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Lecture Notes

Part 1

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APPLICATION OF REMOTE SENSING FOR MARINE FISHERIES AND CLIMATE CHANGE STUDIES IN INDIA

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Introduction

The term 'remote sensing' implies feeling from a distance and applies to "the acquisition of information about a portion of the earth's surface, utilizing instruments operated from a distance". The term is restricted to the methods that employ electromagnetic energy such as light, heat and radio waves as the means of deflecting and measuring target characteristics. The physical basis of remote sensing is the platforms like aircraft and satellites. Operational types of remote sensing include aerial photographs, false colour IR photos, radar imaging, thermal IR scanning and satellite remote sensing.

Operational types of remote sensing

Aerial photography utilizes visible part of the electromagnetic spectrum while the use of other wavelengths had become prevalent since 1960's utilizing thermal infrared and microwave region of the electromagnetic spectrum. Electromagnetic energy (EME) interacts with matter by being scattered, reflected, transmitted, absorbed or emitted.

When EME is received back, the satellite images are generated. Wavelength regions used for remote sensing ranges from short wavelength UV energy to long wavelength microwave and radio-energy. Electromagnetic regions are further subdivided into narrow wavelength bands. For remote sensing systems, the distance between the target and the satellite determines the details of information obtained and the total area imaged by the sensor. Satellite sensors view a large area but can not provide great details whereas by flying on board airplane finer details can be obtained but only over a smaller area. Remote sensors are electronic devices that acquire data using scanning systems.

These systems employ a sensor with narrow field of view that sweeps over and build a two dimensional image of the earth's surface for an area (known as swath) beneath the system. The sensor refers to the sensing mechanism that receives electromagnetic energy (EME) and records it. Thus, two main types of sensors are photographic and non- photographic and two main types of output generated are photographic outputs and satellite images. The aerial photographs and satellite images are directly usable as maps and can be read and identified after suitable processing.

Aerial photographs and satellite images are subjected to suitable processing prior to interpretation. Photographs require normal processing as photographic sensors involve instantaneous exposure of the entire scene within its field of view on a light sensitive emulsion such as film. The film serves both as a recording and storage medium whereas in case of satellite images output is recorded in digital form on suitable recording devices and processed by computers with corrections, calibrations and interactive manipulations. These images must be interpreted and validated by the ground truth data. Main steps in image processing are image restoration, image enhancement and image extraction.

Remote sensing in India

In India, use of remote sensing for marine fisheries applications started in 1989 by involving various national agencies. Initially NOAA AVHRR data for Sea Surface Temperature (SST) was utilized for finding out thermal fronts. The thermal fronts were projected as Potential Fishing Zone or PFZ areas. For validation of the data National Remote Sensing Agency (NRSA), Hyderabad, and Central Marine Fisheries Research Institute (CMFRI) Cochin, started an integrated programme and reported encouraging results.

For comparison of data during validation, PFZ charts were prepared and the information was disseminated through FAX, Telephone, Radio, TV, Newspaper and Fisheries societies etc. within shortest possible time. Fishing data collected from the PFZ and non-PFZ locations were compared and noticeable differences in the catch were recorded from various areas, especially off Minicoy Island for pole and line fishing of skipjack tuna.

During the second phase, with the launch of IRS P3 and availability of the IRS P-3 MOS (Marine Observation Satellite) data, the programme was further strengthened. However, due to limitations of the swath area (200 km) and limited repeativity (once in fifteen days), the desired output could not be received. The programme had the ambitious objective of PFZ prediction based on the hypothesis that fish stocks are likely to gather in those thermal fronts that are rich areas with algal food. Highly productive areas, rich in chlorophyll *a* are likely to emit different EM spectrum. This can be measured by the satellite sensor and validated. Geo-coordinated and geo-referenced composite picture of the SST and chlorophyll when generated in real time basis and transmitted to the fishers in the vicinity may result in better catch.

Since the marine system is highly dynamic and feature consistency may exist only for few days, limitations of the MOS mission were resolved when earth observation mission OCEANSAT-1 was launched in May 1999 as a payload on IRS P4. This was specifically tailored for the measurement of physical and biological oceanography. An ocean colour monitor (OCM) with 8 narrow spectral bands and with a Multi-frequency Scanning Microwave Radiometer (MSMR) operating in 4 frequencies provided valuable ocean surface related observation capability.

