# The relation between the rate of change of gravity and vertical displacement $\left(\frac{\dot{g}}{\dot{u}}\right)$ in former glaciated areas[1]

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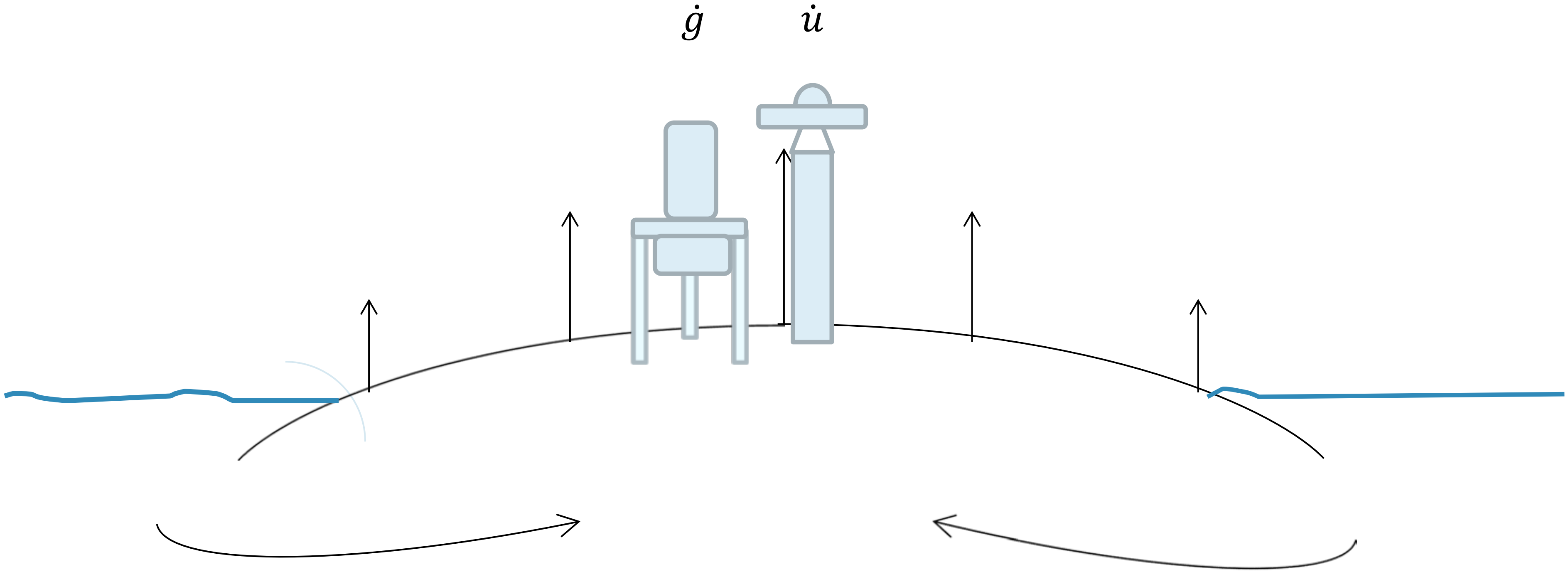
[1] Olsson (2013), Olsson et al (in press)

# What are we talking about?



## Why study the relation between $\dot{g}$ and $\dot{u}$?

- A long history of observations of both in Fennoscandia
- Different observables of the same phenomenon (GIA)
- Their ratio contain information on the underlying physics
- A trustworty relation allows to combine $\dot{u}$ and $\dot{g}$ and strengthen the overall accuracy

- Published ratios are rough estimates for areas with present day ice mass variations (elastic + viscous contribution)[1]

- Are these ratios valid also for Fennoscandia?
- Accurate enough for our purposes?
- Is the ratio constant?
- If not, how does it vary, how much and why?

[1] Wahr et al (1995), James and Ivins (1998), Fang and Hager (2001), Purcell et al (2011), Memin et al (2012)

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# We have...

... predicted $\dot{g}$ and $\dot{u}$ with a GIA-model

... studied their relation with respect to e.g.

