PUBLICATION OF THE NETHERLANDS GEODETIC COMMISSION

GEODETIC WORK

IN

THE NETHERLANDS

1979–1982

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RIJKSCOMMISSIE VOOR GEODESIE; THIJSSEWEG 11, DELFT, THE NETHERLANDS

GEODETIC WORK IN THE NETHERLANDS, 1979-1982

1 CONTROL SURVEYS

1.1 Primary triangulation

An investigation was carried out into a possible displacement of the first order point Middelburg, the tower of the abbey. The reasons for this investigation were the inexplicable differences occurring in lower order measurements. Moreover a displacement was not unlikely because the point had been seriously damaged during the second world-war.
To investigate this, a trilateration network including the first order points around Middelburg was measured with the Tellurometer MRA 4. Together with the observed directions from the Belgian-Netherlands connection network from 1961 a displacement could be proved. The newly computed coordinates differed - 0.083 m and - 0.025 m from the old coordinates.

1.2 The connection of Kootwijk and Delft to the primary triangulation network

In earlier years the satellite observatory Kootwijk was connected to the first order network (see the previous report 1975 - 1978). The connection to the point Veluwe, situated at a distance of only seven kilometres from Kootwijk, could then only be realised with the auxiliary station radio-beacon Nieuw Milligen.
Thanks to the Niedersächsisches Landesvermessungsamt (FRG, Hannover), which built a 40 m high measuring tower on the point Veluwe, the direct connection network could be observed. In this way the reliability of the connecting network could be considerably improved. The distances were measured with the Tellurometer MRA 4 and the Hewlett-Packard 3808A, the directions with a theodolite Wild T3.
The connection of Delft (Delft University of Technology, Department of Geodesy) was also improved. The existing connection network was strengthened by adding distances, measured with the Tellurometer MRA 4.
The reason for carrying out the additional observations was the Netherlands English Doppler Campaign (NEDOC) in which Kootwijk and Delft were involved together with four points of the primary triangulation network.

1.3 Levelling

1.3.1 General

The Fourth Precise Levelling of the Netherlands was completed in 1978. Densification of the first-order network by measurements of second order was started.

1.3.2 Instruments

For first-order levellings the automatic instruments Zeiss Ni-1 and Ni-2 and Jena Koni 007 were used.

1.3.3 Datum of the network

The datum of the network is Normaal Amsterdams Peil (N.A.P.), fixed by an underground benchmark at Amsterdam.

1.3.4 Adjustment of the network

The adjustment of the Fourth Precise Levelling of the Netherlands has been completed.
A free adjustment of the network has been carried out, starting from the datum point at Amsterdam. Comparing the new heights of stable benchmarks with the results of the Second Precise Levelling (measured in 1926-1940), several points in the eastern and southern part of the country indicate a significant uplift of 4-5 cm. The new "scientific" heights, resulting from the free adjustment, will be used for scientific purposes only.
To obtain new heights for practical purposes the measurements have been adapted to the heights of stable (underground) benchmarks of the Second Precise Levelling.
It is planned to study the vertical movement of the Netherlands more thoroughly by comparing the results of all precise levellings and using the testing procedures developed by the Delft University of Technology.

1.3.5 Junctions with contiguous network

The following junctions have been measured:

Delfzijl	- Knock	1981 hydrostatically
Reide	- Knock	1981 "
Nieuwe Schans	- Bunde	1978, 1981
Sellingen	- Hassenberg	1982
Coevorden	- Agterhorn	1982
De Haandrik	- Laar	1982
Oldenzaal	- Frensdorferhaar	1982
Eibergen	- Wennerick	1982
Alten	- Hemden	1982

1.3.6 Special measurements

Hydrostatic levelling to connect isolated tide gauges in the North Sea and the Rhine Estuary with the levelling network on land was continued.
At the request of the Bundesanstalt für Gewässerkunde three hydrostatic levellings were carried out in the Elbe, (Freiborg - Brokdorf and Twielenfleth - Jueissand) and Weser (Kleinesiel - Dedesdorf) in 1980, as well as two levellings in

the Baltic (one of them over a distance of 10.8 km) to connect the light-houses Kiel and Kalkgrund with the German levelling net.

