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H4.SMR/645-3

SCHOOL ON PHYSICAL METHODS FOR THE STUDY OF THE UPPER AND LOWER ATMOSPHERE SYSTEM

26 October - 6 November 1992
Miramare - Trieste, Italy

In Situ Measurement Techniques for the Middle Atmosphere

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For presentation at the

School on Physical Methods for the Study of the Upper and Lower Atmosphere System

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INTRODUCTION:

The middle atmosphere stretches from the tropopause (~15 km) to the lower thermosphere (~100 km). Rockets and balloons play an important role for in situ study of this region, since most of the region is inaccessible to aircraft (too high) and orbiting spacecraft (too low). Balloon-borne instruments, albeit limited to altitudes below 50 km and to constant heights except during ascent or descent, can provide long term records for specific events, particularly on those balloon platforms of the super pressure variety. Above 50 km within the mesosphere and lower thermosphere, rockets provide the only viable platform for measurement of many parameters incapable of detection by remote sensing techniques. These include electrodynamic parameters such as electrical conductivity, electric fields, and ion mobility, as well as neutral atmospheric parameters such as aerosol layers and turbulence characteristics. Although the rocket can at best provide a "snapshot" of the middle atmospheric environment, it becomes a powerful tool when selectively employed to probe during specific and unusual type of phenomena. For the last forty years, numerous measurement techniques to study the neutral and charged atmospheric structure and dynamics have evolved, providing a wealth of instruments for probing into the mysteries of this difficult-to-measure region. In these lectures, various measurement techniques will be discussed relating to atmospheric meteorology, minor constituents, and electrodynamics. Both rocket and balloon instrumentation will be considered. Although the emphasis of these lectures will be on measurement techniques, results will be discussed to show the importance of the discussed techniques to our understanding of the atmosphere.

GENERAL APPROACH: A brief overview of the atmosphere, including the need for rocket and balloon measurements will be presented. For each of the designated measurement categories, an overview of various instruments will be provided. Specific instruments will be discussed in greater detail with emphasis on instruments currently used to sample the middle atmosphere. Finally, specific examples of studies using the described instruments will be introduced, emphasizing the need to make multiple measurements simultaneously for meaningful results. Rocket and balloon platforms will both be considered. The first lecture will consider measurement techniques and problems related to the plasma or charged particle environment. Lecture 2 will merge into techniques dealing with meteorology, dynamics, and and composition of the neutral environment. General problems involving simultaneous measurements with multiple techniques will be discussed as time permits.

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LECTURE 1: The Plasma Environment with Emphasis on the Middle Atmosphere

I. Discussion of instrumentation to measure:

A. Anomalous energy sources.
Solar and magnetospheric electrons, protons, x-rays.
Energy deposition.
Mapping techniques.

Primary instruments:
Scintillators, Solid State Detectors.

B. Electrodynamic response.
Conductivity, electric fields, electron and ion density, ion mobility;
Irregularities and turbulence.

Primary instruments:
Electric Field- Double probe, field mill.
Ion Conductivity, density, and mobility - Gerdien condensor, blunt probes (conductivity only).
Electron conductivity- Blunt probes, Langmuir probe, capacitance probes.
Electron density- Probes, Faraday rotation and absorption.
Electron and ion turbulence and irregularities- Spherical and nose-tip probes.
Also used to track neutral turbulence.

C. Ion composition
Normal composition.
Metallic Ions.
Water cluster ions.

Primary instruments:
Mass spectrometers-
Massenfilters- Quadrupole, monopole, 3D-quadrupole
Mass spectrometers and spectrographs-
Focussing, double focussing, sector type.

II. Platforms:

A. Rockets: Benefits and disadvantages.
Timing, size, altitude, parachutes, aspect, pointing, duration of flight.

B. Balloons: Benefits and disadvantages.
Timing, size, duration of flight, super pressure balloons.

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LECTURE 2: The Neutral Environment ; Examples of Problems Involving Instrument Clusters

III. Discussion of instrumentation to measure:

A. Meteorology of the middle atmosphere.
Winds, temperature, pressure, density, waves.

Primary instruments:
Sondes, falling spheres.

B. Minor constituents.
Ozone, HO_x, NO_x, etc.

Primary instruments:
Photometers, chemiluminescent chambers, radiometer, UV spectrometer, microwave, etc.

IV. Rocket and/or balloon instrument clusters including comparison with satellite and ground based data; examples of specific problems relating to coupling which can be attacked with this approach:

- ❑ Electrodynamic and neutral response to energetic radiations.
- ❑ Wave particle interactions: lightning induced electron precipitation.
- ❑ Atmospheric response to the x-ray star- Sco X-1. Data use to establish the presence of heavy ions.
- ❑ High latitude summer mesosphere: NLC's and PMSE's, gravity waves.
- ❑ Modulation of stratospheric electric fields by thunderstorms, low pressure systems, and neutral dynamics.
- ❑ Metallic ions in the E Region; study of local dynamics, cometary abundances, etc.