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Heat and Salt Transports by Mesoscale Eddies in the Lofoten Basin of the Norwegian Sea

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Introduction

We apply an automatic eddies' identification method to detect and track mesoscale eddies in the Lofoten Basin (LB) for the period 1993-2017. Then we exclude tracks of eddies with a lifetime of less than 35 days (99% eddies) in order to exclude the vortices associated with synoptic variability, as well as errors that could arise due to the small discreteness of satellite measurements in the study basin. Thus there were found only 120 CEs and 210 ACEs to study. All the tracks were divided onto 4 groups according to location of eddy genesis and dissipation:

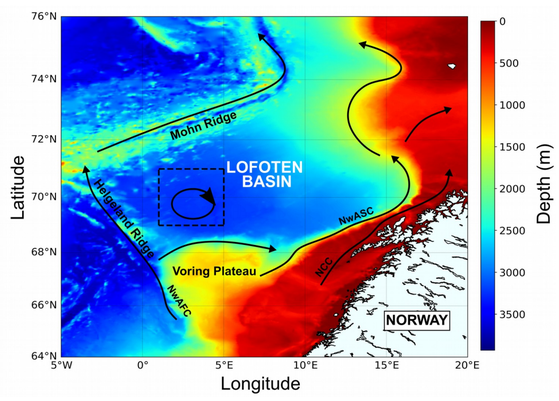

Figure 1. Bottom topography and general circulation of the study region. Area 1 – inside dotted line square (Lofoten Vortex). Area 2 - outside it.

Group 1 - Eddies born and dissipated in area 1; group 2 - Eddies born and dissipated in area 2; group 3 - Eddies born in area 2 and dissipated in area 1; group 4 - Eddies born in area 1 and dissipated in area 2. We focus mostly on the long-lived eddies in the LB and analyze the spatial variations in eddy temperature and salinity anomalies. The most interesting groups are the third and the fourth because they show heat and salt transport between the Lofoten Vortex and the Norway Current.

Materials and methods

- High resolution (0.25° x 0.25° grid) AVISO altimetry data of sea level anomalies for the 25 years from 1993 to 2017.
- GLORYS12V1 product of the Global Ocean Physics Reanalysis available at CMEMS (Copernicus Marine Environment Monitoring Services) with a horizontal resolution equals 1/12° and 50 standard levels in a vertical direction.
- An open-source code for automatic identification and tracking of eddies developed by Faghmous et al. (2015) on the altimetry data for the detection and tracking of mesoscale eddies.
- The borders of eddies were found on anomalies by the last closed isoline of temperature (figs. 4-5 a-b). In this case we considered the moment when at center of eddy according to altimetry data, there was a minimal (CEs) or maximal (Aes) value of temperature anomaly.
- Eddies' heat and salt contents (table 1) were calculated by these equations:

$$AT = \rho c_p \int \grave{T} dxdydz \qquad AS = \rho \int \grave{s} dxdydz$$

Results

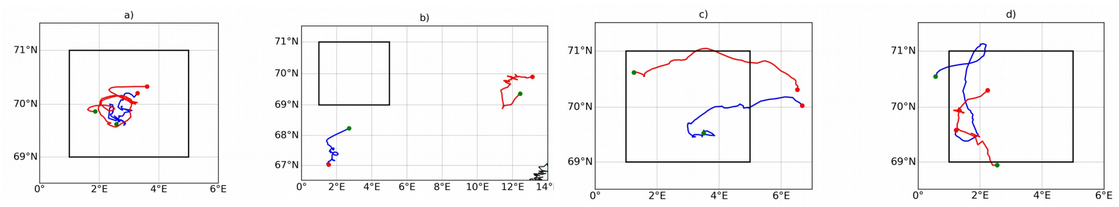

Figure 2. Tracks of analyzed long-lived eddies: (a) – Group 1, area 1, (b) – Group 2, area 2, (c) – Group 3 (d) – Group 4. Blue lines display the cyclonic and red lines the anticyclonic eddies. The red points exhibit location of eddies and the green points show location of their dissipation.

