Regional Arctic Reanalysis
SODA3 to RARE1 to RARE2

Jim Carton and Gennady Chepurin

Carton, J. A., and G. A. Chepurin, 2023: RARE: The Regional Arctic Reanalysis. J. Climate, 36, 2333–2348, https://doi.org/10.1175/JCLI-D-22-0340.1.

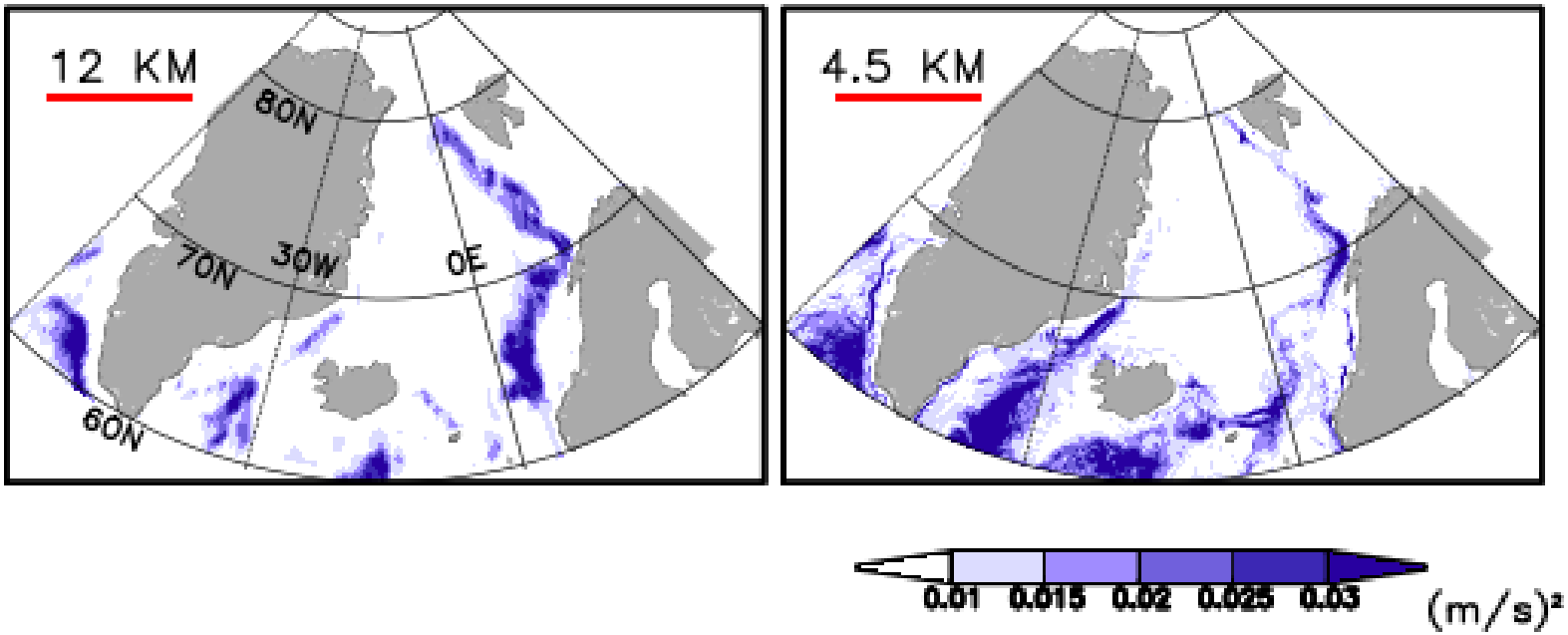
www.soda.umd.edu
www.soda.science

Barents Sea
Andreassen et al., *Science*, (2017)

