has to be moved horizontally); then the sum total, which I call "convection-resistance" due to mixtures, presents an important factor in the turbulent motion of the atmosphere, and may be treated by methods that Boussinesq developed for the study of tumultuous river currents.

5. The reaction between the wind and the ocean by virtue of which surface waters are blown horizontally with a speed of perhaps 1 per cent of the general motion of the adjacent air, introduces a secondary term for the oceanic surface, which does not occur in the land surface, but this is comparatively a minor matter.

6. The superior quantity of latent heat contained in moist air is probably next in importance to the resistance offered by the irregularities of continental or other large masses of land, and its importance may be best evaluated by a study of the quantity of rain, snow, cloud, or fog. The formation of cloud or fog not only evolves latent heat, but entirely alters the coefficient of radiation or absorption of the atmosphere; cloudy air differs in these respects from clear air; the precipitation of rain or snow does even more than this, for it leaves a corresponding amount of latent heat free in the atmosphere, thereby permanently affecting its temperature, and the atmospheric temperature that our equations now have to deal with is that due on the one hand to insolation and its attendant absorption, conduction, and convection, and on the other hand to the latent heat left in the atmosphere by precipitation. The formation of cloud or fog as such, by virtue of the cooling due to expansion, does not materially affect the quantity of heat in the atmosphere. It produces only a temporary local phenomenon, since the expanding air is very soon brought under high pressure, compressed and warmed, before the latent heat, at first evolved, has had time to be lost by radiation or otherwise.

ORIGIN OF THE RARE GASES IN THE EARTH'S ATMOSPHERE.

In a report made by Dr. S. A. Mitchell on the spectroscopic work done by him during the solar eclipse of May 18, 1901, at Sumatra, and published by Columbia University (New York City), there occur the following interesting paragraphs relative to the earth's atmosphere and the spectra of the aurora borealis:

> Consequently, it seems that the more volatile gases of terrestrial atmospheric air uncondensed at the temperature of liquid hydrogen, together with hydrogen, helium, neon, and argon, are present in the solar chromosphere, while the evidence in regard to krypton and xenon is inconclusive.
>
> The finding of these gases in the sun and the undoubted presence of free hydrogen in the earth's atmosphere have an importance for cosmical physics that can hardly be overestimated. According to Liveing and Dewar, "if the earth can not retain hydrogen or originate it, then there must be a continued accession of hydrogen to the atmosphere (from interstellar space), and we can hardly resist the conclusion that a similar transfer of other gases must also take place." (Proc. Roy. Soc., vol. 67, p. 468, 1900.) It has been shown by these distinguished physicists, and again by Dewar in his presidential address before the British Association for the Advancement of Science, that these new gases, and particularly the more volatile gases of atmospheric air, play an important part in the spectra of the aurora, of nebulæ, and of the corona. "Of more than a hundred auroral rays observed by Stassano, more than two-thirds of them appear to belong to the more volatile gases of atmospheric air, while the majority of the remainder seem to belong to argon, krypton, and zenon." We are also told by Dewar that of a "list of 339 lines photographed by Humphreys during totality" [this, however, was called the spectrum of the corona, whereas it was the spectrum of the chromosphere] "only 55 do not differ by more than one unit on Ångström's scale from lines measured in the most volatile gases of the atmosphere or in krypton or xenon. It seems rather to the present writer that the great majority of these lines more closely correspond to Fraunhofer lines than to the lines of these rare gases.
>
> These gases may take their origin from the earth itself; in fact, helium and neon are occluded from the waters of the Bath Spring in England. The presence of free hydrogen in the atmosphere can not be explained in this way. It is more likely that hydrogen comes to us in small ionized particles from the sun, being sent hither, as has been shown by Arrhenius, by the pressure of light; and likewise helium and the more volatile gases are present in the atmosphere through being repulsed from the sun by the ionization of small particles of these gases.
>
> It seems, therefore, that the finding of these new gases in the sun's chromosphere is an independent verification of the truth of the theory of Arrhenius, which tells us that particles of matter are being continually scattered throughout the universe, starting from one sun and reaching another, with the result that all bodies of the universe are gradually becoming more and more alike.

