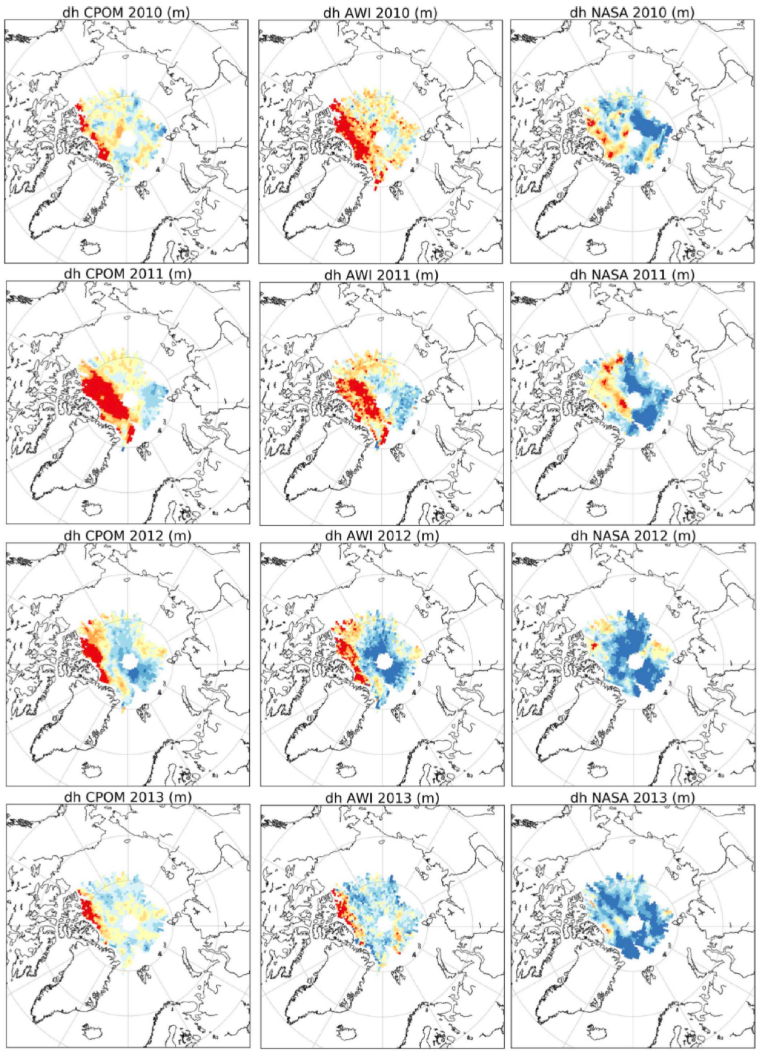
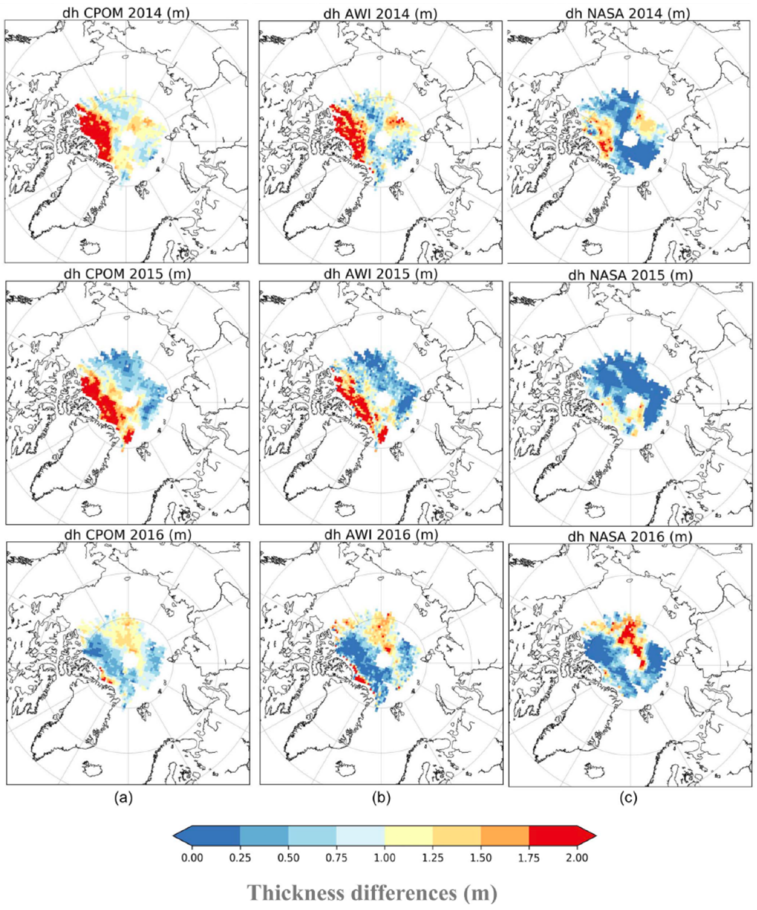
Winter Arctic Sea Ice Volume Budget Decomposition over the CryoSat-2 period (2010-2019)

Michel Tsamados, Oliver Racher ,
Paul Holland, Noriaki Kimura,
David Schroeder, Danny Feltham,
Julienne Stroeve, Andy Ridout,
Harry Heorton, …

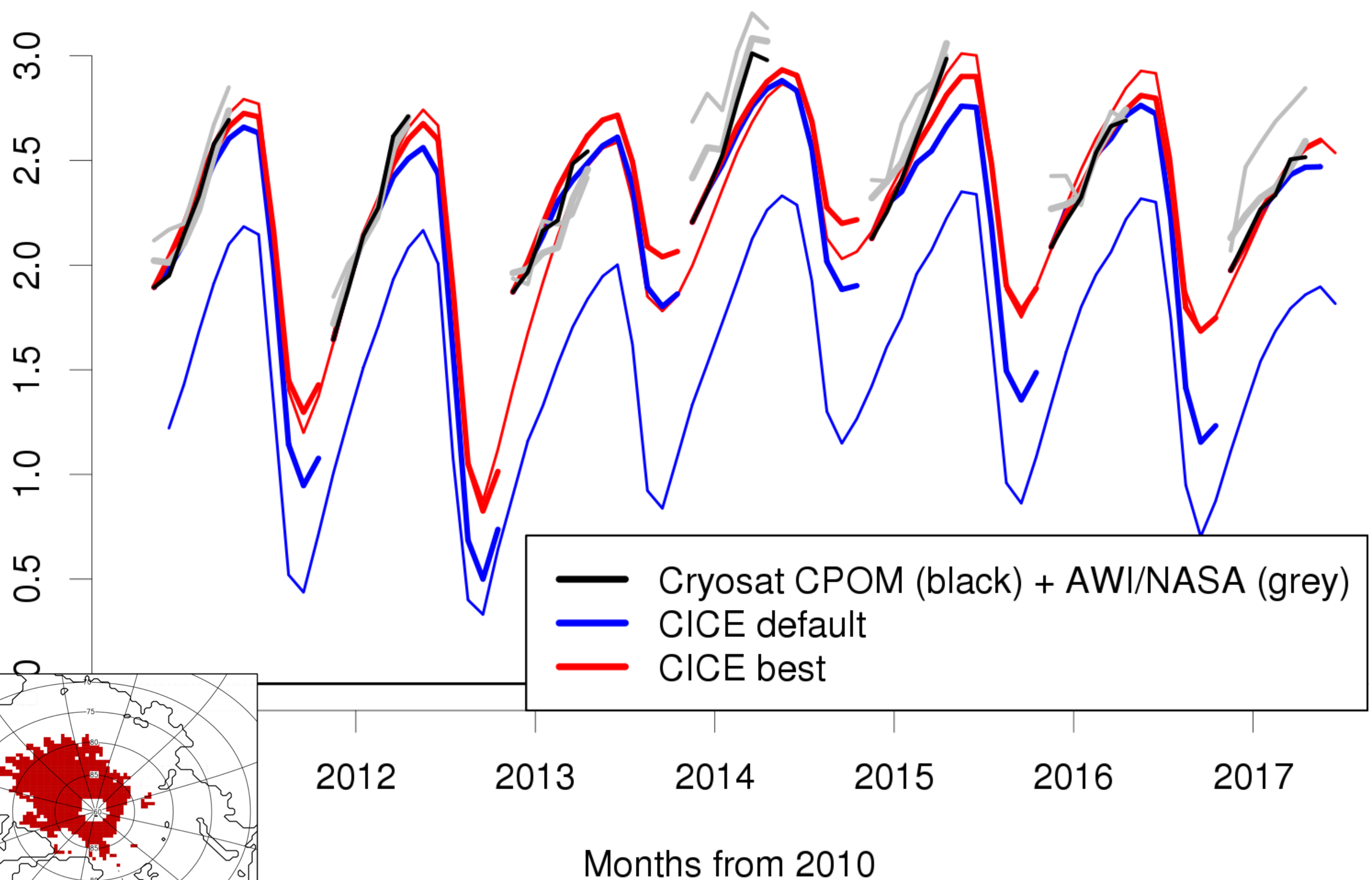
➢ *Sea ice thickness growth from CryoSat-2 different from year to year and for different product*