- ... different earth model parameters
- ... different ice sheet geometry
- ... evolution in time
- ... local effects (elastic signal and direct attraction)

... made some conclusions

# The GIA-model

- Normal mode approach, 1 dimensional earth rheology[1]
- Sea Level Equation[2] with time dependent coast line geometry[3]
- Ice model: ICE-5G[4]
- Earth model: PREM[5]

| Model name | Comp. | Incomp. | Lithospheric thickness [km] | Upper mantle viscosity [$10^{21}$ Pa s] |
|---|---|---|---|---|
| 96_0.5_10 | yes | | 96 | 0.5 |
| 96_0.5_10_incomp | | yes | 96 | 0.5 |
| 96_0.1_10 | yes | | 96 | 0.1 |
| 96_1_10 | yes | | 96 | 1 |
| 71_0.5_10 | yes | | 71 | 0.5 |
| 120_0.5_10 | yes | | 120 | 0.5 |

[1] Peltier (1974, 1976), [2] Farrell and Clark (1976)
[3] Mitrovica and Milne (2003), Kendall et al (2005)
[4] Peltier (2004), [5] Dziewonski and Anderson (1981)

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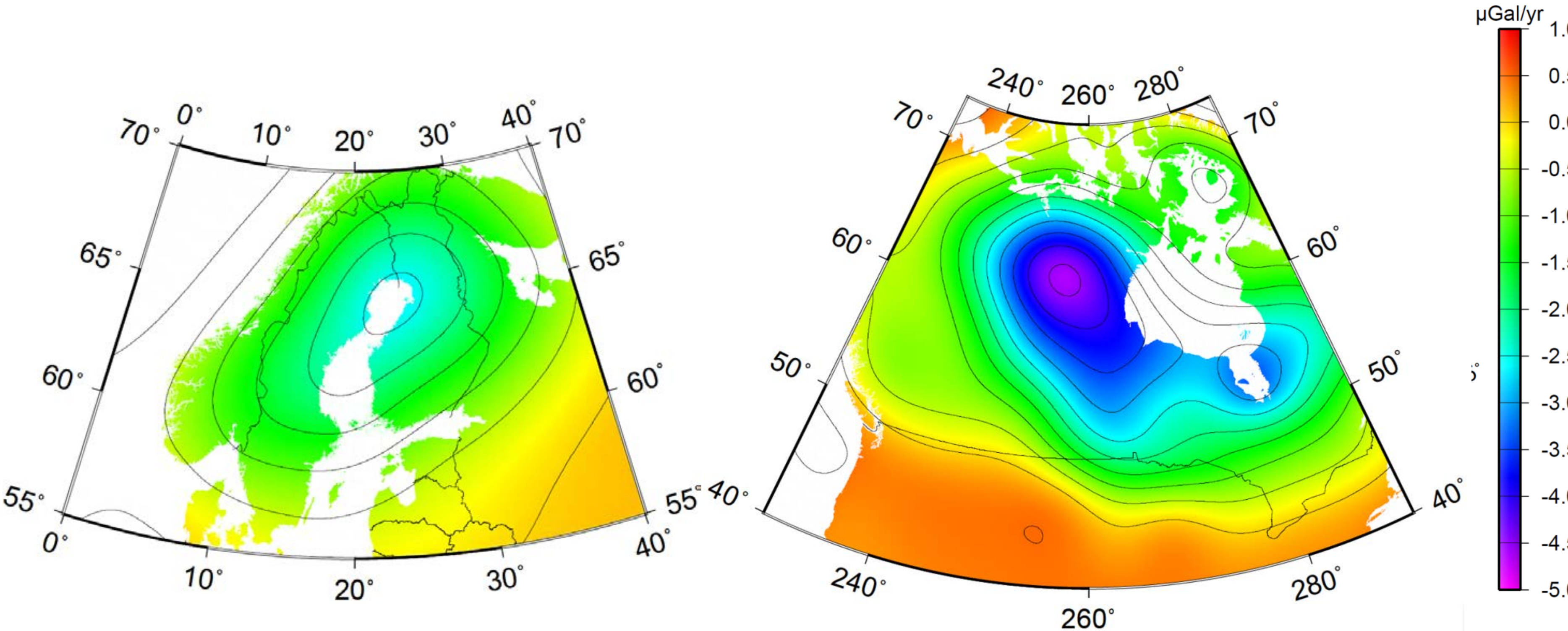
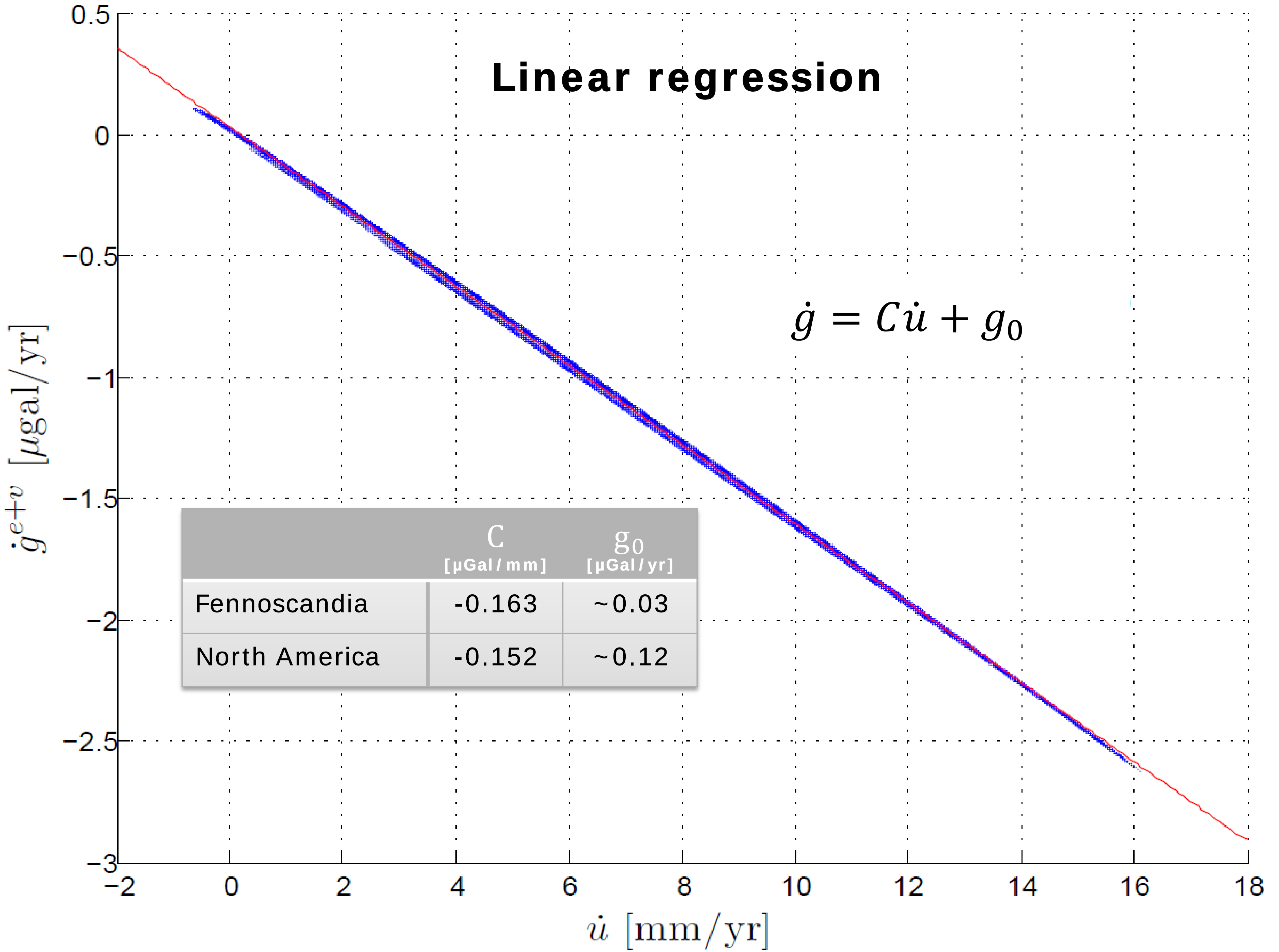
# Predictions of $\dot{g}$

