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INTERNATIONAL CO-OPERATION IN METEOROLOGY: AN HISTORICAL REVIEW

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At the end of the XVIIIth century and during the XIXth century scientists all over the world (Lamarck, Levoisier and Le Verrier in France, Brandes in Germany, Kreil in Austria, Fitzroy in Great Britain, Franklin in the U.S.A., Wild in the U.S.S.R., Buys-Ballot in the Netherlands, ...) became gradually aware that the physical phenomena occurring in the atmosphere had a planetary scale and were deeply influenced by their environment through complicated actions, intricate interactions and tangled feedback effects. The least one can say is that atmospheric phenomena and in particular weather systems, are not independent. Therefore, it is indispensable to observe them continuously, simultaneously and everywhere over the earth's surface. From this imperative necessity, it follows that meteorology requires an international organization and close worldwide scientific co-operation with a view both to co-ordinating observational and research programmes and to implementing and operating an adequate network of observing stations in all parts of the world. The word adequate means that the distance between stations and the time interval between observations must be selected as a function of the linear dimensions and local life-time of the phenomena to be explored. In addition observations must be performed in accordance with agreed procedures and following a prescribed time-table, so that observations are comparable and adapted to the study of weather by means of the synoptic method, the only one suitable for investigating phenomena on a planetary scale.

Thus our knowledge of the atmosphere depends on the extent and density of an international network of observing stations and in addition on the frequency of meteorological observations, i.e., it depends in the first place on an organization which I do not hesitate to call industrial. "This forced dependence of scientific research on industrial organization is a particular feature of meteorology (1)." I should add that this particular feature of meteorology is inescapable.

It also has long been realized that progress in meteorology does not only depend on the improvement of instruments or on the discovery of new methods of observation: it depends above all, as we have just pointed out, on the organization of a network of stations suitably distributed throughout the world and equipped with comparable and calibrated instruments. Hence, it is not surprising that the history of progress in meteorology coincides with the history of the successive developments of the network of meteorological stations. Of course, one should not underestimate the importance of technological advances. It is quite clear that the rapid progress in meteorology is to be ascribed to a great extent to present advanced electronic techniques. These techniques allow meteorologists to explore, in principle, any portion of the atmosphere. Advancement of our knowledge of the atmosphere as a whole, however, depends on the implementation and operation of a network of observing stations and certainly not on the establishment of a single station whatever the importance and quality of its instrumental equipment may be. With a single station it is possible to work out some physics in the atmosphere but certainly not to study the physics of the atmosphere.

The idea of observing the weather in different places at the same time and in the same way is so obvious that attempts at establishing networks

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(1) "Ce caractère de subordination forcés de la recherche scientifique à l'organisation industrialle est très particulier à la météorologie."

of observing stations were made as soon as meteorological instruments became available (middle of the XVIIth century). Two of these attempts deserve mentioning.

> The Academia del Cimento (Florence, 1645-1667) set up a network of thermo-hydrometric stations in Northern Italy (seven stations) and outside Italy (four stations).[2] In 1780, the Societas Meteorologica Palatina (Meteorological Society of Mannheim) established a network of stations, equipped for the first time with comparable and calibrated instruments: in Germany (fourteen stations).
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> Through co-operation between the Academy of Sciences and Arts of Mannheim and other national academies: in Europe (twenty-two stations): in the U.S.A. (one station at Cambridge); and in Greenland (one station at Godthaab).
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> All stations were equipped with a barometer, a thermometer, a hygrometer; some of them, with a windvane and a raingauge. Each observer had an instruction manual at his disposal [2]. Unfortunately this first very successful, international and well-organized network of meteorological stations was destroyed by the wars of the French Revolution (The siege of Mannheim, 1795).

There is still another essential factor contributing to the advancement of geophysics in general and to meteorology in particular. Geophysical sciences are now making rapid progress not only because technology is advancing at an impressive speed but also because mankind is at present becoming increasingly aware of the importance of these sciences for his own existence. Mankind is in fact ignorant of the properties of the medium in which he lives; additional knowledge in this field would be most beneficial for us all. It is well known that an impelling curiosity drives mankind towards the understanding of all natural phenomena. In the case of meteorological phenomena which he cannot elude and which constantly influence all his activities and sometimes even threaten his life, his self-interest, if rightly understood, urges him imperiously to reach this understanding as rapidly as possible. Governments therefore are prepared to support financially the implementation of networks of observing stations and the establishment and operation of national meteorological services and institutions. It is clear that governmental authorities will not provide meteorologists with funds simply to allow them to enjoy research!

In short, one may say that there can be neither a public service nor a science of meteorology without permanent global observations of the atmosphere and adequate world-wide data exchange and data processing systems. The very great eonomic importance of meteorology however justifies largely the implementation of a network of observing stations, the establishment of national meteorological services and telecommunication centres. Clearly the operation of international networks of observing stations and the organization of the essential exchanges of observational material are impossible in the absence of close international co-operation. Hence meteorology not only has an outstanding economic importance but also an eminent human value. In performing properly their everyday job, meteorologists all over the world contribute ipso facto to international understanding and hence to peace.

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In the light of these introductory remarks it is not astonishing that international co-operation in meteorology has indeed already a long history.

As a matter of fact, the International Meteorological Organization (IMO) is, in the field of international co-operation, one of the oldest international institutions in the world. One hundred and fourteen years ago, on the 23rd of August 1853, the First International Meteorological Conference was held in Brussels at the initiative of Lieutenant M. F. Maury, a United States Navy Officer, and under the chairmanship of A. Quetelet, the first director of the Royal Belgian Observatory and the author of the first climatography of his country. The main object of the conference was to achieve a uniform system of meteorological observations at sea. This same system extended to the whole surface of the earth and to all levels of the atmosphere, is still on the agenda of most of the World Meteorological Organization meetings today.

Since 1853, meteorologists of all countries have continued to meet together. After several preliminary international conferences held from 1853 to 1878, the IMO was founded at a time when the means of communication and transport were very rudimentary compared with those which we enjoy today. In spite of these difficulties, the occurrence of two world wars and many other obstacles, this organization was not only kept alive but, thanks to the untiring efforts of several generations of meteorologists, it has thrived. An international organization for meteorology unquestionably meets an urgent need (5).

