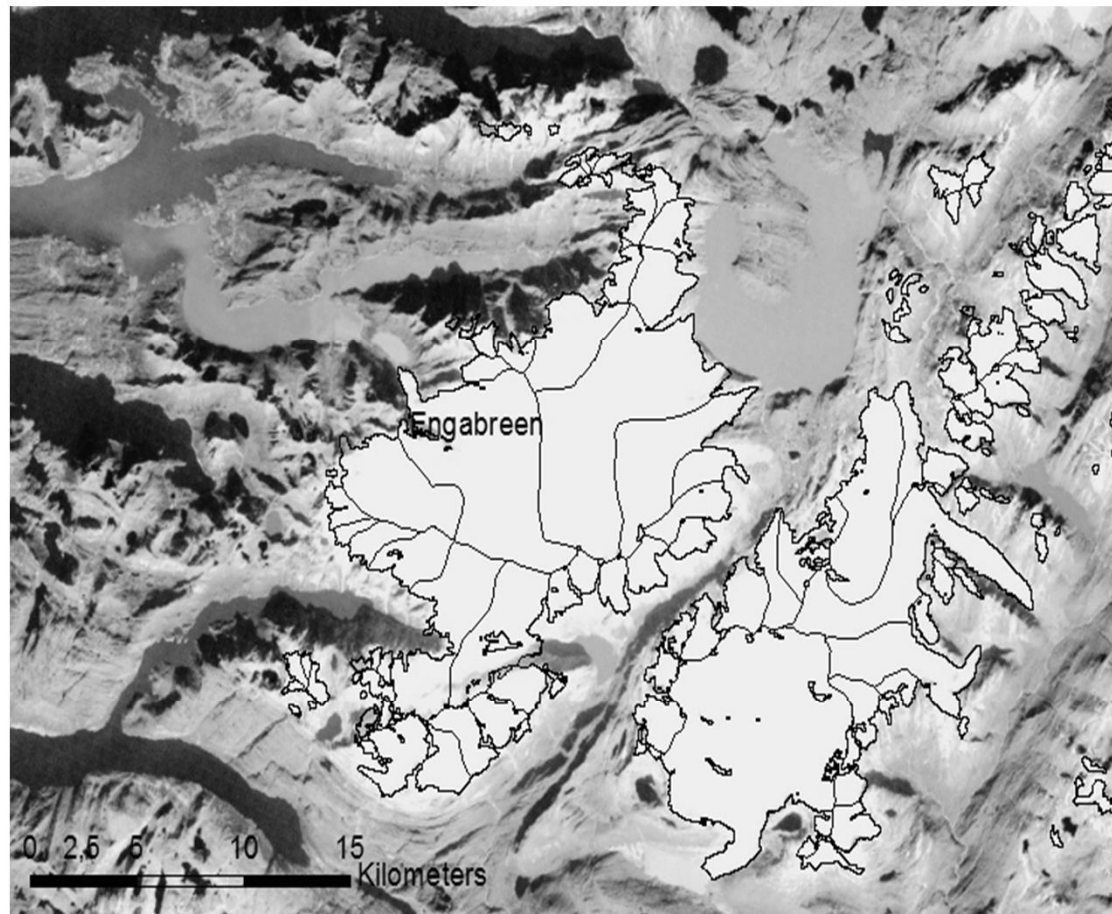
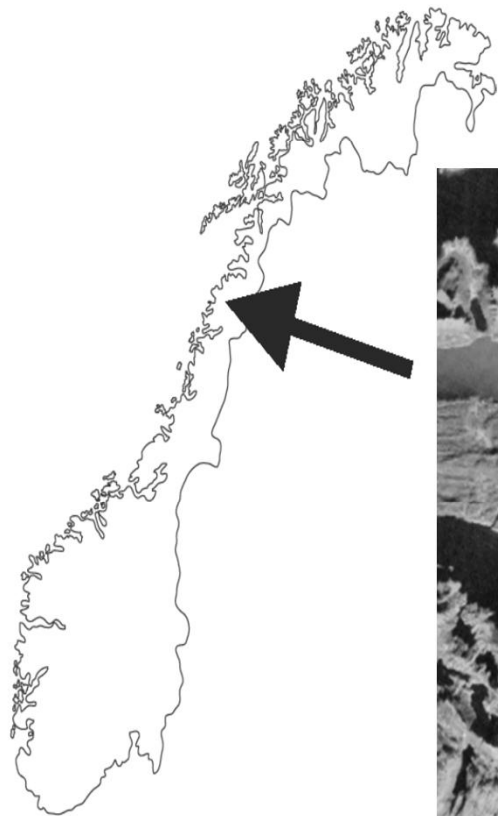
