Cloud Forms of the Jet Stream[1]

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Abstract

A combination of four cloud types including specific forms of cirrus, cirrocumulus and altocumulus have been successfully correlated with the reported location of the major axis of the jet stream. Recognition of these cloud patterns from the ground may prove to be a simple method for locating the high velocity component of the jet. Field observations of these spectacular clouds have been made at various parts of the United States. More than 500 feet of time-lapse motion pictures have been obtained of such clouds and show remarkable high velocity, shear, turbulence and waves which typify portions of this high velocity stream of air. These cloud structures display the coherency and the high rate of motion which would be expected of the jet stream. Preliminary studies have indicated that the proximity of the major axis of the jet stream sometimes modifies air motions at low altitude and may be responsible for excessive winds on mountain summits and anomalies of forest fire behavior. Detailed studies by time-lapse photography should establish more of the physical properties of this important component of the atmosphere.

During the past year observations have been made by the writer which indicate the probability that the jet stream may often be located from the ground by visual observation of cloud structures.

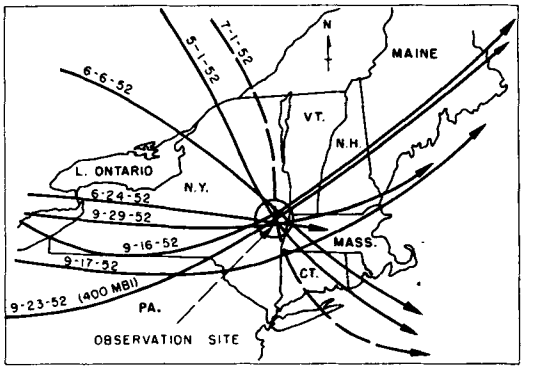
This possibility was suggested recently by SAWYER (1951) after making a statistical study of cloud types reported on synoptic maps during passage of the jet stream.

For nearly ten years a spectacular pattern of clouds has been observed by the writer at occasional intervals in the vicinity of Schenectady, in eastern New York. These were observed and sometimes photographed.

When the high altitude isotach charts prepared by WBAN Analysis Center in Washington were added to the Facsimile network in the spring of 1952, the opportunity arose for correlating field observations of cloud forms with the observed location of the jet stream. This paper reports the preliminary results of a phase of field research conducted during the past summer by the Munitalp Atmospheric Research Project.

Within a few weeks, it was discovered that a combination of specific and rather spectacular cloud types invariably coincided with the close proximity of the jet stream.

Figure 1 illustrates the position of the jet stream as shown by the WBAN charts during several different field observation periods during the spring and summer of 1952. Ob-



CENTER OF JET STREAM AT 500 mb. AS DRAWN ON WBAN 1000 MAPS FOR DAYS WHEN TYPICAL CLOUDS OCCURRED

Fig. 1.

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[2] The field research studies reported in this paper were conducted as part of the program of basic research in meteorology sponsored by The Munitalp Foundation, Inc.

Fig. 2. Cirrus.

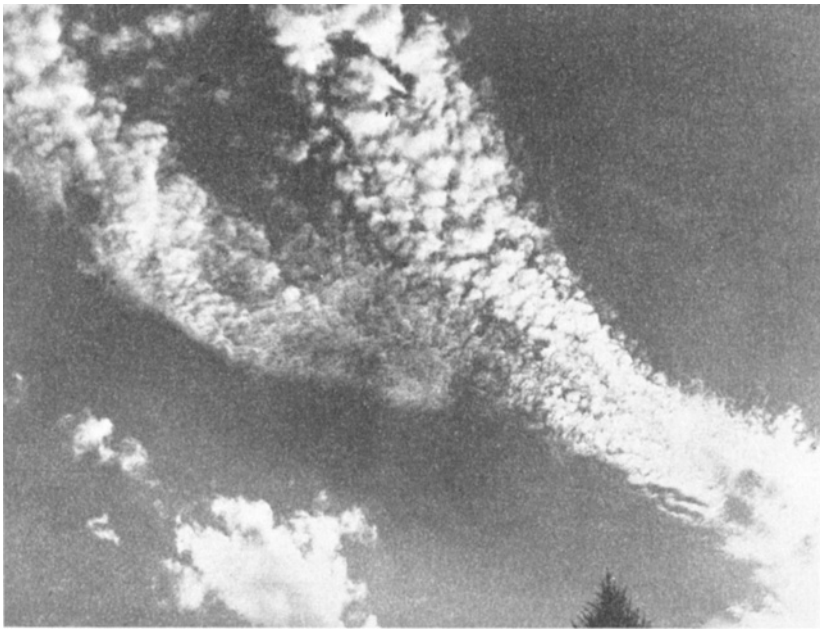

Fig. 3. Cirrocumulus.

