SOME EFFECTS OF DIFFERENT SOURCES OF VARIATION OF LATITUDE DATA ON MERIDIAN CIRCLE CATALOGUES

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ABSTRACT

Fundamental meridian circle observations require the variation of latitude to be applied before the observations are combined to form a catalogue. In the past 80 years, different observatories have used various determinations of polar motion to reduce their observations. This study shows that the use of different determinations of the latitude variation significantly affects the individual observations and can introduce large zonal errors of the level of 0.05 seconds of arc into the catalogue's declination system.

INTRODUCTION

Fundamental meridian circle observations of declination, which are derived from zenith distance measurements, must be corrected for the variation of latitude caused by polar motion. Since the observations are made over a period of from six to ten years, the observations are corrected so that they are referenced to the same pole before they are combined. The meridian circle, as well as its observing program, are not well suited for the nightly determination of polar motion, making it necessary to use other sources. In the past 80 years, there have been two classes of sources used by the various observatories that do fundamental work. Some observatories use a local instrument which is devoted to determining polar motion, such as a photographic zenith tube or a floating transit. Users in this class believe that there is a local component of the variation of latitude that only a nearby instrument can detect. Other observatories use services that have global systems of instruments suited for determining polar motion, such as the International Latitude Service (ILS) or the Bureau International l'Heure (BIH). The user of the global services either have no local instrument for polar motion data or believe the determination made with a great number of instruments reduce the errors that a single instrument might introduce to its determination.

In the 1960s, the Naval Observatory made observations for two fundamental

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programs. One program was made with the six-inch transit circle located in Washington, DC, and is referred to as the W5-50. The observations of the W5-50 were reduced using the variation of latitude data from a local PZT - a practice followed since 1918. The Naval Observatory also operated a seven-inch transit circle in Argentina. That instrument did not have a local source for variation of latitude data, so its observations were reduced using the data from the BIH.

ANALYSIS

Computational experiments have been carried out to illustrate what changes to the makeup of the W5-50 would occur if it were reduced with a different source of variation of latitude data than the local PZT. Figure 1 shows the differences between the BIH and PZT data over the nine year period observations were made for the W5-50. Figure 2 shows an harmonic analysis of the differences. The most notable feature on the graph are the annual differences. Since the polar motion does have a large annual period that is believed to be caused by seasonal events, this annual difference between BIH and the PZT could be thought of as a true local, seasonal, effect. About two years after the PZT data was applied to the observations, the Time Service Division of the Naval Observatory revised the star catalogue used to reduce the PZT observations. The old catalogue was referred to as MC2 and the revised catalogue called MC3. The differences in the variation of latitude as a result of the two catalogues are shown in figure 3. A harmonic analysis of the differences (figure 4) show that the annual differences were cut in half. This means that most of annual term was a catalogue generated error and not a true local component of the variation of latitude. A comparison between the BIH and the revised PZT data (PZT(MC3)) (figures 5 and 6) still shows large differences between the two sources.

Given these differences in the sources of variation of latitude data, how do they affect the overall transit circle catalogue? Many observations of each star are combined to determine the final position and the combining might weaken any systematic differences between the sources. Nearly 99 thousand observations were used to derive the positions of some 15 thousand stars making up the W5-50. By knowing the date when each star was observed, a correction can be determined for each star to switch from one source of variation of latitude data to another. In this way it was not necessary to use the actual observational measurements made with the transit circle and the effect the variation of latitude data had on the catalogue could be seen more readily.

