A weekly periodicity in eastern U.S. precipitation and its relation to hemispheric circulation

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ABSTRACT

Recurrence of precipitation during weekends—and of precipitation-free weekdays—was especially prominent over the southeastern quarter of the United States during much of the 1964–65 winter. This paper, with the help of maps averaged by day of the week, points out the relation of the weekly precipitation periodicity to interactive cyclone-scale and long wave systems over North America and the Pacific. Despite the averaging, the continuity in these maps is surprisingly clear. For example, an upper trough over west-central portions of the country in mid-week progresses to a position off the Atlantic Seaboard at the beginning of the week. This progression is associated with periodic (largely diabatic) development of the Gulf of Alaska Cyclone, which, in turn, can be traced to the periodic establishment of a ridge in the Bering Sea and occurrence of cyclogenesis in middle and lower latitudes of the North Pacific. An increase in hemispheric wave number, provided periodically by development of the Gulf of Alaska trough, leads to eastward motion of downstream features over the U.S., but when the Gulf trough fills abrupt retrogression sets in until its redeepening reestablishes the eastward motion.

One of the primary circulation forcing elements, cyclogenesis in the Pacific, appears to be related to abnormal sea-surface temperature fields established during the preceding fall and maintained by the overlying atmospheric circulation during winter. While this interaction may offer a clue to the sequence of downstream events, it does not imply a weekly periodicity. Not even the transmission of the periodicity downstream is suggested by present numerical forecasts, but this failure can be attributed to typical errors in these forecasts. Further empirical studies, detecting weather periodicities and relating them to the time-averaged circulations or regimes in which they occur, might help in understanding and eventually predicting the occurrence of the periodicities.

Prefatory note

Of the meteorologists of the world, Prof. Tor Bergeron, through his varied work, is probably as cognizant as anyone of the interdependence of atmospheric systems on all time and space scales. Several items in the following paper touch at least indirectly upon his research on planetary wind systems, centers of action, synoptic-scale systems, and rainfall patterns.

I. Introduction

In an earlier paper published in Tellus (NAMIAS, 1954), I investigated a sequence of several months during which an atmospheric periodicity of about 10 days was observed over much of North America. In that paper, an attempt was made to show that such periodicities are inherent in the large-scale, time-averaged flow patterns of the troposphere and that the centers of action comprising these flow patterns condition the entire life history (birth, growth, and movement) of synoptic-scale systems. Periodicities in meteorological elements—other than the diurnal and annual ones—would therefore not be climatologically stable features because of the continually different forms of the general circulation found in the same months and seasons for different years.

Reports describing periodicities of about a month have appeared in the lierature occasionally, and of about a week, frequently. Examples are the papers of LANGMUIR (1951) and BRIER (1955). The extended-range forecasting methods developed by Multanovsky and applied by PAGAVA (1940) utilize "natural periods" of certain types of cyclonic and anticyclonic activity. These periods generally range from 5

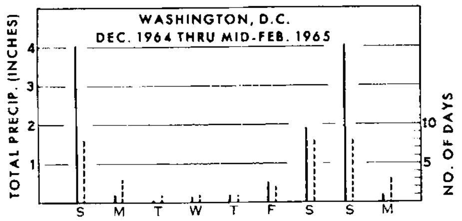

Fig. 1. Cumulative precipitation (solid) by day of the week and number of precipitation days (broken) at Washington, D. C. during period December 1, 1964 through February 14, 1965.

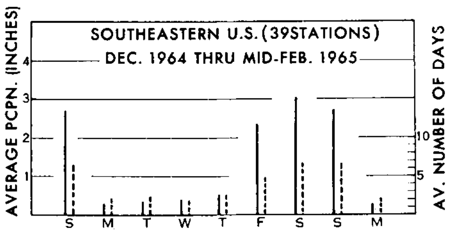

Fig. 2. Cumulative precipitation (solid) and number of precipitation days (broken) averaged for 39 stations over the southeast quarter of the U.S. indicated in Fig. 3.

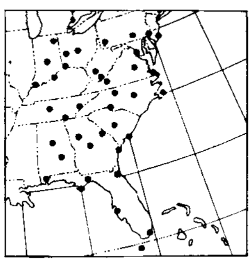

Fig. 3. The 39 stations used for constructing Fig. 2 (and identified in Tables 1 and 2).

to 10 days, frequently a week. Of course, both the layman and meteorologist are more likely to detect weekly recurrences of weather than any others.

In the case to be described, a pronounced recurrence of substantial precipitation on weekends over the eastern U.S.A. was sandwiched between relatively precipitation-free weekdays over an 11-week period. Averaging rainfall and pressure patterns during this interval for each day of the week brings to light a series of regular and continuous developments resembling those on regular daily charts. These developments indicate that an oscillatory system became established wherein a periodic increase in planetary wave number was introduced by the repeated development of a trough in the Gulf of Alaska. This phenomenon set the stage for *progression* of long waves over the United States, but when the Gulf trough filled, *retrogression* set in until the trough reappeared a week later. These downstream trough developments and motions led to broad precipitation zones whose phase velocity was very clear over the United States.

II. Periodicity in the precipitation field

The author's attention was drawn to the periodic nature of broadscale precipitation during the winter of 1964–65 by the remarkable tendency in his home city (Washington, D.C.) for rain or snow to occur on weekends while other days were relatively fair.[1] Fig. 1 shows by day of the week the cumulative precipitation and the number of days with measurable precipitation (0.01 inch or more) for Washington for the eleven weeks from December 1, 1964 through February 14, 1965. There are eleven of each of the days except Mondays, of which there are ten.

This same weekend precipitation tendency was evident at many stations in the eastern United States, so that a diagram (Fig. 2) of the averages of 39 stations shown in Fig. 3 indicates the same tendency. Tables 1 and 2 illustrate dramatically the overwhelming tendency for frequent and relatively heavy rainfall at most of the 39 stations on weekends. Thus the precipitation-producing systems were large scale and not local. Taking the 39-station area as a whole, almost 60 % of the 11-week total fell on Saturday and Sunday and about 85 % fell in the three days Friday through Sunday. Also, precipitation on Saturdays and Sundays was roughly three times more frequent than on any of the first four days of the week.

