REPERTOIRE DE PUBLICATIONS CONCERNANT L'EFFET DE L'ENVIRONNEMENT SUR LA MESURE DE LA PESANTEUR

par

Richard Bastien

Rapport interne 86-03

Div. de la Gravité, Géothermie et Géodynamique,
Direction de la Physique du Globe,
Ministère de l'Energie, Mines et Ressources,
1 Prom. de l'Observatoire,
Ottawa, Canada,
K1A 0Y3

INTRODUCTION

La présente bibliographie a été répertoriée afin de servir comme source de références et de documentation pour les travaux de recherches entourant l'utilisation du gravimètre absolu et principalement pour orienter l'étude des effets de l'environnement sur la mesure de la gravité.

Le rapport est composé de deux parties: la première comprend une liste alphabétique selon l'auteur, avec le titre et la source seulement, alors que la deuxième est constituée d'une liste des mêmes titres, mais par ordre chronologique des publications incluant le titre, la source et un résumé du document. Cette méthode de classification est très pratique puisqu'elle offre deux approches possibles pour accéder à l'information.

La principale source de ces références provient du service CAN/SDI (Canadian Service for the Selective Dissemination of Information). Leur répertoire mensuelle des publications récentes sur le sujet qui nous concerne, permettra de maintenir à jour la présente bibliographie. La topographie des sources est conforme à la Liste des Périodiques de la Bibliothèque de la Direction de la Physique du Globe, Energie, Mines et Ressources de février 1986.

Une copie du présent rapport est accessible sur l'ordinateur de la Section par l'entremise du logiciel GTX.
Une copie intégrale de chaque référence inscrite dans la liste est conservée sous forme de brochures dans la filière de la gravité absolue.

Première partie

Bibliographie
par ordre alphabétique d'auteur

Barnes R.T.H. LENGTH-OF-DAY CHANGES AND POLAR MOTION CORRELATED WITH ATMOSPHERIC ANGULAR MOMENTUM FLUCTUATIONS (Abstract only). EOS, American Geophysical Union Transactions, 63, No.51, p.1278, 1982.

Boulanger J.D. NONTIDAL GRAVITY VARIATIONS (Abstract only). EOS, American Geophysical Union Transactions, 62, No.17, p.214, 1981.

Boulanger Yu.D. SOME RESULTS OF THE STUDY OF NONTIDAL GRAVITY CHANGES. Geotectonics, 17, No.5, 364-372, 1983.

Bulanzhe Yu.D., Arnautov G.P., Kalish Ye.N., Koronkevich V.P., Stus Yu.F., Tarasyuk B.G. and Shcheglov S.N. THE RESULTS OF THE FIRST INTERNATIONAL COMPARISON OF ABSOLUTE GRAVITY METERS, SEVRES, 1981. Physics of the Solid Earth, 19, No.3, 196-202, 1983.

Bursa Milan VARIATIONS OF THE EARTH'S GRAVITY FIELD DUE TO THE FREE NUTATION. Studia Geophysica et Geodaetica, Prague, 16, 122-125, 1972.

Coleman Paul J. Jr. SOLAR WIND TORQUE ON THE GEOMAGNETIC CAVITY. Journal of Geophysical Research, 76, No.16, 3800-3805, 1971.

Currie Robert G. ON BISTABLE PHASING OF 18.6 YEAR NODAL INDUCED FLOOD IN INDIA. Geophysical Research Letters, 11, No.1, 50-53, 1984.

Dittfeld H.-J. and Elstner Cl. TEMPORAL VARIATIONS OF TIDAL GRAVITY PARAMETERS. Hungary, Eotvos Lorand Geophysical Institute, Study of the Earth Tides, Bull.5, 70-76, 1983.

Elstner C., Harnisch M., Kautzleben H. and Schwann W. ON THE DETERMINATION AND VALUATION OF THE GRAVIMETRIC Mf-TIDE. Proceedings of the International Association of Geodesy Symposia, 1, 195-203, 1983.

Eubanks T.M., Dickey J.O. and Steppe J.A. A SPECTRAL ANALYSIS OF THE EARTH'S ANGULAR MOMENTUM BUDGET: GEOPHYSICAL IMPLICATIONS. EOS, American Geophysical Union Transactions, 64, No.18, p.205, 1983.

Frostman T.O., Martin D.W. and Schwerdtfeger W. ANNUAL AND SEMIANNUAL VARIATIONS IN THE LENGTH OF DAY, RELATED TO GEOPHYSICAL EFFECTS. Journal of Geophysical Research, 72, No.20, 5065-5073, 1967.

Haubrich Richard A. and MacKenzie Glenn S. EARTH NOISE, 5 TO 500 MILLICYCLES PER SECOND; 2. REACTION OF THE EARTH TO OCEANS AND ATMOSPHERE. Journal of Geophysical Research, 70, No.6, 1429-1440, 1965.

Hide R. and Malin S.R.C. NOVEL CORRELATIONS BETWEEN GLOBAL FEATURES OF THE EARTH'S GRAVITATIONAL AND MAGNETIC FIELDS: FURTHER STATISTICAL CONSIDERATIONS. Nature Physical Science, 230, p.63, 1971.

Hide R. and Malin S.R.C. CORRELATIONS BETWEEN THE EARTH'S GRAVITATIONAL AND MAGNETIC FIELDS: EFFECT OF ROTATION IN LATITUDE. Nature Physical Science, 232, 31-33, 1971.

Jobert G. DEFORMATIONS D'ORIGINE THERMIQUE. Annales de géophysique. Paris, 16, 34-55, 1960.

Juihao Li, Dongsheng Chen and Zhao Zhu Fu STUDY OF GRAVITY TIDES IN SHANGHAI REGION. Observatoire Royal de Belgique, Bulletin d'information des Marées terrestres, 87, 5595-5599, 1982.

Khorosheva V.V. EFFECT OF THE ATMOSPHERIC PRESSURE ON THE TILTING OF THE EARTH'S SURFACE. Physics of the Solid Earth American Geophysical Union, pp.77-79, 1958.

King R.W., Morgan P.J. and Shapiro I.I. IMPROVED REPRESENTATION OF LENGTH-OF-DAY VARIATIONS FROM COMBINATION OF DIFFERENT TYPES OF OBSERVATIONS. EOS, American Geophysical Union Transactions, 64, No.18, p.205, 1983.

Kirita Masami and Kikuchi Naokichi VERTICAL DISTRIBUTION OF AN ASYMMETRIC ATMOSPHERIC LOAD ACTING ON THE ATMOSPHERIC EXCITATION FUNCTION OF THE POLAR MOTION. Publications of the International Latitude Observatory of Mizusawa, 8, No.1, 127-140, 1971.

Kiviniemi Aimo HIGH PRECISION MEASUREMENTS FOR STUDYING THE SECULAR VARIATION IN GRAVITY IN FINLAND. Finnish Geodetic Institute, Reports of, No. 78, 64pp., 1974.

Lambert A. THE RESPONSE OF THE EARTH TO LOADING BY THE OCEAN TIDES AROUND NOVA SCOTIA. Geophysical Journal of the Royal Astronomical Society, 19, 449-477, 1970.

Lambert A., Liard Jacques and Dragert H. CANADIAN PRECISE GRAVITY NETWORKS FOR CRUSTAL MOVEMENT STUDIES: AN INSTRUMENT EVALUATION. Tectonophysics, 52, 87-96, 1979.

MacDonald Gordon J.F. IMPLICATIONS FOR GEOPHYSICS OF THE PRECISE MEASURMENT OF THE EARTH'S ROTATION. Science, 157, 304-305, 1967.

Malkus W.V.R. PRECESSIONAL TORQUES AS THE CAUSE OF GEOMAGNETISM. Journal of Geophysical Research, 68, No.10, 2871-2886, 1963.

Melchior Paul EARTH TIDES AND POLAR MOTIONS. Tectonophysics, 13, 361-372, 1972

Melchior Paul and De Beeker M. A DISCUSSION OF WORLD-WIDE MEASUREMENTS OF TIDAL GRAVITY WITH RESPECT TO OCEANIC INTERACTIONS, LITHOSPHERE HETEROGENEITIES, EARTH'S FLATTENING AND INERTIAL FORCES. Physics of the Earth and Planetory Interiors, 31, 27-53, 1983.

Molodenskiy M.S., Molodenskiy S.M. and Pariyskiy N.N. A POSSIBLE RELATION BETWEEN THE VARIATION OF THE FORCE OF GRAVITY AND THE RATE OF ROTATION OF THE EARTH. Physics of the Solid Earth, 11, No.1, 345-350, 1975.

Molodenskii S.M. INFLUENCE DE LA NUTATION FORCEE DE LA TERRE SUR LES RESULTATS DES OBSERVATIONS DE MAREES. Observatoire Royal de Belgique, Bulletin d'information des Marées terrestres, 86, 5515-5520, 1981.

