



International
Association of
Geodesy

Gravity and Geoid in Africa
African Geoid Project



Effect of Land Depressions in Africa on Gravity and Geoid

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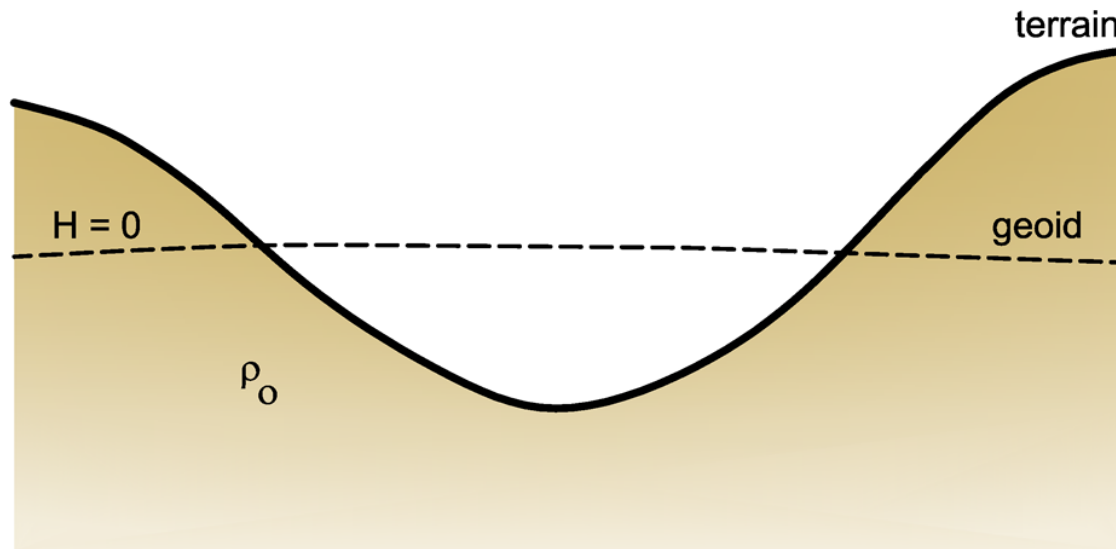


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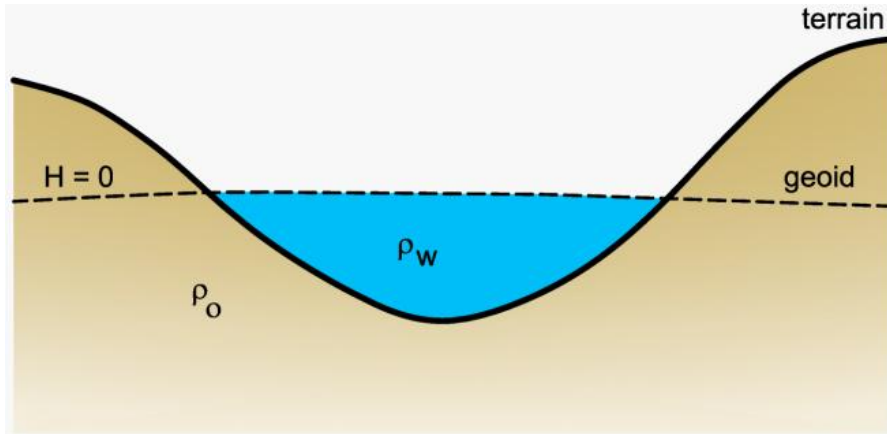
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The Problem

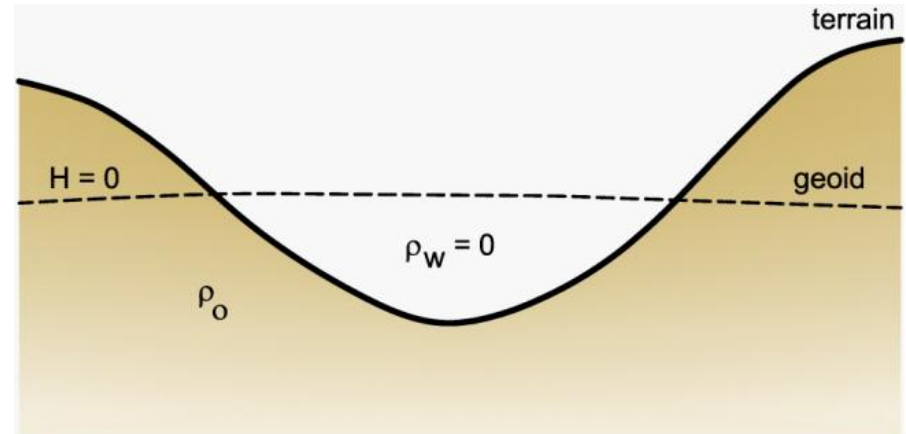


If the terrain correction software uses unclassified Digital Terrain Models (DTMs), such as TC-program, it pre-assumes that negative heights are filled with water, however, it is filled with air.

