Sea-ice turbulent dynamics derived from Lagrangian buoys tracks

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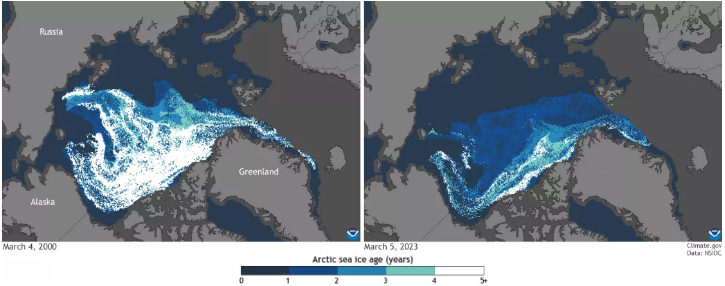
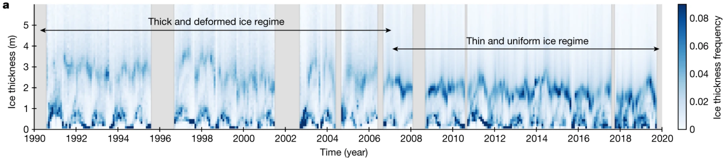
Sea ice evolution



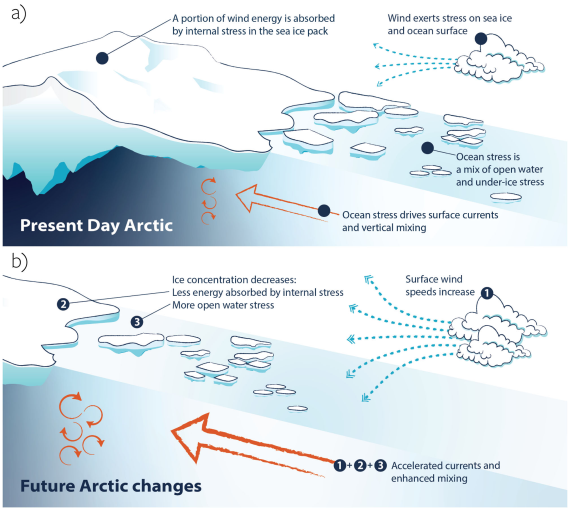


Evolution in:

- Heat fluxes
- Freshwater
- Albedo
- Biology

Figure adapted from Sumata et al. (2023)

Sea ice mediates wind stress



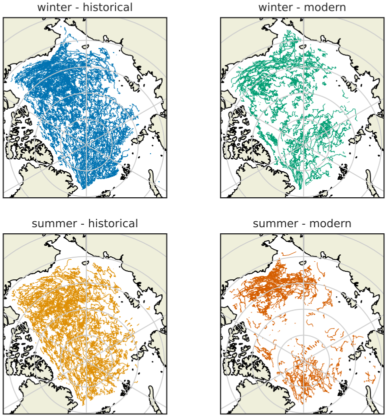
- Sea ice absorbs part of wind stress
- Fractures: dissipation of energy
- Transfer to and from the ocean (e.g. eddy killing)

Figure from Muilwijk et al. (2024)

Research question

How is energy transfered across scales in sea ice?

Data: International Arctic Buoy Programme (IABP) drifters



- Buoys from 1979 to 2016
- 3 hourly
- Compute velocities, remove mean to get fluctuating velocities

historical: 1979–2006

modern: 2010–2016

Example of a decomposition into mean and fluctuating

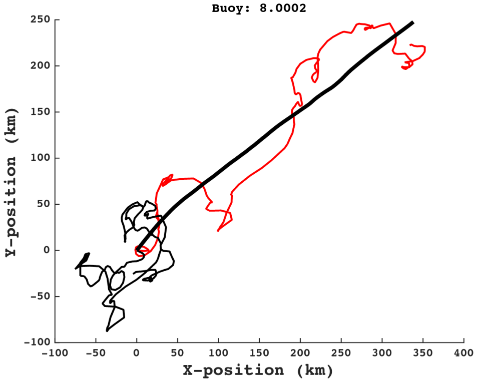
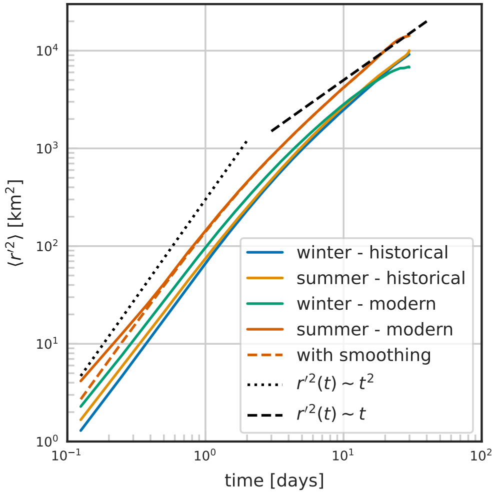