Molodenskii S.M. L'INFLUENCE DE L'OCEAN ET DE LA VISCOSITE DU MANTEAU SUR LA NUTATION DE LA TERRE. Observatoire Royal de Belgique, Bulletin d'information des Marées terrestres, 86, 5545-5565, 1981.

Muller T. and Zurn W. OBSERVATION OF GRAVITY CHANGES DURING THE PASSAGE OF COLD FRONTS. Journal of Geophysics, 53, 155-162, 1983.

Newton Robert R. EXPERIMENTAL EVIDENCE FOR A SECULAR DECREASE IN THE GRAVITATIONAL CONSTANT G. Journal of Geophysical Research, 73, No.12, 3765-3771, 1968.

Ooe Masatsugu and Hanada Hideo PHYSICAL SIMULATIONS OF EFFECTS OF THE ATMOSPHERIC PRESSURE AND THE GROUND WATER UPON GRAVITATIONAL ACCELERATION AND CRUSTAL DEFORMATION. Mizusawa International Latitude Observatory Proceedings. No.21, 6-14, 1982.

Pertsev B.P. ON THE EFFECT OF OCEAN TIDES ON TIDAL VARIATIONS OF GRAVITY. Physics of the Solid Earth American Geophysical Union. No.1, 636-639, 1966.

Richter Bernd THE LONG-PERIOD TIDES IN THE EARTH TIDE SPECTRUM. Proceedings of the International Association of Geodesy Symposia, 1, 204-216, 1983

Rochester M.G. PERTURBATIONS IN THE EARTH'S ROTATION AND GEOMAGNETIC CORE-MANTLE COUPLING. Journal of Geomagnetism and Geoelectricity, 20, No.4, 387-402, 1968.

Rochester M.G. THE EARTH'S ROTATION. GEOP Research Conference on The Rotation of the Earth and Polar Motion, Ohio State University, Columbus, 1973.

Schwiderski Ernst W. ON CHARTING GLOBAL OCEAN TIDES. Reviews of Geophysics and Space Physics, 18, No.1, 243-268, 1980.

Singh Richi Narain EARTH TIDES. Geophysical Research Bulletin, 13, Nos. 1 & 2, 215-221, 1975.

Sorrells G.G., McDonald John A., Der Z.A. and Herrin Eugene EARTH MOTION CAUSED BY LOCAL ATMOSPHERIC PRESSURE CHANGES. Geophysical Journal of the Royal Astronomical Society, 26, 83-98, 1971.

Spratt R.S. MODELLING THE EFFECT OF ATMOSPHERIC PRESSURE VARIATIONS ON GRAVITY. Geophysical Journal of the Royal Astronomical Society, 71, 173-186, 1982.

Stolz A. and Larden D.R. SEASONAL DISPLACEMENT AND DEFORMATION OF THE EARTH BY THE ATMOSPHERE. Journal of Geophysical Research, 84, No.B11, 6185-6194, 1979.

Tomaschek R. NON-ELASTIC TILT OF THE EARTH'S CRUST DUE TO METEOROLOGICAL PRESSURE DISTRIBUTIONS. Geofisica Pura e Applicata, 25, 17-25, 1953.

Wahr John M. and Sasao Tetsuo A DIURNAL RESONANCE IN THE OCEAN TIDE AND IN THE EARTH'S LOAD RESPONSE DUE TO THE RESONANT FREE 'CORE NUTATION'. Geophysical Journal of the Royal Astronomical Society, 64, 474-765, 1981.

Wahr John M., Sasao Tetsuo and Smith Martin L. EFFECT OF THE FLUID CORE ON CHANGES IN THE LENGTH OF DAY DUE TO LONG PERIOD TIDES. Geophysical Journal of the Royal Astronomical Society, 64, 635-650, 1981.

Wahr John M. THE EXITATION OF THE EARTH'S WOBBLE BY THE ATMOSPHERE AND OCEANS (Abstract only). EOS, American Geophysical Union Transactions, 63, No.18, p.302, 1982.

Wahr John M. THE EFFECTS OF THE ATMOSPHERE AND OCEANS ON THE EARTH'S WOBBLE -- I. THEORY. Geophysical Journal of the Royal Astronomical Society, 70, 349-372, 1982.

Wahr John M. THE EFFECTS OF THE ATMOSPHERE AND OCEANS ON THE EARTH'S WOBBLE -- II. RESULTS. Geophysical Journal of the Royal Astronomical Society, 74, 451-487, 1983.

Wahr John M. A REVIEW OF EARTH TIDES; ARE THEY SIGNAL OR NOISE ? (Abstract only). EOS, American Geophysical Union Transactions, 64, No.18, p.203, 1983.

Warburton Richard J., Beaumont Christopher and Goodkind John M. THE EFFECT OF OCEAN TIDE LOADING ON TIDES OF THE SOLID EARTH OBSERVED WITH THE SUPERCONDUCTING GRAVIMETER. Geophysical Journal of the Royal Astronomical Society, 43, 707-720, 1975.

Warburton Richard J. and Goodkind John M. THE INFLUENCE OF BAROMETRIC-PRESSURE VARIATIONS ON GRAVITY. Geophysical Journal of the Royal Astronomical Society, 48, 281-292, 1977.

Wells Frederick J. and Chinnery Michael A. ON THE SEPARATION OF THE SPECTRAL COMPONENTS OF POLAR MOTION. Geophysical Journal of the Royal Astronomical Society, 34, 179-192, 1973.

Wilson Clark R. and Haubrich Richard A. METEOROLOGICAL EXCITATION OF THE EARTH'S WOBBLE. Geophysical Journal of the Royal Astronomical Society, 46, 707-743, 1976.

Wilson Clark R. and Haubrich Richard A. ATMOSPHERIC CONTRIBUTIONS TO THE EARTH'S WOBBLE 1901-1970. Geophysical Journal of the Royal Astronomical Society, 46, 745-760, 1976.

Zumberge M.A., Rinker R.L. and Faller J.E. A PORTABLE APPARATUS FOR ABSOLUTE MEASUREMENTS OF THE EARTH'S GRAVITY. Metrologia, 18, 145-152, 1982.

Zeman Antonin and Simon Zdenek INDIRECT EFFECT ON THE CONSTANT SOLID EARTH TIDAL WAVE. Proceedings of the International Association of Geodesy Symposia, 1, 217-226, 1983.

Deuxième partie

Résumés
par ordre chronologique

Tomaschek R. NON-ELASTIC TILT OF THE EARTH'S CRUST DUE TO METEOROLOGICAL PRESSURE DISTRIBUTIONS. Geofisica Pura e Applicata, 25, 17-25, 1953.

Abstract: A typical disturbance observed in the records of tilt measurements performed with horizontal pendulums in a mine at a depth of 145 m below surface, under very constant temperature conditions, has been analysed as to its correlation with the barometric pressure distribution. It is shown that the observed load tilts are not due to elastic deformations of the Earth's crust, but may be ascribed to movments of tectonic blocks of large extension.

Khorosheva V.V. EFFECT OF THE ATMOSPHERIC PRESSURE ON THE TILTING OF THE EARTH'S SURFACE. Physics of the Solid Earth American Geophysical Union, 77-79, 1958.

Introduction: The study of tilting of the earth's surface is of particular interest since it yields a method of disclosing secular movements of the earth's surface. Observations of tilts of the earth's surface, and their analysis showed the necessity of investigating elaborately some questions concerning the physical phenomena and the methods as well, e.g., determination of the depth of penetration of deformations due to the variations of temperature or atmospheric pressure, influence of deformations of suspension support on the readings of a pendulum, etc. The magnitude and depth of penetrations is calculated in this paper for the case of atmospheric pressure.

Jobert G. DEFORMATIONS D'ORIGINE THERMIQUE. Annales de géophysique. Paris, 16, 34-55, 1960.

Pour tenter d'expliquer les perturbations constatées dans l'observation des marées terrestres, on étudie d'abord la possibilité d'une explication par une déformation thermique globale. On étudie ensuite la possibilité d'une explication d'origine régionale en faisant abstraction de la courbure du Globe et en étudiant la déformation d'un solide borné par un plan. On tentera ensuite de mettre en cause l'influence d'une variation très locale de la température ou l'hétérogénéité du sous-sol.

Malkus W.V.R. PRECESSIONAL TORQUES AS THE CAUSE OF GEOMAGNETISM. Journal of Geophysical Research, 68, No.10, 2871-2886, 1963.