1.4 Geodetic Astronomy

1.4.1 Deflection of the vertical

According to a resolution of the RETrig subcommission of the International Association of Geodesy (I.A.G. Brussels, 1977) astronomical latitude and longitude were determined in Kootwijk using a Danjou-Astrolabe. The measurements were carried out by the Deutsche Geodätische Forschungsinstitut, München in 1977.

1.5 Marine-geodetic activities of the Hydrographic Service of the Royal Netherlands Navy

1.5.1 The Netherlands

Hydrographic surveys were carried out in deep draught routes across the Netherlands part of the continental shelf of the North Sea.
Horizontal control during the surveys was carried out with a Hi-Fix/6 radiopositioning system.

1.5.2 Continental Shelf Activities

The inventory of available trilateration and triangulation data and doppler-satellite data was successfully finished in October 1980. The results were laid down in a list of coordinates of a number of exploitation platforms on the continental shelf.

1.5.3 General

The data of the inventory completed with data resulting from mining law regulations are being gathered in a special data base acting as a basis for cartographic and checking purposes.

1.6 Publications

1.6.1 Levelling

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1.6.2 Geodetic astronomy

KANIUTH, K., W. WENDE - Bestimmung astronomischer Langendifferenzen für das europäische Längennetz in den Jahren 1977 bis 1979. Deutsche Geodätische Kommission bei der Bayerischen Akademie der Wissenschaften. Reihe B: Angewandte Geodäsie. Heft Nr. 250/1980.

1.6.3 Marine Geodesy

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GEIN, W.A. VAN - Operational properties and possibilities of Hi-Fix/6. The Hydrographic Journal, London, 1982, no. 23, pp. 13-19.

2 SPACE TECHNIQUES

2.1 Kootwijk Observatory for Satellite Geodesy

The Observatory for Satellite Geodesy at Kootwijk (Gelderland) is an institute within the Department of Geodesy of the Delft University of Technology. This institute by the end of 1981 succeeded the former Working Group for Satellite Geodesy.
The Observatory's activities are part of the scientific programme coordinated by the Netherlands Committee for Geophysics and Space Research and thus annually reported to COSPAR. These activities cover the fields of:
1. design, construction and development of satellite geodetic instrumentation;
2. satellite geodetic observations;
3. data analysis and utilization.

2.1.1 Instrumentation

The main observing technique applied was ground-based laser ranging. The ranging instrument since 1976 operating from a location at the observatory identified by number 7833 was upgraded to better precision and performance; its principal characteristics by the end of 1982 were:

nominal laser wave length:	694 nm
emitted energy:	1 J
pulse width:	2 ns
pulse repetition rate:	15/minute
receiver aperture:	50 cm
single-shot ranging precision:	10-15 cm r.m.s.

In trilateral cooperation with the Observatory for Satellite Geodesy and with the Institut für Angewandte Geodäsie (IfAG) at Frankfurt am Main (Federal Republic of Germany) the Institute of Applied Physics TNO-TH (TPD) at Delft, in 1980 embarked on the design and construction of a Modular Transportable Laser Ranging System (MTLRS). This system features the following main characteristics:

nominal laser wave length:	532 or 539 nm
emitted energy:	0.01 J
pulse width:	0.2 ns
pulse repetition rate:	600/minute
receiver aperture:	40 cm
normal point ranging precision:	1-2 cm r.m.s.

The MTLRS will be both road-and air-transportable.
In the course of 1983 one MTLRS will be delivered to IfAG and one to the Delft University of Technology, the latter to be operated by the Observatory for Satellite Geodesy.

