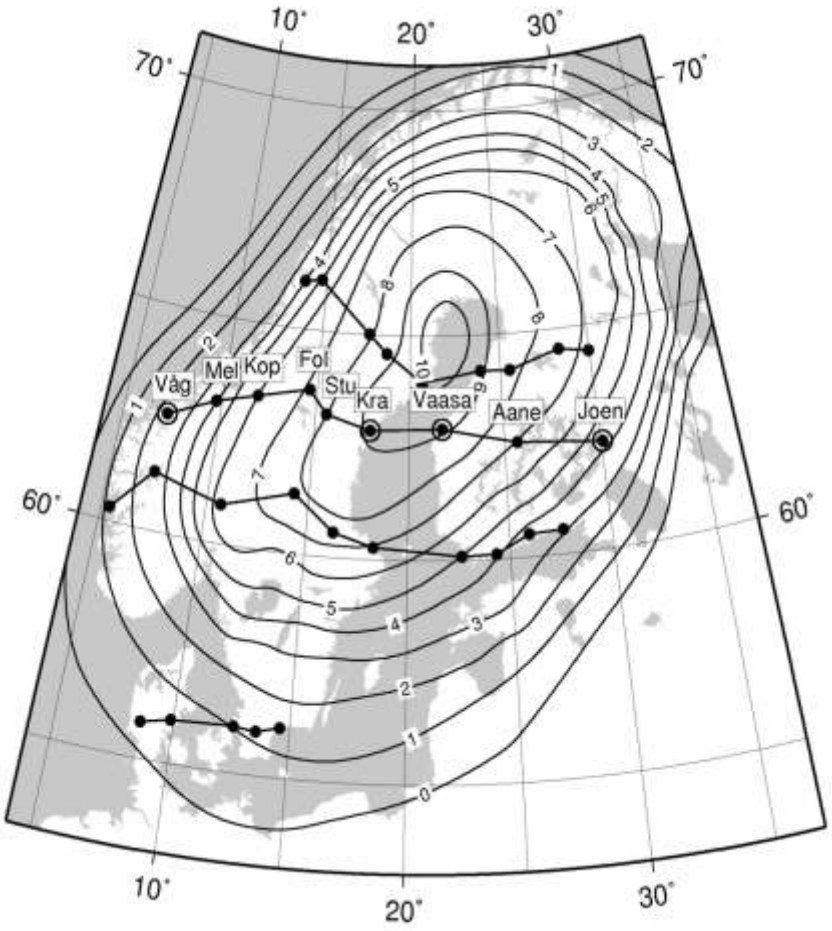
# The Fennoscandian Land Uplift Gravity Lines: comparison of observed gravity change with observed vertical motion and with GIA models.

J. Mäkinen (1), A. Engfeldt (2), L. Engman (2), B.G. Harsson (3), T. Oja (4), S. Rekkedal (3), K. Røthing (3), P. Rouhiainen (1), H. Ruotsalainen (1), H. Skatt (2), G. Strykowski (5), H. Virtanen (1), K. Wieczerkowski (6), D.Wolf (6)

# Affiliations

(1) Finnish Geodetic Institute,  Masala, Finland, Jaakko.Makinen@fgi.fi
(2) Lantmäteriet, Gävle, Sweden
(3) Norwegian Mapping Authority, Hønefoss, Norway
(4) Estonian Land Board, Tallinn, Estonia
(5) DTU Space, National Space Institute, Technical University of Denmark, Copenhagen, Denmark,
(6) GeoForschungsZentrum Potsdam, Potsdam, Germany