Fig. 4. Altocumulus lenticular.

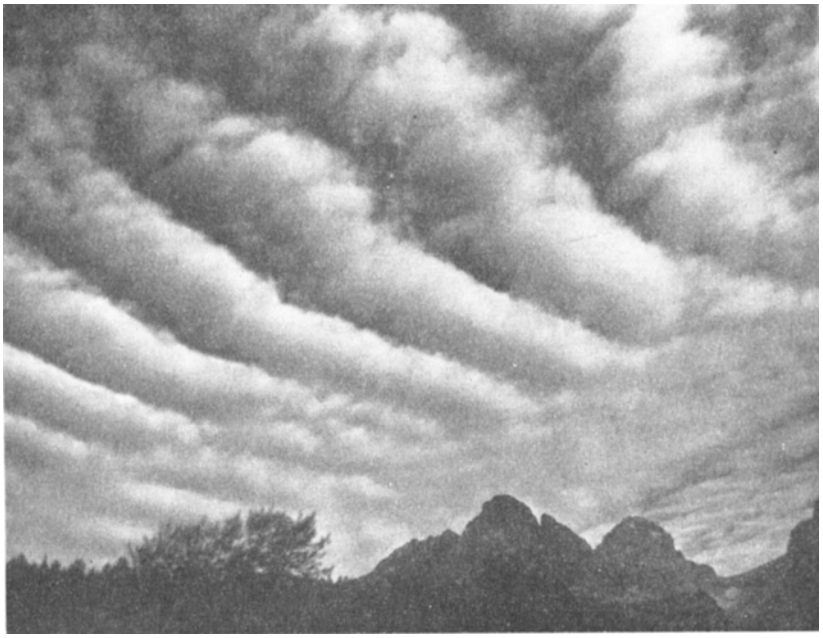

Fig. 5. Altocumulus billows.

servations made on these days and more than twenty other periods when the reported position of the jet stream coincided with the site of field observations have established the following cloud types as forms which may be utilized to establish the location of the jet stream.

1. High Clouds (H_4 and H_5)—Cirrus streamers of great complexity moving at high velocity and showing long tufted streamers, complex shear lines, and massive whorls. Illustrated by Fig. 2 and Fig. 6 a, b, c, d.

2. High Clouds (H_9)—Cirrocumulus in blanket-like masses scattered in a random fashion although sometimes in a line showing evidence of being at the crests of undulations in the stream. Clouds sometimes changing in character, shifting rapidly to cirrus streamers or showing fine structured waves at very high altitude. Some blankets show high order Tyndall spectra in green, red, and other colors when near the sun. Illustrated by Fig. 3 and Fig. 7 a, b, c, d.

3. Middle Clouds (M_4 and M_7)—Altocumulus lenticular wave clouds sometimes in great profusion with large lateral dimensions in the direction of flow of the stream. Often with considerable vertical depth and piling up in many layers. Such clouds show little apparent relationship to ground topography, although they are basically "standing clouds" and, therefore, do not exhibit rapid movement except when snow is shed from them. When this occurs, long streamers may extend downwind for many miles to emphasize the high velocity nature of the air. When near the sun, high order Tyndall spectra colors are commonplace. Illustrated by Fig. 4 and Fig. 8 a, b, c, d.

4. Middle Clouds (M_3 and M_5)—Altocumulus. A billow type cloud which may extend from horizon to horizon with the waves in parallel bands at right angles to the air flow. At times the cloud sheet may appear as a relatively thin layer with the units more cellular in form. Illustrated in Fig. 5 and Fig. 9 a, b, c, d.

In addition to the four basic cloud types which seem to be closely related to the main axis of the jet stream, the following three other characteristics have been noted.

High Velocity—In all instances the clouds show evidence of the high velocity characteristic of the jet stream. This is most easily seen by using as a reference point some distant object. No trouble is experienced in observing the high velocity, except with the lenticular forms which do not move rapidly. Extremely rapid cloud changes may occur with the cloud cover shifting from 1/10 to 9/10 and back to 1/10 in less than an hour. In several instances, the writer has watched a storm form along the apparent axis of the jet. The storm development proceeded rapidly and suggested frontogenesis. In most cases I have observed, precipitation under the axis of the jet stream has been limited to sporadic sprinkles of rain or snow. As a rule, the weather under the major axis and to the north has been typified by cool crisp air, unlimited visibility, mostly blue skies, and persistently fine weather.