THE WEATHER OF THE MONTH.

By Mr. W. B. STOCKMAN, District Forecaster, in charge of Division of Meteorological Records.

PRESSURE.

The distribution of mean atmospheric pressure is graphically shown on Chart IV and the average values and departures from normal are shown in Tables I and VI.

The mean monthly pressure was high from Kentucky, Tennessee, and Georgia northwestward to the coast of the northern and central Pacific districts, and the northern portions of the southern Pacific, with the crest overlying the northern Plateau, and a second area of relatively high but considerably lower mean pressure over the interior of Louisiana, Mississippi, and Alabama. At Boise, Idaho, the mean monthly pressure was 30.40 inches.

The mean pressure was lowest over the northern upper and eastern lower Lakes, northern Middle Atlantic States, and New England, which was the only portion of the country where the mean pressure was below 30.00 inches. The lowest mean monthly barometer reading was 29.90 inches at Eastport, Me.

The mean pressure was below the normal from Minnesota, Iowa, northern Missouri, eastern Kentucky, eastern Tennessee, and northeastern Georgia eastward to the Atlantic Ocean; and above the normal in all other districts.

The greatest minus departures ranged from —.05 to —.10 inch, and occurred in New England, the northern part of the Middle Atlantic States, the lower Lake region, and the northeastern half of the upper Lake region.

Throughout the entire Plateau region the barometer was .10 inch or more above the normal, maximum plus departures occurring over the middle Plateau, and the eastern portion of the north Pacific district, where they ranged from +.20 to +.23 inch.

The mean pressure decreased from that of November 1903, in the Lake regions, New England, Middle Atlantic States, northern portion of the South Atlantic States, eastern parts of the Ohio Valley and Tennessee, upper Mississippi Valley, Missouri Valley, North Dakota, and eastern Montana; and increased over the preceding month in the remaining portions of the United States. The greatest decreases occurred in the northern border States from Minnesota eastward, and were comparatively small, being less than .10 inch, while over the north Pacific, Plateau, and portions of the slope and middle Pacific regions the increase amounted to +.10 to +.28 inch, —the maximum occurring over the northern portions of the northern Plateau and north Pacific districts.

TEMPERATURE OF THE AIR.

The distribution of maximum, minimum, and average surface temperatures is graphically shown by the lines on Chart VI.

The mean temperature was below the normal from the west Gulf States, Missouri Valley, and central North Dakota eastward to the Atlantic Ocean, and in portions of the Plateau regions; and above the normal elsewhere. Over the region east of the Mississippi River the departures were very marked, and averaged from —4.0° to —10.1° per day, the maximum defi-

ciencies being reported from the Ohio Valley northwestward to central Wisconsin. The greatest increases occurred in the slope regions, and the average daily departures (except in a limited area) were, as a rule, not so marked as in the region of deficiency, the maximum departures being reported from eastern and north-central Montana, where they ranged from +9.4° to +10.7° per day.

In the South Atlantic and Gulf States, Florida Peninsula, Ohio Valley and Tennessee, and the Lake region there were but few days when the mean daily temperature was not below the normal. In the Middle Atlantic States it was below the normal on all but 8 days—5th, 13th, and 20–25th, inclusive.

The isotherms of 40°, 50°, and 60° of mean monthly temperature lay considerably to the southward of their position in 1902, as also did that of 30° to the eastward of the Missis- River, and 20° and 10° over the Lake region. The mean monthly temperature was lower than any previous December, as follows: Birmingham, Ala., Sandusky, Ohio, Syracuse, N. Y., Scranton and Harrisburg, Pa., 1°; Binghamton, N. Y., Columbia, S. C., and Modena, Utah, 2°; Lexington, Ky., and Richmond, Va., 3°; Parkersburg, W. Va., 4°; Elkins, W. Va., 5°, and Wytheville, Va., 6°, the decided differences, as a rule, occurring at stations having short records.