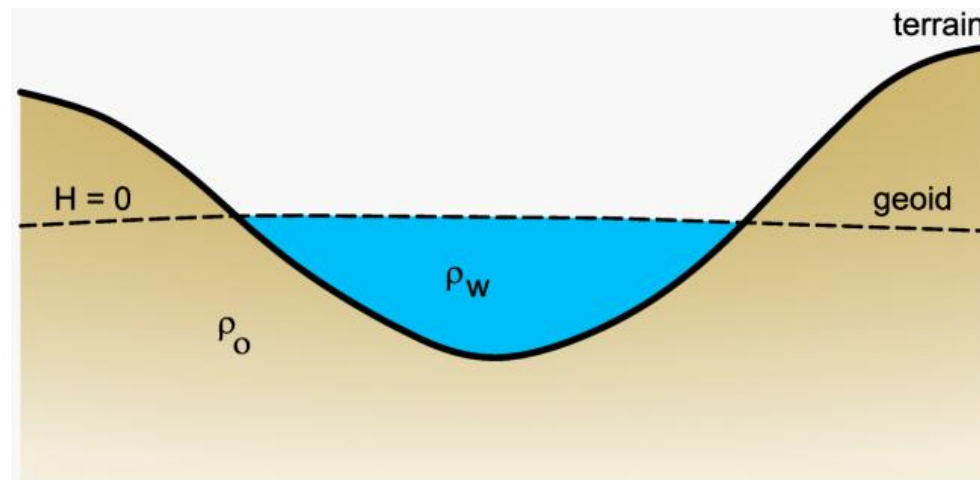
The Solution



TC-Case 1

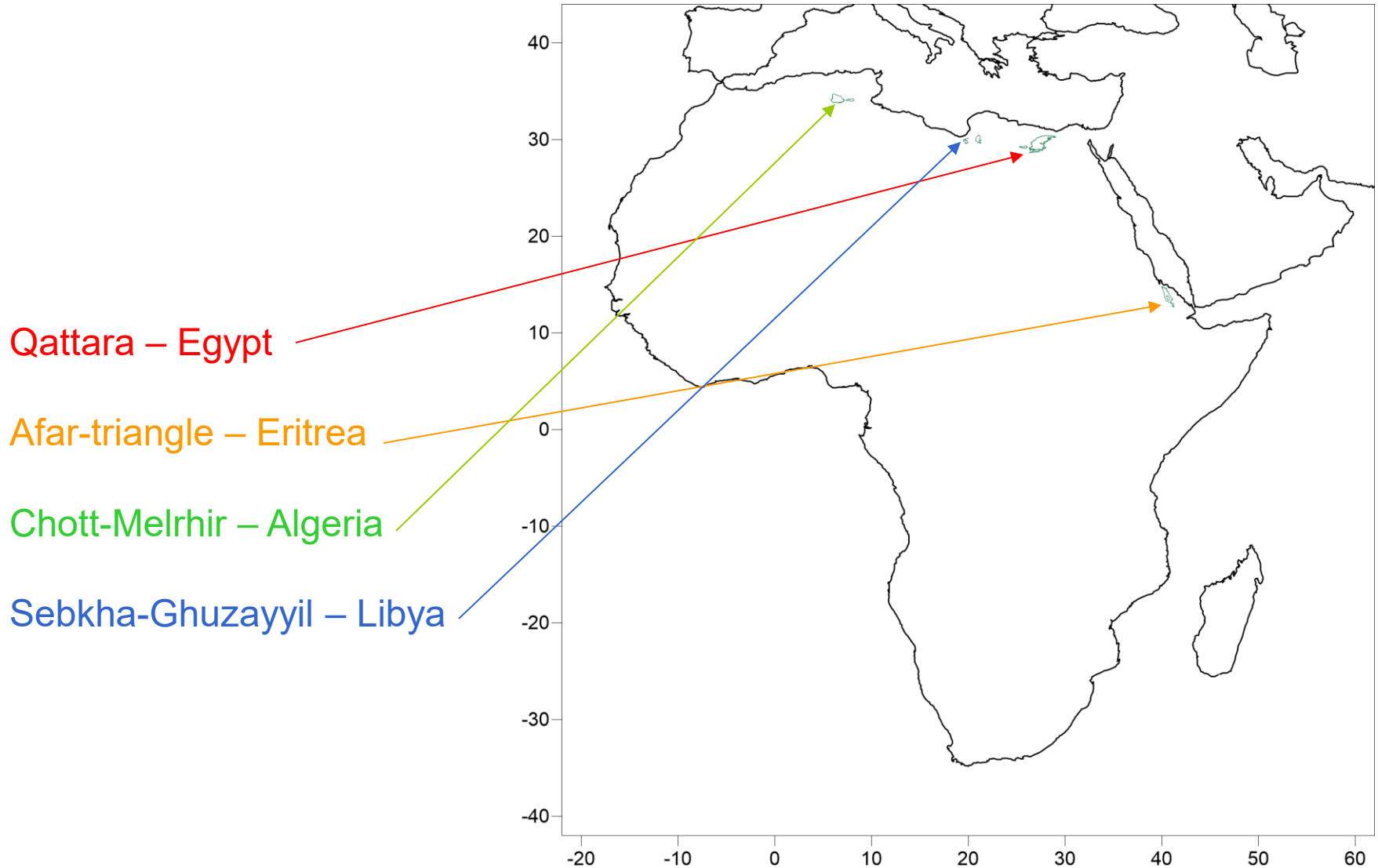


TC-Case 2



TC-Case 1 – TC-Case 2

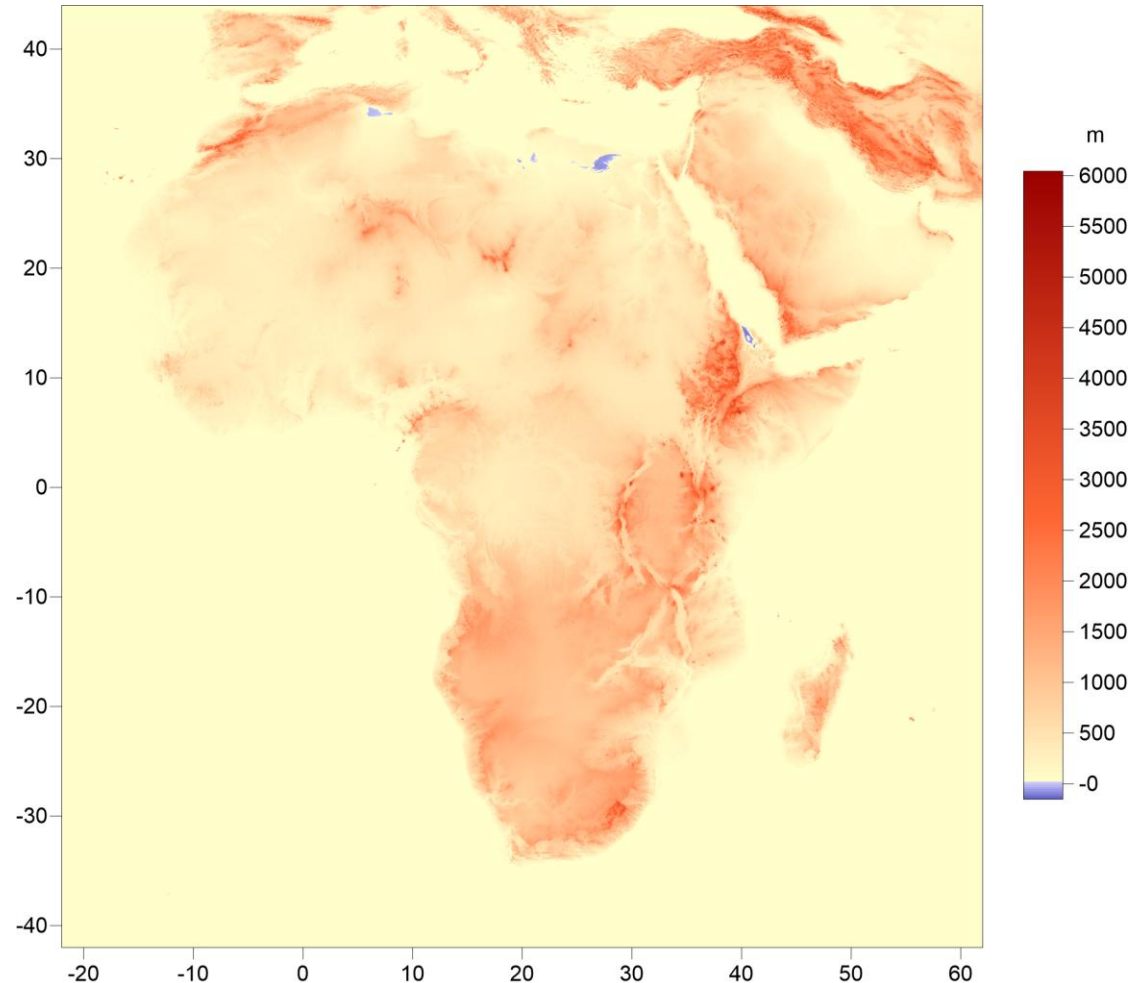
Great Depressions in Africa



The No-Sea Digital Terrain Models

Resolution	15"x15"
Maximum	6044 m
Minimum	-153 m

Used for both TC-Case 1
and TC-Case 2



AFH16S15 DTM

(Abd-Elmotaal, H., Makhloof, A., Abd-Elbaky, M. and Ashry, M. (2017) The African 3" × 3" DTM and its Validation. International Association of Geodesy Symposia Journal, Vol. 148, 79–85, https://doi.org/10.1007/1345_2017_19)c

Methodology – Window Technique

Remove Step

TC-Case 1

$$\Delta g_{win-red} = \Delta g_F - \Delta g_{GM} - \Delta g_{TI\ win} + \Delta g_{wincof}$$

TC-Case 2

$$\Delta g_{win-reddep} = \Delta g_F - \Delta g_{GM} - \Delta g_{TI\ win\ dep} + \Delta g_{wincofdep}$$

TC-Case 1 – TC-Case 2

$$\begin{aligned}\Delta g_{windep-eff} &= \Delta g_{win-red} - \Delta g_{win-reddep} \\ &= \left(\Delta g_{TI\ win\ dep} - \Delta g_{TI\ win} \right) - \left(\Delta g_{wincofdep} - \Delta g_{wincof} \right)\end{aligned}$$

Window Remove-Restore approach according to Abd-Elmotaal, H. and Kühtreiber, N. (2003)
Harmonic analysis for the TI masses for the data window according to Abd-Elmotaal, H. and Kühtreiber, N. (2021)
Method for geoid determination as described in Abd-Elmotaal et al. (2026): AFRgeo2025.

Methodology – Window Technique

Compute Step

TC-Case 1

$$N_{\Delta g_{win}} = \frac{R}{4\pi\gamma} \iint_{\sigma} \Delta g_{win-red} S(\psi) d\sigma$$

TC-Case 2

$$N_{\Delta g_{win dep}} = \frac{R}{4\pi\gamma} \iint_{\sigma} \Delta g_{win-red dep} S(\psi) d\sigma$$

TC-Case 1 – TC-Case 2

$$\begin{aligned} N_{\Delta g_{win}} - N_{\Delta g_{win dep}} &= \frac{R}{4\pi\gamma} \iint_{\sigma} (\Delta g_{TI win dep} - \Delta g_{TI win}) S(\psi) d\sigma \\ &\quad - \frac{R}{4\pi\gamma} \iint_{\sigma} (\Delta g_{wincof dep} - \Delta g_{wincof}) S(\psi) d\sigma \end{aligned}$$

Methodology – Window Technique

Restore Step

TC-Case 1

$$N_{win} = N_{\Delta g_{win}} + \zeta_{GM} + N_{TI\ win} - \zeta_{wincof} + (N - \zeta)_{win}$$

TC-Case 2

$$N_{win\ dep} = N_{\Delta g_{win\ dep}} + \zeta_{GM} + N_{TI\ win\ dep} - \zeta_{wincof\ dep} + (N - \zeta)_{win\ dep}$$

TC-Case 1 – TC-Case 2

$$N_{win\ dep-eff} = (N_{\Delta g_{win}} - N_{\Delta g_{win\ dep}}) + (N_{TI\ win} - N_{TI\ win\ dep}) \\ - (\zeta_{wincof} - \zeta_{wincof\ dep}) + [(N - \zeta)_{win} - (N - \zeta)_{win\ dep}]$$

Methodology – Window Technique

Restore Step (continued)