Coherency—In every instance when cloud forms have been related to the jet stream, they have occurred in a coherent pattern often extending from horizon to horizon. Figure 8 c is an example of a common formation where the jet passes in the vicinity of a mountain ridge.

Gustiness—in about half of the cases observed to date, a peculiar persistent gustiness in the air at ground level has been noted. Although this feature has not yet been studied in detail, such winds seem to be most common under conditions having a super adiabatic lapse rate. The gustiness at ground level which seems to be related to the effect of the jet stream may be related to the instability of the air. In a number of cases, small stratocumulus clouds with tops less than 8,000 feet above the ground have displayed profound modification due to the jet.

A preliminary check of the incidence of high winds at the summit of Mt. Washington, New Hampshire made by Mr Raymond Falconer of our laboratory shows a high correlation between such high winds and the close proximity of the main axis of the jet stream to the mountain. It is quite likely that the world record in recorded wind velocity at a ground station measured at Mt. Washington of 231 m.p.h. and similar excessive winds of the past will show a high correlation with the presence of the jet stream.

In this respect the writer has recommended to the U.S. Forest Service that anomalies in

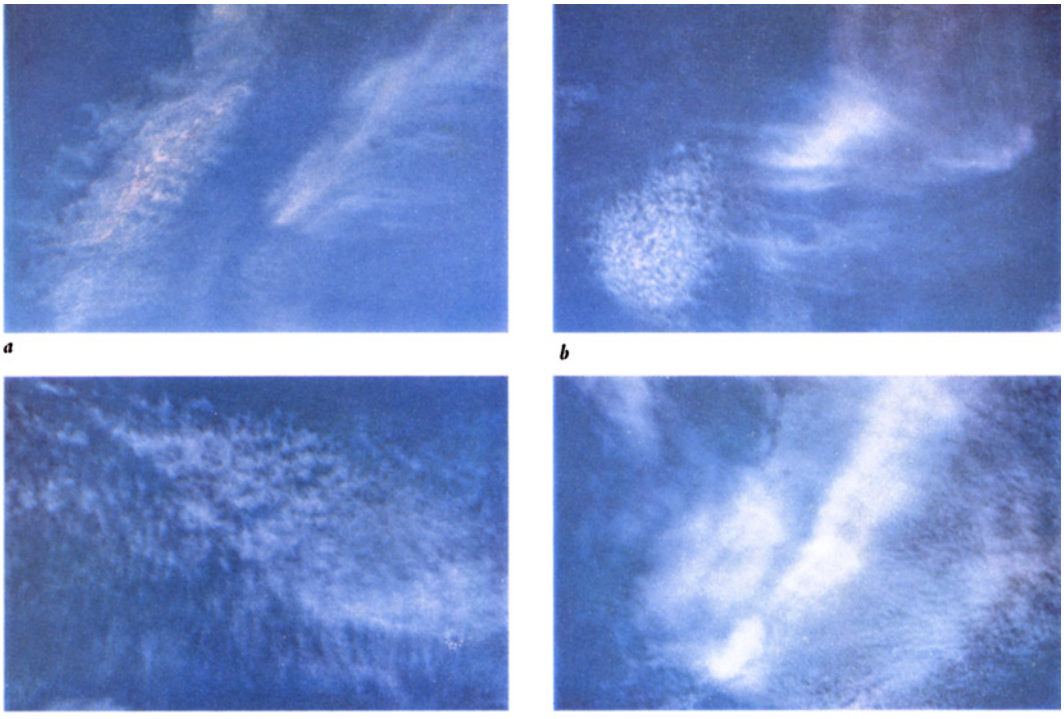

Fig. 6. Cirrus.