III. Mid-tropospheric flow patterns associated with the precipitation periodicity

Because of the similarity of upper-level developments a week apart on many of the daily contour charts during this period, it was decided to compute average charts for each day of

[1] Fortunately, the inauguration of President Johnson took place on January 20, a Wednesday.

TABLE 1. *Cumulative daily precipitation (in inches) for period December 1, 1964 through February 14, 1965 at stations in the southeastern quarter of the United States.*

Italicized numbers are two highest daily averages.

Station	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
Ft. Wayne, Ind.	.38	.24	.65	1.52	.38	*2.43*	*2.46*
Indianapolis, Ind.	.80	.21	.88	1.65	*1.73*	*3.13*	1.53
Evansville, Ind.	.37	.35	.97	*2.68*	1.46	2.38	*2.48*
Dayton, Ohio	.71	.16	.58	.37	.71	*3.16*	*1.49*
Columbus, Ohio	1.01	.50	.92	.37	.83	*3.56*	*2.20*
Cincinnati, Ohio	.89	.32	.93	.43	1.99	*4.08*	*2.53*
Pittsburgh, Pa.	2.10	.29	.52	.26	.83	*2.81*	*2.51*
Harrisburg, Pa.	*4.01*	.25	.10	.40	.17	1.58	*1.75*
Philadelphia, Pa.	*3.71*	1.43	0	.23	.02	1.26	*2.42*
Atlantic City, N.J.	*3.88*	1.02	.09	.24	.08	1.37	*1.96*
Washington, D.C.	*4.05*	.20	.01	.12	.20	.50	*1.92*
Richmond, Va.	*4.45*	.31	0	.14	.05	.40	*1.75*
Norfolk, Va.	*3.84*	.36	.30	0	.10	.43	*2.63*
Roanoke, Va.	*5.14*	.02	.08	.08	.16	.42	*2.47*
Flat Top, W.Va.	*4.97*	.39	.24	.17	.58	1.36	*3.12*
Charleston, W.Va.	*2.32*	.09	.22	.14	.98	1.68	*2.85*
Louisville, Ky.	1.29	.13	.49	.50	1.88	*3.97*	*3.05*
Nashville, Tenn.	1.55	.19	.36	.67	*2.94*	2.50	*3.05*
Chattanooga, Tenn.	*2.76*	.43	1.05	.34	.76	*2.77*	2.52
Knoxville, Tenn.	*3.12*	.46	.32	.18	.90	1.52	*3.63*
Charlotte, N.C.	*2.66*	0	.35	.20	0	.66	*3.12*
Greensboro, N.C.	*3.58*	.17	.13	.13	.02	.37	*2.43*
Raleigh, N.C.	*3.60*	.02	.02	0	.10	.33	*3.42*
Hatteras, N.C.	*4.06*	*1.92*	.26	.03	.16	.79	1.65
Columbia, S.C.	*4.09*	0	.11	0	.54	1.32	*3.25*
Charleston, S.C.	*2.98*	.03	.30	0	.12	*2.33*	1.59
Savannah, Ga.	*2.34*	.01	.10	0	.01	*3.55*	1.32
Macon, Ga.	*3.16*	0	.35	.18	.01	*2.96*	2.79
Augusta, Ga.	*3.51*	0	.14	0	.10	2.31	*2.39*
Atlanta, Ga.	2.27	.12	.34	.18	.14	*3.75*	*4.69*
Birmingham, Ala.	1.74	.41	.08	2.41	.15	*5.13*	*2.98*
Montgomery, Ala.	1.50	.01	.15	0	.06	*4.54*	*8.90*
Mobile, Ala.	.94	.21	.38	0	.44	*3.74*	*10.13*
Tallahassee, Fla.	5.16	.15	.73	.04	.21	*11.84*	*6.17*
Apalachicola, Fla.	*4.35*	.41	.29	.05	.14	*3.72*	2.16
Jacksonville, Fla.	*3.92*	.29	.66	0	.06	*2.40*	1.51
Tampa, Fla.	*2.31*	.21	.48	0	.15	.71	*2.02*
Miami, Fla.	*2.03*	.14	.30	.05	.14	.30	*5.93*
Key West, Fla.	.13	0	.12	1.37	*1.66*	.15	*2.53*
Mean	*2.71*	.29	.36	.39	.54	2.36	*3.01*

the week. Let us begin our discussion with the mean chart for Tuesdays (Fig. 4). Immediately apparent to the experienced extended forecaster is the exceptionally long wave length between the central Pacific trough and the trough along the east coast of the U.S. It measured about 100° of longitude at 40°N, whereas unpublished empirical studies by O'Connor set the typical wave length at 90 degrees with the trough tilting sharply southwestward in the U.S. Therefore, it is not surprising to find that on the mean chart for Wednesdays an abrupt shortening of the wave length to about 80 degrees took place. Because the trough originally over the eastern U.S. had actually progressed eastward, only to be replaced by another, this was a case of "discontinuous retrogression" (CRESSMAN. 1948).

We next direct our attention to the incipient development of a ridge in the Bering Sea and a trough over the Gulf of Alaska. On the mean chart for Thursdays (Fig. 6) both the central

TABLE 2. *Total number of days with precipitation December 1, 1964 through February 14, 1965 at stations in the southeastern quarter of the United States.*

Italicized numbers represent two (or three) highest number of days.

