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MMS 96-0016
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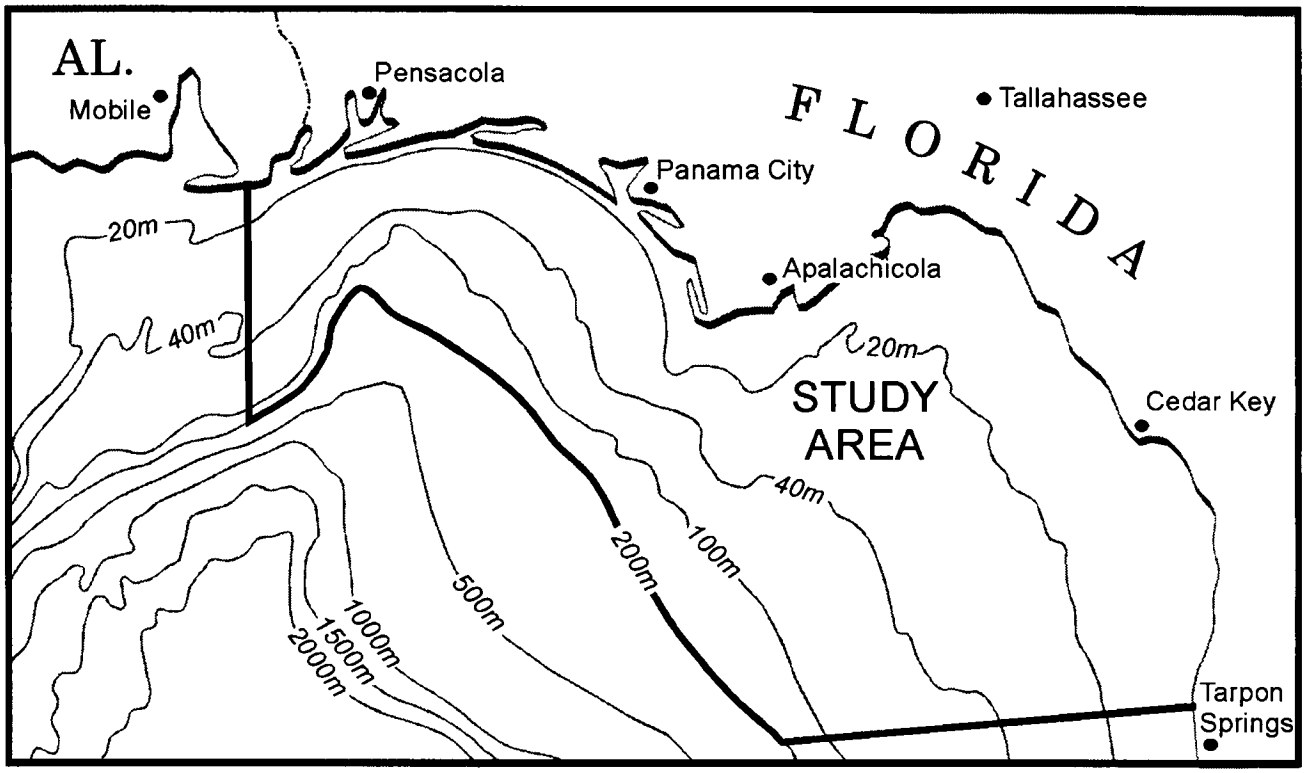
Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Data Search and Synthesis, Annotated Bibliography

Appendix B: Meteorology



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Gulf of Mexico OCS Region

NBS U.S. Department of the Interior
National Biological Service
Eastern Region

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Thanks are extended to Paul Blankinship whose knowledge of Papyrus was essential to integrating the results of the many different electronic search formats. Those from outside this project who made our job more manageable by locating and sending the requested electronic copies of existing bibliographies include:

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All the above are thanked for their efforts. A number of others went to considerable effort in locating and sending printed versions of existing bibliographies. They too are thanked.

Alphabetic Index

Alliss, R.J., G.D. Sandlin, S.W. Chang and S. Raman. 1993. Applications of SSM/I data in the analysis of Hurricane Florence (1988). J. Appl. Meteorol. 32(10):1581-1591.

Abstract. Data from the Special Sensor Microwave/Imager (SSM/I) on board a Defense Meteorological Satellite Program satellite are used to study the precipitation patterns and wind fields associated with Hurricane Florence (1988). SSM/I estimates indicate that the intensification of Florence was coincident with the increase in total latent heat release. Additionally, an increase in the concentration and areal coverage of heavier rain rates near the center is observed. SSM/I marine surface winds of Florence are examined and compared to in situ data, and to an enhanced objective isotach analysis over the Gulf of Mexico. Results indicate that the SSM/I winds are weaker than those depicted in the enhanced objective analysis and slightly stronger than in situ observations. Finally, center positions of Florence are estimated using the 85 GHz brightness temperature imagery. Much improved estimates are achieved using this imagery compared to using GOES infrared imagery. These results concur with previous studies that applications of SSM/I data could be valuable in augmenting current methods of tropical cyclone analysis.

American Meteorological Society. 1970. Cooperative Investigation of the Caribbean and Adjacent Regions (Cicar). Bibliography on Meteorology, Climatology, and Physical/Chemical Oceanography. Volume I. American Meteorological Society. Washington, D.C. 391 pp.

Abstract. The abstracted bibliography has been compiled from the files of the Meteorological and Geoastrophysical Abstracts Office of the American Meteorological Society (AMS) and from files of Government libraries in the Washington, D.C., area. Its purpose is to provide the participants of CICAR with a reasonably comprehensive and timely review of the published literature in physical/chemical oceanography and in meteorology/climatology concerned with the Caribbean Sea, Gulf of Mexico, Greater and Lesser Antilles Regions, and the adjacent coastal areas of North, Central, and South America. Articles dealing with weather phenomena outside of this geographical region, but influencing the atmosphere within the area, have been included occasionally. Similarly, references to oceanographic region, but influencing the atmosphere within the area, have been included occasionally. Similarly, references to oceanographic cruise data taken outside of but close to this area were also sometimes included.

Anon. 1991. Symposium on Air-Sea Interaction and Air Mass Modification over the Gulf of Mexico, Galveston, Tex., Jan. 7-9, 1991. Bulletin of the American Meteorological Society. 72:827-832.

Anon. 1992. Air-sea interaction and airmass modification over the Gulf of Mexico. J. Appl. Meteorol. 31(8):817-1017.

Abstract. The following topics were dealt with: Gulf of Mexico precipitable water and return flow event, marine atmospheric boundary layer near intensifying cyclone, GUFMEX return-flow event synoptic analysis, frontal overrunning and surface baroclinicity, cold-air modification, mixed layer modelling, airmass transformation model forecasts, tropical ocean-atmosphere interactions, severe thunderstorm forecasting, boundary layer properties affecting wind forecasting, cold-air outbreaks and moisture field evolution.

Bailey, J.F., J.L. Patterson and J.L.H. Paulhus. 1975. Hurricane Agnes rainfall and floods, June-July 1972. U.S. Geol. Surv. Prof. Pap. 924:403.

Abstract. Hurricane Agnes originated in the Caribbean Sea region in mid-June. Circulation barely reached hurricane intensity for a brief period in the Gulf of Mexico. The storm crossed the Florida Panhandle coastline on June 19, 1972, and followed an unusually extended overland trajectory, combining with an extratropical system, to bring very heavy rain from the Carolinas northward to New York. This torrential rain followed the abnormally wet May weather in the Middle Atlantic States and set the stage for the subsequent major flooding. The record-breaking floods occurred in the Middle Atlantic States in late June and early July 1972. Many streams in the affected area experienced peak discharges several times the previous maxima of record. Estimated recurrence intervals of peak flows at many gauging stations on major rivers and their tributaries exceeded 100 yr. The suspended-sediment concentration and load of most flooded streams were also unusually high. The widespread flooding from this storm caused Agnes to be called the most destructive hurricane in U.S. history, claiming 117 lives and causing damage estimated at $ 3.1 billion in 12 states. Damage was particularly high in New York, Pennsylvania, Maryland, and Virginia. The detailed life history of Hurricane Agnes, including the tropical depression and tropical storm stages, is traced. Associated rainfalls are analyzed and compared with climatologic recurrence values. These are followed by a detailed description of the flood and streamflows of each affected basin. A summary of peak stages and discharges and comparison data for previous floods at 989 stations are presented. Deaths and flood damage estimates are compiled.

Baltz, A.J. 1978. A climatology of monthly sea surface temperatures for the Gulf of Mexico. WSAFETACPR-78-0001. USAF Env. Tech. App. Center. Scott AFB, IL. 15 pp.

Abstract. This report presents monthly mean sea surface temperatures for the Gulf of Mexico in one degree quadrangles. It also includes a short discussion of the temperature data and the ocean currents in the Gulf of Mexico.

Barrett, B.B., J.W. Tarver, W.R. Latapie, J.F. Polland, W.B. Mock, G.B. Adkins, W.J. Gaidey, C.J. White and J.S. Mathis. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase II, hydrology. pp. 9-130. *In* Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana. Phase II, Hydrography and Phase III, sedimentology. Louisiana Wildlife and Fisheries Commission, New Orleans, LA.

Abstract. Louisiana's estuaries from Sabine Lake to the Pearl River were sampled at 109 stations during 1968 and 1969. Salinity and water temperature were measured at all stations; dissolved oxygen, turbidity, and the nutrients nitrate, nitrite, inorganic phosphate, and total phosphorus were sampled at 82 stations. Tide, barometric pressure, rainfall and wind speed and direction were measured at one station. Coastwind data on air temperature, precipitation, and stages and discharges of the principal rivers were also collected. Salinities were highest during the fall and lowest during the peak river discharge while water temperatures were seasonal, closely following air temperatures. Dissolved oxygen concentrations were highest during periods of low water temperature and salinity. Turbidities generally fluctuated directly with

river discharge and wind speed. The seasonal distributions of nutrients were generally irregular; however, nitrate values were highest at stations near the mouths of the Atchafalaya and Mississippi rivers during periods of peak discharge. In general, Louisiana's estuaries and near offshore waters are low in salinity and high in nutrient concentrations as compared with other states bordering the northern Gulf of Mexico. These characteristics are due primarily to Louisiana's high rainfall and the large volume of river water which makes its way through rich alluvial soils to the Gulf of Mexico. The major contributors of nutrients to the estuaries are the Mississippi and Atchafalaya rivers. These rivers are also responsible for major salt water dilutions within the coastal area and in the near offshore waters.

Bennett, C.M. and F.C.W. Olson. 1971. An assay of environmental data collected off Panama City, Florida from 1962 to 1968. NSRDL/PC 3444. Naval Ship Research and Development Lab. Panama City, FL. 314 pp.

Abstract. Presents oceanographic and meteorological data collected from the offshore research stages off of Panama City.

Black, P.G. 1983. Ocean temperature changes induced by tropical cyclones. Ph.D. Thesis. The Pennsylvania State University, Graduate School, Department of Meteorology. State College, PA.

Abstract. Discusses how major Gulf of Mexico storms (in particular storms Frederic, Anita and Allen) interact with the Loop Current and associated mesoscale eddies. Investigates both SST and mixed layer depth (MLD) changes caused by hurricane passage.

Blaha, J.P. and W. Sturges. 1978. Evidence for wind forced circulation in the Gulf of Mexico. Technical Report. Department of Oceanography, Florida State University. Tallahassee. 134 pp.

Blaha, J.P. and W. Sturges. 1981. Evidence for wind-forced circulation in the Gulf of Mexico. J. Mar. Res. 39(4):711-734.

Abstract. A study is conducted into the response of sea level and dynamic height to fluctuations of alongshore wind stress and wind stress curl at periods greater than a few months per cycle. Monthly tide gage data from Key West to Progreso, Mexico, during 1954-1974 are adjusted to remove the effects of local atmospheric pressure and seasonal steric heating. The adjusted mean monthly sea level elevations are significantly greater from Progreso to Port Isabel than they are elsewhere in the Gulf. This observation remains unchanged after the elevations are reduced for the effect of local alongshore winds. Among the tide gages in the western Gulf, Galveston is the most coherent, with the local alongshore wind forcing at periods greater than 2 mo/cycle, exhibiting a phase with the winds not significantly different from PI. At the other coastal sites, at least half of the elevation signal remains. This residual signal is presumed to be caused by the geostrophic fluctuations of an offshore boundary current. The available wind data from the western half of the Gulf show a negative wind stress curl; the mean is -11×10^{-9} dyne/cm^3, and curl is most negative in July. A common feature in the sea level elevations from Progreso to Port Isabel and in curl is the sharp transition from summer to fall. It is suggestive of a seasonal component to the Gulf circulation forced by the wind stress curl. This transition occurs from July to Sept. in curl but from Aug. to Oct. in sea level, a

one-month lag. The observed 17 cm of change in elevation corresponds to 23×10^{-9} dyne/cm^3 of change in curl. A mean baroclinic circulation in the northwestern Gulf is evident, in which the mean difference in dynamic height (sea surface relative to 700 db) from offshore to inshore regions is about 14 dynamic cm. The total seasonal variation across the flow (after the influence of Loop Current rings has been minimized in the data) is about 5 dynamic cm, which is one third the above-mentioned change in sea level attributed to curl.

Blain, C.A., J.J. Westerink and R.A. Luettich Jr. 1994. The influence of domain size on the response characteristics of a hurricane storm surge model. J. Geophys. Res. 99(C9):18467-18479.

Abstract. The influence of domain size on boundary condition specification and on computed storm surge response is investigated. Storm surge response along the Florida shelf in the Gulf of Mexico due to Hurricane Kate is examined over three domains using two different open ocean boundary forcing functions, a still water (or zero elevation) condition and an inverted barometer condition which accounts for the atmospheric pressure component of the meteorological forcing. The first domain is relatively small and is situated primarily on the continental shelf in the region of intense storm surge generation. A second domain includes the entire Gulf of Mexico basin. The first domain covers the Gulf of Mexico, contiguous basins, and extends out into the deep Atlantic Ocean. The computed storm surge response indicates that the small domain is inadequate, since cross-shelf boundaries are in regions of significant storm surge generation where surge and therefore boundary conditions are not known a priori. Also, the behavior of resonant modes that are physically excited within the Gulf of Mexico due to the passage of the hurricane is unknown at the boundaries of this small domain. The domain that includes the entire Gulf of Mexico captures the primary storm surge well but may not correctly model resonant modes. In general, these resonant modes are difficult to accurately set up by boundary condition specification, since they may be dependent on interactions between the Gulf and contiguous basins. The primary storm surge response as well as resonant modes excited by the storm are best represented using a domain which encompasses the western North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. This domain with deep Atlantic Ocean boundaries facilitates simple boundary condition specification and minimizes the influence of boundary conditions on storm surge generation in coastal regions. Basin resonant modes and basin to basin interactions are also captured.

Blumel, S.M. 1981. Comparison of three major northward-moving Gulf Coast hurricanes: Camille (1969), Eloise (1975), and Frederic (1979). National Weather Digest. 6(3):21-28.

Abstract. The following report serves to analyze both differences and similarities of three recent major northward-moving hurricanes along the Gulf Coast. Hurricanes Camille, Eloise, and Frederic severely affected the mid-Gulf Coast region, between New Orleans, LA., and St. Marks, FL. The comparative weakening rates of two different intensities of storms traversing the same general geographic and physiographic regions are discussed briefly. All tide data is in feet above mean sea level (msl, National Geodetic Vertical Datum of 1929) and is based primarily on

poststorm high water mark surveys. Significant wave heights are based on oil rig and NOAA data buoys and refer to the prevailing wave heights over the sea surface in view. Wave heights were measured from trough to crest.

Bosart, L. 1976. The role of the Gulf of Mexico in cyclogenesis. pp. 9-17. *In* Role of the Gulf of Mexico in the Weather of the United States: A Conference on Meteorology Over and Near the Gulf.

Breaker, L.C., L.D. Burroughs, J.F. Culp, N.L. Guinasso and R.L. Teboulle. 1993. Surface and near-surface marine observations during Hurricane Andrew. Technical Note. Also published as Ocean Products Center, Report No. CONTRIB-68. See also PB93-111060. National Meteorological Center. Washington, D.C. 42 pp.

Abstract. It is the purpose of the study to document the impact of Hurricane Andrew on the near-surface marine environment across the Bahamas and the Gulf through observations of sea level pressure, surface winds, surface air temperature, sea surface temperature, water level, near-surface currents, temperature and salinity. These data naturally take the form of time series and thus characterize the intensification and decay of Andrew at specific locations along its track.

Brown, M. and B. Rhodes. 1982. Navy corrected geostrophic wind data for the Gulf of Mexico, wind stress subset. DOI/DF/MT-88/005; Minerals Management Service, Gulf of Mexico OCS Regional Office. Metairie, LA.

Abstract. The Navy Corrected Geostrophic Winds are the result of a Navy effort to obtain a Gulf of Mexico wind field with the proper temporal and spatial resolution necessary to resolve the highly variable Gulf wind field. The report that documents the techniques used and results obtained is a NORDA Technical Note titled 'Navy Corrected Geostrophic Wind Set for the Gulf of Mexico', NORDA, NSTL Station, Mississippi, 39529. The wind stresses were calculated from the Navy corrected geostrophic wind data set using constant atmospheric density and a drag coefficient equal to .0013. The delivered data set consists of 17 files (blocksize 2400 and record length 80) on 3 tapes. The first file on the first tape contains an internally documented FORTRAN 77 program for reading any of the other 16 files. All other files contain the geostrophic wind data on a 1 degree grid with each file corresponding to one years worth of data from 1967-1982.

Bunpapong, M., R.O. Reid and R.E. Whitaker. 1985. Investigation of hurricane-induced forerunner surge in the Gulf of Mexico. Technical Report CERC-85-5. Army Corps of Engineers, Coastal Engineering Research Center. Vicksburg, MS. 201 pp.

Abstract. A system of coupled, normal mode equations, describing a two-layer ocean basin of variable depth, was derived from the quasi-hydrostatic equations of motion by using a general form of the method of Veronis and Stommel (1956). A finite-difference, time marching, numerical model for the normal mode equations, which uses an alternating direction implicit (ADI) scheme on a space-staggered grid, was developed. The model is quasi-linear and allows for variable bathymetry and variable Coriolis parameters. The model domain includes the Gulf of Mexico and the Cayman Sea with a resolution of 15'. A no-flow condition is taken at all solid boundaries, and the inverted barometer term is used to stipulate barotropic height anomalies on the open boundaries. Hurricanes Carla

(1961) and Allen (1980) are used as historical storms to verify the model by comparing numerical and observed hydrographs. A parametric study utilizing three forward speeds, two radii to maximum winds, and five paths characterizing Gulf hurricanes is presented. The results of the study show that volume transports through the Florida and Yucatan straits consisted of in-phase (both in or both out) and out-of-phase components. The in-phase volume transport excited a volume mode in the Gulf of Mexico, having periods of ~28 hr and ~3.4 days. The mode of oscillation can produce a forerunner surge for many storm tracks. The hurricane path and evolution play important roles in generating a forerunner. The out-of-phase volume transport through the ports was found to produce a Gulf-wide, quasi-geostrophic tilt mode of ~6.5-day period. Surges on the shelf, including the forerunner, are primarily a barotropic response. The quasi-linear model transmitted only a fraction of the baroclinic energy onto the shelf.

Burdin, W.W. 1977. Surge effects from Hurricane Eloise. Shore and Beach. 45(2):3-8. Also published in The Proceedings of the Mississippi Water Resources Conference, Mississippi State Univ., 1976.

Abstract. The impact of this hurricane on Panama City Beach.

Burk, S.D. and W.T. Thompson. 1991. Numerical Forecasts of Postfrontal Air-Mass Modification Over the Gulf of Mexico. International Conference on Mesoscale Meteorology and TAMEX, p. 295-301, 3-6 Dec. 91. Naval Oceanographic and Atmospheric Research Lab. Monterey, CA. 9 pp.

Abstract. During the winter and early spring, cold fronts periodically plunge southward across some, or all, of the Gulf of Mexico. For a period of time (typically several days), the Gulf states are cut off from the tropical and subtropical moisture source of the Gulf. In the cold air to the rear of the front, a low-level anti-cyclone invariably is present. Its position and movement determine the timing and location along the Gulf coast where the wind first develops a southerly component and the so-called 'return flow' is established. Thus, accurate forecasts of these postfrontal surface highs are critical to forecasts of the return flow. Forecasts of the return flow itself are not sufficient, however, to define the thermodynamic structure of the returning air mass -- and it is this factor that is most crucial to forecasting the actual weather type to be expected. Air-sea fluxes modify the continental polar (cP) or maritime polar (mP) air masses as they traverse the Gulf. The strength of these fluxes and the over water fetch of the air mass determine the extent to which the boundary layer air is modified by processes from below. In addition to modified cP or mP air, the return flow also may contain warm, moisture-laden tropical air that has advected northward, thereby making deep convection more probable due to the destabilizing effect of a low-level Increase in equivalent potential temperature. Operational forecasters often need to know whether there is sufficient moisture in the return flow to fuel a growing baroclinic system and produce severe weather. In the data sparse Gulf, such knowledge concerning the thermodynamics of the return flow is very difficult to obtain.

Burk, S.D. and W.T. Thompson. 1992. Airmass modification over the Gulf of Mexico: Mesoscale model and airmass transformation model forecasts. J. Appl. Meteorol. 31(8):925-937.

Abstract. Several numerical models are used to examine strong air-sea fluxes and resultant air mass modification following a cold-frontal passage over the Gulf of Mexico. Data from the Gulf of Mexico Experiment (GUFMEX), which was conducted in February-March 1988, are used for model validation. To provide a benchmark by which to evaluate the role of diabatic processes in airmass modification, the mesoscale model was initially run with surface fluxes deleted. Subsequent full physics runs show profound alterations to the boundary layer due to the diabatic processes. A one-dimensional airmass transformation (AMT) boundary-layer model is also tested and compared with the mesoscale modal and GUFMEX data. The Lagrangian character of the AMT model is a useful compliment to the mesoscale model output. Further, at least in one forecast, the AMT model yields a better forecast of boundary-layer depth. Strong sensible and latent heat fluxes in the vicinity of the cold front act frontolytically, while a subsidence-induced local maximum in latent heat flux appears in the return flow that is established in the western Gulf. The precipitable-water field shows a tongue of moist air returning to the Louisiana coast and indicates that substantial mesoscale horizontal gradients in the moisture field are to be expected in the return flow. Global modeling, air-sea interaction, fine mesh modeling, tide modeling.

Burk, S.D., W.T. Thompson and R.H. Langland. 1991. Numerical weather prediction of the marine atmospheric boundary layer. Naval Oceanographic and Atmospheric Research Lab. Monterey, CA. 6 pp.