PFZ validation programme

The PFZ validation programme received a boost with the OCM as satellite remote sensing techniques were found capable of obtaining information on water quality parameters like turbidity, suspended sediments, chlorophyll concentration and presence of algal blooms and large sized aquatic weeds. Advantage of large swath area (1420 km) and better repeativity (once in two days) gave better chance to conduct validation exercise. The PFZ areas could now be charted with more accuracy and an integrated exercise started by involving more active participation from stakeholders.

The agencies involved in the validation exercise include the National Remote Sensing Agency, Space Application Centre, Central Marine Fisheries Research Institute, Fishery Survey of India, state fisheries departments, various fishermen co-operatives and individuals. To generate forecast, the data is first acquired by the satellite and transmitted to the earth station. This data is processed at the forecasting centre or agencies. The processed image is interpreted and communicated to research vessels and fishing craft operating in the PFZ and non-PFZ areas. The fishing efforts and catch are recorded and processed to develop holistic picture of the fishery and results of PFZ and non-PFZ areas are compared to complete the validation exercise. Now the Indian National Centre for Ocean Information Services generates regular PFZ advisories.

Monitoring pollution

Another application of remote sensing is monitoring of the source, effect and extent of pollution and formulation of appropriate management plan. Remote sensing technology has proved its capability to identify the source of pollution and accurately determine location, extent and type of pollutants. However, variety of environmental problems on land, air and sea can only be effectively dealt with using multisensor approach. This will provide capability to address the issues both at regional and global scale. Some of the capabilities of remote sensing in governing marine pollution are:

i. Detection and monitoring of rate of disposal of dumped waste along sea coasts, and

ii. Detection and mapping of oil slicks.

The advantage of mapping the oil slicks is due to difference in the emmissivity properties of petroleum products from that of surrounding sea surface. Recent analysis indicate that cost of clean up operations after

tanker accidents could be reduced by 15 to 20% using multisensor approach by identifying the exact area requiring treatment. Quantitative estimation of total oil spill has been based on estimation of its thickness profile derived from radiance measurements. Thus, remote sensing has become an invaluable and inevitable tool for monitoring and dealing with marine pollution. For marine Environmental Impact Assessments (EIA), remote sensing by virtue of its capability of providing frequent and synoptic coverage plays a potential role in both rapid and comprehensive EIA. This can be clearly realized by closely observing the picture of sewage discharge in bay and adjoining coastal areas.

Applications in oceanography

One of the very important applications of remote sensing is in the field of oceanography where wind vectors like wind speed and direction can be measured quickly over a large area and also geo-referenced. Geo-coordinated images can be developed for daily, weekly and monthly averages. In addition to remote sensing (RS), geographical information system (GIS) has been found to be useful for marine fisheries development and management activities.

When application of RS and GIS is taken into consideration for coastal and marine fisheries, prospects of future applications are also taken up in context of information needs. Constraints related to data availability, quality, costs and administration are discussed. Several alternatives are proposed for utilizing the technology from the viewpoint of data requirements. For climate change studies, remote sensing offers many options form international portals.

Application in climate change studies

For climate change studies, remote sensing plays an important role in evaluating global CO_2 transfer velocity, use of SST and ocean color for pCO_2 interpretations and extrapolations, determination of carbon related parameters like primary production and POC (particulate organic carbon). Analysis of factors controlling phytoplankton distribution also can be done at regional and local scale.

Present and future sensors being deployed by various agencies also have potential to measure SST (Sea Surface Temperature), SSH (Sea Surface Height), winds, SSS (Sea Surface Salinity), sea ice, ocean colour, precipitation, cloud cover, aerosols etc. Multiple data sets from various sensors can yield useful insight to study the impact of climate change on marine ecosystem. In addition to the regular oceanographic parameters, images of the vulnerable shoreline that are susceptible to climate change can also be generated. Through integrated use of remote sensing and GIS, the SLR (Sea Level Rise) can also be monitored with proper ground truthing.

Thus, for application of remote sensing in planning and management of Indian marine fisheries and climatic research, India has attained a threshold that is at par with developed countries. Furthermore, in line with computer industry as a whole, more variety and sophistication of basic data retrieval, storage, manipulation, analysis and reporting are becoming available at decreasing costs. Therefore, an application of these technologies to marine fisheries and climate change research is the need of the time.

Suggested Reading

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