INCLUSION OF DERIVED DATA IN TO AN EXISTING DATABASE OF REMOTELY SENSED DATA

By

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DECLARATION

The work described in this thesis was carried out by me at the department of Physics, University of Ruhuna, Matara and Faculty of Applied Sciences under the supervision of Dr. D.B.M.Wickramaratna and Dr. K.K.A.S.Yapa. A report on this has not been submitted to any other University for another degree.

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To My Parents....

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ABSTRACT

An existing database for remotely sensed ocean data at the department of physics, University of Ruhuna, developed using Visual Basic programming is modified here to include processed sea surface temperature from NOAA (National Oceanic and Atmospheric Administration) satellites. The processed sea surface temperature data are in ASCII format. The composite data for April 1996 were used here to test the portion of the database program. The data covers the area with in the Latitudes of 4.5N - 11N and Longitudes of 78E - 85E in the Indian ocean surrounding Sri Lanka. Interested scientists are able to access the database to visualize and extract all or any portion of the data from the files in the database with request. A summary of satellite ocean remote sensing, how data were collected through satellite and the features of the satellite is also included.

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CHAPTER I

Introduction

The number of satellite missions dedicated to earth observation has increased significantly over the past decade and will further increase over the coming decade and beyond. Data from these missions offer the potential for contributing to the security of human existence on earth in a wealth of different ways.

Satellite remote sensing has appreciably advanced our knowledge of surface oceanic features. It must be remembered, however, that remote sensing effectively covers only the surface water of the ocean and therefore complements the conventional oceanographic measurements of the subsurface structure. When visual wavelengths are used in operations such as ocean colour detection cloud cover can be a problem. When possible some sensors operate in the microwave part of the electromagnetic spectrum in which clouds are transparent.

The NIMBUS series of satellite carried a visible wavelength scanner designed to observe ocean colour, named Coastal Zone Colour Scanner (CZCS), which has supplied a wealth of synoptic views of the colour of the large areas the world's ocean, at spatial resolution of about 1 km square. The electromagnetic radiation penetrates the sea surface only to about 30 m depth.

Spacecraft with dual channel radiometers include the Geo - stationary satellites operated by the National Oceanic and Atmospheric Administration (NOAA) with it visible infrared spin scan radiometers. The NOAA satellite carried the Advance Very High Resolution Radiometer (AVHRR).

The channel centered at 3.7×10^{-3} m corrects the variable amount of water vapor in the atmosphere and thereby derive much more accurate sea surface temperature. Here, the characteristics of the AVHRR in it's NOAA configuration will be briefly reviewed, along with the effects anticipated from a cloud free atmosphere. The first-order effects of clouds will then be described. Following this, a combined data set of AVHRR sea surface temperature will be examined to derive and then test procedures for converting AVHRR data to sea surface temperatures. Finally, the Visual Basic procedures used to create a sea surface temperature map around Sri Lanka from the processed data of NOAA - 12 is discussed.

Objectives

The aim of this project is to include processed NOAA sea surface temperature data into an existing data base developed with Visual Basic for remotely sensed data. The variations of sea surface temperature can be used in identifying the possible fishing grounds of the ocean. Ocean colour (from which surface chlorophyll is derived) can be used to determine possible improvements in the prediction of fishing zones by combining these data with AVHRR data. Ocean colour data enable determination of the amount of marine primary production which can then be used to estimate the latent amount of marine resources, and hence improve the fishing zone and the meteorological forecasts.

CHAPTER II

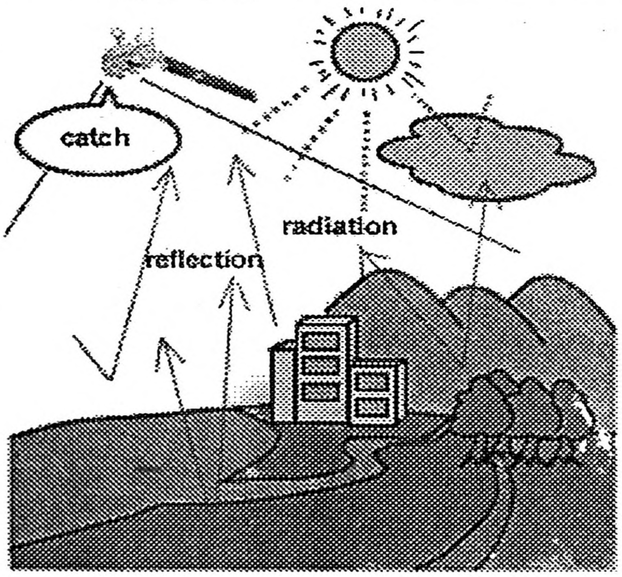
Literature Review

2.1 History

NOAA has been providing global estimates of sea surface temperature since 1970 with first improved TIROS series of satellite. In 1973 only one channel had been used and only crude empirical estimates of water vapour could be obtained with this single channel. In the mid of 1976, 1978 the new Scanning Radiometer (SR) and Vertical Temperature Profile Radiometer (VTPR) had been introduced and being improved, later the AVHRR / HIRS technique provide a significant improvement in the accuracy of satellite derived sea surface temperature. In 1983 multi-channel sea surface temperature (MCSST) a operational and with several advantages like high resolution, better correction for atmospheric attenuation and better use of cloud detection day by day and visible band of reflected IR data over the earlier one.

2.2 The Remote sensing

Fig 2.1: Observing the earth by the satellite



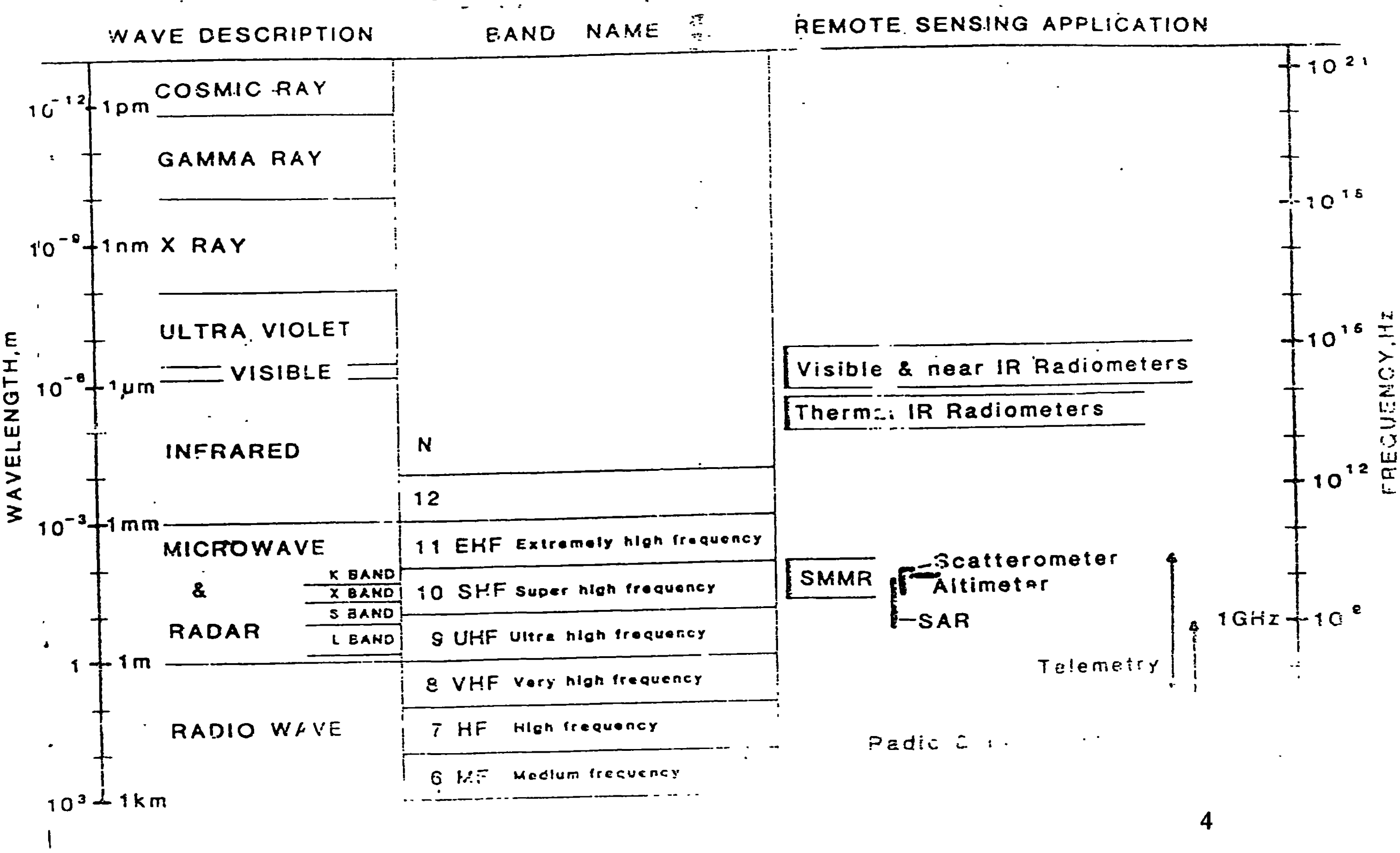
(source: http://ceos .cnes.fr.)

Remote sensing is a technology to observe an object's size, shape and character without physically contacting with the object. The electromagnetic waves reflected or radiated from the objects are received by sensors aboard earth observation satellites. Such sensors rely upon the detection of energy emitted from or reflected by the object. In any water body some of the light which penetrates the water upwell through the surface after going through scattering and absorption processes. Of this emergent flux 90% originates with in the optical depth. It can be regarded as a sample derived from the underwater light field and so by studying it with appropriate detection instruments above the surface, information about that field and therefore about the optically significant components of the medium can be obtained. There is not much point in having detection instruments just above the surface because it covers very smaller area, but they would be useful as well. If we are interested in obtaining information for a wider surface area. However, in Situ, measurements are very important to use with remotely sensed data.

2.3 Sensors on satellite

2.3.1 Sensors in relation to the electromagnetic spectrum

Fig 2.2: The electromagnetic spectrum, showing some band definitions and typical remote - sensing applications.



