Satellite Remote Sensing of Large Scale Ocean Transients

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LONG-TERM GOALS

Improved understanding of mesoscale, ocean surface transient response on time scales of days and longer using satellite observations of SST, topography, color and wind stress. Improved measurement of ocean temperature, color and topography fields determined by satellite observations.

OBJECTIVES

The long-range objectives of this project include study of transient behavior of western boundary currents and associated eddy structures, frontal processes, and their response to atmospheric forcing as observed by satellite remote sensing techniques. Attainment of these objectives requires development and implementation of quantitative assimilation methods for satellite data on both large and small scales supported by suitable tools that yield timely access to calibrated, navigated satellite observations.

APPROACH

Efforts have focused on analysis of the interannual and seasonal sea surface temperature (SST) variability from NOAA AVHRR Pathfinder data and output from the Luther-Ji USF-model of the Arabian Sea and development of mesoscale feature tracking methodologies for altimetric fields, ongoing improvement of IR radiometer calibration and atmospheric correction techniques; continuation of global AVHRR LAC and GAC collection; and operation of this global retrieval capability for the ocean science community using the DOD/ONR furnished satellite receiving system.

WORK COMPLETED

D. Wilson-Diaz, A. J. Mariano, R. H. Evans, and M. E. Luther. A principal component analysis of sea surface temperature in the Arabian Sea. Submitted to Deep Sea Research, October 1998.

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D. Wilson-Diaz, A. j. Mariano, and R. H. Evans. A principal component analysis of sea surface temperature from the Arabian Sea Pathfinder data and the Luther-Ji USF model. Poster presented at the Spring 1998 Ocean Sciences Meeting.

PCA comparison study of SST in the Arabian Sea, between Pathfinder AVHRR and preliminary results from the Arabian Sea open-boundary version of the Miami Isopycnic Coordinate Ocean Model (MICOM, Esenkov, personal communication). See results below.

PCA comparison study of Pathfinder AVHRR derived SST for years when the SWM winds were stronger/weaker than average, and for when the rainfall was above/below average. See results below.

RESULTS

1) MICOM-Pathfinder study

We compared the mean SST derived from the Pathfinder AVHRR data set (5 year average) and the preliminary climatological mixed layer depth temperature from the Arabian Sea open-boundary version of the MICOM. The annual and semi-annual signal observed in previous studies (Wilson-Diaz et al., 1998) is again visible, with the coolest SST occurring during the South West Monsoon (SWM) due to wind-induced upwelling. The model mean SST is consistently warmer than Pathfinder mean SST, and exhibits the one-month lag found in previous studies. Reasons for the one-month lag are discussed in the next section. The MICOM mean SST being warmer than the Pathfinder may be due to the forcing winds being underestimated as a result of averaging over long time periods. Evaporative cooling accounts for a large part of the air-sea heat exchange, and areas of weak winds are associated with warmer SST (McCreary and Kundu, 1989). However, the structure across the basin is similar. The model's first principal component correctly places the greatest SST variability along the coasts of Somalia and Oman (Figure 1), in contrast to the results of other models previously studied. The minimum depth that the mixed layer of the MICOM model is permitted to approach is 20 m, whereas the other models previously studied have a minimum of 30 meters. This shallower depth allows the MICOM SST to show greater variability as a result of the forcing winds.

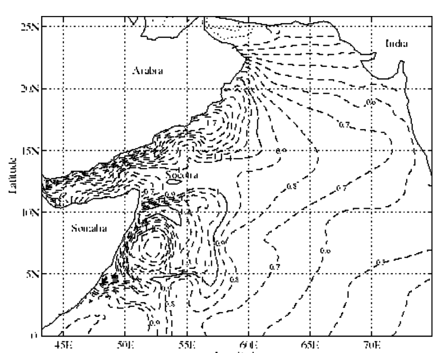

Figure 1. Amplitude of PC 1 for MICOM climatological study

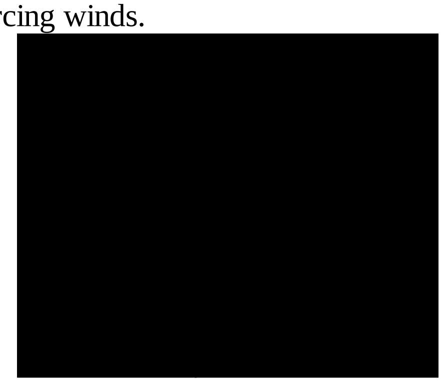

Figure 2. Detrended mean SST

2) One-month lag inquiries

a) Wind strength: SST from years during which the SWM winds were very strong (1990,1994) was compared to SST for years during which the SWM winds were weaker than normal (1987, 1992). The winds used to force the models are a monthly average at best, and do not show the temporal variability of the monsoon winds. Weaker winds would cause warmer SST and might be responsible for the lag between the mean curves. But this lag did not show up between the Pathfinder SST data for strong wind years and for weak wind years (Figure 2).

   The mean SST does show that the upwelling areas off the coasts of Somalia and Oman can be up to a degree cooler during years of strong winds as compared to years of weak winds (Figure 3).