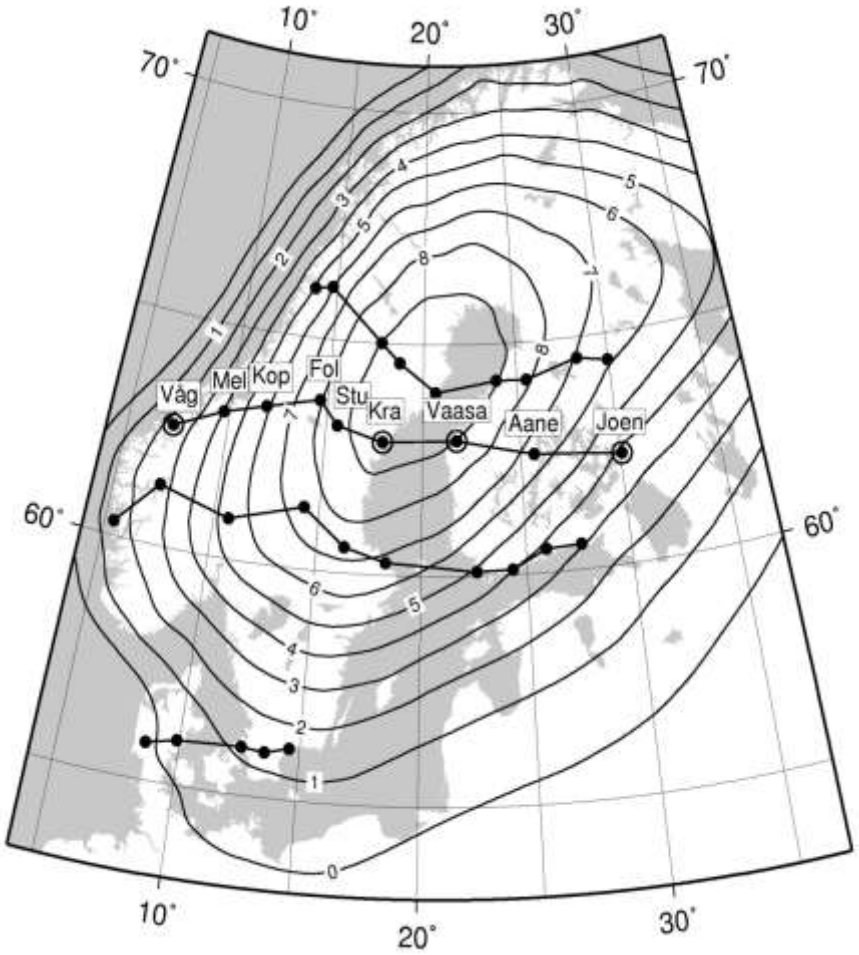
# High-precision relative-gravity profiles accross the Fennoscandian PGR area




Map: PGR rates relative to Earth's CM, modified from Ekman (1996)

- lines are called 65 N, 63 N, 61 N, 56 N
- Finnish part of 63 N started in 1966
- designed and realized by Aimo Kiviniemi
- Sweden, Norway followed 1967; more lines 1975-
- cooperation through Nordic Geodetic Commission, WG for geodynamics (NKG WGG)
- plus guests from 10 institutes

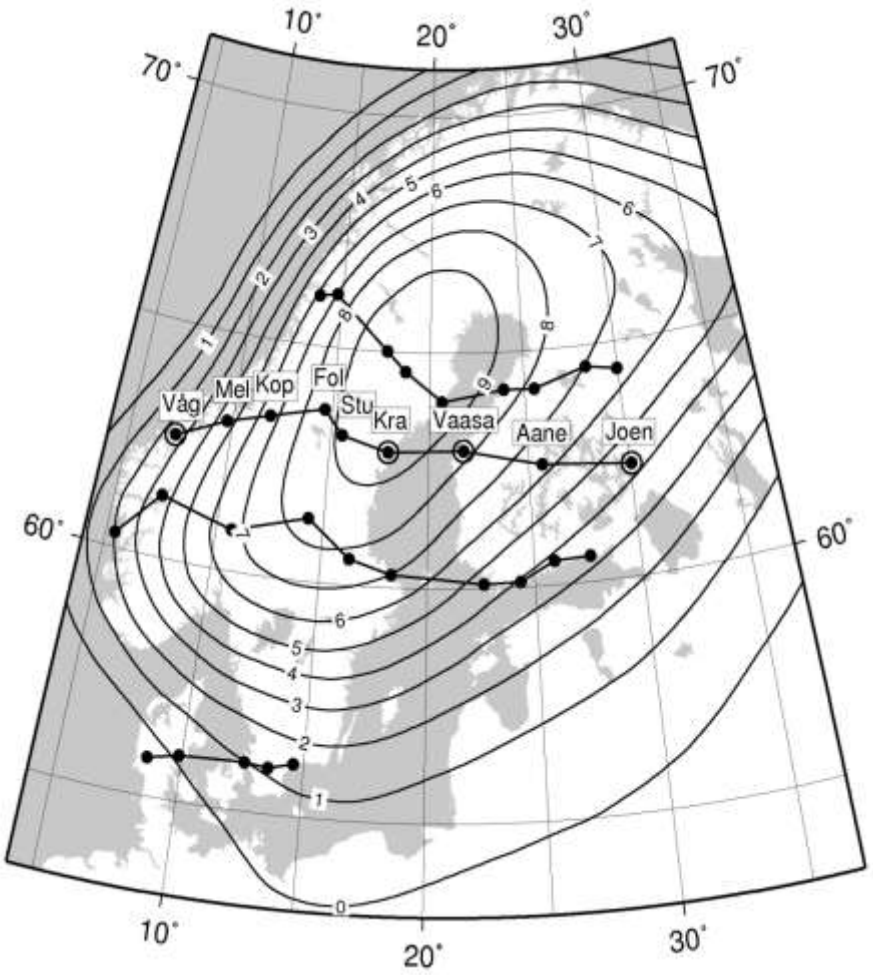
# Original research agenda (I)




