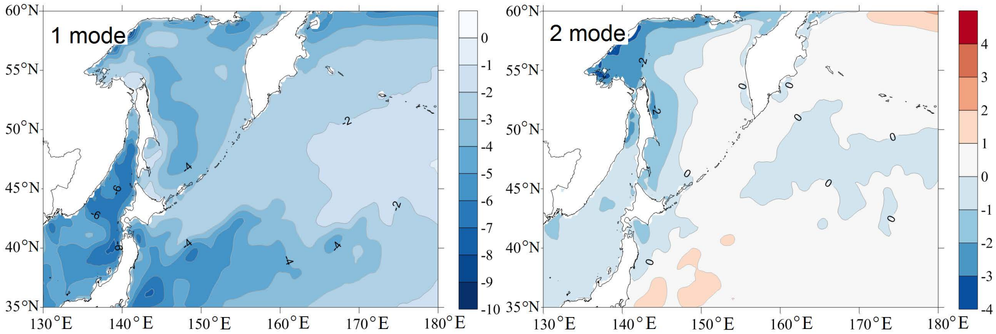
F i g. 3. Spatial distributions of the *LHF* linear trend coefficients in different seasons of a year

Decomposition of LHF in terms of EOF. The EOF decomposition method is often used for a detailed study of the spatial and temporal variability of hydrometeorological fields [8]. Fig. 4 shows the spatial functions of the first two modes of decomposition of the sequence of the LHF time layers using this method. The first mode is the main one accounting for 94.5% of the total variance of the parameter. Its spatial distribution (all values are negative, assumed to be dimensionless) is quite simple; values of ~ −5 are noted in vast areas of the northeastern part of the Northwest Pacific Ocean, in the Bering Sea, in the eastern and central parts of the Sea of Okhotsk. In the north-west of the latter, the smallest absolute values from −2 to −3 were identified and the highest ones were noted in the Sea of Japan off the western coast of Japan (from −10 to −12) and in the south of the considered part of the Northwest Pacific Ocean (up to −20 at Honshu eastern coast).

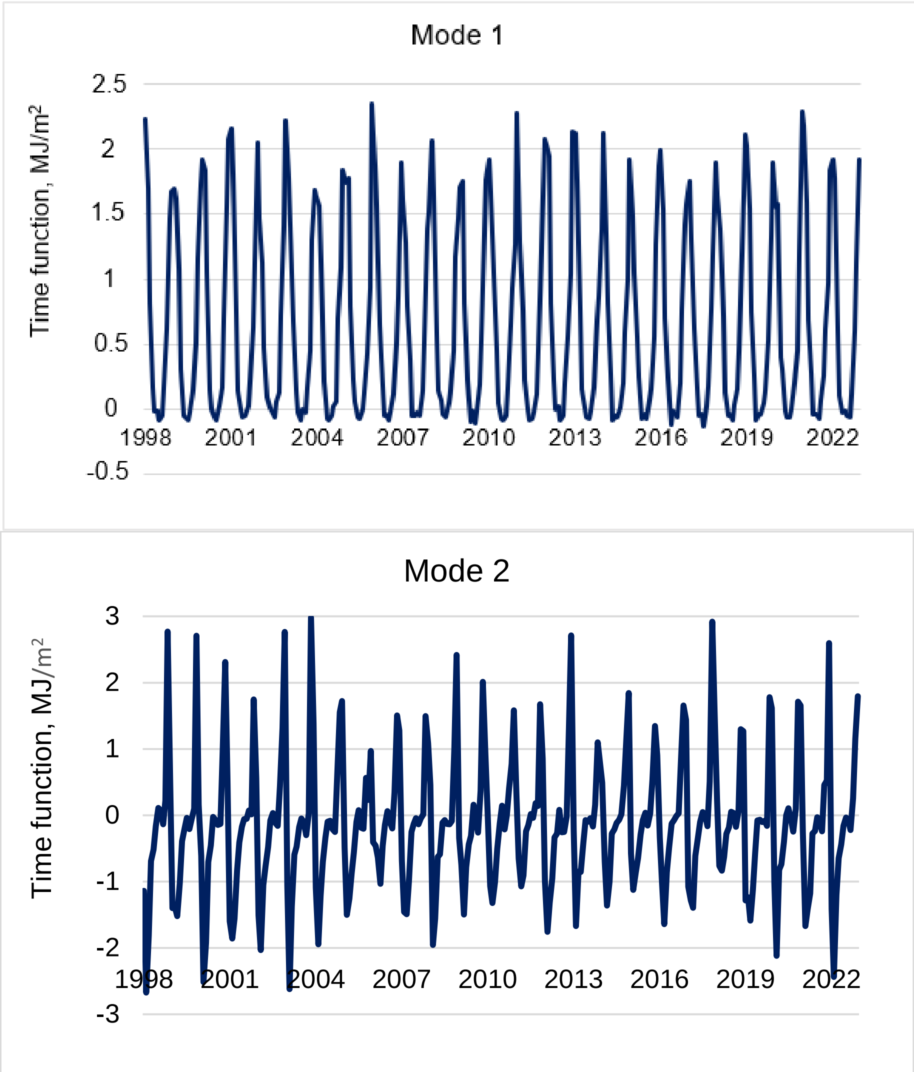


F i g. 4. Spatial distribution of the first two modes of decomposition of a sequence of the *LHF* time layers using EOF (dimensionless)