Abstract: The difference in the precessional torques on the core and mantle of the earth can produce a small relative rotation between the two. The magnitude of the relative rotation depends upon the inertial reaction resulting from the figure of the core-mantle boundary and upon the frictional torque caused by the shearing flow. It is concluded in this study that the frictional torque due to a turbulent hydromagnetic Ekman layer is the principal restraint on relative rotation. From the gross geophysical parameters of figure and density and the electrical conductivity of core material, the resulting magnetic fields, fluid velocities, and characteristic periods are found to compare favorably with the available information.

Haubrich Richard A. and MacKenzie Glenn S. EARTH NOISE, 5 TO 500 MILLICYCLES PER SECOND; 2. REACTION OF THE EARTH TO OCEANS AND ATMOSPHERE. Journal of Geophysical Research, 70, No.6, 1429-1440, 1965.

Abstract: Sources of earth noise have been identified and located for different parts of the frequency band from 5 to 500 mc/s. In the typical microseism bands around 75 and 150 mc/s, sources are associated with storm waves arriving at both distant and local sea coasts. During the winter months the primary-frequency microseisms measured at La Jolla come mostly from the coast north of Cape Mendocino and are due to major storms in the North Pacific. Double-frequency microseism sources are generally within a few hundred kilometers of La Jolla, but more distant sources have also been observed. In addition, both ocean and atmosphere produce local loading which becomes significant at frequencies below the storm microseism band.

Pertsev B.P. ON THE EFFECT OF OCEAN TIDES ON TIDAL VARIATIONS OF GRAVITY. Physics of the Solid Earth American Geophysical Union. No.1, 636-639, 1966.

Abstract: The influence of semidiurnal ocean tides on the tidal variations of gravity at points that are distant from the sea is estimated. In order to estimate the indirect effect, the ocean tide is expanded into a series of spherical functions to the order n=16. The variable attraction of the tidal water masses of the oceans as well as the changes in the gravitational field that are caused by deformation of the earth by ocean tides are taken into account. The obtained corrections in the values of the tidal variations for the European stations reach 7%.

MacDonald Gordon J.F. IMPLICATIONS FOR GEOPHYSICS OF THE PRECISE MEASURMENT OF THE EARTH'S ROTATION. Science, 157, 304-305, 1967.

Abstract: A radio interferometer could yield an error on the order of 10^-9 second at the semidiurnal frequency. With errors of this magnitude, yearly changes in the rate at which the earth's rotation is slowing down could be determined. The proposed interferometer could also yield significant improvements in the determination of the Love number k and its variation with frequency, and in the changes in angular momentum of the atmosphere for periods greater than one week.

Frostman T.O., Martin D.W. and Schwerdtfeger W. ANNUAL AND SEMIANNUAL VARIATIONS IN THE LENGTH OF DAY, RELATED TO GEOPHYSICAL EFFECTS. Journal of Geophysical Research, 72, No.20, 5065-5073, 1967.

Abstract: Using exact time observations for the years 1958 through 1963, a re-examination is made of the seasonal variations in length of day and their relation to geophysical effects. For the most important parameter, the relative angular momentum of the atmosphere, a large body of aerological data has been evaluated, which was not available when Mintz and Munk carried through the first study of this kind about 15 years ago. The seasonal change of atmospheric mass over the Antarctic is introduced as an additional minor effect. The other geophysical phenomena contributing to the annual and semiannual variations of the length of day are used as given in Munk and MacDonald's recent monograph on the rotation of the earth. The result is that there remains a semiannual term in the yearly march of the length of day that cannot be explained by known geophysical effects, too large to be considered an error effect alone.

Newton Robert R. EXPERIMENTAL EVIDENCE FOR A SECULAR DECREASE IN THE GRAVITATIONAL CONSTANT G. Journal of Geophysical Research, 73, No.12, 3765-3771, 1968.

Abstract: This paper combines data from a variety of sources relating to changes in the earth's spin for the purpose of estimating changes in the earth's popar moment of inertia Ce and in the gravitational constant G. The changes in Ce and G cannot be inferred with confidence until an important question in lunar theory is resolved and until certain types of measurement are improved. Plausible assumptions lead to the tentative conclusion that Ce is increasing and that G is decreasing at rates of the order of one part in 10^8 per century. These estimates agree to order of magnitude with the rate of upward transport of material at the mid-ocean ridges.

Rochester M.G. PERTURBATIONS IN THE EARTH'S ROTATION AND GEOMAGNETIC CORE-MANTLE COUPLING. Journal of Geomagnetism and Geoelectricity, 20, No.4, 387-402, 1968.

Abstract: The effect of electromagnetic core-mantle coupling on small changes in the length of day and the geographical location of the pole is treated by a simplified model which neglects the time required for magnetic diffusion through the lower mantle, and approximates the poloidal field by the centred dipole. The resulting formulae for the time constants of the coupling are more meaningful physically than, and give nearly the same numerical values as, those derived previously by more rigorous methods. It is shown that, despite the complexity of the electromagnetic interactions at the coremantle boundary, the two kinds of perturbation in the Earth's rotation can be treated independently. Simple expressions are given for the electromagnetic restoring torque on the accelerating mantle. The effect of the geomagnetic coupling on the diurnal wobble is discussed, and concluded to be negligible.

Lambert A. THE RESPONSE OF THE EARTH TO LOADING BY THE OCEAN TIDES AROUND NOVA SCOTIA. Geophysical Journal of the Royal Astronomical Society, 19, 449-477, 1970.

Summary: The tidal loading effects on gravity and tilt caused by the large amplitude tides in the Bay of Fundy have been separated from the effects of the tides in the larger scale Gulf of St Lawrence and the North Atlantic Ocean. An eight-month series of north-south, east-west tilt observations was made near Rawdon, Nova Scotia, with a pair of Verbaandert-Melchior horizontal pendulums at a site 30 metres below the surface of the ground. The gravity observations were made with a LaCoste-Romberg earth-tide gravity meter and consisted of two short series of observations at the coastal sites of Isle Haute and Victoria Harbour followed by a 48-day series at Berwick, Nova Scotia. The tidal constituents of the observed tilt have been corrected for the theoretical body tilt by assuming a range of values for the global diminishing factor from 0.5 to 0.9. The resulting load tilts at the semi-diurnal frequencies (M2,N2,S2) have been separated into Bay of Fundy and North Atlantic load tilt components by a least squares method utilizing the known amplitude and phase relationships of the M2, N2, and S2 ocean tide constituents around Nova Scotia. A similar separation of the Bay of Fundy and Gulf of St Lawrence load tilts has been made at the diurnal frequency (O1).

The isolated Bay of Fundy tilt has been compared with the measurements of Nishimura and the theoretical studies of Takeuchi and Jobert. The results suggest that a simple two-layer elastic model having rigidities compatible with seismic models for the area would fit the observations within the experimental uncertainties. On the other hand, the tilts due to the tides in the Gulf of St Lawrence and in the North Atlantic Ocean are not compatible with any reasonable laterally

homogeneous, elastic models. Notably, the diurnal tilt contribution from the Gulf of St Lawrence is anomalously large at Rawdon, Nova Scotia.
The results of the gravity observations on the whole, confirm the tilt results. If there is a deviation of the gravimetric factor from a theoretical value of 1.16 at Berwick, Nova Scotia, it appears to be secondary to the ocean tide effect. The semi-diurnal gravity residuals show that a strong influence from the North Atlantic tides is superimposed on the Bay of Fundy effect, whereas the diurnal residuals are correlated with the diurnal tides in the Gulf of St Lawrence alone. The diurnal gravity results are consistent with the anomalous diurnal tilt and suggest that a large-scale continental structure may be responding coherently to the tidal loading in the Gulf of St Lawrence.

Hide R. and Malin S.R.C. NOVEL CORRELATIONS BETWEEN GLOBAL FEATURES OF THE EARTH'S GRAVITATIONAL AND MAGNETIC FIELDS: FURTHER STATISTICAL CONSIDERATIONS. Nature Physical Science, 230, p.63, 1971.

First paragraph: A geophysical test of the suggestion that the topography of the interface where the Earth's liquid core meets the solid mantle interacts strongly with core motions led to the discovery of novel correlations between global features of the Earth's gravitational field g and the non-dipole part of the main geomagnetic field B when the latter is displaced in longitude.

Hide R. and Malin S.R.C. CORRELATIONS BETWEEN THE EARTH'S GRAVITATIONAL AND MAGNETIC FIELDS: EFFECT OF ROTATION IN LATITUDE. Nature Physical Science, 232, 31-33, 1971.

First paragraph: In two earlier articles we reported the discovery of a high degree of correlation between the gravitational potential, g, and the non-dipole geomagnetic potential, B, when the latter is displaced in longitude, and discussed the significance level of this correlation. Attention was confined to a rotation in longitude alone because the physical argument that led to the investigation suggested that the geomagnetic features might be found "downstream" of the corresponding gravitational features, and the core motions are chiefly longitudinal. But it was suggested at the time that in future work this restriction should be relaxed, and the effect of a more general rotation of B relative to g should be considered.

