North American Influences on the Circulation and Climate of the North Atlantic Sector

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ABSTRACT

During the post-war period the pressure field at Greenland has been characterized by long-sustained winter regimes of alternating high and low pressure, with important effects on the winter climate of Europe. Although these alternations of pressure anomaly at Greenland may be shown to be associated with periods when the pattern of long waves in the upper westerlies showed a general reversal over much of the Northern Hemisphere, it is also suggested that within this hemispheric pattern of change, contemporary variations of winter climate along the Atlantic seaboard of North America have exerted an important influence on the pressure field at Greenland and, through teleconnections, elsewhere (e.g., the North Atlantic and Europe). Comparing months of extreme winter warmth and cold over the southeastern United States it is shown that changes in the strength of the baroclinic field at the coast are associated with major changes in the distribution of winter storms. More specifically, during winters of extreme cold over the southeastern United States and the associated enhanced baroclinicity at the Atlantic seaboard, the zone of peak winter storm frequency is drawn far to the southwest of normal, with a corresponding decrease in cyclonic activity in the Iceland-Greenland area.

1. Introduction

Since the mid 1950's until recent years, the establishment, intensification and persistence (on average) of a major pressure anomaly ridge at Greenland has constituted a dominant control on the winter climate of the eastern North Atlantic. Along the eastern flank of this cell, the augmented northerly airflow brought climatic deterioration to the European arctic and subarctic seas and to northwest Europe itself, until the winter of 1970–71 when the Greenland anomaly ridge showed an almost total collapse (Dickson *et al.*, 1975). Since that date a succession of mild winters has been experienced over most of Europe, and the marine climate at north Iceland has shown renewed amelioration resulting in a partial recovery to the conditions which prevailed in the early 1950's.

Supplementing the descriptive account of Dickson *et al.* (1975), this report has the aim of setting the recent climatic developments of the North Atlantic sector into the context of Northern Hemisphere climatic change, and in particular seeks to establish some partial cause for the major and persistent changes in the pressure field over Greenland. The use of the phrase "partial cause" requires some clarification. The periods of presence or absence of the pressure anomaly ridge at Greenland will be shown to be a local reflection of periods when the pattern of long waves in the upper westerlies showed a general reversal over much of the Northern Hemisphere. The reasons for the establishment of one hemispheric wave pattern and for its subsequent abrupt change to a pattern of opposite sign remain obscure. However, it is suggested that *once such a wave pattern becomes established*, the thermal condition of the underlying surface may, through identifiable feedback mechanisms at certain key locations, be responsible for encouraging the prolongation or repeated occurrence of the wave pattern as a whole, thus protracting a short-term climatic change into a longer term climatic regime. Thus, in seeking a "partial cause" of the observed climatic regimes at Greenland, we are seeking to identify localized remote influences capable of "anchoring" the wave patterns at Greenland during successive groups of years.

An initial indication as to what this remote influence might be was provided in the recent trends of winter air temperature over the United States east of the Continental Divide. Here, as Namias (1972a, b) has already demonstrated, mean winter air temperatures have undergone stepwise changes of regime in recent decades with a period of abnormal

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[1] This work was accomplished while the author was a visiting scientist at the Scripps Institution of Oceanography.

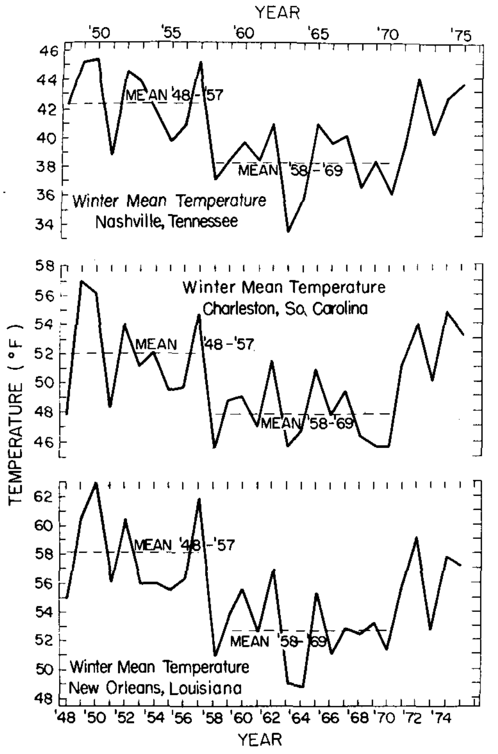

FIG. 1. Winter mean temperatures at Nashville, Charleston and New Orleans from 1947–48 (labeled "48") to 1974–75 (labeled "75").