TC-Case 1 – TC-Case 2

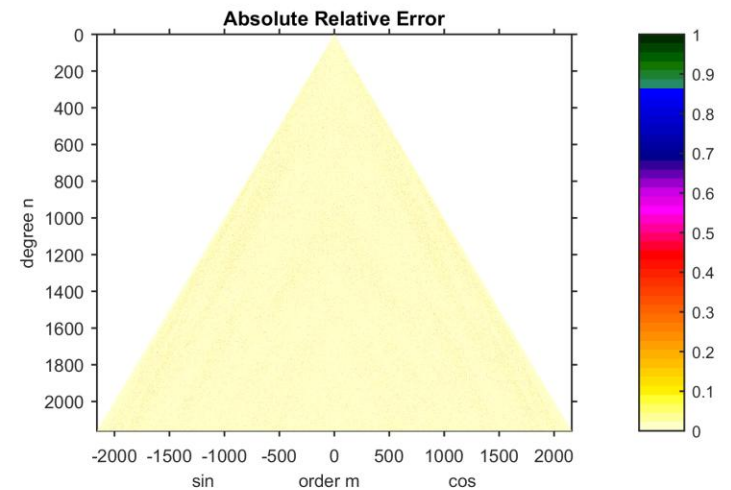
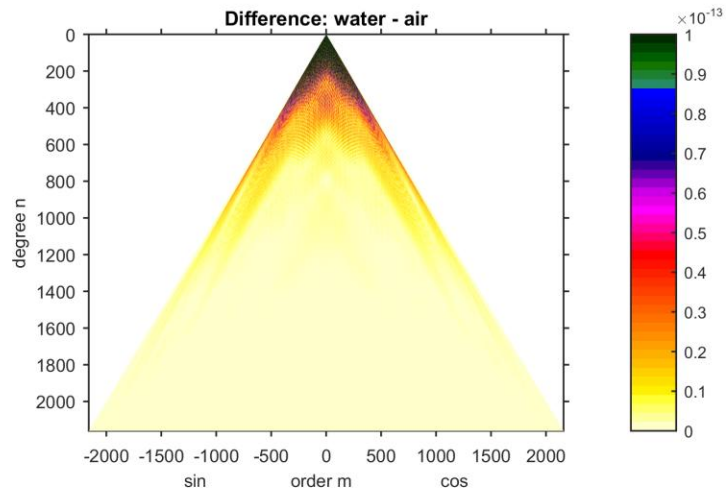
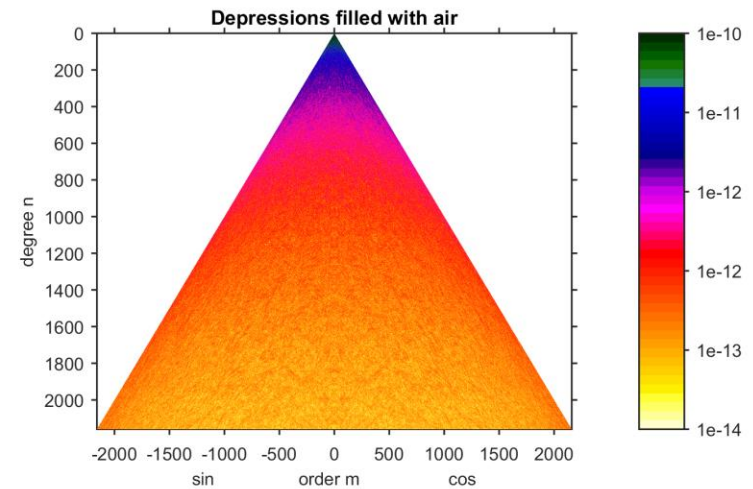
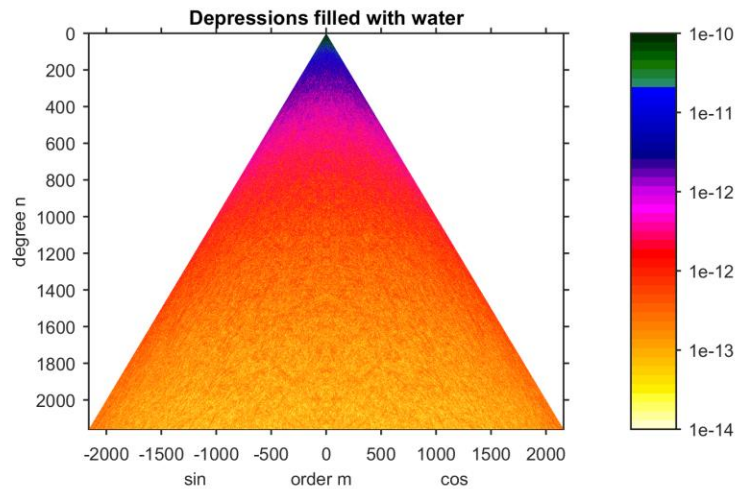
$$(N - \zeta)_{win} = \frac{H}{\gamma} (\Delta g_{GM} - \Delta g_{wincof})$$

$$(N - \zeta)_{windep} = \frac{H}{\gamma} (\Delta g_{GM} - \Delta g_{wincofdep})$$

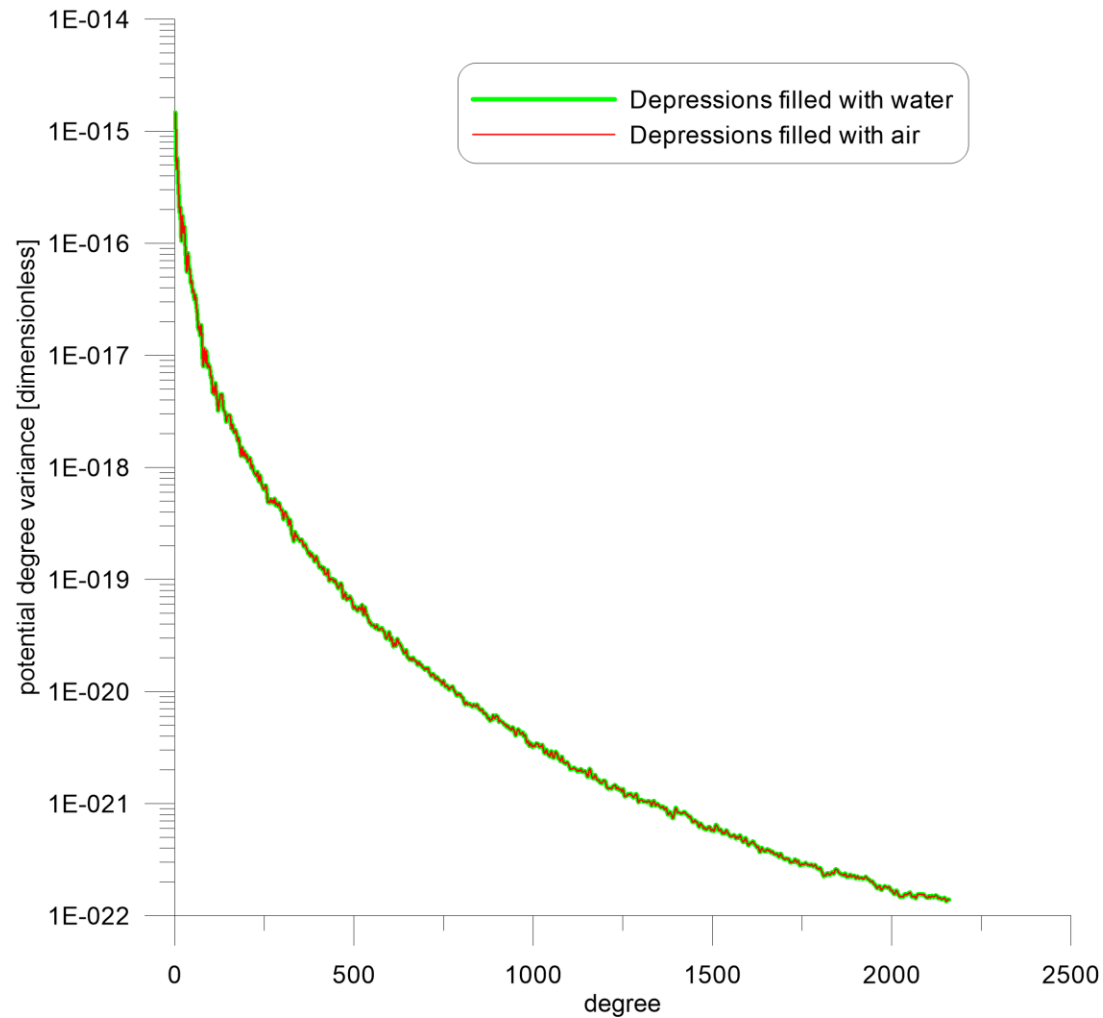
$$(N - \zeta)_{win} - (N - \zeta)_{windep} = \frac{H}{\gamma} (\Delta g_{wincof} - \Delta g_{wincofdep})$$

$$\begin{aligned} N_{windep-eff} = & \left(N_{\Delta g_{win}} - N_{\Delta g_{windep}} \right) + \left(N_{TIwin} - N_{TIwindep} \right) \\ & - \left(\zeta_{wincof} - \zeta_{wincofdep} \right) + \frac{H}{\gamma} (\Delta g_{wincof} - \Delta g_{wincofdep}) \end{aligned}$$

