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**Seminar on Hurricanes, Ciudad Trujillo, February 1956\***

**1. Introduction**

At the invitation of the Government of Dominican Republic, a seminar on "Hurricanes" was held at Ciudad Trujillo under the joint auspices of the United Nations Technical Assistance Administration and the World Meteorological Organisation from 16 to 25 February 1956. The proposal to hold the seminar, which is the first regional project organised by the WMO under the United Nations Expanded Programme of Technical Assistance, had its origin in a recommendation of the Eastern Caribbean Hurricane Committee of the Regional Association IV (North and Central America) of the WMO. The purpose of the seminar was to review, on a comprehensive scale, meteorological knowledge and experience on the development and behaviour of hurricanes by means of lectures and discussions.

The programme of the seminar consisted of the following major items—(a) Lectures by a chosen group of world experts on the

subject of hurricanes; (b) Practical work on the analysis of weather maps in the Caribbean region and (c) Group discussions between attending meteorologists with a view to exchanging knowledge, experience, views and ideas.

Invitations were extended by the WMO to eighteen leading experts from ten countries to deliver lectures on different aspects of hurricanes. In addition, twentytwo governments were invited to send qualified meteorologists to participate in the seminar. The countries invited included not only those in the Caribbean region and regions likely to be affected by the Caribbean hurricanes, but also countries in the other regions of the world where similar tropical storms are experienced. Appropriate international organisations were also invited to send observers. The Government of India received an invitation to nominate a meteorologist to take part in the Seminar. Dr. P. Koteswaram, Meteorologist, India Meteorological Department who was

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\*This brief report is based on notes provided by Dr. P. Koteswaram, Meteorologist, who attended the Seminar as a delegate from India.

working as a Research Associate in the Department of Meteorology, University of Chicago, at the time was deputed to attend the Seminar on behalf of India.

The conference was opened by Mr. Moliné, Director of the Dominican Meteorological Service, who was selected to preside over the sessions. After introductory remarks by Mr. D. A. Davies, Secretary-General, WMO and the representatives of RA IV and the Caribbean Commission of RA IV, the meeting got to work.

Since the meeting was organised as a forum for the exchange of scientific opinion, no resolutions were passed. Lectures by authorities on the subject and reading of papers and discussion were the main features. In addition, there were laboratory classes in analysis of tropical "Hurricane Charts" for the Atlantic Ocean.

## 2. Historical development

The first lecture was by Mr. Gordon Dunn, Chief of the Hurricane Warning Centre, Miami, Fla., U.S.A. He traced the history and development of hurricane forecasting in the Atlantic, and emphasised the significance of modern methods of radar, radiosonde and airplane reconnaissance. This was followed by a lecture on "Public Works in Trujillo Era" by Engineer Bonnelly, Chief Engineer of the Dominican Government.

## 3. Methods of observations

Father Gherzi who is well known for his work on Typhoons gave the next lecture on the methodology in the study of the origin and development of Tropical Cyclones. He developed the argument that tropical cyclones are found in areas where large islands are

situated and hence the convective lift provided by the islands in the moist tropical air mass under certain conditions, is responsible for the generation of tropical disturbances. He cited in support of his argument the absence of cyclones off the South American coasts, where there are no large islands.

Commander Millás, Director of the Cuban Meteorological Service read a paper on "Cloud motion and sea swell in hurricane detection". The importance of reporting medium and high cloud movement for determining air motion at high levels in hurricanes was emphasised during the discussion.

Messrs Dunn, Jordan and Lygda of U.S.A. read interesting papers on network requirements for hurricane forecasting and the use of aircraft reconnaissance and radar in hurricane detection and analysis. The first probe by an aircraft into a hurricane was made by a twin engine light bomber B-25 on 27 July 1943, and since then, aircraft reconnaissance has become the primary means of locating and tracking the hurricanes in the Atlantic.

Mr. Gentry, Asst. Director of the U.S. National Hurricane Project which is to undertake an extensive and intensive research on hurricanes during the 4-year period, May 1956 to 1960, explained the plans laid out for his project, which include (i) investigation of the synoptic disturbances when hurricanes are formed, (ii) examination of details of hurricane structure to determine energy exchanges, (iii) individual contribution of various factors in the movement of hurricanes and (iv) determination of parameters for hurricane forecasting.