warmth in 1948–57 giving way to a period of extreme cold in 1958–70 and, subsequently, to a renewal of warm conditions in succeeding winters. Fig. 1 provides an illustration of these changes at three representative stations in the southeast United States (Nashville, Charleston and New Orleans). Evidently, there is an association in timing between the changes of regime in winter air temperature in the eastern United States and in pressure at Greenland, but more important, there is a conceptual basis for linking the observed events in these two areas. As Houghton *et al.* (1974, p. 31) reemphasized, "The climatology of the North Atlantic is highly dependent on features of the strong baroclinic zone along the east coast of North America. The surface temperature gradient is an indicator of the general tropospheric baroclinic field." (see also, Namias 1962; Ugryumov 1974). In this key area, wave cyclones form and move northeastward feeding on the great baroclinicity established over the area between the cold continent and warm ocean, developing rapidly into large-scale occluded systems and eventually, in the statistical aggregate, forming the quasi-permanent Iceland low. From this the question arises as to whether, during periods of exceptional cold in the southeastern United States, the sharpened thermal contrast between the continent and western Atlantic might lead to a redistribution of winter storms or to the more rapid development of coastal storms to occlusion, so that they form deep semistationary systems well before reaching their normal point of greatest development at Iceland. The converse suggests that in winters of abnormal warmth along the eastern seaboard the weakening field of baroclinicity at the coast will instead be associated with enhanced storm activity along the U.S.–Canada border and with a more normal progression of storms to full development at Iceland. In other words, the presence of the Greenland positive anomaly cell in the late 1950's and 1960's might more properly be regarded as the less frequent occurrence of Iceland lows during a period when conditions of extreme cold in the southeastern States and enhanced baroclinicity at the North American seaboard brought about cyclone development well to the southwest of the normal zone of maximum storm intensity.

To explore this possibility further, a range of climatic parameters were contrasted in two groups of winter months representing extremes of the warm and cold regimes of air temperatures in the southeastern United States. The selection of these extreme months was based on the record of mean monthly winter air temperature at four representative locations, New Orleans, Nashville, Atlanta and Charleston, over the period 1948–74. The months selected are listed in Table 1 together with an indication of the extreme nature of the observed mean air temperature in each month and at each station (e.g., 2wF indicates the second warmest February of record at the listed station in the period 1948–74, etc.).

2. Pressure and circulation anomalies in the "warm SE" and "cold SE" groups of months

In Figs. 2a and 2b the mean distributions of 700 mb height anomaly are shown in standardized form for

TABLE 1. Selected winter months representing extremes of mean monthly air temperature in the southeastern United States during the period 1948–74.

	New Orleans	Nashville	Atlanta	Charleston
(A) Warm SE Group				
January 1949		2wJ	3wJ	3wJ
January 1950	1wJ	1wJ	1wJ	2wJ
February 1956		3wF	3wF	2wF
December 1956	2wD	1wD	1wD	2wD
February 1957	1wF	1wF	1wF	3wF
December 1971	1wD	2wD	2wD	1wD
January 1974	2wJ	3wJ	2wJ	1wJ
(B) Cold SE Group				
February 1958	3cF	1cF	1cF	2cF
January 1963	3cJ	1cJ	3cJ	
February 1963	2cF	3cF	3cF	
December 1963	1cD	1cD	1cD	2cD
January 1966	1cJ	2cJ	2cJ	
February 1968	1cF	2cF	2cF	1cF
January 1970	2cJ	3cJ	1cJ	1cJ

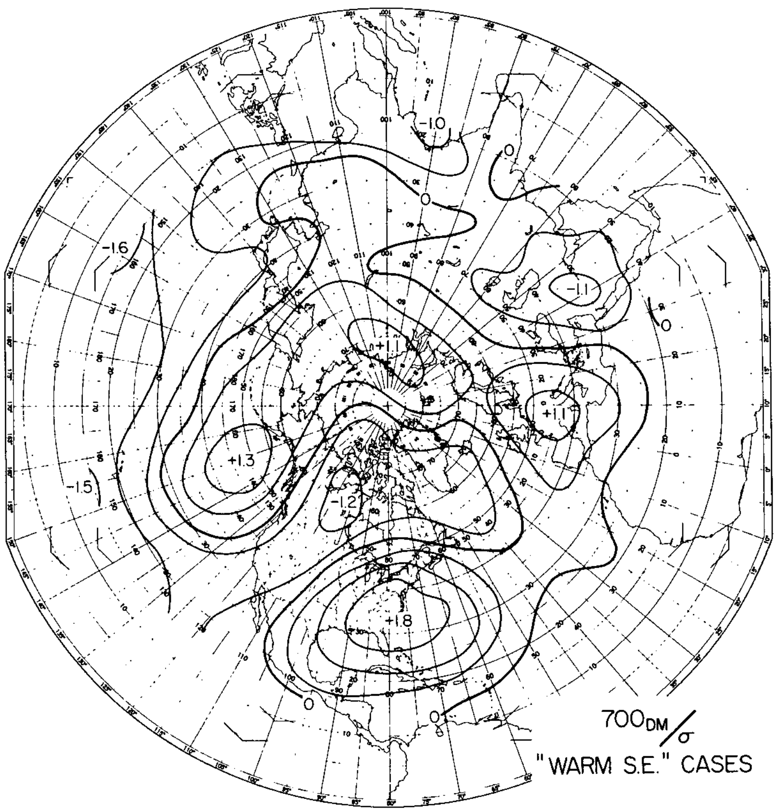

Fig. 2a. Mean distribution of standardized 700 mb height anomaly for the warm SE group of winter months. The terms "anomaly" or "DM" refer to the departure from the long term mean; σ is the standard deviation.

