Satellite Altimetry over Inland Water: A New Tool to Detect Geoid Errors!

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Motivation

Nowadays satellite altimetry is not only used over open ocean but also over inland waters. Some applications as, for example, investigations on inundation zones require to consider physical heights which tell you where water will flow. This implies to reduce geometric ellipsoidal lake heights by an utmost precise geoid.

Physical heights of a lake surface should exhibit a flat surface, as in general the water is in balance with gravity and the hydrodynamics of lakes can be neglected or is small compared to open ocean conditions.

In this poster we investigate physical heights over a few rather large lakes by using different geoid models.

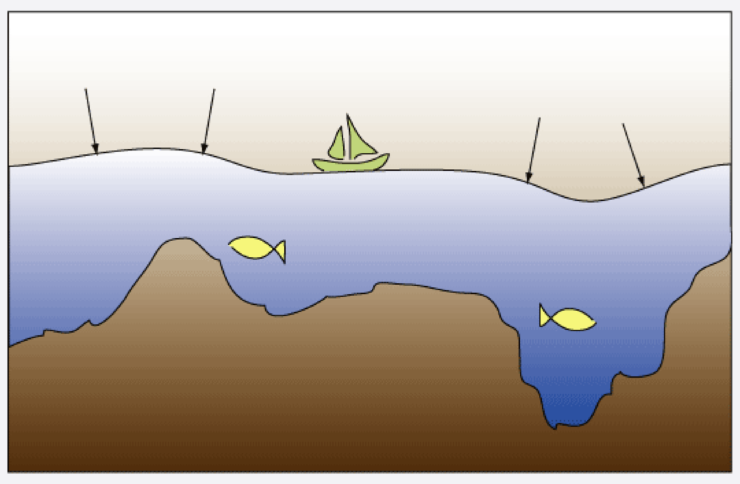

Figure 1: Water level in balance to gravity

Geoid - Models

In this poster, two different geoid models were considered:

- ***EGM2008*** up to degree ***2190***
- A hybrid model which includes the ***GOCO02S*** from degree ***0 to 220*** and the ***EGM2008*** from degree ***221 to 2190***

GOCO02s is the most recent GOCE based gravity field filled with suggest improved accuracy in the spectral range up to degree 220

Differences between both models are shown in figure 2. Differences greater than 1m can be found in areas such as the Amazon, Central Africa and Himalaya.

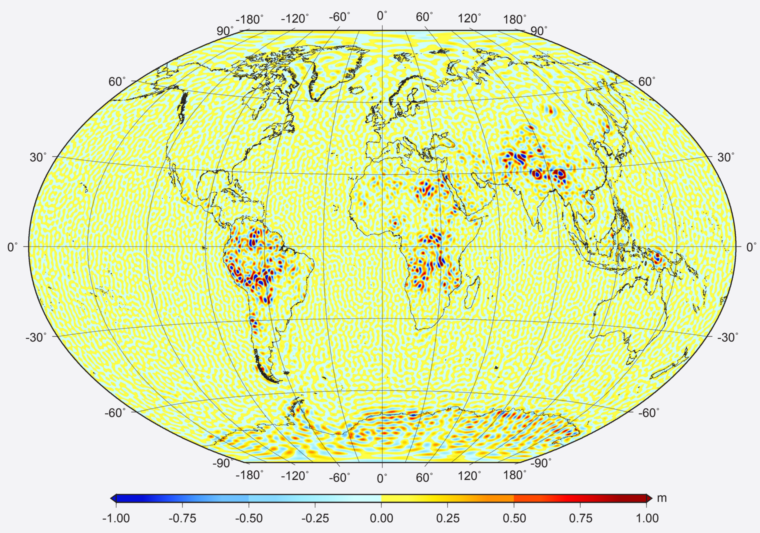

Figure 2: Differences between EGM2008 and the hybrid model containing EGM2008 and GOCO02S up to degree 2190

