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A LOOK AT THE USE OF GOES-8 DATA FOR MONITORING WATER MOTIONS IN TURBID COASTAL WATERS

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1. INTRODUCTION

Water motions associated with coastal circulation affect many economic, biological, ecological, and other concerns. For example, timely knowledge of pollutant transport (e.g. oil spills) can be critical to minimizing impact on endangered marine biology. Along coasts of the world, turbid effluent from major river mouths contrasts with clear saline nearshore waters. GOES-8, providing essentially continuous monitoring of North and South America, can potentially track nearshore turbidity contrast for tracers of water motions.

From April 1994 into January 1995, GOES-8 was positioned at 90°W, providing near nadir viewing of turbid waters flowing from the Mississippi River distributary system into the Gulf of Mexico. Transport of effluent from the Atchafalaya River (Figure 1), a distributary of the Mississippi River, has been under study using the MODIS Airborne Simulator (MAS) (King et al., 1995) on NASA's ER-2 high altitude aircraft; turbid plume response to surface winds has been documented (Moeller et al., 1993). In this paper, the use of GOES-8 1 km visible data is explored as a possible source of water motion information along the Louisiana coast. GOES-8 1 km and MAS 50 meter resolution visible data documenting a cold front passage case from January 1995 are examined.

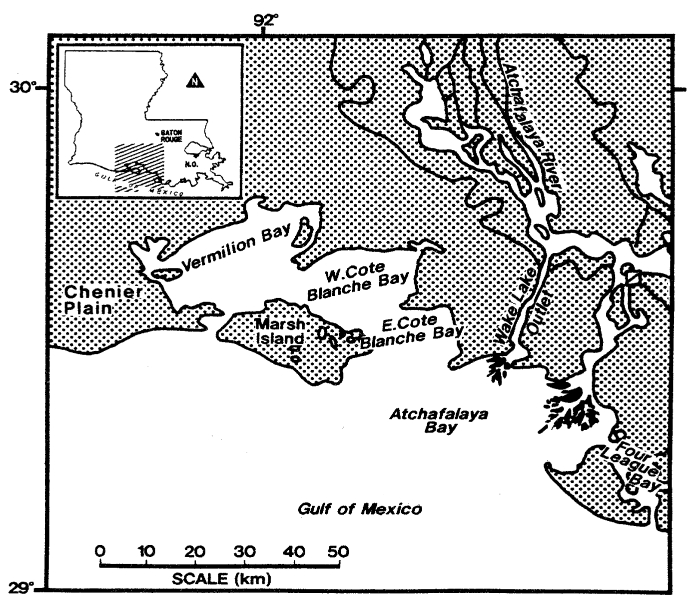

Figure 1. Louisiana coastal region and primary study region for turbid water motions.

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2. WATER MOTION DETECTION APPROACH

Imagery from GOES-8 can be viewed in sequence (looped) using the Man-computer Interactive Display System (McIDAS) at the University of Wisconsin's Space Science and Engineering Center (SSEC). Researchers at SSEC have been active in detecting cloud motions in satellite imagery for more than a decade (e.g. Merrill et al., 1991). Motions are inferred by following trackable features, or targets, from image to image. Targets are tracked either manually (human operator visually tracking targets with a cursor), or by using a variety of automated techniques, most relying on some form of cross correlation statistics. For our exploratory effort into tracking turbid water motions, a manual tracking approach was used. Targets are selected at locations where the water turbidity gradient is large.

The accuracy of manually tracked water motion vectors is limited by image to image registration accuracy, image resolution, and the operator's ability to recognize target displacement from image to image. The GOES-8 imager 15 minute image to image registration performance requirement is 1.5 km and increases to 3 km for a 90 minute interval (Menzel and Purdom, 1994); however, through careful adjustment based on identifiable land features, image to image registration accuracy can be maintained at a sub-pixel level for small regions (such as the Louisiana coast region). For GOES-8 visible data sampling resolution of 1 km north-south and 0.6 km east-west, a sub pixel registration accuracy of 0.5 km and 0.3 km can be achieved. The relative error of the motion vector is the ratio of the registration error over the displacement distance of the vector. Thus, longer time intervals (implying larger displacement) decrease relative error, assuming that a given target is accurately tracked by the operator over the longer time interval. A relative error of 10% requires 5 hour and 3 hour time intervals for a water motion velocity of 28 cm/s (~1 km/hr) in the north-south and east-west directions respectively. Using the 90 minute interval registration performance requirement of 3 km, a 5 hour time interval results in a 60% relative error for a 28 cm/s north-south water motion. Thus, for typical water motions, image registration adjustment reduces the relative error of water motion estimates markedly.

