1.1. Solar UV - B radiation measurements.

Solar UV - B radiation measurement was continued with international light spectrometer from 290 - 400 nm wavelength for direct as well as global radiation at fixed solar zenith angles. Also total erythema was measured by a sensor peaking at 297nm. The global measurement, by automatic integrating type photometer, was continued for full day observation. The data of spectroradiometer was analysed for direct, diffuse and global variation of UV - B radiation for different days. Global UV - B radiation measurements made at Pune, Mysore, Waltair and direct UV - B radiation measurements at Trivandrum were analysed. It was observed that UV - B radiation received at ground in the year 1991 was less in comparison to previous three years, although there was appreciable increase in ozone values. This decrease could be due to increase in particulate matter and turbidity of the atmosphere.

1.2. Aerosol measurements:

Data sets pertaining to last four years (1987-1991) were analysed for monthly mean extinction coefficient. Measurements were taken at 9 discreet wave lengths in 400 - 1025 nm range. Measurement of last two filters at 935 nm and 1025 nm also provided the estimate of water vapour in the atmosphere. A steady increase in extinction coefficient was observed at all the wave lengths from 1989 to 1991. The increase during January 1991 for the first four filters, from 400 - 590 nm was quite appreciable compared to remaining filters, while in February 1991, the increase was in the entire region. This abnormal high extinction coefficient may be due to increase of particulate matter, especially carbon and sulphur dioxide compounds drifting from the gulf region.

1.3 Solar infrared measurement

The solar spectroradiometer was calibrated using a 200 watt quartz halogen tungsten coiled - coil filament lamp standard traceable to NBS spectral irradiance scale. Line of sight water vapour measurements were made and using an inversion technique, water vapour content was evaluated. Measurement of solar infrared radiation in 2.5 to 14.5 μm range using sunphotometer was continued. A few well defined absorption lines of water vapour, carbon dioxide, ozone etc were identified. The data obtained was used to estimate total ozone content in the vertical column.

1.4 Rocket measurement of minor species.

Data obtained from the flight carried out in 1989 was analysed and the nitric oxide concentration was derived as a function of altitude. Theoretical simulation of nitric oxide in the mesosphere and thermosphere was also undertaken and profiles were generated for all rocket flight conditions. The theoretical and experimental profiles showed fairly good agreement above 90 Km. Ozone concentration profiles were also derived from the data obtained from the two rocket flights carried out in March, 1991 under DYANA Campaign of IMAP. These profiles were also compared with the profiles obtained by other groups around the same time under this campaign and were found to be in fairly good agreement.

1.5 Ozone studies.

A systematic analysis of global ozone data was made using satellite and ground based observations. An important result was a missing peak in the Quasi Biennial Oscillation (Q.B.O) in ozone during 1983. It was also seen that there was a reversal in the oscillatory peak above 34Km. The missing Q.B.O was attributed to El Chichon volcanic eruption which contributed to aerosol loading. Studies of ionospheric absorption and total ozone data at a few stations showed low frequency oscillations. Fast fourier transform spectra indicated peaks with 20, 30 and 50
day (a broad band between one to two months) periods. An attempt was made to see whether a mechanism existed between tropospheric, stratospheric and mesospheric levels.

**SROSS AERONOMY SATELLITE**

Flight packages of the sensors and electronic hardware of satellite payload were fabricated, tested and space qualified. The payload consisted of four packages named as RPA 11, RPA 12, RPA 13 and RPA 20. The fabrication of sensors was done in a dustfree controlled environment at the mechanical QA laboratory of ISAC, Bangalore. The packages were handed over to ISRO for spacecraft integration. The testing and qualification of the payload was done at the test and evaluation laboratory of ISRO Satellite Centre, Bangalore. The payload passed successfully all the environmental tests for flight acceptance.

The testing of RPA payload, during bench and other environmental tests, was done with the help of a payload checkout console (PCC) developed at NPL. The complete operation of the RPA payload was controlled with PCC. The data coming out of the payload was also stored in the PCC memory and was analysed in near real time to have the tabular or graphic display of results. Simultaneous to the activity of payload integration with the spacecraft, the work on the development of software, compatible to VAX as well as to the IBM PC was started for data recording and near real time analysis, after the satellite is being launched.

Preparations were going on for the launching of two high altitude RH - 560 rockets from SHAR coinciding with the overhead passess of the SROSS aeronomy satellite, to be sent into orbit towards the end of 1991. The rockets will be launched two or three months after the launching of satellite.