Coleman Paul J. Jr. SOLAR WIND TORQUE ON THE GEOMAGNETIC CAVITY. Journal of Geophysical Research, 76, No.16, 3800-3805, 1971.

Abstract: It is argued that the rotation of the ionospheric plasma drives unipolar induction currents through the solar wind plasma in the boundary layer of the geomagnetic cavity. The consequences of this current include a torque on the earth, Joule heating of the ionospheric plasma, and a magnetic field that is mainly eastward in the northern hemisphere and westward in the southern hemisphere. Assuming that all of the magnetic flux from the regions above the auroral zones threads the solar wind plasma in the boundary layer, the torque on the earth at magnetically quiet times is in the neighborhood of 10^20 g cm2/sec2, corresponding to a decrease in the earth's rotation rate of about one part in 10^13 per year. The Joule heating rate is of order 10^16 ergs/sec compared with the 10^18 ergs/sec presently estimated for the dissipation rate associated with the magnetospheric convection.

Kirita Masami and Kikuchi Naokichi VERTICAL DISTRIBUTION OF AN ASYMMETRIC ATMOSPHERIC LOAD ACTING ON THE ATMOSPHERIC EXCITATION FUNCTION OF THE POLAR MOTION. Publications of the International Latitude Observatory of Mizusawa, 8, No.1, 127-140, 1971.

Abstract: Main part of the annual term of the polar motion is caused by the coupling with an asymmetric distribution of air mass in the atmospheric circulation. The coupling is expressed by the excitation function of the angular velocity of the rotating Earth. Definition of the excitation function of the polar motion is modified as an asymmetric atmosphric load acting on any level of the atmosphere in this paper.
Vertical distribution of the atmospheric exitation function is analysed to clear up asymmetric characters of the atmospheric circulation based on the view of the Earth's rotation.
Vertical distribution of the atmospheric exictation function, phi is derived from a summation of results of the latitude belts, by taking into account for the geographical correction, over the northern hemisphere from the surface to 26 km in height for every month. The results are shown in the followings;
1) Vertical distribution of phi shows clearly a seasonal variation
2) The direction of phi changes clockwise according to the height from the surface. The deflecting angle reaches to 90° and 180° at 5 km and 12 km respectively.
3) Singular points are found in the vertical distribution of phi, corresponding to the patterns of the atmospheric circulation.
4) Semi-annual variation of phi shows a significantly large amplitude at 5 km in height, which corresponds to the center of gravity of the Earth's atmosphere.
5) Secular variation is found in phi.
These results show that the vertical distribution of phi represents an important feature of the atmospheric circulation.

Sorrells G.G., McDonald John A., Der Z.A. and Herrin Eugene EARTH MOTION CAUSED BY LOCAL ATMOSPHERIC PRESSURE CHANGES. Geophysical Journal of the Royal Astronomical Society, 26, 83-98, 1971.

Summary: Observations have been made of the local atmospheric pressure field and the long-period seismic noise fields both on the surface of the Earth and in a mine at a depth of 183 metres. The observations show that during windy intervals and in the period rang 20-100 s there is a strong correlation between local atmospheric pressure changes and the noise recorded by a vertical seismograph located on the surface. In contrast, over the same range of periods there is no correlation between the seismic noise recorded in the mine and local atmospheric pressure changes except during the passage of acoustic waves. It is shown that the noise in this pass band is not due to the buoyant response of the seismograph, but is caused by the motion of the Earth responding to atmospheric pressure changes.

Melchior Paul EARTH TIDES AND POLAR MOTIONS. Tectonophysics, 13, 361-372, 1972

Abstract: Problems about the origin of polar motions and earth tides, and the accuracies reached in their determination, are discussed. The common references system (C.I.O.) for the measurement of the instantaneous pole of rotation is defined. Hypotheses for the origin of the Chandler wobble are critically reviewed. The importance of the seventy years of star pairs observation is stressed. Calibration errors of the screw pitch have to be considered first for an improvement of the found declinations. Earth tides now have been measured at many places and the theory of their generation is confirmed by these observations. Strong anomalies have been found in their amplitude, stressing the importance of a denser station network and the investigation of the relation to the geotectonic foundation.

Bursa Milan VARIATIONS OF THE EARTH'S GRAVITY FIELD DUE TO THE FREE NUTATION. Studia Geophysica et Geodaetica, Prague, 16, 122-125, 1972.

Summary: Expressions for the time variation of gravity and for deformations of equipotential surfaces due to the free nutation of the Earth have been derived. The possibility has been shown of determining the polar motion by means of accurate gravity observations under the assumption that the other effects, particularly tidal, may be expressed with sufficient accuracy theoretically. The necessity of introducing gravity corrections due to the polar motion has been pointed out in investigating the secular variations of gravity and in accurate gravity measurements (standard error of the order of 0.02 mgal and less), in general.

Rochester M.G. THE EARTH'S ROTATION. GEOP Research Conference on The Rotation of the Earth and Polar Motion, Ohio State University, Columbus, 1973.

Second paragraph: In this review I attempt to summarize, as briefly as possible, the current state of knowledge in a field that is complex, extensive, and resurgent under the impact of late 20th century technology. I shall begin with a survey of the appropriate reference frames and problems involved in defining them and then outline the accuracy with which the earth's rotation can be measured relative to these frames by techniques already in use or on the threshold of realization. Following that, I shall discuss in turn the various spectral features of changes in the axis orientation and spin rate of the so-called 'solid' earth and the physical mechanisms known or likely to effect and affect them. Copious references are given for deeper study. I shall concentrate almost exclusively on developments in the past decade or so since the appearance of the now-classic monograph by Munk and MacDonald (1960), the standard reference for most aspects of the subject.

Wells Frederick J. and Chinnery Michael A. ON THE SEPARATION OF THE SPECTRAL COMPONENTS OF POLAR MOTION. Geophysical Journal of the Royal Astronomical Society, 34, 179-192, 1973.

Summary: This paper presents a novel method for the separation of the annual and Chandler spectral components in astronomic latitude or polar motion data. The method relies upon the high resolving power of maximum entropy spectral analysis. This separation technique is applied to astronomic latitude data from 10 International Polar Motion Service stations for the time interval 1962.0 to 1971.0, and is also applied to the two orthogonal polar motion components as determined from the data of these 10 stations. The results of this separation technique are compared with those from a method used by S. Yumi of the International Polar Motion Service. There is good agreement between the methods for the annual component determination. It was found that the annual component amplitude and phase varied widely among the ten stations. There is not good agreement between the methods for the Chandler component determination. However, evidence is given that the results of the novel separation technique are more internally consistent than those for the previously used separation method. The Chandler polar motion is plotted for the 2 years 1963.0 to 1965.0. This Chandler polar motion was determined by a least-squares fit to the 10 IPMS stations' data after the individually determined annual components were removed from each station's data.

Kiviniemi Aimo HIGH PRECISION MEASUREMENTS FOR STUDYING THE SECULAR VARIATION IN GRAVITY IN FINLAND. Finnish Geodetic Institute, Reports of, No. 78, 64pp., 1974.

Contents:

Warburton Richard J., Beaumont Christopher and Goodkind John M. THE EFFECT OF OCEAN TIDE LOADING ON TIDES OF THE SOLID EARTH OBSERVED WITH THE SUPERCONDUCTING GRAVIMETER. Geophysical Journal of the Royal Astronomical Society, 43, 707-720, 1975.

Summary: The superconducting gravimeter has been calibrated to an accuracy of 0.2 per cent and was used to measure the influence of the ocean tides on the tides of the solid earth at two locations in southern California. These measurements, which show a signal to noise ratio of 70 db in the 1 and 2 cycle per day band, and the accurate calibration of the gravimeter make possible a quantitative test of ocean load calculations for the O1 and M2 constituents and the ocean models upon which they are based. We have computed the ocean load effect by using Farrell's Green's functions and modifications of previously published ocean co-tidal charts. The agreement between observed and computed earth tides is within 0.2 per cent and corroborates the placement of an M2 amphidrome at 1500 km south-west of San Diego. If the amplitudes of the computed tides are correct it also sets an upper limit of 0.1° on the phase shifts of the solid earth tides. We have also observed the loading effect on the coast due to the nonlinear M4 ocean tide.

Molodenskiy M.S., Molodenskiy S.M. and Pariyskiy N.N. A POSSIBLE RELATION BETWEEN THE VARIATION OF THE FORCE OF GRAVITY AND THE RATE OF ROTATION OF THE EARTH. Physics of the Solid Earth, 11, No.1, 345-350, 1975.

