Modelling the present-day structure of the southern Norwegian lithosphere

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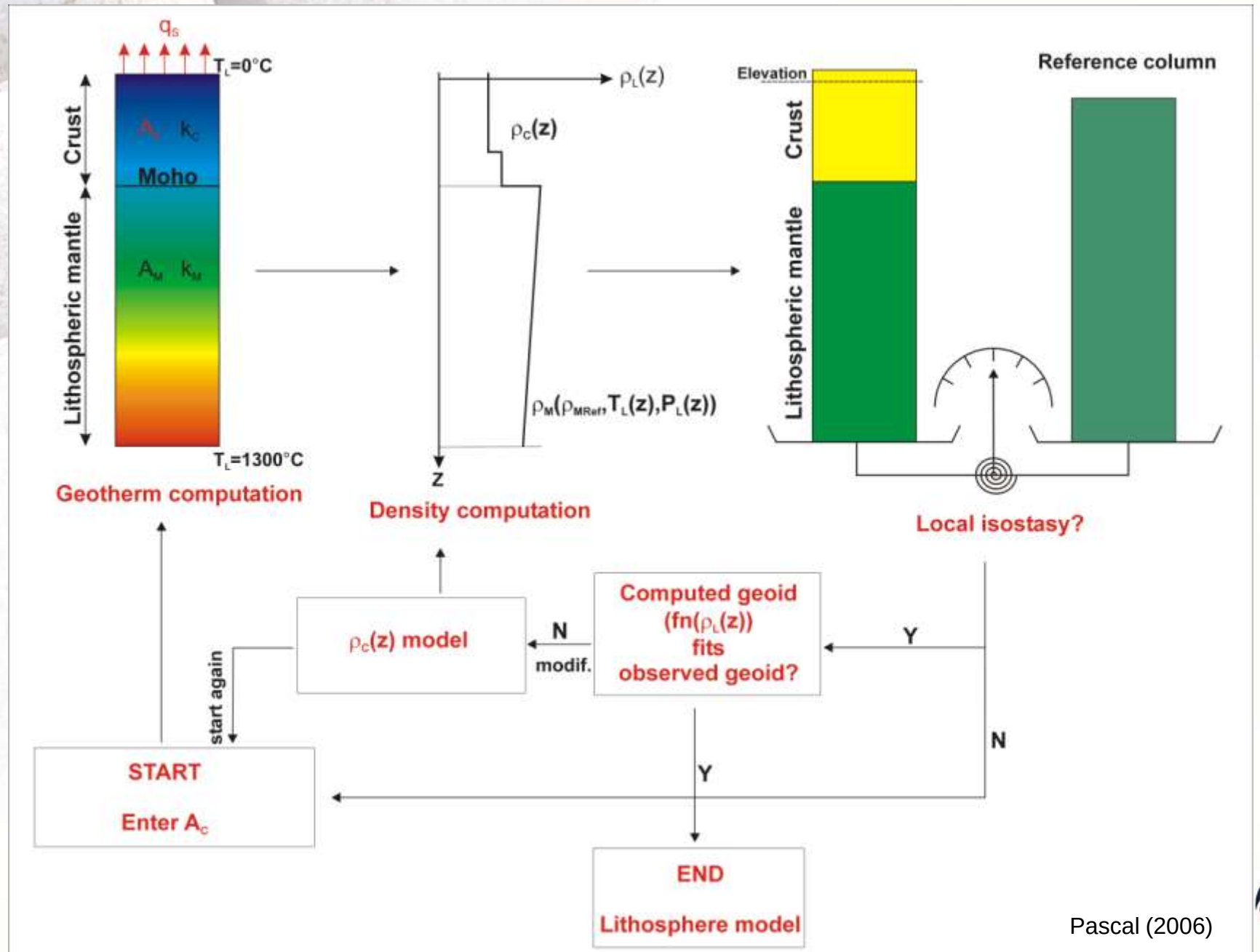
Our contribution to TopoScandiaDeep

- To provide a thermal/rheological model of the lithosphere of southern Norway (and adjacent areas).
- To evaluate the role of the modelled lithosphere rheology on present-day stresses and seismicity.
- To furnish the model as starting point for further numerical modelling.

Thermo-isostatic modelling of the Fennoscandian lithosphere

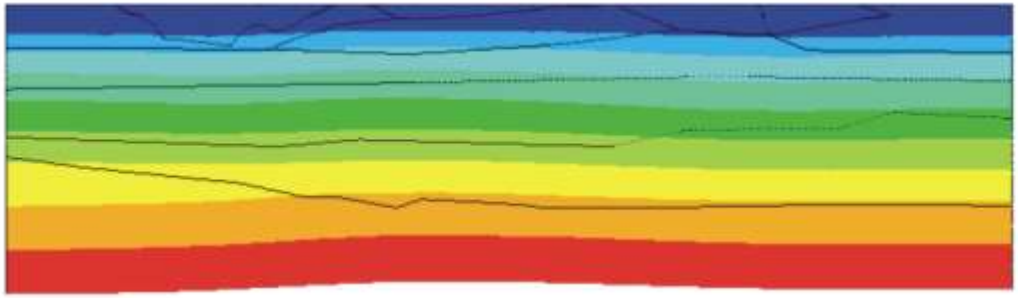
Camille Raulin MSc thesis (2007)

Method

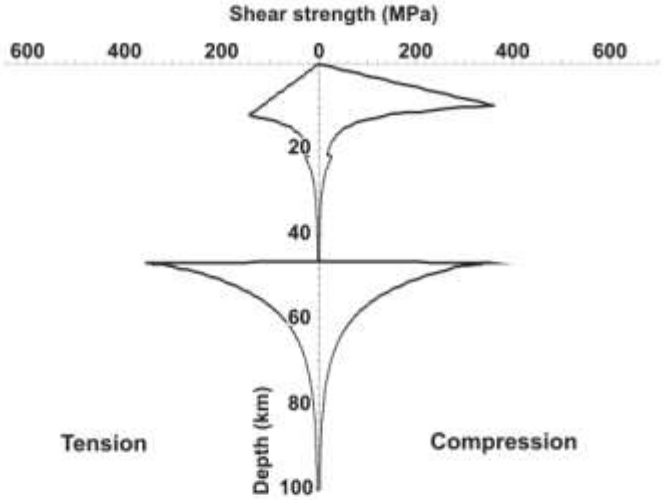


Pascal (2006)

