Modelling the Arctic & *North Atlantic* at high resolution

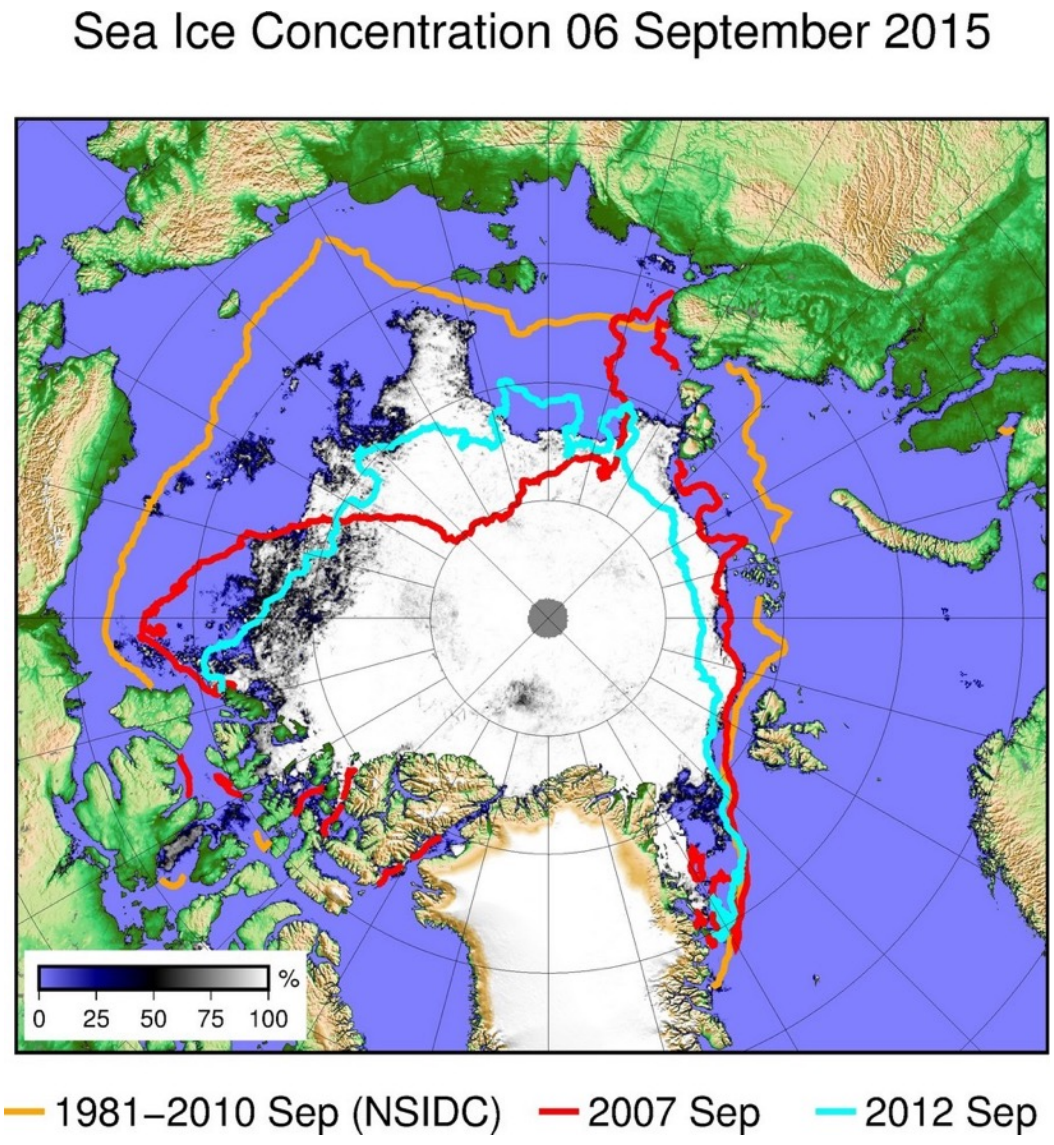
Claude Talandier, Camille Lique
Fabrice Ardhuin, Verena Haid,
Mickael Accensi, Guillaume Boutin

Laboratoire d'Océanographie Physique et Spatiale
CNRS – IFREMER – IRD – UBO, Brest, France