Figure 7 shows the stars of the W5-50 grouped into zones of right ascension and declination and the mean correction for each zone to change from BIH to PZT(MC2) results. A systematic effect as a function of right ascension can be easily seen. Using the improved PZT results derived with the MC3 catalogue shows some improvement (figure 8), but a significant systematic effect still appears. A determination for the pole using the stars observed both above and below the pole shows a shift in its position. Though I have not yet determined the effect the differences in the

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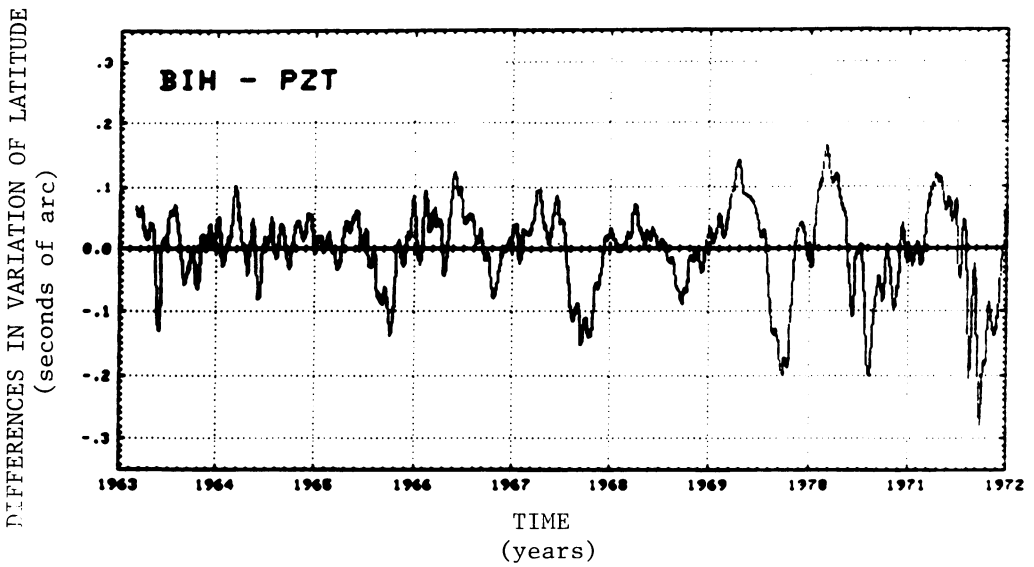

Figure 1 - The differences between polar motion data from the Bureau International de l'Heure (BIH) and the Washington PZT.

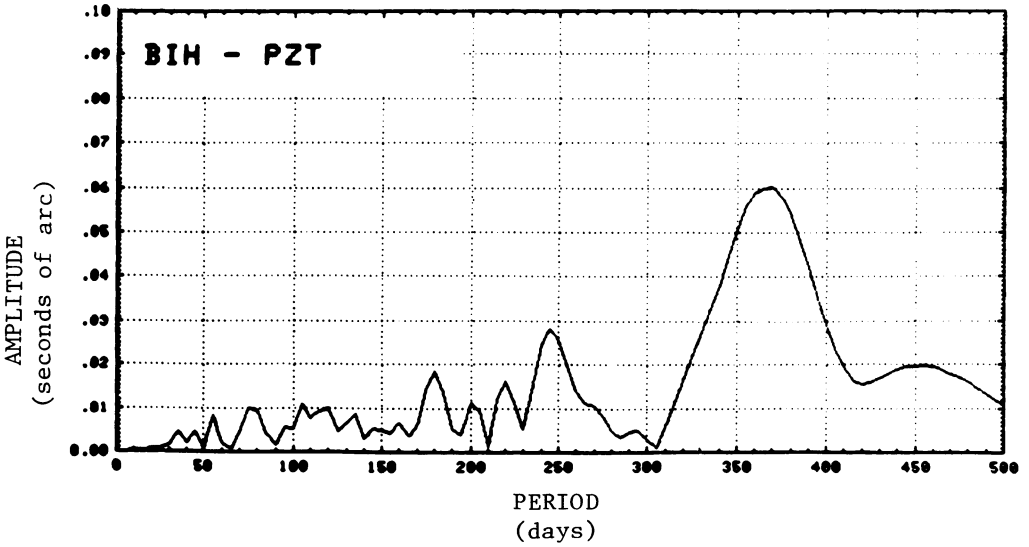

Figure 2 - Harmonic analysis of the differences between polar motion data from the BIH and PZT.

