Letters

Trajectory of Lunik III

Using available tracking data released by Tass, the General Electric Company has computed the trajectory of the Russian automatic interplanetary station (AIS), otherwise known as Lunik III, which obtained the first pictures of the far side of the moon.

The results showed that the 7th perigee passage of the vehicle occurred on 21 January at 12.87 hours (universal time) at a distance of 18,225 kilometers from the earth's center, and predicted entry into the earth's atmosphere on 8 March at 5.19 hours.

The U.S.S.R. had predicted 7th perigee passage on 22 January at 9.03 hours at a distance of 18,486 kilometers, and final entry into the earth's atmosphere late in March. Subsequent corrections to the initial conditions of the General Electric program were made to permit agreement with the 7th perigee time predicted by the U.S.S.R.; computations made on this basis show little change in the value for perigee distance. However, these computations place entry into earth's atmosphere in April or later.

The calculations are obviously very sensitive to initial conditions; this is due primarily to a second close approach to the moon (of about 50,000 kilometers), on 24 January. Additional tracking or sighting data are therefore needed to confirm, or permit corrections to be made in, the trajectory predictions if a meaningful entry watch is to be established. We would be pleased to receive such additional information and would undertake to rerun the computations and to advise both *Science* and others interested in the results.

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Evapotranspiration

It is surprising that no comments or criticisms have appeared in reference to the report by Holdridge [*Science* **130**, 572 (4 Sept. 1959)] concerning a "Simple method for determining potential evapotranspiration from temperature data."

The formula

$$\text{Potential evapotranspiration (in mm)} = \left[58.93\left(\frac{\text{Unit period of time}}{\text{No. of units of time in 1 yr}}\right)\right] \times \left[\text{Comparative plant growth mean temperature (°C)}\right]$$

is not consistent with Holdridge's statement that "the potential evapotranspiration at a given temperature decreases proportionately along the gradient of increasing precipitation from arid to wet areas. . . ." It is difficult to see a theoretical basis for the formula.

Work by Penman [*Proc. Roy. Soc. (London)* **A193**, 120 (1948)], Thornthwaite [*Geograph. Rev.* **38**, 55 (1948)], and Blaney-Criddle ["Water," *Yearbook Agr.* (*U.S. Dept. Agr.*) (1955)] indicate that such a formula, based on temperature alone, is of doubtful validity. Ramage [*Pacific Sci.* **13**, 1 (1959)] found that both the Penman and Thornthwaite formulas gave values of potential evapotranspiration which were too high during the wet summer months at Hong Kong. Use of the Holdridge formula on the Hong Kong data shows the same tendency. In fact, values for potential evapotranspiration for Hong Kong for 1951–56 computed by the Holdridge formula are intermediate between those computed by the Penman and the Thornthwaite equations, respectively, and are considerably higher than observed values for an evapotranspiration battery.

Potential evapotranspiration is dependent upon a number of meteorlogical factors which fluctuate from day to day and from season to season, so that a formula based on temperature alone will be valid only under very restricted conditions of insulation, humidity, and wind.

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Regarding the comments of Noffsinger, which I appreciate because they offer me an opportunity to clarify certain points in my report in *Science*, the following discussion is submitted.

Noffsinger's first paragraph looks convincing only because he has misquoted from my report, using in his letter "the potential evapotranspiration at a given temperature decreases. . . ." rather than, as appeared in the article, "the potential evapotranspiration rate at a given temperature decreases. . . ." Naturally, potential evapotranspiration is quite distinct from the potential evapotranspiration rate, which is equal to the mean potential evapotranspiration in millimeters per year divided by the mean precipitation in millimeters per year.

As for his statements on temperature, my formula uses the comparative plant growth mean temperature, preferably called "mean biotemperature," which discards temperatures below 0°C. The mean biotemperature is derived by summing up the positive time-unit means of temperature and dividing this total by the number of time units in the period. The workers cited, who found values based on temperature alone to be of doubtful validity, presumably utilized normal mean period temperatures, which may include below-zero temperatures, when plants are inactive. Plant activity or growth is the same at −5°, −20°, or −40°C, so the inclusion of such data in means obscures the marked differences in plant activity that occur at even less widely separately positive temperatures.

My potential evapotranspiration values should be higher than the observed values for an evapotranspiration battery in moist-to-wet climates, since the former apply to natural, mature vegetation and not to the low, artificially established vegetation of the latter. Contrarily, one would expect my values to be lower than battery values in arid or drier climates, provided the battery is set up with a moist-climate vegetation such as the commonly utilized Kentucky blue grass.

Further, the factors of insolation, humidity, and wind, which, if they differ, would be certain to alter the potential evapotranspiration readings for a given type of artificially established vegetation in distinct areas, are canceled out in natural vegetation by the evolved physiognomic changes in such characters as leaf size, leaf texture, and vegetation height. In fact, the physiognomic variations in natural vegetation provide the theoretical basis for the formula.

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Intragalactic Communication

The "Next question" proposed in the 25 December editorial [*Science* **130**, 1733 (1959): "May not other civilizations [on other planets] . . . be waiting in silence [due to restraints imposed by local fiscal authorities] for our signal before they give their response [and are we to await approval from our own fiscal authorities before beaming signals into space, the mutual wait yielding an impasse]?" is indeed thought-provoking.

In addition to financial considerations there may be other factors responsible for man's not having been contacted by other beings. It has taken the earth some 4½ billion years to cool and evolve life to the point where radio astronomy could be developed. For man to suppose that planet X has arrived technologically in the same decade (10 years compared with 4.5 $\times$ 10^9) smacks of egocentricity and lack of perspective. More probably the galaxy contains planets varying widely