All sensors employed on ocean - observing satellites use electromagnetic radiation to view sea. The above figure shows the electromagnetic spectrum ranging from gamma rays at 10 picometer to radio waves at 1 km wavelength, shows the corresponding frequency of the radiation, all of which travel through free space at the speed of light, c, $3 * 10^8 ms^{-1}$. Wave length λ and the frequency are of course related by $f \lambda = c$.

The choice of the bands is governed firstly by the atmospheric transmission spectrum, and secondly by the application. The source at a temperature of 6000K corresponds to the sun, and at 300K to the earth's surface. Thus if features of the land or the sea are to be observed by the reflection of incident solar radiation in the same way as the human eye observes, then the wavelength range of high energy solar radiation should be used, between 100 nm and 100 micrometer (visible light 400 nm - 700 nm), peaking in the visible range. Alternatively, if the self-emission of radiation by the sea is to be the means of remote sensing, sensors should be used for the 3 to 40 micrometer wavelength range. However, not all of these wavelength ranges are useful, since the atmosphere will not transmit them.

The atmosphere (both the air itself and water vapour and other aerosols) absorbs most radiation with a wavelength less than 400 nm and much above about 1 micrometer. There is a definite window at the visible wavelength range, and also at select bands within the infrared. These bands have therefore been exploited for remote sensing, leading to the visible / near infrared and thermal infrared families of sensors. Although there is little reflected or emitted energy at high frequencies and these radar bands are exploited by the active microwave sensors which create their own radiation with which to illuminate the target, and then observe the nature of the reflected signal. According to their configuration and application, these active microwave devices are known as altimeters, scatterometers or synthetic aperture radar. Use of sunlight in remote sensing applications is referred to as passive remote sensing.

2.3.2 Energy Sources

Remote sensing devices may be designed to detect various type energies, such as electromagnetic radiation, gravity, magnetism and sound waves. Electromagnetic energy is what most commonly sensed by earth remote sensing devices. Sensors such as radar sends signals of a particular wavelength towards an object and then detect the amount of that energy which is radiated by the object. But in passive remote sensing methods like in aerial photography and in Landsat, NOAA satellites the radiation originating from some other sources like sun is used as the source. These remotely sensed data may be recorded in either photographic or digital form. But data must be in digital form for computer processing.

2.4 Type of sensor

It is mentioned that sensors play an important role is receiving information from the ground. Here, various types of sensors are discussed. Sensor type is roughly divided into two, which are Optical sensors and Microwave sensors.

2.4.1 Optical sensor

Optical sensors detect visible lights and infrared rays (near infrared, intermediate infrared, thermal infrared). There are two kinds of detection methods using optical sensors. visible / near infrared remote sensing and thermal infrared remote sensing.

2.4.1.1 Visible / Near Infrared Remote Sensing

The method here is to acquire visible light and near infrared rays of sunlight reflected by objects on the ground. By examining the strength of reflection, we can understand a conditions of land surface, e.g. distribution of plants, forests and farm fields, rivers, lakes and urban areas. During the period of darkness, this method can not be used. Also, clouds block the reflected sunlight reaching the sensor and therefore this method would not detect areas under clouds.

2.4.1.2 Thermal Infrared Remote Sensing

This method is to acquire thermal infrared rays, which are radiated from land surface heated by sunlight. Also it can detect high temperature areas, such as volcanic activities and fires. By examining the strength of radiation, we can understand surface temperatures of land and sea, status of volcanic activities and forest fires. This method can used at night as well when there are no clouds.

2.4.2 Microwave sensor

Microwave sensors receive microwaves, which have longer wavelength than visible light and infrared rays, and observation is not affected by day, night or weather. There are two types of observation methods using microwave sensor. active and passive.

2.4.2.1 Active type

The sensor aboard earth observation satellite emits microwaves and observes microwaves reflected by land surface. It is suitable to observe mountains and valleys.

2.4.2.2 Passive type

This type of sensors detects microwaves naturally radiated from land surface. It is suitable to detect sea surface temperature, snow accumulation, thickness of ice, etc. The range of wavelength a sensor can observe depends on the type of sensor. This is because each sensor has a specific observation purpose and wavelength range to operate at to achieve its purpose.

2.5 Sea Surface Temperature (SST)

Satellite derived sea surface temperature (SST) measurements have been available for two decades and have been widely used for the derivation of circulation patterns, structure of oceanic fronts, behaviour of eddies / meanders and to locate upwelling zones. The temperature in the upper layer of the ocean is influenced by radiative processes and both incoming and outgoing surface heat fluxes. Vertical mixing usually ensures that the temperature of the thin surface " skin " (from which the radiation is emitted) is close to the " bulk " temperature of the upper few meters of water. Surface temperatures therefore generally reflect the subsurface thermal structure which is in turn related to ocean currents.

Sea surface temperatures can be estimated using thermal infrared sensors such as AVHRR on the NOAA series of satellites, with a maximum resolution pixel size of 1.1 km^2 and a swath width of about 2800 km. Two NOAA satellites are maintained operationally at any time, and each passes over any particular place on the earth's surface twice per day. The visible and near infrared bands are useful in daylight for land / sea / cloud discrimination and cloud detection. SST are computed by combining the radiance temperatures derived from the two individual thermal bands accounting for the varying amount of water vapour in the atmosphere.

2.5.1 Resolution

Resolution means the size of the ground objects distinguished by sensors aboard earth observation satellites. Sensors of higher resolution detects smaller objects better. The unit of resolution is meter square (m^2). Surface resolution is also called spatial resolution. For example, a sensor with 30 m^2 resolution can distinguish the objects with surface area larger than 30 m^2.

2.6 Ocean Colour

The " colour " of the ocean is determined by the interactions of incident light with substances or particles present in the water. The most significant constituents are free-floating photosynthetic organisms (phytoplankton) and inorganic particulate. Phytoplankton contain chlorophyll, which absorbs light at blue and red wavelengths and transmits in the green. Particulate matter can reflect and absorb light, which reduces the clarity (light transmission) of the water. Substances dissolved in water can also affect its colour.

Water leaving in the visible region of spectrum indicates colour variations in the upper part of the water column, depending on the absorption, reflection and scattering of sunlight from particles in the water. It also depends on surface illumination, wave roughness, foam and surface films. In fact the spectral characteristics of a water body depends on the mix of the phytoplankton species present, the ages of the various component and the presence of the inorganic particles about 80% of the light reaching the sensor originates from atmospheric scattering of direct sun light.

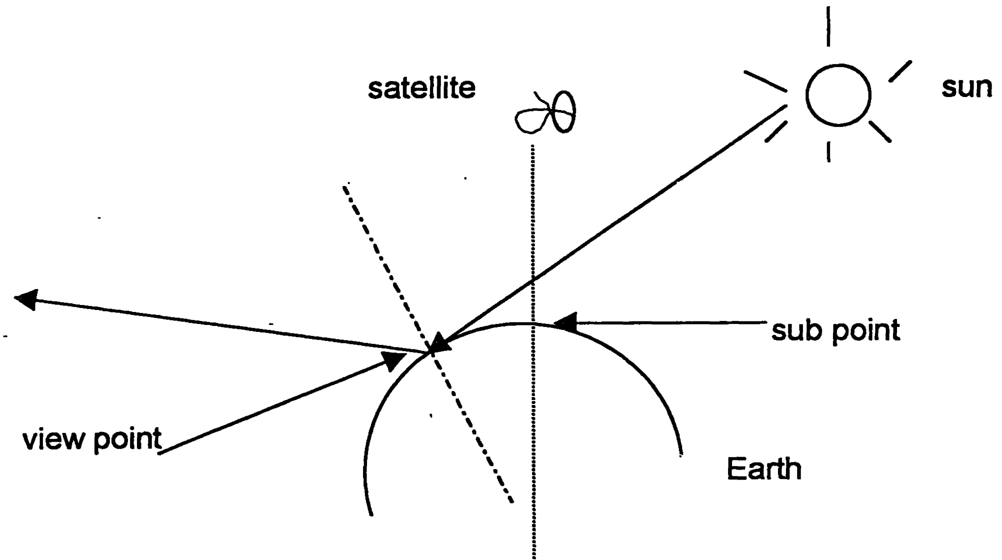
The colour sensors which have been most widely used are the Multi - Spectral Scanner (MSS) and the thematic mapper on the landsat series of satellite. The CZCS was the sensor used in Nimbus - 7 satellite, dedicated to monitoring the phytoplankton and sediment of the near surface water of the ocean.

CHAPTER III

Materials and Methods

3.1 AVHRR Instrument Description

fig 3.1: NOAA - AVHRR cross track scan geometry for typical pass



NOAA 6 was the second spacecraft of the TIROS-N generation and launched in sun synchronous near polar orbit at an altitude of about 800 km. At sub point, directly below the satellite, the AVHRR spatial resolution is 1.1 * 1.1 km^2.

Routines were developed for determining earth location of any sample from a given scan line, referred to as pixel. The four spectral bands of AVHRR are digitized to 10 bit (1024 levels) in equal increments of energy . then a radiometric calibration procedure for AVHRR was implemented. The calibrations for the first two bands are based entirely on pre-launch test and are expressed in terms of percent solar albedo. A cloud free pixel over the ocean, on the side of swath away from the sun, gives a reading of a few percent albedo, due almost entirely to sun light scattered of the atmosphere. The third and the fourth bands in the thermal infra-red are radiometrically calibrated every scan line, on every rotation of the scan mirror, the optics scan the earth below, followed by a view of a black body target. The target temperature is measured by four platinum-resistance temperature probes embedded in it. The least count is an increment in energy, rather than temperature, the corresponding resolution in blackbody equivalent temperature thus depends on the channel and the temperature of the viewed target.

At typical ocean target temperatures of 270K to 300K, temperature resolution ranges from 0.17K to 0.05K for channel 3 and from 0.13K to 0.10K for channel 4. Channel 3 responds to the emitted radiation as well as that 3.7 micrometer solar radiation reflected from clouds and the ocean surface. Cloud-free ocean pixels on the anti sun side of the swath, well outside of the sunlight area, reflect only the emitted radiance. For the channel 4 all 11 micrometer, solar radiation is very weak compared with that emitted by the ocean.

Infrared radiation emitted from the ocean surface is particularly absorbed by the atmosphere and re-emitted at a cold temperature. The net effect for a satellite radiometer is that it observes a blackbody equivalent ocean surface temperature which is different than, and usually colder than the actual surface. This temperature difference which is a function of wavelength.