The isotherms of 60°, 70°, and 80° of maximum temperature are located to the southward of their position in December, 1902, as also are those of 40°, and 50° over the Lake region and the northern portion of the upper Mississippi Valley.

At Lander, Wyo., the maximum was 4°, and at Carson City 5°, higher than during any preceding December since the establishment of the stations.

The isotherms of minimum temperature generally lay somewhat to the southward of their position in December, 1902. Binghamton, N. Y., a short record station, reports a minimum 6° lower than during any previous December.

The average temperatures for the several geographic districts and the departures from the normal values are shown in the following table:

Average temperatures and departures from normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	8	25.9	— 4.0	— 0.1	0.0
Middle Atlantic	12	31.5	— 4.8	+ 1.1	+ 0.1
South Atlantic	10	42.4	— 5.5	— 4.4	— 0.4
Florida Peninsula *	8	56.1	— 5.0	— 1.6	— 0.1
East Gulf	9	45.7	— 5.2	—14.9	— 1.2
West Gulf	7	49.4	— 2.1	—14.2	— 1.2
Ohio Valley and Tennessee	11	30.6	— 7.6	— 5.8	— 0.5
Lower Lake	8	23.7	— 6.8	+ 2.2	+ 0.2
Upper Lake	10	17.4	— 7.0	+ 5.3	+ 0.4
North Dakota *	8	13.2	+ 0.8	+ 2.3	+ 0.2
Upper Mississippi Valley	11	21.9	— 6.5	— 1.5	— 0.1
Missouri Valley	11	25.9	— 2.8	— 0.8	— 0.1
Northern Slope	7	29.4	+ 4.9	+ 5.1	+ 0.4
Middle Slope	6	36.3	+ 1.4	— 2.7	— 0.2
Southern Slope *	6	43.3	+ 1.6	— 8.5	— 0.7
Southern Plateau *	13	40.4	+ 0.2	— 9.6	— 0.8
Middle Plateau *	8	27.8	+ 0.6	—18.8	— 1.6
Northern Plateau *	12	30.4	+ 0.2	+ 3.0	+ 0.2
North Pacific	7	42.5	+ 0.6	— 0.6	0.0
Middle Pacific	5	50.1	+ 1.4	— 2.3	— 0.2
South Pacific	4	54.2	+ 1.5	+ 0.8	+ 0.1

* Regular Weather Bureau and selected voluntary stations.

In Canada.—Prof. R. F. Stupart says:

The mean temperature of December was higher than the average over the Northwest Territories and the larger portion of British Columbia, and lower than the average over all other parts of the Dominion; the largest positive departures, amounting to nearly 12°, occurred in western Assiniboia and northern Alberta, and the largest negative in the more northern portions of Ontario and Quebec. Near the mountains the mildness of the month was almost phenomenal, with but one really cold spell between the 11th and 15th. In Manitoba and eastward, cold weather was pretty steady throughout the month, with the principal cold dips about the middle of the month, and again in Christmas week when very low temperatures were recorded.

PRECIPITATION.

The distribution of total monthly precipitation is shown on Chart III.

The precipitation for the month was slightly in excess of the normal in western Minnesota, North Dakota, northern and western South Dakota, northeastern and central Wyoming, extreme southern Illinois, western Tennessee, in New York about the eastern ends of Lakes Erie and Ontario, the extreme southeastern parts of Pennsylvania, New Jersey, and Vermont; and between 1 and 2 inches in excess in east-central New Jersey; elsewhere there was a deficiency, and in amounts ranging from 1 to 2 inches in southeastern New England, central New York, about the northwestern part of Lake Michigan, generally in the Middle and South Atlantic and Gulf States, the Ohio Valley and Tennessee, the central Mississippi Valley, and the Pacific and slope regions; 2 to 4 inches in southern Indiana, eastern Tennessee, the northern portion of the east Gulf States, and the Pacific coast districts, and 4 to 6.5 inches in the western portions of Washington, and Oregon, and southwestern California. No precipitation occurred in southeastern California and western Arizona.