Thermal structure

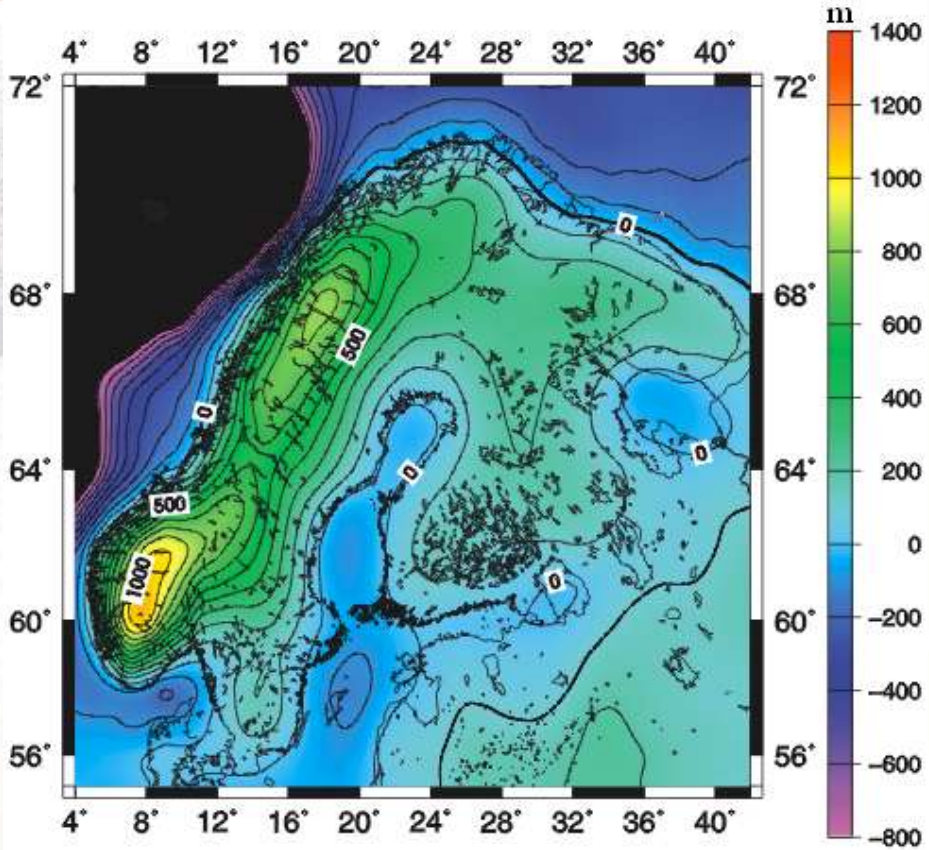


Rheology

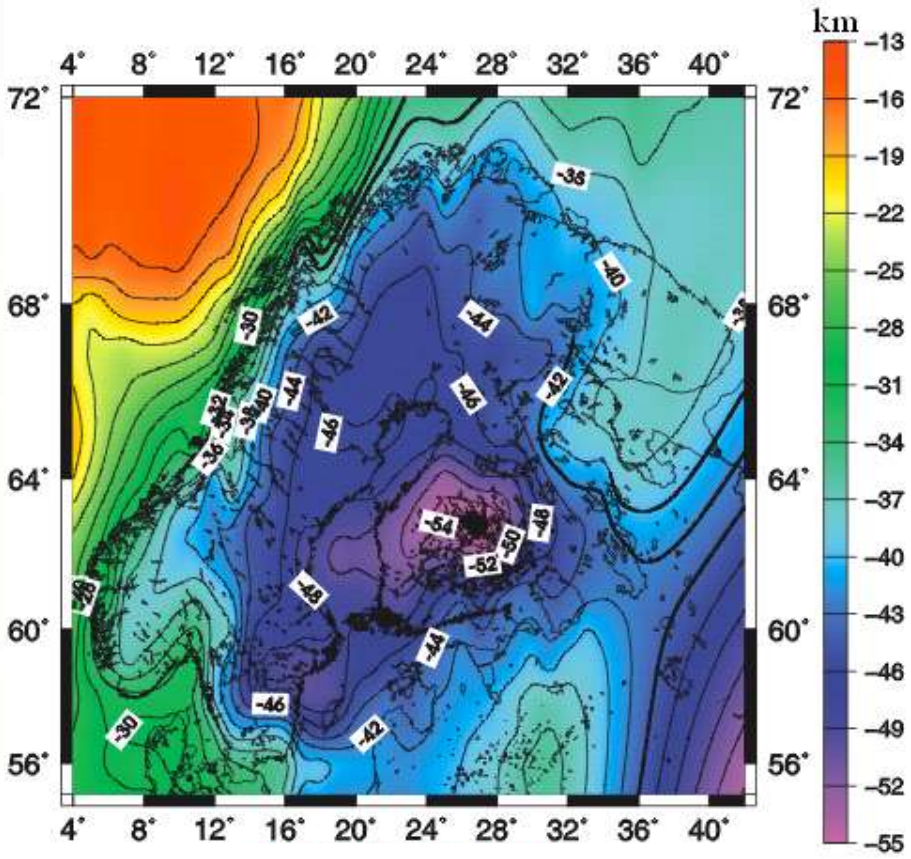


Input

1. Filtered topography

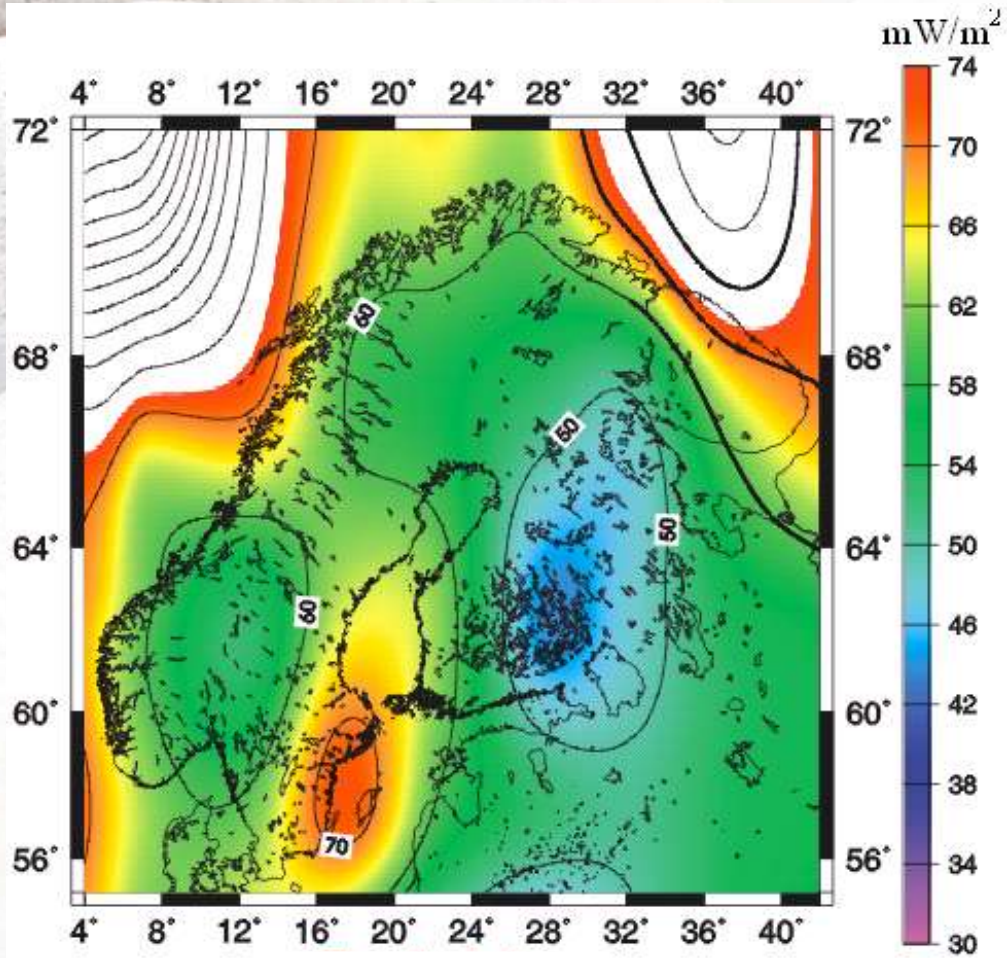


2. Moho depth (Kinck et al. 1993)



Input

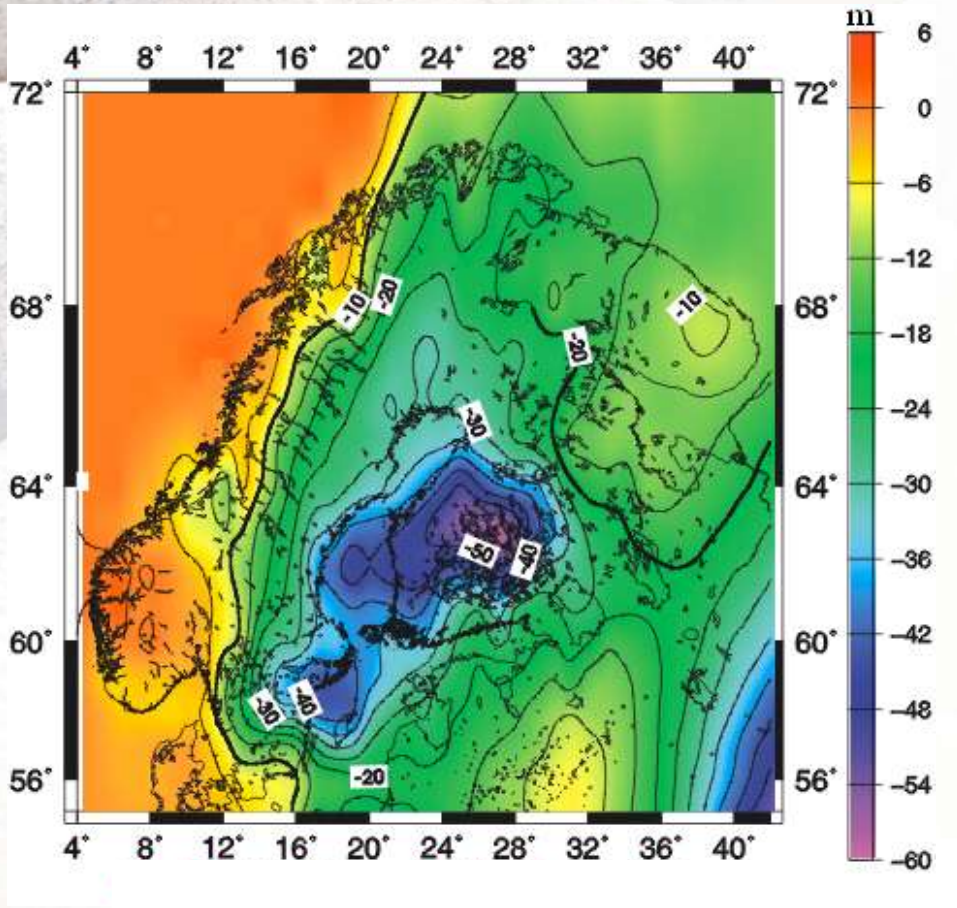
3. Heat Flow (Pollack et al. 1993)



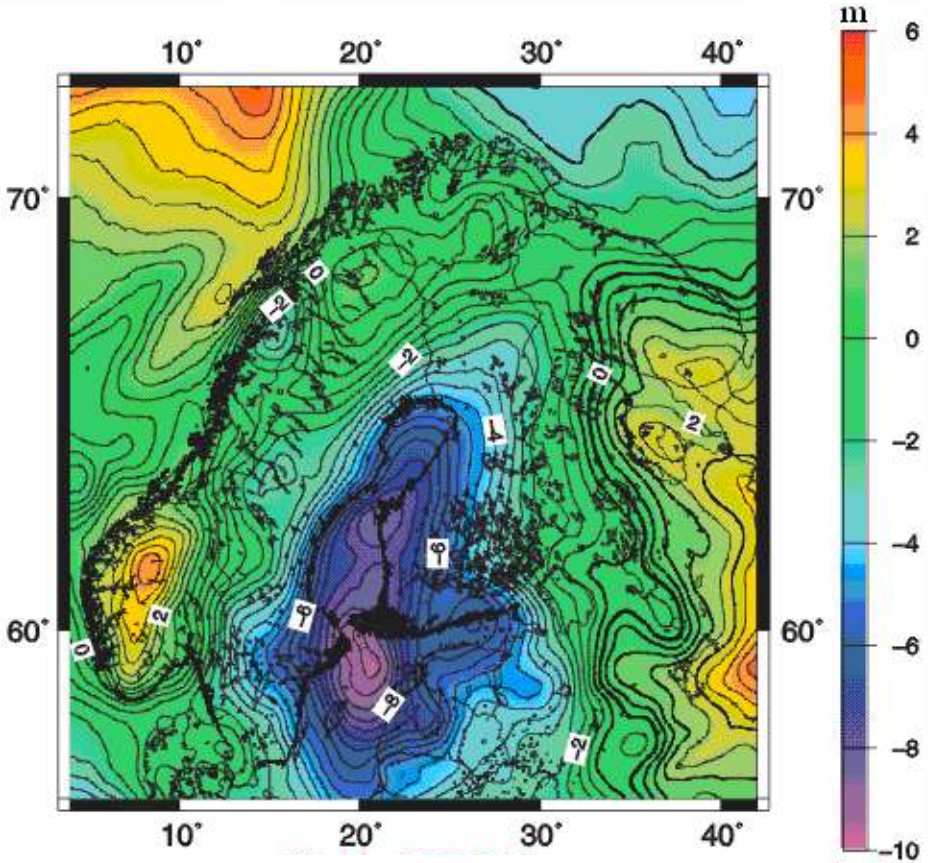
+

4. Crustal density model

RESULTS (MODEL 1, ρ_C= 2830 kg/m³)

