

Hochgenaue regionale Geoidbestimmung durch die Kombination von terrestrischen und Satellitendaten

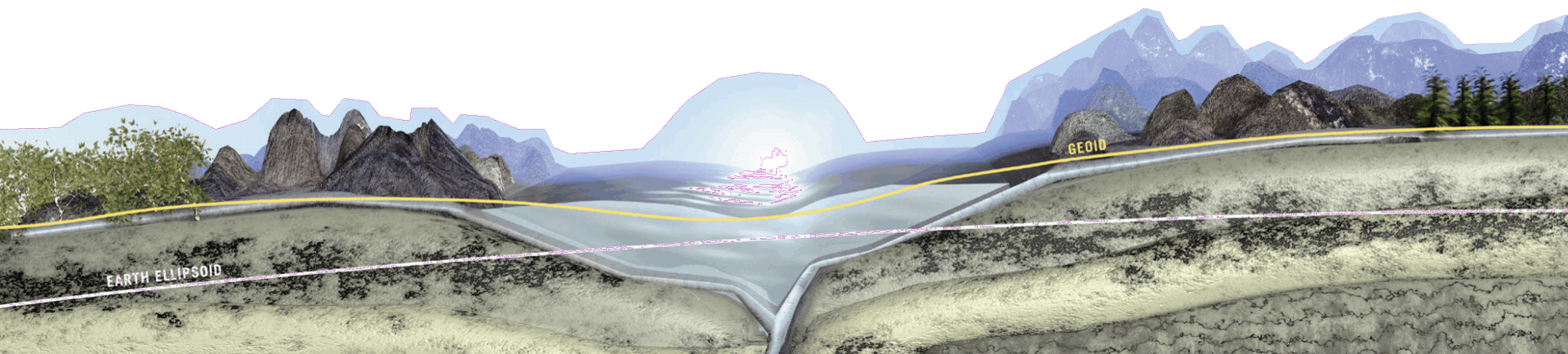
Christian Pock¹, Torsten Mayer-Gürr¹, Daniel Rieser¹, Norbert Kühtreiber²

1) Institute of Theoretical Geodesy
and Satellite Geodesy

2) Institute of Navigation

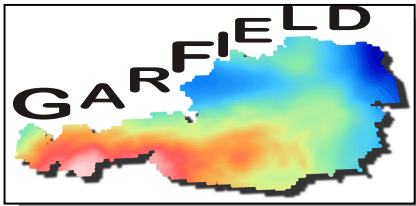
Graz University of Technology

Geodätische Woche 2014
Berlin, Deutschland



Introduction

- Current Austrian geoid initiative “Geoid for Austria - Regional gravity FIELD improved” (GARFIELD) - P25222-N29

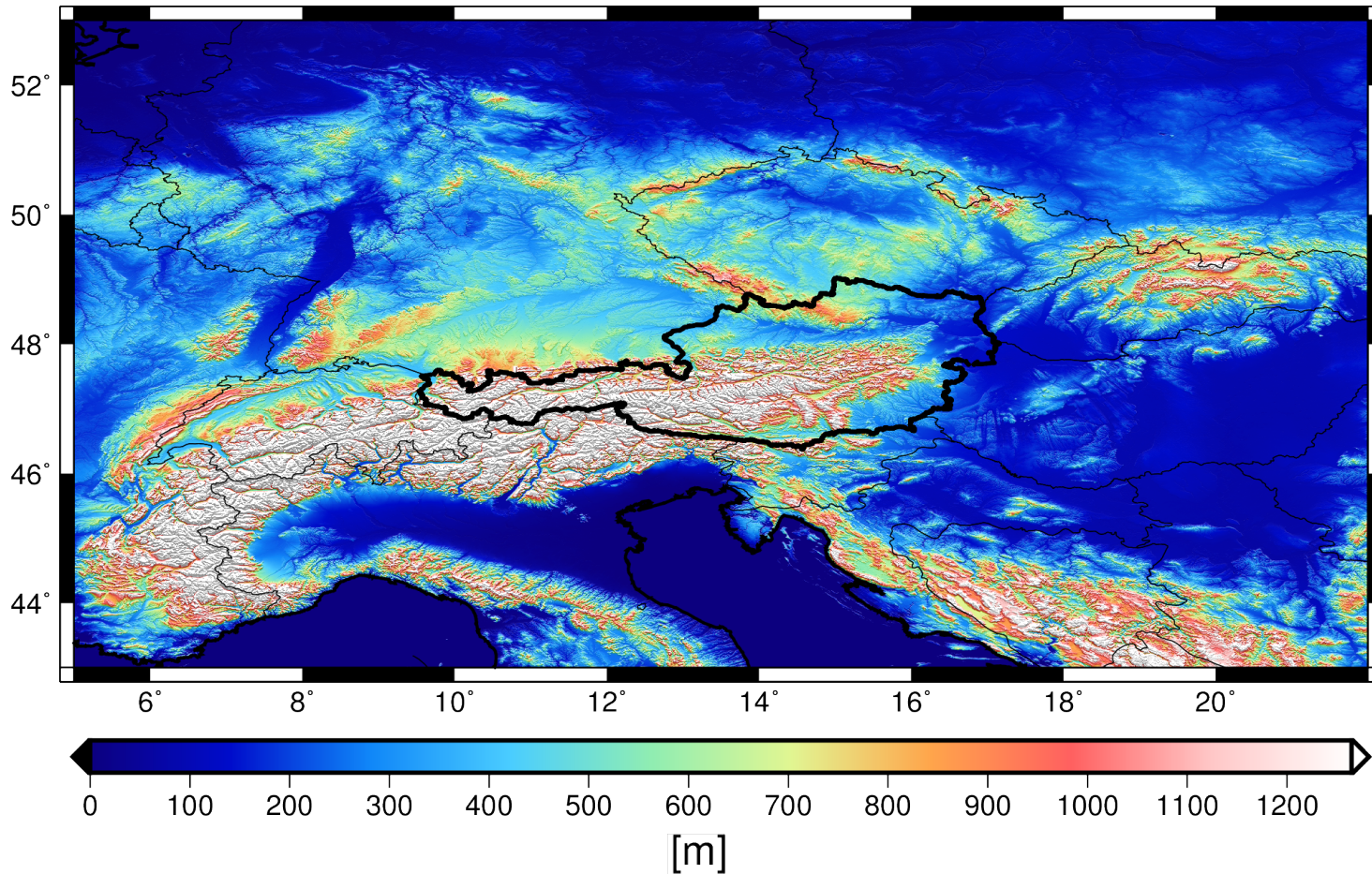


- Combination of global gravity field models with terrestrial observations
- Discussed today:
 - ***Effect of height differences between Digital Terrain Model (DTM) and gravity stations***
 - ***Useful gravity observation groups for Variance Component Estimation***

What is the magnitude of these effects for the geoid computation?

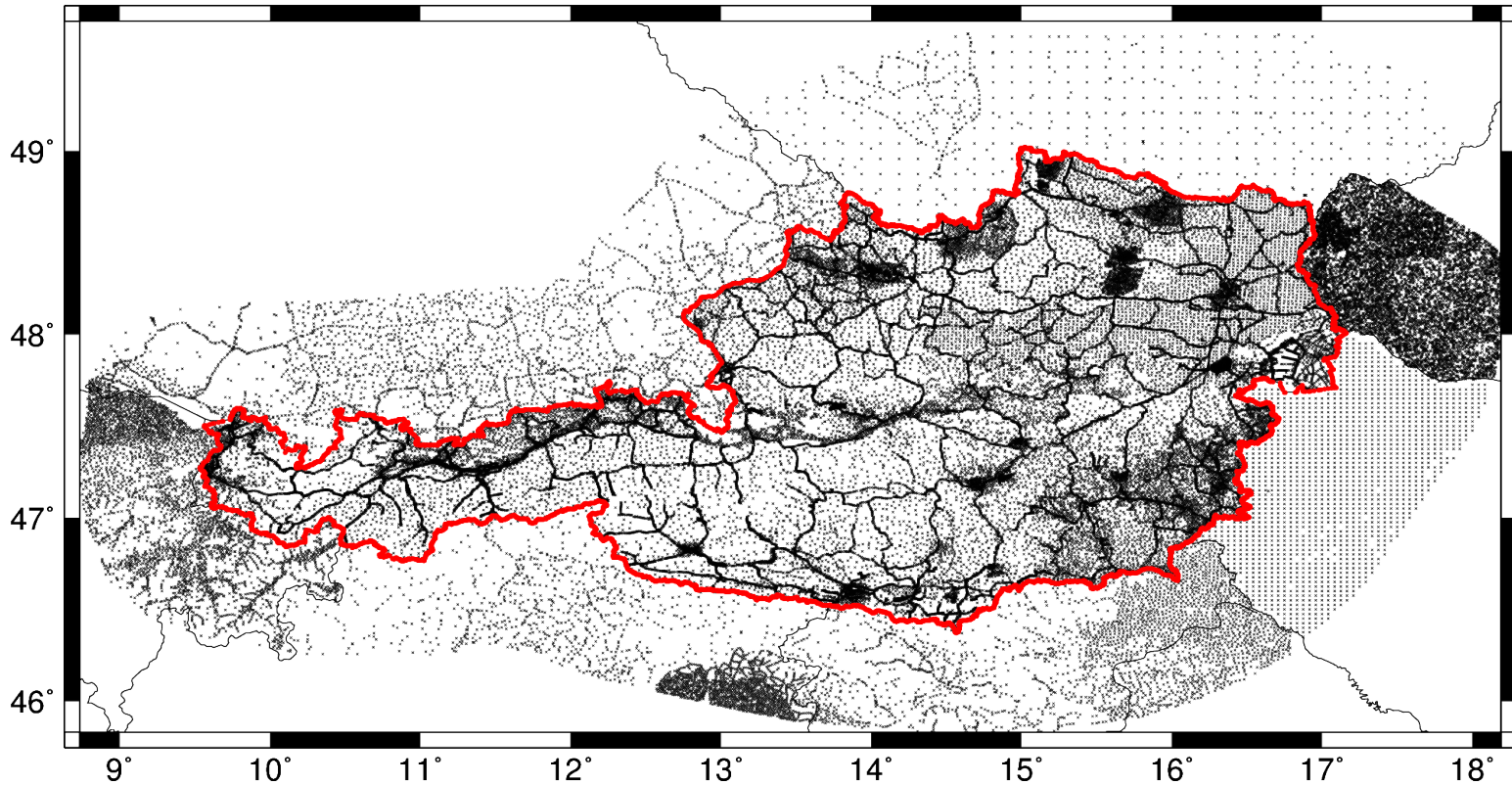
Used Input Data Set (1)