Abstract. The burgeoning interest in mesoscale meteorology, particularly in coastal regions, has necessitated an enhanced emphasis on boundary layer physics and their parameterization in numerical weather prediction (NWP) models. Here we discuss several NWP models used by our group and describe some unique techniques we have developed for producing detailed forecasts of marine atmospheric boundary layer dynamics and thermodynamics. Forecasts are compared with data from the Gulf of Mexico Experiment (GUFMEX) of 1988. We examine an instance of cold frontal passage over the Gulf, and the return flow to the Gulf states that is established in the wake of the front.

Cardone, V.J. 1978. Forecasting hurricane winds and waves, a pilot study. pp. 1027. *In* United States National Oceanic and Atmospheric Administration. Atlantic Oceanographic and Meteorological Labs., Collected Reprints, 1977. Vol. 2. NOAA, Miami, FL.

Abstract. A directional spectral wave hindcast model developed at the City University of New York Institute of Marine and Atmospheric Sciences for application to Gulf of Mexico hurricanes is modified for implementation on the NOAA Atlantic Oceanographic and Meteorological Laboratories' computer facility for application in real time to forecasting of Gulf and East Coast hurricanes. The results of this model are compared to results from a simpler parametric model developed at the AOML Sea-Air Interaction Laboratory for several severe historical storms that have affected the Gulf and East Coast. The intercomparison indicates that the models produce similar results for slow moving (£15 knots) storms and increasingly divergent results for faster moving storms. A real time forecast of Hurricane Belle is described. The forecast sea states verified at a NOAA data buoy suggest that both models are limited mainly by errors in operational forecasts of hurricane track, intensity, and scale.

Carter, M.T. 1983. Probability of hurricane/tropical storm conditions: a users guide for local decision makers. National Climatic Data Center. Asheville, NC. 25 pp.

Abstract. In a growing number of communities along the Atlantic and Gulf coasts, local decision makers must begin initiating protective actions before the National Hurricane Center can confidently issue a Hurricane Warning for their community. In an attempt to provide these decision makers with useful long range forecasts of a hurricane's movement, the National Hurricane Center will issue probabilities that the hurricane will affect any of 44 communities from Brownsville, Texas, to Eastport, Maine. This manual was written to acquaint local decision-makers with some of the characteristics of these probabilities and outline some of the ways that they may be used to guide decision making when facing a hurricane threat. While it is hoped that local decision makers find this manual useful in effectively utilizing this new forecast information, it should be remembered that National Weather Service field personnel are available, as always, to answer any questions and to provide specific interpretations of both the probabilities and the forecast tracks that are issued for any given storm.

Chang, Fong-C. 1986. On the seasonality of climate fluctuations over the contiguous United States (air-sea interaction). Ph.D. Dissertation. University of Washington, Seattle, WA. 180 pp.

Abstract. The dominant spatial patterns of climatic fluctuation over the contiguous United States during the winter and summer seasons (1931-82) are examined using monthly mean temperature and monthly total precipitation anomalies for the 344 climatic divisions. These data are expanded into orthogonal components using rotated principal component analysis. Related patterns of sea-level pressure over the Northern Hemisphere (1931-82) and sea surface temperature over both the North Pacific and the North Atlantic (1950-79) for these dominant patterns are discussed. These results are used to evaluate the seasonal dependence of climate fluctuations. The Palmer Drought Severity Index, relative humidity and dewpoint anomalies were used to document the relationship between the soil moisture and summertime climate anomalies. The results suggest that some of the summer climate fluctuations over the contiguous United States are forced by soil moisture anomalies.

Chermock, R.L. 1976. Hurricanes and tornadoes in Alabama. Geological Survey of Alabama, Information Series. Series 46

Cooper, C.K. 1987. Hurricane-generated currents on the outer continental shelf. Ph.D. Dissertation. University of Maine. 204 pp.

Abstract. This work focused on currents generated by hurricanes on the outer continental shelf and slope. Emphasis has been on the maximum mixed layer response. This restricts the time scales of interest to within a few hours of storm passage. But considerable insight has also been gained about the lower layer response, and the post-storm response including shelf waves. A numerical model is developed using a layered, explicit finite difference formulation based on the nonlinear primitive equations including thermodynamics. The problem of topography intersecting the model layer is resolved by introducing artificial steps where the layer intersects the slope. Comparisons are given between the model simulations and six test cases in which the solutions either are known, or results

are available from other numerical models which have been proven. The favorable comparisons validate the numerical scheme and the model code. The model is configured for the Gulf of Mexico and used to hind-cast three storms using a 0.2 degree grid. In the mixed layer, the model typically reproduces better than 80% of the observed variance with correlation coefficients of greater than 0.8 for the mixed layer. In the bottom layer, the correlation falls, although the predicted variance still compares well. The model simulations suggest that substantial shelf waves can be generated by Gulf hurricanes. These have phase speeds of 4-10 m/s, suggesting a resonance coupling with the storm translation speed. A parameter study is conducted to quantify the sensitivity of the maximum mixed layer response to variations in the storm parameters, model physics, and topography. Results reveal the most important factors are (in decreasing order): wind speed, storm translation speed, direction of storm approach, asymmetry in the wind field, entrainment parameterization, and advection at slower translation speeds. For a storm approaching cross-shelf, the response is primarily baroclinic (greater than 90%) and only weakly dependent (less than 10%) on the water depth at the site. For a storm with an alongshelf component, the free surface pressure component can modify the response by 20%.

Cooper, C. and J.D. Thompson. 1989. Hurricane-generated currents on the outer continental shelf. I. Model formulation and verification. J. Geophys. Res. 94(C9):12513-12539.

Abstract. A numerical model is developed to simulate currents generated by hurricanes on the outer continental shelf and slope. Emphasis is on the mixed-layer response within a few hours of storm passage; however, some attention is given to the lower layer and shelf wave responses. The model is based on a layered, explicit, finite difference formulation using the nonlinear primitive equations including conservation of heat. The problem of topography intersecting the model layer is resolved by introducing artificial steps of the order of 100 m where the layer intersects the slope. Model comparisons are presented for three Gulf of Mexico hurricanes using a 0.2 degrees grid.

Council On Environmental Quality. 1980. The Eleventh Annual Report of the Council On Environmental Quality. Council On Environmental Quality. Washington, D.C. 497 pp.

Cragg, J., G. Mitchum and W. Sturges. 1983. Wind-induced sea surface slopes on the west Florida shelf. J. Phys. Ocean. 13(12):2201-2212.

Abstract. Tidal and meteorological records at stations in the eastern Gulf of Mexico have been studied. The sea level response is a maximum for winds along the coast and varies symmetrically with angle. The coherence is maximum at periods of 4-10 days. The horizontal coherence of sea level is high out to 500 km for 4- to 10-day periods. The horizontal coherence for wind (measured at coastal stations) is high out to at least 500 km. The amplitude of the response of sea level to winds is larger by a factor of 4 here, on a broad shelf, than on the Oregon coast, which is narrower by approximately the same ratio. A response of ~16 cm is induced by ~4 m/sec wind. This response, or transfer function, is uniform over the spectral range (4-100 days). The sea level response to the longshore wind stress is not linear, but to the power 0.8 $\pm$ 0.1, and is attributed to the relatively low tidal currents in this region. The large horizontal

coherences of wind and sea level imply broad longshore flows extending 500 km or more along the coast. Over 85% of the variance between 4 days and 3 yr is contained in fluctuations with periods <3 mo. A longshore slope of sea level is observed; in the 4- to 10-day band, this slope can be explained by longshore variation in the width of the shelf. A mean longshore slope of ~0.6×10^{-7} is found, and it may be caused by the (weak) mean winds. Freely propagating coastal trapped waves are found in a narrow band ~0.18 cpd.

Cragg, J. and W. Sturges. 1974. Wind induced currents and sea surface slopes in the eastern Gulf of Mexico. Technical Report/NSF Grant GA-29734/ONR Grant N00014-67-A-0235-0002. Florida State University, Department of Oceanography. Tallahassee, Florida. 50 pp.

Crance, J.H. 1971. Description of Alabama estuarine areas-cooperative Gulf of Mexico estuarine inventory. Ala. Mar. Resour. Bull. 6:1-85.

Abstract. Physical characteristics of estuarine areas are given; importance as nursery areas are discussed. Maps include: study area, sediment types, pollution sources, oyster beds, isotherms, isohalines, and some economic characteristics. Tabular data include: climate, tides, open water surface area and average depth, tidal marsh, stream discharge, domestic and industrial wastes, navigation channels, and commercial fisheries.

Crescenti, G.H. and R.A. Weller. 1992. Analysis of surface fluxes in the marine atmospheric boundary layer in the vicinity of rapidly intensifying cyclones. J. Appl. Meteorol. 31:831-848.

Crisp, C. and J. Lewis. 1992. Return flow in the Gulf of Mexico. Part I: A classificatory approach with a global historical perspective. J. Appl. Meteorol. 31(8):868-881.

Abstract. Return-flow events have been examined with the aid of a classification scheme that identifies each event with cold air masses that invade the Gulf during the cool season (February-March). These air masses were classified as either continental polar (cP), maritime polar (mP), or a mix of two or more of these basic types (MIX in future reference). Each event was viewed as a cycle in which the first phase represented an offshore flow typifying the cold-air outbreak over the Gulf and the second phase was associated with the return of modified air to the continent. Surface data for a 12-yr period, 1978-89, were used to make a statistical analysis of the event and each of its phases. The principal results of the study are 1) a total of 127 events occurred in this cool season over the 12-yr period. The relative percentages of mP, cP, and MIX air masses are 28%, 20%, and 52%, respectively. A median of 10.5 return-flow events occurred in the cool season where the MIX category was the dominant regime. The median duration for a return-flow cycle is 3.3, 5.2, and 6.2 days for mP, cP, and MIX, respectively, for the cool season. 2) The median duration of the offshore-flow phase for the cool season shows a wide range depending on airmass type with 30, 55, and 49 h as median times for mP, cP, and MIX, respectively. 3) The median duration of the return-flow phase for the cool season was significantly longer than the offshore-flow phase when all cases were examined en masse; but when the cases were segregated according to airmass type, the duration of the return flow for the cool season exhibited a wide range with 47, 57, and 62 h as median times for mP, cP and MIX, respectively.

In order to view the return-flow events in the Gulf of Mexico from a wider perspective, a historical summary of research on this event and similar events around the world is included.

Cummings, A.D. 1968. Climatological aspects of the balance of water-vapor in the atmosphere overlying the Gulf of Mexico. M. S. Thesis. Texas A&M University. Meteorology Department. 38 pp.

Curry, T.F. 1986. Time series prediction of hurricane landfall (nonlinear, threshold autoregression). Ph.D. Dissertation. The University of Texas at Austin, Austin, TX. 152 pp.

Abstract. For many years, land development in the coastal regions of the Gulf of Mexico and the eastern seaboard has continued unabated. As coastal populations increase it is becoming more and more difficult to evacuate people from hurricane threatened areas, and to secure industrial plants. Greater accuracy is required in predicting hurricane landfall in order to insure that everyone can get out alive. In this dissertation, it is shown that the landfall of North Atlantic hurricanes and tropical storms can be accurately predicted by modeling the storm track as a bivariate (latitude and longitude) fifth-order autoregressive process. A threshold approach is used to allow model parameters to change as the storm moves to a new region of the ocean. For test cases, operational average 72 hour prediction error is at least three standard deviations below the average error of the official forecasts issued by the National Hurricane Center. A significant result is the classification of past storms by time series stationarity category which relates to direction of movement. Also, a psi-weight representation of the forecast is used to develop a bivariate normal confidence ellipse for the threshold autoregressive model.

Dagg, M.J. 1988. Physical and biological responses to the passage of a winter storm in the coastal and inner shelf waters of the northern Gulf of Mexico. Cont. Shelf Res. 8:167-178.

Davidson, K.L., P.J. Boyle and P.S. Guest. 1992. Atmospheric boundary-layer properties affecting wind forecasting in coastal regions. J. Appl. Meteorol. 31:983-994.

Davis, D.R. and W.C. Bridges. 1971. A Blocked Minimal Tropical Depression Becomes a Storm of Rare Occurrence. NOAA-TM-NWS-SR-59. National Weather Service, Southern Region. Fort Worth, TX. 22 pp.

Abstract. A small tropical low, marginal in intensity between a depression and disturbance, moved out of the Gulf of Mexico on September 19-20, 1969. An absence of steering currents aloft and the blocking action of a surface high caused the low to become stationary on the Florida coast for approximately 48 hours. Torrential, record-breaking rains occurred in a small area 60-65 miles to the east and 50 miles inland from the point where the low made landfall. Record-breaking floods resulted. The 23-inch maximum rainfall in 1969 was about 9 inches greater than the previous maximum rainfall of record produced by a 1924 tropical storm in the same area. The location of the area of maximum rainfall, with respect to the point of landfall of the low's center, closely follows the pattern previously reported for the more intense hurricanes and tropical storms.

de la Cruz, A.A. 1981. Differences between South Atlantic and Gulf Coast marshes. pp. 10-20. *In* Carey, R.C., P.S. Markovits and J.B. Kirkwood, eds. Proceedings of the U.S. Fish and Wildlife Service Workshop on Coastal Ecosystems of the United States. Office of Biological Services, Washington, D.C. FWS/OBS-80/59.

Abstract. The one factor that determines the biological (plant communities), ecological (primary productivity, food web, energy flow), and chemical (salinity, nutrients) differences between the South Atlantic and Gulf Coast marshes is water-the hydrological processes and hydrodynamic regimes that characterize each region. Gulf Coast marshes are developed primarily on deltaic formations constructed on alluvial deposits created by several major river systems, while the South Atlantic marshes are basically formed on estuarine and lagoonal soft silt deposits bridging the barrier islands and the mainland shorelines. Tides in the South Atlantic (a tidal dominated coast) are normally semidiurnal with fluctuations of more than 2.0 m; meteorological phenomena are more stable with fewer events of major storm surges. In the Gulf, tides are generally diurnal with maximum fluctuation of 0.3 m; but during periods of lowest fluctuations, tides can change over to very weak semidiurnal occurrences. Prevailing local weather conditions, the occurrence of seasonally changing major wind directions, high energy summer tropical storms, and Gulf basin natural oscillations complicate the hydrodynamics of the Gulf marsh system. The peculiar hydrology of the Gulf Coast (a wave dominated coast coupled with the great freshwater input dominated by the Mississippi River) influences salinity producing a more diverse vegetation structure and seasonal fluxes of material into the Gulf Coast marsh-estuary.

DeWald, O.E. 1980. Severe storm and hurricane impacts along the Gulf and lower Atlantic coasts. Minerals Management Service, Gulf of Mexico OCS Regional Office. Metairie, LA. 10 pp.

Eleuterius, C.K. and S.L. Beaugez. 1981. Mississippi Sound: A hydrographic and climatic atlas. MASGP-79-009. Mississippi-Alabama Sea Grant Consortium. Ocean Springs, MS. 135 pp.

Estoque, M.A. 1976. Behavior of fronts over the Gulf of Mexico. pp. 1-8. *In* Role of the Gulf of Mexico in the Weather of the United States: A Conference on Meteorology Over and Near the Gulf. University of Miami, Miami, FL.

Fernandez-Partegas, J. and M.A. Estoque. 1981. Climatology and meteorology of the Gulf of Mexico. *In* Proceedings of a Symposium on Environmental Research Needs in the Gulf of Mexico (GOMEX). NOAA Publication 89-126, (NOAA Publication 89-126.)

Fernandez-Partegas, J. and C.N.K. Mooers. 1975. Some front characteristics over the eastern Gulf of Mexico and surrounding areas. Contract No. 08550-CT4-L6. Bureau of Land Management.

Florida A&M University and T. College of Engineering Science and Agriculture. 1988. Meteorological Database and Synthesis for the Gulf of Mexico. Vol. OCS Study MMS 88-0064 Prepared for MMS by Florida A&M University under

Contract No. 14-12-0001-30191. U.S. Department of Interior, Minerals Management Service. New Orleans. 486 pp.

Abstract. Lists and describes ship, buoy and platform data sets collected to produce final summary in FAMU Gulf of Mexico study, including sources, formats and periods covered. The summary includes monthly, seasonal and annual means, extremes and variance of velocity and stress components at each of the stations. Wind stress curl calculations are also evaluated.

Franceschini, G.A. 1953. The distribution of mean monthly wind stress over the Gulf of Mexico. Reference 53-1. Department of Oceanography. Texas A&M University, College Station. 19 pp.

Abstract. The areal distribution of the mean monthly and annual wind stress on the Gulf of Mexico is presented. Approximate values of the stress were determined for each 2 degrees latitude-longitude quadrangle using mean monthly wind tabulations of ship observations. Calculations were based on the assumption that wind stress is proportional to the square of the wind speed. Prominent features of the stress distribution are noted. Qualitative agreement, according to classical theory, of this distribution which observed mean surface currents in the western half of the Gulf is indicated. A brief discussion of the association in this area between mean surface flow and the mean pattern of surface water temperature is included.

Franceschini, G.A. 1976. A portraiture of the horizontal fluxes of dry and moist static energy around the Gulf of Mexico. pp. 13. *In* Role of the Gulf of Mexico in the Weather of the U.S: A Conference on Meteorology over and near the Gulf.

Frank, N.L. 1972. Atlantic tropical systems of 1971. Mon. Weather Rev. 100(4):268-275.

Abstract. The 1971 hurricane season featured 103 seedlings, 23 depressions, and 12 named storms. An anomalous circulation pattern developed over the Gulf of Mexico and the southwestern Atlantic Ocean in September and spawned a large number of depressions and storms within the subtropical belt near or north of latitude 25°N.

Franklin, M.A. and L.R. Bohman. 1980. Hurricane Frederic tidal floods of September 12-13, 1979 along the Gulf coast, Oriole Beach, Garcon Point, Holley, south of Holley, and Navarre quadrangles, Florida. US Geological Survey. Hydrologic Investigations Atlas. Map HA-0641. Scale 1:24,000.

Abstract. Shows the areas flooded along the shores of Santa Rosa Sound and the Gulf of Mexico from Pensacola Beach eastward to The Narrows near Fort Walton Beach, Fla. The areas flooded along the shores of Pensacola, Escambia, Blackwater and East Bays were not delineated; however, floodmark elevations were determined.

Fu, J. 1991. Atmospheric deposition of nutrients to north Florida rivers: A multi-variate statistical analysis. Master's Thesis. Florida State University, Tallahassee, FL. 95 pp.

Abstract. Atmospheric nutrient input to the Apalachicola Bay estuary was studied because it has been demonstrated that atmospheric deposition can be a major source of nutrients to eastern US estuaries. Besides the Apalachicola River, the Sopchoppy and the Ochlockonee were also selected for a comparative analysis. Receptor model, absolute principal of

component analysis (APCA), and mass balance methods were applied in the study. The results of the study show that nitrogen is probably not a limiting nutrient in the three rivers because their N: P mole ratios are nearly 3 times higher than the Redfield ratio for photosynthesis. The total atmospheric nitrogen depositions in the three river watershed are at least as great as their river fluxes. In the Apalachicola River, the atmospheric source of nitrogen is found to be several times higher than the largest possible input of urban sewage. Atmospheric deposition, therefore, might be the dominant nitrogen source entering the estuary. The results of APCA show that Apalachicola River water is mainly a mixture of components that correspond their compositions to aged rain, ground water, and fresh rain. Atmospheric nitrate deposition is the result of the air pollution, i.e., acid rain. The studies also show that the annual average deposition of nitrate has a narrow range, mainly from 5.8 to 11.5 kg/ha/yr in most of the NADP sites in the 8 southeastern states. Since all the software and date sets employed in the study are accessible nationwide, the methods could be applied in other watersheds.

Gaby, D.C., D.R. Cochran, J.B. Lushine, S.C. Pearce and A.C. Pike. 1975. Atlantic tropical cyclone classifications for 1974. NOAA-TM-NESS-68; NOAA-75042803. National Environmental Satellite Service, Satellite Field Services Station. Coral Gables, FL. 12 pp.

Abstract. Estimates of the locations and maximum sustained winds (classifications) of all named tropical cyclones in the North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico during 1974 were made using the technique developed by Dvorak. This technique was applied to pictures from the SMS-1 (Stationary Meteorological Satellite) and ATS-3 (Advanced Technology Satellite) geostationary satellites. These estimates were compared with other data to establish the measure of accuracy achieved. The results are presented together with comments on expected future performance.

Galtsoff, P.S. 1954. Gulf of Mexico, its origin, waters and marine life. U.S. Fish Wildl. Serv. Fish. Bull. 55(89):1-604.

Abstract. Contents: I. Historical sketch of the explorations in the Gulf of Mexico; II. Geology; III. Marine meteorology of the Gulf of Mexico, a brief review; IV. Bacteria, fungi, and unicellular algae; VII. Protozoa; VIII. Sponges, coelenterates, and ctenophores; IX. Free-living flatworms, nemerteans, nematodes, tardigrades, and chaetognaths; X. Parasitic worms; XI. Bryozoa, Brachiopoda, Phoronida, and Enteropneusta; XII. Echinoderm; XIII. Annelids and miscellaneous worms; XIV. Arthropods; XV. Mollusks; XVI. Tunicates and lancelets; XVII. Fishes and sea turtles; XVIII. The birds of the Gulf of Mexico; XIX. Mammals of the Gulf of Mexico; XX. Pollution of water.

Garcia, A.W. 1991. On the relationship between the intensity of extratropical frontal cyclone systems and water levels in the Gulf of Mexico (cyclones). Ph.D. Dissertation. Purdue University. 138 pp.

Abstract. The effects of winter season frontal cyclone systems on tidal-period Gulf of Mexico water levels are investigated. The passage of a series of hypothetical and observed frontal cyclone systems across the Gulf of Mexico is simulated using a Gulf-wide hydrodynamic model driven by a synoptic-scale, balanced flow wind model. The observed frontal cyclone systems were selected to represent a fast moving front, a slow moving

front, and a frontal system which involved Gulf cyclogenesis. Evaluation of the model simulations was based upon comparison of tidal anomalies acquired at National Ocean Service tidal monitoring stations. Results of the model simulations show generally good qualitative agreement with the tidal anomalies. Because the wind model used routinely available meteorological data, forecasts of surge levels in the Gulf may be possible.

Gaul, R.D. 1965. Air-sea environmental studies off Panama City, Florida. Unpublished report. Texas A&M Univ., Dept. of Oceanography and Meteorology. College Station, TX. 11 pp.
Abstract. A description of the projects being conducted from the Navy's offshore stages.

