

# COPERNICUS MARINE 8<sup>th</sup> GENERAL ASSEMBLY

## ● White Ocean – Models

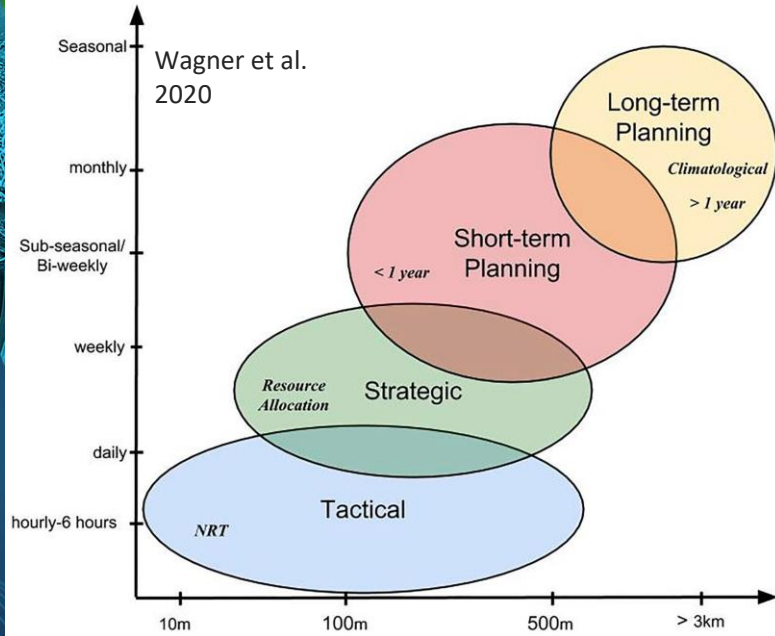
Achievements from 2023, plans for 2024

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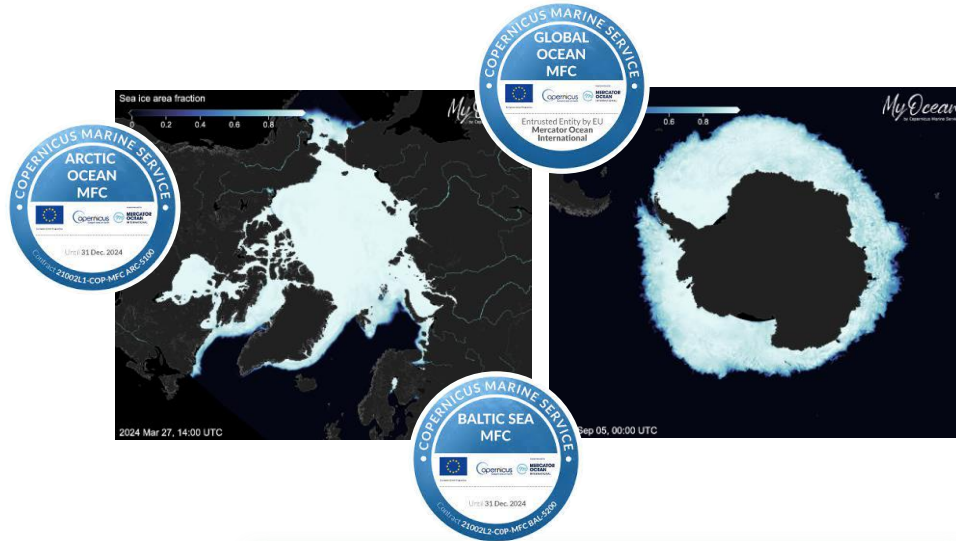
# Sea ice Modeling Systems: The needs



- Planning & tactical advice for navigation and fixed assets (high resolution)
- Readiness for search and rescue, oil spills in sea ice (sea ice drift)
- Sea ice is important for the ocean, waves, and the ecosystem (coupling)
- Compare present conditions to “normal” conditions (multi-year)
- Honour observations (data assimilation)