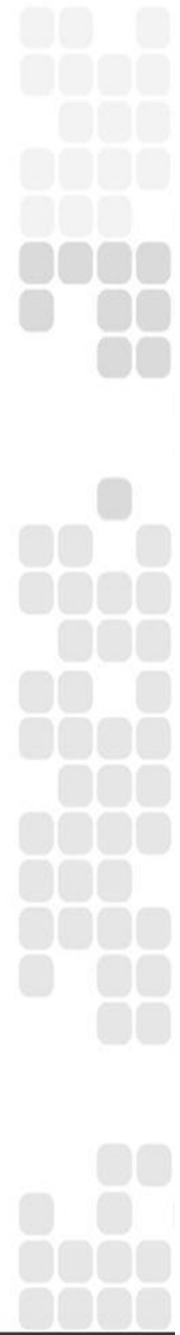
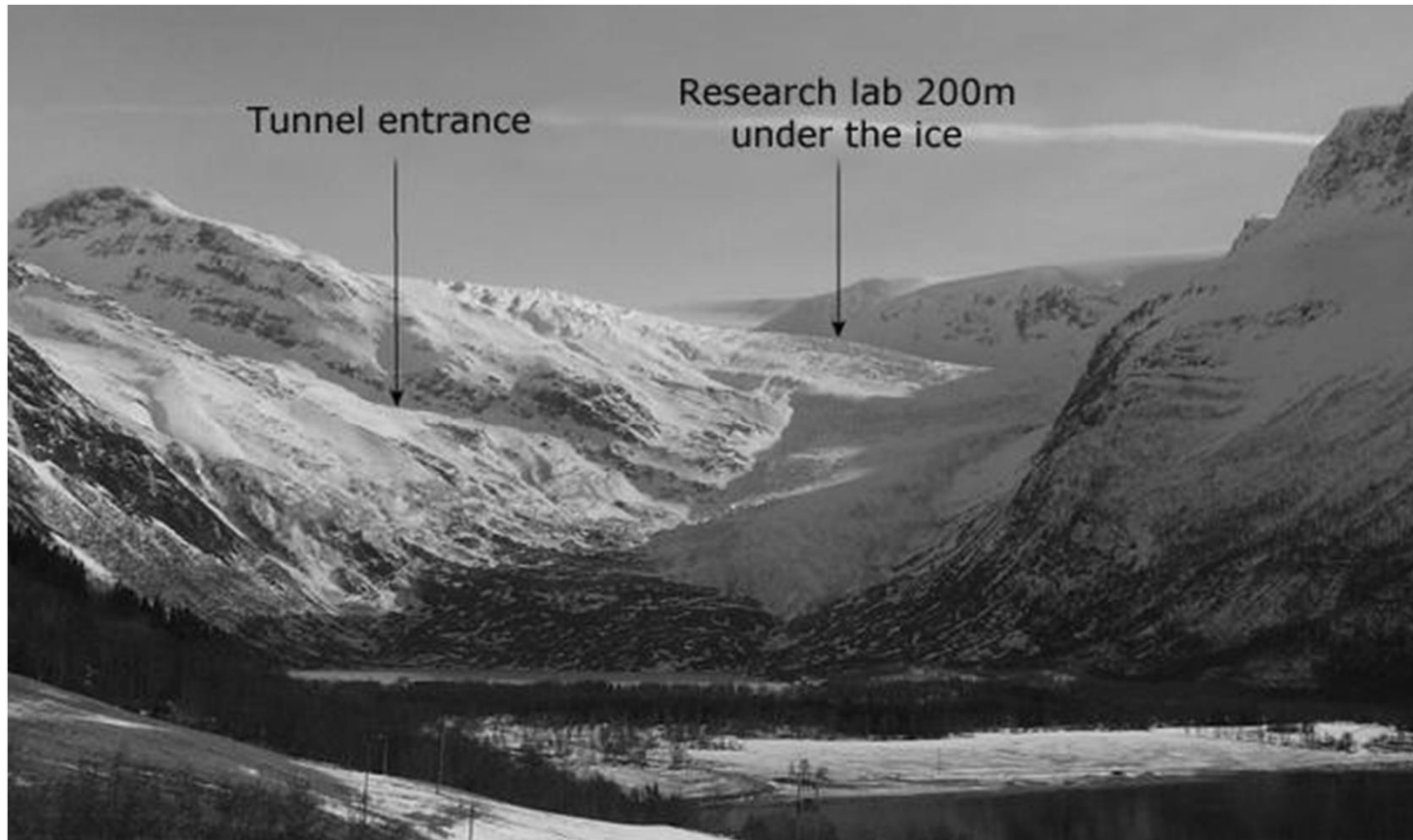