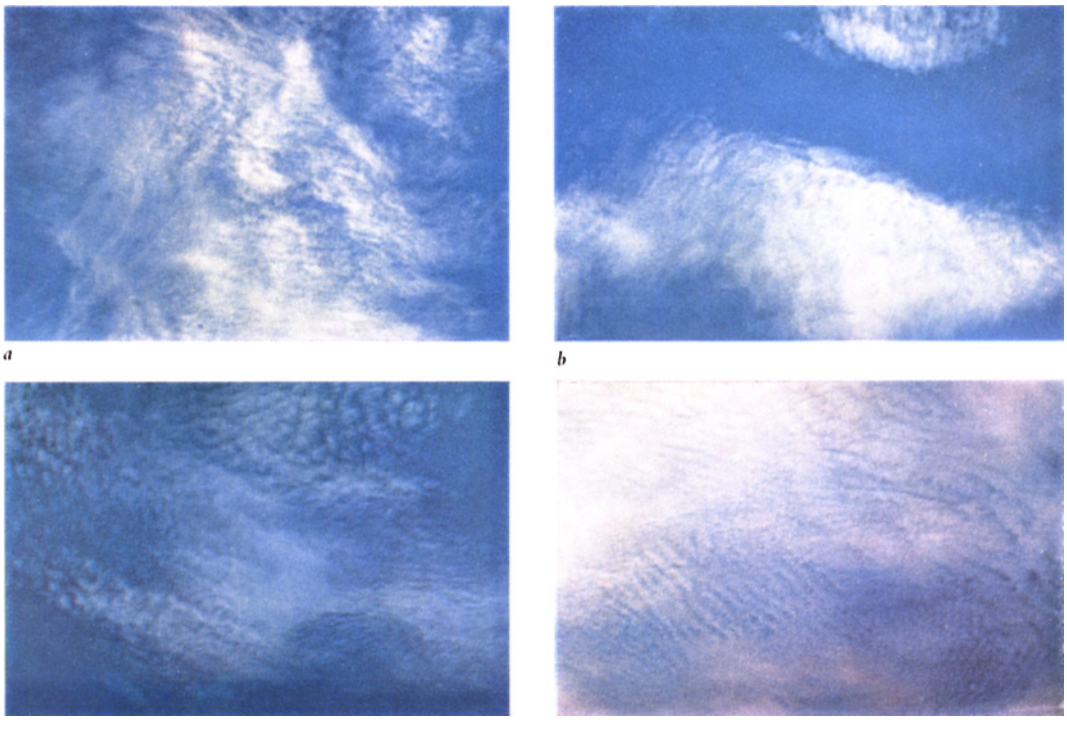

Fig. 7. Cirrocumulus.

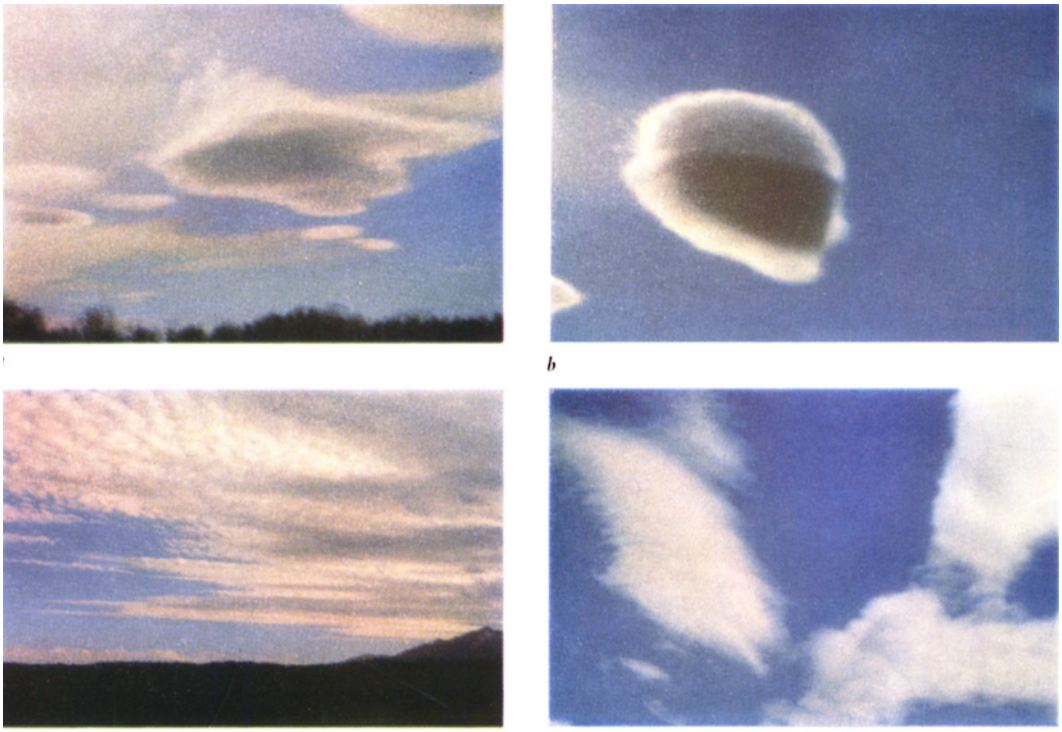

Fig. 8. Altocumulus lenticular.