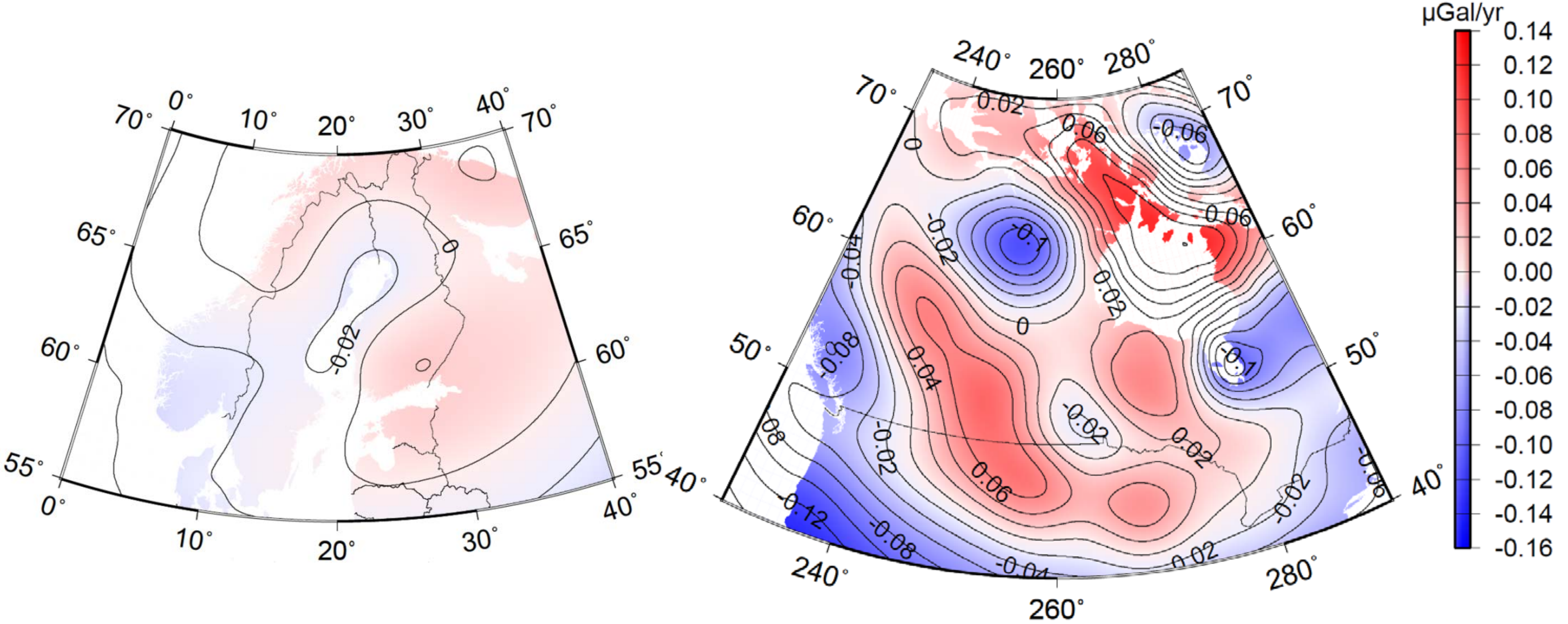





| | C [μGal/mm] | $g_0$ [μGal/yr] |
|---|---|---|
| Fennoscandia | -0.163 | ~0.03 |
| North America | -0.152 | ~0.12 |

