

coast States, from which district it extended over the middle and northern Plateau regions on the 20th and 21st and the Northwestern States on the 22d. During the 25th and 26th frost conditions extended from the Northwestern States over the upper Lake region. The frosts of the month were, as a rule, accurately forecast on the days preceding their occurrence.

Heavy rains caused freshets and damaging floods in the rivers of eastern Tennessee, eastern Kentucky, West Virginia, Virginia, and the Carolinas from the 21st to the 24th. Timely advices or flood warnings were issued in connection with the more important floods in the several States named. On the 16th the Willamette River passed the danger line, 15 feet, at Portland, Oreg. The daily stages of the Willamette were accurately forecast. In Cuba much damage was caused on the 21st and 22d by freshets resulting from heavy rain.

CHICAGO FORECAST DISTRICT.

Frost extended over the Northwest on the 10th, 11th, 12th, and 13th, warnings for the occurrence of which were sent out in advance.

A storm moved from the Rocky Mountain region across the central valleys during the 23d and 24th, which was followed by an unusually rapidly rising barometer over the northern Lake region. On the morning of the 23d storm warnings were ordered on Lake Superior for "brisk to high east shifting to north winds." The forecast issued that day for Lakes Michigan and Huron was "brisk and possibly high southerly winds, becoming variable Friday; showers and squalls." On the morning of the 24th northeast storm warnings were extended over Lakes Michigan and Huron, and warning was given to vesselmen that the winds would be dangerous northerly. Several wrecks occurred on the 24th during this storm, and some lives were lost, although high winds were reported only on Lake Michigan and at Duluth. The steamer *Baltimore* in seeking shelter in the storm ran aground in Lake Huron off Au Sable and met with total loss. The other vessels wrecked were generally small sailing craft.—*H. J. Cox, Professor.*

SAN FRANCISCO FORECAST DISTRICT.

The month was remarkable chiefly for the unsettled weather conditions which prevailed during the last decade. The total rainfall at San Francisco was .69 inch (which is the normal for the last thirty years), .66 inch of this fell after May 20. Unusually heavy rains occurred in Utah on the 3d and 4th, a 24-hour rainfall of 2.32 inches being reported at Salt Lake City. An area of high pressure which followed a disturbance that was central over northern Utah and southern Idaho on the 21st was accompanied by killing frosts generally in Nevada and southern Utah. An unusually large number of thunderstorms were reported from the 24th to the 27th.—*A. G. McAdie, Forecast Official.*

PORTLAND, OREG., FORECAST DISTRICT.

No severe storms occurred and no storm warnings were displayed.

Forecasts of frost were issued on the 2d, 17th, 19th, 21st, 29th, and 30th, and they were generally verified.

River forecasts for Portland and The Dalles, Oreg., were made and published daily from the 15th. On the 14th the river at Portland began to rise rapidly and passed the danger-line, 15 feet, the evening of the 16th, and continued above the danger-line the remainder of the month. The daily stages

were forecast two or three days ahead, and no 24-hour forecast varied more than three-tenths of a foot from the stage reached, while forecasts for longer periods were relatively as accurate. Large property interests were endangered, but no losses of consequence occurred.—*E. A. Beals, Forecast Official.*

HAVANA, CUBA, FORECAST DISTRICT.

No warnings were issued during the month. Excessive rains on the 21st and 22d caused considerable damage in Havana and vicinity, and high winds and floods caused damage over the island.—*W. B. Stockman, Forecast Official.*

AREAS OF HIGH AND LOW PRESSURE.

Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
High areas.							<i>Miles.</i>	<i>Days.</i>	<i>Miles.</i>	<i>Miles.</i>
I.....	1, a. m.	54	114	5, a. m.	39	88	2, 025	4.0	506	21.1
II.....	4, a. m.	51	114	9, a. m.	48	85	1, 400	3.0	467	19.5
III.....	10, a. m.	53	118	18, a. m.	48	84	4, 100	7.0†	586	24.4
IV.....	24, a. m.	51	104	27, p. m.	38	86	1, 925	3.5	550	22.5
Sums.....							9, 450	17.5	2, 109	87.9
Mean of 4 paths.....							2, 362		527	22.0
Mean of 17.5 days.....									540	22.5
Low areas.										
I.....	1, a. m.	46	106	10, p. m.	40	74	2, 625	5.0†	525	21.9
II.....	1, p. m.	47	87	3, a. m.	50	64	1, 000	1.5	667	27.8
III.....	6, p. m.	51	120	12, a. m.	48	71	2, 600	6.5	473	19.7
IV.....	12, a. m.	47	84	12, a. m.	48	68	800	1.0	533	22.2
V.....	17, a. m.	45	88	16, a. m.	46	74	700	1.0	700	29.2
VI.....	18, a. m.	39	77	19, p. m.	34	78	3, 425	1.5	229	11.8
VII.....	19, a. m.	30	103	24, a. m.	48	54	3, 425	5.0	685	23.5
VIII.....	23, a. m.	46	106	25, a. m.	37	76	1, 775	3.0	592	24.7
IX.....	25, a. m.	32	86	28, a. m.	41	70	1, 575	3.0	525	21.9
Sums.....							14, 925	27.0	4, 933	207.7
Mean of 9 tracks.....							1, 658		534	23.1
Mean of 27 days.....									533	23.0

* Stationary for 2 days. † Stationary for 1 day.
‡ Stationary for 4 days. § Stationary for 1 day.

RIVERS AND FLOODS.

The stage of the Mississippi River was somewhat lower than during the preceding month, although it remained quite high below the mouth of the Ohio River. The upper Missouri River was higher, and a general rise was in progress as far as Kansas City, Mo., at the close of the month. The Ohio River stages averaged considerably lower than during April, 1901, although they were high during both the opening and closing days of the month.

Flood stages were experienced along the Tennessee River, and the following report of the upper Tennessee flood was prepared by Mr. L. M. Pindell, official in charge of the Weather Bureau office at Chattanooga, Tenn.:

Barometric depressions passed over the Southern States from the 18th to 22d and produced exceedingly heavy rainfall over the Tennessee River system from Chattanooga to the extreme headwaters, beyond our rainfall stations, flooding every stream and tributary, and causing one of the worst floods known over upper east Tennessee, particularly over the tributaries on the south side, including the Holston, Little Tennessee, Hiwassee, Nolachucky, Wautauga, and other streams. The Clinch, French Broad, and Powells did not have as much rainfall over their drainage areas. The total rainfall at the various stations in this center from the 18th to the 22d, inclusive, was as follows:

	Inches.
Murphy, N. C.	7.62
Charleston, Tenn.	7.13
Bryson, N. C.	5.57
Asheville, N. C.	5.04
Chattanooga, Tenn.	5.26
Kingston, Tenn.	4.13
Speers Ferry, Va.	3.93
Greeneville, Tenn.	3.73
Bluff City, Tenn.	3.52
Bridgeport, Ala.	3.45
Knoxville, Tenn.	3.32
Clinton, Tenn.	3.24
Rogersville, Tenn.	3.01
Tazewell, Tenn.	2.49
Florence, Ala.	1.05
Riverton, Ala.	0.91

From the above table it will be seen that the rain was light at Riverton, Ala., became heavier as it moved to Bridgeport, Ala., Chattanooga and Charleston, Tenn., and was the heaviest at Murphy, N. C., becoming lighter as it moved northeastward to Virginia. The river reached 19.8 feet at 8 a. m. on May 22, at Speers Ferry, Va., which was within two-tenths of the danger line; at Bryson, N. C., on the 21st, the river was at 11.5 feet; at Knoxville, Tenn., the water reached 34.8 feet at 2 p. m. on the 23d, or 5.8 feet above the danger line; it was 3.7 feet higher than in April, 1886, when the river reached 52.2 feet at Chattanooga, and 4.2 feet below the freshets of 1867 and 1875. At Charleston, Tenn., the river reached 23.5 feet at 8 a. m. May 22, or 1.5 feet above danger line. The Clinch at Clinton, Tenn., reached 26 feet at 8 a. m. May 24, or 1 foot above danger line, but did not quite reach the danger line at Kingston, Tenn. The Tennessee at Chattanooga reached 33.5 feet between 10 and 11 p. m. on May 26; it did not quite reach the danger line (24 feet) at Bridgeport, Ala., or Riverton, Ala. (25 feet), and passed the danger line at Florence, Ala., by two-tenths (16.2 feet).