**RADIO COMMUNICATIONS**

1.1 Long term solar and ionospheric predictions

A new computerized method for predicting sunspot cycle was developed and the declining part of the current cycle No. 22 which peaked during July 1989, was predicted. Comparisons made between predicted values of smoothed sunspot number and those obtained from observations for the year 1990 were found to be satisfactory. A draft atlas of ionospheric communication parameters over the Indian sub-continent was prepared. The atlas contained characteristics along with error analysis on monthly basis for different stations in this region. A report entitled “Performance analysis of an HF radio link between India and Antarctica” was compiled for the Department of Ocean Development. It presents an analysis of the performane of the HF radio link between Delhi and the Indian Antarctic station Dakshin Gangotri.

1.2 Studies on HF field strength.

The study of field strength measurements of several HF broadcast transmissions yielded some important results. It was observed that transmission losses in HF bands arising due to random and short term ionospheric phenomena at low latitudes were particularly large during equinoxial methods. A provision of 4 dB towards transmission losses, other than free space and ionospheric absorption losses, seemed to bring the predicted values closer to measured field strength values for single-hop circuits in about 50% of cases in the Indian region and 8 dB about 90% of cases. These results were of great relevance in planning of HF circuits in India.

1.3 Line of sight propagation

A detailed study was made on the effects of path inclination on fading based on the experimental measurements carried out on various LOS links situated in different geographical locations of India. In regions, where super refractive and ducting layers prevailed for a considerable percentage of time, the design of LOS links should incorporate the concept of path inclination for minimizing the fading. It was also found that the rising layer in the morning hours reflected the electromagnetic signals to far off distances and acted as a source of interference. The
electromagnetic interference potential has shown that the range of an LOS transmitter for a normal reception could be as large as 110 Km.

1.4 Rain rate characterization

The characteristics of rain rate were studied using rain gauges having different integration time (10 secs, 15 mins. and 1 hour) over Delhi. The results on the relationship between rain intensity measured with different integration times were studied. The rain rate durations and return periods of the specific rain rate occurring within continuous rain events were also studied.

1.5 VHF propagation

Influence of obstacles such as mountains, ridges on VHF TV signal propagation was studied over 13 single knife-edge diffraction propagation paths in India. It was observed that in urban areas additional loss should be added to the predicted path loss to explain the observed values while the predicted pathlosses obtained using Epstein - Peterson, Deygou and CCIR methods were found to be comparable to the observed values in the rural zone.

1.6 Airborne microwave refractometer

Airborne microwave refractometer data was used for collecting information (on near - real-time basis) in convective conditions. The analysis of data obtained during 9 June, 1983, flight revealed layer movement due to convection and the observed convection field growth rate was in agreement with the vertical wind velocity prevailing during the observational period. The observations showed excellent agreement, with the data collected using remote sensing systems.

In order to assess the atmospheric refraction anomalies and their bearing on low angle radar tracking problems, airborne microwave refractometer data was utilized. Path of the airborne radar rays was derived using a three - dimensional computer stimulated ray tracing technique combined with the radio refractivity profiles from refractometer observations.

1.7 ARWC and consultancy services

The period 1990-91 continued to experience high level of solar activity. ARWC issued several special warnings and forecasts on solar and geophysical conditions to aid a number of users, including ISRO, Bangalore. Consultancy services, related to HF, VHF and radio communications, were rendered to a number of organizations including CEERI, Defence Deptt. and Rajasthan Communication Ltd, Jaipur.

1.8 Propagation of TV signals

The diurnal variations of anomalous longdistance TV signals at Delhi were studied. As the peaks occurred both in 1978 and 1991 (solar activity peaks) this indicated to be a solar activity related effect. The operating frequencies of high power short wave radio transmitters were found to be closer to the plasma frequencies of F - region during high solar activity on several occasions especially during night.

INDIAN ANTARCTIC RESEARCH PROGRAMME

An acoustic sounding system was designed and developed in collaboration with the S V University, Tirupati and IIT, Kanpur. The system has a unique acoustic shield designed to survive a wind velocity of 300 Km/hr. The system was established in Antarctica by the NPL team in December, 1990. A microbarograph and an automatic weather station were also established to study the planetary boundary layer effectively.

