VERY FIRST RESULTS OF THE MEDOC EXPERIMENT

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It is already well known that the coordinates of the pole can be derived not only by the classical astronomical methods but also from analysis of the orbits of artificial Earth satellites. The MEDOC experiment (Motion of the Earth by Doppler Observation Campaign) has been initiated by the Groupe de Recherches de Géodésie Spatiale (GRGS) to provide observations and undertake independent analysis for this purpose. Several organisations are participating.

The very first results, presented here, are based on Doppler observations of a Transit satellite, made at 11 stations around the world during a period of 9 months.

Details of the processing and analysis of the data are also given.

1. OBJECTIVES OF THE EXPERIMENT

"Classical" astronomical methods have been used for many years in the determination of polar motion. The tracking of artificial Earth satellites now provides similar data; the analysis is undertaken by the Defense Mapping Agency Topographic Center (DMATC). It appeared to be desirable to investigate the sensitivity of the results to variations in the parameters used in the dynamical analysis, and the GRGS offered to undertake a similar determination with the following final objectives:

- to determine the extent of, and the reasons for, systematic differences between the results of various computer programs;
- to promote satellite techniques;
- to lay the groundwork for a scientific service.

Doppler data have been collected since January 1977 and the investigations are in progress.

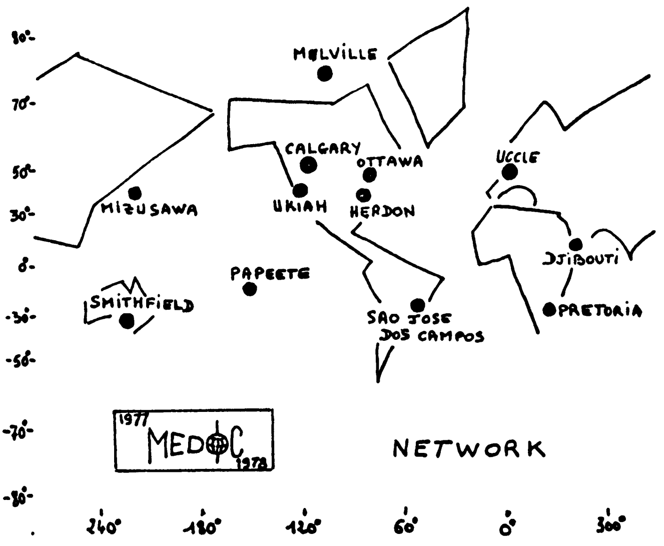
D. D. McCarthy and J. D. Pilkington (eds.), Time and the Earth's Rotation, 295–300.

2. THE ORGANISATION

One advantage of the Doppler satellite-tracking technique is that it permits operation in all weathers; moreover, the Transit satellite family and the corresponding Tranet network already exist and provide an operational service. The stations participating in MEDOC were chosen because they were foreign scientific institutions which could contribute not only by sending data but also by their scientific activity.

SMITHFIELD	. Division of National Mapping - Australia
MIZUSAWA	. International Latitude Observatory - Japan
UCCLE	. Observatoire Royal de Belgique - Belgium
OTTAWA CALGARY	. Earth Physics Branch - Canada
HERDON	. DMA Tranet Station - Virginia U.S.A.
UKIAH	. National Ocean Survey - California U.S.A.
MELVILLE	. Shell Canada - Canada (for a short period)

All the data from these sites are collected by DMATC and sent every week to GRGS by DMATC.



In order to optimize the balance of the network, GRGS (The Institut Geographique National, IGN and Centre National d'Etudes Spatiales, CNES) provides four receivers which are located in:

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DJIBOUTI	. Observatoire sismologique - Djibouti Republic
PRETORIA	. French Tracking station NTIR/CNES - South Africa
SAN JOSE DOS CAMPOS	. Instituto de Pesquisas Espaciais - Brasil
TAHITI	. Laboratoire de Geophysique de Pamatai - French Polynesia

These receivers are of the JMR type; they work in automatic mode and the data are recorded on minicassettes which are read at the computing center. At these four last sites "housekeeping" takes about half an hour per day.

3. DATA PROCESSING

3.1. Preprocessing

The raw data received at the computing center come from different types of receiver and must be preprocessed in order to:

- make them compatible with the measured quantity used in the programs; for each Doppler quantity we must have the number of accumulated cycles, the date at which the count starts and the time for which it lasts;

- ensure that all required quantities, such as meteorological information, and linkage with an accuracy of about 50 μs to a coordinated time scale, are known for each block of data;

- eliminate spurious data and measurements taken at low angles of elevation; the entire pass may be rejected, or only a few points near the start and finish.

3.2. Computations

Schematically, computing the polar coordinates for a two-day interval consists in integrating the equations of the motion of the satellite over that time, and in adjusting some of the parameters in these equations to better fit the observed measurements. The reference system is the inertial frame of dynamics. The geographical coordinates of the receivers located on the Earth have to be rotated towards this inertial frame, and in doing this the polar motion must be taken into account. We can either use given values of the components (for example, values from BIH publications) or introduce them as unknowns and try to determine them.