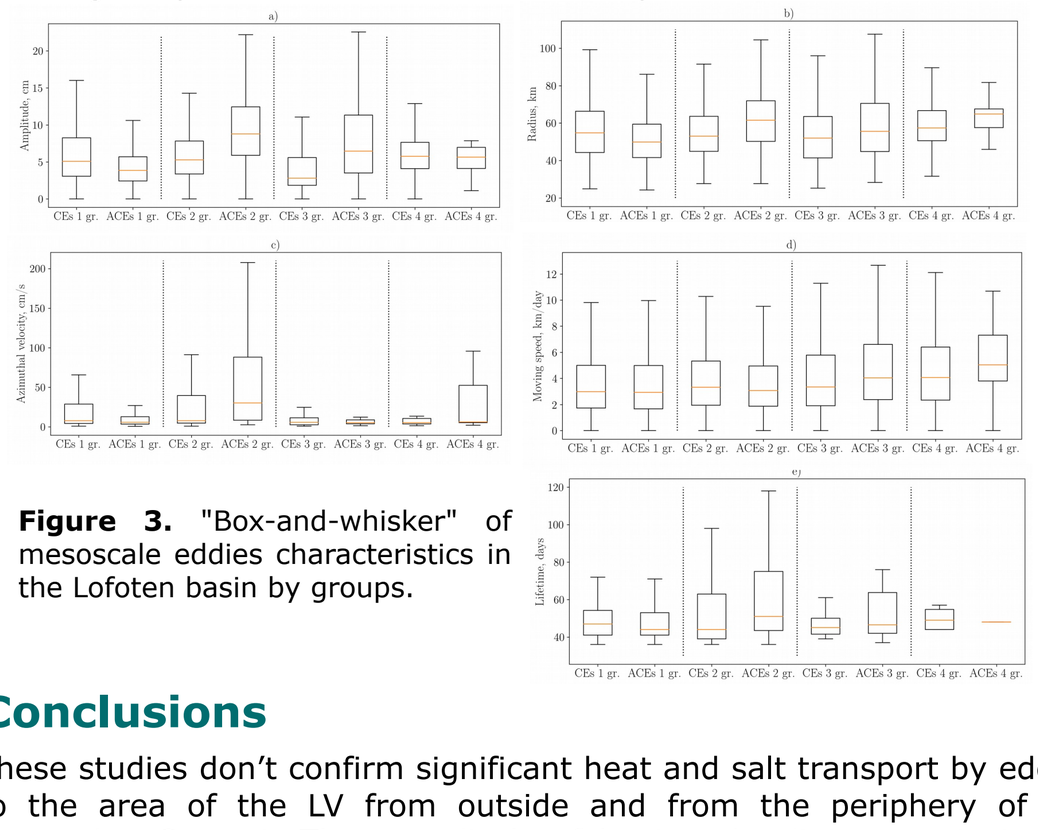

Figure 3. "Box-and-whisker" of mesoscale eddies characteristics in the Lofoten basin by groups.