The IMO was in fact a federation of directors of national networks of observing stations. Many very important achievements were realized under the auspices of IMO, which on the 23rd of March 1950 was transformed into the World Meteorological Organization (WMO). A new structure was imposed on the Organization by circumstances, mainly by new post-war conditions but particularly by the establishment of United Nations Special Agencies in other fields of human activity, in which meteorology was involved. This conversion of IMO into WMO has made it possible to implement the Organization's resolutions and decisions much more efficient.

According to G. Swoboda (4) one should distinguish five stages in the history of the Organization as follows:

(i) Preliminary conferences, 1853-1872;

(ii) Preparatory phase, 1873-1878;

(iii) First period of existence of IMO, 1879-1914;

(iv) Second period of existence of IMO, 1919-1939;

(v) Third period of existence of IMO, 1946-1950;

To these five stages, we have now to add a sixth one:

(vi) First period of existence of WMO, 1951- ?

(i) The initial period 1853-1872 was characterized by the first contacts between meteorologists at the international level and the first attempts at international co-operation. As I already mentioned, the First International Meteorological Conference was initiated by Maury. However, the very first proposal to hold an international meteorological conference with a view to considering a uniform system of meteorological observations on land, originated from Captain James of the Royal Engineers of the British Army. Although this plan was supported by the U.K. Government, it was never implemented. The U.S.A. then presented an alternative and more comprehensive proposal as formulated by Maury. In Maury's own words "the navies of all maritime nations

should co-operate, and make these (meteorological) observations in such a manner and with such means and implements, that the system might be uniform, and observations made on board of one public ship be readily referred to and compared with the observations made on board of all other public ships, in whatever part of the world. And moreover, as it is desirable to enlist the voluntary co-operation of the commercial marine, as well as that of the military of all nations, in this system of research it becomes not only proper, but politic, that the forms of the abstract log to be used, the description of the instruments to be employed, the things to be observed, with the manipulation of the instruments, and the methods and modes of observation should be the joint work of the principal parties concerned". This is a gripping outline of the tasks being undertaken by WMO today - an outline given in the summer of 1853!

Ten countries accepted an invitation to the Brussels' Conference. With the exception of James and Quetelet, all delegates were naval officers. This is but one illustration of the great debt by meteorologists to mariners (1). This first conference was extremely successful: for the first time international rules were issued in order to observe uniformly the weather at sea.

James' proposal was put into effect nineteen years later, in 1872, by the Second International Meteorological Conference convened in Leipzig by Bruhns (Leipzig), Wild (St. Petersburg, Leningrad of today) and Jelinek (Vienna). Fifty-two directors of National Meteorological Services and some other scientists interested in meteorology attended the Leipzig Conference. This conference adopted for the first time internationally agreed rules for meteorological observations on land. In other words, the Second International Meteorological Conference achieved for the observations made on land the same results as those reached in Brussels by the First International Conference for the observations on board ship. The Brussels Conference of 1853 may be considered as the very first meeting of the Commission of Maritime Meteorology and the Leipzig Conference 1872 as the very first meeting of the Commissions for Climatology and for Synoptic Meteorology.

In addition, and for the first time, the idea of an international organization of meteorology was presented in Leipzig; in fact the Leipzig Conference did much more than advocate the needs of such an organization. Indeed the Conference decided to call an official congress, grouping governmental officials with the aim of setting up a permanent "International Meteorological Organization". The First International Congress of Meteorology was held in Vienna in 1873. The centenary of this important event will be celebrated in Vienna in 1973 under the auspices of WMO.

(ii) The First International Meteorological Congress held in Vienna in September 1873 is a milestone in the history of international co-operation in meteorology. It marked the beginning of a preparatory phase of six years during which the nucleus of an international organization of meteorology was set up, the statutes of the organization worked out and its structure defined. Thirty-two States were represented in Vienna and the Congress was headed by a troika: Bruhns, Buys-Ballot and Jelinek. The strong personality of Buys-Ballot had a profound bearing on the future of the meteorological organization. The main concern of the First Congress was to ensure continuity in the activities of the organization between sessions. The Congress of Vienna therefore established a Permanent Committee (a board of seven members) entrusted with the following tasks: (a) to take care of the publication of the results of the Congress and of the implementation of its decisions and (b) to prepare the agenda items of the next congress, which was held in Rome, in 1879. Moreover, the Permanent Committee was given the important task of drafting and approving the statutes and rules of the organization. To this

effect, it met four times; in 1873 in Vienna, in 1874 in Utrecht, in 1876 in London and in 1878 again in Utrecht. In Utrecht, in 1878, the charter of the organization was finalized and the IMO founded.

Throughout the entire history of the Organization, its main concern has been continuity in work and action. The Permanent Committee set up to this end in Vienna, is the ancestor of the International Meteorological Committee (IMC) which was still in existence at the end of the third and last period of existence of IMO, that is to say 1951. It should be stressed here that, in those times, there was no secretariat with paid professional staff and assistant personnel. The work between sessions was shared by the members of the Permanent Committee who performed their tasks on a voluntary basis. The amount of voluntary work performed in the framework of our Organization since its very beginning is unbelievably large for any one who is not acquainted with its traditions. Performance of work on a voluntary basis is one of its most characteristic features so that the international organization of meteorology has always been and still is one of the least expensive and, at the same time, one of the most efficient.

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(iii) The second International Meteorological Congress, convened by the Permanent Committee which had been appointed by the First Meteorological Congress, met in Rome in April 1879. The second Meteorological Congress endorsed the statutes and rules elaborated by the Permanent Committee so that this Congress really marked the beginning of the first period of existence of IMO. It made four important decisions:

(1) Establishment of an International Meteorological Committee (IMC) of nine members elected by Congress, with the same terms of reference as those of the Permanent Committee set up by the Vienna Congress. In addition the IMC had to report to Congress on its activities between sessions. The president and secretary of the IMC were elected by the committee. The first IMC president and secretary were Wild and Scott respectively. The tasks entrusted to the IMC were also shared by its members on a voluntary basis.

(2) The Congress of Rome supported the proposal of organizing the First International Polar Year 1882-83 and instructed the IMC to convene a special conference with the view to elaborating a detailed programme.

(3) The Congress of Rome recommended that information on research on "the general laws of meteorology" be exchanged between meteorological institutes and that the publications issued in each country be distributed on a free basis to all these institutes and interested individuals. At the initiative of Buys-Ballot, the Rome Congress also defined a "research programme considered to be of a common interest to all participating countries".

