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Overview of Science Focus of the Scientific Commission C of COSPAR

Space Studies of the Upper Atmospheres of the Earth and Planets Including Reference Atmosphere

[**Duggirala Pallamraju,** Senior Professor & Dean, Physical Research Laboratory, India, Chair of Scientific Commission C, and Indian Representative to COSPAR Council]

Scientific Commission C of COSPAR relates to "Space Studies of the Upper Atmospheres of the Earth and Planets Including Reference Atmosphere". This large canvas of science is covered under four Sub-Commissions and three Task Groups. This commission not only focusses on the behaviour, dynamics, composition, energetics and coupling of atmospheric, ionospheric and magnetospheric regions of Earth and planets under varying solar flux and solar activity conditions, but also solar planetary interactions and space weather. The Earth receives differential amounts of energy with latitude, longitude, local time, solar zenith angle, seasons, and solar activity. The wavelength and amount of absorption of ionizing solar radiation varies with altitude thereby creating altitudinal structures in plasma composition. For magnetized planets like the Earth, the plasma neutral interactions vary along and across the direction of magnetic fields. The exponential decrease in number densities of molecules/atoms with height enable the amplitudes of waves that are generated in the lower atmosphere to grow in amplitude (to conserve energy) as they propagate upward. These differential nature of energy inputs with latitude, longitude, altitude and time gives rise to a host of phenomena that are unique to equatorial-, low-, mid-, and high latitudes. All these dynamics, phenomena, interactions, couplings can be investigated by ground, balloon, rocket, and satellite measurements. The measurement techniques used for these investigations vary in all the range of the electromagnetic spectrum from the X-rays to radio waves. In optical domain they cover low- to high-spectral resolutions and small to large fields-of-view; very low frequency (VLF) to giga hertz in radio; and magnetometers.

The Sub-Commissions are focussed on Earth's upper atmosphere and ionosphere; the Earth's middle atmosphere and lower ionosphere; planetary atmospheres and aeronomy; and theory and observations of active experiments. Scientific Commission C also has three Task Groups that focus on several of the modelling aspects. The three Task Groups are Reference Atmospheres of Planets and Satellites (RAPS); International Reference Ionosphere (IRI); and COSPAR International Reference Atmospheres, including ISO WG4 (CIRA). In combination, the Sub-Commissions and the Task Groups comprehensively address both the science and modelling aspects related to the topic of SC-C: *"Space Studies of the Upper Atmospheres of the Earth and Planets Including Reference Atmosphere"*.

▲ The author, Duggirala Pallamraju

A brief description of the focus areas of Sub-Commissions and Task Groups are given below:

Sub-Commission C1:
The Earth's Upper Atmosphere and Ionosphere

The Ionosphere, Thermosphere, and Mesosphere (ITM) is the region that extends between approximately 90 and 1000 km in altitude and it continues to be an arena of active international space-based and ground-based research. The density, composition, and dynamics of this region are highly responsive to direct energy inputs and their variations from the Sun, the magnetosphere (high latitudes), and the middle atmosphere. The ionosphere is created by the interaction of solar extreme ultraviolet (EUV) radiation with the upper atmosphere and it extends from about 60 km above the Earth's surface to several thousand km. At high latitudes, energetic electrons precipitate

into the lower ionosphere and create additional highly variable ionized regions. The ionized and neutral gases are closely linked through collisions and dynamics, responding to energy and momentum forcing from both, the magnetosphere above, and the atmosphere below.

Sub-Commission C2:
The Earth's Middle Atmosphere and Lower Ionosphere

The "Middle Atmosphere and Lower Ionosphere (20 – 110 km)" is the focus of extremely active research, involving groups in all the major nations of the world which engage in atmospheric and space research. Much of the work is coordinated with, or is consistent with, global research programs. As this region contains the ozone layer, and will be involved in all aspects of Global Climate Change, this research is of enormous significance. The dominant themes are wave energy incoming from the lower atmosphere, wave interactions and momentum/energy dissipation within the region, and solar/magnetospheric influences from above; and the changes in chemical and physical aeronomy resulting from these dynamical processes.

Sub-Commission C3:
Planetary Atmospheres and Aeronomy

COSPAR Sub-Commission C3 addresses the study of planetary atmospheres (including lower and upper neutral atmospheres, ionospheres, and magnetospheres) and associated aeronomical issues. An appropriate emphasis is placed upon recent spacecraft datasets and corresponding model simulations that assist in the interpretation of the measurements. As our exploration of the solar system expands, the comparison of common features and processes across several planetary bodies is emerging as an important objective of this sub-commission.

Sub-Commission C5/D4:
Theory and Observations of Active Experiments

The Sub-Commission on Active Experiments promotes research involving the active perturbation of laboratory plasmas as well as space plasmas to enhance the understanding of the natural space plasma environment and the interaction of space vehicles with this environment. Some of the active perturbations used in these investigations include (1) tethered satellites, (2) VLF transmitters, (3) charged particle beam injections, (4) chemical releases, and (5) high-power radio waves. A wide variety of diagnostics are used to isolate physical processes found in actively perturbed space plasmas. Ground-based space plasma experiments rely heavily on radar and optical observations. Space-based experiments rely on diagnostics, such as in situ electric field and charged particle measurements. Important physical processes in space plasmas studied with active experiments include plasma turbulence, wave-particle interactions, wave-wave interactions, and plasma resonances. Physical processes studied associated with spacecraft environmental interactions include vehicle charging and plasma wakes and turbulence produced by vehicles passing through the charged media in space.

Task Group on Reference Atmospheres of Planets and Satellites (RAPS)

This Task Group focuses on developing and standardizing atmospheric models for planets and their moons. Its primary aims include creating models compatible with operational environments (like satellite drag calculation), standardizing atmospheric modelling procedures, and encouraging the use of advanced, physics-based models for better accuracy in scientific and technical applications.

URSI/COSPAR Task Group on the International Reference Ionosphere (IRI)

The Working Group was initiated in 1969 jointly by the Committee on Space Research (COSPAR) and the International Union of Radio Science (URSI) with the goal of establishing an internationally accepted standard for the description of the most important parameters of Earth's ionosphere. COSPAR's prime interest is in a general description of the ionosphere as part of the terrestrial environment for the evaluation of environmental effects on spacecraft and experiments in space. URSI's prime interest is in a reference model for defining the background ionosphere for radio wave propagation studies and applications. Both organizations requested that the model should be primarily based on experimental evidence using all available and reliable ground and space data sources. Theoretical considerations can be helpful in bridging data gaps and for internal consistency checks. At present this working group consists of a team of 68 ionospheric experts from 29 countries. More information on the current status of the model can be obtained by visiting the IRI homepage (http://irimodel.org/).

COSPAR/URSI Task Group on Reference Atmospheres, including ISO WG4 (CIRA)

The Task Group aims at developing and improving atmosphere models that are compatible with use in an operational environment, notably for satellite drag calculation. Presently, empirical upper atmosphere models are still used, but recently physics-based whole atmosphere models are being developed that potentially can be used in the near future. Temperature, composition, neutral density observations are necessary for model validation and assessment, in addition to data assimilation techniques. The derivation of the densities, and notably the