Lake Victoria

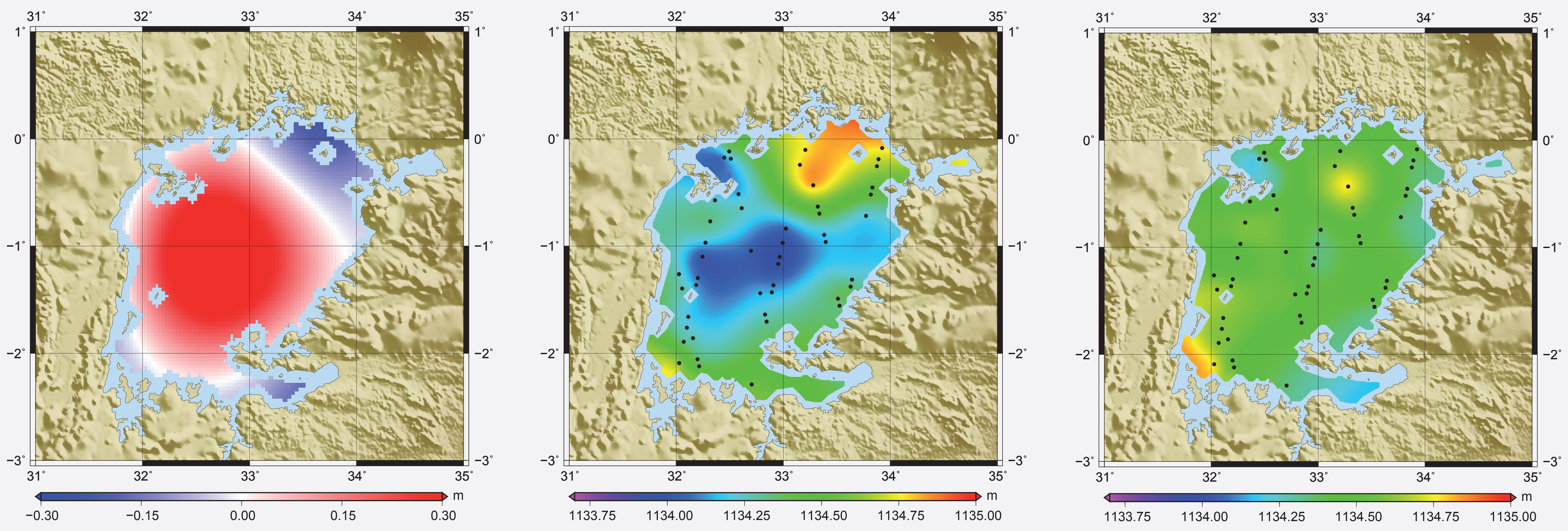

Figure 3: Difference between both geoid models (left). Physical heights obtained by reducing altimetry derived ellipsoidal lake heights from Envisat (Cycle 34) by (middle) EGM2008 geoid heights and (right) geoid heights from the hybrid model.

Pass No.	EGM2008	Hybrid Model	ΔRMS
27 (Env)	18.2	10.4	-7.8
70 (Env)	15.1	10.4	-4.7
113 (Env)	5.4	4.9	-0.5
485 (Env)	19.5	7.0	-12.5
528 (Env)	24.1	7.3	-16.8
571 (Env)	7.0	6.4	-0.6
986 (Env)	15.0	5.6	-9.4
All	17.2	10.4	-6.8

Table 1: RMS (in cm) along each altimeter track and all observed points.

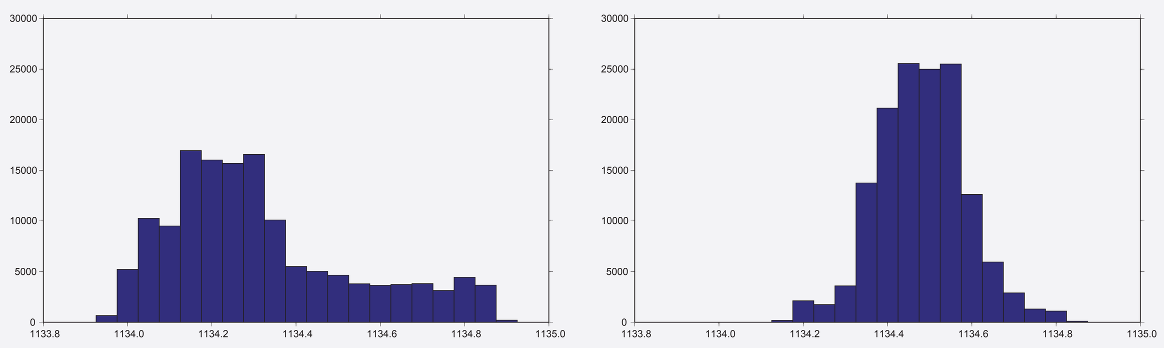

Figure 4: Histogram shows the distribution of physical heights over the lake by using the EGM2008 geoid model (left) and hybrid geoid model (right)