Time mean eddy kinetic energy

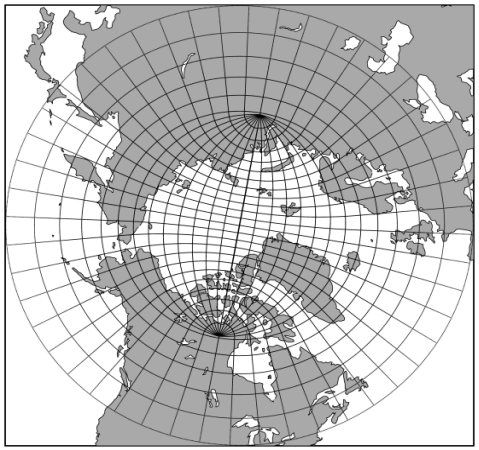
SODA3

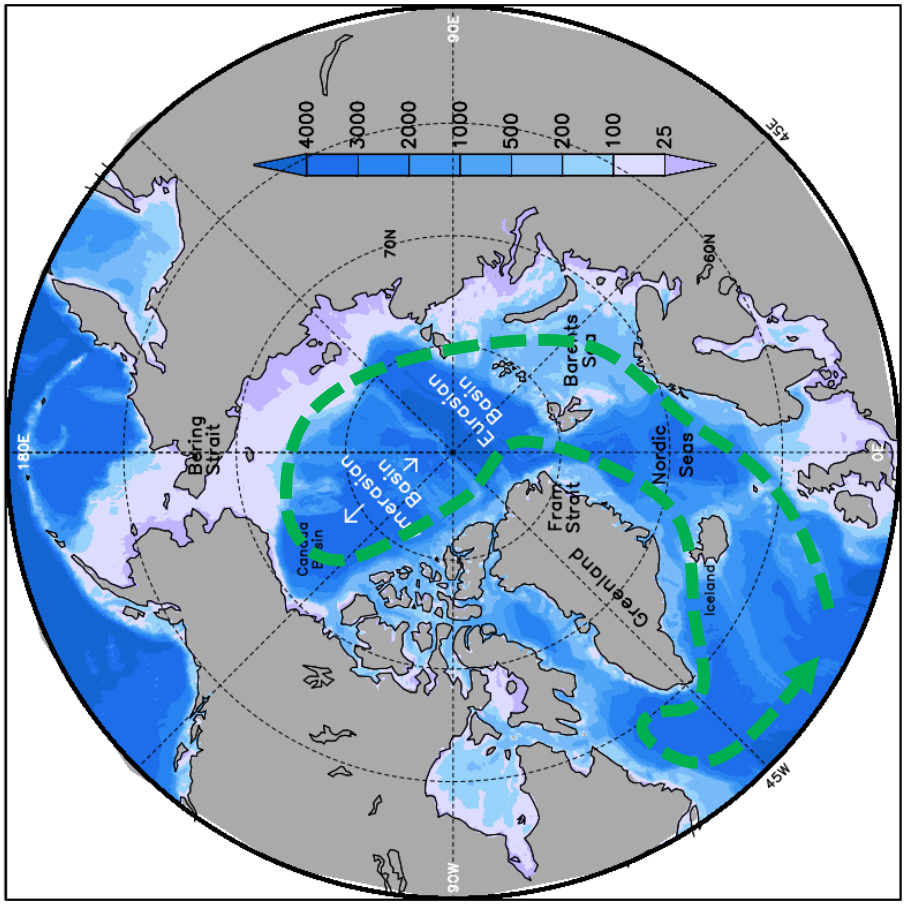
RARE1



RARE1: Regional Arctic Reanalysis

- 4-5 km horizontal resolution
- 75 z*-coordinate vertical levels
- GFDL MOM5 numerics
- 5 category SIS1 sea ice
- WOD observations & sat SST
- New discharge data set
- ERA5 forcing
- PIOMAS sea ice constraint
- Optimal Interpolation
- 1980-2022 (360K CPUhr)





WOD vs UDASH observation coverage

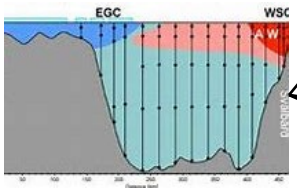
<- Two different data collections ->

WOD

2000

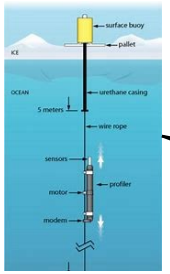
UDASH

Moored Arrays



IMB

ITP

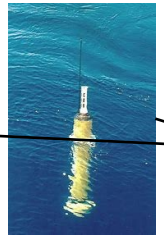


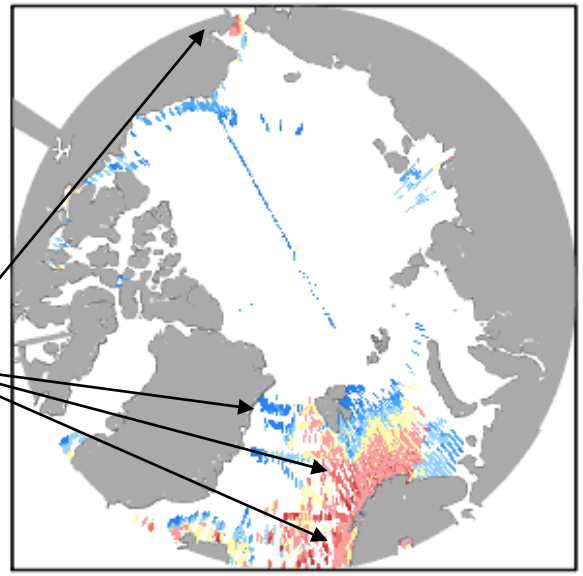
2015

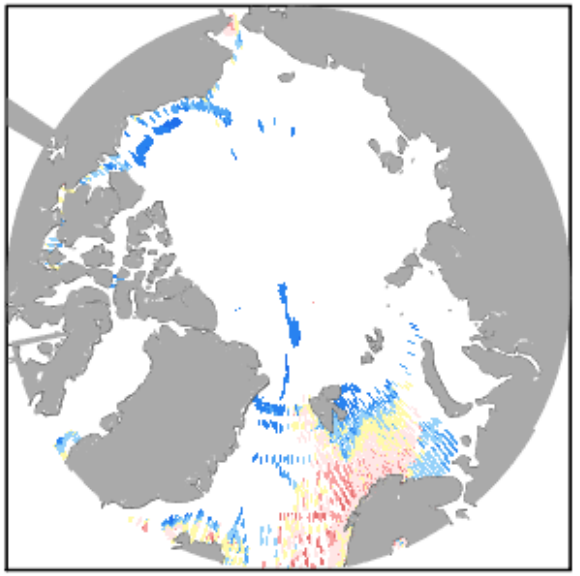
Nothing!

