A mechanism for winter sea ice opening north of Svalbard.

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Expérimentations et Approches Numériques

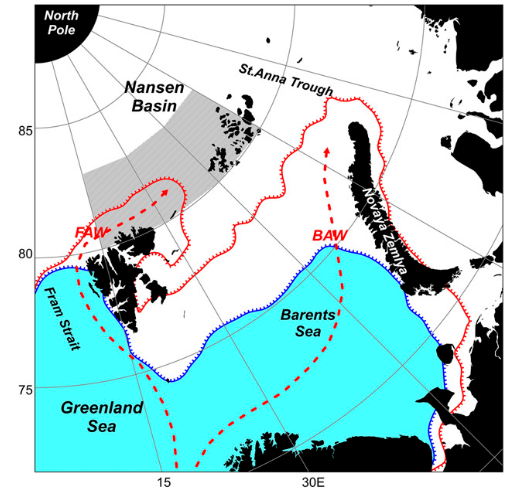
- Regional dependence of Arctic ice loss (Close et al, 2015; Onarheim et al, 2018).
- Trend in winter ice loss of the Atlantic sector are related to AW heat transport (Årthun et al., 2019, Yeager et al. ,2015).
- At interannual time scale: relationships between ice variations in the Barents Sea and heat transport at BSO have been shown (Ornaheim et al., 2015), but wind can also contribute to ice variations (Herbaut et al., 2015)

In the Eurasian basin:

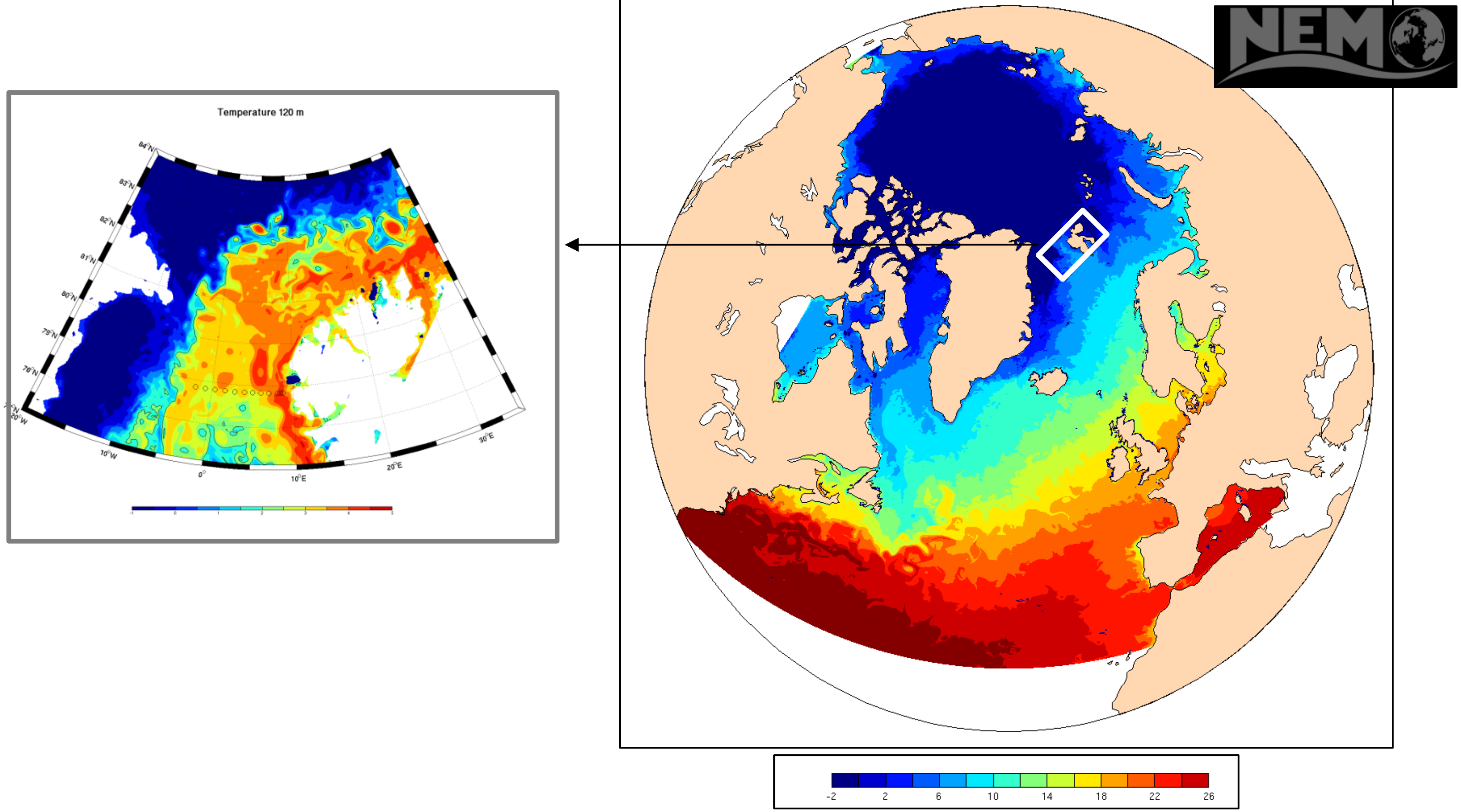
- low winter ice cover in 2013-2014 was a consequence of reduced ice cover in summer: less ice in summer less meltwater is surface leading to more favorable conditions in winter to vertical heat transfer to the surface by convection (Ivanov et al. 2016)
- 2012 winter ice opening attributed to an upwelling (Falck-Petersen et al. 2015)
- Large vertical heat flux due to storms(Meyer et al. , 2017)
- Atlantification in the Eurasian Basin: oceanic conditions prevailing north of Svalbard tends to extent eastward in recent years (Polyakov et al., 2017).

Aims of the study:

- Can we identify opening events before the 2010s?
- What drives the opening?
- Does the ocean play a role in these openings



Ivanov et al , 2016



1/24° ocean-sea ice model (NEMO)

Arctic-North Atlantic, 75 levels

Simulation: 1995-2003: spin-up with SSS restoring

2004-2014: no SSS restoring

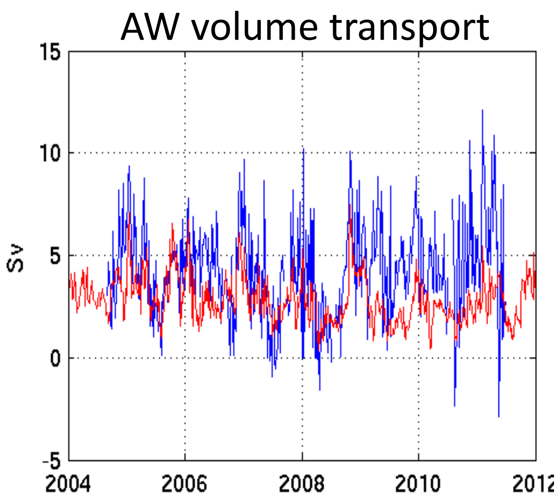
Observations:

ASI SSMI sea ice concentration (1992-2014) *(Kaleschke et al., 2001)*

Mooring data in Fram Strait (Beszczinska-Möller et al, 2015)

NABOS CTD (https://uaf-iarc.org/NABOS/).

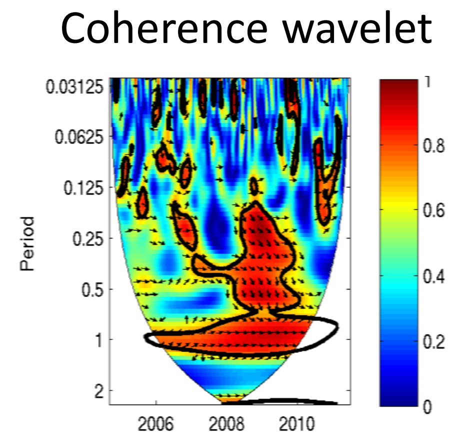
How does the model compare with the observations in Fram Strait and North of Svalbard?



