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Annual Progress Report For NASA

NASA Grant: NAGW-3979

Principal Investigator: Michael P. Hickey

Period of Performance: May 1, 1995 to April 30, 1996

Accomplishments

Our initial full-wave model only approximately included eddy diffusion of heat and momentum, and three coupled second-order DEs in the vertical coordinate were solved to derive the perturbation variables u', w' and T' (horizontal and vertical velocity components and temperature, respectively). We have significantly improved the full-wave model in a number of ways. First, we allowed for wave propagation in any azimuth by including the velocity component v' (orthogonal to u' and w'), increasing our equations to 4. Then we introduced the addition variable p' (perturbation pressure) and removed our approximation of the eddy diffusion terms, increasing the equations to 5. The upper boundary had previously been manually set at a prescribed value for a given wave. Now the upper boundary height is chosen automatically based on tests using the radiation condition at the upper boundary. The height is increased until the wave is experiencing severe dissipation at the upper boundary, which ensures that substantial absorption would occur for any possible reflection from the upper boundary.

The collaboration that was established between Dr. Hickey and Drs. Mike Taylor, Mike Kelley and William Ward to interpret observations of gravity waves observed over Arecibo in the O(^{1}S) nightglow continues. Apart from the winds derived from the radars, the radar did not provide much in the way of waves. However, our chemistry modules have now been successfully integrated with the full-wave model with the result that we can calculate nightglow intensity perturbations. We are in the process of comparing these modeled values with those measured by Mike Taylor. By re-normalizing our wave amplitudes in the full-wave model by a constant scaling factor, we will replicate his observed values of $I'/\bar{I}$. Our model will then provide all that we need to define the energetics of the observed waves, including energy fluxes, and energy and momentum flux divergences (important inputs for the mesopause region). A paper is currently in preparation for submission to the Journal of Geophysical Research by 1 March 1996 (the deadline). This collaboration resulted from the 10-day January 1993 campaign.

A similar study is also underway using data derived from the ALOHA-93/ANLC-93 campaign. The more extensive data base that includes multiple emissions will allow us to constrain the wave energetics much better. With OH observations included, we will be able to compare exothermic heating rates (including our modifications due to wave effects) directly with wave transport effects.

A saturating wave algorithm with scale-dependent, self-consistent diffusion was previously developed and incorporated into our WKB gravity wave model for testing purposes. It is was also incorporated into the full-wave model, but testing is still proceeding. Once complete, we will be able to simulate waves saturating in a realistic atmosphere.

A paper entitled "The propagation and dissipation of gravity waves in the terrestrial atmosphere: Full-wave versus WKB models" was presented at the 1995 Fall AGU Meeting. Authored by Mike Hickey, Richard Walterscheid (Aerospace Corporation), and Gerald Schubert (UCLA), the paper discussed what fraction of wave kinetic energy can reach 110 km altitude from 30 km. Results obtained using the full-wave model were compared with those obtained with two WKB models, and showed under what conditions the WKB results are approximately valid.

Tasks to be Implemented During the Period 1 May, 1996 to 30 April, 1997 (Statement of Work)

Main tasks will include:

- wave-modified exothermic heating will be compared to wave mechanical heating and cooling

- time-dependent modeling will be initiated, for both the mean state major gas as well as for the minor species
- wave spectra will be used as inputs to the full-wave model to enable complete calculation of the wave energetics

In addition to these main tasks, the model will continue to be used frequently in collaborations with experimentalists to explain their observations of waves in the MLT region.