CHAPTER II
OBJECTIVES, DATA AND METHODS

2.1 Introduction

The discussion presented in chapter I clearly indicated that the tropical Indian Ocean is unique among the world oceans owing to the presence of a number of oceanographic features. These features make the prediction a challenging problem for the modellers. It is essential to understand the variability of these features both on temporal and spatial domains before attempting modelling studies. The best way to tackle this problem is to analyse the surface marine met fields. The very objective of present study is to document various sea surface parameters of the Indian Ocean and to examine the anomalies found in them. Hence to relate the anomaly to the variability of monsoon over India, highlighting the occasion of contrasting monsoon periods.

Since atmosphere and ocean act as a closely coupled system it is essential to study their behaviour in a detailed manner to document the variability both on temporal and spatial domains. From the above discussions it is observed that tropical Indian Ocean poses a major problem for modellers with all the complex features described in the above sections. It is felt that the variability of the fields has to be addressed in a comprehensive manner to understand the air-sea interaction processes over the tropical Indian Seas. In this thesis attempts
have been made to study the variability of surface marine meteorological and heat fluxes and their possible link with summer monsoon activity.

The thesis is presented in six chapters. Besides this introductory chapter, the thesis contains five other chapters.

Chapter II deals with the objective of study, data used, methodology followed and the limitations of the data.

The anomalies of the sea surface temperatures, sea level pressure and wind speed, wind direction and cloud are the four parameters involved in the investigated in chapter III. Here we are interested in the following main questions.

(a) What is the nature of variability of sea surface temperature, sea level pressure, surface wind and cloud in the Indian Ocean area?

(b) Do these variability in Indian Ocean coincide with the occurrence of Dipole events, Equatorial Indian Ocean Oscillations and ENSO related features?

(c) How do they feed back on the variability of monsoon over India?

Chapter IV describes the latent heat radiation, short wave radiation, net heat radiation, evaporation and heat budget anomalies of the Indian Ocean for the deficit and surplus monsoon years. Also investigate whether they can explain the occurrence of good and bad monsoons of India.

Chapter V depicts the relation between Indian Summer Monsoons and the occurrences of Equatorial Indian Ocean Oscillation and ENSO related features.
The variability of Indian summer monsoon is widely discussed in this chapter.

Chapter VI summarises the results and portray the conclusions of the work.

2.2 Data

Since this thesis is concerned with the variability over the tropical Indian Seas, we have used Comprehensive Ocean Atmospheric Data Set (COADS) processed and averaged over 1° known as Surface Marine Data Set (Da Silva et al 1994). Among many data fields present in the data set we make use of objectively analysed fields of surface marine anomalies of sea surface temperature, sea air temperature, sea level pressure, surface wind, fractional cloud cover, latent heat radiation, short wave radiation, net heat radiation and evaporation over most of the global ocean. These revised monthly mean fields are derived from individual observations in the Comprehensive Ocean-Atmosphere Data Set (COADS) January 1945 to December 1993 and are analysed on a 1° by 1° global grid. Corrections have been made to reduce wind speed bias associated with an erroneous Beaufort equivalent scale, and to quality control night-time fractional cloud cover observation according to the brightness of the sky. Various anomaly fields from January 1945 to 1993 December have been used for the analysis.

The availability of this data set has significantly contributed to advancing our understanding of the atmosphere-ocean climate system. One of the main
contributions of the COADS project was to unify several historic data sets in a single and consistent format and to subject the ship reports to the same quality control procedures. The primary data source for this study is the Release I of the Comprehensive Ocean-Atmosphere Data Set (COADS), which cover the period of 1854-1979, and subsequent releases cover upto 1993.

Anomalies are the departures of a parameter from its mean value. It is computed by subtracting the monthly climatological mean derived from the whole length of data, from the individual observations. Positive values of the anomalies indicate high values compared to the climatology and vice versa.

