U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU,

CO-OPERATING WITH THE

MARYLAND STATE WEATHER SERVICE

Established by an Act of the General Assembly of the State of Maryland, 1892, and Maintained in Connection with

The Johns Hopkins University and the Maryland Agricultural College.

CENTRAL OFFICE, JOHNS HOPKINS UNIVERSITY, BALTIMORE, MD.

PROF. WM. B. CLARK, Johns Hopkins University, Director.

PROF. MILTON WHITNEY, Maryland Agricultural College, Secretary and Treasurer.

DR. C. P. CRONK, U. S. Weather Bureau, Meteorologist in Charge.

VOL. II. MONTHLY REPORT OF OBSERVATIONS, NOVEMBER, 1892. NO. 8.

The Production of Rain.

PROFESSOR ABBE SUMS UP THE PRESENT STATE OF OUR KNOWLEDGE CONCERNING THE SUBJECT.

Following the publication, in the October Report, of Professor Abbe's article "On the Production of Rain," a letter was received from Professor Curtiss, in which he requested some further information relative to the condensation of the moisture of the atmosphere, and in regard to the condition and behavior of the moisture subsequent to its condensation. A copy of the letter was forwarded to Professor Abbe, who kindly replied, explaining the present status of the knowledge of the subject and the part possibly played by electricity in the condensation of aqueous vapor. The letters are printed below:

OAKLAND SCHOOL,
Fallston, Md., Dec. 1st, 1892.

Dr. C. P. Cronk, Meteorologist in charge,
Baltimore, Md.

DEAR SIR:—I was much interested in the article on the "production of rain" in the last report. I want information on these points:

Why does not the condensed vapor, heavier than air, settle towards the earth as soon as condensed? In Humboldt's researches on the Alps or Andes he found cloud vapor to be made up of microscopic bubbles like soap bubbles. Now, from some cause must not the condensed air be kept much warmer than the exterior air, and the bubble be sustained like a hot-air balloon? (I have seen the air dark with mist when the mercury indicated 4° below freezing, and this must be the condition of winter clouds much of the time.)

Why does not the water congeal in snow or hail, and fall? If the vapor (visible) is made up of small bubbles, why does not the concussion of an explosive collapse these bubbles, and so, as a solid drop, cause them to fall, as when a soap bubble collapses? I confess I expected in this way some success from explosives. All have noticed, I suppose, a more rapid downfall in a shower after a loud clap of thunder.

It seems certain that there is some connection between condensation and electrical action. In a thunder shower the cold current no sooner begins to blow from the N. W. than the lightning flashes.

I would like to see an experiment conducted in this way. Have air-pump and screw-capped receiver. Place a dish of warm water on the plate under the receiver. Have in connection with the top of the receiver a tube for air admission. So place the tube that the air admitted should pass through a mass of pounded ice and salt and be at zero temperature. Exhaust the receiver, and the vapor from the warm and boiling water fills the receiver. Now open the faucet and let in the air. It would doubtless snow in the receiver, as I have seen it do when very cold air was let into a room filled with vapor (steam) on washing day. Now have in the receiver some delicate form of electrometer, as we could not, I suppose, hope to see a flash of lightning, but in this way I think we would in all conditions imitate the circumstances of a thunder shower. The perfectly defined outline of a cloud surprises me. How is the vapor so piled up as in the summer cumulus cloud? Why does it not shade out to the last condensed atom of vapor?

Very respectfully,

G. G. CURTISS.

WEATHER BUREAU,
Washington, Dec. 7, 1892.

DEAR MR. CRONK:

The interesting letter of Prof. G. G. Curtiss suggests the following remarks which I think present a fair statement of the little knowledge that we have on these points at the present time.

1). The condensed vapor of the atmosphere, although it is heavier than air and undoubtedly does, therefore, tend to settle towards the earth, descends so very slowly, when the vapor globules are small, that a very gentle ascending current of air carries them upward. The rate of fall of a small body through a resisting medium like the air is by no means the same as the rate of fall through a vacuum, but depends not only on the size and density of the falling object, but (and especially for small globules) on the so-called viscosity or internal friction of the air. For minute fog and cloud globules the rate of fall is almost inappreciable, and they fly about just as do the motes of dust in a room.

