

## 1960s Advances in Middle Atmosphere Research

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The 1960s might be referred to as the "Golden Age for Atmospheric Waves," and advances made during that decade have set the stage for many areas of research into Atmospheric Coupling Processes. Important papers in this general area include Hines' classic paper on gravity waves; Matsuno's classic paper on quasi-geostrophic motions near the Equator; Kato and Lindzen's independent discovery of missing Hough function modes; the independent discovery of the quasi-biennial oscillation by Reed and by Ebdon and its subsequent successful theoretical explanation by Lindzen and Holton; the Charney-Drazin theory for vertical planetary wave propagation (with important later contributions by Dickinson and Matsuno); the non-interaction concepts by Eliassen and Palm and by Charney and Drazin; the need for wave drag to explain the mesospheric circulation by Leovy; gravity wave critical level theory by Booker and Bretherton; and surely others that I haven't mentioned.

Many other important research topics also had important beginnings in the 1960s. For instance, it was in 1965 that the HO<sub>x</sub> catalytic cycle for destruction of stratospheric ozone was first suggested. Lively discussions occurred as to whether measurements of a very dry stratosphere were real or not. Pioneering rocket experiments took place during the 1960s on mesosphere structure and its relation to noctilucent clouds. Early clear air echoes were noted during the 1960s that helped to lay the foundation for MST radars, now an important mainstay of middle atmosphere research. These latter two research areas helped to establish the basis for today's research into PMSEs. Early transportchemistry models of the middle atmosphere were appearing, as were the first general circulation models of the troposphere/stratosphere. These works have evolved into present-day troposphere-middle atmosphere chemistry-climate models.

A few examples are given to trace some of today's research areas back to their early, foundational phases during this pivotal decade for middle atmosphere, the 1960s.