Ocean Science

Supplement of

Structure and dynamics of mesoscale eddies over the Laptev Sea continental slope in the Arctic Ocean

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Supplementary materials

Introduction

The following supporting information includes text describing the wavelet-based method used for eddy identification and figures to illustrate uncertainties of the location of eddy sources due to differences in salinity and variability of the hydrography in the EB and vertical profiles of temperature, salinity, and potential density inside the core of typical cyclonic eddy originated over the Severnaya Zemlya slope.

S1 Description of the wavelet method of eddy identification

This section describes a semi-automated method of the identifying coherent eddies in mooring current records using rotational wavelet analysis. The variety of possible forms of coherent eddies evident in mooring records is very broad (Lilly and Rhines, 2002). Therefore, the process of identifying eddies in mooring observations may involves a substantial level of subjective judgment and the automated methods can only provide a "first-guess" insight on eddy-like structures. In the method applied here, we firstly decompose the MMP and ADCP velocities (U, V) at every level into a low-frequency ("mean") current (U_{mean}, V_{mean}), and rotational current anomalies (U_{rot}, V_{rot}), with a cut-off period of 30 days.

$$U_{rot}(t) = U(t) - U_{mean}(t), \tag{s1}$$

$$V_{rot}(t) = V(t) - V_{mean}(t). \tag{s2}$$

Further, we calculated complex rotational wavelet $W_t(\tau, a)$ of complex eddy velocities $U_{rot} + iV_{rot}$. The total wavelet transform of a time series of rotational velocities may be calculated as follows:

$$W_t(\tau, a) = \frac{1}{a^n} \int_{-\infty}^{\infty} (U_{rot}(t) + iV_{rot}(t)) \, g^* \left(\frac{t-\tau}{a} \right) d\tau, \tag{s3}$$

where n=1/2 is a normalization exponent; g(t) is a wavelet function; the asterisk denotes the complex conjugate.

By direct analogy with the rotational spectra, the complex-valued wavelet transform of (U_{rot}, V_{rot}) series contains four real valued transforms, which can be combined together into three different set of physically meaningless transform pairs (see Gonella, 1972). The separation of the wavelet transform into locally even (W_e) and locally odd (W_o) components can be obtained using the real and imaginary parts of the wavelet function:

$$W_e(\tau, a) = \frac{1}{a^n} \int_{-\infty}^{\infty} (U_{rot}(t) + iV_{rot}(t)) \, Re\{g^*((t-\tau)/a)\} d\tau, \tag{s4}$$

$$W_o(\tau, a) = \frac{1}{a^n} \int_{-\infty}^{\infty} (U_{rot}(t) + iV_{rot}(t))\, Im\{g^*((t\text{-}\tau)/a)\} d\tau, \qquad \text{(s5)}$$

where *Re and Im are* the real (cosine-like) and imaginary (sine-like) parts of the wavelet.

5   Following the approach suggested by Lilly et al. (2002), two consequent extrema of even wavelet transforms (W_e) — the real part of complex-valued wavelet transforms applied to complex-valued time series indicate the reversal direction of currents at the frontal and rear edges of the eddy. With the extrema of W_t between the pair of W_e extrema, that pattern serves as a robust "first-guess" indicator of coherent eddies advected through the mooring site. We note that, for example, in the case of a unidirectional increase of currents both the even and total components of the wavelet show the coherent peaks that match