As the water vapour levels increase towards the tropical case, the temperature difference increases only slightly for channel 3, but much more for channel 4, this unequal response may be used to estimate the actual sea surface temperature. An expression for the channel 3 temperature difference in terms of the AVHRR measured temperatures in channels 3 and 4, in addition, they estimate the sea surface temperature accuracy which should be achieved using that expression. For perfect data, in which a noise-free atmosphere, an accuracy of 0.28K is predicted. As the instrument noise at any equivalent geophysical noise source in the atmosphere grows, so do the errors in the sea surface temperature. For the typical AVHRR instrument noise levels of 0.1K - 0.2K, an accuracy of 0.35K - 0.40K is predicted. It rests on the assumption that other residual atmospheric error source is clouds, in particular, spatially unresolved clouds, smaller than the 1.1 km^2 field of view of the sensor.

3.2 Sensor measurements

All sensors respond to the flux of electromagnetic energy incident upon them within the wavelength band for which they have been designed. However, different sensors have been developed to measure different aspects of radiation which may carry the information about the conditions on earth and sea surface.

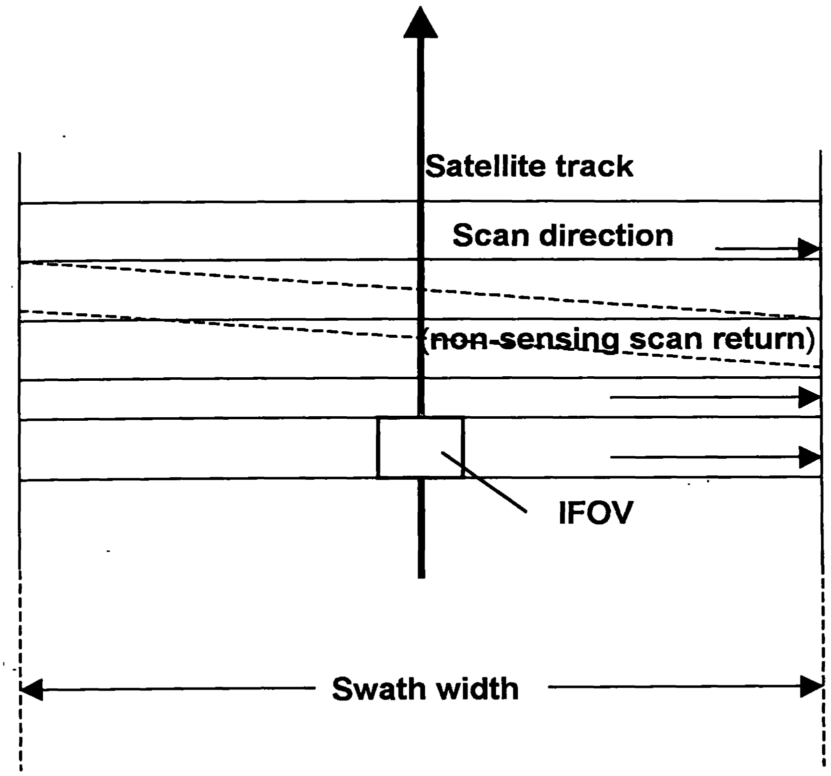
The basic sensor is a radiometer which measures the flux of electromagnetic energy reaching the sensor from a given small cone of directions. Radiometers are employed to measure in the visible, thermal infrared, and the microwave parts of the spectrum. Continuing the analogy with the human eye, we use not only intensity but also colour of light to convey information about remote objects.

The Synthetic Radar (SAR) uses the amplitude of the return signal as a measure of the radar reflectance of the sea surface, but it is able to gain a very high spatial resolution by using the travel time of the return pulse as a measure of a the distance between the point being illuminated and the satellite sub track, and by using the shift in frequency if the return pulse compared with the emitted as a measure of the Doppler shift, and hence of position in the along track direction.

3.3 Spatial sampling capabilities of sensors

Sensors may be broadly divided into two categories - those which scan and those which do not. The design of the sensor is the arrangements of optical lenses and mirrors or the geometry of the microwave antenna, controls the angle of view from which a signal is received by the sensor at any one instant. This is called the instantaneous field of view (IFOV) of the sensor. It is normal with optical systems to produce a square of rectangular IFOV which enables IFOVs to be patched together to provide efficient aerial coverage without overlap or blind spots. Radar antennae, working with much larger wavelengths, are able to focus the radiation so easily, and the IFOV is likely to be circular and less precisely defined, except in the case of SAR where the phase and frequency information of the received signal is used to effectively synthesize the small discrete field of view and hence to achieve a fine spatial resolution.

Fig 3.2: Swath - filling geometry of scanner ground track



(source: I. S. Robinson, 1983)

The AVHRR on the NOAA satellites which measures in the visible and infrared, or the CZCS on Nimbus 7, measuring in the visible and near infrared, have IFOV of about 1 km square or 800 meters respectively. The radiometer is sampled at a rate so that the subsequent IFOVs just overlap along the scan direction, and there are typically 2000 to 4000 samples along a scan line.

The scanning is usually achieved by a rotating mirror, and may be performed in one direction only or backwards and forwards across the swath depending on the sensor design. The spatial resolution which is possible for a given sensor is dictated by the IFOV and not by the sampling rate. It is the latter which normally dictate pixels (picture elements) spacing, but this is not the same as the spatial resolution.

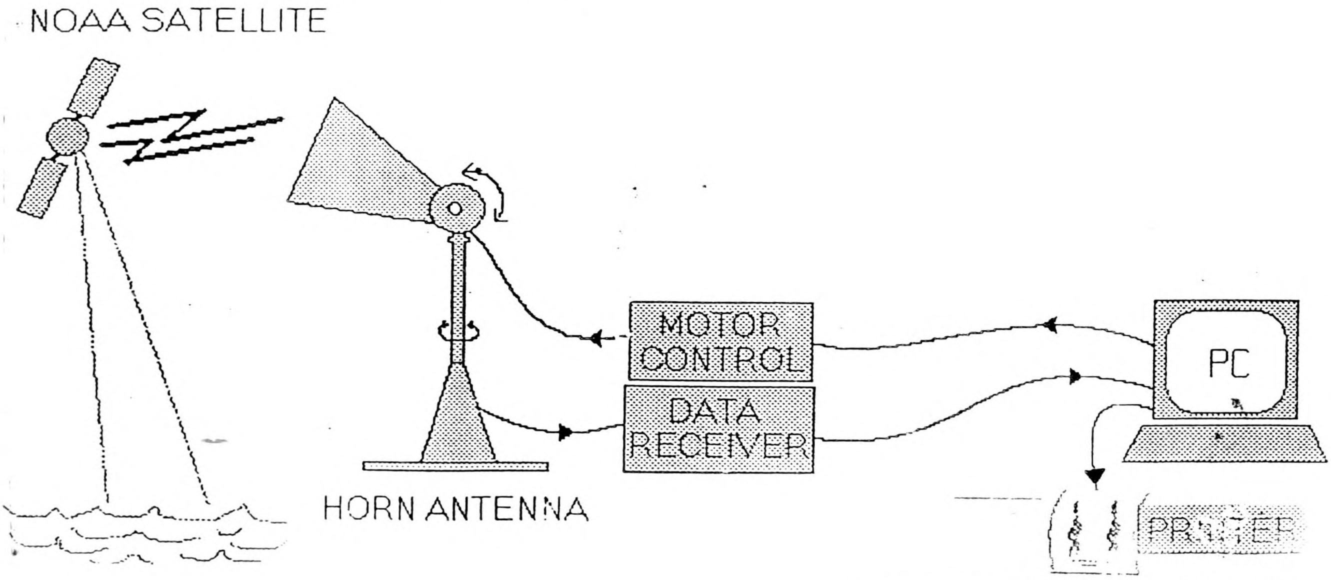
Finally, mention must be made on the way of ground resolution varies with position along the scan line. On scanners such as AVHRR and CZCS which cover swath of several thousand kilometers. This is exacerbated by the curve of the earth too. Furthermore, if the IFOV is square, the projection from the sea surface will be square at the sub point but increasingly rectangular towards the extremes of the scan line, the loner axis being along the scan direction.

3.4 Data Retrieval

No matter how long - lived a satellite is, or how sophisticated, robust, and sensitive a sensor it carries, neither is of any value to the oceanographer unless the measurements observed by the sensor can be communicated to him in a useful form. This requires the encoding of the data on board the satellite, its transmission to earth, and its subsequent dissemination to users. The encoding and transmission of the data back to earth place demands on the power supply, and constrain the data rate which can be generated by the sensor, which in turn limits the spatial resolution and sampling rate. Without transmission a satellite is useless. The data reception on earth, or " ground segment " as it is called, must also be reliable. Although it can be maintained and repaired if it fails to receive transmission from the satellite, any data that is missed will be lost completely.

3.5 Satellite - to - earth data transmission

fig 3.3: satellite data reception system



(source: http// www.CNES)

The earth viewing sensor will normally generate a voltage or a frequency signal corresponding to measurement being made. In AVHRR this information is encoded in a video wave form for transmission back to earth, effectively as an analogue signal. Most satellite cover analogue to digital signal for transmission to earth, because an analogue signal can be corrupted by noise and interference during transmission and storage.

In binary coding, n bits of information are required to represent a whole number in the range **0 to 2^n -1** scanned radiant data is often digitized in the range **0 to 255**, which requires 8 bits for every pixel value.

The scanning sensors which largely dictated the capacity of the communication down link to earth. As sensors have been developed, so the data transmission rates have increased. The NOAA satellites carrying the AVHRR have a lower data rate of 665.4 kilo bits s^{-1} and the carrier frequency 99 kHz can be used. The lower frequency transmission and lower data rate make it easier to receive data from the NOAA satellites, and high - quality data can be received at relatively moderate costs. If the satellite can be accurately tracked by the antenna as it passes over head, then the antenna size can be reduced.

Using TERAS LAN software (By Dr K.K.S.Yapa), the original data which derived from NOAA satellite were converted, and a part of the data during the April 1996 are below. In the data set, first column is Latitude, second column is Longitude and the third column is the Temperature which is used to draw the map of Sri Lanka as pixels. Here, the Latitudes and Longitudes are given as pixel values and the Temperature is given as colour value (0 - 255). The asterisks (***) are showing the clouded or the landed areas.