# Gravimetrisk observasjonar og modelleringar ved Svartisen

Siri Eikerol

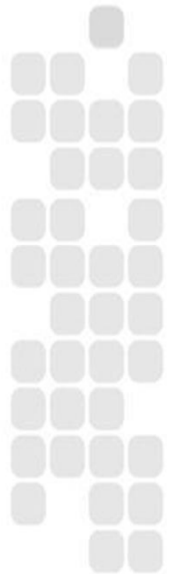


Det subglasiale laboratoriet (+Worlds most claustrophobic lab+)



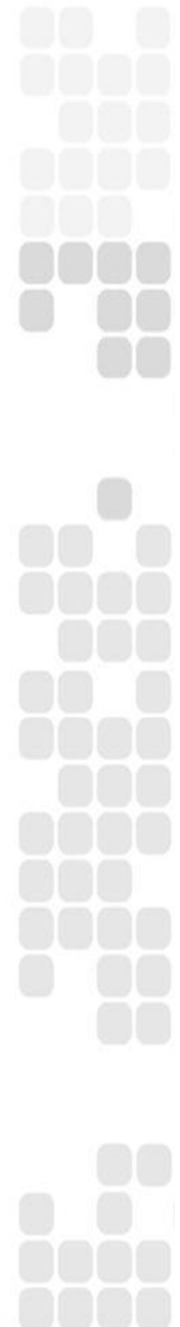
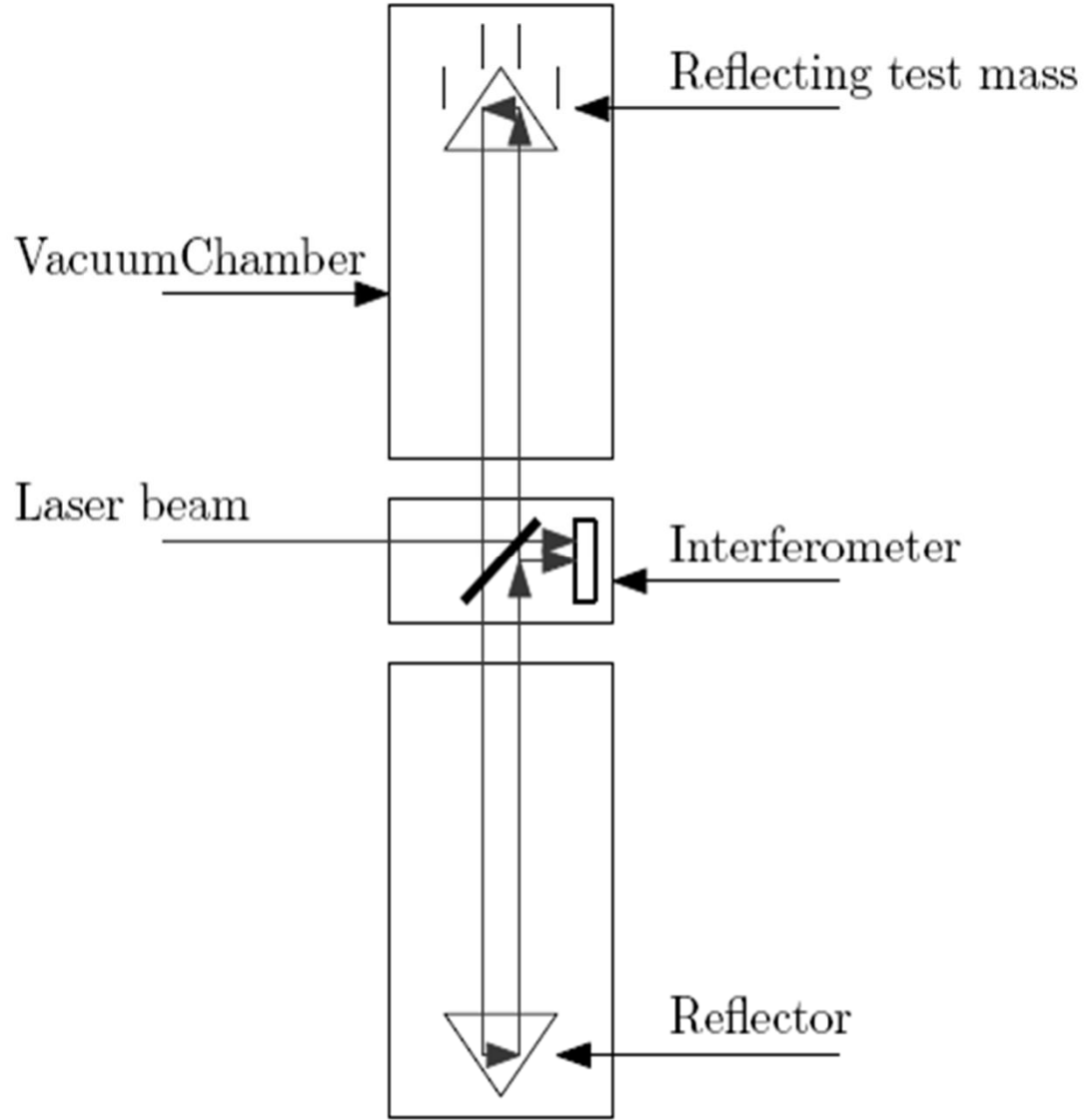
## Føremål med arbeidet

- “ Etablere tyngdestasjonar under isen
- “ Måle absolutt tyngde og gjere relative målingar
  
- “ Modellere effektar av endringar
  - “ Isoverflate
  - “ Snødekke
  - “ Tidsvarierende massar i tunnelen
  
- “ Kva kan detekterast?



