# Multisatellite observation of Indian ocean tropical cyclones

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Multi-satellite observations for two tropical cyclones, one over the Arabian Sea that occurred during May 16-22, 1999 and the other over the Bay of Bengal (November 26-03 December, 2000) have been analyzed to understand the evolution of tropical cyclones over the northern Indian Ocean. This thesis focuses on the observational aspects of the diurnal variation of inner-core convection and the relationship between low level moisture transport and the intensification of core. The infrared data from geostationary satellite INSAT-1D and geophysical parameters from SSM/I and TRMM-PR have been used for the present study. 85 GHz observations from TMI and scatterometer observations from ERS-2 and QuikSCAT have been used for center determination of the cyclones under the study. A general overview pertaining to the statistics, structure and factors affecting the formation of tropical cyclone is provided. Use of satellite observations in tropical cyclone studies where both the visible / infrared and microwave techniques have been discussed in detail. The information regarding the swath, operating channel frequencies, resolution, field of view, satellite orbit etc. of those sensors is give whose observations were used for the present study viz. INSAT-VHRR, TRMM-TMI, TRMM-RR, SSM/I, ERS-2 and QuikSCAT scatterometers. The results include the synoptic overview of the two cyclones under study, the information regarding the available satellite observations, the methodology of center determination using scatterometer and 85 GHz observations and their inter-comparison. A section that deals with the distribution of precipitation, winds and water vapour fields over the cyclonic areas which includes a study of the asymmetries associated with the cyclones under question, the changes in intensity of the cyclone on landfall and relation of precipitation with low level convergence. Another section deals exclusively with the diurnal variation or the convective band cycle of the two cyclones using SSM/I and INSAT-VHRR observations. Study of the evolution of infrared signatures and identification of major cloud types during the life span of the cyclones has also been carried out. Impact of wind asymmetries on the future track of tropical cyclones is briefly discussed. Also the impact of inner-core precipitation, and low-level moisture convergence on the future intensity of cyclones is assessed and our analysis indicates a direct relation between the above two parameters and intensification of tropical cyclones. Diurnal variation of inner-core convection of Indian Ocean tropical cyclones has been studied using 3-hourly infrared images from INSAT. The Arabian Sea cyclones show a regular diurnal variation with band formation during day time and merging of bands with inner-core, and strengthening of inner-core convection during mid-night hours. Bay of Bengal cyclones show such diurnal variation only during development and decaying phase, and not during the mature phase of cyclone. This contrasting diurnal behavior of cyclones of two neighboring basins is a matter of further investigation.

## Ionospheric Tomography at low latitudes

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The Earth's ionosphere is partially ionized gas, that envelope the Earth and in some sense forms the interface between the atmosphere and the space. The effect of solar ultraviolet radiation on the upper atmosphere is to ionize the constituent gases of the upper atmosphere. The ionization commences at a base near the mesopause (~ 80 km above earth's surface) and extends up to the highest limits of the atmosphere. However the ionization is not at all uniform throughout .It is divided into several "regions" or "layers" of maximum ionization .the principal ionospheric regions are known as , D ,E and F with protonosphere as the outermost layer. The D region extends from about 50 km to 90 km, E region from 90 km to 150 km, F-region from 150 km to 700 Km with the protonosphere above it. These are approximate altitude regions .The F- region may be further subdivided into F1 (150-200 km) and F2 (200-700 km) regions. During nighttime both these regions merge to form a single F- region. Recently, experimental and theoretical evidence has suggested the existence of another layerabove F2 termed as the Glayer or F3 layer. The photo-ionization by extreme UV and X-rays from the Sun is the most important source of ionization in the ionosphere. In the D region, hydrogen Lyman-alpha (121.6 nm) and Hard X rays (0.2 0.8 nm) are the main ionizing radiations. In the E- region extreme UV and X rays (1-10 nm) are the main ionizing radiations. In F1 region, wavelengths between 20 nm to 90 nm contribute to ionization, while in the F2 region 79.6 nm wavelength is important from ionization point of view. In the D- region cosmic rays can also give rise to ionization, but its contribution is less important compared to solar radiation in that region. During nighttime, the D-region does not exist over equator while the electron density in the E-region decreases by an order of magnitude at night as compared to day. The F-region at night is still maintained due to transport. The F-region density also decreases by an order of magnitude at night as compared to day. With the increase in solar activity, the ionospheric electron density increases since the intensity of extreme UV and X-ray flux increases with increase in solar activity.

