Geosistemy perehodnykh zon = Geosystems of Transition Zones / Геосистемы переходных зон

2025, vol. 9, No. 2, pp. 145–163
http://journal.imgg.ru/archive.htm; https://elibrary.ru/title_about.asp?id=64191
https://doi.org/10.30730/gtrz.2025.9.2.145-163; https://elibrary.ru/vnnhjw

Impact of latitudinal position and ice cover on wave and temperature dynamics in the Laptev Sea and the Sea of Okhotsk

Kovalev, Dmitry P. (https://orcid.org/0000-0002-5184-2350), d.kovalev@imgg.ru
Kovalev, Peter D. (https://orcid.org/0000-0002-7509-4107), p.kovalev@imgg.ru
Borisov, Aleksander S. (https://orcid.org/0000-0002-9026-4258), a.borisov@imgg.ru
Zarochintsev, Vitaly S. (https://orcid.org/0000-0002-4015-9441), zarochintsev@imgg.ru
Kirillov, Konstantin V. (https://orcid.org/0000-0002-0822-3060), k.kirillov@imgg.ru

Institute of Marine Geology and Geophysics of the Far Eastern Branch of RAS, Yuzhno-Sakhalinsk, Russia

Abstract PDF RUS PDF ENG Full text PDF RUS

Abstract. This study presents a comparative analysis of wave and temperature conditions in the Laptev Sea and the Sea of Okhotsk (Mordvinov Bay), based on long-term observations of the sea level and temperature fluctuations, which were obtained using autonomous recorders ARV-14 and RBR. In the Laptev Sea, the gauge was placed at 75.20° N, near the critical latitude of 74.5°, resulting in the amplification of the semidiurnal M_2 tidal harmonic. The Sea of Okhotsk, on the contrary, is dominated by diurnal tides, which determine primary sea level oscillations. Spectral analysis of low-frequency temperature fluctuations (30 min to 24 h) revealed that in November, the spectra in both seas are similar in shape but differ by two orders of magnitude in amplitude, while in February, they become comparable in amplitude due to the influence of ice cover. A spectral peak at a 12.4-hour period, attributed to the critical latitude effect, was identified in the Laptev Sea but not in the Sea of Okhotsk. Short-period oscillations of sea level and temperature (12 s to 120 min) were largely absent in the Laptev Sea under solid ice conditions, enabling identification of the periods of solid ice coverage. In the Sea of Okhotsk, spectral peaks at periods of 22.7 and 29.2 min were observed, associated with the edge wave activity, while pronounced spectral variability in February was linked to the formation of cracks and polynyas. The attenuation of short waves (12 s to 3 min in the Laptev Sea and 12–20 s in the Sea of Okhotsk) was found to depend on ice thickness: in the Sea of Okhotsk, the attenuation increases throughout the winter, whereas in the Laptev Sea, it may either intensify or weaken. During the period of solid ice cover (January to March), spectral densities of temperature fluctuations in the 12–50 s range exhibited broadband noise characteristics, hindering their quantitative comparison. The identified differences and similarities in wave and temperature characteristics reflect the combined effects of latitude, tidal forcing, and ice conditions on the dynamics of the marine environment, which is crucial for understanding dynamics in Arctic and Subarctic seas.

Keywords:
Laptev Sea, Sea of Okhotsk, critical latitude, ice cover, surface and internal waves, tidal and edge waves, sea level and temperature fluctuations, spectral analysis

For citation: Kovalev D.P., Kovalev P.D., Borisov A.S., Zarochintsev V.S., Kirillov K.V. Impact of latitudinal position and ice cover on wave and temperature dynamics in the Laptev Sea and the Sea of Okhotsk. *Geosistemy perehodnykh zon = Geosystems of Transition Zones*, 2025, vol. 9, No. 2, pp. 145–163. (In Russ., abstr. in Engl.). https://doi.org/10.30730/gtrz.2025.9.2.145-163; https://elibrary.ru/vnnhjw

Для цитирования: Ковалев Д.П., Ковалев П.Д., Борисов А.С., Зарочинцев В.С., Кириллов К.В. Влияние широтного положения и ледового покрова на волновые и температурные процессы в морях Лаптевых и Охотском. *Геосистемы переходных зон*, 2025, т. 9, № 2, с. 145–163. https://doi.org/10.30730/gtrz.2025.9.2.145-163; https://elibrary.ru/vnnhjw

References

1. Yuan Y., Lei R., Liu L., Cheng B., Heil P., Cheng X., Wang Y., Tian-Kunze X., Zhan Z., Zhang Y. **2023**. Enhancing sea ice inertial oscillations in the Arctic Ocean between 1979 and 2019. *Water*, 15(1), 152. https://doi.org/10.3390/w15010152
2. Zhang L., Li Y., Xie J., Lin Y., Guo Y., Fu L., Chen L., Wang J., Song X. **2023**. Spatial and seasonal variations of near-inertial kinetic energy in the Ross Sea. *Frontiers in Marine Science,* 10, 1173900. https://doi.org/10.3389/fmars.2023.1173900
3. Shen X., Yu X., Zhang Y., Wang J., Wang D. **2023**. Near-inertial wave propagation in the deep Canadian Basin. *Journal of Geophysical Research: Oceans*, 128(5), e2023JC020228. https://doi.org/10.1029/2023JC020228
4. Konyaev K.V., Sabinin K.D. **1992.** [*Waves inside the ocean*]. St. Petersburg: Gidrometeoizdat, 272 p.