Journée scientifique de l'équipe Océan & Climat – Janvier 2017

The Arctic basin: sea-ice trend observed

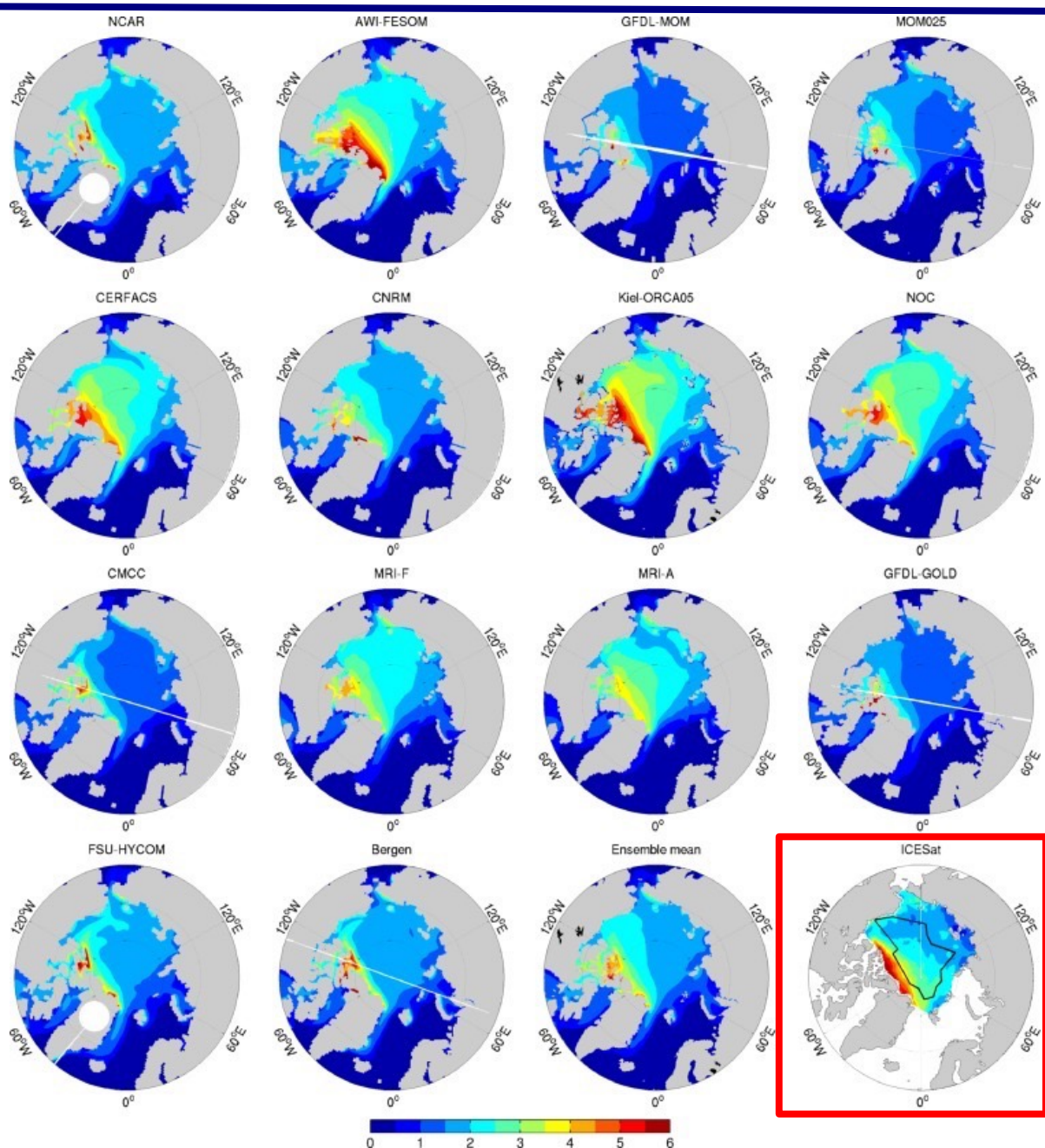
- *The Arctic region is changing rapidly …*



- All the components are affected (ocean, sea ice, land biochemistry…)
- Sea ice cover is diminishing and thinning (opening prospect for socio economics developments)
- The ocean is becoming warmer, fresher, directly forced by the wind (more mixing ? more instabilities ?)