## Study on atmospheric aerosols by measuring the aerosol optical depth using hand held sun photometer

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Columnar aerosol optical depth measurements have been made over Indore (22.7° N, 75.9° E) during May 2001 - March 2002 at four spectral bands centred around 400, 499, 668 and 858 nm using a hand-held sun-photometer. The aerosol optical depth (AOD) shows seasonal variation with high values (0.6 at 400 nm) in summer and low values (0.35 at 400 nm) in winter. The summer increase is found to be due to the high wind speed producing larger amount of wind-derived dust particles. As the summer monsoon sets in at the end of June there is an appreciable decrease in the AOD values. The AOD values decrease further in winter and the decrease is more at higher wavelengths (858 nm) indicating that there is a general reduction in the number of bigger particles. Also during winter months the wind direction changed to southerly and south-easterly which brings air that is more rural to the measurement site. The amplitude of the observed high AOD values in summer and low during winter, is higher for longer wavelengths which shows that the coarse particles contribute more to the observed variation as compared to sub-micron particles. Comparison of the AOD values over Indore with that of Trivandrum and Visakhapatnam shows that the Indore values are comparable to that of Visakhapatnam, but much higher than the Trivandrum values.

## Chemistry of lower Ionosphere of Mars

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The ion neutral chemistry of the lower Martian ionosphere is more complex than any other ionospheric region. It is similar, in some aspects, to the D region of Earth's ionosphere. In this report, we have studied the impact ionization processes and ion-neutral chemistry in the lower ionosphere of Mars. The production rates, loss rates and ion/electron densities are calculated below 90 km using one dimensional continuity and momentum equations under photochemical steady state equilibrium condition. The impact ionization sources in this model are solar radiation and cosmic rays. The chemical model couples ion-

neutral, electron-neutral photo-dissociation of positive and negative ions, electron photo-detachment, ion-ion and ion-electron recombination processes through over 100 chemical reactions. The electron density is calculated using charge neutrality condition. The present report consists of six chapters .All these chapters are self- consistent and develop the subject of study in systematical manner. The first chapter gives the general introduction on the lower atmosphere of Mars. It also describes D, E and F regions of the Earth's ionosphere, which is considered principally for comparison with Martian ionosphere, because they share many important physical characteristics with it. In the second chapter, we have explained theoretical models, which are used in the present report. These models are, (1) Analytical Yield Spectrum (AYS) approach (2) Energy Loss Model and (3) Continuity and momentum equation. We have described the solar flux, total elastic, total inelastic, photo-ionization and photo-absorption cross sections in chapter three. In the fourth chapter, the ion production rates due to photo-ionization, photo-electron impact ionization and cosmic ray ionization are calculated at solar zenith angle zero degree. In the fifth chapter, the densities of positive and negative ions are calculated in the lower ionosphere of Mars at solar zenith angle zero degree. The chemistry of these ions is also described in this chapter. Finally, in the sixth chapter, we have given summary ,conclusion and future directions on the work carried out in the present report.

