

WORLD METEOROLOGICAL ORGANIZATION

**UPPER-AIR INSTRUMENTS
AND OBSERVATIONS**

Proceedings of the WMO Technical Conference,
Paris, 8-12 September 1969



Secretariat of the World Meteorological Organization - Geneva - Switzerland

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AVANT-PROPOS

Il est, depuis longtemps, reconnu que les progrès de la météorologie dépendent dans une large mesure des perfectionnements apportés aux méthodes d'observation de la haute atmosphère. Ainsi, par exemple, l'apparition de la radiosonde durant les années 20 avait marqué un progrès important. Depuis lors, on utilise - ou l'on envisage d'utiliser - des dispositifs tels que les satellites, les fusées et les ballons à niveau constant. En outre, la mise au point de méthodes de prévision numérique a révélé qu'il était plus nécessaire que jamais d'améliorer les réseaux de stations d'observation en altitude et d'atteindre des niveaux plus élevés lors des sondages.

Ces diverses considérations ont incité l'Organisation météorologique mondiale à convoquer une Conférence technique sur les instruments de mesure et les observations en altitude. On en avait conçu l'idée pour la première fois en 1966, et le Groupe de travail exécutif de la Commission des instruments et des méthodes d'observation (CIMO) de l'OMM avait élaboré, en août 1967, un programme provisoire pour la conférence. Le gouvernement français s'est aimablement proposé d'accueillir celle-ci à l'occasion de la cinquième session de la commission, qui s'est tenue en septembre 1969, et M. V. Marc (France) a été élu directeur technique de la conférence.

Vu le succès de cette dernière, et dans l'intérêt de ceux qui n'ont pas pu y assister, il a été décidé d'en publier les comptes rendus.

Je suis heureux de profiter de cette occasion pour remercier de leur précieux concours le bureau de la conférence et tous les participants. Je voudrais ici rendre un hommage tout particulier à l'appui enthousiaste de M. V.D. Rockney, président de la CIMO.



D.A. Davies
Secrétaire général

ПРЕДИСЛОВИЕ

Давно признано, что прогресс в метеорологии зависит в большой степени от прогресса в методах наблюдений за верхней атмосферой. Так, например, появление радиозондов в 20-х годах нашего столетия ознаменовало собой важный шаг вперед. С тех пор в повседневную практику вошли (или вопрос об этом находится в процессе рассмотрения) такие технические средства, как спутники, ракеты и уравновешенные шары. Кроме того, развитие методики численных прогнозов погоды подчеркнуло необходимость в улучшенных сетях аэрологических станций, а также необходимость в достижении больших высот при зондированиях.

Имея в виду эти соображения, Всемирная Метеорологическая Организация решила провести техническую конференцию по аэрологическим приборам и наблюдениям. Эта идея впервые возникла в 1966 году, и предварительная повестка дня конференции была подготовлена исполнительной рабочей группой Комиссии ВМО по приборам и методам наблюдений (КПМН) в августе 1967 года. Правительство Франции любезно предложило провести конференцию у себя в стране совместно с пятой сессией Комиссии, состоявшейся в сентябре 1969 г., и г-н В. Марк (Франция) был выбран в качестве технического директора.

Ввиду успеха этой конференции и для пользы тех, кто не смог принять в ней участия, было решено опубликовать ее труды.

Я рад воспользоваться этой возможностью, чтобы выразить свою признательность за ценную помощь, оказанную ответственными сотрудниками по проведению этой конференции и всеми участниками. Я особенно благодарен за полную энтузиазма поддержку со стороны г-на В.Д. Рокни, президента КПМН.



Д.А. Дэвис
Генеральный секретарь

PROLOGO

Desde hace tiempo se ha llegado a la conclusión de que el progreso de la meteorología depende en gran medida del perfeccionamiento de los métodos de observación de la atmósfera superior. Así, por ejemplo, la aparición del radiosonda alrededor del año 1920 constituyó un avance importante en esta materia. Desde entonces se han empezado a utilizar o a estudiar instrumentos tales como los satélites, cohetes y globos de nivel constante. Por otra parte, la creación de las técnicas de predicción meteorológica numérica ha acentuado la necesidad de disponer de redes más perfectas de estaciones de observación en altitud y de que los sondeos alcancen niveles más elevados.