10   in time, which make a distinguishing with the eddy-like pattern. Since the rotational components were derived by subtracting low-frequency velocities of eddy advection, this pattern is not sensitive to the direction of eddy translation through the mooring.
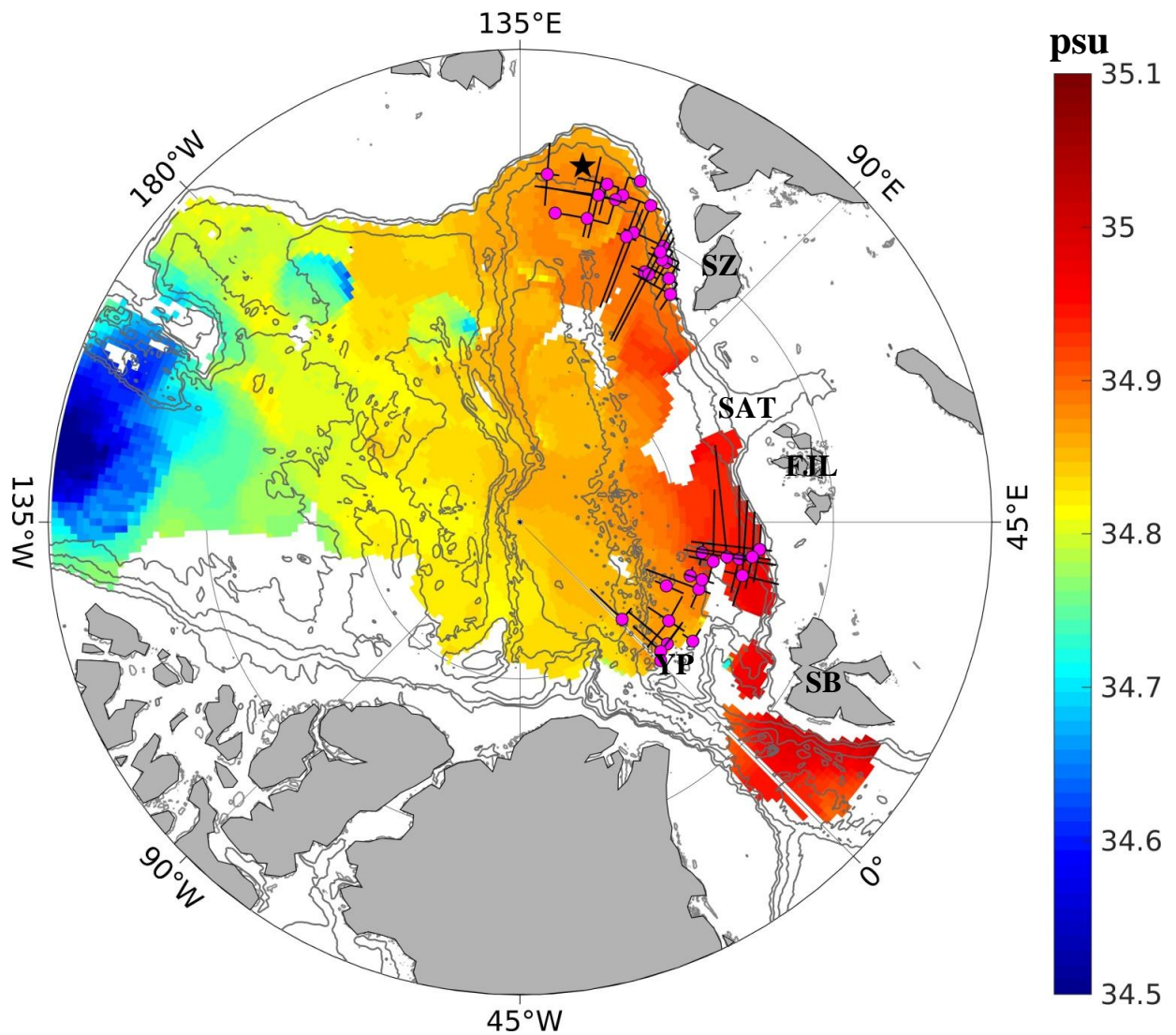
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Figure S1: Results of identification of eddy origins, using the M1f mooring record (2007-2011). Pink circles show the locations of climatological profiles with maximal temperature and salinity similarity, with profiles observed inside the eddy cores. Black star shows the M1f mooring position. Climatological salinity (psu, colorbar) for the 2000s averaged within 200-800 m layer is shown by color (white spots indicate no data). Black crosses with uneven crossbars at the center of each origin indicate estimated errors of eddy origin position using