The river at Chattanooga, rose slowly, about one-tenth of a foot an hour for sixteen hours after it had begun to fall at a point about 50 miles above. The rise at Chattanooga was unusually prolonged; it rose for eighty-three hours after it had begun to fall at Knoxville; about one hundred hours after it had begun to fall at Charleston, and sixty hours after it had started to go down at Kingston, Tenn. On the morning of the 23d the observer at Knoxville was notified that the river would reach about 35 feet by the morning of the 24th, and the river observer at Kingston was informed that the Clinch would reach a stage of 24 feet by Friday morning, May 24. Several private telegrams received from persons on the river below Chattanooga, as well as telephone messages, were replied to at once, giving them desired information relative to stages expected at various points between Chattanooga and Florence and whether it was necessary to move live stock off the islands. As far as can be learned, no loss due to lack of warning occurred on the river below Knoxville. The actual loss to crops in the river bottoms can never be estimated.

The loss and damage to the upper east Tennessee towns and country is estimated at \$3,000,000. The press dispatches state that Elizabethton, Tenn., is a wrecked town, and the loss and damage there is placed at \$1,000,000. The Doe River has changed its course and runs through the residence section and over the ruins of many homes. All the stores in Allentown, Tenn., were swept away and 1,000 people were without food. Saw mills, homes, bridges (wood and steel) were all swept away by the flood, as well as much live stock. The number of persons drowned is placed at 14. At Asheville, N. C., the damage to the Southern Railway is estimated at \$500,000. No eastern mail was received in this city for three days. All the railroads in east Tennessee suffered by reason of washouts and loss of bridges and tracks.

Over the lower Tennessee the flood was more moderate, and was remarked upon as follows by Mr. P. H. Smyth, official in charge of the Weather Bureau office at Cairo, Ill.

Heavy rains over the upper Tennessee watershed on May 18, 19, and 20, caused the lower river to rise from the 20th to the 31st. At Florence, Ala., the crest stage was 16.25 feet, reached at 10 a. m. on the 28th (May). At Johnsonville, Tenn., the crest stage was 22.7 feet, and occurred on the 31st. The maximum stage predicted for Johnsonville was 24 feet, and for Florence, 16 feet. No damage resulted from the high stage of the river, except to growing crops. Bottom lands were inundated in some places. Ample warning was furnished to places interested.

A remarkable feature of the flood, and one that was anticipated, was the comparatively low crest stages reached at points on the lower river. The crest stage reached at Chattanooga was 33.5 feet, which would, in the average case, give Florence about 21.5 feet, and Johnsonville about 33 feet.

The comparatively low crest stages at Florence and Johnsonville were due to the fact that, when the rise set in, the lower Tennessee was at a low stage and the lower Ohio at a comparatively low stage.

A flood of marked proportions also occurred in the James River, and its history is given herewith by Mr. E. A. Evans, official in charge of the Weather Bureau office at Richmond, Va.:

Showery weather had prevailed over the James River basin for several days prior to the 22d, wetting the soil and establishing a condition favorable to a maximum run off. In addition the percentage of humidity was high, and the skies cloudy, so that evaporation was much retarded. Hence when the heavy rains occurred on the 22d all conditions were extremely favorable for high water. During the forenoon of this date special rainfall telegrams were received from Baena Vista, Cliftonforge, Lynchburg, and Columbia, Va., reporting precipitation of 1.90, 1.30, 1.26, and 1.00 inches, respectively, and in the afternoon and early night from Charlottesville, Columbia, and Lynchburg, Va., reporting 5.20, 2.00, and 1.40 inches, respectively. At 4:45 p. m. advisory flood warnings were issued locally and also telegraphed to Sabot and Charlottesville, Va. The river at this time was low, but began to rise after midnight. At the morning observation of the 23d it was reading 10.8 feet, rising. Final warnings were then issued locally, forecasting a 21 foot rise from the lowest point a day or two before, and for upper river points between Lynchburg and Columbia, of 14 feet. At 1:10 p. m. the local gage reading was 13.2 feet, at 4 p. m. 14.7 feet, and at 7 p. m. 16.0 feet, still rising. By this hour the river was sufficiently high to cover a large area of the low-lying business section of Cary and Dock streets, while the steamboat wharfs and Lester and lower Main streets had been under water since about 2 p. m. These conditions had been anticipated, however, as early in the forenoon the messenger had been sent out to personally notify parties living in the districts liable to inundation of the expected rise. The telephone was also used freely, and this, together with the newspaper warnings issued, amply prepared the people living in the threatened districts in time for them to take such precautions as their situations required.

Throughout the night the river rose steadily, invading an increasing area of the business sections. In the early morning it had reached Main and Franklin streets in the vicinity of the "Old Market," driving out hucksters and others, running in on the first floors of business houses and compelling a complete cessation of business. Persons desiring to get to the lower part of the city had to be ferried across the streets in row boats. The river front from Fifteenth to Twenty-fifth streets and from Twenty-eighth street to the city limits was under from 1 to 3 feet of water, while those portions of the city adjacent to Shockoe and Gillies creeks were also flooded. The yards of the Trigg Shipbuilding Company were submerged and many wholesale houses and manufactories were obliged to close down.

At 6 a. m. on the 24th the gage reading was 19.3 feet; 7 a. m., 18.9; 8 a. m., 19.0; 10 a. m., 19.2; 11:30 a. m., 18.9; 5 p. m., 18.3; 10 p. m., 17.7. During the night the river continued falling slowly, receding from the streets of the city, and by morning of the 25th, when the gage read 14.5 feet, most of the business portions were free from water and clearing up of debris was in progress. The docks were still under water, also Main street at Twenty-eighth street, and a portion of Lester street, and it was not expected that they would be clear until nightfall, information to this effect being sent to the navigation companies. Throughout the day the river continued to fall and by night was within its banks.

The freshet was of considerable magnitude, being the highest since March, 1889, yet the damage to property was quite small, and in nearly all cases to fixed objects. The warnings issued were generally heeded by the people.

The same heavy rains that caused the Tennessee and James rivers floods also caused others in the New and Great Kanawha rivers. At Charleston, W. Va., the Great Kanawha River reached a stage of 38.5 feet, 2.1 feet above the stage of April, 1901, and 8.5 feet above the danger line. Mr. S. S. Bassler, official in charge of the Weather Bureau office at Cincinnati, Ohio, has furnished the following account of this flood:

The remarkably heavy rains that occurred over southern Ohio, West Virginia, and more especially the regions affecting the New River on the 21st of May, 1901, resulted in a swift flood of decided and destructive proportions in the New and Kanawha rivers, and a consequent rise in the Ohio below Point Pleasant, W. Va.

On the morning of the 22d the report from Radford, Va., indicated a stage of 23 feet, a rise of 21.3 feet in the New River at that point. This was already 9 feet above the danger line. At 10:33 a. m. on the 22d, a telegraphic warning was rushed to Hinton, W. Va., as follows: "River will pass your danger line to-day. Heavy rains above you and great rise at Radford." A special 2 p. m. report from Radford on the 22d showed the river to have risen to 26 feet and still rising, and Charleston, W. Va., was telegraphed at 3:40 p. m., as follows: "Radford, 2 p. m., 26 feet. Heavy rains. You will have sharp rise, reaching danger line Thursday."