- **Digital Terrain Model: 176x196m**



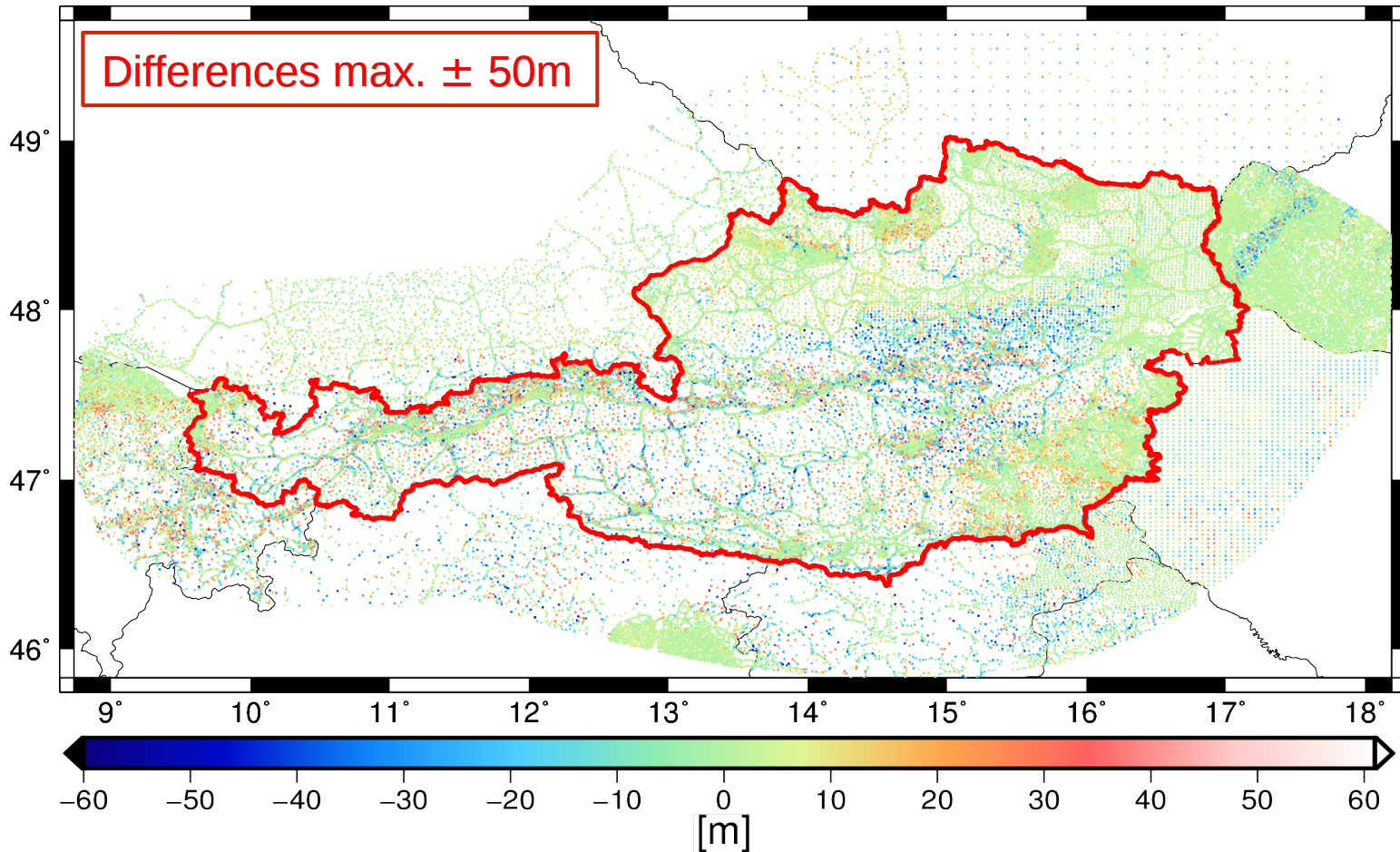
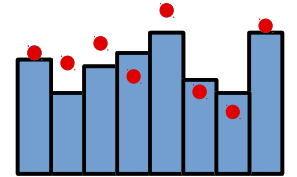
Used Input Data Set (2)

- Measured gravity: 71261 points



Used Input Data Set (3)

- **Measured gravity:** 71261 points
- Digital Terrain Model: 176x196m



Options for Investigation

- **Where are the height differences coming from?**
 - DTM heights or gravity station heights?
- **How to correct?**
 - 1st Do nothing
 - 2nd Fit DTM to station heights
 - 3rd Fit station heights to DTM

Options for Investigation

- **Where are the height differences coming from?**

- DTM heights or station heights?

- **How to correct?**

- 1st Do nothing
- 2nd Fit DTM to station heights
- 3rd ~~Fit station heights to DTM~~



| Description input data set | Austrian gravity height quality [BEV] |
|--------------------------------|---------------------------------------|
| 1 st order leveling | < 0.5 cm |
| 2 nd order leveling | < 2 cm |
| Triangulation | < 20 cm |
| Elevation number | < 200 cm |
| : | |
| : | |

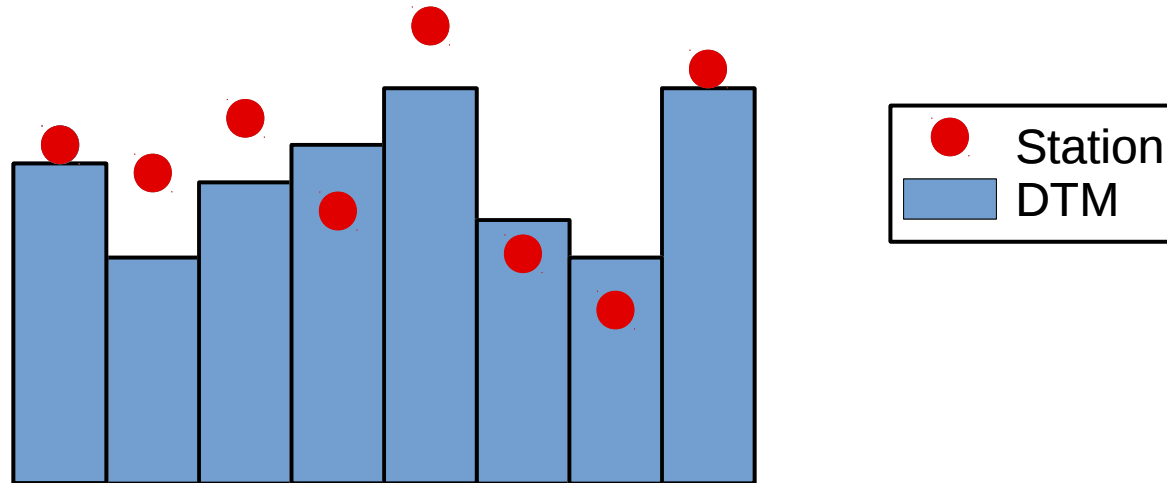
- **Changes in gravity reduction?**

- **Relative geoid changes?**

- **Absolute GPS/leveling validation?**

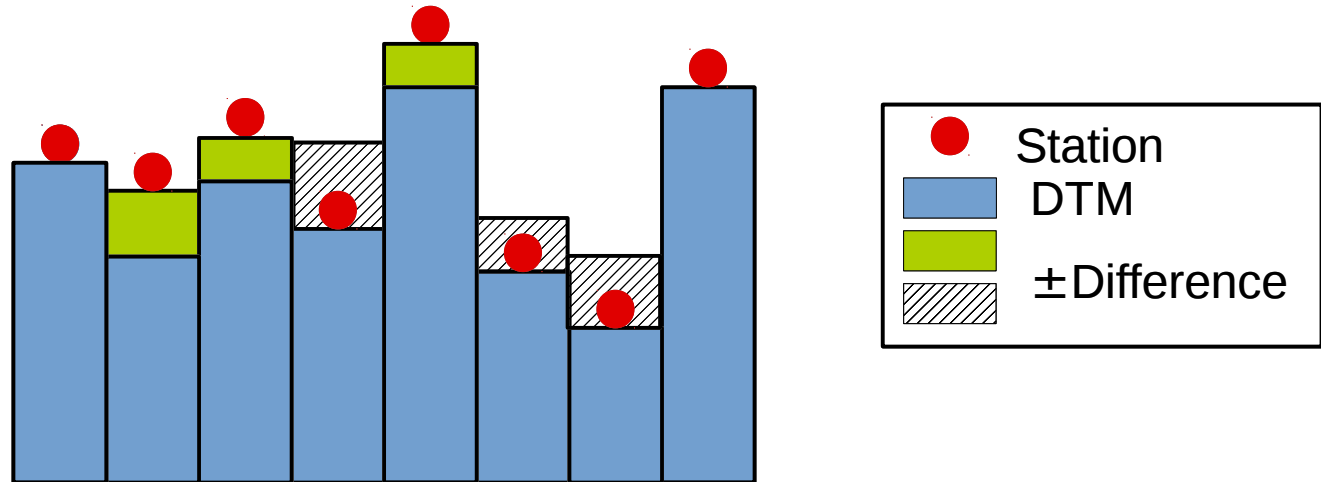
Gravity Station Height vs. DTM (1)

- Deviations between station height and DTM
 - Searching for nearest DTM point



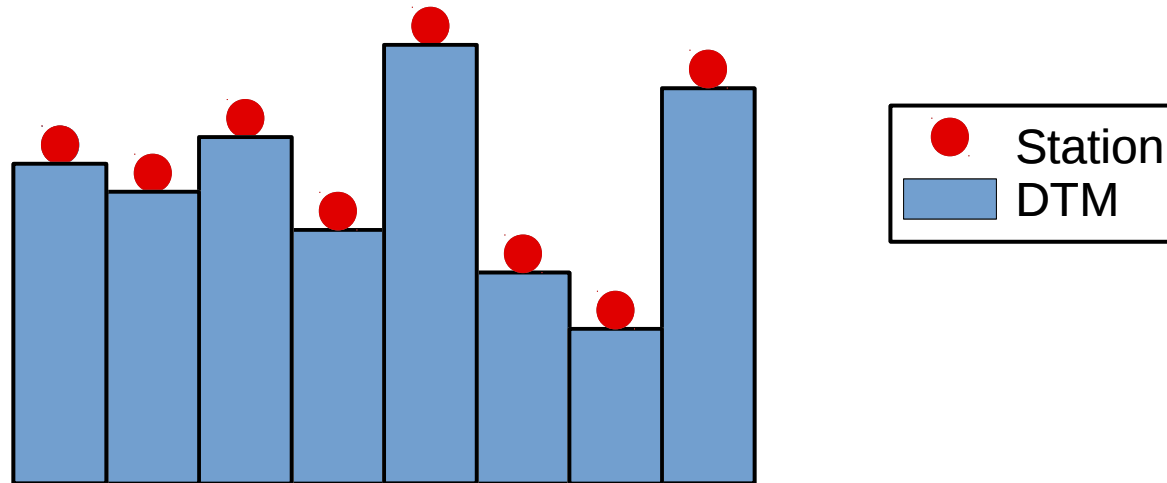
Gravity Station Height vs. DTM (2)

- Deviations between station height and DTM
 - Searching for nearest DTM point
 - Compute difference between gravity station height and DTM



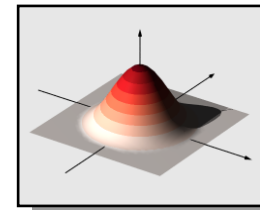
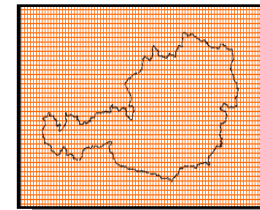
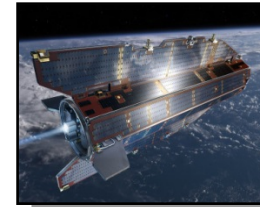
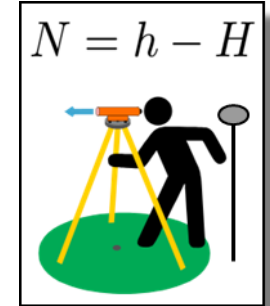
Gravity Station Height vs. DTM (3)

- Deviations between station height and DTM
 - Searching for nearest DTM point
 - Compute difference between gravity station height and DTM
 - Apply difference to DTM (only one single prism)