Harmonic Analysis for the Depressions



Potential Degree Variance for the Depressions

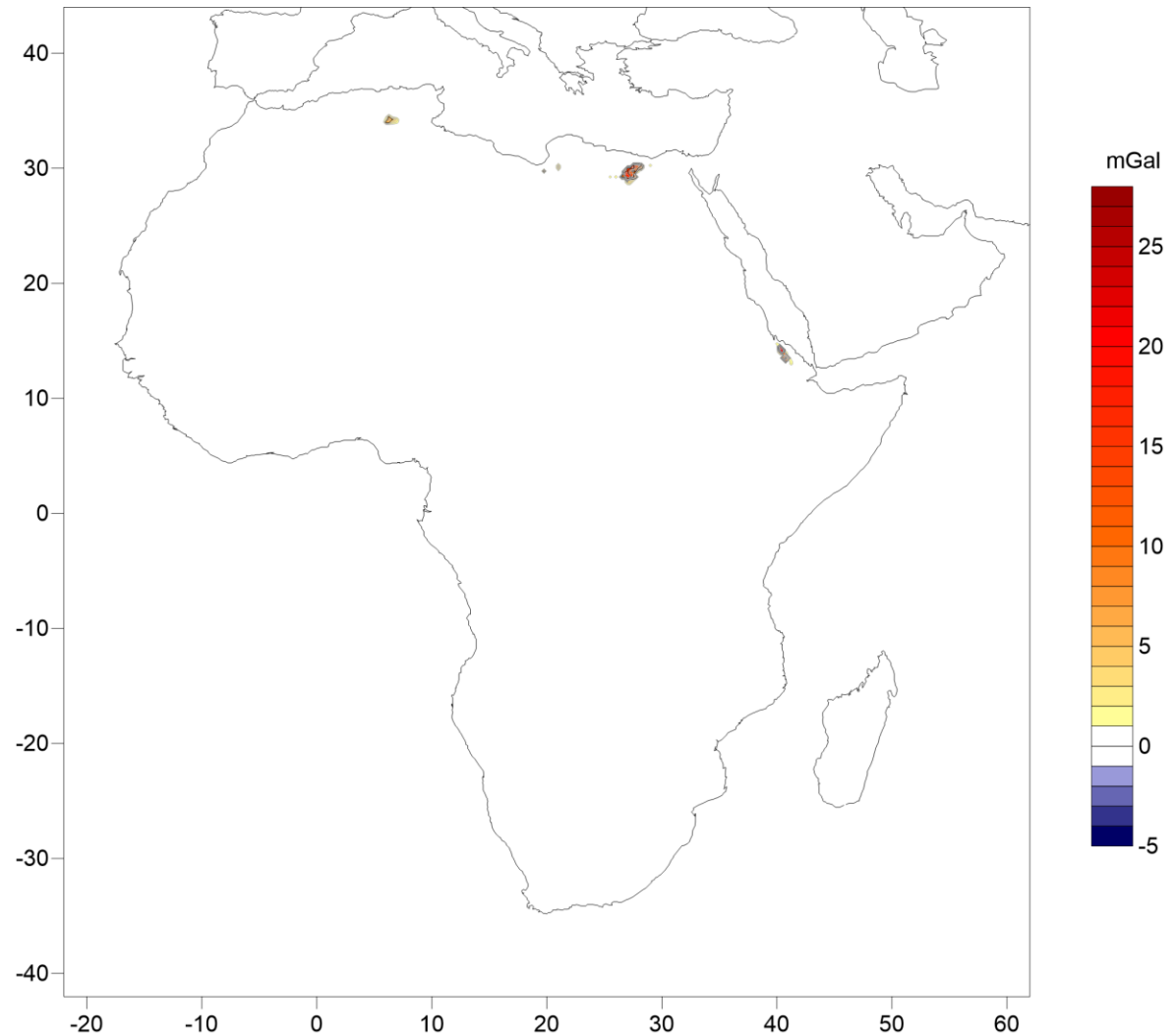


The power is preserved, i.e., small effects, on both gravity and geoid, are expected

Effect on Gravity – 1st component

$$\Delta g_{TI\ win\ dep} - \Delta g_{TI\ win}$$

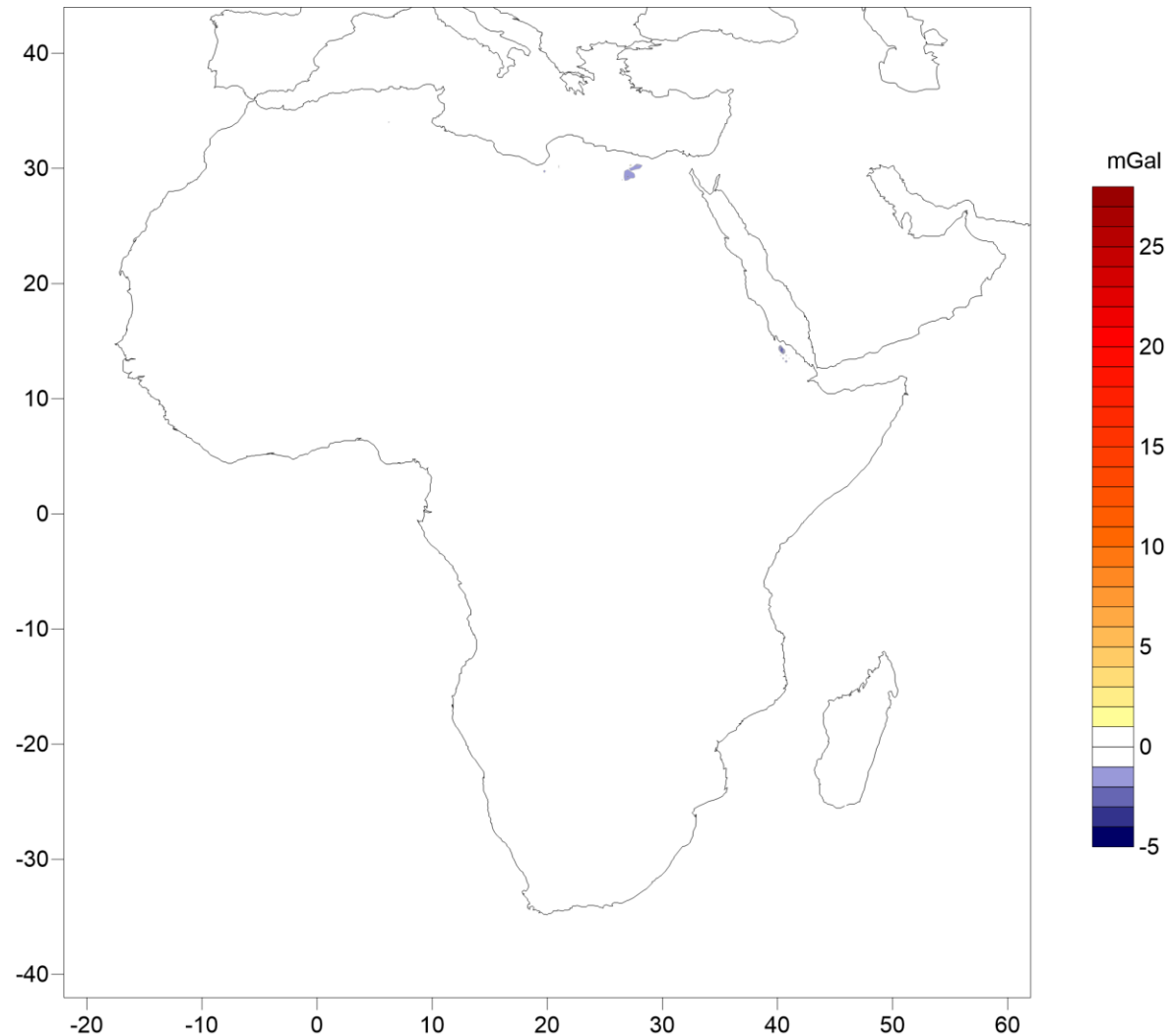
Minimum	0.00 mGal
Maximum	23.71 mGal
Mean	0.01 mGal
STD	0.25 mGal



Effect on Gravity – 2nd component

$$\Delta g_{wincof\ dep} - \Delta g_{wincof}$$

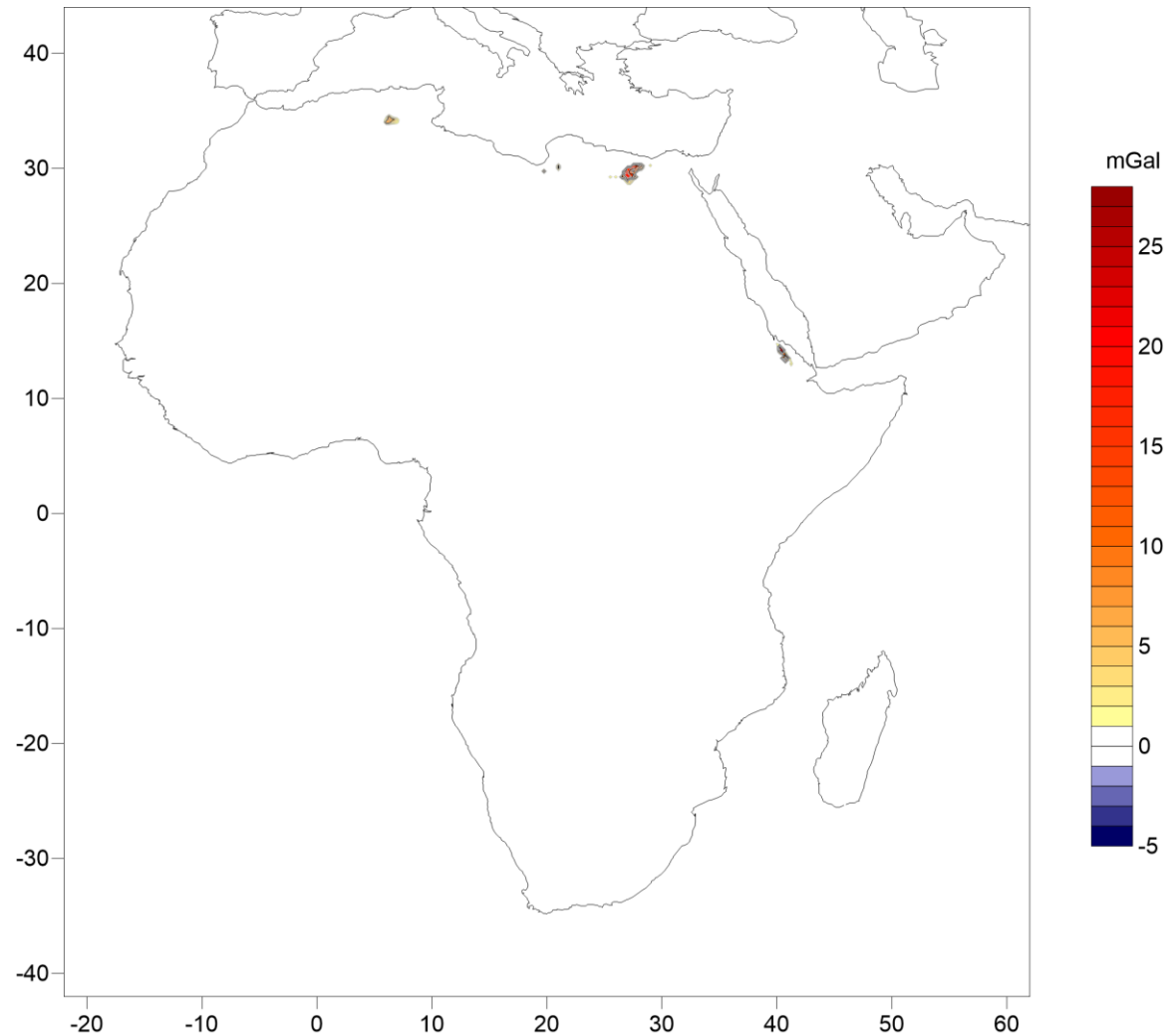
Minimum	-3.81 mGal
Maximum	1.44 mGal
Mean	0.00 mGal
STD	0.04 mGal



