ASSESSING THE GEOMORPHIC EVOLUTION AND HYDROGRAPHIC CHANGES INDUCED BY WINTER STORMS ALONG THE LOUISIANA COAST

A Second Year Progress Report
and Request for Third Year Support

W. Paul Menzel
Christopher C. Moeller

Cooperative Institute for Meteorological Satellite Studies
at the University of Wisconsin-Madison
1225 West Dayton Street
Madison, WI 53706-1695
608/262-0544

Oscar K. Huh
Harry H. Roberts

Coastal Studies Institute
Louisiana State University
308 Howe-Russell Geoscience Complex
Baton Rouge, LA 70803-7527
504/388-2952

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1. INTRODUCTION

This project is a unique study of: 1) processes and depositional forms common to many of the world river-dominated deltas, 2) results of coastal sedimentary processes induced by Mississippi Delta lobe switching (a once in roughly 1000 year event), 3) results of atmospherically forced coastal sedimentary processes, vice the more common tectonic or sealevel variation induced changes, and 4) coastal accretion vice coastal erosion processes. The results of this project will contribute to advances in basic science and environmental management skills. This project specifically addresses the response of coastal environments to winter storms, including remotely sensing coastal mudstreams, transport (circulation), sea surface temperature, growth/erosion of coastal geomorphic features, and quantitatively relating these observations to the characteristics of passing cold fronts in a Geomorphic Impact index. This project capitalizes on U.S.G.S. and Minerals Management Service projects running concurrently, as mutually supportive government projects. It illustrates the practical importance of the synoptic remote sensing approach to environmental change detection for environmental research and management programs. It also indicates the importance of making ground-based observations and measurements to verify interpretation from image analyses. Although site specific for coastal Louisiana, these geological processes are active to greater or lesser degrees downdrift of all major and minor river deltas around the globe. Methods and knowledge developed here provide seeds for a comprehensive global assessment of the current state of great deltas and estuaries. This could be critically important baseline information from which impact of global change might be quantitatively assessed using MODIS and the entire Earth Observing System (EOS).

2. PROGRESS TO DATE

A. Surface wind, pressure, temperature and dew point data has been collected from National Weather Service stations at New Orleans and Lake Charles, Louisiana for the 1993-94 winter cold front season. The data set is being used to monitor important meteorological parameters in the assessment of geomorphic impact by individual and cumulative cold front passages. The cold front season cumulative wind energy for 93-94 is remarkably similar to that of the 90-91 season both in pattern and strength (Figure 1). The season was characterized by relatively strong southerly energy, in fact at about the same energy level as the northerlies. This contrasts quite clearly with the 91-92 and 92-93 seasons in which the southerly energy is significantly weaker than the northerly energy (~80% for 91-92;~50% for 92-93). It is believed that wind energy is a key component for assessing the geomorphic impact of cold front systems. This is because of a direct effect by winds on wave action and water level setup along the Louisiana coast.

Individual storm strength appears modest for 93-94 (as shown by individual storm energy at 180° and at 360° directions). The number of strong (>300m^2/s^2) southerly events increased compared to recent years, with 6 strong southerly events and another 3 that were very close to the arbitrarily chosen 300m^2/s^2 threshold. This contrasts with 91-92 (5 events) and 92-93 (2 events). In 91-92 there were no other events close to the threshold. Bringing this into perspective with 90-91 (9 events plus 2 very close to threshold), the pattern of individual events of 93-94 seem to have been more like 90-91 though not quite as impressive. Northerly events above the threshold increased in 93-94 over all previous years, however none are dramatically strong, indicating a series of modest frontal passages. This indicates that while a good number of frontal passages of note occurred in 93-94, no bigtime events occurred. It is of interest that an El Nino event occurred in 91-92 and to a lesser extent in 92-93. The 90-91 and 93-94 seasons were essentially devoid of any El Nino.