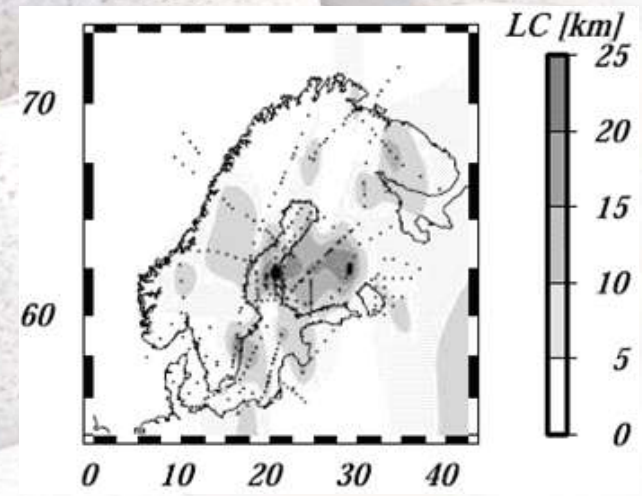


Modelled geoid

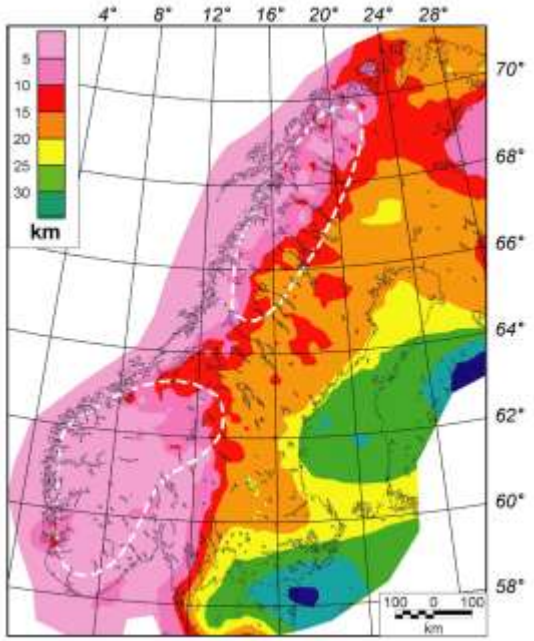


Observed geoid
(Lemoine et al. 96)

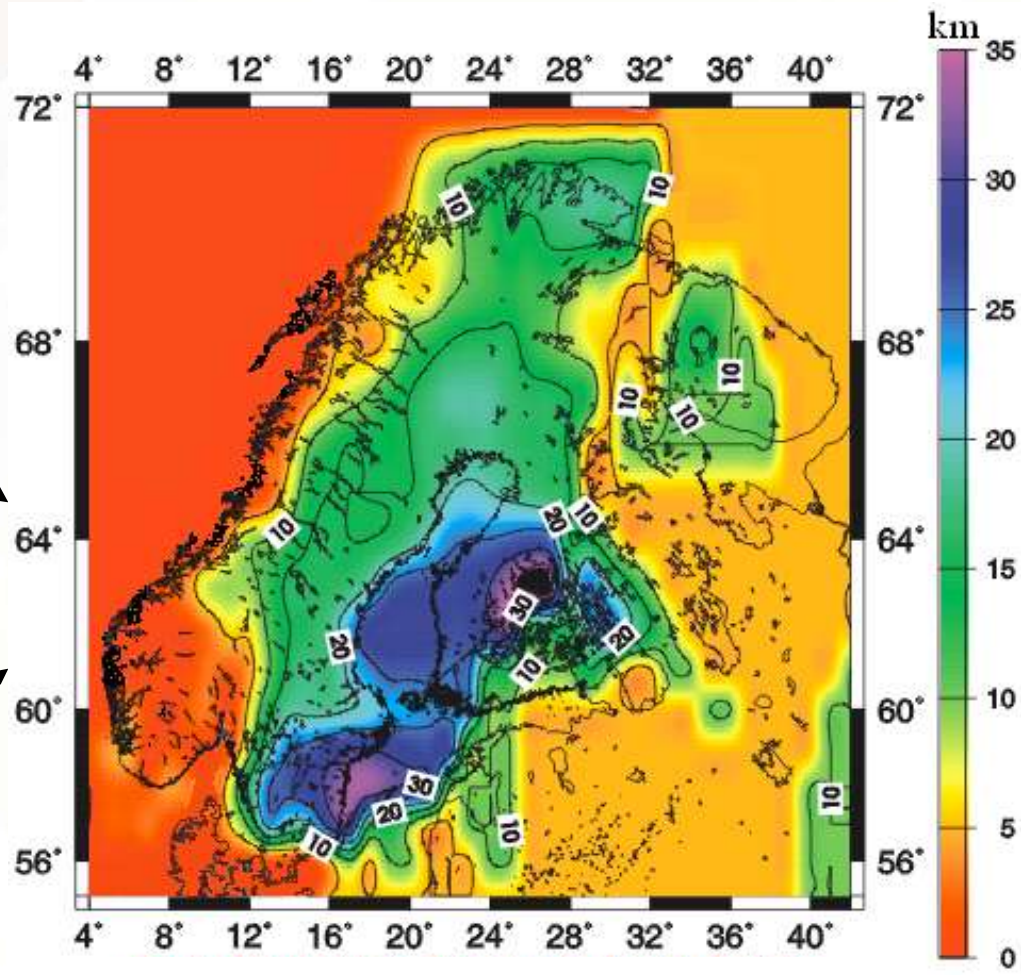
MODEL 2: with high density lower crust (3000 kg/m³)



