A new free drift sea ice velocity dataset for improved representations of ice drift trajectories

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Overview

- We revisit **free drift motion of sea ice** represented as a **linear relationship** between sea ice velocity and wind velocity:

$$\overrightarrow{U_i} = \alpha\overrightarrow{U_A} + \overrightarrow{U_o}$$

where $\overrightarrow{U_i}$ is sea ice velocity, $\overrightarrow{U_a}$ is wind velocity, α is the wind-ice transfer coefficient, and $\overrightarrow{U_o}$ is the ocean contribution to ice motion (following Thorndike & Colony, 1982).

- We include a **sea-ice state dependent** wind-ice transfer coefficient to **reduce the error** on the sea ice motion estimates.

Motivation

- **Composite sea ice motion products**, such as the Polar Pathfinder (Tschudi et al. 2019), rely heavily on free drift estimates in the summer, when less satellite-derived drift vectors are available.
- **Current** parameterization for free drift consider **α constant**.
- Finer estimates of free drift ice motion will **improve ice tracking** methods, especially during summer.

Datasets

- Daily values, 1979-2018, for constraining α and $\overrightarrow{U_o}$
- $\overrightarrow{U_i}$ → **Buoy ice motion [cm/s]:** Int'l Arctic Buoy Program (IABP)
- $\overrightarrow{U_a}$ → **Wind [m/s]:** ERA-5 10m wind
- A → **Sea ice concentration:** NSIDC-Climate data record (CDR)

$\overrightarrow{U_i} = \alpha\overrightarrow{U_A} + \overrightarrow{U_o}$ Estimating the ocean circulation

- For every grid cell where buoy data is available, we take the best **linear fit** between all pairs of **buoy ice motion and wind velocity**.
- The **intercept** is the total ice motion unexplained by the wind, we make the assumption that it corresponds to the **ocean contribution,** to first order.
- We retrieve a climatology of the main features of the general circulation in the Arctic Ocean: **Beaufort Gyre** and **Transpolar Drift** ($|\overline{U_o}|$ = 2.6 cm/s, excluding Fram Strait) .

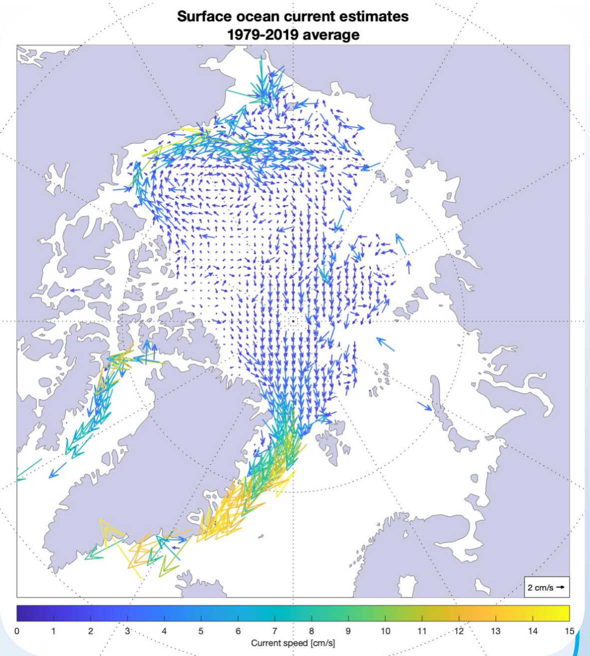

Fig.1: Yearly averaged estimate of the climatological surface currents for the 1979-2018 period.

$\overrightarrow{U_i} = \alpha\overrightarrow{U_A} + \overrightarrow{U_o}$ A sea ice state dependent wind-ice transfer coefficient

- The wind-ice transfer coefficient includes a **magnitude** (Fig.2) and a turning angle:

$$\alpha = |\alpha|e^{i\theta_a}$$

- $|\alpha|$ is parameterized as having an **exponential decay** with respect to **sea ice concentration**.
- Least square fit is performed on all the pairs of buoy motion, wind velocity and sea ice concentration.
- $|\alpha|$ is in the range **[1.2, 1.8]%**, with a sharp decline at ice concentration above 0.9.
- Estimated $\overrightarrow{U_i}$ compared to buoy drifts yields a root mean squared error of rmse = 5.41 cm/s.

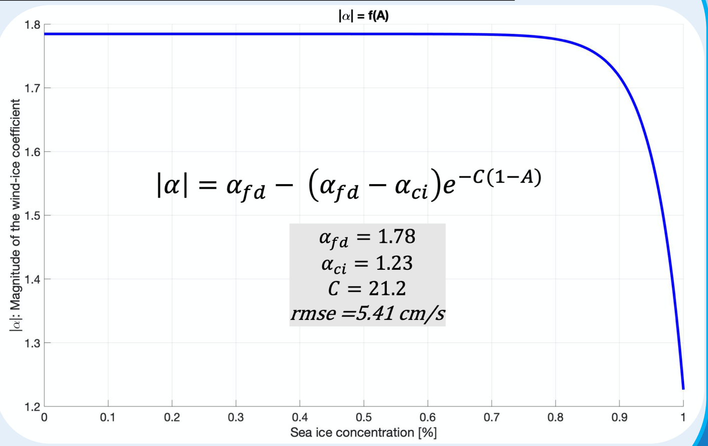

Fig.2: Dependence of the magnitude of α on sea ice concentration

References: Tschudi, M., W. N. Meier, J. S. Stewart, C. Fowler, and J. Maslanik. (2019). Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors, Version 4. ; Thorndike, A. S., & Colony, R. (1982). Sea ice motion in response to geostrophic winds. Journal of Geophysical Research: Oceans

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