B. Short term (hour to hour) motion and circulation in Louisiana coastal waters is being investigated by sequencing MAMS and MAS imagery. Cases where ER-2 aircraft repeat coverage is available from a single flight are being used. Repeat coverage images are carefully georeferenced to each other and then displayed in sequence on McIDAS to depict motion. Imagery over the Atchafalaya Bay and Chenier Plain regions are being highlighted. Observable motions range from hundreds of meters to kilometers in the imagery, depicting very fine scale to relatively large scale ciruculation. Wholesale reversals of circulation have been found in the data when comparing motions from different flights (figure 2). It has been found that adding the third dimension of time to the analysis illustrates the water motion without ambiguiety for most locations; the analysis confirms the source of water types in the data. A further effort is being made to process water motion vectors in an automated algorithm using correlation technique. This effort will benefit from previous experience in tracking cloud motions from satellite imagery at CIMSS, University of Wisconsin. Circulation patterns will be compared to water level and other in situ data to further understand variation in circulation patterns.

C. The MODIS Airborne Simulator (MAS) flew missions over the Louisiana coast on Feb 2, 14 and 17 in support of NASA grant NAGW-3318. All three flights took place in clear, post-frontal conditions. Boat teams from the Coastal Studies Institute at

Louisiana State University were deployed for all three flights, collecting in situ water quality samples. An example of the data set is shown in Figure 3, with in situ data overlain on the imagery. These missions were the first MAS missions dedicated to the science of cold front passages and their impact on the Louisiana coast. Aircraft false color infrared photography data (5 and 10 meter resolution) was also collected during the flights. The quality of these data sets is excellent. The 50 meter spatial resolution of MAS data provides an improved depiction of small scale variation in coastal waters. These data sets will be used for coastline mapping (Feb 2, 17), water motion and circulation estimation (Feb 14), suspended sediment and sea surface temperature modeling and mapping (all dates), and water type estimation (all dates). Also, an investigation into sea surface temperature change over time will be used to explore heat flux characteristics of warm coastal waters under cold atmospheric conditions. The data set is in the process of being archived into straight line flight tracks.

D. A series of field efforts have been undertaken by the Coastal Studies Institute at LSU in support of field data collection for the project. These include:

- Feb 9: Field trip to Mississippi birdfoot delta by seaplane and airboat to verify observations made with MAMS imagery and aerial photography (Huh, Majersky).
- March 30-31: Two day cruise of RV "Changes in Latitude" to profile Atchafalaya River Discharge plume and turbid waters along Chenier Plain coast. Documented strongly stratified condition of Atchafalya discharge plume in spite of strong cold front passage on previous day. Found temperature, salinity, and turbidity fronts are not congruent; temperature and turbidity fronts are congruent inshore, temperature and salinity fronts are congruent offshore. Uncorrelated salinitiy gradients detected offshore interpreted as relic plumes (Huh, Ransibrahmanakul, Gibson, Roy).
- July 6: Obtained permission and installed newly acquired precision water level sensor on offshore oil platform. This sensor will provide storm surge and sea state data during late summer 1994 through spring 1995 (DeMers, Chaky).
- Aug 17-18: Exploration of Chandeleur and Cat Islands for coastal change sites (Huh, Majersky, Seymour, Ransibrahmanakul, Luthy, Thevenot, Fitzgerald, Roy).
- Sept 19: Completed photographic enlargement documentation of prograding Chenier Plain showing extensive sedimentary buildup in three stages: 1987, 1988, and 1993.
- Experimental trip into Chenier Plain muddy coastal environments in airboat. This proved to be a successful way to access these environments. Mud is too soft and deep to walk through and is too thick for power boats. The airboat was easily maneuvered, even when deeply sunk into fluid mud (Huh, Rouse).
- Oct 19: Surveyed in sediment burial/erosion pipes and marked the key coastal progradation sites, the Exxon Canal and DeWitt Canal (Rouse, Chaky, DeMers).
- Nov 6-7: Using airboat, surveyed and installed full array of 19 sediment burial pipes in shore normal lines 30 meters apart. The surface of sedimentation at each site was marked with a fixed stainless steel hose clamp. These pipes will serve as geomorphic measurement sites for individual and seasonal cold front impact during next several cold front seasons (Huh, Chaky, DeMers).