The Arctic basin representation in global models : I

- *Models exhibit common biases in the Arctic*
  -> Sea ice



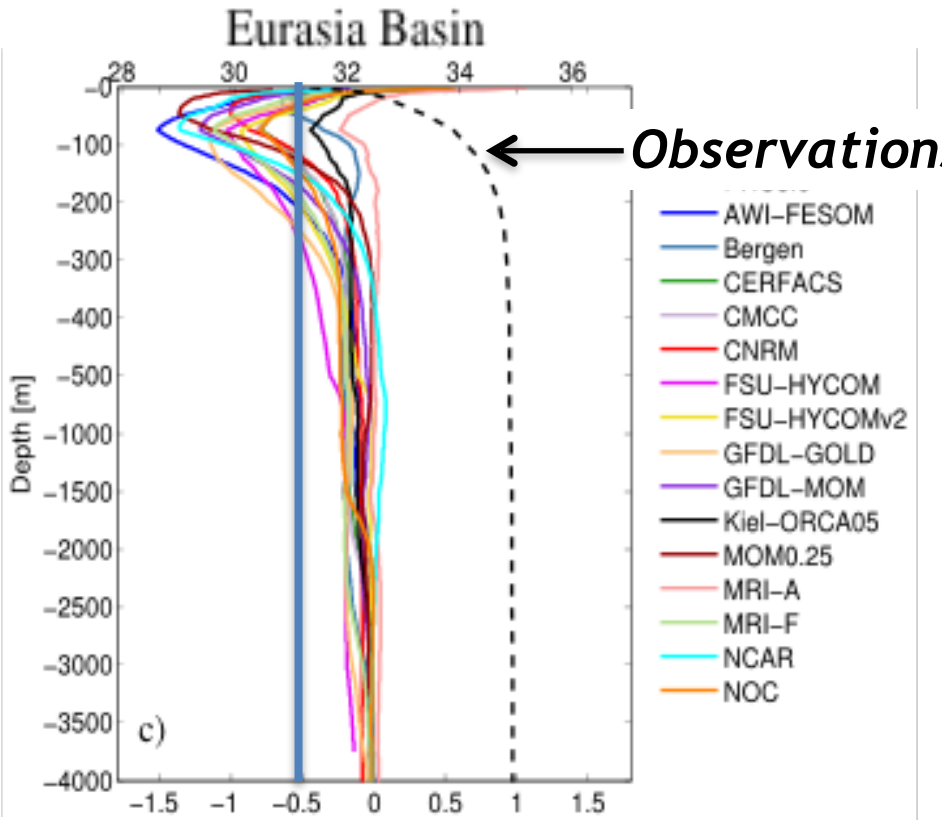
Sea ice thickness in CORE II models and ICESat observations

Wang et al. (2016)

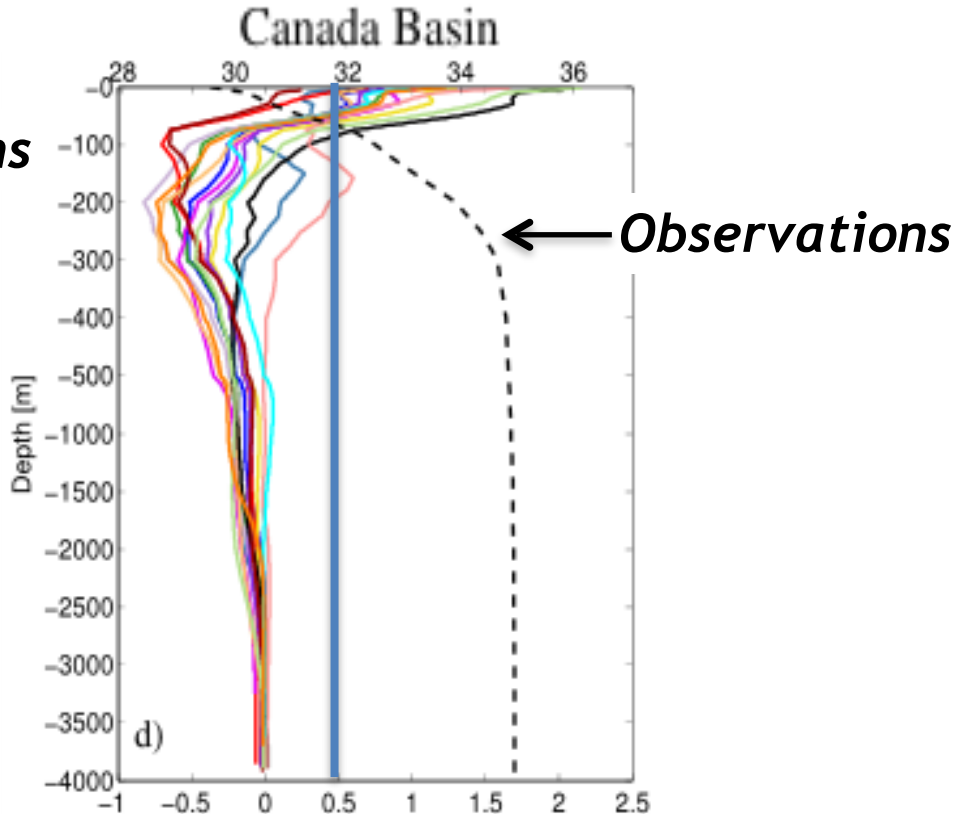
The Arctic basin representation in global models : II

- *Models exhibit common biases in the Arctic*
  - *-> Sea ice*
  - *-> Stratification (set by S)*

CORE II models (mean over 1970-2007), differences with the PHC climatology
Ilicak et al. (2016)



Salinity (difference to obs.)