2). The statement that particles of clouds are microscopic bubbles and not microscopic globules is, I believe, not accepted by any high authority at the present time. The observations on "vesicles," made fifty or a hundred years ago, are believed to have been erroneous; many recent observers have looked for these vesicles but are unable to find them. Even if the vesicles exist and are broken to pieces by the concussion of an explosion, the resulting globules would be much smaller than the original vesicle, and would float in the air even longer than it would do. Even if the vesicles exist, the air or vapor within them could not be much warmer than the exterior air, so that the bubble would not be sustained like the hot-air balloon.

3). Both winter and summer clouds are undoubtedly often colder than the freezing temperature, but it does not necessarily follow that the component globules of clouds must be bubbles or vesicles. It is perfectly possible for these globules to be formed of either liquid water, at a temperature far below freezing, or of spheres of ice similar to the larger spheres that we call sleet and crystalline hail. Ordinarily the globules become crystals and spiculae of ice such as we call snow. In any one of these shapes (and all of them occur in nature) the rate of fall to the earth depends, as before stated, on the size and also on the shape of the mass.

4). If there be no vesicles or bubbles in the clouds, then concussion, or the noises produced by explosions, cannot produce rain by breaking them to pieces.

5). The fact that rapid or special showers of rain follow after loud claps of thunder may be offset by the fact that a still greater number of such showers occur without any thunder. Now thunder is the consequence of a special electrical discharge, and electricity is invariably present in the atmosphere. We are living upon a highly charged conductor, which is discharging through our atmosphere into an upper region. The air, in this upper region, is flowing from the equator to the poles; here and there the upper air descends, while in other places it ascends. Our thunder storms occur in the ascending districts, and our auroras in the descending. It is very likely that there is some connection between this electrified condition of the atmosphere and the condensation of aqueous vapor, and some features of this connection have been demonstrated by laboratory experiments. We can show that the noise of the thunder, in and of itself, is not likely to cause the formation of rain; but the electrified condition, or the change in that condition that attends the lightning may possibly be of some importance. So far as my own observations go, however, I find that it is only after the rain has been formed and has fallen half-way down to the earth, that the lightning flash and the thunder occur. Apparently the falling raindrops bring down a charge of electricity from the clouds, thus bringing about a deficiency above and an excess below, so that a discharge and a flash may occur either from the rain to the ground, or between neighboring clouds in the upper regions.

6). The perfectly well-defined outline of a cumulus cloud is due to the fact that when rising air cools and the cloud is formed, the latter is a little more buoyant than the neighboring air and continues rising. The volume of rising air is characterized by and made visible by the presence of the water globules, just as a vortex ring is ordinarily made visible by smoke particles.

The reason why a cloud has such a definite and sharp outline is the same as the reason why a vortex ring has such a sharp outline: we are not dealing with an indefinite diffusion of vapor, but with a sharply defined mass of moving gas.

Yours truly,

CLEVELAND ABBE.

Review of the Month.

WEATHER.

The storms of November traveled eastward over more southerly routes than those of several preceding months, and one of the results of this movement was increased precipitation in Maryland, the District of Columbia, and Delaware. Three of these storms passed northeast over Maryland; one passed north near the coast to the eastward, and several others passed northeast near the western boundary of the State.

Precipitation (in inches). — Average, 4.31. Greatest amount, 6.60, at Seaford, Del. Least amount, 3.10, at Easton.