E. Additions to the MAS processing and analysis code are being incorporated into the RISC6000 environment. This includes code tailored to atmospherically correcting MAS visible and near infrared channels, navigating (earth referencing) MAS imagery, and producing estimates of water motions from MAS imagery. The RISC environment

facilitates improved turnaround of tasks and reduces mainframe usage charges and has become the primary environment of MAS data processing, analysis, and algorithm development. In addition, an Exabyte model 8505 tape device has been added to this workstation. This hardware allows MAS data to be read directly into the RISC environment, bypassing costly mainframe processing, and is a critical link in moving all MAS data processing to the RISC environment.

F. A paper entitled "Remote Sensing of Turbid Coastal and Estuarine Waters: A Method of Multispectral Water-Type Analysis" (Huh, Moeller, Menzel, Rouse, Roberts) has been submitted to the Journal of Coastal Research. The paper documents the characteristics of water types in the Atchafalaya Bay region as seen with the Multispectral Atmospheric Mapping Sensor (MAMS). A paper entitled "A Verification of Two Shear Velocity Equations for the Wind-Wave Interaction in a Lake Environment" (Hsu) has been submitted to Boundary Layer Meteorology.

G. Plans have been furthered for MAS Louisiana coast flights in the Jan/Feb 1995 timeframe from Houston, TX. Coordination with LSU boat teams is being worked. The use of a thermal radiometer on the boats is being discussed for a comparison of sea surface radiometric temperature to bulk water temperature. For this deployment MAS will be integrated with a 50 channel 16 bit digitizing system, a significant improvement over the old 12 channel 8 bit digitizing system. This will enhance the spectral information available from each flight. Objectives of these flights include documentation of seasonal/annual variation in coastline, coastal water response to pre- and post-frontal conditions (especially for a strong north to south moving frontal system), short time interval water motions and circulation, water types mapping, and heat flux mapping. One to two flights will be used to cover the entire Louisiana coast with an additional flight dedicated to capturing short time (< 1 hour) variation over the Atchafalaya Bay region, the region that is selected for coordination with Louisiana State University intense ground truthing operations. Short time interval data is very useful for identifying scales of variability in response to cold front passages.

H. Oscar Huh presented a paper entitled "Suspended Sediments and Water Type Formation in a Developing Lobe of the Mississippi River Delta: Observations with AVHRR and MAMS Sensor Systems" (Huh, Walker, Rouse, Moeller) at the AGU Ocean Science meeting, San Diego CA, Feb 21-25, 1994.

I. Chris Moeller and Paul Menzel of the University of Wisconsin (UW) met with Oscar Huh of Louisiana State University (LSU) in June for a joint project planning meeting at LSU. Topics discussed at this meeting included MAS data flights in Feb 94, water typing of MAS data, formulation of the Geomorphic Impact Index, and in situ instrumentation of various sites along the Louisiana coast. Also discussed were plans for MAS flights in fiscal 95. In addition, excursions were made into the field in both light plane and boat. A project plan was set forth. The highlights of this meeting were summarized in a document, a copy of which was forwarded to Earnest Paylor at NASA Headquarters.