No general precipitation occurred on any day during the month in the southern slope, middle and southern Plateau, and southern Pacific districts.

Snow occurred, except near the coast in the South Atlantic and east Gulf States, in Florida, Texas and Oklahoma generally, southern and western Arizona, southern Nevada, southern and western California, and in the western portions of Oregon and Washington. The heaviest snowfalls were reported from the mountain regions of New England and the Middle Atlantic States, the Lake, and the northern and middle Plateau regions, the greatest amounts being reported from Michigan.

At the end of the month appreciable amounts of snow lay on the ground as far south as the central parts of New Jersey and Maryland, extreme southern West Virginia, northeastern Kentucky, southwestern Indiana, central Illinois, southern Iowa, northeastern Nebraska, and generally over the northern and middle slope and Plateau regions.

HAIL.

The following are the dates on which hail fell in the respective States:

Arkansas, 24. California, 17, 31. Georgia, 25. Idaho, 2. Indiana, 1, 15. Indian Territory, 24. Kansas, 12. Maine, 9, 20. Michigan, 12. New York, 13. Oklahoma, 23. Oregon, 10, 13, 17, 18, 19, 20, 22. Rhode Island, 3, 29. Tennessee, 19. Texas, 4. Utah, 11, 17. Virginia, 11, 20. Washington, 10, 14, 16, 22, 26.

SLEET.

The following are the dates on which sleet fell in the respective States:

Alabama, 5, 9. Arizona, 6. Arkansas, 1, 7, 9, 12. California, 17. Connecticut, 29. Georgia, 2, 9, 10, 19, 20. Idaho, 19. Illinois, 3, 11, 12, 13, 19, 20, 23, 27, 30. Indiana, 12, 13, 19, 20, 24, 25. Iowa, 2, 3, 12, 19, 21, 24, 25, 27, 29. Kansas, 8, 9, 12, 19, 23. Kentucky, 12, 13, 19, 24. Louisiana, 1. Maine, 1, 9, 10, 20, 24. Maryland, 9, 20, 24. Massachusetts, 2, 3, 9, 26. Michigan, 19, 20, 24. Minnesota, 2, 18, 19. Mississippi, 1, 9. Missouri, 8, 9, 12, 13, 19, 24, 25. Montana, 2, 24, 31. Nebraska, 9. Nevada, 17. New Hampshire, 9, 10, 20. New Jersey, 2, 3, 9, 24, 25, 26, 27. New York, 3, 4, 5, 13, 19, 20, 21, 24. North Carolina, 2, 3, 9, 10, 19, 20, 24. North Dakota, 2. Ohio, 12, 13, 19, 20, 24. Oregon, 10, 11, 12, 13, 14, 15, 16, 19. Pennsylvania, 2, 20. Rhode Island, 3, 29. South Carolina, 9. South Dakota, 2, 9, 25, 28. Tennessee, 9, 10, 13, 19, 20, 26. Texas, 4, 24. Utah, 11. Vermont, 14, 20, 21. Virginia, 10, 13, 19, 20, 24. Washington, 1, 10, 12, 13, 14, 15, 19, 22, 30. West Virginia, 19, 20. Wisconsin, 19.