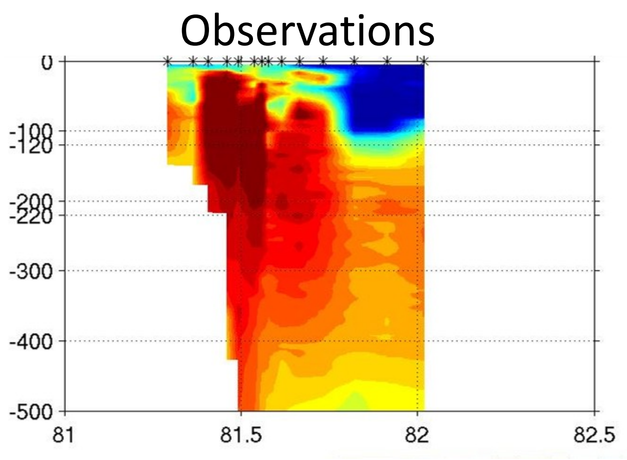
Fram Strait

Observations

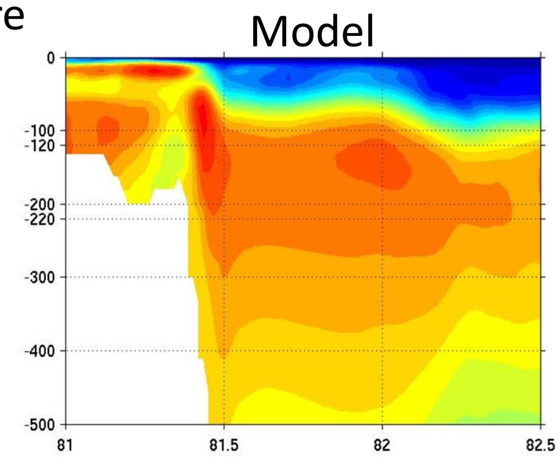
Model



Summer temperature



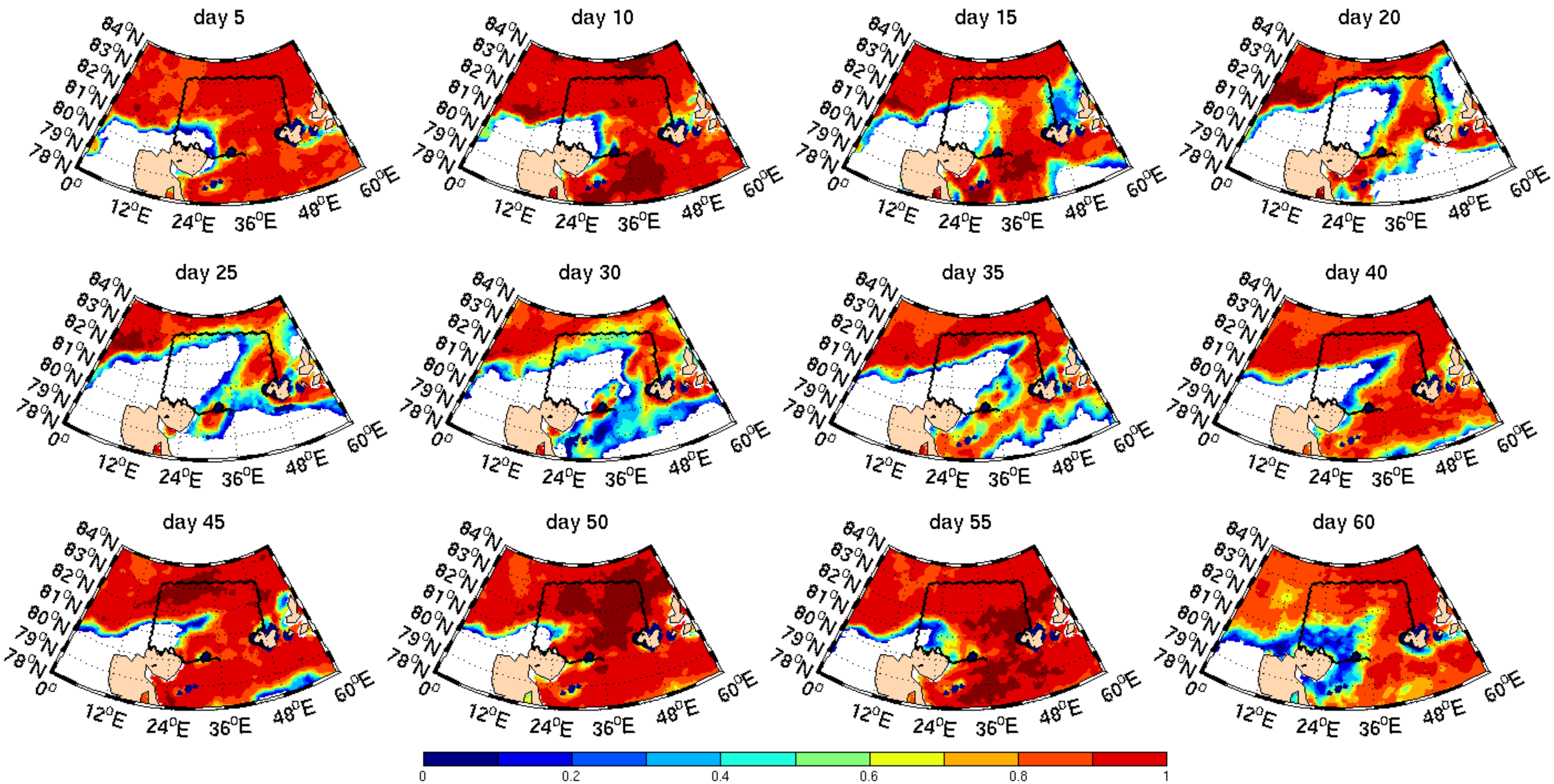
Eurasian Basin 30°E



- Fram Strait : Good agreement between model and observations mainly due to well representation of annual cycle
- Eurasian Basin: The AW temperature distribution is well reproduced in the model, although model has a cold bias

Example of Winter sea ice opening North of Svalbard: the 2006 event

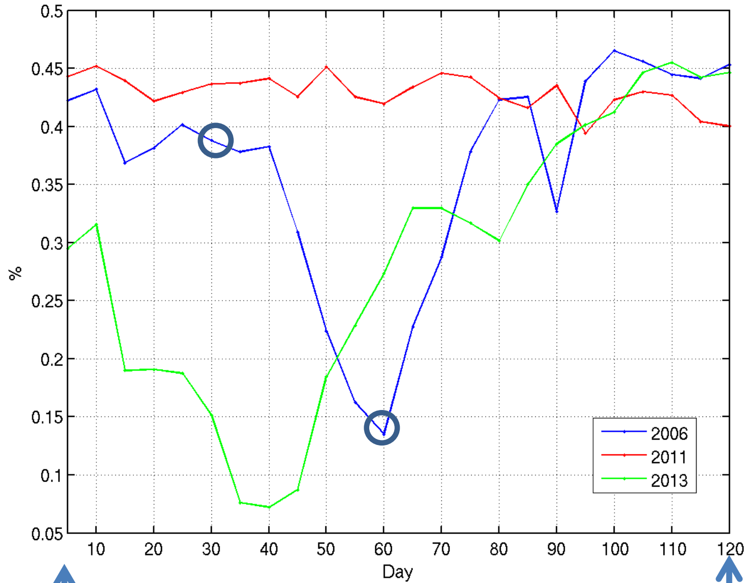
Sea ice concentration in 2006 (ASI-SSMI)



Duration: ~30-35 days

Major ice opening events.