Station	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
Ft. Wayne, Ind.	4	4	4	5	4	*8*	*6*
Indianapolis, Ind.	3	2	3	3	5	*7*	*6*
Evansville, Ind.	2	2	2	3	5	*7*	*7*
Dayton, Ohio	4	3	3	5	6	*8*	*7*
Columbus, Ohio	*7*	3	3	5	6	*7*	6
Cincinnati, Ohio	4	3	3	3	*6*	*6*	*8*
Pittsburgh, Pa.	*8*	5	5	5	4	*8*	7
Harrisburg, Pa.	*11*	4	3	3	3	5	*7*
Philadelphia, Pa.	*7*	5	0	2	1	5	*7*
Atlantic City, N.J.	*8*	5	2	1	2	4	*8*
Washington, D.C.	*8*	3	1	1	1	2	*8*
Richmond, Va.	*9*	3	0	1	3	5	*7*
Norfolk, Va.	*9*	3	1	0	2	5	*6*
Roanoke, Va.	*8*	1	1	2	3	5	*7*
Flat Top, West Va.	*11*	4	5	3	4	*8*	7
Charleston, West Va.	*10*	3	3	4	3	7	*8*
Louisville, Ky.	4	1	3	3	6	*7*	*9*
Nashville, Tenn.	4	2	2	3	*5*	4	*8*
Chattanooga, Tenn.	4	1	3	2	2	*5*	*8*
Knoxville, Tenn.	*7*	1	2	1	3	6	*8*
Charlotte, N.C.	*8*	0	2	1	0	3	*7*
Greensboro, N.C.	*7*	1	1	1	2	4	*6*
Raleigh, N.C.	*9*	1	1	0	2	3	*6*
Hatteras, N.C.	*10*	4	2	2	3	5	*6*
Columbia, S.C.	*10*	0	2	0	3	4	*7*
Charleston, S.C.	*8*	1	2	0	2	2	*7*
Savannah, Ga.	*8*	1	1	0	1	*3*	*3*
Macon, Ga.	*8*	0	5	1	1	5	*8*
Augusta, Ga.	*9*	0	2	0	1	4	*6*
Atlanta, Ga.	*6*	1	3	2	1	5	*8*
Birmingham, Ala.	*5*	1	2	3	2	*5*	*9*
Montgomery, Ala.	2	1	3	0	1	*6*	*8*
Mobile, Ala.	*6*	1	3	0	4	*6*	*6*
Tallahassee, Fla.	*8*	2	2	1	1	4	*8*
Apalachicola, Fla.	*7*	2	2	1	2	5	*6*
Jacksonville, Fla.	*7*	2	2	0	2	3	*4*
Tampa, Fla.	*5*	*2*	1	0	1	*2*	1
Miami, Fla.	*4*	2	2	2	2	3	*5*
Key West, Fla.	*3*	0	1	2	2	1	*6*
Mean	*6.7*	2.1	2.3	1.8	2.7	4.9	*6.7*

U.S. trough and the Gulf of Alaska trough amplified considerably. The latter extended its influence into lower latitudes while the former began to advect air from the Gulf of Mexico. (The effect of the overrunning moisture is shown in the precipitation field of Fig. 11, where an extensive area of precipitation with cumulative amounts greater than 2 inches developed in the southern U.S. by the Thursdays.) By the Fridays both of these troughs extended into the temperate latitude westerlies —especially between 40°N and 50°N—and the number of long wave troughs (four) between the central Pacific and the west-central Atlantic obviously demanded adjustment of the wave pattern.

The Gulf of Alaska trough is well known to be largely generated and maintained by the outpouring of cold Arctic air over the open waters of the Gulf. The rapid diabatic heating of such cold air streams intensifies and retards synoptic-scale systems (WINSTON, 1955, and

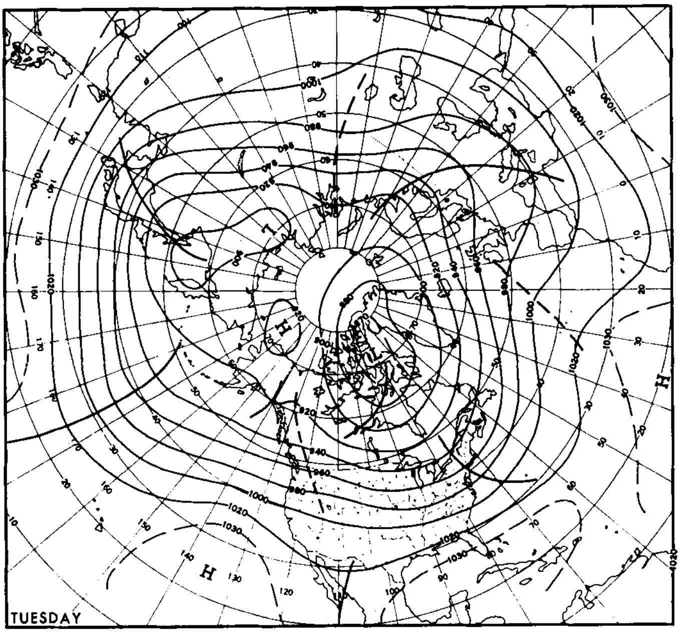

FIG. 4. Mean 700-mb charts for each day of the week during the period December 1, 1964 through February 14, 1965. Heavy solid lines indicate trough positions.

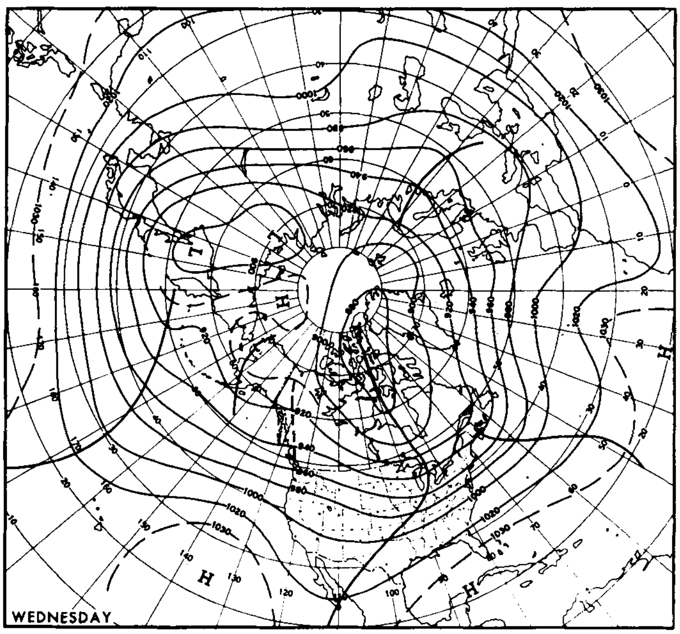

FIG. 5. See text for fig. 4.