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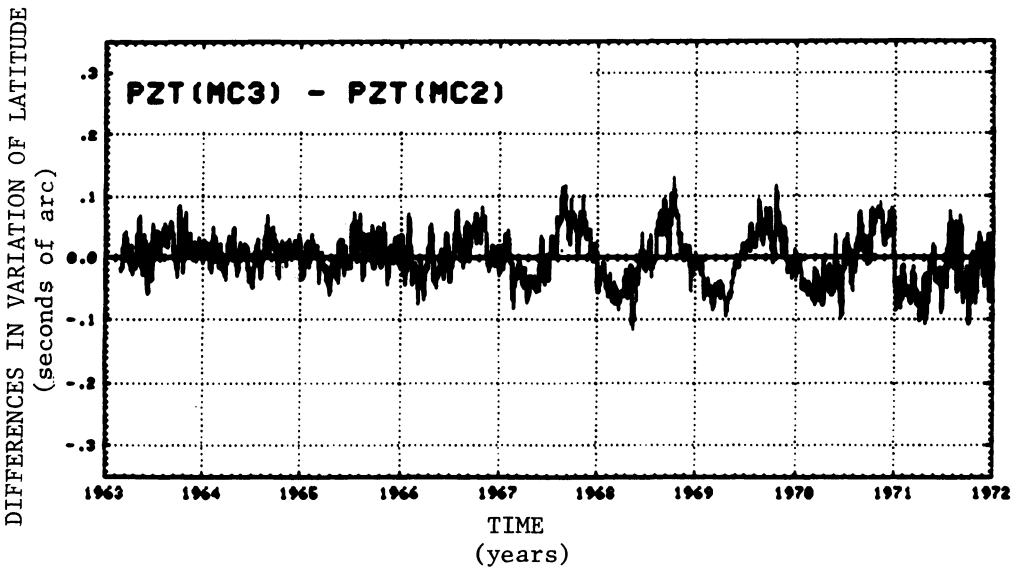

Figure 3 - The differences between polar motion data from the Washington PZT reduced with the star catalogues MC2 and MC3.

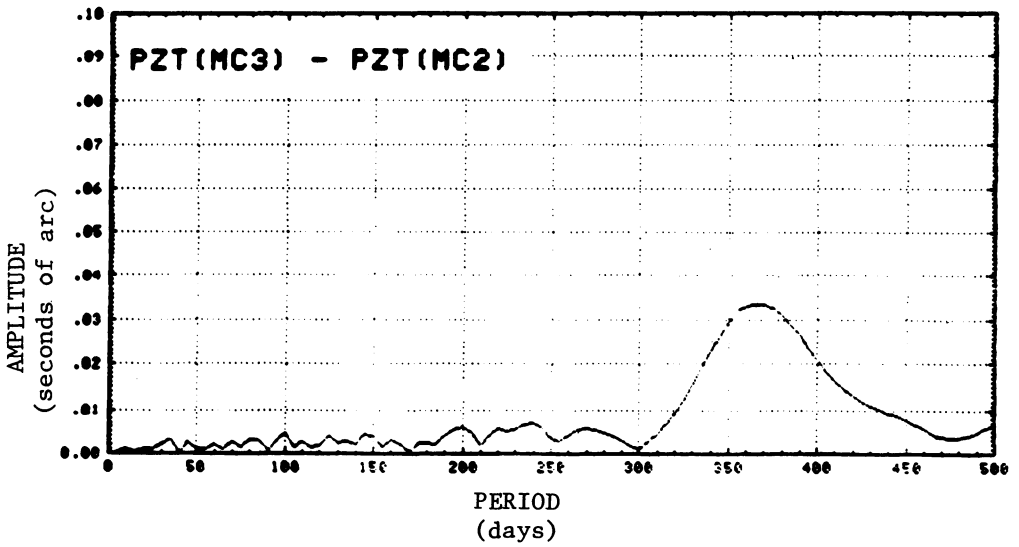

Figure 4 - Harmonic analysis of the differences between polar motion data from the PZT reduced with the star catalogues MC2 and MC3.