The copious and general rains of November were in striking contrast with the light and scattered showers of October. The table of daily precipitation, on page 66 of this report, shows that there were but three days in November on which no rain fell in any portion of Maryland, while in October there were fifteen days without rain. For general comfort and enjoyment, no finer autumn weather could be than that in Maryland during the month of October, but the precipitation was not sufficient for the needs of the agriculturist. November made up the deficiency, but the rainfall was so equably distributed throughout the month, as shown by the table, that every drop of rain was of benefit to the soil. A glance at the map, page 67, shows how the November rainfall was distributed over the territory embraced by the Maryland State Weather Service. More than half the surface received above four inches, while between two and four inches fell on the remaining portion.

Temperature (degrees).—Mean monthly, 42.9. Highest monthly mean, 46.8, at Leonardtown. Lowest monthly mean, 40.0, at Boettcherville. Highest temperature, 77.0, at Edgemont, on the 4th. Lowest temperature, 15.0, at Edgemont, on the 24th. Greatest local monthly range, 62, at Edgemont. Least local monthly range, 34, at Denton. Mean monthly range, 48.3. Mean maximum, 51.2. Mean minimum, 35.9.

If you will turn to the map on page 67 of this report, you will not fail to notice the curvature of the lines of monthly mean temperature, upward, as they approach the Bay, or Ocean, downward, as they recede from the coast. The direction taken by these lines graphically illustrates the influence of large bodies of water upon temperature. During the summer the Ocean and Bay exercise a cooling influence upon the surrounding atmosphere, because the rapid evaporation, then going on from the surface of the water, is a cooling process, and because the heat received from the sun is distributed through a deeper layer of water than of land. Large bodies of water are storehouses of heat. During the depth of winter, when the crust of the earth may be cooler than the air itself, the great body of water still retains some of the heat it obtained from the summer's sun. This is slowly given up to the surrounding air, the lowest temperature of which is far above that of the interior of the country in the same latitude.

Wind.—Prevailing direction, northwest. Total movement in miles, Baltimore, 6567; Norfolk, Va., 7481; Washington, D. C., 5743.

Thunderstorms.—At Solomon's, on the 18th; at Woodstock, on the 18th.

Hail.—At Barron Creek Springs, on the 9th, 10th, 19th; at Seaford, Del., on the 9th.

Halos.—Lunar. At Baltimore, on the 2nd; at Barron Creek Springs, on the 1st, 2nd, 5th, 6th, 7th, 26th; at Cumberland (H. Shriver, on the 6th; * at Woodstock, on the 6th; *at Jewell, on the 1st, 27th.

Solar. Dover, Del., on the 10th.

Polar Bands.—At Cumberland (H. Shriver), on the 19th.

Meteors.—At Baltimore, on the 23rd; at Barron Creek Springs, on the 6th, 18th, 20th; at Fallston, on the 23rd; at Jewell, on the 23rd; at Solomon's, on the 23rd; at Woodstock, on the 23rd.

Average number of clear days, 10; fair days, 8; cloudy days, 12; rainy days (.01 of an inch or more), 11.

MONTHLY SUMMARY OF REPORTS, NOVEMBER, 1892.

