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REMOTE SENSING OF OCEANS FOR CLIMATE STUDIES : SOME INDIAN EXPERIENCES

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ABSTRACT

Monitoring of the state of the oceans is a vital requirement for understanding climate, and this is particularly true in the Indian monsoon region. Satellite remote sensing observations can provide a cost-effective means of monitoring several oceanic parameters of relevance to climate. A resume of currently available satellites and future possible satellites for this purpose is given and is followed by a brief overview of the Indian efforts in this area.

Key-words : Remote sensing, climate, satellite.

INTRODUCTION

The Study of climate, particularly in the Indian region, intimately involves an understanding of the role of the ocean in influencing it. Monitoring the vast oceanic areas is a difficult and expensive task; satellite remote sensing has been recognised as a valuable means of accomplishing this, for certain oceanographic parameters of importance to climate. India has also made a beginning in this technique and there are plans for further developments. These experiences and possible plans are briefly outlined in this overview. An earlier review (Pandey and Hariharan, 1984) may also be referred.

OCEANIC PARAMETERS

The oceanic parameters of relevance to climate which are amenable to satellite remote sensing include :-

- Sea Surface temperature
- Sea Surface wind/windstress
- Sea state including wave height
- Surface radiation budget components
- Sea level and inferred surface currents
- Surface salinity
- phytoplankton/chlorophyll (of relevance in CO_2 budget)

In addition, atmospheric boundary layer parameters are also sensed by certain satellite sensors, from which air-sea exchanges of sensible and latent heat (evaporation) could be inferred.

SOURCES OF OBSERVATION

The operational meteorological satellites presently available are: INSAT-1 and NOAA series. The geosynchronous INSAT Satellite carries a two channel Very High Resolution Radiometer (VHRR) consisting of a visible channel with 2.75 km spatial resolution and a thermal infra-red channel with 11 km spatial resolution. The infra-red channel can provide approximate sea-surface temperature field, but atmospheric correction due to water vapour absorption can not be estimated accurately, as no other suitable channels are available. The visible and infra-red channels could be used, to estimate short-wave and longwave radiation fluxes at the top of the atmosphere and at the surface, but considerable degree of approximation is involved in extending narrow spectral radiance observations to wide-band fluxes and in estimating surface fluxes from top-of-the-atmosphere observations. The cloud images in the visible channel not only provide indications of low-pressure systems, tropical cyclones etc. but also through processing of successive half-hourly imagery, give lower tropospheric winds via cloud tracer motion, and these winds could be approximately extrapolated to the sea-surface.

Another meteorological service provided by INSAT is that of Data Collection Platforms, and this too is useful in oceanography, especially if buoys are developed for oceanic data collection via INSAT.

The polar sun-synchronous NOAA satellites carry a 5-channel Advanced Very High Resolution Radiometer (AVHRR) with 1-km spatial resolution and a 20-channel 'TIROS — Operational Vertical Sounder' (TOVS), with resolutions ranging from 20 to 200 km. These instruments can provide accurate (about 1°K) sea-surface temperatures except in heavily clouded areas, and also several atmospheric parameters. Radiation budget components can also be inferred from NOAA; the larger number of channels give it an advantage but the sun-synchronous orbit may give it a bias in relation to the diurnal cycle. A combination of NOAA and INSAT may be able to resolve this latter problem.

The next generation of NOAA satellites may carry an Ocean Colour Scanner for chlorophyll detection; this would be a refined version of Coastal Zone Colour Scanner (CZCS) used earlier on NIMBUS satellites. This is an optical multichannel sensor which includes blue, green and other narrow spectral channels from which chlorophyll concentration on the sea-surface can be estimated. Diffuse attenuation coefficients in the euphotic zone can also be inferred, which would be relevant in heat budget considerations.

For the other parameters listed earlier, although at present there is no available operational satellite, there are several experimental missions planned in the coming 5-year period which may be relevant. These include the European Remote Sensing Satellites-1 (ERS-1, launching around 1989), which will carry a compliment of passive and active microwave sensors for sea-state, sea-surface-wind, wave spectrum and sea-level observations, the NSCATT mission

with microwave scatterometer for surface windstress distribution observations, the TOPEX (Ocean topography experiment) with an altimeter for sea-level detection, and a Japanese Marine Observation Satellite (MOS-1). Also, Indian Remote Sensing Satellite-1 (IRS-1) may be able to provide chlorophyll estimation, while future IRS would have scope to deploy microwave oceanic payloads. In the meanwhile, ROHINI series of satellites could also be utilised for experimenting with such payloads. There will also be occasional opportunities such as shuttle imaging radar, which can be used for familiarisation although not for operational climate related observations. There is also scope for Indian collaboration with other countries in oceanic remote sensing.

INDIAN EXPERIENCES

The derivation of sea-surface-temperature from NOAA satellite has been studied intensively, particularly for the tropical humid region around us, where moisture and cloud correction procedures may need special treatment (Agarwal, 1983), since global regression coefficients are found to yield biased values (Pathak 1982). Using high-resolution sea-surface-temperature fields, it should be possible to monitor thermal features such as fronts, upwelling zones, gyres etc., and a joint experiment between Space Application Centre (SAC) and National Institute of Oceanography (NIO) is under way for coastal upwelling detection through NOAA satellite.

Upwelling in particular, and mixed layer dynamic response to the monsoon wind stress forcing in general, have been studied by Ali, Simon and Desai (unpublished) with the help of geosynchronous satellite winds extrapolated to sea-surface, satellite sea-surface-temperatures, and ship's surface and profile observations. An equatorial aspect, the reversal of the mixed layer zonal slope, has been studied in these papers. Equatorial Indian Ocean heat budget is being studied with the help of polar satellite heat budget component data. Another input required in this study is the surface heat exchanges and these are being approximately estimated from geosynchronous satellite winds and polar satellite temperature and moisture profiles, all extrapolated to the surface by approximate techniques.

Chlorophyll and diffusion coefficient estimates from NIMBUS, CZCS have been achieved in the Indian region (Narain, unpublished). In this context, optical properties of sea-water are important (Sathyendranath, 1984).

Sea-surface-wind and sea-surface-wave-height have been estimated from the Indian BHASKARA Satellite Microwave Radiometer (SAMIR) and compared with sea-truth (Vishwambharan, Rao and Rao, 1984, Rao, Vishwambharan and Rao 1984). Theoretical modelling of microwave backscatter from a wind roughened sea-surface (Sarkar and Bhaduri 1984, Sarkar, Rajkumar and Bhaduri, 1985; unpublished) and of the retrieval of sea-surface-wind vector from scatterometer observations (Gohil and Pandey, unpublished) have been studied with a view to using these experiences in defining a suitable scattero-

meter payload configuration for surface wind observations and in developing the algorithm for wind vector estimation.

Some studies of ocean wave observations from satellite imagery, and their relationship to bottom topography have been initiated. These would be relevant to microwave radar imagery when available.

As for salinity, there is no initiation as yet, but if required, appropriate microwave radiometer could be developed for this purpose.

Depending on opportunities of data availability, many of the above and related themes can be developed further in the future.

A viable national program can be developed for oceanic observations relevant to climate studies with proper multi-agency effort.

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