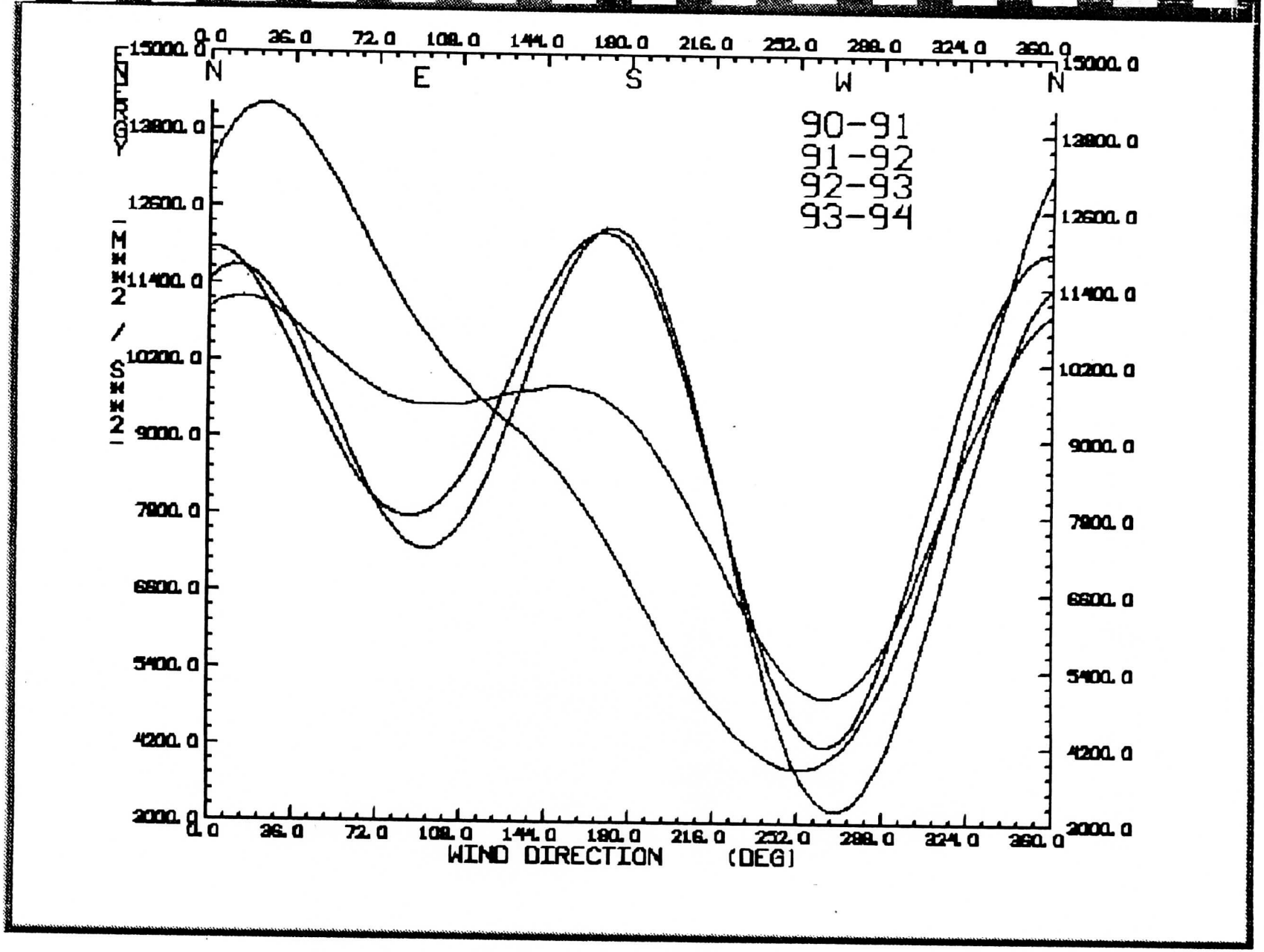

Figure 1. Winter season surface wind energy for 90-91 through 93-94 winter seasons as represented by data from Lake Charles, LA. Wind energy is $V^2 * \cos(\theta)$ where $\cos(\theta)$ is the wind component in a given direction. This data is being used to assess seasonal cold front geomorphic impact along the Louisiana coast. For example, southerly wind energy increases water levels, resulting in coastal overwash. Where suspended sediments are prevalent this results in new deposits of fluid mud on the shoreface.