Geo-Marine. 1973. A program of field measurements to define the thermal and dissolved oxygen distribution at the Lansing Smith Plant on West Bay/St. Andrew Bay. Geo-Marine. St. Petersburg, FL. 27 pp.
Abstract. Hydrographic and meteorological data from the vicinity of the power plant.

Gray, W.M. 1987. Forecast of Atlantic seasonal hurricane activity for 1987. (Updated July 28, 1987). Colorado State University. Fort Collins. 32 pp.
Abstract. The author's updated forecast of the amount of seasonal hurricane and tropical storm activity which can be expected to occur in the Atlantic basin, Caribbean, and Gulf of Mexico region in 1987 is discussed. This updated forecast is issued just before the start of the most active part of the hurricane season. The author's previous forecast for 1987 was issued on 27 May and called for 5 hurricanes (1 below the average of the 1947 to 1986 seasons), 8 named tropical storms (2 below average), and 20 hurricane days (5 below average). This updated forecast is based on the author's earlier forecast and more recent June and July meteorological data. This revised forecast is considered to be more reliable than the forecast issued at the end of May. Statistical information received by the author as of 28 July indicates that the hurricane and tropical storm activity for 1987 can be expected to be a somewhat more suppressed than that anticipated in late May. This revised forecast indicates a probability for 4 hurricanes (2 below average), 7 hurricanes and tropical storms (3 below average), and 15 hurricane days (10 below average).

Gray, W.M. 1992. Forecast of Atlantic seasonal hurricane activity for 1992. Colorado State University. Fort Collins. 17 pp.
Abstract. Details are presented of the forecast for the amount of tropical cyclone activity which might be expected to occur in the Atlantic Ocean region, including the Caribbean Sea and the Gulf of Mexico, during 1992. This forecast is based on ongoing research relating to the amount of seasonal Atlantic tropical cyclone activity that can be specified in early June by four factors: (1) the Quasi-Biennial Oscillation of equatorial stratospheric wind (QBO); (2) the El Niño (EN); (3) West African Rainfall (AR) anomalies of the previous year; and (4) West African west to east gradients of surface pressure and temperature during Feb. through May. Information received through 3 June 1992 indicates that the 1992 hurricane season should be below average with about 4 hurricanes, 8 named storms of at least tropical storm intensity; about 15 hurricane days, a total of 35 named storm days and a Hurricane

Destruction Potential of 35. Reduced hurricane activity during the 1992 season will be due to Tropical Pacific Sea Surface Temperature anomaly patterns; below average rainfall conditions are expected in the Sahel region of West Africa; and West Africa west to east pressure and temperature gradients during Feb. to May indicate a weaker than normal summer monsoon trough and consequently, below average hurricane activity.

Gray, W.M. 1992. Updated forecast of Atlantic seasonal hurricane activity for 1992. Colorado State University. Fort Collins. 17 pp.

Abstract. Presented here are the details of the author's updated forecast of tropical cyclone activity for the Atlantic Ocean region including the Caribbean Sea and the Gulf of Mexico during 1992. This updated forecast includes meteorological data for June and July and is based on the ongoing research activities which relates the amount of seasonal Atlantic tropical cyclone activity to five factors: (1) three measures of the Quasi-Biennial Oscillation of equatorial stratospheric zonal wind (QBO) at 50 mb (20 km) and 30 mb (23 km) and the absolute value of the shear between these levels; (2) the El Niño (EN) as specified by the Equatorial East Pacific Sea Surface Temperature Anomaly (SSTA) and the value of the Southern Oscillation Index (SOI); (3) Caribbean basin Sea-Level Pressure Anomalies (SLPAs) and upper tropospheric 200 mb Zonal Wind Anomalies (ZWA); (4) two measures of West African Rainfall (AR) anomalies, one of June-July in the western Sahel region, and the other the previous year August through November precipitation in the Gulf of Guinea region; and (5) the surface west to east pressure and temperature gradients across the western Sahel region of Africa. Information received by the author through 4 August 1992 indicates that the 1992 hurricane season should be below average with about 4 hurricanes, 8 named storms of at least tropical storm intensity, about 15 hurricane days, a total of 35 named storm days, and a Hurricane Destruction Potential of 35. Because the western Sahel is expected to be dry again this year, it is anticipated that there will be only one intense hurricane of Saffir/Simpson intensity category 3, 4, or 5 this season. This year's forecast is for the same amount of hurricane activity that was previously forecasted on 26 November 1991.

Gray, W.M. 1993. Forecast of Atlantic seasonal hurricane activity for 1993. Colorado State University. Fort Collins. 18 pp.

Abstract. This paper presents details of the author's forecast for the amount of tropical cyclone activity expected to occur in the Atlantic Ocean region, including the Caribbean Sea and the Gulf of Mexico, during 1993. This forecast is based on ongoing research relating the amount of seasonal Atlantic tropical cyclone activity to five basic forecast parameters. These are: (1) the Quasi-Biennial Oscillation (QBO) of equatorial stratospheric wind; (2) the El Niño Southern Oscillation (ENSO); (3) West African Rainfall (AR) anomalies of the previous year; (4) West African west to east gradients of anomalous surface pressure and surface temperature (APT) during Feb. through May; and (5) Caribbean Basin Sea Level Pressure and Upper Level Zonal Wind Anomalies (SLPA and ZWA respectively). Information received by the author through 3 Jun. 1993 indicates that the 1993 hurricane season should be an average season with about 7 hurricanes, 11 named storms of at least tropical storm intensity, a total of about 25 hurricane days, 55 named storm days, and total Hurricane Destruction Potential (HDP) of 65. It is also expected that

there should be two major hurricanes of Saffir/Simpson intensity category 3, 4, or 5 this season and about 3 intense hurricane days. These parameters represent an overall measure of hurricane activity about 95 percent of the last 42-year average. The amount of intense or major hurricane activity has been reduced from that given in the author's 24 Nov. 1992 forecast. This reduction is due to the slow dissipation of the current El Niño and to new estimates of West African drought conditions. Hurricane activity in 1993 will be enhanced by favorable stratospheric QBO westerly phase winds and low values of Caribbean Basin sea level pressure. It will be reduced by expected West Sahel drought conditions, and by a weakening El Niño event. The November forecast had anticipated cold ENSO conditions.

Gray, W.M. 1993. Updated forecast of Atlantic seasonal hurricane activity for 1993. Colorado State University. Fort Collins. 16 pp.

Abstract. Details of the author's updated forecast of tropical cyclone activity for the Atlantic Ocean region including the Caribbean Sea and the Gulf of Mexico during 1993 are presented. This updated forecast utilizes meteorological data for June and July and is based on the author and his research colleagues ongoing research activities which relates the amount of seasonal Atlantic tropical cyclone activity to five factors: namely, (1) three measures of the Quasi-Biennial Oscillation of equatorial stratospheric zonal wind (QBO) at 50 mb (20 km) and 30 mb (23 km) and the absolute value of the shear between these levels; (2) the El Niño Southern Oscillation (ENSO) conditions as specified by the Equatorial East Pacific Sea Surface Temperature Anomaly (SSTA) and the value of the Tahiti minus Darwin surface pressure; (3) Caribbean basin Sea-Level Pressure Anomalies (SLPA) and upper tropospheric 200 mb Zonal Wind Anomalies (ZWA); (4) two measures of West African Rainfall (AR) anomalies, one of June-July in the Western Sahel region, and the other the previous year Aug. through Nov. precipitation in the Gulf of Guinea region; and (5) the surface west to east pressure and temperature gradients across the Western Sahel region of Africa during Feb. through May. Information received by the author through 4 Aug. 1993 indicates that the 1993 hurricane season should, overall be about an average season when compared with hurricane activity of the last 43 years. Our statistical analysis indicates that this season should have about 6 hurricanes, 10 named storms of at least tropical storm intensity, about 25 hurricane days, a total of 50 named storm days and a Hurricane Destruction Potential of 55. Because the Western Sahel is expected to again have below average rainfall this year, it is anticipated that there will be only two intense or major hurricanes of Saffir/Simpson intensity category 3, 4, or 5 this season. This updated forecast is for slightly calmer conditions than were suggested in the 24 Nov. 1992 and 4 Jun. 1993 forecasts for 1993. A verification of this forecast will be issued in late Nov.

Gruber, A. 1968. The energy budget and climatological description of the atmosphere over the Florida peninsula when a convective regime dominates. Ph.D. Dissertation. Florida State University, Tallahassee, FL.

Gruber, A. 1969. Energy budget and climatology of the atmosphere over the Florida peninsula. U.S. Army Elect. Comm., Tech. Rep. ECOM-04367-F:64.

Halper, F.B., D.W. McGrail and W.W. Schroeder. 1982. The response of shelf waters in the Gulf of Mexico to the passage of tropical storms and hurricanes in 1979. EOS. 63:18.

Halper, F.B. and W.W. Schroeder. 1990. The response of shelf waters to the passage of tropical cyclones-observations from the Gulf of Mexico. Cont. Shelf Res. 10(8):777-793.

Abstract. Current meter data obtained from sites on the Alabama, west Florida, and Texas-Louisiana shelves during 1979 coincided with the passage of five tropical cyclones; hurricane Bob, tropical storm Claudette, tropical storm Elena, hurricane Frederic and hurricane Henri, and a sixth storm (hurricane David) which skirted the west Florida coast. The observations suggest that along the Alabama shelf (25 m water depth), where the isobaths were essentially perpendicular to the path of the storms, hurricanes Bob and Frederic and tropical storm Claudette caused coastal set-up/set-down, resulting in a complex response. The observations from the west Florida shelf, where storm paths generally paralleled the isobaths, suggest that the flows associated with hurricanes Frederic, David and possibly tropical storm Claudette were a combination of the storms setting water in motion as they moved through the Gulf of Mexico and local wind forcing.

Hamilton, G.D. 1987. Buoy records: set in 1985 hurricanes. Mar. Weather Log. 31(4):7-10.

Abstract. During the 1985 hurricane season in Sept., a North Atlantic buoy reported the highest significant wave height ever recorded by the National Data Buoy Center (NDBC) in a hurricane (Gloria): 46.9 ft. The track of Gloria from its development near the Cape Verde Islands, within 55 mi of buoy station 41002, is described. In Oct. in the eastern Gulf of Mexico, an NDBC buoy registered a record wind of 92 knots with a 114-knot peak in Kate. The development of Kate and its track are described. The expected winds are compared by means of a numerical wave prediction scheme. By applying the required values of wind speeds from the times of the most extreme wind/wave conditions at the two buoys, the significant wave height (H1/3) and peak period (Tm) are estimated (computed). The estimates during Kate are reasonably close, as is the peak period for Gloria. There is, however, a large discrepancy in the significant wave height predicted for Gloria. Several characteristics of the storms, which may explain the difference involving the discrepancy between wind speed and wave height in the storms, are considered.

Hart, W.E. and S.P. Murray. 1978. Energy balance and wind effects in a shallow sound. J. Geophys. Res. 83(C8):4097-4106.

Abstract. Tidal energetics and wind effects in an extensive (3000 km^2) shallow (3.5m) sound with two widely separated entrances were studied numerically with a two-dimensional vertically averaged model. A comparison of current predictions with observation from 15 current meter stations under differing tidal regimes proved the reliability of the model. Evaluation of the instantaneous energy balance equation showed the change in energy content to be nearly balanced by input energy flux, frictional energy dissipation being of secondary importance. In contrast to the equipartition of energy in classical long waves, there is on the average eight times more potential energy than kinetic energy. Input energy flow shows preferential pathways; the wide northern entrance mainly shows

energy gain to the Sound, the southern entrance shows equal amounts of gain and loss, while small cuts through the barrier island chain serve mainly as conduits for energy loss. When real tidal input is used, the energy balance time-averaged over a diurnal tidal cycle is not in a steady state, and frictional dissipation is the dominant term. Experiments showed that with winds in the 8- to 9-m/s range, extensive setup can occur (20 cm), strongly dependent on wind direction. Increased speeds through the passages can significantly reduce the residence time in the Sound. Relaxation time of the wind perturbations is only about 3 hours.

Hastenrath, S.L. 1968. A contribution to the wind conditions over the Caribbean Sea and Gulf of Mexico. Tellus. 20(1):163-178.

Hawkins, J.D., D.A. May, R.L. Pickett and F. Abell. 1990. Benefits of NOAA-11 Channel 3 in detection of mesoscale eddies in the Gulf of Mexico during s ummer. pp. 356-361. *In* Proceedings Annual Gulf of Mexico Information Transfer Meeting (11th). Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, MS.

Abstract. Monitoring the Loop Current and mesoscale (50-350 km) warm and cold core eddy positions in the Gulf of Mexico year round has taken on enhanced interest as our understanding of the Gulf's physical oceanography and its impact on a diverse set of industrial and scientific disciplines matures. Early sporadic hydrographic cruises were supplemented in the late 1970's and early 1980's with satellite infrared (IR) imagery from the Geostationary Operational Environmental Satellites (GOES) and various versions of the present National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR). The synoptic IR views helped immeasurably by permitting mapping of the major mesoscale features via their sea surface temperature (SST) signatures. The early work of Ichiye (1962), Cochrane (1972) and others was then enhanced considerably when imagery began to fill in the time-space void inherent in Gulf ship surveys. Information pertaining to the cycle of Loop Current penetration, eddy shedding and drift of resultant warm core eddies westward to the Texas shelf rapidly revised earlier speculation and brought us to a now level of viewing the dynamics of the Loop Current System. Several drawbacks remained while utilizing IR imagery to detect Gulf mesoscale features. Cloud contamination often eliminated this valuable resource for time spans lasting weeks when poor meteorological conditions prevailed. Summertime conditions, including solar heating, reduced the SST gradients associated with all features, requiring the capability to measure relative and absolute SSTs to the accuracy of 0.25°C and better in order to view the faint surface signatures.

Ho, F.P., R.W. Schwerdt and H.V. Goodyear. 1975. Some climatological characteristics of hurricanes and storms on the Gulf and East coasts of the United States. NWS-15. National Weather Service, NOAA Technical Department.

Abstract. A climatology of hurricane factors important to storm surges is presented for the U.S. Gulf and East coasts. A smoothed frequency of tropical storms and hurricanes entering and exiting the coast and storms passing within 150 n.mi. of the coast during the period 1871-1973 is given. Directions of landfalling hurricanes and tropical storms at the

time they crossed the coast at selected points were also analyzed. The probability distribution of each factor was plotted and analyzed for each 50-n.mi. interval along the coast. Selected probability levels of each distribution were then summarized, and smoothed variations along the coast were obtained by analysis. The speeds of motion for two classes of hurricanes (those that entered the coast and those that passed within 150 n.mi. of the coast) were studied separately and a smooth speed analysis determined for each. The question of joint probability among the various factors and with latitude is discussed qualitatively.

Ho, F.P. and R.J. Tracey. 1975. Storm tide frequency analysis for the Gulf Coast of Florida from Cape San Blas to St. Petersburg beach. National Oceanic and Atmospheric Administration, National Weather Service Technical Memorandum. NOAA TM NWS HYDRO-20:34.

Hope, J.R. and C.J. Neumann. 1971. Computer methods applied to Atlantic area tropical storm and hurricane climatology. Mar. Weather Log. 15(5): 272-278.

Abstract. Tropical cyclone advisories and bulletins for the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico are issued or coordinated through the National Hurricane Center of the National Weather Service. Relevant to this responsibility is the maintenance of suitable documentation of past tropical cyclone tracks. Such data are stored on magnetic tape and can be instantly processed by a digital computer. With the data now stored on tape, the National Hurricane Center, using fully computerized methods, has the capability of quickly consulting the climatology of areas of any size for such portions of the hurricane season as may be pertinent to a particular forecast problem or for long-range planning purposes. The HURRAN technique, an analog process used routinely as a basic forecast aid, is discussed.

Hopkins, C.K. 1990. Ocean response to hurricane forcing. Master's Thesis. Naval Postgraduate School, Monterey, CA. 90 pp.

Abstract. The current meter records collected at three sites in the Gulf of Mexico during the passage of Hurricane Frederic are analyzed to determine the storm-induced flow at various ocean depths, determine the associated energy increase and decay, and compare these observations to similar results from a numerical model. The records at the two deeper sites are rather unique because they are within 100 km of the hurricane track. Pre-storm conditions are controlled by topography, and as the storm passes there is an abrupt change in the direction of flow and initiation of a strong inertial response at all levels of the two deeper sites. After this initial surge, the residual flow tends toward the pre-storm direction. The horizontal kinetic energy associated with inertial motion is calculated. The energy increase and decay is shown to vary with depth. An embedded mixed-layer ocean circulation model is forced with an idealized storm translating at the same speed as Frederic. The abrupt response and strong inertial component predicted by the model is qualitatively similar to the observations.

Hsu, S.A. 1977. Atmospheric dispersion characteristics in the Louisiana coastal zone. Center for Wetland Resources, Louisiana State University, Baton Rouge, LA. Bull. No. 229:29.

Abstract. Atmospheric dispersion characteristics in the coastal zone are unique in that physical processes of air, sea, and land combine at the shoreline to create motions on many scales which differ in important respects from processes over land or over water. Some of these differences in coastal Louisiana are reviewed. Synoptic-scale characteristics indicate that the coastal zone is superior to areas farther inland for dispersing pollutants. However, mesoscale and microscale studies reveal that diurnal circulation of land-breeze and sea-breeze systems and the development of an internal boundary layer because of aerodynamic roughness changes across the shoreline may actually increase pollution concentration in the nearshore region. Specific studies on these scales of atmospheric motion in relation to the optimum siting for industrial plants are outlined and recommended.

Hsu, S.A. 1992. Effects of surface baroclinicity on frontal overrunning along the central Gulf coast. J. Appl. Meteorol. 31:900-907.

Hsu, S.A. 1993. The Gulf of Mexico--a breeding ground for winter storms. Mariners Weather Log, Washington. 37(2):4-11.

Abstract. Cyclogenesis, that is, the development or strengthening of cyclonic circulation in the atmosphere, is studied for storms in the Gulf of Mexico. Using 1972-1982 as a control period, an average of 10.4 winter cyclones developed each year over the Gulf of Mexico, and in 5.5 of these, central pressures dipped to 1010 millibars or below. Additionally, from November 1982 through March 1983 a total of 26 surface cyclones affected the Gulf region, and five of these met the criteria for meteorological bombs. During these intensification periods the mean subtropical jet stream was about 5 degrees farther south than normal over the Gulf of Mexico, and was an important factor in the formation of upper level disturbances. One classic example of such cyclogenesis and its effect on shelf waters occurred on February 16, 1983, when central pressure fell 12 millibars within a 24-hour period, lowest pressure was 1001 millibars, and there was a maximum wind of 15 m/s (29 knots), and a significant wave height of 4.3 meters. A classification scheme is presented that uses the relationship of maximum winds to minimum pressures to acknowledge the importance of these winter storm systems. This mathematical development recognizes that the airflow around the center of these storms in the Gulf is nearly circular, and that as a first approximation the cyclostrophic equation may be applicable such that the forces between the centrifugal force and the pressure gradient are in balance. There are two constraints in this storm ranking scheme, however: (1) when minimum pressure of the storm is greater than 1015 mb no cyclogenesis was observed; and (2) when the minimum pressure is less than 980 mb, the minimum (or central) pressure approaches the hurricane classification scheme of Saffir/Simpson.

Hsu, S.A., E.A. Meindl and D.B. Gilhousen. 1994. Determining the power-law wind-profile exponent under near-neutral stability conditions at sea. J. Appl. Meteorol. 33(6):757-765.

Abstract. On the basis of 30 samples from near-simultaneous overwater measurements by pairs of anemometers located at different heights in the Gulf of Mexico and off the Chesapeake Bay, Virginia, the mean and standard deviation for the exponent of the power-law wind profile over the ocean under near-neutral atmospheric stability conditions were

determined to be 0.11 ± 0.03. Because this mean value is obtained from both deep and shallow water environments, it is recommended for use at sea to adjust the wind speed measurements at different heights to the standard height of 10 m above the mean sea surface. An example to apply this P value to estimate the momentum flux or wind stress is provided.

Hsueh, Y., G.O. Marmorino and L.L. Vansant. 1982. Numerical model studies of the winter-storm response of the west Florida shelf. J. Phys. Ocean. 12(10):1037-1050.

Abstract. The wintertime, wind-driven ocean circulation on the West Florida Continental Shelf is studied within the framework of a linearized storm-surge model. The model bathymetry incorporates a realistic shelf, extending from New Orleans to the southern tip of Florida, and a deep ocean region. The boundary condition at the coast is that there is no normal flow. At the open boundaries, located off the shelf in deep water, the adjusted sea level is fixed at zero. It is found that 1) a coastally trapped response is achieved within one local inertial period following the imposition of the wind; 2) the curved coast forces a mass exchange between the coastal water and the deep ocean; 3) this exchange leads to the generation of a series of mesoscale eddies along the shelf edge; and 4) these eddies give rise to long-period, shelf-wide oscillations that persist beyond the local spin-up time. A hindcast of the wind-driven flow on the West Florida Shelf for a particular period (11-25 March 1978) that contains the passage of a distinct cold front produces coastal sea-level and current fluctuations that are in reasonable agreement with observations.

Hughes, R.M. 1967. Balance of atmospheric water vapor over the Gulf of Mexico. M.S. Thesis. Texas A&M University. College Station, TX. 41 pp.

Huh, O.K., L.J. Rouse and N.D. Walker. 1984. Cold air outbreaks over the northwest Florida continental shelf: Heat flux processes and hydrographic changes. J. Geophys. Res. 89(C1):717-726.

Abstract. An experimental study of the meteorology and oceanography of cold air outbreak cycles was conducted during the fall of 1978 off Panama City, FL. Details of the air-sea interaction processes they induce on such upwind continental shelves are poorly known because of a lack of appropriate measurements. Shallow depths and proximity to land make the processes significantly different from their deepwater counterparts. The cycle has three phases that are recognizable in the measurements: the prefrontal, frontal passage, and cold air outbreak-high-pressure phases. The time variability of oceanic heat fluxes was monitored through the cycle in two ways: by measuring heat content changes and by measuring turbulent and radiative heat fluxes. Advective effects on the heat budget were minimized by the site selection. A mild cold air outbreak stripped 26.8×10^6 J/m^2 (640 cal/cm^2) of heat and 1.1 cm of liquid water from the shelf in 63 hr, and a severe cold air outbreak removed 147.6×10^6 J/m^2 (3528 cal/cm^2) and 4.4 cm of liquid water in 87 hr. For these events, evaporation, sensible heat loss, and radiative heat loss were 51, 16, and 33, and 58, 25, and 17% of the totals, respectively. A simple one-dimensional shallow water heat flux model predicted temperature and heat content changes during severe cold air outbreaks to within 8%.

