TABLE I

Class (1)	Freq. (2)	Mid-points (3)	x (4)	y (5)	r (6)	z (7)	$y^2 \times 10^2$ (8)	$y^2z \times 10^2$ (9)	z^2 (10)	$y^2z^2 \times 10^2$ (11)
0.0–0.1	5	0.05	0.5	0.005	1	0.0025	0.0025	0.00000	0.0000062	0.00000
0.1–0.2	18	0.15	1.5	.018	2	.0140	.0324	.00045	.0001960	.00000
0.2–0.3	40	0.25	2.5	.040	3	.0430	.1600	.00688	.0018490	.00029
0.3–0.4	33	0.35	3.5	.033	4	.0795	.1089	.00865	.0063202	.00069
0.4–0.5	60	0.45	4.5	.060	5	.1260	.3600	.04536	.0158760	.00572
0.5–0.6	75	0.55	5.5	.075	6	.1935	.5625	.10884	.0374422	.02106
0.6–0.7	80	0.65	6.5	.080	7	.2710	.6400	.17344	.0734410	.04700
0.7–0.8	93	0.75	7.5	.093	8	.3575	.8649	.30920	.1278062	.11054
0.8–0.9	82	0.85	8.5	.082	9	.4450	.6724	.29922	.1980250	.13315
0.9–1.0	73	0.95	9.5	.073	10	.5225	.5329	.27844	.2730062	.14548
1.0–1.1	74	1.05	10.5	.074	11	.5960	.5476	.32637	.3552160	.19452
1.1–1.2	55	1.15	11.5	.055	12	.6605	.3025	.19980	.4362602	.13197
1.2–1.3	52	1.25	12.5	.052	13	.7140	.2704	.19306	.5097960	.13785
1.3–1.4	57	1.35	13.5	.057	14	.7685	.3249	.24968	.5905922	19188
1.4–1.5	47	1.45	14.5	.047	15	.8205	.2209	.18125	.6732202	.14871
1.5–1.6	28	1.55	15.5	.028	16	.8580	.0784	.06727	.7361640	.05772
1.6–1.7	27	1.65	16.5	.027	17	.8855	.0729	.06455	.7841102	.05716
1.7–1.8	22	1.75	17.5	.022	18	.9100	.0484	.04404	.8281000	.04008
1.8–1.9	12	1.85	18.5	.012	19	.9270	.0144	.01335	.8593290	.01237
1.9–2.0	17	1.95	19.5	.017	20	.9415	.0289	.02721	.8864222	.02562
2.0–2.1	12	2.05	20.5	.012	21	.9560	.0144	.01377	.9139360	.01316
2.1–2.2	7	2.15	21.5	.007	22	.9655	.0049	.00473	.9321902	.00457
2.2–2.3	7	2.25	22.5	.007	23	.9725	.0049	.00476	.9457562	.00463
2.3–2.4	6	2.35	23.5	.006	24	.9790	.0036	.00352	.9584410	.00345
2.4–2.5	2	2.45	24.5	.002	25	.9830	.0004	.00039	.9662890	.00039
2.5–2.6	2	2.55	25.5	.002	26	.9850	.0004	.00039	.9702250	.00039
2.6–2.7	0	2.65	26.5	.000	27	.9860	.0000	.00000	.9721960	.00000
2.7–2.8	2	2.75	27.5	.002	28	.9870	.0004	.00039	.9741690	.00039
2.8–2.9	2	2.85	28.5	.002	29	.9890	.0004	.00039	.9781210	.00039
2.9–3.0	5	2.95	29.5	.005	30	.9925	.0025	.00248	.9850562	.00246
3.0–3.1	2	3.05	30.5	.002	31	.9960	.0004	.00040	.9920160	.00040
3.1–3.2	0	3.15	31.5	.000	32	.9970	.0000	.00000	.9940090	.00000
3.2–3.3	2	3.25	32.5	.002	33	.9980	.0004	.00040	.9960040	.00040
3.3–3.4	1	3.35	33.5	.001	34	.9995	.0001	.00010	.9990002	.00010
Sums						23.9220	5.8786 M_0	2.62878 M_1		1.48254 M_2

$p = \frac{M_1}{M_0} = 0.4472$; $q = \frac{M_2}{M_1} = 0.5640$; $m = 0.6695$; $n = 1.0634$; $k = 0.2743$; $m + n = 1.7329$.

