19. ROTATION OF THE EARTH (ROTATION DE LA TERRE)

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1. INTRODUCTION

It is to be first noted during the past three years that the former Director of the Central Bureau of the ILS, G. Cecchini has published the Results of the ILS from 1949.0 to 1962.0, Vol. XI under the support of the Italian Geodetic Commission in 1973. Here we express our hearty thanks and high esteem for his assiduous work completed after his retirement. It is of deep significance for investigating polar motion that all the definitive results of the ILS have been published by the respective central bureau up to 1962.0 when the ILS was reorganized into the IPMS. Consecutively, the revision of all calculations of the ILS data under a unified system is now nearing completion.

It has been reflectively discussed among several authors what can be derived from the conventional astronomical observations. Relating to this subject, the *IAU Colloq.* **26** on 'Reference Coordinate System for Earth Dynamics' was held at Toruń, Poland in 1974.

It has also become the future programme of work in the field of Commission 19 how to arrange and organize the continuing development of new techniques such as Doppler tracking and laser ranging of artificial satellites; lunar laser ranging; very-long baseline interferometry (VLBI) into new international services for determining the rotation of the Earth.

2. CHANGES IN INSTRUMENTATION

Lists of the instruments collaborating in international programmes are published in the Annual Reports of the IPMS and of the BIH.

Cagliari: a Wanschaff zenith telescope, VZT2 ($a = 8$ cm) has been installed in the Astronomical Observatory of Cagliari on 39°08′12″ and parallel observations with VZT1 at Carloforte have been commenced in the summer of 1975. The old Mizusawa PZT is scheduled to be installed in the near future.

Hamburg: an astrolabe which had been used for time and latitude observations at Braunschweig was removed to the Deutsches Hydrographisches Institut at the beginning of 1973. Determinations of UT and latitude with the PZT have been continued. For current check of the carriage motion a moire fringe displacement transducer was installed.

Herstmonceux: the Danjon astrolabe was equipped with a new timing unit which records micrometer contact-times through a paper-tape punch. The objective prism was also replaced by a reflecting prism made of cervit. A new control console has been installed and a new rotary drive powered by a stepping motor has been manufactured. The work in progress is directed towards the complete automation of night observing.

Kitab: a PZT was removed from Pulkovo and installed at Kitab in 1975. The PZT is scheduled to commence operation in 1976.

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Mizusawa: a new PZT was brought into service in March 1974 and a new star programme for the ILS PZT chain was used.

Potsdam: a PZT was brought into service in March 1974 at the beginning of 1975 (1).

Uccle: a second Danjon astrolabe has been used simultaneously with the first astrolabe from January 1972 to December 1974. The differences between the mean coordinates in longitude and latitude deduced with both instruments are in fairly good agreement.

Washington: PZT3 has been automated in 1975 and PZT6 has been tested at Richmond. The installation of the 65 cm PZT has been completed and is currently undergoing tests. A new astrolabe replaced the previous one in 1974 and an improved motor has been installed in 1975.

3. RESEARCH IN INSTRUMENTATION AND ASTRONOMICAL REFRACTION

A bubble shift of the Talcott level due to temperature difference between both ends of the level has been experimentally confirmed to be about $0''.57$ per $0^\circ.1$ C at Mizusawa (2). An electromagnetic level (TEM) has been attached to the zenith telescope and simultaneous comparisons with the Talcott level are continued since October 1973 at Mizusawa. At Hamburg the PZT observations were sometimes made through an inverted chimney and then the instrument was surrounded with a cabin ranging from the roof to the fundament. For ventilation, air was exhausted at the bottom. The scatter of the results proved to be greater with this arrangement than with the roof open. At Mizusawa the new PZT which is installed in the underground air-conditioned room shows fairly good agreement in time and latitude results with the old one, but it has become necessary for preventing the effect of discontinuous distribution of air-temperature between the ground surface and the objective lens to modify the air-conditioning at times (3). The new photoelectric transit instruments (PPI-2A, PPI-2B), which are insensitive to thermal effects, have been constructed by N. N. Pavlov at Pulkovo. Some improvements on the Danjon astrolabe are in progress, such as the command of a new driving system for the micrometer and the installation of a digital tape recorder for its contacts at San Fernando.

