PICES 2025 Annual Meeting
Innovative Approaches and Applications to Foster Resilience in North Pacific Ecosystems

Estimation of water exchange between the Bering Sea and the Pacific Ocean through the Near Strait using GLORYS12V1, GOFS 3.1 and JCOPE2M

POI FEB RAS SPbU

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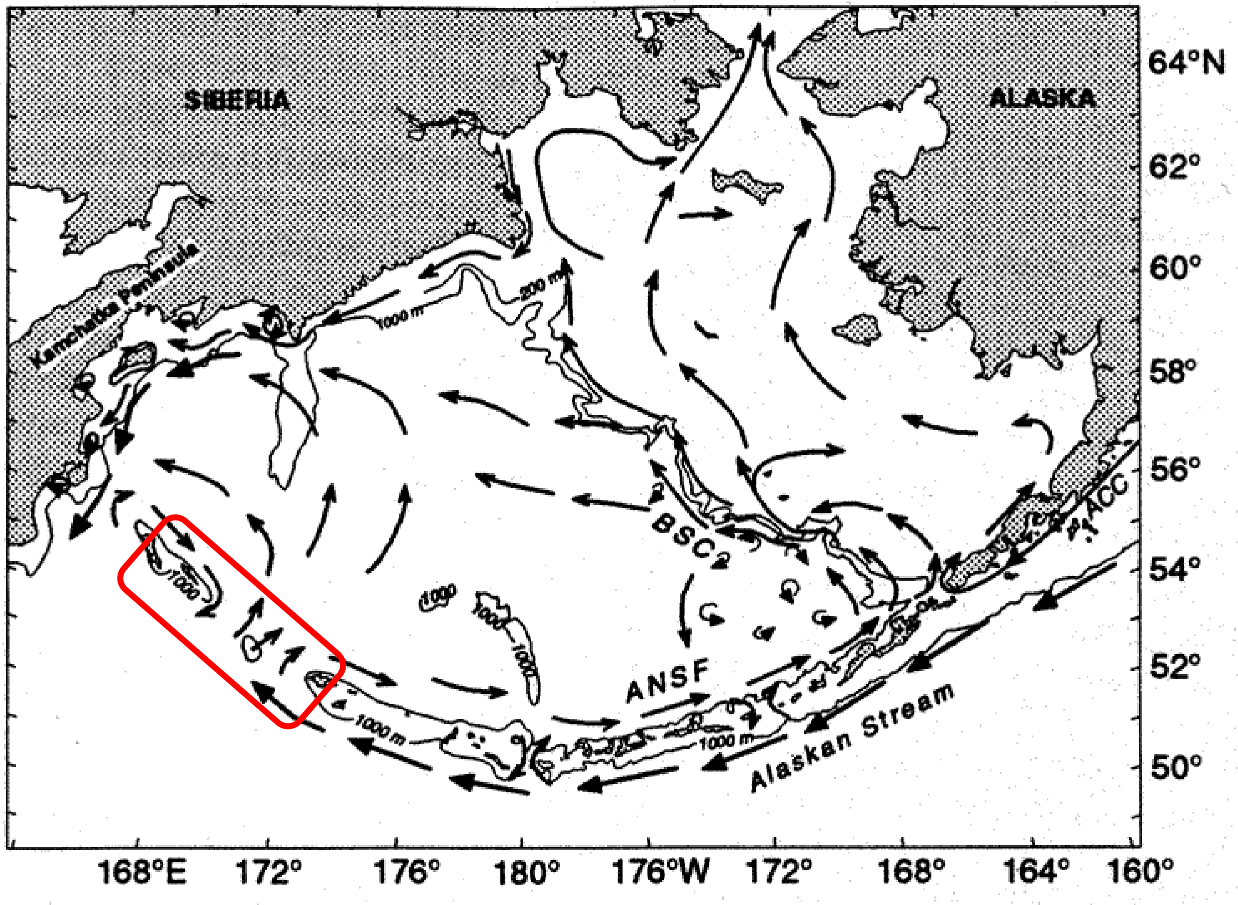
Research area



The scheme of surface (up to 40 m) circulation (Stabeno, 1999)

Near Strait is the widest of the Aleutian Ridge straits. The width of the Strait is estimated at 423 km, and the maximum depth is more than 3,500 meters.

