ERRORS IN POLE COORDINATE OBTAINED BY THE DOPPLER SATELLITE POSITIONINGS

S. Takagi
International Latitude Observatory of Mizusawa
Japan

ABSTRACT

The pole coordinate obtained by the Doppler observation of Earth satellite shows good results, but there are some important difference from those of the astronomical observation, for example, that of the IPMS.

The Doppler observation of the Navy Navigation satellite has proved to be precise enough to supersede the astronomical observation in the geodynamics. (Anderle, 1965, 1966, 1970, 1971a, 1971b, 1971c, 1974). Yumi et al. (1979) showed that the local terms in the astronomical observation was not found in the Doppler latitude obtained at Mizusawa. This shows the superiority of the Doppler observation to the astronomical one.

However, our investigations show:

a. Pole coordinate obtained with the Doppler observation has a large secular variation (about 0."02 per year) with respect to that of the IPMS (Report of the IPMS at the IAU Meetings, 1979).

b. Doppler latitudes derived from north and southbound passes of a satellite show systematic differences (Kakuta et al., 1979).

c. Doppler latitude shows some unexpected deviation from the astronomical latitude (Takagi, 1974).

It will be necessary for us to make detailed theoretical analysis of errors in the Doppler data before we proceed to use the Doppler results in place of the astronomical ones in the studies of geodynamics. Lambeck (1971) investigated effects of pole motion in the orbital elements of an Earth satellite. Takagi (1975) summarized theoretical results which should be considered in deriving pole coordinates from the results of the Doppler observations of an Earth satellite. O'Tool constructed a precise system of reduction of the Doppler satellite observation (O'Tool, 1976).

E. M. Gaposchkin and B. Kołaczek (eds.), Reference Coordinate Systems for Earth Dynamics, 229–231.

The reduction method of the Doppler observation has been developed by several organizations for the geodetic use, (Anderle, 1974; Beuglass, 1975; Smith et al., 1976). The principles of these methods are not essentially different from each other. The pole motion derived from these methods has complicated correlations with errors in the orbital and instrumental parameters (Anderle, 1974; O'Tool, 1976).

The reduction method is: the data for twenty one TRANET stations are used to determine eleven parameters to be applied to the two day span; two bias parameters in each satellite pass and nine parameters. The nine parameters are six constants of integration, pole coordinates, one scaling factor for atmospheric drag effect, while two parameters are a scaling factor for tropospheric refraction (a scale factor of unity is used as an apriori observation of refraction correction with standard deviation of 0.1) and a frequency bias parameter for each pass.

The perturbations in the satellite orbit include the Earth's gravitational field (up to 19 degree and higher order terms, over the total number about 400), the solid Earth tides (Love's number = 0.26), the solar and lunar attraction, atmospheric drag and direct solar radiation. The satellite orbit is computed by twelfth-order numerical integration of equations of motion.

The next step is to compute coordinates of stations with respect to the two bias parameters for each pass.

The random error in the pole coordinate is estimated as 7.4 cm and 6.8 cm in x and y respectively. The standard deviations of the individual pole position with respect to the mean position for a five day interval are 66 cm and 50 cm in x and y on the average (Anderle, 1976).

	Mean Difference				S.D. of Difference			
	DMA-BIH		DMA-IPMS		DMA-BIH		DMA-IPMS	
	x	y	x	y	x	y	x	y
1973	-.3	- .9	-.2	-1.2	.6	.8	.5	.6
1974	-.1	-1.1	.0	- .9	.5	.5	.6	.4
1975	-.4	-1.1	.0	- .5	.6	.5	.3	.6

S.D. of the Doppler Observation at Mizusawa
(1976.0 - 1977.5)

	Longitude	Latitude	Height (meter)
Daily Mean	0".015	0".018	$0^m.147$
5 Days Mean	0.027	0.032	0.288

https://doi.org/10.1017/S0252921100081306 Published online by Cambridge University Press

It is certain that we must make further investigations of the motion of the Earth satellite to get the true pole motion. The precision of the satellite observation is good enough to be used in the investigation of geodynamics and the further improvements of the theory of motion of the satellite affected by the geophysical phenomena, such as, pole motion, will be expected to promote the studies in the geodynamics.

The orbital elements obtained from the satellite observation are combined with the reference system which can not be revised from the observation itself, for the orbital elements to be improved appear in combination with parameters which are to be determined simultaneously. Accordingly, parameters, such as, precession and nutation, should be determined from another point of view. This fact means that the reference system determined from Doppler observations should be to be compared with the fixed reference system determined from the so-called astronomical observation, such as astrometry and VLBI.

REFERENCES

Anderle, R. J., 1965, J. Geophy. Res., 70, 2453-2458.

Anderle, R. J., 1966, in The Use of Artificial Satellite for Geodesy 2, G. Veis, editor, National Technical University, Athens.

Anderle, R. J., 1970, NWL - Technical Report, TR-2432.

Anderle, R. J., 1971a, NWL - Technical Report, TR-2508.

Anderle, R. J., 1971b, NWL - Technical Report, TR-2559.

Anderle, R. J., 1971c, NWL - Technical Report, TR-2889.

Anderle, R. J., 1974, J. Geophys. Res., 79, 5319.

Beuglas, L. K., 1975, NSWC/DL - Technical Report, TR-3173.

Kakuta, C. et al., 1979, J. Geod. Soc. Japan, 25, 194-208.

Kakuta, C., 1978, in The Use of Artificial Satellite for Geodesy and Geodynamics. G. Veis and E. Livieratos, eds., National Technical University, Athens.

Kozai, Y., 1975, Orbit of an Artificial Satellite. Special Publ. of NHK, Japan (Excellent summaries of his discussions on the motion of the artificial satellite and we referred to this book without notice).

Lambeck, K., 1971, Bull. Geod., 101, 263.

Lambeck, K., 1973, Celes. Mech., 7, 139.

O'Tool, J. W., 1976, Proc. Int. Geod. Symposium, Satellite Doppler Positionings, 2 (Las Cruces, USA). DMA editor.

Smith, R. W. et al., 1976, Technical Report No. DMATC 76-1.

Takagi, S., 1974, Proc. IAU Colloquium No. 26 (Torun).

Takagi, S., 1975, Publ. Int. Lat. Obs. Mizusawa, 10, 53-108.

Takagi, S., 1977, Publ. Int. Lat. Obs. Mizusawa, 11, 57-75.

Yumi, S. et al., 1979, Proc. Int. Geod. Symposium. Applied Research Laboratory, University of Texas, Austin.