(4) The Second Congress held in Rome in 1879 adopted a final position regarding a proposal presented by Buys-Ballot at the First International Meteorological Congress in Vienna in 1873. This proposal was to create an international fund for subsidizing "research of world-wide value or collective undertakings such as the establishment of observing stations on islands or in isolated localities". I do not think it is possible to formulate, in terms which are at the same time simpler and clearer, the fundamental problem of the international organization of meteorology. Buys-Ballot's foresight concerning future

meteorological developments is really astounding[5]. No doubt he would have been an enthusiastic supporter of the "New Development Fund", the "World Weather Watch", including the "Voluntary Assistance Programme" and, last but not least, the "Global Atmospheric Research Programme". Unfortunately, his proposal was turned down by the Rome Congress. The question of "international funds" was however taken up and rediscussed at nearly all the international conferences which followed the Vienna and Rome Congresses. We shall see that after the first World War Buys-Ballot's proposal was even extended.

The IMC met five times: in Rome (1879), Berne (1880), Copenhagen (1882), Paris (1885) and Zurich (1888). At its Zurich meeting, the IMC took an important decision: the International Meteorological Congress should not be reconvened but the directors of National Meteorological Services should be called together. The Conference of Directors (CD) met for the first time in Munich in 1891: thirty directors attended the meetings. From 1891 on, the CD was the leading body of the IMO until the end of IMO in 1951.

Henceforth the Organization was composed of the CD and the IMC with its Executive Bureau. At the beginning this bureau comprised only the president and the secretary; it was enlarged later on and called the Executive Council of the IMC. This executive body is the ancestor of the WMO Executive Committee, the IMC being rather a reduced CD entrusted with executive powers, and whose executive functions were carried out on a voluntary basis by the Executive Council.

The First Conference of Directors (Munich, 1891) introduced an important innovation: the first technical commission was formed. Curiously enough this first commission was the Commission for Earth's Magnetism and Atmospheric Electricity. Other technical commissions were set up during the first period of existence of the organization. At the Second Conference of Directors (Paris, 1896), two new commissions were formed: the Commission for Scientific Ballooning (H. Hergesell, the first president) and the Radiation Commission. The first one is still viable after four changes of name: Commission for the Exploration of the High Atmosphere (CD, Paris 1919) with V. Bjerknes as president, Aerological Commission (CD, Warsaw, 1935) with L. Weickmann as president, Commission for Aerology (First WMO Congress, Paris 1951) and Commission of Atmospheric Sciences (Fifth WMO Congress, Geneva 1967). In 1919 after the war, Radiation Commission merged with the Solar Commission (formed by the IMC at its meeting in Southport in 1903) and was called the Commission for Solar Radiation.

From 1894 to 1913, the IMC held eight sessions, under the presidency of Mascart from 1894 to 1907 and Napier Shaw from 1907 on. By the eve of the First World War, the Organization had taken shape. Nine technical commissions were in existence [4]:

- Commission for Earth's Magnetism and Atmospheric Electricity (CD, Munich 1891),
- Commission for Scientific Ballooning (CD, Paris 1896),
- Radiation Commission (idem),
- Solar Commission (IMC, Southport, 1903),
- Commission of Meteorological Telegraphy (IMC, Paris, 1907),
- Commission for Maritime Meteorology (id.),

- Commission of the World Network (id.),

- Commission for Polar Meteorology (IMC, Rome 1913),

- Commission for Agricultural Meteorology (id.).

The Commission of Meteorological Telegraphy (established at the Paris session of the IMC in 1907) is the ancestor of the WMO Commission for Synoptic Meteorology. At the CD held in Copenhagen in 1929 its name was changed to the Commission for Synoptic Weather Information.

The terms of reference of these technical commissions were basically the same as those of the WMO Technical Commissions of today: survey of a certain field of scientific or technical activity of interest to the Organization, standardization of the performances of instruments and of methods of observation, elaboration of internationally agreed procedures and, more generally, advice on technical matters to the executive body of the Organization.

At its Third session in Innsbruck in 1905, the CD felt it necessary to put some order into the resolutions adopted previously by the Organization and to codify the internationally agreed rules. The CD directed the IMC to prepare draft technical regulations to be submitted to the next CD which should have been held in Utrecht in 1915. Mascart prepared a draft on the basis of which the IMC adopted (Paris, 1907) a final draft containing the following main sections: times of observations and units of measure, synoptic meteorology, climatology and aerology. The First World War prevented the IMC from presenting for approval this final draft to the CD. Nevertheless one may say that the very first edition of the Technical Regulations of our Organization was issued sixty years ago!

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Taking a bird's-eye view, in other words a synoptic view, one may safely state that during the first period of existence of IMO (1879 - 1914) meteorology was in its infancy as were also radio and air navigation. Thus the services that radio could render to meteorology and in turn meteorology to air navigation were practically non-existent. Nevertheless, as we have seen the IMO organized its work, gave some structure to the Organization and defined its programme. In its second period of existence (1914 - 1939) which we will review below, the Organization strengthened its structure and took steps to obtain an official status. A secretariat was established. Codes for the dissemination of meteorological information were standardized and collective broadcasts ensuring their dissemination were organized.(4). This last item gives me the opportunity to stress the rapidity with which the Organization has always taken full advantage of the latest advances in technology. This very progressive attitude is a particular feature of meteorology as a science and as a public service. Many other more recent examples illustrate this fact: the use on a routine basis of radiosondes, radio-theodolites, radar, automatic observing stations, electronic computers and artificial satellites. Not only do meteorologists use the most advanced techniques available for their studies and research in the same way as other scientists, but they also take advantage of these techniques immediately and fully, in order to improve operationally the systems of observation and communication and the public service of meteorology on an international scale.

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(iv) After preliminary contacts by correspondence, Napier Shaw, president of IMC from 1907, invited some of his colleagues, most of them members

of the IMC, to attend an informal meeting in London, in July 1919, with a view to renewing contacts after the war and to agreeing on the steps to be taken to revive the Organization rapidly. It was decided to organize an official session of the CD. The French Government invited the directors of the National Meteorological Services to meet in Paris at the end of September 1919.

The CD held in Paris in 1919, immediately after World War I, adopted the final draft of the Technical Regulations prepared by the IMC in Paris (1907) and left unchanged the pre-war structure of the Organization: CD, IMC with its Executive Council, and the Technical Commissions. The pre-war technical commissions were maintained in existence and a new one was added: the Commission for the Application of Meteorology to Air Navigation, the ancestor of the WMO Commission for Aeronautical Meteorology.