Map: PGR rates relative to Earth's CM according to the empirical NKG2005LU_ABS model (Vestöl, Ågren, Svensson 2005-2006)

- repeat high-precision relative gravity measurements to determine (relative) gravity rates with time *g_dot*
- obtain difference in PGR rates *h_dot*
- compare the ratio *g_dot* /*h_dot* with theory

# Original research agenda (II)




Map: PGR rates relative to Earth's CM, from the GIA model by Lambeck et al. (1998)

- two naive geometrical models of *g_dot* /*h_dot* historically used:
- "free air model": decompression without additional mass
  *g_dot* /*h_dot* = –0.31 µgal/mm
- "Bouguer model" with mass flow in upper mantle (density 3300 kg/m$^3$) leads to
  *g_dot* /*h_dot* = –0.16 µgal/mm

1. Previously published 1966–1993 (GJI 126, 1996)
Western and eastern max differences

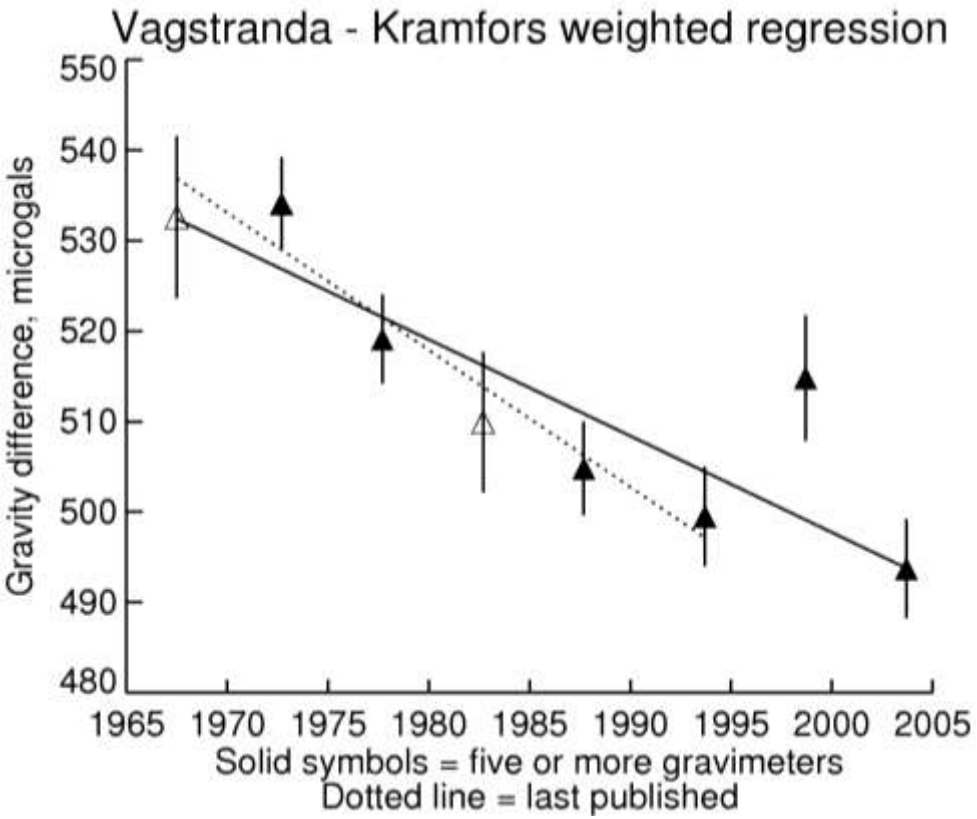
*g_dot/h_dot* = –0. 20  0.06 µgal/mm (95% confidence)

