NOTES AND CORRESPONDENCE

Comments on "Intransitive Model of the Earth-Atmosphere-Ocean System"

M. BUDYKO

Main Geophysical Observatory, Leningrad, USSR

8 June 1972

An interesting paper by Faegre (1972) suggests a simple model of the thermal atmospheric regime. Application of this model to calculation of the mean latitudinal temperature distribution near the earth's surface leads to five different solutions, three of which, according to the author, have physical meaning, i.e., they result in temperature distributions 1) in accord with actual climatic conditions, 2) for the case of complete glaciation of the earth, and 3) with mean latitudinal temperatures ~15C below the existing values. The author believes that only the second distribution is stable to a change of incoming radiation by several percent.

Faegre points out that a derived degree of contemporary climate stability approximately agrees with the results that have been previously obtained by Budyko and Sellers. In addition, he suggests that the thermal regime models of Budyko and Sellers imply a single-valued correspondence of contemporary climate to external climatic-forming factors, i.e., climate transitivity, while a conclusion concerning climate intransitivity is a unique feature of his model.

We believe that results, based on a concept involving the absence of a single-valued correspondence of contemporary climate to external climatic-forming factors, were obtained for the first time by calculating thermal conditions for the "white earth," i.e., for the case of complete glaciation of our planet. It follows from simple physical considerations that with the existing magnitude of the solar constant and a complete glaciation of the earth, the temperature of the earth's surface would be equal to several tens of degrees below zero, ensuring great stability of the glaciation regime (Budyko, 1962). Such a conclusion has also been drawn from our model of the atmospheric thermal regime, as mentioned in Faegre's paper. This model has been used for calculating the distribution of the mean latitudinal temperatures for the "white earth," giving values which ranged from −68C at the equator to −73C at the pole (Budyko, 1971). While the compiled temperature depends considerably on the choice of albedo for the ice-covered earth's surface, the mean latitudinal temperatures remain below zero for any plausible albedo. Thus, the "white earth" is a second type of climate which is possible under existing conditions.

From our thermal regime model we also have drawn a conclusion about the possible existence of a third variant of climate, involving partial glaciation of the earth and lower temperatures as compared to the actual ones (Budyko, 1972).

Thus, the results obtained by Faegre agree with the conclusions drawn from our model. Similar conclusions may also probably be drawn from Sellers' model.

The problem of contemporary climate intransitivity has been discussed in one of our papers (Budyko, 1972), where it is indicated that a conclusion about the possible existence of three climatic regimes with the actual value of the solar constant follows from rather general physical considerations and can be obtained from different models of the theory of climate. We believe that the results of Faegre's work agree with this conclusion.

REFERENCES

Budyko, M. I., 1962. Polar ice and climate. *Iz. Akad. Nauk SSSR, Ser. Geogr.*, No. 6.

——, 1968. On the origin of glaciation epochs. *Meteorology and Hydrology*, No. 11.

——, 1971. *Climate and Life*. Leningrad, Gidrometeoizdat, 472 pp.

——, 1972. *Man's Impact on Climate*. Leningrad, Gidrometeoizdat, 48 pp.

Faegre, A., 1972. An intransitive model of the earth-atmosphere-ocean system. *J. Appl. Meteor.*, 11, 4–6.

Sellers, W. D., 1969. A global climatic model based on the energy balance of the earth-atmosphere system. *J. Appl. Meteor.*, 8, 392–400.