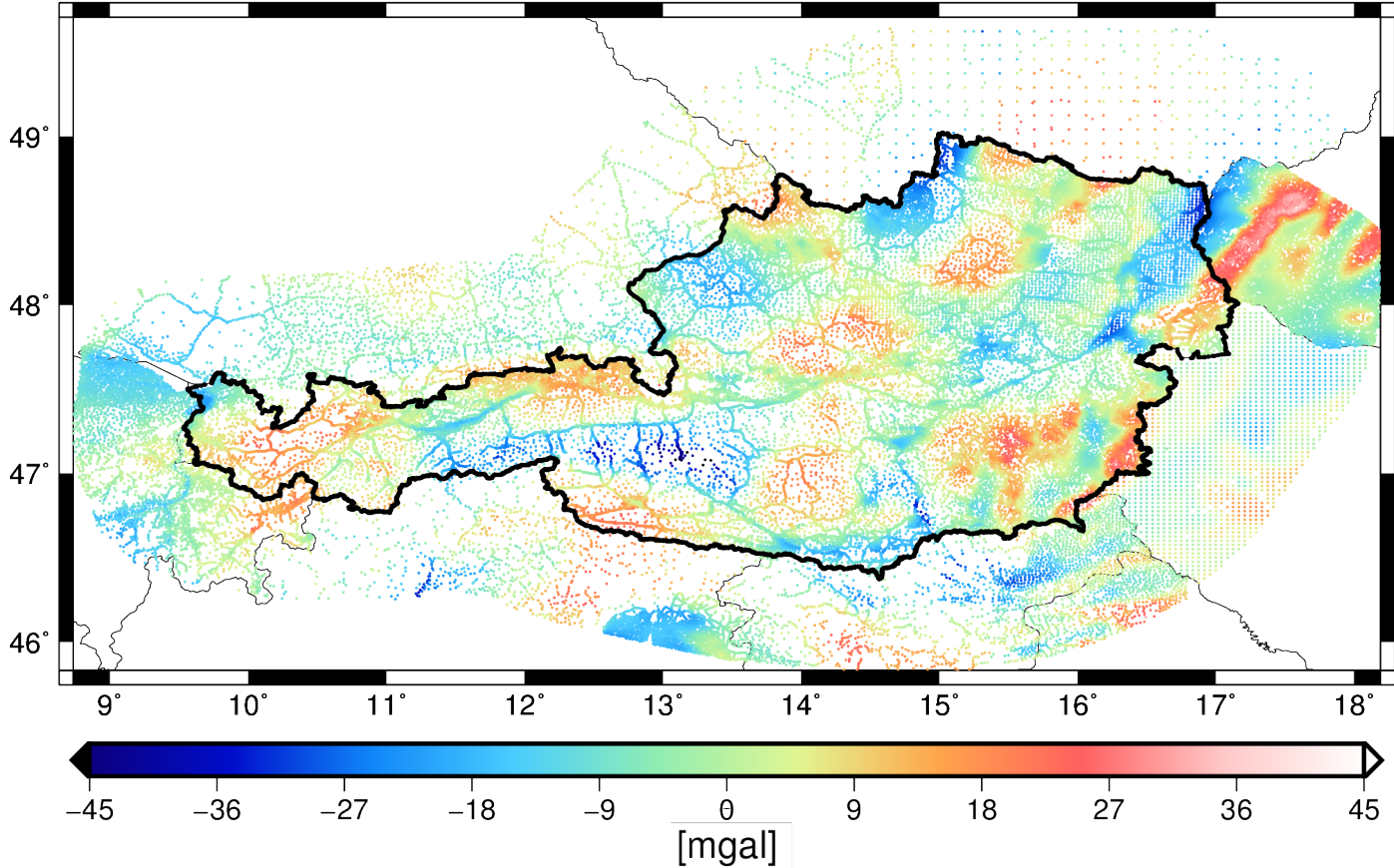
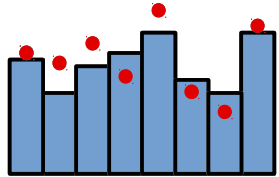
Computation Parameters

- **Remove-Compute-Restore** Technique
- Terrestrial input data
 - **71261** gravity measurements
 - **192** GPS/leveling observations (validation)
- Global gravity field model
 - - **GOCO03s** [Mayer-Gürr T., et al. (2012)]
- Topographic reduction: **Prism formula**
 - DTM 176x196m
 - Standard crustal density of 2.670 kg/m³
- Computation: **Least squares approach**
 - Radial Basis Function parametrization



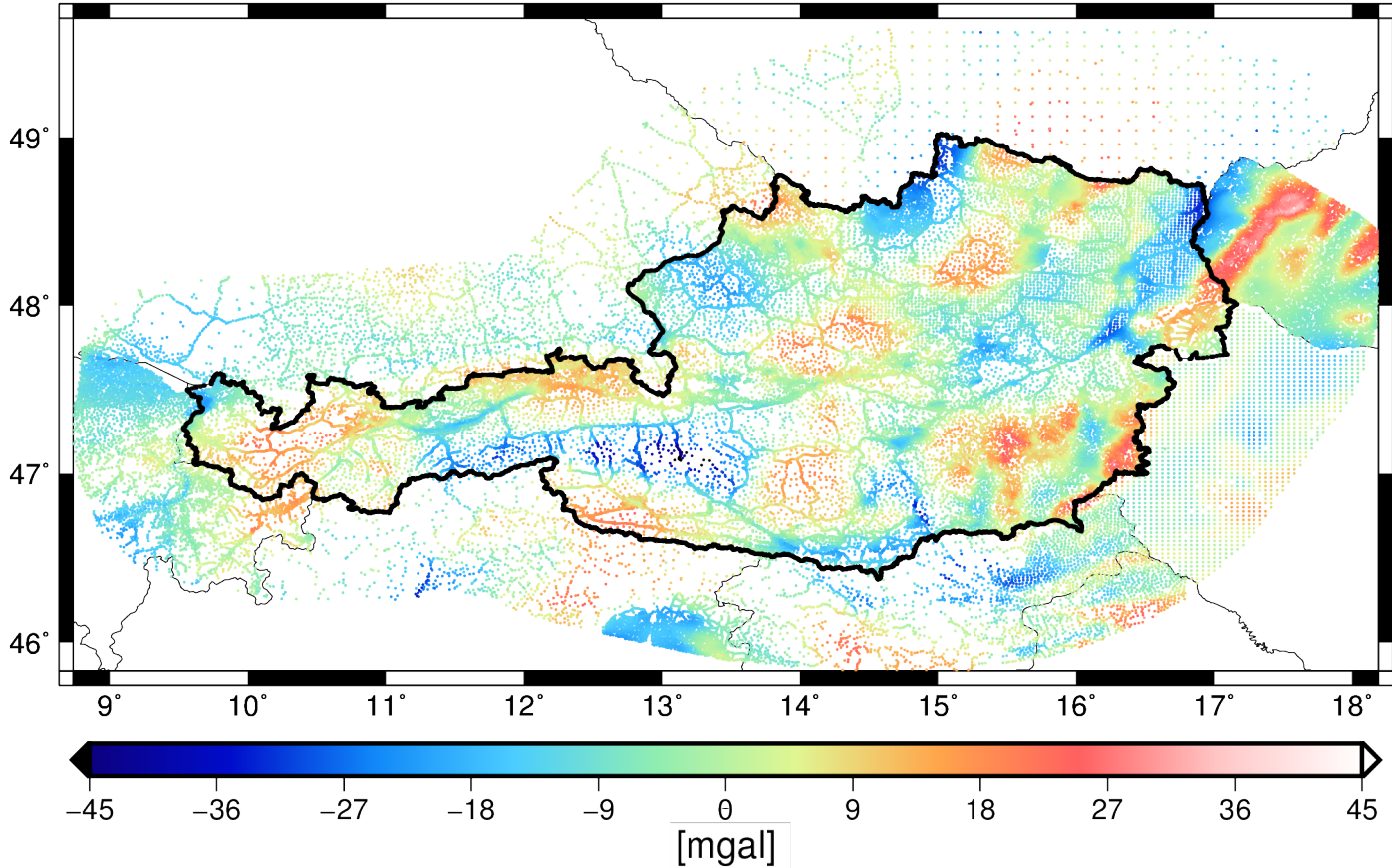
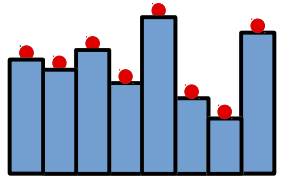
Remove – Let Heights Unchanged

| [mgal] | min | max | mean | rms |
|--------|--------|-------|-------|-------|
| | -46.64 | 39.98 | -1.28 | 11.64 |



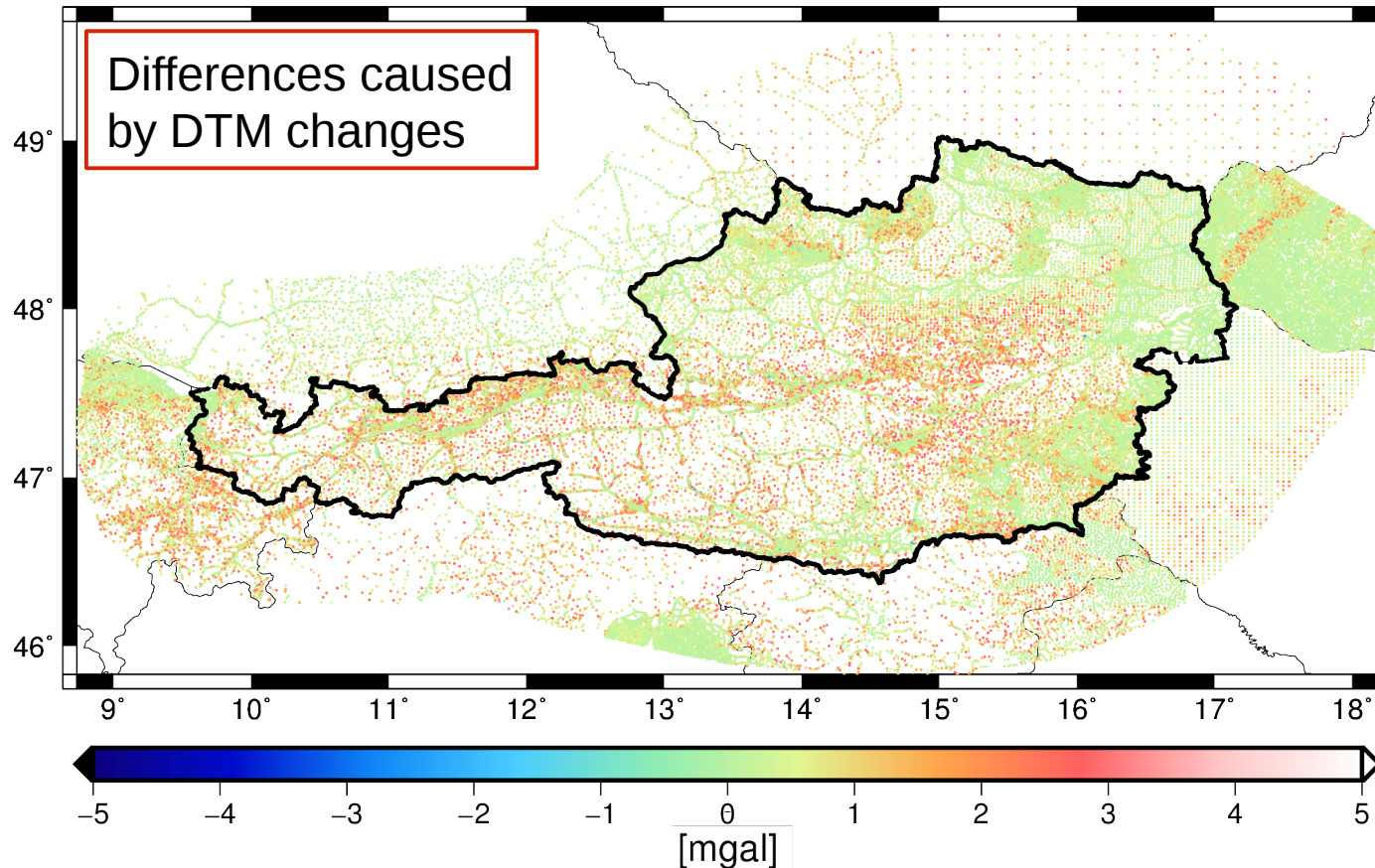
Remove – Fit DTM to Station Heights

| [mgal] | min | max | mean | rms |
|--------|--------|-------|-------|-------|
| | -47.17 | 38.85 | -1.88 | 11.65 |



