

WIND AND THERMAL STRUCTURES OF THE
TROPOSPHERE OVER THE SOUTHWEST ISLANDS
OF JAPAN DURING JANUARY 1968
— A PRELIMINARY STUDY FOR AMTEX* —

By

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Abstract

An analysis is made of wind and thermal structures of the troposphere over the Southwest Islands of Japan for the period of January 1968 using aerological data at upper-air observation stations. The troposphere is likely to be divided into two layers: one below around 800 mb level characterized by low wind steadiness, high humidity and low static stability, and the other the layer above this in which wind is extremely steady and humidity is low. In the lower layer is found temporal variation within a period of 3~5 days which may be associated with intermediate-scale cyclones to be investigated in detail in AMTEX.

1. Introduction

An experimental program for the study of air-mass transformation was proposed at the Planning Conference on Global Atmospheric Research Programme (GARP) in Brussels, 1970 by the Japanese National Committee for GARP and was discussed in the framework of the GARP air-surface interaction programme. In 1971 the program on the Air-Mass Transformation Experiment (AMTEX) in the area around the Southwest Islands of Japan was approved as a subprogram of GARP by the ICSU/WMO Joint Organizing Committee. The basic objective of AMTEX is to improve physical understanding of the transfer processes of energy and momentum in various forms when an intensive air-mass transformation takes place as a result of changing conditions of the underlying surface. The AMTEX program is scheduled to take place in the winter of 1974-1975 in the area around the Southwest Islands of Japan which is one of the most favorable regions for studying air-mass transformation (see Fig. 1).

The present article is a preliminary report on wind and thermal structures of the troposphere over the AMTEX area in winter. This report is confined primarily to qualitative analyses of thermal and wind characteristics of the troposphere over the area concerned in January 1968 through the use of aerological data of routine observations.

* The Air-Mass Transformation Experiment (AMTEX) will be conducted in the region of the Southwest Islands of Japan in the winter of 1974-1975 as a subprogram of the Global Atmospheric Research Programme (GARP).

2. General characteristics of wind and temperature

The distribution of wind steadiness in a vertical meridional cross section along the $130^{\circ}\sim 140^{\circ}\text{E}$ longitude in January 1968 is shown in Fig. 2. The wind steadiness in percent, S_w , is defined by the formula

$$S_w = \frac{|\bar{V}|}{\bar{V}} \times 100,$$

where $\bar{V}$ is the resultant (vector mean) wind velocity and $\bar{V}$ is the mean wind speed regardless of wind direction. As is shown in Fig. 2, the area concerned between 25° and 30°N is characterized by low wind steadiness in the layer lower than around 800 mb level and extremely high wind steadiness above the lower layer. This is quite different from the trade wind belt as seen at the southern end of Fig. 2 where wind steadiness is very high in the layer below the trade wind inversion and low in the upper layer (e.g., Riehl, Yeh, Malkus and LaSeul [1951]). In the area concerned the wind steadiness increases rapidly upwards as compared with middle latitudes where low wind steadiness extends throughout an entire troposphere. The feature of wind steadiness observed around the AMTEX scheduled area seems to be associated