Salinity (difference to obs.)

FREDY & ArcticMix projects: modelling the Arctic basin

- **FREDY** (for FReshwater Export Dynamics)
  -> What drives the variability of the Arctic freshwater export ?
  -> Funded by LEFE (GMMC 2016-2017 & IMAGO 2017-2018)

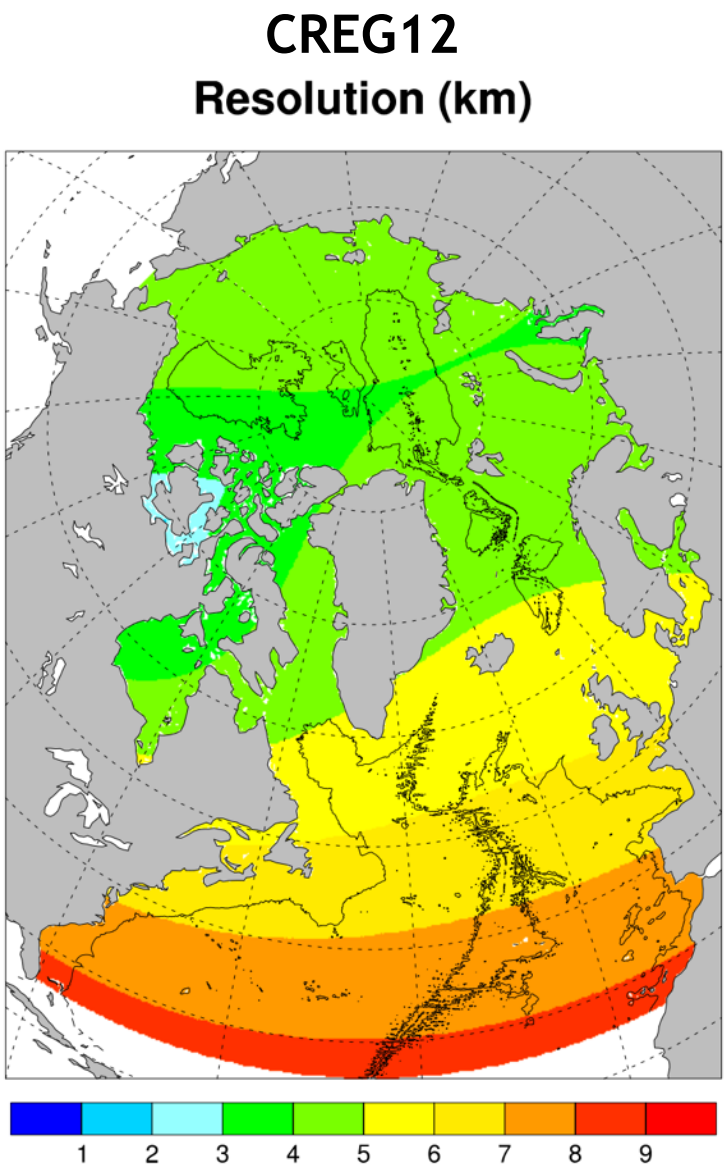
- **ArcticMix**
  -> Impact of additional contributions to the vertical mixing for the simulation of Arctic Ocean and sea ice states
  -> Funded by CMEMS Copernicus Call 1 (2016-2017)

FREDY & ArcticMix projects: modelling the Arctic basin

- **FREDY** (for FReshwater Export Dynamics)
  -> What drives the variability of the Arctic freshwater export ?
  -> Funded by LEFE (GMMC 2016-2017 & IMAGO 2017-2018)