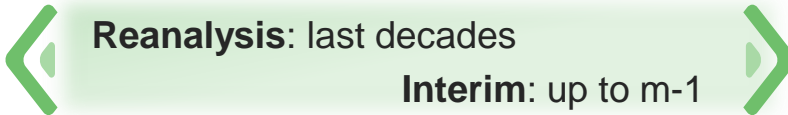
# 3 Monitoring & Forecasting Centers



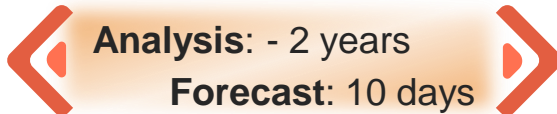
- Concentration (SIC)
- Thickness (SIT)
- Drift (SIUV)
- Snow depths
- Classification / Type
- Age
- Albedo

- Monthly mean
  - Daily Mean
  - Hourly Mean

**Multi Year**



**Near Real Time**







White Ocean

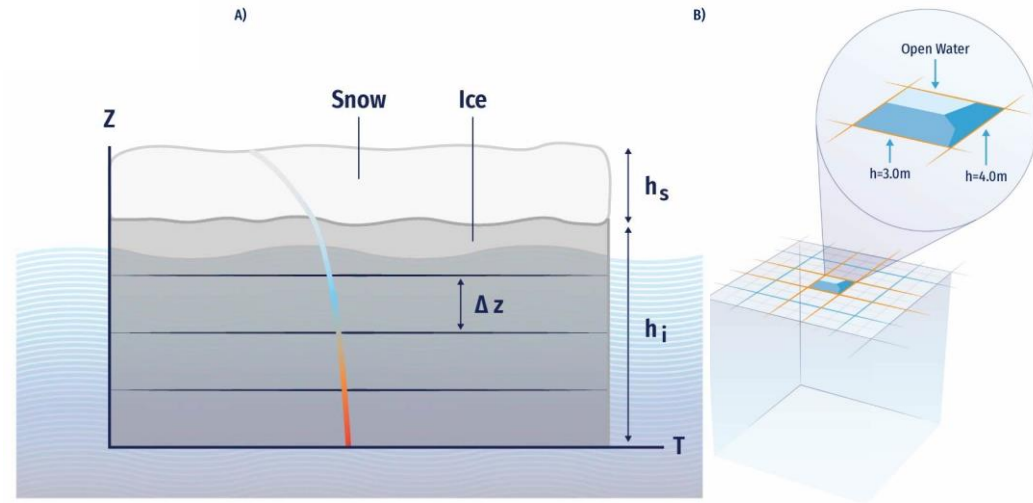
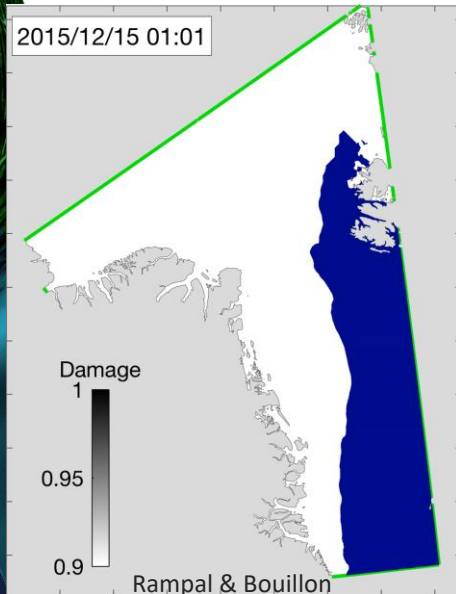
# What are Sea ice models?

## Dynamics (rheology)

- Simple (LIM, CICE, SI<sup>3</sup>)
- Brittle (neXtSIM)

## Thermodynamics

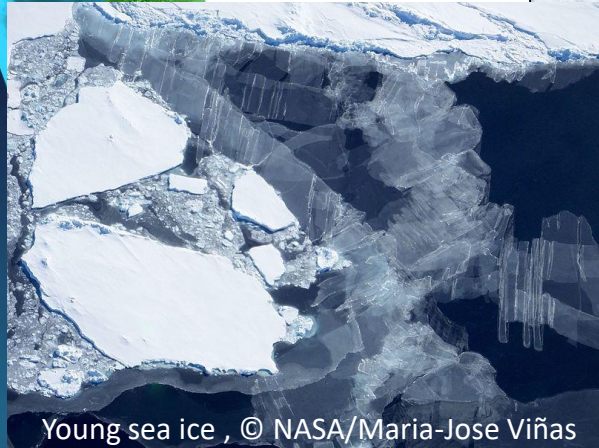
- Simple (LIM2, CICE3, neXtSIM)
- Ice Thickness Distribution (ITD: LIM3, CICE5, SI<sup>3</sup>)