2. Previously published 1966–2003 (GGSM2004 proceedings)
Eastern max difference

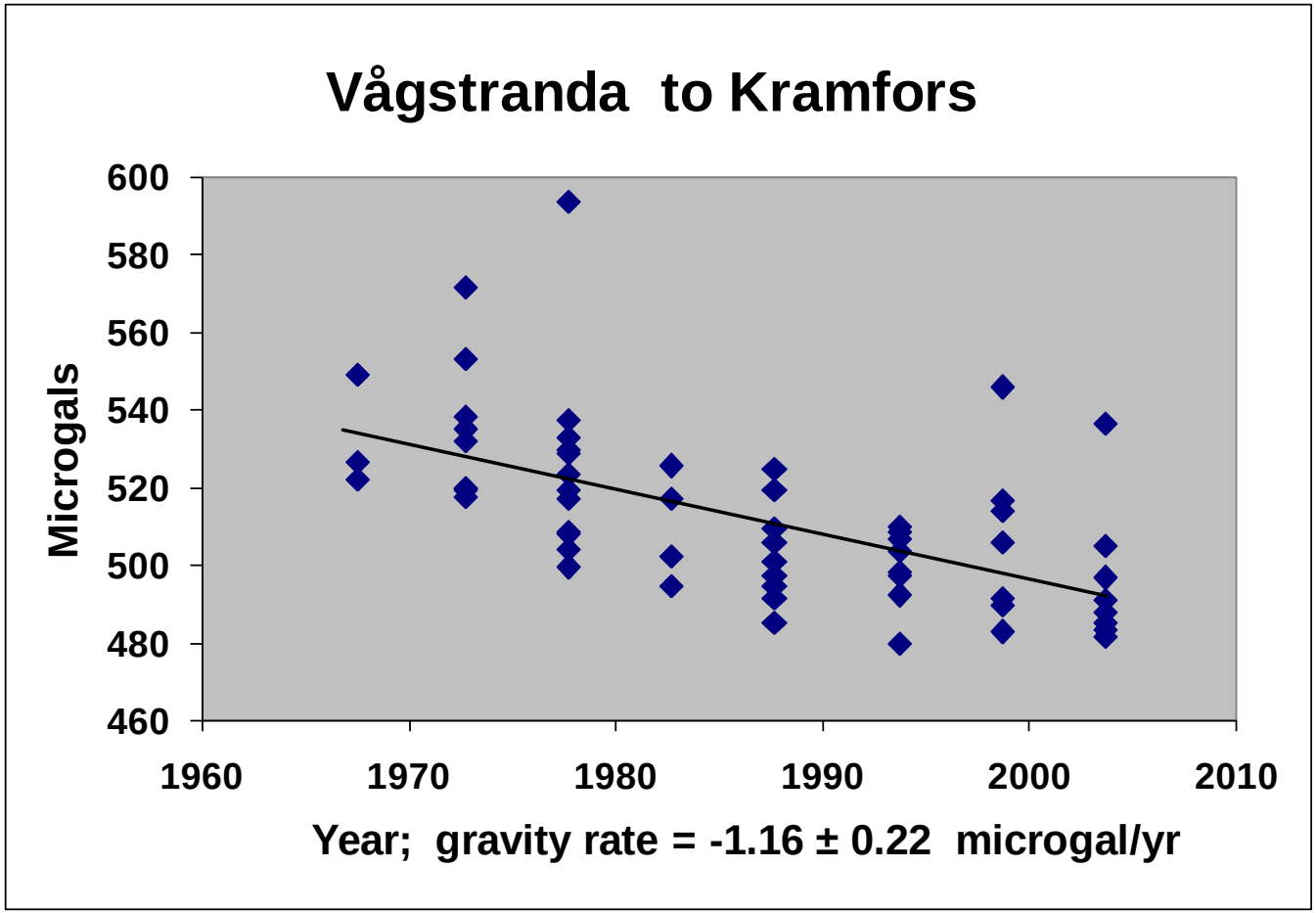
using various sources of *h_dot*

*g_dot/h_dot* = –0. 20… – 0.16  0.04…0.06 µgal/mm (2-sigma)