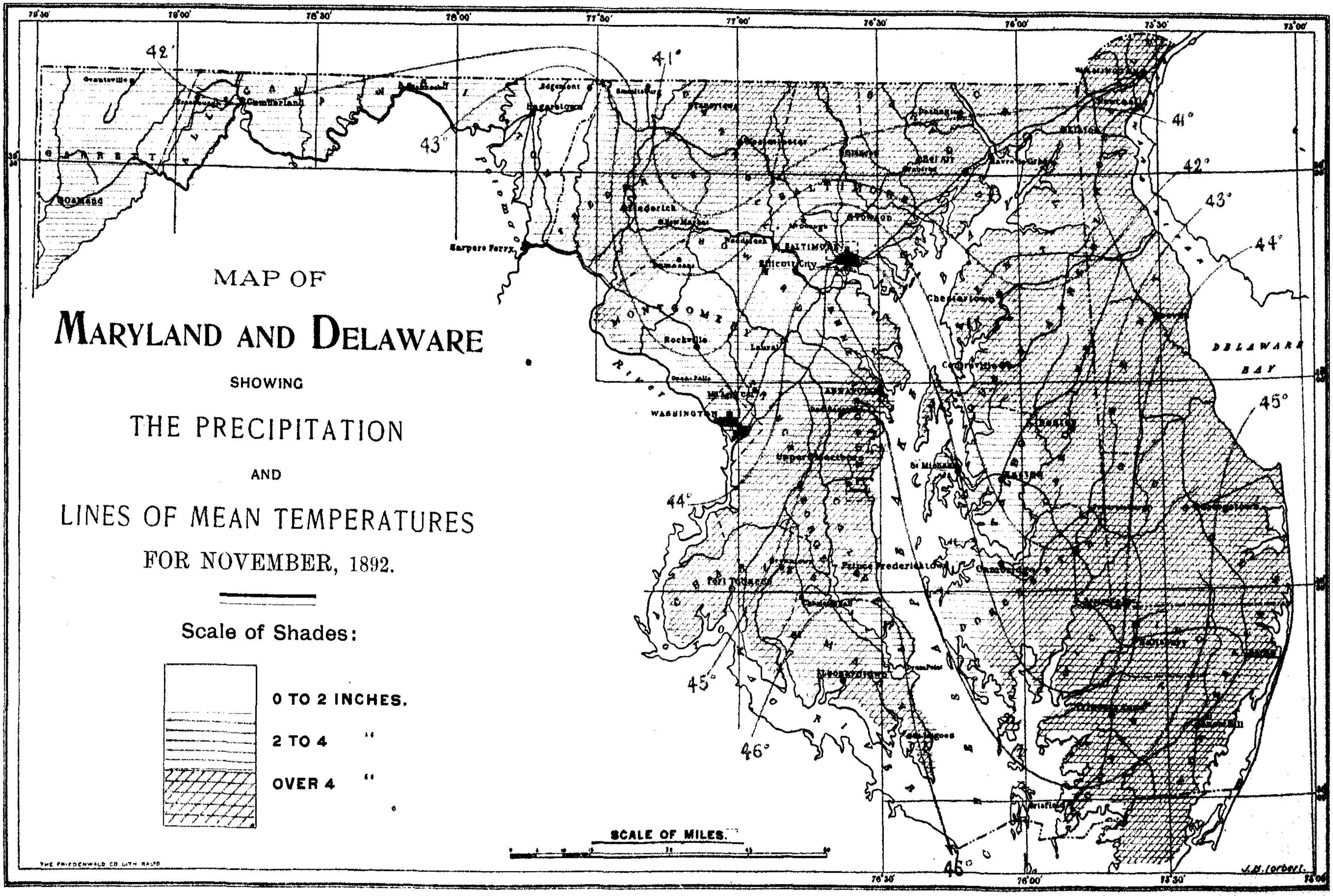
Stations.	Counties.	Altitude above Sea in feet.	Latitude.	Longitude.	† Barometer. Monthly Mean.	Barometer. Maximum. Height.	Barometer. Maximum. Date.	Barometer. Minimum. Height.	Barometer. Minimum. Date.	Temperature. Monthly Mean.	Temperature. Mean of Maximum.	Temperature. Mean of Minimum.	Temperature. Maximum. Degrees.	Temperature. Maximum. Date.	Temperature. Minimum. Degrees.	Temperature. Minimum. Date.	Monthly Range.	Total Precipitation.	Clear Days.	Fair Days.	Cloudy Days.	Rainy Days.	Prevailing Wind.
Baltimore		179	39°17′	76°36′	30.098	30.467	9	29.621	18	43.8	50.2	37.3	70	3	21	24	49	3.85	9	14	7	11	N.W.
*Barron Ck. Springs	Wicomico.	25	38°30′	75°39′						43.4	50.6	36.2	72	3	24	24	48	5.39	9	13	8	13	N.W.
Boettcherville	Alleghany		39°39′	78°48′						40.0			70	2	20	6	50	3.70					
Cumberland (a)	Alleghany	650	39°39′	78°46′	30.089	30.454	9	29.610	18	43.0	49.7	36.3	67	2, 3	24	23, 24	43	3.58	3	4	23	11	N.W.
Cumberland (b)	Alleghany	700	39°39′	78°45′						41.0	46.0	35.9	65	2	22	24	43	3.16	9	11	10	11	
Darlington	Harford	300	39°39′	76°14′						41.0	48.8	33.2	69	3	18	24	51	4.51	12	8	10	9	N.W.
§Denton			38°47′	75°41′						44.1			66	18	32	23	31	6.58				9	
Distribut'g Res., D.C.			38°52′	77° 0′						43.4			68	3	22	24	46	4.76					
Dover, Del	Kent		39° 9′	75°31′						44.6	52.0	37.3	70	2	22	24	48	5.79	10	12	8	14	N.W
Easton	Talbot	35	38°42′	76° 6′						42.8	52.6	33.1	70	2	22	24	48	3.10	8	11	11	13	N.W.
Edgemont	Washington		39°45′	77°29′						44.5	54.0	35.0	77	4	15	24	62						
