NOTE

Note on the Symposium on the Use of Models in Geophysical Fluid Dynamics[1]

A symposium was held September 1—4, 1953 at The Johns Hopkins University, Baltimore, Maryland to discuss the problems and potentialities of models in investigations of geophysical phenomena. About 25 research workers in the fields of oceanography, meteorology, aeronautics, geo-magnetism, civil engineering, and applied mathematics attended the conference. Fifteen papers were presented followed by discussions.

The first session was devoted to a paper by Professor Stanley Corrsin, The Johns Hopkins University, on general problems of modeling and dimensional analysis. One of the important parts of Corrsin's paper was the suggestion that a fluid system is not sensitive to changes in a non-dimensional number, characteristic of the system, if the number is very small or very large. This was supported by several examples.

Next Professor G. W. Morgan of Brown University presented an historical summary of theoretical and experimental work with rotating, homogeneous liquids, together with an account of his own research in this field. Most of the theoretical work was inspired by Taylor's experiments which showed a definite tendency for the relative motion of a rotating fluid to become two-dimensional when the relative motion becomes very small (highly geostrophic). Most theoretical solutions, assuming small motions, involve singularities in the velocity field and it is not apparent whether this is due to neglect of viscosity or of the non-linear convective acceleration terms. Morgan discussed a publication by R. R. Long on the motion of an obstacle along the axis of a rotating fluid in which the relative motions need not be small. Questions were raised regarding the existence and uniqueness of such flows.

The discussion of basic problems of rotating fluids was completed by a paper by Professor Dave Fultz of Chicago which included a number of experiments with obstacles towed in rotating vessels of water. Many of these were similar to the basic experiments of Taylor.

The next session was concerned with realistic models of large-scale atmospheric phenomena and was devoted largely to a description by Professor Fultz of the "dish-pan" experiment, and some theoretical work on this experiment by Drs H. L. Kuo and Edward Lorenz of Massachusetts Institute of Technology. This experiment involves a cylinder of rotating water heated at the bottom perimeter in an effort to simulate the rotating atmosphere heated at the equator. Fultz described in detail the two regimes of motion that occur. They are called the Hadley and Rossby regimes. The former is characteristic of low rotations and strong heating and resembles the classical trade-wind cell. The motions on the free surface are zonal without sensible disturbances. The Rossby regime occurs for higher rotations at a given heating and is characterized by zonal winds at the free surface, but with regular or irregular, long wave patterns resembling the flow at high levels in the atmosphere.

Kuo and Lorenz presented two separate approaches to the problem of explaining the breakdown of the low-rotation regime. Although some of the assumptions and boundary conditions of the theory were questioned by several of the participants, both approaches seemed very promising for this very important and very difficult problem.

[1] The symposium was supported by the Office of Naval Research with the cooperation of the U. S. Weather Bureau and the Geophysics Research Directorate, U. S. Air Force. A complete report of the proceedings, including papers and discussions, will be published at a later date.

Morton Rubin, U.S. Weather Bureau, discussed the general circulation of the southern hemisphere. Rubin pointed out that the simplicity of the topography of this hemisphere and the apparent stabilizing effect of the huge cold source of the antarctic continent might make the southern hemisphere a more suitable prototype for the dish-pan experiment.

Professor Paul Raethjen of Hamburg gave a discussion of cyclogenesis in the atmosphere together with some considerations of the problems of constructing models of developing highs and lows. Raethjen discussed the role of the "adaptation number" in this process. This is the ratio of Rossby and Froude numbers.

The use of rotating models in other geophysical problems was discussed by William von Arx of Woods Hole and Raymond Hide of Cambridge. Von Arx gave an account of a model of the effect of wind stress on the motion of water in the oceans. He showed how it was possible to reproduce the effect of the latitudinal variation of Coriolis parameter by an appropriate variation of the basic depth of the fluid shell measured parallel to the axis of rotation. This is extremely important for large-scale models of oceans and atmosphere. Hide gave a summary of the very careful experimental observations of the jet stream and wave patterns in his experiment with a rotating, heated fluid. This resembles the dish-pan experiment of Fultz except that it incorporates a carefully controlled heat and cold source. Hide's work was inspired by the problem of explaining the earth's magnetic field, which is believed to be caused by slight motions in the molten core of the earth. The remarkable feature of Hide's experiment is the regularity of the wave patterns. His empirical investigation should inspire a theoretical attack on this model.

The remainder of the conference was devoted to a discussion of smaller scale geophysical phenomena in which the rotation of the earth is not a major factor. First, Dr C. S. Yih of Iowa State gave a paper on a theoretical and experimental investigation of convection above a heat source. Yih included a discussion of possible applications to convective phenomena in the lower atmosphere.

Professor R. R. Long of Johns Hopkins discussed a model of air flow over mountain barriers, together with a demonstration of this experiment in the hydrodynamics laboratory. In the demonstration a fluid with continuous density gradient was moved over a barrier. The motion resembled very closely the violent type of flow frequently encountered in the vicinity of the Sierra Nevada mountains in California. In particular, motion resembling that in the rotor cloud of the atmosphere was also observed in the experiment.

Professor George S. Benton, The Johns Hopkins University, discussed the concepts of critical flow in a stratified fluid. Supercritical and subcritical regimes were examined from the viewpoint of energy and momentum transfer. A general equation was derived for finding the lower limit of the absolutely supercritical regime for any velocity and density distributions. The equation was solved for a rather general class of flows. Benton gave a brief account of the connection between these regimes and the occurrence of shock waves.

Harlow Farmer gave a discussion of model experiments being conducted at Woods Hole Oceanographic Institute. The problems in this work involve mainly the flow of fresh water over salt water in estuaries.

Dr M. G. Wurtele of Massachusetts Institute of Technology gave an example of a technique that permits the calculation of the development of lee waves downstream of a source of disturbance in a homogeneous fluid with free surface. The indeterminacy that arises from a steady-state assumption is avoided by this approach. Unfortunately, this method cannot be applied to stratified fluids.

The final discussion of the symposium was presented by Professor Robert T. Knapp of California Institute of Technology. Knapp showed a number of motion pictures of models of density current. The discussion included suggestions for applications of these models to various phenomena in oceans and reservoirs.

Considerable time was available for informal discussion of the papers. These comments contributed significantly to the overall success of the symposium.

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