5. Dobrovolsky A.D., Zalogin B.S. **1982.** *Seas of the USSR*. Moscow: Moscow University Press, 192 p.
6. Rippeth T.P., Lincoln B.J., Lenn Y.-D., Mattias Green J.A., Sundfjord A., Bacon S. **2015.** Tide-mediated warming of Arctic halocline by Atlantic heat fluxes over rough topography. *Nature Geoscience*, 8: 191–194. doi:10.1038/ngeo2350
7. Krumpen T., Hölemann J.A., Willmes S., Morales Maqueda M.A., Busche T., Dmitrenko I.A., Gerdes R., Haas C., Heinemann G., Hendricks S., Kassens H., Rabenstein L., Schröder D. **2011.** Sea ice production and water mass modification in the eastern Laptev Sea. *Journal of Geophysical Research*, 116, C05014. doi:10.1029/2010JC006545
8. Nekrasov A.V. **1990.** *Energy of ocean tides*. Leningrad: Gidrometeoizdat, 288 p.
9. Parker B.B. **2007.** *Tidal analysis and prediction*. Maryland: Silver Spring, 378 p. http://dx.doi.org/10.25607/OBP-191
10. Furevik T., Foldvik A. **1996.** Stability at M2 critical latitude in the Barents Sea. *Journal of Geophysical Research: Oceans*, 101(C4): 8823–8838. https://doi.org/10.1029/96jc00081
11. Kjersti L., Daae K.L., Fer I., Abrahamsen E.P. **2009.** Mixing on the continental slope of the southern Weddell Sea. *Journal of Geophysical Research*, 114, C09018. doi:10.1029/2008JC005259
12. Lappo S.S. **1979.** [*Medium-scale dynamic processes of the ocean excited by the atmosphere*]. Moscow: Nauka, 179 p.
13. Daae K.L., Fer I., Abrahamsen E.P. **2009.** Mixing on the continental slope of the southern Weddell Sea. *Journal of Geophysical Research: Oceans*, 114, C09018. doi:10.1029/2008JC005259
14. Bai X., Liu Z., Li X., Chen Z., Hu J., Sun Z, Zhu J. **2013.** Observations of high-frequency internal waves in the Southern Taiwan Strait. *Journal of Coastal Research*, 29(6): 1413–1419. https://doi.org/10.2112/jcoastres-d-12-00141.1
15. Colosi J.A., Beardsley R.C., Lynch J.F., Gawarkiewicz G., Chiu C.S., Scotti A. **2001.** Observations of nonlinear internal waves on the outer New England continental shelf during the summer Shelf Break Primer study. *Journal of Geophysical Research: Oceans*, 106(C5): 9587–9601. https://doi.org/10.1029/2000jc900124
16. Duda T.F., Lynch J.F., Irish J.D., Beardsley R.C., Ramp S.R., Chiu C.S., Tang T.Y., Yang Y.J. **2004.** Internal tide and nonlinear internal wave behavior at the continental slope in the northern South China Sea. *IEEE Journal of Oceanic Engineering*, 29(4): 1105–1130. https://doi.org/10.1109/joe.2004.836998
17. Lee C.-Y., Beardsley R.C. **1974.** Generation of long nonlinear internal waves in a weakly stratified shear-flow. *Journal of Geophysical Research*, 79(3): 453–462. https://doi.org/10.1029/jc079i003p00453
18. Squire V.A., Kovalev D.P., Kovalev P.D., Medvedev I.P., Kulikov M.E. **2021.** A cornucopia of oscillations on the Laptev Sea shelf. *Continental Shelf Research*, 227(2021), 104514. https://doi.org/10.1016/j.csr.2021.104514
19. Zakharchuk E.A. **1999.** Internal waves in the Laptev Sea. In: *Land-Ocean systems in the Siberian Arctic. Dynamics and history*. Berlin: Springer-Verlag, p. 43–51. https://doi.org/10.1007/978-3-642-60134-7_5
20. Darelius E., Smedsrud L.H., Osterhus S., Foldvik A., Gammelsrod T. **2009.** Structure and variability of the Filchner overflow plume. *Tellus A: Dynamic Meteorology and Oceanography*, 61(3): 446–464. https://doi.org/10.3402/tellusa.v61i3.15559
21. Levine M.D., Paulson C.A., Morison J.H. **1985.** Internal waves in the Arctic Ocean – Comparison with lower-latitude observations. *Journal of Physical Oceanography*, 15: 800–809. doi:10.1175/1520-0485(1985)015
22. Garrett C., Munk W. **1972.** Oceanic mixing by breaking internal waves. *Deep Sea Research and Oceanographic Abstracts*, 19(12): 823–832. https://doi.org/10.1016/0011-7471(72)90001-0
23. Garrett C., Munk W. **1975.** Space-time scales of internal waves: A progress report. *Journal of Geophysical Research*, 80: 291–297. https://doi.org/10.1029/jc080i003p00291
24. Kowalik Z., Proshutinsky A.Y. **1994.** The Arctic Ocean tides. In: *The Polar Oceans and their role in shaping the global environment: Geophysical Monograph*, 85: 137–158.
25. Dolgikh G.I., Kovalev P.D., Kovalev D.P., Kirillov K.V. **2018.** Peculiarities of waves in fast ice in the Southwestern Sea of Okhotsk. *Doklady Earth Sciences*, 481: 1073–1078. https://doi.org/10.1134/s1028334x18080123
26. Wadhams P. **1973.** Attenuation of swell by sea ice. *Journal of Geophysical Research*, 78(18): 3552–3563. https://doi.org/10.1029/jc078i018p03552
27. Mellor M. **1983.** *Mechanical behavior of sea ice*. Cold Regions Research and Engineering Laboratory Monograph, 83(1). 105 p.