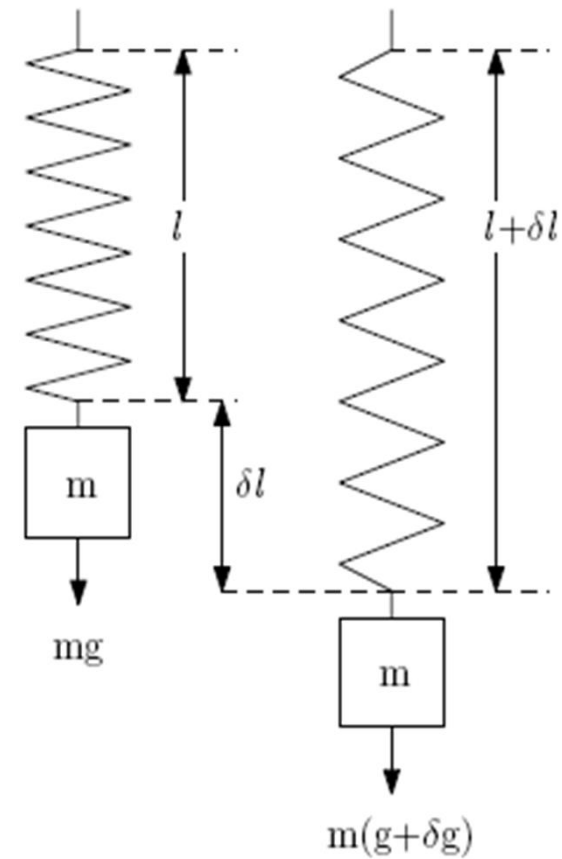
Absolutt gravimetri

“ Micro-g Lacoste FG  
- Fritt-fall-prinsipp



## Relativ gravimetri

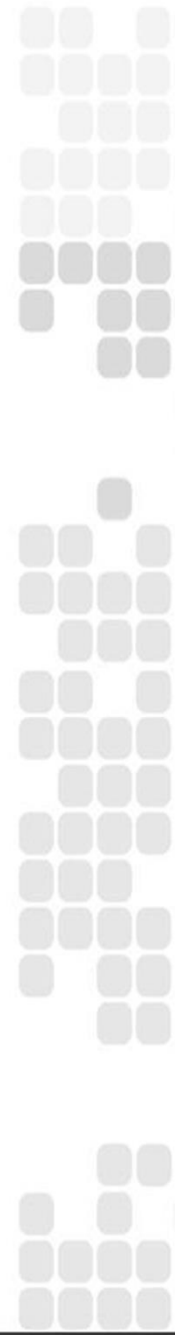
- “ LaCoste & Romberg Gravity meter
  - fjørbasert metode for observasjon av ringdeending
- “ ZLS Burris Gravity meter
  - basert på prinsipp til LaCoste & Romberg