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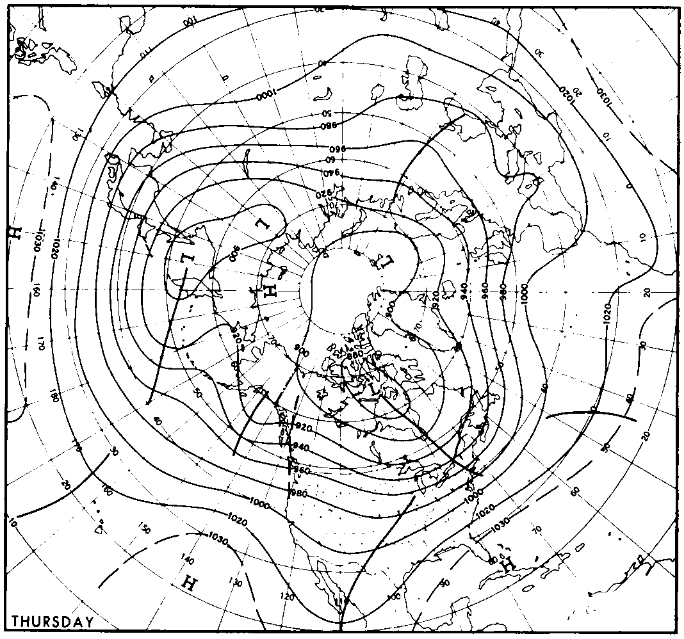

FIG. 6. See text for fig. 4.

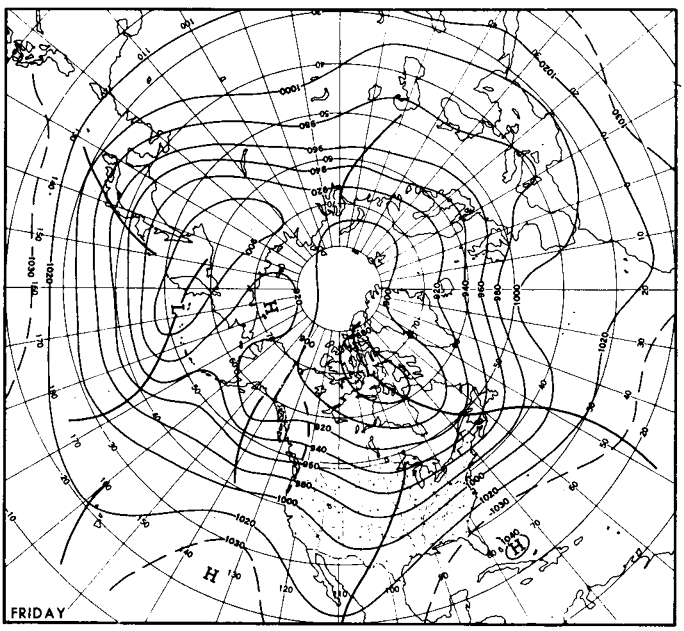

FIG. 7. See text for fig. 4.

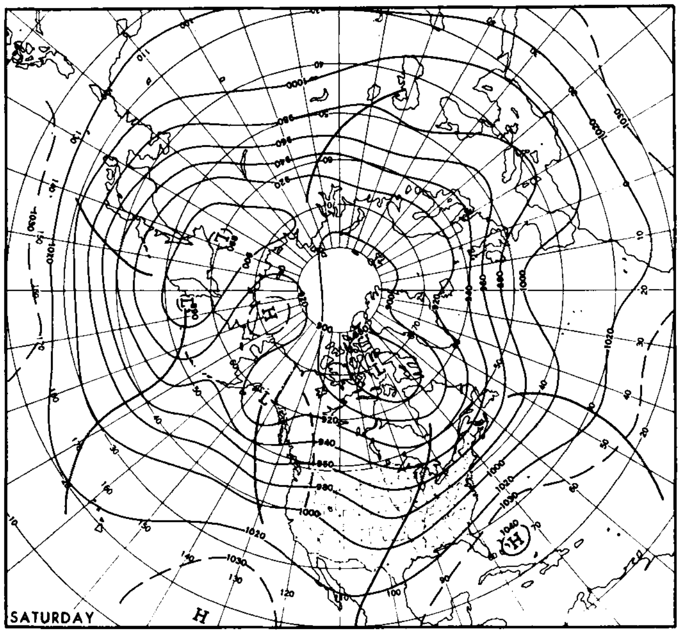

FIG. 8. See text for fig. 4.

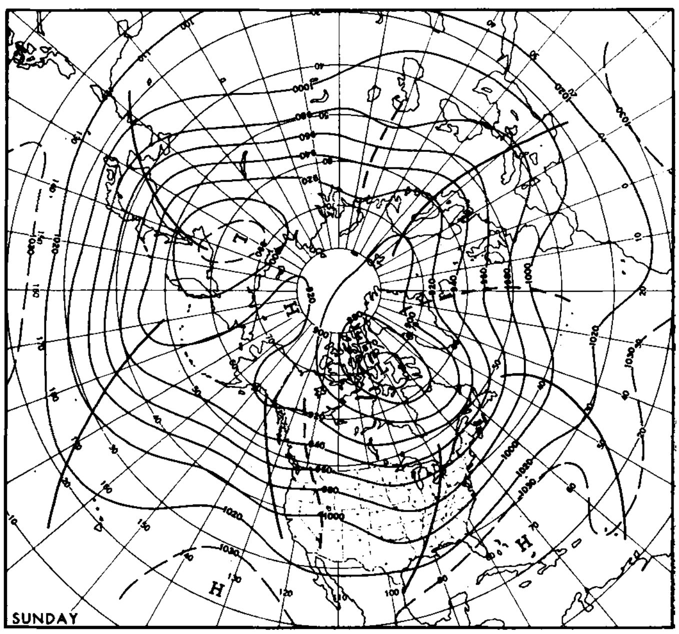

FIG. 9. See text for fig. 4.

