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# THE HUDSON LABORATORIES MICROBAROGRAPH SYSTEM: RESULTS AND FUTURE TRENDS

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ABSTRACT

An outline of the Hudson Laboratories Microbarograph system is given, with mention of some results and problems for periods ranging from a few minutes to a few hours.

## 1. THE HUDSON LABORATORIES MICROBAROGRAPH ARRAY

In late 1965 the development of an ultra-low frequency ($10^{-4}$ Hz<f<1 Hz) microbarograph array was undertaken at Hudson Laboratories, Columbia University. Since we desired to include periods up to 90 min or so, we had to make our own microbarographs. This was done during the fall of 1965 and early 1966, following a design suggested and already partially tested by J. Young and R. Cook of the ESSA infrasonics groups in Washington, D. C. Since 1966, the number of sensors operating in the field has varied between 1 and 16, depending upon the particular experiment being conducted. On the whole, the system has steadily grown to its present size of 16 microbarographs. A map showing the distribution of sensors as of spring 1968 is given in Fig. 1.

In addition to the microbarographs, the system includes one Doppler-shift type ionosounder and magnetometers at the Catskill (New York), Thornhurst (Pennsylvania), and Lebanon (New Jersey) sites.

All instrument outputs are transmitted by telephone lines to the central recording station at Hudson Laboratories in Dobbs Ferry. The data are recorded in digital form (BCD) on magnetic tape, with a total capacity of 32 channels capable of recording one four-digit number each twice a second.

## 2. TYPE OF PHENOMENA INVESTIGATED SO FAR. SOME RESULTS.

Most of the system's work to date has been oriented toward a study of background pressure fluctuations for periods of 5 min to 90 min, approximately. Velocities of propagation for naturally occurring disturbances in this band appear to vary from about 10 m sec$^{-1}$ to several hundred m sec$^{-1}$. The corresponding wavelengths therefore vary from a few km to $10^3$ km or so. This scale of dimensions corresponds to what the meteorologists refer to as the mesoscale, somewhere between meteorological phenomena proper at one end and boundary layer turbulence and wind effects at the other (micrometeorological effects, see, e. g., Lumley and Panofsky, 1964). Insofar as the acoustician is concerned, periods 1 sec$\leq T \leq$10 min are in the infrasonic domain. Periods $T>10$ min, when they do correspond to wave phenomena, belong to the internal gravity wave part of the spectrum.

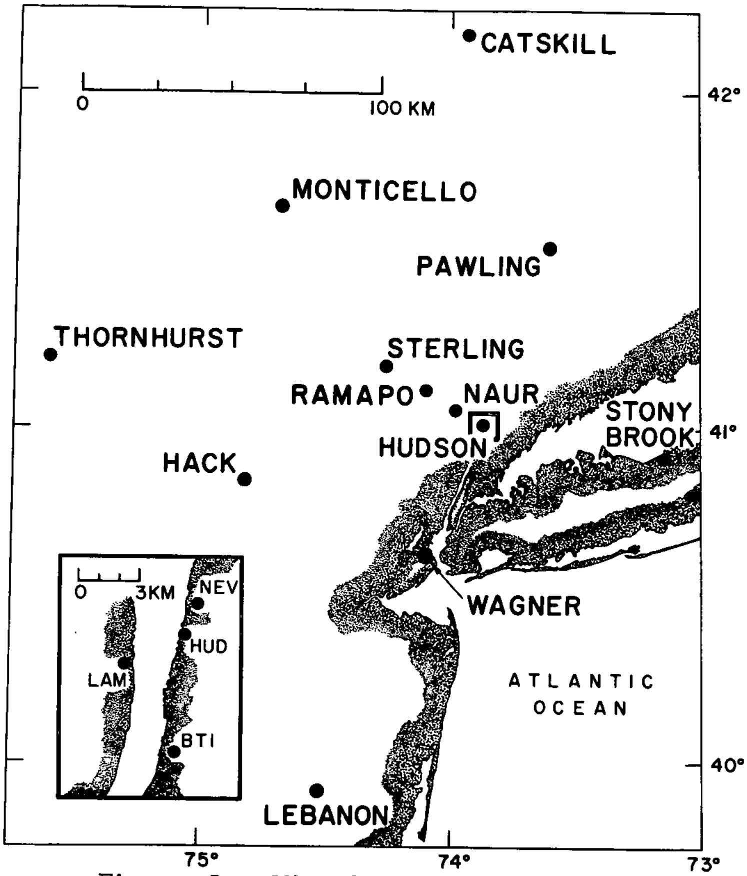


Figure 1. Microbarograph array.

The spectral distribution of the background energy given by our studies is typified by the average, smoothed, type of behavior shown in Fig. 2. This particular curve is an average over many weeks of data. It is representative of hundreds of curves of this type obtained by us over a period of about two years. It is also consistent with earlier results of Gossard (1960), Golitsyn (1964), and Pinus et al. (1967).