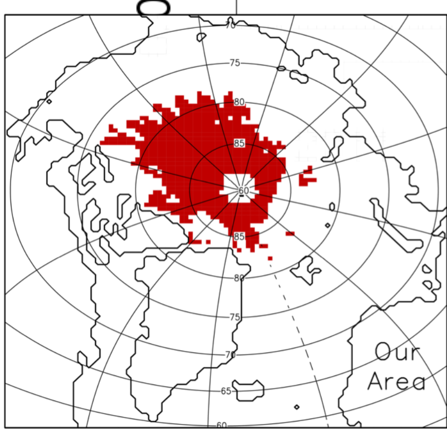




J. Stroeve, D. Schroeder, M. Tsamados, D. L. Feltham, Warm winter, thin ice? The Cryosphere, 2018

➢ *Focusing on the thermodynamic growth with CICE model*

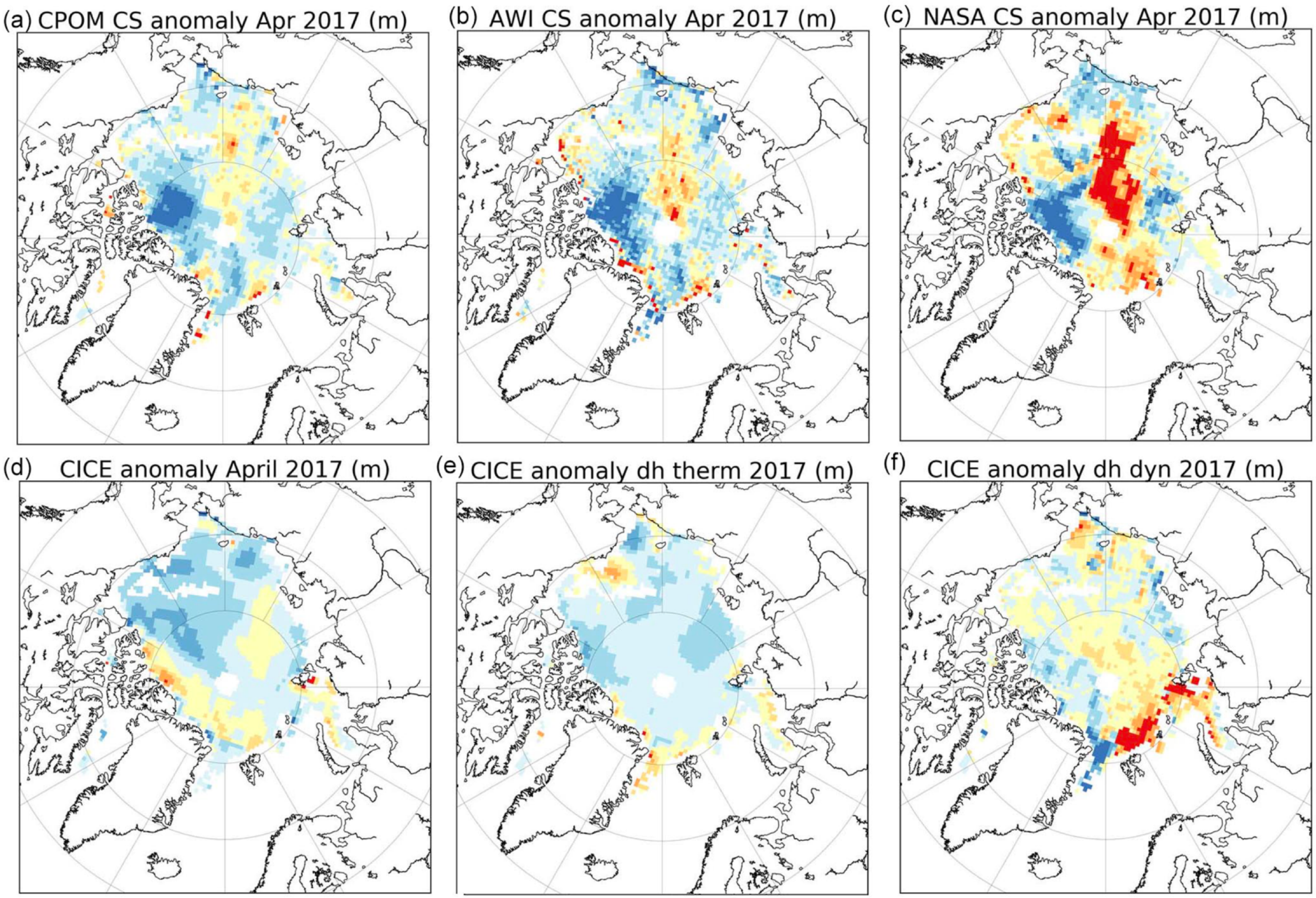




Using CryoSat-2 sea ice thickness to improve model performance by advancing sea ice growth physics, D. Schröder, D. L. Feltham, M. Tsamados, A. Ridout and R. Tilling