According to the publication Stabeno, 1999 most of the transport into the Bering Sea occurs through Near Strait (6–12 Sv).

Purpose and objectives

Purpose: to obtain up-to-date estimates of volume transport and water exchange through the Near strait based on modern datasets

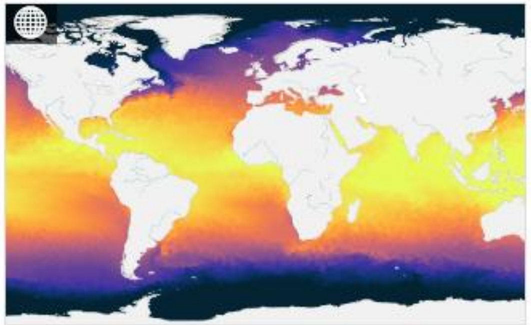
Objectives:

- To compare the volume transport through the Near Strait, calculated from four datasets, over the time interval of CMEMS products overlap
- To define the main water transport paths through the Near Strait
- To describe the mechanism of the water outflow from the Bering Sea to the Pacific Ocean through the example of the Near Strait

Data

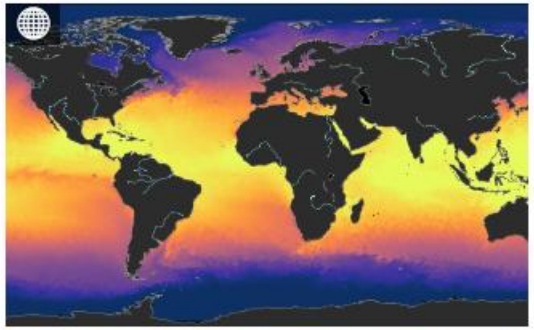
- Global Ocean Physics Reanalysis (DT) (01.01.1993→01.06.2021)
- Global Ocean Physics Analysis and Forecast (NRT) (01.01.2021→01.06.2021)

daily zonal (u) and meridional (v) velocity at 50 available horizons on a grid with a resolution of 1/12°



Global Ocean Physics Reanalysis

GLOBAL_MULTIYEAR_PHY_001_030
Models
Global, 0.083° × 0.083° × 50 levels
1 Jan 1993 to 26 Mar 2024, daily, monthly
Temperature, salinity, sea surface height, velocity, mixed layer thickness, sea ice



Global Ocean Physics Analysis and Forecast

GLOBAL_ANALYSISFORECAST_P... 001_024
Models
Global, 0.083° × 0.083° × 50 levels
1 Jan 2019 to 11 Jul 2024, hourly, daily,...
Temperature, salinity, sea surface height, velocity, mixed layer thickness, wave, sea ice...

Data

- GOFS 3.1 (01.01.2021→01.06.2021)

daily zonal (u) and meridional (v) velocity at 40 available horizons on a grid with a resolution of 1/12°

HYBRID COORDINATE OCEAN MODEL

- JCOPE2M (01.01.2021→01.06.2021)

daily zonal (u) and meridional (v) velocity at 47 available horizons on a grid with a resolution of 1/12°

国立研究開発法人海洋研究開発機構
JAMSTEC
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Data

- ERA5 (01.01.2021→01.06.2021)

hourly 10m zonal (u10) and meridional (v10) components of wind speed and mean sea level pressure (msl), displayed on a grid with a spatial resolution of 1/4°

- META3.2 DT (01.01.1993→02.08.2021)

daily trajectories of long-lived (more than 10 days) mesoscale anticyclonic eddies

Methods

We obtain the flow velocity components normal to the strait axis by rotating the original coordinate system (x, y), where the x axis is directed to the east and the y axis to the north:

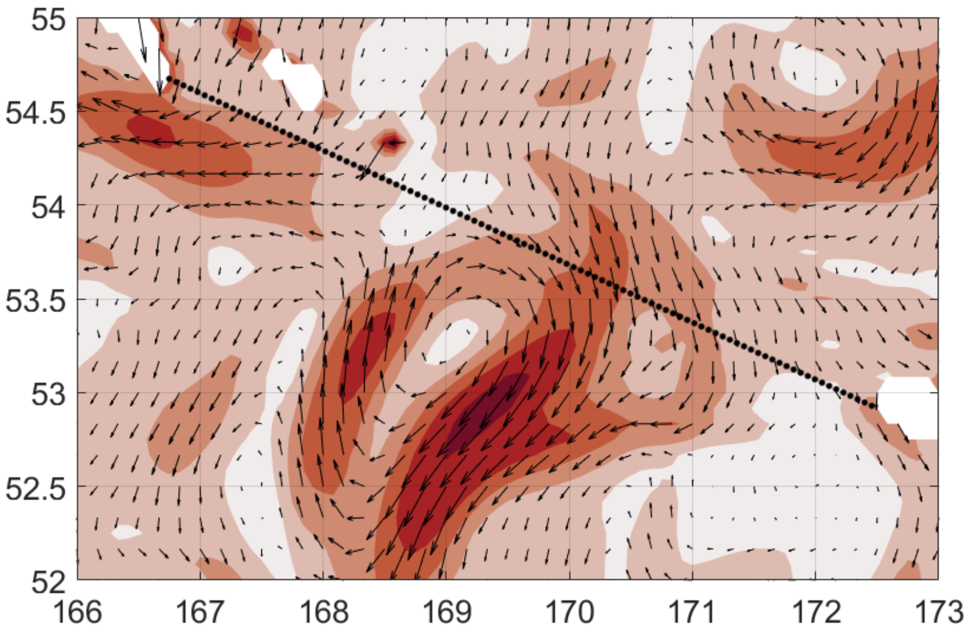
$$V = u \sin\theta + v \cos\theta$$

We get the **inflow** (Q+) and **outflow** (Q-):