Teniendo presente estos hechos, la Organización Meteorológica Mundial decidió organizar una Conferencia Técnica sobre instrumentos y métodos de observación en altitud. La idea fue concebida primeramente en 1966, y en agosto de 1967 el Grupo ejecutivo de trabajo de la Comisión de Instrumentos y Métodos de Observación (CIMO) de la OMM elaboró el orden del día de dicha Conferencia. El Gobierno de Francia ofreció amablemente su hospitalidad para acoger la Conferencia, con motivo de la quinta reunión de la Comisión que se celebró en septiembre de 1969. El Sr. V. Marc, de Francia, fue nombrado Director Técnico.

En vista del éxito de la Conferencia y en beneficio de las personas que no pudieron asistir, se decidió publicar las actas de la misma.

Me complace aprovechar esta oportunidad para expresar mi agradecimiento por la valiosa ayuda aportada por las autoridades de la Conferencia y por todos los participantes. Doy las gracias especialmente al Sr. V.D. Rockney, Presidente de la CIMO, por su entusiástica colaboración.



(D.A. Davies)
Secretario General

INTRODUCTION

This Technical Conference brought together, for the first time on the international scale, scientists and engineers concerned principally with weather measurements in the upper air. Nine key subject areas became the basis for the formal programme, with special emphasis on the new and emerging technologies. In consideration of this emphasis, special attention was given to such questions as indirect measurement of temperature and water vapour profiles from satellites, constant-level balloons and their instrumentation, meteorological rocket systems, new land and marine radiosonde and radiowind systems, systems for soundings of the lower troposphere, and the problems of sounding at high levels for supersonic transport aircraft and for investigation of stratospheric warmings.

It is believed that the conference succeeded in its principal purpose, that of bringing together for technical discussions many of the key persons involved in the design and operation of equipment used for measurements in the upper air. It is the purpose of this publication to place on permanent record the proceedings of the conference, so that its benefits can likewise be extended to those who are interested in the subject but who were not privileged to attend.

I should like to take this opportunity, on behalf of WMO's Commission for Instruments and Methods of Observation, to express sincere appreciation to the Government of France for their gracious hostship of the conference, to Mr. V. Marc for his capable leadership as its Technical Director, and to Mr. G. W. Kronebach for his service as Executive Secretary.

Vaughn D. ROCKNEY
President, CIMO

INTRODUCTION

Cette conférence technique a rassemblé pour la première fois sur le plan international des hommes de science et des ingénieurs qui s'occupent principalement de mesures météorologiques en altitude. Neuf sujets principaux avaient été inscrits au programme, l'accent portant tout particulièrement sur les techniques récentes et sur celles qui sont conçues actuellement. Ainsi, une attention particulière a été accordée aux questions suivantes : mesure indirecte des profils de la température et de la vapeur d'eau à partir de satellites, ballons à niveau constant et leur appareillage, systèmes de fusées météorologiques, nouveaux systèmes de radiosondage et de radiovent utilisés sur terre et en mer, systèmes de sondage de la basse troposphère, problèmes liés aux sondages à haute altitude pour l'assistance aux avions de transport supersoniques et pour l'étude du réchauffement de la stratosphère.

Nous pensons que la conférence a atteint son objectif principal, qui était de rassembler pour des discussions techniques de nombreux éminents spécialistes de la mise au point et du fonctionnement des équipements utilisés pour les mesures en altitude. Grâce à la présente publication, qui contient les actes de la conférence, tous ceux qui n'ont pas eu le privilège d'y assister et qui s'intéressent aux sujets traités pourront également en tirer profit.