Some features of the wind effect at night and daytime latitude observations with the VZT have been studied by N. A. Popov and O. V. Chuprunova (4). The present state and future of the refraction investigations was published by the edition of G. Teleki as the Proceedings of the Study Group on Astronomical Refraction (SGAR) of Commission 8 in 1974 (5). C. Sugawa *et al.* investigated the mean characteristics of refraction in the northern hemisphere (6). T. Goto has pointed out that inversion layers of temperature passing over a station may affect accuracies of time and latitude data at the station (7). O. A. Mogilin is investigating the temperature field around the ZTL in Sternberg Institute in Moscow. V. V. Kir'jan and T. R. Kir'jan have organized the temperature investigations around the instruments in Pulkovo. G. Teleki is now investigating the physical causes of some strong diurnal variations in latitude at Kitab and Ukiah by using an aerological atlas of density.

4. DEFINITION OF REFERENCE SYSTEM

The adopted mean latitudes of the ILS stations which define the CIO have been re-examined by using the Melchior-Dejaiffe (MD) catalogue. E. Fichera has concluded that the CIO can be considered as a pole of inertia in the Albrecht-Wanach system, only if we use, for its definition, the mean latitudes 1900.0–1907.0 of the four stations (MCUG); but if the extrapolated mean latitude of Kitab, the definition of the CIO becomes arbitrary (8). K. Sato and Y. Wako have also confirmed that the adopted mean latitudes should be equally corrected by an amount of $+0''.149$ (at 1961.0) (9).

R. d'E Atkinson pointed out that the luni-solar nutation used in the ephemerides, including

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the Day Numbers, should correspond to that of the pole of figure and not to that of the instantaneous pole (10). Following the concepts of H. Jeffreys, E. P. Fedorov and Atkinson, M. Ooe and T. Sasao have discussed the relation of references between polar wobble, sway and astronomical observations. What can be derived from the conventional astronomical observations has been shown to be the direction of the axis of mean figure relative to stars. The polar motion which is determined by observations should correspond to the geographical motion not of the true pole but of the celestial pole of the adopted star catalogue. There exists a simple kinematical relationship between amplitude of the wobble and the sway. Their theoretical separation can therefore easily be performed (11).

5. REVISION OF OBSERVING CATALOGUES AND OF EARLIER OBSERVATIONS

At Paris the results of latitude observations with one Danjon astrolabe for the period 1956.5–1970.8 and those of time observations for the period 1956.5–1970.0 have been published (12). For the period of ten years the results of time observations at Potsdam and Prague have been analysed in order to study the influence of personal, local and instrumental errors in the derivation of seasonal variations in the Earth's rotation (13). At Mizusawa the results of latitude observations with the FZT under the FK4 system have been analysed for the period 1967–1972. The results of the FZT show the least values of errors as compared with those of the VZT's at the 5 ILS stations. The aberration constant has been deduced as $20''.512$ (14). Parallel observations with the new and old PZT have shown fairly good agreement (15). Tokyo Observatory is consecutively engaged in a programme of observations of PZT stars by the meridian circles for 14 observatories. Systematic differences between astrolabe and FK4 of $\Delta\alpha_\alpha$ and $\Delta\delta_\alpha$ type at Santiago have been analysed by F. Noël (16). At Herstmonceux joint chain method analyses of the PZT observations made at Calgary over the years 1968.5–1973.0 and at Herstmonceux over the years 1958.0–1973.0 in which, using the improved proper motions, errors in the adopted positions of stars have been computed. The new catalogue was introduced in both Calgary and Herstmonceux at the beginning of 1975. The earlier observations have since been reduced to the new system.