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3.6 Programming with Visual Basic

For the purpose of read these data and draw, it can be used several programming techniques such as C, C++, COBOL, Visual Basic and etc. But using Visual Basic was most flexible here for me. This programming is modified by me to include sea surface temperature variation maps view, around Sri Lanka and data can be extracted using this database. A few part of this programming is follows,

```
Option Explicit
Const INVERSE = 6
Dim column As Variant
Dim oldx As Single
Dim oldy As Single
Dim once As Boolean
Dim bottomX As Double
Dim bottomY As Double
Dim pathname1 As String
Dim pathname2 As String

Private Sub cmddraw_Click()
Const ForReading = 1
Dim mean As Double
Dim datafile, df
Dim fname1, f1
```

```
Dim t As String
Dim t1 As String
Dim a1 As String
Dim b1 As String
Dim c1 As String
Dim a2 As Double
Dim b2 As Double
Dim c2 As Double
Dim i As Integer
Dim intpos1 As Integer
Dim intpos2 As Integer
cmddraw.Enabled = False
Picture1.AutoRedraw = True
Picture1.Visible = True
Screen.MousePointer = vbHourglass
Set datafile = CreateObject("Scripting.fileSystemObject")
Set df = datafile.OpenTextFile("C:\faz\Apr96sst.dat", ForReading)
Do While df.AtEndOfStream <> True
 t = df.Readline
 t1 = Trim$(t)
  intpos1 = InStr(1, t1, Chr(9))
  intpos2 = InStr(intpos1 + 1, t1, Chr(9))
  a1 = Trim(Mid(t1, 1, intpos1))
  b1 = Trim(Mid(t1, intpos1, (intpos2 - Len(a1))))
  c1 = Trim(Mid(t1, intpos2 + 1, (Len(t1))))
  a2 = CDbl(a1)
  b2 = CDbl(b1)
   If c1 <> "***" Then
    c2 = (CDbl(c1) * 0.0235) + 26
     If (c2 >= 32#) Then
      PSet (b1 * 400, a1 * 400), RGB(255, 120, 0)
      Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(255, 120, 0)
     Else
      If (c2 >= 31# And c2 < 32) Then
```

```
    PSet (b1 * 400, a1 * 400), RGB(255, 0, 0)
    Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(255, 0, 0)
   Else
    If (c2 >= 30# And c2 < 31#) Then
     PSet (b1 * 400, a1 * 400), RGB(255, 255, 0)
     Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(255, 255, 0)
    Else
     If (c2 >= 29# And c2 < 30#) Then
      PSet (b1 * 400, a1 * 400), RGB(0, 255, 0)
      Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(0, 255, 0)
     Else
      If (c2 >= 28# And c2 < 29#) Then
       PSet (b1 * 400, a1 * 400), RGB(0, 0, 255)
       Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(0, 0, 255)
      Else
       If (c2 >= 27# And c2 < 28#) Then
        PSet (b1 * 400, a1 * 400), RGB(0, 235, 255)
        Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(0, 235, 255)
       Else
        If (c2 >= 26# And c2 < 27#) Then
         PSet (b1 * 400, a1 * 400), RGB(255, 0, 205)
          Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(255, 0, 205)
        Else
          PSet (b1 * 400, a1 * 400), RGB(0, 0, 0)
          Picture1.PSet (b1 * 14.5, a1 * 14.5), RGB(0, 0, 0)
         c1 = c2
       End If
      End If
     End If
    End If
   End If
  End If
 End If
End If
```

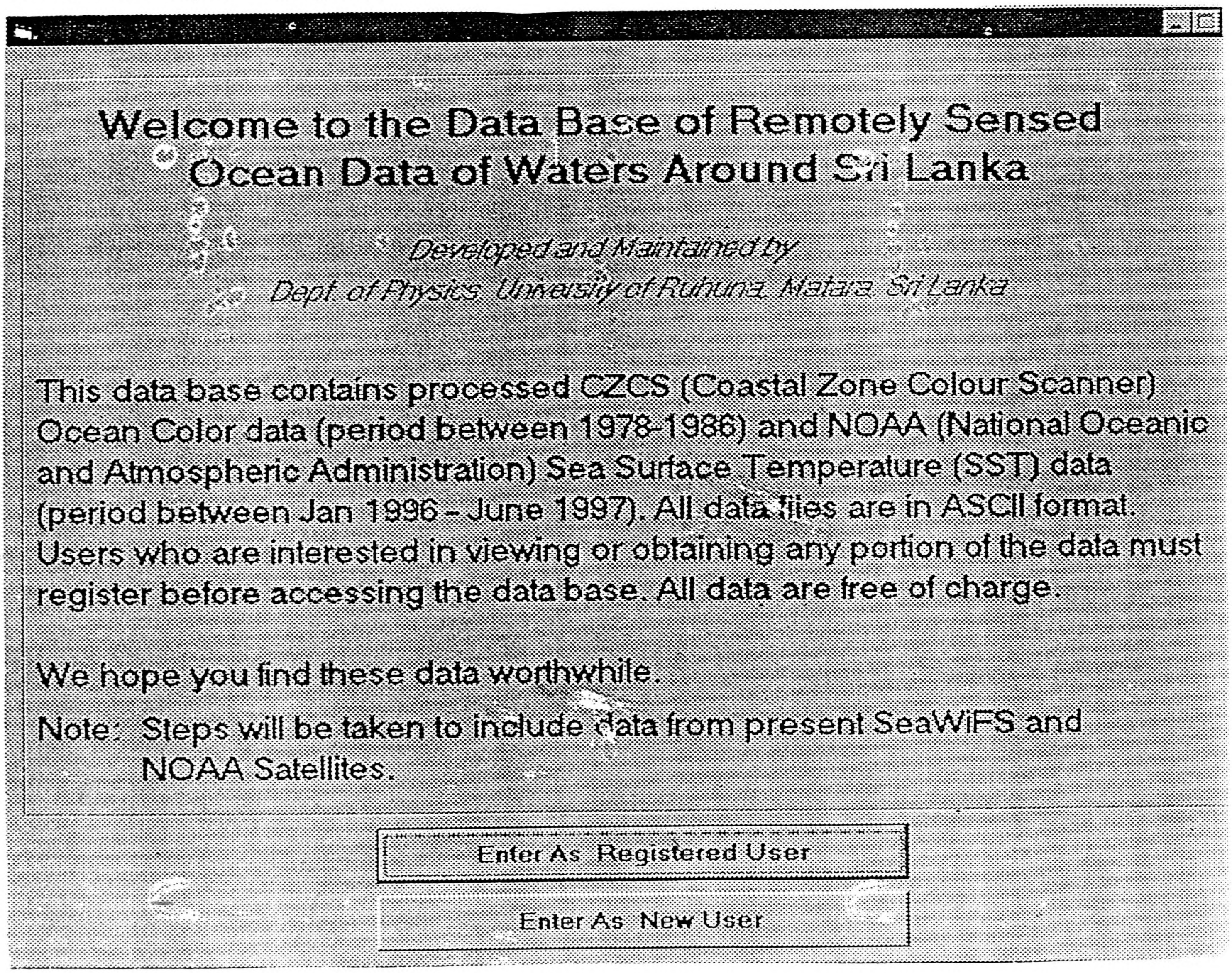
```
    Loop
df.Close
SavePicture Picture1.Image, "sst.bmp"
Cls
Picture1.AutoSize = True
Picture1.Cls
Picture1.Picture = LoadPicture("sst.bmp")
Picture1.Visible = True
Screen.MousePointer = vbDefault
Picture1.Line (9000, 800)-(9400, 1600), RGB(255, 120, 0), BF
Picture1.Line (9000, 1600)-(9400, 2400), RGB(255, 0, 0), BF
Picture1.Line (9000, 2400)-(9400, 3200), RGB(255, 255, 0), BF
Picture1.Line (9000, 3200)-(9400, 4000), RGB(0, 255, 0), BF
Picture1.Line (9000, 4000)-(9400, 4800), RGB(0, 0, 255), BF
Picture1.Line (9000, 4800)-(9400, 5600), RGB(0, 235, 255), BF
Picture1.Line (9000, 5600)-(9400, 6400), RGB(255, 0, 205), BF
'Picture1.Line (7000, 3200)-(7400, 3600), RGB(255, 125, 255), BF
'Picture1.Line (7000, 3600)-(7400, 4000), RGB(255, 0, 255), BF
Picture1.Line (100, 100)-(100, 7500), RGB(255, 255, 255)
Picture1.Line (100, 7500)-(7510, 7500), RGB(255, 255, 255)
Picture1.Line (7510, 7500)-(7510, 100), RGB(255, 255, 255)
Picture1.Line (7510, 100)-(100, 100), RGB(255, 255, 255)
For i = 100 To 7500 Step 1100
  Picture1.Line (0 + i, 7500)-(0 + i, 7550), RGB(255, 255, 255)
Next
For i = 0 To 7500 Step 1100
  Picture1.Line (0, 650 + i)-(0, 550 + i), RGB(255, 255, 255)
Next
End Sub
```