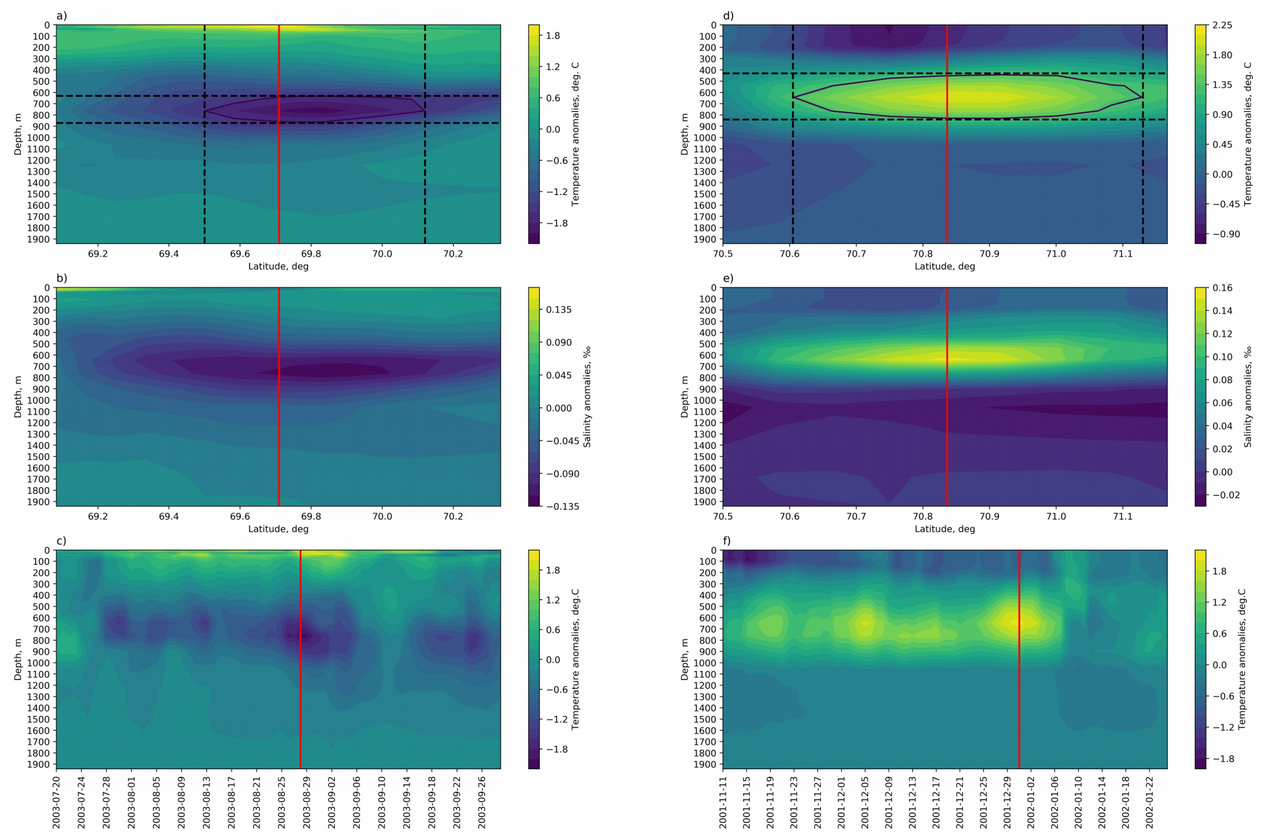

Figure 4. The cyclonic eddy (CE) (left) and the anticyclonic eddy (ACE) (right) for the Group 3: temperature anomalies (a), (d), salinity anomalies (b), (e), temporal variability of temperature anomalies for CE (c) and ACE (f). Red line shows the position of the eddy center according to altimetry data. Dashed lines indicate the eddy borders