➢April 2017 obs. + <u>model</u> dynamic and thermo. Growth

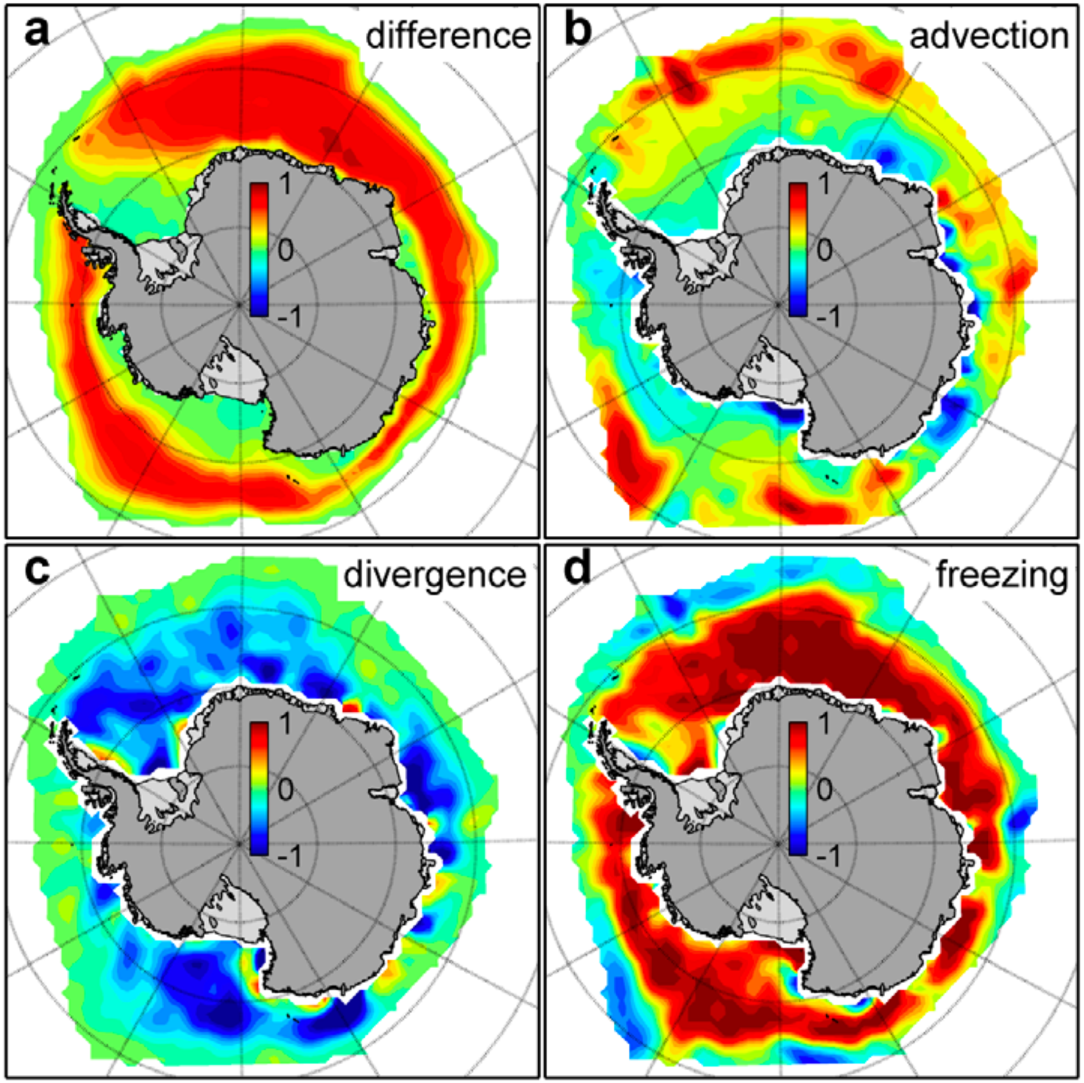
-> But what about dynamic vs thermodynamic from satellite observations?



J. Stroeve, D. Schroeder, M. Tsamados, D. L. Feltham, Warm winter, thin ice? The Cryosphere, 2018

➢ *The idea: decompose changes into dynamic + thermo.*

-> This was first introduced for changes in sea ice concentration in Antarctica



$$\frac{\partial C}{\partial t} + \nabla.(\boldsymbol{u}C) = f_C - r$$

$$\int_{t1}^{t2} \frac{\partial C}{\partial t} dt =$$

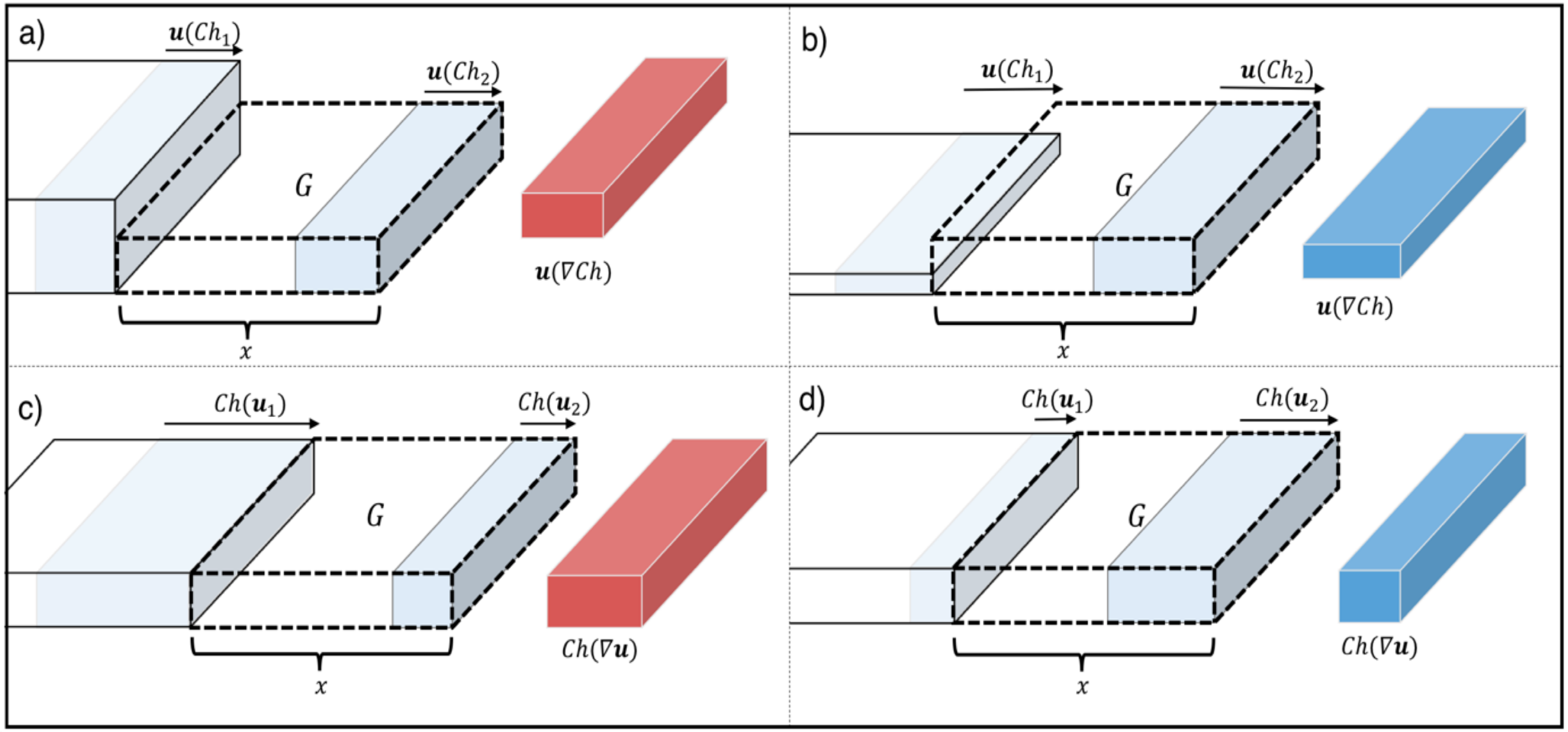
$$-\int_{t1}^{t2} \boldsymbol{u}.\nabla C dt - \int_{t1}^{t2} C\nabla.\boldsymbol{u} dt$$