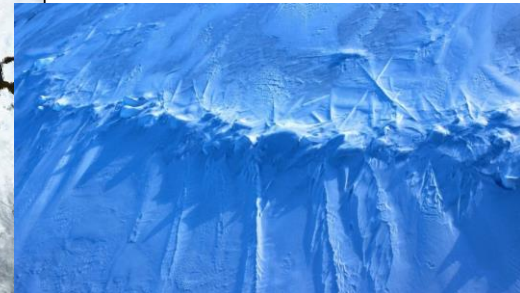
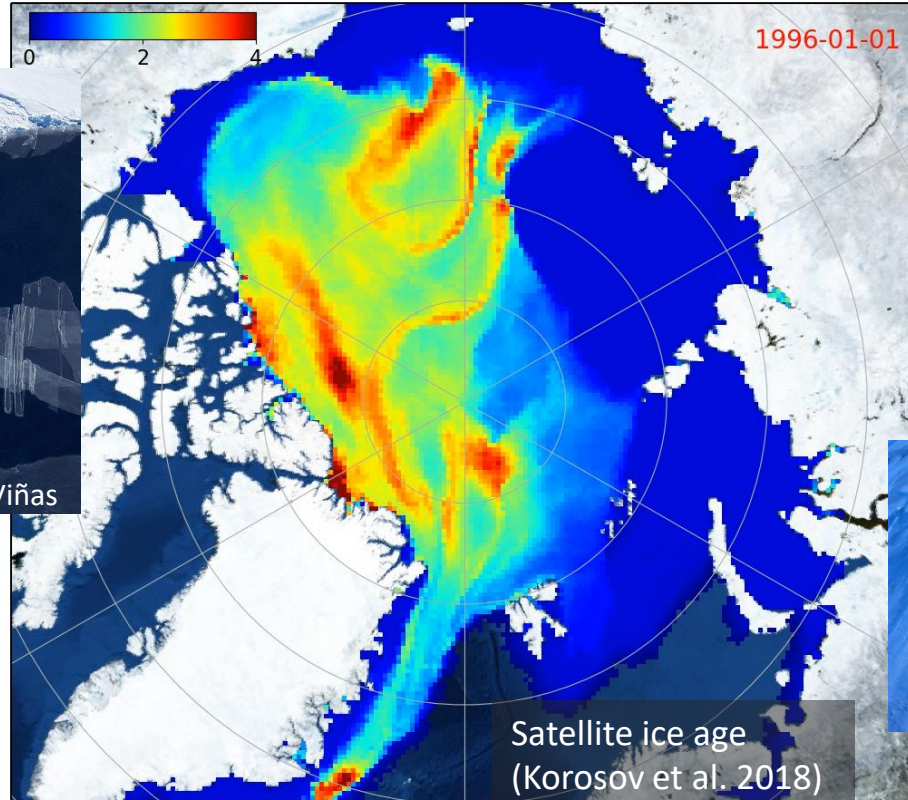