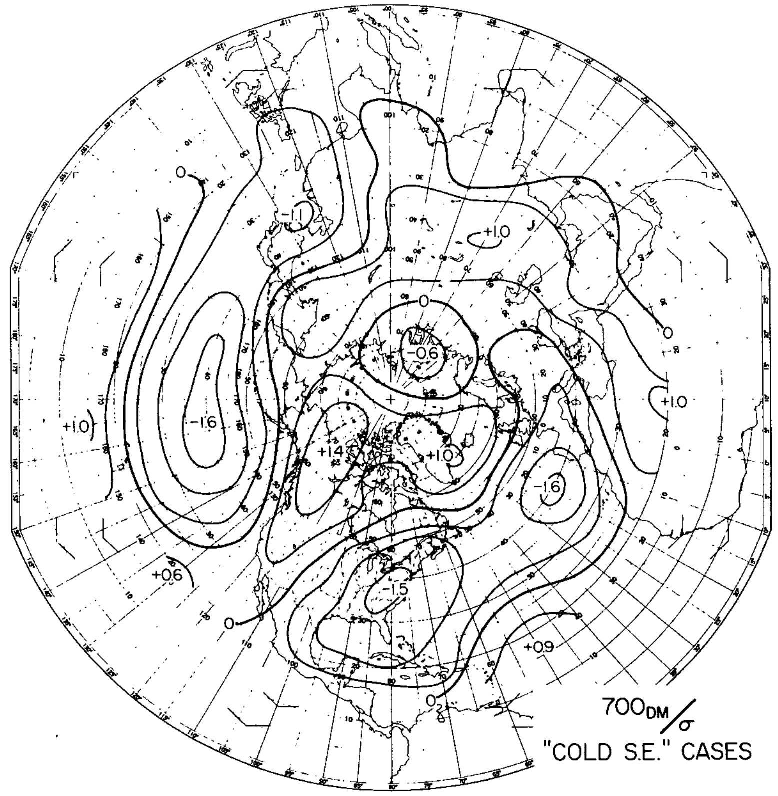

Fig. 2b. As in Fig. 2a except for the cold SE group of winter months.

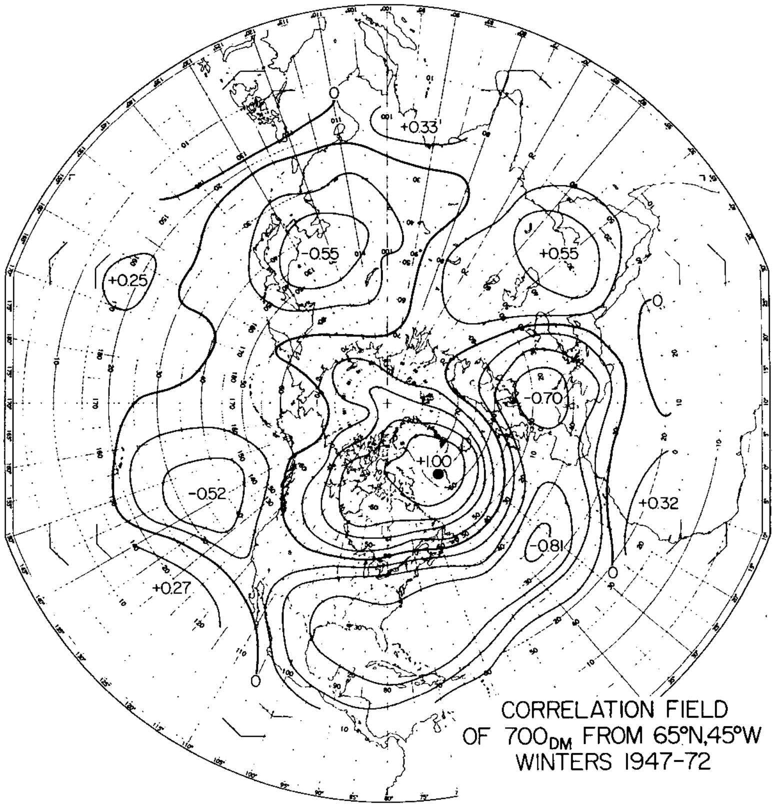

FIG. 3. Correlation field of 700 mb height anomaly from 65°N, 45°W for winters 1947–72.

the groups of seven selected months representing the "warm SE" and "cold SE" cases respectively.[2]

Over the specific area of the southeastern United States, a marked circulation reversal is shown between the two selected groups of winter months (c.f. Figs. 2a and 2b). During warm SE cases an anomaly ridge in the 700 mb surface amounting to 1.8 times the standard deviation of appropriate winter monthly means led to an augmented flow of air into the southeastern States from warm source regions in the Gulf of Mexico, while during cold SE cases a mean trough of 1.5 standard deviations of 700 mb height lay at the eastern seaboard bringing an increased flow of arctic air to this region. Overall, the change in 700 mb height at the east coast amounted to 410 ft between these two mean conditions and in each case this cell was coupled with a pressure anomaly of opposite sign over western North America.

More generally, a comparison of Figs. 2a and 2b shows an almost total reversal of the height anomaly field over the entire Northern Hemisphere between the warm SE and cold SE cases. A belt of positive anomaly circles the hemisphere at mid-latitudes in the warm SE group of months, with centers at the southeastern United States, western Europe, arctic Russia and the eastern Pacific. This zone of positive anomaly surrounds a negative anomaly center over arctic Canada from which troughs extend over western North America and Greenland. In the alternate case (cold SE) a high-pressure cell over arctic Canada with outlying ridges over western North America and Greenland is encircled by a chain of negative anomaly centers at mid-latitudes.