# Residuals

$$\epsilon = \dot{g} - (C\dot{u} + g_0)$$

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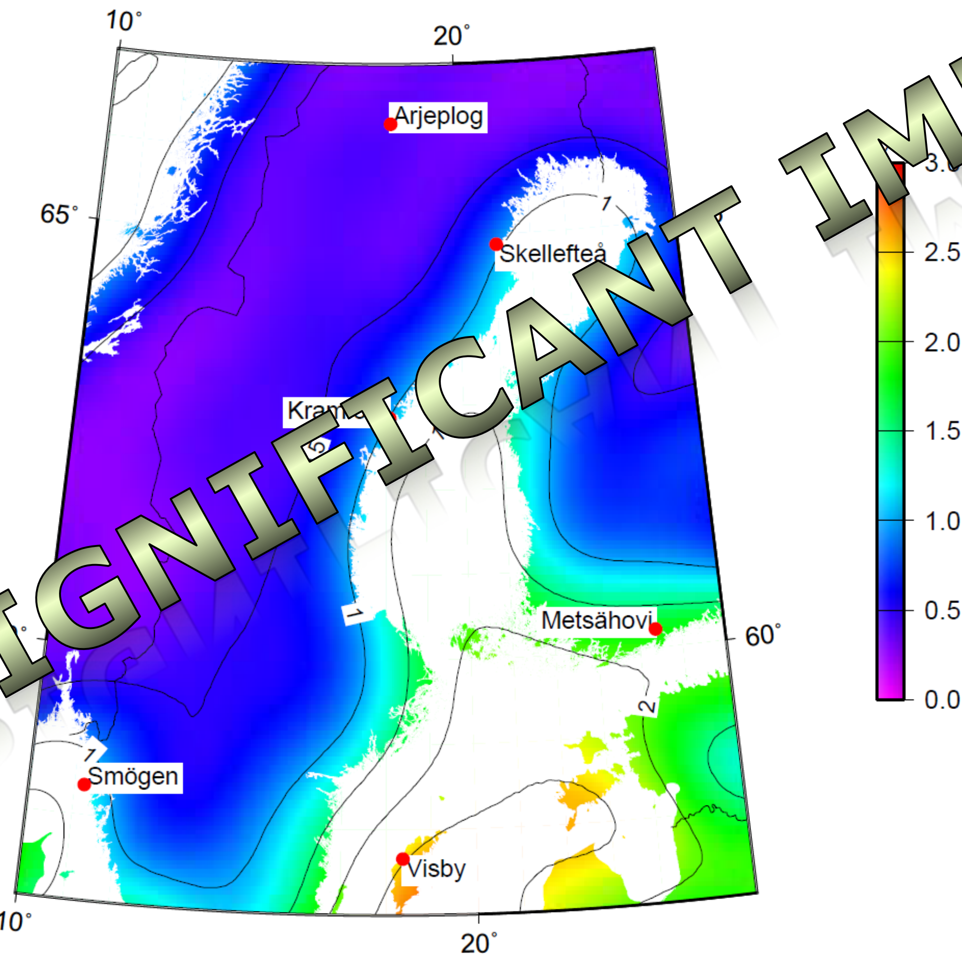
# Local effects?

- Direct attraction from relative sea level change?
- High degree elastic deformation terms?