A supplementary list of stars has been observed in Washington and Rochmond. After corrections to their positions and proper motions have been evaluated, they will double the number of stars observed at each station. Plans have been formed to co-operate with the PZT in Mizusawa so that one improved catalogue for both Washington and Mizusawa instruments will be produced based on all observations of both stations. The corrections to proper motions of 34 Washington zenith stars have been obtained by E. I. Obrezkova from observations of scale pairs with the Poltava ZTL. Fedorov has discussed the relative positions and motions of different coordinate systems used by time and latitude services during the last century (17). New reductions and analyses of latitude observations have been carried out for the Pulkovo ZTF during 1948–1967 by V. I. Sakharov (18), for the Blagoveshchensk ZTL during 1959–1965 by G. S. Sheptunov (19), for the Poltava VZT during 1959–1965 by R. I. Popova (20) and for the Poltava Danjon astrolabe during 1961–1968 by A. A. Slavinskaya *et al.* (21). At Hamburg 16 stars of the PZT catalogue were replaced by new stars in order to keep the mean zenith distances of the star groups within the range of about 2′ for future 12 years. The new stars' positions and proper motions were derived from observations from 1963 to 1972. The star positions and proper motions used are still those of the System 1962. Intercomparison with AGK3, AGK3R, Washington 7″TC and Belgrade KSZ has resulted in:

	AGK3	AGK3R	Washington 7″TC	Belgrade KSZ
$\Delta\alpha$	$-0^s.001$	$+0^s.004$	$+0^s.010$	
$\Delta\delta$	$-0''.08$	$-0''.11$	$-0''.10$	$-0''.07$

At Uccle the observations performed from 1966 to 1972 have been reanalysed (22). For 64 stars observed at two passes (east and west) a catalogue of $\Delta\alpha$ and $\Delta\delta$ will be published at the end of 1975. A qualitative test of 106 meridian catalogues used for the Melchior-Dejaiffe system of the ILS have been performed by R. Dejaiffe (23). Systematic differences between the U.S.S.R. Time Service Catalogue and FK4 have been examined in Pulkovo (24). The pole coordinates from 1825.0 to 1897.9 have been computed by using the single station method of A. Orlov in the Peking Observatory (25).

Concerning the South parallel service, the Punta Indio and Mount Stromlo PZT's have obtained observations of the same stars from August 1971 to March 1972 and from June 1972 onwards. An analysis has shown that the results compare favourable with those of other pairs of the PZT.

6. RESEARCH IN PROBLEMS CONCERNING THE ROTATION OF THE EARTH

A. *Chandler Wobble*

Fairly reliable explanations on the excitation mechanism of the Chandler wobble have recently been presented by several authors. H. Jochmann has derived the excitation function of the annual motion and has found that about 70% of the Chandler wobble may have the same excitation function as the annual motion (26). Using the excitation functions of E. M. Hassan (1959) and N. Kikuchi (1975), M. Ooe has succeeded in simulating the Chandler wobble by the atmospheric excitation which is fairly similar to the observed Chandler wobble but has about 40% of its amplitude (27). C. R. Wilson also has computed a 70-yr long time series of the wobble excitation due to winds and airmass redistribution in order to estimate the atmospheric contribution to the Chandler wobble and has found some evidence of coherence between this atmospheric series and observed polar motion, supporting the hypothesis that the Chandler wobble is maintained by meteorological variation.

On the other hand, D. Pines and J. Shaham pointed out that a resonant coupling between seismic activity and polar motion has the right sign and strength to explain the pumping of the Chandler wobble as a consequence of in-phase release of elastic energy. They tried to interpret that the Chandler wobble and earthquakes may have a common excitation source, that is, the relaese of elastic energy stored in the Earth (28). F. A. Dahlen showed, based on the dislocation theory, that the seismic activity failed by two orders of magnitude to provide the necessary energy to polar motion (29). C. Sugawa and Ya. Yatskiv have determined the maximum entropy power spectrum of the monthly values of the seismic energy release.

Yatskiv *et al.* showed that there were no reason for adopting the two-component model of the Chandler wobble for the years 1846–1971 (30). D. D. McCarthy has evaluated the Chandler and annual variations of latitude using Washington and Richmond PZT observations. A two frequency Chandler variation has been indicated (31). Ooe *et al.* have analysed polar motion in the ILS for the years 1900–1968 by using an autoregressive and moving average model (generalized Walker and Young method) and have confirmed that the Chandler wobble has only one frequency. The Chandler period is $1^{y}\!.193$ and the value of Q is about 60. After having analysed the revolution angle of polar motion, N. Sekiguchi has discussed that multi-peaks of the Chandler spectrum may be attributed to the sudden variation of the Chandler period. Yatskiv found the parameters of the damping model of the Chandler wobble: period $T = 1.187 \pm 0.005$ yr and $Q = 40$ (32). The recent claim by Verhoogen, that viscous friction at the core-mantle interaction could damp the Chandler wobble at the observed rate (33), was shown by M. G. Rochester, Yatskiv and Sasao to be based on a mis-interpretation of the dynamics of wobble. Using Gan's value for the core viscosity ($\simeq 10^{-6}$ m^2 s^{-1}), viscous core-mantle coupling fails by a factor of $\sim 10^{10}$ to provide the necessary damping (34).