Mean ice concentration North of Svalbard

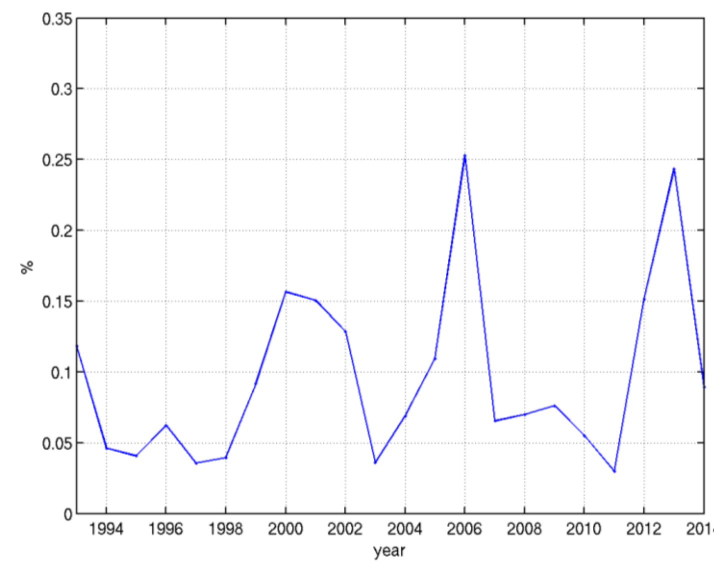


December 1

March 31

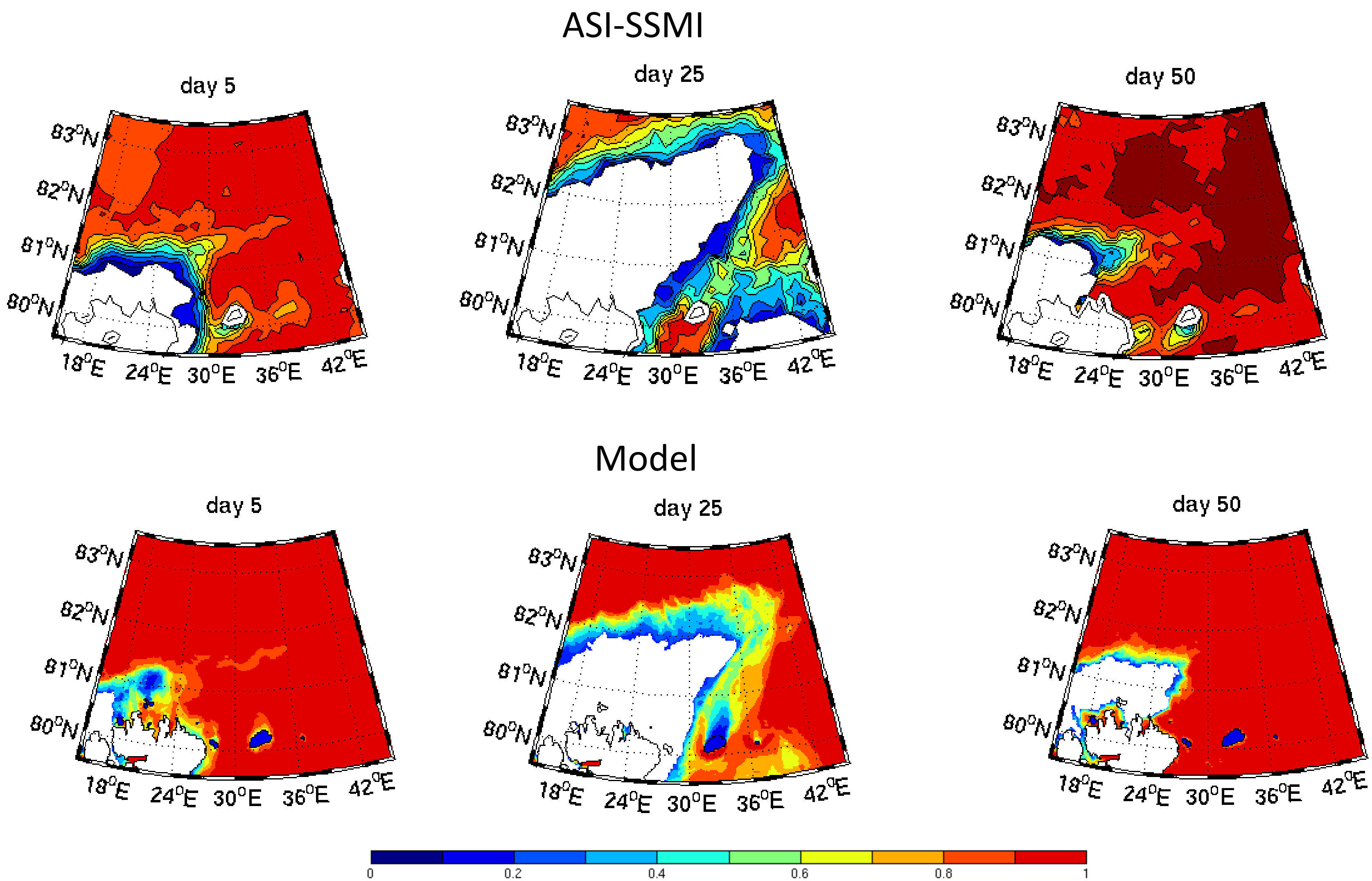
Index of sea ice opening:
Difference between the SIC minimum in January-February northeast of Svalbard and the maximum in the preceding month.

Index of sea ice opening



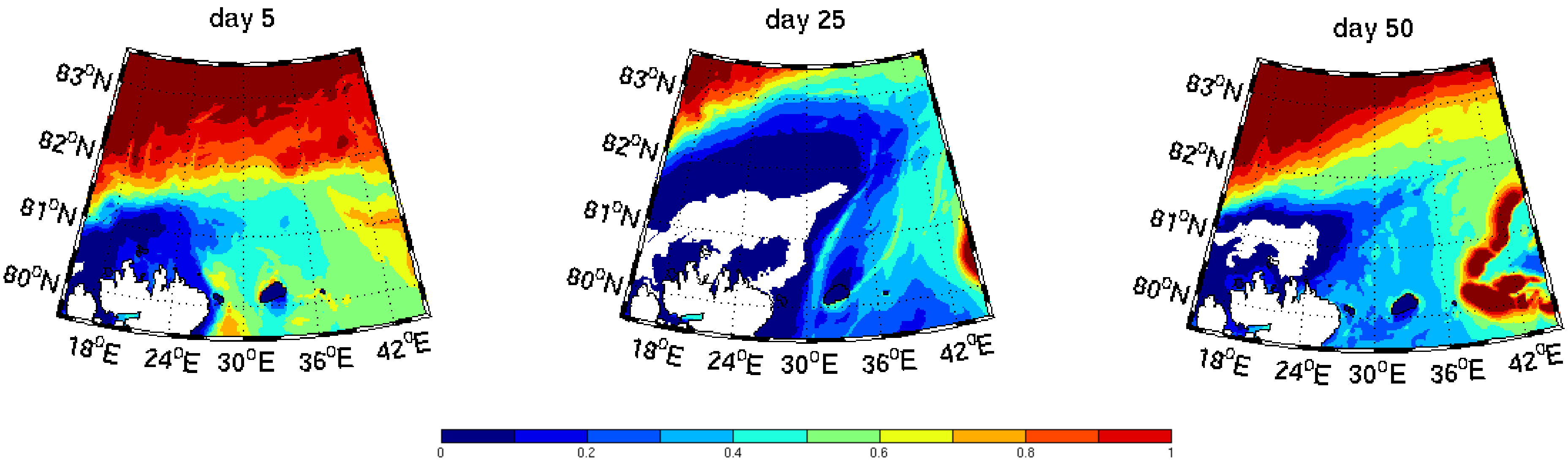
Main sea ice openings: 2000, 2001, 2002, 2006, 2012, 2013.