Fallston	Harford	450	39°31′	76°24′						41.5			70	2	17	24	53	5.36				12	
Frederick	Frederick	280	39°24′	77°18′						42.4	49 7	35.2	69	3	22	24	47	4.66	19	6	5	11	
Great Falls	Montgomery		39° 0′	77°14′						43.0			69	2	22	24	47	3.11					
Jewell	Anne Aru'del		38°44′	76°36′						40.8			65	3	22	24	43	5.17	12	4	14	11	
Kirkwood, Del	New Castle		39°35′	75°40′						41.6			72	8	22	24	50					11	
Leonardtown	St. Mary's		38°18′	76°40′						46.8	55·1	38.4	72	1, 4	21	24	51	5.31	12	8	10	7	N.W.
*McDonogh	Baltimore	535	39°23′	76°44′	30.109	30.470	9	29.599	18	43.8	52.6	35.0	70	2	19	24	51	3.12				8	
Mt. St. Mary's	Frederick	720	39°41′	77°21′	30.120	30.456	9	29.620	18	41.2	48.4	34.0	68	3	18	23	50	3.23	6	7	17	10	N.W.
New Market	Frederick	500	39°23′	76°27′	30.100	30.481	9	29.630	18	41.4			72	2	20	23, 24	52	5.36	10	7	13	7	N.W.
Receiving Res., D. C.			38°52′	77° 0′						43 2			67	3	22	24	45	3.85					
Seaford, Del	Sussex		38°40′	75°27′						44.6	53.8	35.5	71	2, 3	22	24	49	6.60					
Solomon's	Calvert	20	38°19′	76°27′						46.4	52.9	39.8	72	2	23	24	49	3.90	9	5	16	14	N.W.
Taneytown	Carroll		39°40′	77° 9′														5.57					
Washington, D. C.		112	38°52′	77° 0′	30.110	30.450	9	29.570	18	43.7	50.9	36.5	71	3	22	24	49	3.38	9	9	12	12	N.W.
Woodstock	Howard	392	39°20′	76°49′	30 122	30.446	9	29.599	18	41.8			69	2	19	24	50	4.68	9	10	11	11	N.W.
†Norfolk, Va.		43	36°51′	76°17′	30.134	30.438	13	29.677	18	49.2	56.9	41.4	77	2	25	24	52	2 38	12	8	10	11	N.W.
Averages					30.107					42.9	51.2	35.9					48.3	4.31	9.7	8 6	11.7	10.8	N.W.