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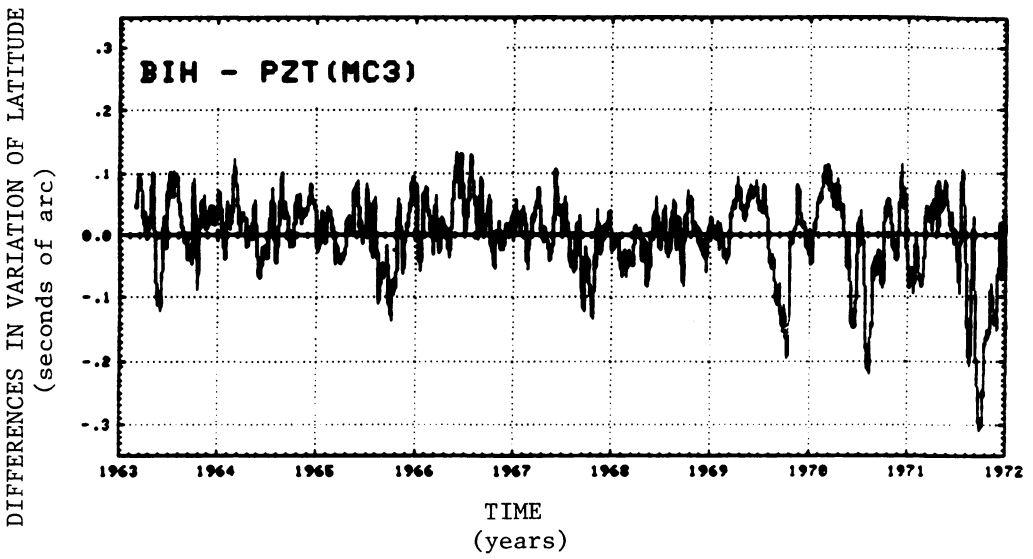

Figure 5 - The differences between polar motion data from the BIH and the PZT reduced with star catalogue MC3.

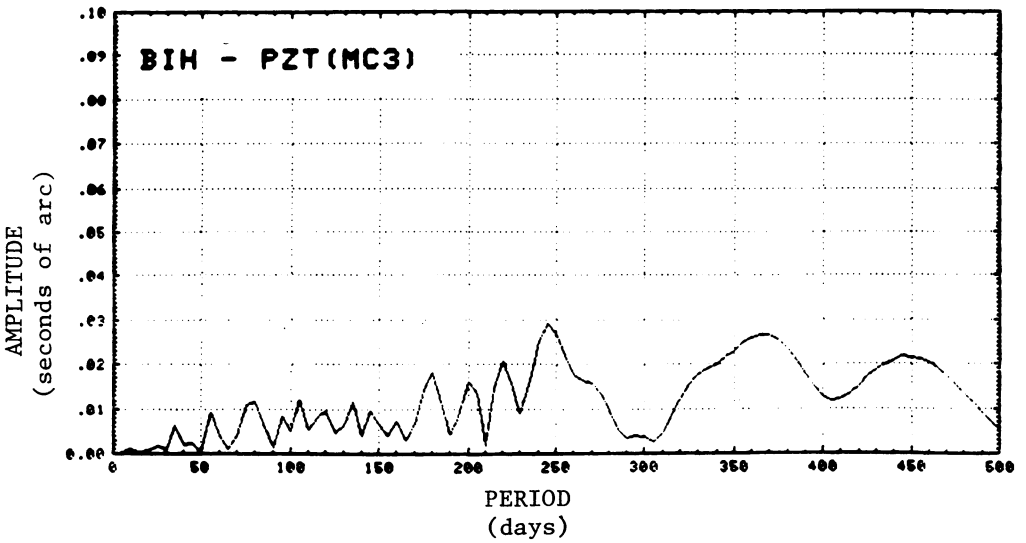

Figure 6 - Harmonic analysis of the differences between polar motion data from the BIH and the PZT reduced with star catalogue MC3.