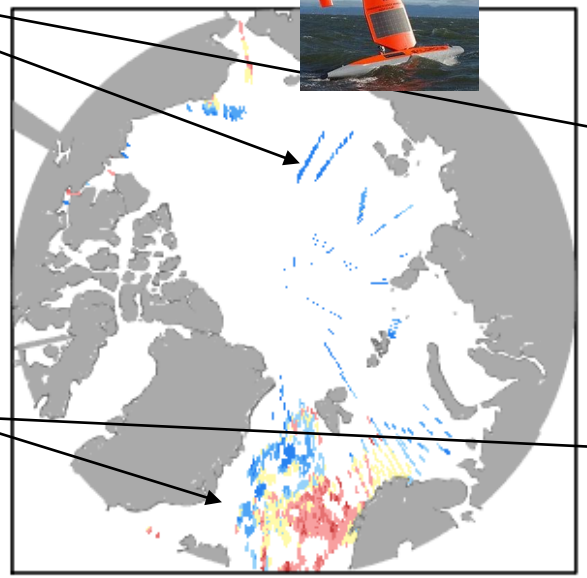
CTDs

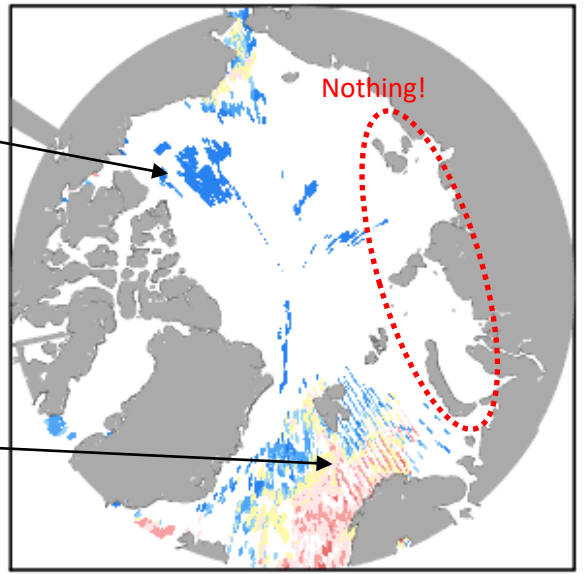
ARGO

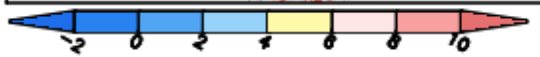




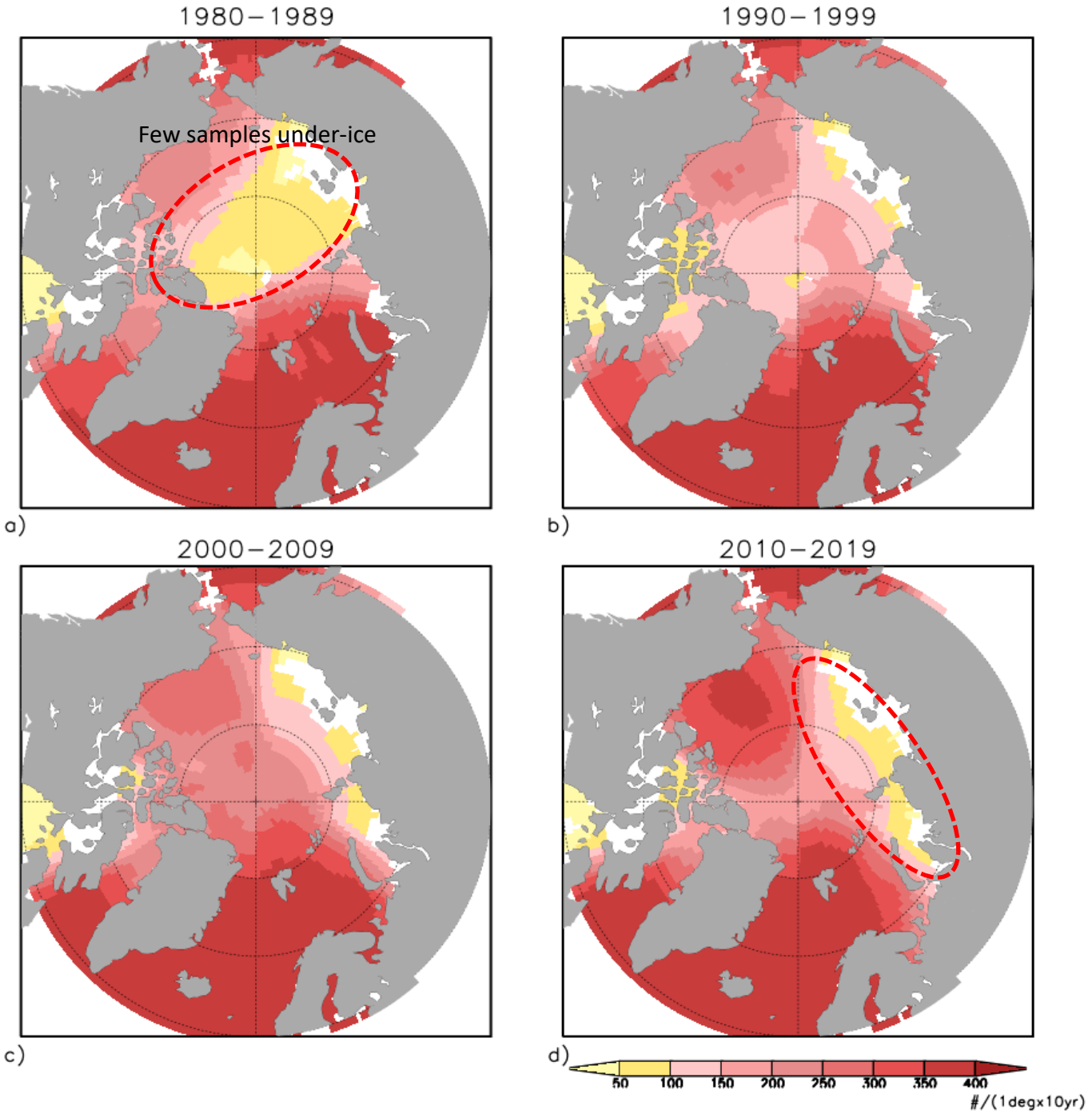








T/S coverage by decade



RARE sea ice thickness assimilation

via regulating surface flux

Sea ice thermodynamics

$$m\left(C + \frac{L\mu S}{T^2}\right)\frac{dT}{dt} = F \quad + F'$$

Winton (2000)

m: ice mass
C: latent heat of fusion
F: heating of the ice
T: ice temperature
S: salinity
F' α ($m-m_o$)