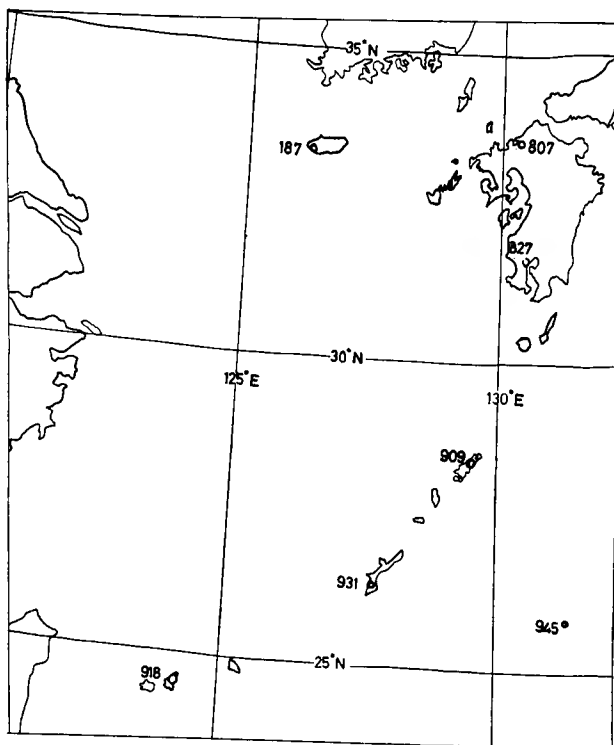


Fig. 1. The AMTEX scheduled area and location of aerological observation stations used for the present analysis.

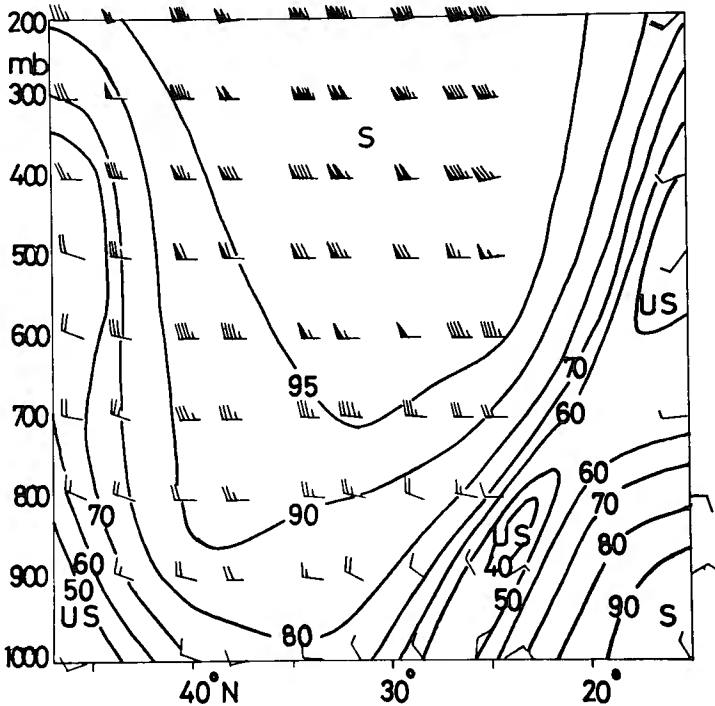


Fig. 2. Vertical meridional cross section of wind steadiness (%) in January 1968. Wind arrows are plotted for 0900 JST.

with the southern fringe of polar airmass where cyclones formed are still immature and shallow.

One of the significant properties of temperature field in the area concerned is the presence of a remarkable inversion layer in the lower troposphere. Figure 3 indicates the frequency distribution of pressure heights of the base of inversion layer observed in the lower troposphere at Naze during January 1968. Bimodal frequency distribution is seen in Fig. 3: one is a sharp peak around 800 mb level and the other is a second maximum of frequency which corresponds to the absence of an inversion layer below 700 mb level. Note that this may cause some ambiguity in the physical significance of "mean" soundings.

3. Temporal variation of wind and thermal structures

Aerological data at the five stations as shown in Fig. 1 are used to investigate characteristics of wind and thermal structures of the troposphere and their temporal variations over the AMTEX scheduled area. Figures 4 to 8 show vertical time sections for the period of 1–31, January 1968 at Kagoshima (47–827), Naze (47–909), Kadena (47–931), Minamidaitojima (47–945) and Ishigakijima (47–918), respective-