B. *Nearly Diurnal Nutation*

A. Toomre argued that the nearly diurnal wobble must be accompanied by a nutation of the rotation axis in space (sway) of amplitude hundreds times larger than the wobble (35). Toomre, Rochester *et al.* stated that earlier reports on the determination of this wobble can not be correct because the sway has not been observed (36). However, Fedorov *et al.*, Ooe and

Sasao have pointed out that this statement is not correct because astronomical observations are capable of giving nothing but the combination of effects of wobble and sway (37). As regards the nearly diurnal nutation term, Ooe detected the period of $23^h57^m06^s$ (sidereal time) with the amplitude of 0″.008 ± 0″.002 from residual latitudes of the ILS and other stations for the years 1962–1971 (38). Yatskiv *et al.* have pointed out the existence of both the retrograde (theoretically predicted) and forward motion with very close periods (39). Sasao and Yatskiv have tried to explain the observed forward motion by the ellipticity of the free diurnal wobble provided that the Earth's fluid core would be triaxial (40).

C. *Other Periodic Terms in Time and Latitude Observations*

Sugawa *et al.* found the periodicities of 19, 26 and 34 months in the ILS z term and discussed the relation between the meridionally asymmetric mass distribution of the Earth and z term (41). They also have discussed some correspondence between the decade variation of z term and a large-scale oceanic motion (42). Some remarkable correspondence between the strong variations of polar motion and those of the Kuroshio current and large earthquakes have been pointed out by T. Okuda *et al.* (43).

The correction to the annual solar nutation for the rigid Earth which was suggested by P. Melchior as the resonance effect of the liquid core, has been confirmed by K. Yokoyama that it is not likely to be required from the analysis of the semi-annual z term. The semi-annual z term of about 0″.01 may be attributed to some geophysical origin such as the variation of plumb line. The existence of a common 1.6-yr component has been confirmed significantly (44). He also has determined the nutation constant as 9″.203 by using the ILS z terms for the years 1955–1966 (45). Further, he has pointed out that a new term which describes an effect of the error in the semi-annual nutation term should be added to the equation of observation in the variation of longitude. A stable annual variation found in the newly added term has revealed a good correlation with the annual z term (46). Thus the role and nature of z term have been fully discussed during the past three years.

N. P. J. O'Hora analysed the fortnightly terms in time and latitude observations with the Herstmonceux PZT. His periodogram solutions disclosed three well defined terms with periods of 13.66, 14.19 and 14.77 days. Ooe has detected the same terms in latitude observations with the Mizusawa FZT (47). B. Guinot has determined the Love number k from the periodic waves of UT1 for the years 1967.0–1947.0 as 0.334±0.005(M_f) and 0.295±0.011 (M_m) (48). O'Hora investigated the semi-diurnal tidal effects in the PZT data at Herstmonceux, but the results are complicated because the deflections are associated with changes in the attraction of the proximate waters of the English Channel (49).

D. Djurovic has found a periodic term with the period of 122 days in (UT1-UTC) and polar motion (50). H. Krüger at Potsdam has found the same period of 11 years in the variations of the Earth's rotation and the geomagnetic field (51). The periodicities of the Earth's irregular rotation have been analysed for long years 1820–1970 at Shanhai Observatory and the observed variation of the Earth's rotation has been fitted with good accordance by a combination of 12 periods from 9 to 179 yr (52).

C. Wunsch studied a dynamical model of the ocean tide generated by the Chandler wobble and the damping of the Chandler wobble (53). Hosoyama *et al.* have investigated the tidal admittance in the northern hemisphere (54). PZT observations at Washington and Richmond show that both stations experience a normal responce to the effects of earth-tides at the semi-diurnal and fortnightly frequencies (55). PZT observations have been used to determine the amplitude of the dynamical variation of latitude (56). I. J. Rogowski has computed the effects of Oppolzer terms, annual parallaxes, and the variation of the vertical due to earth tides on the latitude of Jozefoslaw. I. Moczko has carried out an analysis of the periodical variations in time and latitude at Jozefoslaw. J. Rambousek has investigated the short periodic variations in latitude at Prague.