At the CD in Paris (1919) Buys-Ballot's proposal of gathering "international funds for international purposes", presented for the first time at the First International Meteorological Congress in Vienna (1873), was extended and the question of creating a "Meteorological Bureau with International Funds at its disposal" was included in the agenda. At about this time the CMM, which had been reconstituted after the First World War, called the attention of the IMC to the services such a bureau could render if it handled the statistical investigation of observations made at sea. In its turn the Commission for the Exploration of the Upper Atmosphere (the WMO Commission for Atmospheric Sciences of today) suggested that the Bureau should be made responsible for publishing the results of soundings carried out during the "International Aerological Days", which were published before the First World War by the national institute headed by the president of the commission (Hergesell). The problem of creating an International Meteorological Bureau was re-discussed at the London IMC meetings in 1921 and again in Utrecht at the 5th CD, in 1923, when a commission was set up to study this important question. The report of this commission was discussed at length by the IMC in Vienna in 1926. In spite of the strong recommendation made by the commission and the eloquent plea of its president, Delcambre, and in spite of the official promise from the League of Nations offering the hospitality of the Institute for Intellectual Co-operation in Paris, the IMC, at its Vienna session (1926), turned down the plan for an International Meteorological Bureau and was content with establishing a modest Permanent Secretariat.

The IMC invited the directors of National Meteorological Services to appeal to their respective Governments in order to obtain the necessary financial support for the operation of the Secretariat. The Secretariat took over the administrative tasks previously carried out on a voluntary basis by the Bureau of the IMC. The first chief of the IMO Secretariat was H. G. Cannegieter and the second was G. Swoboda appointed in 1938. He became in 1951 the first Secretary General of WMO; his successor Mr. D. A. Davies was elected by the Second Congress in 1955.

The same problem came up again at the time of the transformation of the IMO into the WMO. Under the new Organization, the functions of the Permanent Secretariat were enlarged after the First WMO Congress (Paris, 1951) by the addition of a Technical Division and later on, after the Fourth WMO Congress (Geneva, 1963), by the addition of a Planning Unit. But let us not anticipate too much at once. On the whole, one may say that the attitude of the Organization with regard to technical matters has always been rather progressive, but has been a bit lacking in boldness when a costly but essential decision has had to be taken.

At its London session in 1921 the IMC adopted a new international code for the dissemation of meteorological messages, established a new commission (the Commission for the study of Clouds) and decided to call the next CD in 1923. The directors of meteorological services met in 1923 in Utrecht. This 5th CD re-examined the functions of the Organization and its relationship with other recently formed international organizations, took measures in order to increase the uniformity in the functioning of national meteorological services and to improve the application of meteorology to the safety of sea and air navigation as well as to agriculture. They met again in Copenhagen in 1929. This 6th CD took important decisions on technical questions. It organized for the first time the collective broadcasts of meteorological information in Europe and to North America and adopted new ad hoc forms of international meteorological codes for the exchange of this information. Among these code forms I recall the famous Copenhagen code elaborated on the basis of the new knowledge acquired by the Bergen School. This code was the first true synoptic code and unfortunately the last. The code in use today which is a slightly improved version of the code recommended by the Commission of Synoptic Weather Information (CSWI) immediately after the Second World War (Paris, 1946), is in fact an aeronautical code because it meets fully the needs of civil aviation and not fully the requirements of synoptic meteorology. The needs of all users of meteorology, without exception, should of course be met, but the international professional daily work of meteorological personnel and the internationally agreed meteorological procedures should also, without exception, be based on sound scientific principles. The CD in Copenhagen formed two new commissions: the Commission for the Polar-Year 1932-33 and the Commission for Climatology which is still active. This CD confirmed the existing structure of the IMO: the CD, the IMC with its Executive Council (relieved from the burden of administrative work) the Secretariat and the Technical Commissions of the Organization. Finally, for the first time, the CD acknowledged the importance for the IMO to be officially recognized by Governments.

The 19th IMC Session, held in Lucarno in 1931, devoted practically all its time to the preparation of the meteorological programme of the Polar-Year 1932-33 and the establishment of new observing stations in the Arctic. By so doing the IMC demonstrated once more the interest of the Organization in research, although its main efforts were concentrated on organizational problems and technical questions, that is to say in the public service of meteorology. In its next session, in De Bilt in 1933, the IMC formed the Commission for Bibliography (abolished in Geneva by Third WMO Congress, 1959) and decided to convene a new CD. This CD, the Seventh, held in Warsaw in 1935 was the most important one held between the two world wars. This CD revised in detail the meteorological codes, introduced new ones, extended considerably the collective broadcasts of meteorological information (recommended in 1929 by the Copenhagen CD), took some steps in order to increase the efficiency of the work of the organization and tried to ascribe a more official character to the IMO. In this connection it should be recalled here that the IMO Commission for the Application of Meteorology to Air Navigation had already experienced some difficulties because the Commission entered into competition with the International Commission for Air Navigation (CINA = Commission internationale de Navigation aerienne), an intergovernmental organization set up by the International Aeronautical Convention (Convention aerienne internationale), adopted by Governments on the 13th October 1919. Having at its disposal more ways and means than IMO, CINA was able to implement its decisions, more rapidly than IMO. The CD of Warsaw tried to overcome these difficulties by transforming the existing IMO-Commission into the International Commission for Aeronautical Meteorology (ICAeM) with a special status, the members of this new commission being appointed by the National Aeronautical Services in order to establish a close liaison between CINA and IMO and to co-ordinate their work in an efficient way. The first president of the ICAeM was R. Bureau.

In order to ensure a better implementation of the IMO resolutions in different parts of the world, the CD in Warsaw decided to establish two regional commissions: Regional Commission I for Africa and Regional Commission II for the Far-East. These two new IMO organs were the ancestors of the six WMO Regional Associations. Finally, some modifications were made in the IMO statutes in order to make provisions for the special status of the ICAeM, to ensure a more efficient representation in the Organization of the national networks of observing stations and to allow the Organization to approach Governments more easily. From that time on invitations to attend sessions of the CD were sent to the Governments and they were urged to send the directors of their respective National Meteorological Services as national delegates to the CD and to authorize the directors to vote on behalf of their respective Governments. The hope of the Organization was of course to give more weight to the IMO resolutions but also to obtain one day official recognition by the Governments involved.

