

# Change of Plumb Line referred to the Axis of the Earth as found from the Results of the International Latitude Observations

(the second paper<sup>1</sup>)

By Eiiti Nisimura

(Received July 30, 1937)

In continuation of the first study on the subject of this title by Prof. T. Shida and Prof. M. Matsuyama,<sup>2</sup> we analysed the data given in "Ergebnisse des Internationalen Breitendienstes von 1912.0 bis 1922.7 (von B. Wanach und H. Mahnkopf)." The Report contains the results of the six observing stations of north parallels ( $\varphi = +39^{\circ}8'$ ).

Mizusawa, Japan	$\lambda = -141^{\circ} 8'$	period, 1912.0-1922.7
Tschardjui, Central Asia	- 63 35	1912.0-1919.4
Carloforte, Italy	- 8 19	1912.0-1922.7
Gaithersburg, East America	+ 77 12	1912.0-1915.0
Cincinnati, Middle America	+ 84 25	1912.0-1916.0
Ukiah, West America	+ 123 13	1912.0-1922.7

And the present study was made of the results of the three stations—Mizusawa, Carloforte, and Ukiah, because of their continuous observations during the whole period.

The daily corrections read from the most probable curve of latitude at each station given in the Report, were applied to each observed value of each star-pair to eliminate the proper variation of latitude. The residuals thus obtained for each star-pair were divided into six sets (each containing two groups of stars), and in each set were arranged according to the hour-angle of the true moon at the time of observation of each star-pair. The mean of these six means shows the correlation of the moon's hour-angle and the latitude. The number of star-pairs used and mean hourly values obtained for three stations are shown in Tables I, II, III and Figs. 1, 2, 3. Analysing harmonically, multiplying by the augmenting factor and reducing to the

1. This paper was read at the Annual Meeting of the Physico-Mathematical Society of Japan, Osaka, 1935 April.

2. Mem. Coll. Sci. and Eng., Kyoto Imperial Univ., 4 (1912) 277-284.

mean inclination of the moon's orbit to the equator, the numerical values give the following expressions;

1912.0-1922.7

Mizusawa . . . . .	$0.''0032 \cos(2t - 260^\circ) \pm 0.''0014$
Carloforte . . . . .	$0.''0118 \cos(2t - 334^\circ) \pm 0.''0008$
Ukiah . . . . .	$0.''0105 \cos(2t - 11^\circ) \pm 0.''0013$

where  $t$  is the hour-angle of the true moon.

The slight difference between the present result and that formerly obtained in the first paper for Carloforte ( $0.''00878 \cos(2t - 356^\circ)$ ) is considered to be attributable partly to the point that in the present analysis the hour-angle of the true moon was used instead of the mean moon in the first study. The results obtained are certainly influenced by the secondary effect of the ocean tide, and for two stations—Carloforte and Ukiah—the roughly estimated values of these effects may account for the inconsistency of the results. For Mizusawa, the secondary effect alone can not serve as the quantitative interpretation of its peculiar result and the problem remains unexplained. We intend to obtain in the near future more accurate values by covering the longer period of observation with the same analysing method and eliminating the secondary effect of the ocean tide in more detailed points.

In conclusion the writer wishes to express his cordial appreciation to the late Prof. T. Shida, by whose kind suggestion and encouragement the present analysis was commenced and carried out. The writer's cordial thanks are also due to Messrs. K. Itô, T. Kawahara, and H. Hayasi for their kind help provided in the present computation.

Mizusawa

Table I.

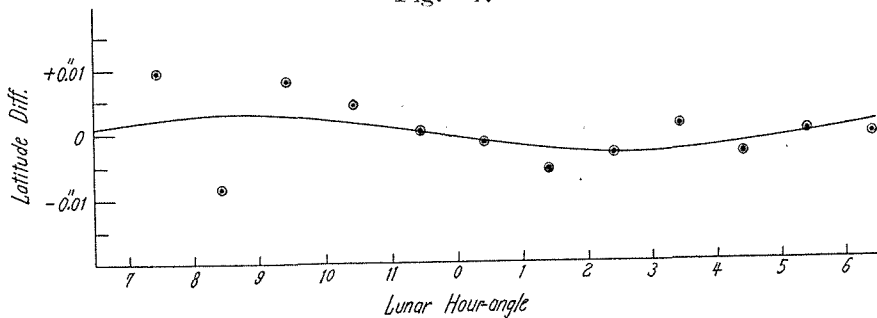
Number of Star-pairs

Hour-angle Group	0h	1	2	3	4	5	6	7	8	9	10	11
IV, V	204	228	251	242	247	239	241	259	293	290	286	273
VI, VII	264	263	299	323	315	298	286	243	236	239	283	270
VIII, IX	275	290	299	325	327	307	317	275	289	323	305	296
X, XI	310	316	308	280	306	299	318	290	326	349	337	308
XII, I	324	323	390	386	343	327	291	283	313	317	377	349
II, III	279	262	264	275	294	281	283	222	219	275	259	269
Sum	1656	1682	1811	1831	1832	1751	1736	1572	1676	1793	1847	1765

Mean Hourly Values

Hour-angle Group	0h	1	2	3	4	5	6	7	8	9	10	11
IV, V	0.6823	6868	6905	6639	6741	6836	6675	7029	6271	6819	7002	6909
VI, VII	6564	6389	6445	6486	6529	6345	6339	6252	5969	6286	6264	6237
VIII, IX	5204	5320	5402	5765	5487	5659	5493	5434	5263	5393	5177	5150
X, XI	6008	6096	6169	6313	6161	6334	6454	6637	6739	6579	6332	6325
XII, I	6736	6517	6568	6617	6585	6566	6760	6663	6742	6905	6915	6884
II, III	6759	6648	6595	6424	6479	6448	6417	6761	6705	6687	6763	6712
Mean	0.6349	6306	6332	6374	6330	6364	6356	6463	6281	6445	6409	6369
	-15	-58	-32	+10	-34	0	-8	+99	-83	+81	+45	+5

Fig. 1.



