This Week's Citation Classic®

Charney J G & Eliassen A. A numerical method for predicting the perturbations of the middle latitude westerlies. *Tellus* 1:38-54, 1949.
[Institute for Advanced Study, Princeton, NJ]

A linearized geostrophic version of the barotropic atmosphere model was used to predict the height profile of the 50 kPa isobaric surface along the 45° N latitude circle. The profile was found to be a superposition of two parts: a free, transient wave and a stationary wave forced by the continental elevations. [The *SCI®* indicates that this paper has been cited in over 230 publications since 1955.]

Arnt Eliassen
Institute of Geophysics
University of Oslo
P.O. Box 1022, Blindern
0315 Olso 3
Norway

January 14, 1988

The eminent American meteorologist Jule G. Charney, who died in 1981, visited my hometown, Oslo, Norway, in 1947. He invited me to join a meteorological research project at the Institute for Advanced Study in Princeton for the academic year 1948-1949. The project was set up by the Hungarian-American mathematician John von Neumann. At his initiative an electronic computer was being built at the institute. Von Neumann was fully aware of the possibilities opened up by these new calculating tools, and with remarkable foresight he decided that a suitable problem for his new computer would be experiments aimed at predicting future weather. To this end a small meteorological research team was set up in Princeton.

Charney, who led the group, had planned to base the first experiments on the so-called barotropic model. In this highly simplified model, initiated by the Swedish-American meteorologist Carl-Gustav Rossby, the atmosphere is replaced by an equivalent ocean, with the ocean surface representing the 50 kPa isobaric surface in the middle troposphere. If the elevation of this surface as a function of horizontal coordinates is known at a certain point in time, then its elevation at a later time can be predicted from a nonlinear partial differential equation of second order, expressing conservation of potential vorticity.

As the Princeton computer was not yet operative, this integration experiment in two space dimensions had to be postponed. Instead, we tried a still simpler one-dimensional version that could be done on desk calculators. Our objective was to predict the height profile of the 50 kPa isobaric surface along the 45° N latitude circle from a linearized form of the differential equation for the barotropic model. At first, the method gave a large systematic error: the longest features of the profiles were predicted to move rapidly westwards, in accord with the theory of Rossby waves, whereas in reality they hardly moved at all. Then why didn't the long waves follow Rossby's wave formula? To this question we found the following answer: the stationary part of the profile is a forced wave, caused and held in a geographically fixed position by the great continental mountain areas. The remaining, transient part can be predicted with some skill from Rossby's theory. However, the predictions thus corrected were still too crude to be of much practical value.

The significant result of our paper, and the reason for its frequent citation, is undoubtedly the demonstration we gave that the continental elevations, by disturbing the airflow, may cause persistent large-scale weather anomalies and have an important influence on the geographical distribution of climate. The paper brought us the Meisinger Award for 1949 from the American Meteorological Society.

With a revival in the last decades of interest in global climate and large-scale weather, many studies of orographic forcing effects have been made in recent years.[1-3]

1. Grose W L & Hoskins B. On the influence of orography on large-scale atmospheric flow. *J. Atmos. Sci.* 36:223-34, 1979.
2. Held I M. Stationary and quasi-stationary eddies in the extratropical troposphere: theory. (Hoskins B & Pierce R, eds.)
   Large-scale dynamical processes in the atmosphere. London: Academic Press, 1983. p. 127-68.
3. Egger J. Stochastic orographic forcing of barotropic β-plane flow. *Tellus* 36A:147-56, 1983.

©1988 by ISI® CURRENT CONTENTS®