White Ocean

# Being young, ageing and ridging



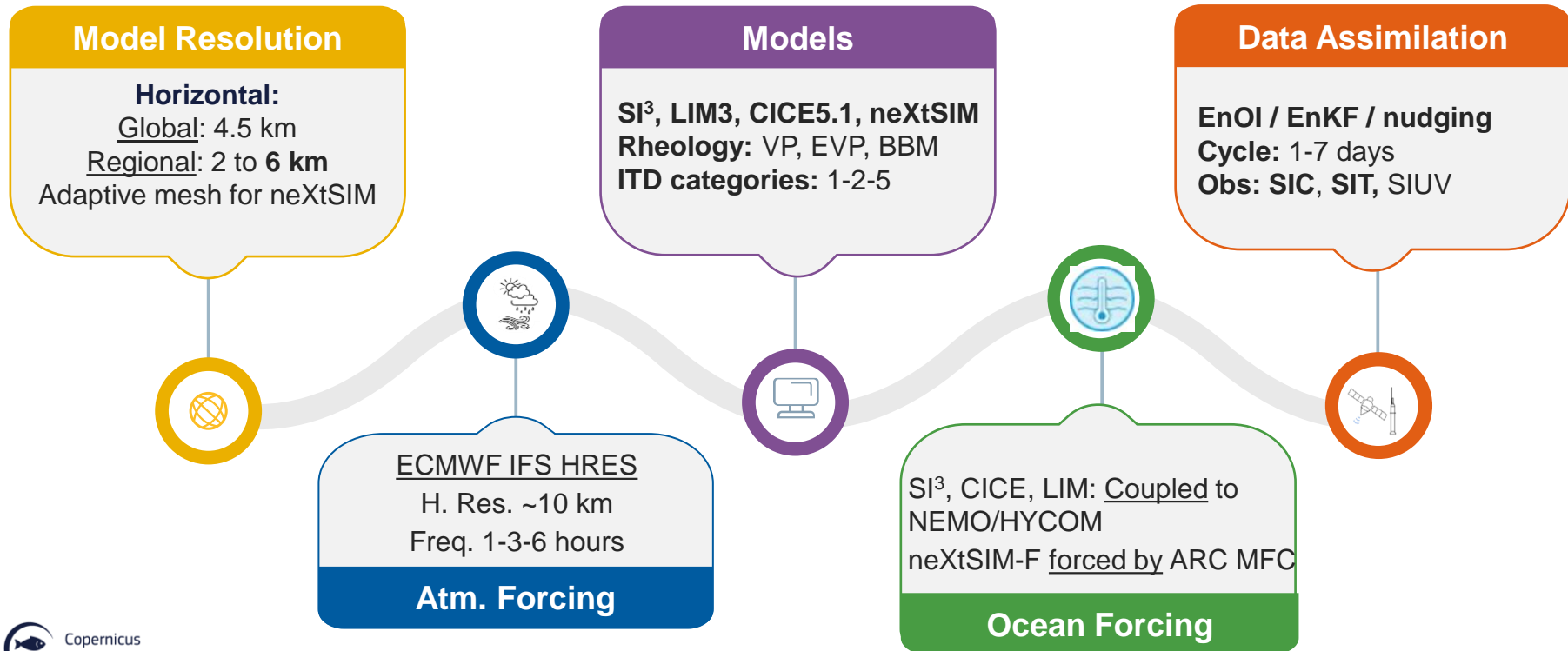
Young sea ice , © NASA/Maria-Jose Viñas



Pressure ridge, © Grace Shephard



# Near Real Time Models' Characteristics





White Ocean

# Multi-Year Time Models' Characteristics

## Model Resolution

**Horizontal:**  
Global: 4.5 km  
Regional: 2 to 12 km

## Models

SI<sup>3</sup>, LIM2, CICE3  
Rheology: VP, EVP  
ITD categories: 1-2-5

## Data Assimilation

EnOI / EnKF / nudging  
Cycle: 1-7 days  
Obs: SIC, SIT, SID

ECMWF ERA5  
H. Res. ~25 km  
Freq. 1-6 hour

## Atm. Forcing

SI<sup>3</sup>, CICE, LIM: Coupled to  
NEMO/HYCOM  
neXtSIM-F forced by ARC  
MFC

