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Introduction

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Introduction

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In this introduction at the beginning of a meeting devoted to the presentation of observations regarding the middle atmosphere, it is appropriate first to define the region of the atmosphere under consideration, then briefly to survey the history of observation of the middle atmosphere, and finally to list a few of the major problem areas at the present time.

The middle atmosphere is a rather recent name given to the region of the atmosphere between altitudes of 10–15 km and about 100 km (figure 1). Its lower boundary is the tropopause, the level at which temperature ceases to fall with height and which defines the upper boundary of the troposphere (or turning sphere), a region dominated by convection. Between the tropopause and the high temperature peak around 50 km (the stratopause) is the stratosphere, so called because it is a region where temperature increases with height and where, therefore, vertical eddy motions are strongly inhibited. Above the stratosphere is the mesosphere (or middle-sphere) up to the mesopause, the temperature minimum at around 85 km altitude, above which is the thermosphere. At some level, commonly between 100 and 120 km, is the turbopause, below which the atmosphere is reasonably well mixed, the mixing being dominated by eddy processes and above which molecular diffusion dominates so that molecular species are separated out according to their respective masses. Above these levels, also, the action of electric and magnetic fields on the ionized component of the atmosphere is important in determining the motion. Methods of analysing atmospheric structure and dynamics in the higher atmosphere are, therefore, very different from those in the middle atmosphere and it is convenient to define the top of the middle atmosphere at around 100 km.

The history of observation in the middle atmosphere goes back to the years around 1900 when Teisserenc de Bort, in investigations of the atmosphere's temperature structure from balloons, reached the stratosphere on a number of occasions. Table 1 lists some of the milestones in middle atmosphere observation between then and 1967 when the first satellite observations of stratospheric temperature structure were made from the Tiros 7 spacecraft by Kennedy and Nordberg.

The major features of middle atmosphere temperature structure are controlled by the absorption and emission of radiation. Absorption of ultraviolet solar radiation by ozone leads to the high temperature around 50 km; emission from the 15 μm infrared band of carbon dioxide is the main cause leading to the cold temperatures at the mesopause. Solar radiation absorbed by atomic and molecular oxygen leads to the rapid increase of temperature above the mesopause. Even a cursory inspection of figure 1, however, will demonstrate that radiation alone cannot explain the latitudinal distribution of temperature. For instance, the polar mesopause in the summer hemisphere is much colder than in the winter hemisphere despite substantial heating by absorption of solar radiation on the summer side. Atmospheric motions are responsible for transporting large quantities of heat and momentum; in the process they

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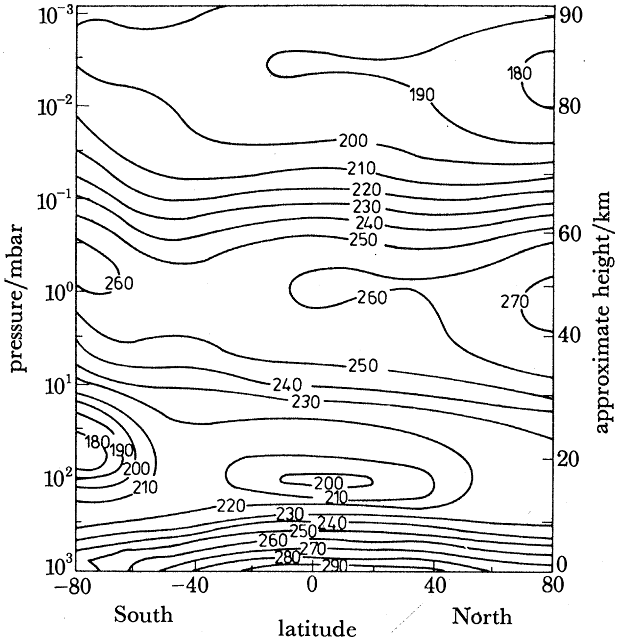

FIGURE 1. Temperature (K) cross section of the atmosphere from 80° N to 80° S as deduced from radiance measurements from the selective chopper radiometer on Nimbus 5 and the pressure modulator radiometer on Nimbus 6 for 4 August 1975. After Houghton (1978).

TABLE 1. MILESTONES IN MIDDLE ATMOSPHERE RESEARCH

1900	discovery of the stratosphere: Teisserenc de Bort
1922	discovery of high temperature around 50 km: Lindemann & Dobson
1927	ozone network set up: Dobson
1930	theory of ozone layer: Chapman
1943	dryness of stratosphere discovered: Brewer & Dobson
1949	Dobson–Brewer circulation postulated
1952	stratospheric warming discovered: Scherhag
1958	radiative sources and sinks computed: Murgatroyd & Goody
1959	meteorological rocket network set up in U.S.
1961	theory of planetary-wave propagation: Charney & Drazin
1961	discovery of quasi-biennial oscillation: Veryard, Ebdon & Reed
1964	theory of mesospheric circulation: Leovy
1967	remote sounding of stratospheric temperature from Tiros 7: Kennedy & Nordberg

TABLE 2. MAJOR TOPICS OF MIDDLE ATMOSPHERE RESEARCH

radiation:	detailed radiative budget of lower stratosphere; non-L.t.e. (local thermodynamic equilibrium) in mesosphere; effect of variable solar input (in ultraviolet and in particle flux)
chemistry:	detailed reactions (especially involving ozone); detailed distribution of constituents (e.g. hydrogen, nitrogen, chlorine compounds); effect of artificially produced constituents (e.g. chlorofluoromethanes); neutral and ion chemistry of D-layer
dynamics:	propagation of planetary waves; mechanism of stratospheric warmings; interaction with troposphere; wave–mean flow interactions (e.g. mechanism of quasi-biennial oscillation); propagation and absorption of gravity waves; control of mean mesospheric circulation

also transport minor atmospheric constituents, namely water vapour, ozone, atomic oxygen and other compounds such as the oxides of nitrogen which are involved in the very complex chemistry of atmospheric ozone production and destruction.

The complex interplay which occurs in the middle atmosphere between radiation, dynamics and chemistry is what gives the region much of its fascination as a scientific discipline. Some of the major topics of middle atmosphere research being tackled at the present time are listed in table 2. To further our understanding regarding these questions will require a large increase in observations of structure and composition, especially in their coverage in space and time. Associated with the observational programme, further development will be needed of a variety of models which include the important processes in the three areas of chemistry, radiation and dynamics and which also include details of the interaction with the troposphere below where much of the dynamical forcing originates, and where many of the minor constituents have their origin.

Because of the possibilities presented by new observational methods and by the availability of satellites, a Middle Atmosphere Programme has been formulated under the Special Committee on Solar–Terrestrial Physics (Scostep) of the International Council of Scientific Unions, whose purpose is to encourage and coordinate research in the middle atmosphere in the early 1980s. That such a programme should be set up is also appropriate in the light of the concern which exists regarding the possibility that substantial changes in the ozone layer may occur because of the release into the atmosphere of chemicals (such as chlorofluoromethanes) arising as a result of man's activities. We can, therefore, look forward to a considerable increase in research activity in the middle atmosphere during the next decade. The purpose of this meeting is to summarize our present knowledge and to provide a perspective against which future plans can be formulated.

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