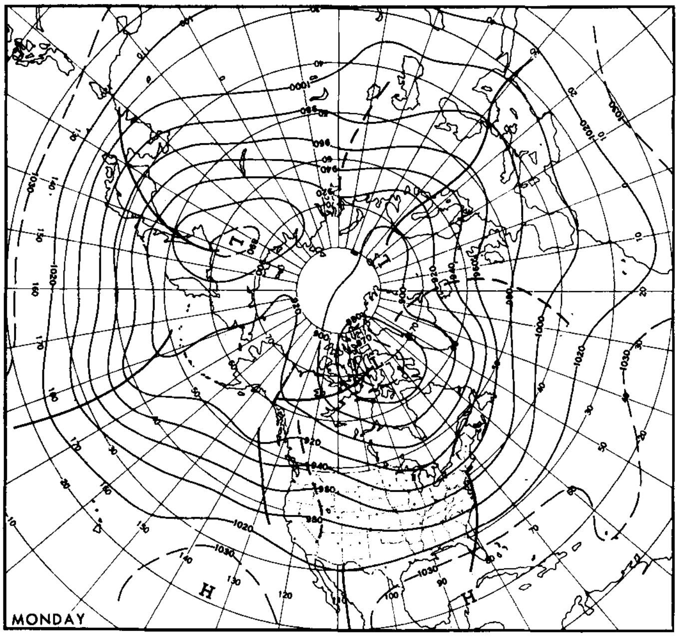

FIG. 10. See text for fig. 4.

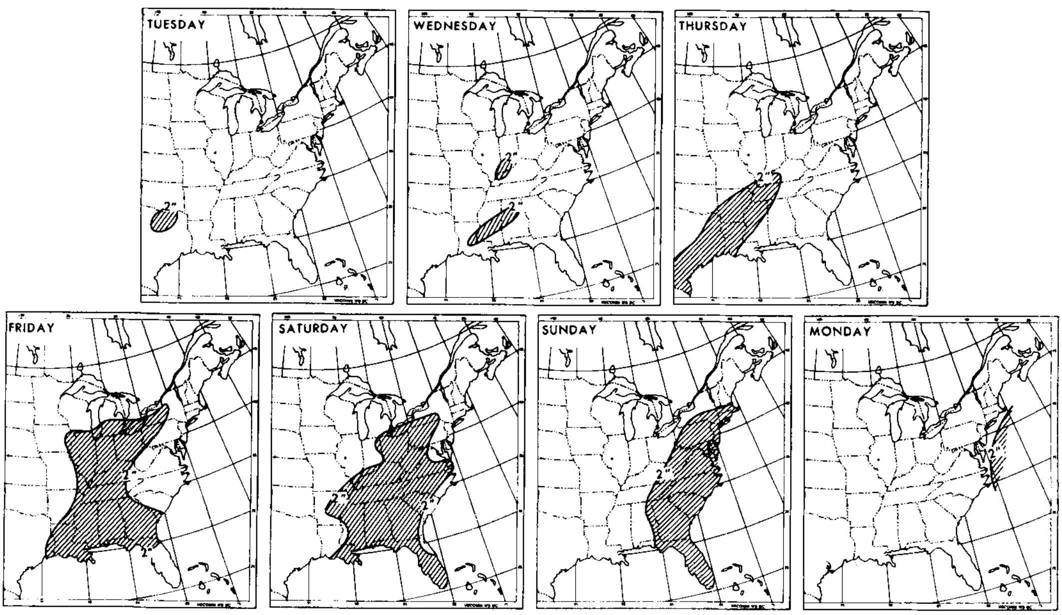

FIG. 11. Areas (shaded) where cumulative precipitation on each day of the week exceeded two inches.

PETTERSSEN, 1956). In addition to the cyclonic impulse furnished to the north winds by the conservation of absolute vorticity, further cyclogenetic effect is provided by the flow of those winds over the Alaskan coastal mountain ranges. Thus the Gulf of Alaska winter cyclone, once developed, is usually a quasi-stationary and not a migratory system, although it may be eliminated or temporarily weakened when the initiating and maintaining influence, the northerly upper-air flow, has terminated.

Fluxes of cyclonic vorticity from the Gulf of Alaska Cyclone usually enter North America in the form of occluded fronts and associated upper-level short waves, leading to readjustments of the North American long-wave pattern. Consequently, on the Fridays, Saturdays, and Sundays of the period under study eastward propagation of the U.S. trough and a large precipitation area took place (Figs. 7–9, 11).

By the Sundays the Gulf of Alaska trough extended its influence southward near the California coast and weakened in more northern portions, probably in response to the vorticity

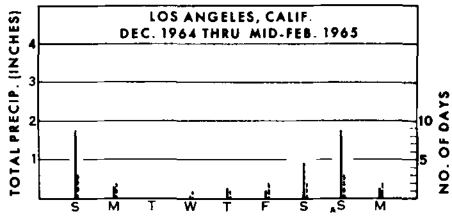

FIG. 12. Cumulative precipitation (solid) and number of precipitation days for each day of the week during the period December 1, 1964 through February 14, 1965 at Los Angeles, California.

flux from the deepened central Pacific trough. The cumulative precipitation and precipitation frequency diagram for Los Angeles (Fig. 12) reflects the weekend strengthening of the Gulf of Alaska trough to low latitudes.

By the Mondays the eastern U.S. trough was displaced to the East Coast and the cumulative precipitation and frequency of precipitation (Figs. 2 and 11) had diminished sharply. The Gulf of Alaska trough continued to weaken until barely discernible by the Tuesdays, completing the cycle.

