Ionosphere was discovered by Appleton and Barnett by using a loop and a vertical aerial receiving the direct and sky waves in 1925 and the pulse experiment of Breit and Tuve in 1926 provided further validation of the discovery. Appleton was awarded the Nobel Prize for this discovery. This provided the first scientific basis of trans-Atlantic radio propagation engineered by Marconi, which set in motion an era of radio communication via the ionosphere. For radio science, this was the second major milestone: the first was the pioneering work of J C Bose, Hertz and Oliver Lodge during the turn of the nineteenth century on generation, propagation and characterisation of microwaves.

The microwave efforts were, however, soon forgotten (to be resumed later, only after some three decades) with the death of Hertz, Bose moving on to the study of plant responses to external stimuli and Lodge to parapsychology. Thus the real beginning of radio science was the discovery of the ionosphere.

Remarkably, within a few years of this discovery, work on ionosphere began at Calcutta by S K Mitra (with H Rakshit) using a medium wave transmitter made available by the Calcutta station of the Indian State Broadcasting Service. Mitra produced the first experimental evidence of the E-region of the ionosphere. A series of papers came in quick succession relating to the behaviour of ionospheric layers over Calcutta. It is remarkable that the quality of ionospheric mapping achieved at that time with such simple equipment was so excellent.

This was an exciting period for ionospheric science in India. The second polar year programme was being organized, and the study of the ionosphere was being included for the first time. Mitra decided to formally participate in this programme; this was India’s first entry into organized international science. Questions were being asked about the origin of ionospheric layers. There was no clear idea about the relative contributions of energetic particles from the sun and electromagnetic radiation. An excellent opportunity soon came that allowed a distinction between ionization produced by solar electromagnetic radiation and solar corpuscles. This was the occurrence of the annular solar eclipse visible at Calcutta on August 21 1933. Mitra’s work confirmed the predominant role of e.m. radiation for low latitudes.

Scientists were already looking for the existence of additional layers in the ionosphere. There was indirect evidence of a layer below the E-layer at levels where collisions between electrons, ions and gaseous molecules are frequent and absorption of medium wave radio waves is large. Mitra and Shyam announced in 1935 the detection of regular echoes from low heights (55 km); later even echoes from as low as 20 km (20-30 km range) were reported. The former were attributed to the D-region, and the very low level reflections were believed to come from a hitherto unsuspected layer, which Mitra called the C-layer. Reflections from heights around and above 55 km were later to be observed extensively with HF transmissions, particularly in Australia, USA and Canada, and the technique came to be known in later years as partial reflection technique. The very low level reflections that Mitra and his colleagues detected from heights of 20-30 km and also reported soon after by Coldwell and Friend in the USA and Watson–Watt, Bainbridge–Bell, Wilkins and Bowell in U K were however not taken seriously for a long time until the concept of using HF atmospheric radars came up in the sixties. In that sense, these early pioneering works can be treated as the forerunners of HF radars.

_The Upper Atmosphere_ was first published by the Asiatic Society in 1947. It was Mitra’s intention to have
the book published by a foreign publisher, and he wrote to two or three firms, but the replies were disappointing and in some ways curious. To quote from the reply from one of the publishers:

"From previous experience of books of this nature we feel very doubtful whether it would have a large enough sale to cover the expense of publication, in fact; we anticipate that it would involve us in considerable financial loss. A further consideration is that even in the small field covered by your book it would have to compete with Chapman and Bartels' Geomagnetism and works by Sir Napier Shaw'.

And yet, when the book was published by the Asiatic Society, 2000 copies were sold out within three years; the second revised edition published in 1952 went out of print in a few years, and generations of students in radio communication, ionospheric and upper atmospheric physics, geomagnetism and space science have been using this book as a major reference document.

The Upper Atmosphere was a milestone in atmospheric science. It considered for the first time the atmospheric environment as a whole, neutral and ionized, its thermal structure and distribution of constituents, its motions, the interaction of the solar radiation and particle stream with these gaseous constituents, and the mechanism of airglow. The ionosphere was treated as only a part of this vast panorama that interlinked the sun, the earth and the atmosphere. This was then an entirely new concept. Secondly, deviating from the then existing practice of studying the ionosphere from the point of view of propagation of radio waves, Mitra viewed the exploring radiowave as a remote sensing tool, sensing levels which could not be reached with balloons and were only beginning to be explored by rockets. From considerations of escape of Helium; observations of auroral streamers at heights of 1000 km; twilight flash of the red oxygen lines traceable upon 1300 km; a number of ionospheric parameters such as electron collision frequency, scale heights, recombination coefficient; and the width of emission lines from the night airglow, he deduced the existence of very high temperatures in the upper atmosphere and came up with models of atmospheric density and temperature which have remarkable similarities with contemporary models using satellite drag.

At the time of launch of Sputnik I in 1957, the Russian space scientists found that the only reasonable atmospheric models they could use for predicting the lifetimes of satellites were those given in the Upper Atmosphere.

Ionospheric chemistry, as we know now, had not emerged but, even here, Mitra made a beginning through detailed discussions of the formation and destruction of ozone, of dissociation of N₂ and O₂ and of night airglow. For ozone, the descriptions were surprisingly detailed; there were also discussions of heat balance of the stratosphere including cooling and heating of the middle atmosphere due to ozone absorption – problems that we are still discussing in an essentially similar manner.

During the last four decades the entire picture of the Sun-Earth system has drastically changed. The upper boundary of the atmospheric environment has now been pushed to many earth radii i.e. to hundreds of thousands of kilometers with different components of the atmospheric environment interacting with each other. Even in this vastly changed (and greatly expanded) canvas, much of the information given in The Upper Atmosphere and the results of his scientific investigation stand as benchmarks.

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