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Research Article

SPECTROSCOPIC APPLICATIONS OF REMOTE SENSING IN BIOTIC-ATMOSPHERE

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ABSTRACT
With rapid progress in remote sensing programs occurring in India and elsewhere, these techniques are becoming the pivotal component of global observing systems for both research and operational environmental monitoring. In the coming years, remote, sensors will provide an unprecedented volume of data that present real challenges to engineers and scientists. Satellite imaging techniques use the principle of molecular spectroscopy to sense and understand the earth and the atmosphere above it. This amalgamates the interests of different disciplines in modeling, algorithm, processing, information distribution and application. This way institutional and personal collaboration and interaction advances our optical remote sensing knowledge and skill to meet increasing demands for understanding and management of our environment (M Bath, 1974).
Tropical cyclones or hurricanes are extremely dangerous to mankind. Early detection of these systems by traditional methods was inaccurate and had less range. Five tropical cyclones that developed over Indian Ocean in last three years were classified by using the satellite imagery data. Authors in this paper have focused on the latest accomplishments and future advances of the remote sensing techniques to optimize the use of the satellite data. The results obtained by using the satellite imagery data embedded in pseudo colors, are more impressive. With fewer weather stations and search aircraft, the use of the satellite data can greatly improve tropical cyclone identification and prediction. For a system developing close to land, this earlier prediction could mean the difference between life and death for those living in this region.

Keywords: *Cyclone, Vortex, Intensity, Genesis*

INTRODUCTION
Remote sensing is the acquisition of physical data of an object without touch or contact. It is the collection of information related in some way to the Earth' natural resources or environment. The data are then processed by digital computer or optical techniques to extract information of value of interest. Different sensors can provide unique information about the properties of the surface or shallow layers of the earth .The electromagnetic spectrum is the basis for all remote sensing. Remote sensing takes advantages of the unique interaction of radiation from the specific regions in the spectrum and the Earth (Barret, 1983). Data is collected by satellite involving measurements of the electromagnetic spectrum that can be used to characterize or infer properties of it in conjunction with localized ground-based surveys and measurement. There are four basic components of a radiation based remote sensing system (Slater, 1980; Curran, 1985;)
1. radiation source (i.e. the Sun, radar);
2. transmission path (i.e. atmosphere, vegetation canopy);
3. target (i.e. water, soil);
4. sensor (i.e. multispectral scanner, photographic film.).

The type of sensor is perhaps the only characteristic of remote sensing over which the user can has some control. The most commonly used sensors are explained below.
Multispectral scanners are instruments that measure the spectral reflectance of narrow wavelength bands and record the information electronically. This technique involves measuring simultaneously the spectral

response of the landscape in two or more narrow wavelength bands of the electromagnetic spectrum. Multispectral classification of this data is then used to discriminate objects based on the characteristic of reflectance. Multispectral analysis has developed from early system, using two or more cameras with different lens filters to make images. The Landsat satellites have been providing four spectral bands of the Earth's surface with the Multi Spectral Scanner, and more recently with the Thematic Mapper.

Thermal sensors directly measure the emitted thermal energy of the Earth's surface. Surface temperature changes are the result of the balance of radiant, latent, sensible and ground heat fluxes.

Microwave sensors can directly measure the dielectric properties of the Earth's surface. Any changes in these properties directly affect the reflectivity or emissivity measured by microwave systems. Measurements in the microwave region of the electromagnetic spectrum can be related to the moisture content of the atmospheric layers. The ability of microwave sensors to penetrate cloud cover, make microwave sensors a useful all-weather sensors to measure the moisture of the Earth's surface. Meanwhile, active microwave systems (radar) send out an energy pulse and measure the reflected pulse and the Earth's naturally emitted microwave radiation. Active microwave and passive microwave systems have been flown on aircraft and satellites. Examples of the use of microwave data are to estimate moisture content, vegetation type, synoptic scale systems, condition of sea etc.

The various gases present in the atmosphere have different absorption and emission bands shown in Fig (1). Ozone (O_3) primarily absorbs in the ultraviolet and in the 9.6 μm region. Solar radiation in the Hartley spectral band (0.2-0.3 μm) is absorbed in the upper stratosphere and mesosphere by ozone. Absorption by O_3 in the Huggins Band (0.3-0.36 μm) is not as strong as in the Hartley bands. O_3 absorbs weakly in the 0.44 to 0.76 μm region, and strongly around the 9.6μm region, where radiation is emitted by the surface. N_2 and O_2 are the most abundant gases in the atmosphere, from an atmospheric energetics point of view these are of small importance. Water vapor absorbs in the vibrational and rotational bands (ground state transitions). In terms of radiative transfer through the atmosphere, the important water vapor absorption bands in the solar spectrum are centered at 0.94, 1.1, 1.38, 1.87, 2.7, and 3.2 μm. In the infrared, H_2O has a strong vibrational-absorption band at 6.3 μm. The rotational band extends from approximately 13μm to 1 mm. In the visible and IR region, there are two bands in whichthe atmosphere is "transparent". None of the atmospheric gases has an absorption band in this region. This property of the earth's atmosphere is used by satellite based sensors to obtain images of the surface of the earth and the clouds above it as shown in Table 2.