How can the model reproduce the 2006 event?

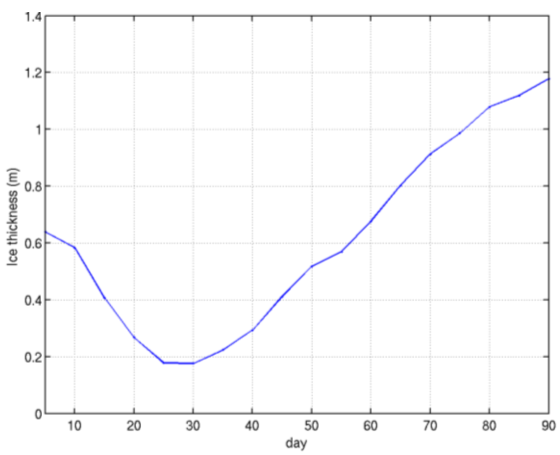


- opening is well reproduced in the model
- similar time evolutions

Modeled Ice thickness (m)



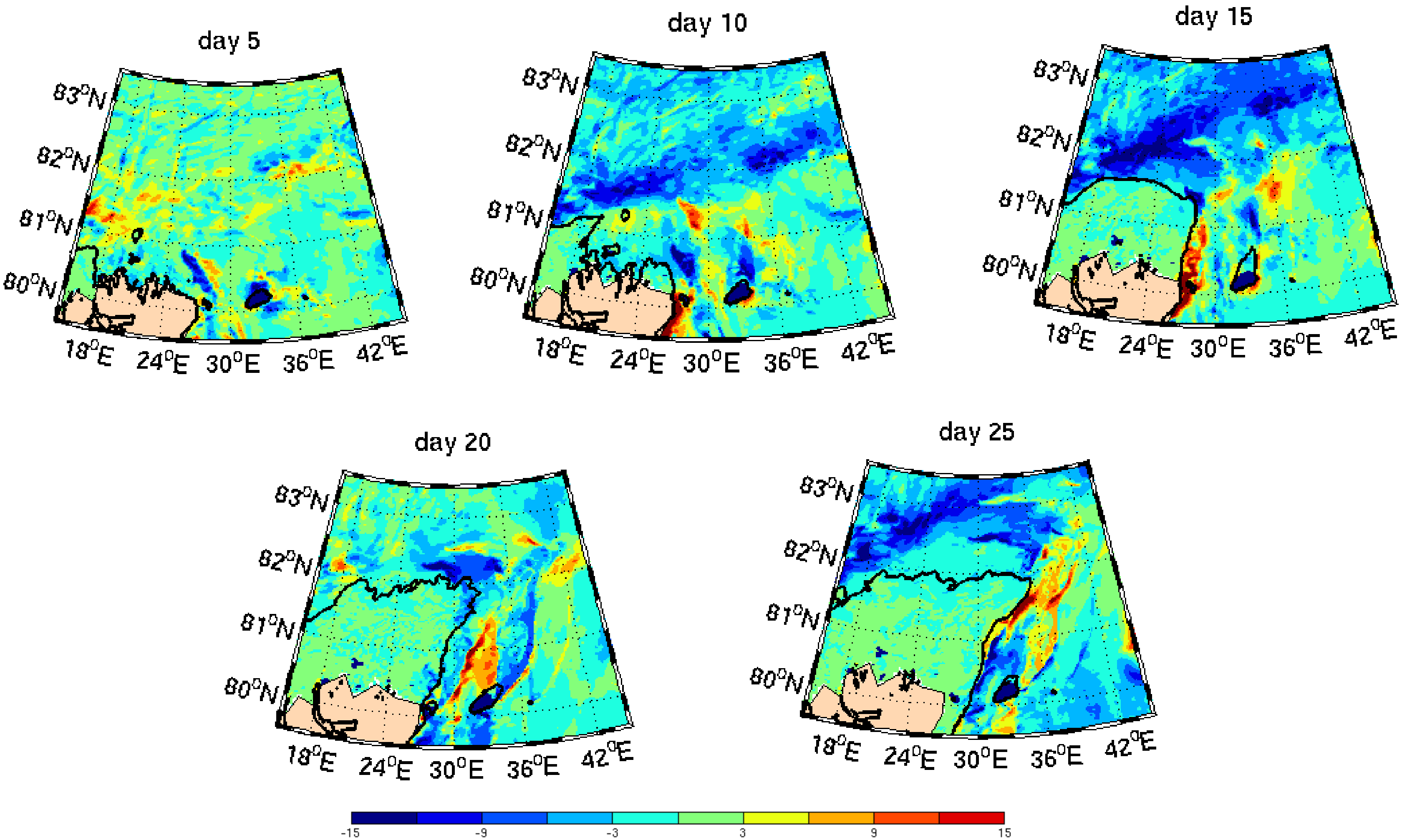
Mean Ice thickness northeast of Svalbard



The opening is associated with a 70% decrease of the mean ice thickness northeast of Svalbard.

Origin of the ice volume decrease

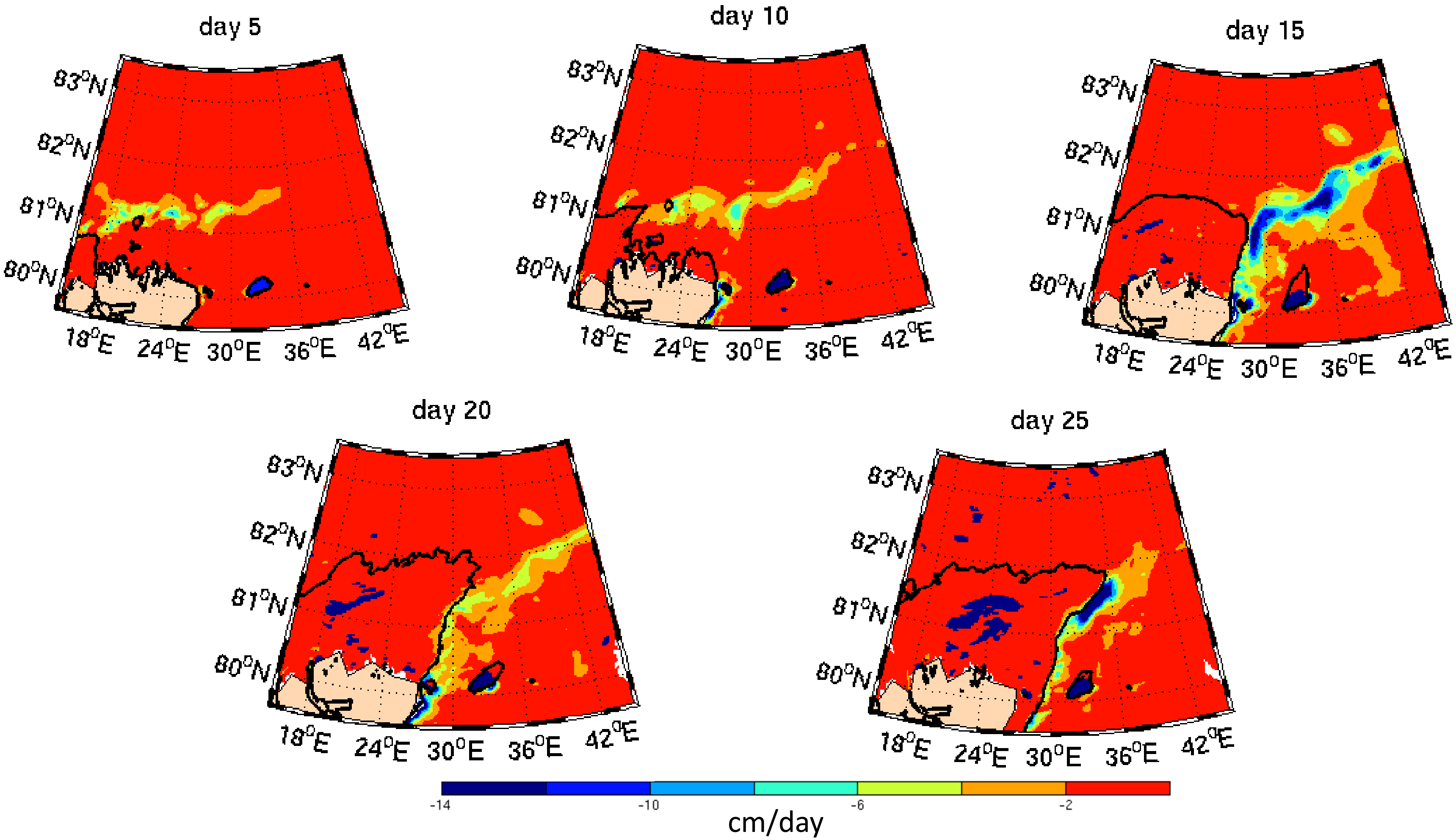
Ice volume budget: ice convergence (<0 = decrease of volume)