Headquarters of all Kanawha interests located in Cincinnati were

promptly notified and all took immediate action looking to the protection of their floating property on the Kanawha, telegraphing the information to their people.

The maximum stage reached at Radford, Va., was 26.4 feet at 3:30 p. m. on the 22d. This was 12.4 feet over the danger line. A special on the same day from Hinton, W. Va., showed that by 6 p. m. the river had exceeded the danger line 4 feet and come to a stand 18.8 feet by 9 p. m., remaining at that stage until near midnight.

On the morning of the 23d the report from Charleston, W. Va., showed a stage of 36.6 feet, a rise of 29.7 feet in the past twenty-four hours. A crest of about 39 feet was forecast, and a maximum of 38.5 feet reached at 1 p. m. of the 23d. The river remained stationary at that stage until 3 p. m. of the same day.

On the 24th the Kanawha rise had again subsided and no serious effect was produced upon the Ohio River, the resulting crest stage at Cincinnati being 35.9 feet on the morning of the 26th. The local crest stage forecast several days previous was between 36 and 38 feet.

Mr. Arthur Roberts, special river observer at Radford, Va., reports, as follows: "Great damage was done to farmers all along New River; impossible to estimate the loss. The damage to the Norfolk and Western Railway Company, by bridges and tracks washing out, will probably amount to \$20,000."

Miss Vella V. Flanagan, special river observer at Hinton, W. Va., reports, as follows: "The official information was timely and of great benefit. It gave the people time to get out themselves and to pack up their household effects. There were five one-story houses taken entirely away and three others practically rendered worthless, part of one being taken away. Lumber and farming interests above this point also suffered severely."

Mr. J. W. Crider, special river observer at Charleston, W. Va., reports in part, as follows: "Several tipples and barges from farther up the river were swept away. What damage was done was principally to cellars and houses located in the lowlands. The public had a better warning of this rise than ever before. * * * I personally notified a number of firms here to get their goods out of their cellars to places of safety. We also kept the railroad officials posted, and the warning saved a good many bridges and trestles which otherwise would have been swept away. The warning was given them in time to weight the bridges, etc., down with loaded cars. The value of the warning can

hardly be estimated in dollars and cents, but had it not been given promptly thousands of dollars additional loss would have occurred. The United States Engineers in charge of the Kanawha River improvements, with their telephone service, spread the warning up and down the river to the various towns and mines."

It will be seen from these accounts that all the high waters were well anticipated by the Weather Bureau warnings. The flood forecasts were timely, and afforded another example of the great value of this branch of the service.

The Brazos River was somewhat higher during the month, particularly over the lower portion. The service on this river was improved during the month by the opening of a new special at Booth, Tex. On the Pacific coast the only item of interest was the annual rise of the Columbia River. It was in progress during the entire month, and at the close of the month the stages in the lower river were but a few feet below the danger lines. At Portland, Oreg., on the Willamette River, the back water caused a stage of 19.9 feet on the 31st, 4.9 feet above the danger line. Special river bulletins were issued daily from the Weather Bureau office at Portland during the flood, and a detailed report thereof will appear in the WEATHER REVIEW for June.

The highest and lowest water, mean stage, and monthly range at 137 river stations are given in Table VII. Hydrographs for typical points on seven principal rivers are shown on Chart V. The stations selected for charting are: Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport on the Red.—*H. C. Frankenfield, Forecast Official.*

CLIMATE AND CROP SERVICE.

By JAMES BERRY, Chief of Climate and Crop Service Division.

The following summaries relating to the general weather and crop conditions are furnished by the directors of the respective sections of the Climate and Crop Service of the Weather Bureau.

[Temperature is expressed in degrees Fahrenheit and precipitation in inches and hundredths.]

Alabama.—The mean temperature was 69.8°, or 1.4° below normal; the highest was 99°, at Bermuda on the 16th, and the lowest, 49°, at Opelika on the 27th. The average precipitation was 5.08, or 1.83 above normal; the greatest monthly amount, 9.34, occurred at Valley Head, and the least, 2.32, at Florence.