The individual cells of these contrasting patterns conform with the known physical and statistical teleconnections of the Northern Hemisphere winter circulation (e.g., Walker and Bliss, 1933, p. 59; O'Connor, 1969). In Fig. 3, for example, the 26-year series of mean winter 700 mb height anomaly (1947–72) at south central Greenland (65°N, 45°W) has been correlated with corresponding series for each 5° grid intersection in the Northern Hemisphere north of 15°N, with the resulting correlation field contoured at intervals of 0.2. The distribution obtained is in remarkably good agreement with the distributions shown in Figs. 2a and 2b with a limited zone of positive correlation over Greenland and arctic Canada encircled at mid-latitudes by centers of opposite correlation. The good agreement with Fig. 2 is important, suggesting that the anomalous circulation patterns observed during the 14 selected winter months were

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[2] The terms "anomaly" or "D. M." refer to the departure from the long-term mean for the appropriate month and at the given location.

in fact representative of the prevailing winter circulation *regimes* of the post-war period as a whole.

3. Air temperature and snowfall anomalies in the warm SE and cold SE groups of months

As described earlier, the reversal of the winter circulation regimes in the post-war period brought successive and protracted deployments of Gulf and arctic air over the southeastern United States. Figs. 4a and 4b illustrate the resulting mean distributions of air temperature anomaly over the United States during the selected groups of warm and cold months, and as such, represent the extremes of temperature change which occurred during these climatic regimes. In the southeast, the mean change of air temperature anomaly exceeded 18°F between these two groups of months, while in the west temperature changes in the opposite sense gave rise to core anomalies of +2.4° and −8.2°F in the 7-month means.

This change in air temperature was accompanied by an extensive and radical change in the distribution of winter snowfall (Fig. 5[3]). In the east the average monthly snowfall at Rochester, N.Y., rose from 15.3 to 37.8 inches between the warm and cold selected months, augmented by instability in the arctic airstream as it crossed the Great Lakes; more generally this change to a northerly winter airflow was associated with excess snowfall far into the southern states to its maximum extent between Jackson and Meridian, Miss. (zero snowfall and +3.3 inches, respectively). In the far west an anomalous airflow of the opposite sense brought a simultaneous decrease of over 10 inches in mean snowfall between these two selected groups of months, with a deficit of over 5 inches per month covering a broad band running from the Pacific Northwest to Utah, Colorado and Wyoming.

Relatively few U. S. stations have provided routine upper-air soundings over the entire period covered by our selected groups of winter months (i.e., January 1949–January 1974). Nevertheless, the data coverage at seven eastern stations was adequate to examine the extent of the temperature change aloft between the warm and cold groups of months under discussion. These stations form two sections which cross the zone of greatest temperature change in the east between Sault St. Marie–Buffalo–Washington–Hatteras and Columbia–Nashville–Charleston. At each station and in each of the 14 selected winter months,[4] air temperatures at six isobaric levels to 200 mb were compared with the long-term mean for the appropriate month to form group means for the warm SE and cold SE cases. On both sections the greatest change of temperature from the warm group mean to the cold occurred close to the surface, but with a "dome" of cooling extending through to the tropopause at ~250 mb (not shown). Thus, we are dealing with anomalous air masses of great vertical extent. The cooling decreased rapidly toward the Atlantic seaboard, though lack of data prevented the extension of the transect offshore.

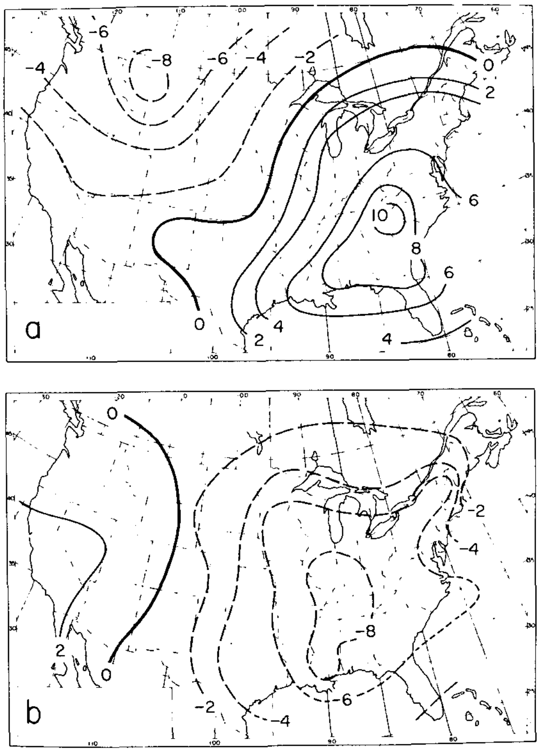

FIG. 4. Mean distribution of surface air temperature anomaly over North America during (a) the warm SE group of winter months and (b) the cold SE group of winter months (°F).

As in the case of circulation changes described earlier, we may now set the changes in surface temperature of continental North America into the context of hemispheric temperature change. Figs. 6a and 6b present composite plots of mean sea surface temperature anomaly and surface air temperature anomaly (land masses only) in each of the groups of winter months under discussion; each covers a broad sector of the Northern Hemisphere running between the east coast of Asia and eastern Europe and lying between 20° and 60°N. The surface temperature anomaly data for the North Pacific (°F contoured at intervals of 0.5°F, base period 1947–72) are those routinely computed at 5° grid intersections at Scripps Institution of Oceanography and derive from 2°×2° means compiled by the National Climatic Center, Asheville (1947–67) and the National Marine Fisheries Service (after 1967). Similar data for the Atlantic west of 60°W (but with base period 1948–67) derive from 1°×1° means computed from National Climatic Center Tape Data Family-11 by D. R.

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[3] Compiled from *Local Climatic Data, Annual Summary* (U. S. Weather Bureau, 1974) at 74 U. S. stations.