Abstract: The elastic-deformation equations are solved for a nonhomogeneous earth containing a deformation-focus at various depths modeled by discontinuities in the radial and tangential components of the displacement. The corresponding variation in the moment of inertia of the earth and the part of the variation of the force of gravity at the surface described by a second-order spherical harmonic are investigated. The relation between these two quantities is strongly dependent on the nature of the deformation and the focus depth.

Singh Richi Narain EARTH TIDES. Geophysical Research Bulletin, 13, Nos. 1 & 2, 215-221, 1975.

Abstract: A careful observation of the Earth's elastic deformation induced by luni-solar gravitational torque can be used to answer a large number of questions in planetary physics. The very significant advantage of such studies as compared to those using other types of forces to excite the earth lies in the fact that this torque is known in greater detail. The methods of analysis of the tidal records as well as sufficiently refined model of earth tides are also largely availables.

The earth-tide studies in India besides being helpful in world-wide tidal prediction should also help in resolving various controversies regarding the influence of Earth's core in Earth tides. Past work, and future plans in this field will be discussed.

Wilson Clark R. and Haubrich Richard A. METEOROLOGICAL EXCITATION OF THE EARTH'S WOBBLE. Geophysical Journal of the Royal Astronomical Society, 46, 707-743, 1976.

Summary: The objective of this paper is to examine the seasonal variations in the oceans and atmosphere that force the Earth's annual wobble, and to determine whether motions of air and water are a significant source of Chandler-wobble excitation. Alghough our investigation is similar to the one undertaken by Munk and Hassan over 15 years ago, we come to entirely different conclusions, largely because of differences in the details of our analysis. We find that the oceans and atmosphere are not observed well enough to fully explain the annual wobble, although much of it can be accounted for by annual changes in atmospheric mass distribution and continental water storage. Near the Chandler frequency there is evidence of significant coherence between polar motion and atmospheric pressure observations for the years 1901 and 1970, suggesting that the atmosphere is important in maintaining the Chandler wobble. The magnitude of meteorological variation appears to be large enough to account for more than half, and perhaps most of the Chandler wobble variance.

Wilson Clark R. and Haubrich Richard A. ATMOSPHERIC CONTRIBUTIONS TO THE EARTH'S WOBBLE 1901-1970. Geophysical Journal of the Royal Astronomical Society, 46, 745-760, 1976.

Summary: Using atmospheric observations taken between 1901 and 1970, we have estimated the variations in atmospheric torques that excite the Earth's wobble. We have refined and brought up to date the time series of wobble excitation due to atmospheric mass redistribution that was obtained by Hassan over fifteen years ago, and have computed an entirely new time series of wobble excitation due to the mountain torques. A separate paper, (Wilson & Haubrich) compares the atmospheric series with a time series of the Earth's pole motion derived from astronomical observation.

Warburton Richard J. and Goodkind John M. THE INFLUENCE OF BAROMETRIC-PRESSURE VARIATIONS ON GRAVITY. Geophysical Journal of the Royal Astronomical Society, 48, 281-292, 1977.

Summary: The superconducting gravimeter has been used to measure the influence of barometric pressure on gravity in the frequency range 0.1-10 cycles/day. These measurements show that the incoherent barometric fluctuations are the major cause of random fluctuations in local gravity and account for much of the 'noise' on our gravimeter records. A simple model has been constructed which adequately explains the response of gravity to the local pressure fluctuations. These measurements also show a response to the global atmospheric tides at S1 and S2 which is much larger than the response to local fluctuations. Although this behaviour is most likely due to the response of the world-wide oceans to the atmospheric tides, no theoretical model has yet been constructed.

Lambert A., Liard Jacques and Dragert H. CANADIAN PRECISE GRAVITY NETWORKS FOR CRUSTAL MOVEMENT STUDIES: AN INSTRUMENT EVALUATION. Tectonophysics, 52, 87-96, 1979.

Abstract: Precise gravity networks and profiles have been established in three locations in Canada for the purpose of measuring possible gravity changes associated with seismic events. All measurements were made using two LaCoste and Romberg model D gravimeters. The standard deviation of a single observed gravity difference ranges from 50 to 120 nm/sec2. The precision of the measurements appears to depend mainly on the amount of exposure to vibration during transportation. A preliminary comparison between results of different instruments reveals unexplained discrepancies, and calibration tests show that the D meter scale factor varies significantly with either dial reading or reset screw position or both.

Stolz A. and Larden D.R. SEASONAL DISPLACEMENT AND DEFORMATION OF THE EARTH BY THE ATMOSPHERE. Journal of Geophysical Research, 84, No.B11, 6185-6194, 1979.

Abstract: Mass transports on the surface impart a space motion to the earth. The shift induced by seasonal atmospheric pressure variations is calculated. The magnitude of the displacement is approximately 1.6|cos (sun - 9°)| mm where (sun) is the sun's longitude measured from the beginning of the year. The motion is thus too small to be detected at present. Deformations of a model earth caused by atmospheric loading are estimated. The seasonal distortions over parts of Asia and Greenland approach the 1 cm measuring goal of the new laser ranging techniques and exceed it over the Antarctic continent. They are not generally significant in other parts of the globe. The results are depicted in contour form on world maps for each of the four seasons.

Schwiderski Ernst W. ON CHARTING GLOBAL OCEAN TIDES. Reviews of Geophysics and Space Physics, 18, No.1, 243-268, 1980.

Abstract: This review article highlights the three-century development of our scientific understanding of ocean tides, culminating through myths, paradoxes, and controversies in a global tide model that now permits the prediction of the instantaneous total tide anywhere in the open oceans with an accuracy of better than 10 cm. All major aspects of tidal research, including empirical, mathematical, and empirical-mathematical methods, are considered. Particular attention is drawn to the most recently developed computerized techniques comprehending hydrodynamical dissipation and secondary tide-generating forces, finite-differencing schemes, geometric boundary and bathymetry modeling, and hydrodynamical interpolation of properly selected empirical tide data. Numerous computer experiments are mentioned that were carried out by various researchers in order to evaluate the magnitudes of the featured effects. Further possible improvements are mentioned, especially in nearshore areas, in the Arctic Sea, and near Antartica, where empirical tide and bathymetry data are either rough or marginal.

Wahr John M. and Sasao Tetsuo A DIURNAL RESONANCE IN THE OCEAN TIDE AND IN THE EARTH'S LOAD RESPONSE DUE TO THE RESONANT FREE 'CORE NUTATION'. Geophysical Journal of the Royal Astronomical Society, 64, 474-765, 1981.

Summary: The luni-solar forced nutations and body tide are believed to be resonant at frequencies near (1 + 1/460) cycle/sideral day as seen from the rotating Earth. This resonance is due to the Earth's rotating, elliptical fluid core. We show here that tides in the open ocean and the Earth's response to those tides must also be resonant at (1 + 1/460) cycle/day. We examine these resonant oceanic effects on the Earth's nutational motion and on the body tide. Effects on the forced nutations might be as large as 0.002 arcsec at 18.6 yr. The effects on the observed resonance in the body tide are more important. For tidal gravity, for example, the difference between K1 and O1, which is usually used to determine the resonance, can be perturbed by 30 per cent or more due to the oceanic resonance effects.

Wahr John M., Sasao Tetsuo and Smith Martin L. EFFECT OF THE FLUID CORE ON CHANGES IN THE LENGTH OF DAY DUE TO LONG PERIOD TIDES. Geophysical Journal of the Royal Astronomical Society, 64, 635-650, 1981.

Summary: The long period luni-solar tidal potential is known to cause periodic changes in the Earth's rotation rate. We find that the effect of a dissipationless fluid outer core is to reduce the amplitudes of these tidal perturbations by approximately 11 per cent. When the fluid core effect is added to Agnew & Farrell's estimate of the effect of an equilibrium ocean, the result is in accord with observation.
The effects of dissipative processes within the fluid core are also examined. We find out-of-phase perturbations which could be as large as nearly 10 ms at 18.6 yr. We conclude, however, that the poorly understood decade fluctuations in the Earth's rotation rate will prohibit observation of this effect.

Molodenskii S.M. INFLUENCE DE LA NUTATION FORCEE DE LA TERRE SUR LES RESULTATS DES OBSERVATIONS DE MAREES. Observatoire Royal de Belgique, Bulletin d'information des Marées terrestres, 86, 5515-5520, 1981.

1er paragraphe: Pour déterminer les nombres de Love avec une précision de plus de 1% par rapport aux résultats des mesures de marées on doit ajouter les corrections de l'influence des forces d'inertie aussi bien sur la marée dans le corps de la Terre que directement sur les indications de l'instrument. Dans le travail on a tenu compte de l'influence des forces d'inertie apparaissant lors de la rotation régulière de la Terre, sur le gravimètre et le clinomètre. Dans cette remarque on note l'influence de l'irrégularité de rotation de la Terre sur les indications des instruments enregistreurs de marées. Comme on le sait, les marées semi-diurnes n'exercent pas d'influence sur la rotation de la Terre de révolution. C'est pourquoi nous nous limiterons plus loin à l'examen des marées presque diurnes provoquant la précession et la nutation forcée de la Terre et également des marées à longue période provoquant la variation de la durée du jour.