These satellite imageries are used for providing the idea of Tropical cyclones (TC) over Indian Ocean.

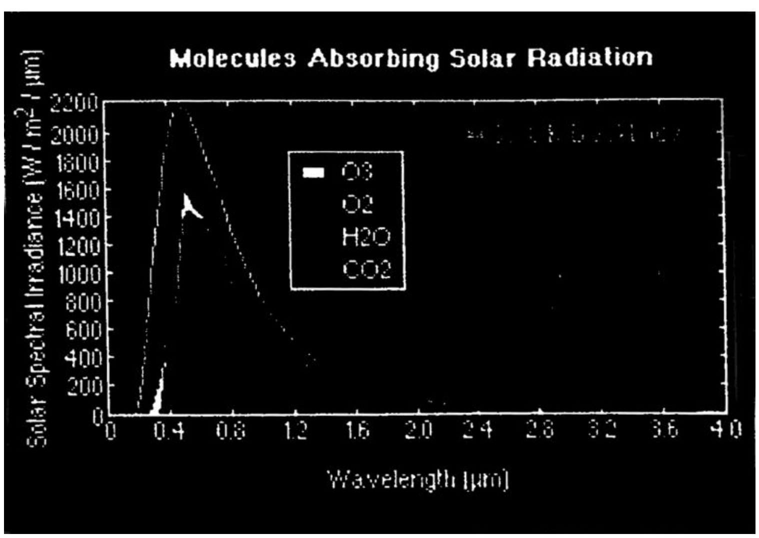

Figure 1: Absorption and emission spectroscopy of gases in atmosphere

Table 1: INDIAN NATIONAL SATELLITE (INSAT) SERIES

Satellite	Launch Date	Met. Payload with Wavelength Bands	Major Applications
INSAT- 2A	July 10, 1992	Very High Resolution Radiometer (VHRR) Bands : 0.55 - 0.75 µm 10.5 - 12.5µm	• Monitoring cyclones & monsoon • CMV Winds • OLR • Rainfall Estimation • Mesoscale features • Flood/intense precipitation advisory • Snow detection
INSAT-2B	July23, 1993	Very High Resolution Radiometer (VHRR) Bands : 0.55 - 0.75µm 10.5 - 12.5 µm	-do-
INSAT-2E	April, 1999	1. VHRR : As above + WV Band : 5 -7.1µm 2. CCDPayload Bands : 063 - 0.79µm 0.77 - 0.86um 1.55 - 1.70um	-do-
METSAT	12m September,2002	Very High Resolution Radiometer (VHRR) Bands : 0.55 - 0.75µm 10.5 - 12.5µm WV Band : 5.7 µm	• Monitoring cyclones & monsoon • CMV Winds • OLR • Rainfall Estimation

MATERIALS AND METHODS

This study uses INSAT observed IR imagery data to estimate the intensity of the tropical cyclones. India Meteorological Department, New Delhi have INSAT data reception and processing system in the Satellite Meteorology Division .The reception bit rate of INSAT 1-D and INSAT-2E are 400 kbps and 526.5 kbps respectively. Reception and processing software of INSAT 1-D is METDAS (Meteorological Data Acquisition System) running on VAX mainframe and customized Linux based software for INSAT -2E. Very High Resolution Radiometer (VHRRs) flown onboard INSAT series of satellites have been frequently observing TCs since early 1980s through VIS and IR spectra. Met payload around INSAT-2E was improved and having VIS, IR and WVimagery also. IT carried additional an additional payload called Charged Couple Device (CCD) which provides 1 km imagery in 3 (VIS, near IR and shortwave IR) channels. Future INSAT satellite starting from INSAT-3D will have improved resolution in VIS (1km) and IR (4km).

