Upper Mean Flow over the North Atlantic during January 1952

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(Manuscript received 30 July 1954)

Abstract

Three mean atmospheric cross sections, one along the eastern coast of North America near longitude 80° West, one extending from Hudson's Bay out over the western Atlantic and the third along the western coasts of Europe and North Africa for January 1952 are presented. Four distinct currents are discussed in some detail; they are:

A. A polar stratospheric jet stream which is most clearly defined over Scandinavia where it shows up as a separate current centered near latitude 62° North. The maximum winds are above the 100-mb level.

B. A tropospheric jet stream in middle latitudes which weakens appreciably between the eastern coast of North America and western Europe but can be traced through all three cross sections (central potential temperature about 335° A).

C. A well-defined maximum over North Africa at latitude 24° North which has no clear connection with any maxima over North America and may form over the Atlantic Ocean. This current is centered at a potential temperature of approximately 345° A.

D. A mean low-latitude west-wind maximum over Panama at 45,000 feet near latitude 11° North. Mean observed wind profiles at Albrook Field, Panama and at Swan Island indicate that this really is a separate current and not the south edge of the middle-latitude jet stream. The central potential temperature in this maximum is about 355° A.

Introduction

A number of mean atmospheric cross sections through North America, in particular along longitude 80° West, have now been published. One of the primary reasons why this longitude has received so much attention is the excellent network of aerological stations which is found here. However, the network over western Europe is even more dense in places, and yet there has been a hesitancy on the part of most synoptic meteorologists to construct monthly-mean cross sections along the eastern side of the Atlantic.

Over the ocean itself, the limiting factor in cross-section analysis has obviously been the scarcity of reporting stations. There are, nevertheless, enough weather ships to allow construction of mean sections over part of the North Atlantic. Since we have no upper-air stations at low latitudes in the middle of the ocean, it is only possible to draw conclusions about the upper flow here through the study of sections upstream and downstream.

The work described in this paper was undertaken in an attempt to determine whether or not large scale features in the general circulation could be traced from one side of the Atlantic to the other. The jet stream maps of NAMIAS and CLAPP (1951) indicate a lack of continuity in this region; the authors point out, however, that large changes may be necessary as more data become available.

Mean Flow at 200 MB

In figure 1 is presented a chart of the mean 200-mb contours over the Atlantic Ocean and adjacent land areas during January 1952. The analysis is based upon mean values of the 0300 GCT radiosonde reports from those stations indicated by black dots. The larger dots give the locations of the stations used in the cross sections which will be discussed later.

course, no coincidence, for the role of the earth's orography in determining the location of the semi-permanent centers of action is fairly well known (eg. BOLIN 1950).

From a casual inspection of figure 1, one can also see that the broad current maximum (jet stream) over the United States must weaken considerably downstream. This is evident from the marked diffluence of the 200-mb contours, especially over western

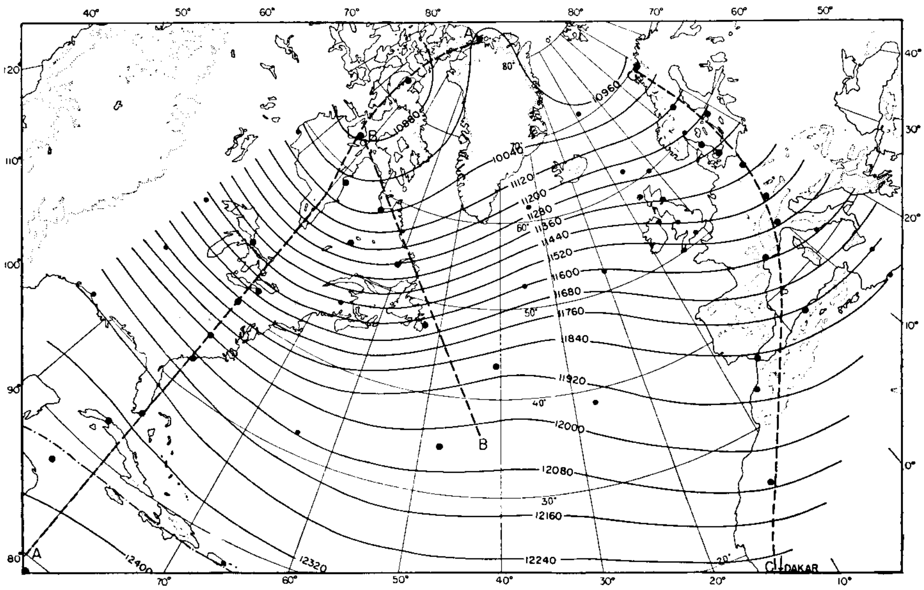

Fig. 1. Mean 200-mb chart at 0300 GCT for January 1952. Black dots represent stations used in analysis. Thin solid lines, 200-mb contours at intervals of 80 meters. Heavy dashed lines, locations where mean cross sections were constructed.