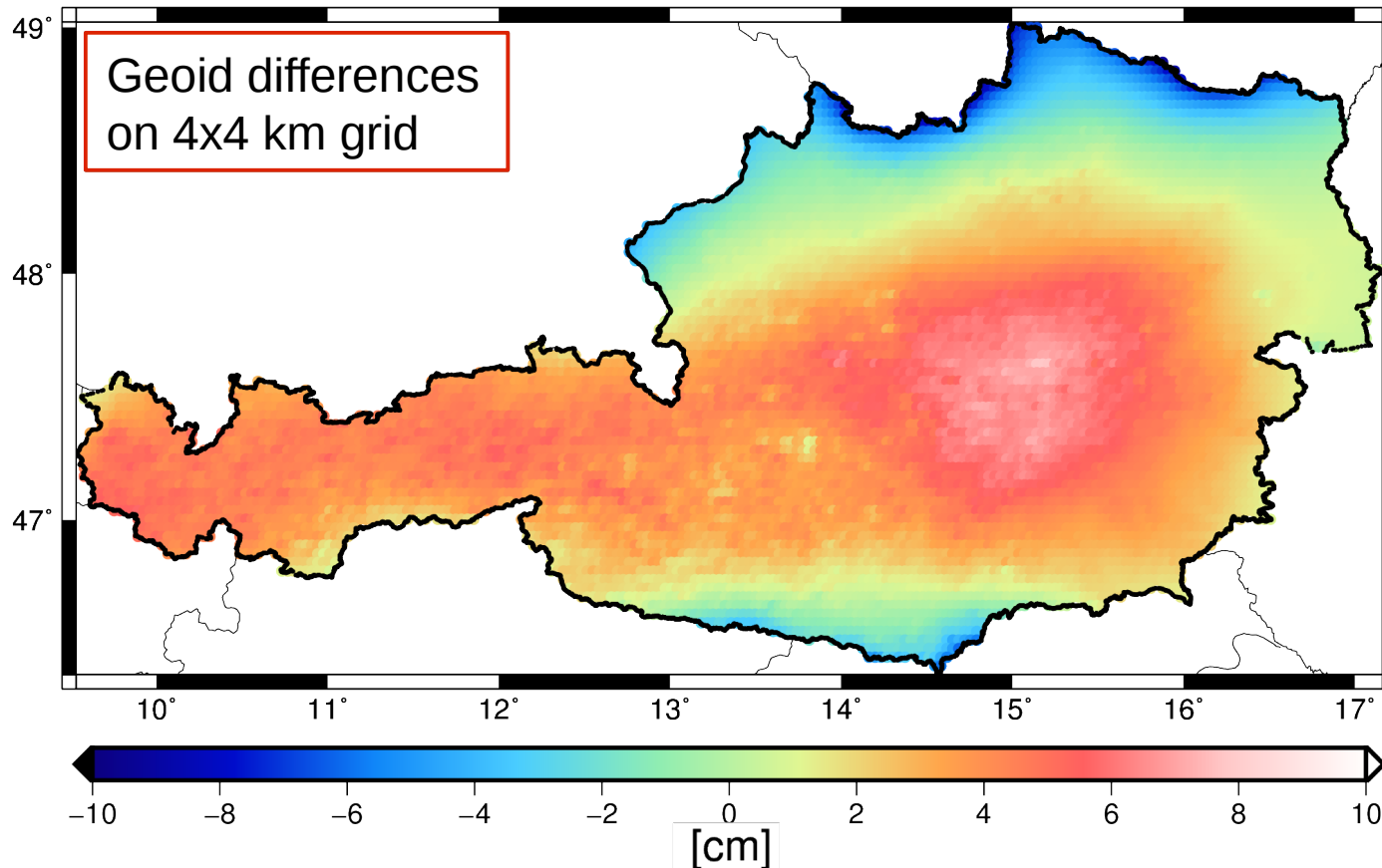
Remove – Changes in Reduction Step

| [mgal] | min | max | mean | rms |
|--------|-------|------|------|------|
| | -3.55 | 4.36 | 0.60 | 0.96 |



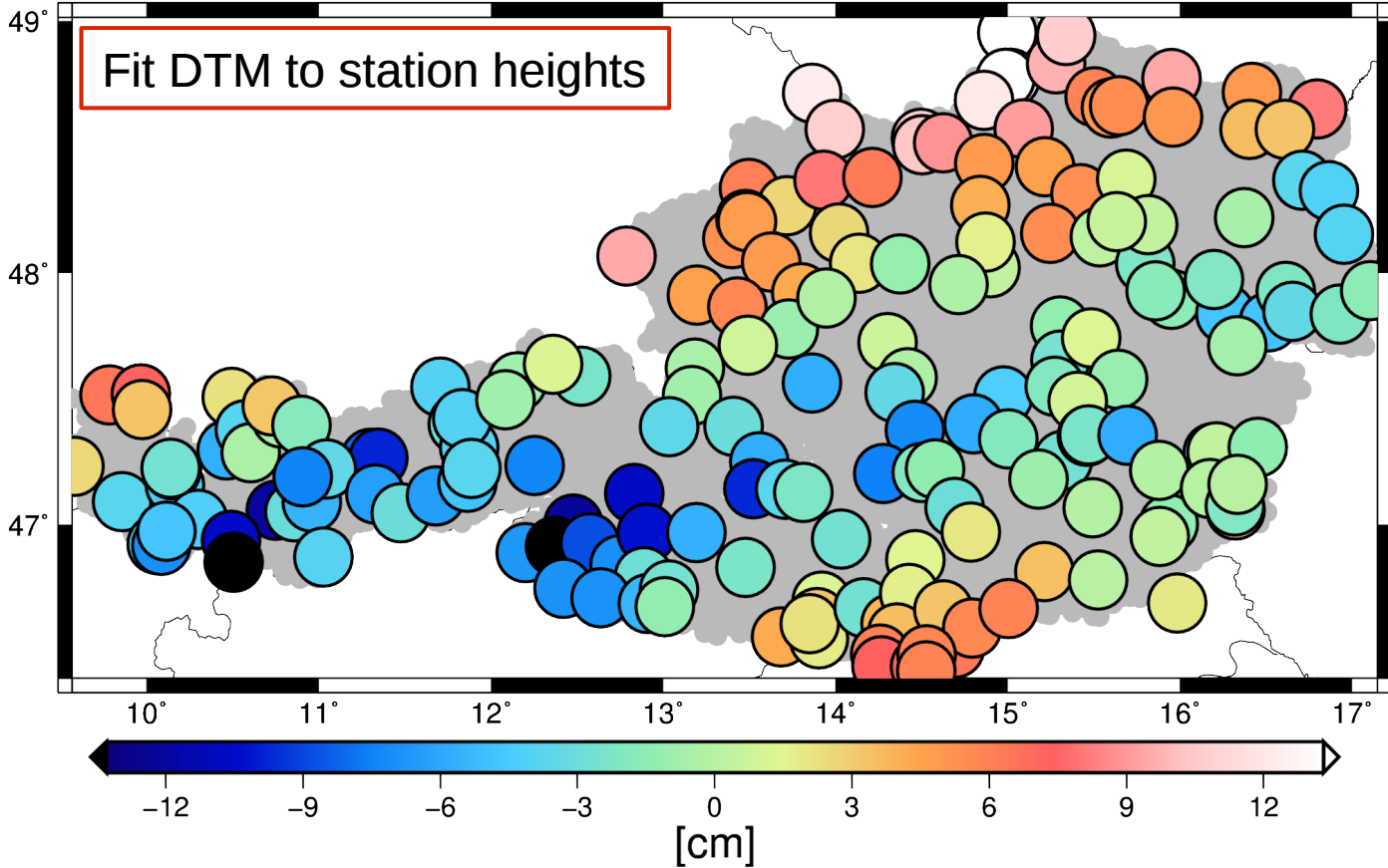
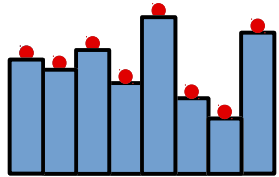
Restore – Relative Geoid Changes

| [cm] | min | max | mean | rms |
|------|-------|------|------|------|
| | -9.23 | 7.82 | 2.44 | 3.72 |



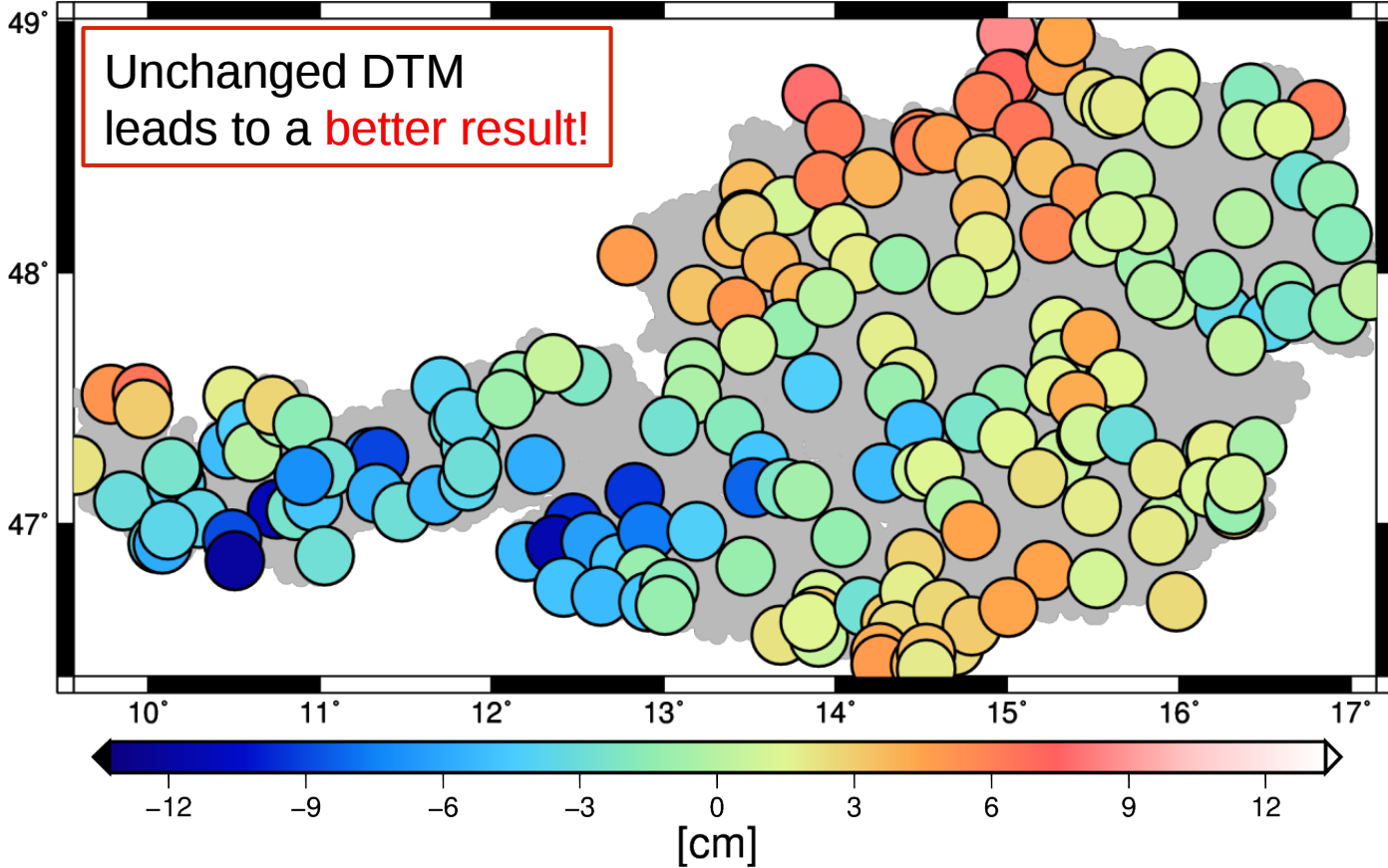
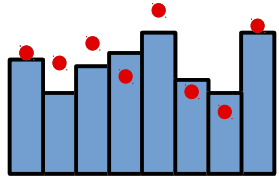
Restore – Absolute Validation (1)