$$+\int_{t1}^{t2} f_C dt$$

Holland and Kwok, 2012

➢ Sea ice volume decomposition

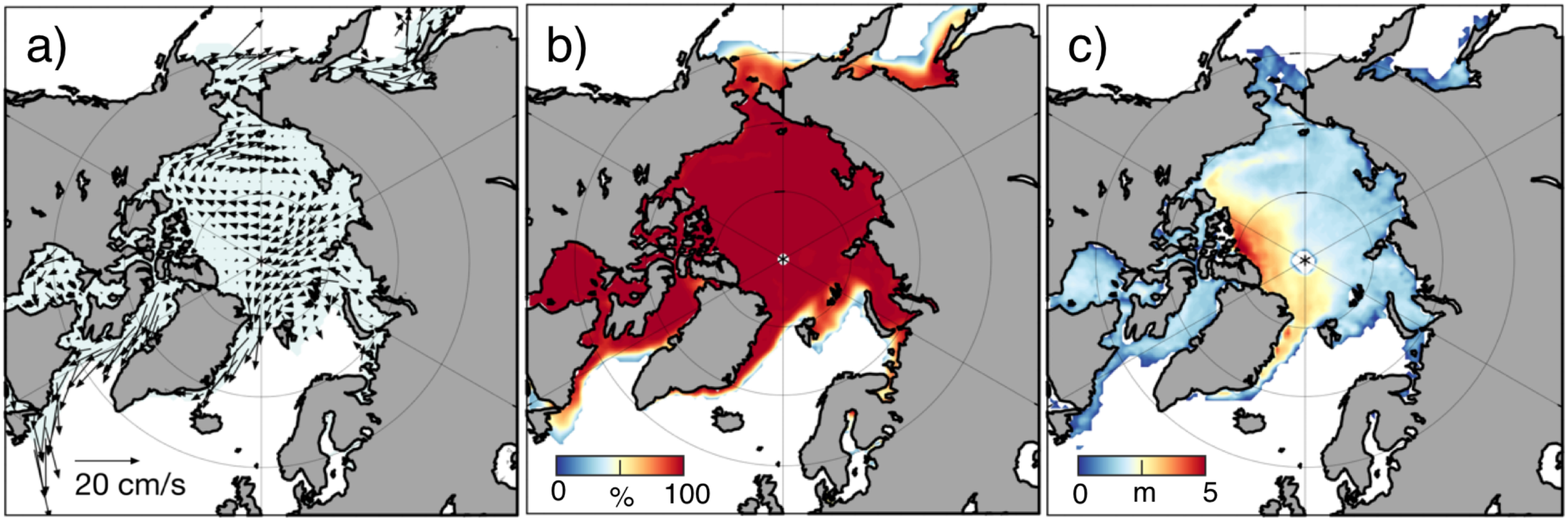
-> What about sea ice thickness or volume?



$$\frac{\partial Ch}{\partial t} = -\underbrace{\left(\boldsymbol{u}\frac{\partial Ch}{\partial x} + \boldsymbol{v}\frac{\partial Ch}{\partial y}\right)}_{-\boldsymbol{u}.\nabla Ch} - \underbrace{\left(Ch\frac{\partial \boldsymbol{u}}{\partial x} + Ch\frac{\partial \boldsymbol{v}}{\partial y}\right)}_{-Ch\nabla.\boldsymbol{u}} + f_{Ch}$$