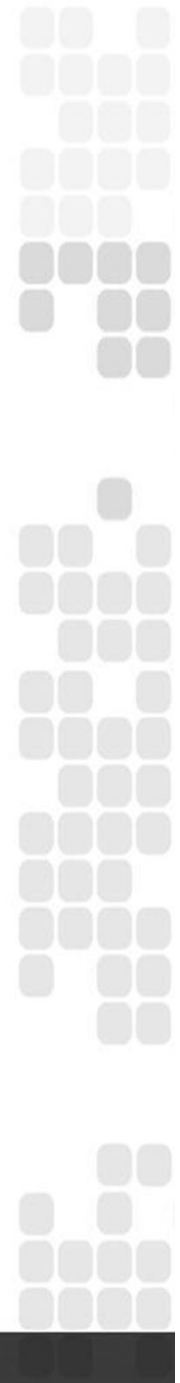
## Etablering av tyngdestasjonar

” Fundament for FG5 bygd i september 2013

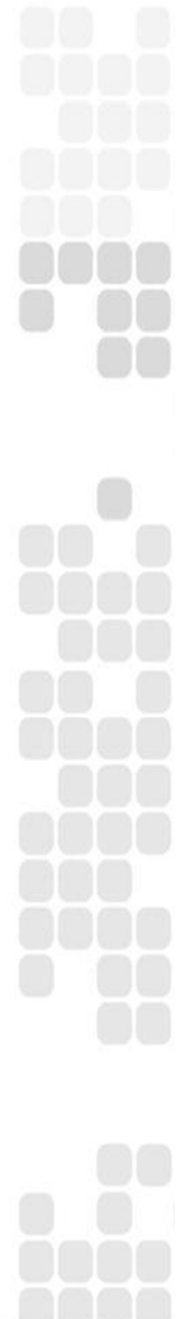
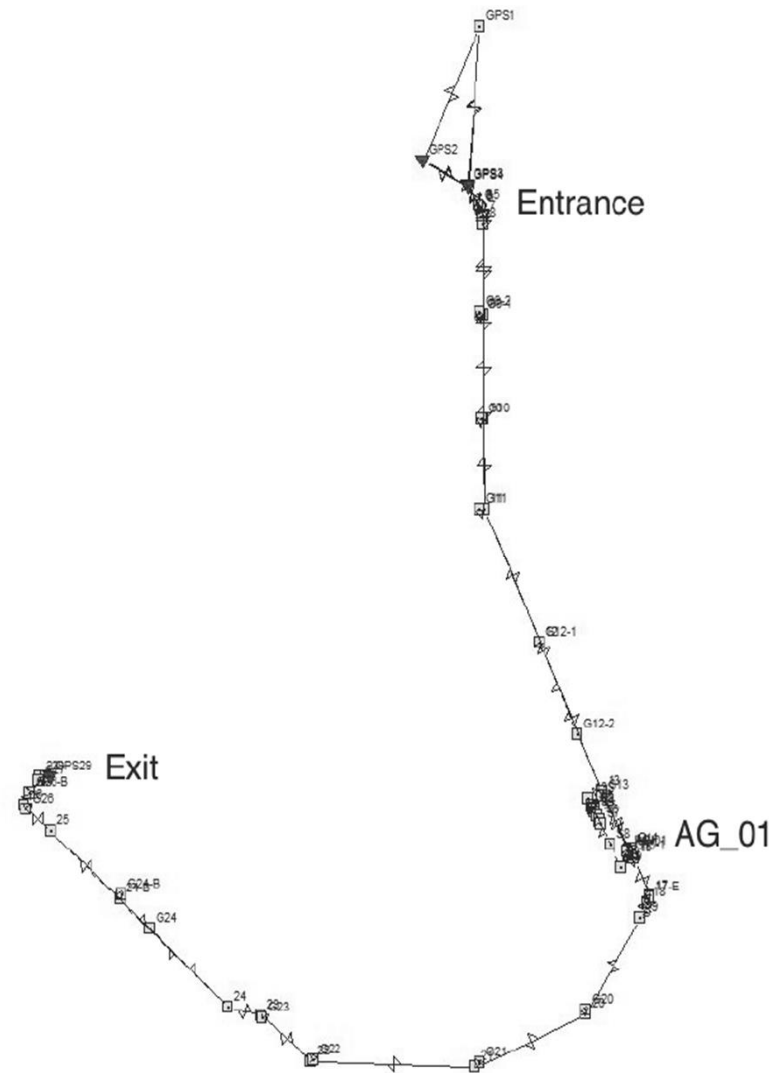








- “ 20 koordinatfesta stasjonar
- “ Stasjonane er fordelt på om lag 3 km



## Tyngdegradient

“ Observasjonar gjort på fundament til FG5

- Gradient:            -2,4  $\mu\text{Gal}/\text{cm}$

- Avvik:                0,0047  $\mu\text{Gal}/\text{cm}$



Absolutt tyngde

“ Observasjonar gjort med FG5

- 982202709.74 ± 6.6 μGal (0 m)