Pérez-Gussinyé et al. 2004

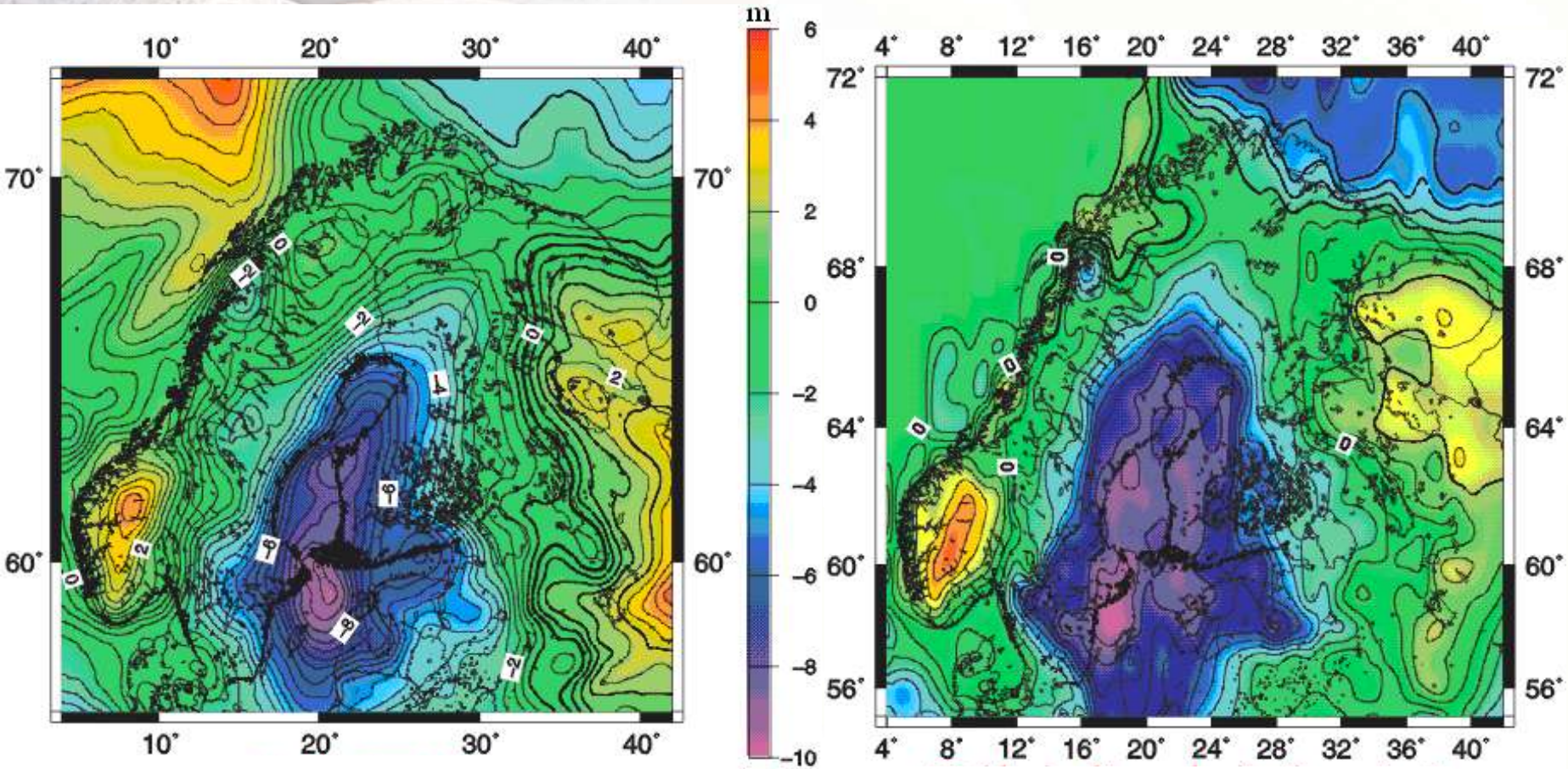


Ebbing 2004



HDLC thickness

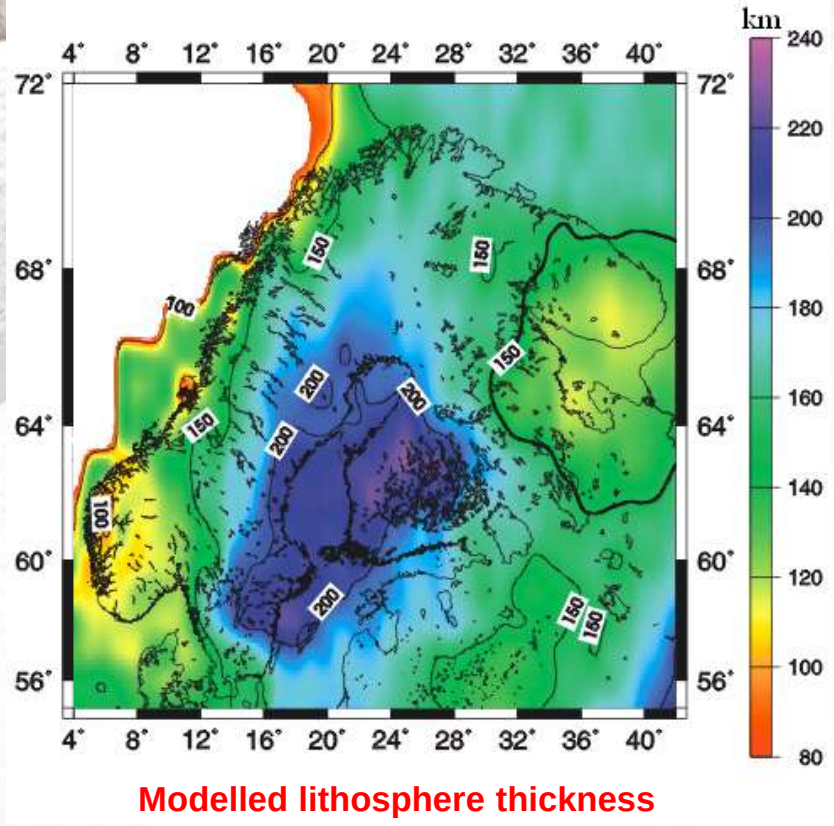
RESULTS (MODEL 2)



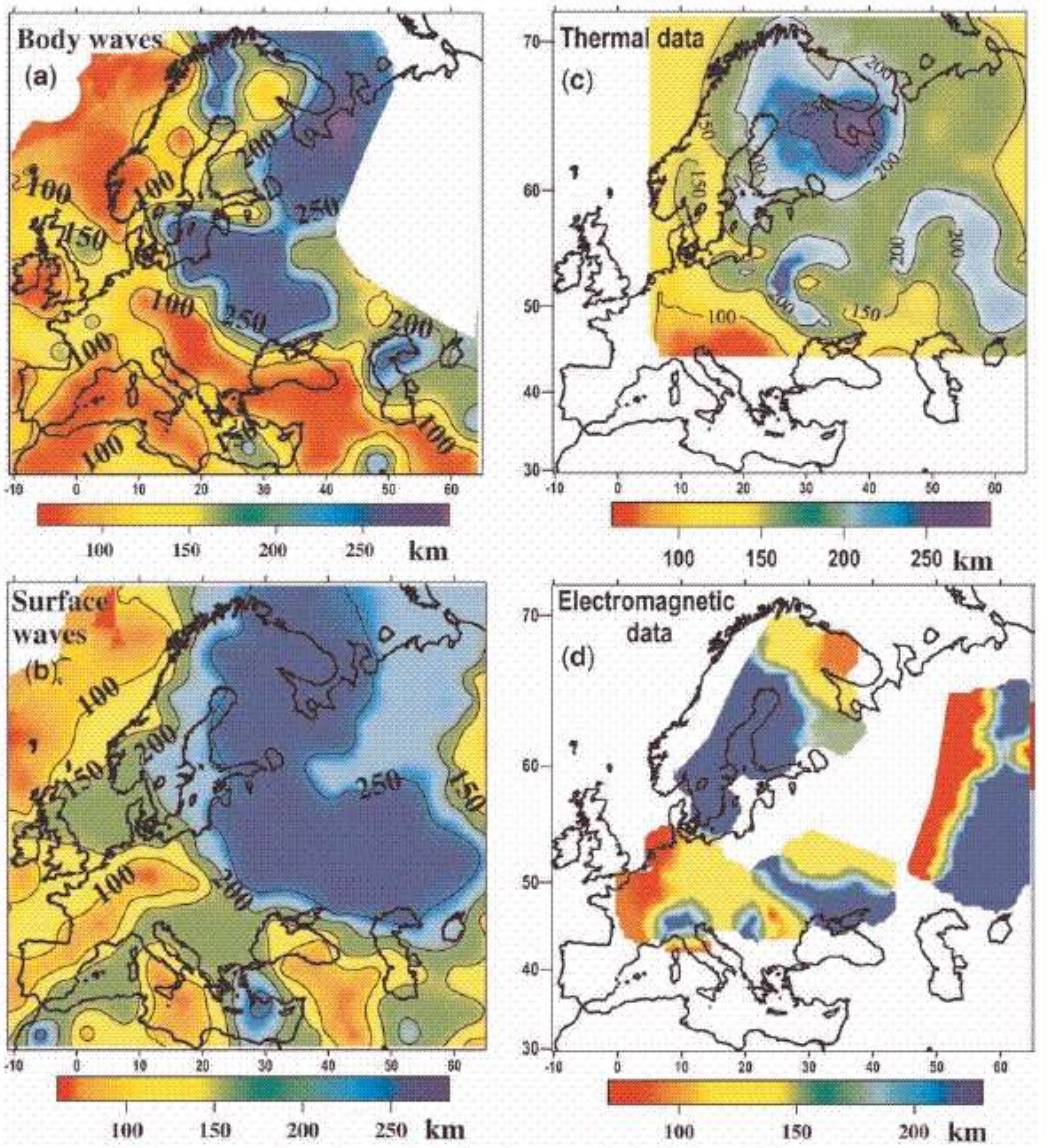
Observed geoid
(Lemoine et al. 96)

Modelled geoid

RESULTS (MODEL 2)



Modelled lithosphere thickness

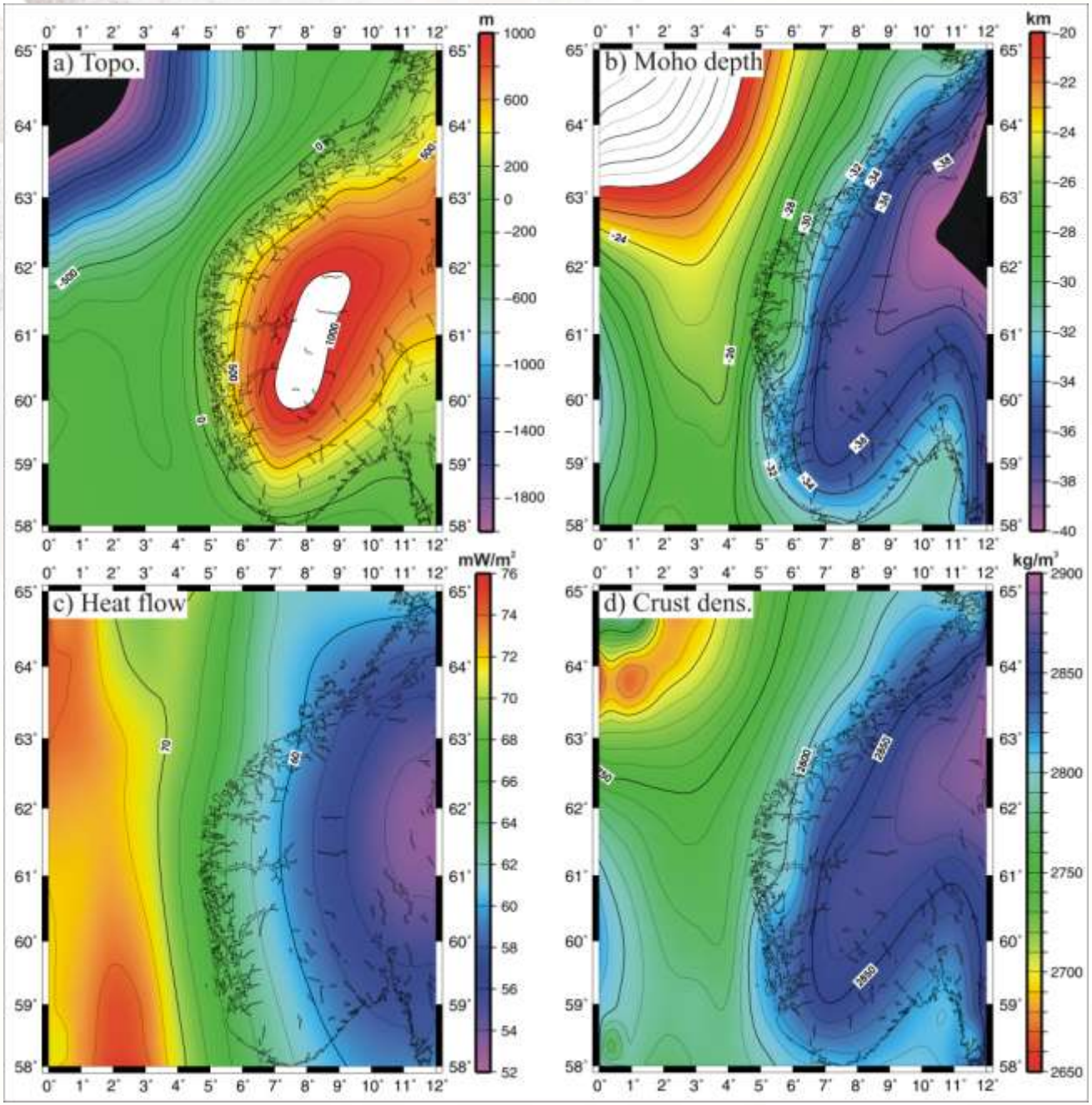


Determined lithosphere thickness (Artemieva 06)