Observations indicate the extreme time variability of heat flux processes and the hazards of extrapolating to daily rates from spot measurements or very short time series.

Ichiye, T. 1971. Circulation changes caused by hurricanes. Oceanographic Studies. 2, Ch 13:229-257. CONTRIB-509-CH-13.

Abstract. Observations in the Gulf of Mexico of temperature and salinity changes due to passing hurricanes are reviewed. Observations for Hurricane Carla (1961) and for Hurricane Inez (1966) were made on the continental slope in the northwestern and the western Gulf, respectively. The data from the latter case indicate upward displacement and deepening of the thermocline near to and to the left hand side of the hurricane center, respectively. The data from Hurricane Hilda (1964) were obtained on several transects across the track in the central Gulf and are the most comprehensive. Comparison of hydrographic data with those of the undisturbed state indicate upward and downward displacement of the thermocline at and outside the track of the eye, respectively.

Irwin, G.A. and R.T. Kirkland. 1980. Chemical and physical characteristics of precipitation at selected sites in Florida. USGS Water Res. Investigations. 80-81

Janish, P.R. and S.W. Lyons. 1992. NGM performance during cold-air outbreaks and periods of return flow over the Gulf of Mexico with emphasis on moisture-field evolution. J. Appl. Meteorol. 31(8):995-1017.

Abstract. The National Meteorological Center's Nested Grid Model (NGM) analyses and 24-48-h forecasts of cold-air outbreaks and their associated return flows are examined from January through March 1988 coincident with the Gulf of Mexico Experiment (GUFMEX). Seven episodes of moderate-to-strong cold-air outbreaks and associated return flows are isolated. A good index of these cycles is the 950-mb meridional wind component. Composites and individual cases of the horizontal, vertical, and temporal structure of wind, temperature, and moisture are diagnosed for NGM analyses and 24-48 h forecasts of these events. Primary focus is on air and moisture modification over the Gulf during the return-flow cycle. Comparisons among observed inversion layers capping the low-level moisture and those present in NGM analyses and forecasts are examined. These differences highlight model strengths and weaknesses. With regard to humidity-field evolution during the return-flow cycle, NGM forecasts are consistently too dry over the Gulf during both offshore and onshore flow phases. Isentropic trajectory computations suggest that advective processes clearly dominate the moisture modification processes in the NGM forecasts. Comparisons indicate that low-level moisture errors in the model forecasts result more from short comings in model physics than from inadequate or poor model initialization. Recently, changes to the NGM input analyses and physics package have been implemented. While the affects of these changes have yet to be determined, this study illustrates strengths and weaknesses of the NGM during the 1988 cool season and emphasizes the necessity for accurate simulation of boundary-layer processes during return-flow events and times of air mass modification.

Jarrell, J.P., G.C. April and D.C. Raney. 1981. Hydrodynamics of Mobile bay and Mississippi Sound - pass exchange studies. MASGP-80-023, University of Alabama Bureau of Engineering Research Report No. 271-112. Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS. MASGP-80-023. 177 pp.

Abstract. This research was undertaken to develop a mathematical model of Mobile Bay and East Mississippi Sound, Alabama capable of describing the hydrodynamics in Pass aux Herons and Main Pass. The elucidation of the complex interaction of these passes is necessary to further the knowledge of the Alabama coastal system gained through previous modeling efforts. The recently developed WES Implicit Flooding Model, version II (WIFN II) is applied to the Mobile Bay-East Mississippi Sound system. This model is suitable for the indicated purpose because of the implicit solution form and variable grid size capabilities which it possesses. This model is determined to be an effective trend analysis tool for the study of the pass hydrodynamics on the basis of field calibration and verification data.

Jehn, K.H. 1976. Observational methods and needs. pp. 77-85. *In* Role of the Gulf of Mexico in the weather of the United States: a conference on meteorology over and near the Gulf. TAMU, College Station, TX.

Jelesnianski, C.P. 1972. SPLASH (Special Program to List Amplitudes of Surges From Hurricanes) 1. Landfall storms. NOAA Tech. Memo. NWS TDL-46:52.

Jensen, J.J. 1970. Calculated and observed changes in sea surface temperature associated with hurricane passage. Master's Thesis. Naval Postgraduate School, Monterey, CA. 56 pp.

Abstract. Analyses were made of the sea surface temperatures in the Gulf of Mexico in August for the four years 1965 through 1968. No one pattern was found to predominate. The subsurface temperature profiles were then considered, and a rate of simulated withdrawal of 4000 calories of heat per day was made, until there was no heat in excess of 26°C. This withdrawal represented heat removed during passage of a hurricane. Difference analyses were constructed for the initial sea surface temperature at each station and that after twenty-four hours of simulated withdrawal. The differences ranged from less than one degree to over four degrees. Again, no consistent pattern was found but generally areas of high concentrations of heat experienced smaller decreases. Actual sea surface temperatures collected after two hurricanes were then analyzed and compared to temperature patterns predicted by the computer model. Illustrations of the relative availability of sensible heat energy for different sea surface temperatures are presented and a hypothesis made to account for the greater than average intensities of Hurricane Betsy (1965) and Camille (1969).

Johnson, D.R. 1989. Vector EOF analysis of SSH and wind stress for the GEOSAT pre-ERM mission in the Gulf of Mexico. Naval Ocean Research and Development Activity. NSTL Station, MS. 2 pp.

Abstract. Sea Surface Height (SSH) data collected during the Pre-exact Repeat Mission of the U.S. Navy's GEOSAT satellite were analyzed together with wind stress data from FNOC to determine basin scale patterns of coherent variability. Time series of SSH variations were formed from altimeter cross-over points in 3-degree diamond-shaped grids in the Gulf of Mexico (GOM). Similarly, wind stress time series were formed at selected grid

points in the GOM and in the North Equatorial Trade wind region of the Atlantic. The two sets of time series, one year in length, were subjected to Empirical Orthogonal Function analysis. The first EOF mode contained more than twice the variance of the second mode, with the largest amplitudes (sigenvectors) of the pattern occurring just west of the loop current intrusion for SSH and in the western and northern Gulf for wind stress. A comparison is made with similar combined data for the Northern Indian Ocean where ocean response to Monsoon winds is strong, and better understood. In addition to the EOF analysis, events are followed through the Gulf in both wind and SSH records.

Johnson, G.A., E.A. Meindl, E.B. Mortimer, M.C. Koziara, W.L. Read and J.S. Lynch. 1986. Winter cyclogenesis over the Gulf of Mexico. NOAA/NWSFO, Slidell, LA, 7 pp.

Jordan, C.L. 1973. Climate. pp. 22. *In* Jones, J.I., R.E. Ring, M.O. Rinkel and R.E. Smith, eds. A Summary of Knowledge of the Eastern Gulf of Mexico. State University System of Florida, Institute of Oceanography, St. Petersburg, FL.

Abstract. Climatological data from coastal stations and summaries of meteorological observations from ships are used to describe the broad climatic features of the eastern Gulf of Mexico. The seasonal changes in wind, temperature, cloudiness, and precipitation are related in a general way to the character of the large-scale circulation patterns and the associated seasonal changes in storm tracks and air masses. Statistical information is presented for selected coastal stations and for a summary area in the east-central Gulf for a number of climatological elements including rainfall, thunderstorms, fog, winds, and waves. Information is also provided on the frequency and seasonal distribution of tropical and extra-tropical cyclones in selected areas, and data are given on maximum hurricane surge heights for the region. Data sources and reliability are discussed in relation to the possibility of providing more detailed climatological information for the eastern Gulf.

Jordan, C.L. 1984. Florida's weather and climate: Implications for water. pp. 18-35. *In* Fernald, E.A. and D.J. Patton, eds. Water Resources Atlas of Florida. Florida State University, Tallahassee, FL.

Kirwan, A.D., Jr., G. McNally, M.-S. Chang and R. Molinari. 1974. The Effect of Wind and Surface Currents on Drifters. J. Phys. Ocean. 5(2):361-368.

Abstract. The problem analyzed here is the motion of a drifter acted on by wind, surface and subsurface currents. From the condition of static equilibrium of all drag forces acting on the drifter, the effects of wind and surface current of arbitrary direction and magnitude and drogue characteristics are examined parametrically. Specific application is made to a recently developed drifter with 9.2 and 11.85 m parachute drogues and a window shade drogue. The calculations show that for some environmental conditions the deviation between the magnitudes of the drifter velocity and the water parcel velocity may exceed 50%. Furthermore, the direction of velocity vectors may differ by as much as 45 degrees. Drifter data from an experiment conducted by the Atlantic Oceanographic and Meteorological Laboratories and the NOAA Data Buoy Office in the Gulf of Mexico Loop Current are examined in light of the theoretical results. The wind effects predicted by the theory were

observed in the field. Thus wind corrections to the drifter velocity records which are based on the theory can significantly improve the velocity records.

Kjerfve, B. 1983. Analysis and synthesis of oceanographic conditions in Mississippi Sound, April thru October, 1980. U.S. Army Corps of Engineers, Mobile District. Mobile, AL. 436 pp.

Lamb, D. and L. Comrie. 1991. Meteorological and chemical factors controlling the composition of precipitation in eastern North America. International Conference on Precipitation Scavenging and Atmosphere Surface Exchange Process (5th), Richland, WA (United States), 15-19 Jul. 1991. Sponsored by Department of Energy, Washington, D.C. Pennsylvania State Univ., Dept. of Meteorology. University Park. 4 pp.

Abstract. Precipitation in eastern North America is characterized by high concentrations of free acidity and sulfate that are generally attributed to anthropogenic air pollution. The relatively long record of precipitation chemistry measurements at the Penn State MAP3S site is used to analyze the seasonal and interannual variability of precipitation composition in terms of specific mechanisms of atmospheric transport and chemical transformation. The interrelationships of the chemical variables in the precipitation record and in recent air measurements clearly link the precipitation acidity with the wet deposition of sulfate derived from the in-cloud oxidation of sulfur dioxide. High-deposition events are shown through meteorological trajectory analyses to be associated with moist air from the Gulf of Mexico that passes through the upper midwestern parts of the United States. The main chemical factor controlling the deposition of sulfate appears to be the availability of strong oxidants for transforming dissolved sulfur dioxide into aqueous sulfate. Excess sulfur dioxide is expected to exit the storm systems at high altitudes and experience truly long-range transport. This interpretation of the data gives confidence that episodes will occur even after sulfur dioxide emissions have been reduced substantially.

Leipper, D.F. 1954. Marine meteorology of the Gulf of Mexico, a brief review. pp. 89-98. *In* Galtsoff, P.S., ed. Gulf of Mexico, Its Origin, Waters, and Marine Life. U.S. Fish Wildl. Serv. Bull. 89.

Leipper, D.F. 1965. The Gulf of Mexico after Hurricane Hilda (preliminary results). Texas A&M Project 286, Reference 65-12T. Texas A&M University, Oceanography Department. College Station, TX. 19 pp.

Abstract. Hurricane Hilda crossed the Gulf of Mexico in the period September 30 to October 4, 1964, developing to a very severe hurricane in the central Gulf. Sea temperature data available prior to the storm indicated what is probably a typical late summer situation with some surface temperatures running above 30°C. Beginning on October 5, a seven-day cruise was conducted over the area where hurricane winds, had been observed. Using the Bureau of Commercial Fisheries vessel GUS III, four crossings of the hurricane path were made, one where the maximum 150 mph winds were observed, one south of that where the winds had first reached 120, one north where they had decreased to 120 and one in shallow water (40 fathoms), where prior data had been collected by the U. S. Fish and Wildlife Service from their Galveston Biological Laboratory. Bathythermograms were taken regularly to depths of 270 meters and

hydrographic casts to 125 meters. All four sections of observations indicated similar patterns of upwelling. During the passage of the hurricane it appears that sea surface temperatures over an area of some 70 by 220 miles decreased by more than 5°C, and that a cyclonic ocean current system was established around this area. The data collected on the GUS cruise appear to be the first systematic oceanographic observations available in such a situation.

Leipper, D.P. and D. Volgenau. 1972. Hurricane heat potential of the Gulf of Mexico. J. Phys. Ocean. 2(3):218-224.

Abstract. Presents data suggesting significant influence of the amount of heat initially available in Gulf waters on the ability to sustain a hurricane.

Le Ngoc Ly and L.H. Kantha. 1993. A numerical study of the nonlinear interaction of Hurricane Camille with the Gulf of Mexico Loop Current. Oceanol. Acta. 16(4):341-348.

Abstract. A three-dimensional, primitive equation, ocean general circulation model is used to study the response of the Gulf of Mexico to Hurricane Camille (1969). The free-surface dynamics and the mixed-layer features are included in the model. The numerical model incorporates the realistic coastline and bottom topography. The sigma coordinate model has eighteen levels in the vertical and 0.2x0.2 degree horizontal resolution for the entire Gulf. The study focuses on nonlinear interaction between hurricane induced currents and the Loop Current. The numerical simulations show that there is a strong nonlinear interaction between the hurricane and the Loop Current in the southern and central parts of the eastern Gulf. The surface currents due to nonlinear interaction obtain a maximum of over 1 m/s in the southern Gulf. The numerical results also show that the hurricane interaction with the Loop Current strongly affects current, mixed-layer depth, and elevation fields.

Lewis, J.M. 1993. Challenges and advantages of collecting upper-air data over the Gulf of Mexico. Marine Technology Society Journal. 27:56-65.

Lewis, J.M., C.M. Hayden, R.T. Merrill and J.M. Schneider. 1989. GUFMEX: a study of return flow in the Gulf of Mexico. Bulletin of the American Meteorological Society. 70:24-29.

Ling, T.F.T., G.C. April, D.C. Raney and J.N. Youngblood. 1981. Hydrodynamic and salinity models for Mobile Bay and east Mississippi Sound. MASGP-81-020, University of Alabama Bureau of Engineering Research Report No. 283-112. U.S. Army Corps of Engineers, Mobile District. Ocean Springs, MS. 149 pp.

Abstract. This research undertakes the task of determining numerical solutions to the equations of hydrodynamic change as applied to Mobile Bay and East Mississippi Sound. In doing so, results from the calibrated and verified models can be used to better explain and understand the complex behavior of these water bodies and the interactive forces that occur between them at Cedar Point. The hydrodynamic model is exercised over four tidal cycles, beginning with the estimates from a previous run, until no significant change in the magnitude of the parameter is observed. In addition, an isolated subsystem model of the Cedar Point area was developed for the purpose of obtaining salt concentration profiles in

this pass exchange area. The subsystem model for salinity is a valuable tool in determining the influence that Mobile Bay has on East Mississippi Sound under varying meteorologic and hydrodynamic conditions.

Liu, Q., J.M. Lewis and J.M. Schneider. 1992. A study of cold-air modification over the Gulf of Mexico using in situ data and mixed-layer modeling. J. Appl. Meteorol. 31:909-924.

Ly, L.N. 1992. Gulf of Mexico response to Hurricane Frederic simulated with the Princeton numerical ocean circulation model. Technical Report. Institute for Naval Oceanography. Stennis Space Center, MS. 44 pp.

Abstract. This report is a three-dimensional, nonlinear, primitive equation, ocean general circulation model developed at Princeton University and is used to study the response of the Gulf of Mexico to Hurricane Frederic. The model has surface dynamics and a second order turbulence closure scheme for the mixed layer. The study focuses on nonlinear interaction between Hurricane Frederic and the Loop Current, the hurricane induced current, shelf wave, and sea level response to hurricane forcing.

Ly, L.N. and L.H. Kantha. 1993. A numerical study of the nonlinear interaction of Hurricane Camille with the Gulf of Mexico Loop Current. Oceanol. Acta. 16(4):341-348.

Abstract. A three-dimensional, primitive equation, ocean general circulation model is used to study the response of the Gulf of Mexico to Hurricane Camille (1969). The free-surface dynamics and the mixed-layer features are included in the model. The numerical model incorporates the realistic coastline and bottom topography. The sigma coordinate model has eighteen levels in the vertical and 0.2 x 0.2 degree horizontal resolution for the entire Gulf. The study focuses on nonlinear interaction between hurricane induced currents and the Loop Current. The numerical simulations show that there is a strong nonlinear interaction between the hurricane and the Loop Current in the southern and central parts of the eastern Gulf. The surface currents due to nonlinear interaction obtain a maximum of over 1 m/s in the southern Gulf. The numerical results also show that the hurricane interaction with the Loop Current strongly affects current, mixed-layer depth, and elevation fields. There is a strong current response to Hurricane Camille in the surface layer on the shelf with a peak velocity approximately 2.2 m/s. There is a definite right hand bias in the mixed-layer depth field with a maximum of about 90 m.

Mailhot, J. 1992. Numerical simulation of airmass transformation over the Gulf of Mexico. J. Appl. Meteorol. 31(8):946-963.

Abstract. A mesoscale numerical simulation (35 km) of a return-flow event over the Gulf of Mexico that occurred during the Gulf of Mexico Experiment (GUFMEX) is presented in order to examine the structure and the transformation of the polar air mass and to assess the model's skill in simulating the event. The study deals with the phase of cold-air outbreak over the Gulf of Mexico and the subsequent rapid modification of the cold air mass by the underlying warm ocean, prior to the onset of return flow. The investigation focuses on the physical processes operating during the airmass transformation, notably the air-sea fluxes and the vertical destabilization of the airmass. The results are compared with various data gathered during GUFMEX and suggest that a realistic simulation of airmass transformation can be obtained. The results indicate a strong

interplay between 1) large-scale subsidence above the planetary boundary layer behind the front and 2) destabilization near the sea surface and in the boundary layer. In particular, advective processes play a central role in the airmass modification above the boundary layer and in the maintenance of a strong capping inversion. However, very large surface energy fluxes and vigorous turbulent vertical mixing appear as dominant mechanisms within the boundary layer itself. A sensitive experiment where surface energy fluxes are turned off supports these conclusions and clearly demonstrates their impact on the advance of the cold air mass over the Gulf and on the changes in moisture and stability of the return flow.

Manty, R.E. 1993. Effect of the El Niño/southern oscillation on Gulf of Mexico, winter, frontal-wave cyclones: 1960-1989. (Volumes I and II). Ph.D. Dissertation. The Louisiana State University and Agricultural and Mechanical Col. 806 pp.

Abstract. Seasonal counts of frontal-wave cyclones forming over the Gulf of Mexico and its coastal plain show more storms in the five El Niño winters and fewer storms in the eight La Niña winters, from 1960 to 1989, significant at the .01 level by a rank sum test. This is corroborated by two results. First, during the same period, the frequency of frontal-overrunning weather conditions in the region, indicative of storms, was higher in El Niño winters and lower in La Niña winters, significant at the .05 level. Second, 100 years of precipitation and temperature records show wetter, cooler El Niño winters and drier, warmer La Niña winters at Gulf-region land stations and climatic divisions. A threefold explanation, based on National Meteorological Center, upper-air data, is offered for the greater frequency of Gulf-region cyclogenesis during El Niño winters between 1960 and 1989.

Maresca, J.W., Jr. and C.T. Carlson. 1977. Tracking and monitoring hurricanes by HF skywave radar over the Gulf of Mexico. SRI-5630-1; AFOSR-TR-78-0762. SRI International. Menlo Park, CA. 123 pp.

Abstract. This report describes the results of a study to evaluate the effectiveness of a high-frequency skywave radar used to determine the track, movement, size, and intensity of hurricanes from ocean gravity waves. Experimental data were collected using the Wide Aperture Research Facility (WARF), a high-resolution skywave radar capable of forming a 1/2° beam at 15 MHz, located in central California. The data were collected for hurricanes Anita, Babe, Caroline, and Eloise in the Gulf of Mexico, and Hurricane Kate in the Pacific Ocean. One or more position estimates were made from radar-derived surface wind direction maps covering a 2° of latitude radius for each hurricane, and agreement to within 10 to 40 km of the National Hurricane Center Best Tracks was found. Both day and night measurements were made, as well as one- and two-ionospheric-hop measurements extending out to ranges of 2800 to 4000 km. The first WARF-measured track was generated for hurricane Anita from 20 independent position estimates over a 5-day period. WARF measurements of the ocean wave spectrum and surface currents were made during hurricanes Anita and Babe. A parametric wave model developed elsewhere was used to compute wind speeds. Preliminary WARF wind-speed measurements show agreement to within 1 to 2 m/s when compared with winds measured by aircraft and at several offshore oil platforms.

Maresca, J.W., Jr. and C.T. Carlson. 1978. Tracking and monitoring hurricanes by HF skywave radar over the Gulf of Mexico. AFOSR-TR-79-0042. Air Force Office of Scientific Research. Bolling AFB, D.C. 111 pp.

Abstract. This report describes the results of a study to evaluate the effectiveness of a high-frequency (HF) skywave radar used to determine (1) the track of a hurricane, and (2) hurricane wind velocity and wave height throughout all regions of a storm. Experimental data were collected using the SRI-operated Wide Aperture Research Facility (WARF) located in central California. The WARF radar is a high-resolution skywave radar capable of forming a 0.5° beam at 15 MHz. HF skywave radar sea-echo Doppler spectra were recorded for six hurricanes/tropical storms in the Gulf of Mexico and Pacific Ocean between 1975 and 1978. Both day and night measurements were made, as well as one- and two-ionospheric-hop measurements ranging out from 2800 to 4000 km. Surface wind direction maps were computed for all 6 tropical storms. In situ measurements were available for two storms for comparison to the WARF radar wind maps. The radar-derived wind directions coincident in time and space with National Data Buoy Office moored buoys showed agreement to within 10°. The center of the hurricane was estimated from each WARF wind map and was compared to the official track compiled by the National Hurricane Center (NHC). The mean difference between the WARF radar positions and the interpolated positions along the NHC track was 19 km for Hurricane Anita 1977.

Marmorino, G.O. 1982. Wind-forced sea level variability along the west Florida shelf (Winter, 1978). J. Phys. Ocean. 12(5):389-405.

Abstract. Coastal tide gauge and meteorological records from Pensacola to Key West for the period January-April 1978 have been examined for low-frequency fluctuations. The dominant 6-day period signals in sea level, alongshore wind stress, and atmospheric pressure were coherent over the entire shelf and propagated southward, consistent with the movement of cold fronts through the area. Sea level response lagged the local wind stress by 18 h (in the north) to 9 h (in the south). In response to a 1 dyn/cm^{-2} alongshore stress, sea level amplitudes were largest (similar to 60 cm) where the shelf is widest (200 km) and undergoes an abrupt bend, and were similar to 30 cm elsewhere; large transient alongshore sea level slopes, on the order of 10^{-6}, were thus set up. A linear steady-state shelf circulation model (Hsueh, 1980) is used to explore the sea level distribution that is in frictional equilibrium with a wind stress of given orientation.

