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APPLICATIONS OF SATELLITE DERIVED SEA SURFACE TEMPERATURE

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The sea surface temperature (SST) observations have been produced operationally from satellite infrared data by NOAA (National Oceanic and Atmospheric Administration) since 1972, but the utility of these observations for various applications has been limited by large spatial and temporal variations in coverage and accuracy. The recent implementation of multichannel

techniques for calculating SST, however, has substantially improved the SST reliability. These multichannel techniques use combinations of the two or three spectral channels of the Advanced Very High Resolution Radiometer (AVHRR) flown on the TIROS - N (Television Infrared observational satellite) series of polar orbiting satellites (See Appendix A).

The current reliability of satellite derived SST can be assessed (Pichel and Banks, 1984) by considering the following five factors:

a) Geographical coverage:

Except in regions of persistent cloudiness or ice, coverage is global within 3 days.

b) Production success:

Over 95% of all data acquired by the satellite are processed to produce SST's.

c) Timeliness:

Satellite SST observations from 78% of all the satellite orbits are placed in a user accessible data base within 8 hours after acquisition by a ground station.

d) Repeatability:

Satellite monthly mean SST's rarely have standard deviations above 1.5 C as compared to the ship monthly mean standard deviations which are generally higher than 1.5 C.

e) Absolute accuracy:

Satellite SST observations have been compared with coincident ship and buoy observations by numerous authors (Pichel and Banks, 1984; Mc Clain et al., 1985 and Pathak, 1987) on a daily as well as monthly basis. Root mean square (RMS) satellite buoy differences are generally lower than 1.0 C. In a recent study, Ramesh Kumar et al., (1988) have shown that the SST measured by the thermal infrared scanner and the conventionally measured SST (either by bucket method or intake method) differs significantly.

In light of the improved accuracy and coverage of the new multichannel satellite SST measurements, they can be used for a variety of ocean related applications.

Sea surface temperature is one of the most important parameter which plays a vital role in the air-sea interaction studies, weather forecasting, pollution monitoring, climatological studies, global circulation model (GCM) studies, management of marine resources, identification of thermal fronts, mesoscale eddies, upwelling areasetc.

Emery et al., (1986) have shown that the sequential infrared satellite imageries can be used for computing advective surface velocities. The velocities determined from coincident, near surface drogued (5-10 m) buoys, positioned every half hour by internal LORAN - C units showed excellent agreement with the image advective velocities. The geostrophic currents derived from the coincident Conductivity, Temperature and Depth (CTD) measurements are consistent with those of buoy and sequential image displacements.

Using the satellite derived SST's time series, Legeckis (1986a) has studied in detail the 1982-1983 El-Nino and Southern Oscillation as well as the coastal and equatorial upwelling events in the Pacific Ocean.

Ramesh Kumar et al., (1988) utilizing the satellite derived SST charts have shown that they can be used for successfully predicting the monsoon rainfall over different meteorological subdivisions of the Indian subcontinent. Their study has shown that the SCZASST (Somalia Coast Zonal Anomaly of Sea Surface Temperature) is negatively correlated with the monsoon rainfall over the central and western parts of India; whilst the CIOZASST (Central Indian Ocean Zonal Anomaly of Sea Surface Temperature) is positively and significantly correlated with the monsoon rainfall over the central and western parts of India.

Numerous scientists (Lasker et al., 1981; Laurrs et al., 1984; Laurs and Austin, 1985; Fiedler and Bernard, 1987; Pelaez, 1987) have clearly demonstrated that the satellite thermal infrared data can be used for monitoring the variability in circulation and water mass characteristics and their influence on fishery resources and fishing grounds.

Lasker et al., (1981) has shown that the satellite thermal infrared imageries can be successfully used for describing the spawning of the northern anchovy in conjunction with the various oceanic processes like upwelling. Parrish and Maccall (1988) have tried to relate the offshore transport and their relationship with the distribution of anchovy spawning. They also tried to relate various oceanic processes with the survival of fish eggs and larvae.