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D. *Secular Motion of the Mean Pole and Related Problems*

W. Markowitz confirmed that the westward secular motions of the mean pole indicated by the ILS, the IPMS and the BIH for observations made since 1962.0 are in reasonably good agreement (57). Utilizing time and latitude observations at a number of observatories, N. T. Mironov and A. A. Korsun have derived relative displacements of the zeniths of these observatories which are completely independent of polar motion (58). N. T. Mironov studied the nature of trend in latitude variations (59). The hypothesis that linear trends in latitude variations of the IPMS stations are random values has been shown by Fedorov and it does not contradict to observations from 1900 to 1972 (60). Abraham has pointed out that the libration appears to affect the phase of the Chandler wobble and has suggested that libration characteristics are due to time-dependent responces (61). R. O. Vicente has re-determined the mean period of the main libration by using the maximum entropy method of spectral analysis. Criticising F. H. Busse's theory, C. Kakuta *et al.* have discussed that it may be impossible to explain the main libration with the period of 24 yr in terms of the response of the mantle to the excited nutation of the rigid inner core (62).

E. Proverbio and V. Quesada have confirmed the existence of movements of continents by analysing a homogeneous series of the ILS observations and accurate longitude ones. The resulting rate has been found to be in good agreement with plate tectonics theory (63). M. Feissel carried out a measurement of the displacement of the Eurasian and American plates by using the 1962–1972 local drifts in latitude and longitude of 45 observatories with respect to the BIH system. The coordinates *d* found for the pole of their relative motion are in good accordance with the geophysical results, while the angular velocity is larger than the one admitted for the past 100 million years (64).

N. N. Pavlov has revealed that the longitude variations at Pulkovo during the years 1901–1972 and at Potsdam during the years 1903–1960 are in good agreement with the secular pole motion.

E. *Changes in the Rate of the Earth's Rotation*

S. Okazaki has investigated the amplitude changes of seasonal components in the rate of the Earth's rotation. He has found that the annual term has the amplitude enhancement of about 0.10 ms per day with a 6-yr period and this amplitude change shows a close correlation with the westerly zonal winds at 500 mbar level in the 35°–55°N zone (65). N. and A. Stoyko have studied an accuracy of the UT extrapolation for a short interval (about 15 days) at Paris and Washington (66). They have also re-examined the value of a tropical year at 1700.0 derived by Euler. A comparison between the value derived by Euler and that at 1900.0 determined by Newcomb indicates that the secular retardation of the velocity of the rotation per day is $0^{s}.00269$ per century. This result is in good agreement with De Sitter's value, $0^{s}.00240$ per century. They have confirmed that the amplitude of seasonal variation for the years 1934.0–1949.0 is more twice larger than that for the years 1949.0–1974.0 and that it may be attributed to the effect of water vapour on the electric circuit of a quartz clock (67).

K. Lambeck and A. Cazenave investigated the relation between the seasonal variations in the Earth's rotation and the global wind circulation and the high frequency part of the length-of-day spectrum. They have confirmed some evidence that the zonal winds will contribute to the long-period variations in the Earth's rotation which are usually attributed to core-mantle coupling (68). By combining these results with a theorem on the deformation invariance of the trace of the Earth's inertia tensor, Rochester and Smylie have been able to lower by a factor of three the upper limit on the spatial gradient of the gravitation constant *G* across the Earth's orbit and to show that the annual fluctuation in the geopotential deduced by Kozai was an order of magnitude too large, i.e. $|\Delta J_2| \lesssim 10^{-10}$ (69). L. V. Morrison has determined timings of 40 000 lunar occultations of stars from 1943 to 1972 to derive improvements to the Moon's orbital elements and difference between the ephemeris (ET), universal (UT) and atomic time (AT) scales. He has noted that any variation of *G* with respect to an atomic time scale will not be apparent and that an extension of the work of Spencer Jones to include observations since 1937 is urgently required (**70**). Rochester *et al.* have estimated the power input to the magnetic field in the Earth's core as a result of electromagnetic coupling of the core to the mantle during procession, taking into account inertial coupling due to the ellipticity of the core-mantle boundary. No more than 10^8 W is available, and this falls short by at least two orders of magnitude from the power required to drive the magnetic dynamo (**71**).

