PROGRESS REPORT

HURRICANE AIR-SEA INTERACTION MODEL STUDY

Faculty Research Grant No. 560

James Bruce Bole

Principal Investigator

May 10, 1971

CER70-71JBB79

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Although the research plan originally proposed (October 23, 1970) has been reduced in scope owing to the lack of sufficient funds, there has been significant progress made toward the major objectives of the plan. The small-scale, hurricane air-sea interface model facility has been built. An in-depth survey of several mathematical models of the hurricane boundary layer has been completed. The similitude relationships between prototype and model hurricanes have been investigated. At present, preparations are being made to obtain experimental measurements during the last two weeks of May 1971. External research proposals will be submitted following analysis of this data.

Hurricane Model Facility

Briefly, the hurricane model facility consists of the following. An eight-foot diameter stock tank, completely filled with water, comprises the sea basin on which the hurricane acts. A flat, circular roof, supported four inches above the tank top, defines the upper boundary of the air tunnel in which the hurricane surface winds are generated. A pair of vaneaxial fans provide the wind generating force for the model hurricane. The fans are mounted in series above the center of the air tunnel roof in a vertical conduit of circular cross-section. They draw air horizontally into the tunnel at the circumference of the tank, vertically up through the conduit section, and discharge back into the atmosphere. Adjustable vanes located at the entrance of the air tunnel impart to the wind a dominant circumferential velocity component, characteristic of the inwardly spiraling flow of natural hurricane surface winds.

Aid to Mathematical Models

One significant conclusion of the survey of mathematical models of the hurricane boundary layer[1,2,3,4] is that, while the turbulent exchange coefficients (eddy viscosities) used in the models have strong influence on the model results (in the form of pressure and velocity distributions), they must be assumed by the model investigator. Further, it was noted that extremely idealized water surface roughness distributions (surface drag coefficients) must also be assumed for use in the models. An important experimental contribution to improving the validity of the mathematical models would be made by the measurement of the turbulent exchange coefficients and the surface drag coefficients.

Prognosis for Model Utility

The investigation of similitude relationships, which must be satisfied for the physical modeling of hurricane air-sea interaction, revealed that it is extremely difficult to achieve complete geometric, dynamic, and kinematic similarity in an air-water model of economically reasonable size. However, it does appear that useful qualitative information related to the gross hurricane scale (i.e., pressure, velocity, and water surface roughness distributions) as well as certain quantitative information about small-scale, local phenomena within hurricanes (i.e., coefficients of turbulent exchange and surface drag) can be obtained from such a model.

Future Plans

The experimental measurements planned for the last two weeks of May 1971 will of course shed more light on the possibilities of modeling hurricane air-sea interaction. Unfortunately, there are only enough funds available to document the gross characteristics and capabilities of the model facility.

The primary measurements will be of mean pressure, velocity, and water surface roughness distributions for a few fan discharges.

Following analysis of the data, a research proposal will be submitted to the National Science Foundation and possibly also to the Office of Naval Research. The proposal will emphasize the hurricane air-sea interaction groundwork already completed and the availability of an experimental model facility. An appeal will be made for funds to improve the facility, gather extensive data, and begin work on our own mathematical modeling.

A proposal for a Faculty Research Grant to continue the present work accompanies this progress report. It is felt that such funding is necessary in order to complete many of the objectives described in the original proposal, which were curtailed due to insufficient funds, and to place on firmer ground subsequent proposals for external research support.

Use of Funds

An accounting of the grant funds to May 10, 1971 and planned disbursals to June 30, 1971 are included in the attached budget report. A large percent of the materials and equipment used respectively in constructing and operating the model facility were obtained at no cost from surplus stock at the Engineering Research Center. In addition, the Civil Engineering Department made available $300 from project E71-90-1029 for the cost of shop labor in the construction of the facility.

BIBLIOGRAPHY

1. Rosenthal, S. L., 1962: A theoretical analysis of the field of motion in the hurricane boundary layer, National Hurricane Research Project Report No. 56, 12pp.

2. Miller, B. I., 1965: A simple model of the hurricane inflow layer, National Hurricane Research Project Report No. 75, 16pp.

3. Smith, R. D., 1968: The surface boundary layer of a hurricane, Tellus, 20, pp. 473-484.

4. Leslie, L. M. and R. K. Smith, 1970: The surface boundary layer of a hurricane, II, Tellus, 22, pp. 288-296.

BUDGET REPORT

Accounting to May 10, 1971		
Materials and Supplies		
Hurricane model materials	$163.00	
Electrical conduit	35.00	
Equipment		
Stock tank	63.00	
Pressure measurement apparatus	10.00	
Wages		
Graduate student	325.00	
Total		$596.00
Planned Disbursals to June 30, 1971		
Materials and Supplies		
Miscellaneous measurement apparatus	$ 14.00	
Equipment		
Pressure transducer maintenance	30.00	
Mosely recorder maintenance	45.00	
Miscellaneous equipment maintenance	25.00	
Wages		
Graduate student	190.00	
Total		$304.00
Grand Total		$900.00