What do we validate when comparing geometric with gravimetric height anomalies?

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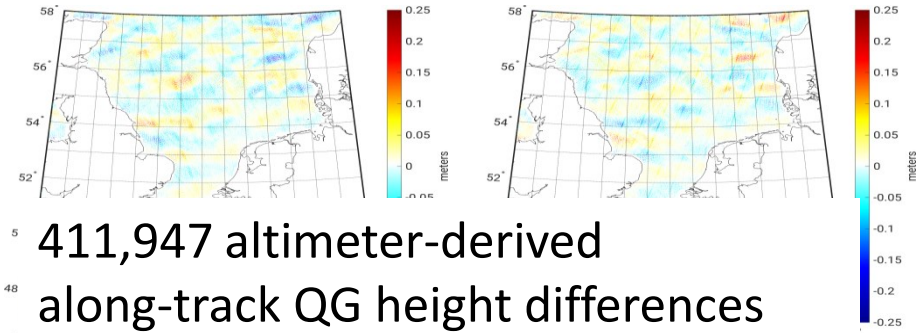
Main objective NEVREF project

Required with cm accuracy

…

*To obtain accurate realizations of the **quasi-geoid** and **lowest astronomical tide** surface, including the necessary **transformations** from/to all common land and marine vertical reference surfaces*

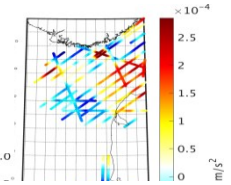
…to obtain this one with accuracy of 1 dm!

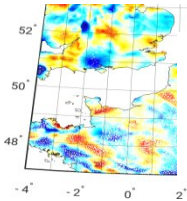


411,947 altimeter-derived along-track QG height differences

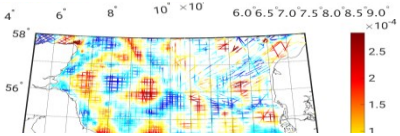
- Altimeter data corrected for dynamic topography from DCSMv6;
- Colored noise in altimeter-derived QG height differences accounted for using an ARMA process;
- Remove-compute-restore:
  - **GOCO05S** as priori gravity field;
  - **RTM** correction applied using the TS (tesseroids) software;