Molodenskii S.M. L'INFLUENCE DE L'OCEAN ET DE LA VISCOSITE DU MANTEAU SUR LA NUTATION DE LA TERRE. Observatoire Royal de Belgique, Bulletin d'information des Marées terrestres, 86, 5545-5565, 1981.

7e paragraphe: Ce travail est consacré à l'étude de l'influence de l'océan et de la viscosité de l'enveloppe sur la nutation de la Terre. Nous donnerons le résultat de la solution analytique du problème sur la rotation de la Terre gravitante avec noyau homogène ellipsoidal non compressible. A partir de cette solution on étudie l'amortissement du mouvement libre du pôle et également l'influence de l'océan sur les amplitudes et les phases de la nutation forcée.

Boulanger J.D. NONTIDAL GRAVITY VARIATIONS (Abstract only). EOS, American Geophysical Union Transactions, 62, No.17, p.214, 1981.

Abstract: For a long period of time now the Institute of Physics of the Earth carries out repeated gravity measurements with the purpose of study of its variations in time. The application of relative methods has shown that gravity field on the Eurasian continent is stable and the observed variations do not exceed measurement errors.
Since 1976 the Soviet gravimeter GABL was used for this purpose, which allowed:
- to reveal the systematic error in the system IGSN-71 in the order of 14* x 10^-5;
- to establish that the stability of gravity field on the Austialian continent, on the average over the continent, is +3.3 +/- 1.2 mcgl/yr, whereas in Singapore it is -0.0 +/- 2.5 mcgl/yr;
- to find on latitude nearly phi = 55* on the Eurasian continent the quasiperiodic gravity changes. In the time interval from 1975 to 1978, at Potsdam gravity variations had the rate of -10 mcgl/yr, at Moscow -9.5 +/- 2.0 mcgl/yr, and at Novosibirek 10.7 +/- 0.9 mcgl/yr.

Wahr John M. THE EFFECTS OF THE ATMOSPHERE AND OCEANS ON THE EARTH'S WOBBLE -- I. THEORY. Geophysical Journal of the Royal Astronomical Society, 70, 349-372, 1982.

Summary: The theory of wobble exitation for a non-rigid earth is extended to include the effects of the earth's fluid core and of the rotationally induced pole tide in the ocean. The response of the solid earth and oceans to atmospheric loading is also considered. The oceans are shown to be affected by changes in the gravitational potential which accompany atmospheric pressure disturbances and by the load-induced deformation of the solid earth. These various improvements affect the excitation equations by about 10 per cent. Atmospheric and oceanic excitation can be computed using either an angular momentum or a torque approach. We use the dynamical equations for a thin fluid to relate these two methods and to develop a more general, combined approach. Finally, geostrophic winds and currents are shown to be potentially important sources of wobble excitation, in contrast to what is generally believed.

Ooe Masatsugu and Hanada Hideo PHYSICAL SIMULATIONS OF EFFECTS OF THE ATMOSPHERIC PRESSURE AND THE GROUND WATER UPON GRAVITATIONAL ACCELERATION AND CRUSTAL DEFORMATION. Mizusawa International Latitude Observatory Proceedings. No.21, 6-14, 1982.

Abstract: High sensitive observations of geophysical phenomena, such as gravitational accerelation and crustal tilts and strains are quantitatively estimated. The effects of the atmospheric pressure upon gravitational accerelation consist of two parts, namely, Newtonian attraction and crustal deformation. We calculate the both effects. The crustal deformation due to the atmospheric pressure changes is estimated by using Green's function for Gutengerg-Bullen's model given by W.E. Farrell. It is supposed in our calculation that the effect of atmospheric pressure on ocean floor is isostatically compensated. Calculations show that the effect of atmospheric pressure upon gravitational accerelation in Mizusawa is about -0.36 mcgl/mbar, which is consistent with the observations. The effect of atmospheric pressure upon crustal strain is also calculated and the results are compared with the observations made at the Esashi Earth Tide Station. In addition, calculations show that the atmospheric pressure can generate crustal tilt or order 10^-8 rad in coastal region, which is comparable to tidal tilts. Correction of the effect of ground water level changes is essential for absolute gravimetry, because the seasonal changes in ground water level amount to 2 or 3 meters in Mizusawa, which would generate gravity changes of several micro gals.

Juihao Li, Dongsheng Chen and Zhao Zhu Fu STUDY OF GRAVITY TIDES IN SHANGHAI REGION. Observatoire Royal de Belgique, Bulletin d'information des Marées terrestres, 87, 5595-5599, 1982.

Abstract: The authors analyse and compare the observation data obtained with two gravimeters: Askania GS-15 No.227 and CG-2 No.317. They specially discuss the ocean loading effect and find that the Schwiderski Maps are very effective for the interpretation of the gravity tides in Shanghai region. The numerical values (O1) and (M2) before and after considering the loading effect are equal to 1.207 and 1.167, and 1.150 and 1.152 respectively.

We carried out tidal gravity observations for six months (from December 1980 to May 1981) by using the gravimeters Askania GS-15 No.227 and CG-2 No.317 installed at the Seismological Station of Shanghai. The over-urben thickness above the tunnel is about 40 m, and the length of the tunnel is about 120 m; the temperature fluctuation is less than 0.5° C a year. In order to ensure that the astatic behaviour of gravimeter CG-2 does not influence the tidal output signal of the instrument, the range of displacement of the reference line in the field of vision on the microscope of the instrument is restricted between divisions -2.5 and +2.5 during the recording period, a range which corresponds to

about 1200 mcgls. The drift behaviour for this instrument is of positive tendency. When the line is close to the division +2.5, it is re-adjusted back to a place near the division -2.5, and a sensitivity calibration is carried out simultaneously.
Nakai fit and Venedikov filter are adopted for pre-process and harmonic analysis for the observed data. The analysis results for the six main tidal waves are presented, introducing the inertial corrections.

Barnes R.T.H. LENGTH-OF-DAY CHANGES AND POLAR MOTION CORRELATED WITH ATMOSPHERIC ANGULAR MOMENTUM FLUCTUATIONS (Abstract only). EOS, American Geophysical Union Transactions, 63, No.51, p.1278, 1982.

Abstract: All three components of the atmosphere's angular momentum, Ha, show fluctuations on timescales upward of a few days, due to variations in the distribution of mass within the atmosphere and changes in the pattern of winds, particularly the strength and location of the major mid-latitude jet-streams.
Variations in the axial component of Ha have been shown to be well correlated with length-of-day changes, as would be expected if the total angular momentum of the solid Earth and atmosphere is conserved (allowing for lunar and solar effects). Fluctuations in the equatorial components of Ha should contribute to the observed wobble of the instantaneous rotation pole with respect to the Earth's crust, but this has not been shown conclusively by previous studies. In this paper we comment on the assumptions made in earlier treatments, some of which we find unsatisfactory. Currently available meteorological data are not adequate for evaluating all the terms in the unapproximated excitation function, but we have shown that it can be partially integrated to a simpler function which can be evaluated without approximation. Daily values of this new 'atmospheric function' (which is simply related to Ha), calculated from the 'initialized analysis global data-base' archived by the European Centre for Medium-range Weather Forecasts, are presented for January 1981 - March 1982 and are compared with astronomically observed lenth-of-day and polar motion from the Bureau International de l'Heure. During this period, changes in length-of-day can be accounted for almost entirely by angular momentum exchange between the atmosphere and solid Earth, and the existence of an oscillation in this exchange, with period about 50 days, is confirmed. Our analysis also shows that meteorological phenomena provide an important contribution to the excitation of polar motion, detailed knowledge of which will be needed by those seeking, e.g., to use polar motion data in earthquake prediction studies.

Zumberge M.A., Rinker R.L. and Faller J.E. A PORTABLE APPARATUS FOR ABSOLUTE MEASUREMENTS OF THE EARTH'S GRAVITY. Metrologia, 18, 145-152, 1982.

Abstract: We have developed a new and portable apparatus for making absolute measurements of the acceleration due to the Earth's gravity. We use the method of free fall, and interferometrically determine the acceleration of a freely falling cube corner. In the design and development of this instrument, particular attention was paid to those aspects which would affect its performance in the field. The resulting instrument, we believe, provides a viable new tool for the study of tectonic motions. The system is very small; it can be transported in a small van and requires only two hours for assembly. A high rate of data acquisition is available; if necessary, a single measurement can be made every two seconds. Further, we have made a concerted effort to detect and (we hope) eliminate systematic errors. The results of extensive tests indicate that the achievable accuracy for g is about six parts in 10^9. This instrument therefore provides a sensitivity to vertical motions (e.g., of the Earth's crust) as small as 2 cm.