2.1.2 Observations

Laser range observations were performed of the following satellites:

BEACON EXPLORER C	(1965-32A), and INTERKOSMOS-22 (1981-75A)
STARLETTE	(1975-10A)
GEOS-3	(1975-27A)
LAGEOS	(1976-39A)

These observations were made as contributions to geoscientific programmes. Within the framework of such programmes the observatory took part in two campaigns of dedicated laser ranging: a campaign coordinated by the European Range Observations to Satellites (EROS) organization (April 1-June 30, 1979) and the Short Campaign of IAU/IUGG Project MERIT (August 1-October 31, 1980).
Pre-processed laser range data was filed by the Kootwijk Observatory and made available to other scientific investigators on a running basis or upon special request.

2.1.3 Data analysis

In continued fruitful collaboration with the Section Orbital Mechanics of the Delft University's Department of Aerospace Engineering laser data analysis and related investigations were performed as contributions to the Lageos-and Crustal Dynamics Projects initiated by the U.S. National Aeronautics and Space Administration (NASA). In this context emphasis was placed on the recovery of interstation distances in view of the detection and monitoring of ongoing crustal movements.
In this regard the Section Orbital Mechanics focussed on the utilization of actual data, the Kootwijk Observatory on the simulation of strategies of data taking and analysis.
Jointly with the Section Orbital Mechanics, the Observatory for Satellite Geodesy took part in preparatory studies concerning candidate missions considered by the European Space Agency (ESA) for geoscientific research.

2.2 **Doppler positioning**

In aid of the Seasat project, the Norsdoc campaign (April 18-28, 1979) was organized in order to obtain the heights of the gauging stations along the North Sea coasts into one reference coordinate system by means of simultaneous Doppler Satellite Positioning Observations. The Dutch contribution consisted of Doppler observations at the gauging station of Petten.
One observer with one receiver rendered assistance to the 2nd Deutsch-Oesterreichische Doppler Campaign (July 17-26, 1979).
Instrumental assistance was given to the Technical University of Hannover (Dept. of Theor. Geodesy) for Marine Geodetic Research (September 17-27, 1979); the Harz-Doppler Campaign (April 14-May 14, 1980); and the West-East Doppler Campaign (May 17-27, 1980).

The observation and calculation of 16 Doppler stations in Upper-Volta, performed by teams of the Delft Department of Geodesy, and of the Wageningen Department of Surveying of the Agricultural University with regard to a development program of the International Institute of Aerial Surveys (I.T.C.) Enschede.
These observations will be used also in the African Continent Doppler Observation Campaigns (ADOS).

Sponsored by the Netherlands Geodetic Commission c.q. the Doppler Satellite Positioning Working Group, the Delft Department of Geodesy, in cooperation with the Department of Theoretical Geodesy of the Bonn University, organized the European Radio Interferometry and Doppler Campaign (ERIDOC), for the purpose of connecting the European Radio Observatories equipped with Very Long Baseline Instruments (VLBI) into the one coordinate system by means of Doppler Satellite Positioning. The Campaign also made possible the comparison of the various geodetic aspects of VLBI. Simultaneously 18 stations have been observed and adjusted (April 7-17, 1981).
A Netherlands-U.K. Doppler Satellite Observation Campaign has been conducted in cooperation with the Ordnance Survey of Great Britain (April 22-May 1, 1981). The network consisted of two stations on the British S-E coast; two British and two Dutch platforms in the North Sea; and six stations being part of the Netherlands 1st order triangulation. The purpose of the campaign was:

1. the comparison of the Doppler coordinates with the coordinates of the six 1st order Dutch triangulation stations.
2. The precise positioning of the four platforms in the North Sea in respect of both the British and Dutch 1st order triangulations.
3. The strengthening of the ties between these triangulations e.g. for RETrig.
4. To strengthen the translation parameters with regard to ED50 coordinates at the North Sea.