The IMC at its sessions in Salzburg (1937) and Berlin (1939) did its utmost in order to implement the important resolution adopted by the CD of Warsaw (1935). In particular, the IMC adopted the rules on which the ICAeM should base the general regulations for the safety of aircraft and, in this connection, it accepted the proposal of the ICAeM to study in effect the organization of the stationary weather ships in the North Atlantic. The IMC in Salzburg adopted also for the first time resolutions regarding the establishment of a network of radiosonde stations. Finally, the IMC formed two new regional commissions: one for South America and another one for North and Central America, and decided to organize the next CD in Washington in 1941, with the understanding that all Technical Commissions should meet beforehand in Toronto. The IMC in Berlin 1939 formed a fifth Regional Commission for the South West Pacific and examined two important projects: one on the meteorological protection of civil aviation, elaborated by the ICAeM, in co-operation with CINA, and another one prepared by Th. Hesselberg, president of IMC, on a World Meteorological Convention to replace the existing statutes of the Organization with a view to giving an intergovernmental status to IMO. Among the arguments set forth by Hesselberg, I wish to recall the following:

(1) The economic importance of meteorology is so great that governments should have more influence on the activities of the Organization: (2) The financial resources of the Organization should be assured on a permanent basis: (3) That one technical commission, the ICAeM, has an intergovernmental status, while the Organization as a whole has none, is an unhealthy situation: (4) Other International Organizations (CINA, IUGG,...) had a more official status than IMO: (5) Governments did not have sufficient influence on the selection of national representatives to the IMO meetings.

Unfortunately, the Second World War broke out in the second half of 1939 and the excellent project of Hesselberg (sometimes called the Berlin Project) could not be submitted to the CD planned for 1941[4].

The IMO Secretariat was transferred in November 1939 from De Bilt to Lausanne where the management of the administrative and financial affairs of the IMO continued on a reduced scale. It should be noted here that during the war period, from 1939 to 1945, the contributions of the members of the Organization arrived quite regularly in Lausanne, thereby demonstrating the faithfulness of the IMO members to their organization, and these members expressed on many occasions their vivid wish to revive international co-operation immediately after the war.

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After World War II the IMO revived as rapidly as after World War I. The future development of civil aviation, namely the organization of long distance flights over continents and oceans, was easy to predict as a consequence of the tremendous development of military aviation during the war. The war had also demonstrated the increasing importance of meteorology. The first post-war contacts were renewed in London, in February 1946, at an Extraordinary Conference of Directors. On this occasion the Organization, aware of its new responsibilities, immediately resumed its work. Provisional decisions were adopted concerning the immediate operation of the international network of observing stations on land and at sea and the exchange of meteorological messages. The maintenance of the stationary weather ships established during the war was strongly recommended. In accordance with the decisions made at Warsaw (1935) and at Berlin (1939), the Extraordinary Conference of Directors directed the IMC to resume its work on the legal status of the Organization and to envisage a possible affiliation of the Organization with the United Nations (UN), without losing its independence and its technical character. The pre-war ICAeM was asked to elaborate on, in co-operation with the Provisional International Civil Aviation Organization (PICAO), an agreement between the two organizations. On the completion of this task the Commission was dissolved. The London Extraordinary CD set up ten technical commissions: Aerological Commission, Commission for Bibliography and Publications, Climatological Commission, Hydrological Commission, Commission for Instruments and Methods of Observation, Commission for Agricultural Meteorology, Commission for Maritime Meteorology, Commission for the Projection of Meteorological Maps, Commission for Synoptic Weather Information (CSWI). Commission for Aeronautical Meteorology (this time without a special status in IMO). The underlined commissions were new. It should be noted incidentally that the IMO had a Hydrological Commission while WMO has only a Commission for Hydrometeorology. This fact shows that a non-governmental organization may sometimes have a less conservative attitude than an inter-governmental one. Six Regional Commissions were established: they correspond to the present six WMO Regional Associations. The sixth Regional Commission for Europe was new. Finally it was decided to call a new CD in Washington in 1947 and that all technical commissions should meet beforehand in Toronto as had been decided in Salzberg (1937) before the war.

The CSWI, the Regional Commission for Europe and the IMC met in Paris in the summer of 1946. The CSWI revised completely the codes for the dissemination of weather information and the system of collective broadcasts, and recommended the extension in Europe of teletype links and the establishment of radiosonde stations. The CSWI recommendations were endorsed by the IMC. This committee under the presidency of Nelson K. Johnson devoted most of its time to the preparation of an International Meteorological Convention on the basis of the Berlin Project, amended during the war by its president, Th. Hesselberg, in consultation with G. Swoboda, chief of the IMO Secretariat. Three basic documents were drafted; a draft World Meteorological Convention, draft General Regulations and draft Technical Regulations (annex to the Convention). These drafts were adopted and submitted for comments to the National Meteorological Services and to their Governments.

As planned, the ten IMO Technical Commissions met in Toronto in the summer of 1947. The reports of all these Commissions were submitted to the Conference of Directors held in Washington immediately after the never-to-be-forgotten Toronto meetings! This Conference, presided over by Nelson Johnson, adopted 220 resolutions, - a record! -, on numerous subjects related to networks of stations, codes, telecommunications (sub-continental, continental and inter-continental broadcasts), safety of air navigation, units, diagrams and symbols, climatological statistics, publications and documents, instruments and methods of observation, education and professional training, meteorological studies and research, legal and administrative questions.

The Washington CD enlarged considerably the co-operation between the ICAO Division for Meteorology and the IMO Commission for Aeronautical Meteorology and recommended the organization of joint meetings of these bodies. The Conference insisted on the necessity for National Meteorological Services to take care of the meteorological aspects of the safety of civil air navigation. The Conference formed two new technical commissions: The Commission for Polar Meteorology and the Commission for Radio-Meteorology, so that twelve Technical Commissions were active at the end of the third and last period of existence of IMO.

The most important question on the agenda of the Washington CD was the proposal, discussed many times before, to transform IMO into a WMO with intergovernmental status. After long discussions and very many sessions, including night sessions, a World Meteorological Convention was drafted. It was unanimously adopted on the condition, however, that the Organization should keep its world-wide character and its independence. The affiliation of the new Organization with the UN was also decided. The World Meteorological Convention came into force on 23rd March 1950. The last CD was held in Paris in 1951, just before the First WMO Congress, in order to dissolve IMO and to transfer its responsibilities to the new organization.