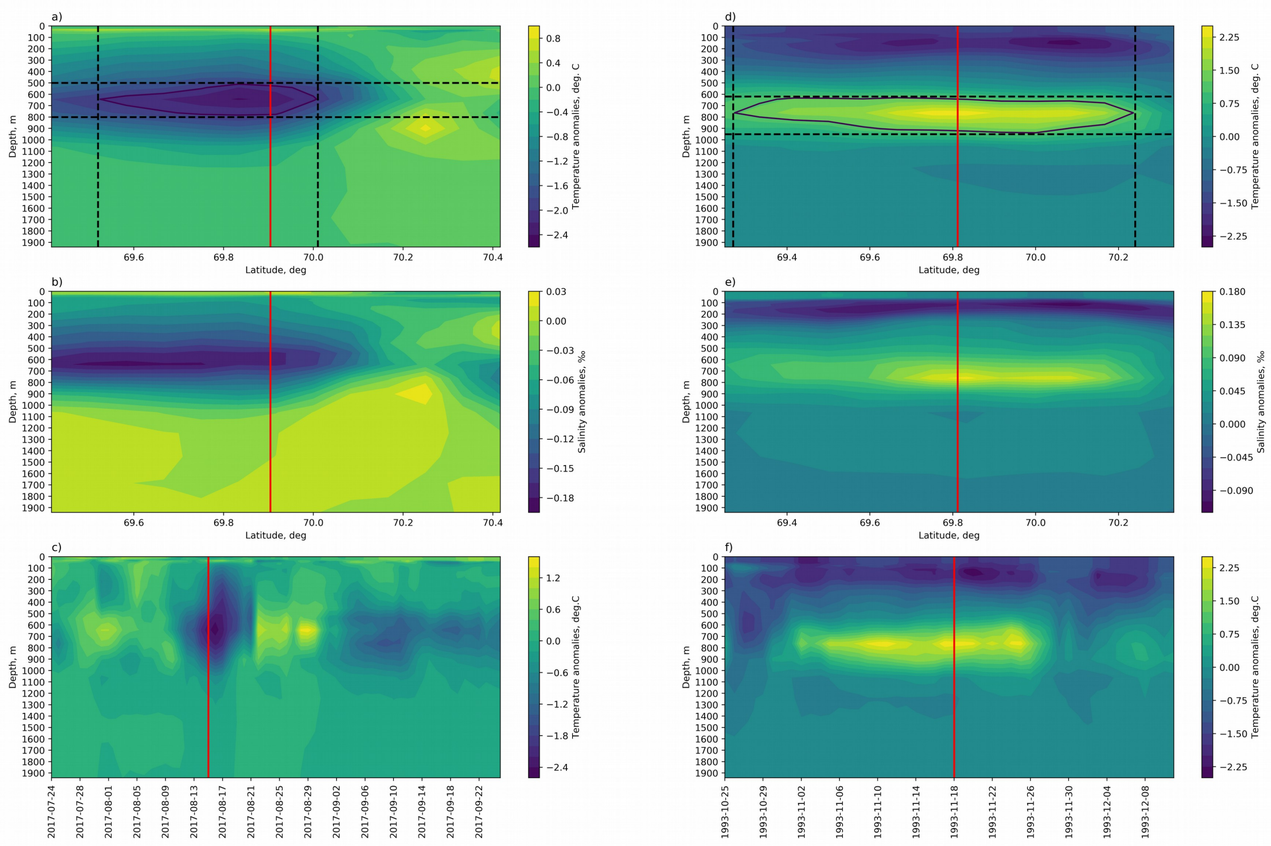

Figure 5. The cyclonic eddy (CE) (left) and the anticyclonic eddy (ACE) (right) for the Group 4: temperature anomalies (a), (d), salinity anomalies (b), (e), temporal variability of temperature anomalies for CE (c) and ACE (f). Red line shows the position of the eddy center according to altimetry data. Dashed lines indicate the eddy borders

Table 1
Thermohaline Contents and Associated Transports Integrated Over the Volume of the Long-lived Cyclonic and Anticyclonic Eddies

	Group 3		Group 4	
	CE	**ACE**	**CE**	**ACE**
Date of birth	2003-08-28	2001-12-31	2017-08-15	1993-11-18
Period of life, (days)	72	76	64	48
Thickness, (m)	260	410	300	340
Radius, (km)	34.41	29.14	26.92	53.83
Volume transport, (Sv)	0.10	0.32	0.43	2.18
AT, (J*10^{19})	-0.59	0.68	-0.6	1.76
AS, (kg*10^{11})	-0.95	1.07	-1.02	2.87
Heat transport, (W*10^{13})	-0.08	0.20	-0.37	1.3
Salt transport, (kg*s^{-1}*10^{5})	-0.13	0.32	-0.68	2.05
Total heat transport, (W*10^{13})	0.88	1.6	-1.48	1.3
Total salt transport, (kg*s^{-1}*10^{5})	-1.43	2.56	-2.72	2.05
Annual heat transport, (W*10^{12})	0.35	0.64	-0.59	0.52
Annual salt transport, (kg*s^{-1}*10^{4})	-0.57	1.02	-1.09	0.82

Conclusions

These studies don't confirm significant heat and salt transport by eddies to the area of the LV from outside and from the periphery of the Norwegian Current. The magnitude of heat and salt transports to the area of the LV from outside is estimated to be 0.9*10^{13} W and 1.8*10^{5} kg*s^{-1}, respectively. Annual average means are 3.6*10^{11} W for the heat and 7.2*10^{3} kg*s^{-1} for the salt transports.