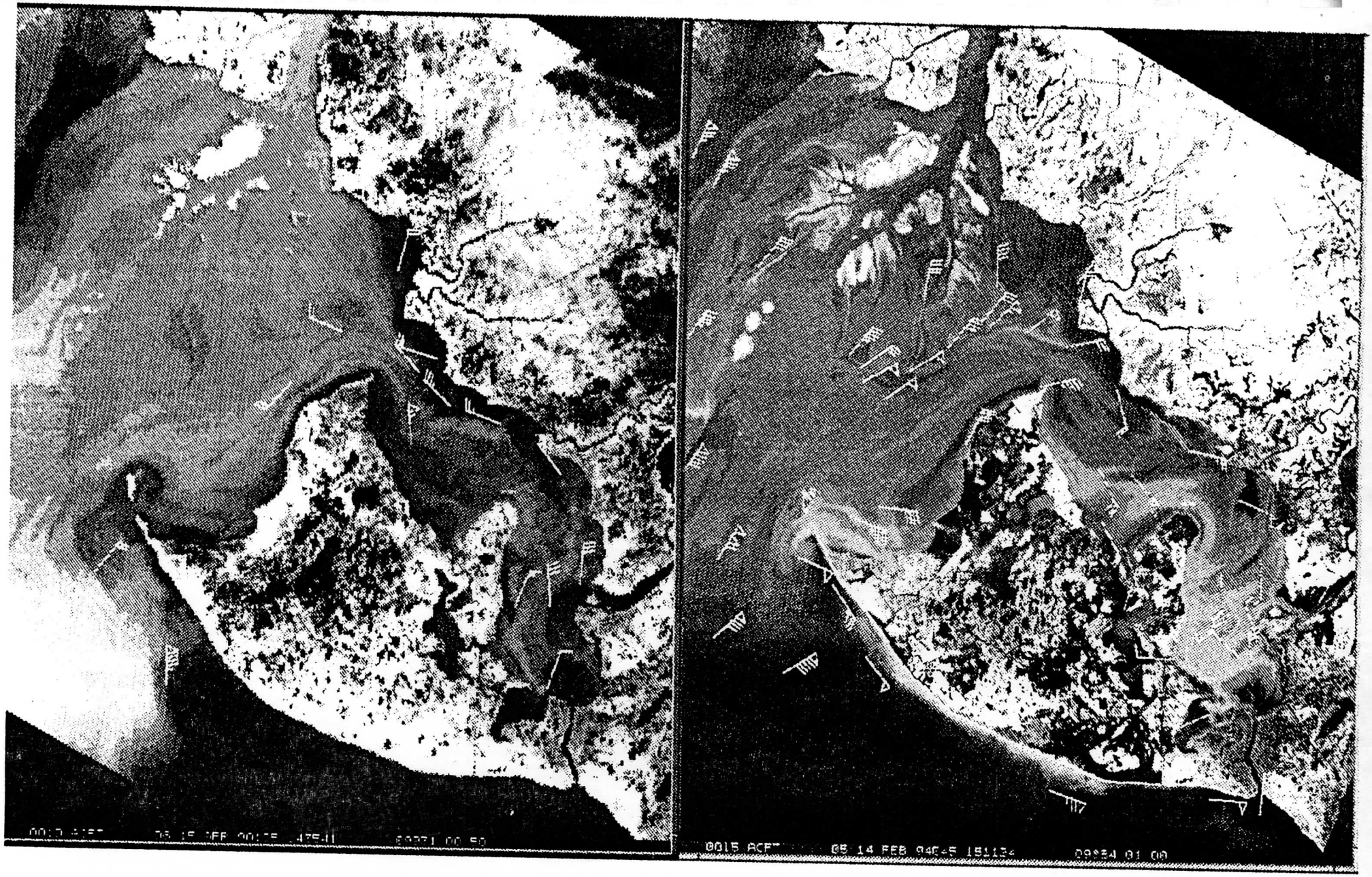

Figure 2. Manually generated one hour water motion vectors from MAMS 100 meter 15 April 1990 data (left) and MAS 50 meter 14 February 1994 data (right). Each barb represents 0.2 km/hr motion with one flag equal to 5 barbs (1 km/hr). The circulation pattern shows significant variability in this example. Such variability is anticipated to exist on a daily basis due to the influence of astronomical tides (about 1 - 2 feet along the Louisiana coast) and wind systems associated with cold fronts (similar to astronomical tide influence). Circulation information is important because it defines avenues of sediment transport as well as marsh and soil water drainage (Water Types analysis). Note the relative abundance of trackable features in the 50 meter MAS as compared to the 100 meter MAMS near infrared imagery.