Je voudrais saisir cette occasion pour exprimer, au nom de la Commission des instruments et des méthodes d'observation de l'OMM, mes remerciements sincères au gouvernement français, qui a accueilli si aimablement la conférence, à M. V. Marc qui en a assumé la direction technique avec une compétence remarquable, et à M. G.W. Kronebach qui exerçait les fonctions de secrétaire exécutif.

Vaughn D. ROCKNEY
Président de la CIMO

ВВЕДЕНИЕ

Эта техническая конференция собрала вместе – впервые в международном масштабе – ученых и инженеров, занимающихся преимущественно вопросами метеорологических измерений в верхних слоях атмосферы. Девять основных тем явились основой для официальной программы, в которой особое внимание было уделено новой появляющейся технике. При рассмотрении этого аспекта особое внимание было уделено таким вопросам, как измерения со спутников с помощью косвенных методов профилей температуры и водяного пара, уравновешенные шары и приборы, метеорологические ракетные системы, новые наземные и морские радиозондовые и радиоветровые системы, системы для зондирования нижней тропосферы и проблемы зондирования верхних уровней для целей сверхзвуковой транспортной авиации и для исследований потеплений в стратосфере.

Считается, что конференция имела успех в отношении своей главной цели, т.е. собрала вместе для технической дискуссии многих из известных лиц, занимающихся вопросами проектирования и работы оборудования, используемого для измерений в верхних слоях атмосферы. Цель настоящей публикации заключается в издании трудов конференции с тем, чтобы ее результатами могли также воспользоваться все те, кто заинтересован в этом вопросе, но кто не имеет возможности принять участие в ее работе.

Я хотел бы воспользоваться этой возможностью, чтобы выразить от имени Комиссии ВМО по приборам и методам наблюдений искреннюю признательность правительству Франции за любезное гостеприимство, г-ну В. Марку за его умелое руководство в качестве технического директора и г-ну Дж.У. Кронбаху за его услуги в качестве исполнительного секретаря.

В.Д. Рокни
Президент КТМН

INTRODUCCION

Esta Conferencia Técnica reunió por primera vez y con carácter internacional a los científicos e ingenieros dedicados principalmente a las medidas meteorológicas de la atmósfera superior. El programa oficial se fundó en nueve temas fundamentales, concediéndose especial interés a las nuevas y futuras técnicas. Por este motivo se estudiaron especialmente las cuestiones siguientes: medidas indirectas de la distribución de la temperatura y del vapor de agua, a partir de los satélites; globos de nivel constante y sus instrumentos; sistemas de cohetes meteorológicos; nuevos sistemas de radiosonda y de radioviento para las estaciones terrestres y marítimas; sistemas de sondeo de la troposfera inferior; problemas de sondeo a niveles superiores para los aviones supersónicos de transporte e investigaciones de los calentamientos estratosféricos.

Se cree que la Conferencia fue un éxito por lo que se refiere a su objeto principal que fue el de reunir, con el fin de celebrar debates técnicos, muchas de las personas más calificadas que intervienen en el diseño y funcionamiento del equipo utilizado en las medidas de la atmósfera superior. El objeto de esta publicación es hacer constar con carácter permanente los debates de la Conferencia, de modo que sus beneficios puedan llegar a las personas interesadas en estas cuestiones pero que no tuvieron el privilegio de participar en la reunión.

Quiero aprovechar esta oportunidad para expresar, en nombre de la Comisión de Instrumentos y Métodos de Observación de la OMM, mi sincero agradecimiento al Gobierno de Francia por haber ofrecido graciosamente su hospitalidad para la Conferencia, al Sr. V. Marc por su competente labor como Director Técnico de la misma y al Sr. G.W. Kronebach por los servicios prestados como Secretario Ejecutivo.