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BIH - PZT(MC2)

RIGHT ASCENSION ZONES (HOURS)	-40 TO -30	-30 TO -20	-20 TO -10	-10 TO 0	0 TO 10	10 TO 20	20 TO 30	30 TO 40	40 TO 50	50 TO 60	60 TO 70	70 TO 80	80 TO 90	90SP TO 80SP	80SP TO 70SP	70SP TO 60SP
0	0	-79	-77	-74	-77	-39	-41	-31	-49	-37	-38	-37	-36	0	20	27
1	-57	-84	-75	-80	-72	-29	-41	-74	-33	-27	-38	-26	-45	11	10	39
2	-30	-74	-62	-66	-60	-36	-42	-31	-33	-33	-29	-28	-29	4	23	28
3	-11	-68	-66	-51	-67	-20	-40	-34	-41	-28	-34	-27	-18	29	25	22
4	-53	-78	-52	-52	-54	-26	-28	-32	-34	-37	-54	-24	-14	19	2	10
5	-57	-49	-40	-41	-54	-57	-33	-28	-54	-57	-12	-27	-15	6	7	0
6	-12	-28	-24	-25	-23	-21	-49	-18	-41	-17	-8	-15	-6	0	-45	-38
7	-34	-8	-11	-8	-12	-8	-1	-12	4	-2	-2	-8	-11	-48	-41	-71
8	0	24	11	10	11	15	20	7	-5	5	-12	13	-12	-39	-46	-46
9	5	7	12	16	12	10	25	8	18	17	28	8	-8	-56	-35	-46
10	23	29	24	28	26	12	32	17	16	13	19	10	7	-44	-35	-49
11	6	50	33	30	26	8	20	5	22	9	12	32	8	-41	0	-44
12	25	39	25	25	25	13	21	14	12	26	20	18	14	-34	-41	-66
13	0	41	24	20	22	14	23	13	19	7	26	27	14	-37	-47	-89
14	13	46	28	30	17	14	22	15	21	18	29	27	11	-32	-28	-80
15	22	46	28	29	25	19	36	17	14	20	18	26	14	-7	-48	-46
16	51	40	26	30	27	8	17	25	27	10	6	13	14	8	-36	-71
17	-30	16	27	17	12	0	13	-8	5	0	-11	-7	-8	-22	-24	-32
18	-7	-42	-20	-25	-22	-16	1	-19	-21	-18	-11	-24	-23	-39	-7	-22
19	-38	-67	-51	-49	-40	-24	-3	-20	-17	-22	-8	-18	-15	0	-25	-14
20	1	-85	-59	-60	-57	-26	-12	-19	-21	-27	-27	-39	-34	-23	18	17
21	-57	-91	-72	-72	-63	-31	-25	-35	-41	-36	-37	-46	-35	0	16	6
22	-47	-80	-61	-82	-69	-42	-27	-34	-35	-25	-38	-39	-36	-4	10	31
23	-156	-73	-75	-78	-73	-43	-35	-36	-42	-42	-46	-42	-35	12	28	16

DECLINATION ZONES (DEGREES)

Figure 7 - The differences in the zenith distances (units are in 0.001 seconds of arc) of the 15,046 stars making up the W5-50 catalogue caused by a change in using the polar motion data from the BIH and the PZT reduced with star catalogue MC2.