M. Tsamados, O. Racher et al., in prep

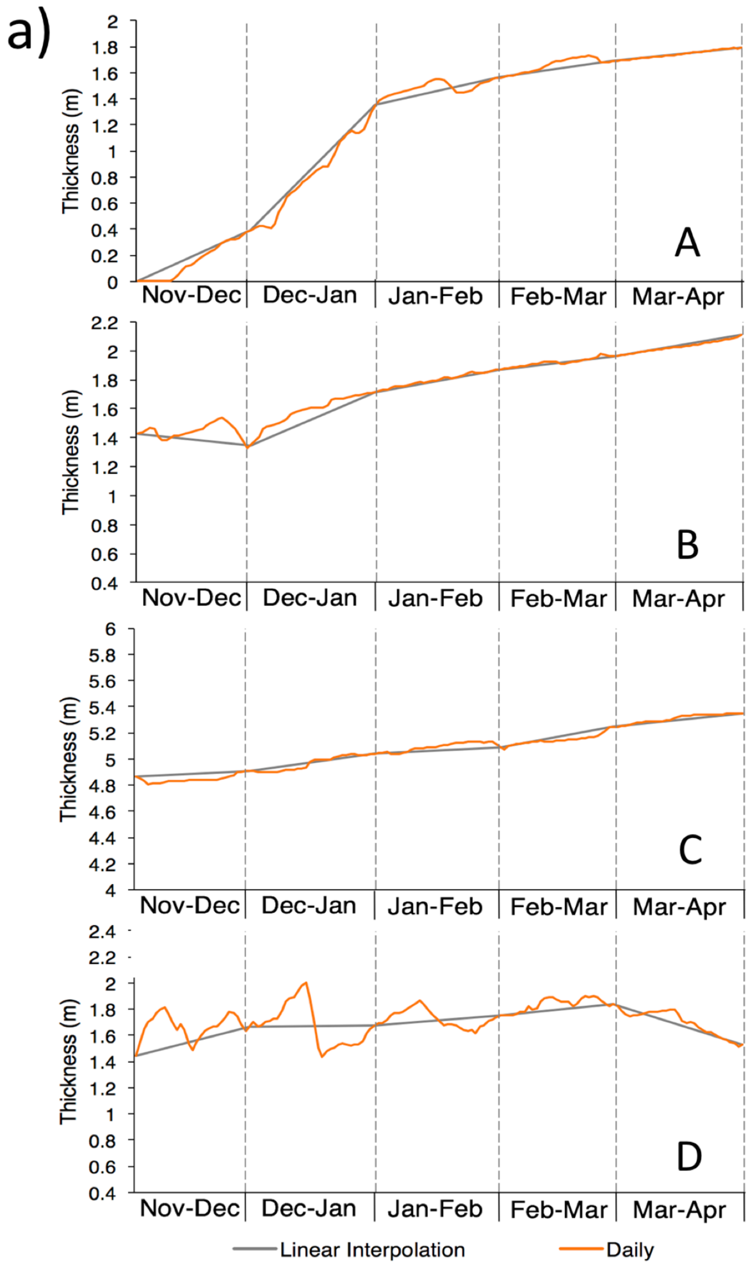
➢Satellite data used for budget

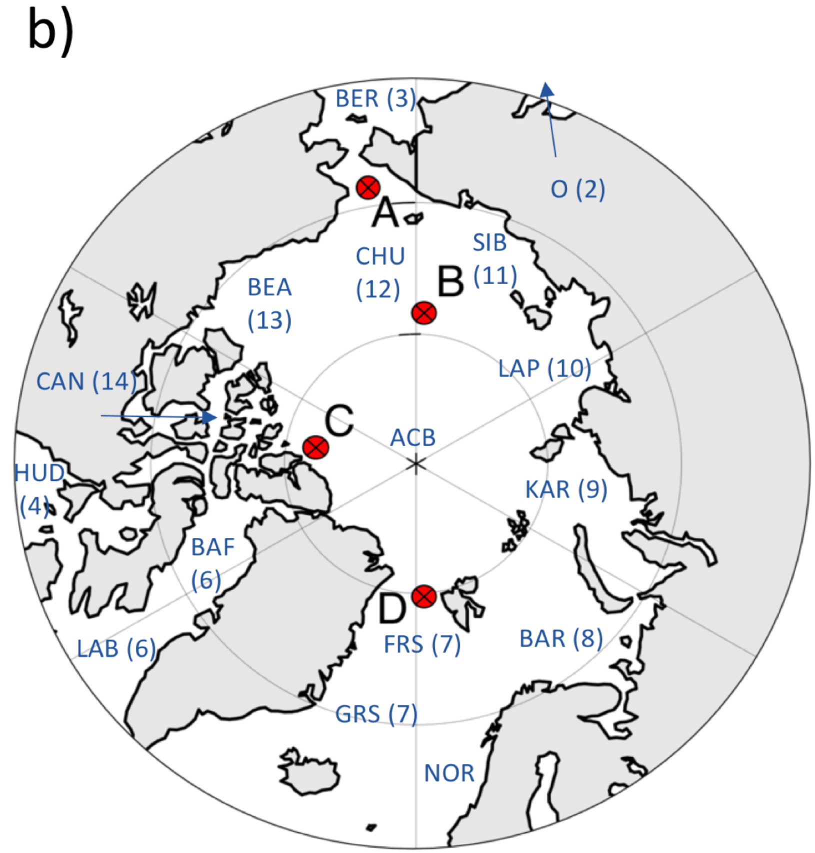


Sea Ice Parameter	Product	Original Data	Algorithm	Temporal Resolution	Spatial Resolution	Period	Summer Data
Concentration[a]	NSIDC	DMSP F17 - SSMIS	CDR	1 day	25km	1978-2017	Yes
Concentration[b]	NSIDC	DMSP F18 - SSMIS	CDR	1 day	25km	2017-Present	Yes
Drift[c]	Kimura	AMSR2 (Summertime: 18-GHz; Wintertime: 36-GHz)	Improved MCC	1 day	60km	2012-Present	Yes
Drift[d]	OSI SAF	SSMI, AMSR2, ASCAT	Improved MCC	1 day	62.5km	2010-Present	Yes
Thickness[e]	CPOM	CryoSat-2 Radar Altimetry	N/A	1 month	50km	2010-Present	No
Thickness[f]	CPOM	CryoSat-2 Radar Altimetry	N/A	1 month	25km	2010-Present	No

[a] NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 3. (Meier, Fetterer, Savoie et al., 2017).
[b] Near-Real-Time NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 1. (Meier, Fetterer and Windnagel , 2017).
[c] Kimura et al., (2013) [d] Lavergne et al., (2010)
[d] Centre for Polar Observation and Modelling [f] Ricker et al., (2017)

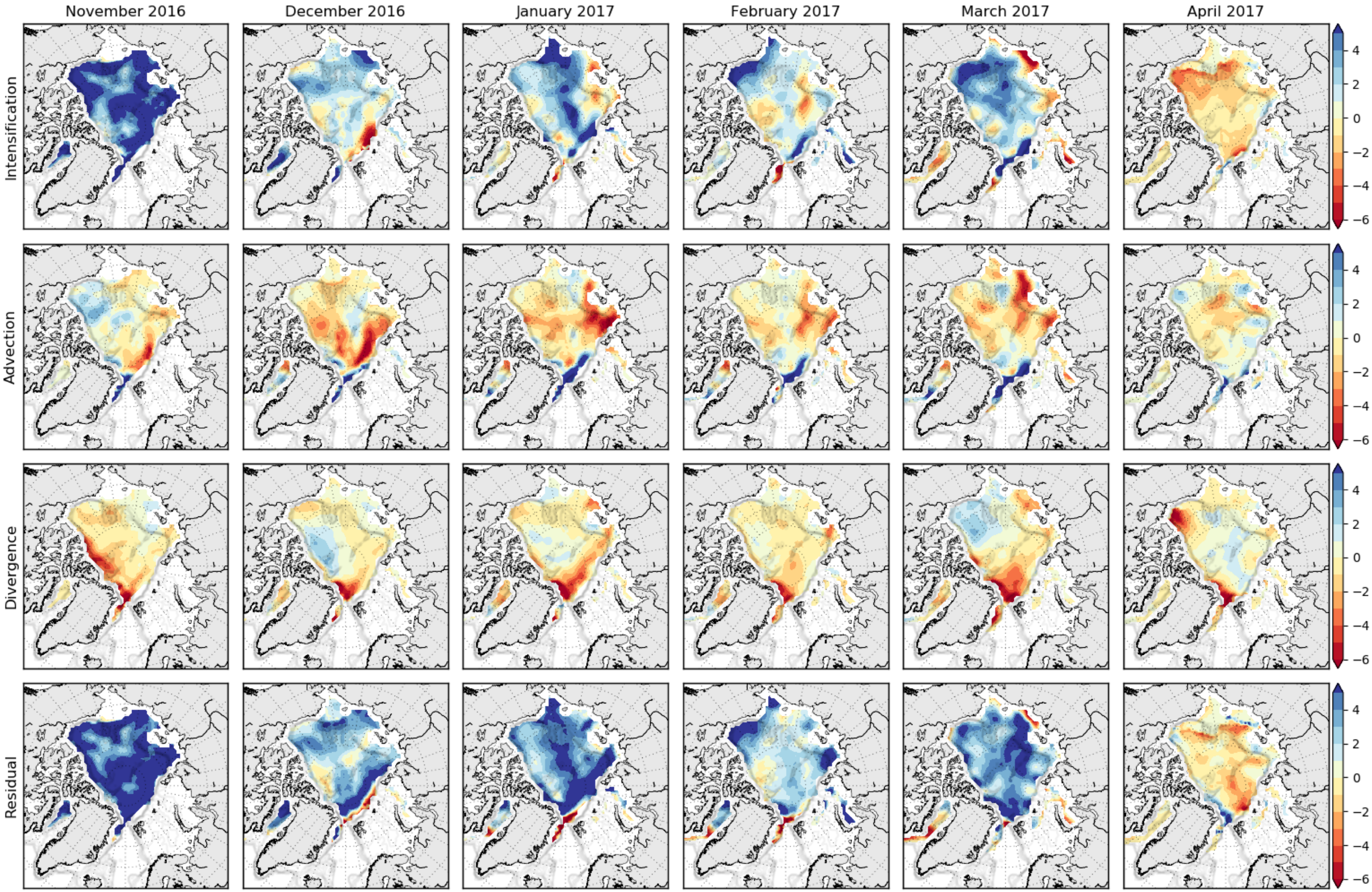
➢ *We focus on sea ice volume changes in key regions*