Time comparisons of the Timation III Earth Satellite of the U.S. Naval Research Laboratories (NRL) commenced in July 1975. Measurements at Herstmonceux are primarily concerned with clock comparisons, but they should also contribute to the geodynamical research of the satellite programme.

F. *Earth Tides*

The Greenwich Observatory has collaborated with the University of Manchester Institute of Science and Technology (UMIST) in studies of the requirements of a new tiltmeter which is being developed in UMIST. It is proposed to install the new instrument in the vicinity of Herstmonceux in order to be able to compare the observed tilting due to earth tides with the deflection of the vertical observed with the PZT. At Mizusawa an apparatus for absolute measurements of gravity is being constructed under technical collaboration of BIPM at Sévres.

H. Kinoshita has recalculated the principal nutation terms for the rigid Earth. Toomre suggested that the kinematic viscosity of the uppermost core fluid cannot exceed 10^5 stokes without affecting excessively the observed 18.6-yr principal nutation.

7. POLAR MOTION DETERMINATIONS FROM DOPPLER OBSERVATIONS

Regular polar motion determinations from Doppler observations of U.S. Navy Navigation Satellites, which began in 1969, continued through the report period. The pole position computations are usually made on the basis of Doppler observations of one satellite, although results have been obtained using as many as three satellites. The 18 stations contributing to the determinations in 1972 were joined during the period by observations in Florence, Ottawa and Calgary. Measurements of latitude variations were also begun at Grasse with respect to the orbit determined by the 21 stations directly participating in the Doppler polar motion determination.

The precision of the determination of the pole position corresponding to the random error of observation is about 6 cm (0.″002). However, errors due to uncertainties in the gravity field at atmospheric drag degrade the repeatability of the data to:

140 cm (0.″045) in the latitude of a station based on any five-day period of observation during the period 1964–1972,

70 cm (0.″023) in the latitude of a station based on any recent five-day period observation,

35 cm (0.″011) in a component of pole position based on a five-day period of observation of one satellite by a net of about a 20 stations.

20 cm (0.″006) in a component of pole position based on a five-day period of observation of three satellites by a net of about a 20 stations.

The actual accuracy could also be worse than the repeatability due to effects of gravity uncertainties, tide effects or other model errors; the value agreed with optical BIH data to about 50 cm (0.″016).

The responsibility for the computations of the satellite ephemeris and polar motion was transferred from the Naval Surface Weapons Center to the Topographic Center of the Defence Mapping Agency (DMATC) in April 1975. The computations are continuing without interruption.

Since June 1972, the Royal Observatory of Belgium has a Doppler tracking station operating in the range of frequencies 150–400 MHz and 162–324 MHz. The station operates semi-automatically and mainly the TRANSIT satellites are observed. The observations are integrated in the computations of the improved orbits used by the DPMS to deduce polar motion. An analysis of the station coordinates obtained by the Doppler method has been performed. The

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internal coherence (m.s.e. on coordinates deduced from each individual pass) is

0.″033 in latitude,
0.″079 in longitude.

The external coherence (m.s.e. of residuals obtained by comparison of the coordinates deduced from each individual pass and the mean coordinates) is

0.″083 in latitude,
0.″154 in longitude.

As the external coherence is greater than the internal one, it means also that the reference orbit is not homogeneous (72).

The Mizusawa Observatory also has a Doppler tracking station since February 1974.

8. REPORT OF THE BUREAU INTERNATIONAL DE L'HEURE

Since the 15th IAU General Assembly, the BIH continues to make available the values of UT1 - UTC and of the coordinates of the pole with a delay ranging from 1 to 2 months. The raw values are computed for every five-day interval from the data of classical instruments and, since 1972, from satellite data processed by the Defence Mapping Agency, USA. Table 1 shows the evolution in the number of participating instruments. The number of astrolabes is decreasing; moreover some of the remaining astrolabes are irregularly used. It must be reminded that the values of UT1 are not yet obtained on a current basis from the new techniques, and that the determinations of the pole path by satellites observations is not effected on a permanent international basis. The IAU should urge not to release the observational effort before the new methods are fully operational.