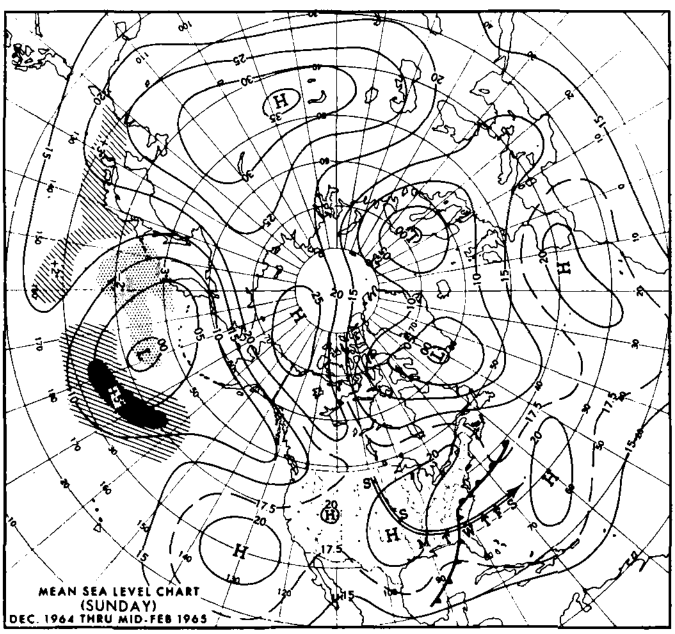

FIG. 13. Mean sea-level pressure for all Sundays during the period December 1, 1964 through February 14, 1965. Hatched and stippled areas in the Pacific indicate prominent pools of abnormally cool and warm surface water for the preceding fall. Central numbers represent maximum departures from normal in °F.

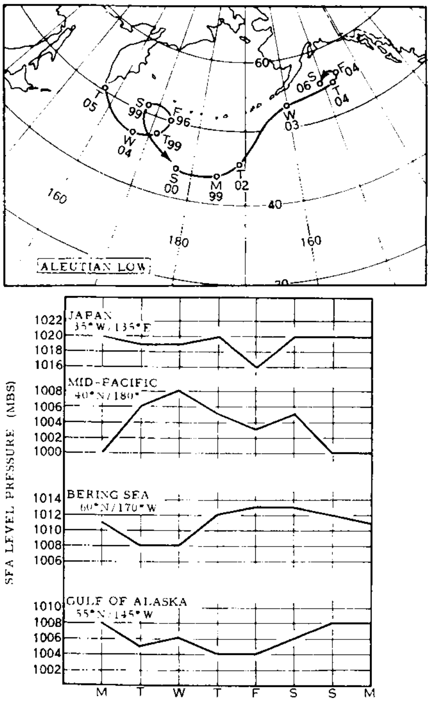

FIG. 14. (Map) Mean positions and intensities (mbs with hundreds omitted) of center of Aleutian Low by day of week.

(Graphs) Mean sea-level pressure at various points on days of the week.

IV. Some associated pressure and contour height change features

Maps of mean sea-level pressure for each day of the week, similar to those shown for the 700-mb level, have also been prepared. In order to conserve space, not all of these charts are reproduced, even though numerous interesting aspects of day-to-day continuity may be found. However, the mean sealevel map for the eleven Sundays in shown in Fig. 13, from which one could easily infer the braodscale Sunday precipitation pattern in the east indicated in Fig. 11. In Fig. 13 I have "analyzed" a hypothetical frontal wave consistent with the pressure distribution. On this figure are also plotted the day-to-day positions of the center of the observed mean anticyclone, starting in North Dakota on the Sundays and moving southeastward, then eastward to an area east of Bermuda on the following Sundays.

Maps of 24-hour height change at the 700-mb level, generally associated with centers of maximum negative and positive vorticity, have also been constructed. An example, the change between the Saturdays and Sundays, is provided by Fig. 15. Here again the large east coast area of height falls was obviously related to the weekend rainfall maximum. This axis of 24-hour negative height change (broken line) may be followed with considerable regularity from California eastward to West Africa with an average speed of roughly ten degrees of longitude a day. Observations were not sufficient to trace it further.

The maps of the sea-level means constructed for each day of the week also illustrate interesting continuity associated with the Gulf of Alaska cyclone and the periodic development of the Kamchatka cyclone. A resume of this continuity is shown in Fig. 14, on which are shown the positions and intensities of these cyclonic centers by day of the week. Thus, the perturbations which entered and remained in the Gulf of Alaska during the latter parts of the weeks started out as centers of low pressure at 176°E on Sundays. The Kamchatka center developed on Tuedays, moved slowly in the form of a loop, and deepened most rapidly (to 999 mb.) on Thursdays just as the eastern center entered the Gulf of Alaska. This behavior of the two centers seems well related to the mean upper-level contour and anomaly chart for the entire period shown in Fig. 16.

V. Possible seat of recurrent circulation abnormalities

In the preceding portions of this report we have attributed the periodicity in the precipitation of the southeast U.S. to remote features of the general circulation. Any attempt at an explanation of the ultimate cause of this periodicity would therefore have to consider the recurrence of the abnormal features or centers of action—particularly the Gulf of Alaska trough, and probably features further upstream.

Let us examine the mean mid-tropospheric chart for *all* days encompassed by our periodicity (from Dec. 1 through mid-February) (Fig. 16). On this chart the departures from the winter normal are superimposed on the mean contours. This mean flow pattern seems to imply an oscillatory system extending from the central Pacific to eastern North America, be-

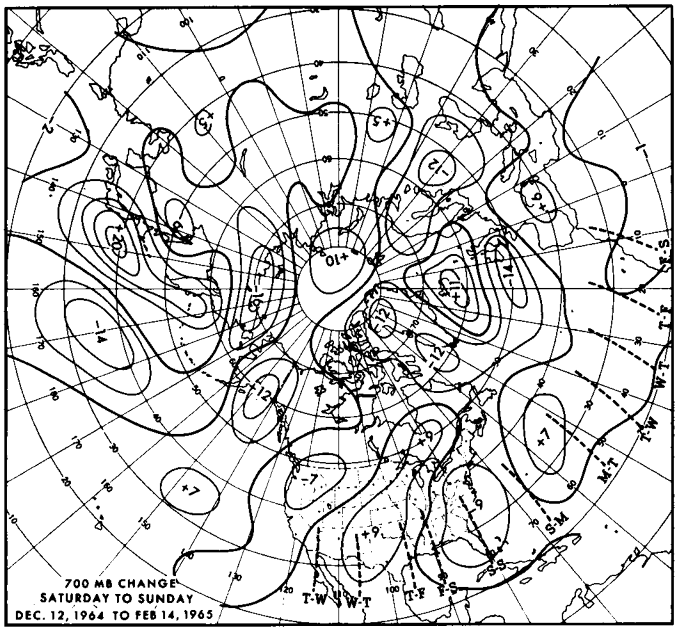

Fig. 15. Mean changes in 700-mb height (expressed in tens of feet) from Saturday to Sunday during the period December 1, 1964 through February 14, 1965. Broken lines indicate steady eastward progression of negative area of height change where appended letters indicate successive days of week.