# 63 N line, western part



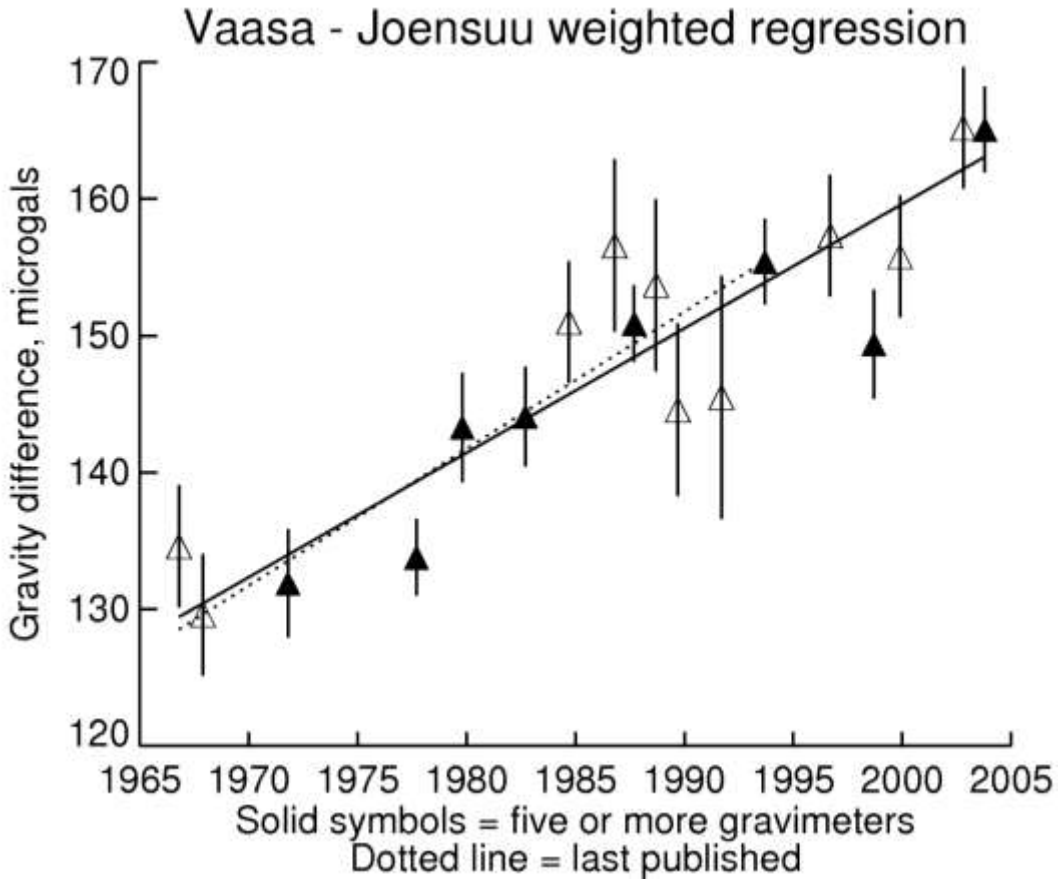

- GJI (1996) slope (dotted)
  –1.52 0.20 µgal/yr (1-sigma)
- GGSM (2004) slope (solid)
  –1.07 0.24 µgal/yr (1-sigma)