McClelland, S.I. 1975. Wind-driven vorticity transport model of the circulation in the Gulf of Mexico and Caribbean Sea: preliminary results. EOS. 56(6):378.

McDonald, G. UNKNOWN YEAR. Water heights associated with various hurricanes. U.S. Army Corps of Engineers, Mobile District. Mobile, AL.

Abstract. Several larger hurricanes occurring in the Gulf of Mexico were investigated and reported on. Water heights associated with each hurricane were included in these reports as well as patterns of movements and dates of occurrence from 1911 to the present time.

McGlothin, C.C. 1991. Ambient sound in the ocean induced by heavy precipitation and the subsequent predictability of rainfall rate. Master's Thesis. Naval Postgraduate School, Monterey, CA. 78 pp.

Abstract. An experiment was performed in the Gulf Mexico to characterize the underwater sound generated by the heavy precipitation and to determine if rainfall rate can be measured using underwater sound. During this stage of the experiment, twenty-two data sets were recorded with rainfall rates up to 340 mm/hr. For a given rainfall rate, it is found that sound levels from heavy convective precipitation are higher at the beginning of the storm and when rainfall rate is increasing than at the end of the storm event or when rainfall rates are decreasing. This may be due to changes in the drop size distribution during the life cycle of the storm or to variations in the temperature difference between the raindrop and the ocean surfaces. Very heavy rainfall generates near surface bubble layers or bubble clouds which attenuate sound energy at higher frequencies. The distinctive 15 kHz peak in the sound spectrum for light rain or absent during heavy rain suggesting that the sound production mechanism previously identified for small drops is suppressed by heavy rain even though those small drops are undoubtedly present during heavy rainfall rates. These data show a very high correlation between underwater sound level and the logarithm of the rainfall rate except when high wind speeds and high rainfall rates are present. An empirical rainfall rate algorithm for convective precipitation is proposed suggesting that sound energy is directly proportional to rainfall rate.

Merrill, R.T. 1992. Synoptic analysis of the GUFMEX return-flow event of 10-12 March 1988. J. Appl. Meteorol. 31:849-867.

Michelena, E. 1990. Joint oil industry Meteorological/Oceanographic Measurement System (MOMS). NOAA National Data Buoy Center, Stennis Space Center, MS, Technical Bulletin. 16(1):1.

Abstract. This article discusses a new joint industry project between the NDBC (National Data Buoy Center) and Chevron USA called MOMS (Meteorological/Oceanographic Measurement System). It is a 3-yr. Gulf of Mexico measurement program that will provide improved environmental information for hurricane evacuation, daily industry operations planning, and design criteria for future deep-water oil platforms. A description is given of the buoy type used, its role in improving modeling capabilities, the functions of the six observation stations, and the measurement instruments installed at the stations. All resulting MOMS data, except for current data and time series data, are acquired and reported hourly via the Geostationary Operational Environmental Satellite (GOES) system and disseminated on NWS communication circuits.

Milliman, J.D. and E. Imamura. eds. 1992. Physical oceanography of the U.S. Atlantic and eastern Gulf of Mexico. Final Report. OCS/MMS/92-0003 Contract: DI-1412-00013-0350. Battelle Ocean Sciences. Herndon, VA. 519 pp.

Abstract. The report provides a summary of the physical oceanography of the U.S. Atlantic and Eastern Gulf of Mexico and its implication to offshore oil and gas exploration and development. Topics covered in the report include: meteorology and air-sea interactions, circulation on the continental shelf, continental slope and rise circulation, Gulf Stream, Loop Current, deep-western boundary current, surface gravity-wave climatology, offshore engineering implications, implications for resource commercialization, and numerical models of pollutant dispersion.

Mitchum, G.T. 1984. Continental shelf water response to large-scale, low-frequency wind forcing with emphasis on the frictional nearshore region. Ph.D. Thesis. The Florida State University. Tallahassee, FL. 90 pp.
Abstract. Three related problems concerning the response of the continental shelf waters to large-scale, low-frequency (synoptic scale) wind forcing are addressed. Briefly the results are as follows. (i) An understanding is gained to the dynamics of the poorly studied frictional region which lies inshore of the region which has been shown (e.g., Gill and Schumann, 1974 and Clarke and Van Gorder, 1984) to be well described by long wave dynamics. Simple accurate solutions for the pressure and alongshore velocity fields are developed and their domains of applicability are given. (ii) Through use of the knowledge gained in (i), a link is established from the frictional nearshore regions to the wave dynamics region by providing a proper boundary condition for models which strictly consider the latter. Also, a formula is given to predict coastal pressure (generally the best data set) given the boundary pressure prediction from a wave dynamics model. (iii) The above results, together with the model of Clarke and Van Gorder (1984), are applied to a data set on the west Florida shelf. It is shown that the response there is accurately modeled. Further, the simplicity of the model allows the west Florida shelf response to be understood as a sum of a forced wave moving with the wind field, a free wave generated at the Florida Keys and a smaller, but significant, free wave flux from the east coast of Florida.

Mitchum, G.T. and A.J. Clarke. 1986. Evaluation of frictional, wind-forced long-wave theory on the west Florida shelf. J. Phys. Ocean. 16(6): 1029-1037.
Abstract. Clarke and Van Gorder have recently formulated a model describing the large-scale, low-frequency response of continental shelf waters to synoptic-scale wind stress in terms of a sum of forced waves. The model includes realistic friction and time dependence and provides an efficient method for calculating the response. Evaluation of the model using west Florida shelf data gave the following results. (i) The model successfully predicts both the coastal sea level and alongshore velocity component. (ii) The west Florida shelf coastal pressure field is dominated by the first mode and can be understood as the sum of a forced wave which travels with the southward-propagating wind stress and a free wave generated at the Florida Keys. (iii) Almost all the wind-induced energy on the west Florida shelf is due to the wind forcing acting on west Florida shelf waters. However, a small but significant energy flux appears to enter the west Florida shelf from the eastern Florida shelf wave guide.

Mitchum, G.T. and W. Sturges. 1982. Wind-driven currents on the west Florida shelf. J. Phys. Ocean. 12(11):1310-1317.
Abstract. Three weeks of current-meter, wind and sea-level data off Cedar Key, Florida are analyzed. Currents and sea level are found to be coherent with alongshore wind stress in the "synoptic" band (similar to 0.05-0.25 cycle per day) and to lag it by approximately half a day. Little coherence is found with cross-shelf wind stress. At the inshore mooring (22 m depth) currents are nearly barotropic for these winter 1978 data. The dominant momentum balance in the alongshore direction is between wind and bottom stress. The offshore frictional length scale (Csanady, 1978) is estimated to be 75-100 km, which implies a seaward extent to a depth

of about 30 m. At the offshore mooring (44 m depth) there is vertical shear between the currents at 9 and 39 m. The upper cross-shelf component, which is large relative to that at the inshore mooring, is consistent with Ekman transport while the lower record shows a return flow. The u, v velocity components correlate significantly at the offshore mooring and lead to an upper layer uv gradient on the order of $10^{-5}cm^2/s^2$ between the arrays (75 km separation).

Molinari, R.L. 1987. Air mass modification over the eastern Gulf of Mexico as a function of surface wind fields and Loop Current position. Mon. Weather Rev. 115(3):646-652.

Molinari, R.L. and G.A. Franceschini. 1972. Bathythermograph sections across the path of Hurricane Celia. pp. 259-264. *In* Capurro, L.R.A. and J.L. Reid, eds. Contributions on the Physical Oceanography of the Gulf of Mexico. Gulf Publishing Co., Houston, TX.

Abstract. Three vertical sections taken across the track of Hurricane Celia using XBTs indicate that the storm may have caused upwelling of colder sub-surface waters, whose effect may be dependent on the length of time strong winds were present.

Molinari, R.L. and D.A. Mayer. 1982. Current meter observations on the continental slope at two sites in the eastern Gulf of Mexico. J. Phys. Ocean. 12:1480-1484.

Abstract. Current-meter observations obtained at two sites on the continental slope of the eastern Gulf of Mexico, at nominal positions of 29°N, 88°W (the Mobile site) and 27.5°W (the Tampa site) are presented. Data were collected at three levels at Mobile (90, 190, and 980 m) from July 1977 through August 1978 and at four levels at Tampa (150, 250, 550 and 950 m) from June 1978 through June 1979. At 90 and 190 m, the flow at Mobile was on the average to the east. Sustained periods of flow to the west were observed during the summer 1977 and spring 1978. During the periods of eastward flow the wind was generally out of the north and during the periods of westward flow, the wind was out of the east. The flow at the top meter at Tampa was on the average to the west, in the same direction as the average wind. At both sites, the motions are perturbed by events associated with the Loop Current. These events make it difficult to define any seasonal variability in the upper layers. The flow at the bottom meters is strongly aligned with the bottom topography and lacks a strong seasonal signal. Little barotropic tidal energy was observed at either site. At both sites, maximum diurnal energy occurred near the local inerital frequency at the upper levels. These motions are probably induced by either cold-front passages or other atmospheric events. At the bottom meters, maximum diurnal-band energy occurred near the K_1-tidal constituent. These motions are strongly time-dependent and they may be related to internal tides.

Mooers, C.N.K., J. Fernandez-Partegas and J.F. Price. 1975. An evaluation of meteorological data from several buoys of the NOAA Data Buoy Office (Eastern Gulf of Mexico, 1973-1974). Technical Report UM-RSMAS# 75030. University of Miami. Miami, FL. 89 pp.

Morgan, C.W. 1977. Average monthly wind stress along coastal regions of the United States and Western Canada. Ocean. Unit Tech. Paper 77-1.
Abstract. Average monthly values for wind stress are provided for Gulf of Mexico and Atlantic regions. These wind stress values can be used as boundary conditions for numerical circulation models but only on coarse-grids.

Murray, S.P. 1975. Wind and current effects on large scale oil slicks. pp. 523-533. *In* 7th Annual Offshore Technology Conference, May 5-8, 1975.
Abstract. The relative effect of local winds and near-surface currents in determining the movement of oil slicks in coastal and shelf waters was determined from 39 surveys by Raydist-equipped helicopters during the Main Pass 41C spilloff the Mississippi Delta in March 1970. Orientation of oil slicks is closely controlled by local wind direction; slicks usually form 10°-40° to the right of the wind. Wind shifts associated with various sectors of migrating high-pressure cells quickly realign new slicks and actively dissipate old ones. Density fronts, both ambient and quasi-stationary, also play important roles in determining slick movement and size. An easily utilized regression model for slick area and orientation as a function of wind velocity and local conditions is also presented.

National Climatic Data Center. 1972. Environmental guide for the U.S. Gulf Coast. National Climatic Data Center. Asheville, NC. 177 pp.

National Climatic Data Center. 1983. Climatic summaries for NOAA data buoys. National Weather Service, NOAA Data Buoy Center. NSTL Station, MS. 214 pp.

National Climatic Data Center. 1984. Local climatological data, annual summary with comparative data - 1983, Mobile, AL. National Climatic Data Center. Asheville, NC. 4 pp.
Abstract. This is an annual NOAA publication which includes a local narrative climatological summary, the meteorological data for the current year and normals, means and extremes. In addition to this data, monthly average temperatures, and precipitation are presented.

Neumann, C.J. 1975. A Statistical Study of Tropical Cyclone Positioning Errors with Economic Applications. NOAA-TM-NWS-SR-82; NOAA-75090301. National Hurricane Center. Coral Gables, FL. 26 pp.
Abstract. Hurricane landfall forecasts are based heavily on the latest available motion vector and position of a storm. Inaccuracies in these data are closely related to errors in the time and place of storm landfall. The study uses a Monte Carlo simulation of hurricane positioning errors to determine a statistical relationship between positioning errors and landfall errors. It is shown that for a typical 18-hour landfall forecast, approximately 22% of the landfall position error can be attributed to initial data uncertainties. It is further shown that a 20% increase in the size of a hurricane warning zone can be expected if the currently observed positioning errors are increased an average of 10 nmi. However, a 10 nmi decrease in positioning error yields only an 11% decrease in the size of the warning area. An economic

analysis of potential changes in the size of hurricane warning areas is also shown. It is estimated that protection costs for a typical 300 nmi Gulf of Mexico coastal hurricane warning zone total $25.1 million.

Neumann, C.J. 1981. Some characteristics of Atlantic tropical cyclone forecast errors. Mar. Weather Log. 25(4):231-236.

Abstract. This paper is part of a study by Charles J. Norman and J. M. Pelissier (Monthly Weather Review, 1981) which involved the examination of approx. 1000 forecasts of tropical cyclone motion issued by the National Hurricane Center over the 10-yr period 1970-1979. The 12- and 24-hr forecast portions of the study which are of interest to mariners are examined. The forecast errors, the factors influencing forecast errors, interannual variation in forecast errors, and regional differences in forecast errors are discussed. It is shown that forecast errors for tropical cyclones are, on the average, directly proportional to the initial latitude of a storm; i.e., low-latitude storms generally have a low forecast error, and high-latitude storms have a high forecast error. An exception exists in the eastern Gulf of Mexico, where forecast errors are less than might be expected. This condition reflects persistence of storm motion in this portion of the Gulf, as well as a large amount of observational data.

Norwine, J.R. 1971. Cities, air pollution, and regional climate: A quantitative analysis of the relationships between climatological parameters and urban influences, primarily atmospheric pollution, in the six-state region of the United States Gulf of Mexico coastline. Ph.D. Dissertation. Indiana State University. 342 pp.

Nowlin, W.D., Jr. and C.A. Parker. 1974. Effects of a cold-air outbreak on shelf waters of the Gulf of Mexico. J. Phys. Ocean. 4(3):467-486.

Abstract. Two surveys of the waters over an area of the continental shelf in the northwestern Gulf of Mexico were made during January 1966. The first observation period was just before a major outbreak of cold, dry air; the second was about 15 days later with the region still under the influence of this outbreak. Waters were well mixed to 100 m, or the bottom in shallower depths. During the 15-day period temperature decreased nearly 5°C and salinity increased near the shore. Some 150 mi offshore, temperature decreased only 1-2°C and salinity showed no significant change.

Nummedal, D., S. Penland, R. Gerdes, W. Schramm, J. Kahn and H. Roberts. 1980. Geologic response to hurricane impact on low profile Gulf Coast barriers. Trans., Gulf Coast Assoc. Geol. Soc. 30:183-195.

Abstract. Hurricane Frederic made landfall near Pasagoula, Mississippi at midnight September 13, 1979. At the time of landfall the central pressure had dropped to 946 mb, onshore winds in excess of 200 km/hr were lashing the Alabama coastline and the open coast storm tide peaked at 365 cm at Gulf Shores, Alabama. Vertical aerial photography obtained in 1976 and again 9 days after Frederic made landfall, combined with multiple reconnaissance overflights and ground surveys by the authors provided the data base for determination of shoreline erosion and the distribution of hurricane scour and sedimentary deposits. Erosion of the Gulf beach at Dauphin Island proved to follow a predictable pattern controlled by nearshore bathymetry whereas retreat of the shoreline of the Mississippi

Sound margin was an unexpected occurrence, apparently due to a hydraulic jump as washover currents entered the deep water of Mississippi Sound. Large scale sediment redistribution on Dauphin Island proper was a consequence of the storm surge flood. However, the ebb surge was responsible for the reopening of three inlets across Little Dauphin Island. Hurricane Frederic also had a major impact on the Chandeleur Islands, Louisiana. Even though the maximum surge height on the left side of the hurricane track was only 1.3 m, pre-existing hurricane channels and washovers acted as conduits for the flood and ebb surge.

O'Neil, P.E., M.E. Mettee, E.J. McCallough, L.A. Acker and D.W. Wilson. 1982. Alabama coastal region ecological characterization. Volume 1. Coastal bibliography. FWS/OBS-82/21. U.S. Fish and Wildlife Service, Office of Biological Services. Washington, D.C. 404 pp.

Abstract. The primary goal of the Coastal Bibliography is to provide a comprehensive data base to potential users of Alabama's coastal areas and resources. The bibliography is comprised of published and unpublished studies that describe the socioeconomic structure and environmental setting of coastal Alabama. Entries include papers from professional journals, unpublished theses and dissertations, unpublished open-file reports, proceedings of symposia on coastal resources, existing bibliographies, and federally funded studies. References to on-going studies are also included. Bibliographic data were organized into a standardized format and indexed by keywords. These data were placed on computer tape and are managed using a computer-base information storage and retrieval system known as FAMULUS. Bibliographic entries may be retrieved by author and keywords.

O'Neil, P.E. and M.F. Mettee. 1982. Alabama coastal region ecological characterization. Volume 2. A synthesis of environmental data. FWS/OBS-82/42. U.S. Fish and Wildlife Service, Office of Biological Services. Washington, D.C. 346 pp.

Abstract. The Environmental Synthesis report consists of two parts. The first contains a detailed description of the natural environment of coastal Alabama relative to its biological, geological, and hydrological resources and processes. The second part presents a conceptual model of energy flow through major coastal ecosystems (freshwater, coastal terrestrial, estuarine and outer continental shelf) and interrelates them to modified and manipulated systems (urban, industrial, and agricultural) in Mobile and Baldwin Counties. Also included are detailed discussions and models of the estuarine ecosystem and one of its components, the marsh, as it relates to coastal Alabama.

Ostapoff, F. 1971. Ocean-atmosphere interaction in the Caribbean Sea: viewed from the oceanographic side. pp. 137-145. *In* Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions, Willemstad, Curacao, Netherlands Antilles, Nov. 18-26, 1968, Papers on physical and chemical oceanography, marine geology and geophysics, and marine biology. UNESCO, Paris.

Abstract. A brief review is given of the large-scale circulation and distribution of water masses once formed under specific climatological conditions at the sea surface, in far removed and widely departed areas, and advected into the Caribbean Sea. The heat and water budget in the area on a seasonal basis is described, and its impact on the oceanic

conditions, in particular, on the sea-surface temperature and salinity distribution. A numerical model on time scales of a few days, combining the atmospheric and oceanic boundary layers, is described with emphasis on the ocean layer. Examples are given with climatological atmospheric and oceanic data input from the area east of Barbados at about 13°N and 56°W. The model includes the simulation of eddy fluxes in stratified flow, mixing due to wind-generated waves on the sea-surface, and cloud-dependent radiative heating. Results will be discussed in terms of diurnal current variations, temperature variations, and salinity variations. An important aspect of ocean-atmospheric interaction in the area is the effect on the ocean of extreme atmospheric forces of short duration, such as a hurricane moving through the Caribbean. An example is presented of the sea-surface temperature distribution as measured in the Gulf of Mexico with IR - instrumented aircraft, after a hurricane. Cold water upwelling in the wake of the storm leaves a temperature signature at the sea-surface. The temperature depression may amount to 5°C. With the help of available technology and the use of aircraft, important problems of time response of the ocean to atmospheric forces may be studied under partially controlled conditions. The Caribbean may be an ideal place where such a complex process may be carried out.

Overland, J.E. 1975. Estimation of hurricane storm surge in Apalachicola Bay, Florida. United States National Oceanic and Atmospheric Administration, National Weather Service, Technical Report. NOAA TR NWS-17:66.

Abstract. A vertically integrated two-dimensional numerical hydrodynamic model is developed for simulation of hurricane surge in Apalachicola Bay. Standard explicit time differencing is used in conjunction with a single Richardson lattice. Model features include finite amplitude effects, space variable wind velocities, parameterization of flooding of terrain, overtopping of barrier islands, and flow through narrow passes. The model uses the results of C. P. Jelesnianski's SPLASH model computation for open coast surge as input seaward of the Bay and continues the same storm track and wind field as used in the SPLASH computation across the Bay. The Bay model was calibrated for the astronomical tides and verified against hurricane Agnes. The response of Apalachicola Bay has been determined from numerical computations for a variety of hypothetical hurricanes as specified by various storm parameters. Surge heights in the Bay increase with hurricane central pressure depression in a nearly linear fashion as does the open coast surge. An important parameter is the duration that the open coast surge remains high, a function of the forward speed of the storm and, to a lesser extent, the radius of maximum winds. Surge heights in the Bay increased relative to open coast surge values for slow moving storms. For bays of the extent of Apalachicola Bay, basin orientation relative to wind direction, headlands, and marsh areas can produce significant local variations in surge heights.

Parungo, F. and J. Miller. 1988. Air chemistry studies over the Gulf of Mexico: A bilateral scientific cooperative project between the United States of America and Mexico; Technical Memo. NOAA-TM-ERL-ESG-29. National Oceanic and Atmospheric Administration. Boulder. 254 pp.

Abstract. The report documents the scientific research of a bilateral cooperative project between the United States of America and The United States of America. In 1986 scientists from both nations joined a research cruise in the Gulf of Mexico to investigate the air chemistry over the

water that the two nations share. Emphases were placed on natural air quality, anthropogenic air pollution, acid rain, air-sea-land exchanges of gases and aerosols. The investigation included in-situ measurements and post-cruise laboratory analyses. Chemical, physical, meteorological, and oceanographic analyses were conducted to survey temporal and spatial variations of diverse parameters throughout the Gulf. The data sets were analyzed, interpreted, and intercorrelated. The results show that during the cruise (20 July-22 August), the large-scale air trajectories were easterly from the Caribbean Sea at all levels; however, the Gulf air measured was highly polluted in general.

Parungo, F., C. Nagamoto, S. Hoyt and A.H. Bravo. 1990. The investigation of air quality and acid rain over the Gulf of Mexico. Atmospheric Environment, Part A [General Topics]. NOAA/ERL. 24A(1):109-123.

Abstract. A research cruise was conducted in the summer of 1986 by a group of scientists from the USA and Mexico to investigate air chemistry over the Gulf of Mexico. Chemical, physical, meteorological and oceanographic measurements were carried out to survey temporal and spatial variations of diverse parameters throughout the Gulf. Emphases were placed on air-sea-land exchange of gases and aerosols, natural air quality, transport of anthropogenic air pollution and acid rain deposition to the Gulf. Although the prevailing winds were easterly from the sea during the cruise, the air was highly polluted with continental aerosols, probably caused by local shifting winds and the oscillation between sea breeze and land breeze. The life cycles of the aerosols in the Gulf, including sources, transport, transformation and wet and dry deposition are discussed.

Paskausky, D.F. 1971. Numerically predicted changes in the circulation of the Gulf of Mexico accompanying a simulated hurricane passage. J. Mar. Res. 29(3):214-225.

Pearl, E.W. 1976. Description of mesoscale systems. pp. 33-42. *In* Role of the Gulf of Mexico in the Weather of the United States: A Conference on Meteorology over and near the Gulf. TAMU, College Station, TX.