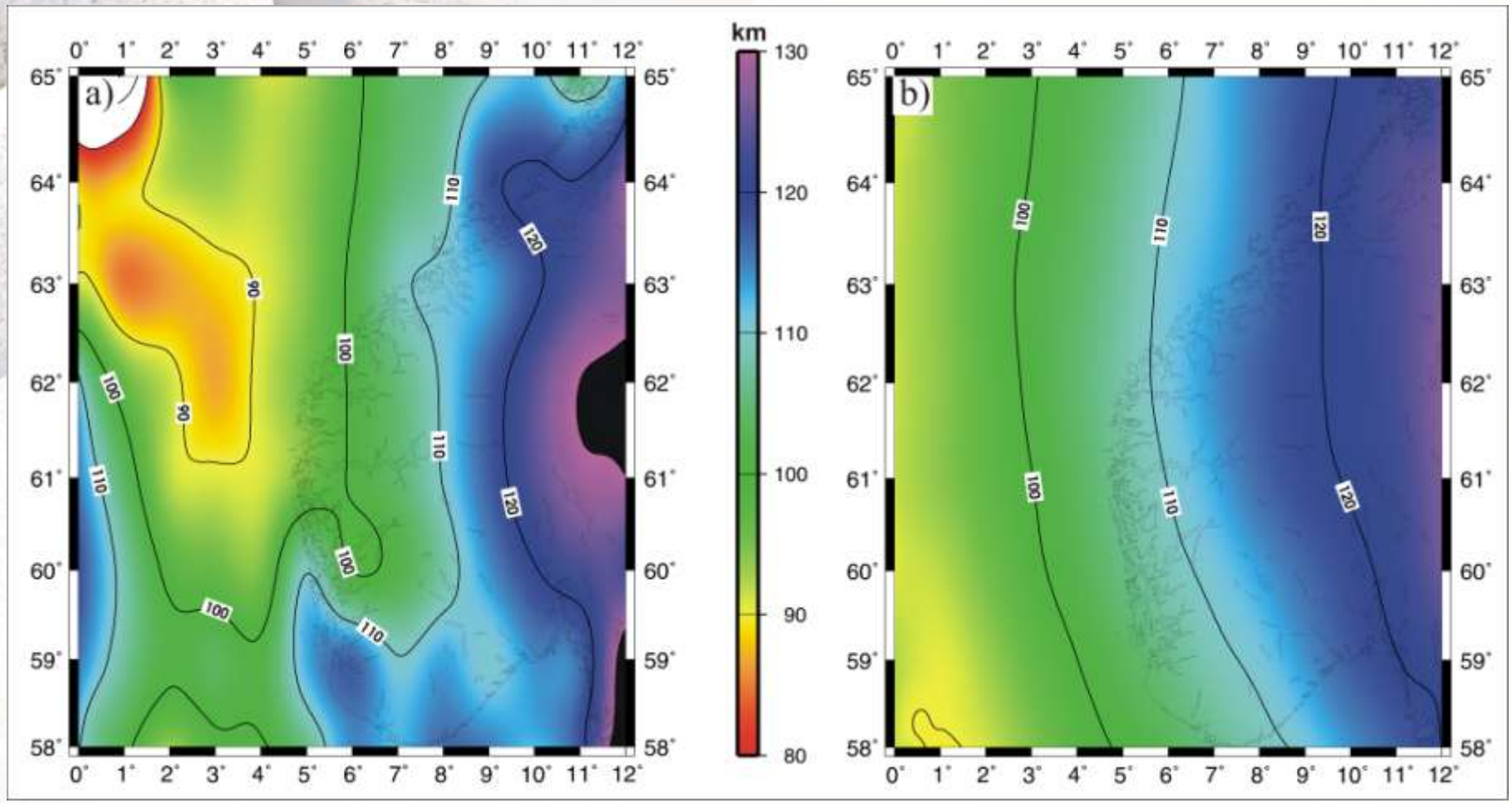
Thermo-isostatic and stress modelling of the Southern Scandes

Pascal and Cloetingh (2009)

Input


a) Topo.
m
1000
600
200
0
−200
−600
−1000
−1400
−1800
b) Moho depth
km
−20
−22
−24
−26
−28
−30
−32
−34
−36
−38
−40
c) Heat flow
mW/m²
76
74
72
70
68
66
64
62
60
58
56
54
52
d) Crust dens.
kg/m³
2900
2850
2800
2750
2700
2650