## Ocean Forcing

From 1991/1993  
onwards

## Time Series



Copernicus  
Marine Service



# Major achievement

## Baltic Analysis & Fcst (NRT)

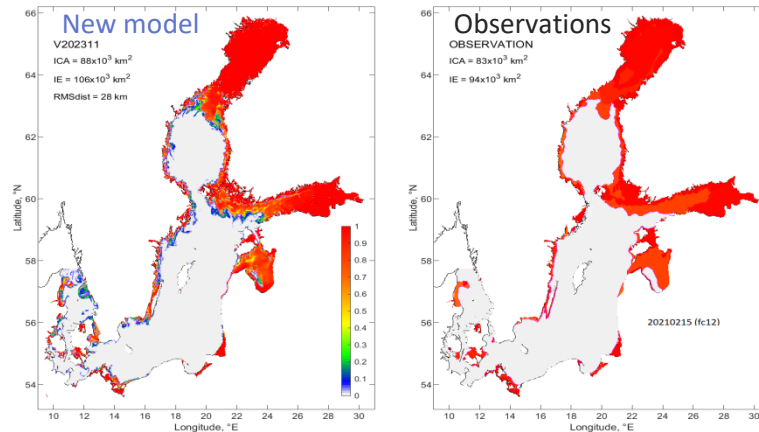
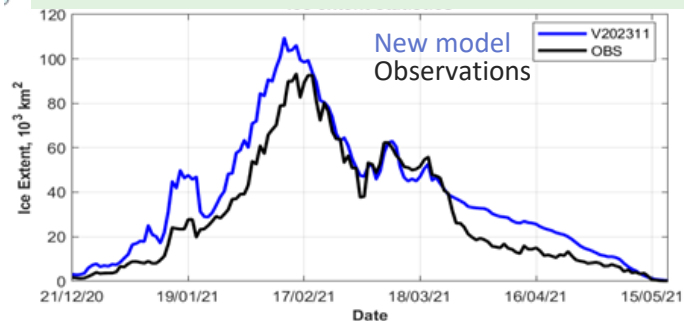
### Introduced assimilation of sea ice concentration (Nov 2023)

- observations of sea ice concentration (SEAICE\_BAL\_SEAICE\_L4\_NRT\_OBSERVATIONS\_011\_004)
- assimilated into midnight (00Z) production during winter
- Univariate assimilation with the PDAF software

### Impact:

- Improved ice extent
- Model still slightly overestimates ice during the ice freezing and melting phases

Time series of ice extent during winter 2020-2021

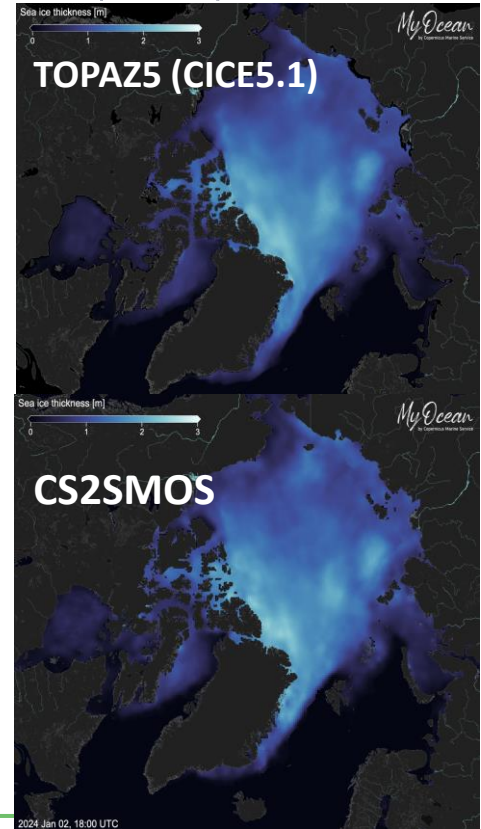
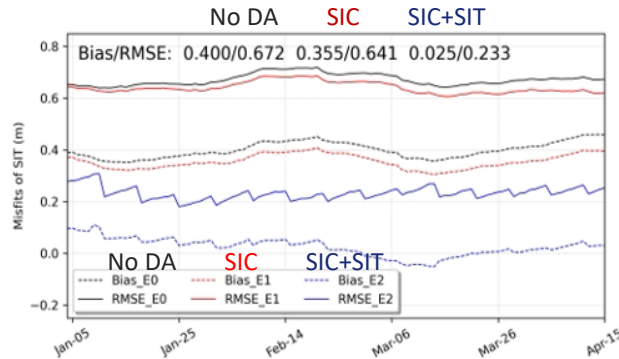