The time function of the main mode (Fig. 5) has a pronounced annual variation with maximum values in December and January (a little more and a little less than 1.5 MJ/m^2) and minimum values in July and June (about 0.2 MJ/m^2). It is well described by the annual cycle with an amplitude of 0.7 MJ/m^2 and a phase of 334° which corresponds to the above noted maximum in December. It is characterized by low-frequency modulation, most pronounced for winter maxima, with a period of about 6 years. The highest function values in December 2020 (1.84 MJ/m^2) and 2005 (1.79 MJ/m^2) stand out noticeably.

In general, the spatial distribution and temporal function of this mode reveal the most general patterns of the LHF distribution: the presence of areas with the most intense evaporation in the cold season in the zones of influence of the warm Kuroshio and Tsushima Currents and low LHF values in the northern part of the region under study including in frozen areas.

The distribution of the spatial function of the second mode (it accounts for 1.4% of the LHF dispersion) is significantly more complex. It characterizes the parameter variations that are not in phase, which are described by the first mode discussed above. Therefore, it has a nodal line dividing zones with the opposite sign. The area with positive values occupies part of the Northwest Pacific Ocean south of the 45°N parallel with maxima near the Honshu eastern coast (~ 2). Positive values of the function were also revealed in the eastern part of the considered area of the Bering Sea and in a narrow strip near the Middle Kuril Islands. In the rest of the Northwest Pacific Ocean (north of the 45th parallel) and in the waters of the Far Eastern seas, the spatial function is negative, the maximum absolute values are noted in the western part of the Sea of Okhotsk and in the Sea of Japan (from −1 to −2), extreme values are found in a small area off the Hokkaido southern coast (~ −3).



F i g. 5. Variations in time functions of the first (*top*) and second (*bottom*) modes of decomposition of a sequence of the *LHF* time layers using EOF

The time function of this mode is described by a combination of annual and semi-annual cycles with amplitudes of about 1 and 0.4 MJ/m^2. The average annual variation of this function is characterized by maximum values in November (1.3 MJ/m^2) and October (1.1 MJ/m^2) and minimum values in April and May (−1.1 MJ/m^2). This means that in autumn the second mode provides a positive correction to the main component in the southern part of the region under study and a negative correction in the northern and especially in its northwestern sections. In spring, the contribution of this opposite nature mode is observed. The interannual variability of the time function of the second mode is more significant compared to the first one and is not regular.

Conclusion

The analysis of an array of average monthly LHF values for 1998–2022 showed the following characteristics of the spatial and temporal variability of this parameter.

The LHF values are universally negative and reach their highest absolute values in the zone of influence of the warm Kuroshio and Tsushima Currents in the cold season (autumn and winter). This is determined by the influence of the winter monsoon characterized by stable and strong winds from the northwest and close to it carrying cold dry air from the mainland. The latent heat flux is insignificant in the northern part of the study area, including in frozen areas.

During the warm period in zones of warm currents, the LHF values decrease significantly in absolute value, which is probably determined by the summer monsoon winds, which are characterized by relatively low speeds and high humidity of the air flow. At the same time, the latent heat flux is positive in a number of areas, although small in magnitude. This indicates the important role of condensation in areas of high cloudiness and in zones of quasi-stationary upwelling.

Calculation of the annual cycle amplitudes showed the greatest range of seasonal variations in the zone of warm currents and its sharp decrease in the northern part of the Northwest Pacific Ocean and the Sea of Okhotsk, as well as in the Bering Sea. This component with an amplitude of 0.7 MJ/m^2 and with high values in December and January (about 1.5 MJ/m^2) and minimum values in July and June (0.2 MJ/m^2) plays a major role in variations in the time function of the EOF main mode. Interannual variations are expressed in quasi-cyclic changes in the envelope along maximum values with a period of about 6 years. Unidirectional trends in interannual LHF variations are weakly expressed.

The results obtained can be used to study the variability of thermal conditions in the surface layer of the Northwest Pacific Ocean and the Far Eastern seas to improve forecasts of the timing and conditions of feeding and spawning migrations of Pacific salmon, as well as other species of pelagic fish.

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The authors have read and approved the final manuscript.
The authors declare that they have no conflict of interest.