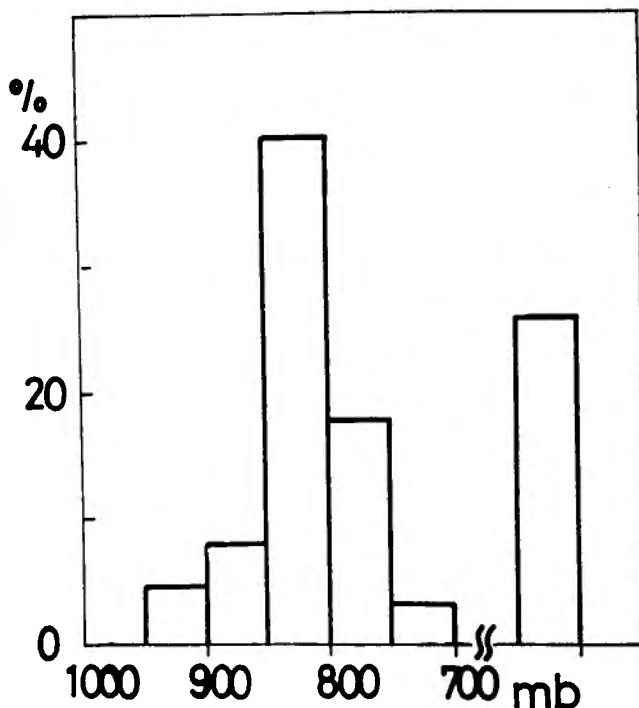


Fig. 3. Frequency distribution of pressure heights of the inversion base at Naze, January 1968. The right side corresponding to levels higher than 700 mb indicates the frequency of the absence of an inversion below 700 mb level.

ly. Potential temperature ($^{\circ}\text{K}$) and mixing ratio of water vapor (gkg^{-1}) are shown by solid and dashed lines, respectively. A short barb indicates a wind speed of 2.5 m sec^{-1} , a long barb 5 m sec^{-1} and a penant 25 m sec^{-1} . A sequence of amounts of 24-hour precipitation is depicted in the upper portion of the respective Figure.

A common feature of all the time sections illustrated in Figs. 4–8 is a periodic variation of 3–5 days which is found most distinctly in undulations of isolines of the mixing ratio. This period of the variations is quite similar to the period of about 4 days during which cyclones develop in this area in winter (Ninomiya [1972]). A layer below about 800 mb level is characterized by such slight static stability that the lapse rate of temperature is close to the dry adiabatic one and is topped by a notable inversion layer above which the air is extremely dry. Occasional disappearances of the inversion layer around 800 mb level are associated with warmer southerly winds and a deep moist layer. The greatest amount of precipitation is observed during these periods without the inversion layer.

As was pointed above, two distinct situations are observed in the troposphere. An example to elucidate the difference between them is given in Fig. 9 which shows