2.3 Very Long Baseline Interferometry (VLBI)

The Geodetic Computing Centre of the Delft University of Technology and the Netherlands Foundation for Radio Astronomy cooperated in a research project on the geodetic applications of VLBI. In connection with this project, theoretical studies on the design and post-correlation analysis of a geodetic VLBI campaign, are described in (Brouwer, 1981a, 1981b); the radio observatory of Westerbork participated in three geodetic VLBI-campaigns of the European Network. The second campaign, called ERIDOC (short for European Radio Interferometry and Doppler Campaign) consisted of 5 radio astronomy and 18 Doppler observatories and was organized in April 1981 by the Department of Geodesy of the Delft University of Technology and the Geodetic Institute of Bonn University. Preliminary results of these measurements have been presented in (Beyer et al.), whereas the final results will be communicated at the I.A.G. General Assembly in Hamburg.

2.4 Publications

2.4.1 Kootwijk Observatory for Satellite Geodesy

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AARDOOM, L. - Selected topics in satellite geodynamics. The Centenary of the Netherlands Geodetic Commission (N. v.d. Schraaf, ed.). Publ. of the Neth. Geod. Commission, 1980, pp. 29-36.

AARDOOM, L. - Techniques of precise satellite positioning for geodesy and related applications; an account of work in The Netherlands. The Centenary of the Netherlands Geodetic Commission (N. v.d. Schraaf, ed.). Publ. of the Neth. Geod. Commission, 1980, pp. 133-145.

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ZWAAN, H.G. - The effect of precession on relative station positioning by laser ranging to satellites as analysed in the long arc mode. Thesis Department of Geodesy, Delft University of Technology, 1980.

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KAMP, A. and J.J.P. VAN HULZEN - State transition matrix computations for Kalman filter orbit determination from laser range observations. Memorandum M-363, Department of Aerospace Engineering, Delft University of Technology, 1980.

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2.4.2 Doppler positioning

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2.4.3 Very Long Baseline Interferometry

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3 GRAVIMETRY

3.1 Gravity measurements in the Groningen gasfield

In 1978 a precision gravity network is measured consisting of 22 points evenly distributed over the area. The base-point Gasselte was outside the area on a geological stable formation.

Between these points 85 gravity differences were measured with a precision of 13 gal each with the La Coste-Romberg gravimeter model G No. 79, which was put to our disposal by the Technological University in Hannover. The adjustment of the network is executed with different assumptions of the correlation between the observations. It shows that a correlation coefficient of = - 0.15 between successive observations gives the best estimation of the variance factor.

The gravity values of the points are obtained after the adjustment with an accuracy of 6 gal.

It is the intention to remeasure the network in 1983 in order to detect gravity changes due to the gas-exploitation. The expected gravity changes can be correlated with the subsidence of the surface (see section 5.1.2) and with the mass decrease due to the gas extraction.

The measurements and computations were executed by the Department of Geodesy of the Delft University of Technology.

3.2 Gravity at sea and satellite altimetry

In the framework of the SEASAT Users Group of Europe (SURGE) a detailed study of the gravity field structure was carried out in the North Sea area. The study consists of an analysis of satellite altimeter data from SEASAT-1 and a combination with data coming from GEOS-3 and a detailed sea gravimetry survey (Rummel, Strang van Hees and Versluijs, 1983). The gravity measurements cover the Dutch part of the North Sea in a grid of 20 km profile spacing creating approximately 300 cross-over points. The measurement lines were linked to the IGSN-71 at Den Helder (The Netherlands), Ipswich (Great Britain) and Stavanger (Norway). The measurements were performed with a KSS-5 system (Bodenseewerke) mounted on a stabilized platform (Anschütz). For the navigation a Hifix-6 system (± 3 m) was available in the southern part and a Pulse-8 system (± 30 m) for the rest. In total 10 000 km was sailed and 30 000 gravity points were measured. The ship, H.M. "Buyskes" was made available for this project by the Dutch Hydrographic Service; the Shell International Oil Company gave assistance with an integrated computer system for navigation and data processing. The adjustment of the gravity measurements, using the control at the cross-over points, yielded a standard deviation of 1.2 mgal (10^{-5} ms^{-2}) for the single observation, compare (Strang van Hees, 1983). From the adjusted gravity data a free air gravity anomaly map was compiled, see Figure 1.
The SEASAT-1 altimeter data were adjusted relative to geoid heights as computed

from the Goddard Earth Model 10. Also in this adjustment the cross-over points of the ground tracks were used as control. The a priori standard deviation of 2.84 m of the cross-over points decreased to about 0.10 m after the adjustment.

