A. D. Sytinskiĭ. Relation between Seismic Activity of the Earth and Solar Activity. Analysis of solar and instrumental seismic data has established that:

1. The overall seismic activity of the Earth, as expressed in terms of the total energy of earthquakes and the number of catastrophic earthquakes per year, depends on the phase of the 11-year solar cycle at a level of significance of about 0.99 (the Student t and the Pearson χ^2 criteria being calculated). Here the greatest seismic activity occurs in the epoch of a maximum (years +1 and +3) and the epoch of a minimum (year +6) of the 11-year solar cycle (Fig. 1).

2. The time of appearance of individual strong earthquakes (with $M \geq 6.5$) depends (at a level of significance of about 0.99, Pearson's χ^2 criterion being calculated) on the position of the active regions of the Sun. Earthquakes mainly occur 2–3 days after an active region has passed the central solar meridian. In order to prove this statement, 594 earthquakes with $M \geq 6.5$ that occurred during 1957–1967 and 1953 were studied (Fig. 2).

A prediction was made (as an experiment) of the time of appearance of strong earthquakes with $M \geq 6.0$, based on the obtained regularities of coupling of earthquakes with activity on the Sun. The predictions were reported beforehand to the Pulkovo seismological station. Estimates of the quality of prediction for 1963 and 1965–1966 obtained at the Pulkovo seismological station and in the Laboratory of Mathematical Statistics of the Institute of Earth Physics of the Academy of Sciences of the USSR showed that the predictions were unrandomly correlated with earthquakes with $M \geq 6$ at a level of significance of about 0.995.

Study of the mechanism of coupling of the seismic activity of the Earth with solar activity has established that this coupling involves all-planet atmospheric processes. Data have been obtained here that indicate a dependence of the time and site of earthquakes on the nature and time of change of the form of circulation of the atmosphere. The mechanism of this dependence consists in perturbation of the quasi-steady-state movement of the atmosphere by enhanced solar activity, which redistributes the mass of the atmosphere over the Earth. That is, it shifts the center of gravity of the Earth-atmosphere system, and hence it disturbs the shape equilibrium of the Earth. Calculations based on observational data show that the energy of such perturbations can amount to 10^{27}–10^{28} ergs. This suffices for causing such observable phenomena as the shifting of the poles and fluctuations in the angular velocity of rotation of the Earth. Apparently, here earthquakes also can arise from displacement of blocks of the Earth's crust caused by perturbations of the equilibrium figure of the Earth.

The mechanism of the effect of solar acticity on the circulation of the lower atmosphere is explained on the

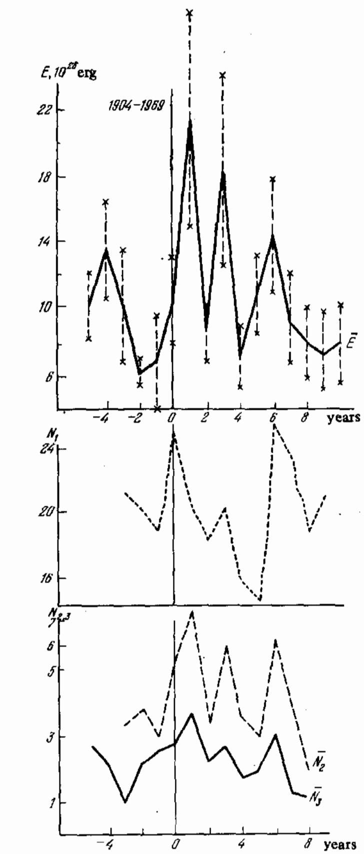

FIG. 1. 367. Mean cyclic curves of the yearly values of the energy $\bar{E}$ of earthquakes and the yearly numbers $\bar{N}$ of earthquakes. $\bar{N}_1 \geqslant 7.0$, $\bar{N}_2 \geqslant 7.5$, $\bar{N}_3 \geqslant 7.75$ for 1904–1969. The zero year is the year of the maximum of the 11-year solar cycle.