Maximum ice extent in winter 2020-2021

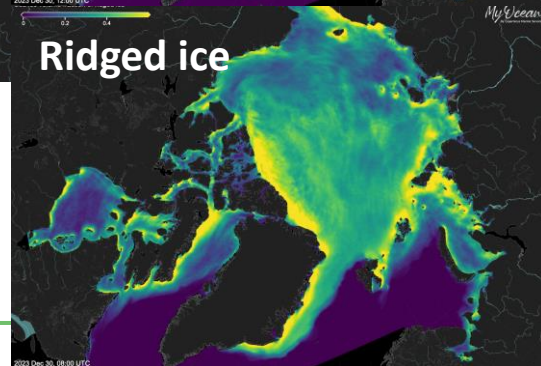
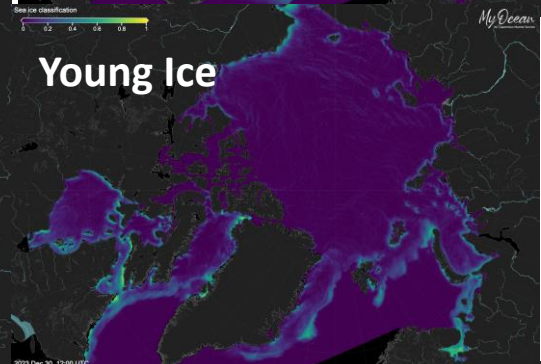
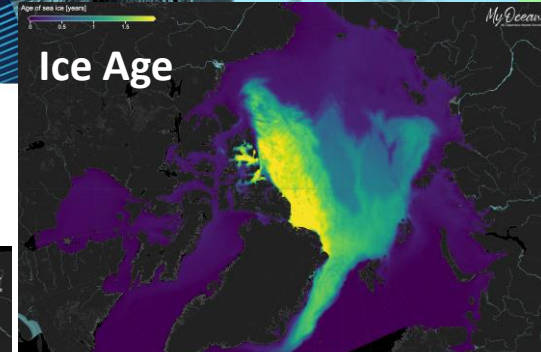
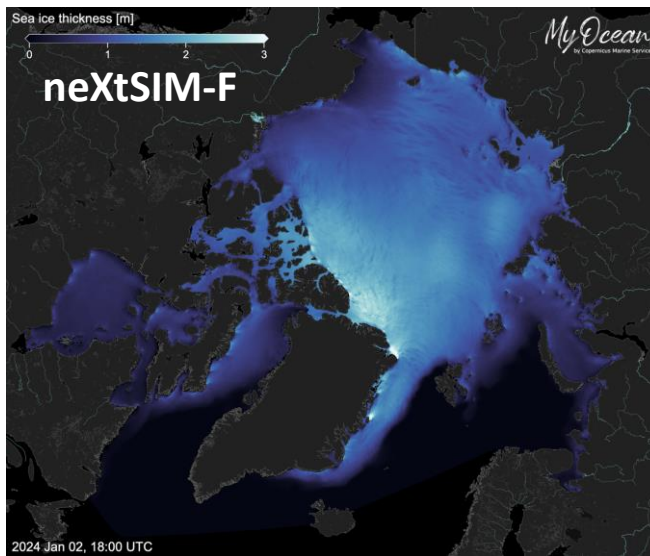
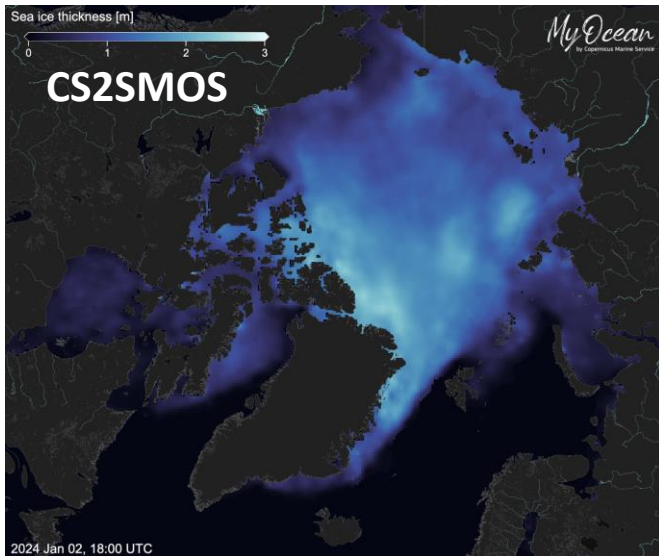


# Major achievement – Arctic Ocean Analysis and Fcst (NRT)

- **Double resolution 12 -> 6 km**
- **Complex thermodynamics**
  - ITD: 5 categories
  - Melt ponds
  - Ice age tracer
- **ESMF coupler**
  - HYCOM and CICE5.1
  - New flux formulas
- **Assimilation of SIT (CS2SMOS) in ITD with the EnKF**
  - Merged from CryoSAT-2 and SMOS satellites in NRT
  - Redistribute total thickness proportionally between categories
  - Effect of assimilation persists in early summer when CS2SMOS is turned off.
  - EVP rheology: smooth SIT ...