**Carloforte**

Table II.

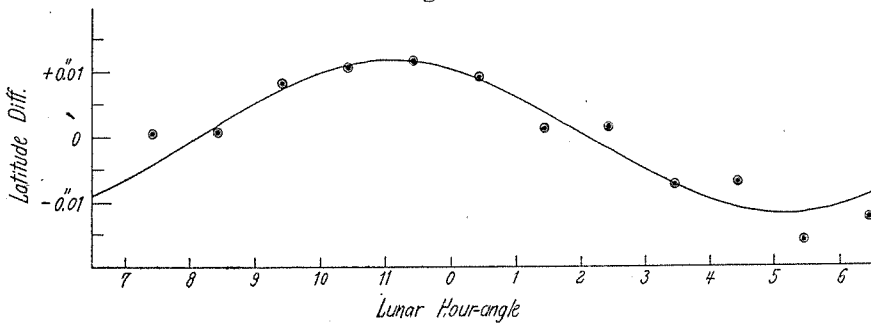
Number of Star-pairs

Hour-angle Group	0h	1	2	3	4	5	6	7	8	9	10	11
IV, V	227	203	215	208	226	262	305	294	239	226	238	225
VI, VII	277	294	288	292	307	287	285	257	257	250	259	239
VIII, IX	402	385	381	413	429	456	438	418	417	392	344	365
X, XI	621	586	593	601	656	719	720	756	757	745	704	659
XII, I	452	441	429	422	433	416	429	433	438	460	484	484
II, III	232	222	197	202	211	235	245	208	212	206	199	222
Sum	2211	2131	2103	2138	2262	2375	2422	2366	2320	2279	2228	2194

Mean Hourly Values

Hour-angle Group	0h	1	2	3	4	5	6	7	8	9	10	11
IV, V	1.0436	1.0059	1.0191	1.0060	.9918	.9737	.9798	.9789	.9825	1.0219	1.0227	1.0356
VI, VII	.9850	.9856	.9899	.9828	.9833	.9804	.9595	.9582	.9664	.9611	.9615	.9690
VIII, IX	.8791	.8746	.8782	.8852	.9042	.8920	.8941	.9010	.8834	.8774	.8684	.8761
X, XI	.9708	.9780	.9581	.9607	.9683	.9714	.9791	.9951	.9962	.9991	.9952	.9761
XII, I	1.0174	1.0064	1.0014	.9927	.9867	.9845	.9966	1.0149	1.0256	1.0243	1.0328	1.0358
II, III	1.0145	1.0121	1.0175	.9819	.9794	.9573	.9734	1.0094	1.0068	1.0221	1.0380	1.0312
Mean	0.9851	.9771	.9774	.9682	.9689	.9599	.9637	.9762	.9768	.9843	.9864	.9873
	+92	+12	+15	-77	-70	-160	-122	+3	+9	+84	+105	+114

Fig. 2



**Ukiah**

Table III.

Number of Star-pairs

Hour-angle Group	0h	1	2	3	4	5	6	7	8	9	10	11
IV, V	166	176	171	183	193	167	173	190	189	181	154	144
VI, VII	167	158	159	187	209	230	208	188	193	204	234	200
VIII, IX	223	201	234	251	277	259	254	244	269	270	235	235
X, XI	357	342	376	383	366	390	426	458	413	405	389	375
XII, I	339	352	366	370	376	369	348	361	348	336	345	363
II, III	170	164	190	206	224	221	211	205	206	190	191	186
Sum	1422	1393	1496	1580	1645	1636	1620	1646	1618	1586	1548	1503

Mean Hourly Values

Hour-angle Group	0h	1	2	3	4	5	6	7	8	9	10	11
IV, V	0.2648	2397	2022	2338	1955	2057	1602	1797	1811	2085	1926	2649
VI, VII	1519	1589	1718	1561	1515	1532	1375	1209	1456	1425	1191	1733
VIII, IX	449	482	507	351	464	460	465	523	645	443	748	337
X, XI	1088	1061	1044	1202	1276	1153	1234	1196	1452	1252	1451	1128
XII, I	1825	1870	1589	1615	1588	1526	1706	1764	1695	1852	1879	2275
II, III	2062	1998	2051	2444	2014	1838	1719	1857	2089	1830	1994	1920
Mean	0.1598 +91	1566 +59	1489 -18	1585 +78	1469 -38	1428 -78	1350 -157	1391 -116	1525 +18	1481 -26	1531 +24	1674 +167

Fig. 3