453,334 terrestrial gravity anomalies

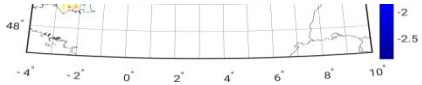


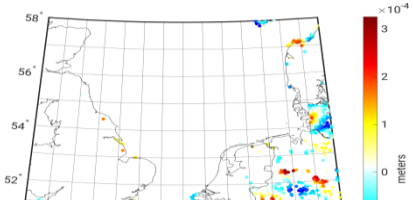


8,205 airborne gravity disturbances



94,137 shipboard gravity anomalies





7,179 spatially interpolated gravity anomalies

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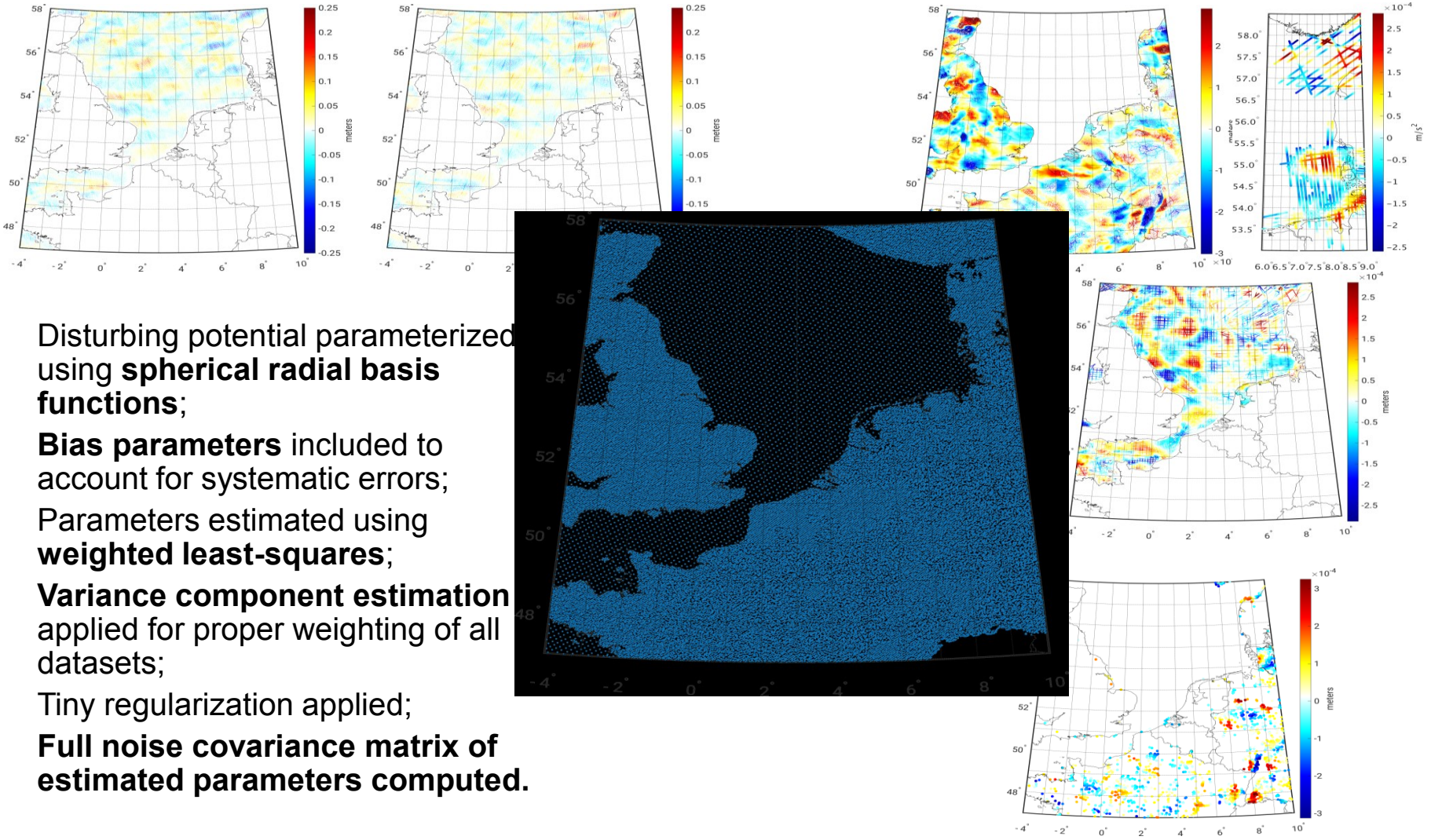


- Disturbing potential parameterized using **spherical radial basis functions**;
- **Bias parameters** included to account for systematic errors;
- Parameters estimated using **weighted least-squares**;
- **Variance component estimation** applied for proper weighting of all datasets;
- Tiny regularization applied;
- **Full noise covariance matrix of estimated parameters computed.**

Results VCE – a posteriori standard deviations

Dataset	# data points	A posteriori SD [cm]	[mGal]
RA[*1]	411,947	0.9 - 4.8	1.40 - 7.31
Terrestrial Δg	453,334		0.70
Airborne δg	8,205		1.33
Shipboard Δg	94,137		1.23
Interpolated Δg	7,179		0.50

- RA does not contribute much;

[*1] For RA, 1 variance factor estimated per mission (phase);

Numbers are reasonable for today's standards, though our datasets include survey data from the 70's and 80's…

Validation - Nethe

$$\varepsilon = (h_{\mathrm{GNSS}} - H_{\mathrm{NAP}}) - c$$

- Acquired during 1996–1997 (5th primary leveling);

- Reprocessed by L. Huisman using Bernese Software Version 5.2;

- ITRF2005;

- Tide free → mean crust;