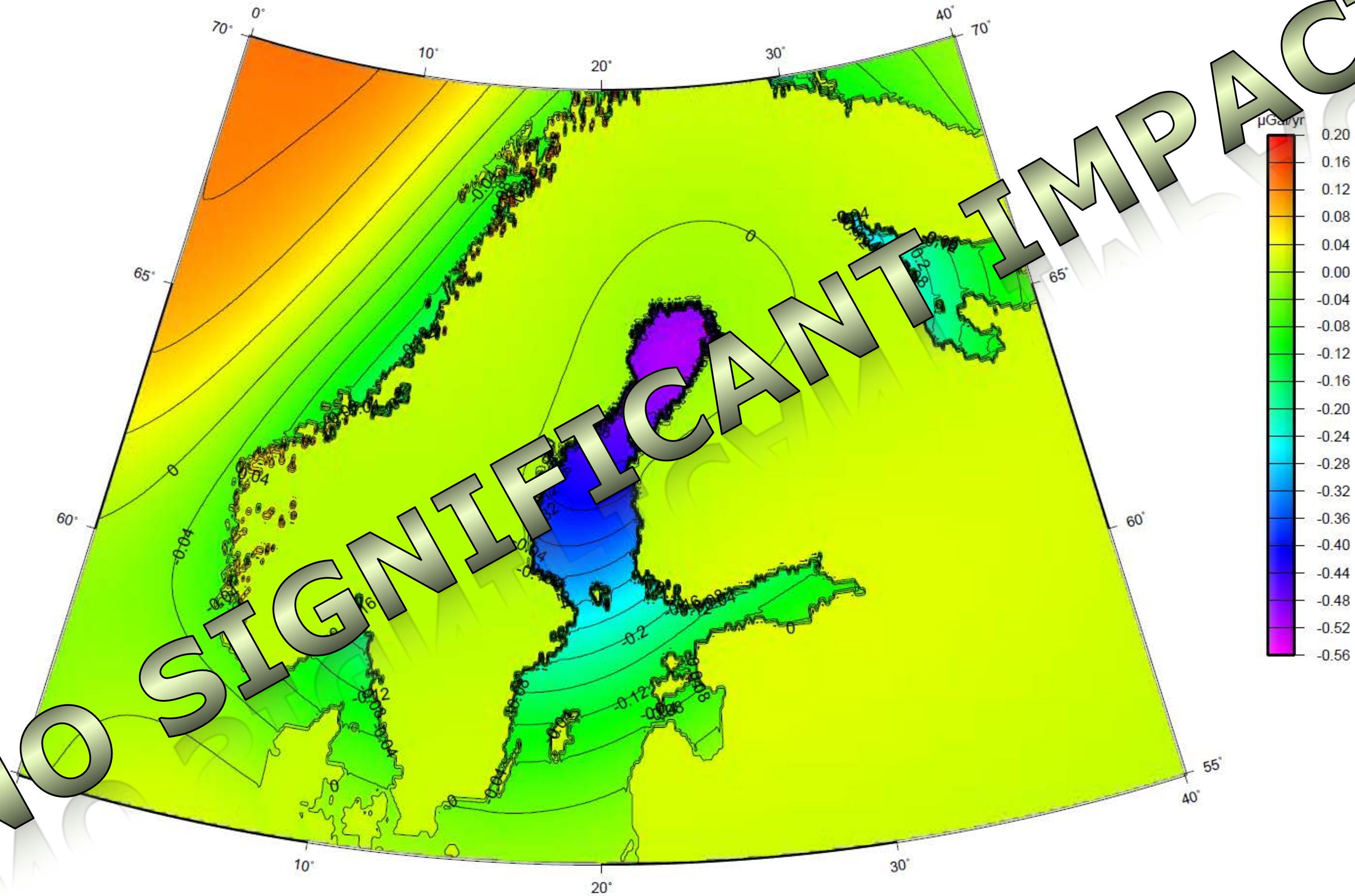
# High degree elastic deformation terms




**NO SIGNIFICANT IMPACT**

# Direct attraction from relative sea level changes

If distance to sea > 10 * height above sea then




NO SIGNIFICANT IMPACT

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# Summary and conclusions

- From our GIA-model (Normal Mode, 1D, Maxwell) follows that:
  - Within a specific region (Fennoscandia or North America) the relation between $\dot{g}$ and $\dot{u}$ is almost linear with a ratio of -0.163 and -0.152 µGal/mm respectively.
  - These values are not sensitive to the choise of earth model parameters.
  - Estimating $\dot{g}$ from $\dot{u}$ using this linear relation in the uplift area deviates less than ±0.02 µGal/yr in Fennoscandia and less than ±0.1 µGal/yr in North America, compared to full modelling of $\dot{g}$.
- The observational accuracy is expected to be ±0.1 µGal/yr after 15-25 years of annual or semiannual AG observations.
- Local effects, such as direct attraction from sea level variations and high degree elastic deformation, do not affect the results other than in extreme cases (distance to the sea < 10H).
- 3D earth?

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