## Relative tyngdeverdiar

- “ Kontrollert for drift
- “ Utjamna med minste kvadrat
  
- “ Avvik mindre enn  $\pm 13.3 \mu\text{Gal}$  ved alle stasjonar



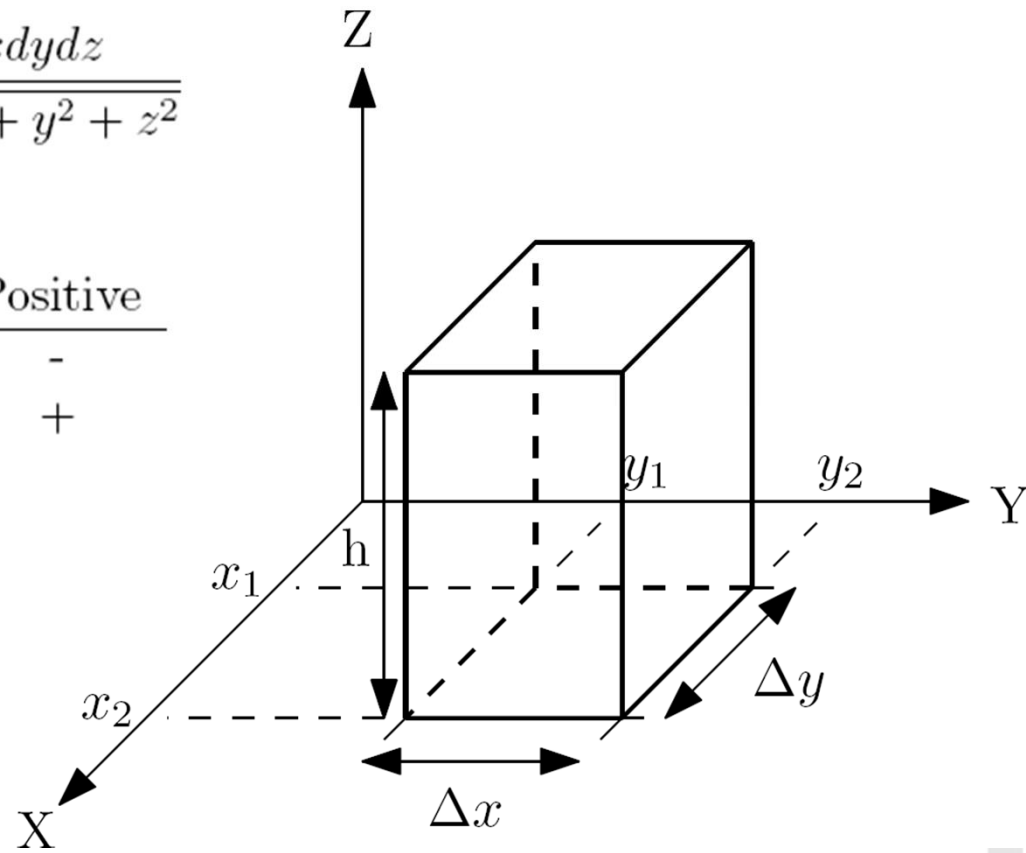
Endelege  
tyngdeverdiar

Station	Absolute values		Relative values		
G5	982227223.0	± 12.3	24513.3	± 10.9	μGal
G09-1	982218878.7	± 12.8	16169.0	± 11.5	μGal
G09-2	982219425.6	± 11.1	16715.8	± 9.5	μGal
G10	982216545.1	± 13.0	13835.3	± 11.8	μGal
G11	982216051.4	± 12.7	13341.7	± 11.3	μGal
G12	982207757.2	± 11.4	5047.4	± 9.9	μGal
G12-B	982203609.0	± 11.8	899.3	± 10.4	μGal
G13	982202282.9	± 10.9	-426.8	± 9.3	μGal
G14	982202301.4	± 10.2	-408.3	± 8.5	μGal
G15-1	982202771.0	± 10.6	61.23	± 9.0	μGal
G15-2	982202557.3	± 10.2	-152.4	± 8.5	μGal
G20	982198273.8	± 12.7	-4436.0	± 11.4	μGal
G21	982196302.5	± 12.7	-6407.2	± 11.4	μGal
G22	982197282.8	± 12.3	-5426.9	± 11.0	μGal
G23	982200377.6	± 12.7	-2332.1	± 11.4	μGal
G24	982198723.4	± 12.8	-3986.3	± 11.4	μGal
G24-B	982199344.2	± 12.4	-3365.5	± 11.1	μGal
G26	982201292.0	± 12.9	-1417.7	± 11.6	μGal
G26-B	982202692.9	± 13.9	-0016.8	± 12.7	μGal
G27	982204329.9	± 14.5	1620.1	± 13.3	μGal
AG_01	982202709.7	± 6.6	0	± 3.5	μGal

## Prisme-metode

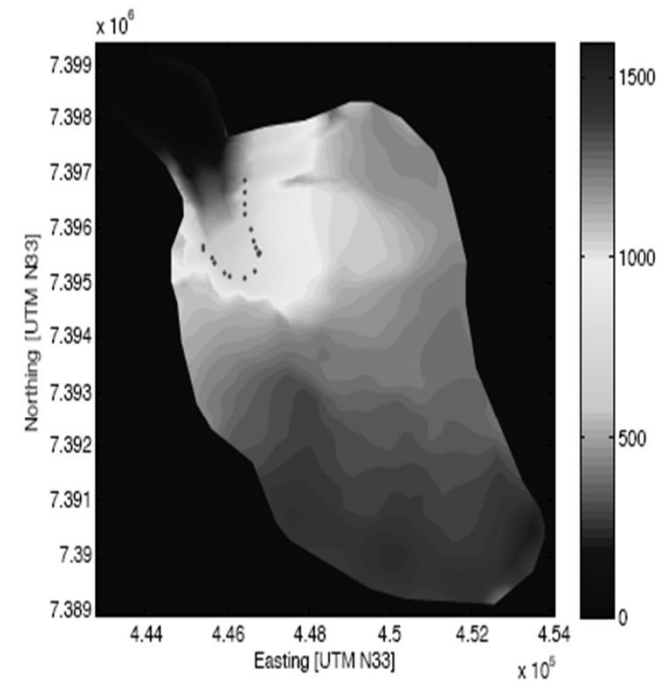
$$V_{top} = G\rho \int_{x_1}^{x_2} \int_{y_1}^{y_2} \int_{z_1}^{z_2} \frac{dxdydz}{\sqrt{x^2 + y^2 + z^2}}$$