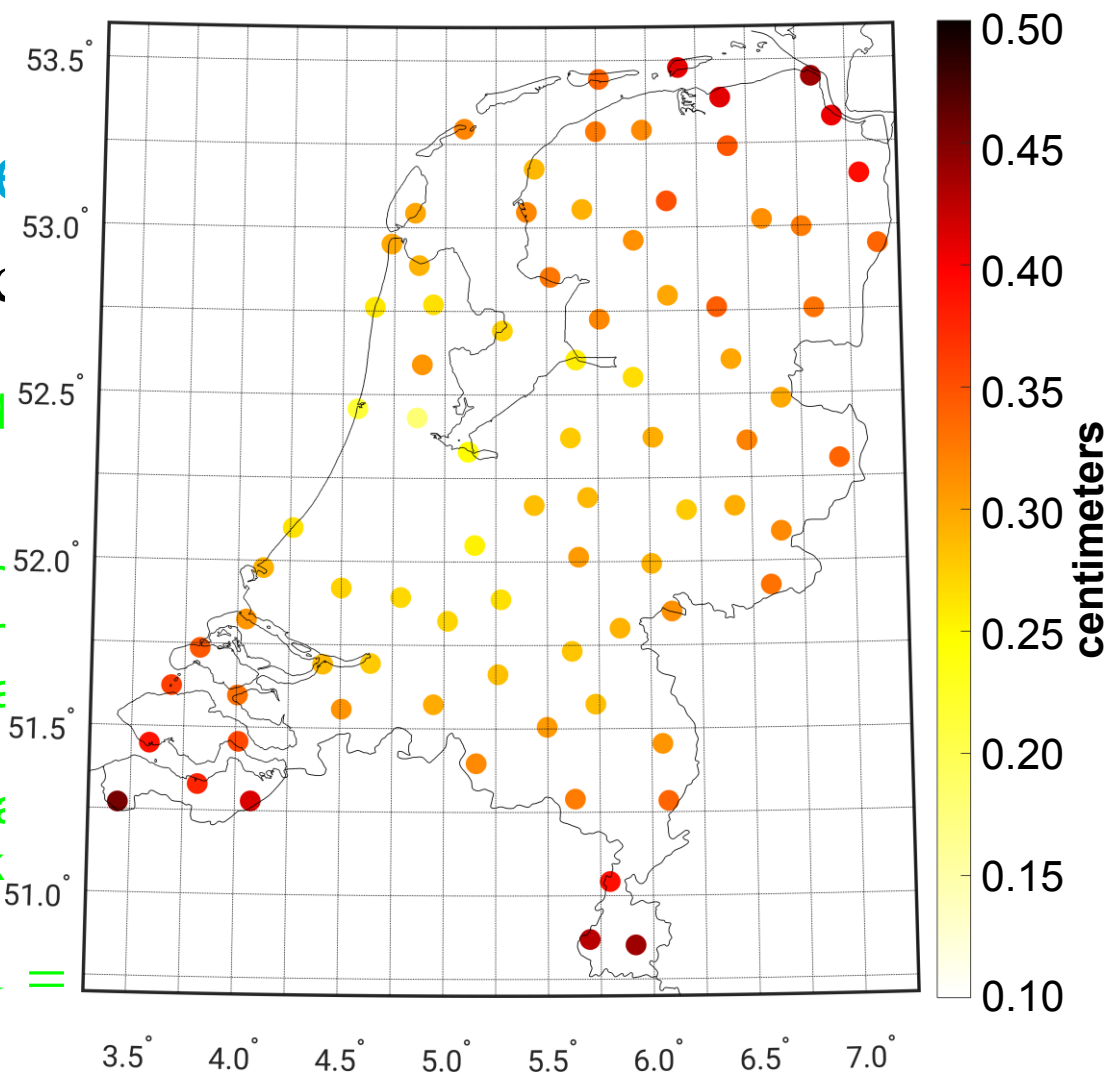
- $\sigma_h \approx 5$ mm (5 days data)