The revised anomaly fields are derived from individual observations in the Comprehensive Ocean Atmospheric data set (COADS, Da silva et al, 1944) from January 1945 to December 1993 are analysed on 1° by 1° global grid. Objective analysis has been done on the data by successive correction method with Barne’s weight function same response functions as Levitus (1982). Climatological Atlas of world oceans has been used by the developers of COADS data set.

The data used is in the netCDF (Network Common Data Form) format, a data format developed at the University centre for Atmospheric Research, University of Boulder, Colorado, and U. S.A. It is an interface for array – oriented data storage and access, which is widely used in climatological research and other fields of Geosciences. Many important data sets and model output files are distributed and shared among the scientists in the netCDF format.
Quality control in COADS is implemented by means of multiple statistical procedures to identify outliers. The first step is to generate *Decadal Summary Untrimmed Limit* for six variables. A detailed description of the statistical procedure can be found in Slutz et al. (1985). In general an observation is rejected if it differs from the smoothed median by more than 3.5 standard deviation.

### 2.3 Limitations and shortcomings of the data set

A description of the marine data set is not complete without a discussion on the problems and shortcomings of the data set. Ship reports are the only record available for surface marine climate. This data set undoubtedly continued to be used in studies of the Ocean-Atmosphere system. An analysis of surface marine data is an evolving system. Constant improvements are necessary as more data or metadata becomes available, physical parameterisations are improved or advances of data assimilation techniques become available. The corrections reported here are the best in the right direction but much remains to be done.

The first and the most uncontrollable errors exist in the ship report themselves. Marine and atmospheric measurement techniques and the recording of these observations are not perfect. Some errors are introduced through poor instrumentation. Surface air temperature can be biased due to heating of the ship's superstructure during the day and inadequate surface ventilation. (Isemer and Hasse 1987; Ramage 1984; Kent et al. 1993a, b). Sea Surface
Temperature observations taken via ship intake will be biased compared to those taken by canvas bucket.

A proper homogenisation of the measured wind speed requires the knowledge of the precise anemometer height information, which is not included in COADS. An average anemometer height of 20 m has been assumed in our calculation. The discrimination between measured and estimated winds is not entirely reliable (Slutz et al. 1985, Cardone et al. 1990. Our wind speed bias correction producer takes the W1 flag at face value and consequently is affected by this uncertainty.

Even when an observation is considered accurate and unbiased, the recording practices may result in errors (Slutz et al. 1985). Some observations are taken in different units (such as Fahrenheit vs. Celsius) without documentation of the fact. All observers do not implement coding practice changes on the same date. Ship position may be erroneous. The transfers of written record to digital also introduce possible errors. Little can be done to miscoded or other human errors. A certain amount of recording errors were repaired by the compilers of COADS, but some miscoded errors undoubtedly remain. The tendency of ships to avoid the stormy weather bias into observations when considered as a whole, although this bias is less problematic in the tropics.
After we deal with correctable biases and calculate raw fields, errors can be introduced by the analysis scheme as well. One problem with the successive correction method used in this analysis is the introduction of unrealistic features (Levitus 1982). One of the most severe problems with surface marine data is the poor coverage in some regions especially away from shipping lanes. Objective analysis of the sort used here fills in the gaps by interpolating/extrapolating smooth data from remote region, but cannot compensate entirely for poor sampling. This effect is particularly troublesome in the tropics and southern oceans where observations are clumped along ship tracks with data void area in between. As a result, wrong features sometimes remain in analysed fields, particularly in anomaly fields.

The analysis of anomaly values rather than the observed values can result in spurious extrema. For example, the analysis has problems handling positive definite quantities such as fractional cloud cover, which only takes values between 0 and 1. The analyses procedure can produce full field values (climatology plus anomalies) less than 0 in broad clear areas or values greater than 1 in broad overcast region. It should also be kept in mind that although the analysed fields are given on a 1° by 1° grid; only features with wavelength greater than 770 km. are retained. The reader is referred to Levitus (1982) or Dailey (1991) for additional discussions of the limitations of the objective analysis technique.
Despite these limitations the COADS data set remain as the best data set
to study the broad scale features occurring over the oceans especially during the
present study period of 1945 – 1993.