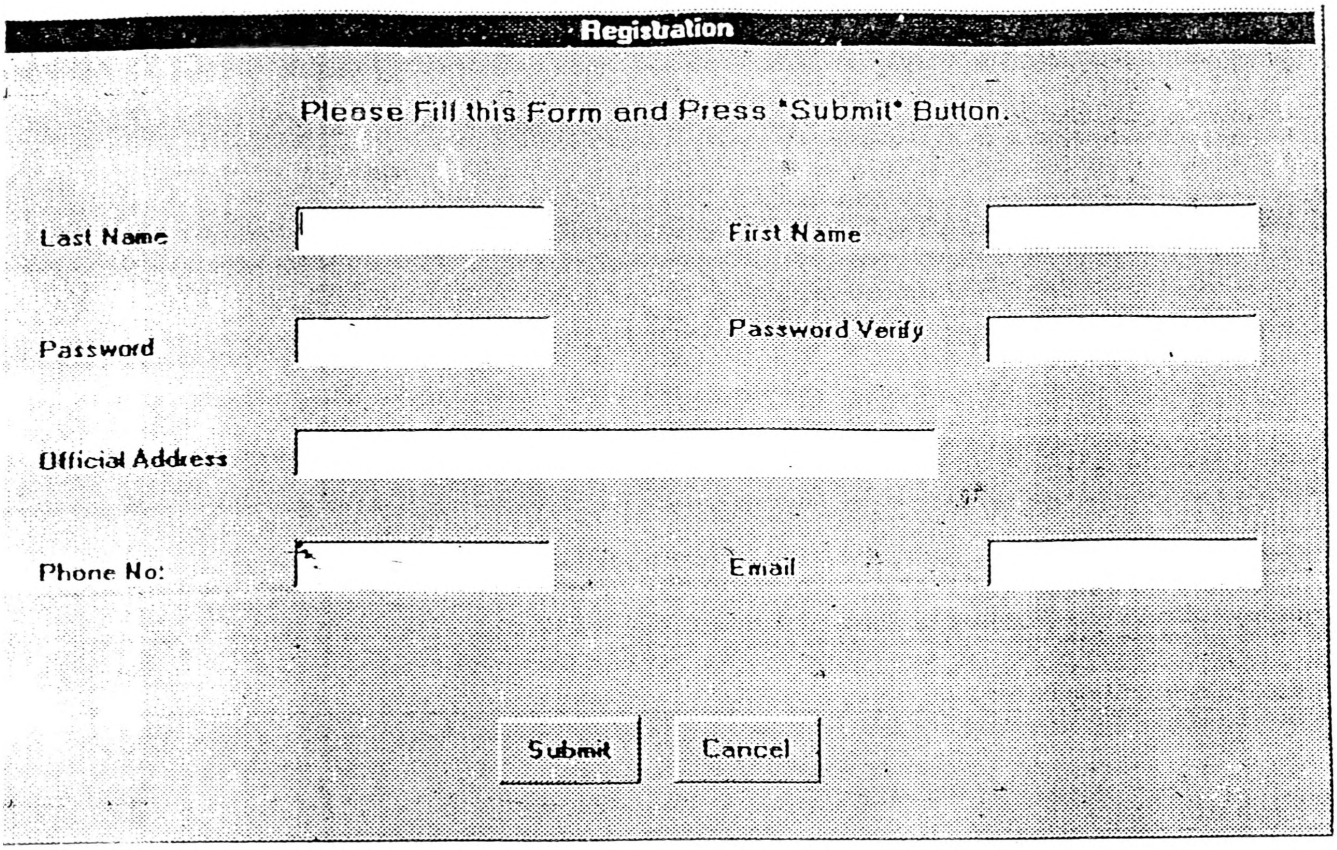
CHAPTER IV

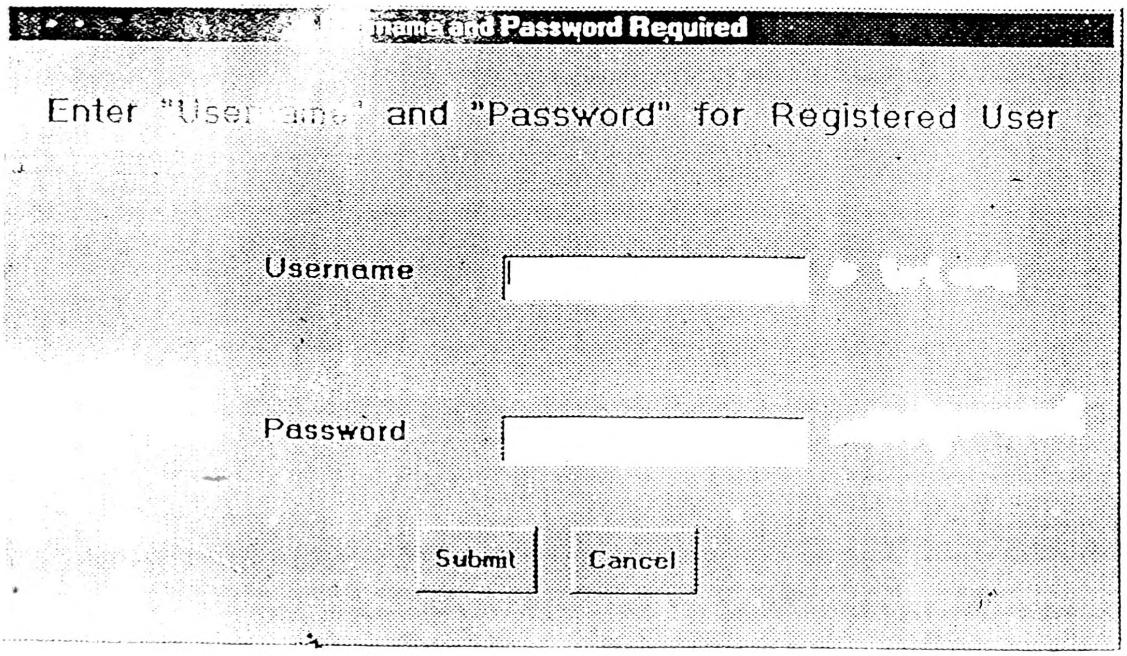
Results and Discussion

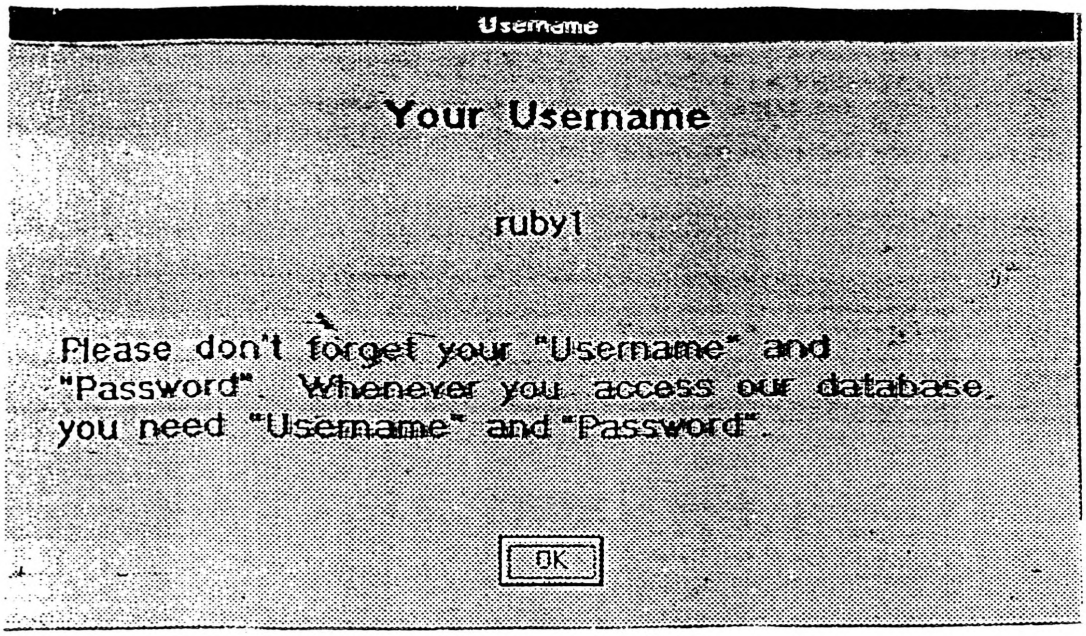
4.1 Run the program

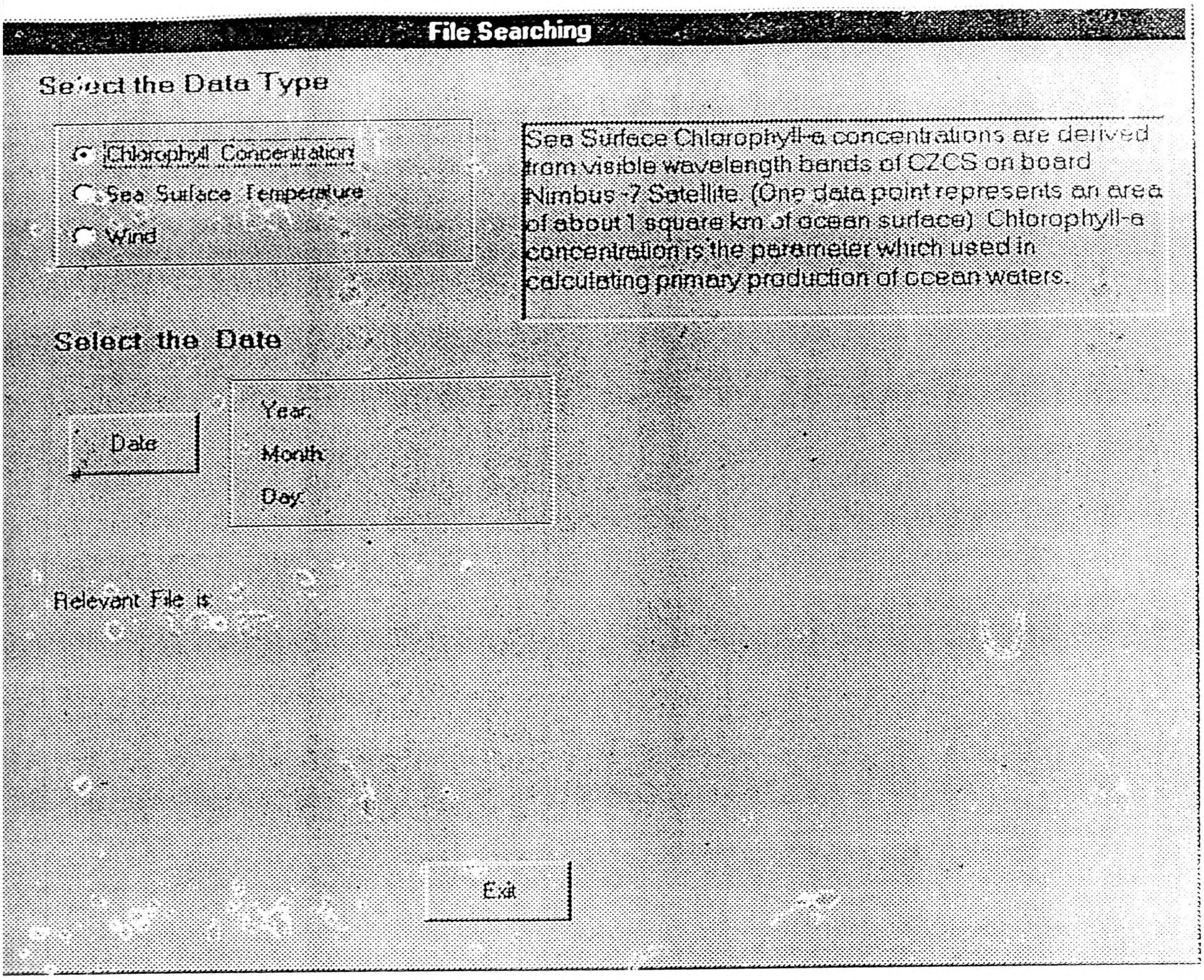
These forms should be filled completely and correctly. A person who registered should remember the password given.

