NOTES AND CORRESPONDENCE

Note on Synoptic Situation and Heat Energy Budget During the AMTEX '74

By K. Ninomiya

Meteorological Research Institute, Tokyo

(Manuscript received 8 June 1974, in revised form 29 August 1974)

1. Introduction

Extensive analytical studies on the air-mass transformation and the wave disturbances over the Kuroshio region were made for February 1968. Ninomiya (1972, 1973 and 1974) analyzed the heat and water budget over the large and small area in the Kuroshio region and the variation in the heat energy budget associated with the development of wave disturbances. Nitta *et al.* (1973) studied the structure of the wave disturbances by means of spectrum analysis.

AMTEX'74 (Air-Mass Transformation Experiment in 1974) was carried out for 2 weeks from 14 February to 28 February 1974. Although the main part of the data processing is not completed yet, some data which were compiled by the real-time data editing system of J.M.A are available*. It is intended in the present note to describe the meteorological events during the experiment and realize the gross features of AMTEX'74.

2. Synoptic situations during AMTEX'74

The cold air outbreak continued for several days preceding the experiment. The warm advection associated with the southerly winds began to

prevail in 14 February. Since the period between 14 and 23 February is characterized by the higher temperature (Fig. 1), we will call it as "warm period" hereafter. Medium-scale cyclones passed over northern part of the East China Sea with the period of 2-3 day during the warm period. The intense cold air outbreak occurred in February 23, when a cyclone developed remarkably over the northeastern Pacific, and the air temperature

Fig. 1. Surface temperature variation at Naha and Kagoshima.

* 12 hourly aerological and surface data at Kagoshima, Naze, Naha, Ishigaki-jima, Minamidaito-jima and Keifu-maru are used in the present report.

Fig. 2. Vertical cross section at Naha.

Fig. 3. Vertical cross section at Kagoshima.

Fig. 4. Surface maps at 12Z 14, 00Z 17 and 12Z 26 February 1974.

fell rapidly over the AMTEX area. The remained period of the experiment will be called as "cold period" because it was characterized by low temperature.

The vertical time section of mixing ratio (q) and wind velocity at Naha (47-936) and Kagoshima (47-827) are presented in Figs. 2 and 3 respectively, where the inversion layer is indicated by stippled layer. We will find in Fig. 2 that the remarkably developed inversion layers exist steadily during the early period of the warm period and the cold period. While westerly winds prevail in the higher level above the inversion, the southerly winds (warm period) or the northerly winds (cold period) prevail in the lower layer below the inversion.

The periodic increases of mixing ratio and the alternation of southerly and northerly winds in the lower troposphere found in Fig. 3 during the warm period indicate the passage of medium-scale cyclones over the northern part of AMTEX area.

The surface maps at 12Z 14, 00Z 17 and 12Z 26 February are shown in Fig 4 as examples for the situations of the early warm period, the passage of medium-scale cyclone and the cold period respectively.

3. Characteristic situations of the cold and warm period

As seen in Fig. 2, the inversion layers lay steadily during the early warm period (00Z, 14~00Z, 17 February) and the cold period (12Z, 24~12Z, 27 February). The mean vertical profiles of the vertical velocity evaluated from the velocity divergence within the area enclosed by the aerological stations (See Fig. 7) and that of the temperature, potential temperature, equivalent potential temperature and wind velocity at Naha for these period are presented in Fig. 5.

The situations in the lower layer below the inversion during the cold period are characterized by the descending motion of the cold airmass

Fig. 5. Vertical profile of ω over the analyzed area and that of temperature, potential temperature, equivalent potential temperature at Naha during the cold and the warm period.

and almost uniform northerly winds while these during the early warm period are characterized by the weak ascending motion of the warm air and almost uniform southerly winds. The almost uniform value of the equivalent potential temperature in the lower layer below the inversion during both period would suggest the strong vertical mixing in the lower layer.

4. Medium-scale variations in the lower troposphere

In the present section we will examine the variations in the lower troposphere by means of statistical manner. Fig. 6 shows the vertical distribution of u , v , q and T -spectrum at Naze (47-909). It is evident that the spectrum peaks for u , v and q exist within the lower layer below 800 mb in the medium-scale period range (*i.e.* about 3 days) while the maximum in T -spectrum appears in the longer period range.

Fig. 6. Vertical distribution of the v, u, q and T -spectrum at Naze.

Fig. 7. Horizontal distribution of $v_{900\text{mb}}, u_{900\text{mb}}$ and $q_{800\text{mb}}$ -spectrum and station network.

The horizontal distribution of spectrum density of $v_{900\text{mb}}, u_{900\text{mb}}$ and $q_{800\text{mb}}$ within the period range between 3.20 and 2.28 day are shown in Fig. 7. It will be seen that the variations associated with the medium-scale disturbance are remarkably larger over the northeastern part of the AMTEX area. This would be due to the fact that the disturbance developed during its eastward propagation over the sea area.