Mass anomaly:	Negative	Positive
Above	+	-
Below	-	+



## Effekt av issmelting på overflate

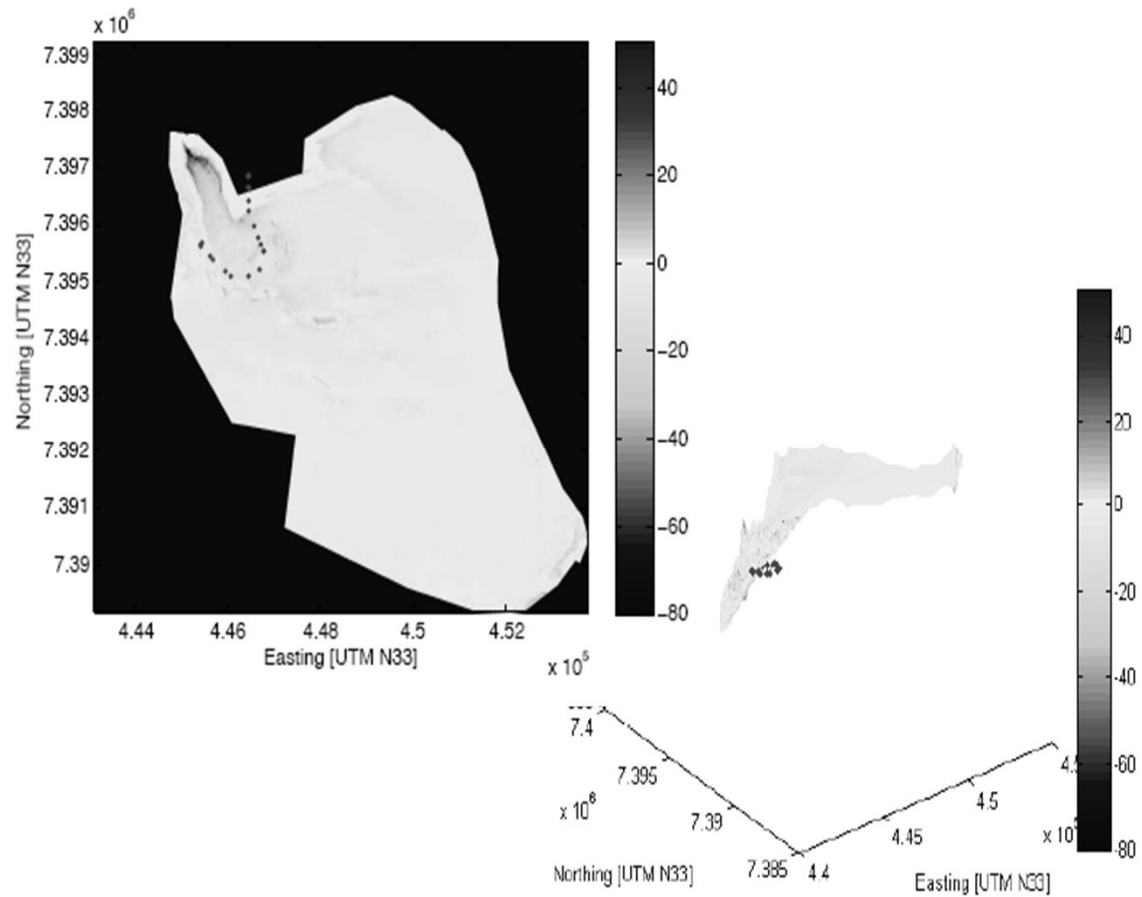
Station	1 m	0.5 m	0.1 m	0.05 m	0.01 m	0.005 m	
G5	62.0	31.0	6.2	3.1	0.6	0.3	$\mu Gal$
G09-1	146.4	73.2	14.7	7.3	1.5	0.7	$\mu Gal$
G09-2	141.1	70.6	14.1	7.1	1.4	0.7	$\mu Gal$
G10	315.1	157.5	31.5	15.7	3.1	1.6	$\mu Gal$
G11	382.1	190.9	38.2	19.1	3.8	1.9	$\mu Gal$
G12	343.6	171.8	34.3	17.2	3.4	1.7	$\mu Gal$
G12-B	335.7	167.8	33.6	16.8	3.4	1.7	$\mu Gal$
G13	340.0	170.0	34.0	17.0	3.4	1.7	$\mu Gal$
G14	346.8	173.4	34.7	17.4	3.5	1.7	$\mu Gal$
G15-1	348.0	174.0	34.8	17.4	3.5	1.7	$\mu Gal$
G20	377.2	188.6	37.7	18.9	3.8	1.9	$\mu Gal$
G21	397.3	198.6	39.7	19.9	4.0	2.0	$\mu Gal$
G22	402.8	201.3	40.2	20.1	4.0	2.0	$\mu Gal$
G23	416.5	208.1	41.6	20.8	4.2	2.1	$\mu Gal$
G24	323.4	161.7	32.4	16.2	3.2	1.7	$\mu Gal$
G24-B	296.0	148.1	29.6	14.8	3.0	1.5	$\mu Gal$
G26	295.9	148.1	29.6	14.8	3.0	1.5	$\mu Gal$
G26-B	304.0	152.0	30.4	15.2	3.0	1.5	$\mu Gal$
G27	214.5	107.1	21.4	10.7	2.1	1.1	$\mu Gal$
AG_01	347.2	173.6	34.7	17.4	3.5	-1.7	$\mu Gal$