Wahr John M. THE EXITATION OF THE EARTH'S WOBBLE BY THE ATMOSPHERE AND OCEANS (Abstract only). EOS, American Geophysical Union Transactions, 63, No.18, p.302, 1982.

Abstract: The two most important features of the earth's wobble spectrum are the annual wobble and the 14 month Chandler wobble. The annual wobble is generally believed to be driven by seasonal effects in the atmosphere, in the oceans, and in the global distribution of fresh water, although good quantitative agreement has remained somewhat elusive. The primary source of Chandler wobble excitation is uncertain. Here, we examine the effects of the atmosphere and oceans on wobble excitation. Where data is insufficient we rely on dynamical models. The most important difference between this work and Wilson and Haubrich (1976, GJRAS, 46, 745) turns out to be our use of an improved analysis scheme for evaluating the effects of atmospheric pressure. We get good agreement with the astronomically observed annual wobble excitation. On the other hand, oceans have a noticeable effect on the Chandler wobble, they are apparently not the primary excitation source.

Spratt R.S. MODELLING THE EFFECT OF ATMOSPHERIC PRESSURE VARIATIONS ON GRAVITY. Geophysical Journal of the Royal Astronomical Society, 71, 173-186, 1982.

Summary: A model is developed to describe the effects of local and global atmospheric pressure fluctuations on local gravity. The calculated admittance of gravity to the pressure tides S1 - S4 at Pinon Flat, California is compared to those measured using the superconducting gravimeter. The theoretical and measured admittances are in good agreement for the S3 and S4 tides. The difference between theory and observation at S2 can probably be explained be the ocean tide at that frequency while the discrepancy at S1 remains unexplained. Techniques for the removal of random pressure variations from gravity records are described. Using statistics derived from spherical harmonic decompositions of the Earth's pressure field, it is shown that more than 80 per cent of the pressure induced gravity variations should be removed from a gravity record by employing a single barometer and least-squares procedure. It is further shown that adding a ring of barometers should increase the effectiveness to about 90 per cent. The amount of barometric pressure 'noise' which remains after subtracting the simultaneous record of two gravimeters is calculated as a function of their separation and indicates that significantly less noise is present in the difference than in the individual records for separations of up to 17° of arc.

Zeman Antonin and Simon Zdenek INDIRECT EFFECT ON THE CONSTANT SOLID EARTH TIDAL WAVE. Proceedings of the International Association of Geodesy Symposia, 1, 217-226, 1983.

Introduction: The ocean tides influence upon the solid Earth tides is usually computes for main diurnal and semidiurnal tidal waves, the parameters of which d and k (or gamma and alpha) may be determined by measuring and for which waves the cotidal charts exist. For longperiodical tidal waves, as far as we know, this influence has not been computed, even when in this case no cotidal charts are necessary, considering that the subject under discussion is a static phenomenon.

In the connection with resolution No.15 of the XVII IAG General Assembly, it is meaningful to determine the indirect effect on the constant tidal wave M0 + S0 . According to this resolution the whole tidal effect is to be removed from all geodetic measurements, including the constant part of the tides. It was pointed out (Zeman, 1979, Simon, 1980, Groten, 1980, Simon, Zeman, 1983) that for constant tidal wave one cannot use Love numbers determined from the periodical part of the tides, so that its influence cannot be determined exactly.

Moreover, it would be taken into consideration that not even for this wave it is possible to use uniform values of parameters d and gamma for the whole Earth's surface. Firstly because of the ellipsoidicity of the Earth (Wahr, 1981), secondly as it is shown in this paper because of the influence of the constant wave of the ocean tides.

Elstner C., Harnisch M., Kautzleben H. and Schwann W. ON THE DETERMINATION AND VALUATION OF THE GRAVIMETRIC Mf-TIDE. Proceedings of the International Association of Geodesy Symposia, 1, 195-203, 1983.

1st paragraph: The continuous recordings of the temporal variations of gravity performed since 1974 at our gravimetric observatory at Potsdam resulted to high accurate parameters (+/- 2 x 10^-4 in the d-factors, +/- 0.02° in the phase lags) of the diurnal and semidiurnal main tidal waves (Dittfeld, Varga, 1983). Also the reliability of the small tidal waves Q1 and K2 was confirmed in the framework of the trans world tidal gravity measurements (Melchior et al., 1983).
The zonal tidal forces directly influence the rate of rotation of the Earth and affect their dynamical response (Wahr et al., 1981). The development of the potential given by Cartwright-Taylor-Edden was used for the computation of the temporal variation of the tide generating forces in the Mf-band for Potsdam in the interesting time interval. The Mf-group consists of two large constituents, the amplitudes and periods of which at Potsdam are:
A1 = 5.627 microgals, T1 = 13.661 days, and
A2 = 2.331 microgals, T1 = 13.633 days, respectively, and a few minor waves. The superposition implies a quasiperiodic variation with a slowly changing period around 13.67 days and an amplitude which oscillates slowly with a period of about 16.5 years between 3 and 8 microgals.

Richter Bernd THE LONG-PERIOD TIDES IN THE EARTH TIDE SPECTRUM. Proceedings of the International Association of Geodesy Symposia, 1, 204-216, 1983

Introduction: A GWR-Superconducting Gravimeter has been registering earthtides continously at the observation station of the Institut fur Angewandte Geodasie (IfAG) at the castle in Bad Homburg near Frankfurt (Phi = 50.2285, Lamda = 8.6113, h = 190 m) since May 1981.
In principle, the mechanical spring of the usual gravimeter is replaced in the Superconducting system by a magnetic field, generated by the persitent currents flowing in two superconducting coils, floating a sperical mass. The position of the sphere between the coils is measured by a capacitance bridge. To avoid nonlinearities the position of the sphere is held fixed by a magnetic feedback system /GWR-Manual 1981/.
An additional cooling compressor system reduces the gas flow rate of the 210 l Dewar, so that the whole system can operate for more than one year without interruption to supply liquid helium /Richter 1982/.

Wahr John M. THE EFFECTS OF THE ATMOSPHERE AND OCEANS ON THE EARTH'S WOBBLE -- II. RESULTS. Geophysical Journal of the Royal Astronomical Society, 74, 451-487, 1983.

Summary: The two most prominent features of the Earth's wobble spectrum are the annual wobble and the 14 month Chandler wobble. The annual wobble is generally believed to be driven by seasonal effects in the atmosphere, in the oceans, and in the global distribution of fresh water, although good quantitative agreement has remained somewhat elusive. The primary source of Chandler wobble excitation is uncertain.
Here, we examine the effects of the atmosphere and oceans on wobble excitation. Where data are insufficient we rely on dynamical models. We get good agreement with the astronomically observed annual wobble excitation. On the other hand, we find that although the atmosphere and oceans had a noticeable effect on the Chandler wobble excitation during 1900-1973, they were apparently not the primary excitation source.
We also consider the role of the atmosphere and oceans in maintaining the semi-annual and annual variations in the length of day. Our estimates disagree with the results of previous studies by about 10-20 per cent.

Muller T. and Zurn W. OBSERVATION OF GRAVITY CHANGES DURING THE PASSAGE OF COLD FRONTS. Journal of Geophysics, 53, 155-162, 1983.

Abstract: Clear observations of small but abrupt changes in gravity during the passage of cold fronts are reported. Instrumental effects can be ruled out by special experiments. Simple models for the atmosphere show that the direction and the order of magnitude of the observed effects can be explained by changes in gravitational attraction of the sensor mass by the atmosphere or by downward acceleration of the ground due to the increasing air pressure. This is additional evidence for the high importance of meteorological causes for long-period seismic noise.

Dittfeld H.-J. and Elstner Cl. TEMPORAL VARIATIONS OF TIDAL GRAVITY PARAMETERS. Hungary, Eotvos Lorand Geophysical Institute, Study of the Earth Tides, Bull.5, 70-76, 1983.