[4] Data from *Monthly Weather Review, Climatological Data National Summary* and *Monthly Climatic Data for the World.*

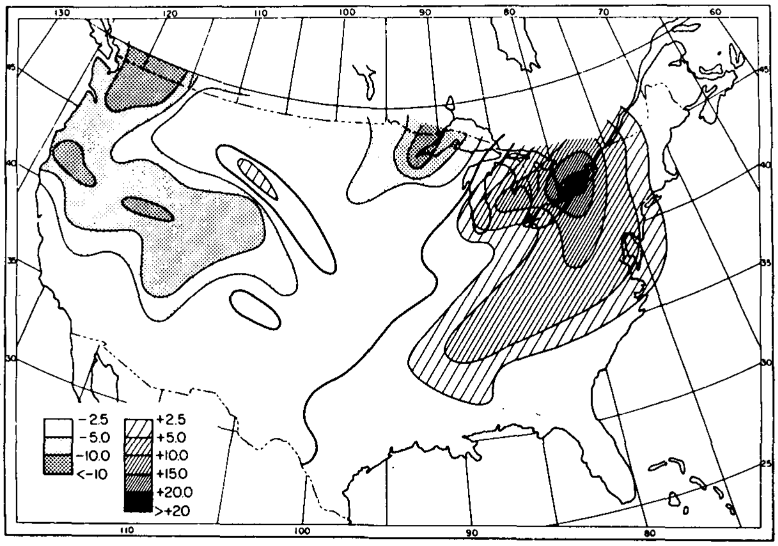

FIG. 5. Change in mean monthly snowfall over the United States between the selected warm SE and cold SE groups of winter months (inches).

McLain, National Marine Fisheries Service, Monterey (see McLain *et al.*, 1976). The air temperature anomaly data for North America and Europe (°F, contoured at 1°F intervals) derive from monthly means published in *Monthly Climatic Data for the World* and use as base period the Grand Monthly Means listed in the issues of January, February and December 1974.

In keeping with the complete reversal of circulation anomaly patterns over the Northern Hemisphere between our selected groups of warm SE and cold SE winter months, Fig. 6 indicates an equally striking reversal in the distribution of surface temperature anomalies both over land and sea. Leaving aside the North American changes already described, a warm pool in the central North Pacific (+2.1°F in the group mean) during the former period gives way to an extensive cold pool (−1.6°F) in the latter; these centers are flanked to the eastward by tongues of cold and warm water, respectively, curving along the west coast of North America toward the Hawaiian Islands and with core anomalies of −3.4° and +2.2°F at the British Columbia and Alaska coasts. In Europe the greatest gradient of air temperature anomaly runs meridionally between centers of opposite sign at Scandinavia and North Africa. The influence of the Greenland anomaly ridge and the northerlies flowing along its eastern flank are marked by intense cold over northwest Europe during the cold SE cases, exceeding −5°F in the group mean over the eastern Baltic. The reverse condition of relative warmth in that location during the warm SE group of months is to some extent underestimated in Fig. 6a. High positive anomalies of temperature in 6 of the 7 months which make up the mean were counterbalanced by a record cold wave over Europe in the remaining month (February 1956) associated with an extreme westward transgression of the Siberian winter anticyclone. [This exceptional event and its antecedents are described in Andrews (1956) and Klein (1956).]

From the point of view of the present discussion, the principal features of Fig. 6 concern the relative magnitudes of the surface temperature anomaly centers over North America and the west Atlantic; changes in the amplitude and location of the surface temperature anomaly gradients between continent and ocean are discussed in relation to storm frequency in the following section.

4. Changes in storm frequency at the Atlantic seaboard between the warm SE and cold SE groups of months

As stated earlier, this paper in part seeks to establish whether sharpened baroclinicity at the Atlantic seaboard during the cold winter climatic regime of the late 1950's and 1960's led to a change in the frequency, development rate or location of Atlantic coastal storms. Klein (1958), for example, indicated in his case study of events in February 1958 that the contrast between cold air masses over the eastern United States and air heated by the Gulf of Mexico and west Atlantic led to baroclinic deepening of coastal storms at relatively low latitudes.

Attempts to estimate the frequency and location of Atlantic coastal storms have been made by Bowie and Weightman (1914), Petterssen (1941), Miller (1946), Andrews (1963), Mather *et al.* (1964), Bosserman and Dolan (1968) and Resio and Hayden (1975). Despite differences in study area, study period and categories of storm considered there is some agreement regarding the mean frequency of extratropical storms in the area (Resio and Hayden, 1975,

p. 1232), and the more recent papers comment usefully on secular changes in storm frequency during the period covered by the present report. Mather *et al.* (1964, p. 694 and Fig. 1) show an increase in the number of *destructive* storms from 2–3 per year in the 1920's to over 7 per year in the 1960's with a major increase in the late 1950's. While increased commercial development of the coastal zone during this period must have exaggerated this trend of destructive storms, Bosserman and Dolan show an increase of 13.4% in the frequency of winter storms of all types along the Atlantic Coast between the 1940's (post 1942) and the 1960's (though 36.3% of their sample were actually migratory anticyclones and tropical storms not considered here) and Resio and Hayden suggest an increase of 8.9% in extratropical storm frequency in an offshore area between Cape Hatteras and Cape Cod from the late 1940's (1947–49) to the 1960's and during December–March. The latter authors make the relevant point (1975, p. 1230) that changes in the spatial distribution of storms have made the increase much higher in some areas than others. Thus, an apparent increase in cyclone frequency may reflect redistribution rather than an absolute increase in cyclogenesis *per se.*