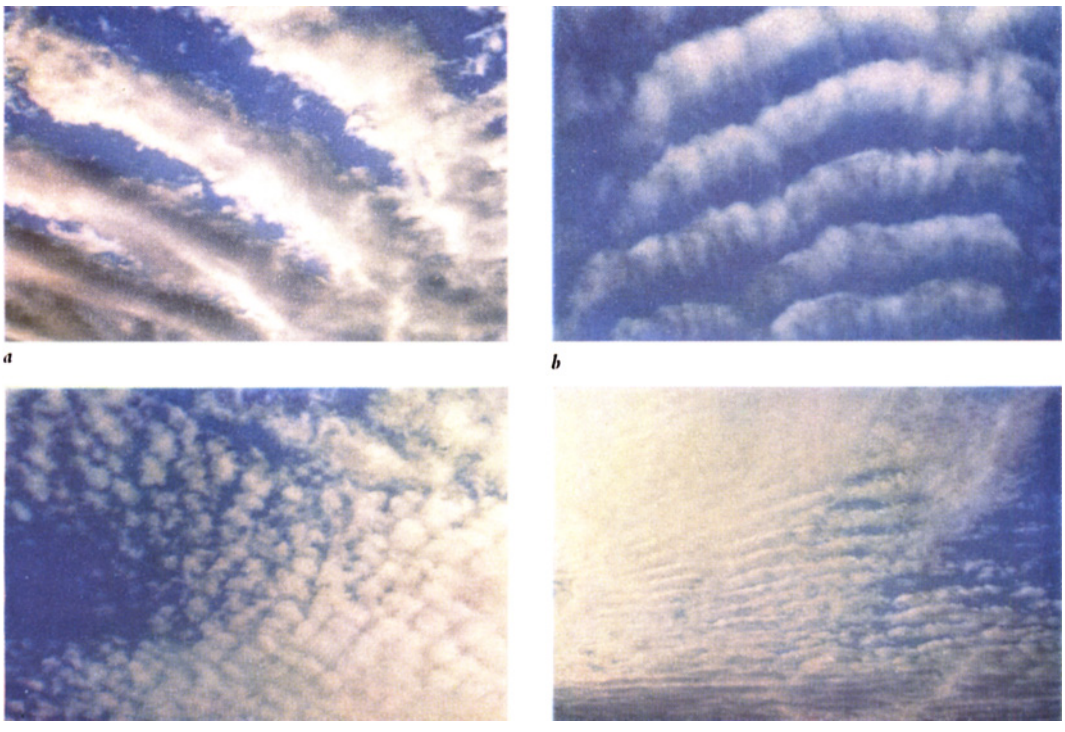

Fig. 9. Altocumulus billows.

forest fire behavior may have a similar relationship.

Detection of the jet stream

A preliminary "rule of thumb" method for using the foregoing cloud types and related characteristics in establishing the near proximity to the observer of the jet stream requires the appearance of at least three of the cloud types described, along with evidence of high velocity movement and coherency. If all four cloud types occur, the evidence may be considered complete.

Since May 1, 1952, the writer has been accumulating photographic evidence of cloud types related to the jet stream. Nearly 500 feet of time lapse motion pictures have been secured thus far in eastern and central New York, western Minnesota, western Montana, northern Idaho, western Wyoming, and southern Colorado. The general characteristics of the type clouds in the various regions are identical, although local variations may be noted.

The use of clouds to establish the location of the main axis of the jet stream is limited, of course, to those periods when lower clouds do not obscure the sky or when enough moisture is in the jet to permit cloud formation. It has been noted that the hour after sunrise and before sunset is most favorable for revealing high thin clouds related to the jet at times when very little moisture is in the air.

An hour by hour study of the cloud forms related to the jet stream illustrates many interesting features of its high velocity, meandering nature, and "micro" structure. This is particularly interesting when the jet is relatively narrow in width. By employing a visual method supplemented by time lapse motion pictures over an extensive network, it is quite possible that a much better understanding of the basic dynamic properties of the jet stream may be obtained.

The relatively dense network of meteorological stations throughout the world could be easily utilized for pin-pointing the location of the jet stream on an hourly basis following the cloud identification procedure described in this paper. This type of data, supplemented by aircraft pilot reports, should lead to a better concept of the physical nature of the jet stream.

REFERENCE

SAWYER, J., 1951: The distribution of medium and high cloud near the jet stream. *Meteorological Magazine*, **80**, 277.