UV spectroradiometer and sunphotometer were used for taking observations during the 10th expedition. The data collected on solar UV - B measurements from 6th expedition onwards was analysed and compared with the satellite data for anti-correlation. Aerosol measurements taken enroute and at Maitri station during the period 1988-1990, were analysed for solar zenith angle dependence and were compared from year to year. It showed slight increase in the aerosol loading from 1988 to 1990.
The air samples brought form Maitri station in April 1990 by the antarctic expedition were analysed for green house molecules viz. methane, carbon dioxide and nitrous oxide. The concentration of methane over the year showed an interesting variation with a minimum during April - May and a maximum in December - January. Mean concentration of methane, carbon dioxide and nitrous oxide were found to be 1.73 + 0.02, 373 + 10 and 0.359 + 0.01 ppm respectively.

The development and fabrication of the laser heterodyne system in collaboration with France was in progress. 1 GHz acousto-optic spectrometer was developed and tested. The system will act as back end of laser heterodyne system to be sent to Antarctica. The absorption / emission lines of the atmospheric minor constituents will be resolved with a high spectral resolution to obtain vertical profiles of various trace species using inversion techniques.

RADIO AND ATMOSPHERIC PHYSICS

1.1 Aeronomy of Venus & Mars - ionopause and electron temperature

Inspite of the long Venus nights there was a remarkable abundance of ions on the nightside, featuring the same constituents as on the dayside. The height of the near terminator ionopause was very crucial, since it determined the strength of the source. It was generally accepted that during solar maximum at times, when solar wind dynamic pressure (PSW) was high and during solar minimum at all the times, the terminator ionopause came down to very low altitudes (250-300 km). It was shown from the pioneer Venus spacecraft measurements that the terminator ionopause always remained above about 500 Km, there by providing a large reservoir for plasma transport from dayside to nightside all the time. The ionopause definition applicable to transport studies, was the altitude where the ions pause and that was used in the analysis.

A detailed comparison of the neutral atmosphere, ionosphere and solar wind interaction of Venus & Mars was made in the light of the recent results from spacecraft missions and the phobos project. Both Venus and Mars have extended atmospheres with CO₂ as the major neutral in the lower atmosphere and O at higher altitudes. On Venus the major ion was O⁺ in the upper ionosphere while O₂⁺ dominated mostly in Mars. Peak electron densities at both Venus & Mars were close to Chapman distribution. The solar wind interacted directly with Venus ionosphere in absence of an intrinsic magnetic field. In Mars ionospheric observations from the Viking mission provided evidence for a Venus type solar wind interaction.

The solar wind interaction produced two distinct regions in the Venus ionosphere, namely (i) the main ionosphere and (ii) the ionopause, the region of steep electron density gradient. A re-examination of dayside electron temperature (Te) in the two regions showed that in the main ionosphere it was affected by changes in PSW. However, in the ionopause region, Te and its height gradient were grossly affected by changes.

1.2 MST Radar spectra and atmospheric waves

A quick fit algorithm, following an approach followed at Poker Flat, was developed and tested for validity using the available spectral data. The agreement between the moments from the present algorithm and those given by Poker Flat was found to be satisfactory, suggesting that it can be used for quick fit algorithm of the data from India MST Radar.

Long series of wind data from regular radiosonde and rocketsonde flights were analysed using Fast Fourier Transformation and Maximum Entropy Method techniques to study atmospheric waves of 30-70 days period. Data of zonal wind over near-equatorial station Thumba, collected by M-100 rockets and radiosonde balloons, was used for the purpose. These atmospheric waves were not confined to south-westerly monsoon season but also noticed to be equally strong in north-easterly monsoon season. The waves were observed at tropospheric as well as stratospheric heights. The phases of both 30-50 days and 50-70
days waves were noticed to be advancing downward. The analysis of meridional wind suggested that waves did not conform to Kelvin waves.

1.3 Incoherent scatter radar studies

The incoherent scatter measurements at Arecibo were used to deduce width and depth of the EF valley. These parameters were compared with those calculated from Gulyaeva's empirical relation. The incoherent scatter measurements did not show any significant valley during daytime, these confirmed the occurrence of significant valley during night. The width of the valley calculated from Gulyaeva's relation was larger during the day but smaller during the night, as compared to the observed values. However, the depth of the valley calculated from Gulyaeva's relation was lower during the day but much higher during the night, as compared to the observed values.