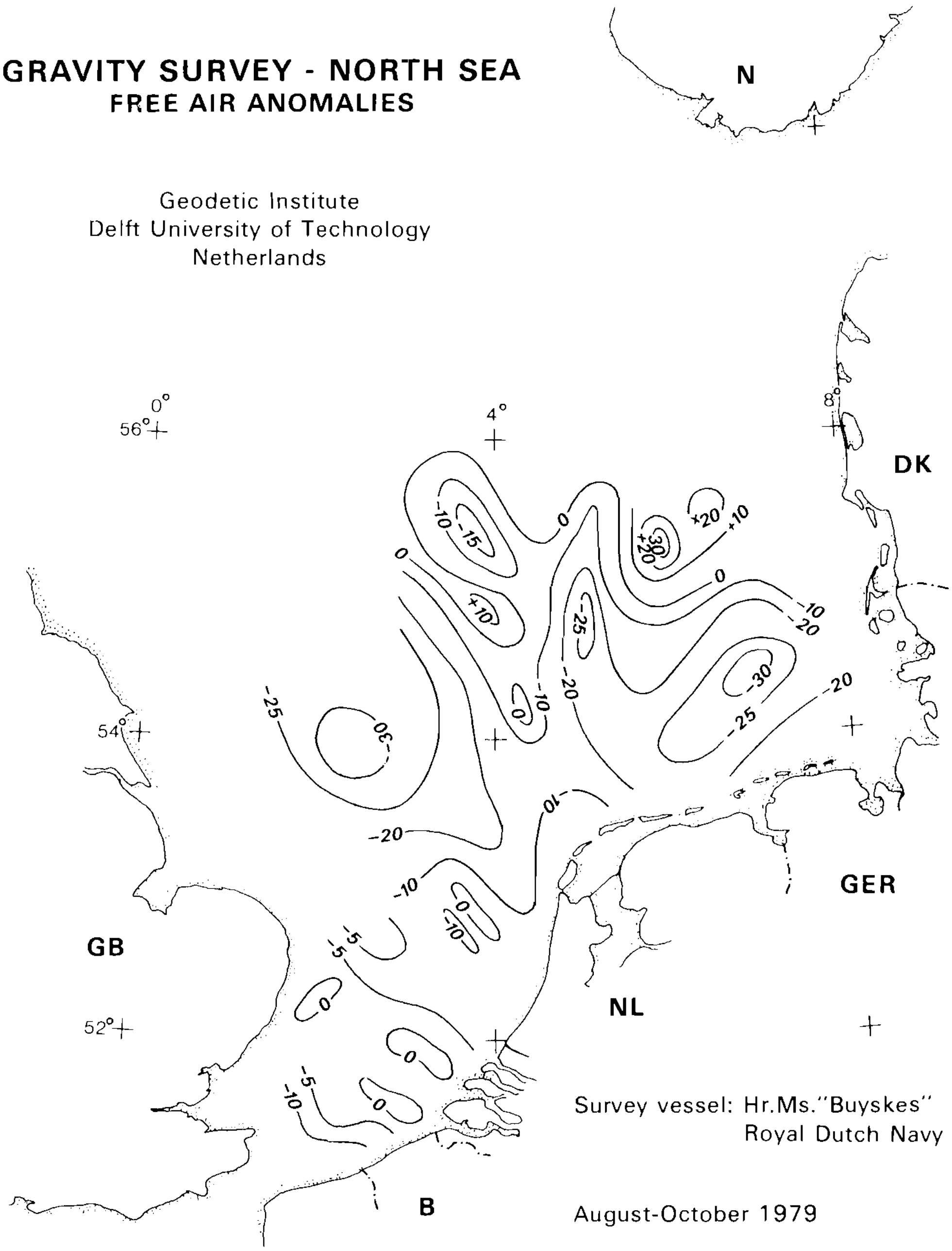

Fig. 1 Free air gravity anomaly map North Sea

A comparison with gravimetric geoid GGNS2 of the University of Hannover gave a mean difference of 0.20 m and a r.m.s difference of 0.46 m, which may be attributed to (1) errors in the geoid, (2) errors in the adjusted satellite altimeter data and (3) unmodelled sea surface topography. First steps were taken to relate both the gravity anomaly field and the sea surface to the main geological features in this area.

3.3 Publications

RUMMEL, R., G.L. STRANG VAN HEES, H.W. VERSLUIJS - Gravity field investigation in the North Sea. Allan, T.D. (ed.): Satellite Microwave Remote Sensing, Ellis Harwood Series in Marine Science, 1983, pp. 389-402.

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4 THEORY AND EVALUATION

4.1 Computing Centre, Geodetic Institute, Delft University of Technology

The theory relating to the precision and the reliability of networks was extensively applied to the design and evaluation of control networks used in practice. A method for the direct computation of the weight optimization problem for scalar target functions was developed. In collaboration with the main national survey services a project was started, aiming at the development of new practical guidelines for the design, measurement and computation of control and detail surveys. Studies are being made on a part of the ESA international astrometric project HIPPARCOS (High Precision Parallax Collecting Satellite); this contribution relates to the data processing and the testing procedures to be applied to the vast amount of data to be collected.
Under the supervision of W. BAARDA, the theory of quaternions for spatial problems was further developed in two doctoral theses. M. MOLENAAR studied the connection with three-dimensional S-transformations and criterion matrices in the context of photogrammetry, H. QUEE elaborated the computation of spatial terrestrial networks. The staff of the Computing Centre took the initiative to the publication of a Festschrift for Professor BAARDA on the occasion of his 65th birthday in 1982. Its two volumes contain many contributions from foreign and Dutch geodesists on a wide range of subjects.