differences in climatological and in-situ salinities inside eddy cores (longer crossbars indicate larger eroor in the eddy origin position). Note that for some eddies, estimated errors are small and not distinguishable at this scale. Gray countours show isobaths. SB, YP, FJL, SAT, and SZ denote Spitsbergen, Yermak Plateu, Franz Joseph Land, St. Anna Trough, and Severnaya Zemlya, respectively.
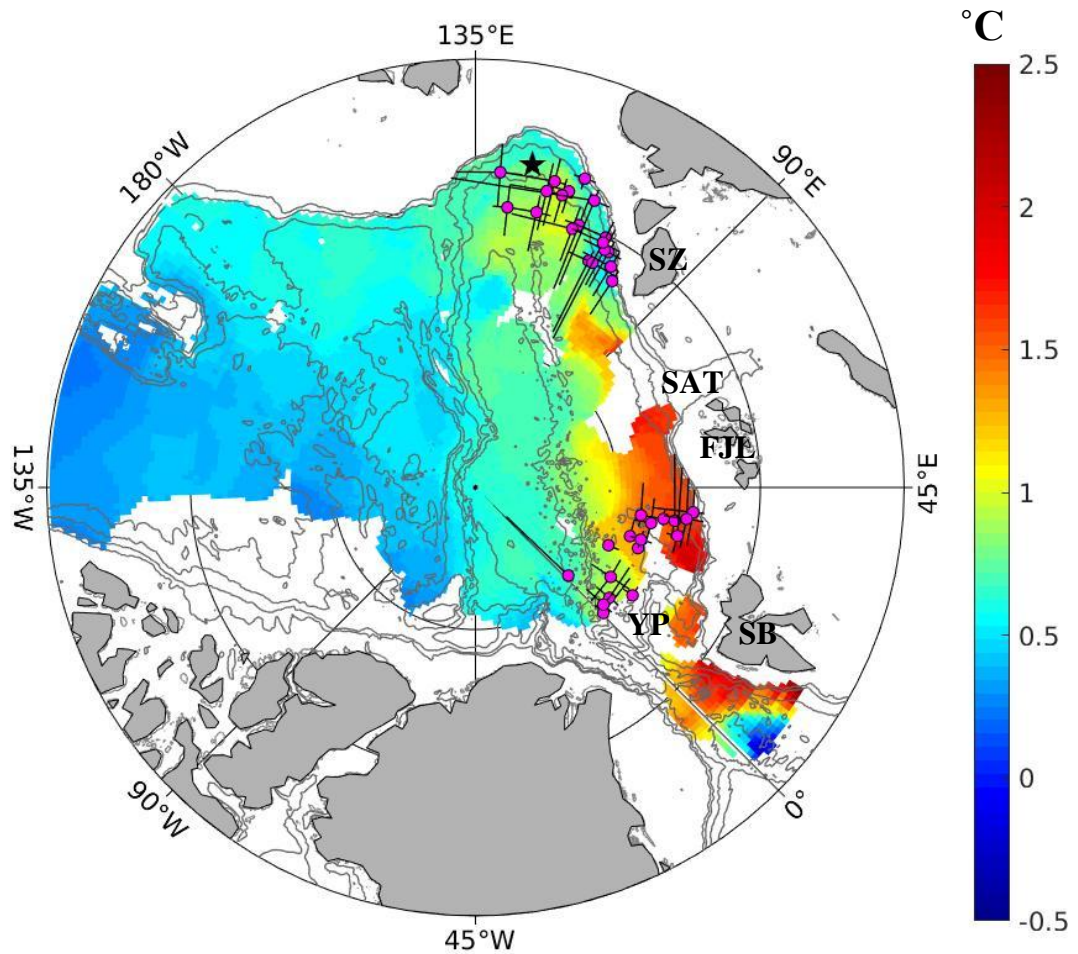
Figure S2: Results of identification of eddy origins, using the M1f mooring record (2007-2011). Pink circles show the locations of climatological profiles with maximal temperature and salinity similarity, with profiles observed inside the eddy cores. Black star shows the M1f mooring position. Climatological temperature (ºC, colorbar) for the 2000s averaged within 200-800 m layer is shown by color (white spots indicate no data). Black crosses with uneven crossbars at the