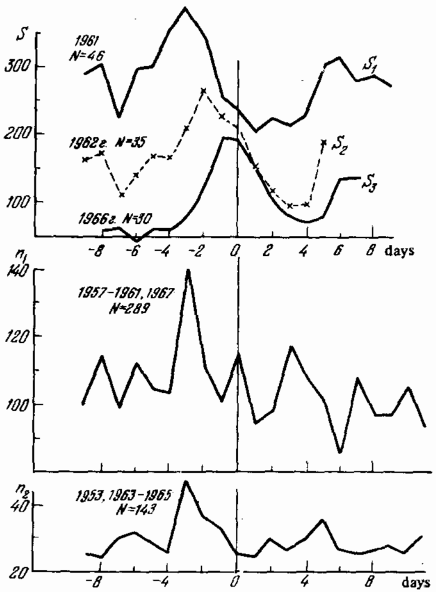

FIG. 2. p. 368. Distribution of the number n of cases of passage of active solar regions across the central solar meridian (CSM) and mean areas S of spots in the region of the CSM with respect to the dates of earthquakes having M ⩾ 6.5 (zero-days). n_1 – for the epoch of a solar-activity maximum (N = 289; 1957–1961 and 1967), n_2 – for the epoch of a solar-activity minimum (N = 143; 1953 and 1963–1965). S_1 – N = 46 (1961), S_2 – N = 35 (1962), S_3 – N = 30 (1966).

basis of the law of conservation of angular momentum:

$$L_a = I_a \omega_a = \text{const} \tag{1}$$

(for the case of absorption of energy in the upper atmosphere). Here the following relationship holds between the potential (Π) and the kinetic (K) energies of the atmosphere.

$$dK = -A\, d\Pi \tag{2}$$

($A = \omega_a^2 r/g$ is the ratio of the centrifugal force to the force of gravity). It has been established that enhancement of solar activity expands the entire atmosphere, and hence, it increases I_a and Π. On the basis of (1) and (2), this must decrease ω_a and K. That is, it disturbs the established movement in the atmosphere caused by temperature gradients in the troposphere. Hence, it enhances macroturbulent exchange, and accordingly also cyclogenesis. As was stated, calculations based on the observational data show that the energy of the perturbations amounts to $\Delta\Pi = 10^{27}-10^{28}$ erg, while $\Delta K = 10^{25}-10^{26}$ erg, which corresponds to the energy of cyclones. Correspondingly, the displacement of the center of gravity of the column of atmosphere is $\Delta h_0 = 4-40$ m, while the needed depth of penetration of energy entering the atmosphere due to solar activity is Z = 35–40 km. The obtained calculated data agree well with the proposed mechanism.

The features of behavior of the zonal circulation index α (the angular velocity of rotation of the atmosphere with respect to the Earth) also confirm the correctness of the treated mechanism. It has been established that decreases in α involve passage of active solar regions across the central solar meridian. On the average they arise a day earlier than the decreases in the temperature gradient between the pole and the equator. Correspondingly, processes in the lower atmosphere involving solar activity show the following sequence: 1) perturbation, or disturbance of thermal equilibrium, and 2) relaxation, or restoration of thermal equilibrium. Thereupon, perturbation sets in again. Since a change in the thermobaric field occurs here, we can assume that the natural synoptic periods are determined by variations in the particle emission of the Sun or the solar activity.

The obtained results open up broad potentialities for further studies of geophysical phenomena. The expected results of these studies seem quite definite. In particular, besides solving some problems of Sun-Earth physics as well as of interaction of the Earth's atmosphere and figure, further studies can result in successful solution of the problem of predicting earthquakes.

The fundamental results of the report have been published in the following papers:

A. D. Sytinskiĭ, Geomagn. i aéronom. 6, 726 (1966); Dokl. Akad. Nauk SSSR 208, 1078 (1972).