SOME APPROACHES TO AUTOMATIC DRAWING METEOROLOGICAL MAPS BY COMPUTER

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ABSTRACT

In this paper some approaches to automatic drawing meteorological maps by computer are introduced. Meteorologists or weather analysts can get 6 kinds of thermodynamic and dynamic maps of atmosphere by use of these methods conveniently and immediately.

Keywords: Cartographic, Computer Graphics, Mapping, Remote Sensing Application

1. INTRODUCTION

In the case of nowcasting or short-term casting, meteorological experts need a useful tool to draw the meteorological maps by use of remote sensing data, such as balloon air sounding data, meteorological satellite data and so on. We developed following 6 kinds of drawing projects(more than one hundred meteorological maps) for choosing:

(1) Distribution maps of wind, temperature, humidity, pressure, rainfall and so on.
(2) Streamline of atmosphere.
(3) Time-height cross section and space-height cross section.
(4) Isogram of functional difference of thickness advection.
(5) Isogram of vertical stability of convection.
(6) Superimposition of graph and image.

2. DRAWING METHOD AND DRAWING RESULT

(1) Distribution map of essential meteorological factors

This program can draw distribution maps of temperature, humidity,pressure, wind direction and wind velocity, rainfall, number of station and other statistical data.
At first, classify the factor data to N levels and give different color, character size and italic angle to the different level, then write the data at every stations'position of map. So the distribution map can display information distinctively.

When we want to draw the wind distribution map, the program can draw wind signals by following formulas:

$$T = V_i / : 20 \tag{1}$$

$$L = (V_i - 20T)/:4 \tag{2}$$

$$S = (V_i - 20T - 4L)/:2 \tag{3}$$

where V_i is the wind velocity of the i station , T,L,S is the number of 20m/s, 4m/s, 2m/s wind feathers, /: means the result of division is an integer.

Fig.1 is the examples of distribution maps.

(2) Cross section

There are 2 kinds of cross section in the meteorology. One is the time-height cross section, another is the space-height cross section. For drawing the space-height cross section, we developed a method for searching stations in a square area. We also developed a rule of limited neighbor density to screen out suitable stations. Using the wind data of 100 hPa pressure layer of the first chosen station, draw a wind signal on the 0 point of coordinate, then remove and rotate the wind signal to a corresponding position (X_i, Y_i) by following formula,

$$[X' \ Y' \ 1] = [X \ Y \ 1] * \begin{bmatrix} \cos w & \sin w & 0 \\ -\sin w & \cos w & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ X_i & Y_i & 1 \end{bmatrix} \tag{4}$$

where (X',Y') is the coordinate of wind signal after removing and rotating, (X,Y) is the coordinate of wind signal before removing and rotating, w is the degree of wind direction.

Then draw the wind signal of 150 hPa pressure layer of the same station, then 200 hPa, 250 hPa, ... ,1000 hPa, ground, layer by layer. Then draw the wind signals of the second chosen station,..., station by station, until all wind signals of all chosen stations were drawn.

Finally, draw the constant value curves of temperature,θ_{se} or another meteorological factor on the map.