Ice divergence is responsible for northward opening of the sea ice cover

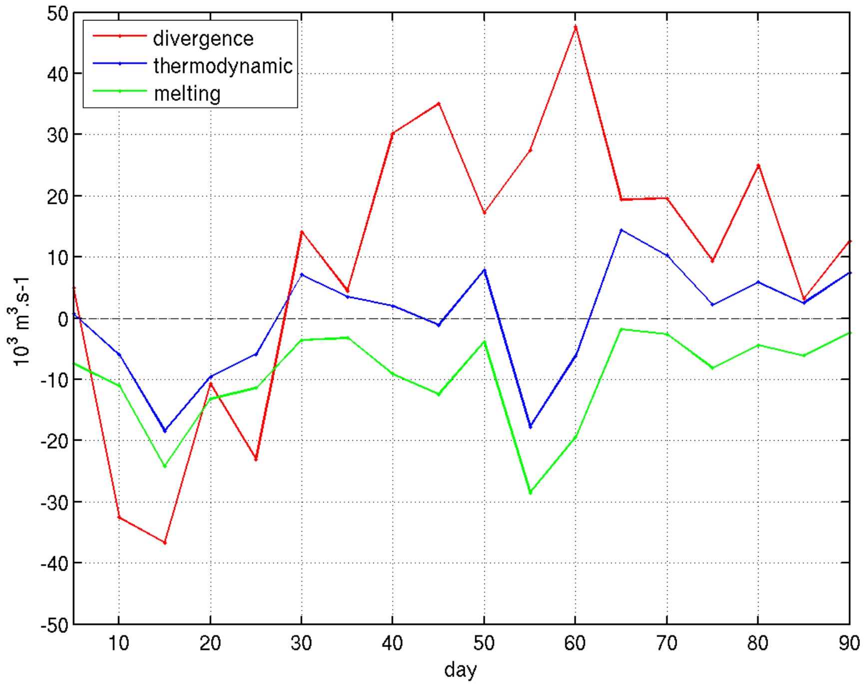
Origin of the ice volume decrease

Ice volume budget: ice melting (<0 = decrease of volume)



Enhanced ice melting ahead of the ice edge, in the inner pack : eastward opening

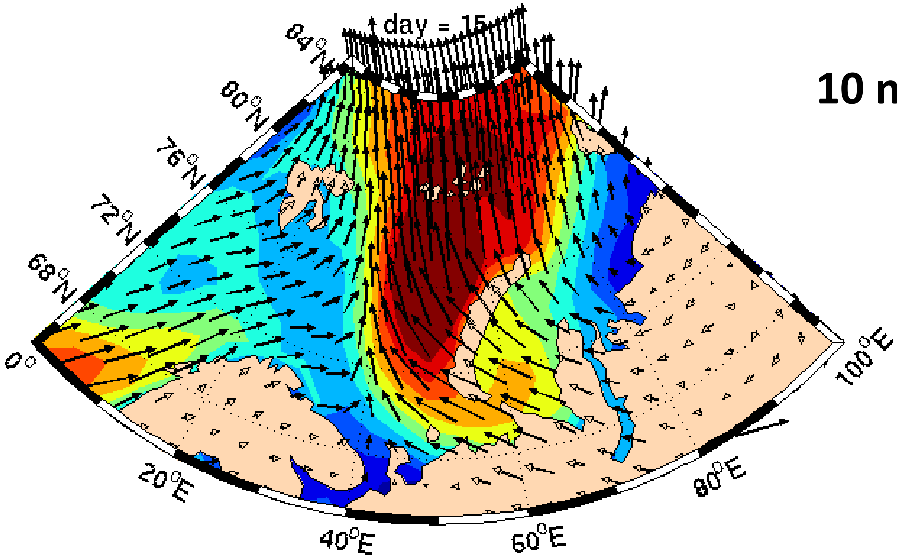
Ice volume budget northeast of Svalbard



- Intra-seasonal variability of the net sea ice growth rate is mainly due to bottom melting.
- Two major melting events : day 5-25 and day 50-60
- Only does the first event leads to sea ice retreat due to concomitant contributions of divergence to the ice volume decrease : melting (40 %) and divergence (60 %)
- Large sea ice convergence in the second event, enhanced melting probably responds to it

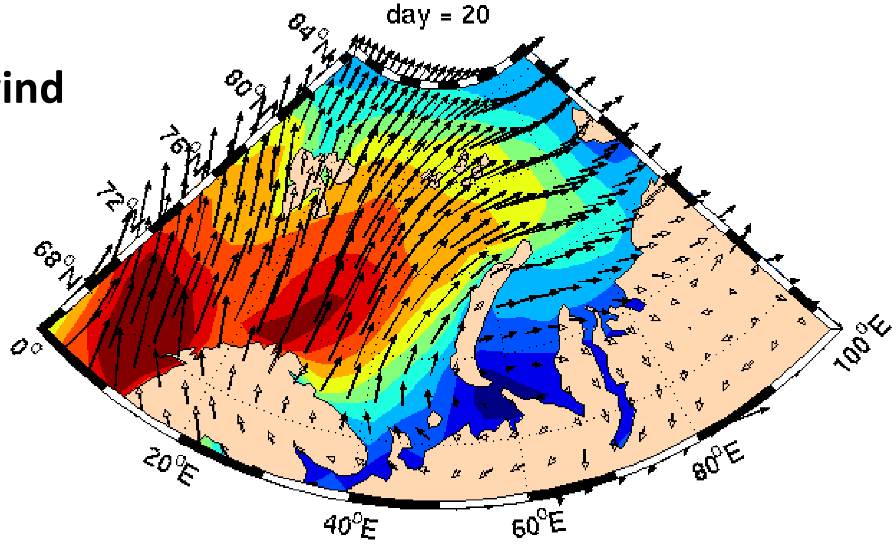
Influence of the wind on the opening.