TABLE II

z (1)	k (2)	1–z (3)	log z (4)	log (1–z) (5)	m log z (6)	n log (1–z) (7)	log y (8)	y×10 (9)	$\frac{1}{2}(y_k + y_{k+1}) \times 10$ (10)	Δx (11)	x (12)
0.000	0	1.000	------	0.00000	------	0.000000					
.001	1	.999	7.00000	9.99956	4.686500	10.633532	7.42926	0.02687	0.0348	0.28736	------
.002	2	.998	7.30103	9.99913	4.888039	10.633075	7.63034	.04269	.0552	.36232	10.17562
.004	3	.996	7.60206	9.99826	5.089579	10.632150	7.83096	.06776	.0782	.25575	9.88826
.006	4	.994	7.77815	9.99739	5.207471	10.631224	7.94792	.08870	.1065	.37559	9.52594
.010	5	.990	8.00000	9.99564	5.356000	10.629364	8.09459	.12434	.1600	.62500	9.27181
.020	6	.980	8.30103	9.99123	5.557539	10.624674	8.29144	.19563	.2247	.44504	8.89622
.030	7	.970	8.47712	9.98677	5.675432	10.619931	8.40459	.25386	.2791	.35829	8.27122
.040	8	.960	8.60206	9.98227	5.759079	10.615146	8.48345	.30440	.3270	.30581	7.82618
.050	9	.950	8.69897	9.97772	5.823960	10.610307	8.54350	.34954	.4372	1.14364	7.46789
.100	10	.900	9.00000	9.95424	6.025500	10.585339	8.72006	.52488	.5864	0.85266	7.16208
.150	11	.850	9.17609	9.92942	6.143392	10.558945	8.81156	.64798	.6923	.72223	6.01844
.200	12	.800	9.30103	9.90309	6.227040	10.530046	8.86721	.73656	.7675	.65146	5.16578
.250	13	.750	9.39794	9.87506	6.291921	10.501139	8.90228	.79851	.8184	.61095	4.44355
.300	14	.700	9.47712	9.84510	6.344932	10.469279	8.92344	.83838	.8487	.58914	3.18114
.350	15	.650	9.54407	9.81291	6.389755	10.435048	8.93403	.85907	.8609	.58079	2.59200
.400	16	.600	9.60206	9.77815	6.428579	10.398085	8.93589	.86276	.8569	.58350	2.01121
.450	17	.550	9.65321	9.74036	6.462824	10.357899	8.92995	.85104	.8381	.59659	1.42771
.500	18	.500	9.69897	9.69897	6.493460	10.313885	8.91657	.82522	.8058	.62050	0.83112
.550	19	.450	9.74036	9.65321	6.521171	10.265223	8.89562	.78636	.7609	.65712	0.26062
.600	20	.400	9.77815	9.60206	6.546471	10.210831	8.86653	.73541	.7043	.70992	0.86774
.650	21	.350	9.81291	9.54407	6.569743	10.149164	8.82813	.67318	.6368	.78518	1.57766
.700	22	.300	9.84510	9.47712	6.591294	10.077969	8.77849	.60047	.5592	.89413	2.36284
.750	23	.250	9.87506	9.39794	6.611353	9.993769	8.71435	.51802	.4723	1.05865	3.25697
.800	24	.200	9.90309	9.30103	6.630119	9.890715	8.63006	.42664	.3769	1.32661	4.31562
.850	25	.150	9.92942	9.17609	6.647747	9.757854	8.51483	.32721	.2741	1.82415	5.64223
.900	26	.100	9.95424	9.00000	6.664364	9.570600	8.34419	.22090	.1652	3.02663	7.46638
.950	27	.050	9.97772	8.69897	6.680084	9.250485	8.03980	.10060	.0870	2.29885	10.49301
.970	28	.030	9.98677	8.47712	6.686142	9.014569	7.80094	.06456	.0424	4.71698	12.79186
.990	29	.010	9.99564	8.00000	6.692081	8.507200	7.30851	.02035	.0151	3.31126	17.50884
.995	30	.005	9.99782	7.69897	6.693540	8.187085	6.98998	.00977	.0077	2.59710	20.82010
.997	31	.003	9.99869	7.47712	6.694123	7.951169	6.75452	.00568	.0037	5.40541	23.41720
.999	32	.001	9.99956	7.00000	6.694705	7.443800	6.24773	.00177	------	------	28.82261
1.000	33	.000	0.00000	------	0.000000	------	------	------	------	------	------

551.54 : 551.501

COMMENTS ON THE LAW OF PRESSURE RATIOS

By F. J. W. WHIPPLE

[6 Addison Road, Chiswick, London, W 4, January 2, 1924]

In his paper on "The Law of Pressure Ratios and its Application to the Charting of Isobars in the Lower Levels of the Troposphere," Dr. C. Le. Roy Meisinger has reached conclusions to which he has given some prominence but which seem to be based on insufficient evidence. The object of this letter is to point out that the argument by which Doctor Meisinger shows that there is a functional relation between his variables x and y shows also that there is an upper limit to the constant which he calls a.