Penland, S. and J.R. Suter. 1984. Process response models for Gulf Coast barrier island breaching. Trans., Gulf Coast Assoc. Geol. Soc. 36:397-400. Thirty-fourth annual meeting of the Gulf Coast Association of Geological Societies, Oct. 24-26, 1984.

Abstract. The analysis of 17 tropical cyclone impacts along the U.S. Gulf Coast leads to the following conclusions regarding barrier island breaching: 1) tropical cyclones are the mechanisms of barrier island breaching, 2) landward and seaward overwash flow can breach barrier islands, 3) storm track orientation controls the direction of barrier island breaching, 4) shore-normal and right-oblique hurricane impacts breach barrier islands by landward overwash flow, and 5) left-oblique hurricane impacts breach barrier island by seaward overwash flow.

Philander, S.G.H. 1992. Ocean-atmosphere interactions in the tropics: a review of recent theories and models. J. Appl. Meteorol. 31:938-945.

Pielke, R.A. 1976. Models of environmental sciences. pp. 55-67. *In* Role of the Gulf of Mexico in the Weather of the United States: A Conference on Meteorology over and near the Gulf. TAMU, College Station, TX.

Pielke, R.A. 1990. The Hurricane. Routledge. London, England. 227 pp.
Abstract. This book describes tropical cyclones in a non-mathematical framework and includes over. 200 charts and photographs. The book begins with a description of the geographical and seasonal distribution of tropical cyclones. It looks at the mechanisms of formation and development and outlines the controls on tropical cyclone movement. The impact of these storms is then described, both on land and over the ocean. Finally, the book examines tropical cyclone forecasting techniques and the attempts made at modification. The appendices include a climatology of tropical cyclone tracks in the Atlantic Ocean and Gulf of Mexico from 1871 to 1989, and a tracking map that the reader can use for future cyclones.

Ponte, R.M. 1993. Variability in a homogeneous global ocean forced by barometric pressure. Dynamics of Atmospheres and Oceans. 18(3-4):209-234.
Abstract. The oceanic response to pressure loading is explored using a constant-density, shallow-water numerical model driven by atmospheric pressure fields. Meridional gradients in mean sea-level are generally large (10-20 cm over 20-30 degrees), particularly in high southern latitude. Sea-level variability is strong in mid- and high latitudes (typical standard deviations of 10-15 cm), but weakens towards the equator. The results indicate a significant contribution of pressure-drive fluctuations to the observed large-scale sea-level variability in mid-and high latitudes away from western boundary regions. Pressure-induced velocity signals are generally small. The validity of the inverted barometer approximation is strongly dependent on frequency and geographical location. Globally, the approximation is not reliable for periods shorter than approximately 2 days; but failure at longer periods occurs over extensive regions (e.g. the tropical Atlantic and Pacific, and the Southern Ocean). Non-isostatic contributions to the sea-level variability are substantial in many areas, including the tropics, the high-latitude North Atlantic, the Gulf of Mexico, and several other boundary regions.

Quayle, R.G. and D.C. Fulbright. 1977. Wind and wave statistics for north American, Atlantic, and Gulf coasts. Mar. Weather Log. 21(1):13-14.

Rabin, R.M., L.A. McMurdie and C.M. Hayden. 1992. Layered precipitable water from the infrared VAS sounder during a return-flow event over the Gulf of Mexico. J. Appl. Meteorol. 31:819-830.

Rabin, R.M., L.A. McMurdie, C.M. Hayden and G.S. Wade. 1993. Evaluation of the atmospheric water budget following an intense cold-air outbreak over the Gulf of Mexico-application of a regional forecast model and SSM/I observations. J. Appl. Meteorol. 32(1):3-16.
Abstract. The atmospheric water budget is examined for a 12-day period following an intense cold-air outbreak over the Gulf of Mexico. Budget terms are compared using analyses from the US National Meteorological Center's operational Nested Grid Model (NGM) and using precipitable water and surface wind speed estimated from the Special Sensor Microwave/Imager (SSM/I) instrument aboard the defense meteorological satellite FS. The

atmospheric-storage term, determined from the areal-averaged total precipitable water, does not differ significantly between that obtained from the NGM and that obtained from SSM/I data. The storage increases by a factor of more than 3 during the initial five days following the passage of the surface high over the Gulf. Horizontal flux divergence of water vapor computed from the full vertical structure in the NGM output is well approximated by the substitution of the surface-700-mb mean wind and the total precipitable water for the vertical profiles along the boundaries of the atmospheric volume. Evaporation from the sea surface is determined using GOES surface temperatures and NGM surface air conditions.

Ramsdell, J.V. and J.D. Thompson. 1981. Surface stress estimation for study of the circulation dynamics of the Gulf of Mexico. NORDA Technical Report 113. Naval Ocean Research and Development Activity. NSTL Station, MS. 20 pp.

Abstract. This report presents the results of a literature search concerning estimation of wind stress over large bodies of water and an evaluation of several sets of stress estimates for the Gulf of Mexico. Wind stress can be estimated directly from wind observations or indirectly from atmospheric pressure by using the pressure gradients and the geostrophic relation. In regions where wind data are sparse, as in the Gulf of Mexico, the use of the indirect method is more practical. The major problems considered in stress estimation are: treatment of the drag coefficient that relates wind to stress, spatial and temporal averaging of the data before and after making stress estimates, and empirical corrections to be applied to winds computed from pressure gradients.

R. Dixon Speas Associates. 1970. Joint Upper Gulf Coast Regional Air Transportation Study, Vol. I. Clearinghouse for Federal, Scientific, and Technical Information. Washington, D.C. 210 pp.

Rhodes, R.C., J.D. Thompson and A.J. Wallcraft. 1989. Buoy-calibrated winds over the Gulf of Mexico. J. Atmos. Oceanic Technol. 6(4):608-623.

Abstract. The large variability of the Gulf of Mexico wind field indicates that high-resolution wind data will be required to represent the weather systems affecting ocean circulation. The report presents methods and results of the calculation of a corrected geostrophic wind data set with high temporal and spatial resolution. Corrected geostrophic wind was calculated from surface pressure analyses compiled by the Fleet Numerical Oceanography Center. The correction factors for wind magnitude and direction were calculated using linear regressions of observed Gulf buoy winds and geostrophic winds derived at the buoys. The regressions were performed for each month to determine the seasonal variability of the correction factors. The corrected geostrophic wind was calculated twice daily from 1967-1982 on a spherical grid over the Gulf, together with the corresponding wind stress and wind stress curl fields.

Rhodes, R.C., A.J. Wallcraft and J.D. Thompson. 1985. Navy-corrected geostrophic wind set for the Gulf of Mexico. NORDA Tech. Note. 310:112.

Ricks, E.L. 1981. Some empirical rules for forecasting fog and stratus over northern Florida, southern Georgia, and adjacent coastal waters. NOAA/NWS Tech. Memo. SR-104:9.

Abstract. The formation and characteristics of sea fog and stratus near the northwestern Florida coast, near fronts or troughs over northern Florida, and in association with anticyclones over the southeastern U.S., and the characteristics of these hydrometeors are described; and empirical rules for forecasting them are presented. Strong low-level winds, especially strong vertical wind shears, generate and maintain enough mixing below the subsidence inversion over southern Georgia and northern Florida to counteract or inhibit low stratus and fog formation. Weaker northeastern and eastern winds favor low stratus and fog formation over southern Georgia and northern Florida when the trajectory is from the Atlantic coast. The same empirical rules seem to apply over the Florida panhandle and southwestern Georgia under a southerly wind regime with a trajectory from the Gulf of Mexico.

Rodgers, E.B., S.W. Chang, J. Stout, J. Steranka and J.J. Shi. 1991. Satellite observations of variations in tropical cyclone convection caused by upper-tropospheric troughs. J. Appl. Meteorol. 30(8):1163-1184.

Abstract. Examines the mutual adjustment between upper-tropospheric troughs and the structure of western Atlantic Tropical cyclones Florence (1988) and Irene (1981). The study suggests that the initiation and maintenance of intense convective outbreaks in these tropical cyclones during their mature stage are related to the channeling and strengthening of their outflow by upper-tropospheric troughs. The convection can be enhanced in response to the outflow jet-induced import of eddy relative angular momentum and ascending motion associated with the thermally direct circulation. Channeling and strengthening of the outflow occur when the upper-tropospheric troughs are located in a favorable position relative to the tropical cyclones. Both Florence and Irene intensify after the onset of these intense convective episodes. Satellite observations also suggest that the cessation in the convection of the two tropical cyclones occurs when the upper-tropospheric troughs move near or over the tropical cyclone.

Rogers, R.F. and R.E. Davis. 1993. The effect of coastline curvature on the weakening of Atlantic tropical cyclones. International Journal of Climatology. 13(3):287-299.

Abstract. This study attempts to determine the relationship between the curvature of the coastline and the filling (increase in central pressure) of hurricanes and tropical storms by comparing both the rate of filling and the total filling for storms striking convex, concave, and linear coastlines. The USA and Mexican coastline was approximated by a subjective smoothing procedure, and the coastal curvature corresponding to each landfalling Atlantic tropical cyclone from 1900 to 1979 was measured and grouped into one of the three curvature categories. Storm-filling rates and total amounts of filling were determined before and after landfall by computing the change in wind speed for various Saffir-Simpson hurricane intensity categories. The averages of these variables within each strength and curvature grouping were compared in order to determine if they were statistically different. Storms were also compared in order to determine if stronger storms fill a greater total amount than weaker storms, regardless of the coastline's curvature.

Salsman, G.G. and A.J. Ciesluk. 1978. Environmental conditions in coastal waters near Panama City, Florida. Naval Coastal Systems Center Technical Report. NCSC-TR-337-78:89.

Abstract. A comprehensive summary of information regarding the coastal waters. Includes topics such as: hydrography, meteorology, bottom characteristics, tides, currents, waves, and biofouling.

Saltzman, B., W. Ebisuzaki, K.A. Maasch, R. Oglesby and L. Pandolfo. 1991. Nonlinear dynamics of global atmospheric and earth-system processes. Yale University. New Haven, CT. 2 pp.

Abstract. General Circulation Model (GCM) studies of the atmospheric response to change boundary conditions are discussed. Results are reported on an extensive series of numerical studies based on the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM) general circulation model. In these studies the authors determined the response to systematic changes in atmospheric CO_2 ranging from 100 to 1000 ppm; to changes in the prescribed sea surface temperature (SST) in the Gulf of Mexico, such as occurred during the deglaciation phase of the last ice age; to changes in soil moisture over North America; and to changes in sea ice extent in the Southern Hemisphere. Study results show that the response of surface temperature and other variables is nearly logarithmic, with lower levels of CO_2 implying greater sensitivity of the atmospheric state to changes in CO_2. It was found that the surface temperature of the Gulf of Mexico exerts considerable control over the storm track and behavior of storm systems over the North Atlantic through its influence on evaporation and the source of latent heat. It was found that reductions in soil moisture can play a significant role in amplifying and maintaining North American drought, particularly when a negative soil moisture anomaly prevails late in the spring.

Schreiner, A.J., C.M. Hayden and C.A. Paris. 1992. A study of satellite-derived moisture with emphasis on the Gulf of Mexico. J. Appl. Meteorol. 31(7):742-757.

Abstract. Visible-Infrared Spin Scan Radiometer (VISSR) Atmospheric Sounder (VAS) moisture retrievals are compared to the National Meteorological Center Regional Analysis and Forecast System (RAFS) 12-h forecast and to 1200 UTC rawinsondes over the United States and the Gulf of Mexico on a daily basis for nearly 1.5 years. The principal objective is to determine what information the current moisture retrievals add to that available from the RAFS and surface data. The data are examined from the climatological perspective, that is, total precipitable water over the seasons for three geographical regions, and also for synoptic applications, that is, vertical and horizontal resolution.

Schroeder, W.W. 1975. Meteorological and oceanographic observations made during Hurricane Carmen (September 1974) At Dauphin Island, Alabama. Dauphin Island Sea Laboratory, Technical Report. 75-003

Schroeder, W.W. 1975. Meteorological and oceanographic observations made during Hurricane Eloise (September 1975) At Dauphin Island, Alabama. Dauphin Island Sea Laboratory, Technical Report. 75-004

Schroeder, W.W. 1976. Physical environmental atlas of coastal Alabama. MASGP-76-034. Mississippi-Alabama Sea Grant Consortium. Ocean Springs, MS. 275 pp.

Abstract. This is an atlas of physical oceanographic data, meteorological data, and hydrologic data for Mobile Bay, eastern Mississippi Sound, and selected nearshore Gulf locations of coastal Alabama. The data were collected from 1973 to 1976. This publication is an atlas in the truest sense in that data are presented as facts without any interpretation. The great majority of this atlas presents data on East Mississippi Sound and Mobile Bay. Data presented include wind, tide, temperature, salinity, dissolved oxygen and currents. The part on the offshore environment presents current measurements collected with a taut-line buoy system anchored adjacent to a Liberty Ship reef some 14 nautical miles south of Dauphin Island. The last part of the atlas presents meteorological data collected at Dauphin Island. Supplements to the atlas are compiled yearly beginning with 1977.

Schroeder, W.W., R. Horton and L. Lutz. 1979. 1978 meteorological data summary, Dauphin Island, Alabama, Technical Report 80-001. Dauphin Island Sea Lab. Dauphin Island, AL.

Abstract. This technical report is part of a series of reports presenting meteorological data collected at the Dauphin Island Sea Lab. The data presented are supplemental to meteorological data found in the "Physical Environment Atlas of Coastal Alabama" (1976).

Schroeder, W.W., R. Horton and L. Lutz. 1980. 1979 meteorological data summary, Dauphin Island, Alabama, Technical Report 80-001. Dauphin Island Sea Lab. Dauphin Island, AL.

Abstract. This technical report is part of a series of reports presenting meteorological data collected at the Dauphin Island Sea Lab. The data presented are supplemental to meteorological data found in the "Physical Environment Atlas of Coastal Alabama" (1976).

Schroeder, W., O. Huh, L. Rouse and W. Wiseman. 1987. Satellite observations of the circulation east of the Mississippi Delta: cold-air outbreak conditions. Remote Sensing Environ. 18:49-58.

Schroeder, W.W. and W.J. Wiseman. 1985. Analysis of the winds (1974-1984) and sea level elevations (1973-1983) in coastal Alabama. MASGP-84-024; NA81AA-D-00050. Alabama Marine Resources Laboratory. Dauphin Island. 112 pp.

Abstract. Monthly and annual wind roses, constructed from 10.5 years of data collected on Dauphin Island, Alabama, exhibit a high degree of variability. However, monthly composite roses present a recognizable seasonal pattern: northerly winter winds; easterly to southerly spring winds; southerly to westerly and back to easterly winds in the summer; and in the fall a return to northeasterly and northerly winds. Mean monthly wind speeds ranged from a high of 8.1 k in January to a low of 5.2 k in July. On a directional interval basis the highest mean speed, 9.5 k, occurred during northerly winds while the lowest mean speed, 4.9 k, occurred during westerly winds. Sustained wind speeds of 30 k or greater were recorded during tropical cyclones, a winter 'cold front' storm and a thunderstorm.

Science Applications International Corporation. 1988. Summary of meteorological conditions affecting oceanographic processes in the Gulf of Mexico, Final Report, MMS Met Study, Contract No. 10-1001-303, 173p.

Abstract. This meteorological summary consists of a compilation of data from a number of sources and a statistical description by month, season and year of the pertinent meteorological variables affecting oceanographic operations in the Gulf of Mexico region. The primary data sets utilized in this study are as follows: National Weather Service (NWS) coastal station data; National Data Buoy Center (NDBC) moored-buoy and marine platform network; a segment of the Ocean Currents Measurement Program (OCMP) data; National Hurricane Center 101-year storm track data (HURDAT) and the University of Virginia Cyclone data set. The coastal data covers the period 1970-1986, while the buoy data exists for only 1976-1986. The hurricane and cyclone climatologies are for 101 and 100 years, respectively. In addition, a ship-based sea surface temperature (SST) climatology is analyzed by 1° quadrangles for the period 1854-1973. The analyses included in this report should provide useful information on the variability of meteorological conditions in the Gulf of Mexico.

Scoggins, J.R. 1976. Diurnal and seasonal variations in mesoscale systems. pp. 43-53. *In* Role of the Gulf of Mexico in the Weather of the United States: A Conference on Meteorology over and near the Gulf. TAMU, College Station, TX.

Scoggins, J.R., J. Arellano, B. Esposito, G.A. Johnson and K.C. Brundidge. 1991. Report on a symposium on "Air-Sea Interaction and Air Mass Modification over the Gulf of Mexico," 7-9 January 1991, Galveston, Texas. Cooperative Inst. for Applied Meteorological Studies. College Station, TX. 7 pp.

Abstract. A Workshop on Atmospheric Forcing of Ocean Circulation (Scoggins and Mooers 1988), and a study called GUFMEX over the Gulf of Mexico in 1988 called attention to the importance of the Gulf of Mexico on the weather over much of the United States east of the Rocky Mountains, and the need to summarize what is known about air-sea interaction and air mass modification over the Gulf. This symposium provided a forum for operational and research meteorologists and oceanographers to present and discuss the state of knowledge of air-sea interaction and air mass modification over the Gulf, and to provide the basis for improved numerical models and weather forecasts particularly for the Gulf coast area. However, areas other than the Gulf were considered in some of the papers. the symposium was divided into four sessions. they were: (1) Measurements; (2) Air Mass Modification; (3) Modeling; and (4) Forecasting. It was recognized by the planning committee that overlap between the sessions was inevitable, but this breakdown seemed to beast characterize the papers and the themes of the symposium.

Shay, L.K., P.G. Black, A.J. Mariano, J.D. Hawkins and R.L. Elsberry. 1992. Upper ocean response to Hurricane Gilbert. J. Geophys. Res. 97(C12):20227-20248.

Abstract. The evolving upper ocean response excited by the passage of hurricane Gilbert (September 14-19, 1988) was investigated using current and temperature observations acquired from the deployment of 79 airborne expendable current profilers (AXCPs) and 51 airborne expendable bathythermographs from the National Ocean and Atmospheric Administration

WP-3D aircraft in the western Gulf of Mexico. The sea surface temperatures (SSTs), mixed layer depths, and bulk richardson numbers were objectively analyzed to examine the spatial variability of the upper ocean response to Gilbert. Net decreases of the SSTs of 3° - 4°C were observed by the profilers as well as by the airborne infrared thermometer (AIRT) along the flight tracks and advanced very high resolution radiometer (AVHRR) imagery. The AXCPs indicated a marked cooling from 29°C to about 25.5°C on September 17, 1988, which was about 1.2 inertial periods (IP) following storm passage. This pool of cooler water (3.5°C) was located further downstream in the hurricane wake by September 19 (2.7 IP following the storm) as a result of the near-inertial currents in the mixed layer.

Shay, L.K., S.W. Chang and R.L. Elsberry. 1990. Free surface effects on the near-inertial ocean current response to a hurricane. J. Phys. Ocean. 20(9):1405-1424.

Abstract. During the passage of hurricane Frederic in 1979, four ocean current meter arrays in water depths of 100-950 m detected both a baroclinic and a depth-independent response in the near-inertial frequency band. The origin of the depth-independent component of velocity is investigated using a linear analytical model and numerical simulation from a 17-level primitive equation model with a free surface. In an analytical model, the Green's function (K_0) is convolved with the wind stress curl to predict a sea surface depression of approximately 20 cm from the equilibrium position. The barotropic current velocities rotate inertially, and the maximum amplitude of 11 cm/s is displaced to the right of the track at $x=2R_{max}$ (radius of maximum winds). The free surface depression simulated by the primitive-equation model is also about 18-20 cm. The primitive equation model simulations indicate that the vertical mean pressure gradient excites 10-11 cm/s depth-averaged currents at $x=3R_{max}$.

Shay, L.K. and R.L. Elsberry. 1983. Observations of inertio-gravity waves in the wake of Hurricane Frederic. EOS, Trans. AGU. 64(45):739. Spring Meeting, American Geophysical Union, Baltimore, MD (USA), 31 May 1983.

Abstract. Hurricane Frederic passed within 80 to 130 km of a U.S. Naval Oceanographic Office current meter array. The transient response detected in the DeSoto Canyon region is dominated by inertial wave excitation in the mixed layer with vertical propagation of energy at about 3 cm/s. The corresponding horizontal propagation of energy is 3 m/s. The observations were demodulated at the inertial frequency. The demodulated series show that inertial waves in the mixed layer maintain a constant energy level over one to two inertial periods (IP) after the relaxation of the wind stress, and then decay over e-folding time scales of 4 IP. The horizontal scales of 100 km or roughly twice the radius of deformation. Vertical phase differences are consistent with the subsequent generation of inertio-gravity waves in the thermocline. These waves spin up with the horizontal scales of the deformation radii (50 km) and reach secondary maxima 6 to 10 IP following storm passage. After these maxima, energy decays over e-folding scales of 4 IP as well. Vertical scales are of the order of the water depth. The vertical structure of 3-dimensional velocity fields was determined using a Brunt-Vaisala profile computed from the AXBT data collected by Black (1983).

Shay, L.K. and R.L. Elsberry. 1987. Near-inertial ocean current response to Hurricane Frederic. J. Phys. Ocean. 17(8):1249-1269.

Abstract. Hurricane Frederic passed within 80 to 130 km of the U.S. Naval Oceanographic Office current meter arrays in water depths ranging from 100 to 470 m near the DeSoto Canyon region, and within 150 km of an Ocean Thermal Energy Conversion (OTEC) mooring in 1050 m of water. Excitation of near-inertial waves by the moving hurricane was observed throughout the water column along the canyon walls and at the OTEC site. The vertical modes of the ocean current field are determined based on AXBT data. Solutions with a flat bottom and with a sloping bottom are compared to illustrate the effect due to bottom topography in the DeSoto Canyon region. The horizontal velocity eigenfunctions are fit to the velocity amplitudes derived from the ocean current time series to estimate the time-dependent modal amplitudes.

Shenk, W.E. and E.B. Rodgers. 1978. Nimbus-3/ATS-3 observations of the evolution of Hurricane Camille. J. Appl. Meteorol. 17(4):458-476.