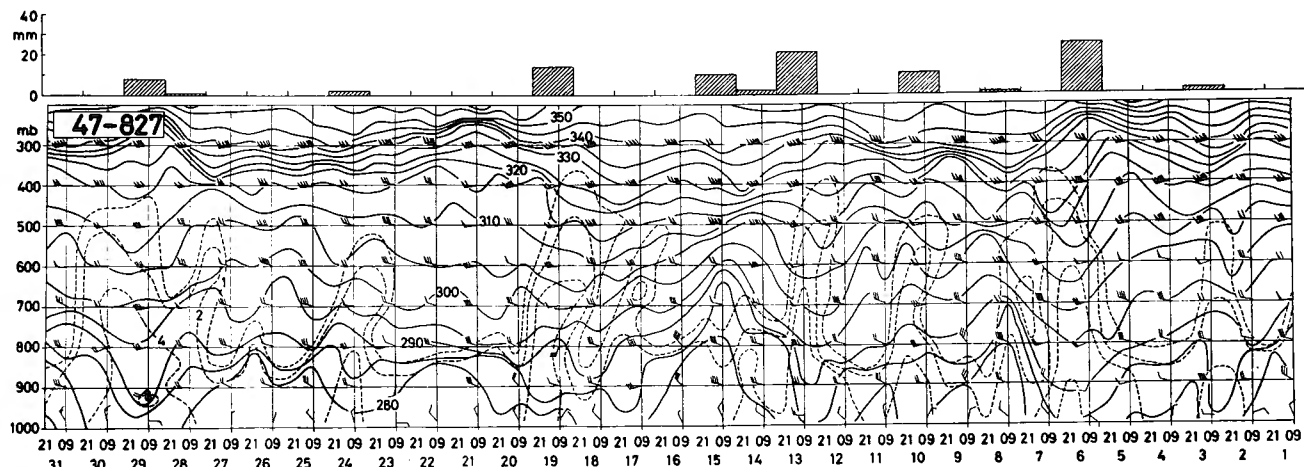


Fig. 4. Vertical time section at Kagoshima (47-827), Jan. 1-31, 1968. Solid and dashed lines indicate potential temperature ($^{\circ}\text{K}$) and mixing ratio (gkg^{-1}). An amount of 24-hour precipitation is shown in the upper portion.

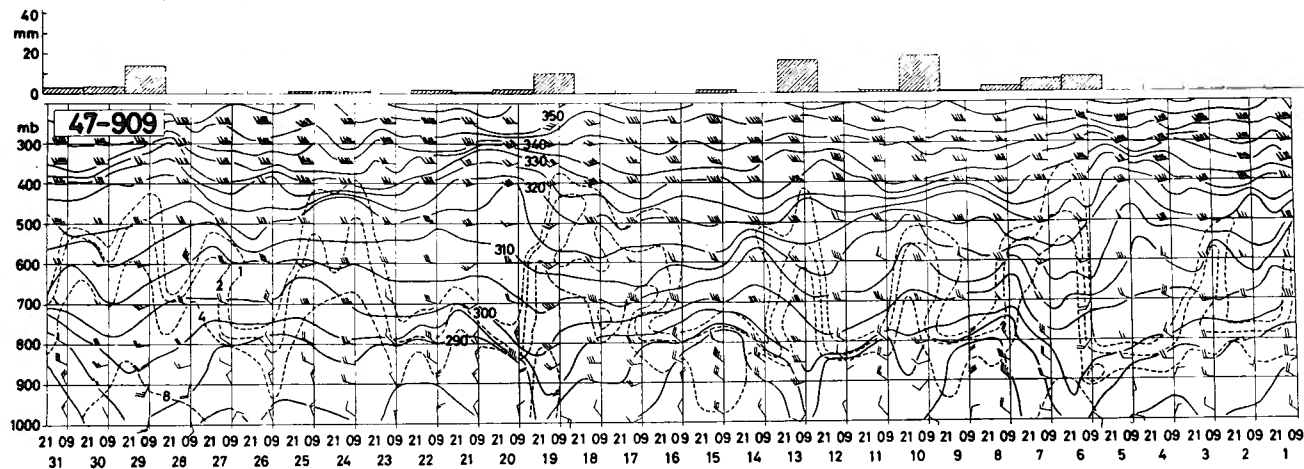


Fig. 5. Same as Fig. 4 except Naze (47-909).