Day 15



10 m wind

Day 20

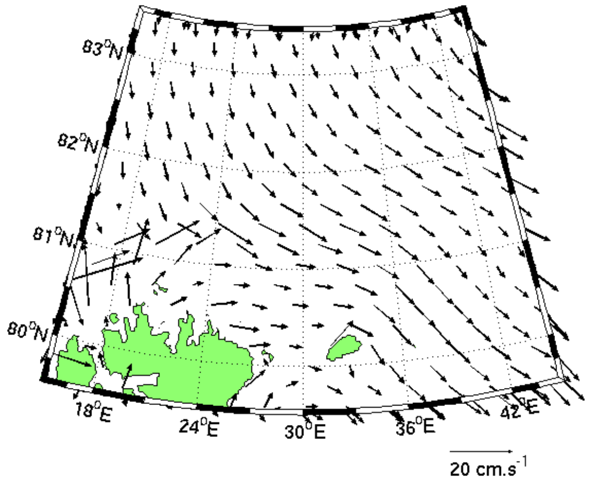


$m.s^{-1}$

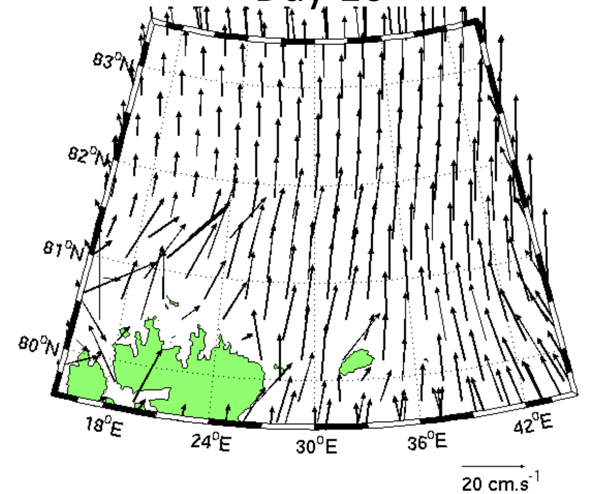
Strong northward component of the wind ➔ northward extension of the opening

Response of the ice drift to wind changes

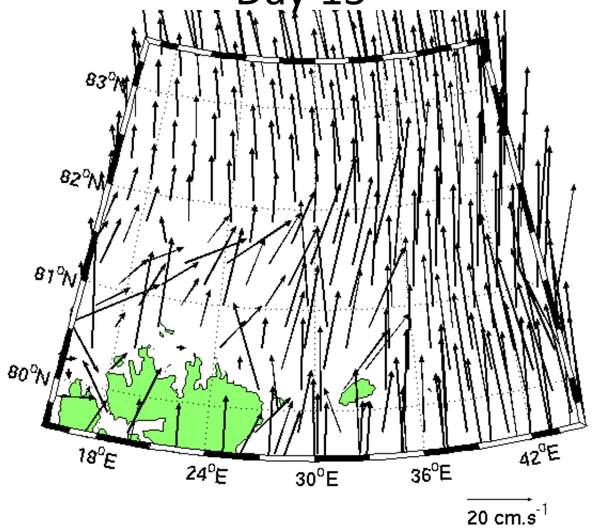
Day 5



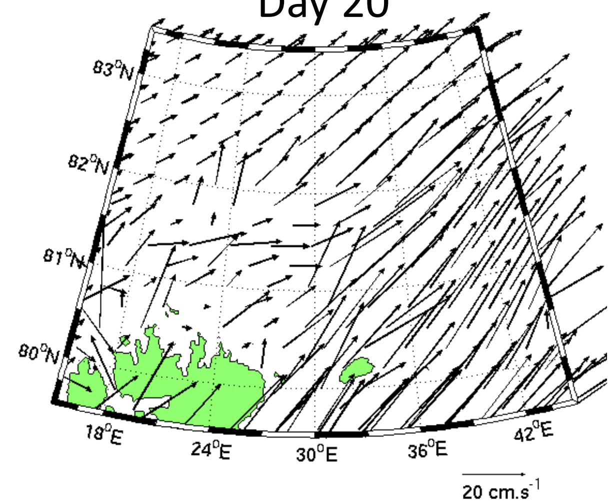
Day 10



Day 15

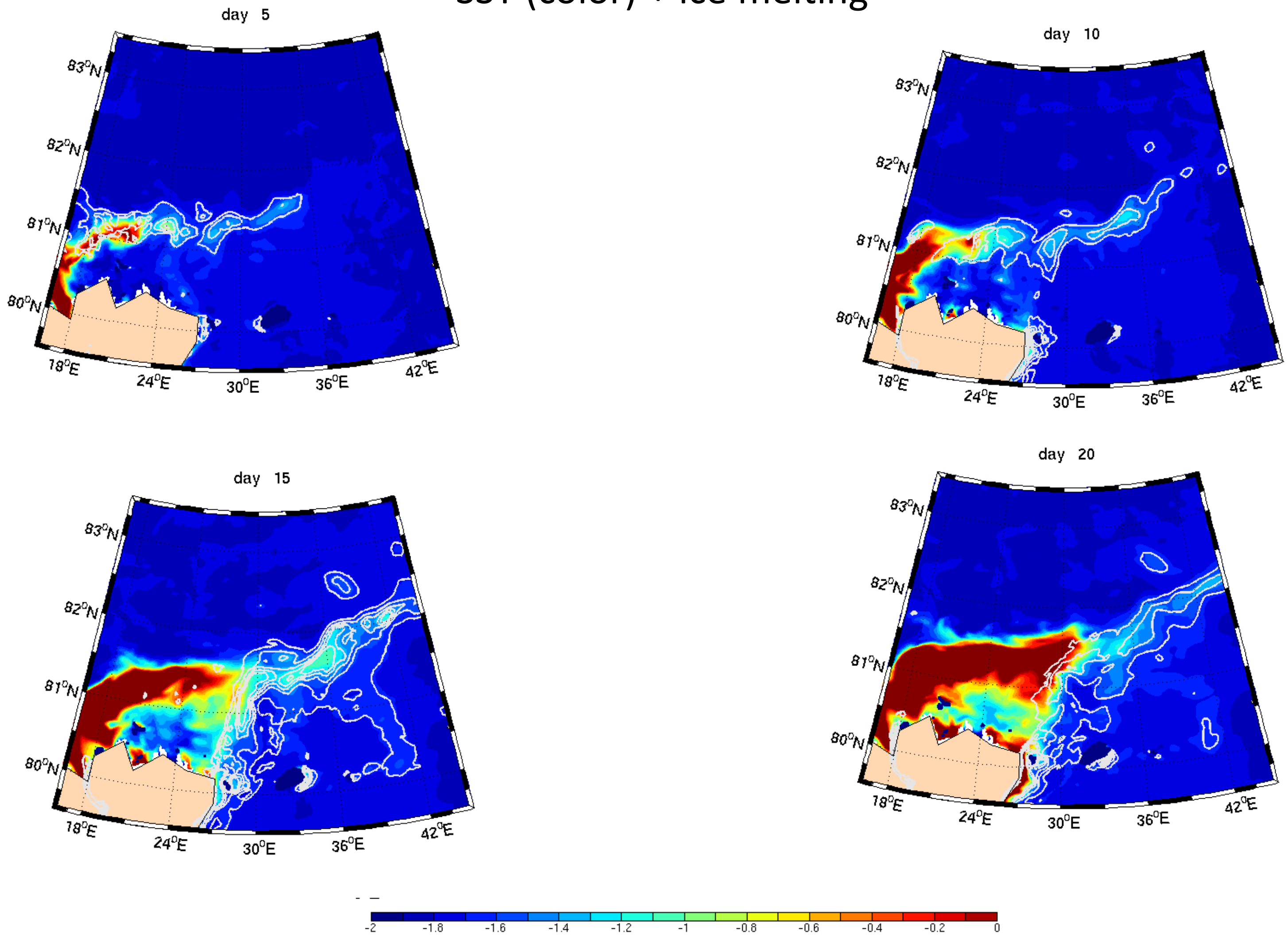


Day 20



Strong northward component of the ice drift which pushes the ice offshore

SST (color) + ice melting

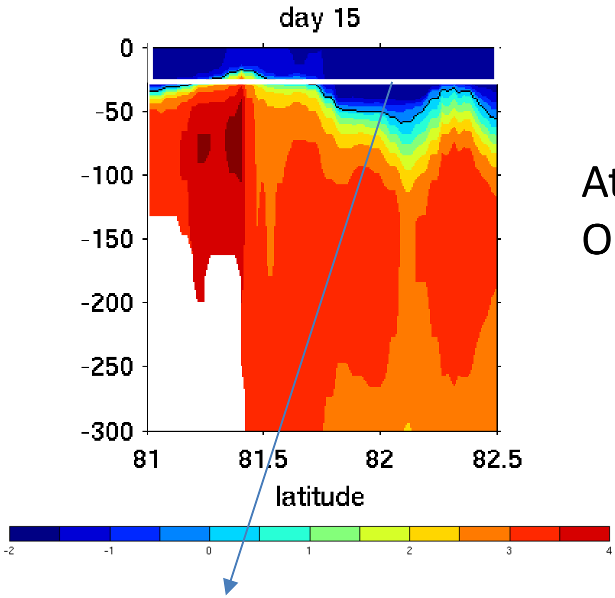


Enhanced sea ice melt associated with warmer SST (up to -1.2°C).