Effect on Gravity – Total Effect

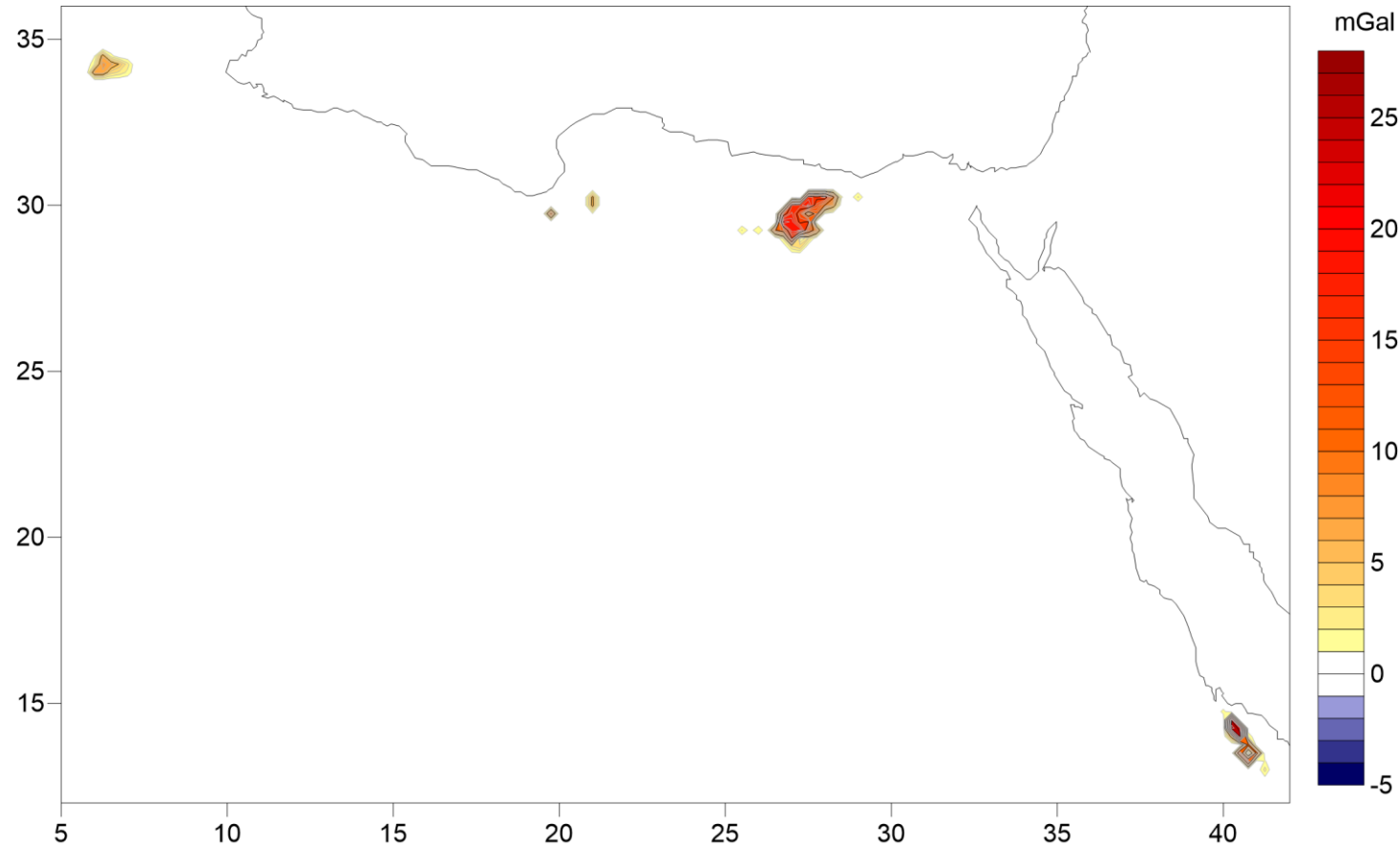
$\Delta g_{win\ dep-eff}$

Minimum	-0.62 mGal
Maximum	26.69 mGal
Mean	0.01 mGal
STD	0.28 mGal



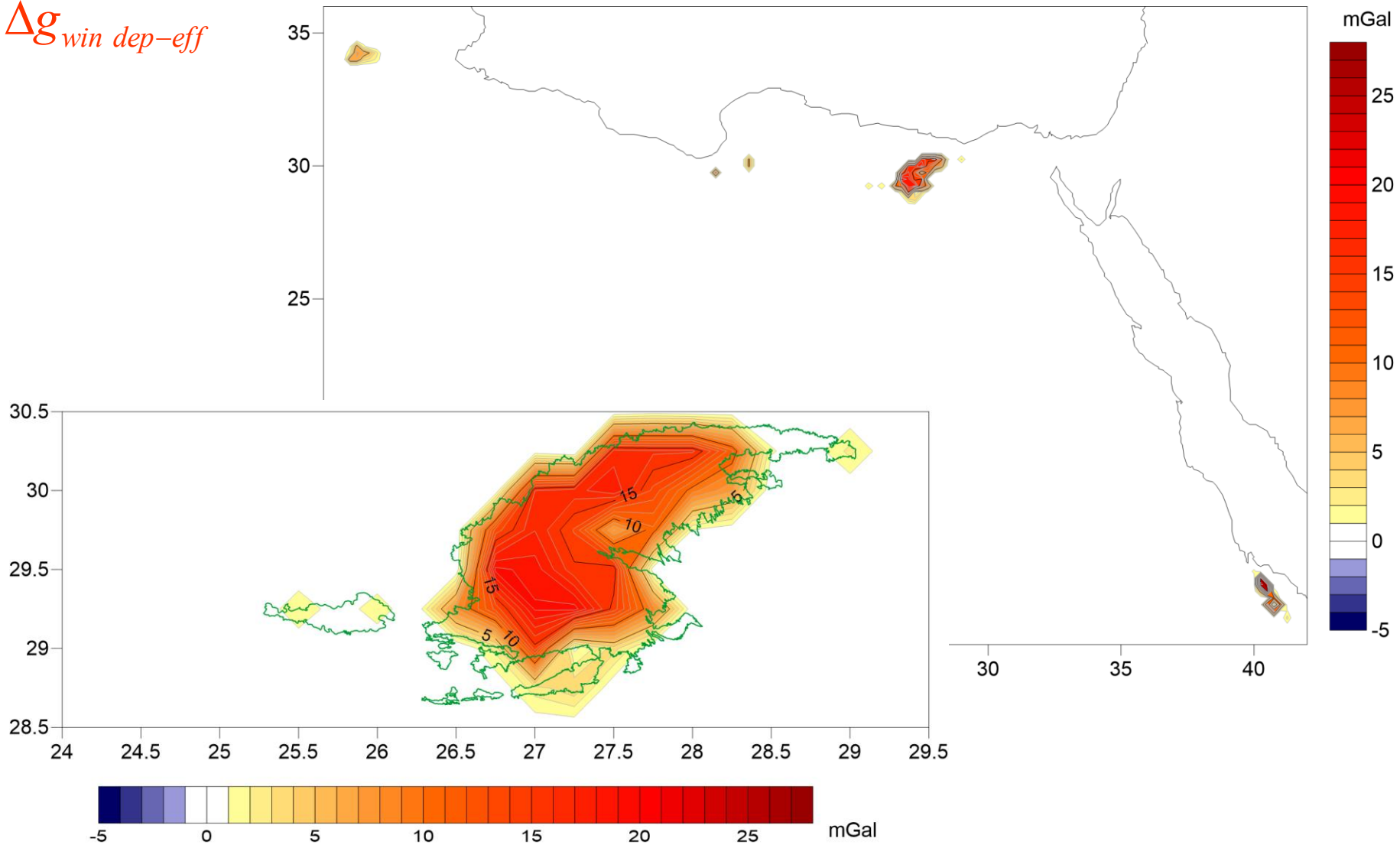
Effect on Gravity – Total Effect

$\Delta g_{win\ dep-eff}$



