Storm Generated Near-Inertial Waves in Eastern Chukchi Sea –
A case study by Saildrone observation and a hybrid coordinate ocean model

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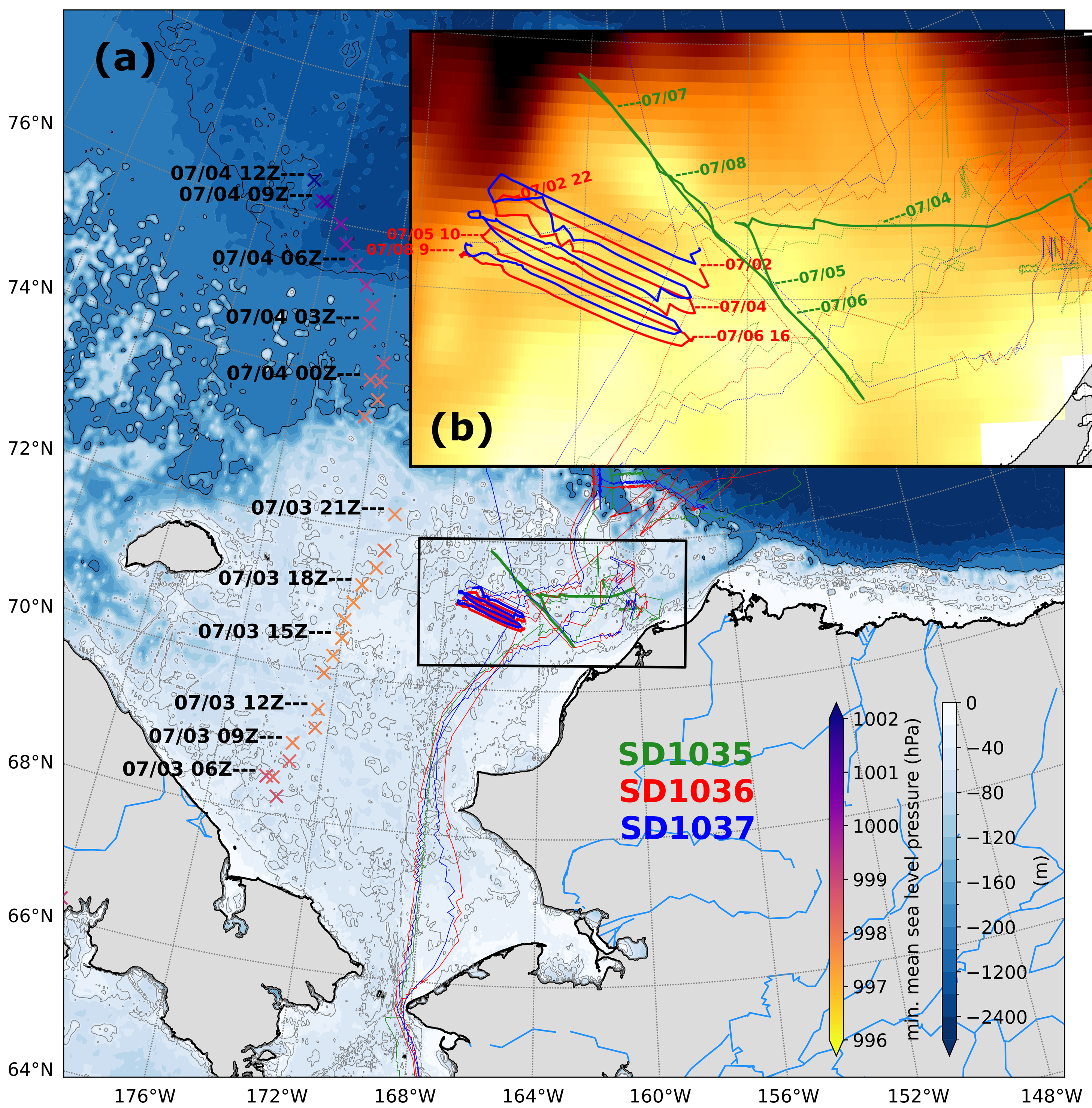
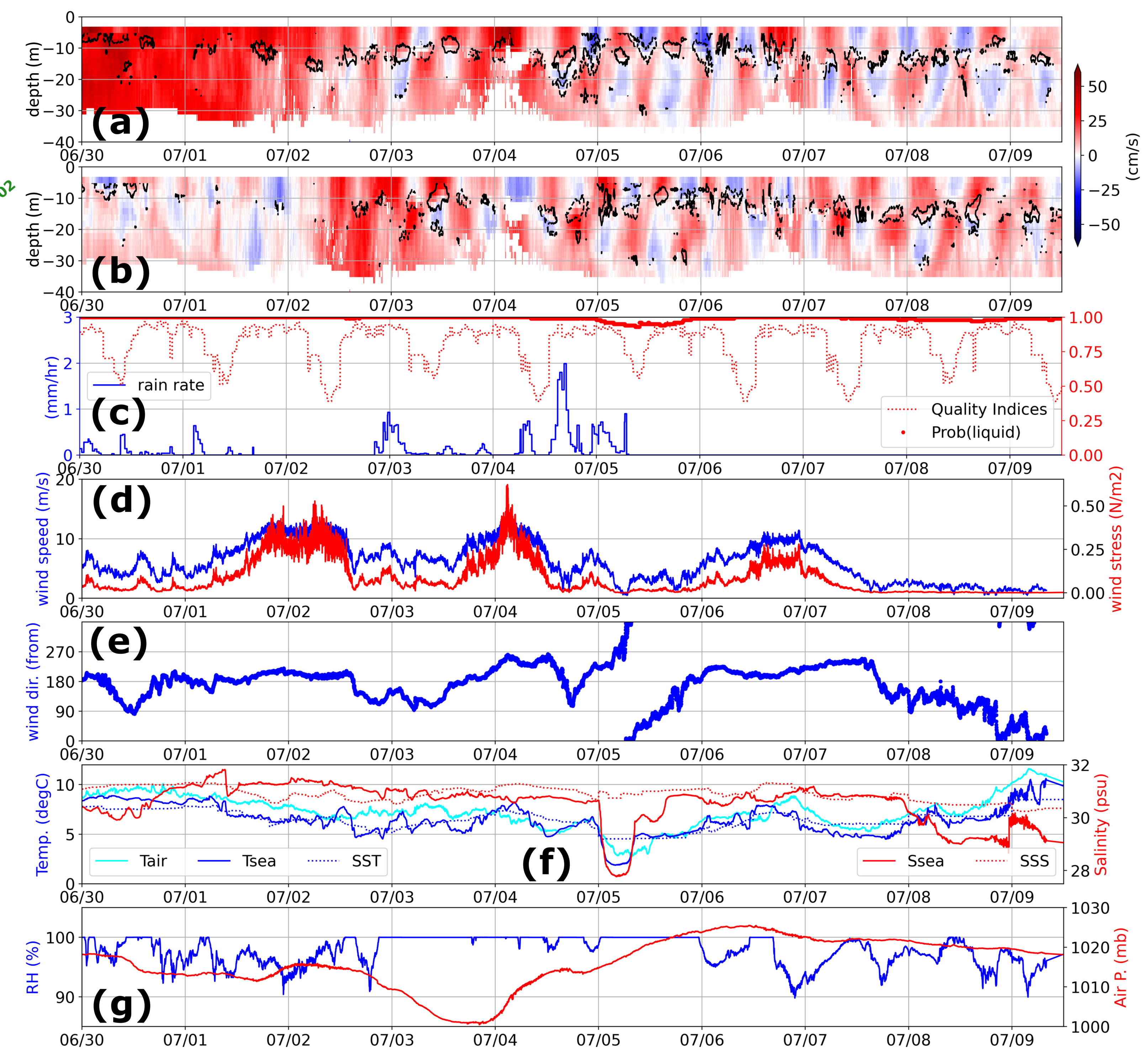
Introduction