| [cm] | min | max | rms |
|------|--------|-------|------|
| | -13.37 | 16.10 | 5.36 |



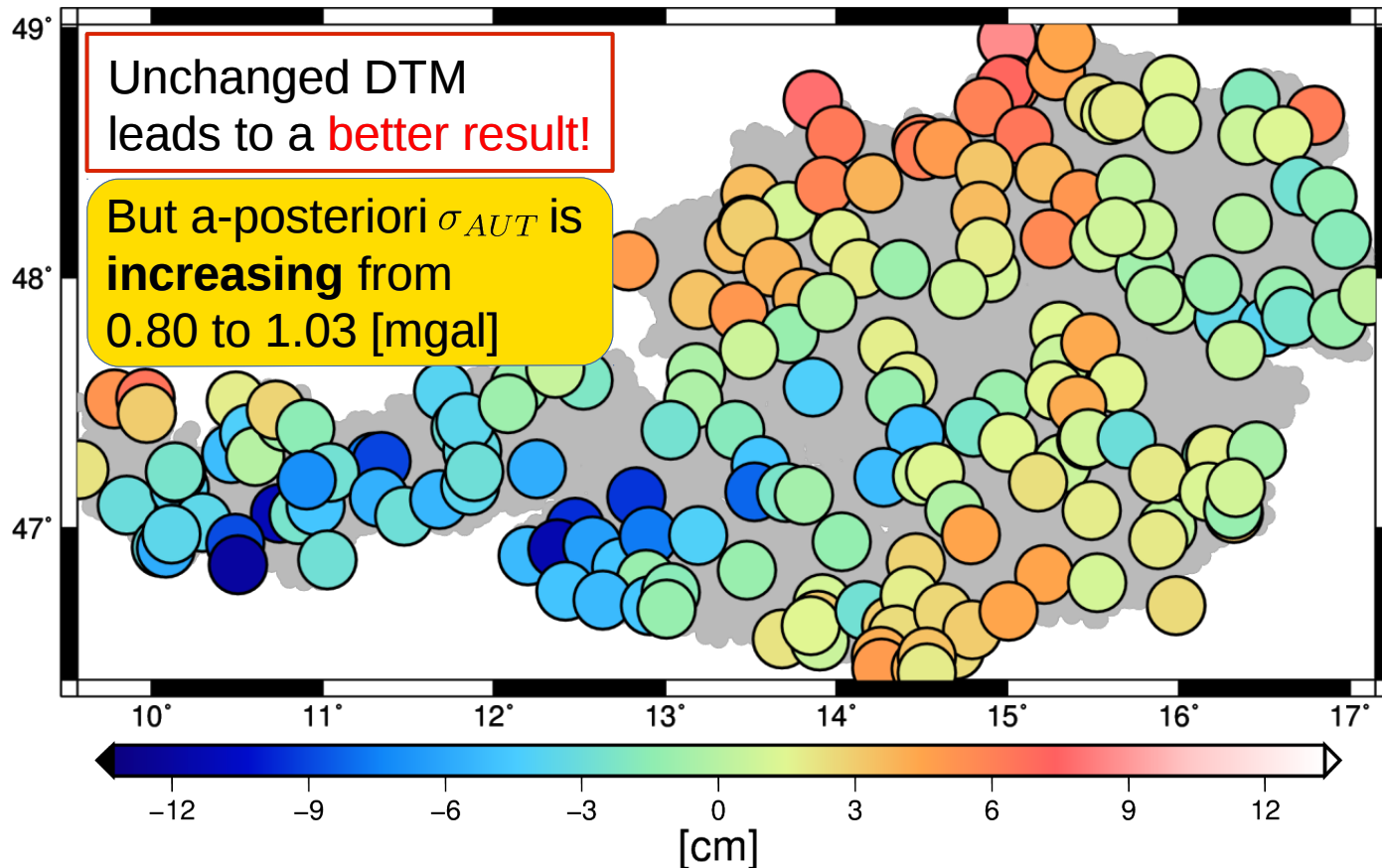
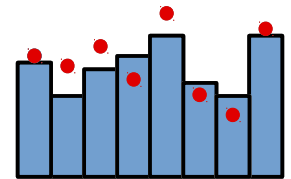
Restore – Absolute Validation (2)

| [cm] | min | max | rms |
|------|--------|------|------|
| | -12.01 | 8.80 | 3.90 |



Restore – Absolute Validation (2)

| [cm] | min | max | rms |
|------|--------|------|------|
| | -12.01 | 8.80 | 3.90 |



Building Observation Groups

• Situation

- Only few absolute measurements
- Huge amount of relative gravity
- Data quality from neighbouring countries?



FG-5



Scintrex



LaCoste & Romberg

| Measurement system & year | Austrian gravity quality [BEV] |
|---------------------------|--------------------------------|
| Absolute gravity | < 0.01 [mgal] |
| Relative gravity | |
| LCR-D | < 0.02 [mgal] |
| LCR-G | < 0.02 [mgal] |
| LCR | < 0.02 [mgal] |
| Scintrex CG3 | < 0.02 [mgal] |
| Worden 500 | < 0.10 [mgal] |
| Norgaard | < 0.30 [mgal] |
| ⋮ | ⋮ |
| ⋮ | ⋮ |

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| ⋮ | ⋮ |
| ⋮ | ⋮ |



FG-5



Scintrex



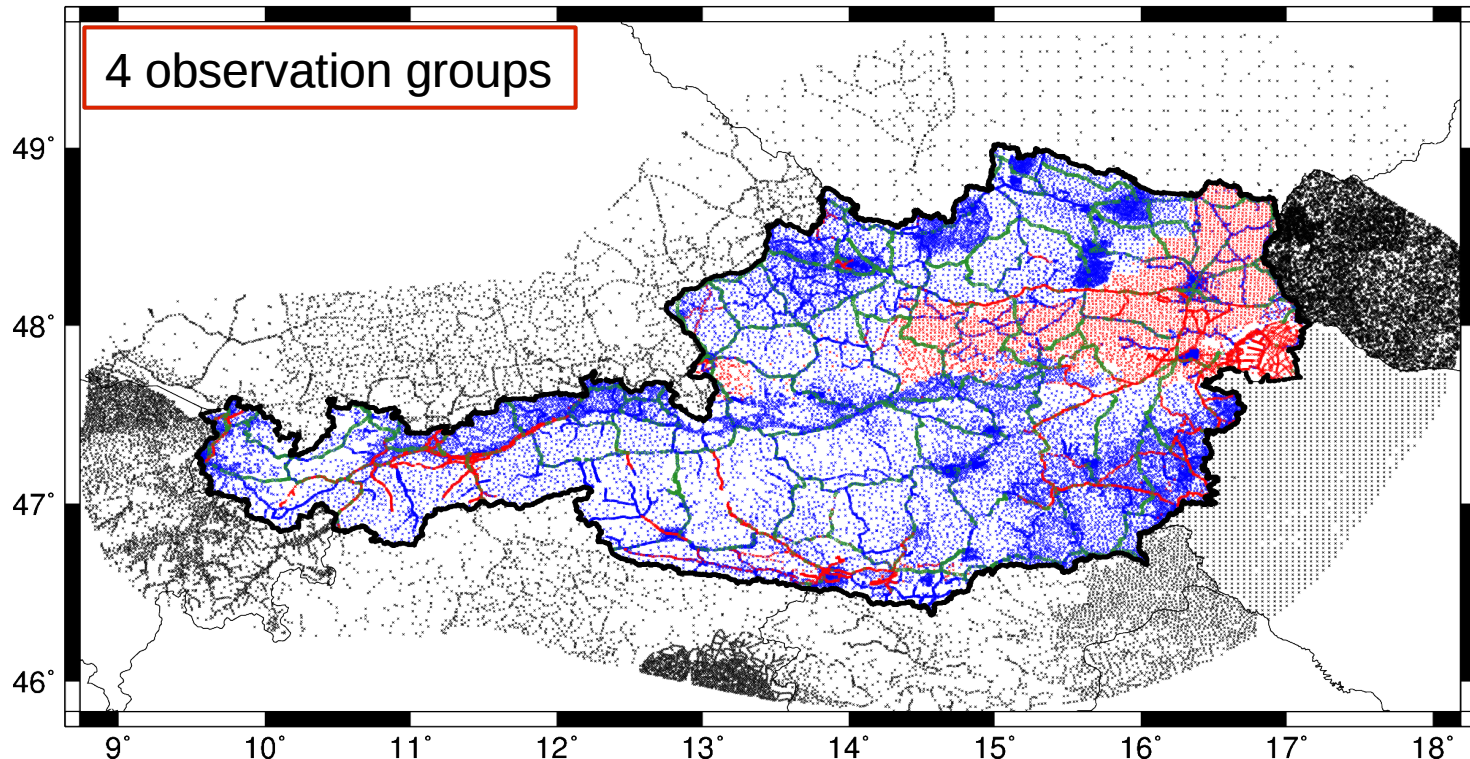
LaCoste & Romberg

Building Observation Groups (1)