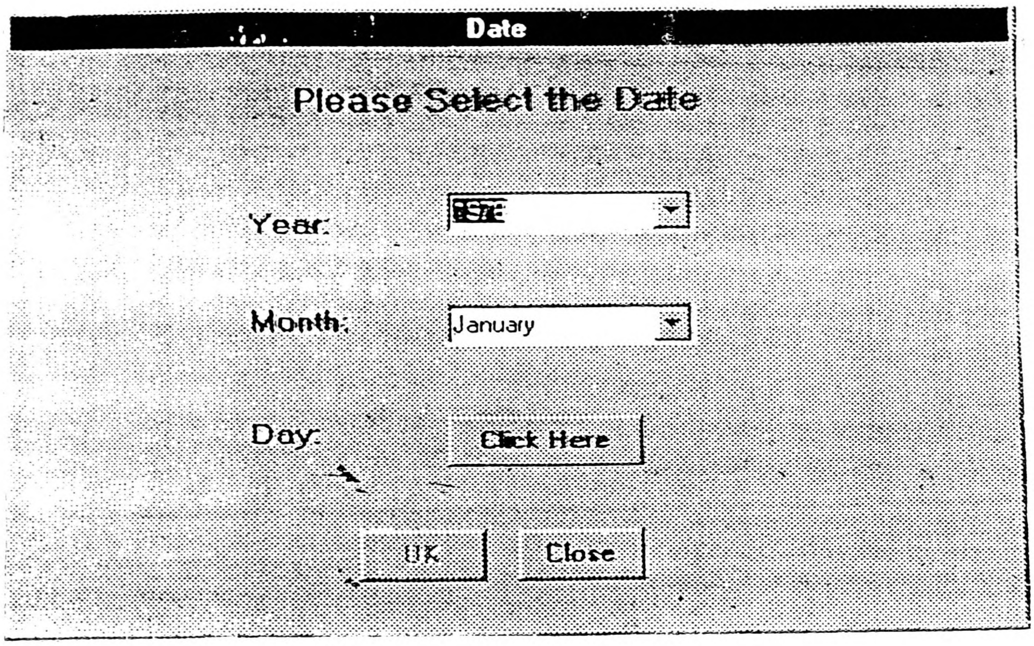


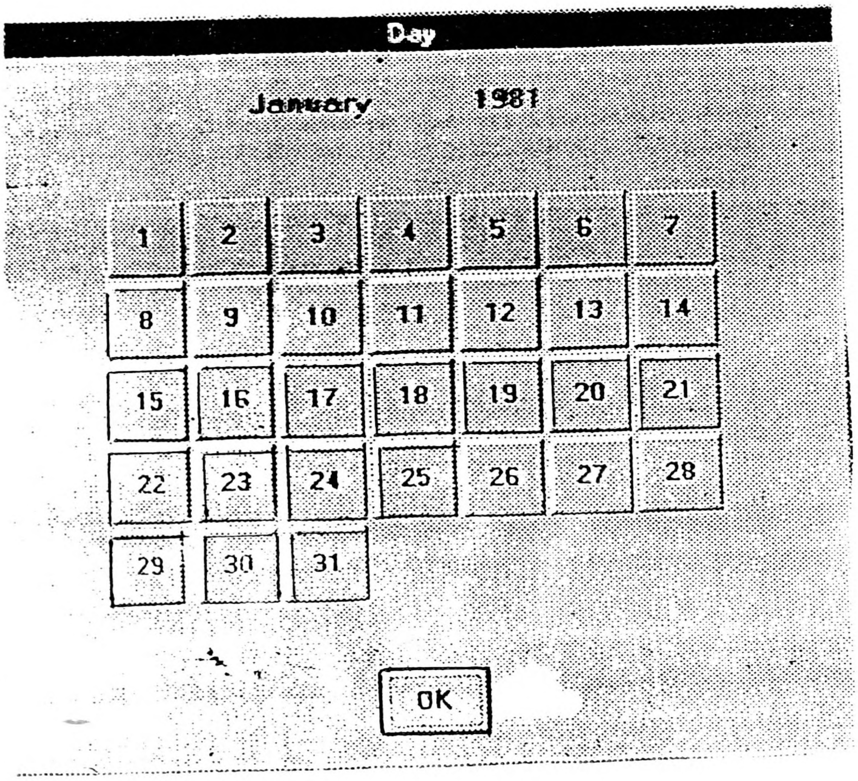

Registration
Please Fill this Form and Press "Submit" Button.
Last Name
First Name
Password
Password Verify
Official Address
Phone No:
Email
Submit
Cancel


name and Password Required
and "Password" for Registered User
Username
Password
Submit
Cancel

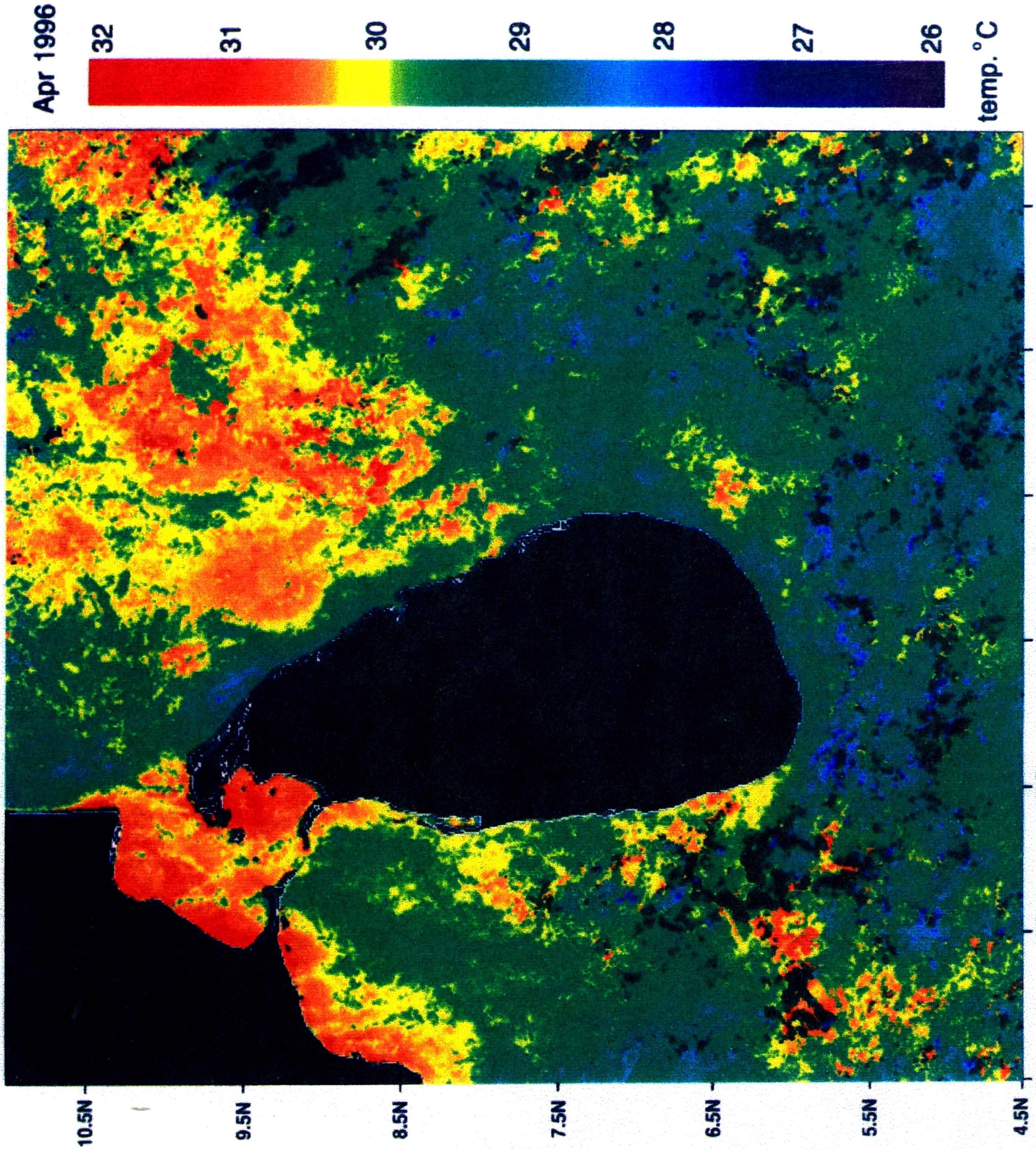

Username
Your Username
ruby1
Please don't forget your "Username" and "Password". Whenever you access our database, you need "Username" and "Password".
OK


File Searching
Select the Data Type
Chlorophyll Concentration
Sea Surface Temperature
Wind
Sea Surface Chlorophyll-a concentrations are derived from visible wavelength bands of CZCS on board Nimbus -7 Satellite. (One data point represents an area of about 1 square km of ocean surface) Chlorophyll-a concentration is the parameter which used in calculating primary production of ocean waters.
Select the Date
Date
Year
Month
Day
Relevant File is
Exit


Date
Please Select the Date
Year:
Month:
January
Day:
Click Here
OK
Close


Day
January 1981
1 2 3 4 5 6 7
8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30 31
OK

The out put of the program, shows the variation of temperature around Sri Lanka. This is the average temperature of the April 1996.



4.2 Uses of remotely sensed satellite data

4.2.1 Specific applications of remote sensing to the aquatic environment

Specifically, concern aquatic photosynthesis, we shall consider the remote sensing only of those qualities of the aquatic environment which relates to its optical properties to photosynthetic bio mass.

