

SCOR WORKING GROUP 34 (WITH IAPSO)
INTERNAL DYNAMICS OF THE OCEAN

Report of Meeting, Grenoble, 5 September 1975

I. Participants:

WG 34 Members Present: A. E. Gill (UK), A.R. Robinson (USA) Chairman,
P. Welander (Sweden - USA)

Absent: L. Fomin (USSR), K. Hasselmann (FRG),
N. Phillips (USA), H. Stommel (USA)

Invited Participants: R. Bernstein (USA), K. Fedorov (USSR), J. Gonella (France),
J. Gould (UK), J. Lazier (Canada - alternate for G. Needler),
G. Siedler (FRG), W. Simmons (USA), J. Swallow (UK)
K. Bryan (USA), T. Sanford (USA), W. Zenk (FRG)

II. Discussion Topics:

This was the first meeting of the group held under the expanded charge
"to identify the critical scientific problems of the internal dynamics of the ocean
and to suggest the most appropriate ways to study them",

as well as the continuing charge

"to advise on the design of mid-ocean dynamics experiments."

The discussion was organized around three major agenda topics with sub-items as follows:

A. International Planning for POLYMODE**.

1. Communication of existing plans for POLYMODE and other related national experiments on eddies.
2. Planning and coordinating the international aspects of POLYMODE and related MODE experiments.

B. Consideration of Longer Term and Global Investigations of the low (and lower) frequency mesoscale variability.

1. Assessment of our present state of knowledge of the dynamics of low frequency mesoscale and of the geographical distribution of eddy characteristics over the world's oceans.
2. Identification of existing and potential data sources related to (1).
3. Long-term observational and experimental considerations.

C. Relationship of the Mid-Ocean Eddy Problem to more general questions in the Internal Dynamics of the Ocean.

1. The interaction of the low frequency mesoscale with other scales; the desirability of future MODE experiments in conjunction with other programmes.
2. Assessment and coordination of theoretical and numerical modelling activities of the eddies among eddy-modellers and with modellers primarily concerned with other phenomena.
3. The role of the eddies in the general circulation; the parameterization problem.

A summary of the discussion is attached as an Appendix.

** See SCOR Proceedings Vol. 10, No. 1, p. 54 and No. 2, p. 119.

III. Conclusions and Recommendations:

A. Mesoscale Mid-Ocean Experimentation in the Eastern North Atlantic in Coordination with POLYMODE.

Being aware of indications that mesoscale phenomena are present in many parts of all oceans, SCOR WG 34 wishes to encourage more active exploration of the geographic distribution of these phenomena. It recognizes also the need to observe at even larger scales in the ocean. A specific opportunity of furthering both these needs is seen in developing a plan for mesoscale observations to be made in the Eastern North Atlantic, simultaneously with POLYMODE. To do this, it is recommended that a sub-group of WG 34 should be formed to consider the possibility of designing a suitable Eastern North Atlantic experiment. They should be invited to work by correspondence, and if necessary to meet, at SCOR's expense, to formulate a plan of work and a first report to WG 34 by the spring of 1976.

B. Near Surface Layer Experiment in POLYMODE.

When exploring the mechanisms of production, transformation and dissipation of mesoscale eddies in the deep ocean, the interaction with processes in the near surface layer and forcing by the atmosphere will have to be considered. As a basis, descriptive and kinematical studies are needed for examining the structure of the near surface part of such eddies. For mesoscale studies of interaction between the surface layer and the deep sea, a parameterization of smaller scale processes is required which is properly based on an understanding of transfer mechanisms at the ocean surface and in the mixed layer and thermocline. While studies of these small scale near surface processes are being undertaken in GARP-related experiments like GATE and JASIN, the exploration of the structure and the kinematics of the near surface layer on the mesoscale should preferably be carried out simultaneously with deep ocean experiments in POLYMODE.

SCOR WG 34 therefore resolves to encourage the development of plans for suitable near surface experiments in connexion with POLYMODE. Some questions which seem appropriate to be considered at this time are: (1) Spatial and temporal scales of the surface wind stress and possible resonant excitation of baroclinic motions on the mesoscale or modification of the existing eddy field; (2) Mixed layer depth variations on the mesoscale in relation to the transfer of momentum, energy and heat from the atmosphere and from below the mixed layer; (3) Upper layer manifestation of mesoscale eddies, indicating the modal structure and possible phase shifts associated with eddy transport of mean density.