As a result of studies performed in the summer and fall of 1967, using the small scale network of microbarographs shown in the inset of Fig. 1, we have succeeded in showing quite conclusively that much of the energy input into this band comes from the jet stream (Herron and Tolstoy, 1968; Tolstoy and Herron, 1968). Thus, for lengthy periods of time (often for weeks on end) the direction of travel of pressure perturbations in this part of the spectrum closely follows that of the jet stream winds aloft. The velocities of propagation, in the 20-50 m $sec^{-1}$ are also of the same order. In addition, a preliminary calculation indicates that the correct order of magnitude for ground level pressure perturbations, as well as the main spectral characteristics, are obtained if one assumes that the wind fluctuation power spectrums obtained from flying aircraft (Kao and Woods, 1964; Reiter, 1963) correspond to internal gravity wave systems being shed by the jet stream. This shedding could occur near the core or, as suggested by Claerbout (1967), near the level of least stability below the core itself. Figure 3 shows a comparison of our calculation with some of our mean and extremal power spectrums. It is seen that this mechanism not only yields the correct orders of magnitude for the pressure fluctuations, but also appears to explain the typical knee appearing on all pressure power spectrums in this band of periods.

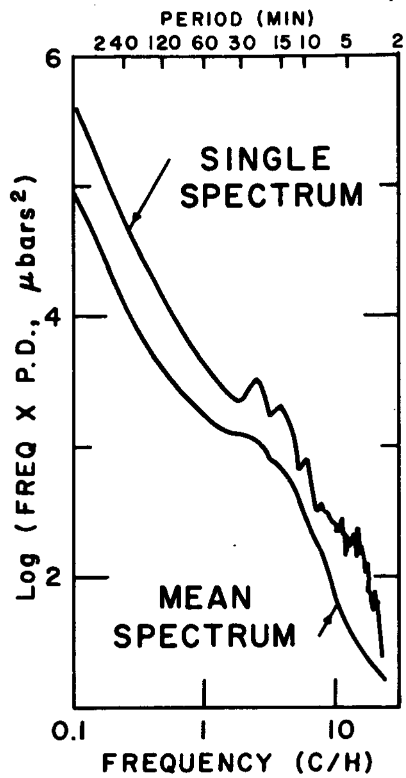


Figure 2. A typical single spectrum (24 hour sample) and a monthly mean power spectrum for background pressure fluctuations at Hudson Laboratories.

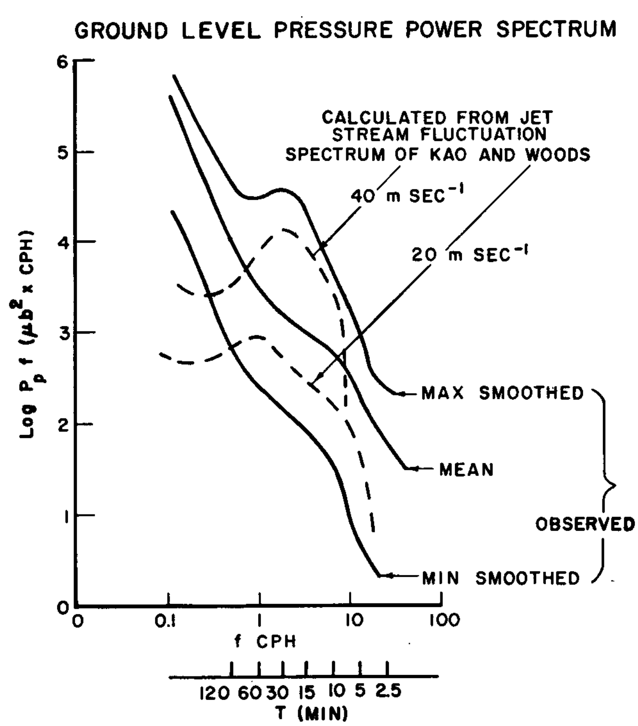


Figure 3. Comparison of mean and smoothed extremum power spectra for pressure with calculated power spectra, based upon a simplified mechanism of internal gravity wave generation by the jet stream, for two different assumptions for the stream velocity (dashed lines).

## 3. SOME FURTHER PROBLEMS TO BE INVESTIGATED

Insofar as larger-scale phenomena are concerned, the use of beam forming techniques on the full array of Figure 1 indicates the existence of disturbances having periods of 15 to 50 min, traveling at speeds of the order of 300 m $sec^{-1}$. A systematic study of these processes is underway. If this is a wave phenomenon, as appears probable, then one is dealing with internal gravity waves of wavelengths between 300 and 1000 km.

Apart from long wavelength internal gravity waves of this type and short wavelength ones of the kind generated by the jet stream, there exist other processes for the propagation of pressure disturbances in the mesoscale range. Obvious candidates are wind-borne convection systems, large-scale eddies, etc. There is also another fairly obvious wave phenomenon, i.e., that of stability (or instability!) waves in shear flows. This type of disturbance is well known to hydrodynamical theorists (see, e.g., Lin, 1955). Clearly the tropospheric wind system which culminates in the jet stream at 10 km altitude represents a steady shear flow capable of supporting waves of this kind. A more thorough theoretical and experimental study of the relevance of these waves is desirable.

## ACKNOWLEDGMENTS

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