- Near-inertial waves (NIWs) are major contributor to upper ocean mixing. Its generation has been broadly studied in the open ocean[1,2] but less documented or observed on continental shelves[4,6], especially the pan-Arctic shelves[5] due to challenging environment in the seasonal ice zone.
- The center of Arctic storm action has shifted towards the Chukchi Sea in the warm season[7] + seasonal increased opening → increasing direct air-sea interactions → suggest crucial need in quantifying the upper ocean mixing near the seasonal ice zone.
- Understanding and quantifying the wind-driven NIWs energetics and mixing on the Chukchi Sea shelf could shed lights on the changes in thermohaline properties of the Pacific Throughflow as they may alter the Arctic halocline up to 200 m[8].
- This study based on the in situ observations aims to provide an estimate of the NIW horizontal scale and the energy of NIWs generated by a run-of-the-mill Arctic storm during ice-free summer over the Chukchi Sea shelf.



▲**FIG 1. (a)** The colored crosses are the locations of the minimum mean sea level pressure (MSLP) of an Arctic storm along its track. The dotted lines are tracks of 3 saildrones during the Saildrone Arctic Mission 2019. **(b)** The blowup of the black box in (a) with contour shading of SMOS sea surface salinity (SSS) on July 5, 2019. The saildrone tracks between July 3 and July 9 are thicker.



▲**FIG 2.** SD1036 meteorological and upper ocean measurements: **(a)** Zonal and **(b)** meridional current (color shading) with barotropic tidal currents removed and vertical shear in contour (black contours = 0.03 s^{-1}), **(c)** IMERG rain rate along SD1036's track, **(d)** wind speed and wind stress, **(e)** wind direction, **(f)** air temperature at 2.3 m, water temperature at 0.5 m depth, water salinity at 0.5 m depth, SMOS SSS and MWIR SST, **(g)** relative humidity and air pressure.

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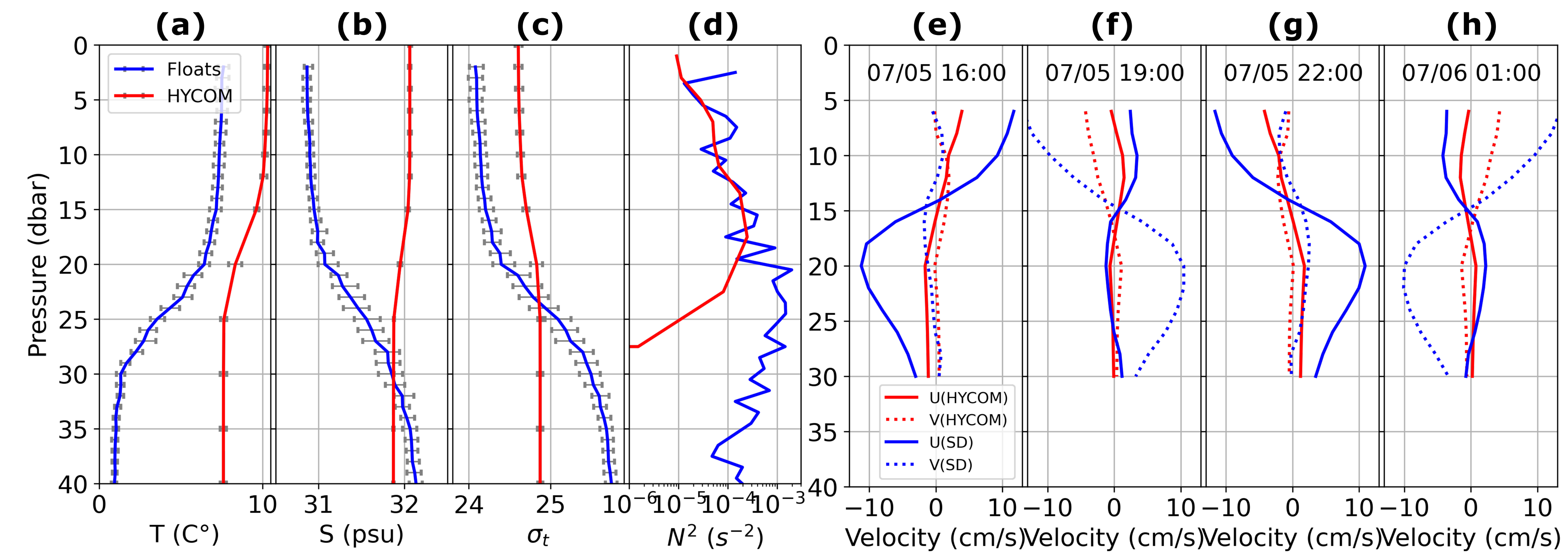
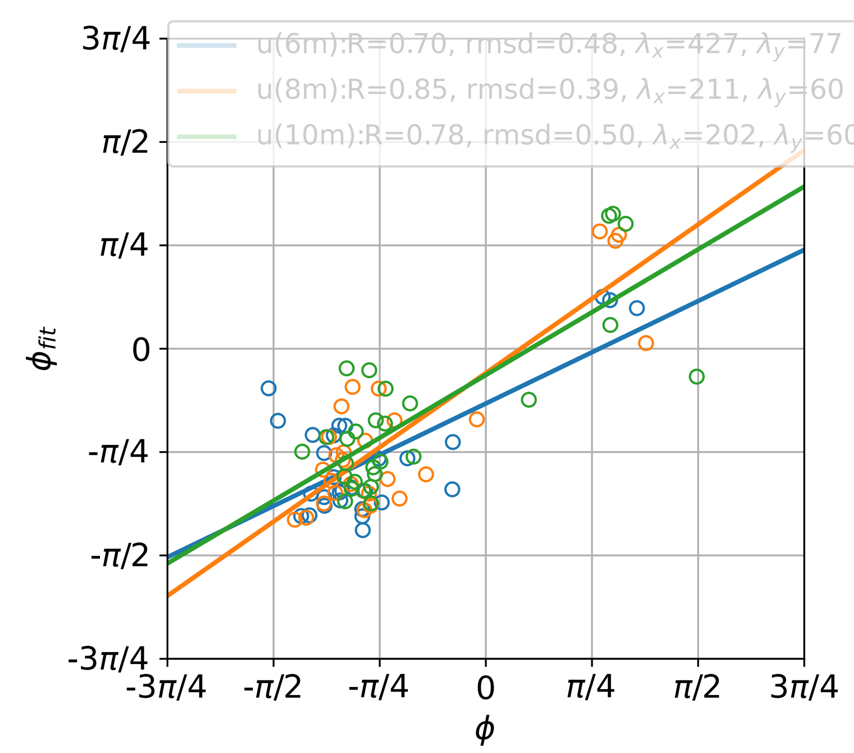
Summary

