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# ORBITAL ATMOSPHERIC PHYSICS AND DYNAMICS

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There are two ways of modeling the upper atmosphere. One is the empirical model that makes use of experimental data on means and excursions from the mean and fits the data in a self-consistent manner. Although useful, such a model sweeps the physics under the rug, and will eventually reach a plateau beyond which progress can only be made by dealing with the underlying processes involved.

The other approach is to deal directly with the physical processes. This is difficult since what is happening is extremely complex. Data measured using an interferometer to give Doppler shifts of airglow lines showed 300-800 m/sec winds with a complex structure in the upper region of the thermosphere at high latitudes. Ionospheric electric fields, strongly influenced by interaction with the solar wind, drive the ionized component and large neutral winds result due to momentum transfer between the charged particles and the neutrals. Frictional heating results from movement of ions through the neutrals, which also influences the compositional structure. These are examples of the complex interactions involved.

Roble has adapted the NCAR General Circulation Model (tropospheric) for use at thermospheric altitudes - the Thermospheric General Circulation Model (TGCM). The model makes use partly of primitive equations and partly of empirical data for some quantities such as electron density, magnetic field, and ion drift.

Roble remarked that the Jacchia 1971 model appears to give more reliable composition while earlier models work better for density. An advantage of the earlier models was that they used Bates temperature models, which allowed for exact analytical integration. Later models introduced a more refined temperature profile fitting scheme which required numerical integration but failed to improve density calculations. It is surprising that the earlier Jacchia models work as well as they do for density, since compositions found by the OGO satellite are completely in variance with Jacchia model predictions. Future revisions of the Jacchia model are planned that will include "pseudotemperatures", a procedure where each component has its own effective temperature.

One might argue several ways regarding choice of models:

1) If there were little difference in density results between old models and new models, then it might be better to use the newer ones, since they yield better composition. Composition enters in through differing behavior of various

components with altitude and season (viz. the observed large changes in helium seasonally and geographically), and through compositional influence on temperature structure. Composition also can influence the drag coefficient, and questions arise regarding activity of specific components such as surface erosion by atomic oxygen.

2) On the other side of the argument, there is the advantage of using density models that are consistent with past experience and that are "good enough" as well as being computationally efficient. Orbit data from NORAD and other sources are model dependent. Another important consideration is that once a model is specified, there is a considerable cost impact in making a change. Once contracts for a space program development have been finalized, any changes are difficult, costly, and undesirable from the standpoint of contract management.

Since new models will undoubtedly be introduced, due consideration should be given to the use of spherical harmonic expansions. There are definite advantages to using spherical harmonics: sizes of coefficients drop off quickly after the first few, so consistent models of various degrees of detail can be readily developed and new effects added with a minimum of disruption.

Roble showed the Workshop an impressive computer-generated animation of thermospheric motions.