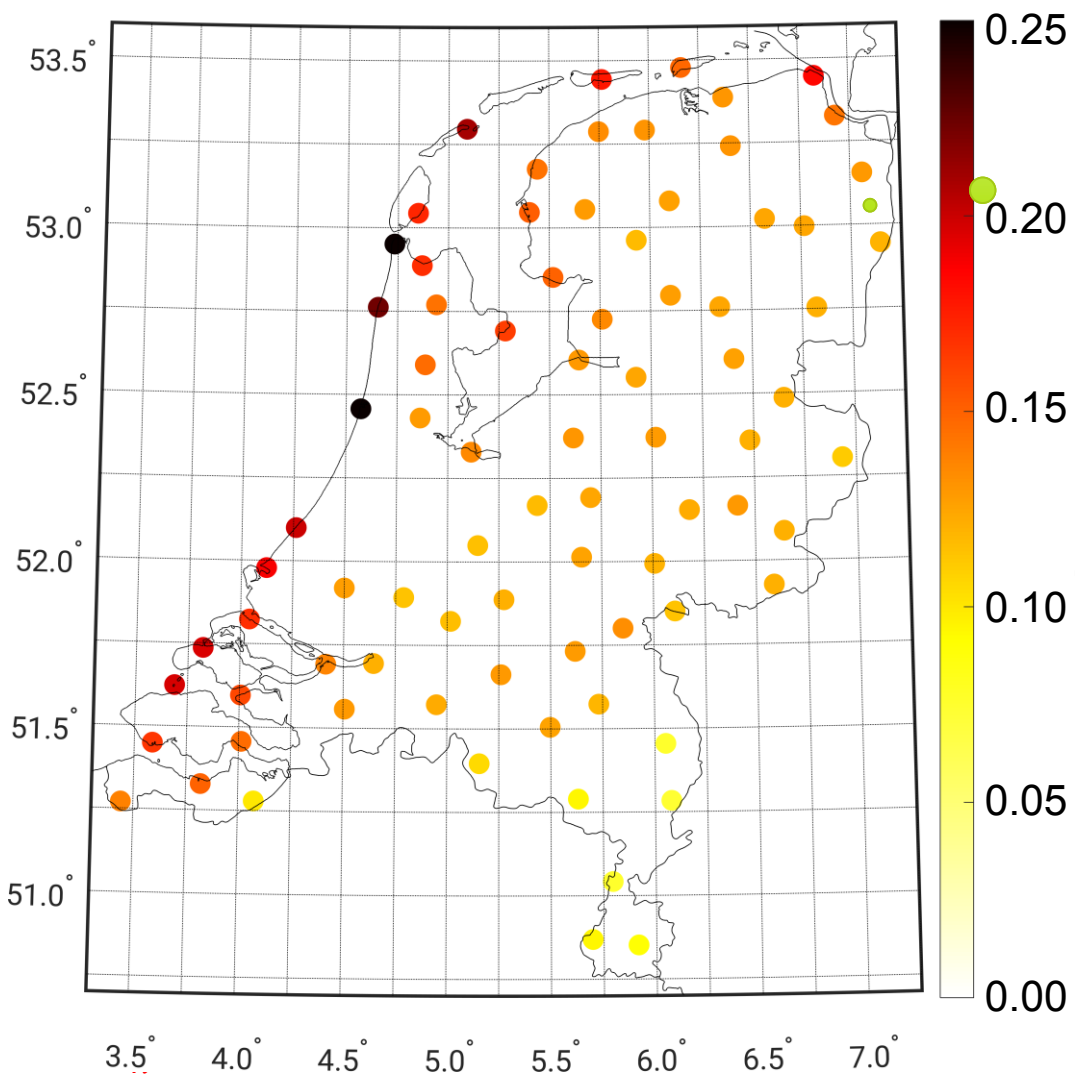
- Acq
after

- Cor
heigh
prima

- Mea
(Mäk

- $\sigma_H =$





Commission errors

$$\left.\right] = \zeta_{\text{geometric}} - \zeta_{\text{gravimetric}}$$

nonth

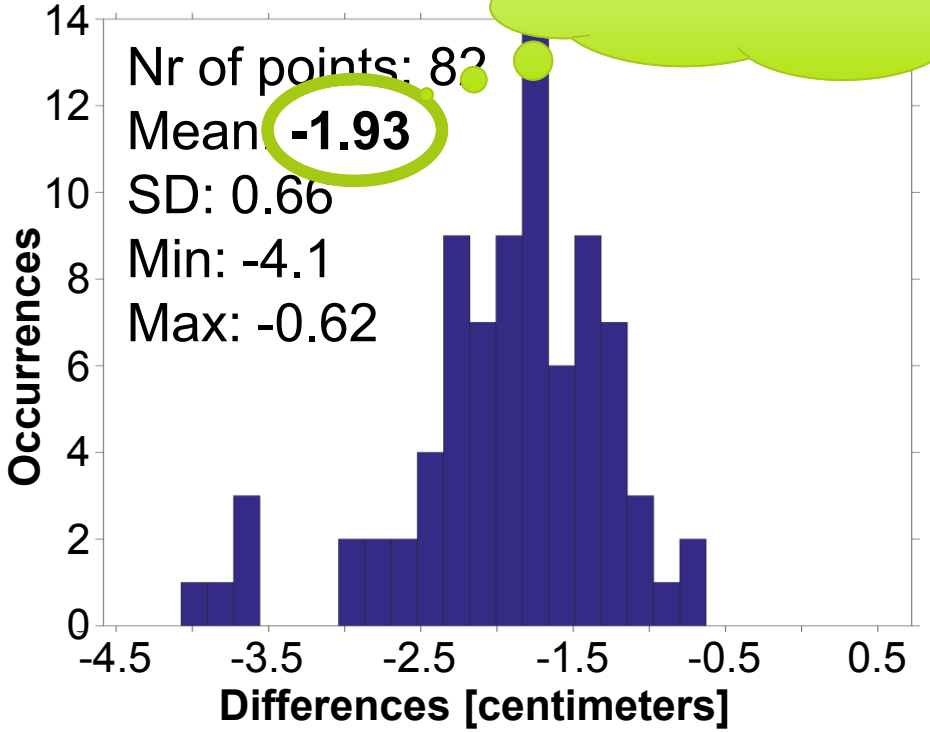
