COMBINED SPACE GEODETIC AND GEOPHYSICAL MEASUREMENTS FOR STUDIES OF CRUSTAL MOVEMENT IN SCANDINAVIA

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INTRODUCTION

Scandinavia rests upon one of the most stable crustal platforms on the Earth, the Baltic shield. None the less the study of crustal movement is of great importance. Inparticular studies of vertical movement induced by post glacial rebound have been carried out for over 100 years. These have been accomplished using water level variations, and more recently in this century using precise leveling methods. The uplift measurements of Fennoscandia has led to a clearer understanding about the rheology of the crust and upper mantle of the Earth.

ACTIVE TECTONICS OF THE BALTIC SHIELD

Although the region is free from major earthquake activity, strain release at shallow depth occures along the Gulf of Bothnia in the center of the Baltic shield. This is almost certainly due to the accumulated strain caused by the different manner inwhich land uplift effects land and water covered areas (Anderson, 1980 and references therein).

Larger earthquakes of deeper origin occur at the edge of the of the shield, in the Oslo fjord region, and in South Western Sweden.

SPACE GEODETIC VLBI ACTIVITY

Present VLBI measurements in Scandinavia are carried out at Onsala Space Observatory under the framework of the NASA Geodynamics Program (see Annual Report for 1979). Further measurements have been made at Metsähovi in Finland and in Norway using a small dish (Nes, et al, 1979). Plans have been discussed to use the large EISCAT antennas in the far north as well as a cooperative venture between the Scandinavian countries for a portable system. Table 1 indicates the VLBI baseline rate changes to be expected on the grounds of present known strain release mechanisms operating on these areas. Both horizontal and vertical effects have been compared.

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Table 1
Rates of uplift, baseline rates, estimated horizontal strain release vrs uplift baseline rates for Scandinavian VLBI baselines.

VLBI BASELINE	ΔZ DIFFERENCE (CM/YR) VERTICAL UPLIFT RATE	ΔZ·SIN(θ/2) BASELINE RATE	HORIZONTAL STRAIN RELEASE (CM/YR) VRS UPLIFT BASELINE RATE (%)		
1. Onsala-Kiruna	+0.6 (cm/yr)	+0.05 (cm/yr)	+0.1 (cm/yr)		+50%
2. Onsala-Sodankylä	0.7	0.07	0.1	Fennoscandia plate	+70%
3. Onsala-Tromsö	0.0	0.00	0.1		00%
4. Dwingeloo- Onsala	0.2	0.01	0.2	Uplift bulge	+05%
5. Dwingeloo- Sodankylä	0.9	0.13	0.2		+65%
6. Bonn-Onsala	0.1	0.01	0.5	Oslo-Rhein graben	+02%
7. Bonn-Sodankyla	0.8	0.13	0.5		+26%
8. Haystack-Onsala	0.2	0.09	1.8	Mid-Atlantic ridge	+05%
9. Haystack-Sodankylä	0.9	0.43	1.8		+24%
10. Goldstone-Onsala	0.1	0.06	1.8		+03%
11. Goldstone-Sodankylä	0.8	0.47	1.8		+26%

Inorder to control the geodetic parameters for the VLBI solution extensive measurements using Doppler Satellite point positioning have been carried out for Onsala (Anderson, 1979, Ekmann, 1980 and others).

A tidal gravimeter has been operated at Onsala and one is to be installed on a permanent basis in late 1980. Figure 1 indicates the anomalous M2 tidal component at Onsala found in the earlier measurement. It is planned to use Onsala as a tie for several types of terrestrial and space geodetic experiments during the 1980's.

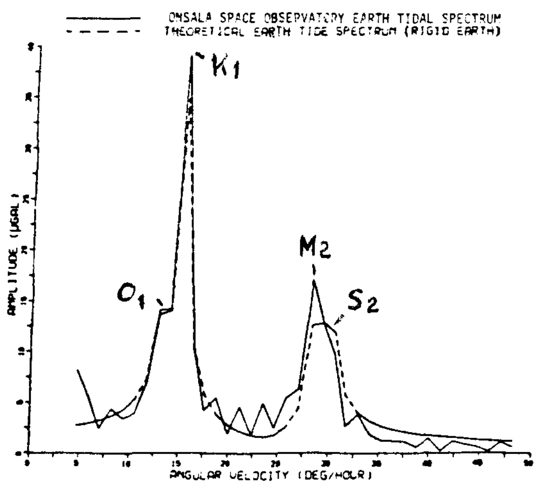

FIGURE 1. SPECTRAL ANALYSIS OF TIDAL GRAVIMETER RECORD TOGETHER WITH THEORETICAL TIDAL SPECTRA FOR ONSALA SPACE OBSERVATORY.

