CHAPTER I

INTRODUCTION

This chapter explains the importance of Radar remote Sensing for Land Surface characterization. It brings out the importance of the present study, explains its objectives and outlines the various elements of the thesis.
1.0 INTRODUCTION

1.1 Land characterization

"Land is a delineable area, encompassing all the attributes of the biosphere immediately above or below the earth surface, including the soil, terrain surface hydrology, the near-surface climate, sediments and associated groundwater reserve, the biological resources, as well as human settlement pattern and infrastructure resulting from human activity” FAO, 1992.

Over 70 percent of the energy absorbed into the climate system is absorbed by the surface which underlies the importance of the surface hydrology for the climate system. The exchange of energy between atmosphere and land surface depends on the characteristics of the land cover, as described in FAO definition of land. Therefore land characterisation is one of the important inputs for weather/climate or environmental analysis.

Remote sensing has promised to revolutionize land characterization by delivering spatial critical information of land surface. Numerous airborne and space-based sensors using multi-angle, multi-spectral and radar techniques have been used to demonstrate the efficiency of a remote sensing/GIS approach to land characterization & management.

Such efforts have led to great advances in our ability to monitor and model the land surface.

1.2 REMOTE SENSING TECHNOLOGIES FOR LAND SURFACE CHARACTERIZATION

Remote Sensing is defined as the science and technology by which the characteristics of objects of interest can be identified, measured or analysed without direct contact with the object. Electro-magnetic radiation that is reflected or emitted from an object is the usual source of remote sensing data. The remote sensing data will be processed automatically by computer and/or manually interpreted by humans, and finally utilized in agriculture, land use, forestry, geology, hydrology, oceanography, meteorology, environment etc.
The multi-temporal data analysis is essential for the characterization of land that is changing its surface properties from season to season. Hence, the pre-requisite data should be available in summer, winter and monsoon seasons. However, during cloudy sky condition, the availability of optical data is a problem. Hence, use of microwave remote sensing technique is a better option. Microwave remote sensing, using microwave wavelengths from about one centimeter to a few tens of centimetres, enables observation in all weather conditions without any restriction by cloud or rain.

There are two types of microwave remote sensing; active and passive. The **active technique** employs its own source of illumination and receives the backscatter signal which is reflected from the ground surface. Synthetic aperture radar (SAR), microwave scatterometers, radar altimeters etc. are active microwave sensors. The spatial resolution (area sensed), of the order of few meters for SAR is much higher compared to scatterometer that is having spatial resolution of the order of few kilometres. However, microwave scatterometer has edge over SAR for the regional land characterization due to its higher revisit capability that increases the number of image acquisition over a specified time interval.

Scatterometers measure geophysical variables related to the earth's water cycle, including: precipitation rate, cloud water, water vapour, sea surface winds, sea surface temperature, sea ice concentration, snow water equivalent, and soil moisture. Scatterometers are unique in their ability to determine wind velocity and wind direction over Ocean surfaces.

Over the land surface, backscatter is related to surface roughness and dielectric properties as well as volume scattering from vegetation and snow cover. Due to such scattering mechanism, it is possible to address some of the large-scale phenomena over the land surface as biophysical variables retrieval. In addition, it is feasible to address the problems related to snow hydrology and soil thawing.

Land surface in India, from north to south and west to east, characterised by wide variety of vegetation cover varies in vegetation densities and also varies from one season to another. Two different monsoon pattern and wide differences in irrigation from one part to another, contributes to
different moisture level that too varies from one soil type to another. All these characteristics need careful remote sensing studies to characterize the land cover.

Though multiple studies have been carried out using scatterometer data to study different land surface characteristics (as described in Chapter-II), there is a need for an integrated study to investigate surface with various moisture conditions (dry to wet soils) and vegetation densities (sparse to dense) with multiple frequencies (C- and Ku-band). The thesis will address some of the important features characterizing the land surface like vegetation (forests, agriculture), desert, urban, water body and soil, etc. using multiple scatterometer frequencies

1.3 NEED FOR FURTHER RESEARCH
Scatterometer data at C-band and Ku-band is not explored over Indian region which represents variability in the characteristics of land surfaces. Further, dual frequencies measurements are not attempted over large area. Thus, research work has been focused on these aspects.