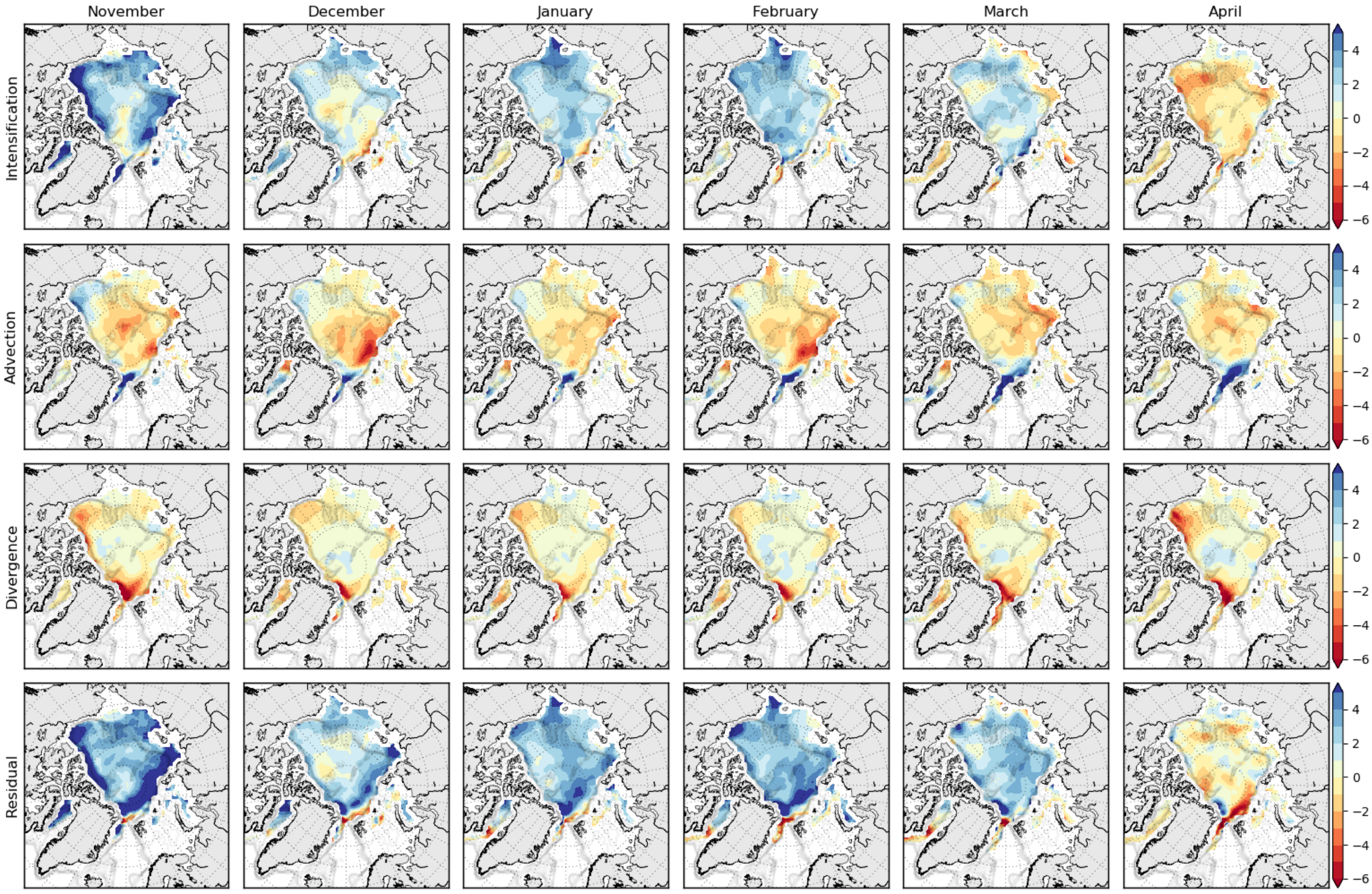


ACB = Arctic Central Basin
BAF = Baffin Bay
BAR = Barents Sea
BEA = Beaufort Sea
BER = Bering Sea
CAN = Canadian Archipelago
CHU = Chukchi Sea
FRS = Fram Strait
GRS = Greenland Sea
HUD = Hudson Bay
KAR = Kara Sea
LAB = Labrador Sea
LAP = Laptev Sea
NOR = Norwegian Sea
O = Sea of Okhotsk
SIB = East Siberian Sea

