This Week's Citation Classic®

Charney J G & Drazin P G. Propagation of planetary-scale disturbances from the lower into the upper atmosphere. *J. Geophys. Res.* 66:83-109, 1961.
[Department of Meteorology, Massachusetts Institute of Technology, Cambridge, MA]

The linear quasi-geostrophic propagation of steady planetary waves, forced in the troposphere, was shown to be analogous to the propagation of light, with a "refractive index" that depends on the mean zonal flow and vertical stratification. Trapping of tropospheric waves at the solstices but not the equinoxes was thereby predicted. Also, a weakly nonlinear theory gave what is now known as a nonacceleration theorem, whereby the eddy stress of the waves vanishes and so the waves do not accelerate the mean zonal flow. [The *SCI*® indicates that this paper has been cited in over 355 publications.]

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I was offered a research associateship by Jule G. Charney when both the theory of geophysical fluid dynamics and the observation of the upper atmosphere by rockets were new. He displayed his characteristic great intuition of what problems in meteorology were important and deep insight into their solution. He suggested that we study planetary-wave propagation from the lower into the upper atmosphere. C.O. Hines[1] had recently demonstrated such propagation of internal gravity waves. Charney wondered how the more energetic planetary waves influenced the stratosphere. He had in mind the prevailing theory whereby shock waves from the sun intensely heat the less dense chromosphere.

To the first approximation Charney had all the ideas and I did all the work. Yet this does justice to neither of us. He did some of the tedious linear algebra and gave me heart to do more. I, coming fresh from a course on quantum mechanics, appreciated the significance of reflection and transmission of waves and the JWKB approximation, as I had worked on mountain waves. Perhaps the visit of A. Eliassen to the Massachusetts Institute of Technology (in the spring of 1961, I think) gave impetus to our nonlinear theory. Eliassen must have been thinking then of transfer of energy by steady internal gravity waves.[2]

Charney was charming and infuriating, kind and unreliable, warm and egotistic, generous and vain, hospitable and inconsistent. As a young bachelor, I was contented enough to work intensely at irregular hours, but I was amazed at working to meet the deadline of a desirable conference, and at his writing an abstract of results before they were established firmly. He also seemed slack in his standards of oral and written presentation. But these adverse feelings are transcended by my good fortune to be one of the many young scientists whom Jule befriended and encouraged at the beginning of their careers.

Our work has been often cited surely because it is fundamental to the dynamics of the stratosphere. This idea is supported by J.R. Holton's book[3] on the upper atmosphere and the paper of D.G. Andrews and M.E. McIntyre[4] on nonlinear waves. They also describe many implications and modern developments of our work. This may be amplified in the forthcoming book[5] on Charney's work.

1. **Hines C O.** An interpretation of certain ionospheric motions in terms of atmospheric waves. *J. Geophys. Res.* 64:2210-1, 1959.
2. **Eliassen A & Palm E.** On the transfer of energy in stationary mountain waves. *Geophys. Publ.* 22:1-23, 1961. (Cited 115 times.)
3. **Holton J R.** *The dynamic meteorology of the stratosphere & mesosphere.* Boston, MA: American Meteorological Society, 1975. 218 p. (Cited 50 times.)
4. **Andrews D G & McIntyre M E.** An exact theory of nonlinear waves on a Lagrangian-mean flow. *J. Fluid Mech.* 89:604-47, 1978. (Cited 130 times.)
5. **Lorenz E N, ed.** *Jule Charney.* Cambridge, MA: MIT Press. (In press.)