Effect on Gravity – Total Effect

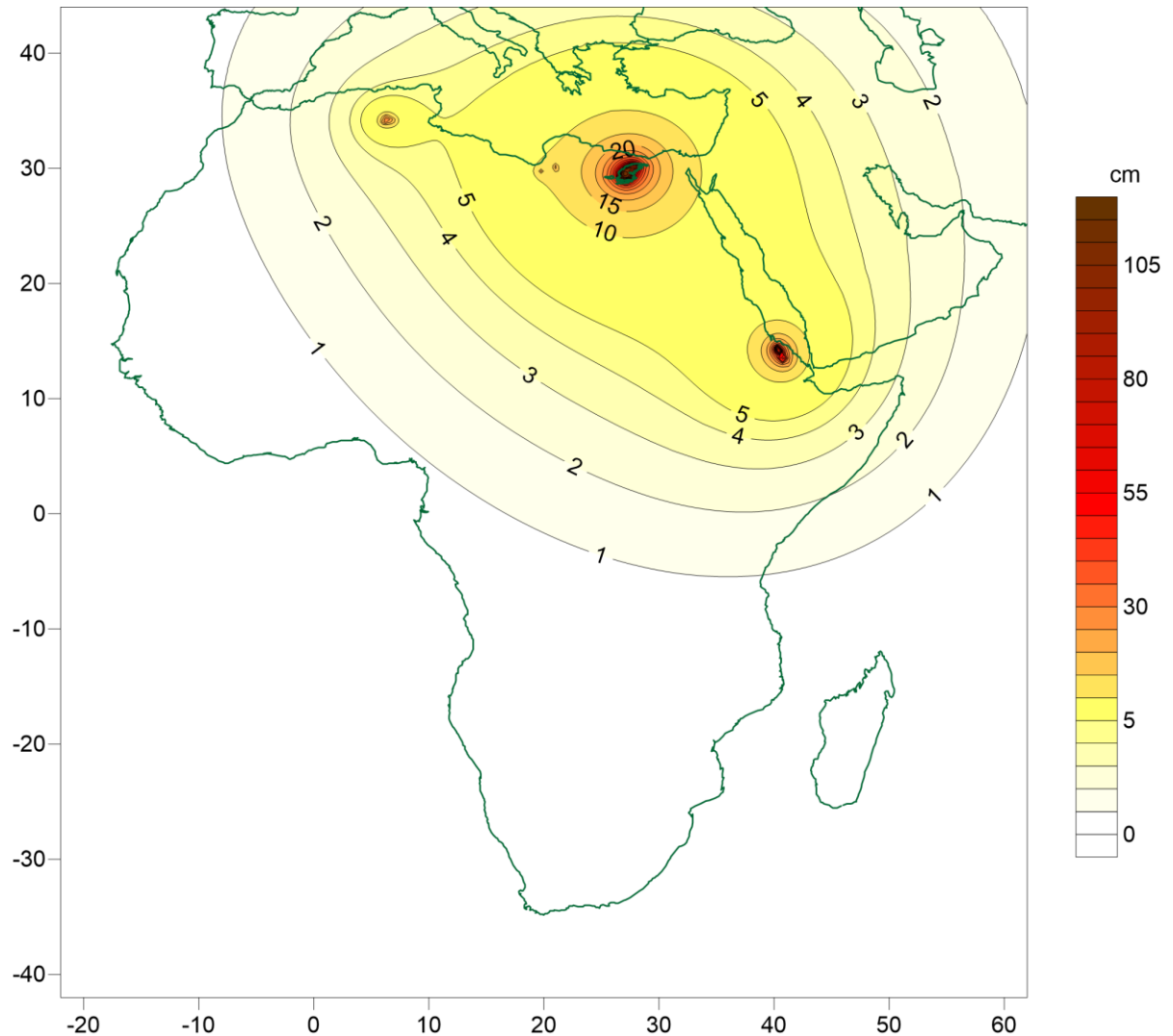
$\Delta g_{win\ dep-eff}$



Effect on Geoid – 1st component

$$N_{TI\,win} - N_{TI\,win\,dep}$$

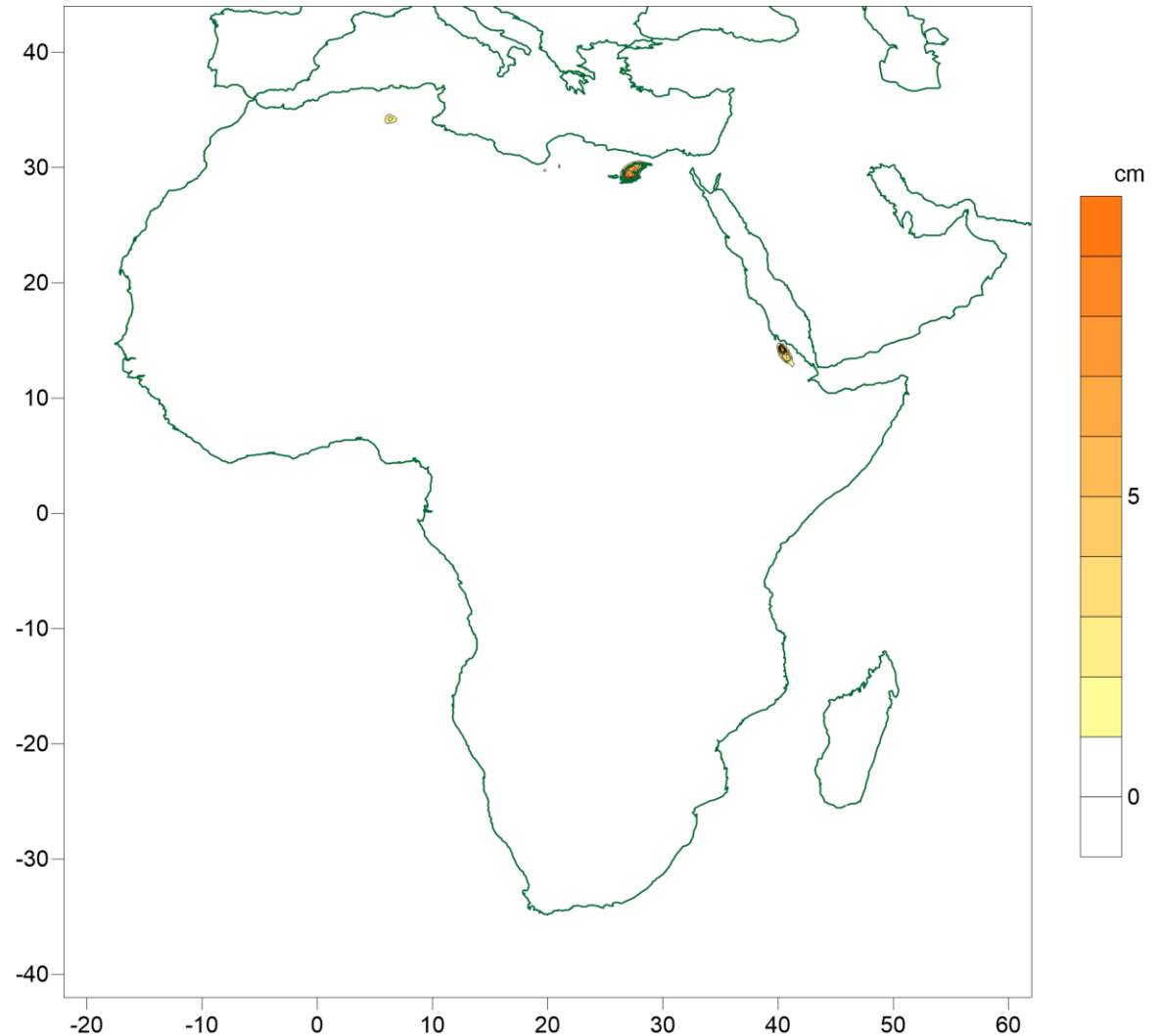
Minimum	-1.28 cm
Maximum	115.10 cm
Mean	1.34 cm
STD	3.67 cm