## Characterizing x-ray emission from solar flares using Solar X- Ray Spectrometer (SOXS)

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Solar flares are sudden transient bursts in the magnetically complex active regions in the solar atmosphere. The solar flares emit enhanced radiation over the whole electromagnetic spectrum covering gamma rays to long radio wavebands. It appears that flare begins in high energy like X-ray and therefore appears initially in soft & hard X- ray emission. The X-ray emission from solar flares enable us to study the various plasma parameters such as temperature, emission measure and spectral index, which in turn allow to study the energetics and dynamics of the flare. The high energy X-rays from solar flares have been studied since last two decades but soft and medium X-ray emission with high spectral and temporal resolution was not studied due to non-availability of such space borne mission. In this context, “Solar X-ray Spectrometer (SOXS)” mission of PRL, India was designed to suit these requirements in order to study the X-ray line and continuum emission. SOXS mission employs state-of-the-art Si and CZT solid state detectors. Si reveals sub-keV energy resolution throughout its dynamic energy range of 4-25 keV, while CZT reveals between 1.7 and 2.2 keV in its dynamic energy range of 4-56 keV. In this context Si is found extremely good to study the soft X-ray emission in general and line emission in particular. The CZT is good to study thermal and non-thermal continuum X-ray emission in the energy above 10 keV. The temporal resolution during flares for intensity and spectra is 100 ms. The SOXS mission has observed more than 200 flares so far satisfactorily. Study carried from SOXS data and its comparison with GOES mission allowed generating calibration of flare's intensity between these two missions. Detailed study of Fe and Fe/Ni line features enabled to establish their evolution characteristics of these lines with reference to the continuum plasma temperature and emission measure. It is found that minimum critical temperature required for Fe and Fe/Ni line evolution is 9 and 15 MK respectively. On the other hand detailed study of several big flares revealed that break energy between thermal and non-thermal components is varying between 10 to 20 keV depending upon the flare's energetics that depend upon the magnetic complexity in the active region.

## Estimation of Fried's Parameter at USO lake site

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The turbulent atmosphere of earth limits the resolution to surprising small values of the order of one arc second, irrespective to the size of telescope. Besides this the meteorological conditions also play a major role in it. That is why some of the sites are better than other sites. We can characterize a site by measuring the Fried's parameter and this has been a matter of prime interest for night time astronomers as well as for day time astronomers since the beginning of the last century. The Fried's parameter $r_0$ at any astronomical site contains information about the statistical measure of seeing at a site. Various distinct methods have been developed to measure it for both types of sites. Daytime measurements require somewhat different methodology to account for high intensity levels. The aim of this project is to measure the Fried's parameter at Udaipur Solar Observatory (USO) Lake Site in conditions when lake is filled with water and when it is without water. We got a chance to measure $r_0$ in both the conditions during last one year. In the first chapter of this report, we have presented the basic concepts of Kolmogorov's statistical theory of turbulence and it's effects on astronomical imaging and then interpreted the as well as it's importance .In the second chapter ,we have described four different methods to estimate $r_0$ . The first method is spectral ratio method, which existed in the literature. The other three methods have been developed during the course of he project. The two of them namely the Quality Factor or Signal to Noise Ratio Method and Contrast of Solar Images as an Estimator of $r_0$ are developed to account for the available facilities at USO .The fourth method is a Method to Estimate Limiting Resolution in Reconstructed Solar Images using intrinsic contrast of solar surface features. We have presented the plan of both the observations done at USO when the lake was dry and filled with water, in the third chapter. In this chapter, we also have presented the extended treatment of simulations and application to real data for all four methods. Plots for concerned quantities in different method shave been presented. In the fourth chapter, we have presented the conclusions drawn from all the methods. The comparative study of seeing at USO in both the aforementioned conditions is also presented. Finally , we have presented the summary of this report with possible future directions in the fifth chapter.