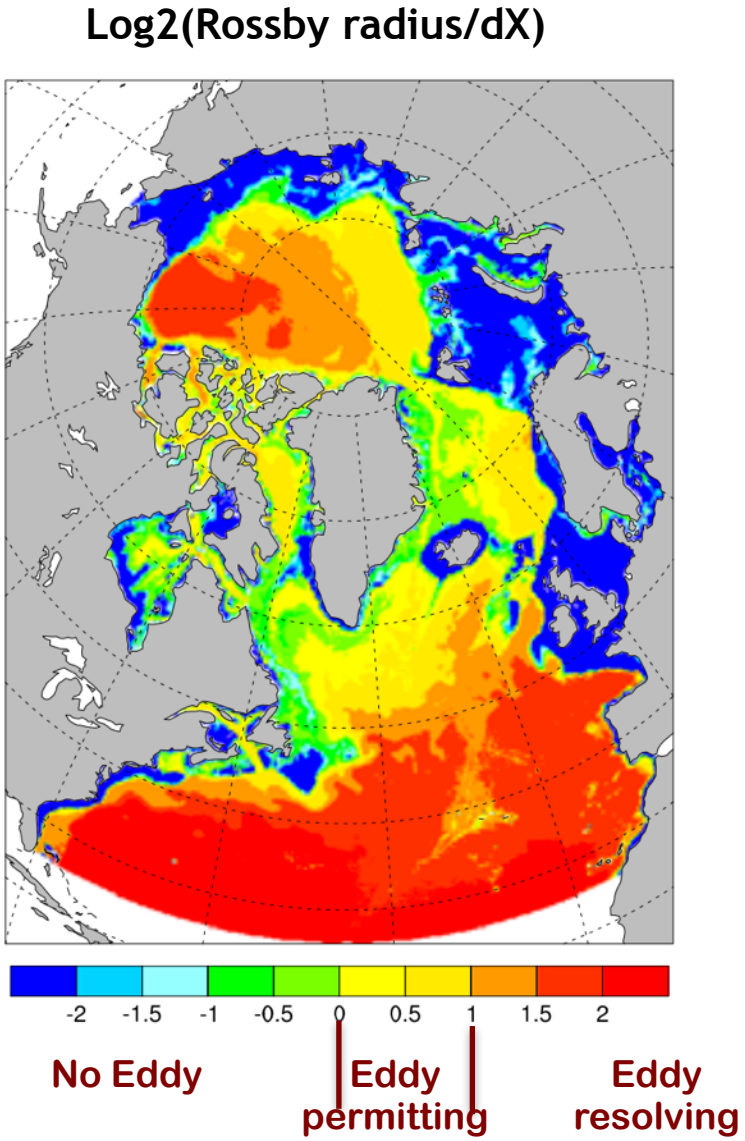
- **ArcticMix**
  -> Impact of additional contributions to the vertical mixing for the simulation of Arctic Ocean and sea ice states
  -> Funded by CMEMS Copernicus Call 1 (2016-2017)

Share the same tools:
CREG12 & CREG025 configurations



Dupont et al (2015)

Model configuration: *CREG12 - description*



- Configuration first developped by Environnent Canada and Mercator-Ocean
- Based on NEMO 3.6 / LIM 3., extraction from ORCA12 (1580 x 1817 x 75 grid points)
- Follow main Drakkar's & Mercator's choices for the numerics (TKE, EEN…), the forcing fields (DFS5) and the boundary conditions (extracted from ORCA12.L46)
- Run on Occigen (CINES)
- 25 000 hCPUs / year

Dupont et al (2015)

Model configuration: *CREG12 – model developments & scientific questions*

Scientific questions:

- To pin down the interplay between the Arctic stratification and vertical mixing

- To understand the dynamics of the Arctic FW exports and their link with the FW storage in the Beaufort Gyre

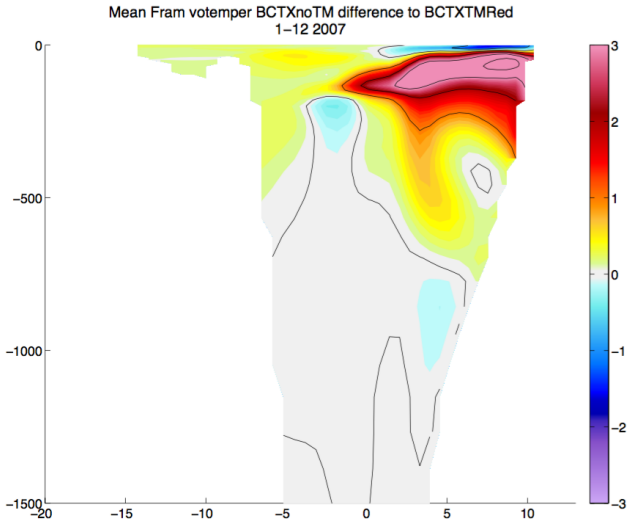
Contributions to model development:

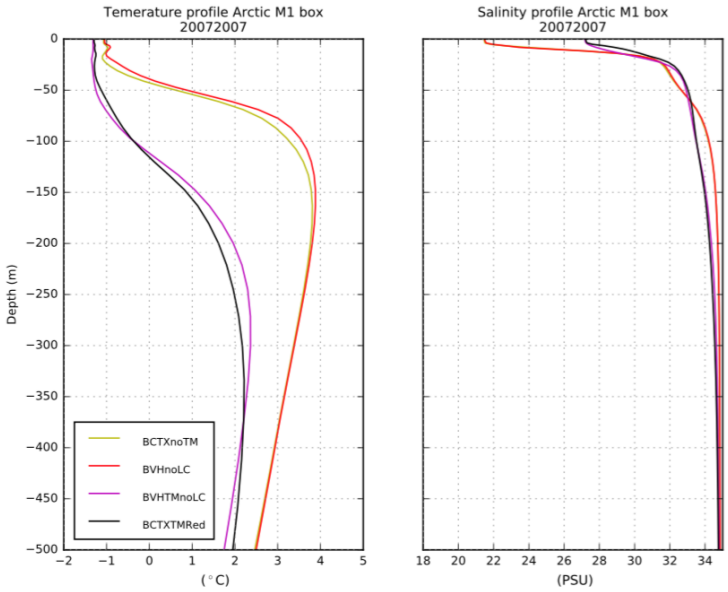
- test of LIM3 at high resolution

- Sensitivity of the Arctic ocean to vertical mixing:
  - Tidal-induced mixing
  - Surface waves/sea ice/ocean interactions:
    - ✓ Wave on ocean surface
    - ✓ Sea ice on wave
    - ✓ Wave on sea ice
  - Double diffusion

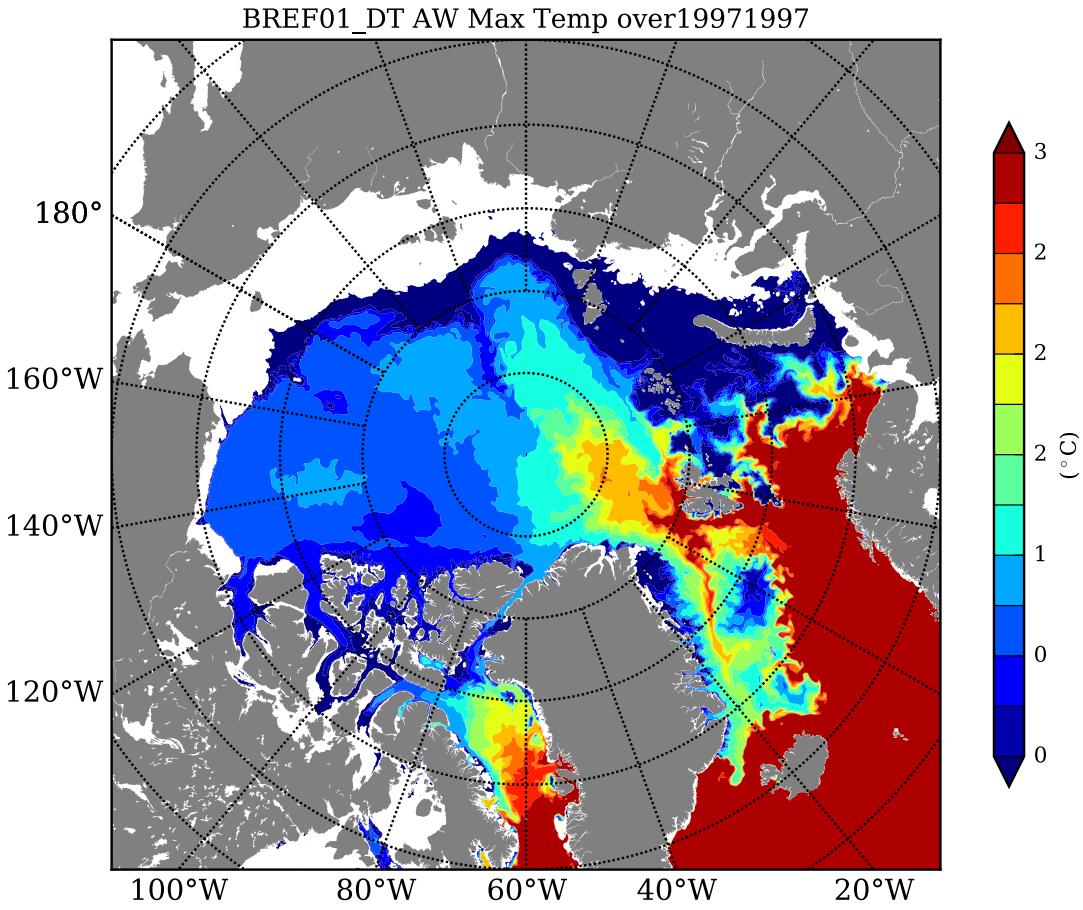
Model configuration: *CREG12 & CREG025 experiments*