m 5th lied;

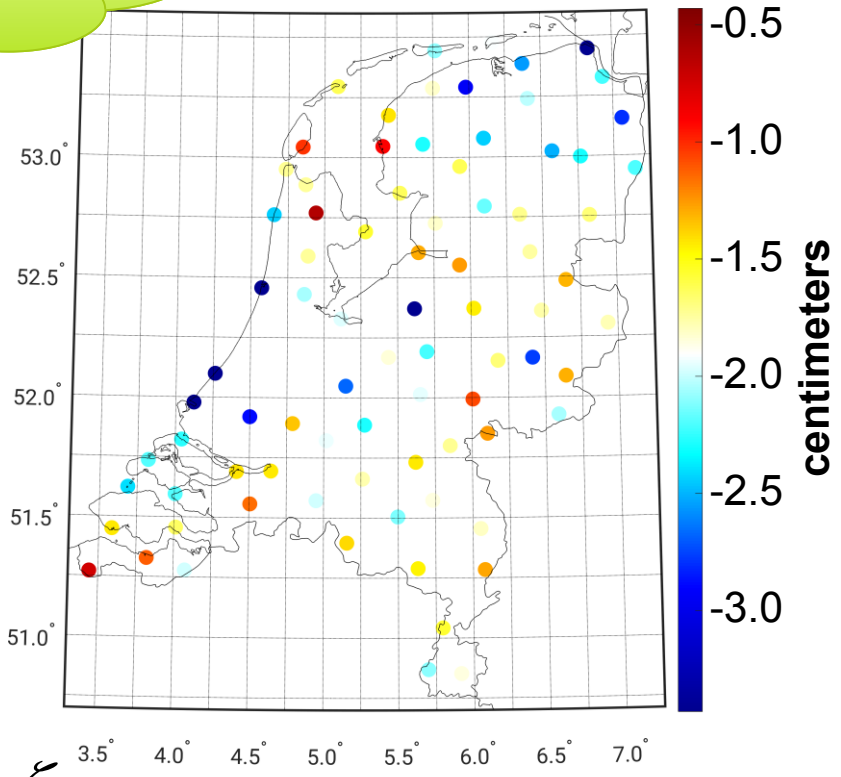
tide;

- In zero-tide system;
- Normal heights of data points refer to EVRF2007;
- When restoring GOCO05s, we used $W_0 = W_{\text{EVRF2007}}$;
- $\sigma_N =$

