ON THE MERIDIONAL FLUX OF WATER VAPOR IN THE NORTHERN HEMISPHERE

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Summary — Maps of the meridional vertically integrated flux of atmospheric water vapor over the northern hemisphere for summer, winter and the entire year of 1950 are presented. These results are derived from all available meteorological soundings of humidity and winds. A corresponding set of three maps showing the average vertically integrated values of the moisture content are included. Tables and graphs of zonally averaged numerical values extracted from these maps are reproduced and discussed in the light of various meteorological considerations.

Résumé — Dans cet article les auteurs présentent des cartes du flux meridional de la vapeur d'eau intégré suivant la verticale, pour l'été, l'hiver et pour toute l'année de 1950. Ces résultats ont été dérivés à partir, de tous les radiosondages disponibles de l'humidité et des vents. On présente d'abord un ensemble correspondant de trois cartes avec l'analyse des valeurs moyennes du teneur en humidité intégrées suivant la verticale. Finalement on reproduit des tableaux et des graphiques avec les valeurs moyennes zonales calculées d'après ces cartes et dont on fait une discussion à la lumière de diverses considérations météorologiques.

1. Introduction — One mode of approach to the study of general circulation of the atmosphere is to examine certain integral requirements deduced from dynamical principles governing the motion of the atmosphere, formulated in terms of physical properties, such as energy, momentum, mass or water content, etc.

The present paper intends to give some aspects of the results obtained in the study of the water balance requirements of the atmosphere. According to the principle of conservation of mass, water substance cannot be created or destroyed within the atmosphere. Accordingly a local change of water content can be brought about only through the addition or abstraction of water. The water balance therefore may be taken as a constraint for the general circulation.

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The necessity for the transport of water in the atmosphere arises from the existence of an excess of precipitation over evaporation over certain regions with a reversal of prevailing conditions in other areas. However, over a sufficiently long period of time, the amount of precipitable water does not change appreciably, which means that the storage effects are small enough so that the deficits and excesses must be made up through the transport of water by atmospheric circulations, since there can be no significant net inflow or net outflow of water in the atmosphere as a whole.

This transport, accomplished by atmospheric circulations, may occur in any one of the three phases, but the transport in the solid and liquid phases is probably very small compared to the transport in the vapor phase. However, in the tropics the southward flow of water in the liquid phase (clouds) may be of some importance as well. From a thermodynamical point of view we are facing then, a monophasic, heterogeneous and plurivariant system. The flux of the component water is accomplished by the exchange of nearly equal masses of moist air with different concentrations in water.

With the great improvement in the network of aerological stations distributed over the northern hemisphere, it has been possible now to treat many new problems as regards the behavior of the atmosphere, using the values of the observations, directly. These observational studies on an extensive hemispheric scale are of decisive importance in order to secure a correct framework for the discussion and further study of the mechanisms of the general circulation (Starr, 1951; Sutcliffe, 1956).

Along this line of thought, the first attempt to measure directly from wind and humidity observations, on a hemispheric scale, the effects of atmospheric motions in transporting water vapor across latitude walls was that of White (1951), for the purpose of including the contribution of latent heat in the study of the energetics of the earth-atmosphere system. Later, these studies were much amplified by Starr & White (1954), again with regard to the energy balance. Some oceanographic and climatological aspects of this study were also given by these writers (1955). See also Benton & Estoque (1954).

Following a procedure similar to the one used by Buch (1954) in the study of wind conditions, it was recognized that the aerological humidity data for the northern hemisphere are sufficient not only for obtaining the zonal average of the humidity flux, but also for drawing of hemispheric maps of several quantities involved in the observational study of this flux. It was decided to use the same time intervals as Buch, namely the calendar year 1950, with a half-year summer and a half-year winter season.

This task has now been accomplished and all of the results are to be published in extenso later. Some special aspects of this extensive study have been treated by Starr & Peixoto (1956), Peixoto (1957) and Peixoto & Saltzman (1957). The present paper, which may be regarded as an extension of the previous study given by Starr & White (1955) deals with still another one of these special aspects. It constitutes an attempt to obtain a direct measure of the total meridional water vapor flux and of the moisture content in the atmosphere, through the averaging of the daily observations at individual stations. Levels up to and including 500 mb for 90 aerological stations distributed throughout the northern hemisphere as presented by Starr & Peixoto (1956) were used for this purpose.