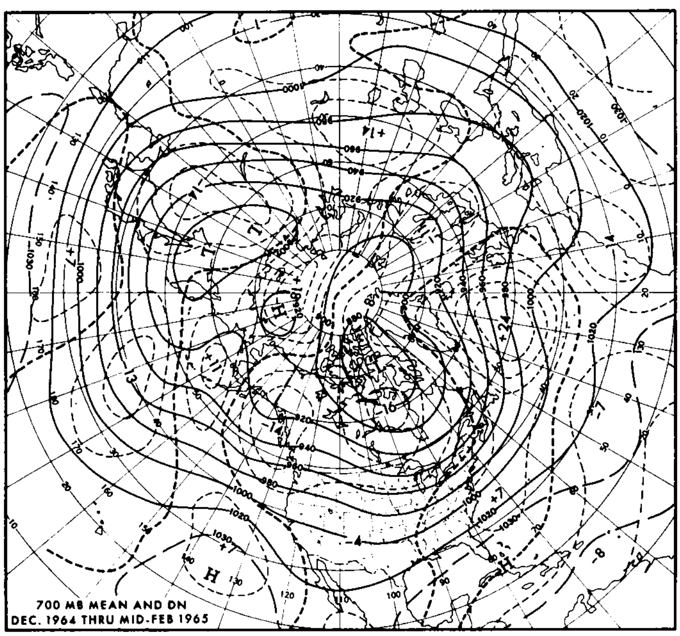

Fig. 16. Mean 700-mb contours (solid) and isopleths of departures from normal (broken) for the entire period from December 1, 1964 through February 14, 1965.

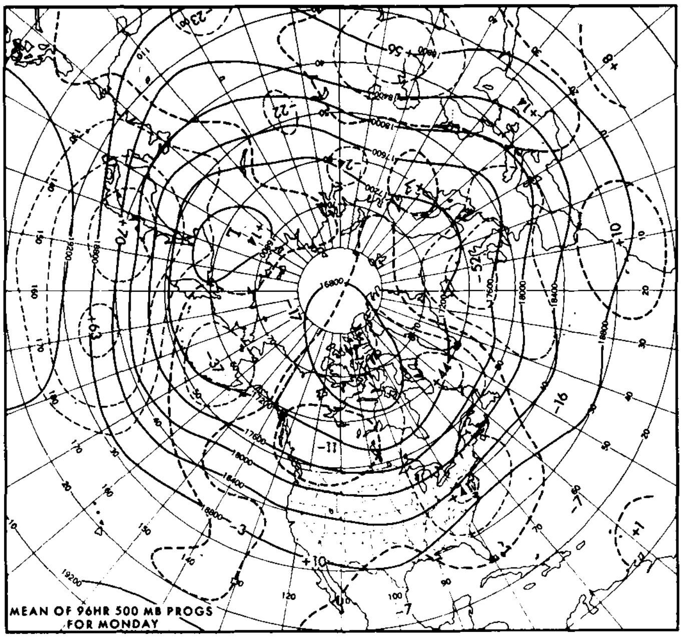

Fig. 17. Mean 500-mb contours of the 96-hour prognostic charts prepared on Thursdays for the following Monday. Broken lines are isopleths of error and the center numbers are expressed in tens of feet.

cause the spacing between troughs is short compared with those usually observed for a month or season or in the long-term normal. Thus, the Gulf of Alaska trough might be expected to be an occasionally pronounced feature arising whenever the Aleutian-Bering Sea ridge initiated southward flow of cold Alaskan air into the Gulf of Alaska. But this ridge is frequently established as a barotropic response to the deepening of the lower-latitude trough around 180°[1]—which, in turn, is associated with low latitude cyclogenesis. Thus, if the cyclogenesis could be explained, a chain of events something like the following might be anticipated:

1. Development of a strong upper-trough in temperate and low latitudes at 180° through cyclogenesis (indicated by the height change pattern over the western Pacific already shown in Fig. 15).
2. Building of a strong ridge north of this in the Bering Sea [largely a barotropic response to (1)].
3. Onset of northerly flow of Arctic air from Alaska into the Gulf of Alaska.
4. Cyclogenesis in the Gulf intensified by strong convection and release of latent heat.
5. Transfer of cyclonic vorticity by short waves into the western United States, and displacement eastward of the trough usually found over the Southwest.
6. Relaxation of the system by migration of the above features from their areas of reinforcement, followed by return to initial conditions.

The persistent and abnormal cyclogenesis at temperate and low latitudes in the central Pacific, our starting point, might have been induced by a pattern of abnormal sea-surface temperatures generated in the fall of 1964 and maintained during winter by abnormal prevailing wind stresses. Prominent sea surface temperature anomalies for the fall in the principal area of the low-latitude cyclogenesis are shown on Fig. 13.[2] A large pool of warm water could have encouraged abnormal cyclogenesis over it by diabatic heating during the winter

[1] See for example the composite maps prepared by Martin (1953), *wherein a wintertime negative* 700-mb height anomaly at 40°N 180° is associated with a strong positive anomaly in the Bering Sea and a negative anomaly in the Gulf of Alaska.