Lake Michigan

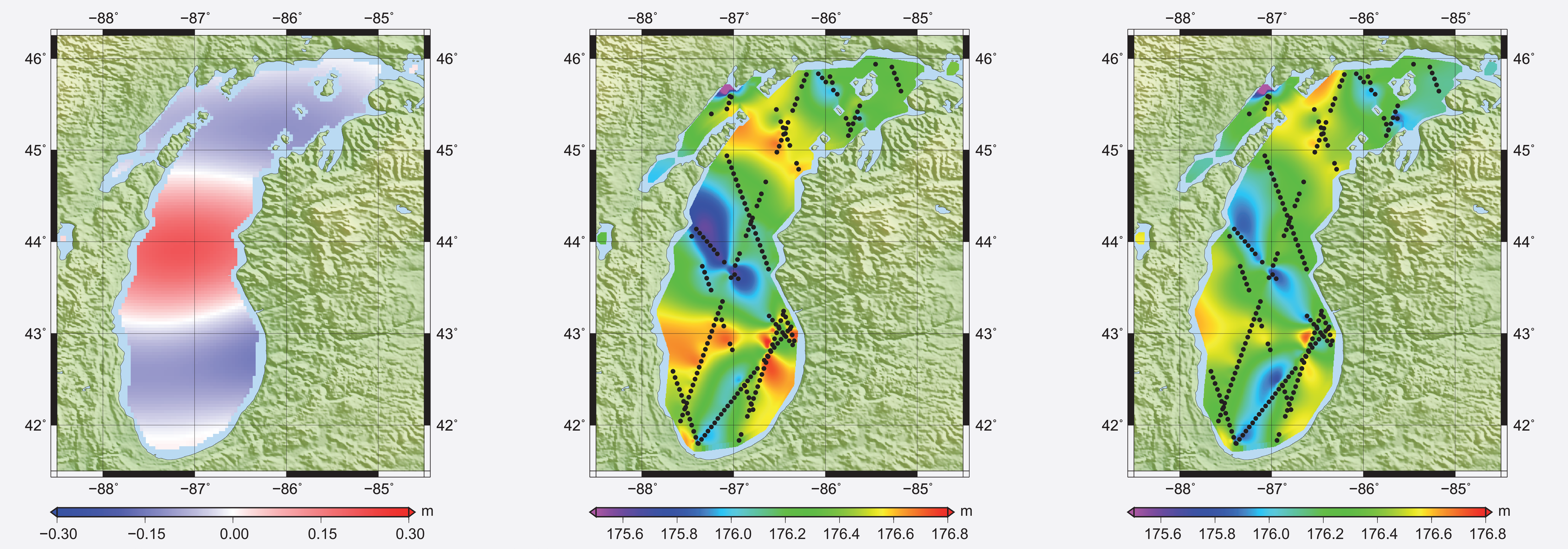

Figure 5: Difference between both geoid models (left). Physical heights obtained by reducing altimetry derived ellipsoidal lake heights from Envisat (Cycle 37) and Jason-1 (Cycle 124) by (middle) EGM2008 geoid heights and (right) geoid heights from the hybrid model.

Pass No.	EGM2008	Hybrid Model	ΔRMS
41 (J1)	13.1	9.7	-3.4
76 (J1)	1.8	9.6	+7.8
254 (J1)	27.3	8.7	-19.6
7 (Env)	17.3	7.3	-10.0
93 (Env)	3.6	1.8	-1.8
338 (Env)	10.6	9.7	-0.9
379 (Env)	1.2	2.7	+1.5
424 (Env)	1.0	2.6	+1.6
465 (Env)	3.9	3.7	-0.2
551 (Env)	22.4	7.3	-15.1
882 (Env)	14.8	9.1	-5.7
923 (Env)	2.9	7.7	+4.8
All	19.9	15.2	-4.7

Table 2: RMS (in cm) along each altimeter track all observed points.