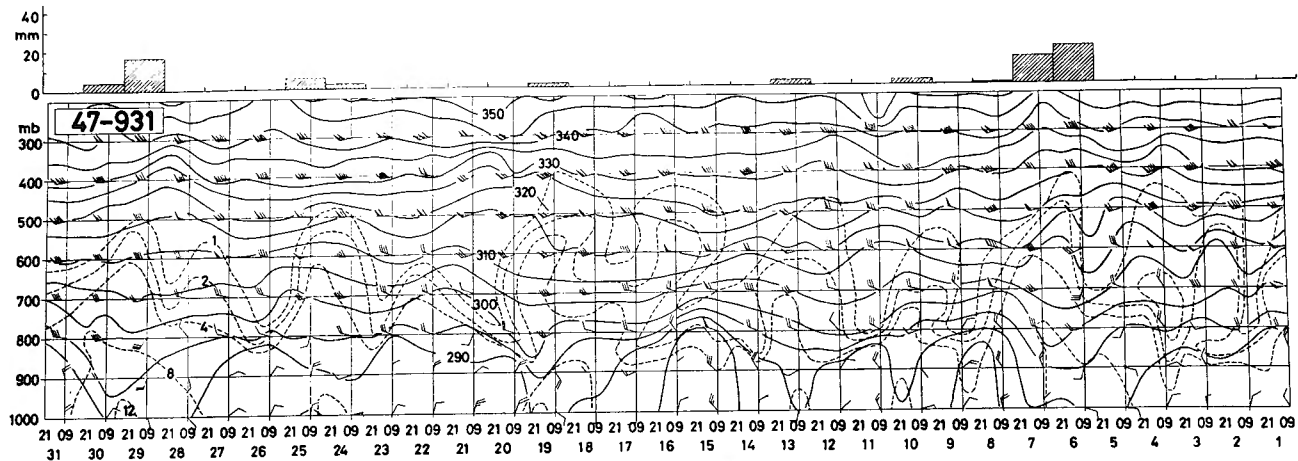


Fig. 6. Same as Fig. 4 except Kadena (47-931).

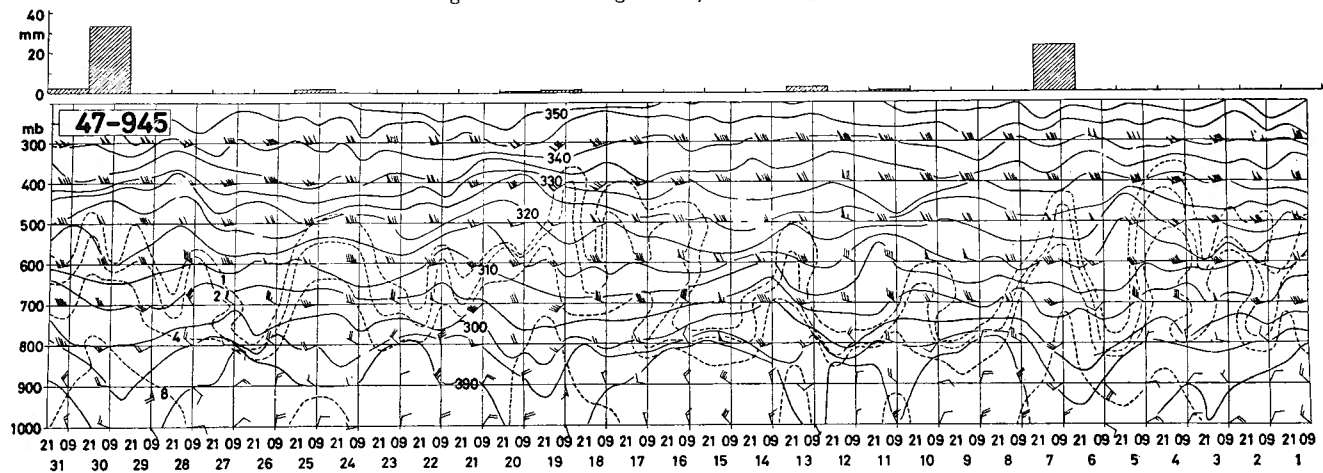


Fig. 7. Same as Fig. 4 except Minamidaitojima (47-945).