*1 day missing. †Omitted in computing averages. ‡Readings reduced to sea-level. §6 days missing.

DAILY PRECIPITATION FOR NOVEMBER, 1892.

STATIONS.		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total.
Baltimore		T	.02	.58			.03		.56	.49					.1	.14		.54			T		.01					.28	.07			3.85
Barron Crk. Spr.		.20		.39				.06		1.25					2.34	.10		.69	.24				T	T				.07	.05			5.89
Boettcherville			.10			.10			1.40									1.40	.10									.60				3.70
Cumberland (a)		.10		.08			.10				1.10							.94	.18				.05		.50			.52		.01		3.58
Cumberland (b)		.08	.07				.09		.98	.05					.04		.82	.35	.14								.52	.02				3.16
Darlington			.07	.32				.13	1.41						.14	1.05		.89											.50			4.51
Denton			.24	.48			.17		.17	1.65				.10	2.60		.83											.33				6.58
Dist. Res. D. C.				.18	.06			.02		1.53					.14	.33		2.07										.35	.03	.05		4.76
Dover, Del				.54				.17		1.84					2.35	.03		.48		.03	.02								.83			5.79
Easton		T	.10	.37	.04	T		.04		1.29						.07		.48	.52									.12	.07			3.10
Fallston			.68	.09			.03		1.45						.86	.55		1.20			T		T					.85	.15			5.36
Frederick			.05	.42				.09		2.02					.65			.87	.05									.51				4.66
Great Falls					.03			.14		1.20					.14	.70			.56									.34				3.11
Jewell		T	T	.40				.12	T	1.25		T				2.50		.50	.10		T							.25	.05			5.17
Leonardtown				.80						2.05					1.15			.87	T				.02						.42			5.31
McDonogh			.14				.04		.68	.48						.08		1.15					.08					.47				3.12
Mt. St. Mary's	.01	.04		.53			.38		.30						.39	.03		1.04	T				.11					.40				3.23
New Market				.62			.25			1.92						.79		1.19	.04				.11					.55	T			5.36
Rec. Res. D. C.		.04	.03	.12	.04			.06		1.40	.03				.19	.47			1.02									.37	.04	.04		3.85
Seaford, Del		.16			.45			.15		1.64					3.13	T		.60		.21			T					.18	.08			6.60
Solomon's		.02	.01	.53			.03	.07	1.04	.59		T			.89	.02		.56	.09		T		T				.01	.17	.07			3.90
Taneytown				.05				1.02	1.02	.58					.70	.30		1.35					.05					.41	.09			5.57
Washington, D. C.		T	T	.28			.02	.01	.83	.48		T			.49	.05		.72	T	.01	.04		T					.41	.06			3.38
Woodstock		.17	.48	.17			.08		1.35						.82			1.15			.05		.01					.37	.03			4.68
Norfolk, Va.				.58			T	.01	.44	.12					.61	.08		.28	.03				.01	T				.22	.02			2.88

NOTE.—"T" indicates a trace of rain or snow.


MAP OF
MARYLAND AND DELAWARE
SHOWING
THE PRECIPITATION
AND
LINES OF MEAN TEMPERATURES
FOR NOVEMBER, 1892.
Scale of Shades:
0 TO 2 INCHES.
2 TO 4 "
OVER 4 "
SCALE OF MILES.
DELAWARE BAY
WASHINGTON
BALTIMORE
Cumberland
Hagerstown
Frederick
Rockville
Harpers Ferry
Chestertown
42°
41°
43°
44°
45°
46°
THE FRIEDENWALD CO. LITH. BALTO
J. H. Corbert.

Notes by Observers.

Baltimore.—9th, first snow of the season, changing to sleet and then to rain. 11th, the first ice of the season. 15th, a severe wind storm from the N.W., accompanied by rain. 18th, wind storm from the N.W. 23rd, light snow. 24th, wind storm from the N.W.; coldest morning of season. 27th, 28th, 29th, light snow.