Surface wave breaking effect based on CREG025:



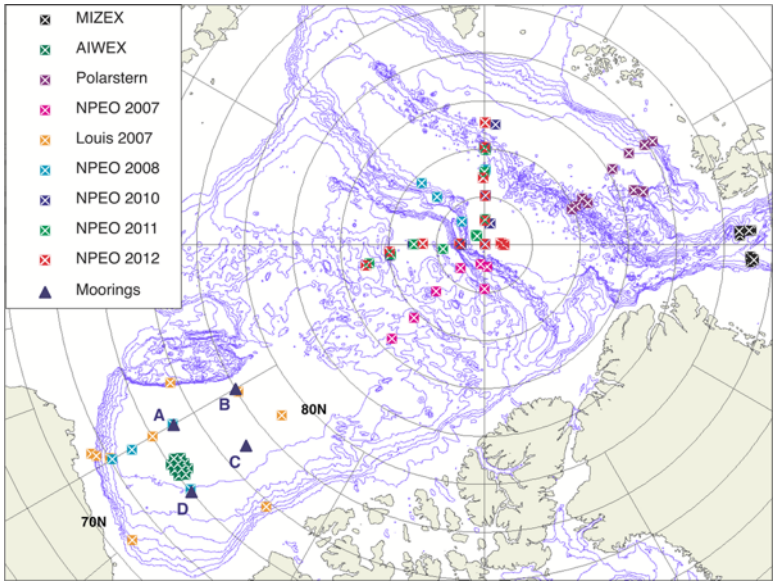


Atlantic Water Tmax diagnostic in CREG12

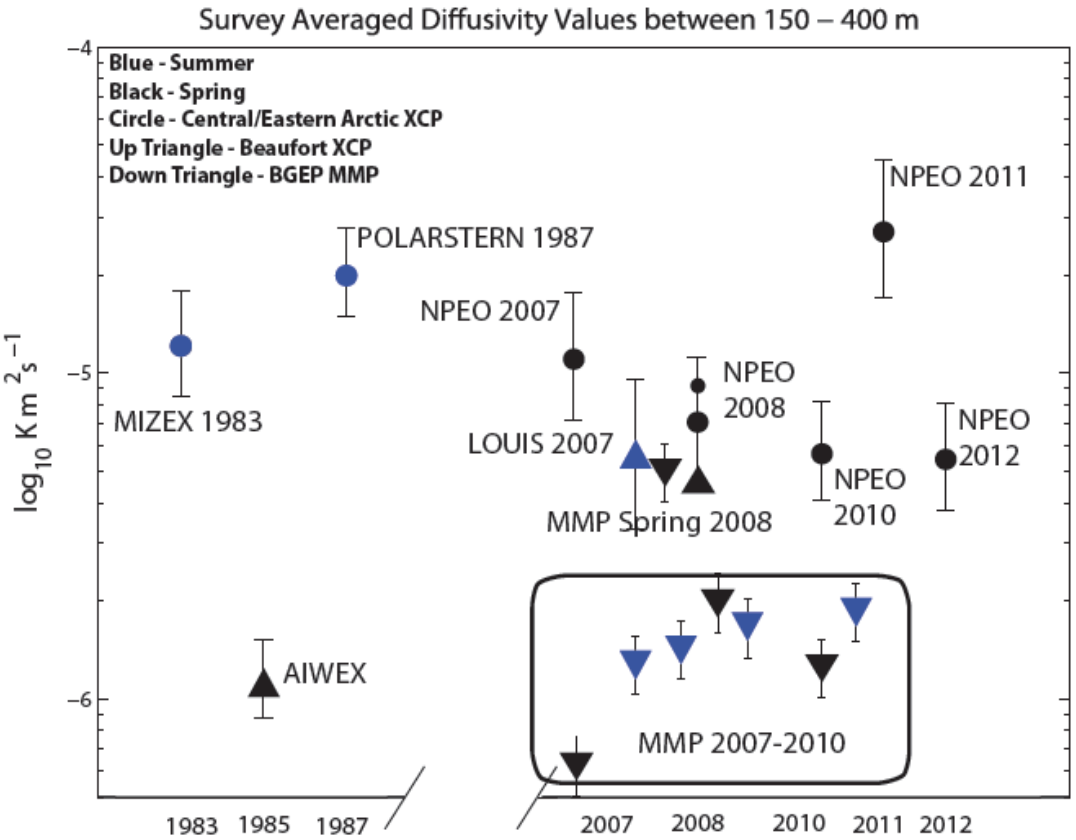


Vertical mixing in the Arctic

- In the Arctic, observations report values of vertical mixing an order of magnitude lower than in the other oceans: Kz ~ 10^{-6} m^2 s^{-1}
- Lack for sources of mixing
  - small tides + above the critical latitude for M2
  - sea ice acts as a barrier between wind and ocean
  - strong stratification (FW input)