[2] This mean chart, while computed only for Sundays, bears a strong resemblance to the mean chart for the entire winter, particularly over the Pacific.

when cold Asiatic air masses along with sharp fronts began to invade its domain (NAMIAS 1963, 1959). The warm pool of water over the area east of 180° did in fact continue to be observed through the winter of 1964–65 and indeed spread northward, as implied by the anomalous circulation in Fig. 16 (NAMIAS, 1965). (The pattern of sea-level pressure anomalies was similar to that of 700-mb heights.) Thus the winter atmospheric circulation, while differing from that observed in the fall, helped to maintain the broad-scale sea-surface temperature anomalies established then.

Further support for the hypothesis that oceanic temperature abnormalities constituted an important link in the seven-day periodicity mechanism is given by graphs of mean sealevel pressure, averaged by day of the week, at several key locations (Fig. 15). In mid-Pacific, the Bering Sea, and the Gulf of Alaska, much of the pressure variance about the weekly mean appears to lie in a seven-day cycle. On the other hand, Japan, across which one might expect any periodic cyclone passage to take place prior to cyclogenesis in mid-Pacific, shows no suggestion of a cycle. 700-mb height change graphs (not shown) conform to these sea-level indications.

Unfortunately, the foregoing explanation of the existence of the central Pacific trough and its downstream consequences implies little or nothing about the existence or frequency of a periodic cycle. However, it is conceivable that an analogy can be drawn between the cyclogenetic effects of the oceanic warm pool and the quasi-periodic cumulus cloud formation often observed over hilltops in summertime or in the tropics. In the latter case recurrent cumuli develop, are periodically carried away by prevailing winds, and the cycle is reinstituted by a new cumulus formation. In our case, one of a much higher order of complexity, we might think of the cyclogenesis as being the recurrently instituted feature. Of course, the cyclones would move out of the area of formation or development (the warm pool), as perturbations in the westerlies and a finite period of time would probably be required for cyclonic reformation. Different values of zonal index or placement of long waves would probably have given other periodicities, or perhaps no well-defined period at all. On the other hand, this case may represent regularly recurring dynamic instability in the westerlies over the Pacific operating in conjunction with the anomalous oceanic surface conditions.

In the hope that currently prepared numerical predictions might have confirmed the dynamical linkages in the seven-day periodicity, I computed the means of numerical prognoses of 500-mb. height made for 24, 48, 72, and 96 hours from the eleven initial Thursday charts. These prognoses, calculated routinely by the National Meteorological Center of the U.S. Weather Bureau, employ a baroclinic model to 36 hours and a barotropic model beyond. Thursday's charts were chosen for initial data because it was hoped that some eastward motion of the southwestern U.S. trough would be suggested, since the Gulf of Alaska trough had developed sufficiently on Thursdays to affect the downstream pattern. Figure 17 displays the mean 96-hour error field of the numerical prognoses. This chart and the corresponding ones for 24, 48, and 72 hours (not shown) show that the numerical model typically erred in propelling the Gulf of Alaska trough eastward into Canada and gradually replacing it by a ridge. Thus, the main factor accounting for the displacement of the U.S. trough to the East Coast on Monday was eliminated and the predicted flow pattern was out of phase with the observed (compare Figs. 10 and 16). This failure, not uncommon when Gulf of Alaska troughs appear in the initial ata, is probably due to the omission from the model of diabatic heating. A similar failure occurs over the warm waters east of Japan. In this case, I have associated the observed seven-day cycle with the form of the general time-averaged circulation and with migratory synoptic systems. A synoptic and physical description of related periodic events far removed from the area of weekly periodicity in rainfall has been given, and a stabilizing effect on the long waves, operating through anomalous sea-surface temperatures, has been proposed.

Despite the bewildering complexity of quasi-periodic weather phenomena, I believe that they may be amenable to early detection and validation if a way can be found to relate their character and duration to prevailing mean circulation patterns and associated synoptic-scale phenomena. This detection could be used for more detailed long-range prediction.

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НЕДЕЛЬНАЯ ПЕРИОДИЧНОСТЬ ОСАДКОВ НА ВОСТОКЕ США И ЕЕ СВЯЗЬ С ПОЛУШАРНОЙ ЦИРКУЛЯЦИЕЙ

Повторяемость осадков во время уик-эндов (и отсутствие осадков во время обычных дней недели) была особенно заметной над юго-восточной четвертью США в течение большой части зимы 1963–64 гг. В статье с помощью карт, осредненных по дням недели, обращается внимание на связь между недельной периодичностью осадков и взаимодействием циркуляции циклонического масштаба с длинными волнами над Северной Америкой и Тихим океаном. Несмотря на осреднение, непрерывность этих карт удивительно ясна. Например, высотная ложбина над западно-центральными частями страны в середине недели продвигается к положению вблизи от Атлантического побережья в начале следующей недели. Это продвижение связано с периодическим (в основном неадиабатическим) развитием циклона над Аляскинским заливом, который, в свою очередь связан с периодическим возникновением гребня в Беринговом море и циклогенезом в средних и низких широтах северной части Тихого океана. Возрастание полушарного волнового числа, периодически вызываемое развитием ложбины в Аляскинском заливе, приводит к перемещению на восток возникающих вниз по течению особенностей. Но когда ложбина над заливом быстро заполняется, возникает движение в обратном направлении, пока новое углубление ложбины не приведет снова к движению на восток.

Один из главных наводимых циркуляционных элементов — циклогенез в Тихом океане — повидимому связан с аномальным полем температуры поверхности моря, которое устанавливается во время предшествующей осени и поддерживается атмосферной циркуляцией зимой. Хотя это взаимодействие может дать ключ к последовательности явлений, возникающих вниз по потоку, оно не подразумевает недельной периодичности. Передача периодичности вниз по потоку не получается с помощью современных численных прогнозов, что может быть объяснено типичными ошибками этих прогнозов. Дальнейшие эмпирические исследования, обнаружение периодичностей погоды и связь их с осредненной по времени циркуляцией или режимом, при котором они имеют место, должны помочь пониманию и в конечном счете предсказанию появления этих периодичностей.