➢ *First 'seasonal' volume budgets – Satellite 2016/17*

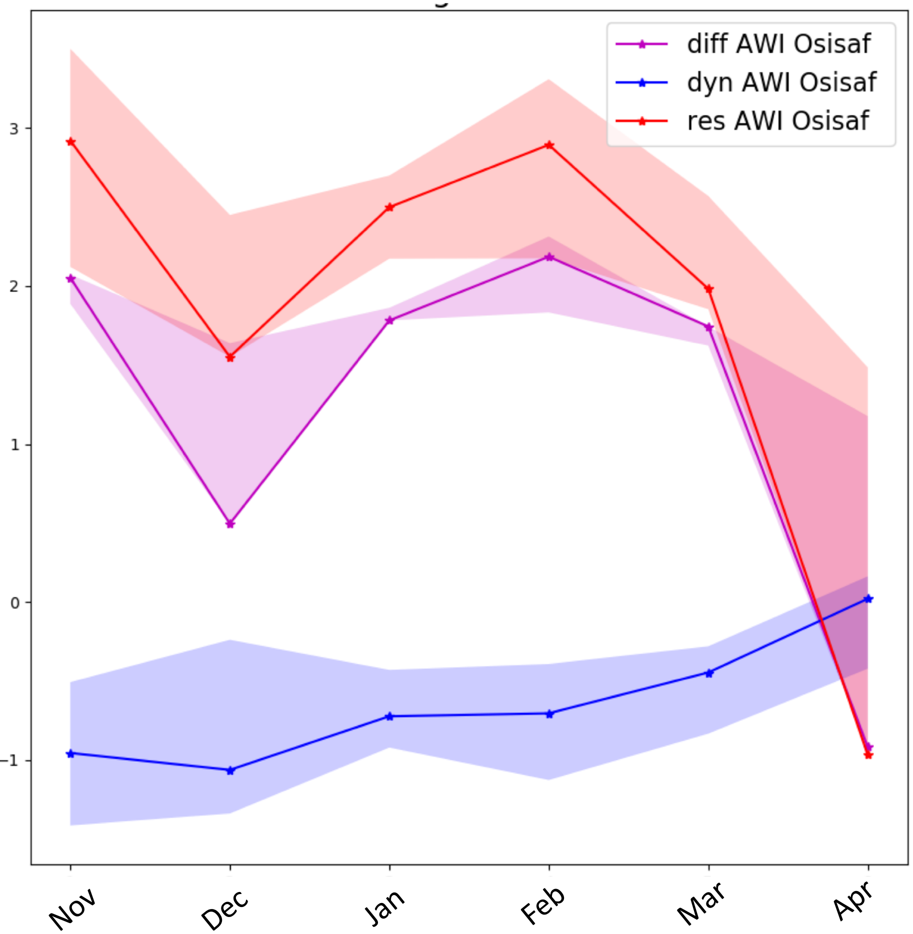


➢First 'seasonal' volume budgets – Satellite climatology

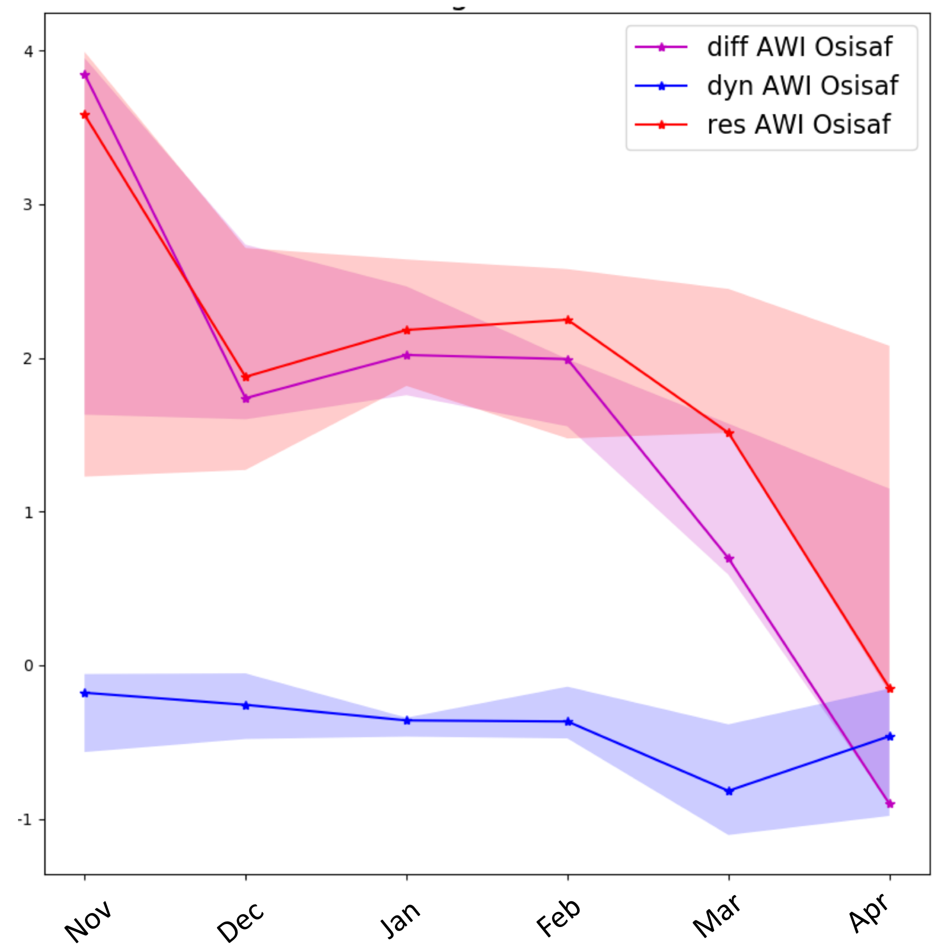


➢ *Seasonal growth can now be decomposed between dynamic and thermodynamic contributions (m/year)*