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It is too early to review the history of WMO. Therefore I will confine myself to some comments.

The WMO has at present 130 Members (States and Territories); this figure demonstrates the truly world-wide scope of the Organization.

The main difference between IMO and WMO is of course the difference in status of the two organizations. Apart from that, the WMO has taken over the structure, the objectives (co-ordination, standardization and improvement of the meteorological activities between countries for the benefit of various human activities) and the traditions of IMO. The WMO Congress, Executive Committee, Regional Associations, Technical Commissions and Secretariat correspond respectively to the IMO Conference of Directors, the Executive Council of the IMC, the IMO Regional Commissions, Technical Commissions and Secretariat. A body equivalent to the IMC does not exist in WMO. The First WMO Congress (Paris, 1951) formed eight Technical Commissions: CAe (Commission for Aerology), CSM (Commission for Synoptic Meteorology) CCI (Commission for Climatology), CAeM (Commission for Aeronautical Meteorology), CMM (Commission for Maritime Meteorology), CAgM (Commission for Agricultural Meteorology), CIMO (Commission for Instruments and Methods of Observation), and CBP (Commission for Bibliography and Publications). The CBP was dissolved at the Third Congress (Geneva, 1959). The commission for Hydrological Meteorology (CHM) was established by the same Congress and the Fourth Congress (Geneva, 1963) changed its name to Commission for Hydrometeorology (CHyM).

Broadly speaking one may say that the WMO like the IMO, has largely achieved its aims by co-ordinating existing national efforts as closely and efficiently as possible. After twelve years of existence, WMO, however, has done more. At the Fourth Congress (Geneva, 1963), an important change occurred. The spectacular advances in three aids to meteorological exploration and investigation (electronics, statistics and numerical analysis), the possibility of using high speed electronic computers on a routine basis, the recent progress in dynamic and physical meteorology, the introduction of space techniques into meteorology, all enabled meteorologists today to build a global observation, data exchange and processing system, the World Weather Watch (WWW), with a view to attaining a global knowledge of the atmosphere. In answer to UN-Resolutions on the peaceful uses of outer space (Res. 1721 (XVI), 20.12.61 and Res. 1802 (XVII), 14.12.62).

The Fourth Congress accepted the principle of the WWW and directed the Executive Committee (EC) to prepare a WWW-plan and to this end provided financial support for a Planning Unit in the WMO Secretariat. Moreover, Fourth Congress established a WMO Advisory Committee in order to advise the EC on the main problems of research and public service in the field of the Atmospheric Sciences. Fifth Congress (Geneva 1967) endorsed this plan and has taken steps for its implementation by the WMO Members. These decisions constitute an important change in the attitude of the WMO towards the international organization of meteorology. From a co-ordinating body, WMO has now become a planning and co-ordinating organ. It is clear that a plan such as the WWW-plan cannot be realized simply by co-ordinating national efforts. Indeed such a realization needs the implementation by the WMO Members of a pre-established plan, elaborated at WMO headquarters under the authority of the WMO-EC. Thus, the WMO has become operational. Certainly in the future this fact will entail some changes in the working procedures and perhaps also in the structure of the organization. But this we must await.

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It is interesting to observe that it is not so long since it was recognized that international co-operation is also indispensable for solving fundamental problems in meteorology. Indeed, the International Association of Meteorology (IAM) was formed more than forty years after IMO. Nevertheless progress in pure meteorology also depends largely upon the international network of observing stations and therefore, as I have already pointed out above, on an international organization of meteorology. Evidently, research workers in meteorology and professional meteorologists use the same raw data obtained from the same international network of observing stations.

It is perhaps useful to recall here that the IAM was founded in Brussels in 1919, under the presidency of Napier Shaw, at the same time as the IUGG, together with three other Associations: Terrestrial Magnetism and Electricity, Physical Oceanography (IAPO), and Volcanology. The International Association of Scientific Hydrology was founded three years later at the First IUGG General Assembly held in Rome in 1922. Co-operation between the Associations of Meteorology, Oceanography and Hydrology has been very close, from the beginning up to now. The International Union of Geodesy and Geophysics (IUGG), one of the constitutive unions of the International Research Council (now International Council of Scientific Unions) was formed at about the same time and in the same place as the Council (Brussels, July 1919) around two pre-existing Associations: The Association of Geodesy, founded in Berlin in 1862 and the Association of Seismology, founded in Strasbourg in 1901.

"The IUGG is a confederation of several International Associations and Commissions whose object is, by international co-operation, to further scientific research and investigation in their various fields of geodetic and geophysical study"(3).

The IUGG and the IAM have held seven General Assemblies from their beginning up to the Second World War: Rome (1922), Madrid (1924), Prague (1927), Stockholm (1930), Lisbon (1933), Edinburgh (1936) and Washington (1939). At an extraordinary Assembly held in Cambridge in 1946 to deal only with administrative matters, it was decided that the first post-war General Assembly of the Union and its Associations would be held at Oslo in 1948. The other post-war General Assemblies of IUGG and IAM are: Brussels (1951), Rome (1954), Toronto (1957), Helsinki (1960), Berkeley (1963) and Switzerland (1967).

The IAM extended its name at the Toronto General Assembly in 1957: from that time forth it decided that it should be called: the International

Association of Meteorology and Atmospheric Physics, just to remind those who had forgotten that Meteorology, by definition, is the Physics of the Atmosphere and not simply weather forecasting and description of climates. The Association's aims remained unchanged (see below).

Membership in the Union is open to any country in which independent activity in geodesy or geophysics has been or is being developed, and automatically carries with it membership in each one of the component International Associations and Commissions of the Union. Membership is usually effected in the name of an academy of science or an appropriate government department or a national committee devoted to geodesy and geophysical subjects. Immediately after the Second World War, in 1948, some thirty-two countries well distributed throughout the world were members of the Union. At present (October 1967) there are sixty-nine members. In many of the member countries the National Committees appointed sub-committees to deal with the subject of each of the Associations(3).

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The objects of the IAMAP are as follows:

a) to promote the study of all problems on the physics of the atmosphere;

b) to initiate, facilitate and co-ordinate, in this field those researches which require international co-operation;

c) to stimulate discussions and provide for the publication of results of the researches.