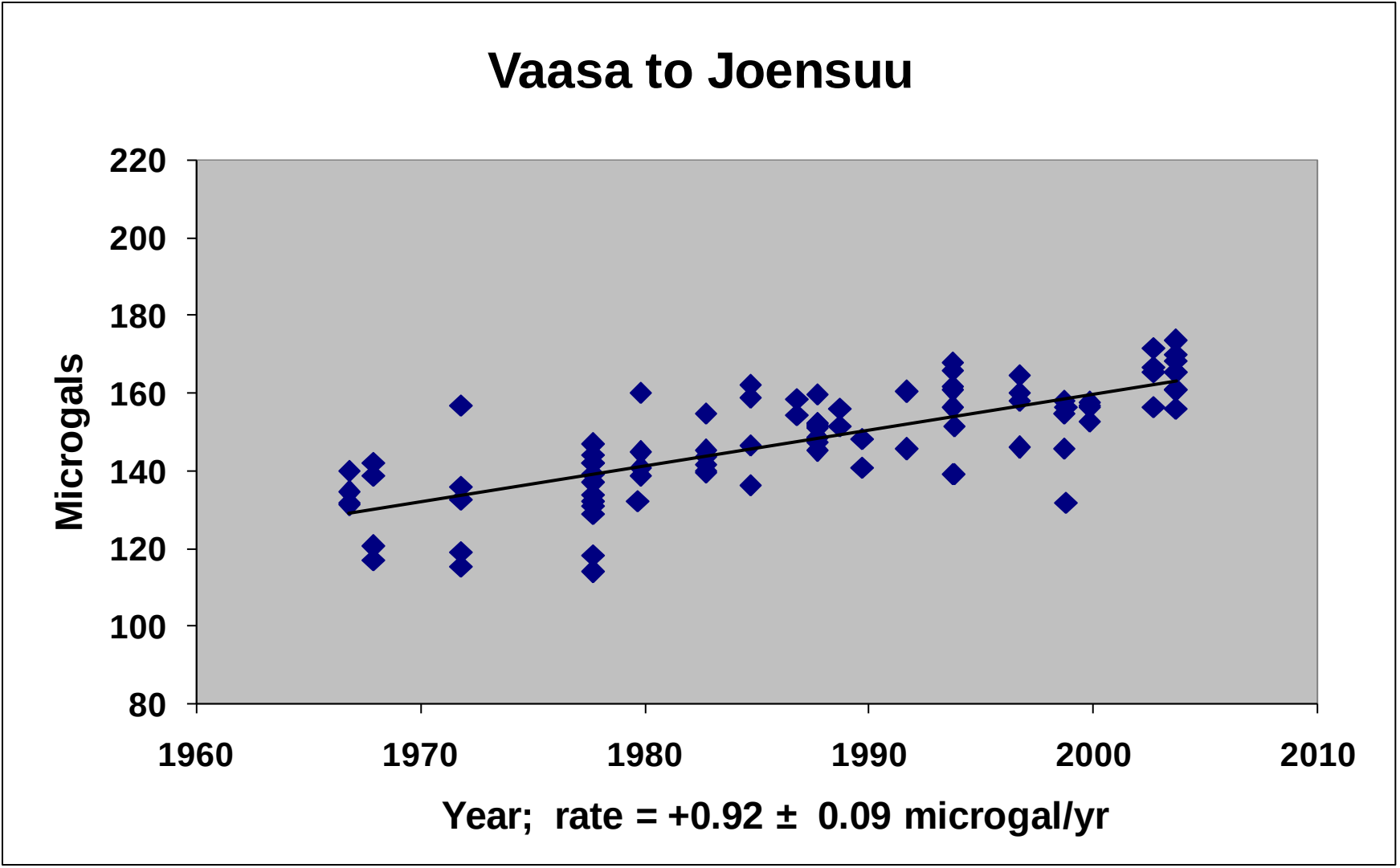

Western part, gravimeters individually

Since the 2004 paper more results became available for the 1998 measurement

# 63 N line, eastern part

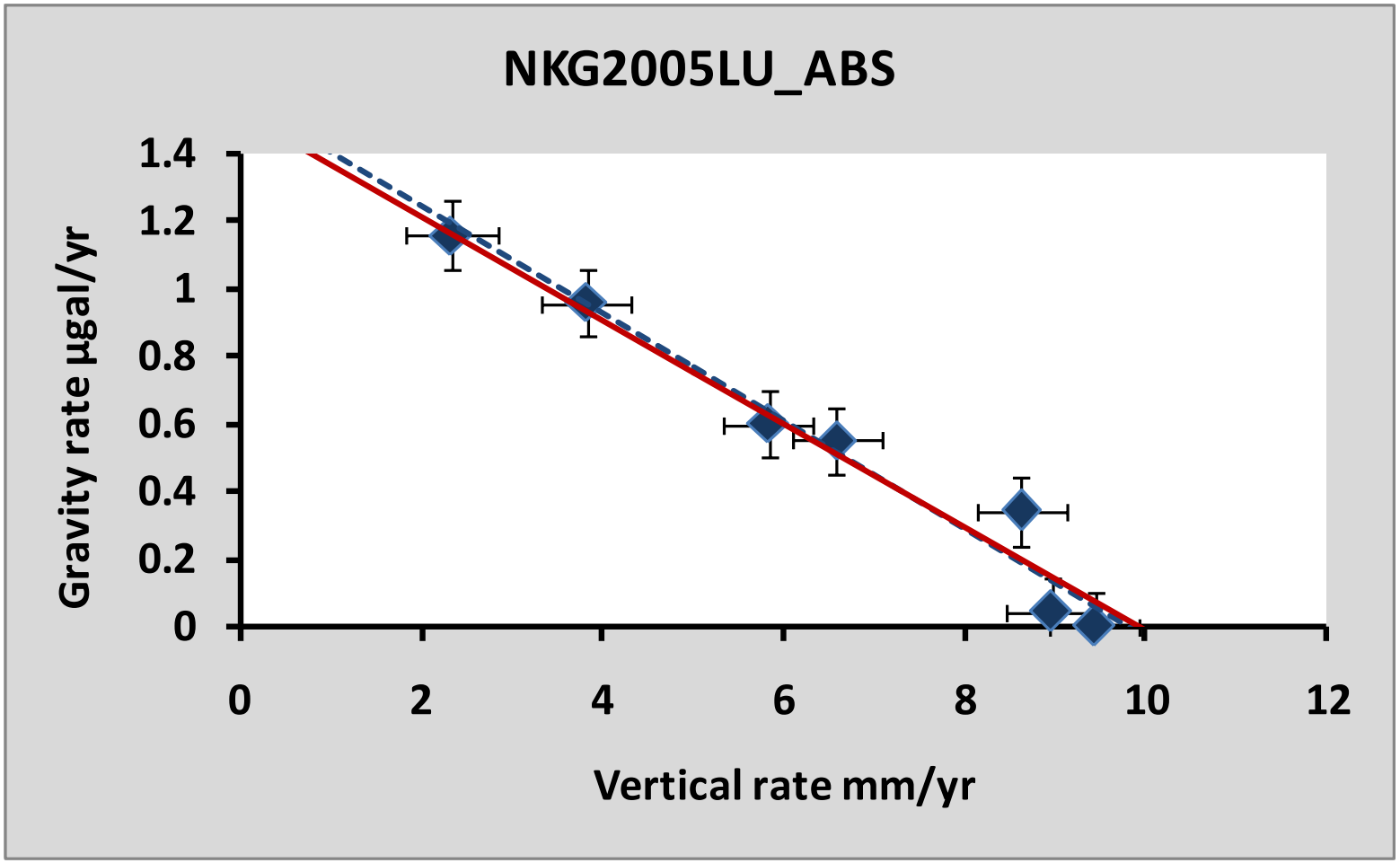



- GJI (1996) slope, dotted
  –1.00 0.14 µgal/yr (1-sigma)
- GGSM (2004) slope, solid
  –0.91 0.09 µgal/yr (1-sigma)