Fig.2 shows a typical cross section map

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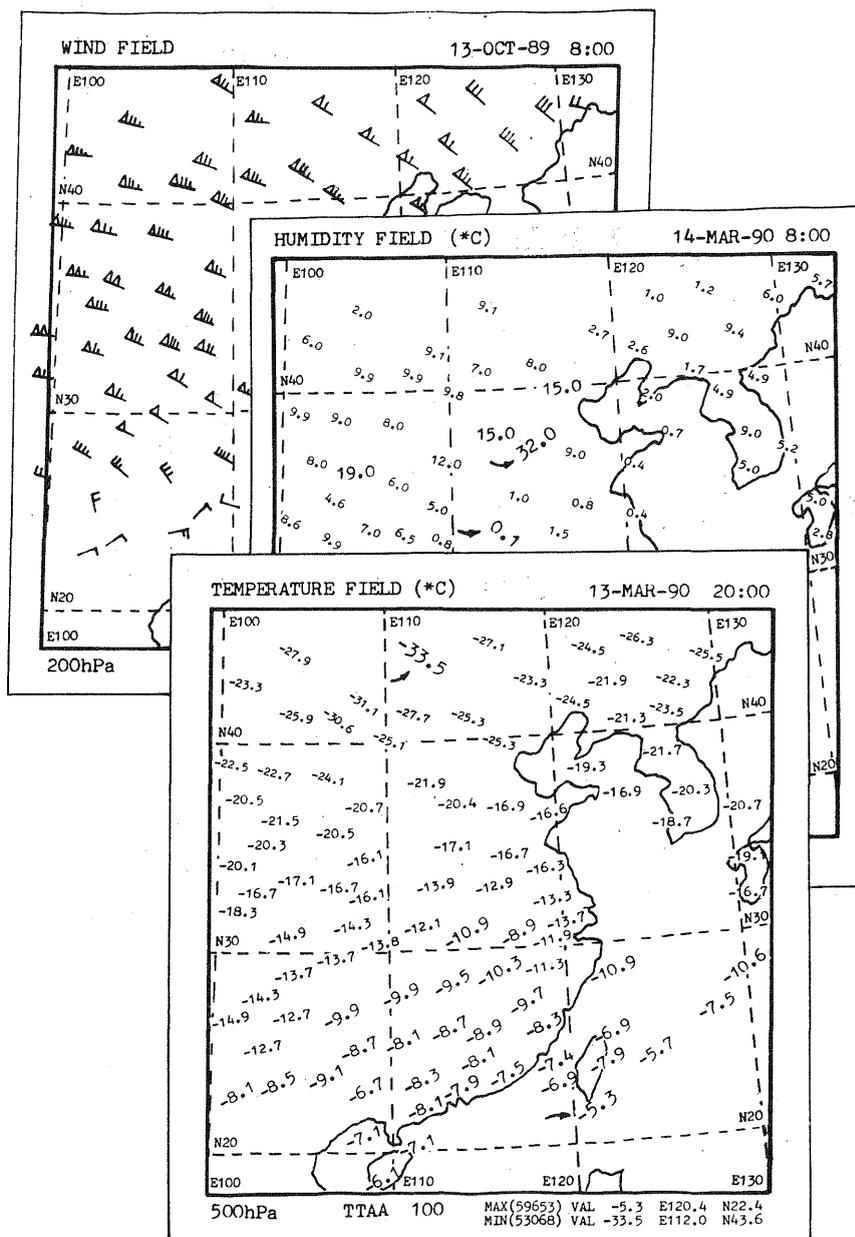
Fig.1 Some distribution maps

SPACE-HEIGHT CROSS SECTION
WIND & SETASE   7-NOV-89   08:00
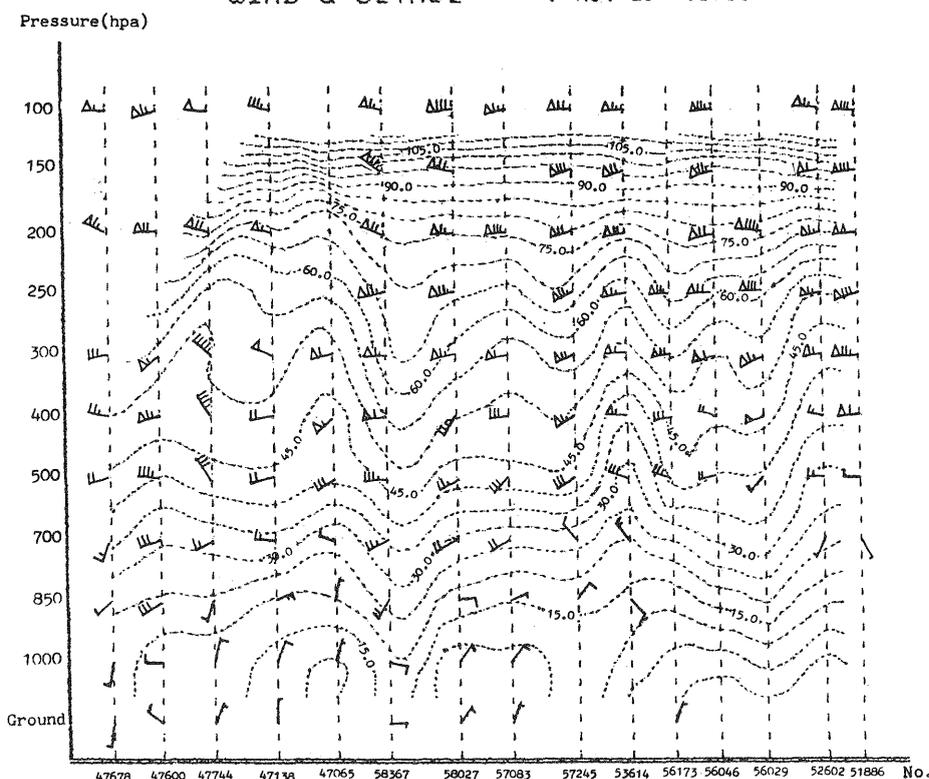
Fig.2 Cross section