center of each origin indicate errors of eddy origin position estimated using sdandard deviations of temperature at the climatology nodes (longer crossbars indicate larger eroor in the eddy origin position). Note that for some eddies, estimated errors are small and not distinguishable at this scale. Gray countours show isobaths. SB, YP, FJL, SAT, and SZ denote Spitsbergen, Yermak Plateu, Franz Joseph Land, St. Anna Trough, and Severnaya Zemlya, respectively.
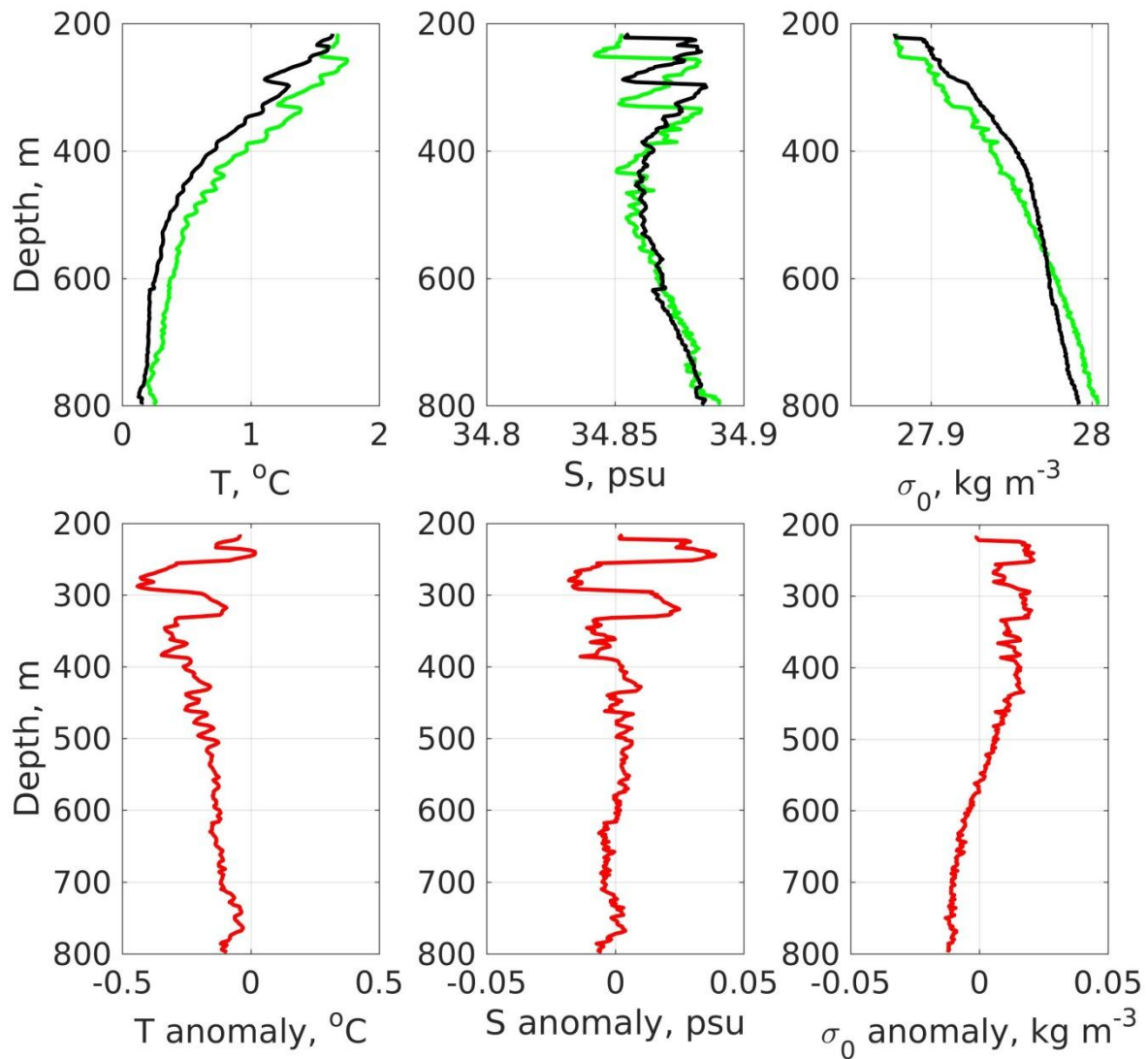
Figure S3: (black) Vertical profiles of temperature (T), salinity (S) and potential density (σ_0) and their anomalies (red lines) inside the core of typical cyclonic eddy originated over the Severnaya Zemlya slope and evident at M1f mooring in March-April 2009. Green lines represent hydrography profiles outside the cyclonic eddy. Anomalies were calculated by subtracting green profiles from the black one.