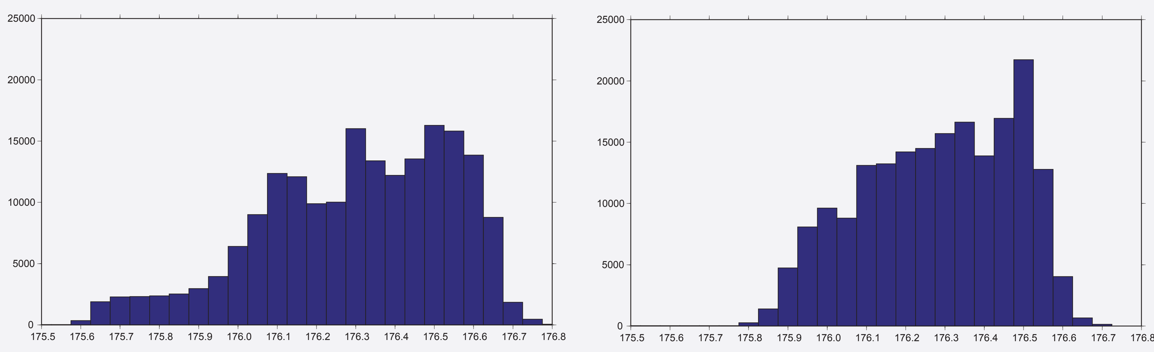

Figure 6: Histogram shows the distribution of physical heights over the lake by using the EGM2008 geoid model (left) and hybrid geoid model (right)

Lake Tanganyika

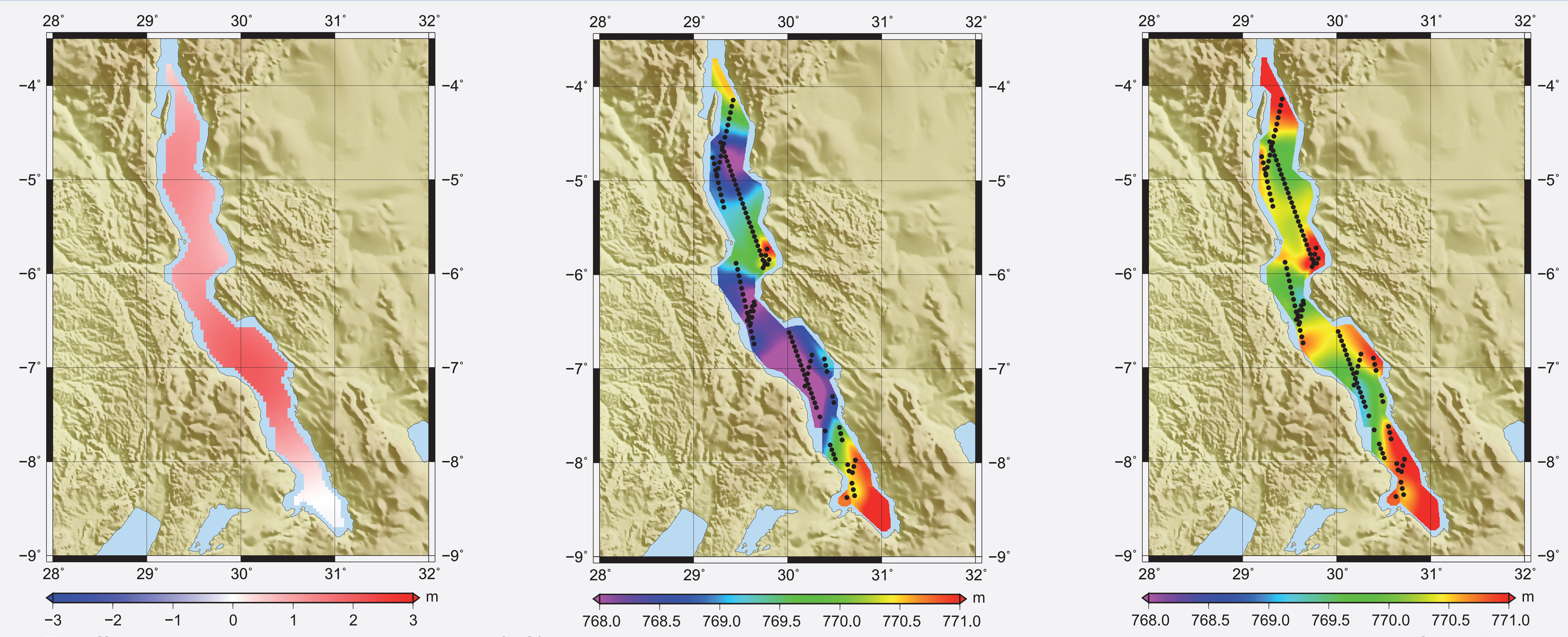

Figure 7: Difference between both geoid models (left). Physical heights obtained by reducing altimetry derived ellipsoidal lake heights from Envisat (Cycle 37) and Jason-1 (Cycle 124) by (middle) EGM2008 geoid heights and (right) geoid heights from the hybrid model.