It is convenient to make a small change from Meisinger's notation and write T_{sz} for the average value of the absolute temperature between the heights s and z.

By definition y is the ratio of pressures at the heights z and s kilometers above sea level so that $y = \exp(-zc/T_{sz})$, where c is a constant.

If T'_{sz} is the mean value of T_{sz} and ΔT_{sz} the departure from the mean, then,

$$y = [1 + zc\Delta T_{sz}/T'^2_{sz}] \exp(-zc/T'_{sz}).$$

Similarly, x, the ratio of pressures at the heights 1 and 2 kilometers may be expressed as follows:

$$x = [1 + c\Delta T'^2_{12}/T'^2_{12}] \exp(-c/T'_{12}).$$

Now the regression equation by which x and y are associated may be written

$$y = ax + b + \epsilon.$$

Here a and b are Meisinger's constants and ϵ is a residual varying term which is not correlated with x. The coefficient a can be found by the method of least squares; it is given by the equation

$$a = z \exp[(c/T'_{12}) - (c_z/T'_{sz})] (T'_{12}/T'_{sz})^2 (\sigma_{sz}/\sigma_{12}) r_{sz.12}$$

In this equation, σ_{sz} and σ_{12} are the standard deviations of T_{sz} and T_{12} respectively, whilst $r_{sz.12}$ is the correlation coefficient for those two variables.

In discussing the possible values of a it will suffice for our present purpose to confine attention to the case in which s and z are identical with 0 and 3, respectively. In this case, T_{12} and T_{sz} are the mean temperatures of columns both centered 1½ kilometers above ground. These two quantities will differ by very little from one another in ordinary circumstances and we may write as very good approximations:

$$T'_{12} = T'_{03}$$
$$\sigma_{12} = \sigma_{03}$$
$$A = 3 \exp(-2c/T'_{12}) r_{03.12}$$

For T'_{12} we may take the annual mean for the United States[1] $T'_{12} = 279$

It follows[2] that $\exp(-c/T'_{12}) = {:}8847$ and hence that

$$A = 3 \times {:}8847^2 r_{03.12} = 2.35 r_{03.12}$$

Now the correlation coefficient must be near to unity but it can not exceed unity. Hence 2.34 is the upper limit for the coefficient a for 3 kilometers.

The values obtained by Doctor Meisinger at two of his stations are 2.58 and 2.76, respectively. These figures seem to be too high; they could only be justified by the supposition that σ_{03} exceeded σ_{12} considerably. This might happen if the series of observations included a large number of "inversions" of temperature but the available evidence is against this supposition. The tables for the stations in question, Groesbeck and Leesburg in Gregg's "Aerological Survey of the United States" do not show any excessive frequency of cold air at the surface and moreover the observations which were utilized both by Gregg and by Meisinger were

[1] Gregg: *Aerological Survey of the United States.* MO. WEATHER REV. SUPP. No. 20, Table 6.

[2] *Computer's Handbook*, London, 1917. 11.2.44.

made with kites and could not have been obtained in the calm air which occurs with inversions. Thus it appears that the results obtained by Doctor Meisinger for the two stations in question can not be accepted without further investigation.

If these data be rejected then the variations in Meisinger's coefficient a are so insignificant that the characteristic features of his charts disappear. This would in fact be an advantage; for a general formula applicable to all parts of the region would be preferable to one suitable only for use within narrow limits.

I trust that Doctor Meisinger will find an opportunity to reexamine the results which have been called in question and that he will let it be known how the anomalous figures are to be explained.

DISCUSSION

I am very greatly indebted to Doctor Whipple for the consideration and constructive criticism he has given my article. Only the pressure of work relative to field activities of the Weather Bureau prevents me from attacking the problem from Doctor Whipple's point of view at once. This reexamination of the data which he has suggested must necessarily be deferred for several months.