Table 1

Number of participating instruments

Year	Classical methods						New methods
	astrolabe	PZT	circum zenithal	zenith tel.	visual tr. instr.	photoel. tr. instr.	
1967	18	9	2	18	22	10	none
1971	21	12	2	20	15	11	none
1974	17	13	2	20	17	10	Doppler/sat$^{\alpha}$

α Defence Mapping Agency (Dahlgren Polar Motion Service).

The short term stability of the BIH results is gradually improving, as shown by Table 2.

Table 2

Square root of the Allan variance of the five-day raw values $\sigma(N=2, T=\tau=5$ days)

	1967	68	69	70	71	72	73	74
σ_x	0.″019	23	15	13	14	10	7	9
σ_y	0.″020	21	16	17	14	9	8	7
σ_{UT1}	0.ˢ0022	21	20	19	19	15	15	16

The introduction of satellite data reduced σ_x and σ_y by more than 50%. The improvement is not so apparent on UT1 which benefits indirectly only of the better values of the coordinates of the pole; moreover in the above figures are included some very short-term irregularities of UT1.

Statistical studies, performed in 1974–1975, showed that the long-term random noise (over several years) in x and y, and UT, deduced from astrometric observations alone, corresponds to the flicker noise model with the following levels (characterized by the Allan variance, independent of the sample time)

$$\sigma_x = 0.''006$$
$$\sigma_y = 0.''007$$
$$\sigma_{UT} = 0.^s0007$$

It is too early to know the noise model of the satellite data, and therefore of the global solution.

Tables giving the differences between the satellite data and the global BIH solution are published yearly in the BIH Annual Reports. On the other hand, Table 3 below gives the comparison of a purely astrometric solution (which is not published) with the global solution.

Table 3

Mean annual differences between the purely astrometric solution and the global solution including satellite data

Year	Astrometry x	Global y	Remarks
1972	0.″000	0.″000	1st year of global sol.
1973	−0.″001	+0.″001	
1974	−0.″001	+0.″001	

As we have obtained a noise model for each series of latitude and UT0 measurements, we are considering the possibility of improving the long-term stability by optimum filtering of the past data, in order to obtain the prediction of the systematic corrections to be applied. We thus put the emphasis on the goal of the BIH, which is to produce UT1 and the coordinates of the pole with the better accurracy within fixed delays. In particular, the BIH continues to operate a weekly service under a contract of the Jet Propulsion Laboratory, for the needs of space research; in some cases results were made available with a delay of one day only.

The study of systematic effects led us to the following actions and results.

(a) It was found desirable to apply corrections for earth-tides and daily forced nutation.

(b) A tentative determination of the tectonic plates motion was performed, but could be biased by errors in proper motions (73).

(c) The Love number k was derived from the waves M_f and M_m in UT1 (48).

(d) The celestial nutation associated to the quasi-diurnal nutation due to the fluid core was looked for, but not found; this shows that the amplitude of the quasi-diurnal nutation given by several authors is probably overestimated (74).

(e) Preliminary studies of the principal term of the nutation show that the conventional value of the nutation constant in longitude is too large.

In association with other scientific teams, studies of the new techniques of determination of the Earth rotation are in progress. A special attention was given to the Doppler Satellite observations (75) and a feasibility experiment of a new service using the satellite data will be undertaken in 1976. We intend to enter in the BIH computations the data of all techniques as soon as their systematic deviations are understood and/or can be allowed for. These new results are entered with the weights they deserve in the BIH system of weighting. We will thus realize a smooth transition from the old to the new techniques without changing the reference system for the pole path and UT.

B. GUINOT
Director of the Bureau

9. REPORT OF THE INTERNATIONAL POLAR MOTION SERVICE

A. *Present Status*

International Polar Motion Service has progressed steadily after its reorganization from the International Latitude Service at 1962.0. At the beginning of 1975, 60 observatories in 25 countries are in collaboration to the service with their 81 instruments for time and latitude observations. The Central Bureau collects all the available data of time and latitude observations made at the collaborating observatories. Data are examined carefully and brought into a uniform system for each observatory so that all of them could contribute to a derivation of the best solution of the pole coordinates.