The study of Lasker et al., (1981) confirmed that there are distinct temperature regimes in the general geographic regions where anchovy spawning takes place. They concluded that the anchovy avoid recently upwelled water. Also the areal extent of recently upwelled water can be easily mapped using infrared satellite imagery.

Fiedler (1983) has demonstrated the use of satellite infrared imagery for studying the variations in spawning habitat of the northern anchovy in the

southern california Bight.

Laurs et al., (1984) have found that the highest catch rates of albacore tuna in the north Pacific Ocean tended to be concentrated in the vicinity of temperature fronts which can be easily identified on satellite imageries.

Laurs and Austin (1985) have studied the small scale migration patterns of albcore in relation to oceanic frontal boundaries using thermal infrared data, ocean colour data and simultaneous fishery / biology data from ship. The study was carried out by tracking the horizontal and vertical movements of the tuna by acoustic telemetering methods. The results indicated that (about three albcore were tracked for 24 hrs and one for about 15 hrs) a) The total distance travelled by them range from 40 to 60 km with the fish remaining in the same parcel of warm water that was separated from the adjoining waters by about 2 C. b) The tracked fish spent most of the time in waters within and below the thermocline and only small amounts of time in the upper mixed layer.

Recent study of Fiedler and Bernard (1987) have shown that the AVHRR and CZCS imageries can be successfully used for finding areas where tuna aggregate and feed. Their study further indicated that the distribution and diet of these predators were related to mesoscale frontal features visible in the satellite SST and phytoplankton pigment imagery maps.

Pelaez (1987) using the satellite images of phytoplankton pigments and of SST was able to observe the evolution of 'red tide' phenomenon and related water structures off La Jolla, California. Intense phytoplankton growth started at the coastal upwelling centres. Onshore advection of warm water dissipated the 'red tide'. The sequence of satellite images also allowed visualization of some oceanographic processes and thus showed that it can be used for short term oceanic forecasting.

Strub and Powell (1987) analysed the fields of SST derived from aircraft and satellite infrared measurements can be used for identifying the surface currents over a lake (In this case Lake Tahoe, California - Nevada) which has dimensions of the order of 20 by 30 km rectangle. The imageries were useful in delineating two gyres, a large anticyclonic gyre in the north and a weak cyclonic gyre in the south which matched well with the model results (Strub and Powell, 1986).

The SST distribution can give more information about the underlying dynamic processes occurring in the upper layers where the seasonal thermocline is weak (Robinson, 1985). Large scale dynamical features, such as those in the equatorial ocean, which cause large vertical excursions in the equatorial thermocline and lead to a SST signature. By analysing the successive SST imageries information on the longwaves (Legeckis, 1986b) in the equatorial region their propagation speeds and length scales can be computed.

Mesoscale eddies, such as those shed by meanders off Gulf stream (Richardson, 1976) and the western boundary currents (Legeckis, 1987) of other oceans. Small scale phenomena such as frontal regions (Legecks, 1979) and coastal upwelling can also be detected by satellite derived SST maps.

Thermal pollution can also be monitored using the SST maps which has both

high horizontal and temporal resolution (at least 1 km). Oil pollution alters the skin sea surface temperature and thus a very sensitive sensor capable of monitoring 0.1 K can monitor the oil slicks having a time resolution of few hours. These sensors need to have a good spatial resolution so that the areal extent of the pollution or its spreading can be easily monitored.

Table 1 reproduced from Robinson (1985) gives the various SST based applications and their sensitivity, accuracy and sampling frequency requirements.

Appendix A gives the spectral characteristics of the AVHRR/1 and AVHRR/2 onboard TIROS - N and NOAA series of satellites.

APPENDIX A

Channel wavelength in micrometers

Channel number	AVHRR/1		AVHRR/2
	TIROS N	NOAA A to D	NOA E to G
1	0.55-0.90	0.55-0.68	0.58-0.68
2	0.72-1.10	0.71-1.10	0.72-1.10
3	3.55-3.93	3.55-3.93	3.55-3.93
4	10.50-11.50	10.50-11.50	10.30-11.30
5	-----	-----	11.50-12.50

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