- **Observation groups for Variance Component Estimation**

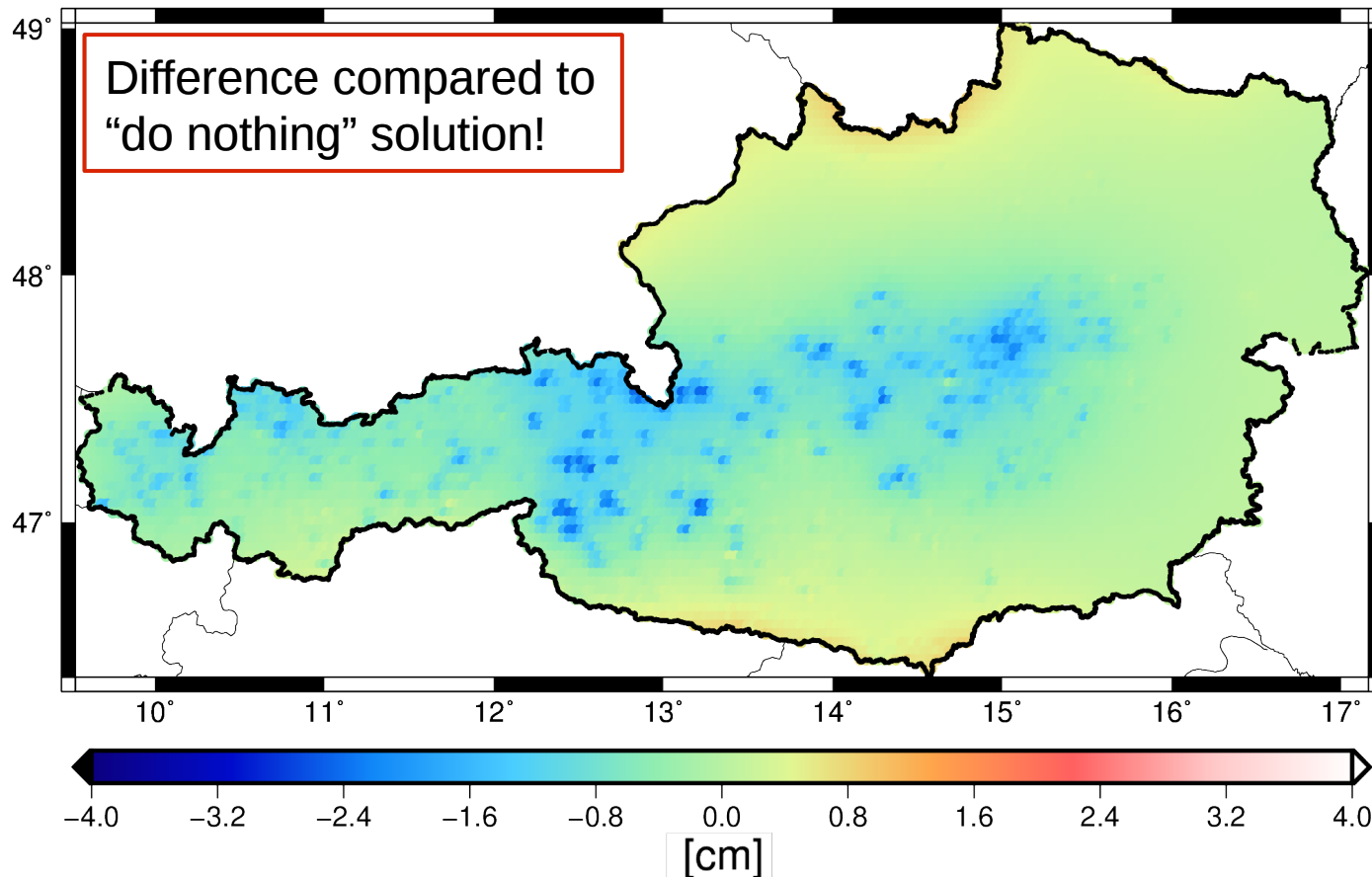
- 35595 LCR+Scintrex, 9339 Worden, 3816 Norgaard

- 22770 from neighbouring countries



Restore – Relative Geoid Changes

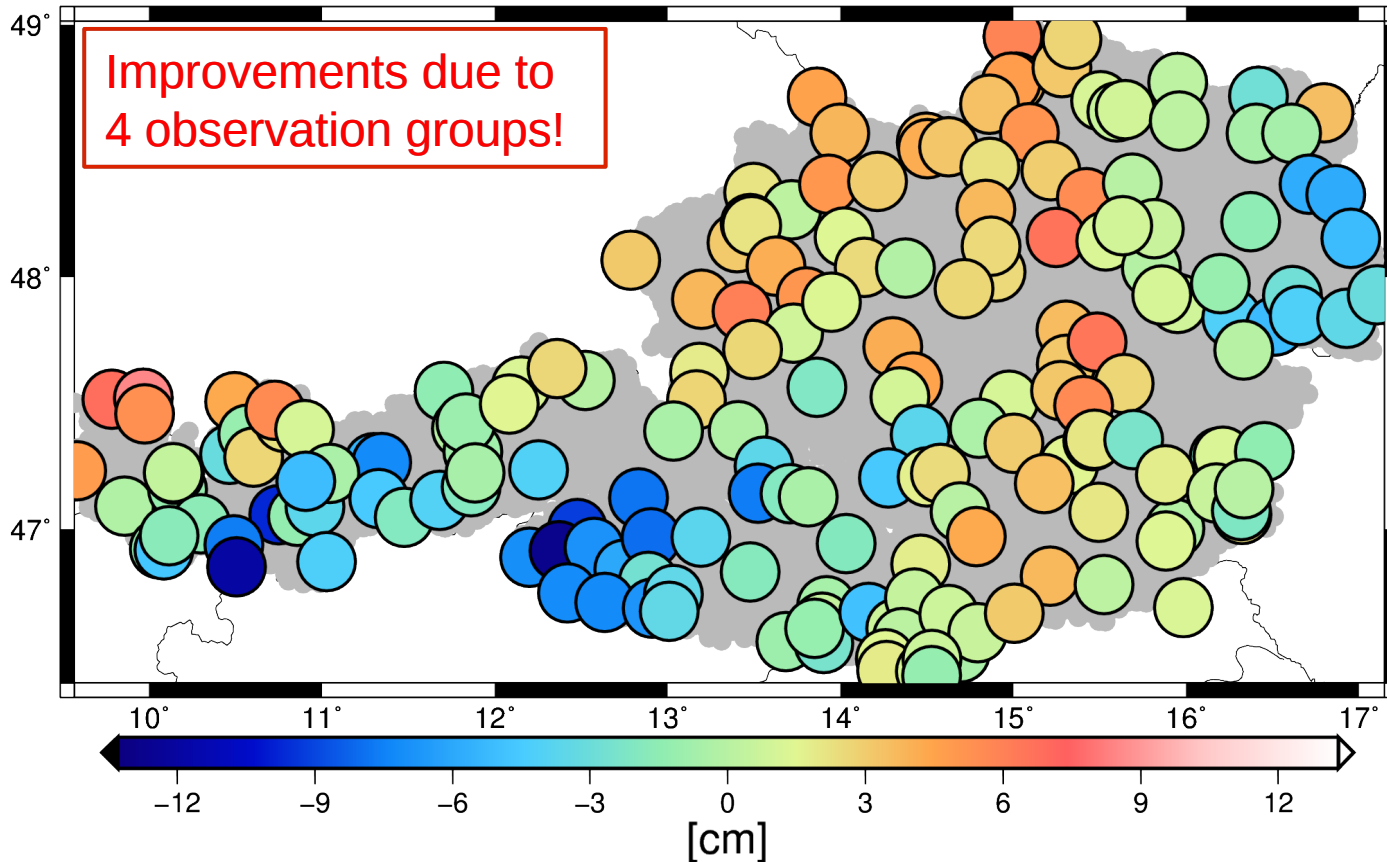
| [cm] | min | max | mean | rms |
|------|-------|------|-------|------|
| | -2.45 | 0.94 | -0.24 | 0.56 |



Restore – Absolute Validation (3)

$VCE [mgal]$
 $\sigma_{LCR} = 1.10$
 $\sigma_{Wor} = 0.81$
 $\sigma_{Nor} = 0.85$
 $\sigma_{Neigh} = 0.74$

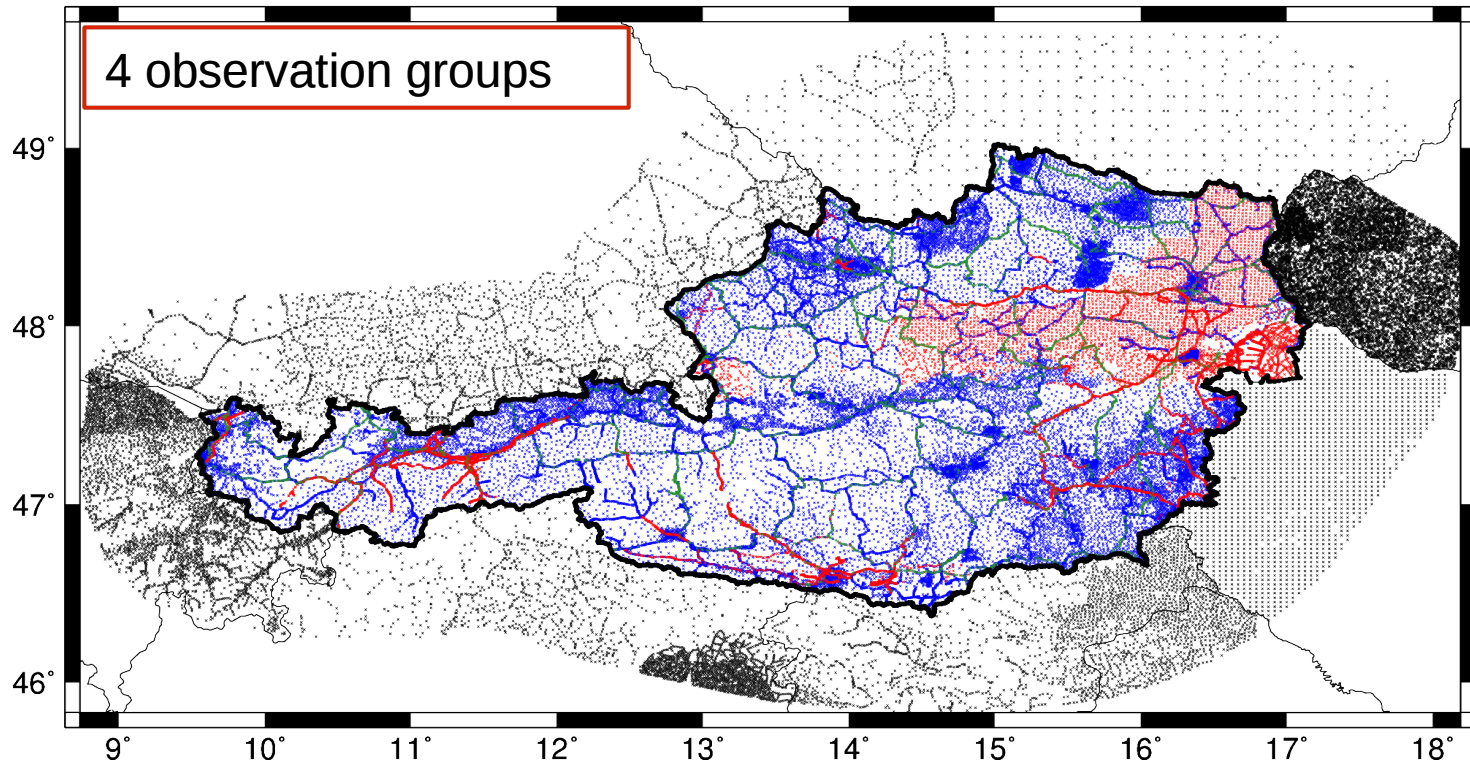
| [cm] | min | max | rms |
|------|--------|------|------|
| | -12.53 | 8.27 | 3.70 |



Building Observation Groups (2)