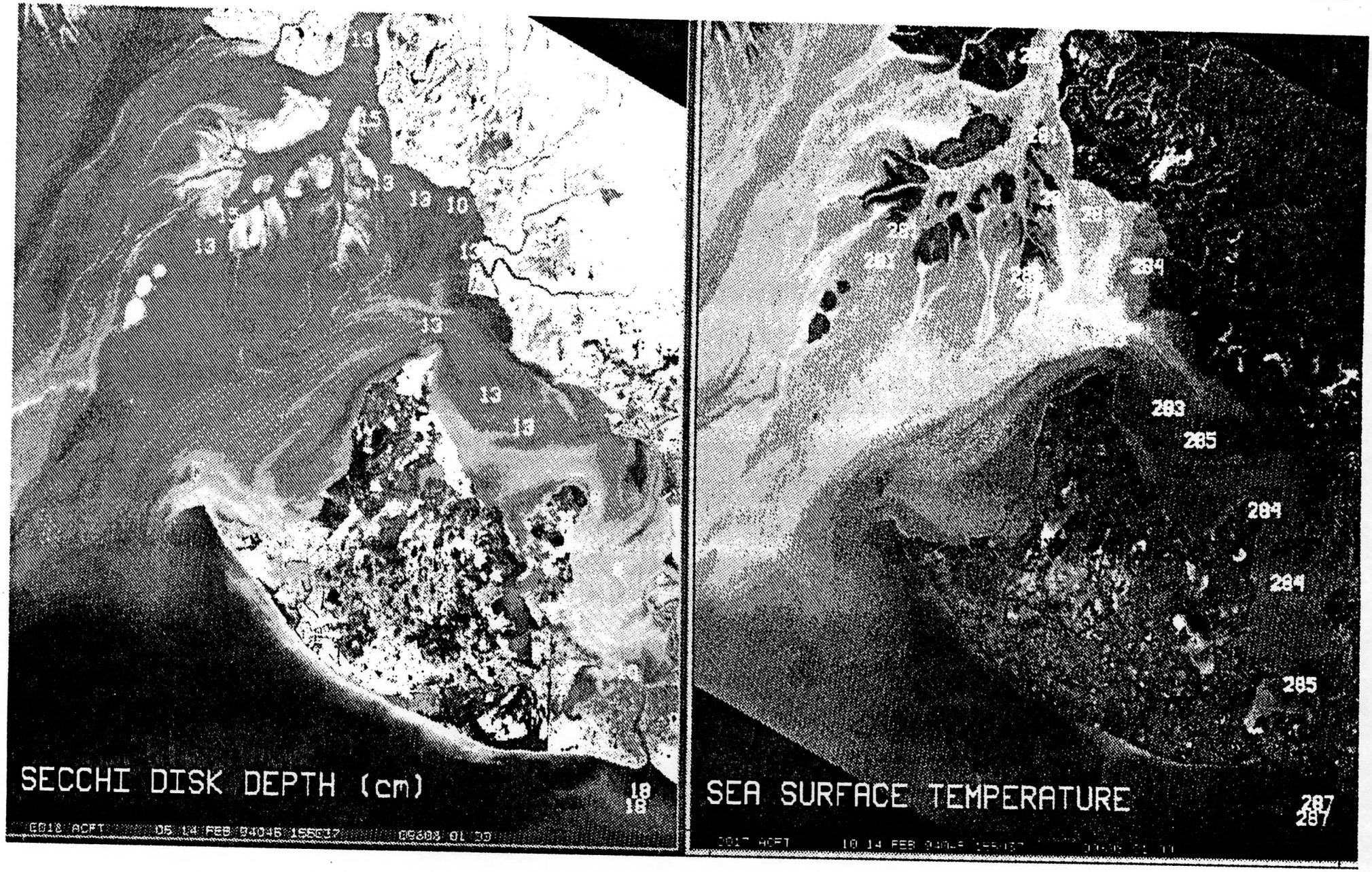

Figure 3. MAS 50 meter near infrared (left) and thermal (right) imagery of the Atchafalaya Bay region on Feb 14, 1994. During the MAS flight, LSU boat teams collected water quality in situ data which is plotted over the imagery. Suspended sediment concentration and sea surface temperature data are being used to establish models of these quantities with the MAS data.

3. STATEMENT OF WORK FOR THE COMING YEAR

The schedule below states the major tasks of the coming year for University of Wisconsin and Louisiana State University investigators. Annual winter season aircraft (ER-2) data collection flights will take place in the January/February timeframe. LSU boat teams will also be deployed during this time for in situ data collection. Analysis of other data sets (winter season daily surface obs, AVHRR data) will continue. Field geomorphic measurements will be collected throughout the winter season. The annual data will be reviewed with a goal for publication of annual impact on Chenier Plain region sometime late in the fiscal year. The ability to monitor water turbidity with the MODIS instrument (planned launch in 1998) will also be investigated by simulating MODIS 250 meter resolution spectral channels with MAS data.

