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A METHOD FOR STUDYING GLOBAL GRAVITY VARIATIONS

Summary

Global variations in gravity caused by the general variation in the mass distribution of the Earth can be investigated by measuring gravity differences around the Earth. When the gravity differences to be measured are small and special arrangements are applied, the gravity differences can be measured with an accuracy of some microgals. Measurement of this kind needs effective and extensive international cooperation.

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In its resolution No 12 at the General Assembly in Moscow the International Association of Geodesy proposed the establishment of a network of permanent stations at which the absolute measurements of gravity would be carried out to an accuracy of a few microgals and repeated periodically ([3], p. 403). Referring to this resolution, the International Gravity Commission recommended in the resolution No 2 at its VII th meeting in 1974 that about 10 permanent stations should be established where absolute gravity could be observed with microgal accuracy, to investigate possible global variations and correlations in these long–term changes in gravity ([4], p. I – 25). When realized, this plan will provide valuable information for the study of changes in the global gravity field. So long as the available instruments are not numerous, measurements of the proposed net will take several years and cannot be simultaneous. The costs of these measurements will be high.

The gravity differences between selected stations in the Fennoscandian area have been measured in order to study the effect of relatively great land uplift. The stations have been selected so that the gravity differences between them are smaller than half a milligal. Because of this measure and other special arrangements, an accuracy of ± 3 μGal is obtained ([1]). It might be worthwhile studying whether it is possible to extend this kind of measurement to a worldwide scale. If this were so, observation material for investigations in gravity and further of the variation in the distribution of the mass in the Earth's interior would be obtained more quickly and cheaply than with absolute measurement.

The most important principles in the accurate and dependable measurement of the gravity differences in the Fennoscandian measurement were ;

- gravity differences were small, less than half a milligal
- shaking and vibration caused by transport was eliminated
- differences in mean temperature during each set of measurement and transport did not exceed 3° C
- differences in outer pressure were avoided
- measurements were planned so that most of the tidal effect was eliminated from the gravity differences
- measurement and transport were carried out as continuously and symmetrically as possible.

These factors naturally cause many practical difficulties in worldwide projects, but can be overcome.

In order to assure the permanence of the sites and to diminish the effect of the ground water, the sites have to be placed on bedrock, and in order to avoid the loading effect of the sea the sites must not be too near the shore.

Sufficiently small gravity differences can be chosen when the measurements are carried out along one and the same latitude and the local gravity anomalies and differences in elevation are considered." Lines" of this kind can be measured around the Earth at different latitudes. Using the gravity values of the I.G.S.N. 71 the following "lines" were planned as possible examples (c.f. Fig. 1) ([2]) :

Latitude 40° N

Site	*Longitude*	*Gravity*
Madrid	0°	979 980 m Gal
Ankara	30° E	939 "
Seoul	130° E	958 "
San Francisco	125° W	975 "
Kansas City	100° W	980 "
Richmond	80° W	980 066 "
Washington	80° W	979 940 "

Latitude 10° N

Site	*Longitude*	*Gravity*
Khartum	40° E	978 288 m Gal
Tessenei	40° E	175 "
Phnom Penh	105° E	223 "
Caracas	70° W	231 "
Conakry	15° W	223 "

Latitude 35° S

Capetown	30° E	979 631 m Gal
Perth	115° E	449 "
Canberra	150° E	600 "
Rosario	60° W	547 "

A more exact reconnaissance will give the proper gravities in the vicinity of the sites mentioned above. In spite of the fact that the gravity differences to be measured are small, careful calibration of the gravimeters is necessary.

Air transport is naturally the only solution for these measurements. The vibration of the airplane can cause unusual drifts in the gravimeters, so special upholstery or suspension must be arranged for the instruments.

Because of the effects of temperature on the instruments, constant temperature during transports, observations and pauses between measurements is important. For that reason the gravimeters have to be transported, observed and kept during pauses in a thermostated box. If the temperature variation in the box is less than 5° C and the instrumental temperature corrections are applied, the error arisen here is not more than ± 1 μGal.

When the gravimeters are transported by air, the airplane has to be equipped with a pressure–proof box. If the variations in the outer pressure caused by flight, weather and elevations of the sites are in the order of 100 mb, the variation in the outer pressure on the instruments causes an error of about ± 1 μGal. Thus it is possible to observe gravimeters outside a pressure–proof box. The instrumental pressure corrections have to be known and applied. In addition, the gravitational force of the atmosphere according to Newtonian law can be reduced accurately enough .

The time schedule of the measurement must be planned so that most of the tidal effect is reversed in the sucessive measurements. Thus the effect of the uncertainty of the gravimetric factor of the Earth's crust will be avoided. The gravitational force of the Sun and the Moon can be computed accurately enough, to one microgal .

An airplane flying at 1000 km per hour can measure one line, of the type mentioned above, in two days. When spare time is taken into account, one line can be measured four times in two weeks. Assuming the above time schedule, the drift of a gravimeter, e.g. the LaCoste and Romberg model G, can be interpolated to an accuracy better than of one microgal.

