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This Week's Citation Classic®

Hines C O. Internal atmospheric gravity waves at ionospheric heights.
Can. J. Phys. **38**:1441-81, 1960.
[DRB Theoretical Studies Group, Defense Research Board, Ottawa, Ontario, Canada]

A wide variety of ionospheric irregularities and motions can be attributed to a single agency: internal atmospheric gravity waves, probably propagated up from lower levels. The waves amplify as they rise into the rarer atmosphere, which accounts for their dominance at high altitudes. [The *SCI*® indicates that this paper has been cited in over 625 publications since 1960.]

C.O. Hines
15 Henry Street
Toronto, Ontario M5T 1W9
Canada

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I began theoretical work on atmospheric waves in the early 1950s at Cambridge University, seeking to explain one class of ionospheric disturbance (traveling ionospheric disturbance, TID). I could show only a plausible, not a decisive, connection between observation and theory. Subsequently, at the Defence Research Board, Ottawa, my attention was turned to radio reflections from meteor trails (intended for beyond-the-horizon communications). Meteor trails had been found to suffer irregular distortion by winds at heights of 80-110 km, where, too, irregular moving fluctuations of ionization were observed. In the late 1950s, the prevalent guess as to the source of these irregularities was atmospheric turbulence, but this view, as applied to meteor-trail deformations, was being challenged as incompatible with certain radar observations. The entire field was sufficiently active and puzzling that an International Symposium on Fluid Mechanics in the Ionosphere was convened in 1959 to bring together ionospherists, fluid dynamicists, and meteorologists.

I had been asked previously to write a review article, "Motions in the Ionosphere," for publication elsewhere. I found much recent observational material to distill into the review but very little new theory. To ease the imbalance and do more than just distill, I injected a new thought of my own: that the meteor winds were manifestations, not of turbulence, but of atmospheric waves, the appearance of irregularity being imposed by the simultaneous presence of many different waves (cf., chop on an ocean). And if the meteor winds were caused by waves, why not the coexistent irregularities of ionization? And if those in the lower ionosphere, why not the TIDs in the higher? I did some back-of-the-envelope calculations to confirm that my suggestion was at least plausible and proceeded to publication of the review.

A colleague visited me soon after, and I tried to reproduce my calculation, just to fill in time. My heart fell when I failed: I established, instead, the falsity of my suggestion. Normalcy returned that evening when, in the seclusion of my home, I recognized the error of the afternoon and regained the original results. Oddly enough, this "reconfirmation" excited me with my own suggestion, and I then bent all my efforts to pursuing it.

I was still consolidating the work when the international symposium was held. It had been organized with a thrust toward turbulence, but I was allowed to squeeze into one of its sessions and swing much interest from turbulence to waves as the dominant dynamic component. My published version (this paper) swung much more, though there continued to be many holdouts well into the 1960s. There still are in one area of application, perhaps properly; but additional types of observational study and analysis have confirmed the widespread significance of the waves at these heights and all heights below.[1]

I believe the paper has been cited frequently because it broke an interpretational logjam for several apparently distinct types of observation, and it opened to theorists a whole new area of useful study. It simply became a convenient base reference for both.

1. **Hines C O,** ed. *The upper atmosphere in motion.* Washington, DC: American Geophysical Union, 1974. 1,027 p.