A digital image is a two-dimensional array of small square regions known as pixels. In the case of a monochrome (also known as gray-scale or "black-and-white" with shades of gray) image, the brightness of each pixel is represented by a numeric value. Gray-scale images typically contain values in the range from 0 to 255, with 0 representing black, 255 representing white and values in between representing shades of gray. Similarly a color image can be represented by a two-dimensional array of Red, Green and

Blue triples. Typically, each number in the triple also ranges from 0 to 255, where 0 indicates that none of that primary color is present in that pixel and 255 indicates a maximum amount of that primary color. *Sampling* is choosing which points you want to have represent a given image. Fourier analysis is based on the concept that real world signals can be approximated by a sum of sinusoids, each at a different frequency. The more sinusoids included in the sum, the better the approximation. The Fast Fourier Transform (FFT), like most computer algorithms, generates an Exponential Fourier Series, instead of a Trigonometric Fourier Series. The two series are identical except that the magnitude generated by the exponential series are half the value of the trigonometric series. Most application software automatically compensates for this and presents the magnitude spectrum as a Trigonometric series. This is done by several common approaches like optimal, Neighborhood-averaging and Mode filtering etc. In high pass filtering we use the approaches like histogram equalization and density slicing etc. This image enhancement using pseudo luts (look up table) with the help of FFT technique is highlight the important meteorological features.

RESULTS AND DISCUSSIONS

Tropical cyclones are special class of large whirling wind systems, which occur over a sizable portion of the global tropical and subtropical oceans. A typically mature tropical cyclone is warm core (relatively warm) than the environments at the same pressure level vortex in the atmosphere with circulation extending horizontally to some 1000 km from the center and vertically to about 15km above sea level. There is an eye at the center of radius 5 to 50km. The Eye is rain free with light winds. It is surrounded by a wall made up to a tall cumulonimbus clouds (cb) clouds rising up to an altitude of ~15km the wall clouds thickness being about 10-15 km radially. Beyond wall cloud surfacewinds speeds decreases gradually with radial distance from the center. Classification of tropical disturbances on the basis of wind intensity is shown in table 2.

Table2: Classification of tropical disturbances on the basis of wind intensity

System(CI Number)	**MWS (KNOTS)**
Low (1.0)	<17
Depress , (1.5)	25
Deep depress (2.0)	30
Cyclone (2-5)	35
Cyclone (3.0)	45
" (3.5)	55
" (4.0)	65
" (4.5)	77
VerySC (5.0)	90
" (5.5)	102
" (6.0)	115
" (6.5)	127
" (7.0)	140
" (7.5)	155
" (8.0)	170

Where,
CI = *Current intensity.*
MWS (KNOTS) = Mean wind in knots.
MSLP = *Mean sea level pressure in milli bar.*
SC = *Super cyclone.*
1 KNOTS = *0.5 m/sec.*

Satellite picture of tropical cyclone indeed show both inward spiraling (anticlockwise) low level clouds &the outward moving (clockwise) cirrus clouds at the upper levels in the N.H. The mechanism for tropical cyclone intensification is conditional instability of the second kind (CISK) (Craig & Grey,1996). Over Atlantic basin techniques for tropical cyclone intensity and track prediction was widely appreciated (DeMaria& Kaplan, 1994, 1999, DeMaria *et al.*, 2005).

We have used the IR imagery data of INSAT 1-D and INSAT-2E (Geostationary satellite) for the October, 1999 (Orissa super cyclone), December 2000, May,2001 and September, 2001 cyclones whose tracks are shown in Fig 2(a),2(b and 2(c) below. Tracks clearly show their genesis, movement, center and decaying positions of each cyclone. Orissa super cyclonic storm on 29 October 1999 made landfall near Paradip. It was accompanied with exceptionally heavy rains which led to devastating floods and cut off the States from the rest of the country. Fig 3 (a), 3 (b) and 4 (a), 4 (b) shows the IR imagery of the Arabian sea cyclones.