3. RESULTS

Manual tracking was applied to hourly GOES-8 January 23 imagery from 1815 UTC through 2115 UTC. A cold front had passed through the Louisiana coastal region earlier in the morning with clearing behind the front reaching the Atchafalaya Bay region around 1700 UTC. Surface winds of 6 to 8 m/s from the NNW were reported at Lake Charles, LA while instrumentation on an oil platform (29° 32.047'N, 92° 24.814'W) just a few kilometers offshore of the western Lousiana coast reported winds of 10 to 12 m/s from the NNW. In shallow Louisiana coastal waters, post cold front passage winds suppress water levels, pushing water essentially in the downwind direction (shallow water Ekman flow). Figure 2 shows GOES-8 January 23 visible imagery with manually tracked water motion vectors. Relative vector error is ~10-25% for these vectors. While vectors are sparse, a definite indication of water motion in the downwind direction is present. Water appears to be flowing out the mouth of Atchafalaya Bay into the Gulf of Mexico. Figure 3 shows the same display for January 24, a day in which surface winds diminished to about 4 m/s from the NE (oil platform instrumentation) as surface high pressure passed to the north of the gulf coast. Water motion vectors (15:45-17:45 UTC interval) indicate an east to west motion in the nearshore coastal waters, essentially a reversal of the January 23 nearshore flow.

The ER-2 with MAS on board made 3 overpasses of the Atchafalaya Bay on January 24 between 15:30 and 17:30 UTC. Water motion vectors estimated from MAS imagery are shown in Figure 4. Measured MAS registration error (through tracking land motions) indicates ~10-20% relative vector error. It is very evident from Figure 4 that many more targets are identifiable in MAS data. These provide a much larger water motion vector data base and increase the reliability of the estimated water motions through opportunity for nearest neighbor comparison. MAS shows water flowing from the southeast into the western Atchafalaya Bay region, in agreement with the few vectors present in the GOES-8 data set. The general directional pattern shown in the MAS data complements that shown in the GOES-8 data. GOES-8 vector speeds appear to be roughly 25% faster than MAS, a value close to the speed uncertainty of both instruments.

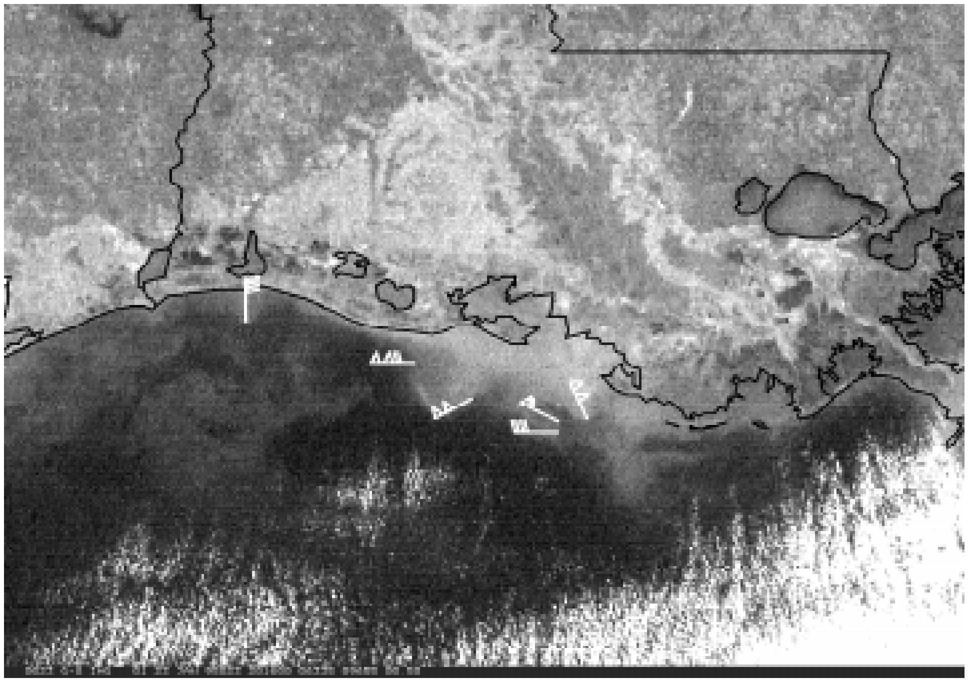

Figure 2. GOES-8 1 km resolution visible image of turbidity pattern along Louisiana coast on January 23, 1995 (20:18 UTC). GOES-8 water motion vectors (cm/s $*$ 2) are shown pointing in direction towards which water is flowing. Water motion towards ESE is apparent on this post-frontal surface wind flow (10-12 m/s from NW) day.