During this month the major trough off the western coast of the United States was well developed in the mean thereby giving more of a westerly flow across the central part of the country than is usual. This in turn must be connected in some way with an inhibition of deep polar outbreaks east of the Rocky Mountains and therefore relatively high index flow.

Perhaps the most predominant feature of the mean flow pattern over the ocean is the semi-permanent long wave which has a wave length roughly equal to the width of the Atlantic. The wave is fairly symmetrical; the troughs are slightly inland from the eastern and western shores, and the ridge is located approximately in mid-ocean. This is, of

Europe. On the eastern side of the North Atlantic the contour gradient is quite weak in the vicinity of the Azores; farther south, however, there is obviously a second current maximum. The confluence of the contours between latitudes 20° and 30° North along the west coast of Africa indicates that this stream has a maximum intensity farther downstream (see BANNON 1954).

The average jet stream charts by Namias and Clapp and the mean January isotachs at 500 mb by MINTZ and DEAN (1951) both indicate that the stream passing over North Africa has no direct connection with that over the eastcentral United States. It is furthermore interesting to note from the isotach analyses referred to above that one jet dies out while the other intensifies at the longitude where the occurrence of blocking action is a maximum (REX 1950).

A "climatological jet" which results from averaging over a period as long as a month is frequently unrepresentative of day-to-tay conditions. We know, for instance, that double jet streams over the United States are not exceptional (see eg. CRESSMAN 1950); it may be that the southernmost of these occasionally continues eastward to the south of Bermuda and the Azores. If such is the case, the mean polar-front jet stream and the mean subtropical jet apparently merge over the Eastern United States to form one broad maximum, and it is only farther downstream that separate current maxima again become distinguishable. The reverse of this may be seen over eastern Asia in winter; one mean jet over south China and another north of the Himalayas (YEH 1950) merge, in the vicinity of Japan, into a single maximum of extremely high winds (MOHRI 1953).

Mean Cross Section for Eastern North America

A mean cross section for January 1952 from Alert on northern Greenland along the dashed line A—A (figure 1) to Albrook Field, Panama Canal Zone is shown in figure 2. The mean heights and temperatures were determined at 1000, 850, 700, 500, 400, 300,

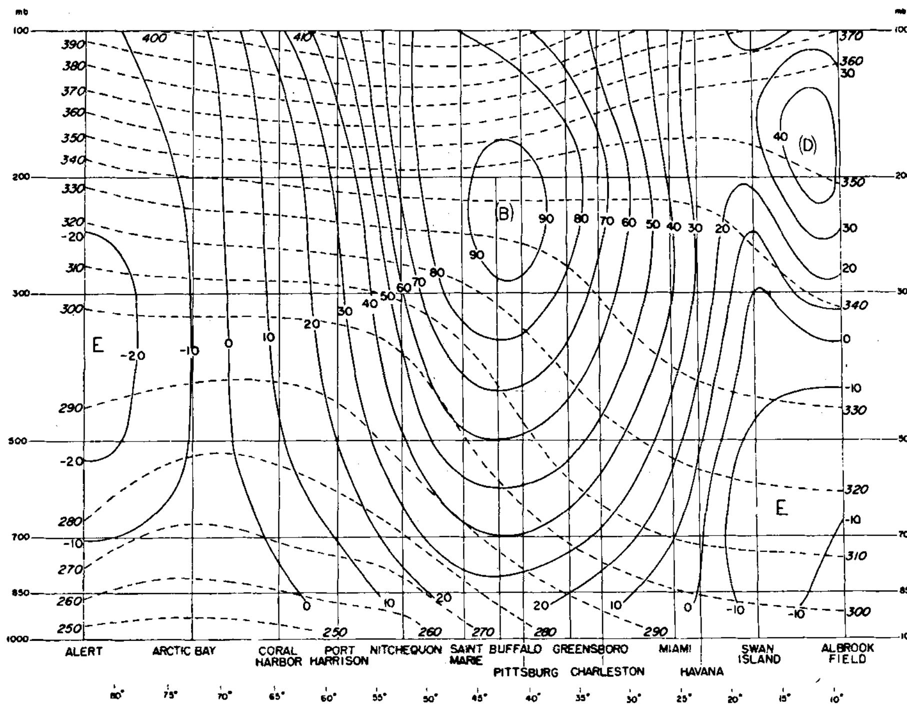

Fig. 2. Mean atmospheric cross section at 0300 GCT for January 1952 from Alert (Greenland) to Albrook Field (Panama) along line A-A in figure 1. Solid lines, geostrophic wind speed (knots) normal to section. Dashed lines, potential temperature (Deg. A.).