BIH - PZT(MC3)

RIGHT ASCENSION ZONES (HOURS)	-40 TO -30	-30 TO -20	-20 TO -10	-10 TO 0	0 TO 10	10 TO 20	20 TO 30	30 TO 40	40 TO 50	50 TO 60	60 TO 70	70 TO 80	80 TO 90	90SP TO 80SP	80SP TO 70SP	70SP TO 60SP
0	0	-24	-20	-14	-21	-3	4	16	0	8	11	13	12	0	36	27
1	-6	-27	-21	-24	-19	15	5	-46	13	18	6	15	-1	18	16	41
2	9	-22	-12	-15	-11	6	-6	10	7	10	8	9	9	8	28	22
3	22	-24	-22	-15	-29	15	-6	7	0	12	3	7	16	25	30	27
4	-18	-34	-20	-22	-18	4	6	1	1	-3	-15	5	5	13	16	28
5	-1	-12	-15	-14	-10	-41	-17	0	-36	-33	6	-1	-7	16	23	22
6	-3	-8	-4	-8	0	-1	-36	1	-40	9	10	6	14	0	-15	-19
7	-20	4	3	7	5	7	15	-8	16	18	18	4	11	-10	-8	-44
8	0	17	18	13	16	18	18	18	-4	5	-8	24	17	9	-7	-13
9	10	4	12	14	13	14	18	14	27	24	29	10	14	-16	5	-10
10	28	14	12	18	21	18	24	23	20	19	20	8	15	-7	3	-17
11	11	30	17	16	15	13	17	13	20	12	12	15	11	-5	0	-7
12	18	22	9	10	13	25	24	15	16	15	22	21	17	1	5	-27
13	0	23	14	8	11	21	27	19	30	10	13	37	32	3	-7	-28
14	15	33	14	18	7	25	30	24	29	31	45	28	-1	-8	6	-17
15	31	32	13	16	14	31	31	24	22	28	22	22	16	-1	-11	-18
16	24	26	9	13	14	16	19	23	21	20	20	21	11	-1	-1	-56
17	4	15	19	13	10	17	25	12	19	20	10	17	5	-6	3	-11
18	24	-10	-3	-6	-4	16	15	6	3	15	20	4	0	-13	15	9
19	2	-18	-17	-21	-7	13	25	12	16	3	25	2	20	0	4	11
20	35	-31	-17	-16	-15	12	19	17	20	13	9	-1	8	15	25	22
21	-42	-28	-21	-18	-13	12	5	2	2	10	2	-10	11	0	22	10
22	5	-23	-21	-24	-11	0	12	6	8	15	3	1	7	14	19	30
23	-118	-17	-14	-19	-15	3	5	11	2	4	-1	0	11	23	22	15

DECLINATION ZONES (DEGREES)

Figure 8 - The differences in the zenith distances (units are in 0.001 seconds of arc) of the 15,046 stars making up the W5-50 catalogue caused by a change in using the polar motion data from the BIH and the PZT reduced with star catalogue MC3.

variation of latitude data will have on the solution for the equinox, it appears, since there is a tilt of the equator that there will be a shift in the position of the equinox.

Other global services, such as the International Polar Motion Service (IPMS) or ILS, show good agreement with the BIH. The fact that the ILS data does agree rather well with the BIH and IPMS is important, even though ILS is no longer in operation. The Naval Observatory plans to rereduce its older observations to form the basis for a combined fundamental catalogue. To do this, we will undo the correction for the variation of latitude applied to the observations and apply the ILS results. The fact that the ILS data goes back to the turn of the century makes its results very useful in putting all of the catalogues on the same base.

CONCLUSION

Significant systematic changes in the makeup of a meridian circle's catalogue can be introduced just by changing the source of variation of latitude data used to reduce it.

REMARKS

In the past decade, other sources of variation of latitude data have become available, such as VLBI, LASER and Doppler. What polar motion data will be used in the future will likely depend on the results from project MERIT - an intense, international one year study of polar motion that is currently underway.

Discussion:

MORRISON: Doppler data from Satellites have been available since the early 1970's. Was any use made of these?

RAFFERTY: My study covered the period 1963-1971. Doppler results were not available until after 1968. Since results from the same source should be used over the entire discussion period on the meridian circle program, I could not use the Doppler results. The observing program the USNO just completed for the W6-50 will have Doppler results covering the whole program and I plan to use Doppler results in my next study.

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