The types of measurements which seem appropriate for the scales considered are:

- (A) Density and current profiling from ships, combined for the near surface and the deep part of the ocean;
- (B) Observations from satellite tracked buoys carrying wind and/or atmospheric pressure sensors and temperature sensors for surface temperature and mixed layer depth, operating quasi-continuously;
- (C) Repeated observations with drifting surface buoys carrying current, temperature and electrical conductivity sensors at several depth levels;
- (D) Sea surface temperature mapping from satellites;
- (E) Observations from surface moorings using wind and/or atmospheric pressure sensors at the surface and current, temperature and conductivity sensors near the surface.

C. Satellite Measurements of the Mesoscale Low-Frequency Variability.

Oceanographic information from orbiting satellites has improved by orders of magnitude over the last decade; work already underway assures that this improvement will continue unabated through the next decade. The major advances during the past decade have been in infrared and visible band scanning radiometers. While this area will continue to show great progress, active and passive microwave band measurements, including radar altimetry of high accuracy, will most likely be the area of greatest advance during the coming decade. The efforts by oceanographers to utilize these data should be encouraged. Organized efforts within existing programmes, such as POLYMODE, to design and carry out particular experimental observations and to combine these emerging tools with more conventional ones, should continue to be developed and pursued.

The considerations that follow deal with the scanning radiometer data now being collected. The systems that produce and handle most of these data are intended for operational meteorological purposes. Nevertheless, significant oceanographic information on sea surface temperature and its horizontal gradient is frequently available. To retrieve this oceanographic information it is generally necessary to obtain the data in a form as close

as possible to the original signal. These original data are frequently not saved or archived in sufficiently original form to perform oceanographic reconstruction.

To improve this situation efforts must be made in three simultaneous ways:

- (i) Original scanner data should be made more accessible to oceanographers. Also the retention time for such data should be increased to allow oceanographers to review these data up to one year after the fact. Special attention should be focused on polar and geostationary orbiting radiometers with the highest spatial and thermal resolutions; it is these radiometers that are proving to contain the highest quality oceanographic information.
- (ii) Data manipulation and display resources should be improved in ways that would allow greater numbers of oceanographers to review the above-mentioned data in an efficient way to extract quickly the most valuable portions for detailed study.
- (iii) Consideration should be given to SCOR sponsorship of a colloquium designed to bring together oceanographic users of satellite infrared scanner systems, and those responsible for operation of these systems, to explore avenues toward improving the oceanographic accessibility and utilization of these data.

D. Investigation, Dissemination, Coordination of Information about Mesoscale Eddies on a Long-Term Global Basis.

Information from ocean experiments: It is important that the notice of as many marine scientists (of all disciplines) as possible be drawn to the characteristics of mesoscale ocean circulation features. Possible methods of doing so are (i) by a notice or "advertisement" in appropriate scientific journals, to be prepared under the direction of WG 34, (ii) by the introduction of appropriate papers and sessions at international meetings. The objects would be (a) to help scientists in the design of experiments, as the mesoscale features may affect the interpretation of their results (b) to alert scientists to the possibility of helping understand the distribution of such features by providing information found in their experiments to scientists particularly interested in the phenomenon. This information could be communicated via journals, via informal newsletters (e.g., Hot Line News) or be sent directly to the chairman of WG 34. The notice or advertisement would give the appropriate addresses.

Ocean monitoring: It is recommended that a small sub-group or group of experts be asked to (i) prepare for WG 34 a statement about the present level of routine collection of (a) ocean surface data (temperature, sea-level, etc.) and (b) sub-surface data, (ii) investigate what feasible expansion of this collection rate could usefully be employed to (a) give a time history of changes in the baroclinic structure of parts of the ocean (b) give a picture of the geographical distribution of mesoscale activity and of changes in this activity with time, (iii) investigate ways of implementing such an expansion. Item (iii) could lead to suggestions about retention of suitable satellite data or about new instruments (e.g., fitting of new ships with e.m. logs, developing a pressure-temperature sensor for towing behind ships of opportunity), etc. The group could consist of (a) IGOSS representative, (b) NORPAX representative with expertise in objective mapping of large scale features, (c) representative of climate panel of WG 48, (d) expert on instrumentation.