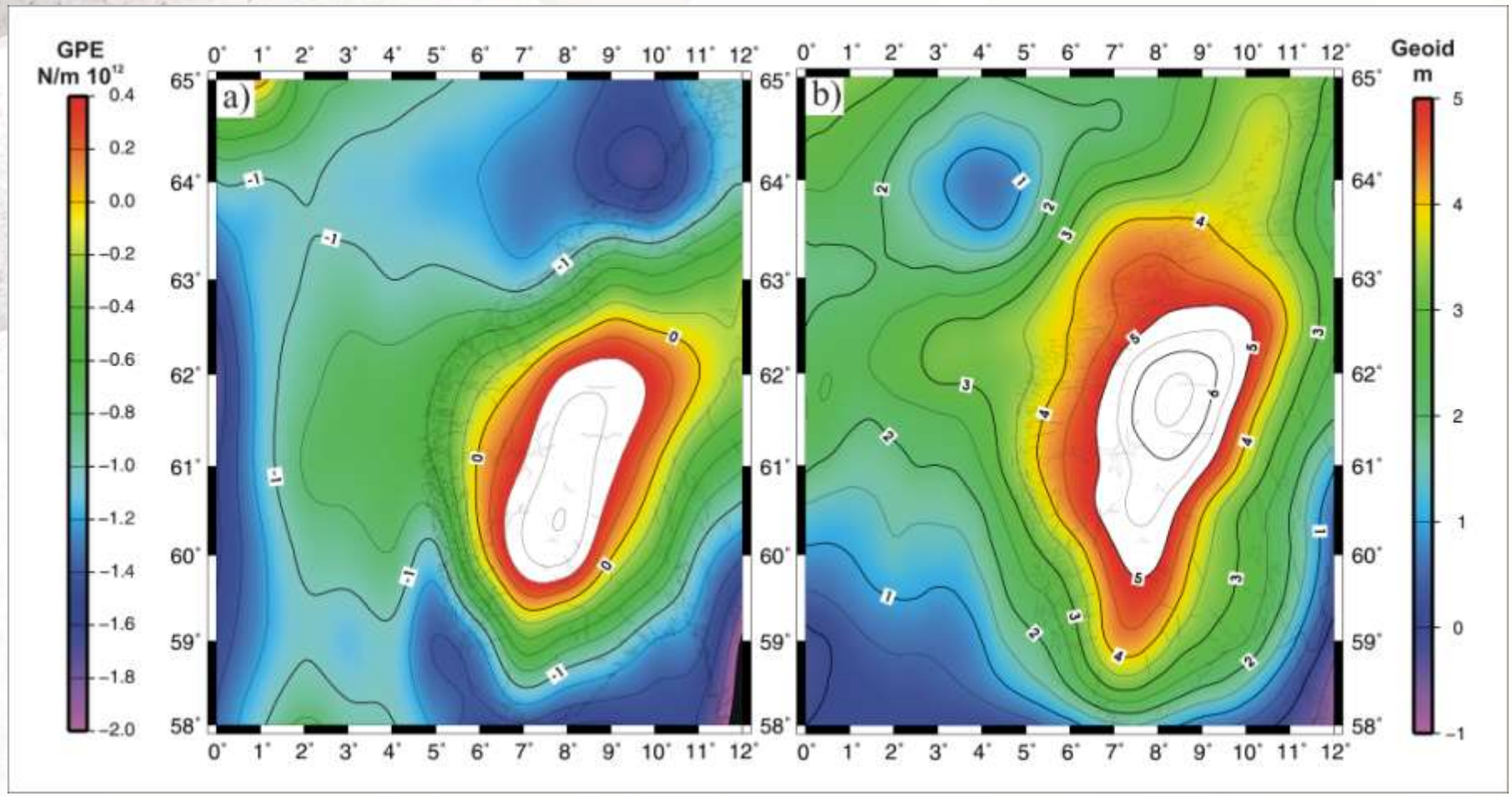
RESULTS



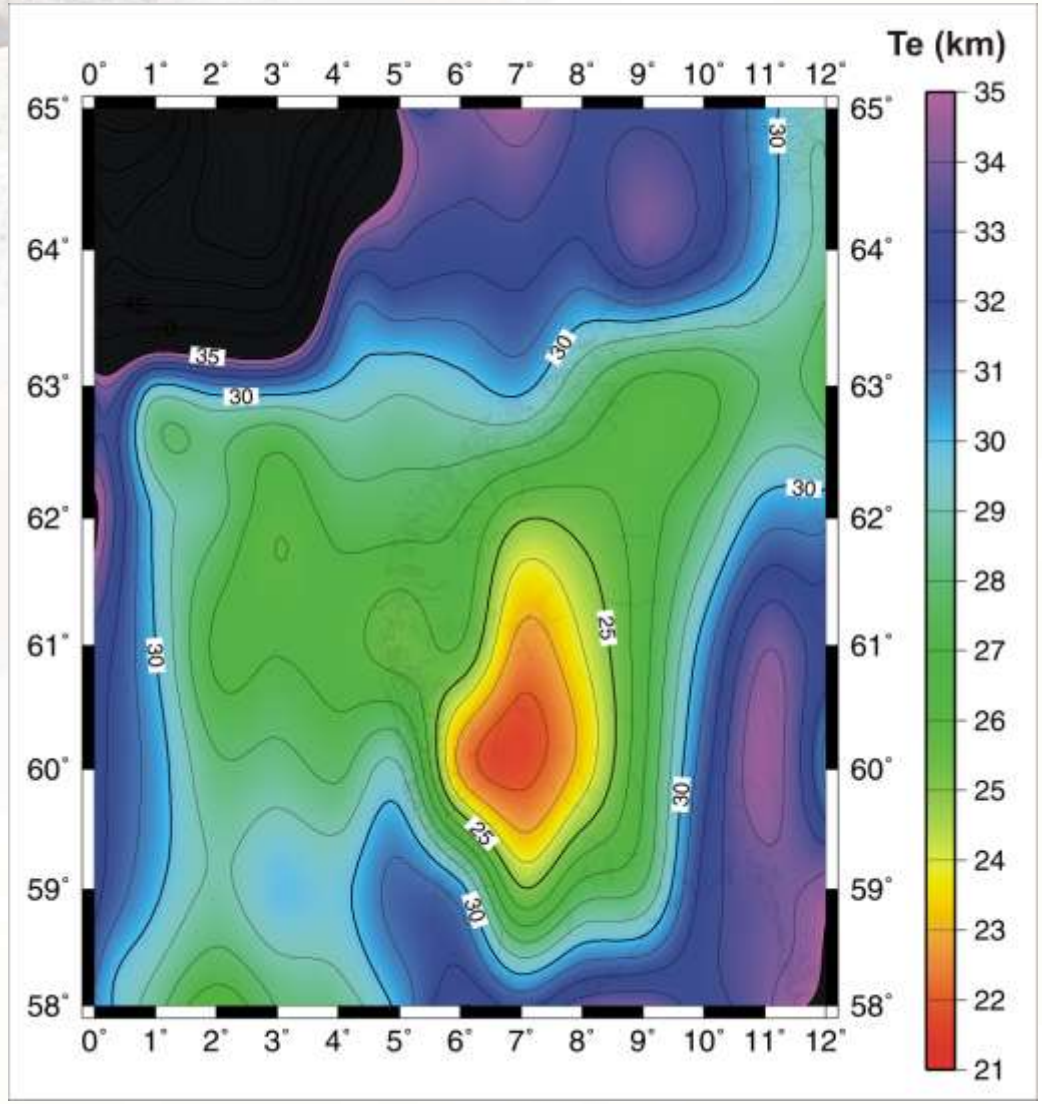
Modelled lithosphere thickness

Lithosphere thickness from surface waves (Calcagnile 1982)

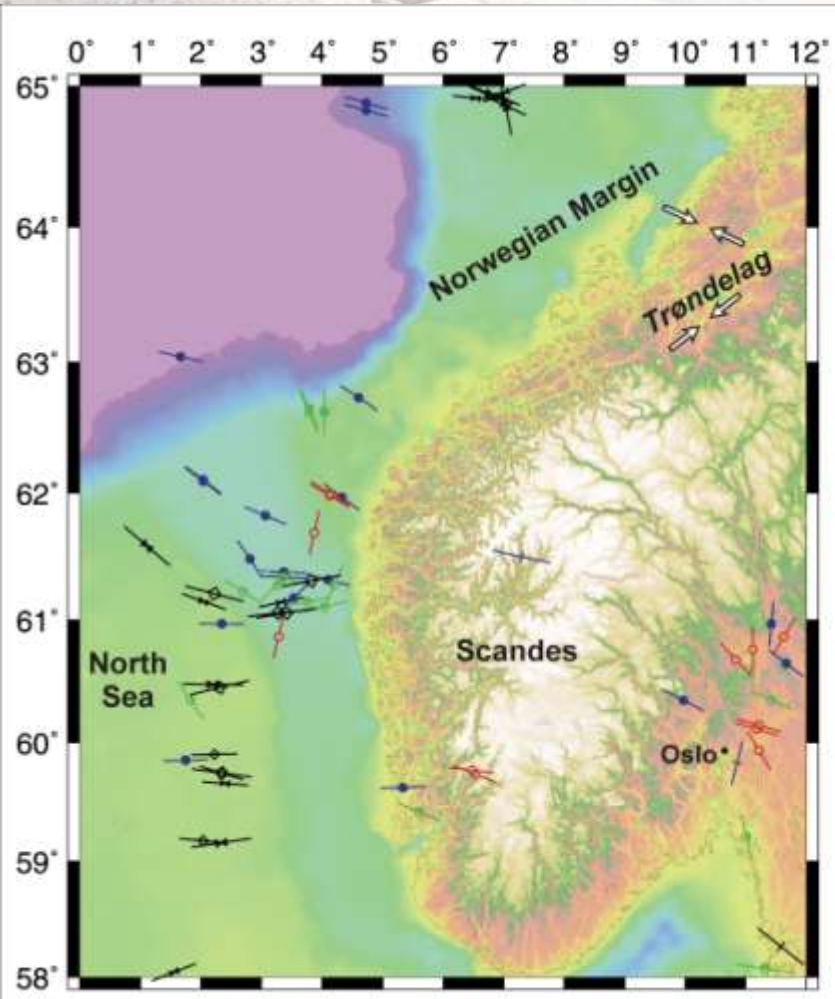
RESULTS


GPE
N/m 10^12
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
−1.6
−1.8
−2.0
a)
b)
Geoid
m
5
4
3
2
1
0
−1
0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 11° 12°
65° 64° 63° 62° 61° 60° 59° 58°

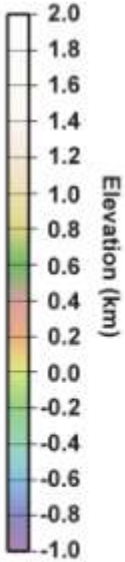
RESULTS

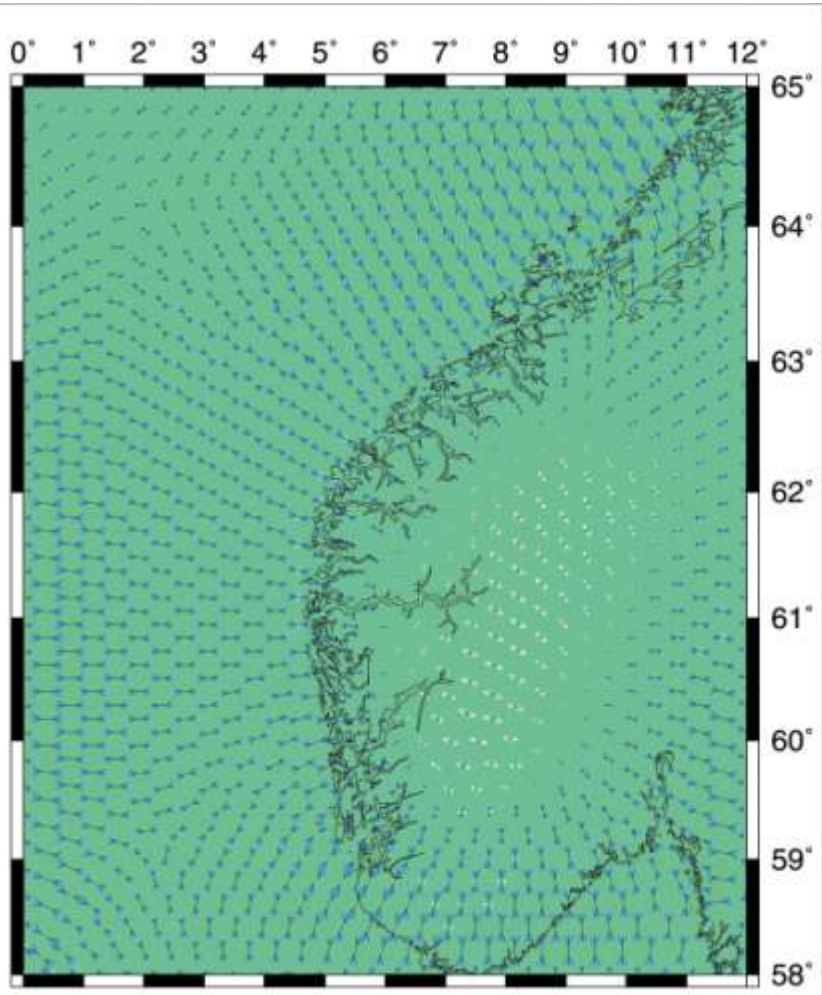

Te (km)
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 11° 12°
65° 64° 63° 62° 61° 60° 59° 58°
35
30
25