Effect on Geoid – 2nd component

$$N_{\Delta g_{win}} - N_{\Delta g_{win\ dep}}$$

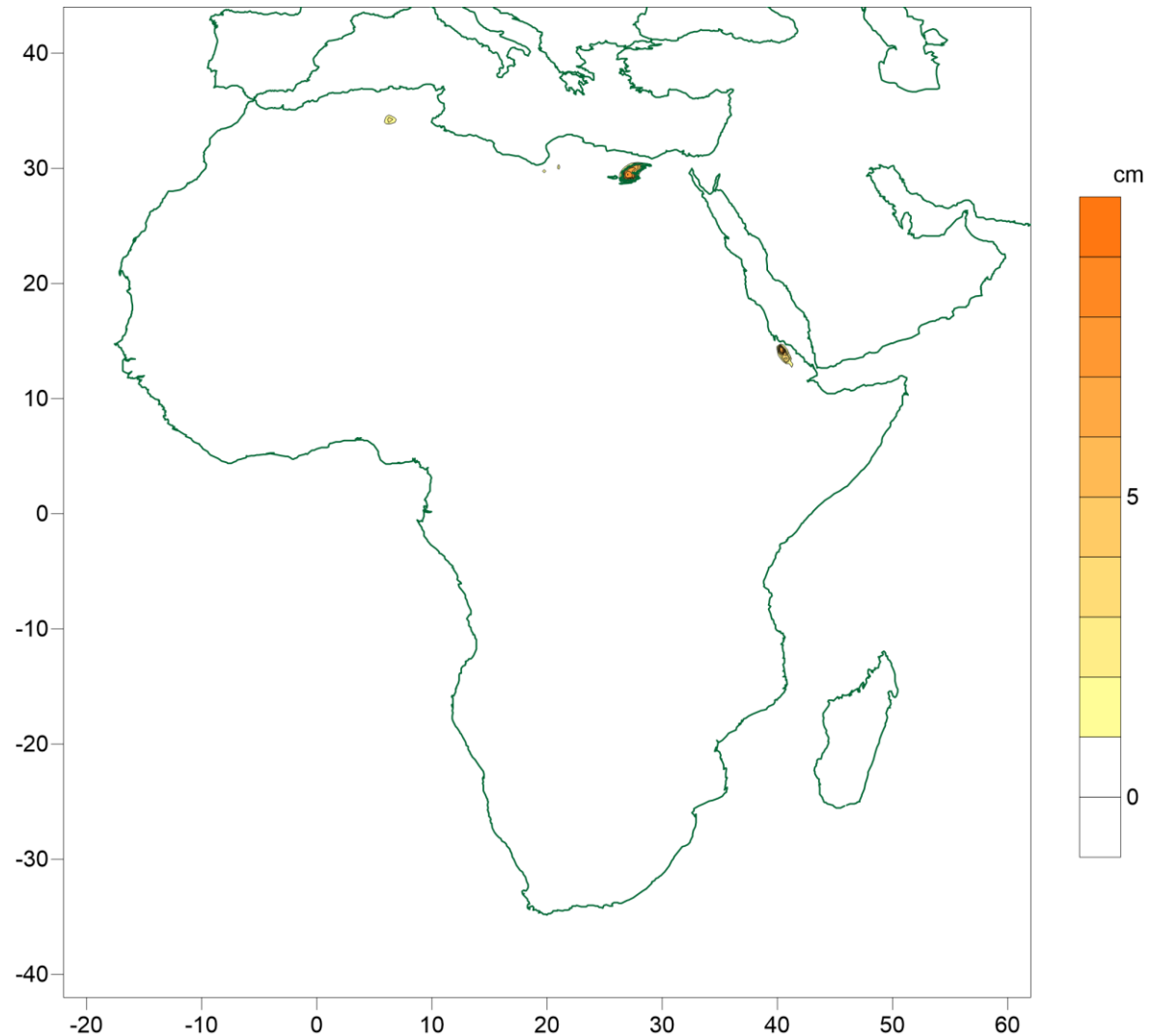
Minimum	0.00 cm
Maximum	8.60 cm
Mean	0.00 cm
STD	0.11 cm



Effect on Geoid – 3rd component

$$\zeta_{wincof} - \zeta_{wincof\ dep}$$

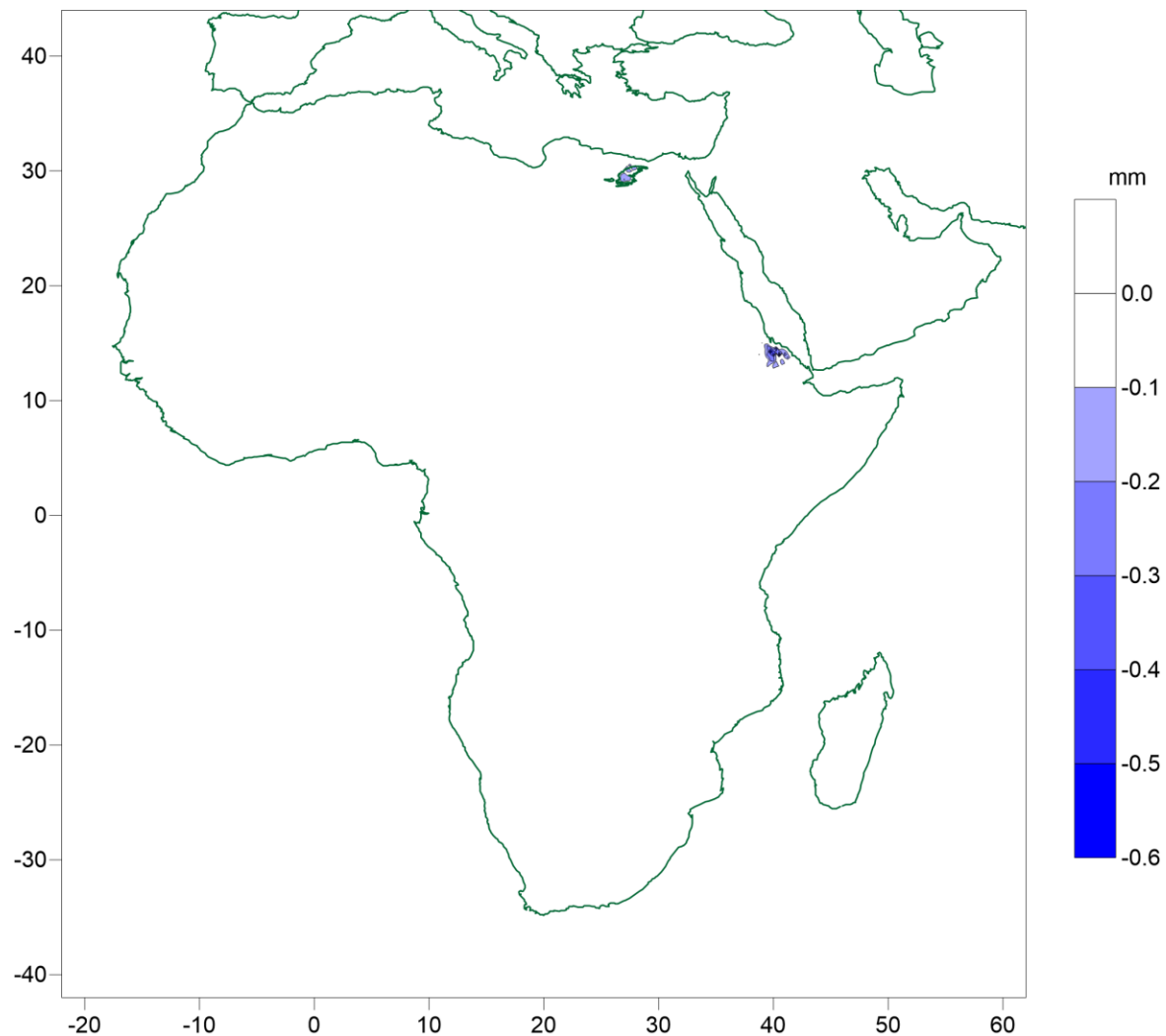
Minimum	-0.01 cm
Maximum	8.49 cm
Mean	0.00 cm
STD	0.11 cm



Effect on Geoid – 4th component

$(N - \zeta)$ effect

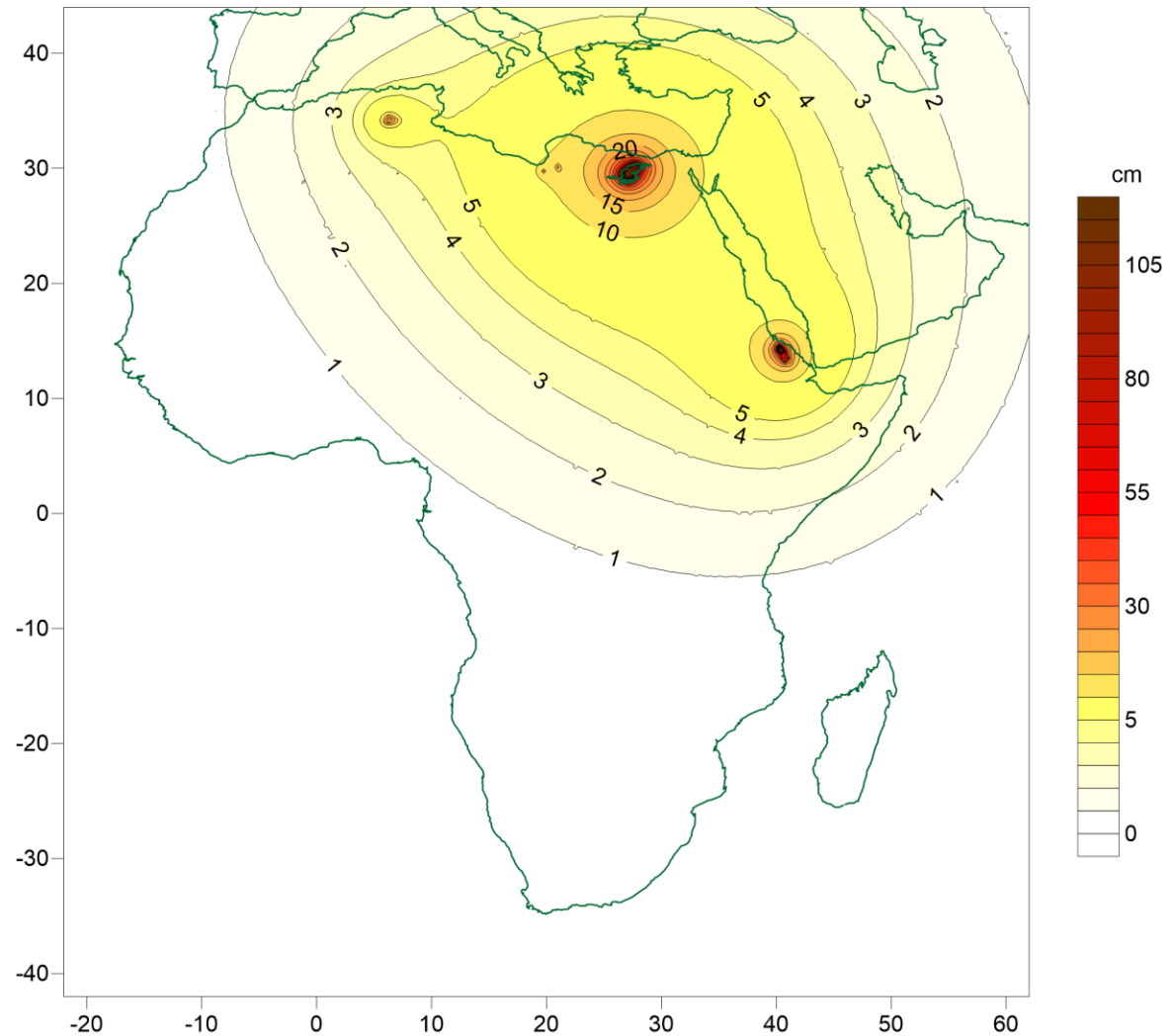
Minimum	-0.57 mm
Maximum	0.08 mm
Mean	-0.00 mm
STD	0.01 mm