$$Q_+ = \int_{x_1}^{x_2} \int_{z_0}^{z_b} V_+(x,z)\,dz\,dx$$

$$Q_- = \int_{x_1}^{x_2} \int_{z_0}^{z_b} V_-(x,z)\,dz\,dx$$

The equation for **volume transport** (Q): $Q = Q_+ - |Q_-|$



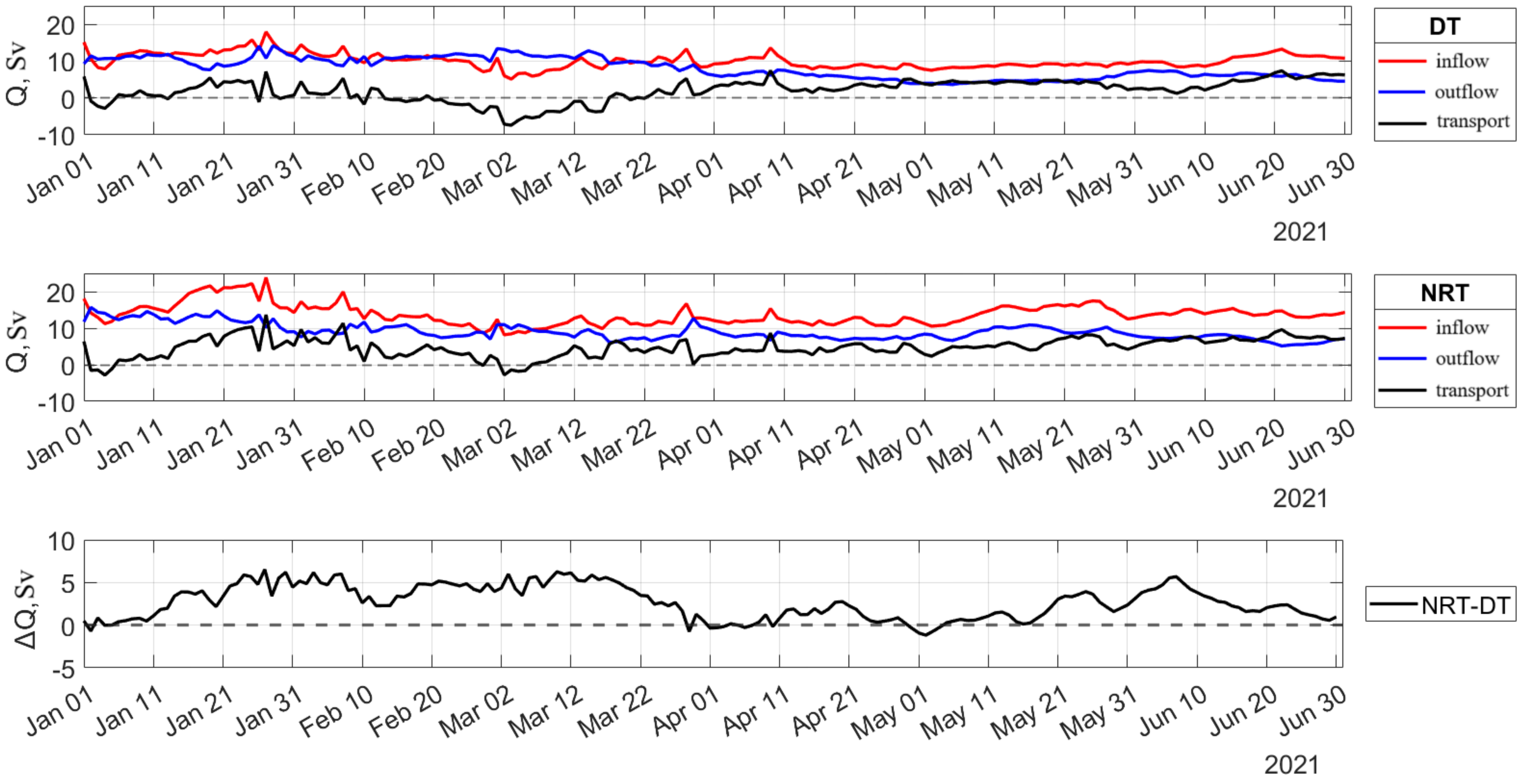
Estimated points on the Near Strait axis

Summing up the inflow and outflow, we get **water exchange** (F):

$$F = Q_+ + |Q_-|$$

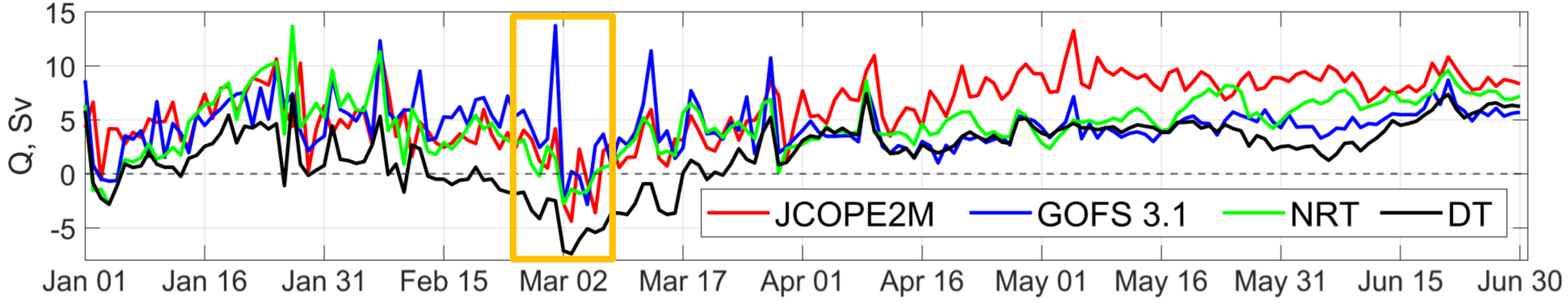
1 Sv = 10^6 m^3s^{-1}

CMEMS product comparison



Volume transport (Q), inflow (Q+) and outflow (Q-) through the Near Strait according to GLORYS12V1 (DT) and GLOBAL_ANALYSISFORECAST (NRT) for the period 01/01/2021 – 30/06/2021