The last item assumes vital importance when it is remembered that in spite of the development of modern techniques like aircraft and radar reconnaissance, it is not yet possible to prognosticate hurricane movement accurately.

It appeared from the general discussions on this paper that sea wave observations reported in the surface weather code are seldom being used in hurricane detection and that the microseismic method (by tripartite seismographs) has been given up as unreliable.

#### 4. Formation, development and movement of Hurricanes

These aspects were dealt with at length by Prof. Hervert Riehl of the University of Chicago. In a series of three lectures, he discussed the results of recent investigations on the subject, mainly conducted under his leadership. The discourses followed mostly the same lines as in his recent text book on Tropical Meteorology. Since large scale warming up in the centre is necessary for the fall of pressure there, he suggested that the 'eye' of the storm may be a fore-runner for its formation. This was a very unorthodox idea and was considered as 'startling' by many present. The U.S. Hurricane Project for this summer is expected to throw some light on this subject. Prof. Riehl also explained the techniques developed by him and his associates for computing the movement of hurricanes from the 500-mb flow patterns which are assumed to approximate the mean flow in the atmosphere. These computations were reasonably accurate and it was understood from the Miami Hurricane Warning Centre that they find such numerical computations very useful. The success of the method

would, however, depend upon the accuracy of the 500-mb chart, which in turn would lean heavily on the closeness of the radiosonde-rain network as well as on the accuracy of the instruments. Since the storms are always out at sea when forecasts of their movement are most necessary, availability of data from the vicinity of the storm is crucial. The only possibility of these data is by airplane reconnaissance.

Mr. Dunn of the Hurricane Warning Centre, Miami, read a paper on the origin, development, and movement of hurricane "Hazel" of 1954 which had a very interesting life history and ultimately changed into an extra-tropical cyclone.

Prof. Palmén of Finland, now at the University of Chicago discussed dynamics of hurricanes, considering them as thermodynamic machines for converting potential into kinetic energy. He showed how one can calculate the magnitudes of the generation, flux and dissipation terms in the energy equations and analysed the various factors controlling these processes.

Dr. Goldbrunner of Venezuela made an original suggestion that the tropical cyclones are formed by bubbles of cold air in the upper air which are brought in by the incursion of the polar trough into tropical latitudes. To him, the tropical cyclones were secondaries of extra-tropical disturbances. He could not substantiate, however, how the cold pool could maintain itself without sinking and spreading out. He had no synoptic evidence for his theory except a series of conjectural models.

#### 5. Tropical analysis

Dr. Riehl and Mr. Gentry held a few laboratory classes on this subject and the

map analyses and discussions were quite useful and instructive. The main maps used were surface, 500-mb and 200-mb charts. The 200-mb chart was considered as a 'must' in tropics since it is representative of the upper tropospheric flow. The 500-mb chart is actually a transitional level between the upper and the lower tropospheres, but still its use was advocated for making numerical computations of hurricane movement. Low level streamlines were used for drawing the isobaric flow patterns on the surface chart. Emphasis was laid on preparation of vertical time section charts at as many stations as possible, since they enable the forecaster to get a quick mental grasp of changes that have taken place in the vertical during the period of analysis. In order to increase the coverage of ships' reports, a 24-hr collection is represented in the same chart. The surface charts were considerably simplified by omitting details not directly of use in tropical analysis—like temperature and visibility.

#### 6. Research into the effects of hurricanes

Mr. Lee Harris of the U.S. Weather Bureau dealt with problems concerning the study of storm surges which are of vital importance in determining inundation. Mr. James Power, a consulting engineer of U.S.A., dealt with effects of hurricanes on buildings and measures to be taken during construction to prevent or minimise damage. Mr. Ralph Higgs of the U.S. Weather Bureau, Puerto Rico, described the effect of orography in causing floods during hurricanes and cited the movement of a shearline over Puerto Rico in support of his ideas.

Prof. Alfonso Arias of Mexico did not look upon hurricanes as an unmixed evil,

but pointed out how they brought beneficent rains to the Mexican peninsula which would fail if there are no tropical disturbances crossing the peninsula—a situation very much similar to the one we have in South India. He correlated agricultural production with storm frequency in his country. His approach to the economic aspects of the problem was very much appreciated.