1. Total suspended solids.

   Remote sensing, particularly using landsat, has been quite commonly used for mapping the distribution of total suspended solids in land and coastal water.

2. Phytoplankton - air craft studies

   Detection of phytoplankton from air craft is generally based on the decreased reflection in the blue , relative to that in the green studies carried out from low altitude have used photometers of the non scanning type. So that distribution along the air crafts' linear track, rather than over an area has been determined.

3. Phytoplankton – satellite studies

   The landsat MSS optical system can, as we have noted previously be used to detect high concentrations of phytoplankton by taking advantage of the increased reflectance in the near infrared (700nm – 800 nm) band without a corresponding increase in the red (600nm- 700nm) band.

4.2.2 The SST changes and cyclogenesis

Increasing atmospheric green house gas concentration may affect tropical cyclones in three ways. Firstly, increasing SSTs may cause tropical storms to be, on average, more intense. Secondly, green house gas induced changes in the general circulation and surface ocean temperatures may change the frequency, tracks and regional occurrence of the storms. Thirdly, sea level rise will be add to the already present problems of coastal inundation.

Relationship have been sought between tropical cyclone activity and SST with a view to speculating on the effect of a local warming of 1 deg C on cyclone frequency. The fact that a warm ocean surface is needed for tropical cyclone development is well-known, but based on empirical evidence SST does not seem to be the primary variable is determining whether incipient storms develop or not. In three of the cases there is evidence that the link between tropical cyclone frequency and SSTs is indirect. Both being associated with changes in the atmospheric circulation. As possible effects of SSTs may arise through changes in atmospheric stability.

If near surface warming were greater than that of in the upper troposphere, enhanced instability may lead to condition that were generally more favourable for cyclogenesis and development. The analyses were found that stability was not a major factor in determining cyclogenesis.

4.2.3 Effects of sea level rise

When global mean sea level rises as a consequence of a global warming due to CO_2 and other green house gases, show lines will changes according to the nature of the particular ecosystems, but mainly as an exacerbation of already existing phenomena. Several responses can be expected, as mentioned in " world-wide basis " and " the entire coast of the world " some of them are,

a) Increase in beach erosion by the simple application of Bruun's rule.
b) Accelerations of coastal retreat where cliffs are exposed to wave action, mainly in areas where the substrate is poorly consolidated and beaches are being eroded by (a)
c) Restriction of sandy barriers
d) Wet lands migration inland and modifications in their vegetation pattern, eventual losses where migration is restricted by highlands.
e) Lowlands exposure to increasing flooding
f) Salinization of coastal aquifers.

4.2.4 Severe tropical storms and storm surges

The relationship between tropical cyclones (TCs) and sea surface temperature (SST) was examined in 1990s. SST was elected as the independent variable because it should change with the green house effected because it is better described by data than other possible casual factors. There is a long but inhomogeneous record of TC occurrence. The short record of TC occurrence from satellite is insufficient for independent validation of relationship with SST.

A better understanding of the conditions of both the intensity and area of occurrence of TCs would be affected by SST changes, if SST were the limiting factor, but it is not always limiting.

The theory of TC formation and, in particular, the hypothesis that the maximum intensity and frequency of occurrence of TCs would increase significantly due to SST increases in the tropics. Experiments with existing general circulation models, have not shown the development of TCs, probably because of poor horizontal resolution. The meteorological forces generating storms surges are wind stress and atmospheric pressure heavily conditioned by water depth profiles. Tides are generated in the deep oceans by gravitational forces. Given accurate data on wind and pressure forcing, a knowledge of a tidal variations at the shelf edge, and detailed bottom and coastal zone to topography, water levels due to tides and storm surges can be predicted with good accuracy. Validation for the Bay of Bengal is, however, very limited due to a serious lack of water level observations during cyclones.

Results of model experiments to determine the effect of an increase in mean sea level on tidal, storm surge and combined tide and storm surge levels. The changes were small compared with the change in mean sea level producing them. Thus the main impact of an increase in mean sea level on the maximum water level during a storm will result from the change in mean sea level itself, consequent changes in tide and surge elevation relative to mean sea level will be of secondary importance. Changes in tidal regimes may, however, be significant in particular areas such as coastal wetlands and some embayments and estuaries.

4.3 Monitoring the oceans in 2000

One of the major problem facing humanity today is the role played by the oceans in the evolution of the earth's climate and the environment. Oceans carry and exchange enormous quantities of products (water vapour, carbon dioxide, etc.). Or energy (heat, kinetic energy) with the atmosphere. In the past , the oceans average level dropped by about 100 meters. Their mass is about 300 times that of the atmosphere and they have a heat storage capacity which is 1200 times as great. In addition they contain 70 tons more carbon.

The oceans level fluctuate overall scales of time and space, from few hours to few hundred years and from a few kilometers to several thousands of kilometers, thus affecting greatly the earth's environment. Swell, cyclones and tides, whose affects on the marine environment are well known, were some of the first phenomena which could be observed directly.

Another famous example of the influence of the oceans of the environment is provided with the " major currents on the western edge", such as the Gulf stream in the North Atlantic or the Kuroshio the North Pacific. These currents arise under the combine influenced of earth's rotation, winds and heat fluxes at the interface in between the ocean and atmosphere. They generate whirlpools up to 100 kilometer in diameter and carry significant amounts of energy . The Gulf stream may be compared to a central heating duct in which surface water circulates at a speed of 80 Km per day.

The first navigators to advantage of this relative velocity when crossing over to Europe. The energy thus transported from the equal to the poll is the equivalent of that which would be provided by 1,500,000 electrical power stations with an output of 1,300 MW each. The temperate European climate benefits greatly from this input of oceanic heat. Having taken a few months to cross the North Atlantic , the tropical surface water is cool and evaporates during its journey. When it reaches the sub Arctic zone , part of this water will return the surface towards to South reaching the equator where it will once again be charged with heat. Another part will cool sufficiently to sink down to the bottom of the ocean starting a round - the - world trip that will last few hundred years. The ocean also undergoes seasonal variations related to the varying intensity of bins and the cooling or solar heating of the water during different seasons.

There is a direct relationship between oceanic seasons and atmospheric seasons, with however a time shifted about three months, due to time taken by ocean water masses to react to atmospheric changes. This seasonal cycles may itself be distributed by unusual annual events. The resulting imbalance may when have significant effects on the climate and hangs on the socio- economic activities of human beings.

Future ocean / atmosphere coupled model will then enable us to make realistic climatic forecasts over several months " space observations " aspect of such an integrated system are based in particular on the dedicated satellite, TOPEX - POSEIDON. This satellite measures the sea level with an accuracy of about 1 cm. This sea level parameter is extremely to sensitive to variations which affects oceanic circulation and corresponding energy and matter which it transports. The monitoring of variations in mean sea level, this monitoring, by extending the five years of high precision TOPEX - POSEIDON measurements which are already available, will make it possible to use various models for long term evaluation of the climate in an attempt to find answers to basic questions such as the rate of the global heating, the role of rejected Carbon Dioxide gas and the regulating role of the ocean, etc.

4.4 Developing countries and remote sensing

The potential of satellite for making observations which would be helpful to developing countries was recognized from the early days of the Space Age. However the means to make valuable space-based observations were initially process by only a handful of industrially advanced countries. Fearing that the benefits of space applications – such as earth observation - would not be fairly distributed. Developing countries use international forums like United Nations to stimulate consideration of the specific needs of developing countries in relation to space technologies and the concept of equity in relation to access to data acquired by space-borne, earth – observing instruments.

Consideration of their important issues, although protracted and at times discordant, resulted in the systemization of important principle which have greatly contributed to the peaceful development and use of the space environment. For a example, on 13th December, 1966 the " Space Treaty " was adopted by the general assembly by the United Nations. This agreement confirmed the Nortion that the use by human of outer space should be in the interest of all humanity, and it encouraged international corporations in space missions.

On December 1986, the United Nations General Assembly accepted the principles on remote sensing. The principles were designed to explicitly address concern of developing countries relative to data access, technology transfer, and the encouragement of international corporation

The second United Nations conference on the exploration and peaceful uses of outer-space was born from a desire to find ways to extend to all nations the benefits of space technologies and space science. The Secretary General of the United Nations Boutros-Ghali, 1993 re-iterated this call, and suggested methods, including the use of space technology previously reserved for military use, for confidence - building and social development in the post- cold war era.

The UN declared in the 1990's to be the International Decade for Natural Disaster Reduction (IDNDR). Subsequently, numerous region and international activities have been directed at improving the operation of natural hazardous warning and amelioration programs. In those programs frequent attention has been drawn to the necessary role of space technology in achieving the decade's objectives. Developing countries are not alone in suffering the consequences of natural disaster- but the paucity of communication, housing and transport, infrastructure often means that their population suffer more severely.

4.5 The future of satellite oceanography

TOPEX - POSEIDON is a space oceanography satellite, developed and operated under the terms of a co-operative agreement signed by CNES (Center National Etudes Spatiales) and NASA (National Aeronautics and Space Administration) in 1987. In this, radar altimetry which provides the data used for the study of marine current, ocean topography and also the state of the sea, has been delivering results of major scientific interest since its launch in 1992. The satellite has enabled observations, with an unprecedented level of accuracy of different phenomena related to variations in the level of oceans and has also shown our capability to forecast certain climatic events. This has been the case in may 1997 with respect to the extremely intense El Nino phenomenon which currently taking place.

While the TOPEX - POSEIDON satellite has exceeded its nominal life time, after more than five years in orbit, a new satellite, Jason-1 which is smaller but which has the same level of performance, is currently being develop by CNES and NASA for a launch date which has been set for may 2000. The scientific perspectives which it has opened for study of the global climate, but also, in the long run, for the operational implications of forecasting ocean conditions, are of vital importance. Not only in the field of oceanography but also in the service of ecology. The Spot - 4 satellite which almost permanently covers the whole world with an accuracy in the order.

4.6 Use of satellite Earth Observation data and additional resources

AVHRR data from the polar-orbiting NOAA meteorological satellites is received by the ground stations associated with the project. NOAA satellites provide coverage over most parts of China four times a day (ie every 6 hours). This time interval determines the maximum time delay between a fire starting and it being detected using the NOAA data.