Validatio

$W_{EVRF2007} \neq W_{NAP}$

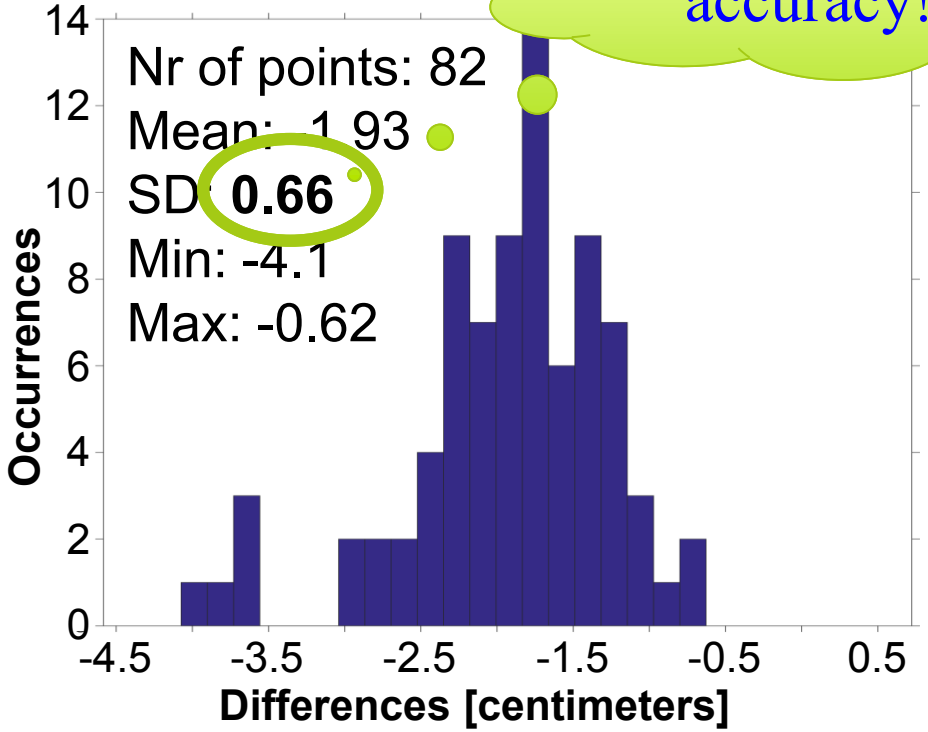


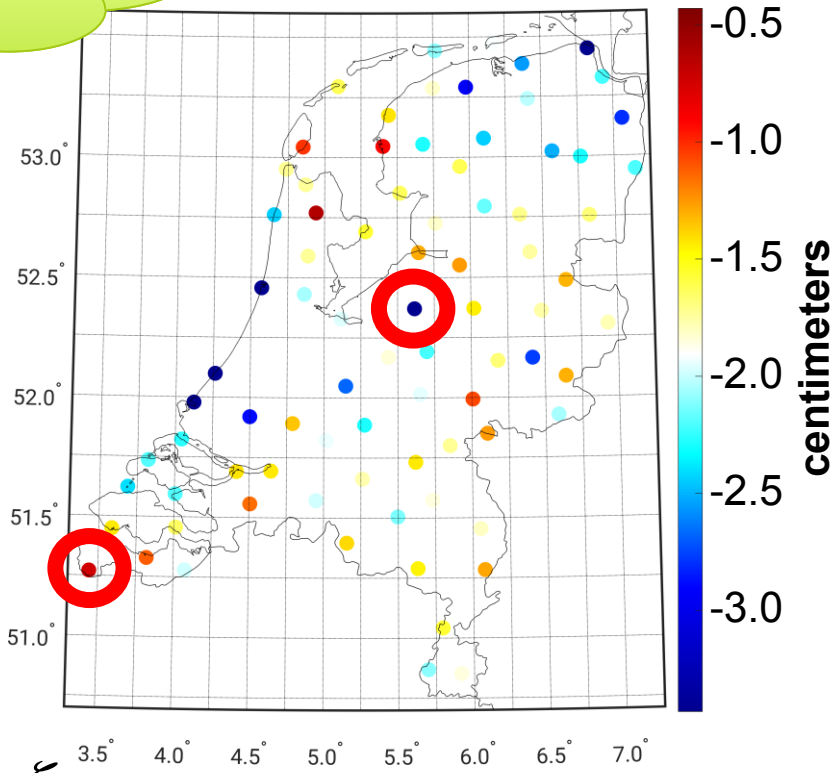


$$\varepsilon = \zeta_{\text{geometric}} - \zeta_{\text{gravimetric}}$$

Validatio

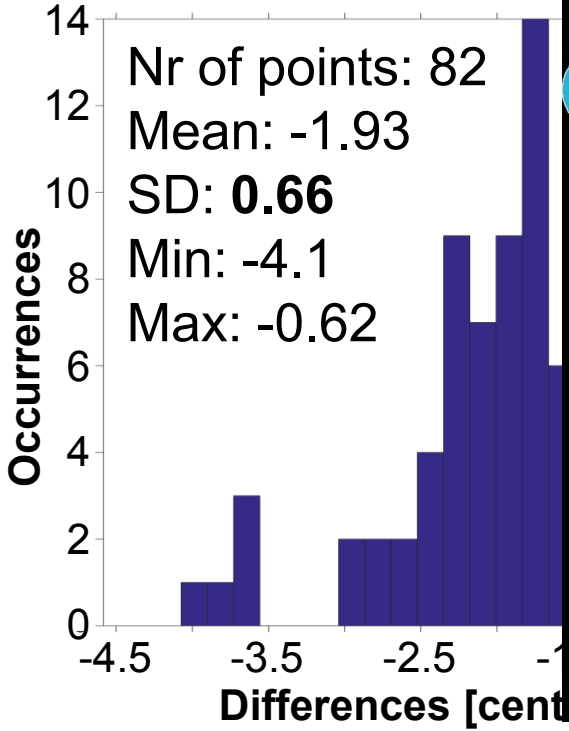
< 1 cm of target accuracy!