Abstract. Three periods within the life cycle of Hurricane Camille (1969) are examined with radiometric and camera measurements from Nimbus-3 and camera information from ATS-3 in conjunction with conventional information. These periods are the deepening phase, the interaction of Camille with mid-latitude westerlies, and the excessive rain-producing period when the cyclone was over the central Appalachians. Just prior to significant deepening, the Nimbus-3 medium resolution infrared radiometer (MRIR) window and water vapor channels showed a band of developing convection that extended to the cirrus level in the southeastern quadrant of the storm, which originated from the ITCZ. Low-level wind fields were derived from conventional sources and from cumulus clouds tracked from a series of ATS-3 images. Within this band were low-level, 30-knot winds that supplied Camille with strong inflow where the air passed over sea surface temperatures that were 1-3 standard deviations above normal. At the beginning of the rapid deepening, the MRIR radiometer measurements indicated a rapid contraction of the central dense overcast and, then, an expansion as the maximum deepening rate occurred. Simultaneously, the increase in the MRIR equivalent blackbody temperatures indicated the development of large-scale subsidence throughout the troposphere northwest of the center. When Camille weakened as it moved over the lower Mississippi Valley, the cyclone acted as a partial obstruction to the synoptic-scale flow and increased the subsidence west and north of the cyclone center, as indicated by the increase in water vapor and verified by three-dimensional trajectories.

Sheres, D. 1992. SAR Observations in the Gulf of Mexico, *In* Summaries of the Third Annual JPL Airborne Geoscience Workshop. Jet Propulsion Laboratory. 3:30-31. University of Southern Mississippi, Bay Saint Louis. Center for Marine Science.

Abstract. The Gulf of Mexico (GOM) exhibits a wealth of energetic ocean features; they include the Loop Current with velocities of about 2 m/s and strong shear fronts, mesoscale eddies, double vortices, internal waves, and the outflow of the 'Mighty Mississippi' River. These energetic features can have a strong impact on the economies of the states surrounding the Gulf. Large fisheries, oil and gas production as well as pollution transport are relevant issues. These circulation features in the Gulf are invisible to conventional IR and visible satellite imagery

during the Summer months due to cloud cover and uniform surface temperatures. Synthetic Aperture Radar (SAR) imagery of the Gulf does penetrate the cloud cover and shows a rich assembly of features there year-round. Below are preliminary results from GOM SAR imagery taken by SEASAT in 1978 and by the AIRSAR program in 1991.

Signorini, S.R., J.S. Wei and C.D. Miller. 1992. Hurricane-induced surge and currents on the Texas-Louisiana shelf. J. Geophys. Res. 97(C2):2229-2242.

Abstract. This study consists of numerical model simulations of hurricane-induced surge and currents on the Texas-Louisiana shelf. The numerical experiment includes the simulation of multiple hurricane tracks with landfalling points along the Texas-Louisiana coast. A parallel storm that traverses the entire Texas-Louisiana coastline is also modeled to assess the difference in shelf response between landfalling and parallel storms. The grid extends from the Texas-Mexico border to the Gulf Coast of Florida, with the ocean open boundary seaward of the shelf break. Along-shelf and cross-shelf surge and current variability are assessed as a function of shoreline geometry and bottom topography. A complementary one-dimensional mixed layer model is used to evaluate the vertical structure of the currents and the maximum depth of hurricane influence.

Simpson, R.H. and M.B. Lawrence. 1971. Atlantic hurricane frequencies along the U.S. Coastline. NOAA-TM-NWS-SR-58. National Weather Service, Southern Region. Fort Worth, TX. 19 pp.

Abstract. From a recently completed climatology of hurricanes at the National Hurricane Center covering a period of 85 years of record, the total number of incidents and the frequency of hurricanes and tropical storms for 50-mile segments of the U. S. Gulf of Mexico and Atlantic coastlines are presented.

Smith, K.S. 1990. Investigation of a gravity wave during GALE: 6 February 1986. Master's Thesis. Air Force Institute of Technology. 79 pp.

Abstract. A mesoscale inertia-gravity wave that propagated northeastward across the southeastern United States on 6 February 1986 is investigated. Barograph traces and surface pressure perturbations based on hourly observations were used to trace the wave to its origin in the northwest Gulf of Mexico. The analysis shows that the wave propagated in the direction of the mid- and upper-tropospheric flow for over 19 hours at a mean speed of 25 ms^{-1}. The wave initially expanded as an arc, but the northern edge became bounded by a frontal system. Over the entire event, the half-period ranged from 25 minutes near its origin to 2 hours at the U.S. east coast. The half-wavelength is about 130 km with a crest to trough pressure range of less than 1.0 up to 5.7 mb along the axis of propagation. Potential source mechanisms for the gravity wave were examined. These included orographic forcing; shear instability; geostrophic adjustment; density impulses and convection. Available evidence leads to the conclusion that intense and explosively growing convection provided the initial energy. After its initiation the gravity wave marked the sharp western edge of a convective line moving eastward along the Gulf Coast. The long-lived horizontal propagation of the gravity wave is shown to be the result of a ducting structure within the mean flow. This structure was revealed by Richardson number and critical

level profiles at several sounding stations along the wave path. The duct is eventually disrupted by the frontal structure which marks the northern edge of the gravity wave.

Smith, P.M. 1981. Measurements of whitecap coverage and surface winds over the Gulf of Mexico Loop Current. NORDA-43. Naval Ocean Research and Development Activity. NSTL Station, MS. 28 pp.

Abstract. The fraction of the ocean surface covered by whitecaps has long been thought to be some monotonically increasing function of the prevailing wind velocity at least for large fetches. In order to determine the extent to which other factors such as air column stability or water mass type can influence the areal coverage of whitecaps, photographic data was collected over the Loop Current from a NAVOCEANO P-3 aircraft. The variation of whitecap coverage along a line of closely spaced (25 km) stations was determined and compared with other aircraft and data buoy information. The data indicates that, on the day of the flight, white-capping within the boundaries of the Loop Current depended little on the local wind, but demonstrated a noticeable dependence on air column stability. The strength and nature of this dependence varied over mesoscale distances. These results indicate that microwave radiometric measurements can be sensitive to variables other than surface wind since microwave brightness is quite sensitive to sea foam. The value of areal whitecap coverage as a measurable geophysical variable is also examined.

Sparks, P., E.J. Baker, J. Belville and D.C. Perry. 1991. Hurricane Elena, Gulf Coast, August 29-September 2, 1985, Natural Disaster Studies, Volume Two. National Academy Press. Washington, D.C. 121 pp.

Abstract. This report concentrates on three aspects of Hurricane Elena: (1) forecasting and collection of meteorological data; (2) evacuation procedures; and (3) the performance of buildings and other structures in the storm. The weather system that eventually became Hurricane Elena was initially identified as a well-organized cloud pattern north of the Cape Verde Islands on August 23, 1985. The system moved westward across the tropical Atlantic Ocean at an unusually fast speed (34 mph) and continued through the Caribbean to Cuba. It intensified and was named Elena on August 28 while situated on the northern coast of Cuba. As the storm moved north-northwest across the Gulf of Mexico, Elena strengthened rapidly and was classified a hurricane on August 29. On August 30, the storm began to decrease its forward speed dramatically. Late on August 30, while located about 200 miles southeast of the mouth of the Mississippi River, Elena made a sudden turn to the east. On August 31 through September 1, this storm moved toward the Florida coast and stalled about 50 miles offshore from Cedar Key. During the afternoon of September 1, Hurricane Elena once again turned westward, increased its forward speed to 10-15 mph, and finally moved ashore at Biloxi, Mississippi, about sunrise on Labor Day, September 2. Hurricane Elena was a rare Gulf of Mexico storm in that it caused hurricane warnings to be issued along an extensive section of the Gulf Coast from Grand Island, LA, to Sarasota, FL.

Spencer, R.W., B.B. Hinton and W.S. Olson. 1983. Nimbus-7 37 GHz radiances correlated with radar rain rates over the Gulf of Mexico. J. Climate Appl. Met. 22(12):2095-2099.

Abstract. A comparison between 37 GHz SMMR brightness temperatures and rain rates derived from radars at Galveston, Texas, and Apalachicola, Florida, showed that the brightness temperatures explained 72% of the variance of the rain rates. The functional form relating these data was significantly different from that predicted by models of radiative transfer through plane-parallel clouds. An hypothesis is offered for the cause of the observed polarization.

Sperber, K.R. and S. Hameed. 1992. Coupled ocean-atmosphere GCM simulation of Southern Oscillation phenomena. pp. 5. *In* Brazilian Meteorological Congress: Climate Change and the Environment (7th), Sao Paulo (Brazil), 28 Sep.-2 Oct. 1992. Department of Energy, Washington, D.C.

Abstract. The Oregon State University coupled upper ocean-atmosphere GCM has, been shown to qualitatively simulate the Southern Oscillation. A composite analysis of the warm and cold events simulated in this 23-year integration has been performed. During the low phase of the SO, when warm anomalies occur in the Eastern Pacific the model simulates for the Atlantic region during March--May (1) a deficit of precipitation over the tropical South American continent (2) Caribbean and Gulf of Mexico sea-level pressure and sea-surface temperature are in-phase with the Eastern Pacific anomalies, while those East of the Nordeste region are out-of-phase (3) northeast trade winds are anomalously weak and southwest trade winds are anomalously strong (as inferred from surface current anomalies). During the high phase of the simulated Southern Oscillation conditions in the atmosphere and ocean are essentially the reverse of the low phase. Thus the model produces a response in the South American region during the opposing phases of the Southern Oscillation which is in general agreement with observations.

Spring, W. 1978. An investigation of the distribution of hurricane generated wave heights. Ph.D. Dissertation. New York University, School of Engineering and Science. 172 pp.

Abstract. A method described by Borgman (1973), to determine wave data fit to a probability distribution was used to test the Rayleigh, Forristall and a mean height distribution with Gulf of Mexico hurricane and tropical storm data. The mean height distribution employs empirically determined shape and exponential coefficients and the record mean wave height is used to normalize wave heights. The poorest fit was shown to be the Rayleigh Distribution with the mean height distribution slightly worse than the Forristall distribution. When shape coefficients were not specified and exponential coefficients tested, the best results were found by using a mean height distribution which allowed the exponential coefficient to vary with each record. Attempts to use this distribution with significant wave height dependent shape and exponential coefficients resulted in a slightly worse fit than the Forristall Distribution. Plots of the variation of the shape and exponential coefficients with significant wave height are presented and a recommendation for the use of significant wave height dependent coefficients in future attempts to determine wave height distributions is made.

State University System of Florida, Institute of Oceanography. 1975. Compilation and summation of historical and existing physical oceanographic data from the eastern Gulf of Mexico in support of the

MAFLA sampling program. BLM/YM/ES-75/1. Bureau of Land Management. Washington, D.C. 292 pp.

Abstract. Physical oceanography has a dual role in determining the environmental implications of development of the Outer Continental Shelf (OCS). It is intrinsically important to determine physical parameters to predict dispersion of materials in OCS waters, but the role of physical oceanography is equally important in the support it must give to other oceanographic disciplines. In fact, it is highly unlikely that meaningful interpretations of biogeochemical data, or the ecosystem structure can be made without adequate knowledge of the advective field, for instance. Cognizant of the importance of understanding the circulation of the eastern Gulf of Mexico, the Bureau of Land Management (BLM) commissioned a group of oceanographers familiar with the area: (a) to "assemble the historical and contemporary physical and associated meteorological data of the northeast Gulf of Mexico...for submission to the National Oceanographic Data Center (NODC)"; (b) to "construct a zero-order synthesis of oceanographic conditions in the northeast Gulf of Mexico and have them graphically displayed"; (c) to "describe the general circulation and oceanographic conditions on the continental shelf area of the northeast Gulf of Mexico and in the Loop Current of the deeper Gulf areas"; (d) to "describe qualitatively the interaction between the shelf circulation of the northeast Gulf of Mexico and the Loop Current"; (e) to "describe the seasonal distribution of the intensity of fish spawning and zooplankton productivity on the western Florida continental shelf and relate these to temperature and salinity data"; (f) to "develop a first-order understanding of the trajectory of a pollutant in the northeast Gulf of Mexico; (g) to provide recommendations on sampling locations for future biological, geological, chemical, and physical oceanographic investigations".

Stone, J.H. 1972. Preliminary assessments of the environmental impact of a superport in the southeastern coastal area of Louisiana--Louisiana superport studies. Report 2. Center for Wetland Resources, Louisiana State University. Baton Rouge, LA. 345 pp.

Abstract. Two offshore sites for a proposed Superport, off southeastern Louisiana, are evaluated for potential environmental impact on the coastal region. The most vulnerable areas along the coast are the estuaries. Oil drift projections indicate that the site more distant from shore would have less effect because a potential spill there would probably not reach the estuarine areas. Oil drift projections of hypothetical oil spills are based on a hydrodynamical numerical model using wind conditions, local tides, and bathymetry. At the closest site oil spills moved either northwest toward Timbalier Bay or northeast toward Barataria Bay. Oil spills at the farther site did not impinge on the shorelines nor into the estuaries. Oil spills at both sites usually assumed an east-west orientation and moved somewhat faster than drift projections based solely on winds. Potential adverse effects resulting from an oil spill would be most severe in the estuaries. Oil could damage or kill extensive areas of marsh grass, thereby reducing or eliminating the most important food source for the major consumers, which are fishery species. This damage could be by direct contact with the top of the plants, the root system, or the microbes which initiate the breakdown of grass into detritus. Regardless of the final location of the superport, research should be initiated on the detailed hydrography and meteorology

of the proposed site, the toxic effects of various crude oils on planktonic stages of fishery species, and the effects of oil on marsh grasses and microbes.

Story, A.H., R.M. McPhearson Jr. and J.L. Gaines. 1974. Use of fluorescent dye tracers in Mobile Bay;. J. Water Pollut. Control Fed. 46(4):657-665.

Abstract. The purpose of this study was to determine current velocity and patterns of current flow from the Mobile River throughout Mobile Bay to oyster reefs downstream. Data were collected for one year beginning in March, 1970. Dye studies were done and notes on wind speed and direction were taken to indicate routes of possible pollutants to these oyster reefs. Different types of dyes were evaluated as to their suitability to a specific study area.

Stumpf, R.P., G. Gelfenbaum and J.R. Pennock. 1993. Wind and tidal forcing of a buoyant plume, Mobile Bay, Alabama. Cont. Shelf Res. 13(11):1281-1301.

Abstract. AVHRR satellite imagery and in situ observations were combined to study the motion of a buoyant plume at the mouth of Mobile Bay, Alabama. The plume extended up to 30 km from shore, with a thickness of about 1 m. The inner plume, which was 3-8 m thick, moved between the Bay and inner shelf in response to tidal forcing. The tidal prism could be identified through the movement of plume waters between satellite images. The plume responded rapidly to alongshore wind, with sections of the plume moving at speeds of more than 70 cm/s, about 11% of the wind speed. The plume moved predominantly in the direction of the wind with a weak Ekman drift. The enhanced speed of the plume relative to normal surface drift is probably due to the strong stratification in the plume, which limits the transfer of momentum into the underlying ambient waters.

Sturges, W. and S. Welsh. 1990. Wind-driven response of ocean surface infrared signals. J. Phys. Ocean. 20(12):1842-1848.

Abstract. In the course of archiving positions of the edge of the Loop Current from satellite infrared (IR) data, the authors have found a substantial amount of energy at periods in the 'wind-driven band'. Using a technique patterned after that of Price et al. (1987) the authors constructed a series of new datasets of IR positions at a variety of angles relative to the daily wind. Using data for a period of November-May, the authors find that the IR fluctuations are coherent with wind, and are at an angle of 80 degrees to the right. The IR data do not resolve periods shorter than approximately 10 days reliably, but motions of approximately 12-16 days are well resolved. These findings show that the wind-coherent motion of the surface IR signal is associated with the Ekman transport of the upper mixed layer.

Tan, C.L. 1990. Characterization of underwater sound produced by heavy precipitation. Master's Thesis. Naval Postgraduate School, Monterey, CA. 70 pp.

Abstract. An experiment by the Naval Postgraduate School and the National Data Buoy Center was performed in the Gulf of Mexico to investigate the underwater sound generated by heavy precipitation under a variety of conditions. During the first stage of the experiment, nine data sets were obtained with rainfall rates up to 300 mm/hr. The characteristic fifteen kilohertz peak in the underwater sound spectrum generated by small raindrops in light rain is absent during heavy rain. These data sets show

a good correlation between rainfall rate and underwater sound levels, suggesting that acoustic measurement of rainfall rate at sea is possible. The correlation is best at lower frequencies (2-10 kHz). At higher frequencies (12-22 kHz) low spectral levels are observed in conditions of high wind (>10 m/s), presumably due to sound absorption by ambient bubble clouds from breaking waves. At very high rainfall rates (>200 mm/hr), low levels at higher frequencies are also observed suggesting that the rain itself is capable of producing large populations of bubbles which absorb the sound radiated form the surface.

Taylor, J.G. 1966. An approach to the analysis of sea surface temperature data for utilization in hurricane forecasting in the Gulf of Mexico. Master's Thesis. Texas A&M Univ., Dept. of Oceanography, College Station, TX. 106 pp.

Abstract. Sea surface temperature (SST) patterns have been analyzed for four major hurricanes in the Gulf of Mexico in an effort to determine if routinely available SST data might be more fully utilized as an aid to the hurricane forecaster. SST data reported by merchant vessels are the primary data used in this study. Mean daily SST charts were prepared for approximately ten to twelve days prior to the time when each hurricane moved inland. Also, a series of 3-day, 5-day, and 7-day mean SST charts were prepared for Hurricane Hilda. The SST charts for Hurricanes Audrey, Carla, and Hilda were plotted and analyzed with the point of hurricane landfall known. In an attempt to stimulate realistic conditions and to insure an objective analysis, a series of daily mean SST charts for Hurricane Betsy were plotted while the storm was in progress. The conservative nature of ocean temperature is discussed, and it is stressed that a great amount of energy is required to make a significant change. It is pointed out that the SST data used are taken at varying depths in the first few meters below the surface, and that the values obtained are not necessarily the same as surface temperatures measured by radiation devices. It is suggested that even though there are obvious limitations to available SST data, it is possible that the data might be more fully utilized as an aid to the hurricane forecaster.

Thompson, P.A. and T.D. Leming. 1978. Seasonal description of winds and surface and bottom salinities and temperatures in the northern Gulf of Mexico, October 1972 to January 1976. NOAA Tech. Rep. NMFS SSRT-719:44.

Abstract. Seasonal surface and bottom salinities and temperatures in the northern Gulf of Mexico are described. The area surveyed, from October 1972 to January 1976, was between Mobile Bay, Alabama (88°00'W), and Atchafalaya Bay, Louisiana (long. 91°30'W), from 5 to 50 fathoms (9 to 91 m). The changing of seasons in the northern Gulf of Mexico between Mobile Bay, Alabama and Atchafalaya Bay, Louisiana from 5 to 50 fm, is recognized when surface and bottom temperatures are similar. The summer begins in Mar. and Apr. at all depths. This change is correlated with changing meteorological conditions as the wind shifts from a northerly to a southerly direction. This shift in direction is accompanied by a decrease in intensity of wind speed and an increase in air temperature. Water and air temperatures reach a peak in July and Aug. accompanied by frequent calm winds. Little wind-mixing during the period, coupled with solar heating, results in a large difference between surface and bottom temperatures. The summer season begins to disappear in Sept. and Oct. with a drop in air temperature and a wind shift. By Nov. and Dec. the winter season has begun with southeasterly winds shifting to a more

northerly direction. This change in direction and intensity causes the mean air temperature to drop 9°C from the July and Aug. high. The wind generally remains out of the N to NW in Jan. and Feb. bringing colder temperatures within the survey area. By Mar. and Apr. the winter season ends with a general warming of air temperature and a wind shift to the SE, completing the annual cycle. Bottom salinities at all depths in 3 survey areas are similar and relatively constant because of the influence of the Loop Current. Surface salinities vary within each survey area, indicating seasonal changes that can be attributed to the discharge from the Mississippi River and calm weather during the summer months.

Thompson, W.T. and S.D. Burk. 1991. Investigation of boundary layer modification during GUFMEX. Proceedings reprint. pp. 86-90. *In* Preprint Volume of the Fifth Conference on the Meteorology and Oceanography of the Canal Zone. Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, MS.

Abstract. Transformation of continental polar air traversing the Gulf of Mexico has been documented by few authors. Dimego et al. (1976) provide a climatology of cold frontal incursions into the Gulf and return flow of warm, moist tropical air into midlatitudes. Their results indicate that the maximum mean monthly frequency of frontal systems occurs in February. Molinari (1987) discusses air mass transformation over the loop current in the eastern Gulf. The loop current causes relatively warm water to move northward through the Yucatan Channel into the eastern Gulf. Changes in the position of the loop current contribute to significant variability in surface latent and sensible heat fluxes and, therefore, variability in air mass transformation (AMT). Boundary layer (BL) modification associated with AMT is discussed by Henry and Thompson (1976). Using soundings from a station in southern Mississippi and from one on the Yucatan Peninsula 24 hours later, they estimate the average total surface heat flux during the 24 hours required for air parcels reaching Yucatan.

Thompson, W.T. and S.D. Burk. 1993. Postfrontal boundary-layer modification over the western Gulf of Mexico during GUFMEX. J. Appl. Meteorol. 32(9):1521-1537.

Abstract. Cold-frontal passages over the Gulf of Mexico in late winter or early spring are frequently followed by return-flow episodes in which modified polar air and warm, moist tropical air move toward the Gulf coast. While both advection and airmass modification due to boundary-layer physics are important in this sequence of events, the relative roles of these processes are unclear. In the present study, the authors utilize data from the Gulf of Mexico Experiment and two distinctive numerical models in addressing this issue. In forecasts of a return-flow event, trajectory computations are performed using a mesoscale numerical weather prediction model to determine the source regions of air arriving on the coast at several different levels. A one-dimensional airmass transformation model is also used in order to delineate boundary-layer physical processes. Simulations were conducted at two sites along the Gulf coast to investigate geographic variability in this return-flow episode, including the effect on boundary-layer structure of sea surface temperature variations in shelf waters. By careful examination of temporal variations in surface flux and advective forcing and by examining changes due both to surface heat flux and differential advection in the forecast vertical

profiles of potential temperature and specific humidity, the authors demonstrate that surface fluxes are important in heating and moistening the boundary layer as the air moves south across the Gulf.

Tolbert, W.H. and G.B. Austin. 1956. Oceanographic data collected off Panama City Beach, Florida, during period 12 April 1955 through 28 December 1955. U.S. Navy Mine Defense Laboratory Data Report. 5602(GX-14):175.
Abstract. The data were collected from two offshore stations and one in St. Andrew Bay.

Tolbert, W.H. and G.B. Austin. 1959. On the nearshore marine environment of the Gulf of Mexico at Panama City, Florida. U.S. Navy Mine Defense Laboratory Technical Paper. 161:104.
Abstract. Hydrography, sedimentology and weather data for the Panama City region.