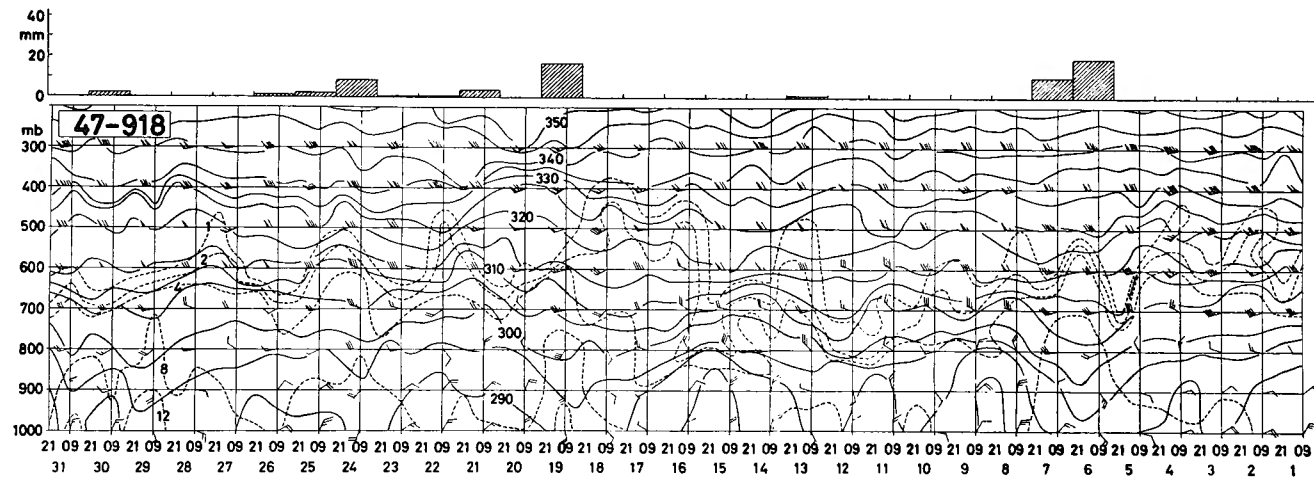


Fig. 8. Same as Fig. 4 except Ishigakijima (47-918).

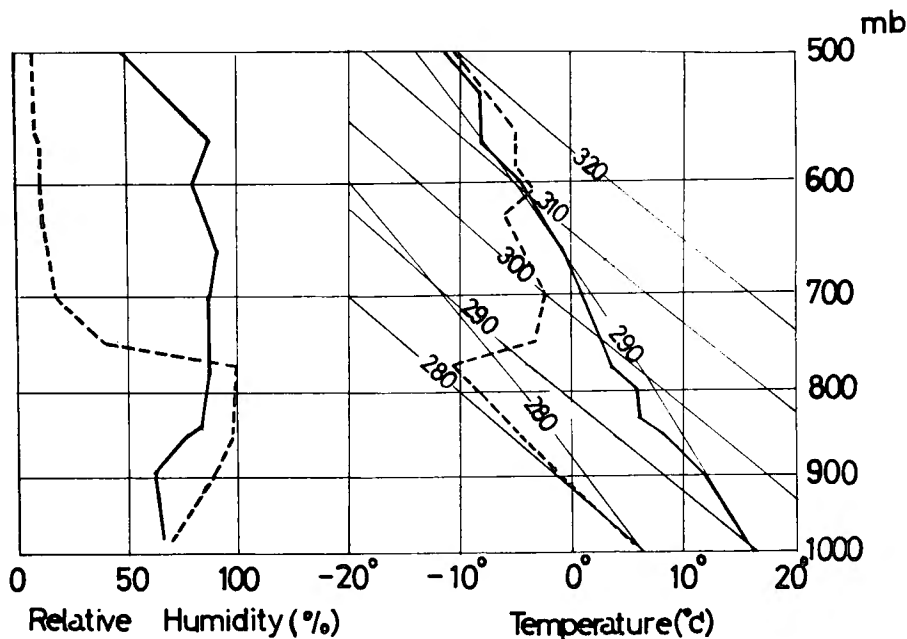


Fig. 9. Vertical profiles of temperature and relative humidity at Naze (47-909). Heavy solid lines are for 0900 JST Jan. 13 and dashed lines for 0900 JST Jan. 15. Thin solid lines denote the dry and the moist adiabats.

vertical profiles of temperature and relative humidity at Naze. Those at 0900 JST Jan. 13 are denoted by heavy solid lines and those at 0900 JST Jan. 15 are denoted by dashed lines. The former represents the situation characterized by a deep moist layer without a notable inversion layer, while the latter indicates the presence of a less stable low layer topped with an inversion layer above which the air is extremely dry. A more detailed analysis will be made of the structures of the troposphere. This will be reported in a separate paper.

Acknowledgments

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