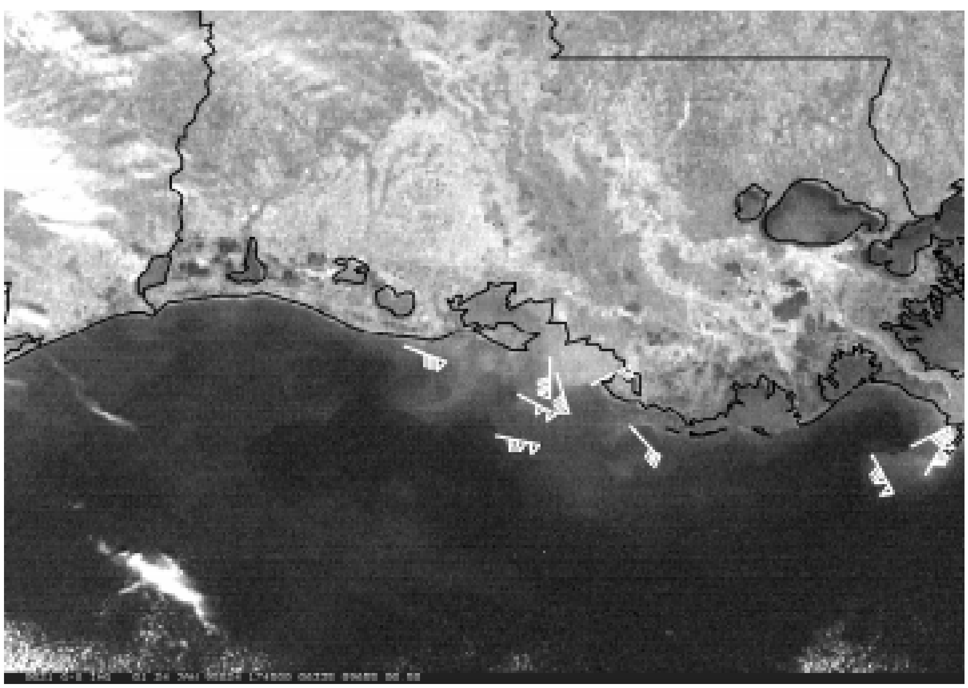

Figure 3. Same as Figure 2 except January 24, 1995 (17:45 UTC). Note reversal of water motions from January 23 1995. Surface winds 2-4 m/s from NE on this day.

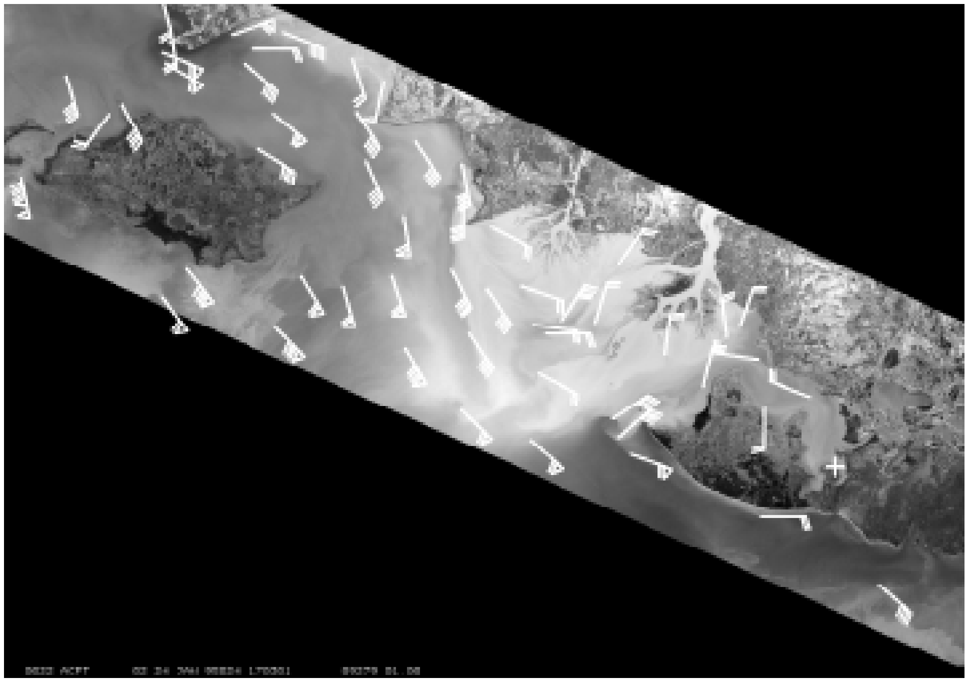

Figure 4. MAS 50 meter resolution visible (0.66μm) imgery on January 24 (17:03 UTC). Water motion vectors (cm/s ∗ 2) show transport patterns in Atchafalaya Bay region (Figure 1) of Louisiana coast.

4. SUMMARY

The contrast of turbid water with clear water in nearshore coastal environments for producing manual water motion vectors is useful with GOES-8 1 km visible data. To achieve good accuracy (10-20%) for typical water motion speeds, it is necessary to improve GOES-8 pixel registration through the use of local landmarks present in the imagery. While unable to resolve the many small scale (< 1 km) targets present in a turbid coastal environment (as shown by 50 meter resolution MAS data), GOES-8 does demonstrate a capability for monitoring general water motion patterns, including an apparent response to a cold front wind system as shown by a reversal of nearshore water motion from January 23 to January 24, 1995. GOES-8 and MAS water motion vectors for January 24 complement each other by displaying transport pattern and general speed estimate agreement (within the limits of vector accuracy). Manual tracking of GOES-8 visible imagery targets will be investigated in the spring season, when distributary outflow is large and nearshore turbidity is high.

5. REFERENCES

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