The real-time multi-channel AVHRR data is used to calculate ground temperature and albedo, from which fire spots may be identified by use of a thresholding algorithm. The output from the analysis is a printout of the position and size of the fire spot, together with imagery showing the burning and burn-out areas, smoke, etc. Forest and grassland maps are then used to identify the nature of the ground cover where the fire is located. This information is transmitted to the authorities to allow resources to be targeted to put out the fire, and, in the case of larger fires, to enable a plan for fighting the fire to be drawnup.

Detection of fires can be regarded rather like looking for a high temperature target on the ground. It is known that as its temperature rises, the wavelength of the radiation emitted by a body gets shorter. At normal temperatures on the ground (say 27 deg C \ 300K), the radiation will be concentrated around about 10 μm or so. For temperatures associated with fires (eg 1,000k - 1,500K) the peak wavelength will be considerably shorter (a few μm). This system makes use of the various infra-red and visible bands available on the AVHRR sensor on NOAA spacecraft to detect fires.

CHAPTER V

Conclusion

The variability of ocean temperature of surface water around Sri Lanka is presented in this study. The existing database of chlorophyll - a concentration around Sri Lanka was modified during this project to show the variation of temperature around Sri Lanka on the Indian Ocean. The program can be used to visualize data on screen using a colour code. Users are able to extract data as well.

It is clear from the images, the water between the Gulf of Mannar and palk strait show high temperature during the month of April 1996. Similarly, the North Eastern province also show high surface temperature during this period.

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APPENDIX

Temperature Data Used in Study.

PIXEL TO IN SITU		SUN-PIXEL-SAT GEOM				$\frac{1+\cos^2\phi}{\cos\theta}$	°K	Z(°K)		
ΔS(km)	ΔT(days)	$\cos\theta_s$	$\cos\theta$	$\cos\phi$	$\cos\theta_r$	$\cos\theta$	$T_{3.7}-T_{11}$	$T_s-T_{3.7}$	$\hat{Z}$ (°K)	$\hat{Z}-Z$ (°K)
4	2	0.429	0.991	0.544	0.305	1.308	1.3	3.5	3.3	-0.2
7	1	0.394	0.896	0.761	−0.054	1.761	1.5	3.4	3.5	0.1
19	2	0.389	0.874	0.787	−0.107	1.852	1.1	3.3	3.4	0.1
44	1	0.508	0.941	0.766	0.190	1.686	0.1	2.2	2.6	0.4
13	4	0.400	0.760	0.871	−0.262	2.313	2.1	3.1	3.9	0.8
26	1	0.570	0.999	0.538	0.601	1.291	0.4	2.2	2.8	0.6
71	1	0.369	0.527	0.933	−0.544	3.549	1.7	4.8	3.6	-1.2
18	1	0.484	0.994	0.386	0.575	1.156	0.1	3.6	2.9	-0.7
11	2	0.701	0.995	0.292	0.108	1.090	0.6	2.6	3.1	0.5
24	2	0.225	0.998	0.182	0.267	1.035	0.4	3.0	3.0	0.0
18	1	0.331	0.661	0.925	−0.487	2.806	0.6	2.4	2.5	0.1
39	1	0.373	0.814	0.842	−0.235	2.101	0.4	2.9	2.5	-0.4
43	2	0.397	0.888	0.774	−0.069	1.801	0.6	2.9	2.8	-0.1
74	2	0.404	0.781	0.886	−0.254	2.286	0.7	2.0	2.8	0.8
54	2	0.475	0.998	0.527	0.422	1.281	0.5	2.2	2.7	0.5
4	1	0.224	0.795	0.764	−0.408	1.993	0.8	3.0	3.0	0.0
15	2	0.293	0.976	0.495	0.076	1.276	-0.1	3.4	2.7	-0.7
4	1	0.237	0.682	0.872	−0.549	2.583	1.3	4.0	3.7	-0.3
47	1	0.263	0.788	0.801	−0.386	2.084	1.2	3.0	3.6	0.6
26	1	0.333	0.701	0.908	−0.441	2.602	0.4	3.0	3.1	0.1
7	1	0.419	0.989	0.540	0.288	1.306	-0.2	2.3	2.8	0.5
7	1	0.443	0.995	0.343	0.539	1.123	0.6	1.9	3.2	1.3
25	2	0.327	0.681	0.914	−0.469	2.694	1.0	3.8	3.4	-0.4
21	0	0.510	0.801	0.899	−0.083	2.258	1.0	4.2	3.2	-1.0
13	0	0.494	0.746	0.920	−0.182	2.473	1.4	3.4	3.3	-0.1
87	2	0.381	0.986	0.502	0.248	1.270	5.3	4.3	5.1	0.8
94	0	0.380	0.986	0.502	0.248	1.269	5.6	5.1	5.2	0.1
14	0	0.375	0.995	0.290	0.457	1.090	4.6	4.5	4.9	0.4
40	0	0.395	0.990	0.282	0.500	1.090	4.2	4.5	4.8	0.3
23	2	0.349	0.609	0.932	−0.509	3.067	0.9	3.7	3.5	-0.2
108	1	0.388	0.660	0.916	−0.406	2.787	1.4	3.1	3.6	0.5
80	1	0.332	0.781	0.848	−0.329	2.202	2.9	4.0	4.1	0.1
66	3	0.329	0.641	0.934	−0.513	2.921	1.4	3.9	3.6	-0.3
65	3	0.382	0.853	0.805	−0.154	1.932	1.0	3.2	3.5	0.3
138	1	0.379	0.682	0.898	−0.382	2.649	1.6	3.2	3.7	0.5
57	5	0.212	0.693	0.829	−0.536	2.436	2.4	4.6	3.9	-0.7
19	1	0.254	0.740	0.833	−0.457	2.289	1.2	4.1	3.6	-0.5
132	5	0.332	0.735	0.880	−0.392	2.414	2.0	3.9	3.9	0.0
78	4	0.352	0.567	0.891	−0.492	3.161	2.3	4.9	4.0	-0.9
52	5	0.336	0.663	0.839	−0.394	2.571	3.5	5.0	4.4	-0.6
82	1	0.263	0.782	0.793	−0.382	2.083	3.7	5.3	4.5	-0.8
41	0	0.387	0.931	0.034	0.686	1.076	3.4	4.5	4.5	0.0
13	5	0.439	0.999	0.478	0.399	1.230	0.7	3.3	3.2	-0.1
21	1	0.435	0.995	0.516	0.350	1.273	0.5	2.5	3.2	0.7
28	2	0.356	0.871	0.767	−0.148	1.824	0.4	3.3	2.7	-0.6
34	0	0.507	0.923	0.798	0.138	1.774	0.4	1.7	2.5	0.8
46	3	0.366	0.598	0.934	−0.496	3.128	2.1	4.3	3.8	-0.5
9	4	0.435	0.868	0.804	−0.048	1.896	0.8	2.9	3.4	0.5
24	1	0.401	0.578	0.937	−0.474	3.251	1.7	3.6	3.5	-0.1
35	2	0.415	0.841	0.841	−0.143	2.030	0.8	4.0	3.0	-1.0
8	0	0.408	0.824	0.850	−0.179	2.091	1.7	3.7	3.4	-0.3
7	2	0.210	0.990	0.087	0.328	1.017	0.0	2.8	2.7	-0.1
18	2	0.313	0.997	0.288	0.136	1.087	0.1	3.0	3.0	0.0
20	1	0.330	0.654	0.928	−0.497	2.847	0.5	2.9	2.4	-0.5
35	2	0.368	0.780	0.869	−0.295	2.251	0.9	2.6	2.8	0.2
15	1	0.416	0.951	0.675	0.117	1.530	0.0	2.8	2.9	0.1
78	0	0.386	0.707	0.924	−0.379	2.624	0.8	3.9	2.9	-1.0
54	[illegible]	0.466	0.992	0.571	0.353	1.338	0.7	2.7	2.9	-0.2
45	1	0.229	0.802	0.760	−0.394	1.968	2.7	3.5	3.0	-0.5
30	[illegible]	0.262	0.880	0.686	−0.226	1.672	0.8	2.3	3.1	-0.8
4	2	0.423	0.993	0.521	0.316	1.281	-0.4	2.3	2.7	0.4
17	0	0.388	0.915	0.722	−0.011	1.662	0.8	2.7	3.2	0.5
20	0	0.375	0.872	0.778	−0.123	1.841	0.8	3.4	3.2	-0.2
8	0	0.357	0.803	0.869	−0.272	2.134	1.6	3.5	3.5	0.0
28	0	0.506	0.788	0.905	−0.108	2.308	1.1	4.0	3.2	-0.8
63	3	0.426	0.997	0.363	0.486	1.135	4.2	3.9	4.7	0.8
11	0	0.401	0.998	0.340	0.460	1.118	5.6	4.6	5.2	0.6
44	0	0.356	0.993	0.445	0.263	1.207	3.3	4.2	4.5	0.3
54	0	0.330	0.921	0.616	−0.007	1.498	5.5	4.7	5.2	0.5
32	0	0.322	0.696	0.812	−0.365	2.387	4.0	4.9	4.6	-0.3
29	2	0.402	0.793	0.863	−0.221	2.200	1.3	2.8	3.6	0.8
47	0	0.390	0.979	0.540	0.223	1.320	4.3	5.1	4.8	-0.3
70	4	0.391	0.913	0.729	−0.015	1.677	0.6	3.6	3.4	-0.2
50	3	0.342	0.699	0.909	−0.431	2.611	1.8	4.4	3.8	-0.6
47	3	0.361	0.775	0.868	−0.308	2.264	1.7	3.7	3.7	0.0
15	5	0.223	0.747	0.794	−0.461	2.182	1.8	3.1	3.8	0.7
55	5	0.209	0.664	0.848	−0.570	2.588	2.2	4.8	3.9	-0.9
43	1	0.253	0.725	0.844	−0.478	2.363	1.0	4.4	3.5	-0.9
93	3	0.382	0.627	0.889	−0.409	2.854	3.4	4.6	4.3	-0.3
94	5	0.362	0.680	0.850	−0.358	2.532	3.2	4.3	4.3	0.0
32	0	0.284	0.875	0.702	−0.205	1.706	4.1	5.3	4.6	-0.7
112	0	0.346	0.991	0.670	0.215	1.233	3.6	4.7	4.6	-0.1

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