Comparison of DT, NRT, JCOPE2M, GOFS 3.1 products

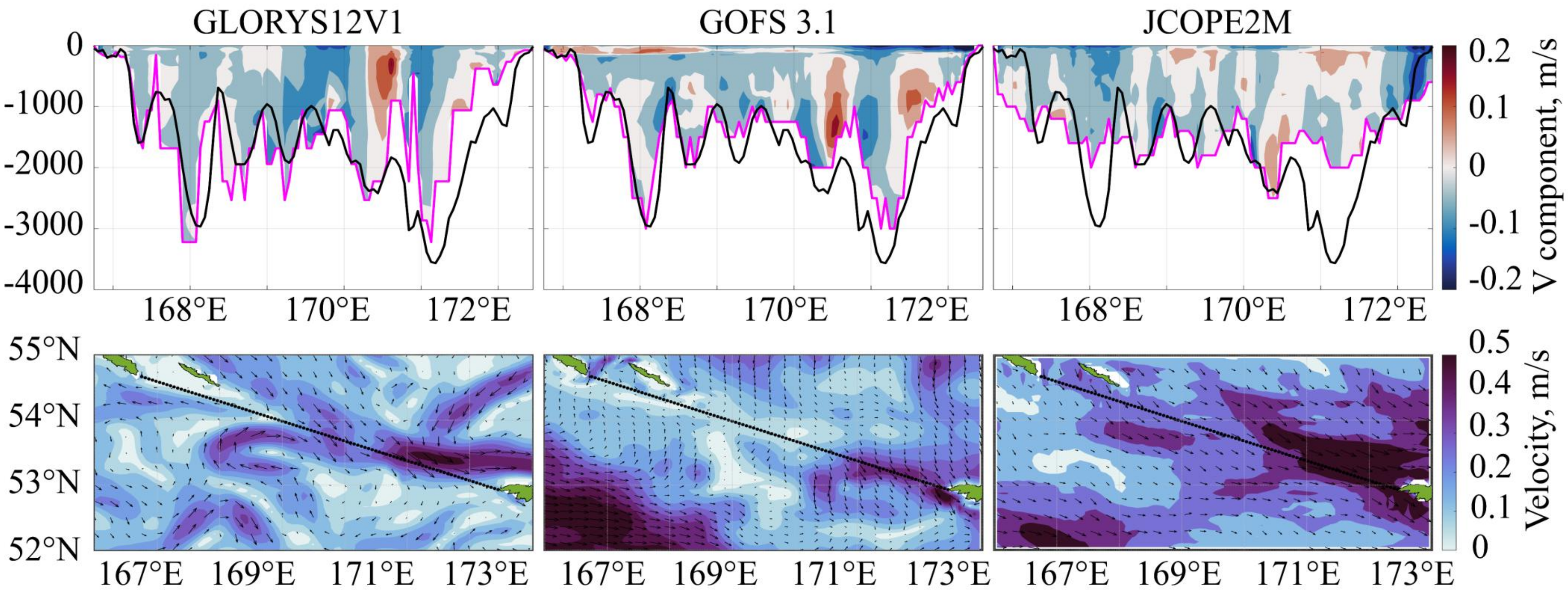


Volume transport (Q) through the Near Strait according to DT, NRT, JCOPE2M u GOFS 3.1 for the period 01/01/2021 – 30/06/2021

Volume transport (Q) and water exchange (F) through the Near Strait according to DT, NRT, JCOPE2M u GOFS 3.1, averaged over the period 01/01/2021 – 30/06/2021