Effect on Geoid – Total Effect

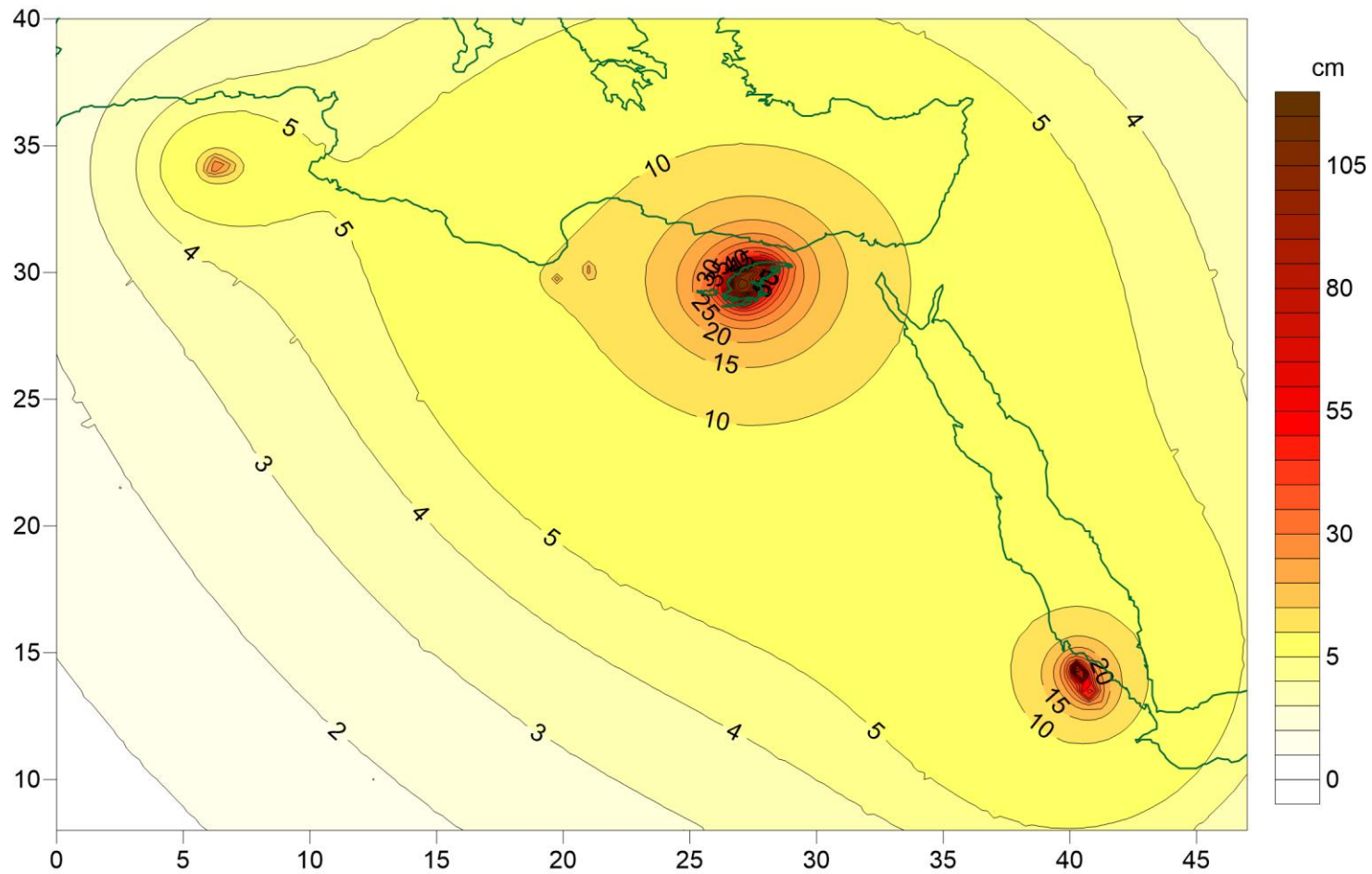
$N_{win\ dep-eff}$

Minimum	-1.28 cm
Maximum	115.04 cm
Mean	1.34 cm
STD	3.67 cm



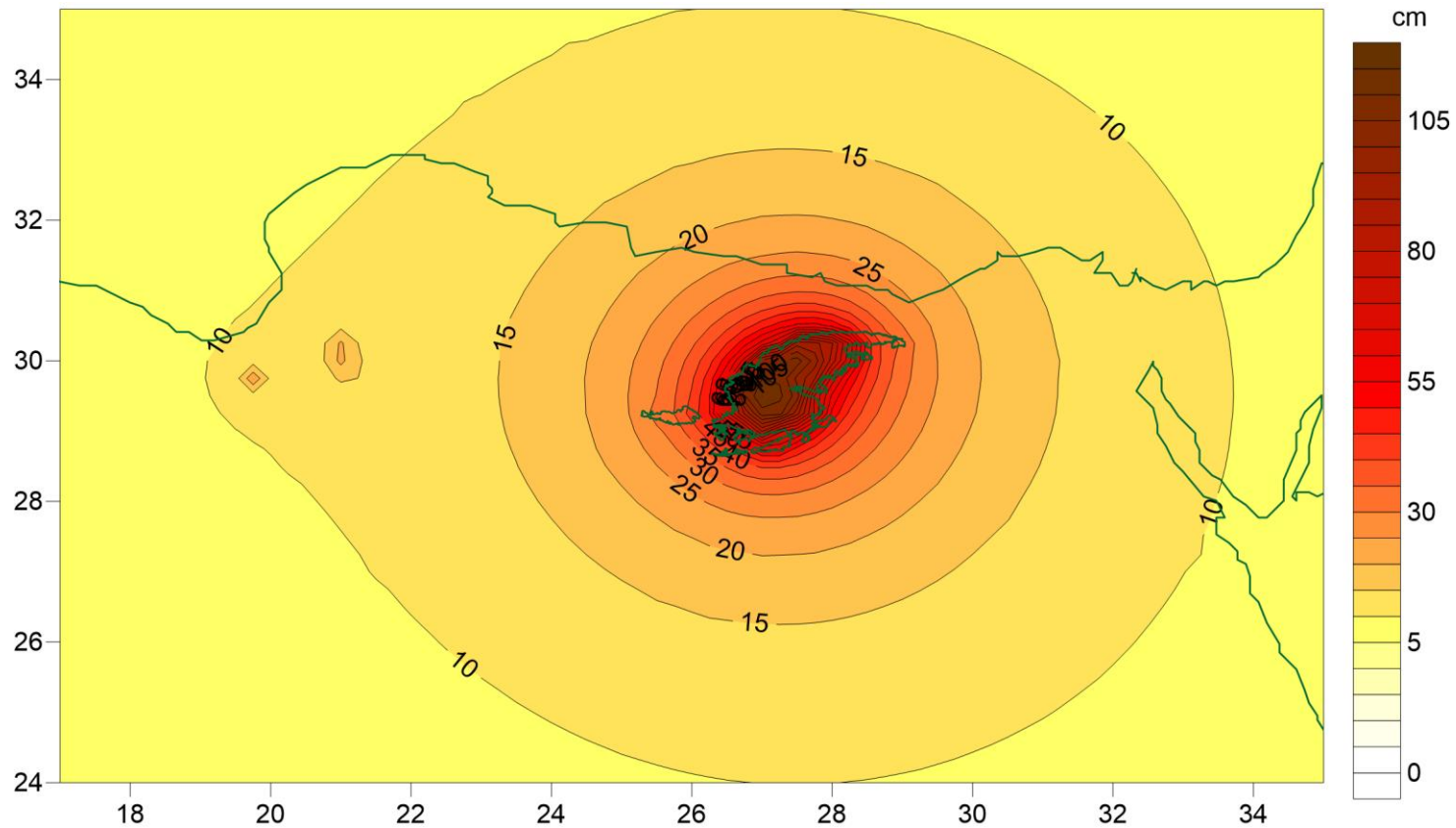
Effect on Geoid – Total Effect

$N_{win\ dep-eff}$



Effect on Geoid – Total Effect

$N_{win\ dep-eff}$



Summary and Conclusion

- Appropriate approach to compute the effect of the land depressions on the gravity anomalies and geoid undulations when using the terrain reduction programs with unclassified digital terrain models (such as TC-program) has been successfully developed.
- This approach depends on the unambiguous window remove-restore technique.
- The effect of the great depressions in Africa on the gravity anomalies reaches 26 mGal and is located only at the area of the depressions.
- The effect of the great depressions in Africa on the geoid exceeds 1 m and is not only limited to the area of the depression but rather spreads out covering half of the African continent with effects on both Europe and Asia.
- This shows its significance and importance to be taken into account for a precise geoid determination.

Thank You!

See you in Hurghada, Egypt



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