Barron Creek Springs.—2nd, rainbow, N.W., 7 A. M. 5th, very heavy wind after midnight. 6th, a very heavy white frost; ice; ground crisp. 9th, hail, 7 A. M. 10th, single peal of thunder, S.W., 11 A.M.; hail, 3 P. M. 11th, cold wave. 13th, heavy frost. 14th, heavy frost; light fog, 7 A.M. 17th, white frost; light fog, 7 A. M., followed by dense fog. 18th, hickories, gums, and oaks have lost their foliage. 19th, slight sleet; white frost; smoky, 7 A. M.; light snow; hail, 9 P. M. to 10 P. M. 20th, frost. 21st, white frost; ground crisp. 22nd, ice. 23rd, parhelion, 2 P. M.; scud of snow, 7 P. M. to 8 P. M. 24th; scud of snow, 10 A. M.; wild geese going S.W., 11 A. M. 26th, white frost; light smoke, 7 A. M.; ground frozen.

Fallston.—18th, violent wind; heavy rain; low barometer. 23rd, light snow. 24th, coldest of season; ice on pond $1\frac{8}{16}$ inch thick. 28th, snow. The mean temperature during November at this point, for the past twenty-two years, not including this year, 42.6 degrees; coldest, in 1873, 37.5 degrees; warmest, in 1870, 46.7 degrees. Mean precipitation during November, at this point, for the past twenty-two years, not including this year, 3.57 inches; most, in 1887, 10.27 inches; least, in 1882, 0.45 of an inch. Mean temperature for November 1891, 41.8 degrees; highest, 65.0 degrees, on the 10th; lowest, 14.0 degrees, on the 30th. Total precipitation for November 1891, 1.74 inches.

Seaford, Del.—9th, hail. 15th, heaviest rain for over two years, 3.13 inches. 18th, very heavy wind storm passed through this section, 12.20 P. M., uprooting trees, tearing down fodder, fences, etc. 23rd, snow.

Solomon's.—6th, first ice. 15th, strong gale from E., 11 A. M. to 11.30 A. M. 18th, thunderstorm from S. W., 10.45 A. M., accompanied by heavy wind and rain. 23rd, first snow.

Woodstock.—6th, frost. 9th, first snow, 11.30 A. M., changing to rain, then to snow, and then to rain again. 11th, 12th, 13th, 14th, 17th, frost. 18th, frost; one flash of lightning and one peal of thunder in N.W., 11.10 A. M. 19th, 20th, 21st, 22nd, frost. 23rd, many meteors seen to fall from the region of the comet, to all parts of the heavens, 7.15 P. M.; frost; light snow. 25th, frost. 28th, frost; snow.

Meteorological Stations reporting to the Maryland State Weather Service.

Stations of Observation.	County.	Observer.
Baltimore		G. N. Wilson, A. T. Brewer, H. D. Steuart.
Barron Creek Springs	Wicomico	Albert E. Acworth.
Boettcherville	Alleghany	F. F. Brown.
Cumberland (*a*)	Alleghany	Howard Shriver.
Cumberland (*b*)	Alleghany	E. T. Shriver.
Darlington	Harford	A. F. Galbreath.
Denton	Caroline	F. C. Ramsdell.
Distributing Reservoir, D. C.		Lieut.-Col. Elliot.
Dover, Del	Kent	Jno. S. Jester.
Easton	Talbot	G. W. Minnick.
Edgemont	Washington	Chas. Feldman.
Fallston	Harford	G. G. Curtiss.
Frederick	Frederick	G. Ernest Bantz.
Great Falls	Montgomery	Lieut.-Col. Elliot.
Jewell	Anne Arundel	Jos. Plummer.
Kirkwood, Del	New Castle	W. C. L. Carnagy.
Leonardtown	St. Mary's	G. W. Joy.
McDonogh	Baltimore	W. W. Walker.
Mt. St. Mary's (Emmitsburg)	Frederick	J. A. Mitchell, A. M.
New Market	Frederick	H. H. Hopkins, M. D.
Receiving Reservoir, D. C.		Lieut.-Col. Elliot.
Seaford, Del	Sussex	H. L. Wallace.
Solomon's	Calvert	W. H. Marsh, M. D.
Taneytown	Carroll	C. W. Weaver, M. D.
Washington, D. C.		S. W. Beall.
Woodstock College	Howard	T. J. A. Freeman, S.J.
Norfolk, Va		A. J. Davis.