Future: include freeboard information to update individual sea ice types: frazil, etc

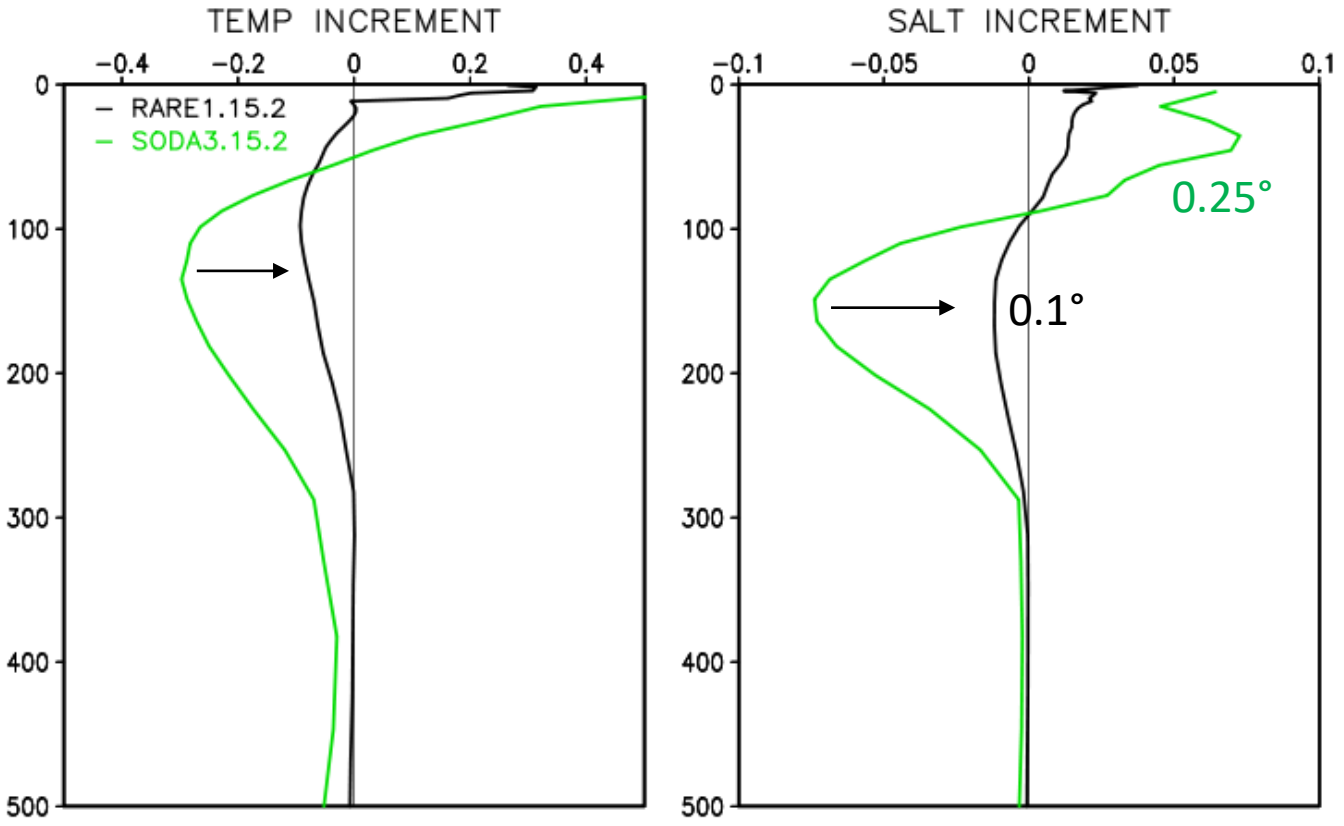
RARE DA

(admittedly simple)

$$\omega^a = \omega^f + \mathbf{K}[\omega^o - \mathbf{H}(\omega^f)]$$

10-dy cycle
K empirical
Bloom-style digital filter

(x,y,t) mean T/S increments



Surface flux & model bias

Increment equations

$$\int \left(\frac{\delta\theta}{\Delta t} + \mathbf{u}\cdot\nabla\delta\theta + \delta\mathbf{u}\cdot\nabla\theta\right)dz \cong \frac{\delta Q}{\rho C_p}$$ & sea ice