All the error sources presented above cause an error of ± 2 μGal. The more significant error source is the observation error of a gravimeter in field conditions. For instance, in the Fennoscandian measurement one observation with the LaCoste and Romberg gravimeter gave an error of ± 13 μGal. The same accuracy can be assumed in worldwide measurement, and if the lines are measured 4 times with 10 gravimeters, an accuracy of ± 3 μGal can be obtained.

The above instrumental and outer factor errors of ± 2 μGal and the observation error of ± 3 μGal indicate that the total error of a gravity difference between the successive sites along the planned latitude lines is ± 4 μGal.

Realization of the plan presented above is technically feasible already to—day. However, there are several factors which can make the measurements difficult. These difficulties are economical and political.

Considering the accuracy and quality of this kind of the difference measurement, it would be well—founded to investigate the practical arrangements needed by an international group. The results, when obtained, would make, in addition to the absolute measurements, a valuable contribution to the study of changes in the global gravity field.

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REFERENCES

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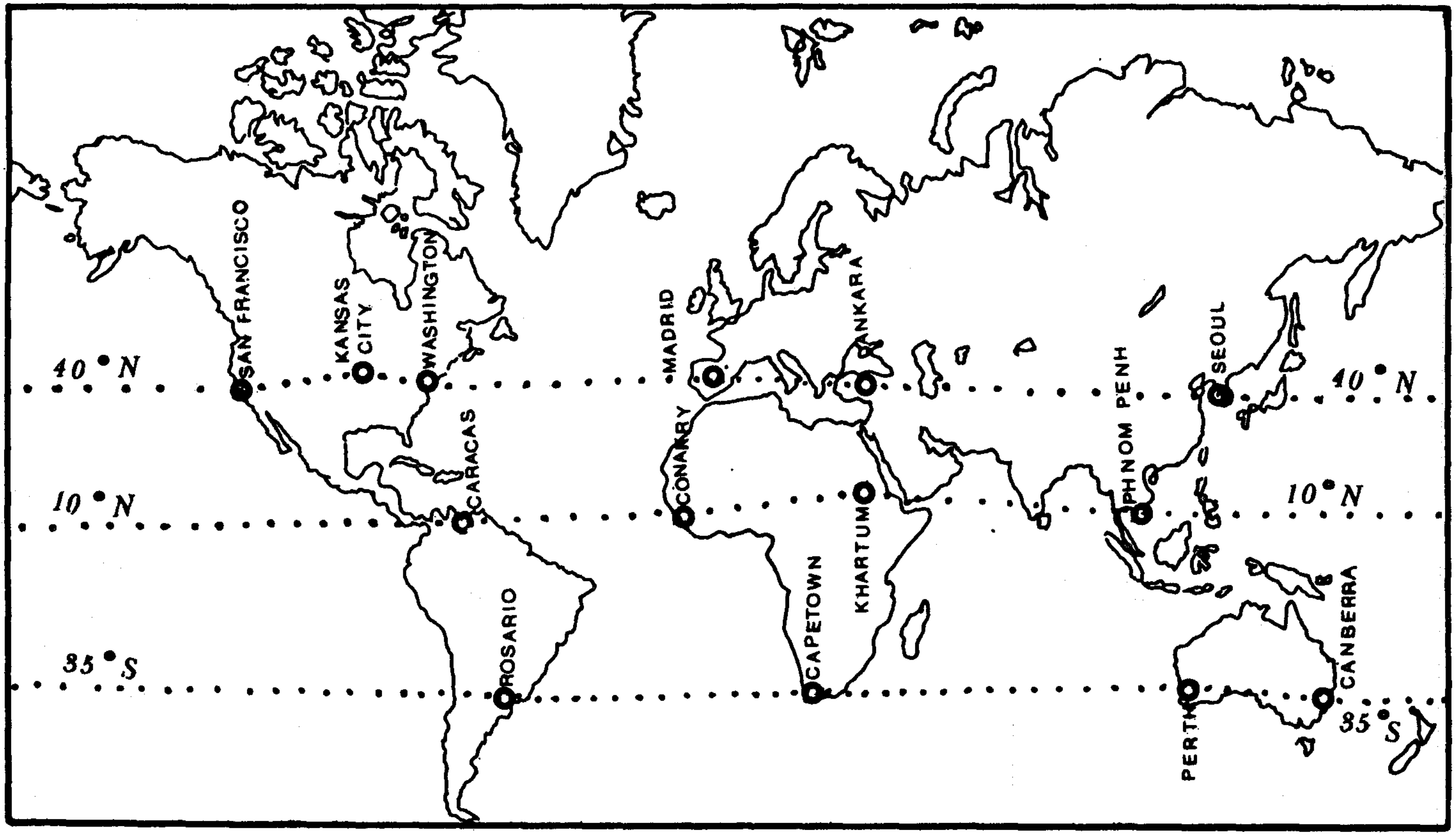

Fig. 1. The planned "lines" around the Earth.