Large scale forcing of the Arctic sea level seasonality and implications for slope currents

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Outline:

**BACKGROUND**
Measurements of **ocean currents** variability along the **Arctic continental slopes**.

**METHODS / RESULTS**
What **temporal and spatial scales** is it possible to observe with a single-mission, gridded product (SAGA dataset)?

**RESULTS / DISCUSSION**
Satellite data as a **link** between local observations and forcing of **large scale variability**.
Is satellite altimetry a viable tool to get insight into the slope currents variability in the Arctic, and help understand its drivers?
BACKGROUND
Measurements of ocean currents variability along the Arctic continental slopes.

METHODS / RESULTS
What temporal and spatial scales is possible to observe with a single-mission, gridded product (SAGA dataset)?

RESULTS / DISCUSSION
Satellite data as a link between local observations and forcing of large scale variability.
...among other challenges of satellite altimetry in the Arctic:

- Very few missions cover high latitudes of the central Arctic (Cryosat-2, ICEsat 1-2)
- Observations in ice-covered regions require dedicated processing
- Only few homogenous, gridded datasets

**METHOD / RESULTS:** ARCTIC MAPS OF SEA SURFACE HEIGHT (SSH) AND GEOSTROPHIC VELOCITY

**SAGA**

*Sea level anomaly and geostrophic velocity of the Arctic ocean*

- Based on Cryosat-2 mission, up to 88°N
- Pan-Arctic, including ice-covered regions as reprocessed by AWI (Hendricks et al. 2021)
- Monthly maps (2011-2020)

**Dataset:** Doglioni et al (uploaded to PANGAEA): [https://doi.pangaea.de/10.1594/PANGAEA.931869](https://doi.pangaea.de/10.1594/PANGAEA.931869)

**Associated manuscript:** Doglioni et al. (subm. 2022, in review at ESSDD): [https://doi.org/10.5194/essd-2022-111](https://doi.org/10.5194/essd-2022-111)
RESULTS: COMPARISON TO SURFACE VELOCITY FROM MOORING ARRAYS

Boundary currents seasonality

- altimetry
- mooring

LAPTEV SEA CONTIN. SLOPE (ABC)
C = 0.61 (p-value < 0.01)

EASTERN FRAM STRAIT (WSC)
C = 0.62 (p-value < 0.01)
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RESULTS: LARGE SCALE SEASONAL ACCELERATION OF BOUNDARY CURRENTS

A large scale acceleration in fall/winter appears in the geostrophic velocity along the continental slopes in the Eurasian Arctic. This result is consistent with several mooring inferred results, integrating them into a basin-wide perspective.

SEASONAL SPEED ANOMALY: October to December
METHODS: SSH VARIABILITY FROM ALTIMETRY FIELDS AND MODEL OUTPUT

What is the nature of SSH variability that contributes to slope currents variability at seasonal time scales?

We used monthly maps, over the period 2011-2020, from:

**SATELLITE DATA**

**MODEL DATA**

**SAGA**

**FESOM**

Finite Elements
Sea ice-Ocean Model

FESOM 1.4, resolution of 4.5 km in the Arctic Ocean, sea ice–ocean coupling.

Using monthly mean maps from an historical run forced by atmospheric reanalysis data of JRA55-do v.1.3 (Tsujino et al., 2018).
**RESULTS:** SEASONAL DIFFERENCES → **OND - JJA**

**SSH (\(\eta\))**

- **Satellite Data**
- **Model Data**

**STERIC (\(\eta_S\))**

**Mass (\(\eta_M\))**

- Largest differences in the *shelf seas*, sharp divide at the Eurasian shelf break

Large-scale behaviour is attributable to variations in ocean mass. →
DISCUSSION: DRIVERS OF OCEAN MASS SEASONALITY

(1) Can the seasonal variability of ocean mass on the shelf seas be explained by **Ekman** transport across the shelf break?

(2) Why are these large oscillations **confined** to the **shelf** seas?
(1) Can the seasonal variability of ocean mass on the shelf seas be explained by *Ekman* transport across the shelf break?

(2) Why are these large oscillations *confined* to the *shelf* seas?
Discussion (1) : Ekman transport (model)

Ekman transport:

\[ U = (U, V) = \frac{1}{\rho_0 f} (\tau_o^y, -\tau_o^x) \]

where ocean surface stress:

\[ \tau_o = A \tau_{io} + (1 - A) \tau_{ao} \]

The \( \eta_M \) seasonality is in phase with the time-integrated Ekman transport across the shelf break, into a “shelf seas box”.

What balances the Ekman transport of mass onto the shelves? ...

… to be continued…

Climatologies (model)
DISCUSSION: DRIVERS OF OCEAN MASS SEASONALITY

(1) Can the seasonal variability of ocean mass on the shelf seas be explained by **Ekman** transport across the shelf break?

(2) Why are these large oscillations **confined** to the **shelf** seas?
Discussion (2): eastwards propagating mass anomaly?

How can we explain the sharp divide at the shelf edge?

Fukumori et al. (2015): wind forcing applied for 1 h, anomalies travel along shelf break

What happens under persistent anomalous seasonal winds?

... to be continued..
Discussion (2): eastwards propagating mass anomaly?

Wind pattern: ascending minus descending phase

Similar to AO>0 wind pattern (experiment done!)

AO>0: η experiment - η control
**Summary:**

**BACKGROUND**
Status of satellite **altimetry** for oceanography in the **Arctic**: what **challenges** are still to be overcome?

**METHODS / RESULTS**
What **temporal and spatial scales** is possible to observe with a single-mission, gridded product (SAGA dataset)?

**SEASONAL AND LARGER TIME SCALES, BOUNDARY CURRENTS**

**RESULTS / DISCUSSION**
Satellite data as a **link** between local observations and forcing of **large scale variability**.

**SEASONAL MASS OSCILLATIONS ON SHELVES, EKMAN TRANSPORT?**

THANK YOU! =)