200, and 100 mb from the 0300 GCT upper-air soundings. Nighttime observations were used throughout this study in order to reduce radiational effects. All soundings which were not complete up to 100 mb were built up to the highest standard level reached by more than half of the soundings for the month. This was done by carefully estimating the missing portion of the p, T curve using analysed charts based upon nearby stations as well as 1500 GCT observations from the same station. Geostrophic winds normal to the section were computed from height profiles for each constant pressure surface.

We see a single broad jet stream (B) over the eastern United States centered at latitude 41° North with its core near 225 mb at a potential temperature of approximately 335° A. The maximum geostrophic wind (95 knots) agrees well with the winter cross section of Hess (1948) along this longitude; however, the latitude of the center is about 5° farther north in this case, as is characteristic of high-index flow. North of 70° latitude the flow

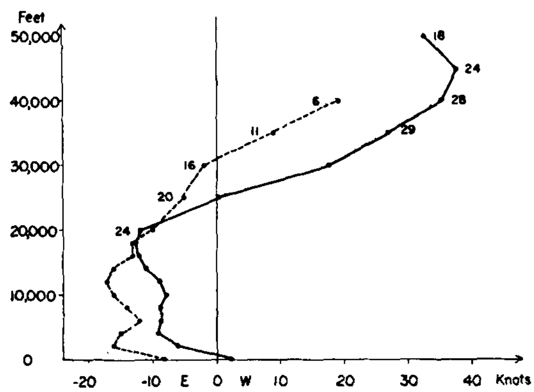

Fig. 3. Mean observed zonal wind profiles (knots) at Albrook Field, Panama (solid line) and Swan Island (dashed line) for January 1952.

was easterly at all levels up to 100 mb although the easterlies decreased in intensity above the polar tropopause.

The most unusual feature in this cross section compared to other mean sections along the same longitude is the presence of a narrow westwind maximum (D) centered near 11° North. Geostrophic wind computations at 200 mb yielded a maximum wind of 47 knots during this month whereas Hess found a mean for four winters (Jan.—Feb., 1942—45) of only 10 knots at the same altitude. The reality of this low-latitude westerly current is confirmed by the wind observations from Albrook Field at latitude 9° North and Swan Island at latitude 17° North. In figure 3 are shown the mean observed zonal wind profiles at Albrook and Swan Island (solid and dashed lines respectively) for the month of January 1952. Wind data at 0300 GCT were used for the most part; however, it was necessary to add some 1500 GCT observations in order to have one ascent for each day of the month.

Although the number of observations from high levels at Swan Island leaves much to be desired, it sems clear that the westerlies were weaker there than over Albrook (in agreement with geostrophic computations). The origin of these strong winds at the latitude of Albrook is difficult to explain. Assuming conservation of angular momentum, a ring of air at rest at the equator would have a relative speed of about 25 knots if displaced to latitude 9° North. This value is considerably less than the observed maximum of 38 knots at Albrook, so it is obvious the observed winds cannot be explained by conservation of momentum. Either the current observed here is the result of some relatively local acceleration, in which case it is not a hemispheric phenomenon, or it is part of a ring extending all the way around the earth, in which case a method whereby momentum can be transferred normal to the flow is required. A mechanism wherein the latter is possible has not as yet been developed.

Some ascents which reached very high levels at Albrook indicate that the flow is again easterly in the stratosphere with a maximum around 80,000 feet. Riehl (1954) has classified this type of wind profile, at least that part in the troposphere, as E_d W meaning deep easterlies with strong westerlies at high levels. It may be that the low-latitude stream found here is well developed only during high-index conditions (when the middle-latitude jet is farther north than usual).

