regions
  - Regional SMOS-RFI mitigation
- CDR Version 5: Jan 2010 – Dec 2023
  - Improved stability with enhanced SMAP and SMOS calibration and radiative transfer model update ; generalization of SMOS-RFI mitigation

River Plumes products:

- CDR v1: May 2002 – Oct 2011

Perspectives: extend time series & improve

L-Band (Global & Polar):

-corrections for solar & RFI contaminations

-absolute calibration over continental plateaux

C/X Band (River plumes):

-Windsat (Feb 2003-Sep 2020) concomitant with L-Band CDR

What's new in CCI+SSS phase 2

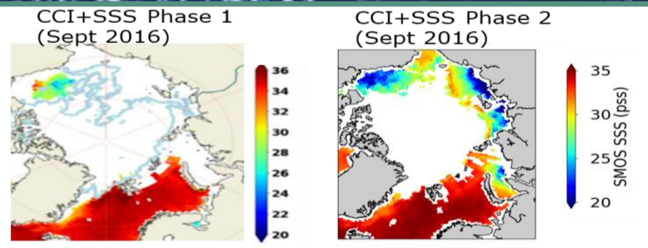
Big improvements with respect to CCI+SSS phase 1 algorithm:

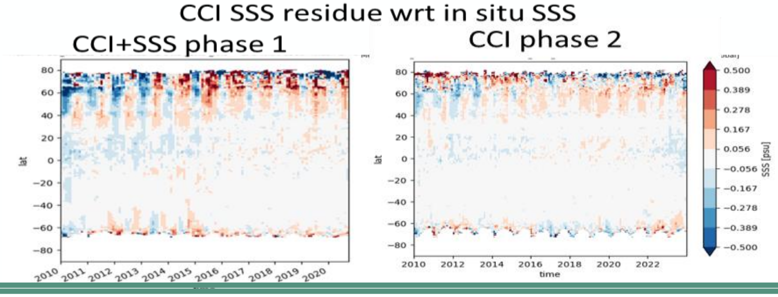
⇒ **Ice filtering** (was too strong in CCI v3)

⇒ Global fields on **rectangular 0.25° grid** and **Polar fields** on EASE polar grid

⇒ **SMOS RFI correction** (Bonjean et al. 2024)

⇒ **Reduction of latitudinal seasonal biases:**
- ⇒ Adjustment of SMOS direct models (wind, dielectric constant, rain)
- ⇒ Latitudinal-seasonal bias correction of SMOS, Aquarius & SMAP



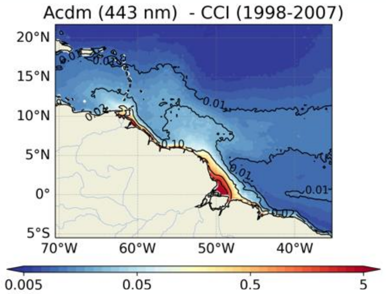


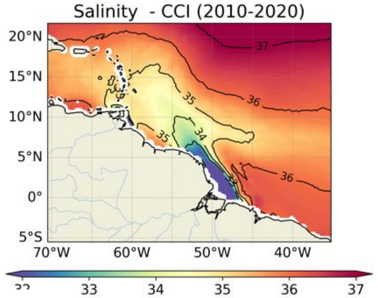
New case studies

⇒ SSS variability related to freshwater fluxes (river plumes, ice melt) & ocean circulation

