SPECTRA OF HUMIDITY PULSATIONS OVER THE MEDITERRANEAN SEA

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Abstract

Full Text

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GEOPHYSICS

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SPECTRA OF HUMIDITY PULSATIONS OVER THE MEDITERRANEAN SEA

(Presented by Academician V. V. Shuleikin on 6 II 1970)

Measurements of humidity in the lowest layers above water were first carried out by V. V. Shuleikin using an Assmann psychrometer and a thermopair probe-psychrometer (*1*). Low-inertia quartz adsorption humidity sensors (*3*) make it possible to measure not only its mean values, but also to investigate pulsations. An attempt to study humidity pulsations over the sea with a sensor of this type was made by us during the First Soviet-French expedition, conducted in the Mediterranean Sea in the summer of 1969 aboard the research vessel *Mikhail Lomonosov*, belonging to the Marine Hydrophysical Institute of the Academy of Sciences of the Ukrainian SSR.

A simplified block diagram of the measuring installation with which the measurements were carried out is shown in Fig. 1. Here A is a transistor radio-frequency generator using quartz; the surface of the quartz resonator is coated with a thin layer of an adsorbent for water vapor; B is a second quartz generator, the surface of the quartz of this generator having no special coating, and the oscillation frequency of generator B being somewhat higher than the oscillation frequency of generator A; 1 is a mixer of the voltages supplied by generators A and B; at the output of the mixer there is a difference frequency proportional to the air humidity; 2 is a transistor amplifier of the difference frequency; 3 is an emitter follower ensuring transmission of signals by cable over a distance of more than 250 m; Pr is a converter of the sensor frequency into voltage; $EDVM$ is the *Dnepr* digital electronic computer.

Fig. 1. Block diagram of the measuring installation used to study humidity pulsations in the First Soviet-French expedition in the Mediterranean Sea

Fig. 2. Energy spectra of humidity fluctuations obtained in various experiments

Figure 2: Fig. 2. Energy spectra of humidity fluctuations obtained in various experiments

Generators A and B, as well as elements 1, 2, and 3, form the humidity sensor. Its dimensions are $125 \times 90 \times 40$ mm (without the quartz resonators), and its time constant is of the order of 0.1 sec.

The principal conditions under which the measurements of humidity pulsations were performed during the expedition are given in Table 1.

In Fig. 2A are shown the energy spectra of humidity fluctuations obtained in experiments 1, 2, and 3. The spectra of humidity fluctuations in experiments 1 and 2 do not obey the $-5/3$ law; the spectral density in these spectra falls off much more rapidly, the attenuation exponent being about -3. Apparently, in experiments 1 and 2 the influence of the ship' s hull is strongly felt. Therefore the subsequent measurements were moved to the bow boom of the ship. The boom is a tubular truss that makes it possible to carry the sensor 5 m forward of the ship' s bow, thereby ensuring measurements with smaller distortions. The spectrum obtained in experiment 3 on the bow boom agrees well with the $-5/3$ law over most of its range.

In the spectrum of experiment 3 there is a sharp peak at a frequency of about 0.6 Hz. It is interesting to note that analogous peaks also occur in experiments 1 and 2 on the gunwale and near it. Experiments 1, 2, and 3 were carried out at different times and under different conditions. The presence of these spikes indicates some common mechanism of their generation.

Experiments 4, 5, and 6 were also carried out on the bow boom. In all these experiments, with the exception of experiment 4, the wind speed was measured with a hand Fuss anemometer. The wind measurement was performed on

Fig. 2. Energy spectra of humidity fluctuations obtained in various experiments

the deck of the vessel, approximately 6 m from the place where the humidity-fluctuation sensor was installed. In Fig. 2B the spectra of humidity fluctuations obtained in experiments 4, 5, and 6 are presented. All of them agree well with the law $-5/3$. For comparison, in this figure, as well as in Fig. 2A, inclined straight lines corresponding to the law $-5/3$ are shown. On all curves, in the frequency range above 1.5–20 Hz, there is considerable noise from the measuring system.

Table 1

Conditions for measuring humidity fluctuations

Experiment no.	Date	Sensor installation location	Time	Sampling frequency, EDVM, Hz	Horizontal wind speed, m/sec	Number of readings	Sea state, points
1	30 VI	Gunwale of the vessel	18 h 15 min	5	2.0	1200	1–2
2	30 VI	1.1 m from the gunwale of the vessel	19 h 00 min	5	2.0	1200	1–2
3	18 VII	Bow boom of the vessel	19 h 00 min	5	3.4	1200	1–2
4	18 VII	Same	19 h 20 min	10	–	1200	1–2
5	18 VII	Same	20 h 10 min	10	7.0	1200	1–2
6	18 VII	Same	21 h 14 min	10	4.5	1200	1–2
10	31 VII	PGS-4 buoy, MTI	13 h 15 min	10	2.0	780	2
11	31 VII	Same	18 h 23 min	10	2.0	5000	2

In Fig. 2B the spectra of humidity fluctuations over the sea are given, obtained in experiments 10 and 11. In this experiment the humidity sensor was mounted on a stabilized buoy of the MGI type ShPS-4 at a height of approximately 1.8 m above the sea surface. The buoy was in the sea in a free-drifting mode at a distance of about 200 m from the vessel. The spectra of humidity fluctuations obtained in these latter experiments are noteworthy in that in their low-frequency part there are small maxima at a frequency of about 0.3 Hz; in addition, in the region of about 0.9 Hz there is a second maximum.

It is known that the mean values of fluctuations of wind speed and temperature prove to be relatively stable for averaging times on the order of 10-20 min ([2]). Therefore, in order to ensure the necessary stationarity of the series, a larger number of samples should have been taken. But because of the limited memory capacity of the "Dnepr" electronic digital computer, we could not, in these experiments, satisfy this condition for humidity fluctuations. In experiment 11 we managed to obtain a sufficiently long recording time (500 sec) thanks to the direct output of information from the sensor to print; therefore the fluctuation spectrum obtained in this experiment is the most interesting. It is also interesting to note that the spectra obtained in experiments 10 and 11, in their character in the low-frequency part, are similar to the spectrum obtained by American researchers near the Bermuda Islands.

The spectra of humidity fluctuations over the sea obtained by us have a complex character and are distinguished by the presence of two maxima, which is evidently connected with the influence of surface waves. A characteristic feature of almost all the spectra obtained is the presence of peaks at a frequency approximately equal to the frequency of the surface waves, and at a frequency approximately four times greater than the frequency of the surface waves. Further investigations should explain the complexity of the nature of the spectra of humidity fluctuations over the sea.

In conclusion, the author thanks the head of the First Soviet-French Expedition, G. G. Neuymin, and the head of the mathematics detachment, Yu. T. Shchetinin, for their unfailingly kind assistance in carrying out the present work.

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Note: Figure translations are in progress. See original paper for figures.