The observations: The digital Earth Tide registrations performed with the Gravimeter GS-15 No.222 at the Central Earth Physics Institute in Potsdam/GDR between March 1974 and June 1979 may be characterised by the results:
dO1 = 1.1515 +/- 0.0006; dK1 = 1.1406 +/- 0.0004;
dM2 = 1.1851 +/- 0.0002; dM2 = +1.22 +/- 0.01 deg
obtained at the ICET/Bruxelles (Belgium) by the aid of Ducarme's programme using 40272 hourly readings. This data set and its residuals resulting from Chojnicki analysises formed the base for a number of

investigations, whose results were reported on the 4th International Symposium "Geodesy and Physics of the Earth", Karl-Marx-Stadt /GDR, 1980./. By more than 20 overlapping analyses, each performed with a data volume between 6000 and 12000 hourly readings, certain temporal variations of the resulting Earth tide parameters were detected /Dittfeld, 1981./. The highest and the lowest dK1- and dP1- value differ by about two percent. For M2, O1 and S2 the d-factors fluctuate by less than one percent. Therefore we have to keep in mind that the variations of the tidal parameters are often exceeding their errors of determination and so the results of temporary Earth tide measurements do not always represent stable values of the tidal parameters, which are valid for a long time. Looking for the reasons of these variations we at first asked for possible relations between the fluctuations of air pressure and those of the tidal parameters.

Bulanzhe Yu.D., Arnautov G.P., Kalish Ye.N., Koronkevich V.P., Stus Yu.F., Tarasyuk B.G. and Shcheglov S.N. THE RESULTS OF THE FIRST INTERNATIONAL COMPARISON OF ABSOLUTE GRAVITY METERS, SEVRES, 1981. Physics of the Solid Earth, 19, No.3, 196-202, 1983.

Abstract: Upon recommendation of the genral assembly of the International Association of Geodesy (IAG), a comparison of absolute gravity meters of different designs built in different countries was conducted in 1981 at Sèvres. Two gravity meters from the United States and one from the USSR were compared simultaneously. Determinations of absolute gravity at Sèvres were made earlier with a Chinese instrument and somewhat later with French- and Italian-made instruments. It has been found that contemporary ballistic gravity meters have all approximately the same measurement accuracy with standard deviation of some 10 mcgl. Coordination of all instruments made it possible to detect the displacement of the IGSN-71 system zero by approximately 50 mcgl.

Boulanger Yu.D. SOME RESULTS OF THE STUDY OF NONTIDAL GRAVITY CHANGES. Geotectonics, 17, No.5, 364-372, 1983.

Abstract: A survey of results since 1935 of the study of nontidal gravity changes leads to the conclusion that, owing to inadequate accuracy and length of observations, there are no reliable data on global gravity changes. If such changes indeed exist, they are small, not exceeding several mcgl/yr. A gravity change of the order of 50 mcgl for the period 1969-1977 has been established for Sèvres. A quasi-periodic, synchronous gravity change has been identified at Potsdam, Moscow, and Novosibirsk, of the order of 20 mcgl in a period of about seven years. There are good records of gravity changes due to a combination of phenomena preceding or accompanying volcanic eruptions.

Melchior Paul and De Beeker M. A DISCUSSION OF WORLD-WIDE MEASUREMENTS OF TIDAL GRAVITY WITH RESPECT TO OCEANIC INTERACTIONS, LITHOSPHERE HETEROGENEITIES, EARTH'S FLATTENING AND INERTIAL FORCES. Physics of the Earth and Planetory Interiors, 31, 27-53, 1983.

Abstract: By the end of 1981 the International Center of Earth Tides (ICET) had collected and evaluated a considerable amount of data from 180 stations, including those of the Trans-Wold Profile which ensure for the first time a world-wide distribution including the tropical areas and the southern hemisphere. In 1979-80, new oceanic cotidal maps of high quality, established by Schwiderski, became available. These maps fit "on-land" tidal-gravity measurements quite successfully. A new theoretical approach developed by Wahr in 1981 has resulted in a set of theoretical formulae establishing the latitude-dependence of the classical elastic amplitude factors for tidal deformations.
We calculate here, for six tidal waves, the correlations between the observed gravity variations and those resulting from a calculation based upon the Schwiderski maps. These correlations are highly significant. After subtraction of these oceanic effects we calculate the latitude-dependences of the experimentally determined amplitude factors, which are found to fit Wahr's theoretical formulae. There remains, however, a serious discrepancy in the constant terms of the various formulae. The effects of heterogeneities in the lithosphere on tidal deformations are also clearly identified.

Eubanks T.M., Dickey J.O. and Steppe J.A. A SPECTRAL ANALYSIS OF THE EARTH'S ANGULAR MOMENTUM BUDGET: GEOPHYSICAL IMPLICATIONS. EOS, American Geophysical Union Transactions, 64, No.18, p.205, 1983.

Abstract: The geophysical implications of a comparison of atmospheric polar angular momentum (Matm) estimates and earth rotation data from January 1976 through December 1981 will be discussed. Special attention will be placed on the possible role of the oceans in the angular momentum budget. Earth orientation estimates from optical astrometry and from lunar and satellite laser ranging were used in the analysis. The Matm data were provided by R. D. Rosen from the National Meteorological Center operational weather analysis and by R. Hide from the analysis of the European Centre for Medium-Range Weather Forecasts. The consistency of the two independent reductions of the meteorological data and of the various earth rotation estimates will also be assessed.
The measured LOD* (the Length of Day minus all significant tidal variations) has a long period drift not matched by the Matm data. This drift is probably the result of an exchange of angular momentum between the core and the mantle. Matm changes were found to dominate earth rotation fluctuations for periods at and below a year. The Matm spectral power is proportional to the inverse frequency squared for periods between 1 year and about 3 days, and flattens out at higher

frequencies. The LOD* spectral power is also proportional to the inverse frequency squared except for periods smaller than about 40 days where the earth rotation measurement noise dominates. The coherence between the LOD* data and the Matm data is highly significant between periods of 700 and 40 days, except for a drop in the coherence at a period of about 96.5 days due to a lack of LOD* power at that period. There is no evidence for phase shifts between the Matm and LOD* data at periods greater than 40 days. There is a significant imbalance in the annual and semiannual angular momentum budget that is brobably due, at least in part, to unmodeled exchanges of angular momentum with the oceans.

King R.W., Morgan P.J. and Shapiro I.I. IMPROVED REPRESENTATION OF LENGTH-OF-DAY VARIATIONS FROM COMBINATION OF DIFFERENT TYPES OF OBSERVATIONS. EOS, American Geophysical Union Transactions, 64, No.18, p.205, 1983.

Abstract: We combined measurements from classical astrometry (CA), lunar laser ranging (LLR), and very-long-baseline interferometry (VLBI), to produce a series of Universal Time (UT1) and length-of-day (lod) variations relatively free from (i) well-known errors of annual and semi-annual period in the CA UT1 series, (ii) errors in terms with periods greater than about 100 days in the SLR UT1, due to deficiencies in the model used for the orbit of the Lageos satellite, and (iii) effects from gaps in the LLR series. The UT1 series was obtained by convolving the ensemble of measurements from all the techniques, suitably weighted, with a Gaussian function whose full-width-at-half-maximum amplitude was 8 days; values of lod at 5-day intervals were obtained by differencing. The 5-day values of lod have a one-standard-deviation error ranging from about 0.4 ms before 1970, when only CA data are available, to under 0.05 ms for most of 1977-1981, when data from at least two of the modern techniques contribute.
We have compared our series of lod values with that derived from variations in atmospheric angular momentum (AAM) as computed by Rosen and Salstein from zonal winds up to altitudes of 16 km for 1976-1981. After accounting for tidal effects, the two lod series are in agreement to within the rss uncertainties, except for amplitude differences (sense: UT1-AAM) of 0.09 +/- 0.03 and -0.13 +/- 0.02 ms, respectively, for the semi-annual and annual components. These differences may be accounted for by some combination of high-altitude winds, ocean currents, and atmospheric-pressure and ground-water effects.

Wahr John M. A REVIEW OF EARTH TIDES; ARE THEY SIGNAL OR NOISE ? (Abstract only). EOS, American Geophysical Union Transactions, 64, No.18, p.203, 1983.

Abstract: Earth tides are among the best understood of geophysical processes. Yet, so far, tidal observations have had only minimal impact on our understanding of the constitution and dynamical behavior of the earth. Tidal theory will probably always be needed to remove the effects of tides from seismic and tectonic observations. But what, if anything, are future tidal measurements apt to tell us about the solid earth, directly:
That question is the subject of this presentation. Existing tidal theory is described, and those parameters which are geophysically interesting but poorly constrained by other types of data are emphasized. Both the body tide and the load tide are considered.

Currie Robert G. ON BISTABLE PHASING OF 18.6 YEAR NODAL INDUCED FLOOD IN INDIA. Geophysical Research Letters, 11, No.1, 50-53, 1984.

Abstract: In agreement with Campbell (1983), Flood Area Indices (FAI) for India are interpreted as being modulated by tidal forcing at the 18.6 yr lunar nodal period. There is evidence maximum flood was approximately out of phase with nodal epoch 1898.9 whereas at epochs 1917.5, 1936.1, 1954.7, and 1973.3 maximum flood was approximately in phase. This interpretation implies that India should be experiencing widespread dryness in an interval +/- 2 to 3 years centered at mid-epoch 1982.6.