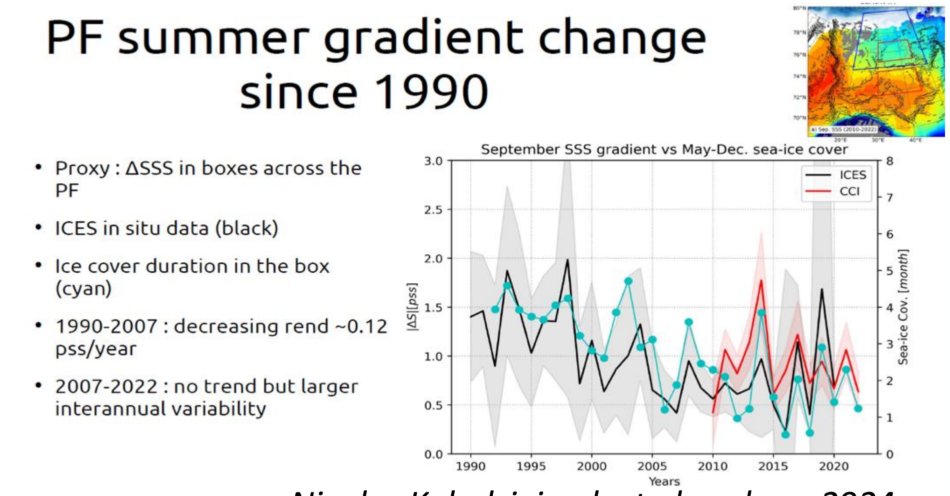
⇒ **Polar Front Summer SSS gradient change**

⇒ **Impact of river plumes on biogeochemistry**





Gevaudan et al. 2022

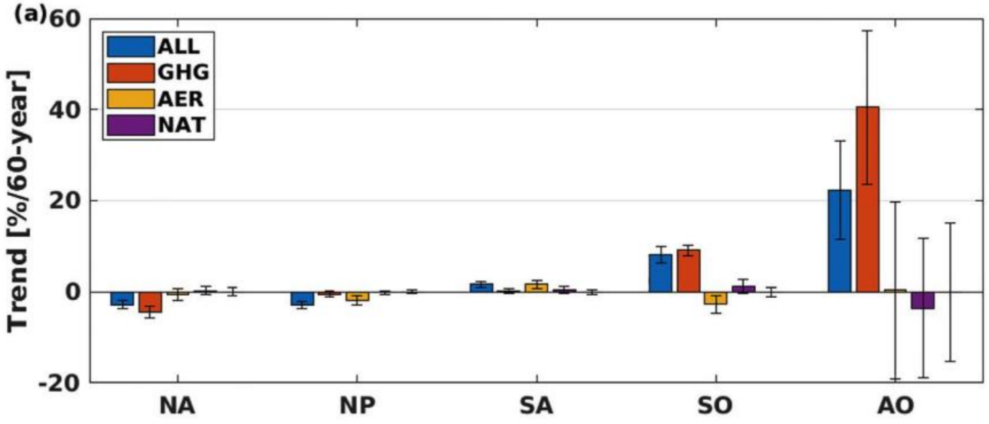


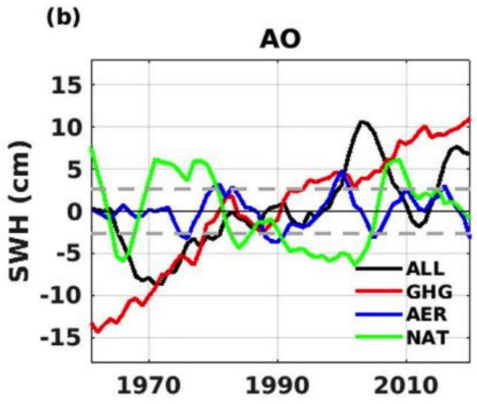
Nicolas Kolodziejczyk et al., subm., 2024