5. Heat and moisture budget during AMTEX'74

The method of the budget analysis is exactly same as was used in the previous paper (Ninomiya 1972). The thermodynamic equation and the continuity equation of moisture is written as

$$\left(\frac{\delta T}{\delta t}\right) + \frac{\partial}{\partial p} \overline{w'T'} = \frac{L}{C_p} m^* - \frac{Q_R^*}{C_p}$$

$$\text{and} \quad \left(\frac{\delta q}{\delta t}\right) + \frac{\partial}{\partial p} \overline{w'q'} = -m^*$$

where the individual change of temperature and the moisture is defined as

$$\left(\frac{\delta T}{\delta t}\right) \equiv \frac{\partial \overline{T}}{\partial t} + \overline{\mathbf{v} \cdot \nabla T} + \frac{\partial}{\partial p} \overline{wT} - \frac{R}{C_p} \frac{\partial \overline{T}}{\partial p}$$

$$\text{and} \quad \left(\frac{\delta q}{\delta t}\right) \equiv \frac{\partial \overline{q}}{\partial t} + \overline{\mathbf{v} \cdot \nabla q} + \frac{\partial}{\partial p} \overline{wq}$$

respectively*. The convective transport of total heat energy is obtained as

$$F_c = -\frac{1}{g} \int_{700\text{mb}}^p \left[C_p \left(\frac{\delta T}{\delta t} \right) + L \left(\frac{\delta q}{\delta t} \right) + Q_R^* \right] dp$$

with the assumption that F_c vanishes at 700 mb. F_c at the surface means, of course, the total heat supply from the sea. The sensible heat supply and the evaporation, i_{se} ,

$$-C_p/g \overline{w'T'} \text{ and } -1/g \overline{w'q'}$$

at the surface, are also evaluated from these equations with an additional assumption that the total amount of condensation is equal to that of precipitation.

We make the evaluations over each of four triangular areas in Fig. 7 and then average the resulted values over the whole domain of the four triangular areas. Shown in Fig. 8 is the vertical distribution of $(\delta T/\delta t)$ and $(\delta q/\delta t)$ for the whole period of AMTEX'74 and the earlier period of the "warm period" (14.00-17.00 February) and the "cold period" (24. 12-27. 12 February).

Fig. 8. Vertical distribution of $(\delta T/\delta t)$ and $(\delta q/\delta t)$ in the AMTEX'74, "warm period" and "cold period".

* The values of the cooling rate by the net radiative process Q_R/C_p obtained by Katayama (1967) is adopted in the present analysis.

The vertical distribution of F_c for these periods are also shown in Fig. 9. The results of the budget analysis are summarized in Table 1.

Fig. 9. Vertical distribution of F_c .

Table 1. Results of budget analysis

	AMTEX'74	Cold Per.	Warm Per.
$\frac{1}{g} \int_{700}^{SFC} C_p \left(\frac{\delta T}{\delta t} \right) dp$	270 ly/day	700	150
$\frac{1}{g} \int_{700}^{SFC} L \left(\frac{\delta q}{\delta t} \right) dp$	270 ly/day	750	100
Rad. Cooling	70 ly/day	70	70
Precipitation	2.5mm/day	2.8	0.8
Sens. Heat Supp.	190 ly/day	600	170
Lat. Heat Supp.	420 ly/day	920	150
Total Heat Supp.	610 ly/day	1520	320

These results show that the influence of the air-mass transformation is mainly confined in the lower layer below 800 mb on the average during the period of AMTEX '74. It is also seen that the amount of the heat energy supply varies

greatly according to the large-scale situation. The amount of energy supply during the "cold period" is as much as 1500 ly. day⁻¹ while that during "warm period" is only 300 ly day⁻¹.

6. Remarks

It is intended in this preliminary report to summarize the features during AMTEX'74. It is suggested that AMTEX'74 includes two quite different situations, i.e., the "warm period" and the "cold period". It would be better to treat these period separately in the further studies since the situations in these period are remarkably different.

References

Katayama, A., 1967: On the radiation budget of the troposphere over the northern hemisphere (III). *J. Meteor. Soc. Japan*, **45**, 26-39.

Ninomiya, K., 1972: Heat and water-vapor budget over the East China Sea in the winter season. *J. Meteor. Soc. Japan*, **50**, 1-17.

_____, 1973: Variation in the heat energy budget over the East China Sea associated with the passage of wave cyclones in February 1968. *J. Meteor. Soc. Japan*, **51**, 435-449.

_____, 1974: Bulk properties of cumulus convections in the small area over Kuroshio region in February 1968. *J. Meteor. Soc. Japan*, **52**, 188-203.

Nitta, Ts. et al., 1973: Wave disturbances over the China Continent and the East China Sea in February 1968. *J. Meteor. Soc. Japan*, **51**, 11-28.

AMTEX'74 の総観状況と熱収支状況

二 宮 洸 三
気象研究所