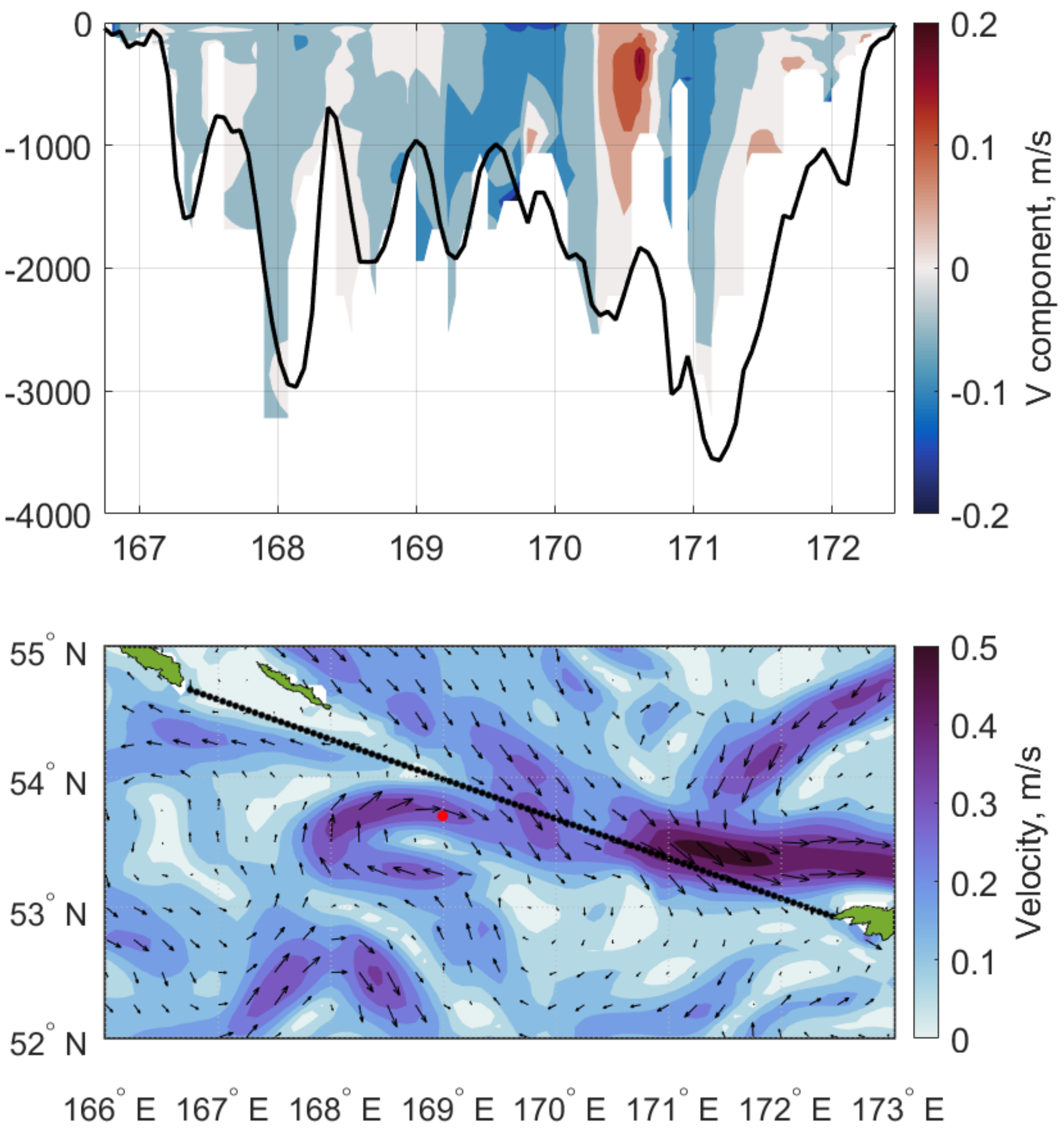
Parameter \ Dataset	DT	NRT	JCOPE2M	GOFS 3.1
Volume transport (*Q*), Sv	2.0	4.7	6.2	4.5
Water exchange (*F*), Sv	18.2	22.8	21.6	14.8