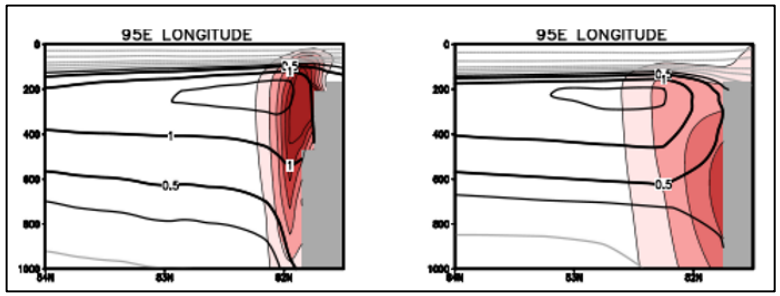
$$\int \left(\frac{\delta S}{\Delta t} + \mathbf{u}\cdot\nabla\delta S + \delta\mathbf{u}\cdot\nabla S\right)dz \cong \delta(P-E+R)S_o$$

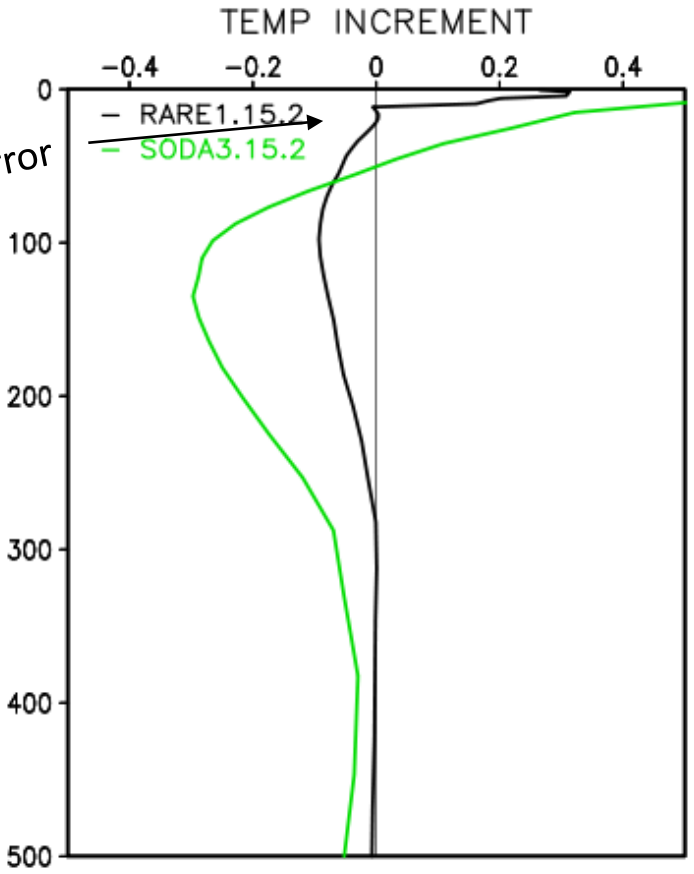
$$\delta Q \approx \frac{\rho C_p}{\Delta t}\int_{z=-D}^{0}\delta\theta dz$$