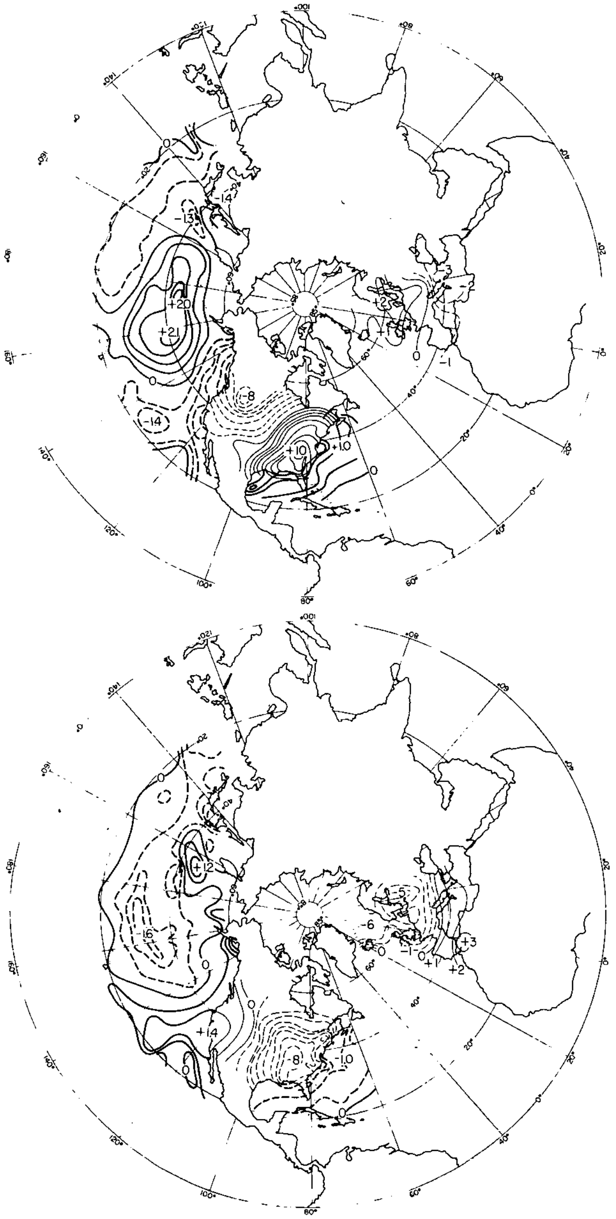

FIG. 6. Composite plots of mean sea surface temperature anomaly and surface air temperature anomaly (land masses only) in (a) the warm SE group of winter months and (b) the cold SE group of winter months (°F; sea surface temperature anomalies shown by bold contours at intervals of 0.5°F, air temperature anomalies shown by narrow contours at intervals of 1°F). Positive anomalies shown by solid lines, negative anomalies by dashed lines.

Thus during the period of transition in United States winter climatic regimes, these studies give a general indication of change in the pattern of winter cyclone frequency at the Atlantic seaboard, and justify a detailed comparative study of cyclone behavior in the selected groups of winter months which form the subject of this paper. For each of these months, "Tracks of the Centers of Cyclones at Sea Level" have been published in chart form in the *Monthly Weather Review* and (in more recent years) in the *Mariners Weather Log.* From these charts the total number of cyclonic centers tracking through (or subsequently reentering) a given 5°×5° square were summed in each of the selected months and these monthly totals were then added to form 7-month totals for the warm SE and cold SE groups of months. Fig. 7 shows the change in the (7-month) total number of cyclones between these warm and cold groups of months for a block of 5°×5° squares lying within the sector 20°–80°N, 25°–100°W. From this it is evident that along the eastern seaboard the change from conditions of extreme winter warmth to conditions of extreme cold and extensive snowcover was accompanied by a striking increase in cyclone frequency in a narrow offshore zone running parallel to the U. S. Gulf and Atlantic coasts. This band of increased cyclonic activity follows the strong baroclinic zone between the winter land mass and the flanking ocean (normally a preferred site for cyclogenesis and cyclone development) and the suggestion is that the dominant cause of the observed increase in cyclone frequency was enhanced baroclinicity at the coast during months of extreme cold in the southeastern United States. As Fig. 7 shows, the change in cyclone frequency was locally greatest at the southern Atlantic coast with an absolute maximum off the Carolinas (30–35°N, 75–80°W), where a total (7-month) increase of 22 cyclones was observed between the warm SE and cold SE cases (i.e., a mean change of +3 per month).