(3) Stream line of atmosphere

In order to draw the streamline by the method of net-points, we chose 3 near stations for inserting a data to net point. We developed a searching method which is named "enlargement from small area". Let us suppose that (x,y) is the longitude and the latitude of a grid point, (x_1,y_1) (x_2,y_2), (x_3,y_3) is the longitude and the latitude of the near stations, their vector(wind velocity or wind direction) is v_1,v_2,v_3, so the inserting formulas are as following:

$$V=(r_2r_3v_1 + r_1r_3v_2 + r_1r_2v_3)/dt \quad (5)$$

Where

$$dt=r_1r_2+r_2r_3+r_1r_3 \quad (6)$$

$$r_1=(x-x_1)^2+(y-y_1)^2 \quad (7)$$

$$r_2=(x-x_2)^2+(y-y_2)^2 \quad (8)$$

$$r_3=(x-x_3)^2+(y-y_3)^2 \quad (9)$$

Fig.3 is a streamline map.

(4) Isogram of functional difference of thickness advection

The functional difference of thickness advection indicates the geopotential change in a baroclinic field of atmosphere. This kind of isograms is a effective map for forecasting the rain gust in the rain season, the change of westerly wind in the east Asia, and so on.

Suppose the pressure of higher layer is P_1, the wind velocity is v_1, the wind direction is a_1. We also suppose the lower layers' pressure is P_2, wind velocity is v_2, wind direction is a_2, if the velocity of thermal wind from P_2 to P_1 is u, so we can calculate the functional value RTM by the following formulas:

$$RTM=fhu/Rln(P_2/P_1) \quad (10)$$

Where

$$f=2wsin\theta$$

$$u=\sqrt{v_1+v_2-2v_1v_2cosb} \quad (11)$$

$$h=2(\sqrt{s(s-u)(s-v_1)(s-v_2)}/u \quad (12)$$

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$$s=(v_1+v_2+v_3)/2 \qquad (13)$$

$$b=a_1-a_2 \qquad (14)$$

$$R=287.054, \ w=7.292*10^{-5}$$

θ is the latitude of the balloon air sounding station. Then we cross some pressure layers to calculate another functional value RTM' by use of above formulas. Finally we can get a functional difference of thickness advection as following:

$$RTMM=RTM - RTM' \qquad (15)$$

Fig.4(a) is an isogram of functional difference of thickness advection.

(5) Isogram of vertical stability of convection

Generally speaking, when the value of vertical stability of convection is as minus, the convection weather will take place as possible. So the vertical stability is useful to forecast the rain gust. It can be calculated by some complex meteorological formulas.

Fig.4(b) shows us a isogram of vertical stability of convection.