- **Observation groups for Variance Component Estimation**

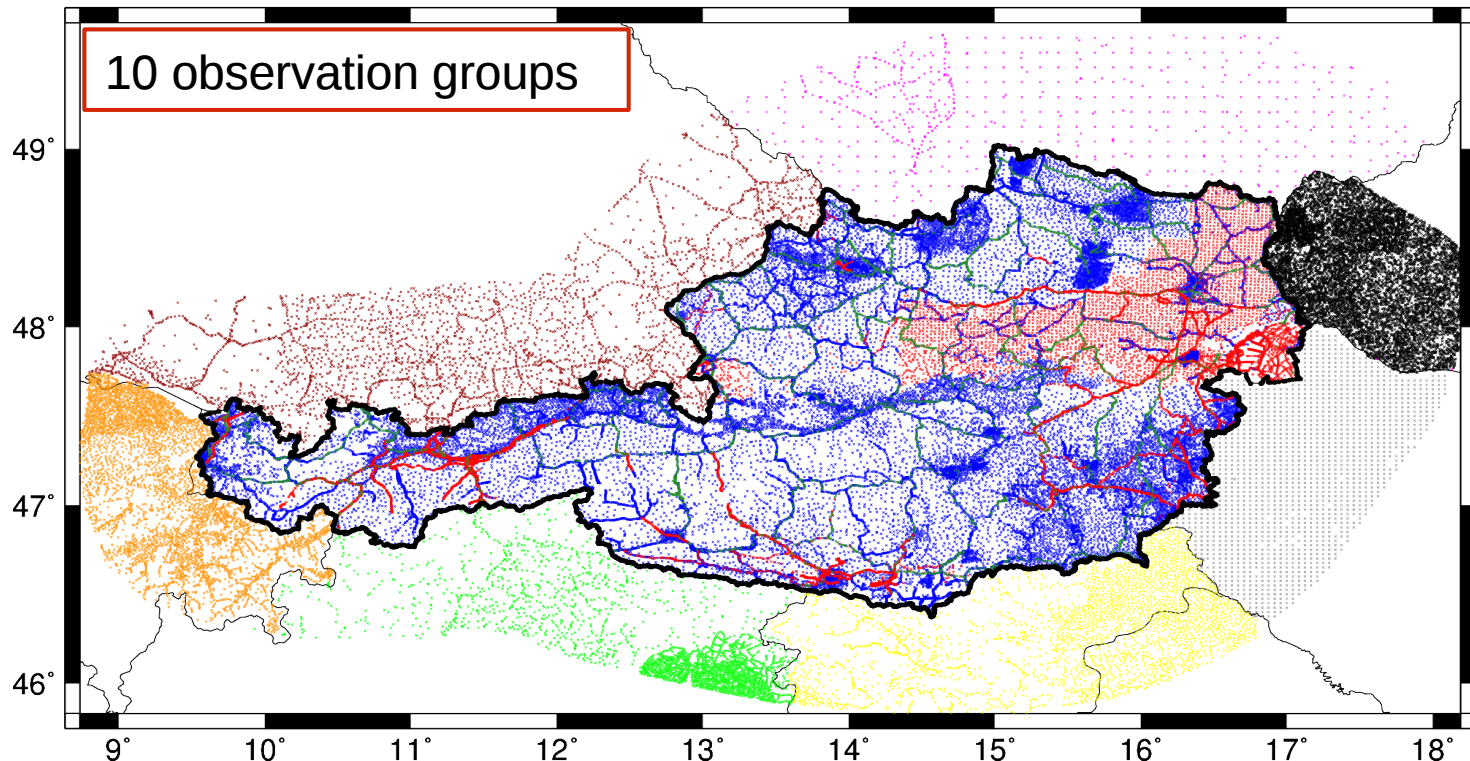
- 35595 LCR+Scintrex, 9339 Worden, 3816 Norgaard
- 22770 from neighbouring countries – *possible refinements?*



Building Observation Groups (3)

- **Observation groups for Variance Component Estimation**

- 35595 LCR+Scintrex, 9339 Worden, 3816 Norgaard
- 22770 allocated for each neighbouring country

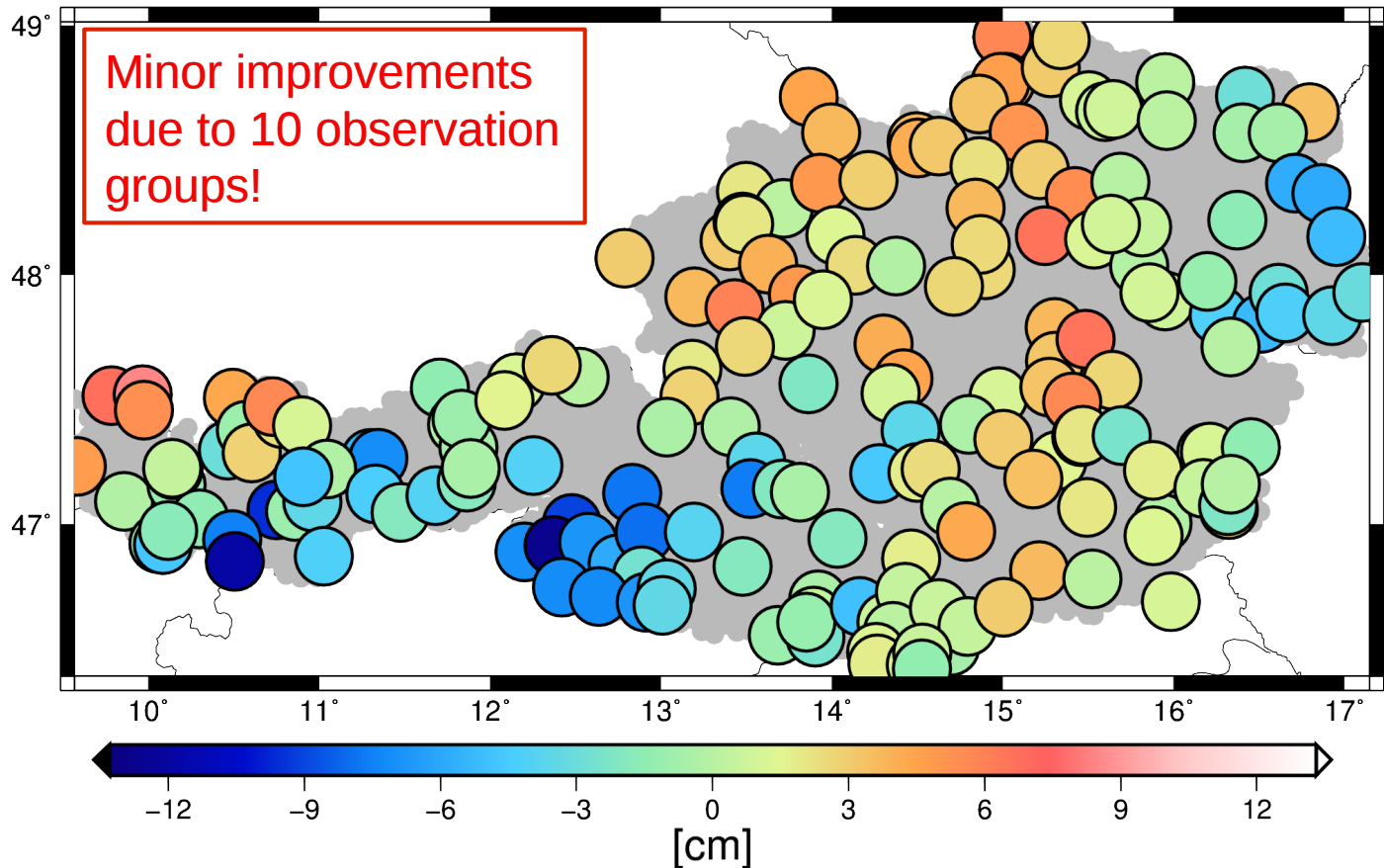


Restore – Absolute Validation (4)

$VCE [mgal]$
 $\sigma_{LCR} = 1.10$
 $\sigma_{Wor} = 0.81$
 $\sigma_{Nor} = 0.85$

 $\sigma_{GER} = 1.06$
 $\sigma_{SUI} = 1.12$
 $\sigma_{ITA} = 1.04$
 $\sigma_{SLO} = 0.98$
 $\sigma_{HUN} = 0.18$
 $\sigma_{SVK} = 0.55$
 $\sigma_{CZE} = 1.87$

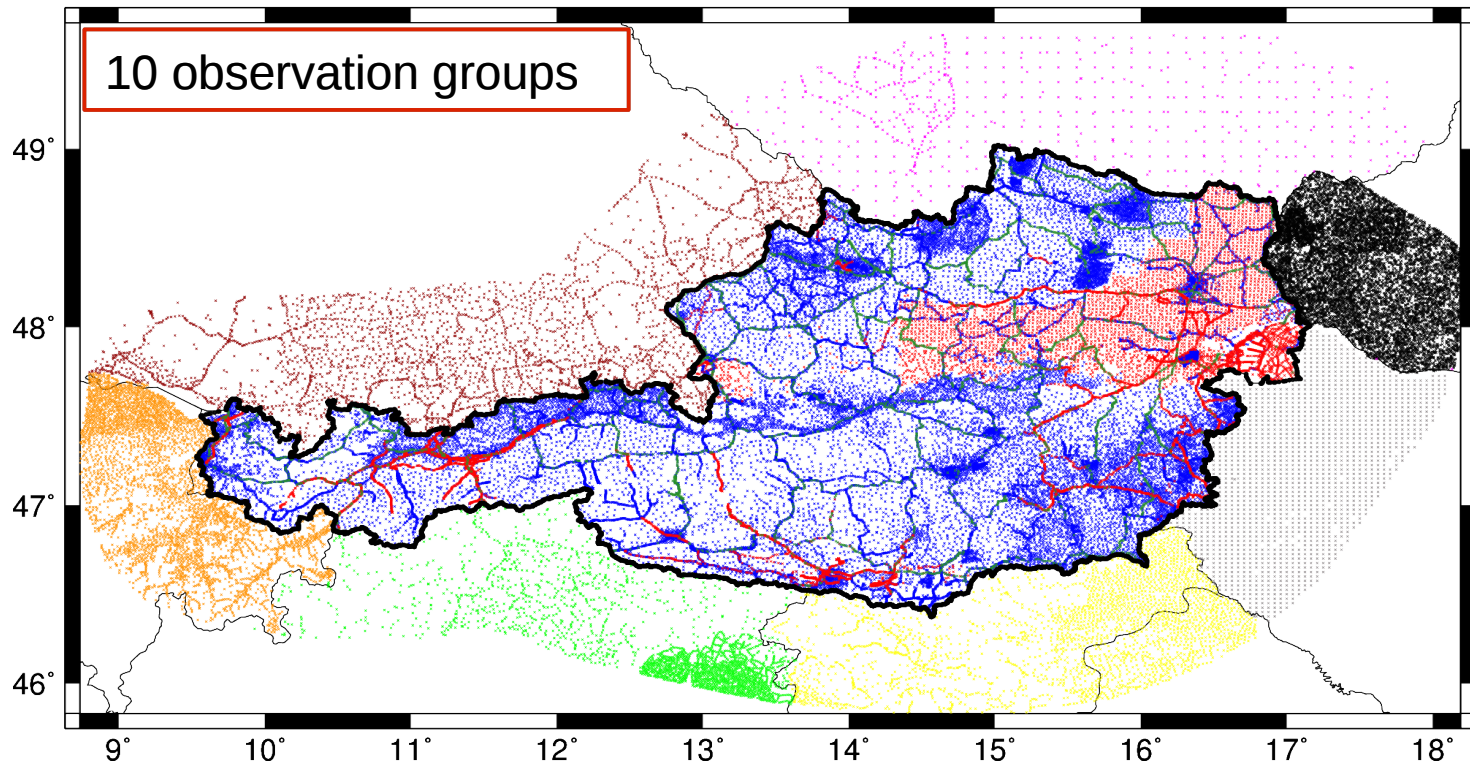
| [cm] | min | max | rms |
|------|--------|------|------|
| | -12.46 | 8.25 | 3.67 |