Figure from Rampal et al. (2016)

Diffusion = mean squared displacement: $\langle r'^2 \rangle = f(t)$

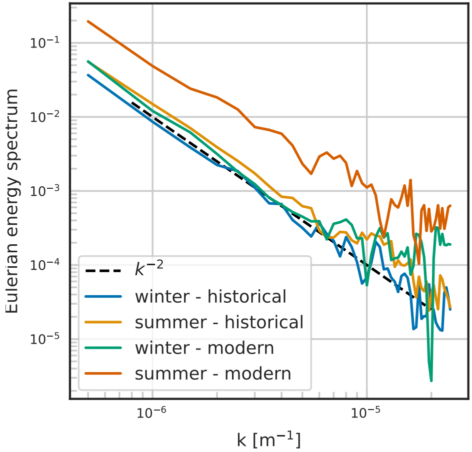


More energy in the modern summer

2 regimes:

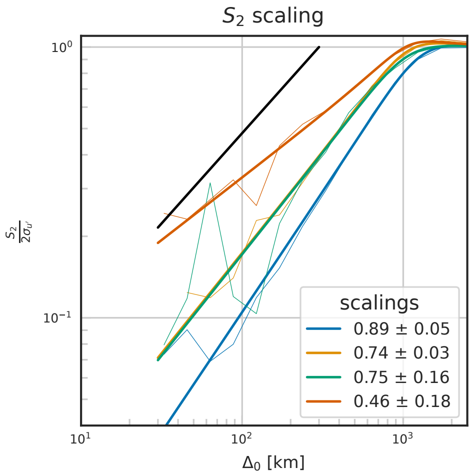
- Balistic regime: the velocities are highly correlated
- Diffusive regime: the velocities are uncorrelated
- Shift between these 2 regimes: around 1–2 days

Eulerian energy spectrum



- The scaling is not $-5/3$
- Ocean: between -3 and $-5/3$
- Eddy killing role of sea-ice, energy input for sea ice
- Multi-scale dissipation in sea ice:
  - fractures
  - ocean drag

Second order structure function S_2



$$S_2(\Delta_0) = \langle(\mathbf{u}(\mathbf{x}) - \mathbf{u}(\mathbf{x} + \boldsymbol{\Delta}_0))^2\rangle$$

- Large scale: flat $\Longrightarrow$ decorrelation
- Winter-hist (blue) has the largest correlation scales: large plate
- New regime in modern summers (red)

From plate dynamics to floes dynamics?

Black curve: $\Delta_0^{2/3}$

Conclusions

- We find a transition of dynamical regimes
- Sea ice turbulent dynamics could come from
  - intermittent fracturing events (dissipation)
  - coupling with the ocean (2 way, scale dependent)
  - also forced by the atmosphere
- We are estimating the contibution from each terms, stay tuned for follow up results!

Muilwijk, M., Hattermann, T., Martin, T., & Granskog, M. A. (2024). Future sea ice weakening amplifies wind-driven trends in surface stress and Arctic Ocean spin-up. *Nature Communications*, *15*(1), 6889. https://doi.org/10.1038/s41467-024-50874-0

Rampal, P., Bouillon, S., Bergh, J., & Ólason, E. (2016). Arctic sea-ice diffusion from observed and simulated Lagrangian trajectories. *The Cryosphere*, *10*(4), 1513–1527. https://doi.org/10.5194/tc-10-1513-2016

Sumata, H., De Steur, L., Divine, D. V., Granskog, M. A., & Gerland, S. (2023). Regime shift in Arctic Ocean sea ice thickness. *Nature*, *615*(7952), 443–449. https://doi.org/10.1038/s41586-022-05686-x