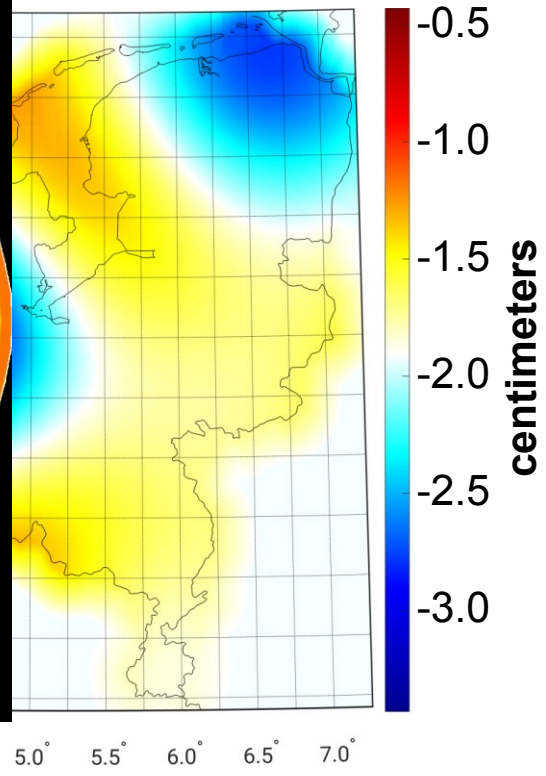




$$\varepsilon = \zeta_{\text{geometric}} - \zeta_{\text{gravimetric}}$$

Validation - Netherlands

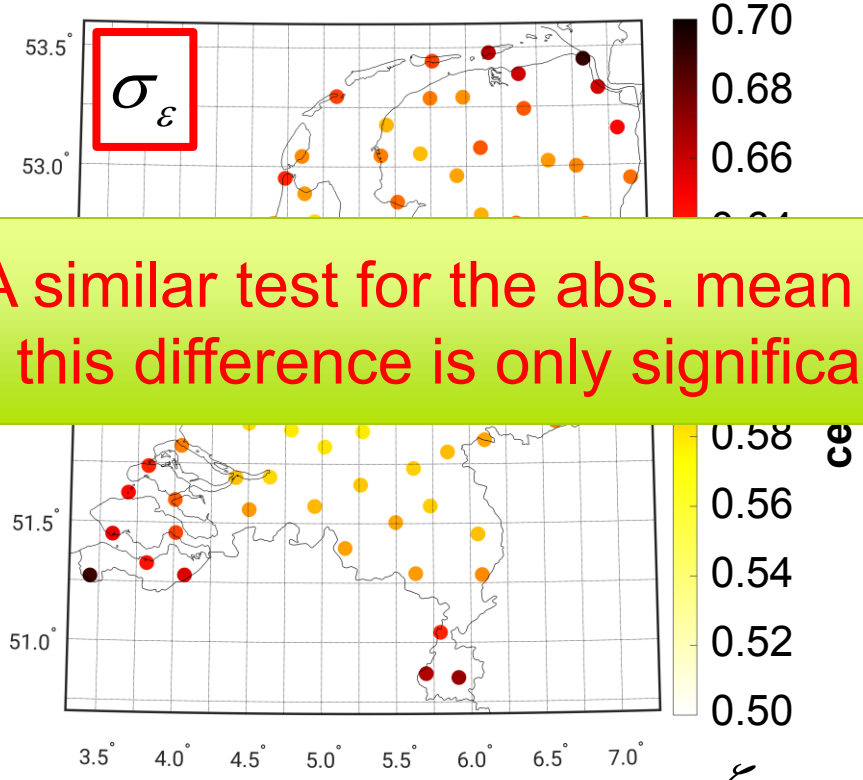


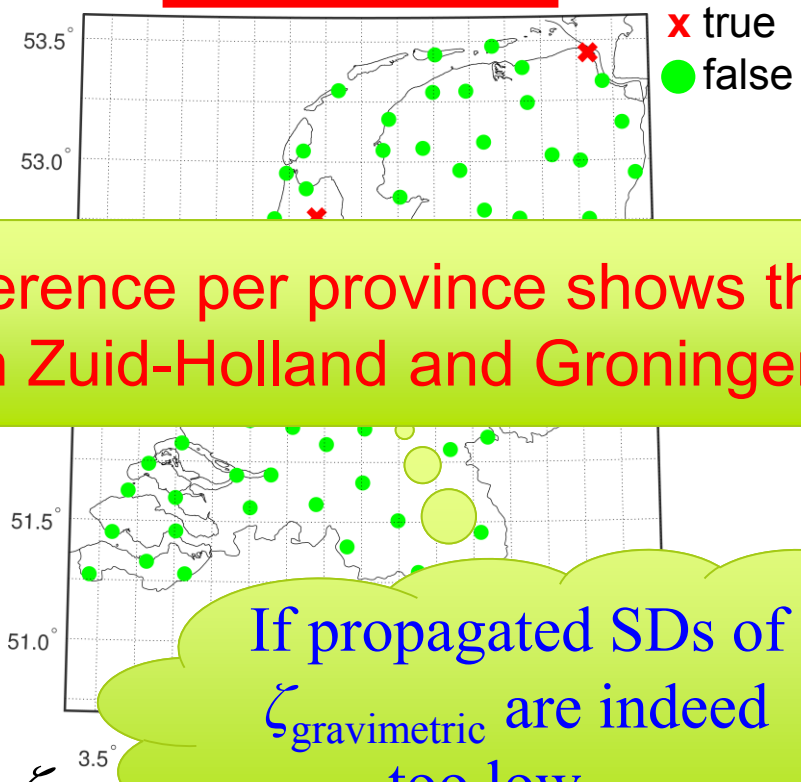


$$\varepsilon = \zeta_{\text{geometric}} - \zeta_{\text{gravimetric}}$$

Validation???

$$\text{abs}(\varepsilon) > 2\sigma_\varepsilon$$





A similar test for the abs. mean difference per province shows that this difference is only significant in Zuid-Holland and Groningen

If propagated SDs of $\zeta_{\text{gravimetric}}$ are indeed too low…

$$\varepsilon = \zeta_{\text{geometric}} - \zeta_{\text{gravimetric}}$$

What do we validate?

Conclusions

- Formal errors in QG smallest contributor to error budget of $\varepsilon = \zeta_{\text{geometric}} - \zeta_{\text{gravimetric}}$
- We computed a QG with a standard deviation of < 1 cm!
- At most locations, differences are statistically not significant!

We need better &
more validation data!

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Thank you!