~ 10Wm^{-2} surface flux error

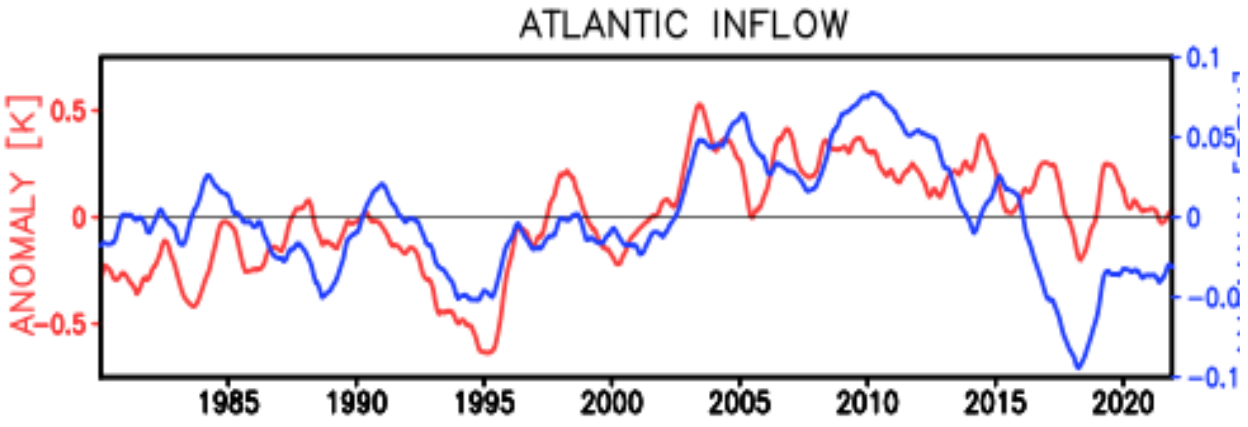
BOUNDARY CURRENT AT 95E

RARE1 SODA3

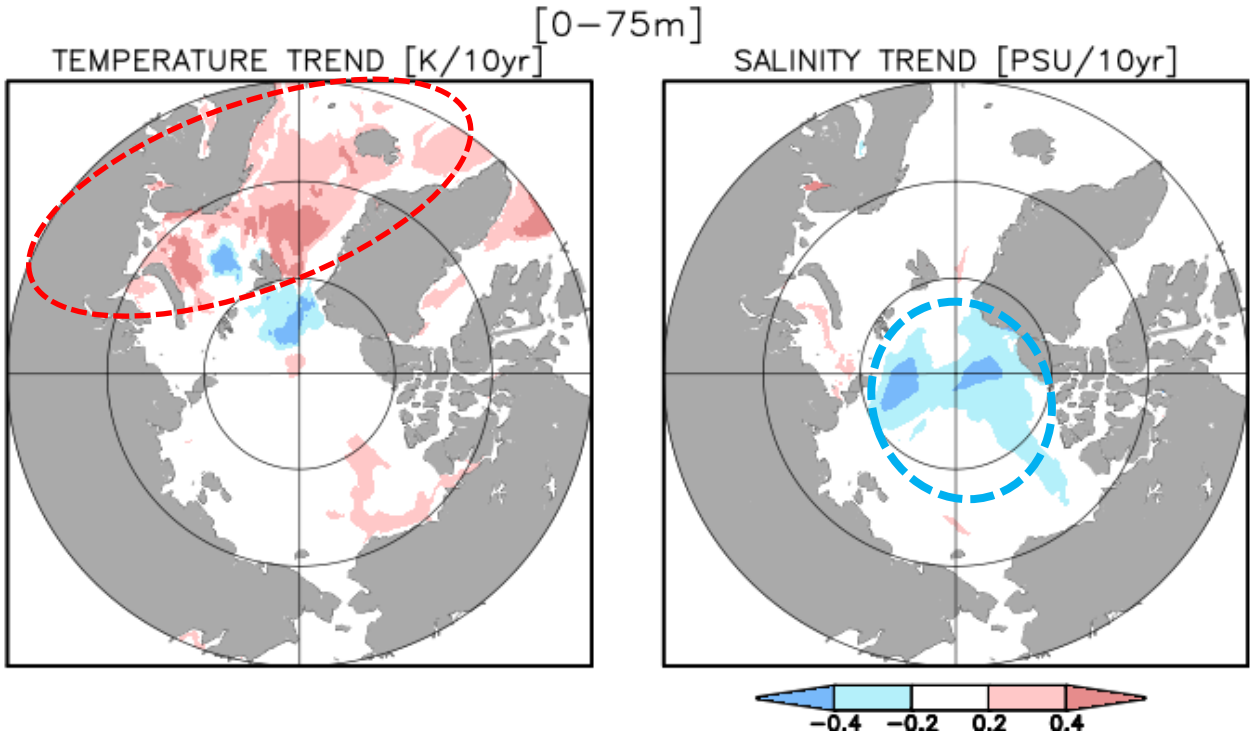




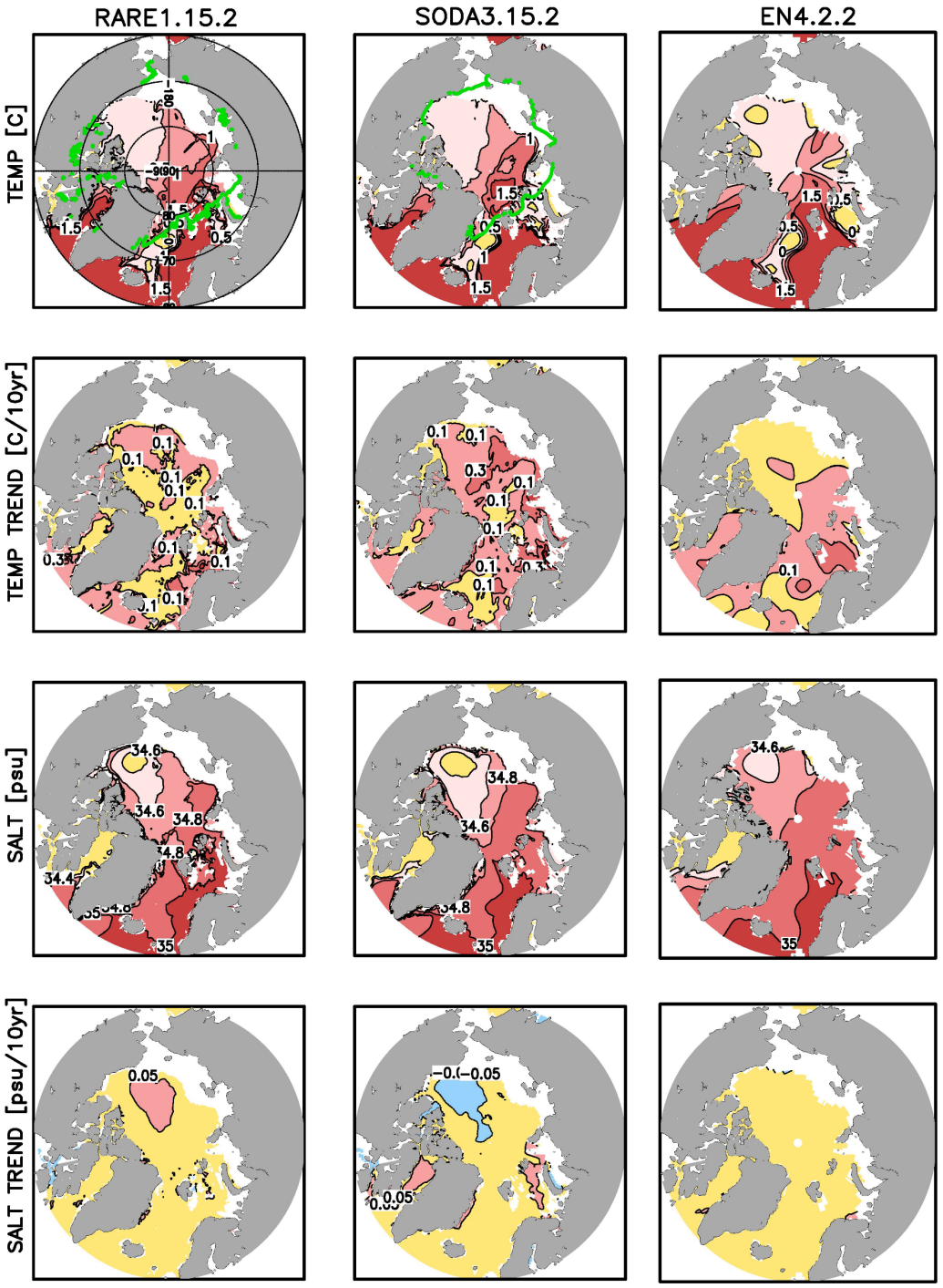
Impact of the subpolar North Atlantic



Linear trend in the upper 75m



200-500m trend

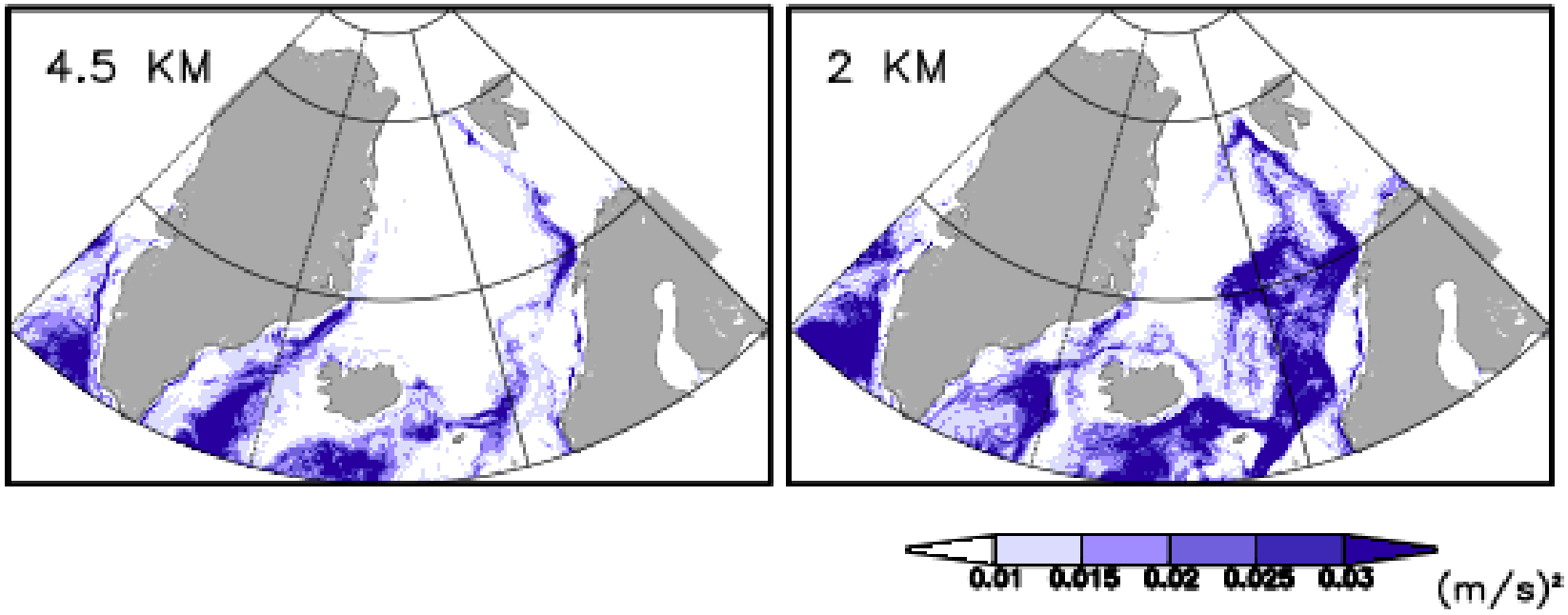


IMPACT OF AN EDDY-RESOLVING GRID

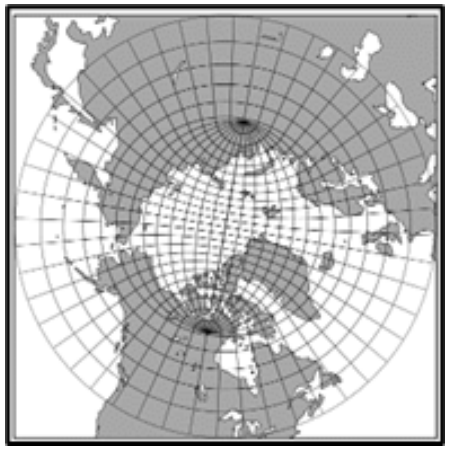