To a large extent this local increase in cyclone frequency came about as a result of *redistribution*

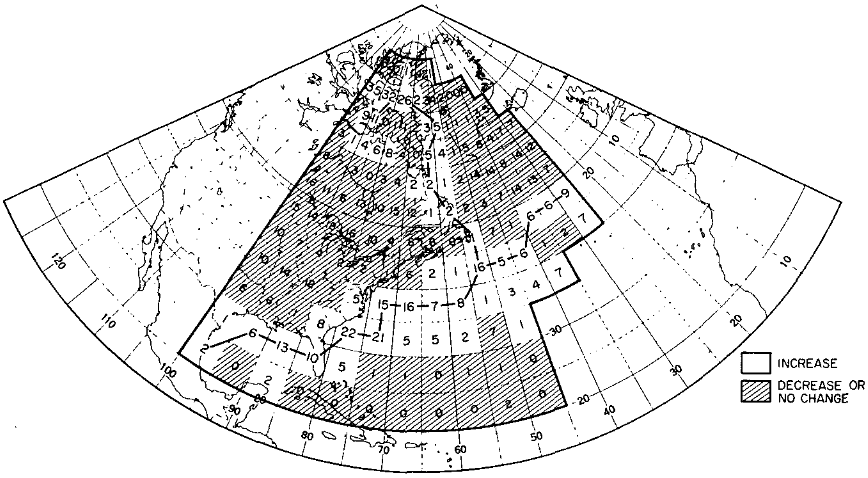

FIG. 7. Change in the (7-month) total number of cyclones (by 5° squares) between the warm SE and cold SE groups of winter months; areas of decreasing or unchanging cyclone frequency are hatched.

rather than increased cyclogenesis. Fig. 8 shows the absolute number of storms per month in both the warm SE and cold SE cases for all 5° squares in which the frequency was 4 storms per month or greater. It is clear from this that although peak cyclone frequencies did show a slight increase in the latter cases, the principal cause of the increase off the southern Atlantic states was a southwestward shift in the entire storm distribution pattern. Between the extremes of coastal baroclinicity which these selected months must represent, Fig. 8 shows that the core area of peak cyclone frequency shifted $\sim$350 n mi to the southwest from a location east of Newfoundland, while the isopleth representing a frequency of 4 storms per month was drawn southwestward by over 700 n mi at both its northern and southern limits. At the same time it is noteworthy that a smaller detached center of high storm frequency at the Great Lakes weakened drastically.

An illustration of the accompanying changes in coastal baroclinicity may be derived from Fig. 9. Combining surface air temperature data for the continental land mass with sea surface temperature data for the west Atlantic, Fig. 9 shows the magnitude of the change in surface temperature gradient $[^{\circ}\mathrm{F}(100\ \mathrm{km})^{-1}]$ between the warm SE and cold SE cases. The sharpening of the gradient along the southern Atlantic coast is as expected, but this plot

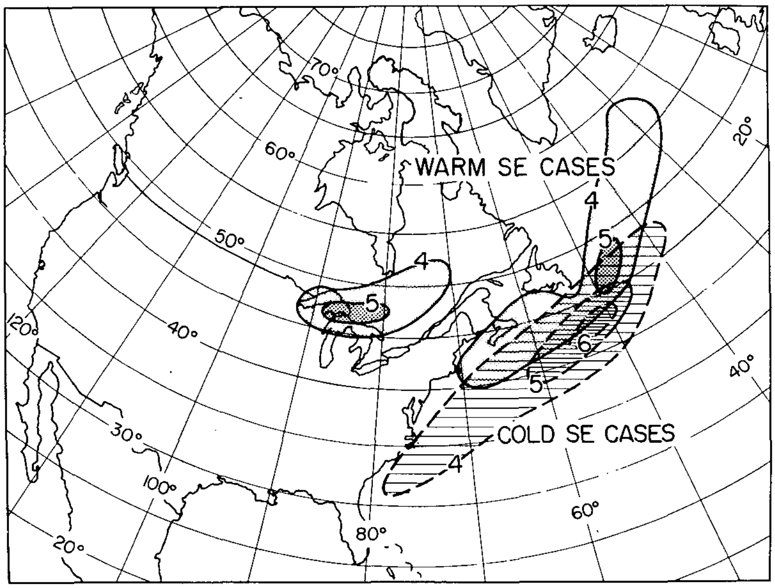

FIG. 8. Mean number of storms per winter month for warm SE and cold SE cases for all 5° squares in which the frequency was 4 storms per month or greater over the area east of 110°W.

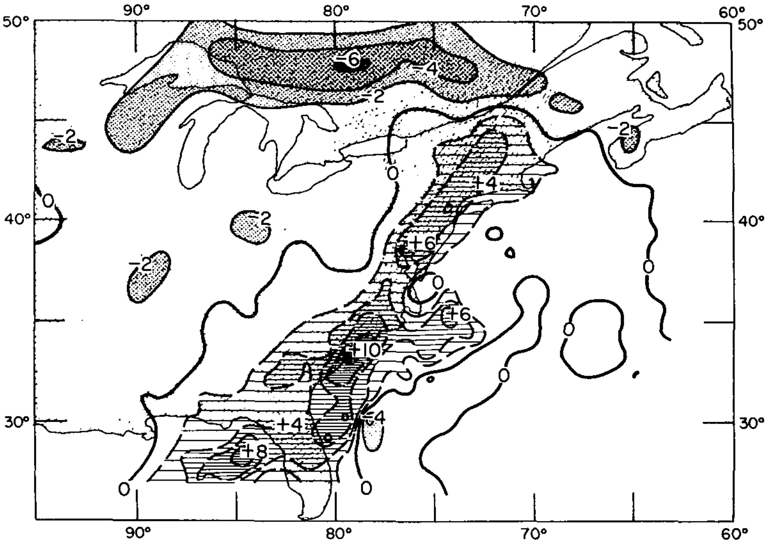

Fig. 9. Magnitude of the mean change in surface temperature gradient [°F (100 km)$^{-1}$] over the eastern United States and west Atlantic between the warm SE and cold SE groups of winter months. The surface temperature fields used were a composite of surface air temperature data over land and sea surface temperature data over the ocean.

also highlights a localized area close to the Great Lakes where the surface temperature gradient changed in the opposite sense, accompanied by a local *decrease* in storm frequency (see Fig. 8). Of course, the surface temperature gradient is to some extent the result rather than the cause of the observed changes in storm frequency and distribution. Nevertheless, the distribution of surface temperatures is lent sufficient persistence by the change in snowcover and by the great heat capacity of the ocean to justify the conclusion that the temperature gradient itself plays a major role in encouraging repeated storm activity along certain preferred tracks.