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Daily values of the pole position as a solution of Doppler satellite trackings are also being collected from DMATC in USA as their polar monitoring service.

B. *Works Made during 1972–1975*

Preliminary summaries of the results of latitude observations have been published regularly in the *Monthly Notes of the IPMS* as a rapid service. The *Monthly Notes* which contain the results obtained during the *i*th month have usually been published at around the 20th of the (i+ 2)th month in order that the materials of the current month could be included as much as possible. This policy has, however, been changed in 1975 to publish at around the end of (i+1)th month in order to meet the users' requests.

After a careful examination on latitude data of all the IPMS stations we decided in 1974 to calculate the pole coordinates with reference to the CIO. Mean latitude referred to the CIO for each station was calculated by using latitude data in the past years after 1962. The weighting system for a combination of the results with several kinds of telescopes was examined. Then the monthly values of pole coordinates were calculated. Detailed description on them is given in the *Annual Report of the IPMS* 1972 (p. 9).

The pole coordinates IPMS for the years 1962–1972 and those for 1973 were published in the *Annual Report of the IPMS* for the years 1972 and 1973 respectively. The values for 1974 were given collectively in the *Monthly Notes* 1975, No. 1. The monthly values of the IPMS pole coordinates and the derived values for every 0ʸ05 have been given in parallel with those by the 5 ILS stations on each issue of the *Monthly Notes* and the *Annual Report* since then.

Time data were also examined carefully and the pole coordinates calculated from the results of time and latitude observations inclusive will be published in the *Annual Report* 1974 at the latest. They will be given in parallel with those by the 5 ILS's and by the IPMS as far as they are needed for a detailed studies on the polar motion in connection with the other fields of Earth Sciences.

All the past observation records of the ILS from its beginning were collected at Mizusawa and about 90% of them were punched on cards. Punching is scheduled to be completed in early half of 1976. Collection, punching and reduction of data are being made under supervision of the working group on the pole coordinates.

C. *Simultaneous Observations of Latitude at Carloforte and Cagliari*

It has been reported by Prof. Proverbio that latitude observations with a Wanschaff zenith telescope (8 cm) at Cagliari Astronomical Institute have been carried on from May 1975 simultaneously with those at Carloforte with a Wanschaff zenith telescope (10 cm).

D. *PZT Chain on +39°8′*

As for a cooperative observation of time and latitude with PZT's on the parallel of +39°8′ recommended by Commission 19 of the IAU (1955 Dublin, 1967 Prague and 1970 Brighton),

(a) Mizusawa already started PZT observation in 1956,

(b) Kitab has been equipped with the Pulkovo PZT in 1975 and test observations are being made,

(c) Cagliari which is not so far from Carloforte but in the mainland of Sardegna will be soon equipped with the old Mizusawa PZT,

(d) Gaithersburg will be covered by the large PZT of the US Naval Observatory in Washington which will be soon completed and

(e) Ukiah is going to be equipped with one of the old Washington PZT's.

E. *Future Plan*

The Central Bureau of the IPMS will enthusiastically continue its work as it has. It will

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collect and analyse not only the results of astronomical observations of time and latitude but also those by new techniques such as Doppler observations (already available), laser ranging of artificial satellites or Moon and even VLBI when they become available. They will be compared very carefully with each other to find relations among their systems.

The definitive results of the ILS during the years 1962–1966 will be prepared by 1976 separately from those after 1967 when the ILS star list was renewed.

F. *Problems on the Future Status of the IPMS and ILS*

The future status of the IPMS and ILS has been discussed very freely and seriously in the light of their responsibilities, effectiveness, reliabilities and of a recent progress in several methods of pole determination by new techniques. Many astronomers and geodesists who are concerned with and interested in this problem have met officially during the 16th General Assembly of the International Association of Geodesy (IAG) and have reached the following conclusions:

(a) IPMS and ILS should continue their activities as they have been.

(b) Systems of new techniques should be organized internationally as promptly as possible. The 5 ILS stations should be equipped with such an instrument as Doppler satellite tracking station. New systems should be compared with the current system by the IPMS, the ILS and the BIH to find a correlation between them.

(c) The visual zenith telescope at Carloforte should be maintained in its present site.

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Director

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