The means by which the IAMAP strives to achieve these aims are threefold: (1) by arranging for discussions at meetings of the Association, normally held at three-yearly intervals, at the time of the General Assembly of the Union; (2) by arranging for discussions jointly with other Associations of the Union and with representatives of other International Scientific Unions federated in the International Council of Scientific Unions (ICSU); and (3) by providing financial assistance for particular investigations.

As in the case of other Associations of the Union, recommendations passed by the IAMAP are submitted to the General Assembly of the Union for approval as resolutions of the Union as a whole. The resolutions are then forwarded by the Secretary-General of the Union to the Governments of the countries concerned.

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At the General Assembly in Edinburgh (1936), the Association made a grant towards investigations in synoptic aerology normally carried out under the auspices of the IMO Aerological Commission. The plan was to extend the network of stations from which upper-air ascents were made in directions westwards and polewards from the European coast during the "International Month" of April 1939 in order to obtain a set of synoptic upper-air charts over a larger region than was ordinarily covered by routine ascents. Support from the Association for this enterprise was given in the form of a gift of radiosondes to a number of outpost stations. The Grant was made on the understanding that the National Meteorological Services, which received the instruments, paid all other expenses incurred in the ascents and carried out the programme as laid down by IMO. A similar research project in synoptic aerology was planned to cover the hurricane season of 1941 in the West Indies.

This project was postponed because of the war and was effectively replaced by large-scale meteorological investigations made during the war years in the same area[3].

Before World War II, the IAMAP had only one Permanent Scientific Commission, that on Solar Radiation formed in Madrid in 1924, and in that commission a sub-committee on Ozone, established in Lisbon in 1933. The main objectives of this commission up to now have been the organization of a network of pyrheliometers, solarimeters and balance-meters, the setting up of standards in actinometry, the provision of advice on the types of instruments and standard filters to be used in investigations in this field, the definition of an international pyrheliometric scale (1932-1956) and the intercomparison of actinometers and balance-meters on an international basis. A Solar Radiation Conference organized jointly by the IAM and IMO Solar Radiation Commissions was held in Oxford in 1936. This was the first international symposium sponsored jointly by IAM and IMO and the first IAM Conference outside a general assembly of the parent union.

After the war (Oslo, 1948) the IAMAP formed the Commission on Atmospheric Ozone which organized the first international network of ozone stations equipped with Dobson spectrophotometers. With the rapid progress of the different meteorological disciplines, the Association has successively established new permanent scientific commissions. At the present time there are six such commissions: Commission on Atmospheric Radiation (previously called Solar Radiation Commission), Commission on Atmospheric Ozone, Commission on Atmospheric Chemistry and Radioactivity (Toronto, 1957), Commission of the Meteorology of the Upper Atmosphere (Helsinki, 1960), Commission on Dynamic Meteorology (Helsinki, 1960), and Commission on Polar Meteorology (Berkeley, 1963). To this list the following committees must be added: IAMAP-IAPO Joint Committee on the interaction between atmosphere and oceans (formed in Edinburgh in 1936, re-established in Helsinki, in 1960), in which WMO is now represented: Ad hoc Committee on Cloud Physics and Cloud Modification (Berkeley, 1963); Committee on Meteorological Data for Research (Helsinki, 1960); and the IAMAP-IAGA Joint Committee on Atmospheric Electricity. The titles of these associations and inter-association bodies indicate clearly the main fields of interest of the IAMAP.

Liaison with WMO is ensured either directly, a staff member of the WMO Secretariat being a member on one of these commissions or committees, or indirectly, but not less efficiently, by a common membership between the IAMAP permanent bodies and the corresponding Working Groups in WMO. This de facto collaboration between IAMAP and WMO was officially recognized in a Working Agreement between WMO and IUGG adopted by the WMO-EC in 1953 and by the Union in 1954. A liaison officer was appointed by IUGG to ensure close co-operation between the two organizations. This working agreement was completed in 1960 by another between ICSU and WMO.

The Association sponsors different International Permanent Services with the help of the IUGG financial contribution to the IAMAP and the UNESCO grant made available through the ICSU-IUGG channel. For example, the Association has taken an active part in subsidizing investigations on the measurement of ozone in the atmosphere on an international scale. When the administrative and financial burden resulting from the supervision of the ozone network became too heavy, the organizational problems of the international network of Dobson Spectrophotometers were transferred to WMO in 1959 (WMO Congress-III) and the secretary of the Commission was appointed rapporteur on Atmospheric Ozone to the WMO Commission for Aerology (1961).

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Each scientific commission or committee of the Association normally organizes a symposium every three years on subjects in their respective fields of interest. These symposia are organized with IUGG/IAMAP funds and UNESCO grants allocated to IUGG through ICSU; many of these symposia also receive financial support from WMO.

The IAM was very active in the Second Polar Year (1932-33), an international co-operative project planned by IMO. During preparations for the International Geophysical Year (IGY-1957-58), from about 1951 to 1957, the WMO-EC Working Group of the IGY, the CAe and the CIMO Working Group on Radiation have co-operated very closely with the IAM Permanent Commissions on Radiation and on Ozone and the IAM Committee for the IGY, under the auspices of the ICSU Special Committee for the IGY. The IGY Meteorological Data Centre was organized by WMO in the WMO Secretariat in Geneva. Although only about sixty-five countries participated in the IGY, the IGY Meteorological Programme was implemented by more than one hundred National Meteorological Services. The establishment of a network of observing stations in Antarctica and the sub-Antarctic seas, the extension vertically of the upper air network by the firing of meteorological rockets and the first launchings of artificial satellites are the most spectacular achievements of the IGY. The IGY 1957-58 is certainly the most striking example to date of world-wide co-operation in the field of geophysics and meteorology.

Finally, it should be mentioned that the IAMAP takes an active part in the work of the Committee on Atmospheric Sciences, a Special ICSU/IUGG Committee, formed in 1963 by ICSU in response to the UN resolutions on the peaceful use of outer space (Res. 1721 (XVI), 20.12.61, Res. 1802 (XVII), 14.12.62 and Res. 1963 (XVIII), 24.12.63,). The Fifth WMO Congress (Geneva 1967) has approved the broad outlines of the Global Atmospheric Research Programme (GARP) prepared by the ICSU/IUGG Committee. On the other hand, in preparing the most important GARP sub-programme to be carried out in the period 1972-73, this committee has taken into account the Tropical Observational Project, recommended by the WMO-CAe Working Group on Tropical Meteorology.