Several cool spells, especially a decided one during the latter part of the month, seriously retarded growth of late planted corn and cotton. Hailstorms quite frequent and in some places damaging.—*F. P. Chaffee.*

Arizona.—The mean temperature was 70.4°, or 2.2° below normal; the highest was 107°, at Mohawk Summit on the 6th, and the lowest, 22°, at Flagstaff on the 22d. The average precipitation was 0.44, or 0.09 above normal; the greatest monthly amount, 3.38, occurred at Fort Defiance, while none fell at a number of stations.

While the early ripening of wheat and barley has been retarded by an unusual amount of cloudiness and by temperature generally below the seasonal average, the conditions otherwise have been favorable for the filling of grain, and crops yielding more than average seem to be assured.—*W. G. Burns.*

Arkansas.—The mean temperature was 68.2°, or 1.8° below normal; the highest was 100°, at Jonesboro on the 2d, and the lowest, 31°, at Pond on the 26th. The average precipitation was 2.95, or 1.65 below normal; the greatest monthly amount, 7.85, occurred at Blanchard, and the least, 0.49, at Pond.

The drought continued during the first two weeks of the month and did considerable damage to all growing crops. The drought was broken on the 12th, and after that date good rains were generally well distributed throughout the State. Some corn and cotton had to be replanted. These crops are now coming up to fair to good stands and are being worked out. Cotton chopping progressing rapidly. Wheat and oats damaged by dry weather and insects. Rust has made its appearance in some wheat. Irish potatoes are generally good, but have been

slightly injured by bugs. The fruit prospects continue good, but in a few localities peaches, plums, and cherries are beginning to drop off.—*E. B. Richards.*

California.—The mean temperature was 62.0°, or 1.7° below normal; the highest was 108°, at Volcano on the 16-18th and 31st, and the lowest, 16°, at Bodie on the 1st. The average precipitation was 1.03, or 0.11 below normal; the greatest monthly amount, 3.87, occurred at Cuyamaca, while none fell at 5 stations.

Frequent and unusually heavy rains during the month materially improved the condition of wheat, rye, barley, and oats, benefited orchards and vineyards, and gave new life to pasturage. Hay was considerably damaged in some localities, but the yield will be heavy. The grain crop will equal and possibly exceed the average yield. Deciduous fruits are in better condition than expected a month ago.—*Alexander G. McAfee.*

Colorado.—The mean temperature was 55.5°, or 1.0° above normal; the highest was 92°, at Blaine on the 9th and at Delta on the 19th, and the lowest, 15°, at Durango on the 5th and 22d. The average precipitation was 2.34, or 0.42 above normal; the greatest monthly amount, 10.52, occurred at Alford, and the least, trace, at Hugo.

Weather conditions more favorable than usual for seeding, planting, germination, and stooling, but hardly ideal for the advancement of corn. Serious damage to crops in eastern part of Larimer County on the 20th-22d by heavy rains, flooding, and hail. Destructive hailstorms in localities of Las Animas County on the 11th and Huerfano County on the 27-29th. Some damage by frost on the 26th in eastern border counties.—*F. H. Brandenburg.*

Cuba.—The mean temperature was 78°; the highest was 100°, at Holguin, Santiago Province, on the 10th and 11th, and the lowest, 50°, at Rosario (Aguacate), Havana Province, on the 1st, and Santa Clara, Santa Clara Province, on the 1st and 11th. The average precipitation was 9.03; the greatest monthly amount, 20.27, occurred at Matanzas, Matanzas Province, and the least, 1.99, at Manzanillo, Santiago Province.

The severe drought conditions which obtained throughout the island at the end of the first week, when in different portions of the island cisterns mostly were empty, wells running dry, springs failing, ponds dry, and stock water was scarce, and in southeast Puerto Principe some of the people did not have water with which to cook, were ameliorated over the greater portion of the western four provinces by abundant