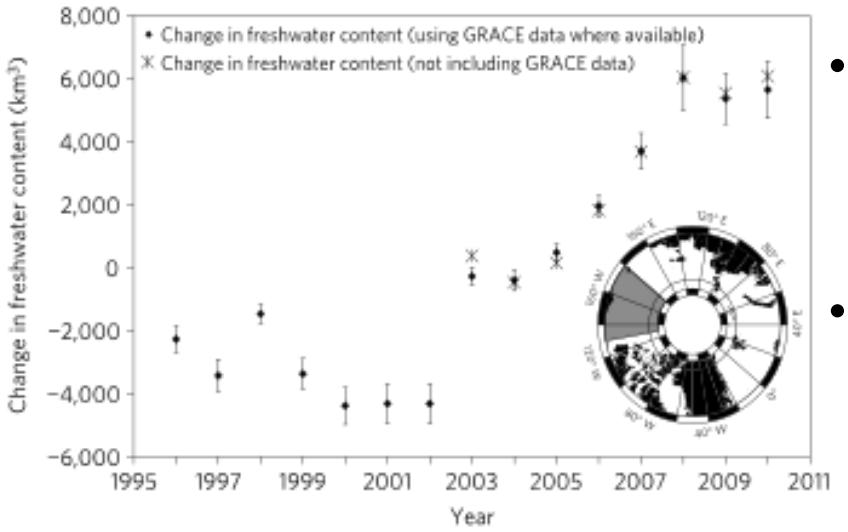


Guthrie et al. (2013)



CREG12 as a tool to address scientific questions

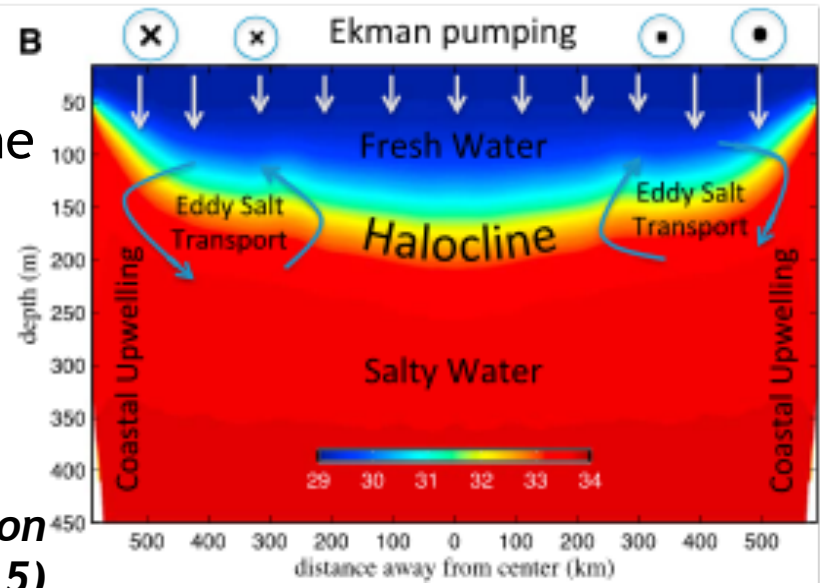
OBJECTIF 2: To understand the dynamics of the Arctic FW exports and their link with the FW storage in the Beaufort Gyre



- Recent spin up of the Beaufort Gyre (stronger winds? stronger stress resulting from thinner ice?)
- Accumulation of a large amount in the Gyre

Giles et al. 2012

- Eddies play a key role in setting up the adjustment timescale of the gyre



Marshall et al. (2002), Davis, Lique & Johnson (2014), Manusharyan and Spall (2015)

CREG12 as a tool to address scientific questions

OBJECTIF 2: To understand the dynamics of the Arctic FW exports and their link with the FW storage in the Beaufort Gyre

- Should we expect that increase in storage will drive an increase in export ??
- Role of boundary current to transport FW into and out of basin ?
- Role of local and remote forcing ?

Why do we need an new Arctic configuration (yet another) ?

- *Models exhibit common biases in the Arctic*
  - *-> Sea ice*
  - *-> Stratification (set by S)*

Comparison of mean salinity profiles at BGOS mooring point in the Canadian Basin

Not just a matter of vertical and/or horizontal resolution!!

Important processes to set the stratification are missing