RESULTS



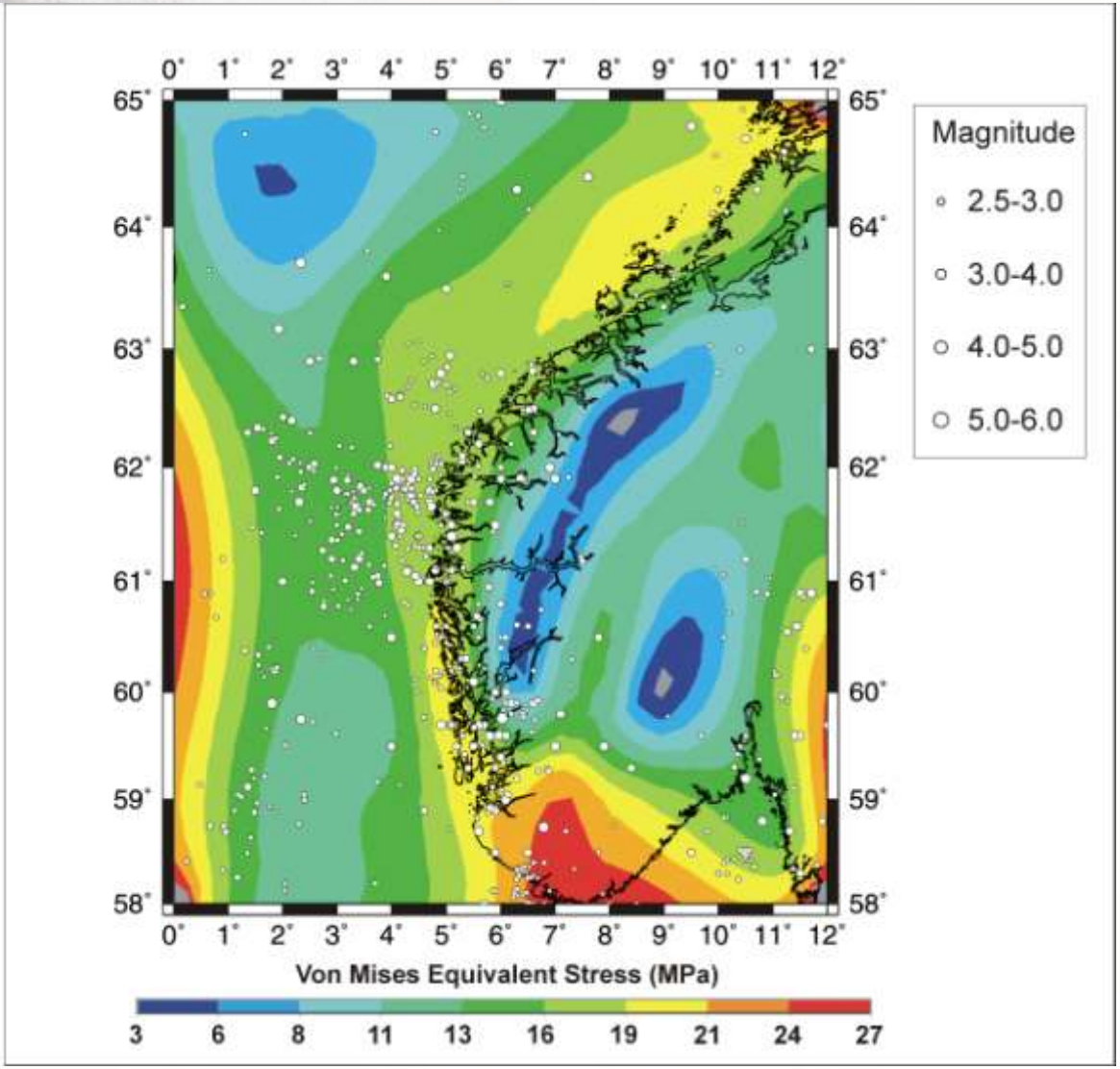
Measured stress directions





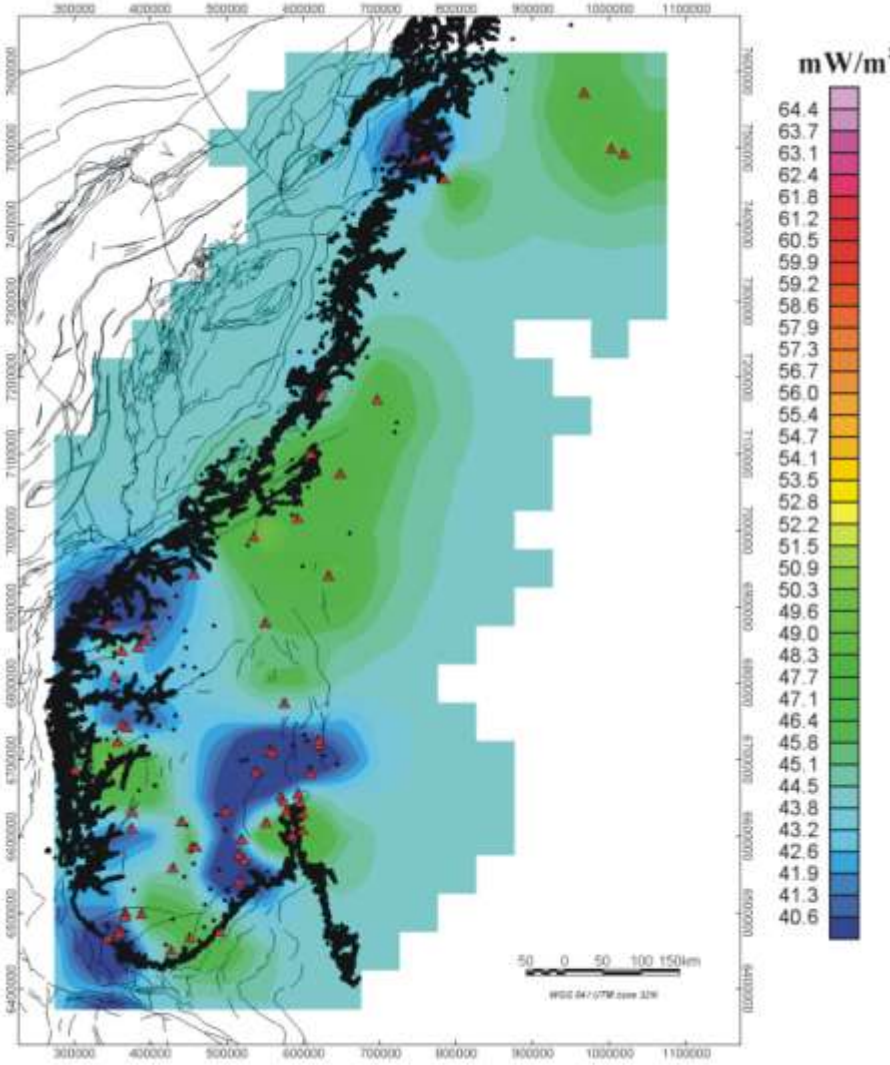
Modelled stress directions

RESULTS

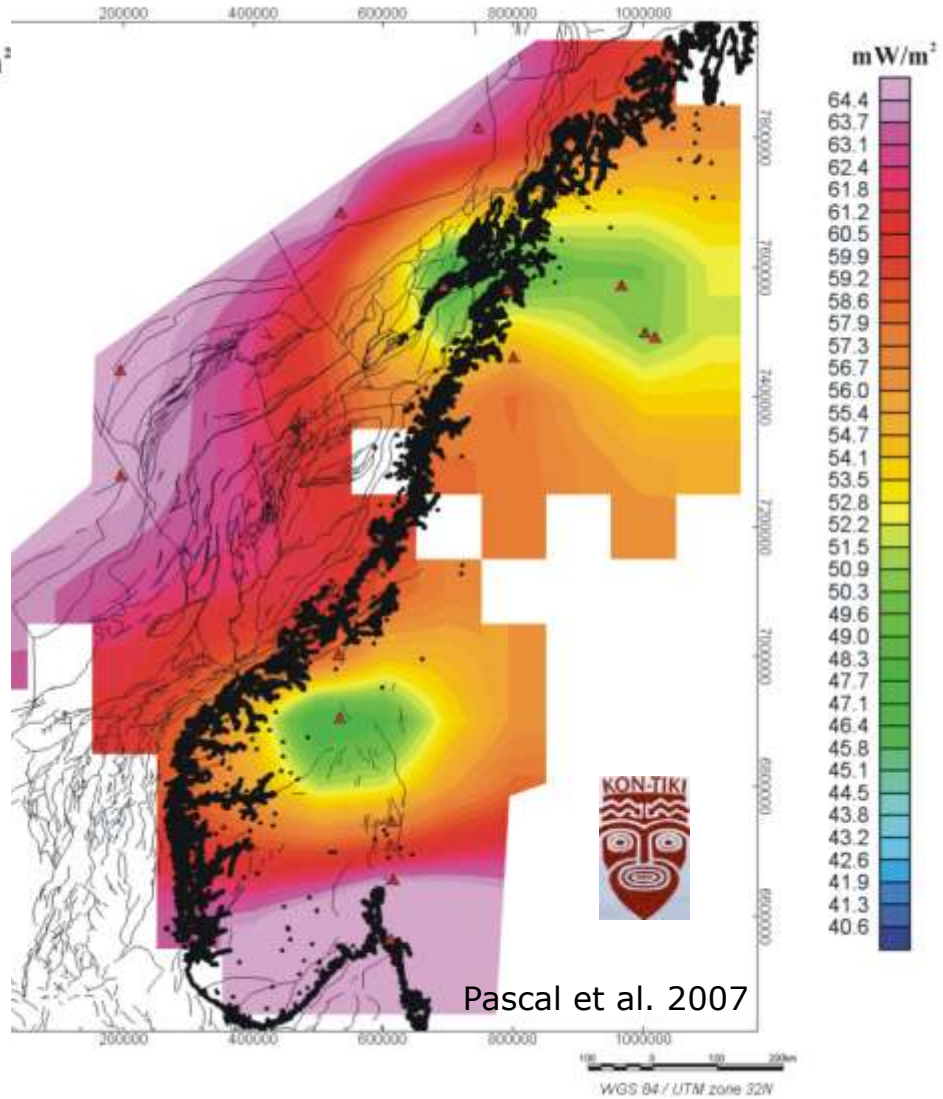

0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 11° 12°
65° 64° 63° 62° 61° 60° 59° 58°
Magnitude
2.5-3.0
3.0-4.0
4.0-5.0
5.0-6.0
Von Mises Equivalent Stress (MPa)
3 6 8 11 13 16 19 21 24 27