Mean Cross Section for Northwest Atlantic

In figure 4 is presented a mean cross section from Coral Harbor, Canada to ocean weather station "E" along the heavy dashed line B—B in figure 1. The broad jet stream which was centered near 41° North over eastern North America crosses longitude 50° West at 47° North latitude; the maximum geostrophic wind in the center has decreased about 10 knots between the two sections. The core is located at the same pressure and has the same potential temperature as farther upstream (225 mb and 335° A). The strongest horizontal wind shear is found on the south side of the jet which probably indicates that the latitudinal fluctuations of the jet from one day to the next are blocked to the south by the relatively stationary Bermuda high. The vertical wind shear in this section is more concentrated in

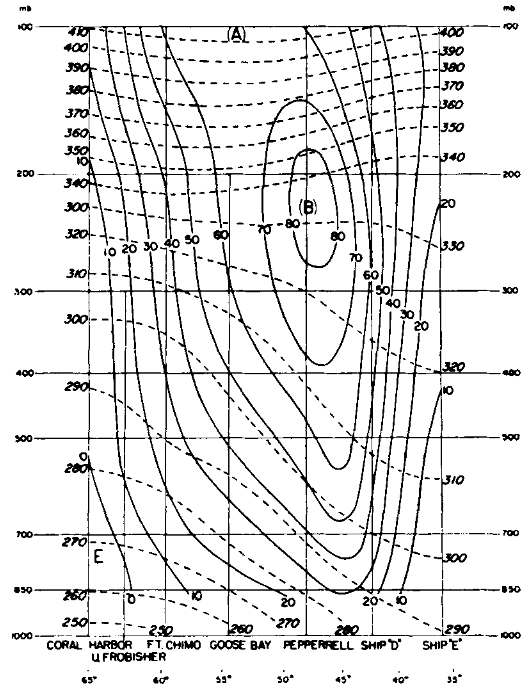

Fig. 4. Mean atmospheric cross section at 0300 GCT for January 1952 from Coral Harbor (Canada) to Ocean Weather Ship "E" along line B-B in figure 1. Legend same as in figure 2.

low levels whereas at longitude 80° West it was fairly uniform throughout the troposphere.

Mean Cross Section for Western Europe and Africa

Figure 5 is a mean cross section for January 1952 from Tromsö, Norway to Dakar, French West Africa. The section was constructed along the curved, dashed line C—C in figure 1. For Gibraltar it was necessary to utilize soundings made at 1500 GCT. At Fort Trinquet soundings are made only every second day; however, this inhomogeniety is probably not serious because of the relatively small changes which occur here.

In this section the middle-latitude jet stream, which was the most prominent feature upstream, has weakened much more and appears over the Mediterranean as a wide maximum with a wind speed of only 54 knots in the core. The jet center is again at approximately the same pressure and potential temperature so that it appears reasonable to consider this stream as being continuous across the Atlantic during this particular period.

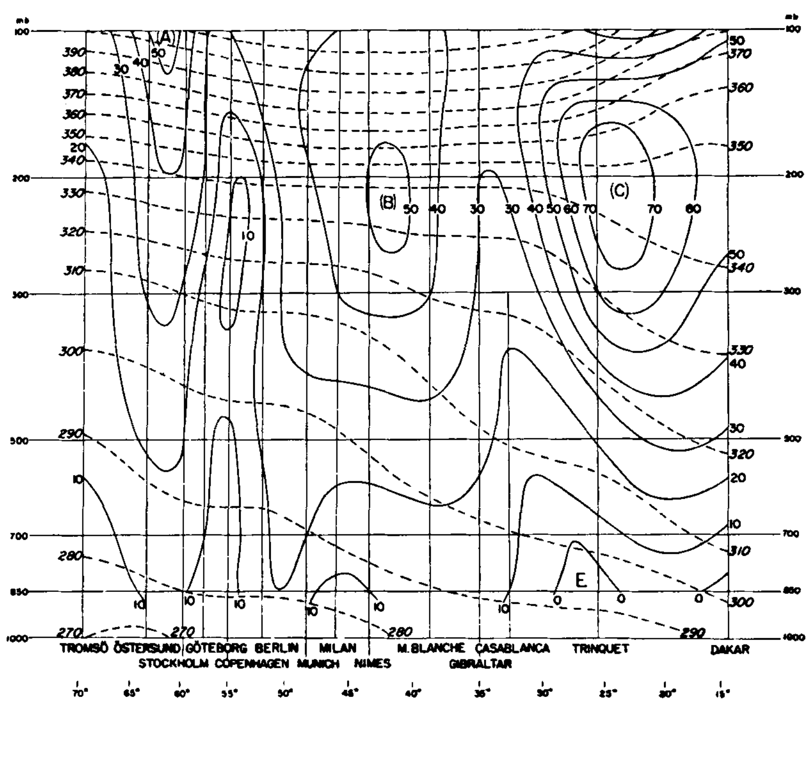

Fig. 5. Mean atmospheric cross section at 0300 GCT for January 1952 from Tromsö (Norway) to Dakar (French West Africa) along line C-C in figure 1. Legend same as in figure 2.