Thus, it would appear that during the cold winter regime over the eastern United States, a southward shift of the main baroclinic zone at the coast was responsible for a sympathetic southerly redistribution of the principal storm pattern offshore (with, in addition, a minor increase in the absolute frequency of storms within this pattern). It is evident, however, that if coastal baroclinicity was not merely redistributed but also enhanced, the southerly redistribution of storm tracks might be reinforced less directly through a change in the rate of development of storms to occlusion. In other words, although the southwestward redistribution of storm tracks may itself be adequate to explain the observed reduction in storm activity between Newfoundland and Iceland (cold SE cases, Fig. 8), a faster development of storms to the sluggish occluded state might be a further partial explanation for the truncation of the storm distribution pattern in this area (see Namias, 1962). At present, however, no direct information on storm development rates over the period under study is available to test this hypothesis.

Thus far our discussion has been mainly concerned with events close to the Atlantic seaboard, where the greatest change in cyclone frequency took place between our selected warm SE and cold SE cases. Reverting to Fig. 7 it is seen that further offshore the increase in cyclone frequency took place along two preferred tracks. These appear to split around the pressure anomaly ridge at Greenland (strongly established during the latter group of months) with one branch running northward and westward up the Davis Strait to arctic Canada, while along the other track breakaway depressions were directed on an extreme southerly trajectory toward Europe. Between these branches, the domain of the Greenland ridge is marked by a deficit of 1–2 cyclones per month (a change of 7–14 cyclones in the 7-month aggregate) over the northern Atlantic south of Cape Farewell and at the southwestern approaches to Iceland.

The development of this pattern of Atlantic cyclone activity during the cold winter climatic regime over eastern North America is thus seen as a response to the following factors. Initially the southward shift of the main coastal baroclinic zone led to a southward displacement of the principal zone of cyclogenesis and cyclone development. As a result, cyclones within this zone tended to develop to stalled occlusion far to the southwest of normal so that a southerly or southeasterly air flow was rather frequently generated in the area of the Labrador Sea and Davis Strait. The vorticity redistribution associated with this southerly air flow in the Davis Strait, coupled with the partial withdrawal of cyclonic activity from sea areas off south Greenland and Iceland, led to the reinforcement—if not to the actual establishment—of the high pressure anomaly cell at Greenland. (As noted earlier this ridge, and indeed the cold winter climatic regime over the eastern United States itself, were elements of coherent hemispheric patterns of change so that the actual *establishment* of the Greenland ridge probably owes more to remote than to local factors.) Once strongly established and maintained the blocking effect of this cell would tend to consolidate the twin branches of Atlantic cyclone activity shown in Fig. 7.

The above describes a local mechanism capable of lending a degree of longevity to an anomalous tendency in the winter circulation over a limited area of the Northern Hemisphere. It must be reemphasized, however, that the changeover observed in winter climatic regimes was almost hemispheric in extent, so that although this mechanism may locally have helped to "anchor" the prevailing circulation pattern once it became established, the underlying reasons for the establishment of contrasting winter circulation tendencies on a hemispheric scale are unknown. Although indications do exist that a coupled change in the ocean/atmosphere system of the North Pacific may have played an important role in developing the circulation tendencies observed downstream (Namias, 1972a, b), it remains unclear as to whether this was an initiating role or merely another linking process within a hemispheric pattern of change.

5. Summary

During the post-war period, sustained anomalous regimes have been observed in the winter pressure field at Greenland. Specifically, pressure tended to be greatly in excess of normal between the mid 1950's and the early 1970's, with relatively low pressure in preceding and subsequent years. Although these changes are often thought to reflect the tendencies of the hemispheric winter circulation as a whole, it is suggested that contemporaneous changes in winter air temperature over eastern North America were locally responsible for encouraging, prolonging and reinforcing the climatic regimes observed at Greenland and through teleconnections, other remote areas. The key importance of the North American Atlantic seaboard to the climatology of the North Atlantic lies in its importance as the preferred site for winter cyclone development. In addition, the great heat capacity of the ocean provides the potential for major changes in the baroclinic field at the coast. During the cold winter climatic regime in the southeastern States, the presence of a deep refrigerated arctic air mass and an extensive snowcover over the continent was coupled with only slight cooling over the west Atlantic, and the sharpened thermal contrast at the coast was accompanied by a sympathic southwestward shift of 350–700 n mi in the zone of maximum storm frequency, including a partial withdrawal of cyclonic activity from the Iceland-Greenland area. By contrast, during the warm climatic regime over the eastern United States winter storm activity was concentrated along the U. S.-Canada border and off the Canadian Maritimes, leading to a more normal progression of storms to full development at Iceland. It is concluded then that changes in the strength of the baroclinic field at the North American Atlantic seaboard were at least partly responsible for amplifying and maintaining the post-war trends of pressure anomaly at Greenland, via induced changes in the distribution of winter cyclone activity.

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