University of Florida and Coastal and Oceanographic Engineering Lab. 1972. Hurricane surge analysis for Choctawhatchee Bay, Florida. University of Florida, Coastal and Oceanographic Engineering Lab. Gainesville, FL. 13 pp.
Abstract. A study of projected storm tides in the area.

U.S. Army Corps of Engineers. 1957. Hurricane wave statistics for the Gulf of Mexico. U.S. Army Corps of Engineers, Technical Memorandum. 98:94.
Abstract. This report contains the results of a statistical hindcast study of the heights and periods of significant waves generated by hurricanes in the Gulf of Mexico in the period 1900 to 1949. Results are presented in a series of polar plots of frequencies of occurrence of waves of given height and period at deep-water (100 fathoms depth) stations at different bearings offshore from five coastal stations.

U.S. Army Corps of Engineers. 1973. Report on Gulf Coast deep water port facilities, Texas, Louisiana, Mississippi, Alabama, and Florida. U.S. Army Corps of Engineers, Lower Mississippi Valley Division. 136 pp.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1972. Environmental guide for the U.S. Gulf Coast. Prepared for the Army Corps of Engineers by NOAA Environmental Data Center.
Abstract. Presents tabulations of summary climate data for potential Gulf Coast deep water port sites. Includes environmental descriptions (extratropical and tropical cyclones, winds, and waves) for the Northeastern Gulf of Mexico sites (Panama City, Mobile, Bayou Lafourche, and Southwest Pass) in addition to other sites throughout the Gulf.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1975. Some climatological characteristics of hurricanes and tropical storms, Gulf and East Coasts of the U.S., 1975. NOAA, NWS Tech. Rep. 15:87.
Abstract. Historical summary of hurricanes and storms occurring in the Gulf of Mexico and the Atlantic Coast for 1975. General characteristics, such as duration, path, severity, wind speeds, origin, and direction are provided for each occurrence.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1975. Wind-driven transport in 1975, Atlantic coast and Gulf of Mexico. NOAA Tech. Rep. NMFS Cir. 416:229-239.
Abstract. Describes the importance of surface layer and wind-driven transport with respect to survivability of plankton. Also provides a qualitative description on how wind driven transport affects nearshore circulation. Minimal quantitative data is presented except to show that the 1985 transport values compare well with ten year mean averages.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979. Meteorological criteria for standard project hurricane and probable maximum hurricane windfields, Gulf and East Coasts of the United States. NOAA, NWS Tech. Rep. NOAA-TR-NWS-23:347.
Abstract. Description of standard hurricane windfield estimates.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979. Summary and analysis of synoptic meteorological observations in selected coastal marine areas. NOAA Report PB 296915.
Abstract. Tabulation of pertinent meteorological parameters derived from synoptic meteorological observations in selected coastal areas including the Gulf of Mexico.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979. Wind-driven transport, Atlantic coast and Gulf of Mexico. NOAA Tech. Rep. NMFS Circ. 427:175-208.
Abstract. Surface waters were found to respond to the surface wind stress by flowing in a direction 45° to the right of the stress direction. The net water transport is 90° to the right of the surface stress direction.

U.S. Department of Commerce, National Oceanic Atmospheric Administration and U.S. National Oceanographic Data Center. 1970. CICAR - Bibliography on Meteorology, Climatology and Physical/Chemical Oceanography. Vol. 1 NODC. Washington, D.C. 380 pp.

U.S. Department of Defense and Department of the Navy. 1981. Surface stress estimation for study of the circulation dynamics of the Gulf of Mexico. NORDA Technical Note 113.
Abstract. Evaluates the available wind data on a fine enough mesh to be of use in forecast models of ocean circulation. Because of the fine grid, more accurate horizontal derivatives can be obtained to estimate wind stress curl as boundary condition forcing in numerical models.

U.S. Department of Defense and Department of the Navy. 1985. Navy-corrected geostrophic wind set for the Gulf of Mexico. Naval Ocean Research and Development Activity Technical Note 310.
Abstract. Geostrophic wind computed from surface pressure analyses resulted in data set with high temporal and spatial resolution. As a result, new features in wind stress curl patterns were observed in seasonal and monthly climatologies.

U.S. Department of Defense and Department of the Navy. 1986. U.S. Navy climatic study of the Caribbean Sea and Gulf of Mexico. Volume 3. Florida coastal waters and Southwest Atlantic. Naval Oceanography Command Report No.: NAVAIR-50-1C-545.

Abstract. Climate study consists of monthly charts and table of a variety of oceanographic characteristics.

U.S. Department of Defense and Department of the Navy. 1986. U.S. Navy climatic study of the Caribbean Sea and Gulf of Mexico. Volume 4. Gulf of Mexico and Gulf of Tehuantepec. Naval Air Systems Command Report No.: NAVAIR-50-1C-546.

Abstract. Charts and tables of oceanographic characteristics focusing on the Gulf of Mexico and Gulf of Tehuantepec.

U.S. Department of Defense and United States Air Force. 1978. A climatology of monthly mean sea surface temperatures for the Gulf of Mexico. Final Report to the United States Air Force Air Weather Service (MAC), Environmental Technical Applications Center, Scott Air Force Base, Illinois (USAFETAC-PR-78-001).

Abstract. Presents charts of monthly mean SST values in 1° quadrangles for entire Gulf of Mexico. A brief discussion of the SST data as it relates to prevailing ocean currents is also included.

U.S. Department of Defense and United States Air Force. 1986. Headquarters Armament Division (AFSC). 100-year hurricane wind, tide, wave and current characteristics and wave-current force. Contract F00635-86-M-0319, ANG/Gulfport, ACMI Storm Wave Study.

Abstract. Summarizes results of an analysis of 100-year hurricane wind, tide, wave and current characteristics and wave and combined wave-current forces at two tower locations of the proposed ANG/Gulfport Air Combat Maneuvering Instrumentation Range in the offshore Mississippi area of the Gulf of Mexico in the vicinity of 29°52'N, 88°27'W.

U.S. Department of Interior and Bureau of Land Management. 1975. Compilation and summation of historical and existing physical oceanographic data from the eastern Gulf of Mexico in support of the creation of a MAFLA sampling program. Submitted to BLM under Contract No. 08550-CT4-16.

Abstract. Describes MAFLA, a BLM-commissioned study to synthesize physical oceanographic and meteorologic data in the northeast Gulf of Mexico to develop an understanding of pollutant trajectories. Summarizes knowledge of atmospheric conditions, tides, river run-off, hydrography, and circulation of the shelf and deep basin. Mechanisms for inducing shelf motions are explored.

U.S. Environmental Protection Agency. 1993. Preliminary assessment of Gulf of Mexico OCS contributions to ozone formation in onshore areas using the regional oxidant model. Final Rpt. See also PB94-140258. Sponsored by Minerals Management Service. Gulf of Mexico OCS Region. New Orleans, LA. 214 pp.

Abstract. The study represents the first assessment of OCS contributions to ozone in the Gulf of Mexico. Two ozone episodes (July 20-August 6, 1988, and July 24-August 1, 1990), which had onshore winds for transporting OCS-derived ozone to onshore areas, were selected for analysis. The model's onshore emissions input consisted of the 1985 National Acid

Precipitation and Assessment inventory, the Biogenic Emissions Inventory System, and mobile sources from the 1986 vehicle traveled data adjusted to 1988. The model's performance evaluation reveals an average normalized gross error of 31%, while the paired accuracy of peaks averaged 22.8%. The results of the assessment suggest that a similar study using an improved emissions database and a photochemical model with finer spatial resolution to gain a better understanding of OCS contributions is desirable.

U.S. Nuclear Regulatory Commission. 1982. Historical extreme winds for the United States: Atlantic and Gulf of Mexico coastlines. NRC Report, May 82, 160 pp.

Abstract. Annual wind data were extracted for the complete period of record for 53 locations along the Atlantic and Gulf of Mexico coastlines. Selected probability estimates were developed from an extreme value model for non-tropical storms and the Weibull model for tropical storms.

Vega, A.J. and M.S. Binkley. 1994. Tropical cyclone landfall in the United States 1960-1989. National Weather Digest. 19(1):14-26.

Abstract. All tropical cyclones which originated in the North Atlantic Basin (including the Gulf of Mexico and Caribbean Sea) and made landfall within the United States during the period 1960-1989 are analyzed. The cyclones are divided into categories based on formation area (six distinct regions), month of cyclogenesis, maximum strength the cyclone achieved (using the Saffir-Simpson scale), and landfall location (nine distinct zones). In order to identify climatological patterns and trends, statistical procedures are used with each of the stated variables. This study differs from others on tropical cyclone climatology through methodology. Here, only tropical cyclones which made landfall within the U.S. during the study period are examined. By incorporating this methodology, a greater understanding of the associated trends and climatological interactions of cyclones which pose danger to U.S. citizens is gained. The study aids in delineating the time period during which a tropical cyclone is expected, the extent of the area likely to experience a tropical cyclone, and the likely severity of the tropical cyclone. Results indicate that landfall zones along the Gulf Coast are primarily affected during the early portion of the hurricane season by tropical cyclones which form in the Gulf of Mexico. As the hurricane season progresses, the cyclones form in the Caribbean and usually make landfall within the state of Florida. During the time of greatest cyclone frequencies (August and September), the cyclogenesis area shifts to its farthest eastern extent, near the Cape Verde Islands. These tropical cyclones typically make landfall along the western Gulf Coast, Florida, or along the East Coast north of 34°N. Late season cyclogenesis reverts back to the Gulf of Mexico and once again plagues the Gulf Coast landfall zones.

Vonder Haar, T.H. 1976. The energy balance of the Gulf of Mexico. pp. 19-24. *In* Role of the Gulf of Mexico in the Weather of the United States: A Conference on Meteorology over and near the Gulf. TAMU, College Station, TX.

Vukovich, F.M., B.W. Crissman, M. Bushnell and W.J. King. 1979. Some aspects of the oceanography of the Gulf of Mexico using satellite and in situ data. J. Geophys. Res. 84(C12):7749-7768.

Abstract. Satellite infrared data and in situ data were combined to study synoptic-scale and mesoscale fronts in the Gulf of Mexico in the period 1973-1977. Deep northward penetrations of the Loop Current were noted in the winter, and a major warm gyre developed in the winter, 1974. Other major warm gyres were seen to develop in the early spring (1974 and 1977). In all cases, a very large meander developed off the southern part of the west Florida shelf prior to the development of the major warm gyre. Smaller meanders were seen to move along the Loop Current boundary at an average speed of 28 km/d and with an average wavelength of 210 km.

Wallcraft, A.J. 1991. Gulf of Mexico circulation modeling study, Annual Progress Report: Years 3 and 4. Final Report. 1982-90. Minerals Management Service. Metairie, LA. 226 pp.

Abstract. This is the final report of a four-year numerical ocean circulation modeling program for the Gulf of Mexico. The aim of the program was to progressively upgrade an existing model of the Gulf of Mexico to provide the most realistic long-term simulation possible of Gulf circulation. The NOARL/JAYCOR multi-layer hydrodynamic and thermodynamic primitive equation circulation models of the Gulf of Mexico on a 0.2 degree and a 0.1 degree grid were used in the program. They were forced by constant inflow through the Yucatan Straits compensated by outflow through the Florida Straits, and by wind stresses from the Navy Corrected Geostrophic Wind data set for the Gulf of Mexico. The most realistic simulation produced by the program was a blending of one- and two-layer experiments, augmented by a perturbation analysis to extract surface currents from the vertically averaged ocean model velocities. Actual wind stresses from 1967-1982 were used to force the simulation, but the resulting currents are intended to be representative of Gulf circulation rather than a hindcast of the actual state of the Gulf over this time period. Wind stress, surface current, and geostrophic surface current fields from this simulation, sampled every three days for 10 years, have been delivered to MMS. Current fields at 100, 300, 750, and 1600 meter depths, sampled every six days for the same 10-year period, have also been delivered. Also, detailed vertical current profiles have been delivered to the locations of all moored buoys used in Years 1 through 5 of MMS's recently concluded Gulf of Mexico Physical Oceanography Program.

Wallcraft, A., T. Townsend and D. Grant. 1985. Wind-driven ocean modeling and ocean model development; Final Rpt. J665-85-006/6251. Jaycor. Alexandria. 89 pp.

Abstract. Numerical simulations were performed with a 0.2 deg, two-layer, free surface, primitive equation, ocean circulation model of the Gulf of Mexico with a realistic bottom topography and coastline. As in previous simulations, with idealized bottom topography and coastline, realistic Loop Current behavior could be obtained without wind forcing and with constant inflow through the Yucatan Straits. However, simulations with both wind and port forcing showed significantly more variation than those with port forcing alone. A similar two layer model was set up for a North Atlantic region, from 20°N, 82°W to 48°N, 30°W, on a 0.25x0.2 deg grid. A 'Black Box' multigrid package was prepared for solving finite difference Helmholtz's equations with staggered grid Neumann boundary conditions in nonrectangular regions. In semi-implicit free surface primitive equation ocean models, it is competitive with other powerful iterative methods but slower than the direct Capacitance Matrix Technique. Several wind stress

data sets were prepared for use in ocean models, based on global analysis products from FNOC and NMC, regional analysis products from FNOC, and ship observations. These data sets have been used to drive ocean circulation model of the World Ocean, the Indian Ocean, the North Atlantic, and the Western Mediterranean Sea.

Wanstrath, J.J. 1976. Storm surge simulation in transformed coordinates, Vol. I, Theory and application. Technical Report No. 76-3. United States Army Corps of Engineers, Coastal Engineering Research Center. Ft. Belvoir, VA. 166 pp.

Abstract. A two-dimensional time-dependent, numerical storm surge model using orthogonal curvilinear coordinates is presented. The curvilinear coordinate system is based on a conformal mapping of the interior region, bounded by the actual coast, the seaward boundary (taken as the 180-m depth contour), and two parallel lateral boundaries, into a rectangle in the image plane. Three regions of the Continental Shelf of the Gulf of Mexico and two regions of the eastern seaboard of the U.S. are mapped. Since the transformation is conformal, the associated modifications of the vertically integrated equations of motion and mass continuity are minimized. The coast, seaward boundary, and the lateral boundaries of the computing grid are straight lines in the image plane, thus facilitating the application of the boundary conditions. The final coordinates allow for the greatest resolution near the coast in a central area of principal storm surge development and modification. The model is used in the simulation of the storm surge induced by Hurricanes Carla (1961) and Camille (1969), which crossed the Gulf coast of the United States, and Hurricane Gracie (1959), which crossed the east coast. Analytical interpretations of the wind and atmospheric pressure-forcing functions are used in the computations.

Wanstrath, J.J. 1976. Storm surge simulation in transformed coordinates. Vol. II. Program Documentation. CERC-TR-76-3-Vol.-2. Coastal Engineering Research Center. Ft. Belvoir, VA. 178 pp.

Abstract. A two-dimensional time-dependent numerical storm surge model using orthogonal curvilinear coordinates is presented. The curvilinear coordinate system is based on a conformal mapping of the interior region bounded by the actual coast, the seaward boundary (taken as the 180-meter depth contour) and two parallel lateral boundaries into a rectangle in the image plane. Three regions of the Continental Shelf of the Gulf of Mexico and two regions of the eastern seaboard of the United States are mapped. Since the transformation is conformal, the associated modifications of the vertically integrated equations of motion and mass continuity are minimized. The coast, seaward boundary, and the lateral boundaries of the computing grid are straight lines in the image plane thus facilitating the application of the boundary conditions. The final coordinates allow for the greatest resolution near the coast in a central area of principal storm surge development and modification. The model is employed in the simulation of the storm surge induced by Hurricanes Carla (1961) and Camille (1969) which crossed the Gulf coast of the United States and Hurricane Gracie (1959) which crossed the east coast. Analytical interpretations of the wind and atmospheric pressure-forcing functions are used in the computations.

Ward, E.G. 1974. Ocean data gathering program, an overview. Shell Development Co.
Abstract. The ocean data gathering program resulted in the collection of oceanographic and meteorological data at six offshore sites in the Gulf of Mexico from 1968-1971. The primary goal of the program was to obtain data on extreme conditions generated by severe hurricanes in the Gulf of Mexico. Parameters continuously recorded are wave amplitude, wind speed and direction, and barometric pressure.

Ward, E.G., L.E. Borgman and V.J. Cardone. 1979. Statistics of hurricane waves in the Gulf of Mexico. J. Petrol. Technol. 31(5):632-642.
Abstract. By using hurricane data from 1900-1974, an historical wave data base was produced by hindcasting. A model was then applied to estimate the cumulative probability distribution function for the largest wave in a given number of years.

Washington, W. and D. Buamhefner. 1976. The Influence of the Gulf of Mexico on baroclinic systems in a GCM. pp. 29-33. *In* Role of the Gulf of Mexico in the Weather of the United States: A Conference on Meteorology over and near the Gulf. TAMU, College Station, TX.

Weather Bureau. 1965. Proceedings of the Sea-Air Interaction Conference, Tallahassee, Florida February 23-25, 1965. TN-9-SAIL-1. Weather Bureau, Sea-Air Interaction Lab. Washington, D.C. 337 pp.
Abstract. Air-sea exchange as a factor in synoptic scale meteorology in middle latitudes; The three-dimensional ocean circulation driven by density gradients in an enclosed basin; On the present state of knowledge in air-sea boundary layer problems; A survey of the role of sea-air interaction in tropical meteorology; Sensible and latent heat exchange in low latitude synoptic-scale systems; Intensity of hurricanes in relation to sea surface energy exchange; The Gulf of Mexico after HILDA (Preliminary Results); Evidence of surface cooling due to typhoons; The modification of water temperature by hurricane CARLA; On the low level thermal stratification of the monsoon air over the Arabian Sea and its connection to the water temperature field; A low-level jet produced by air, sea, and land interactions; U. S. Fleet numerical weather facility activities relating to sea-air interactions on a synoptic scale; Synoptic scale heat exchange and its relations to weather; Laboratory studies of wind action on water standing in a channel; On the instability of Ekman boundary flow; Federal research programs in air-sea interaction.

Weiss, S.J. 1992. Some aspects of forecasting severe thunderstorms during cool-season return-flow episodes. J. Appl. Meteorol. 31:964-982.

Weissman, D.E. 1983. The dependence of the radar modulation transfer function on environmental conditions and wave parameters. DEW-83-1. David E. Weissman. Northport, NY. 27 pp.
Abstract. Recent measurements of ocean wave-radar modulation transfer function (MTF) from fixed ocean platforms, over a period of several years, have demonstrated that the loval hydrodynamic modulation of short centimetric waves is affected by the air-sea interaction. Results from widely separated ocean regions also show different individual properties, that make detailed measurements necessary. An X-band radar with vertical polarization was mounted on a platform in the Gulf of Mexico during Nov.-Dec. 1978. The data set is computer stored and was processed. A selective

study of this data has been conducted on the separate, independent influence of wind speed, air-sea temperature difference and wave slope on the MTF and the average radar cross section. Dependence on all these parameters was observed. Data from other experiments agree with these results. Variations of the coherence function for the modulation transfer function imply that other mechanisms must be found for these modulation effects other than hydrodynamic (wave-wave) interactions. An important conclusion of this study is that the surface stress depends not only on wind speed, but also on air-sea temperature difference and wave slope.

Westerink, J.J., R.A. Luettich, A.M. Baptista, N.W. Scheffner and P. Farrar. 1992. Tide and storm surge predictions using finite element model. Journal of Hydraulic Engineering. 118(10):1373-1390.

Abstract. A finite element (FE) model is used to study tides and hurricane storm surge in the Gulf of Mexico in the region ranging from the Mississippi Sound to the northwest coast of Florida. Issues that are emphasized include the use of large domains, the importance of a high degree of grid resolution in coastal regions of interest, the use of meshes with highly varying nodal densities to minimize the size of the discrete problem, and the use of the generalized wave-continuity equation (GWCE) for FE-based solutions to the shallow-water equations. The computations presented are unprecedented in their scope, level of localized detail, and degree of grid-size variability. The GWCE-based FE model leads to very accurate and efficient flow solutions.

Wolfe, M.A. and G.C. April. 1978. Estimation of hurricane storm surge in Mobile Bay, Alabama. University of Alabama, Olin Summer Project. 37 pp.

Wright, S. 1976. Comparable development of Tropical Storm Hallie with a Gulf tropical disturbance. Mon. Weather Rev. 104(11):1451-1454.

Abstract. A tropical disturbance formed in the western Gulf on May 20, 1976, and subsequently moved northeastward into the Florida panhandle on May 23, 1976, with sustained winds up to 30 knots at Gulfport, MS., and a low pressure reading of 998.9 mb at Tallahassee, FL. The initial development of Hallie (Dvorak, 1975) and this Gulf disturbance were quite similar; both formed east of a quasi-stationary trough aloft and in the vicinity of a weakening cold front. Daily visible satellite imagery taken of Hallie from Oct. 21-24, 1975, is shown in figures and analyzed.

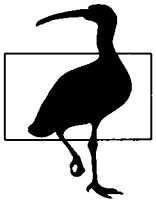
Zervas, C.E., (ed.). 1993. Tampa Bay Oceanography Project: Physical Oceanographic Synthesis. NOAA Tech. Rep. NOS OES 002:184.

Abstract. NOS's Tampa Bay Oceanography Project (TOP) collected a large and diverse set of physical oceanographic and meteorological data between June 1990 and September 1991. This report presents the results of the data analysis and synthesizes these results in order to characterize the hydrodynamics of Tampa Bay. The TOP data set includes: (1) current meter data from 40 fixed stations (20 occupied by acoustic Doppler current profilers (ADCPs) and 20 occupied by electromagnetic current meters), (2) current meter data from a downward-facing towed ADCP along five transects in the Bay, (3) water levels at 16 stations along the shores of the Bay and the Gulf of Mexico, (4) meteorological (wind, temperature, and atmospheric pressure) data at five stations in the Bay, (5) time series of salinity and temperature data at 36 fixed sites, and (6) salinity and temperature profiles over depth along six transects.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The National Biological Service Mission



As a bureau of the Department of the Interior (DOI), the National Biological Service's (NBS) primary mission is to provide the scientific understanding and technologies needed to support sound management and conservation of our Nation's biological resources. Independence from regulatory and management decision making greatly lessens the chance that scientific results will be viewed as less than objective science or subservient to the needs of policy makers. NBS provides credible, objective, and unbiased information needed by resources managers in the Department of the Interior in a form that allows them to assess, predict, and manage the biological consequences of various policies and management practices. Although the primary focus of the biological research is to meet DOI needs, the activities undertaken with natural resource research funding will also serve the science needs of a wide range of partners, including State governments, other Federal agencies, and private landowners.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.