Central Arctic

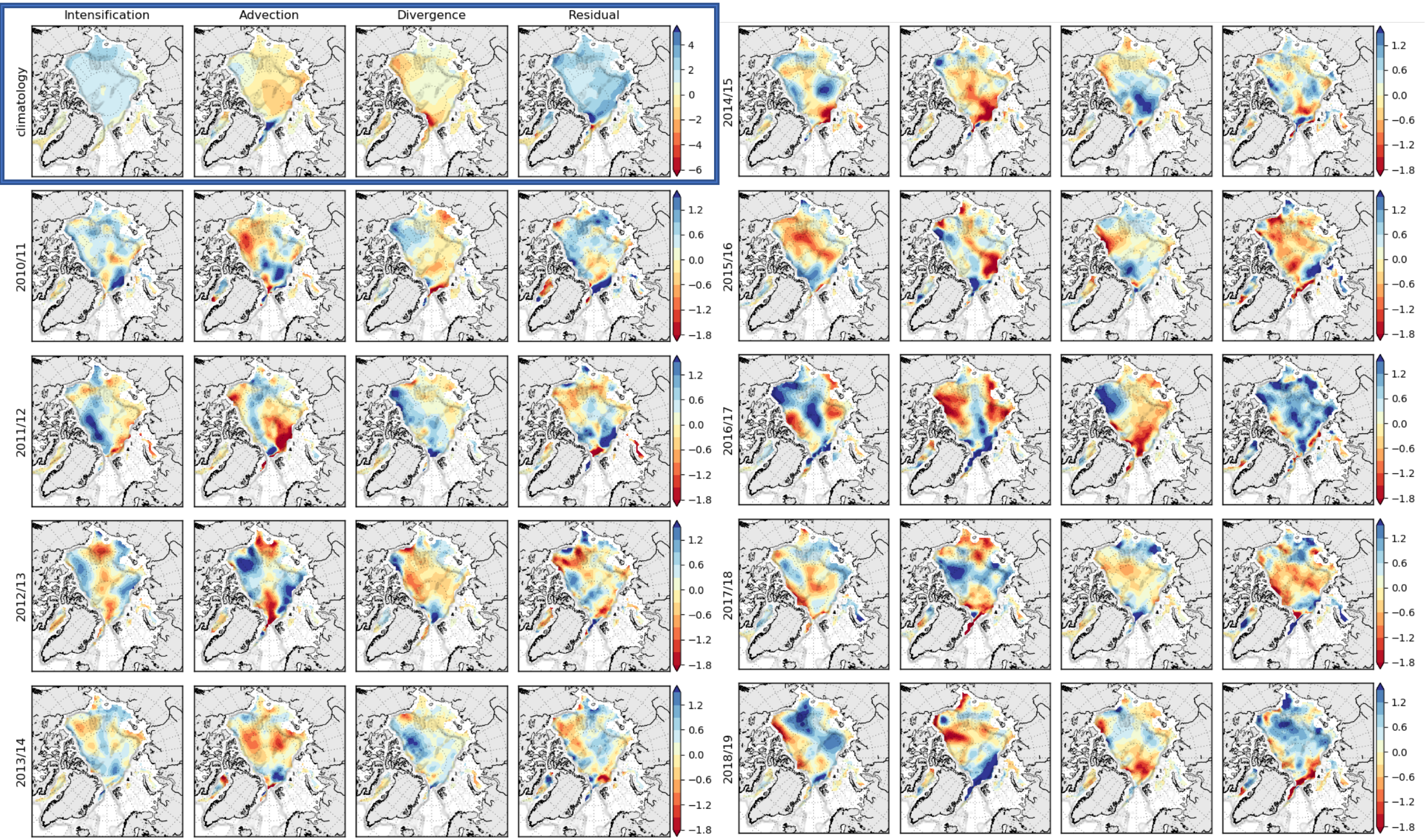


Marginal seas



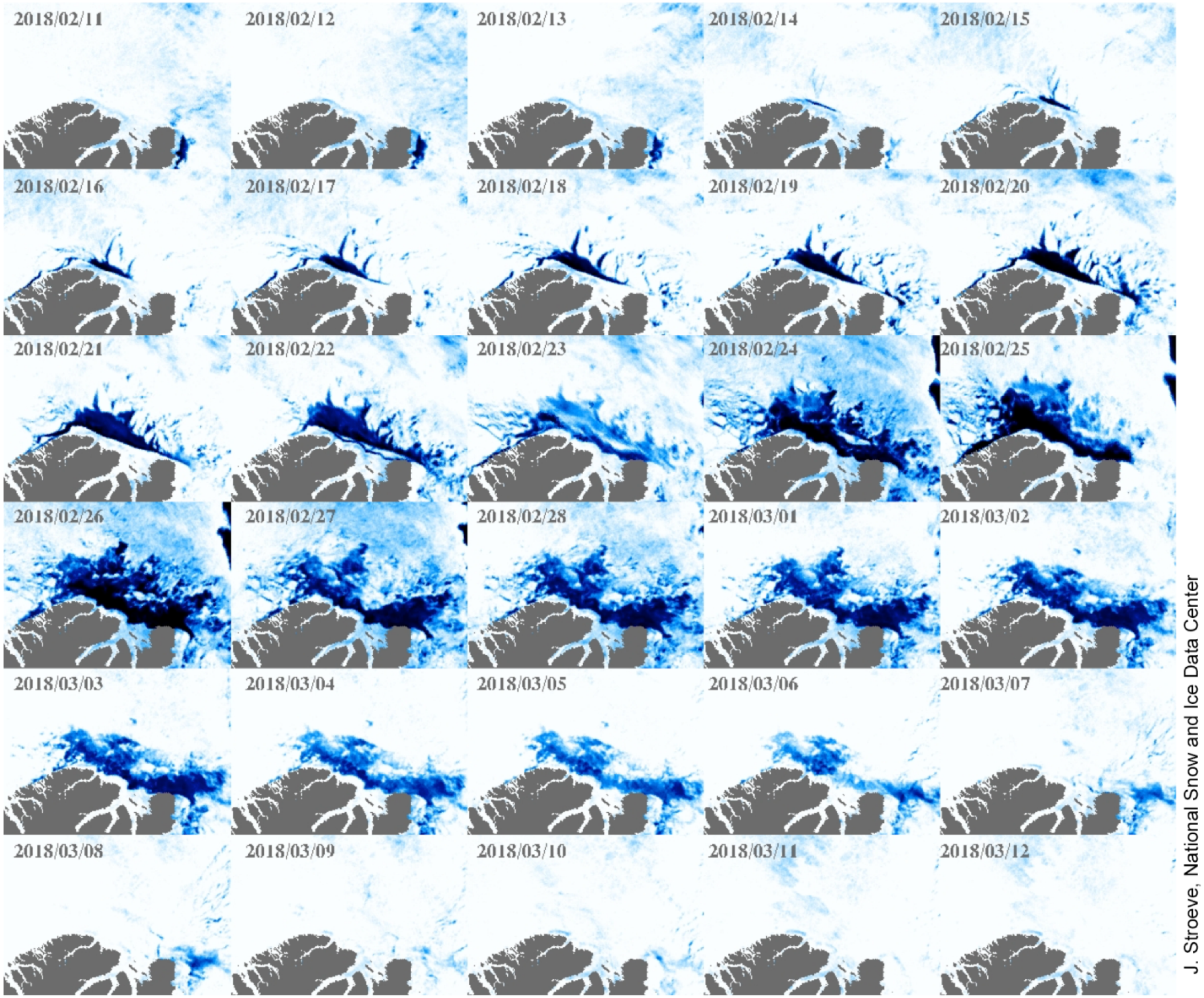
➢First 'seasonal' volume budgets – Satellite climatology

Average (2010-2018) absolute values and anomalies for each year (m/year)



➢ *Next step high resolution regional analyses*

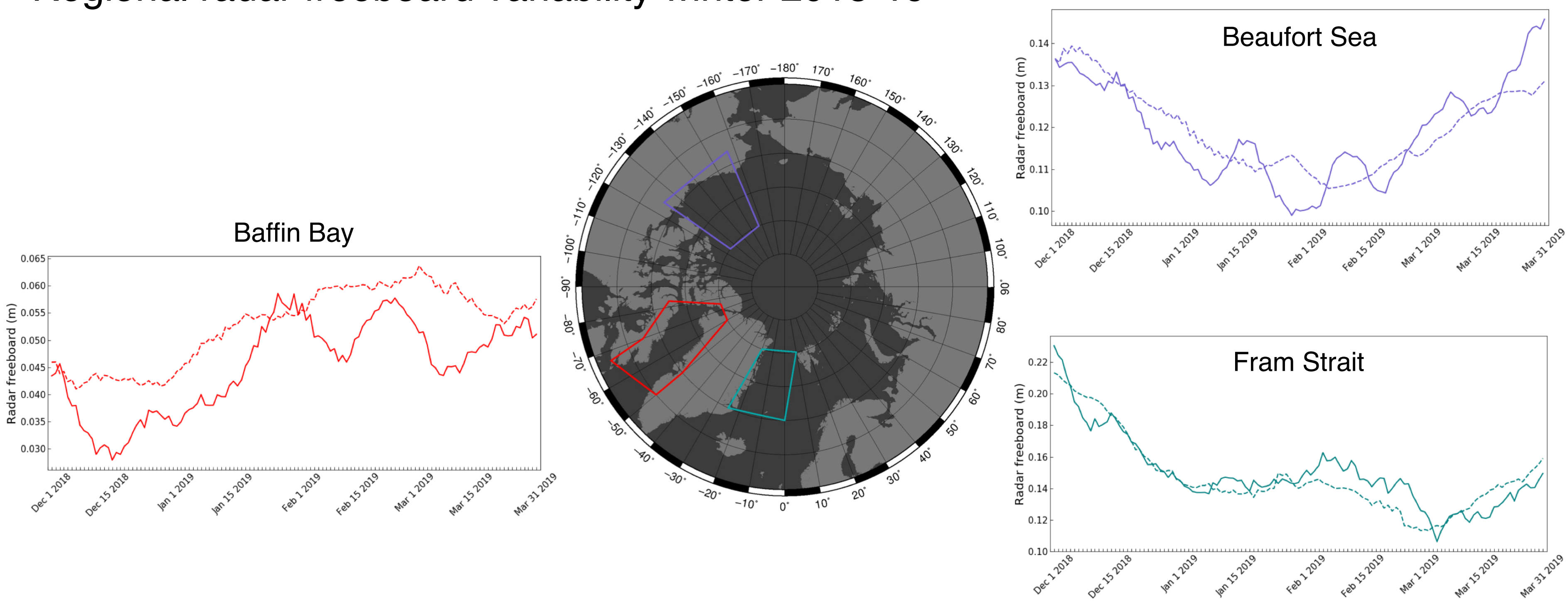
-> i.e. polynya north of Greenland



➢ *With higher spatio-temporal resolution in satellite data:*

- ➢ ***Merged CryoSat-2 + Sentinel3 A + Sentinel3 A***
- ➢ ***HR sea ice drift products***

Regional radar freeboard variability winter 2018-19



EGU2020-20143 | Displays | CR2.6

A merged CryoSat-2 Sentinel-3 freeboard product, its sensitivity to weather events, and what it can tell us about Ku-band radar penetration

Isobel Lawrence, Tom Armitage, Andrew Shepherd, and Michel Tsamados

Thu, 07 May, 08:30–10:15 | D2579

➢ *Conclusions*

- Winter sea ice growth is decomposed for the first time into its dynamic and thermodynamic components from satellite observations over the entire Arctic.
- Comparison with volume budget calculations from model simulation runs from the Los Alamos sea-ice model (CICE) show broad agreement but also regional inconsistencies.
- Sea ice concentration and volume decompositions can serve as a new tool to quantify model deficiencies in sea ice models implemented in CMIP5 and CMIP6.
- We will focus on budget decompositions in the region North of Greenland with higher resolved sea ice thickness and drift products and model simulations as part of the recently funded **PRE-MELT** NERC project. Stay tuned ☺

➢Questions?

PRE MELT