The very gratifying thing about the criticism is that it points the way to a more equable distribution of the constant a over the country. On page 446, second and third paragraphs of my paper now under discussion,[3] the reader will observe that no effort was made to give the tone of finality to the explanation of the empirically determined geographical distribution of this constant. It was confessedly anomalous and Doctor Whipple's suggestions may help to ferret out the reason for the anomaly. While it is true that two of my values exceed that given by Doctor Whipple as a maximum, I may say that I have the utmost confidence in the arithmetical calculations by means of which those values were derived. It is, therefore, a matter of the keenest interest to me to approach the same body of data from another point of view.—*C. Le Roy Meisinger.*

282.271

PROBLEMS OF THE LOWER COLORADO RIVER

By James H. Gordon

[Weather Bureau, Yuma, Ariz., December, 1923]

The lower Colorado River is roughly defined as that portion of the stream below the 500 foot contour. It embraces some 350 miles of channel extending from the southeastern corner of Nevada to the Gulf of California. Along the lower third of this distance the river flows through its delta. It is in this delta country that most development has taken place and here, naturally, most of our problems have arisen.

The Colorado River as it comes to us out of the hills is a quiet and naturally law-abiding stream 10 months of the year. For the other two months it ceases to be quiet and is law abiding only because of strong levees that hold it in restraint. During this period, the time of the spring floods, it becomes a powerful, turbulent river. It is then a threat against every bit of development along its banks.

There is but one important tributary entering the lower Colorado. This is the Gila River. It is a typical southwestern stream flowing "sandy side up" most of the time but capable of staging floods of very serioue proportions occasionally. Fortunately, these floods come during the winter months and within the memory of man, at least, have never coincided with high water in the Colorado. Both the Gila and Colorado are hard working streams. Joining just above Yuma they bring down in an average year some 6,000,000 carloads of silt and sand, a hundred thousand acre-feet of soil, for their delta building.

Having this introduction to the river itself we may turn to its problems. One of them is of especial interest not only because of its importance to the delta country but because it is unique among the river problems of the United States if not of the world. The problem is best understood if traced back to its beginning. The beginning was a good many thousand years ago, about the time the Colorado River emerged from the hills to the north and joined forces with the Gila at Yuma. At that time the Gulf of California extended some 150 miles north of its present limits with an eastward extension to the neighborhood of Yuma. Into this eastern arm of the Gulf the Colorado and Gila poured their muddy waters. (See fig. 1.)

In the long period of time which followed the rivers brought down many hundreds of cubic miles of rock and sand and mud, the scourings of the Grand Canyon and the ten thousand lesser gorges, and the wash-off from 240,000 square miles of territory. The delta grew and filled in the eastern arm of the Gulf. The Colorado and Gila became one river and pushed the delta head farther and farther out until it reached clear to the western shore; built it up until it formed a dam cutting off the northern section of the Gulf from the ocean. (See fig. 2.) This, too, was a good many thousand years ago and the river has kept on building. To-day the dam, above sea level, is nearly a hundred miles wide. The course of the Colorado River lies between the twin crests of this delta cone more than 30 feet above the sea. It turns to the left toward the Gulf, 50 miles away. To the right lies the old sea bed, the Salton Basin, its lowest point more than 300 feet below the river level and but 70 miles away. (See fig. 3.)

One must wonder that the river takes the sluggish way to the Gulf instead of a grade nearly ten times as steep into Salton Basin. It is true that now there are levees to prevent its turning north, but long before the levees were built the river was taking the sluggish course rather than the steep one.

There is little question that the Colorado River has flowed into the Salton Basin a number of times during the last 10,000 years, turned from the Gulf to the old sea bed. Such a change stirs one's imagination. There would be the gradual preparation, the south side of the river building up a little higher each year with an added layer of silt, the north bank cut increasingly by overflow at flood time; then finally at some high water a cut would reach back clear through the north bank to the main channel, the river would feel the urge of the steeper grade and turn roaring onto the desert. It would be something to see, this turning of a mighty river into the dry, barren old basin, the growth of a sea in the desert, the blotting out of a million acres of sand. In 30 or 40 years the basin would be full to the brim, probably with an outlet to the Gulf to carry off the high waters of flood time. But the grade would be gone. Instead of roaring out onto the desert the river would flow sluggishly into a quiet sea to drop its load and start in again on the old business of delta building. With the passing years the river would shift back and forth, east and west, as a

[3] Mo. Weather Rev., September, 1923, 51: 437-448.