Satellite-derived Ocean-Surface Stress and Ekman Circulation in the Arctic

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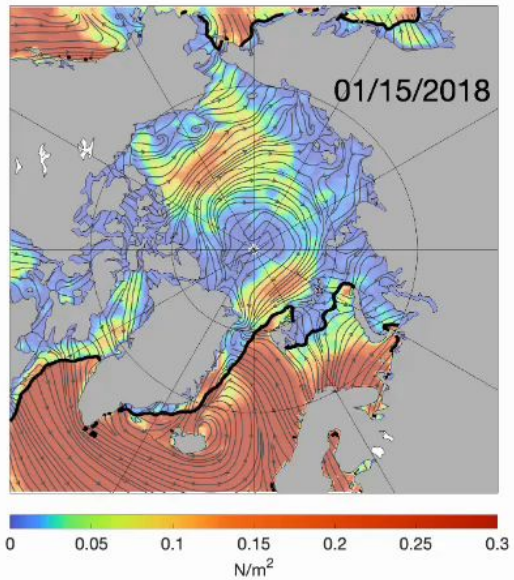
- The persistent decline in Arctic sea ice extent has altered ocean-surface stress, τ_o, across both ice-free and ice-covered regions, impacting ocean circulation and freshwater distribution primarily through Ekman transport.
- Mapping τ_o and associated Ekman circulation using available satellite observations is important for understanding Arctic dynamics and climate change.
- τ_o is the sum of the air-water stress (τ_{aw}) for the open water and the ice-water stress (τ_{iw}) for the water covered by ice: $\tau_o = \alpha\tau_{iw} + (1-\alpha)\tau_{aw}$, where α is sea ice extent.
- τ_{aw} and τ_{iw} are both parameterized using a quadratic drag law:

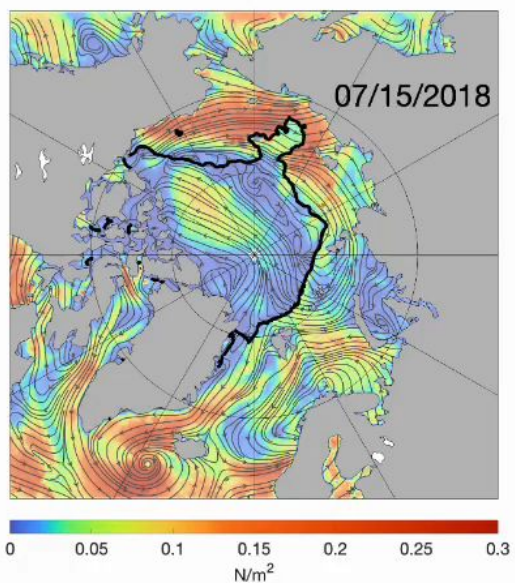
  $\tau_{aw} = \rho_a C_{D,aw} |\mathbf{U}_{10}|\mathbf{U}_{10}$ and $\tau_{iw} = \rho_w C_{D,iw} |\mathbf{U}_{ice} - \mathbf{U}_E - \mathbf{U}_g| (\mathbf{U}_{ice} - \mathbf{U}_E - \mathbf{U}_g)$

  where C_D are drag coefficients, $\mathbf{U}_{10}$ is the wind velocity vector at 10m, $\mathbf{U}_{ice}$ is sea ice motion, $\mathbf{U}_E$ is Ekman velocity, and $\mathbf{U}_g$ is geostrophic velocity.
- Based on above equations, τ_o can be estimated using the following four datasets:

Variable	Product	Resolution
$\mathbf{U}_{10}$	OAFlux2 Satellite Ocean-Surface Winds	Daily 0.25°, 1988-present
$\mathbf{U}_{ice}$	Polar Pathfinder Sea Ice motion V4	Daily 25 km, 1978-present
$\mathbf{U}_g$	CLS multi-mission Ocean Altimeter SSH	3-Day 25 km, 2011-2021
α	Goddard/NSIDC Sea Ice Concentrations V2	Daily 25 km, 1978-present

Ocean-Surface Stress τ_o





Ekman pumping $w_e = \nabla \times (\frac{\tau_o}{f\rho_w})$