Average precipitation and departure from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		*Inches.*	*Inches.*
New England	8	2.99	86	−0.5	−4.2
Middle Atlantic	12	2.56	79	−0.7	+0.2
South Atlantic	10	1.85	54	−1.6	−4.1
Florida Peninsula*	8	1.61	64	−0.9	+2.6
East Gulf	9	2.98	65	−1.6	−6.8
West Gulf	7	2.05	61	−1.3	−4.9
Ohio Valley and Tennessee	11	2.13	62	−1.3	−7.7
Lower Lake	8	2.36	82	−0.5	−0.1
Upper Lake	10	1.59	73	−0.6	−0.6
North Dakota*	8	0.96	112	+0.1	−1.7
Upper Mississippi Valley	11	1.11	55	−0.9	−0.7
Missouri Valley	11	0.61	55	−0.5	+3.3
Northern Slope	7	0.28	48	−0.3	+0.2
Middle Slope	6	0.23	25	−0.7	−0.1
Southern Slope*	6	0.15	11	−1.2	−4.8
Southern Plateau*	13	0.05	4	−1.2	−2.3
Middle Plateau*	8	0.23	17	−1.1	−1.7
Northern Plateau*	12	1.14	62	−0.7	−3.2
North Pacific	7	4.33	51	−4.1	−8.8
Middle Pacific	5	2.73	50	−2.7	−5.2
South Pacific	4	0.22	7	−2.8	−4.0

*Regular Weather Bureau and selected voluntary stations.

In Canada.—Professor Stupart says:

The rainfall in British Columbia was very generally about half the average amount and at low levels there was scarcely any snow. In the Northwest Territories the snowfall was light, ranging between one and six inches. In Manitoba there was a little more snow, the fall being between seven inches and one foot, or just about average. On the higher lands of Ontario, immediately west of Lake Huron, and in the Muskoka and Nipissing districts, the snowfall was very heavy, but in other parts of the Province there was much less. The only important rainfall occurred in southern districts on the 12th. The precipitation in Quebec was below average in most districts and was chiefly snow, although rain fell about the 13th and 20th. Near Montreal and in the eastern townships a very heavy snowfall occurred on the 10th, but in more northern and eastern districts the falls, while frequent, were only moderate. In the Maritime Provinces the precipitation was above average and was part rain and part snow, the former predominating. At the close of the month the lower levels of British Columbia and southern Alberta and western Assinniboia were bare of snow, but all other parts of the Dominion were snow covered, the depth being greatest on the higher lands of western and northern Ontario and in the Ottawa Valley, the depth in the former districts being from thirty to sixty inches, and in the latter from twenty to thirty inches. In Quebec the depth was about eighteen inches in the southwest portion and diminished to about ten inches in eastern and northern parts. The greatest depth reported from the Maritime Provinces was a foot at Fredericton, and sleighing was general in all three provinces.

HUMIDITY.

The relative humidity was normal in the Missouri Valley; above normal in the lower Lake region, northern slope district, and northern Plateau, and north Pacific regions, and below the normal in the remaining geographic districts.

The averages by districts appear in the subjoined table:

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
	%			%	
New England	73	− 3	Missouri Valley	75	0
Middle Atlantic	69	− 6	Northern Slope	73	+ 5
South Atlantic	68	−10	Middle Slope	62	− 4
Florida Peninsula	78	− 3	Southern Slope	58	− 8
East Gulf	68	− 9	Southern Plateau	37	− 9
West Gulf	67	− 7	Middle Plateau	65	− 5
Ohio Valley and Tennessee	74	− 2	Northern Plateau	83	+ 3
Lower Lake	81	+ 3	North Pacific	87	+ 1
Upper Lake	81	− 1	Middle Pacific	76	− 5
North Dakota	78	− 1	South Pacific	60	− 9
Upper Mississippi Valley	76	− 2			

SUNSHINE AND CLOUDINESS.

The distribution of sunshine is graphically shown on Chart VII, and the numerical values of average daylight cloudiness, both for individual stations and by geographic districts, appear in Table I.

The average cloudiness was normal in the northern slope and northern Pacific regions; above normal in the Lake region and North Dakota, and below normal in the other geographic districts.