Fig.3 Streamline

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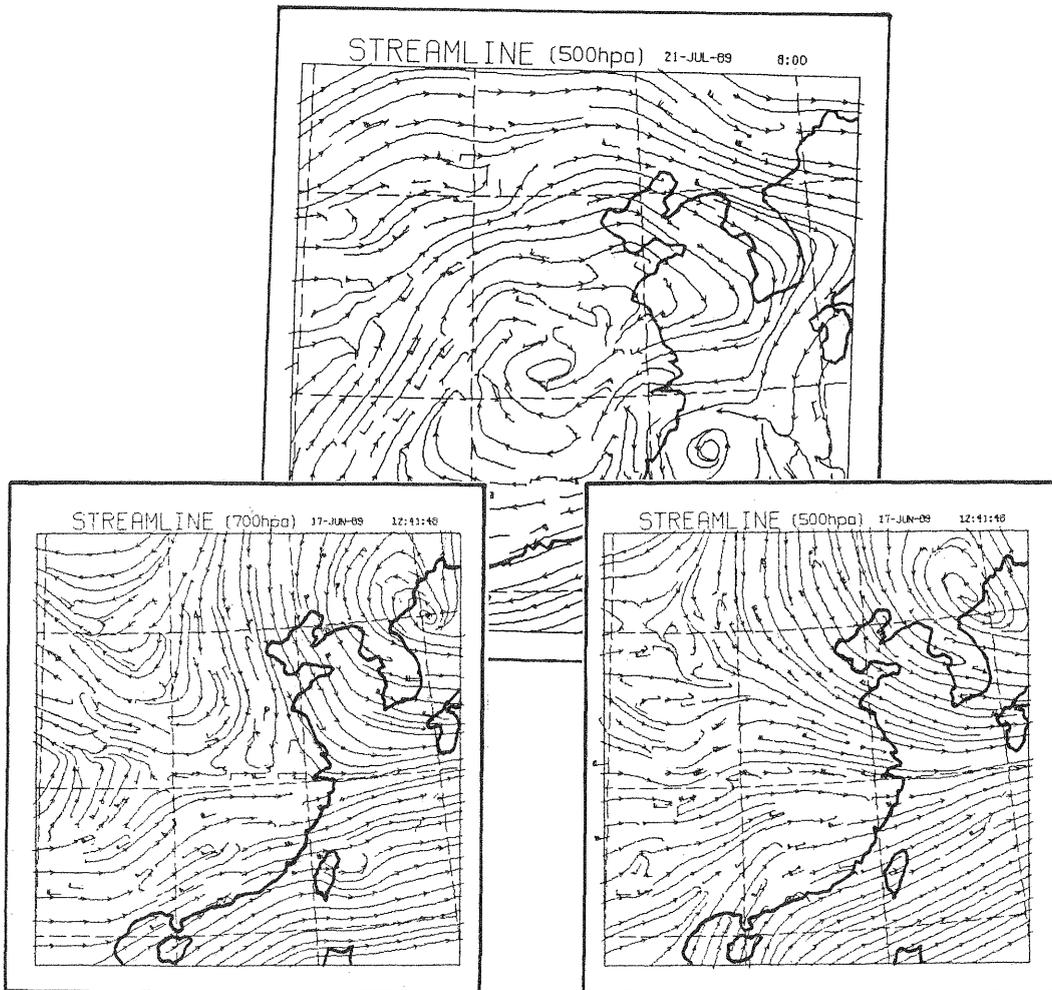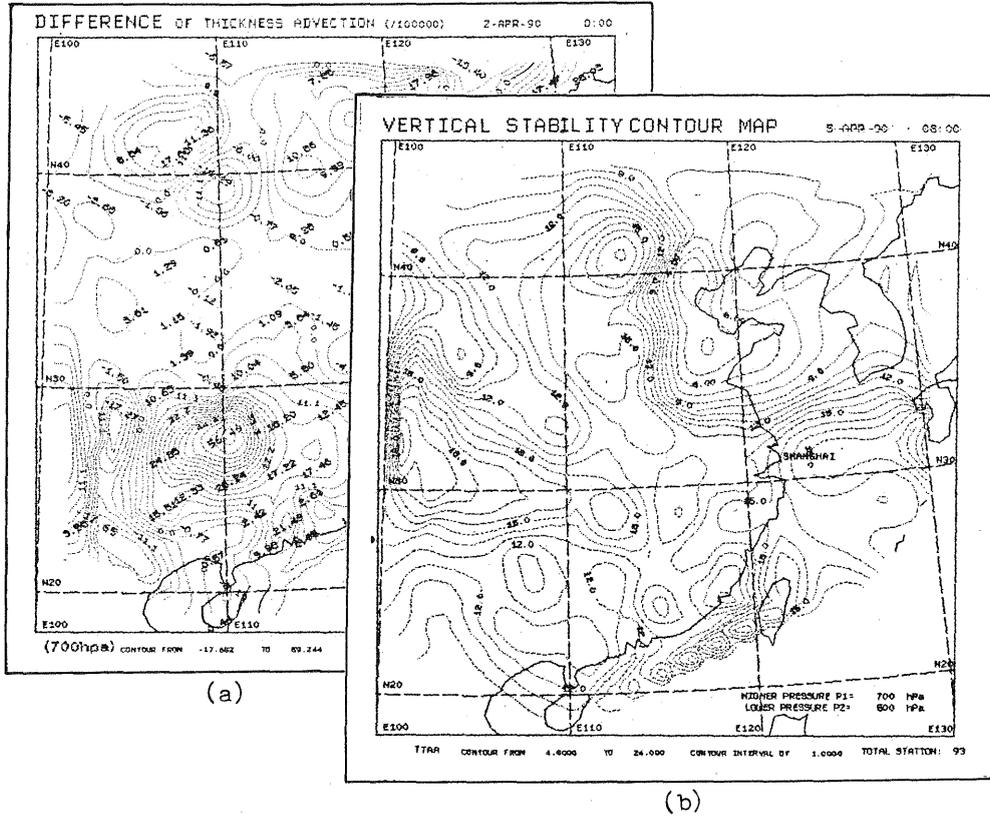
Fig.4
(a)Isogram of functional difference of thickness advection.
(b) Isogram of vertical stability of convection.

(6) Superimposition map

Some times meteorologists or weather analysts need some superimposition maps of graph and image, graph and graph. Therefore the drawing program also includes such superimposition ability.

3. CONCLUSION

These approaches were performed at the meteorological center of Shanghai with a micro VAX-3500 workstation. The program is convenient to use.

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