Dec 94 Completion of archival of MAS 1994 straight line flight track data sets

Jan 95 MAS flights to capture cold front forcing of cold air outbreak event and short time interval variation, including coordination with Louisiana State ground truth data collection.

Feb 95 Water types analysis on MAS 1994 data sets over Louisiana coast.
Simulate MODIS 250 m data with MAS data sets along Louisiana coast.

Mar 95 Ongoing Geomorphic Impact Index analysis/formulation.
Finish documentation of annual geomorphic change along Chenier Plain coast covering 1987 - 1994

Apr 95 Begin product generation of Jan 94 flight data.
Collection of winter 94-95 surface data completed.

May 95 Analyze winter 94-95 individual and cumulative impact of cold front events from surface data collection and AVHRR data collection.

Jun 95 Review of geomorphic data from winter season 94-95.

Jul 95 Begin case studies on MAS flights of Jan 94, including water types analysis, heat exchange, coastal circulation response.

Aug 95 Collaborative meetings with Louisiana State Univ. investigators on results of 94-95 cold front season and planning for 95-96 cold front season.
Publish Note on water motions in Atchafalaya Bay region.

Sep 95 Finish archiving MAS straight line flight tracks for fiscal 1995.

Oct 95

Nov 95 Publish results of 5 year data set documenting Chenier Plain geomorphology and mechanisms.

4. BUDGET FOR THIRD YEAR

$141 K requested for 3rd year

Budget: University of Wisconsin-Madison
Geomorphic Evolution of the Louisana Coast
Year 3: 1 December 1994 - 30 November 1995

		Hours	Rate	Cost	
I.	Labor and Fringe Benefits				
	a) Program Manager	900	29.05	$ 26,145	
	b) Researcher	275	26.00	7,150	
	c) Research Specialist	250	21.99	5,498	
	d) Secretary	40	20.31	812	
	Subtotal				$39,605
II.	Travel				
	a) 1trip/2persons/4days/Baton Rouge, LA			$1,800	
	b) 1trip/2persons/6days/Houston, TX			2,200	
	Subtotal				4,000
III.	Data Acquisition and Processing - IBM McIDAS				2,400
IV.	Publications: 10 pages@$110/pg				1,100
V.	SSEC Indirect Cost at 40%				18,842
VI.	Subcontract: Lousiana State University				73,081
VII.	Equipment Rental				1,980
	TOTAL				$141,008

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YEAR 3

	Hours	Rate	Months	REQUEST	
SALARIES & WAGES					
Huh	366	30.78	2.00	11,264	
Rouse	183	27.34	1.00	5,003	
Hsu	45.75	46.97	0.25	2,149	
Roberts	91.5	50.77	0.50	4,646	
Elec Tech	0	15.79	0.00	0	
Field Tech	366	13.66	2.00	5,000	
Programmer	0	19.67	0.00	0	
Photo/Carto	274.5	11.07	1.50	3,038	
Met Tech	183	11.78	1.00	2,155	
GRADUATE STUDENTS				2,000	
STUDENT WAGES				4,187	
TOTAL S & W					39,441
EMPLOYEE BENEFITS					7,648
TOTAL S & W + BENEFITS					47,089
SUPPLIES					
Field				1,200	
Computer				500	
Lab				500	
TOTAL SUPPLIES					2,200
TRAVEL					
Field				1,600	
U. Wisconsin				2,000	
Meetings				1,200	
TOTAL TRAVEL					4,800
OTHER COSTS					
Light Plane Flights				0	
Air Boat Rental				2,200	
Small Boat Gas				1,200	
Truck Gas				0	
Phone, Postage, Reproduction				300	
Computer Maintenance					
Publication Costs					
TOTAL OTHER COSTS					3,700
MODIFIED TOTAL DIRECT COSTS					57,789
INDIRECT COSTS (23% MTDC)					13,292
EQUIPMENT					
Met Station				2,000	
TOTAL EQUIPMENT					2,000
TOTAL					73,081