1.4 Satellite beacon studies

The VHF signals of the geostationary satellite ETS-2 and L-band signals of the geostationary satellite INMARSAT for amplitude scintillations were monitored. The signals of the ETS-2 were terminated on Dec. 14, 1990, because of the reallocation of the 136 MHz band for mobile communication. Since then 244 MHz signals of the geostationary satellite MARISAT were recorded for amplitude scintillation studies. Data from three station network- Delhi, Meerut and Panipat was recorded during Jul.-Aug. 1990 and from the network-Hyderabad, Shadnagar and Vikarabad was recorded during Nov. 6-28, 1990 for TID studies. An algorithm which detected all the travelling ionospheric disturbances and determined their various parameters viz. amplitude, period, speed, direction and wavelength was developed.

A study of IEC at Hyderabad during 1979-87 showed that IEC increased with solar activity, post sunset secondary maximum was observed during high solar activity and diurnal maximum in summer months showed saturation after 170 units of 10cm solar flux. An analysis of post sunset secondary maximum, scintillations and Faraday polarisation fluctuations at Hyderabad showed that Faraday polarisation fluctuations were observed only on those days when both amplitude scintillations and post sunset secondary maximum were present. Computer simulation studies of the effect of geometry on satellite Faraday polarisation fluctuations showed that during high solar activity depolarisation effects were comparatively less at Hyderabad than at Delhi.

1.5 Ionospheric effects

The ionospheric effects observed during the great storm of 13 March 1989 were studied in detail using ionosonde observations for some equatorial and low latitude stations. Significant longitudinal differences in the stormtime responses were observed both during day and night. The dramatic night time ionization collapse observed at Kodaikanal was not seen at Manila located 45°E of Kodaikanal. The collapse of Kodaikanal could be accounted only partly as due to increased loss rates caused by lowering of layer heights and increased neutral temperature. The presence of a localized heat source was suggested to
account for the observed decay in ionization.

1.6 Electric and dynamo fields

The storm time electric fields at equatorial latitudes were studied from the F region height variation during the high solar activity period. This study revealed that the increase in these electric fields observed during the first day of the storm on certain occasions could be attributed to the penetration of magnetospheric electric fields and the decrease observed during the second day on many occasions could be due to the disturbance dynamo electric fields generated by the thermospheric wind system driven by heating in the polar regions.

The design of the rocket experiment for studying the F-layer dynamo fields, was worked out. It consisted of specifying the time, location and extent of modification to be made in the E region conductivity in the post sunset period and observing its dynamical effect on the F region at Thumba connected by the geomagnetic field line.

1.7 Microwave/millimeter wave radiometry

Microwave propagation studies for slant path attenuation distribution and instant measurement of rainfall rate were evaluated. It was shown from the scatter plot that the attenuation against rainfall rate varied between 0.04 + 0.08 R and 0.04 + 0.11 R. It was observed that for 0.1% of time, the attenuation exceeded for slant path was of the order of 6 dB corresponding to the rainfall rate of 60 mm/h.

An inversion technique for evaluating water vapor content over land and sea from SAMEER on board satellite platform Bhaskara was evaluated and compared with the radiosonde measurements. The integrated water vapor content for different latitude-longitude range over Indian subcontinent was plotted in the form of contours for 0900 and 1400 hrs. Indian Standard Time averaged over the months of July-August 1979. The value of water vapour content was found to be less over the Arabian sea than over the Bay of Bengal. A large cross-equatorial water vapour flux existed in the eastern part of the Indian ocean and brought moisture in the Bay of Bengal.

1.8 Ionospheric time delays

A detailed study of excess time delays recorded in Global Positioning Satellite measurements at 1.57542 GHz following the solar flare events of 12-17 August, 1989, period was made. The delays were of the order of 1280 nano secs. during normal days and increased by about 100-120 nano secs. following the X-20 flare on 16 Aug. 89. The excess time delays showed good correlation with increases seen in $N_mF_2$ values at Ahmedabad, corresponding to sub-ionospheric point of the satellite.

1.9 Equatorial plasma bubble dynamics

The equatorial plasma bubble dynamics was studied using scintillation observations at 4 GHz from two satellites, INSAT-1B (74°E) recorded simultaneously at two earth stations, Sikandarabad and Chenglepet during 1989 along the same geomagnetic meridian. The characteristics and occurrence pattern of the scintillations suggested that these were equatorial plasma bubble-induced events. The east-west plasma bubble irregularity motion was also estimated from the systematic onset time differences observed between the equatorial and low latitude station. The difference in the magnitude observed between the present results and those reported by other techniques were interpreted in terms of the vertical shears in the plasma zonal flow over the equator.