Time mean eddy kinetic energy

RARE1

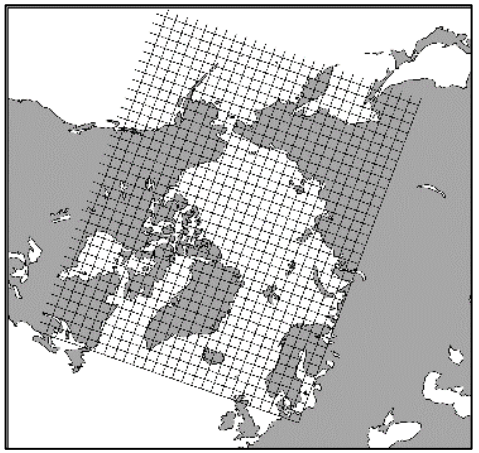
RARE2



RARE1 -> RARE2



- 4-5 km horizontal resolution
- 75 z*-coordinate vertical levels
- GFDL MOM5 numerics
- 5 category SIS1 sea ice
- WOD observations & sat SST
- New discharge data set
- PIOMAS sea ice
- ERA5 forcing
- Optimal Interpolation
- 1980-2022 (360K CPUhr)



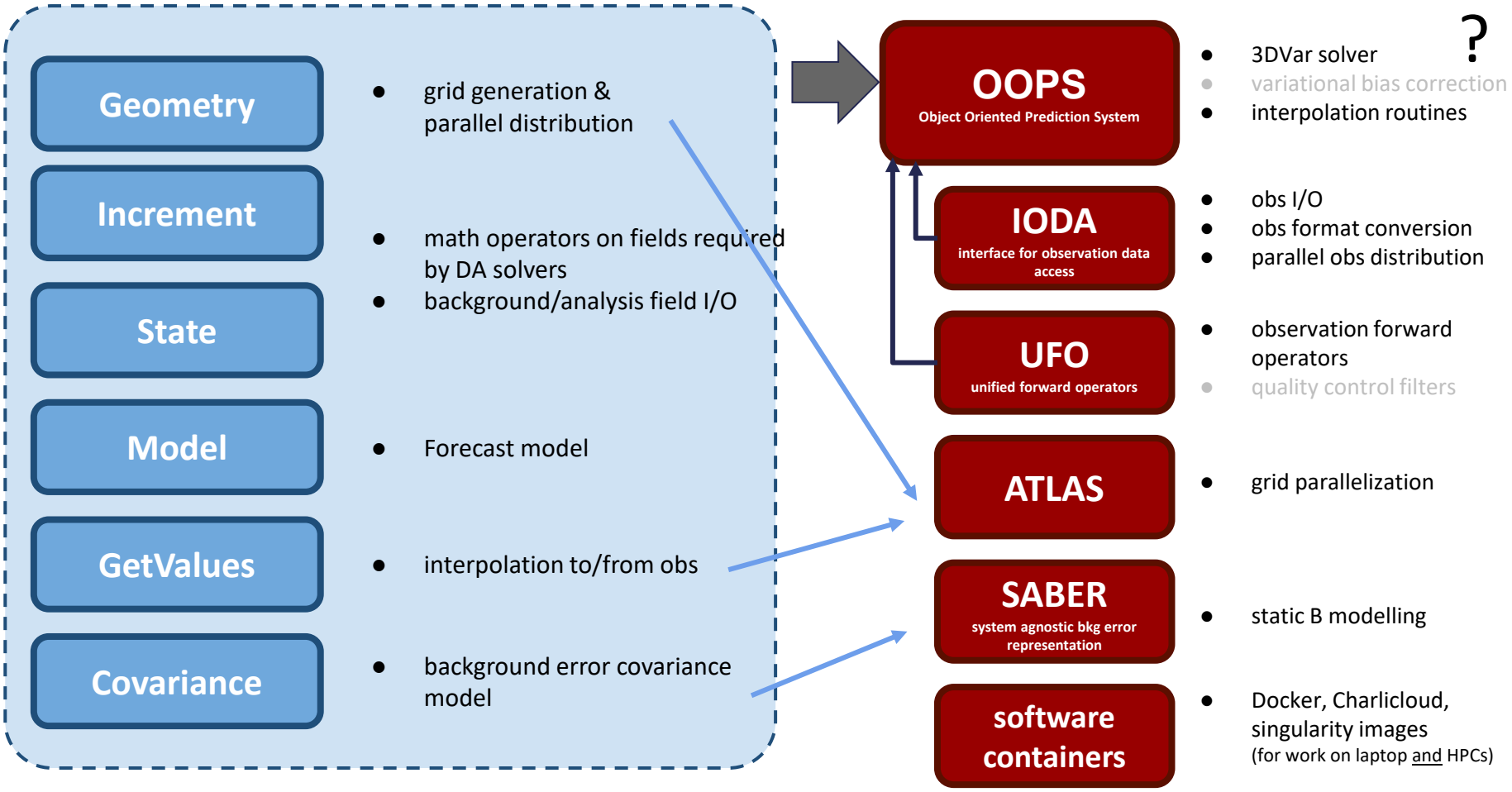
- 2 km horizontal resolution
- 75 z*-coordinate vertical levels
- GFDL MOM6 numerics
- 5 category SIS2 sea ice
- WOD, SLA & new sat SST
- New discharge data set
- PIOMAS sea ice
- ERA5 forcing
- JEDI 3DVar (ENVar)
- 1980-2024

JEDI-RADS 3DVar

UMD-SST code

UMD-SLA code https://github.com/UMD-AOSC/UMD-SST

JEDI code https://github.com/JCSDA



{Work done by Travis Sluka and Ligang Chen}