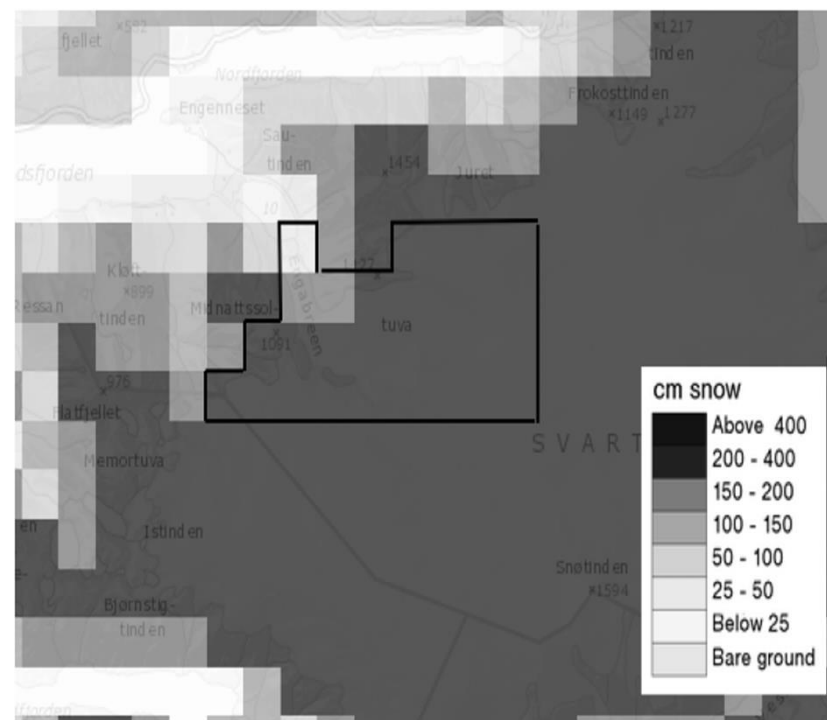
## Effekt av overflateendring mellom 2001-2008

Station		
G5	3.6	$\mu\text{Gal}$
G09-1	27.7	$\mu\text{Gal}$
G09-2	26.2	$\mu\text{Gal}$
G10	104.1	$\mu\text{Gal}$
G11	433.4	$\mu\text{Gal}$
G12	332.1	$\mu\text{Gal}$
G12-B	213.7	$\mu\text{Gal}$
G13	182.1	$\mu\text{Gal}$
G14	172.4	$\mu\text{Gal}$
G15-1	172.8	$\mu\text{Gal}$
G20	206.7	$\mu\text{Gal}$
G21	233.6	$\mu\text{Gal}$
G22	186.2	$\mu\text{Gal}$
G23	200.1	$\mu\text{Gal}$
G24	14.9	$\mu\text{Gal}$
G24-B	-12.4	$\mu\text{Gal}$
G26	-46.8	$\mu\text{Gal}$
G26-B	-57.3	$\mu\text{Gal}$
G27	-74.9	$\mu\text{Gal}$
AG_01	172.7	$\mu\text{Gal}$



## Effekt av snølag på overflate

Station	100 kg/m <sup>3</sup>	400 kg/m <sup>3</sup>	800 kg/m <sup>3</sup>	
G5	-0.7	-2.3	-5.8	<i>μGal</i>
G09-1	-0.9	-3.4	-7.0	<i>μGal</i>
G09-2	-0.9	-3.4	-6.9	<i>μGal</i>
G10	-0.9	-3.7	-7.5	<i>μGal</i>
G11	-1.0	-4.0	-8.1	<i>μGal</i>
G12	-0.9	-3.6	-7.2	<i>μGal</i>
G12-B	-1.0	-4.0	-7.	<i>μGal</i>
G13	-1.1	-4.3	-8.5	<i>μGal</i>
G14	-1.1	-4.5	-8.9	<i>μGal</i>
G15-1	-1.1	-4.5	-8.9	<i>μGal</i>
G20	-1.2	-4.6	-9.2	<i>μGal</i>
G21	-1.1	-4.4	-8.7	<i>μGal</i>
G22	-1.1	-4.4	-8.7	<i>μGal</i>
G23	-1.0	-4.0	-8.1	<i>μGal</i>
G24	-1.0	-3.9	-7.8	<i>μGal</i>
G24-B	-1.0	-3.8	-7.7	<i>μGal</i>
G26	-0.9	-3.6	-7.2	<i>μGal</i>
G26-B	-0.9	-3.5	-7.0	<i>μGal</i>
G27	-0.9	-3.4	-6.8	<i>μGal</i>
AG_01	-1.1	-4.4	-8.9	



## Oppsummering

- “ Tyngdestasjoner med presisjon på mindre enn  $\pm 14 \mu\text{Gal}$  er etablert i tunnelen under Engabreen
- “ Mogleg å detektere endring på  $\pm 0.05 \text{ m}$  i overflata til isbreen