In the light of the history of IUGG/IAM and the IMO-WMO, it appears clearly that the IUGG/IAM has devoted its main efforts to meteorology as a science while IMO-WMO is more vividly interested in meteorology as a public service. However, it should be strongly emphasized that IMO-WMO has constantly shown interest in the research aspects of meteorology while IUGG/IAM has paid attention more than once to organizational problems. It is indeed impossible to find a solution to scientific problems in meteorology without paying due attention to their organizational aspects (observational networks, processing and availability of data) and to solve organizational problems without taking into account the results of recent research work. Thus the activities of the two organizations are largely complementary. Therefore, the recent decision taken by the Fifth WMO Congress (Geneva, 1967), regarding the formation of a joint WMO-ICSU Organizing Committee for GARP, is in the line of the historical evolution of international co-operation in meteorology. A close co-operation between academic and professional meteorologists is indispensable for the progress of meteorology both as a science and as a public service, these two aspects of meteorology being intimately related.

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I wish to conclude with the remarks presented by Maury at the closing session of the First International Meteorological Conference held in Brussels in 1853. The various proposals presented at this very first International

Meteorological Conference were discussed in a most constructive and friendly atmosphere: as Maury remarked "...we are taking part in a proceeding to which we should vainly seek for a parallel in history. Heretofore, when naval officers of different nations met in such numbers, it was to deliberate at the cannon's mouth upon the most efficacious means of destroying the human species. Today, on the contrary, we see assembled the delegates of almost every maritime nation, for the noble purpose of serving humanity by seeking to render navigation more and more secure. I think, Gentlemen, we may congratulate ourselves with pride upon the opening of this new era".

Maury was a naval officer, he was also a meteorologist. Meteorologists have always been and I am sure will always be constructive, friendly and peaceful; they are pastmasters in international co-operation.

Dourbes, August 1967.

C H R O N O L O G Y

(i) Preliminary Conferences

1853, Brussels	: First International Meteorological Conference.
1872, Leipzig	: Second International Meteorological Conference.

(ii) Preparatory Phase

1873, Vienna	: First International Meteorological Congress.
1873, Vienna	: First session of the Permanent Committee;
1874, Utrecht	: Second session of the Permanent Committee;
1876, London	: Third session of the Permanent Committee;
1878, Utrecht	: Fourth session of the Permanent Committee;
	foundation of the International Meteorological Organization (IMO).

(iii) First period of existence of IMO

1879, Rome	: Second International Meteorological Congress;
	establishment of the International Meteorological Committee (IMC).
1879, Rome	: 1st session of IMC;
1880, Berne	: 2nd session of IMC;
1882, Copenhagen	: 3rd session of IMC;
1885, Paris	: 4th session of IMC;
1888, Zurich	: 5th session of IMC;

1891, Munich : First Conference of Directors.

1896, Paris : Second Conference of Directors.

1894, Uppsala : 6th session of IMC;

1899, St. Petersburg (Leningrad) : 7th session of IMC;

1900, Paris : 8th session of IMC;

1903, Southport : 9th session of IMC;

1905, Innsbruck : Third Conference of Directors.

1905, Innsbruck : 10th session of IMC;

1907, Paris : 11th session of IMC;

1910, Berlin : 12th session of IMC;

1913, Rome : 13th session of IMC;

(iv) Second Period of Existence of IMO and First Period of Existence of IAM

1919, London : Informal IMC Meeting;

Paris : Fourth Conference of Directors;

Paris : 14th session of IMC;

Brussels : IUGG established and IAM formed.

1921, London : 15th session of IMC;

1922, Rome : First General Assembly IUGG/IAM;

1923, Utrecht : Fifth Conference of Directors;

16th session of IMC.

1924, Madrid : Second General Assembly of IUGG/IAM.

1926, Vienna : 17th session of IMC - establishment of a Permanent Secretariat.

1927, Prague : Third General Assembly IUGG/IAM.

1929, Copenhagen : Sixth Conference of Directors;

18th session of IMC.

1930, Stockholm : Fourth General Assembly IUGG/IAM.

1931, Locarno : 19th session of IMC.

1933, De Bilt : 20th session of IMC;

Lisbon : Fifth General Assembly of IUGG/IAM.

1935, Warsaw : Seventh Conference of Directors.

1936, Edinburgh : Sixth General Assembly IUGG/IAM.

1937, Salzburg : 21st session of IMC.

1939, Berlin : 22nd session of IMC;

Washington : Seventh General Assembly IUGG/IAM.

(v) Third Period of Existence of IMO and Second Period of Existence of IAM (first part)

1946, London : Extraordinary Conference of Directors.

1946, Paris : 23rd session of IMC;

Cambridge : Extraordinary Assembly of IUGG.

1947, Washington : Eighth Conference of Directors.

1948, Oslo : Eighth General Assembly IUGG/IAM.

1951, Paris : Ninth and last Conference of Directors;

Brussels : Ninth General Assembly IUGG/IAM.

(vi) First Period of Existence of WMO and Second Period of Existence of IAM (second part)

1951, Paris : First WMO Congress.

1954, Rome : Tenth General Assembly IUGG/IAM.

1955, Genève : Second WMO Congress.

1957, Toronto : Eleventh General Assembly IUGG/IAM.

1959, Genève : Third WMO Congress.

1960, Helsinki : Twelfth General Assembly IUGG/IAM.

1963, Genève : Fourth WMO Congress;

Berkeley : Thirteenth General Assembly IUGG/IAM.

1967, Genève : Fifth WMO Congress;

Switzerland : Extraordinary General Assembly IUGG and Fourteenth General Assembly IUGG/IAM.

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International Co-operation in Meteorology :

an Historical Review

by J. Van Mieghem

E R R A T A

p. 108 : At the end of this page read :

" ce caractère de subordination forcée de la recherche scientifique à l'organisation industrielle est très particulier à la météorologie (6)

p. 111 : 3rd paragraph, last line, read :

" efficiently "

p. 112 : 28th line from the top, read :

" ... on board ships "

pp. 120-121 : At the end of last paragraph of p. 120, last line, after "... 14.12.62) change the period (.) into a coma (,) and carry on with the sentence beginning the first paragraph of p. 121, that is to say " fourth Congress... "