Vaughn D. ROCKNEY
Presidente de la CIMO

SESSION I

**New Marine Radiosonde/Radiowind System
(Including Automation)**

Chairman: V. D. Rockney

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ON THE NEED FOR OCEANIC RADIOSONDE AND
RADIOWIND DATA AND THE PROBLEMS OF OBTAINING THEM

by Vaughn D. Rockney

I. Introduction

Insofar as improvement of upper-air weather measurement networks for the World Weather Watch is concerned, one of the greatest problems is that of increasing the amount of rawinsonde data over the oceans. Although new observational techniques, such as meteorological satellites and constant-level balloons, may in the future obviate the need for "conventional" upper-air observations over the oceans, we must plan, for the next decade at least (and if the operational and research needs of WWW and GARP are to be met), to make rawinsonde measurements on many more ships than at present.

The making of radiowind observations on ships is complicated by the fact that ships move horizontally, and change their attitude and orientation. The technique of making such observations on ships that are specially-equipped for the purpose (i.e., with special radar or radio-direction-finding equipment) is well-proved on ships of many countries. Likewise the techniques of making radiosonde observations from a wide variety of "ships of opportunity" (i.e., ships of various kinds, not equipped with high-precision radar or r.d.f. equipment for upper-wind finding, sailing to various places in the world more or less at random, and from which weather observations might be obtained if the ship were properly equipped and staffed), has been well-proved. But the problem of obtaining radiowind data concurrently with radiosonde data, from ships of opportunity, is difficult for the following reasons:

- a) The design of low-cost equipment that will give satisfactory results, presents many technical problems.
- b) Such a ship often changes its route of travel and sometimes travels in areas from which rawinsonde data are not needed, hence the equipment must be reasonably portable so that it can be easily removed for installation on another ship that will sail in an area from which such observations are needed.
- c) On many ships of opportunity, the space aboard for complicated antennas and special equipment is very limited.

- d) There is very limited berthing space on some ships of opportunity for personnel to operate and maintain weather equipment. Therefore, and for reasons of economy, the size of staff must be kept to a minimum. This means that the equipment must be simple to operate and require only a minimum of maintenance.

It is desirable also that the weight of the equipment carried aloft by the balloons should be as small as possible. This minimizes the size requirement for balloons, which in turn decreases the requirement for inflation gas, permits use of a small inflation shelter (which might be able to be installed on ships that could not accommodate a larger shelter), and facilitates balloon release.

It can readily be seen that an anomalous position has been reached; if it is to be economically feasible and technologically practical for us to establish rawinsonde programs on the large number of ships of opportunity that ought to be equipped with rawinsonde equipment to augment the amount of upper-air data over the oceans, we need equipment that is simple, dependable, semi-portable, easy to maintain and operate, light in weight, yet low in cost and yielding accurate results.

II. Technical Requirements for Marine Rawinsonde Data

It is impossible to define a single set of requirements for the accuracy of marine rawinsonde data that will satisfy all users. For the global scale and the WWW it seems best to aspire to meet the global requirements specified by the Commission for Synoptic Meteorology. The latest expression of these requirements is as stated below:

Pressure	± 1 mb.
Temperature	$\pm 0.5^{\circ}$ C
R.H.	$\pm 5\%$ up to the first tropopause or 300 mb., whichever is the lower; $\pm 10\%$ for higher levels
Wind direction	$\pm 5^{\circ}$ in wind speeds above 25 m/sec. $\pm 10^{\circ}$ for lower wind speeds
Wind speed	± 1 m/sec. below 10 m/sec.; $\pm 10\%$ above 10 m/sec.

As to the required altitude that should be sought, it is the author's personal view that for operational purposes this should be about 28 km., based on experience in the USA. (It should be noted that to reach this altitude under all conditions of winds aloft, necessitates that the equipment have the capability of satisfactory reception to slant ranges of 250 km.) Good data can be obtained to this altitude with moderate-priced balloons and reasonably-priced radiosondes; to obtain accurate data at average altitudes much above this would necessitate:

- a) Use of larger balloons, of higher price, requiring more inflation gas and larger inflation shelters, more difficult to release, and
- b) Use of hypsometer-equipped radiosondes and perhaps a different temperature sensor as well.

Based on experience in the USA, it costs at least half again as much to average 33 km. as it does to average 28 km., if one considers only costs of expendables.