- Saildrone observed elevated NIW activities associated with a summer Arctic storm in the ice-free zone of eastern Chukchi Sea shelf. The storm generated NIWs exist in the HYCOM Global 1/12º analysis, though too weak.
- The observed NIWs estimate a horizontal scale of O(100 km), zonal and meridional wavelength of O(211) km, O(60) km. With aids of nearby historical ALAMO float T/S profiles, the estimated vertical and horizontal group velocity are O(-7~19) m day^{-1} and O(5~13) km day^{-1}. They are likely a mixture of multiple locally generated NIWs separated by time, and/or resulting from multiple bottom and surface reflections.
- The observed storm-driven NI kinetic energy is comparable to those on the shelves in the lower and midlatitudes while the horizontal energy flux is O(9-23) W m^{-1}, 1~2 orders of magnitude smaller than the long-range NIWs from dozens of historical moorings in the world oceans.

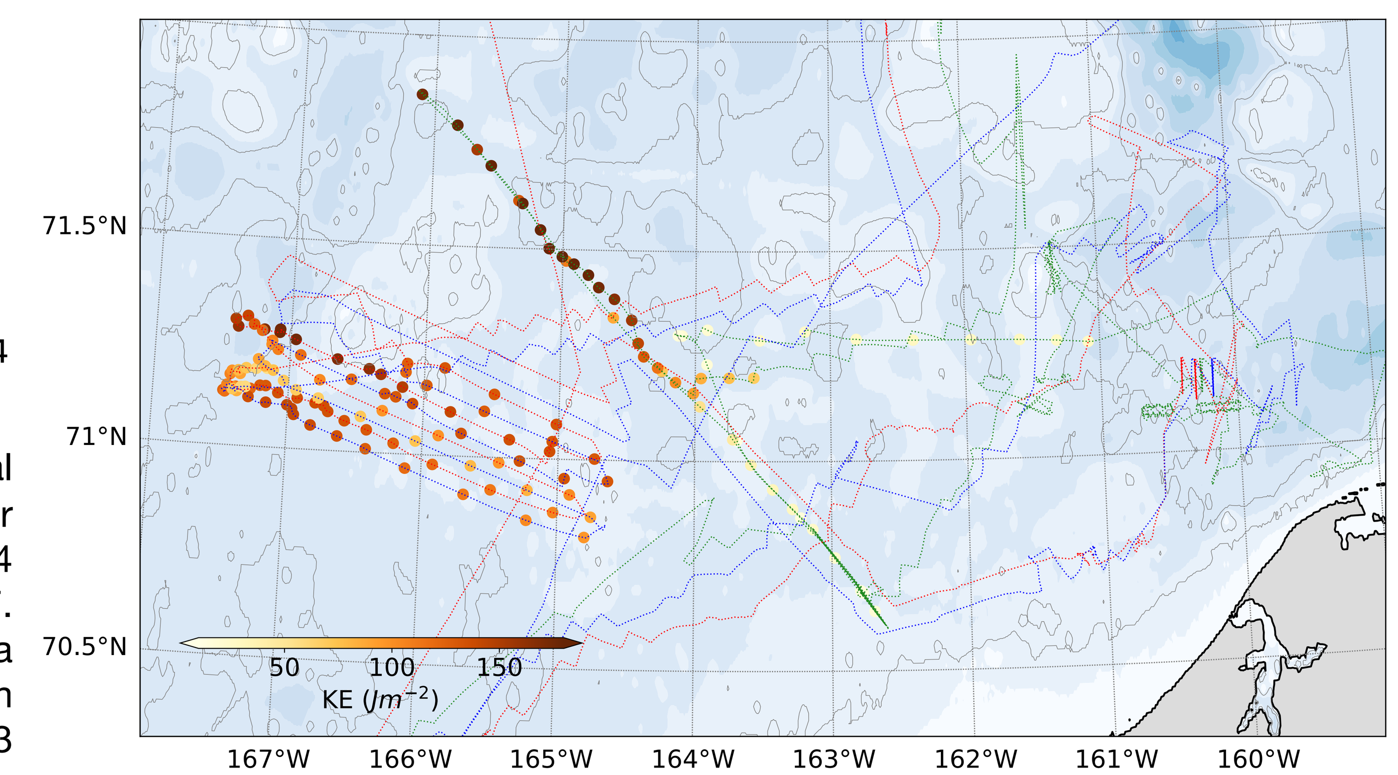


▲**FIG 3.** Mean profiles of **(a)** temperature, **(b)** salinity, **(c)** σ_t, and **(d)** buoyancy frequency squared of July historical ALAMO floats (blue lines) in the region of 167.25ºW~165.25ºW, 69.7ºN~71.7ºN, and the HYCOM data (red lines) following SD-1036 in July 2019. The gray bars are the 95% confidence intervals of the mean values at each ALAMO measured or HYCOM gridded depths. **(e, f, g, h)** The band-passed (0.8~.12f at 71.2ºN) zonal (solid lines) and meridional (dotted lines) velocity profiles at 4 selected times after the passage of the Arctic storm at SD1036 (blue) and the collocated HYCOM data (red).



▲**FIG 4.** The colored dots are the zonal velocity estimated phase (ϕ) (see method) for each 8-hour rolling window between 07/04 12Z and 07/10 0Z on SD1036 and SD1037. Only estimates that meet the following criteria are used: (1) when drone moved < 10km during the 8-hour time series (3) RMSD < 3 cm/s between the 8-hour velocity and the fitted velocity.

◀ **Method (1)** Remove barotropic tidal currents **(2)** every 4 hours a 8-hour rolling window velocity time series is fit to simple sinusoidal waveform, $A\cos(f(t-t_0)+\phi)+B$, to find out phase (ϕ) change with space.
(3) Fit ϕ in $A\cos(f(t-t_0)+\phi)+B$ to $K_xX+K_yY+\theta_0$, where K_x and K_y are zonal and meridional wavenumber.
(4) Horizontal, vertical group velocity and depth-integrated kinetic energy flux are estimated[3] by $C_{gH}\sim N^2K_H/(fK_Z^2)$, $C_{gz}\sim -N^2K_H^2/(fK_Z^3)$, and $C_{gH}KE$.



▲**FIG 5.** The colored dots are the 3-hour mean NI depth-integrated (6-30 m only) kinetic energy from the 3 saildrones between 07/03 0Z and 07/09 0Z.