Pass No.	EGM2008	Hybrid Model	ΔRMS
209 (J1)	108.0	56.8	-51.2
222 (J1)	79.9	35.6	-44.3
70 (Env)	11.6	10.1	-1.5
156 (Env)	133.5	68.4	-65.1
285 (Env)	68.2	20.5	-47.7
614 (Env)	26.8	22.9	-3.9
700 (Env)	55.8	28.0	-27.8
829 (Env)	34.9	28.9	-6.0
All (Env)	82.2	40.0	-42.2

Table 3: RMS (in cm) along each altimeter track and all observed points

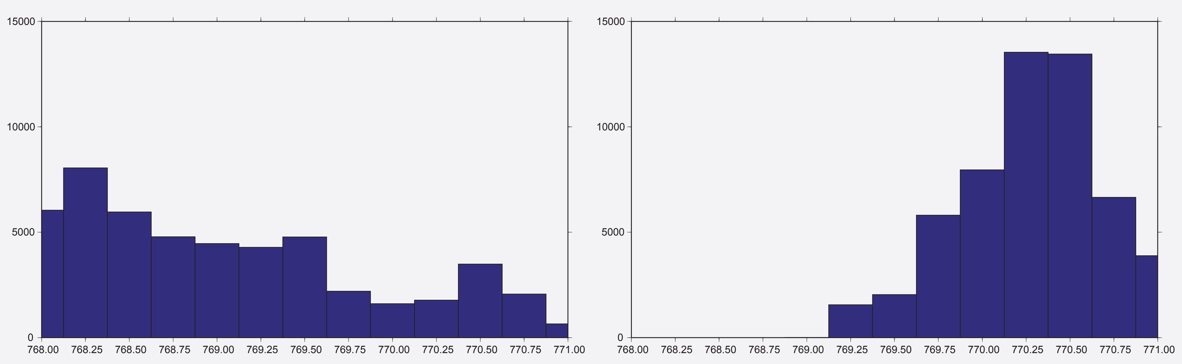

Figure 8: Histogram shows the distribution of physical heights over the lake by using the EGM2008 geoid model (left) and hybrid geoid model (right)