Comparison of DT, JCOPE2M, and GOFS 3.1 products

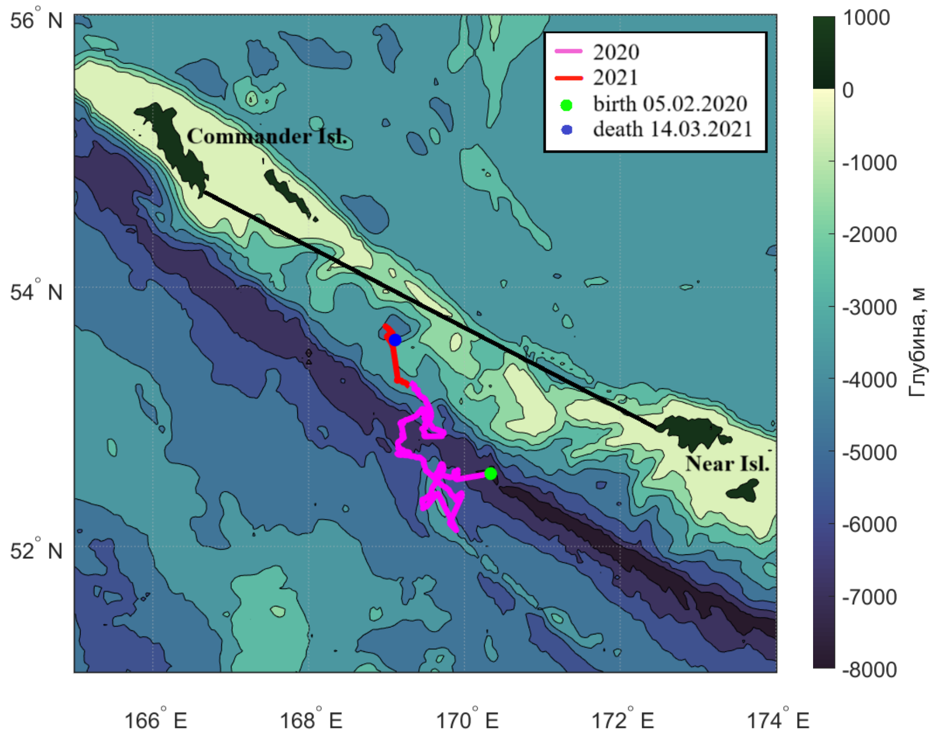


Vertical section of the normal velocity component (V) through the Near Strait (top) and the surface velocity modulus (bottom) according to GLORYS12V1 (DT), GOFS 3.1 and JCOPE2M, 02/03/2021. The black line indicates the bathymetry of GEBCO_2021