New thermal data in Norway

Heat flow map of Norway

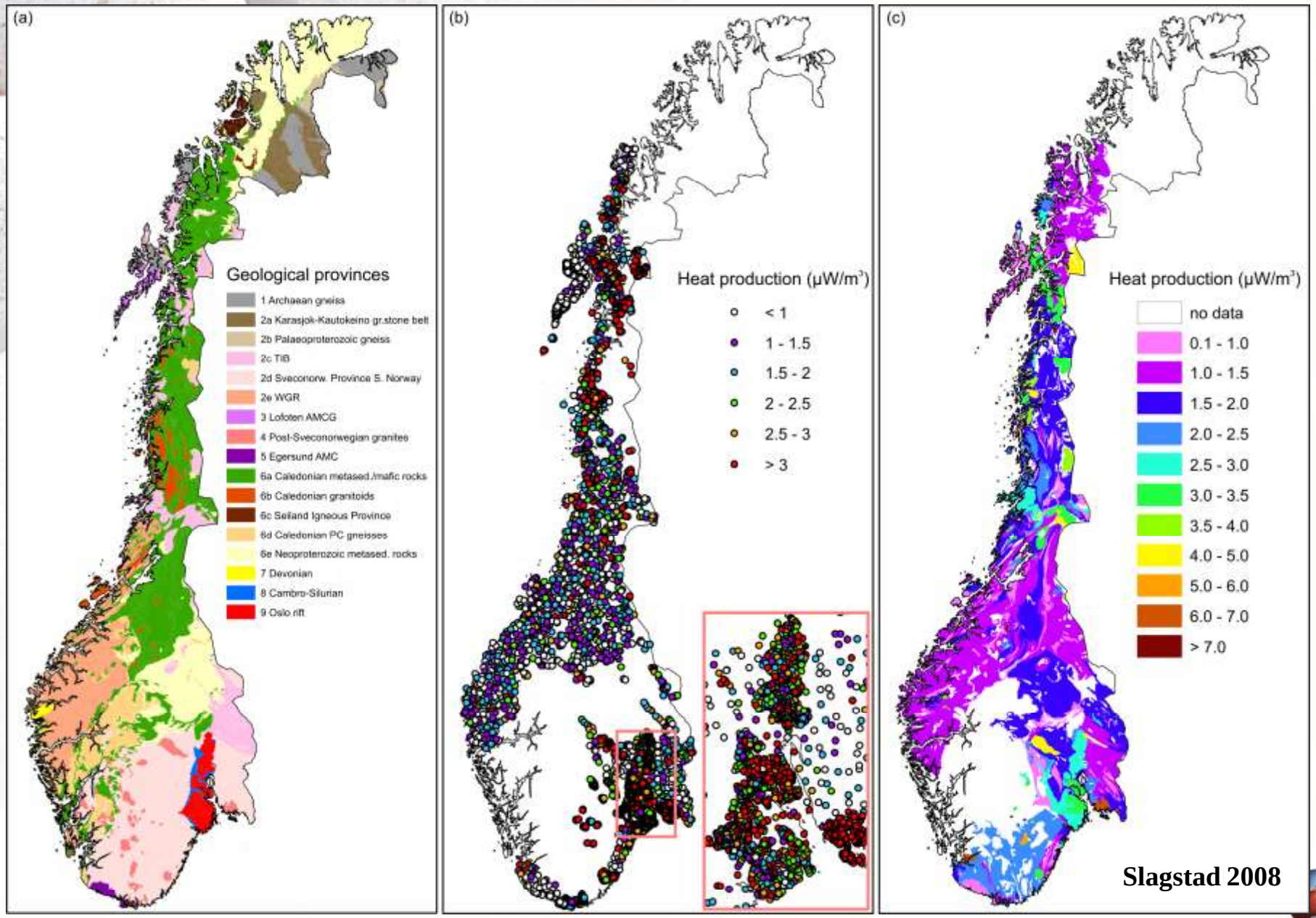


Old data



Kontiki data

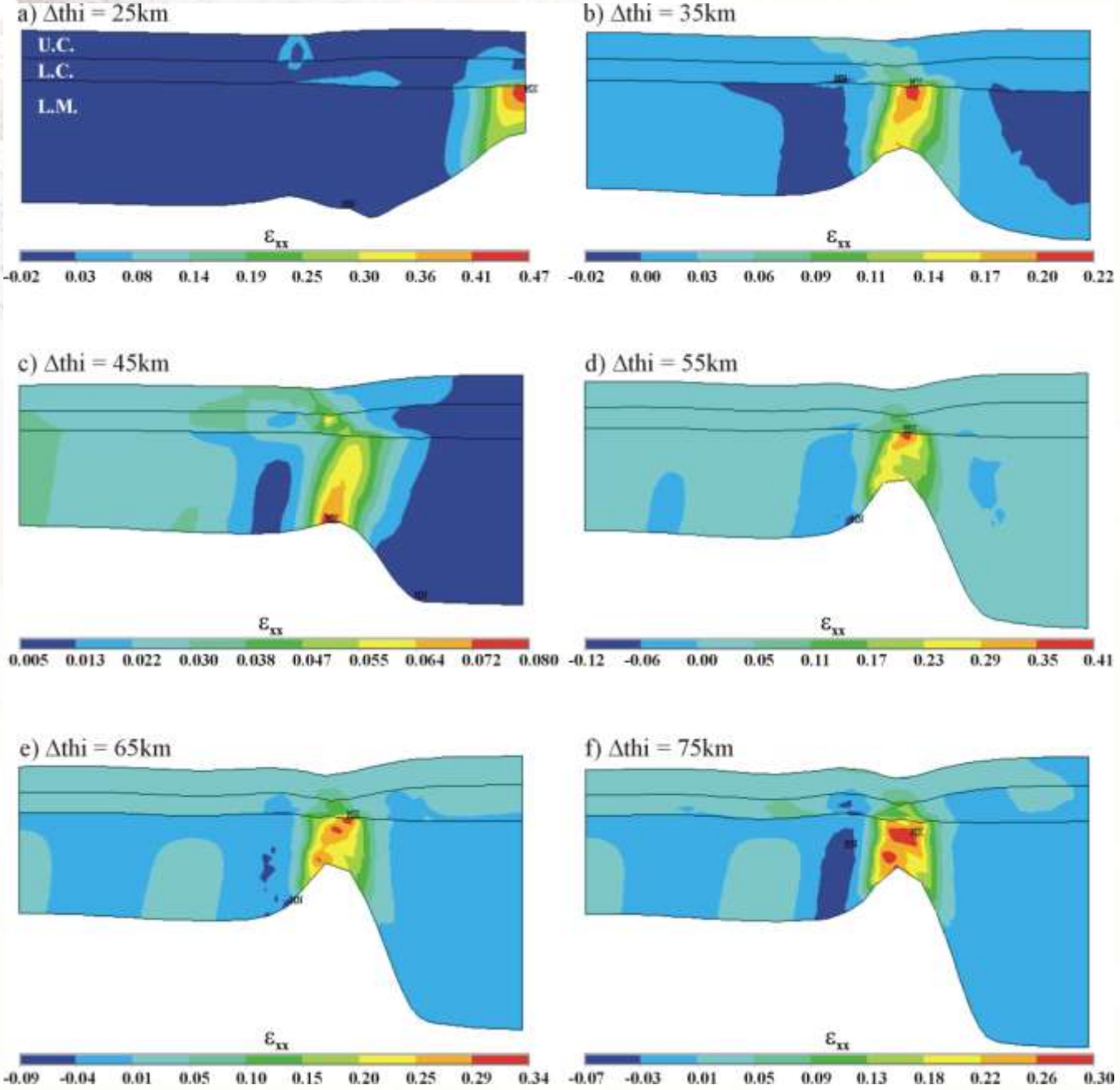
Heat generation database (Lito project)

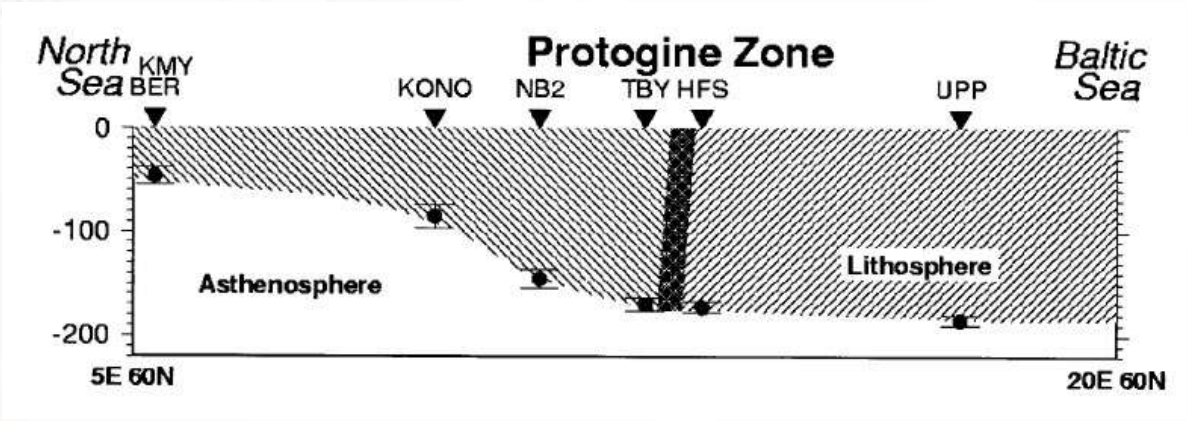


Slagstad 2008

Future work

- Improve modelling techniques (full 3D, regional isostasy).
- Use new constraints from recent heat flow determinations and TopoScandia deep seismic data.


a) Δthi = 25km
U.C.
L.C.
L.M.
ε_{xx}
-0.02 0.03 0.08 0.14 0.19 0.25 0.30 0.36 0.41 0.47
b) Δthi = 35km
ε_{xx}
-0.02 0.00 0.03 0.06 0.09 0.11 0.14 0.17 0.20 0.22
c) Δthi = 45km
ε_{xx}
0.005 0.013 0.022 0.030 0.038 0.047 0.055 0.064 0.072 0.080
d) Δthi = 55km
ε_{xx}
-0.12 -0.06 0.00 0.05 0.11 0.17 0.23 0.29 0.35 0.41
e) Δthi = 65km
ε_{xx}
-0.09 -0.04 0.01 0.05 0.10 0.15 0.20 0.25 0.29 0.34
f) Δthi = 75km
ε_{xx}
-0.07 -0.03 0.01 0.05 0.09 0.13 0.18 0.22 0.26 0.30


North Sea
KMY
BER
Protogine Zone
KONO
NB2
TBY
HFS
UPP
Baltic Sea
0
-100
-200
Asthenosphere
Lithosphere
5E 60N
20E 60N