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TABLE 9. REPEATIBILITY OF INTERSTATION DISTANCES AND HEIGHT DIFFERENCES FROM EDOC-II TO SCANDOC-79.

Line	Distance (m)	Δ Dist. (m)	(ppm)	Δh (m)	Δ(Δh) (m)
TRS...TRD	790873.55	-0.49	-0.62	5.10	-0.15
TRS...EGB	1358712.91	-1.05	-0.77	-4.07	0.48
TRS...JNA	1047592.41	0.53	0.51	11.31	-0.08
TRD...EGB	570717.84	-0.52	-0.91	-9.17	0.63
TRD...JNA	975322.57	0.79	0.81	6.20	0.06
EGB...JNA	1301868.44	0.10	0.07	15.37	-0.57
	Mean	-0.11	-0.15		0.06
	Rms	0.70	0.72		0.44

TABLE 8. REPEATIBILITY OF DOPPLER POSITIONS IN SCANDINAVIA

Station	EDOC-SCANDOC Δx (m)	Δy (m)	Δz (m)	NORDOC-SCANDOC Δx (m)	Δy (m)	Δz (m)
TRS	-0.63	-1.03	-0.18			
TRD	-0.90	-0.45	0.11	-0.59	0.49	-0.54
EGB	-1.47	0.12	-0.26			
MSB				-0.21	0.69	-1.00
JNA	-1.23	0.31	0.06			
Mean	-1.06	-0.26	-0.07	-0.40	0.59	-0.77
Rms	0.37	0.61	0.18			

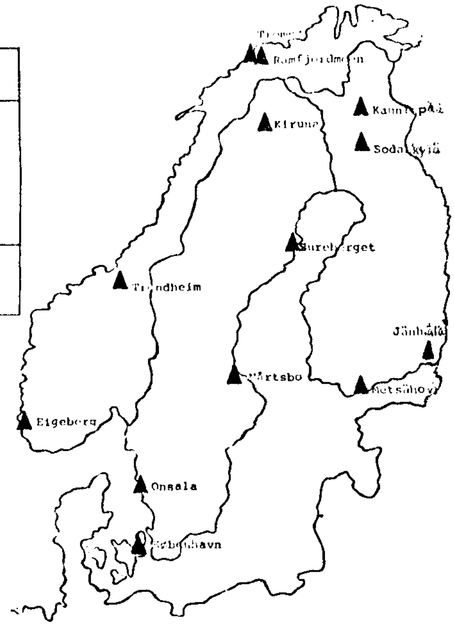

Figure 2. The SCANDOC 79 Results compared with the earlier EDOC and NORDOC results. (after Ekmann,1980)

4. DOPPLER SATELLITE ACTIVITY

Since 1973 Doppler Satellite measurements have been carried out throughout Scandinavia. Presently there are 9 Satellite receivers in Sweden, and over 20 considering Scandinavia as a whole. This situation allows for the establishment of regularly measured networks within the Scandinavian Nations which can be used together with other methods to monitor the stability of the geodetic solutions as well as to be used as a reference field to measure crustal movements.

In 1979 the first of the SCANDOC measurements were made. Figure 2 indicates the network, and several tables have been given indicating the baseline stability which has been acheived in these Nordic networks (Ekmann, 1980).

5. CONCLUSIONS

The Scandinavian Area has several Space Geodetic programs which when coordinated with Terrestrial projects lend themself very well to the study of recent crustal movements. Recent results (Clark,et al,1980) indicating repeatability to 4 CM on the Onsala-Haystack baseline, together with an extensive Doppler Translocation Network in Scandinavia showing baseline repeatibility to better than 0.7 ppm clearly show that these methods are acheiving the level of precision needed for studies of crustal movements in Scandinavia.

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