1.4 OBJECTIVE
The aim of the work presented in this thesis is to study and analyse the C- and Ku-band radar backscatter signals coming from different features covering Indian region, using space-borne scatterometers. The entire work is divided into the following studies to meet the overall goal.

(i) Characterization of land surface using C-band.

(ii) Characterization of Thar Desert using C-band scatterometer data.

(iii) Characterization of Soil wetness using C-band scatterometer data.

(iv) Temporal monitoring of forest covers using Ku-band scatterometer data.

(v) Comparisons of C- and Ku-band signatures of land features.
1.5 ORGANISATION OF THESIS

The work carried out for this thesis is presented in nine chapters.

The objective and importance of land characterization over the Indian region is explained in Chapter 1. The overview of remote sensing and the theoretical background along with its State of art is discussed in Chapter 2. Satellite sensors are discussed in Chapter 3.

In chapter 4 broad-level characterizations of features using C-band is studied. January 2000 data from C-band scatterometer aboard ERS-2 is used for investigation radar signatures of land surfaces over Indian region. The $\sigma^0$ at C-band, VV polarization, depends mainly on the moisture content of the soil and vegetation, vegetation type and density, and surface roughness. The data over Indian region shows the variability of $\sigma^0$ of the order of 12 dB (–18 to –6 dB). High backscattering was observed from forests in North-Eastern region, Western Ghats and Forests in central portion. In general, increase in backscattering coefficient was observed due to forest density. Medium backscattering was for agricultural land whereas desert showed very less backscattering due to specular reflections. Radar backscattering coefficient and slope were also derived for assessing the role of such indices in characterization the surfaces.

In chapter 5 a portion of hot ("Thar") desert in India is studied for its time-series backscatter response. Major dune types were identified and their temporal trends were studied. The year 2000 scatterometer data of ERS-2 C-band over this region showed the variability of backscattering coefficient of the order of 11.27 dB (-20.08 to -8.71 dB). These variations were analysed in terms of scattering due to various factors like soil moisture, vegetation, rainfall, and surface roughness. For this purpose, nine dune signatures over six types of sand dunes have been studied. In general, high backscattering was observed in the month of July and August and low backscattering was observed in the month of May and June. The study indicated the potential of C-band scatterometer data for monitoring temporal variability for modelling and monitoring desert ecosystem. Further, potential of the C-band data for monitoring the aerodynamic roughness length ($Z_0$) over Indian Thar desert was also established.
In chapter 6, soil wetness characterization using C-band scatterometer data using change detection method has been studied. Rainfall was used as surrogate to soil moisture. Moisture wetness index was found to be correlated with rainfall pattern. The study provides an input to large scale observation of soil moisture.

The two sections in Chapter 7, describe the work carried out for the vegetation dynamics studies using sinusoidal model, of $\sigma^0$ and its relation to phenology of Indian tropical-moist-deciduous forests, and other forests has been studied using QuikSCAT (Ku-band) scatterometer data of year 2000. In section A, the temporal behaviour of Indian tropical-moist-deciduous forests has been studied. The impact of vegetation growth and senescence was investigated by comparing $\sigma^0$ time-series to NDVI and rainfall observations. It was observed that $\sigma^0$ varies with different scale than the NDVI. The low correlation coefficients also indicate that the direct relationship between $\sigma^0$ and NDVI is either very weak or absent. Further, $\sigma^0$ was observed minimum during the deciduous period with prevailing high temperature and no rainfall condition. The temporal changes in backscattering coefficient were modeled for understanding the vegetation dynamics. The study suggests the suitability of Ku-band space-borne scatterometer data for understanding the seasonal dynamics of different forest types. In section B, Feasibility of microwave data in understanding Phenological changes of other Indian forests were studied.

In Chapter 8, comparison of C-band and Ku-band signatures of land features is studied. Microwave backscattering coefficient images at C-band and Ku-band over India were generated from wind scatterometer data from ERS-2 and QuikSCAT. Microwave signatures of various land covers at C-band and Ku-band were analysed for assessing the potential of these data sets for land application. In general, major land cover classes could be discriminated based on the scattering behaviour of land cover classes. Effects of polarization ratio, view direction on backscattering coefficient were also examined.

The last chapter summaries the results of the entire research work. It highlights the important results and contribution of this thesis. This chapter ends with a paragraph on scope for future work.