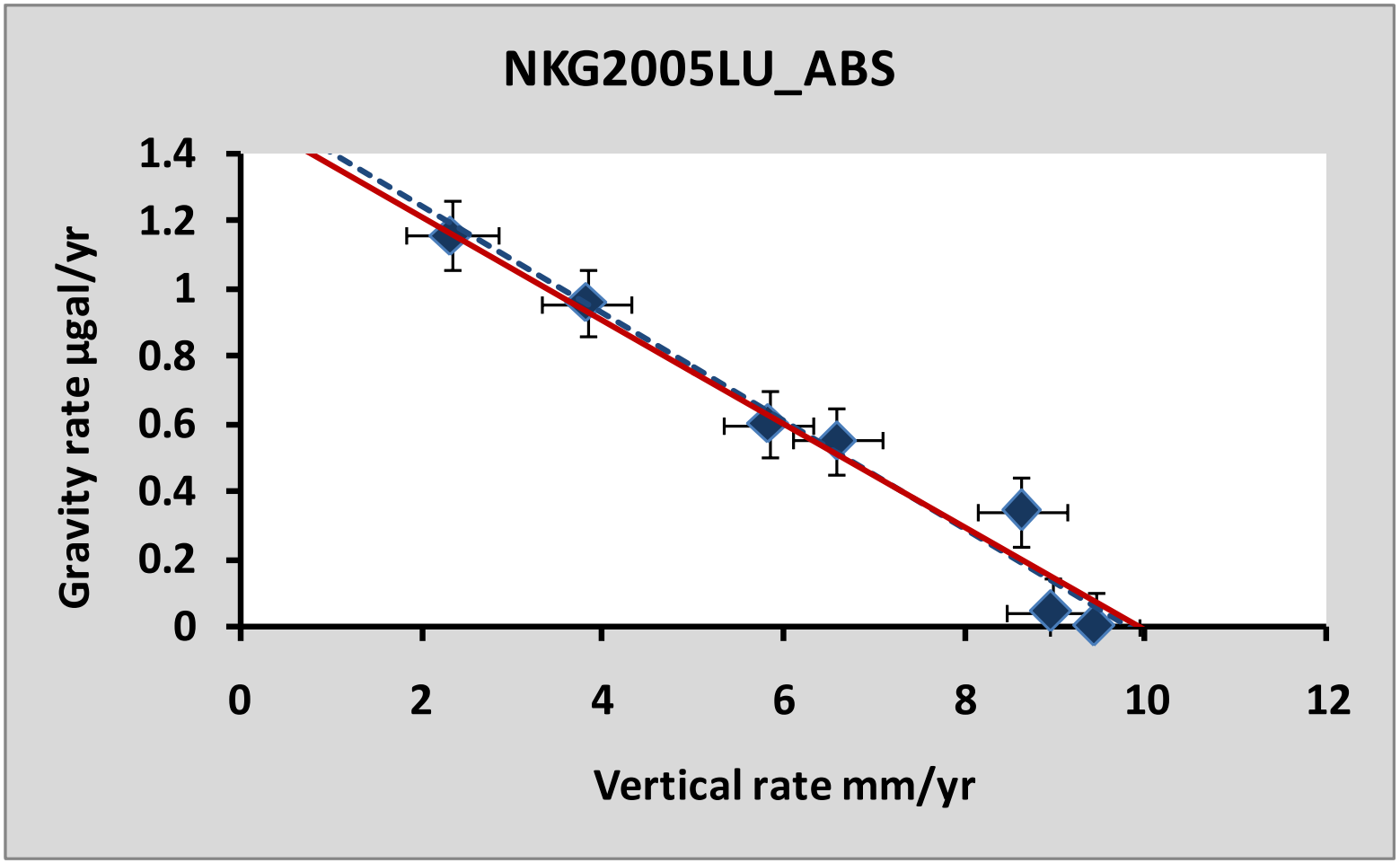



Eastern part, gravimeters individually

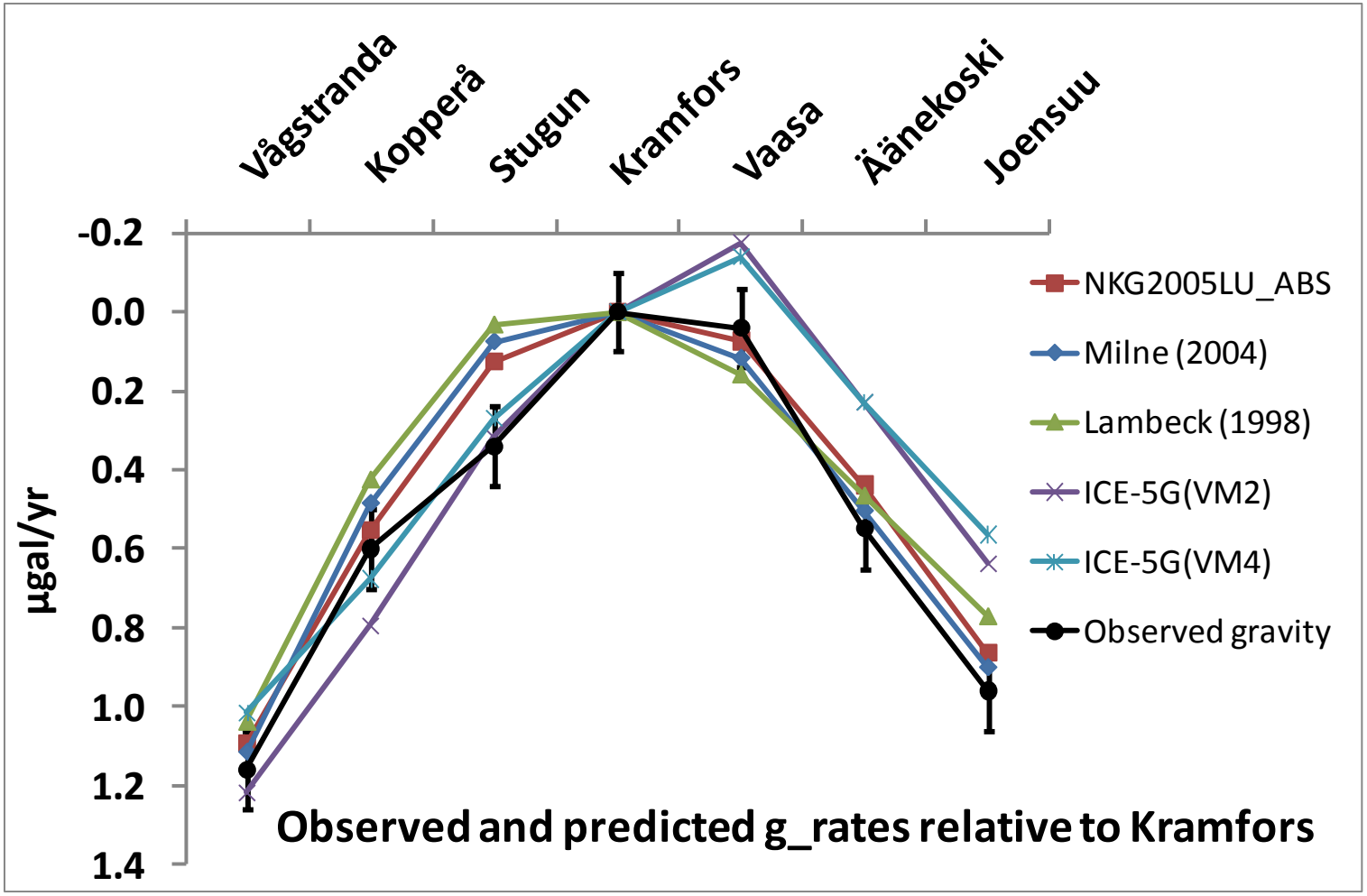
Since the 2004 paper more results became available for the 1998 measurement




Gravity *plotted* relative to Kramfors,
*in fit* "floating"




Solid red line theoretical -0.154 µgal/mm
Blue dashed line fitted linear relationship -0.160 µgal/mm
with *apriori* standard error 0.019 µgal/mm




# 2. Comparison of observed g_dot with models of GIA

# Results of fitting g_dot to h_dot by regression, various models

| Model | Regression µgal/mm | STDE | Chi-square |
|---|---|---|---|
| NKG2005LU | -0.158 | 0.013 | 0.78 |
| Milne (2004) | -0.152 | 0.017 | 1.35 |
| Lambeck (1998) | -0.165 | 0.024 | 2.21 |
| ICE-5G (VM2) | -0.127 | 0.026 | 3.89 |
| ICE-5G(VM4) | -0.154 | 0.029 | 3.42 |

# Summary

- From 40 years of relative gravimetry in Fennoscandia and NKG2005LU_ABS

  *g_dot/h_dot* = –0.160  0.019 (one-sigma),  0.052 (95%)

- Relative gravimetry prefers Milne (2001,2004) , rejects ICE-5G