Computations for the Unified European Levelling Network (UELN or REUN) as well as for the third phase of the European Triangulation Network (RETrig III) were executed by means of the SCAN-II computing system. A method for sequential data-snooping was developed for use with SCAN-II. Improved sparse matrix techniques are being implemented.

4.2 Gravity parameter estimation from large and densly space homogeneous data sets

A gravity parameter estimation technique was further developed. This technique is capable of processing arbitrarily large and globally (or at least locally) dense, homogeneous sets of observations. Two rather independent features characterize the technique: (1) For a posed estimation problem an integral formula with stabilized kernel is deduced. Conceptually it can be considered as least-squares collocation with globally continuous data coverage. (2) A numerical integration based on discrete data is applied to the integral. The required area weights attached to each observation can be computed in a unique way from triangle areas obtained by spreading over all observation points a triangle net of minimum side lengths. The error estimate is also derived from the global limit.
First but still preliminary results were obtained for the computation of $1^{\circ} \times 1^{\circ}$ mean gravity anomalies from GEOS-3 altimetry data and for the geoid computation from a large set of point gravity anomalies in a test area in New Mexico.

4.3 Publications

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5 PHYSICAL INTERPRETATION

5.1 Recent movements of the Earth's Crust

5.1.1 Measurements

At the request of the Subcommission Crustal Movements of the Netherlands Geodetic Commission precise levellings were carried out across several faults in Limburg.
In Enschede a 28 km levelling line through the centre of the town was repeated in 1981.
It is doubtful that the subsidence of about 12 cm since 1936 is caused by pumping of ground water only.