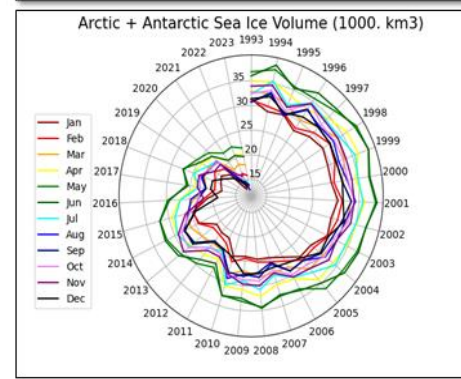
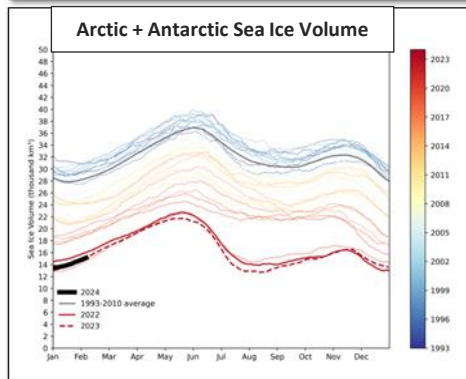
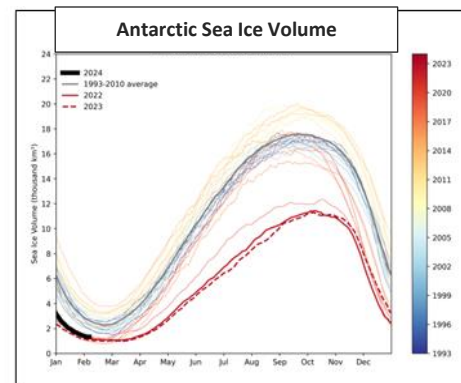
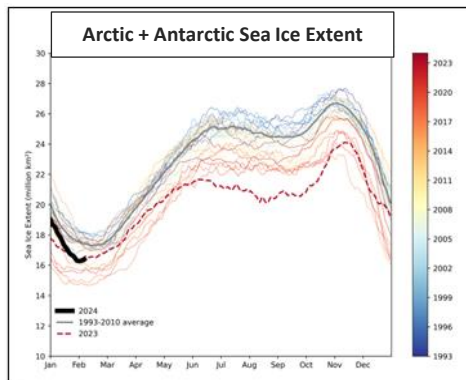
## Major achievement – Stand-alone sea ice Fcst



- Nudging of sea ice thickness (CS2SMOS again) - No ITD
  - Products 002\_001 and 002\_011 more consistent with each other
- New variables:
  - Sea ice Age, classification (Young Ice), Ridged Volume Fraction

# Sea Ice Monitoring Indicator at Global Scale

- The unstoppable loss of sea ice at the surface of the global ocean
- Monitoring with NRT and MYP GLO MFC
- Historic low record in Antarctica in 2023 for sea ice extent and volume
- Global sea ice volume at its lowest level for the last 30 years.