Episode of water outflow from the Bering Sea

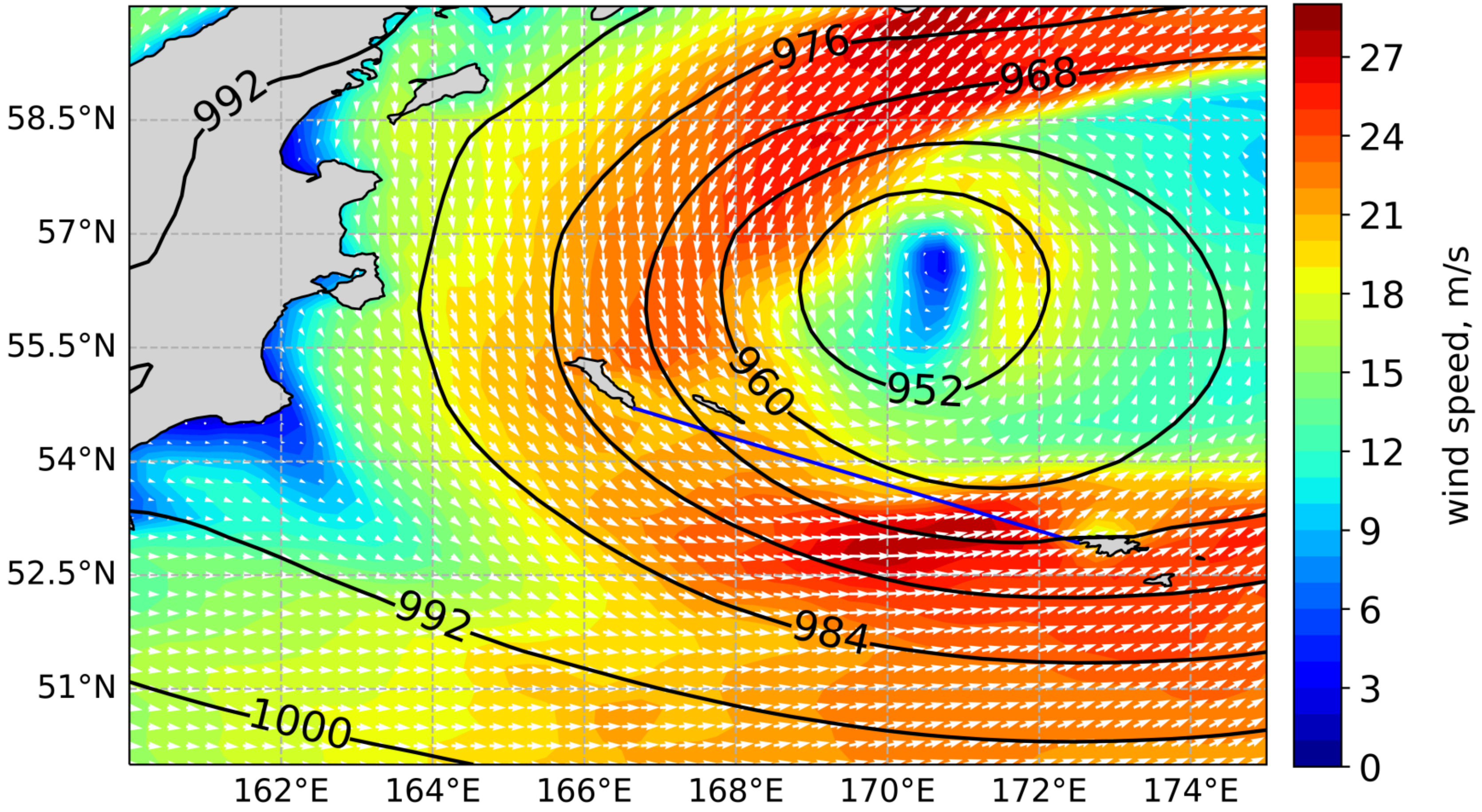


Vertical section of the normal velocity component (V) through the Near Strait (top) and the surface velocity modulus (bottom) according to DT data, 02/03/2021. A red dot marks the center of the eddy according to META3.2 DT data. The black line indicates the bathymetry of GEBCO_2021



Evolution of anticyclonic eddy No.750273 according to META3.2 DT data

Atmospheric circulation



Wind speed (in color) and direction (with white arrows), atmospheric pressure at sea level (with black lines) according to ERA5, 00:00 01/03/2021

Mechanisms of water outflow through the Near Strait

The largest outflow of water in the Near Strait (**-7.6 Sv, 02/03/2021**) over a 30-year period (according to DT data) could have been formed due to a number of factors:

- The turning of the North Aleutian slope current to the southeast
- The stagnation of a large anticyclone south of the strait axis
- The passage of a deep atmospheric cyclone over the Bering Sea

Publications

Khudyakova S.P., Belonenko T.V., Budyansky M.V., Uleysky M.Yu. Estimation of Volume, Heat and Salt Transport between the Bering Sea and the Pacific Ocean through the Near Strait. 2025 // Russian Journal of Earth Sciences [accepted for publication]

Khudyakova S.P., Belonenko T.V., Budyansky M.V., Uleysky M.Yu. Investigation of the volume transport variability through the Near Strait (Aleutian Islands) according to global ocean reanalyses. 2025 // Physical Oceanography [accepted for publication]

Conclusions

- The average volume transport for JCOPE2M turned out to be the highest among all the datasets considered and amounted to 6.2 Sv, the result for GOFS 3.1 (4.5 Sv) and NRT (4.7 Sv) is comparable. The volume transport according to the NRT data exceeds the corresponding values from the DT product with a difference of up to 5 Sv
- Despite the outflow episode the flow of waters from the Pacific Ocean to the Bering Sea (inflow) prevails for the Near Strait
- The mechanism of the water outflow from the Bering Sea through the Near Strait in March 2021 is described: the influence of an anticyclonic eddy, the strengthening of the jet of the North Aleutian slope current and the passage of a deep atmospheric cyclone over the water area is shown