Warmer SST due to horizontal advection or vertical processes?

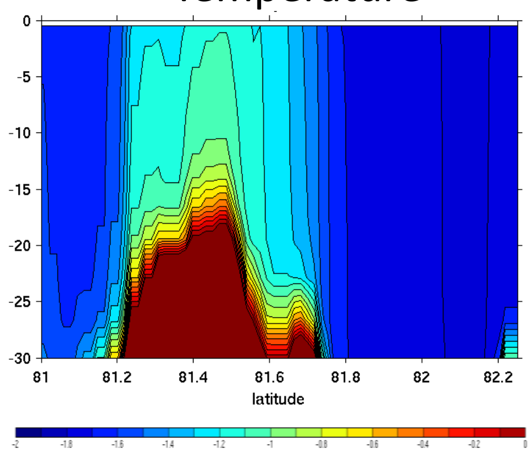
DAY 15

Temperature at 30°E

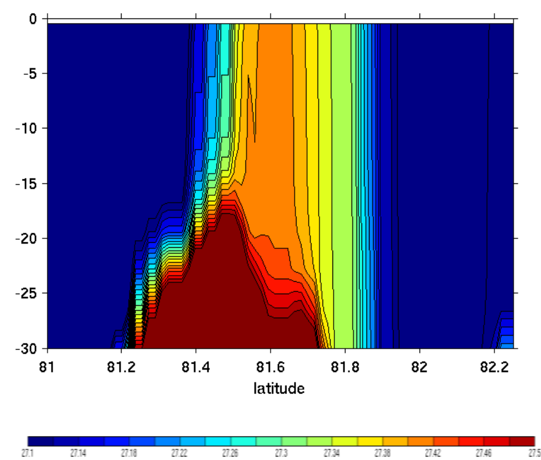


Atlantic Water core located on the upper part of the slope
Opening has not started yet

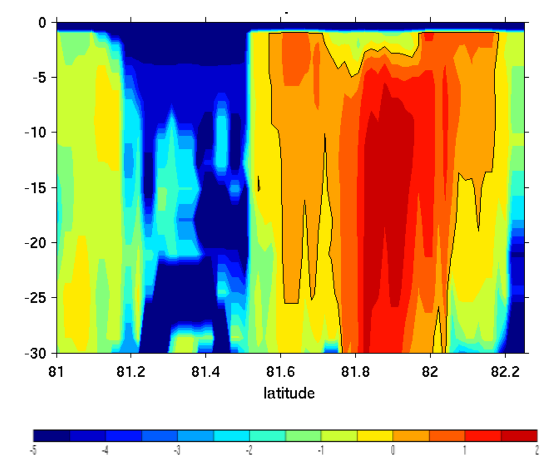
Temperature



Density

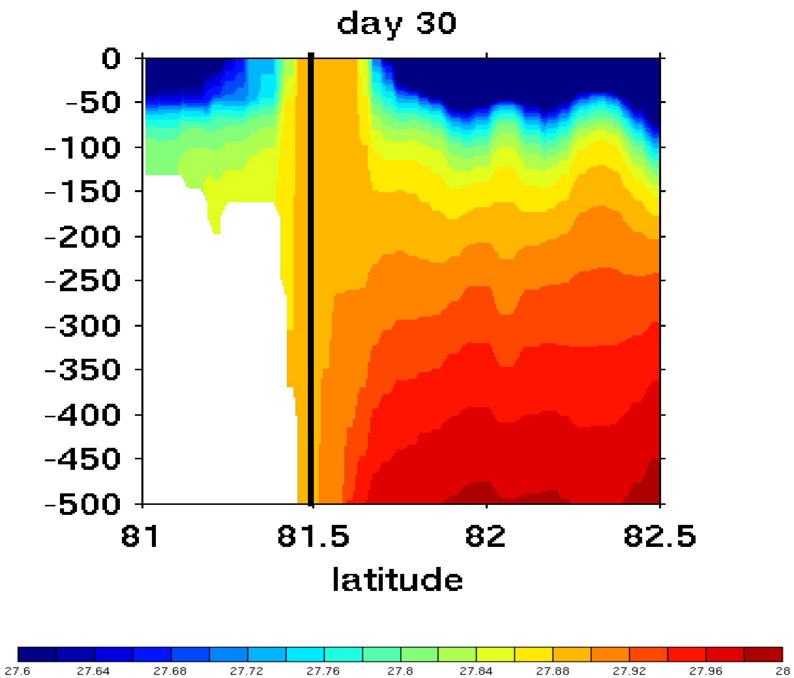


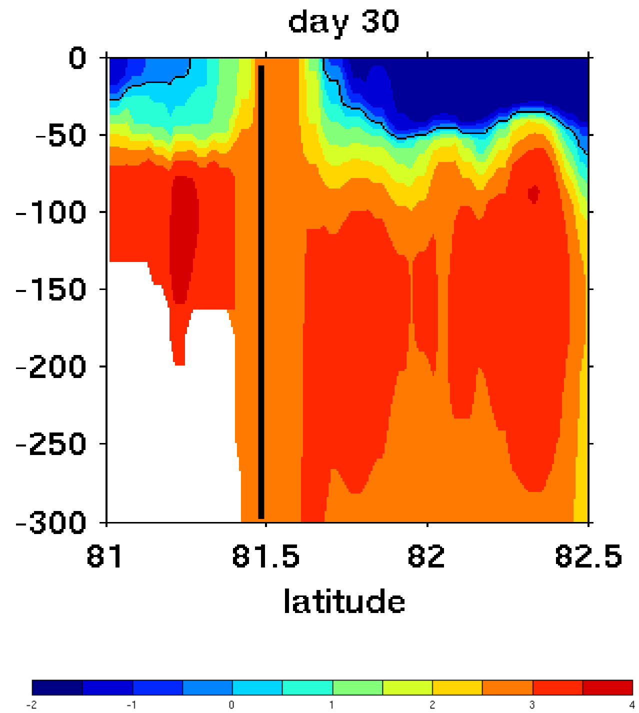
Vertical diffusion coefficient



Strong vertical mixing reaches the Atlantic layer and brings warmer water to the surface.