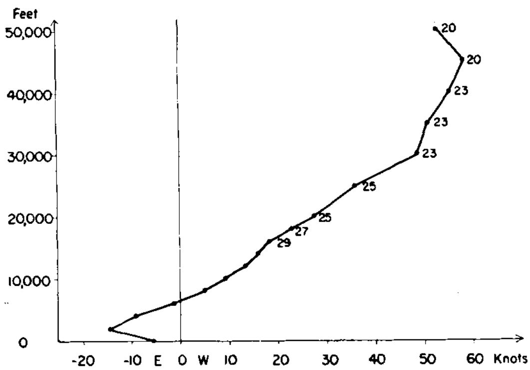

Fig. 6. Mean observed zonal wind profile (knots) at Dakar, French West Africa, for January 1952.

The unusually light winds in the vicinity of latitude 55° North are the result of cut-off lows which persisted over southern Europe during a good part of the month. At Berlin the observed winds at 300 mb had an easterly component from the 19th through the 24th of January. Such persistent anomalies are a common occurrence over Europe, and the monthly mean pattern shown in figure 5 undoubtedly differs from the long-term mean for winter conditions.

A wind maximum in the polar stratosphere near latitude 62° North (A) is visible in this cross section. Mean geostrophic winds of 56 knots were computed at 100 mb, and the thermal field indicates that the winds continue to increase above this level. This polar stratospheric jet stream is found only in mid-winter near the boundary of polar night; the latitudinal variation in direct solar radiation must be very important at high levels during this time of year (PALMÉN 1934).

The strongest winds in this cross section (77 knots) are over North Africa near 24° North. Both the location and intensity of this jet agree favourably with the January means of Namias and Clapp. The central potential temperature of this stream is about 345° A, and the core is located near 210 mb. JAMES (1951), in an earlier mean cross section for February 1951 along the Greenwich meridian, found that the west winds increased with height over North Africa, but he obtained no closed maximum.

Geostrophic computations at both 200 and 100 mb gave some indication that the winds at these levels increase again south of latitude 16° North. Perhaps the west-wind maximum which was found over Panama continues across the Atlantic at approximately the same latitude. The mean observed zonal winds at Dakar, figure 6, substantiate this possibility in so far as the maximum westerlies over Albrook Field and over Dakar occur at the same height (45,000 feet). The time-section from the Finnish Atlantic expedition in October—November, 1939 also shows a westerly current at almost the same altitude and latitude (see VUORELA, 1948).

Conclusions

An attempt has been made in figure 7 to summarize the results of the three mean cross sections by showing the probable locations of the four currents described above. It is possible that the jet stream over North Africa is continuous across the Atlantic and merges with the middle-latitude jet over the east coast of North America; however, since this has not been definitely established, it is depicted as forming over the ocean. The temporary addition of two weather ships at low latitudes in the North Atlantic could settle this question. This could conceivably be accomplished during the next International Geophysical Year.

More investigation of the low-latitude stream over Panama seems warranted. It would be interesting to know whether a maximum here is a relatively rare occurrence and whether the phenomenon is local or hemispheric in scale.

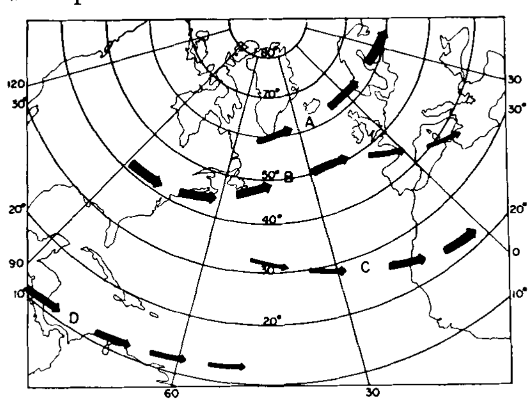

Fig. 7. Attempt to show probable location of the four jet streams found in the mean cross sections for January 1952.

The work involved in constructing these cross sections has emphasized three important points in connection with the collection and handling of data, (1) the need for greater uniformity of radiosonde types, especially in Europe, (2) the need for a single radiosonde code instead of the present feet—°F in one country and meters—°C in another and (3) the desirability of publishing all upper-air data.

Sources of Data

1. Daily Aerological Record of the Meteorological Office, London.
2. Daily Series, Synoptic Weather Maps, Part II, US Department of Commerce, Washington, D.C.
3. Daily Upper Air Bulletin, US Fleet Weather Central, Washington, D.C.
4. Täglicher Wetterbericht des Deutschen Wetterdienstes, Bad Kissingen.

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