The averages for the various districts, with departures from the normal, are shown in the following table:

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	5.6	− 0.2	Missouri Valley	5.0	− 0.1
Middle Atlantic	5.1	− 0.3	Northern Slope	4.6	0.0
South Atlantic	3.6	− 1.1	Middle Slope	2.8	− 1.2
Florida Peninsula	3.8	− 0.8	Southern Slope	3.6	− 0.8
East Gulf	3.6	− 1.6	Southern Plateau	2.0	− 1.0
West Gulf	4.3	− 1.0	Middle Plateau	2.7	− 2.4
Ohio Valley and Tennessee	5.1	− 1.0	Northern Plateau	6.1	− 1.0
Lower Lake	8.4	+ 0.8	North Pacific	7.3	0.0
Upper Lake	7.3	+ 0.2	Middle Pacific	4.0	− 1.4
North Dakota	5.7	+ 0.5	South Pacific	2.4	− 2.0
Upper Mississippi Valley	5.5	− 0.2			

WIND.

The maximum wind velocity at each Weather Bureau station for a period of five minutes is given in Table I, which also gives the altitude of Weather Bureau anemometers above ground.

Following are the velocities of 50 miles and over per hour registered during the month:

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Block Island, R. I.	3	54	ne.	New York, N. Y.	21	57	nw.
Do	13	55	nw.	Do	26	62	nw.
Do	20	52	s.	North Head, Wash	1	52	se.
Do	26	50	nw.	Do	15	72	se.
Buffalo, N. Y.	11	51	sw.	Do	19	73	se.
Do	12	65	sw.	Do	20	50	sw.
Do	13	52	w.	Point Reyes Light, Cal.	11	57	nw.
Do	27	56	sw.	Do	16	50	se.
Cheyenne, Wyo.	20	54	nw.	Sand Key, Fla.	26	56	n.
Chicago, Ill	27	52	sw.	Sioux City, Iowa	25	50	nw.
Cleveland, Ohio	12	61	s.	Do	28	50	nw.
Do	26	52	nw.	Syracuse, N. Y.	13	57	s.
Columbus, Ohio	12	53	sw.	Do	21	50	nw.
Do	25	50	nw.	Tatoosh Island, Wash	3	56	e.
Denver, Colo	20	54	nw.	Do	4	52	e.
Eastport, Me	9	54	e.	Do	8	56	ne.
Do	10	55	ne.	Do	15	54	s.
Do	20	60	se.	Do	19	58	s.
Do	21	58	se.	Do	20	56	sw.
Lexington, Ky	12	54	s.	Do	24	62	e.
Do	25	52	w.	Do	25	64	e.
Nantucket, Mass.	20	50	s.	Williston, N. Dak.	2	60	nw.
New York, N. Y.	13	61	nw.				

ATMOSPHERIC ELECTRICITY.

Numerical statistics relative to auroras and thunderstorms are given in Table IV, which shows the number of stations from which meteorological reports were received, and the number of such stations reporting thunderstorms (T) and auroras (A) in each State and on each day of the month, respectively.

Thunderstorms.—Reports of 164 thunderstorms were received during the current month as against 386 in 1902 and 889 during the preceding month.

The dates on which the number of reports of thunderstorms for the whole country was most numerous were: 12th, 39; 25th, 24; 26th, 23.

Reports were most numerous from: Kansas and Louisiana, 17; Arkansas, 14; Georgia and Mississippi, 13.

Auroras.—The evenings on which bright moonlight must have interfered with observations of faint auroras are assumed to be the four preceding and following the date of full moon, viz: November 30 to December 8.

In Canada: Thunderstorms were reported from Victoria, 19. Port Simpson, 25. Hamilton, Bermuda, 27.

Auroras were reported from St. John, N. B., 13. Port Arthur, 31. Minnedosa, 21. Swift Current, 1. Calgary, 30. Edmonton, 20. Prince Albert, 21. Battleford, 4, 9, 13, 14, 20, 21.