LINKS & INTERCONNECTIONS

Arctic wave heights and sea ice decline

Patra et al. 2024

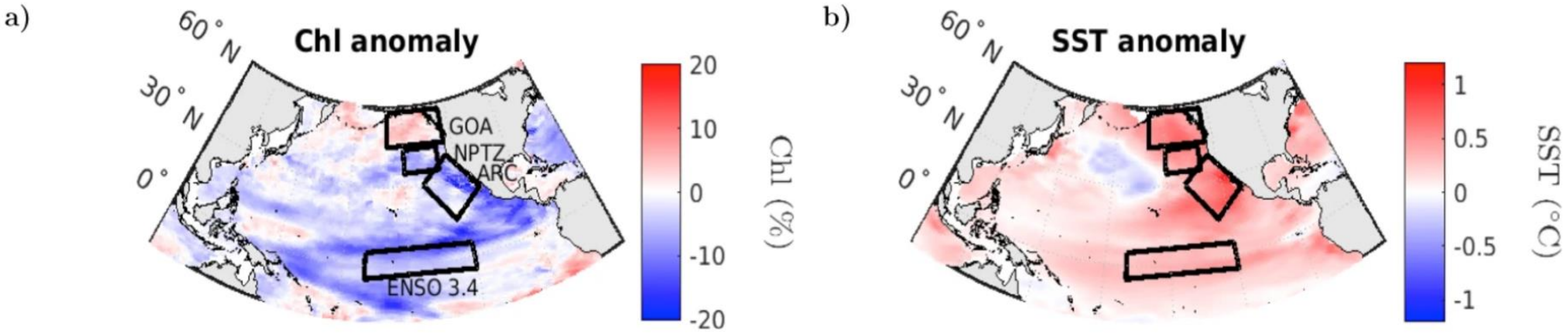




Marine heat waves

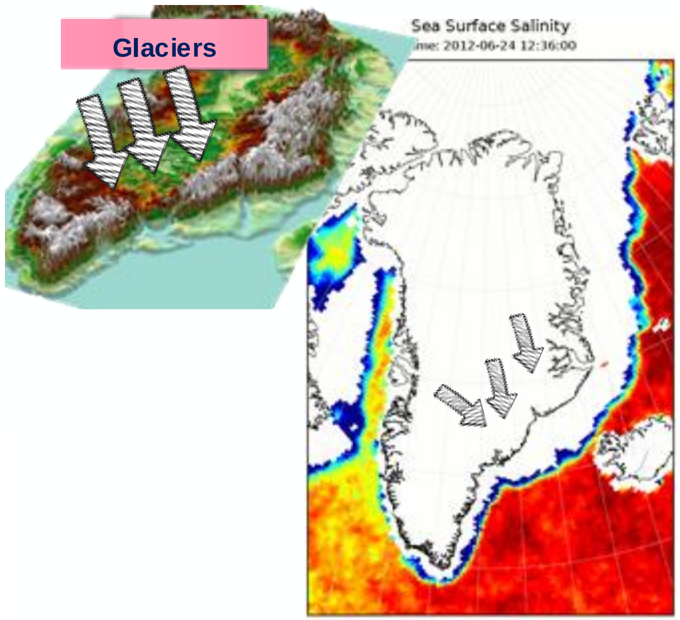
Arteaga & Rousseaux (2023)

From: Impact of Pacific Ocean heatwaves on phytoplankton community composition



Arctic Salinity & Greenland melt

Martinez et al., 2022, Tikhonov. et al 2022
Hall et al 2023, Grodsky et al., 2023



Castaleo et al., 2022
Hu and Zhao, 2022
Reverdin et al., 2024

OBSERVATIONAL CHALLENGES

Challenges vary with

- **observability** (cloud cover for optical and IR, low winds for SAR, RFI for radiometers : issues in war-torn regions…)
- **limited information** (plakton types, different wave parameters)
- **sampling** vs evolution time scale (**wider swaths** with high quality are much better)
- **representativity**:
  vertical gradients and surface effects (cool skin, fresh water lenses)
  horizontal gradients and pixel / altimeter footprints: in particular **near the coast, ice edge …**

in situ **validation** datasets: dedicated efforts performed by each CCI project

PRIORITIES FOR CLIMATE SPACE

Uniqueness of CCI efforts: no other projects have this long, multi-agency mandate

(typically NASA does not fund work on non-NASA missions)

- opportunities with new non-ESA missions (Chinese salinity mission, …)
- **consistency** of long term time series is a never-ending quest
- old data requires more work … and can have a lot of value (long term trends)
- new data and future missions are new opportunities to revisit old data / recalibrate time series …

Consistency and complementarity between ECVs can be leveraged to look at a wider range of questions

What are we missing? Wind and air-sea fluxes, total surface current …

CDRs make new applications possible, including adaptation to climate change

- e.g.: change in wave climate for marine energy management