# NRT & MYP Systems' planned evolutions in 2024

## Model resolution/domain

- ARC NRT stand-alone: Extend the 3 km domain to the Bering Sea

## Sea Ice Models

- BAL NRT: Upgrade NEMO from v4.0 to v4.2.1

## Data Assimilation

- BAL MYP: Assimilation of SIC

## Forcings & Coupling

- GLO MYP: Upgrade NEMO with LIM3 (upcoming...)
- BAL NRT: New bulk formulae for atmospheric fluxes

## Availability

- ARC MYP: new stand-alone neXtSIM reanalysis 1993-2023 @ 3 km
- BAL MYP: Starting in 1980



## Developments to be implemented during 2024

### For the Baltic Multi Year product (BALTICSEA\_MULTIYEAR\_PHY\_003\_011)

- **New model production** “for extension back in time” 1980-1992 to supplement existing Multi Year product
- **NEW:** Assimilation of Sea Ice Concentration will be included to improve ice results

### For the Baltic Forecast product (BALTICSEA\_ANALYSISFORECAST\_PHY\_003\_006)

- Planned upgrade of the NEMO model version (v4.0 to v4.2.1)
- Relevant for sea ice: improved atmospheric bulk formulation

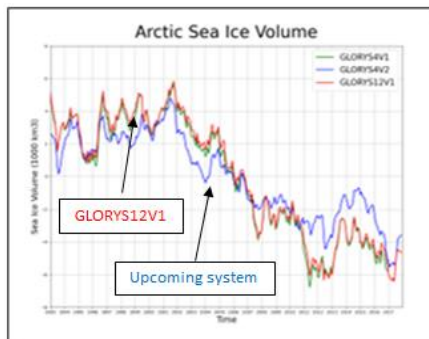
## Ongoing regional Arctic model developments

### A new 3km stand-alone sea ice reanalysis with neXtSIM

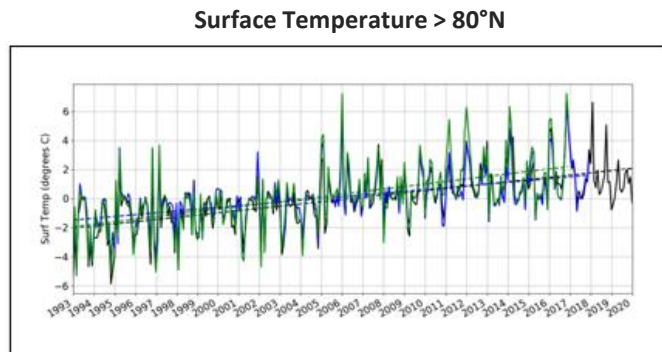
- Same production system as the 002\_011 NRT product => MYP 002\_016
- Nudging of SIC (from passive microwaves)
- Nudging of SIT (merged CryoSAT-2 and SMOS) in winter
- More accurate sea ice drift than the 002\_003 ice-ocean reanalysis
- => Complete and more reliable history of sea ice age, classification, types

# GLO MYP – Development of new Global Reanalysis

- A major development of the global ocean reanalysis at 1/12° resolution is ongoing.
- Update of the NEMO model with LIM3 (ITD); assimilation of Sea Ice Concentration from CMEMS – Preliminary results

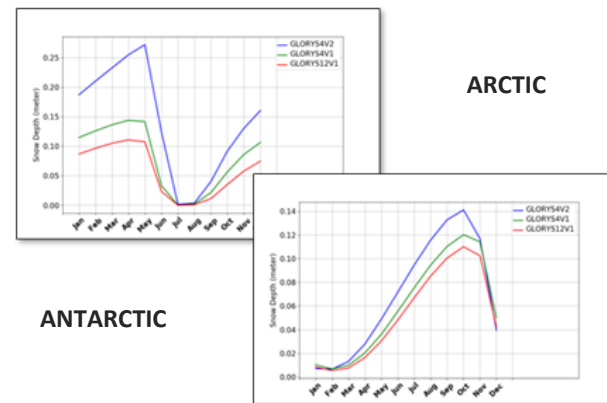


Less volume and reduction of the negative trend in Arctic with the upcoming system --> in better accordance with state-of-the-art reanalysis



Good representation of Arctic surface temperature variability

- Correlation with (CMEMS) = 0.95
- Trend upcoming system (1993-2017) = +3.1°
- Trend OBS (1993-2020) = +4.3°



- More snow depth with upcoming system
- In better accordance with (few) in situ measurements in Arctic
- Little or no validation possible in Antarctica



## ● Take-home Messages

### **Continuous effort to:**

- Bring relevant information from sea ice models to the users
- Improve the consistency between various sea ice products
- Constrain the models to relevant observations
- Increase the model data quality
- Deliver extended time series (Backward)