E. International Symposium on Eddy Dynamics and Parameterization.

In consideration of the progress occurring in the construction and development of theoretical/numerical models of ocean mesoscale eddies, it is recommended that an international symposium be organized to assess and intercompare models and to address the status of, and prospects for, parameterization of eddy processes in large scale ocean models. Participants should include ocean eddy dynamicists, atmospheric dynamicists, and parameterization specialists, including turbulence theorists. The meeting should be organized for sometime during 1977 by a steering committee consisting of the Chairman of SCOR WG 34, together with SCOR WG 49 (Mathematical Modelling of Oceanic Processes) and a representative of JOC-GARP. This constitutes an endorsement of a recommendation initiated by JOC-GARP Ad Hoc Working Group on Coupled Ocean-Atmosphere Models in June 1975 at its Hamburg meeting (but with a suggested possible delay of six months).

APPENDIX TO WG 34 REPORT

Resume of Discussion

1. USA POLYMODE planning to date was summarized: (i) recent evidence (XBT and POLYMODE Array I) for order-of-magnitude geographical variation of the variability over the North Atlantic gyre was reviewed; (ii) evolution from a POLYGON-MODE like experiment over larger-longer scales was noted; (iii) present ideas for statistical, geographical, dynamical experiment with clusters of instrumentation distributed to explore energy levels and scales over the western North Atlantic gyre (with East/West rather than North/South preferred orientation) were presented; (iv) the intention of designing the clusters for local dynamics experiments and of adding special process components was noted; and (v) the support for such an approach from the general results of numerical models was described.
2. The USSR POLYMODE plans for the intensive North/South array of sixteen moorings instrumented at six levels, and mapping and statistical long density lines from several ships were reviewed briefly. Possibility of some change was mentioned. Increased interest in (i) studying the feasibility of satellite measurements, (ii) pursuing insights from historical data, and (iii) obtaining temporal statistics near moorings were noted.
3. The UK Institute of Oceanographic Sciences' topographic influence experiments in the eastern basin of the North Atlantic were described and plans for establishing three site moorings, probably along 30°N for a total of one to two years in six month cycles to determine eddy variability in the eastern basin (24° to 40°) were noted.
4. The Institut für Meereskunde at Kiel, Federal Republic of Germany, has been working in the Eastern North Atlantic at internal wave scales and three to four week durations, off Portugal and off Africa, including upwelling experiments. Possible interest in cooperation with the Institute of Oceanographic Sciences in mooring experiments in the eastern North Atlantic basin was noted.
5. Bedford Institute, Canada, plans a three mooring array under, and along, the Gulf Stream near the northern terminus of USA POLYMODE Array II, 50 km spacing, 18 month duration, and instrumentation up to 1000 m above the bottom.
6. The interest of several French scientists in (i) the effect of eddies on properties of the near surface layer, the (ii) relative importance of direct surface forcing effects on eddies, and (iii) the design of a possible satellite-tracked drifting buoy experiment in POLYMODE was described.
7. The use of meteorological satellite data on one to two day occasions (separated by four months) when wide-spread (~ 1000 km) clearing occurs to produce large scale synoptic surface temperature maps was described. IR data is good to ~ 0.1 cm, as shown by simultaneous hydrographic measurements. Problems are retaining data (storage, and round off), and getting fast response simultaneous ground-truth measurements.
8. A method for dealing with the problem of variabilities in the large-scale ocean circulation in which eddy signals are noise, and therefore averaged over, was described. Credible sea surface temperature maps have been produced and the method is being tried at depth.
9. The use and instrumentation of commercial ships of opportunity for mesoscale XBT tracks was discussed.
10. Recent work on the variability of the Equatorial Current System in the Indian Ocean (by surface currents from navigation plus moved current meters) revealed a variability wave length of 500 km, period of 50 days, and 10-25 cm/sec speeds. Equatorial currents may be a relatively simple and important area for the study of low frequency variability.
11. The importance of informing oceanographers and others making measurements at sea (e.g., fisheries) about the low frequency variability was discussed. In many instances, the eddies would act as noise on the measurements of interest, and should be considered in determining sampling frequencies. Not only would properly adjusted measurements be more useful for their primary purpose, but they could also contain information on eddies of interest to scientists studying that phenomenon. How could this be pursued - by a special Science or Nature article, a WG 34 publication, a special WG sponsored meeting, a symposium at JOA, Edinburgh?
12. Other questions discussed included the desirability of communicating the fact that eddy experiments are not necessarily large scale and sophisticated, and of encouraging experimenters

to make simple observations such as limited surveys that could be performed in all the world's oceans by many nations. Could WG 34 serve to channel eddy inquiries from experimenters at large to the appropriate channels? Could it coordinate global eddy information?

13. The status and progress of numerical modelling of eddy phenomena was briefly reviewed.