## Near-infra red studies of transient clouds on Titan

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Titan is Saturn's largest moon with an atmosphere and is currently the focus of intense research due to Cassini-Huygens space mission (NASA/ESA) to the Saturnian system. The thick atmospheric haze layer of unknown origin in Titan obscures the surface due to which the nature of its surface and atmospheric characteristics still remain a mystery. However, in recent years ground based near-infrared studies of titan have yielded some interesting results. Titan's near infrared spectrum results primarily from the absorption of solar radiation, by methane and scattering of radiation from particles in the atmosphere. This absorption varies considerably with wavelength, giving access to different altitude levels that can be probed in the atmosphere. Several windows exist in the near infrared where methane absorption is weak and the atmosphere is sufficiently transparent to the low sounding of the surface and lower atmosphere. In this thesis, an attempt has been made to search for transient clouds on titan's atmosphere by studying the near infrared geometric albedo variation which could signal the existence of clouds on Titan. Observations of Titan were made with the NICMOS spectrometer of the 1.2 m Mt Abu IR telescope at Gurushikhar, having a resolving power of 1000.The observations presented in this thesis extend over period of 6 months from November 2003 to April 2004, covering the 1- 2.5 μm region. Geometric albedo variations in 1.24, 1.28,1.575,2.12 and 2.17 μm were observed for April 12, 2004, in J, H and K bands in comparison with other observational days. This clearly indicates the presence of transient clouds on Titan varying over a timescale of hours to weeks. Other ground based infrared measurements by large telescopes like UKIRT and VLT have also provided evidence for transient cloud features on Titan. Observational data base of present study is limited and therefore, further intense monitoring over a prolonged period is recommended to fully establish the meteorological properties of titan's atmosphere. However, this thesis demonstrates that significant work can be done even from a modest aperture earth based telescope in unveiling one of the mysterious objects in our solar system.

## Total Ozone measurements over Kathmandu using Brewer Spectrophotometer

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Measurements of atmospheric total ozone over Kathmandu (27.67 N, 83.295 E) are being carried out with a Brewer Spectrophotometer during the period of one year from February 2001 through February 2002. This is the first instrument installed in Nepal to study systematically the behavior of the total ozone and UV-B radiation. The data obtained during the study period have been analyzed to study diurnal and seasonal variations of total ozone over Kathmandu. The Brewer ozone data have also been compared with Total Ozone Mapping Spectrometer (TOMS) data. It has been found that total column ozone values reach maximum around noon. Data show maximum total ozone at near noon and minimum in the evening in almost all cloud free days. The observed increase in total ozone around the noon is 5-10% of average ozone. Such variation is mainly due to the effect of stratospheric ozone, since almost 90% of total overhead ozone is contained in stratosphere. There are significant correlations between Brewer ozone measurements and TOMS ozone data. The difference between the two results are up to 7% of the mean ozone. This small difference is expected due to difference in time of observations and presence of outliers. The daily and seasonal variations of total ozone over Kathmandu have been studied using TOMS ozone data, Brewer direct sun ozone data and Brewer zenith sky ozone data. The measurements show that total column ozone concentrations are more in sunny days or cloud free days rather than cloudy days. In sunny days, the photochemical reaction is predominant for the ozone formation. The result also indicates that total ozone values are low in winter season. The monthly averaged ozone concentrations over Kathmandu are maximum (305 D.U.) in May and minimum (241 D.U.) in December. The low ozone concentration would be caused by chemical and dynamic destruction processes related to the low temperature and less active photochemical reaction due to less intense solar radiation. More research is needed to delineate the relative contributions of dynamic, chemical and catalytic processes that cause ozone depletion.

## Photometric & spectroscopic observation of VW Cephel eclipsing binary star

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VW Cephei (HD 197433, SAO 9828), a well known W UMa system, has been studied in the thesis. The observations were carried out using the 28-cm Schmidt Cassegrain telescope of Fuiji Bisei Observatory equipped with ST-7 CCD imaging camera. Observations were carried out during the time interval 13:18 UT to 15:58 UT on July 16, 1999. The integration time is 24sec which resulted (including the read out time of the CCD) in the sampling time of nearly 70sec. Stars HD 198510 and HD 198547 are used as comparison and check star respectively. Image processing and the data analysis was carried out using the IRAF package distributed by NOAO, USA. The light curve has been constructed and presented in the thesis. The estimated period matches with the reported period of 0.278d. In addition to this spectra of the star VW Cep was obtained using 1.01 meter telescope (F/12 system) of Bisei Astronomical Observatory. The spectra cover the wavelength from 390 to 760 nm with a resolution of 0.7nm at H-Alpha wavelength. The analysis of the spectra has been done using the IRAF package. Standard star HR 8634 has been used for the flux calibration. Several lines like H-alpha(6562.808A), Na D_2 lines(5889.973A), Fe I (4383.557A) etc were identified in the spectra. Since the resolution of the spectra is 7A, the Na D_1 and D_2 lines could not be identified separately. The spectra are presented in the thesis.