The motion of the satellite is computed from a force model which includes gravitation, due mainly to the Earth but also to the Sun and the Moon, atmospheric drag, solar radiation pressure, and the perturbation of the Earth potential due to the Earth tides. In addition, since we actually use the instantaneous reference system as our

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reference frame because this makes the calculations easier and saves computing time, we also have to take into account the apparent (Coriolis) forces due to precession and nutation.

The parameters which are determined by the least-squares fit are:

- six quantities giving the shape and orientation of the orbit;
- one scale factor for the atmospheric drag and one for the solar radiation pressure, because the knowledge of the effective area-to-mass ratio of the satellite is poor;
- one frequency offset for each pass over a station, to account for local oscillator variations; and
- two components of the position of the pole.

3.3. Station reference system

The geographical system is defined by the set of the coordinates of the participating stations; but, because these coordinates are also computed from Doppler measurements, the network is strongly correlated, at least at the tens of meters level, with the model of the Earth potential.

So far, in the MEDOC experiment, we have used the GEM X model from the Goddard Space Flight Center, and station coordinates are computed with respect to that model by an iterative procedure in which the orbit and the set of station coordinates are computed âlternately. Iteration is stopped when successive positions differ by only a few meters. Variations of the reference system with time show similar internal coherence.

4. POLE COORDINATES

4.1. Results

The coordinates of the pole at intervals of two days have been computed by this method for the period from 1977 January to October. The results are compared in the figure with the BIH smoothed values and the DMATC results; X and Y have their usual meanings, X being positive towards Greenwich and Y perpendicular towards the West in the plane perpendicular to the CIO Z-axis.

4.2. General remarks

The bias between the MEDOC solution and the others is attributed to the set of station coordinates used as the reference system; it will be removed when we have accumulated positions for several years.

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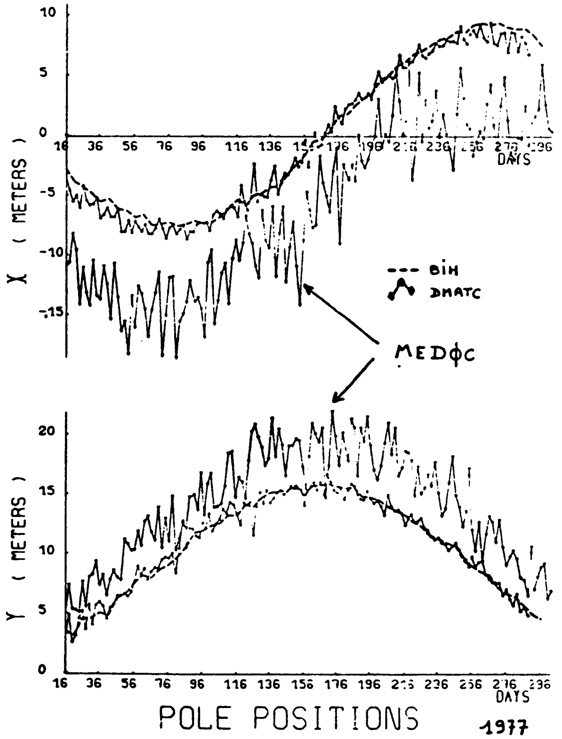
The most important jumps in both components are strongly correlated with the failure of several stations. The stability should be improved by the addition of suitably located stations to the network; it will also improve when the set of station coordinates has been refined to the one meter level and is less sensitive to the presence or absence of a single station.

Some preliminary spectral analysis shows significant peaks which correspond to periods having resonances with particular spherical harmonics in the development of the Earth's gravity field; examples are (13,13), (14,13) and (26,27).



POLE POSITIONS FOR NINE MONTHS

5. CONCLUSIONS AND FUTURE DEVELOPMENT OF MEDOC

The main difficulties arise from the need to maintain the network in routine operation. Receivers must be operated at remote sites at which it is difficult to get them repaired, and non-technical problems often increase the delay before the equipment is returned to use. An increase in the number of receivers will reduce these problems.

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The very first results are promising, but the objectives of MEDOC have not yet been reached. Observations are being accumulated and will be used, in the coming years, to construct a model of the Earth's potential which is appropriate for use with the polar satellite used in MEDOC. Analyses will then be made to investigate the influence of each assumed parameter on the derived coordinates of the pole. In addition, experience gained in collecting, transmitting and processing the data will be useful in studies relevant to the establishment of a permanent polar-motion service based on satellite techniques.

References

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Bowman, B.R., Leroy C.F.; DMATC Doppler Determination of Polar Motion. *International Geodetic Symposium on Satellite Doppler Positioning*, Las Cruces, October 76.

Guinot, B., Nouel, F.; MEDOC Experiment on the French Polar Motion Project. *International Geodetic Symposium on Satellite Doppler Positioning*, Las Cruces, October 76.

DISCUSSION

D.D. McCarthy: How many stations would be required to provide a permanent service delivering an accuracy of 0.01 arcsec, assuming that their distribution was good?

F. Nouel: I suppose that something like 15 stations would be needed if we could start with a good model of the Earth potential; but construction of the model would need more than 15 stations, or another technique such as altimetry.