DAY 30

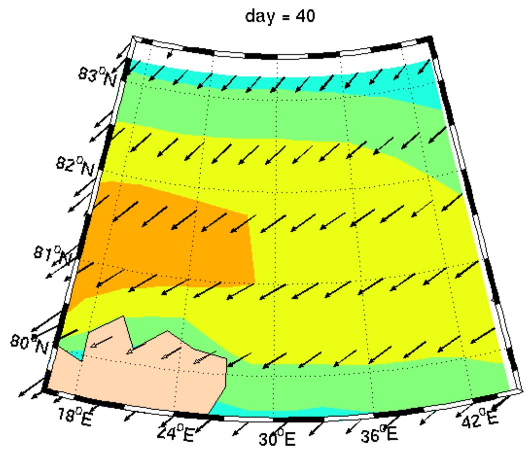




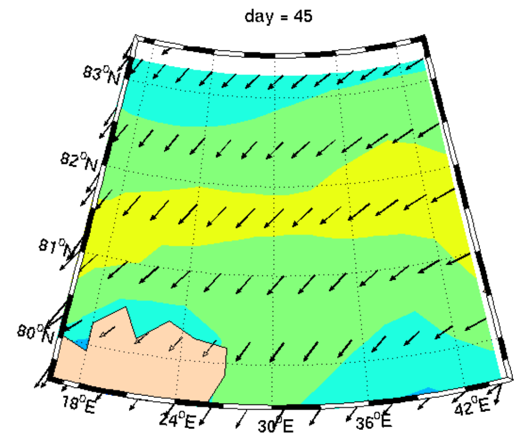
On day 30:

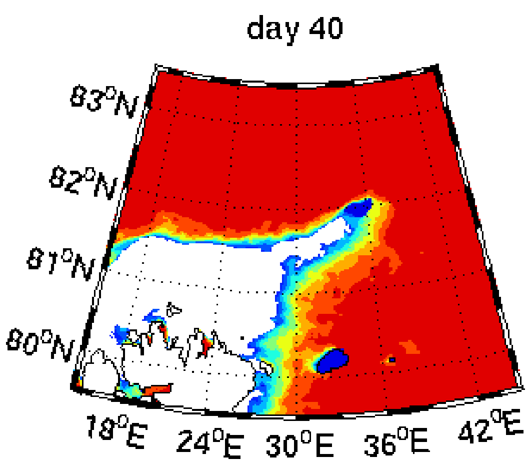
- Ice edge has moved to about 81.5°N
- Water column mixed down to 300-500 meters
- Atlantic as warm as 2.5°C can reach the surface

Ice closing

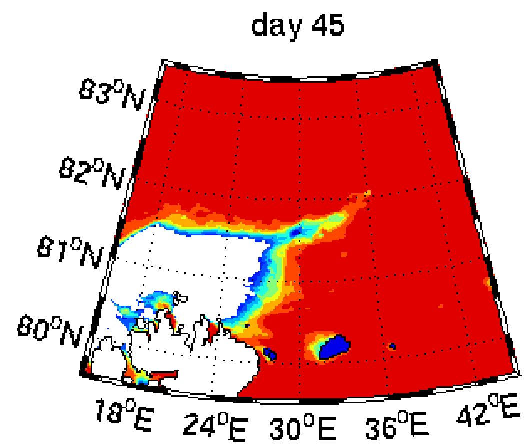


10 meter wind





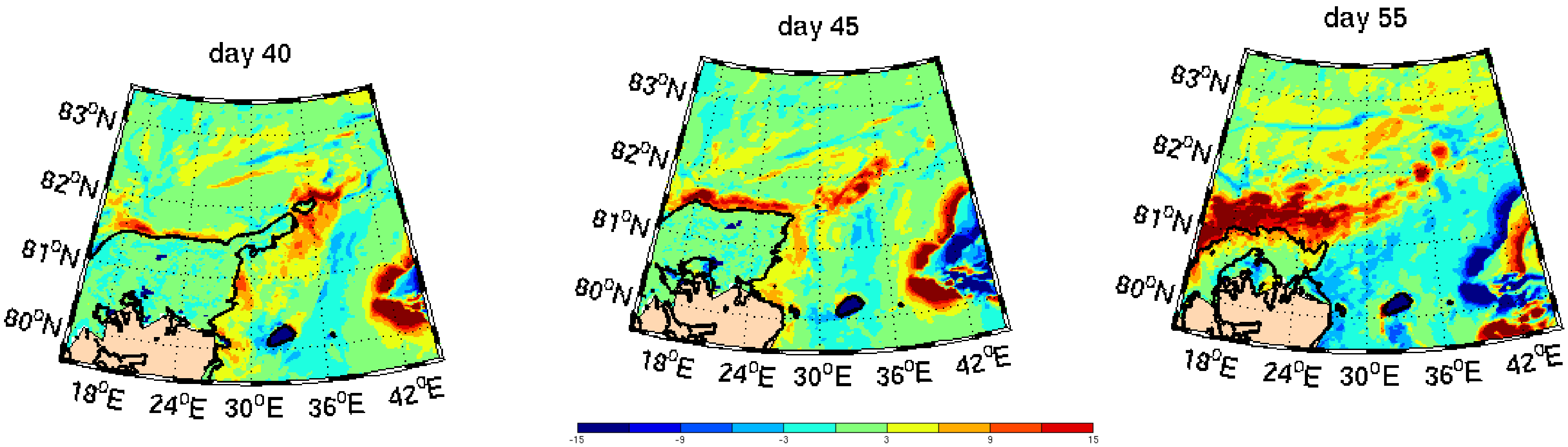
Modeled SIC



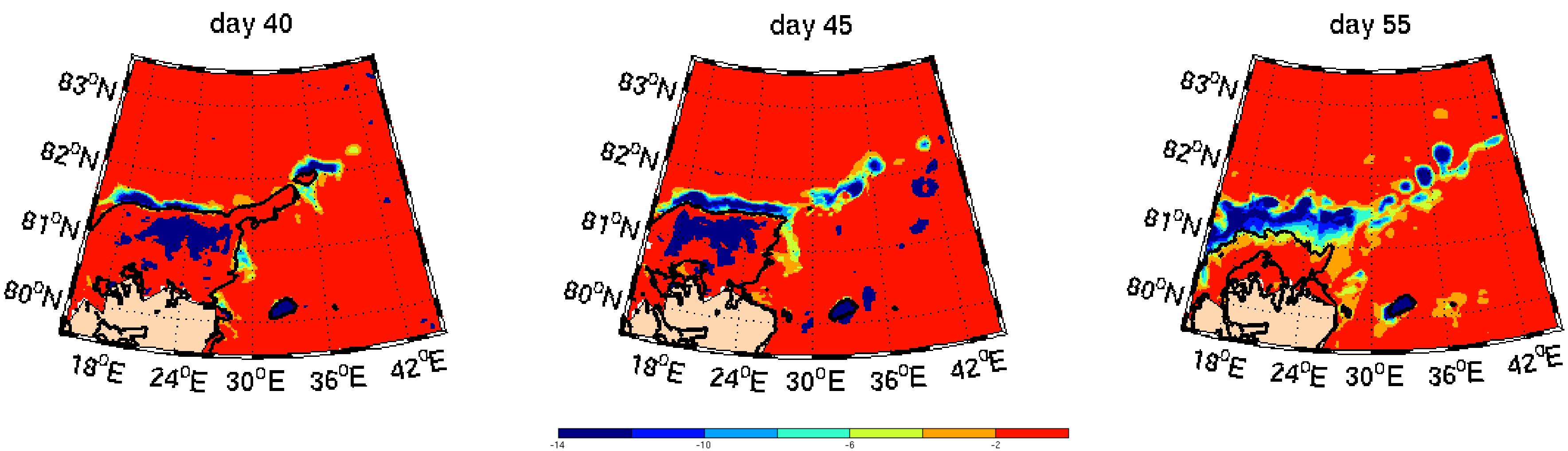
After day 35: wind direction changes

SIC increases

ice convergence



ice melting



Ice is advected towards open water.
The presence of warm SST slows down the ice closing
An equivalent volume of ice is melted during the closing than during the opening

Conclusion :

- Several events of major openings
- 2006 event one of the largest opening
- 2006 event begun with strong northward wind components.
- Melting contributes to 40% of the ice volume loss.
- Strong winds combined with Atlantic layer close to the surface ➔ warm water brought to the surface

BLUE ACTION

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