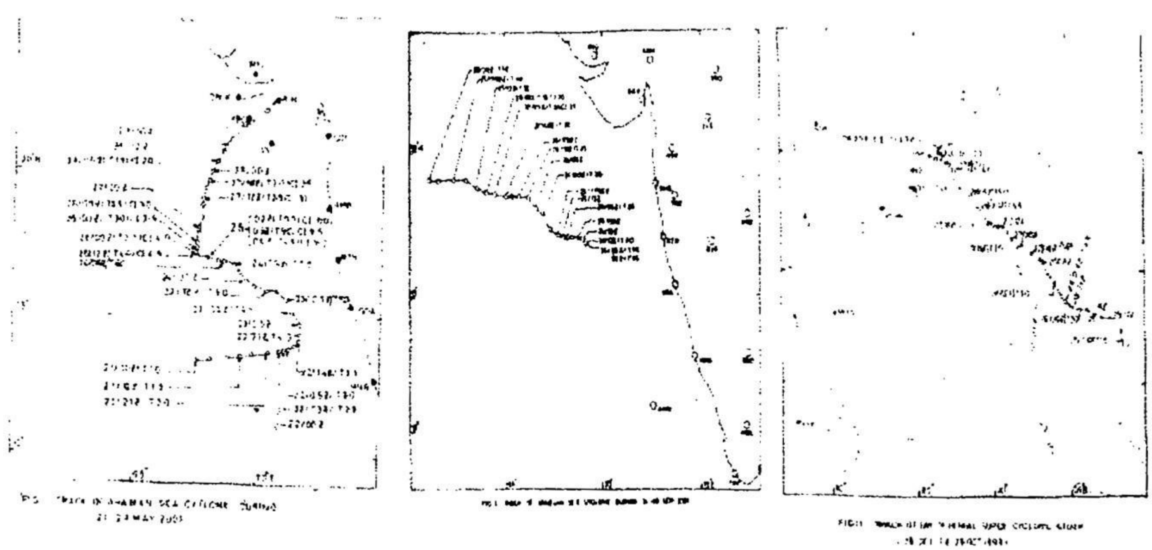

Figure 2: (a), (b), (c) Tracks of the tropical cyclones May, 2001, September, 2001 and October, 1999 respectively (IMD tracks and storms report).

Accurate estimation of the eye of the cyclone and assignment of intensity is of prime importance to predict its future direction of movement and hazardous capability. Using satellite imagery Dvorak (1975) developed a technique to estimate tropical cyclone intensity. This approach is further evaluated and refined for IR images and evolved into a "digital IR" Technique (Dvorak, 1984). T number shown in the table 2 above measures the intensity of a tropical cyclone.

The Data T' Number (DT) defined as determines eye pattern:

DT=CF + BF

Where,

CF = Central feature (central dense overcast (CDO))

BF = Bending feature (curvature, spiral bending)

Additionally, the water vapor imageries have also contributed significantly on the understanding of the convective and subsiding zones & the intensifying cyclones. In parallel to VIS &IR microwave portion is also used a tool to understand the phenomena. Because, it can penetrates into the cloud and provide the information of cloud texture and precipitation estimate.

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T (2.5)

INSAT IR IMAGE 26-05-2001 1000Z

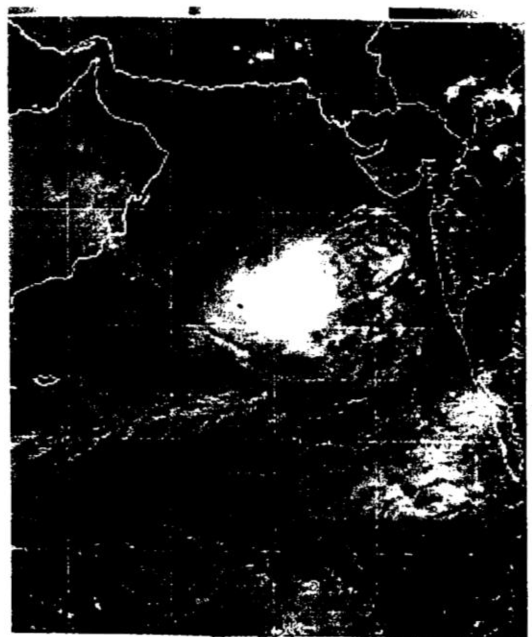

Fig-3(a)

T (2.5)

INSAT IR IMAGE 26-09-2001 0900Z

Fig-4(a)

INSAT IR IMAGE 28-05-2001 0900Z

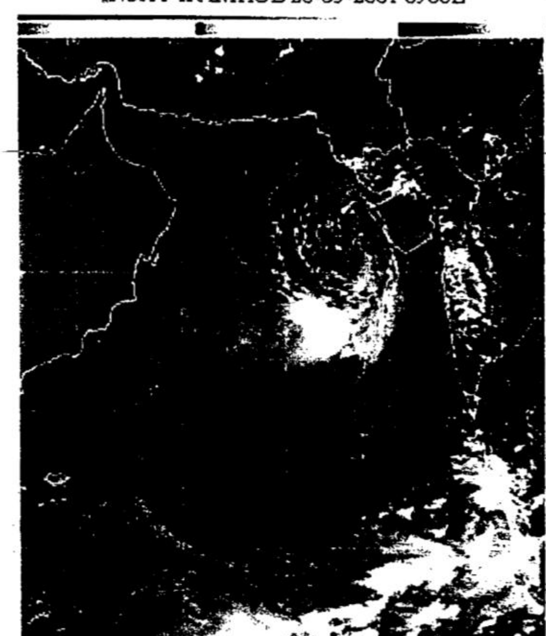

Fig-3(b)

T (1.5)

INSAT IR IMAGE 27-09-2001 0600Z

Fig-4(b)

T (1.5)

However the Dvorak technique although better than traditional synoptic techniques is also an approximation. To further accurately estimate the eye position and the bands of heavy rain bearing clouds it is necessary to apply image enhancement techniques to the imagery as discussed above.

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