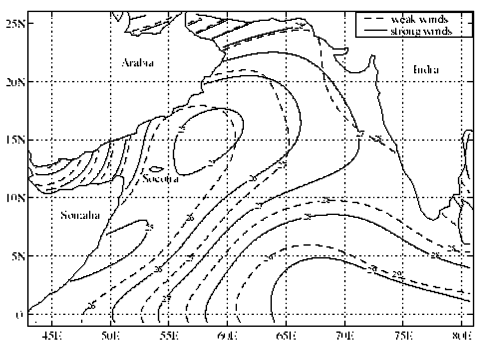

Figure 3. Mean SST

Figure 4. Detrended mean SST

b) Rainfall amount: Years when there was an excess of rain (anomaly exceeding 10%: 1988 and 1994) were considered flood years, and a PCA of their SST was compared to the PCA of the SST of years with drought (anomaly below 10%: 1985, 1986, and 1987). A number of studies carried out in the late 1970's suggest there is a relationship between SST anomalies in the Arabian Sea and anomalies in rainfall over India (Shukla and Misra, 1977). Warm (cold) anomalies of Arabian Sea temperatures correlate with higher (lower) precipitation over India. But the time series of the mean SST from drought and flood years does not show any significant lag between the two curves (Figure 4).

IMPACT/APPLICATIONS

- Cross validation of SST through use of satellite–observed and model–derived and SST fields.
- Development of SST fields with improved accuracy supports research and operational applications.
- Multisensor fusion of remotely sensed and *in situ* observations provides new approaches for the study of mesoscale variability.

TRANSITIONS

- Utilization of in situ fixed and drifting buoys and/or ship observations provided by NAVOCEANO to improve satellite infrared SST retrieval accuracy;

- Improved infrared radiometer calibration methodology through use of improved observational and modeling capabilities.

- Continued collaboration with NAVOCEANO for transfer and implementation of Pathfinder SST computations.

- Acquired Arabian Sea SST time series from October, 1994 to the present.

- Support of graduate student research activities (Ms. Deanna Wilson-Diaz).

RELATED PROJECTS

1. Arabian Sea work is related to Forced Response ARI/JGOFS Arabian Sea Process Study.

2. SST/visible satellite product production capability supportive of NAVOCEANO real-time product requirement.

3. Studies of the physical processes at the air-sea interface have begun with a series of long, transoceanic sections on research ships in the Pacific and Atlantic Oceans. The objectives of the cruises include measurements of the ocean thermal skin effect and the diurnal thermocline, and to study the dependencies of these on macroscale meteorological and oceanic variables. The skin temperatures are measured by the Marine-Atmosphere Emitted Radiance Interferometer (M-AERI) which has an absolute accuracy of <<0.1K and bulk temperatures are measured by a surface following float and/or continuous flow thermosalinograph. Meteorological sensors measure the boundary layer forcing variables.

   The M-AERI was developed as a collaborative project between RSMAS and the Space Science and Engineering Center, University of Wisconsin-Madison, with support from NASA, and was one of the instruments calibrated against a NIST black-body calibration target at a Workshop held at the University of Miami in March 1998 (see http://www.rsmas.miami.edu/ir/). The absolute accuracy of the M-AERI infrared spectra was found to be ~0.02K in the laboratory. Comparison of skin SSTs measured by two M-AERIs running side-by-side on the R/V Roger Revelle showed a mean discrepancy of 0.005K ± 0.077K over an 11-day section between Hawaii and New Zealand (890 data points).

   The results from these cruises show a ubiquitous cool thermal skin effect of ~-0.2K ± 0.2K, with apparent warm skin layers appearing in afternoons when a diurnal thermocline is set up that decouples the near-surface layer from the level at which conventional in situ, bulk measurements are made (see Figure 5).

   This has obvious implications for the accuracy of compilations of satellite SST data, and in the validation of satellite SST retrievals.

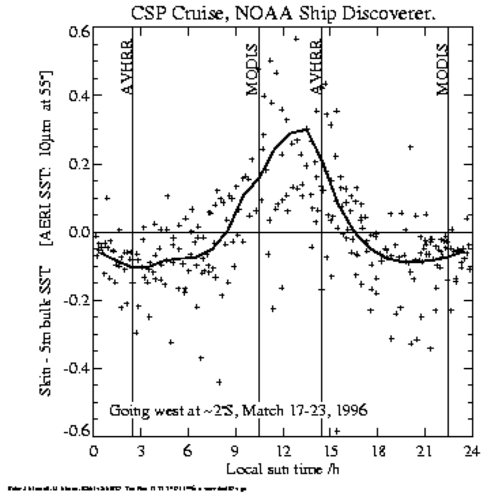

Figure 5. Skin sea surface temperatures measured by the M-AERI referenced to a 5m bulk temperature during the Combine Sensor Cruise of the NOAA ship Discoverer in spring 1996. These measurements were taken with the ship heading west between 180^{o}E and 135^{o}E at 2^{o}S. The distribution is shown as a function of local sun time and the continuous thick line is a smoothed mean.

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