Lake Baikal

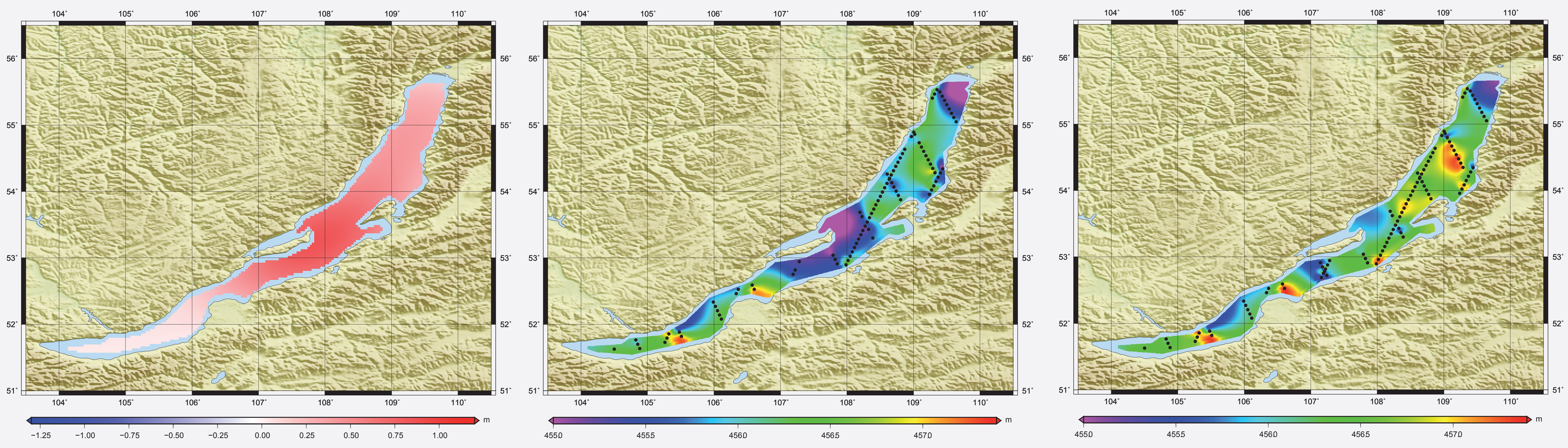

Figure 9: Difference between both geoid models (left). Physical heights obtained by reducing altimetry derived ellipsoidal lake heights from Envisat (Cycle 37) by (middle) EGM2008 geoid heights and (right) geoid heights from the hybrid model.

Pass No.	EGM2008	Hybrid Model	ΔRMS
8 (Env)	9.0	36.1	+27.1
77 (Env)	10.6	12.0	+1.4
94 (Env)	20.7	20.2	-0.5
163 (Env)	15.5	16.0	+0.5
466 (Env)	27.1	20.5	-6.6
535 (Env)	18.3	34.4	+16.1
621 (Env)	11.5	19.4	+7.9
793 (Env)	14.9	5.9	-9.0
879 (Env)	9.5	12.0	-2.5
924 (Env)	30.0	9.1	-20.9
993 (Env)	14.0	30.5	+16.5
All	35.9	38.1	+2.2

Table 4: RMS (in cm) along each altimeter track and all observed points

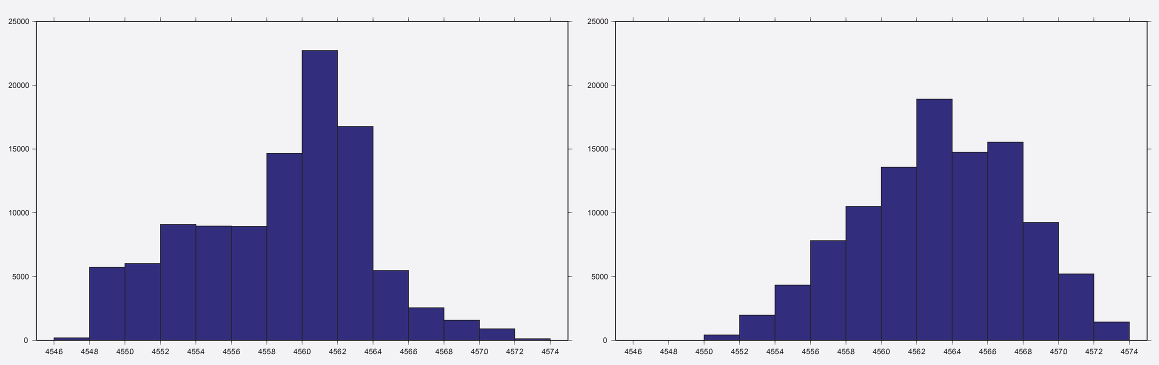

Figure 10: Histogram shows the distribution of physical heights over the lake by using the EGM2008 geoid model (left) and hybrid geoid model (right)

Conclusion

- The usage of GOCO02S in the hybrid model shows an improvement of the physical heights over inland water which become smoother.
- In general RMS values along each altimeter track and mission decrease significantly. This is true for all lakes but Lake Baikal with very short unreliable altimeter tracks
- For the hybrid geoid model improvements of the physical heights are also visible in the histograms due to the decreasing distribution.
- The physical heights from the hybrid geoid model still indicate strong gradients. A computation of geostrophic currents would show unrealistic velocities, much larger than strong ocean currents.
- The applied geophysical corrections show a mostly constant course and can't be made responsible for the residual roughness of the sea surface
- Despite the improved hybrid model, deviations from a flat surface remain. These remaining variations of physical heights must be interpreted as geoid errors of EGM2008 for degrees greater than 220.

References

- Goiginger H., et al.: The combined satellite-only global gravity field model GOCO02S. Presented at the 2011 General Assembly of the European Geosciences Union, Vienna, Austria, April 4-8, 2011.
- Pavlis N., et al.: An Earth Gravitational Model to degree 2160: EGM2008. Presented at the 2008 General Assembly of the European Geosciences Union, Vienna, Austria, April 13-18, 2008.

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