#### 7. Numerical methods

Mr. Charles Jordan of the U.S. Weather Bureau read a paper on the results of his experiments at the University of Chicago, on the use of the electronic computer in tropical forecasting. The area of his study was in fairly high latitudes—20 to 30 degrees—where geostrophic approximation which is a fundamental assumption in most of the existing models, is quite valid. His results were quite encouraging for the area under consideration.

#### 8. Hurricane warning and protective service

The methods used in warning the public in various countries in the Caribbean Area were discussed at a round table discussion presided over by Mr. Grinstead, Director of the British Caribbean Meteorological Service. It appears that a sub-committee of RA IV of the WMO is constituted to advise and co-ordinate these warning and protective measures. The organisation of this service at Puerto Rico is described as an example. This service is undertaken by a committee of five consisting of the Governor of the Island, and representatives of the Federal Civil Defence Administration, Red Cross, Police and the meteorologist. This committee gets together as often as required, soon after the formation of a hurricane in the Caribbean is announced, and an R/T

is provided to each chief to disseminate instructions to his organisation. The Weather Bureau has four R/T transmitters for dissemination of warnings and police, shippers and other interests have a number of channels. Telegraph and telephone have been discarded on account of the congestion in the channels and their undependability in crucial occasions. Police and civil defence radios are used for reaching even remote corners. In cities, T.V. is also extensively used in disseminating warnings at very frequent intervals. In U.S.A., weather bulletins are broadcast hourly or even half-hourly by most of the radio stations. A feature of these broadcasts on radio and T.V. is the explanation in non-technical language of the characteristics of a hurricane and what one may expect in different sectors when hit by a hurricane. Wind directions and speeds in various sectors are also detailed in the broadcasts with indications about veering and backing. All these details will undoubtedly be useful to people in organising protective measures. In the British West Indies, they have found it useful to prepare and sell a small booklet containing the A B C of hurricanes and warning and protective service. The Hurricane Protection Committee mentioned above does not dissolve soon after the hurricane season is over, but meets once or twice during the slack season to review their past service and take measures to improve it. It was mentioned that during the hurricane 'Connie' of 1955, about 45,000 people were evacuated to safety zones in about 2 hours at Puerto Rico. The problem of public co-operation in measures devised for their protection was also discussed. It was found that people, though they are reluctant to adopt all measures, are

slowly getting enthusiastic about them, particularly when they are made aware of their beneficent results. Quoting Puerto Rico figures again, the average death-roll per year was 189 during the decade 1926 to 1935 and loss due to damage 10 million dollars per annum. In the corresponding period 1945—1955 there was a negligible number of deaths and the loss was 2 million dollars per annum.

To an interesting question put to the panel about what they consider as the most outstanding advance in hurricane forecasting, the unanimous answer was "aircraft reconnaissance". On a previous occasion it was pointed out how these flights maintained a very high degree of safety record in spite of the admittedly hazardous nature of the missions, and a well-deserved tribute was paid to airmen who have cheerfully undertaken these flights for the last 13 years and helped in the protection of life and property, in addition to their valuable contribution to the advance of knowledge.

#### 9. Research requirements

This subject was dealt with by Prof. Riehl at the concluding session. He pointed out various fields of investigation not only with regard to the meteorological problems, but also concerning the applied aspects, like improvement in notification to the public and special interests, evacuation of people and improvement in general education about these storms; in the field of inundation and submersion; flood warnings etc. He advocated construction of laboratory scale models of ports, estuaries etc, and study of the effect of winds by laboratory experiments. Similar work is necessary in the development of



designs in housing and industrial construction which can withstand the impact of these natural phenomena.

#### 10. Conclusion

The Seminar came to a close after the customary tributes were paid to the organisers and to the hospitality of the host

government. The proceedings of the Seminar are expected to be published shortly by the WMO and distributed to the member countries. It was undoubtedly a great success in pooling together all available information and in stimulating the quest for improvement. It enabled each participant to size up the deficiencies in his organisation and figure out steps that could be taken to improve it.

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