Building Observation Groups (4)

- **Observation groups for Variance Component Estimation**

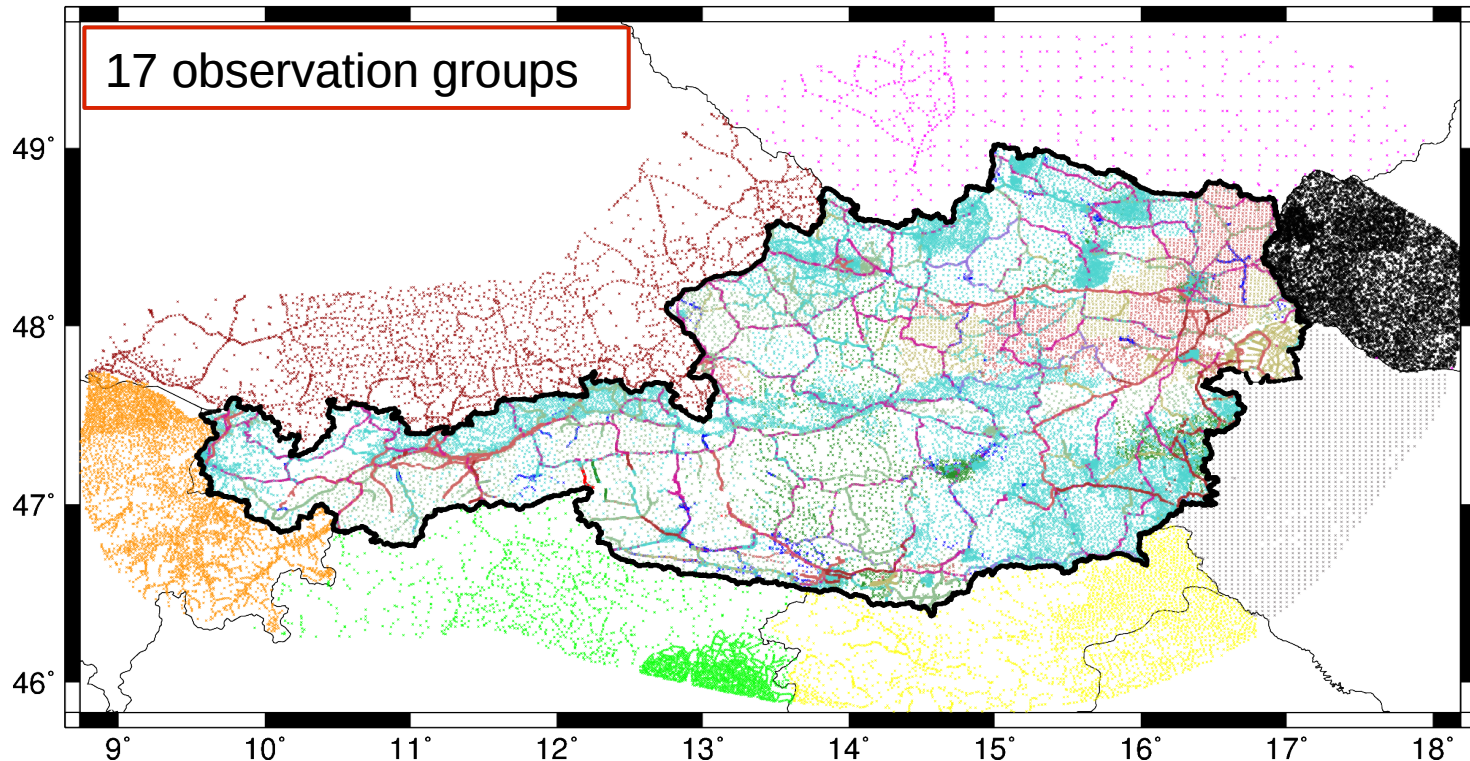
- 35595 LCR+Scintrex, 9339 Worden, 3816 Norgaard – *possible refinements?*
- 22770 allocated for each neighbouring country



Building Observation Groups (5)

- **Observation groups for Variance Component Estimation**

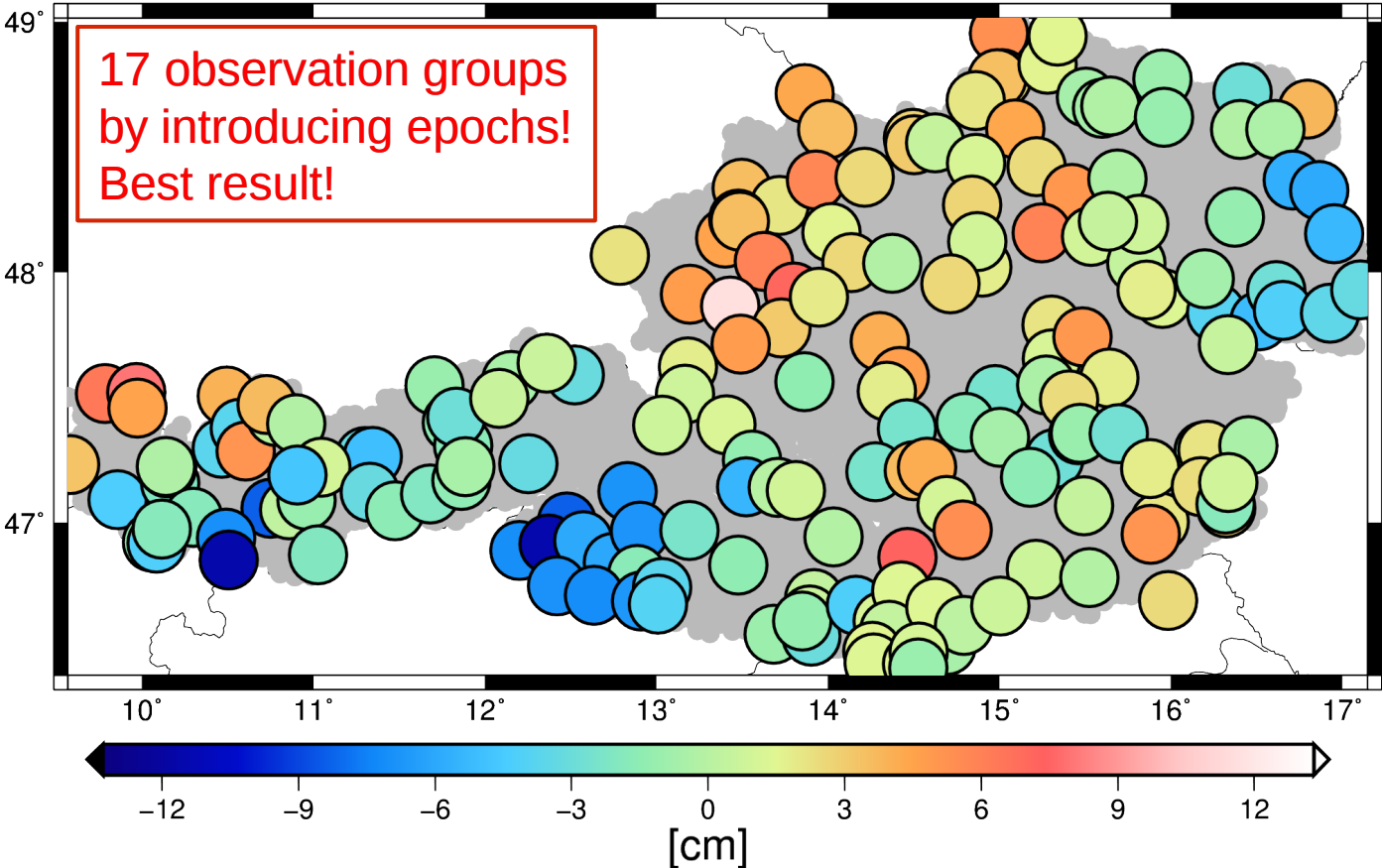
- LCR+Scintrex, Worden, Norgaard and corresponding measurement epochs
- 22770 allocated for each neighbouring country



Restore – Absolute Validation (5)

VCE [mgal]
 $\sigma_1 = 0.86$
 \vdots
 $\sigma_{17} = 1.87$

| [cm] | min | max | rms |
|------|--------|-------|------|
| | -11.35 | 11.38 | 3.53 |



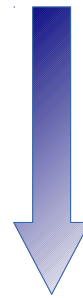
Summary

- **Fit Digital Terrain Model to station heights**

- Let heights to remain unchanged
- Fit of DTM to station heights is not advisable

- **Individual weighting for Variance Component Estimation**

- Solution is slightly improved due to different weighting schemes
- 1 group Austria / 1 Neighbouring
- 3 groups Austria / 1 Neighbouring
- 3 groups Austria / 7 Neighbouring
- 10 groups Austria / 7 Neighbouring



Rms
decreasing
of 4 mm!

- **Absolute geoid validation**

- Truth is not known - maybe still uncertainty in GPS/leveling observations?
- The achieved results are close to the absolute error budget of < 3 cm

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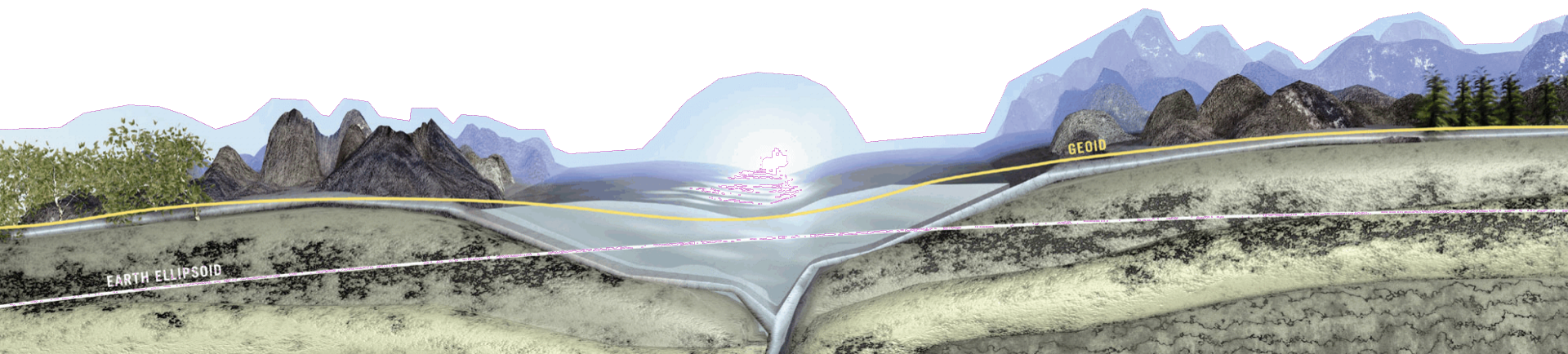
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Absolute Validation – Truth?

| [cm] | min | max | mean | rms |
|------|-------|------|------|------|
| | -7.70 | 6.60 | 0.32 | 1.52 |