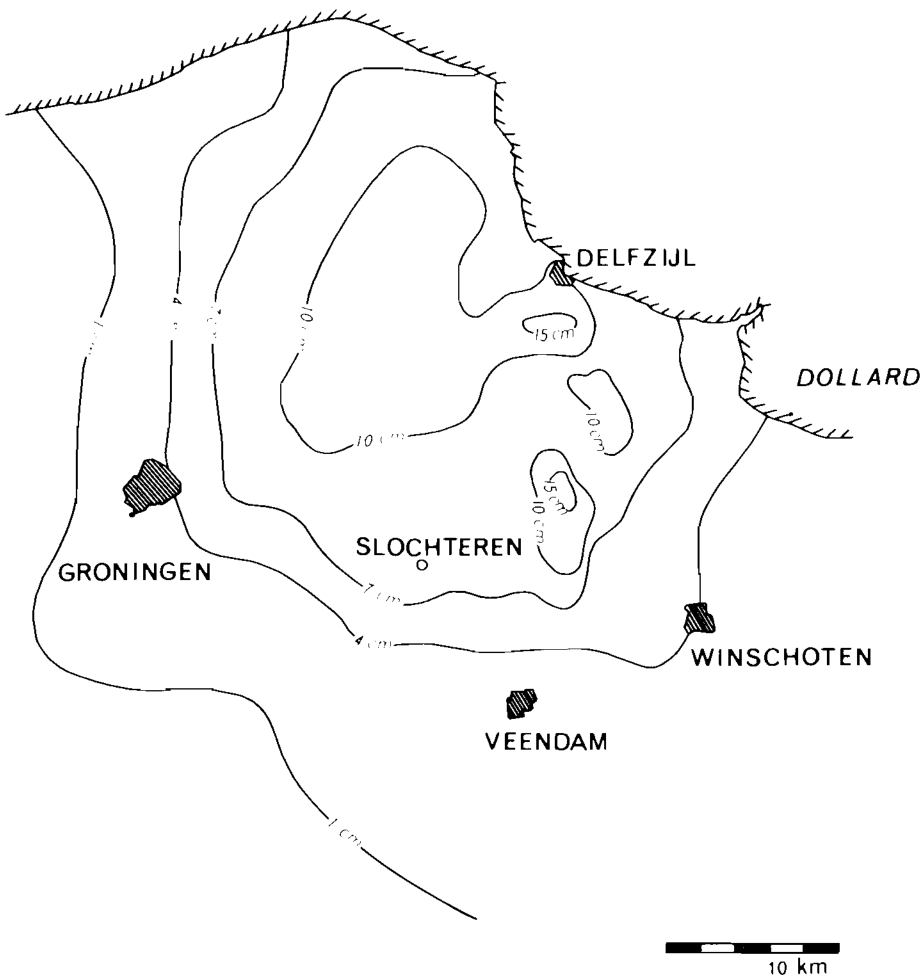

Fig. 2 Subsidence Groningen gasfields 1969-1981

5.1.2 Levellings in the Groningen gasfield

The computation of the fifth levelling across the gasfield, carried out in 1978, was completed.
The sixth levelling was carried out in 1981 (previous levellings in 1964/65, 1968/69, 1972, 1975, 1978). The network consisted of 1460 km of levellings, 92 circuits, 205 nodal points and 298 sections. The standard deviation of this levelling was 1.1 mm/ $\sqrt{}$km. Since the beginning of the gas production in 1965, a surface subsidence of 15 cm was found in the centre of the field. See fig. 2.
(Part of the subsidence is expected to be caused by drainage of ground water). In 1978 a gravity network, consisting of 21 points, was measured.

5.1.3 Levelling in mining area

At the request of the Staatstoezicht op de Mijnen (the state office supervising all mining activities in the Netherlands) the precise levelling in the former coal-district of Southern Limburg was repeated, to detect possible vertical movements after the terminating of the coal-extraction.

5.2 **Publications**

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