Two years experience with the Israeli Official Geoid Undulations Model

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Presentation outline

- What do we mean by Official Geoid Undulations Model (OGUM) and why do surveyors need it.
- ILUM – The Israeli Official Geoid Undulation Model.
- Dealing with height systems based on different ILUM versions.
- Experimental results with ILUM and comparison with the global model EGM08.
- Discussion about the surveyors' needs and the concept of OGUM.
- Summary and conclusions.

What do we mean by OGUM?

- **A Geoid model that was declared "official" by the national geodetic authority.**
- Preferable: The best available model with best fitting to the bench-marks network.
- Derived official (statutory) heights are not necessarily consistent with the known (registered) heights of the bench-marks.
- Actually a new vertical orthometric datum, based on the ellipsoidal heights of the CORS and on the OGUM.

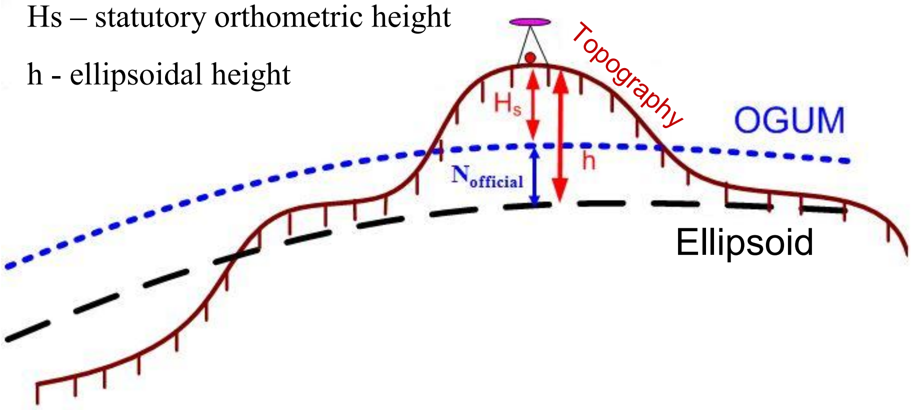
Using the official Geoid undulation model

$N_{official}$ is the official geoid undulation as published by the national geodetic and mapping authority

$Hs = h - N_{official}$

Hs – statutory orthometric height

h - ellipsoidal height



The Surveyors' Needs for Geoid Model

- **<u>Efficiency</u>:** To benefit the GNSS technology for deriving orthometric heights with the same efficiency of deriving horizontal coordinates.

- **<u>Consistency</u>**: To achieve consistent and identical heights to all points (within the desired accuracy) by every surveyor.

The official geoid undulation model in Israel

- The Survey of Israel came to the conclusion that there is no justification to maintain a countrywide vertical orthometric control network.
- A combination of ellipsoidal heights with an OGUM will serve as a substitute to the countrywide vertical orthometric control network.

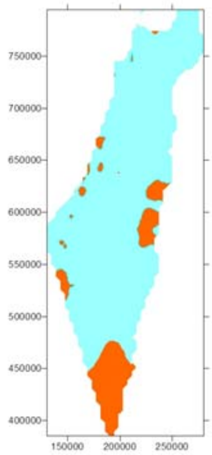
Evaluation of the Israeli OGUM

- The official Israeli undulation model (ILUM) is based on bench-marks with given ellipsoidal and orthometric heights.
- Kriging, a geostatistical approximation method, was used for the construction of a geoid undulation surface. The geoid undulation values were calculated on a grid with a resolution of 0.5 by 0.5 km.

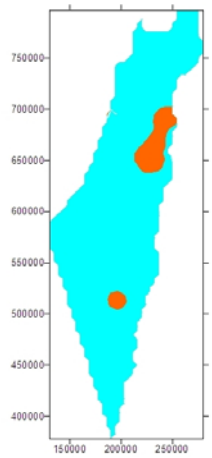
Evaluation of the Israeli OGUM (cont.)

- ILUM 1.0: January 2007, 684 points.
- ILUM 1.1: August 2007, 834 points.
- ILUM 1.2: February 2008, 849 points.
- **Updating and upgrading :** Due to additional data in uncovered area (Eilat, Beit-Shean valley, the Negev desert) and due to some errors.
- ILUM 2.0: About 1200 points, after completing new measurements (mainly of improved and additional ellipsoidal heights).

Undulations differences greater than 5cm between the versions (orange)

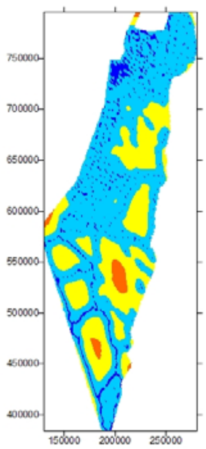


ILUM 1.1 vs. ILUM 1.0

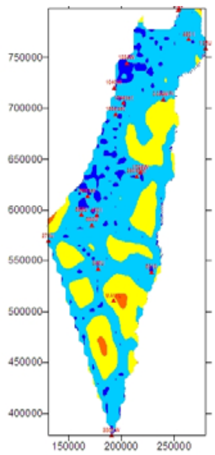


ILUM 1.2 vs. ILUM 1.1

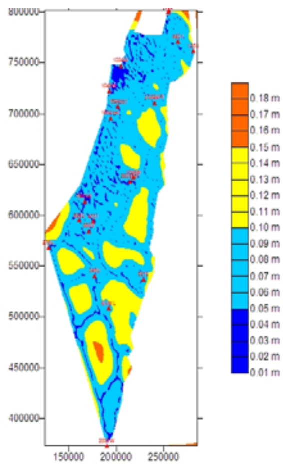
The accuracy of ILUM 1.0 (a), ILUM 1.1(b) and ILUM 1.2(c)



a



b



c

Living with height systems based on different ILUM versions

Living with the "old" system.

- Inconsistency between bench-marks of 4th and 5th order could often reach 5 to 10 centimeters due to the accuracy of the basic stations heights, the errors of the measurements, and some times due to datum inconsistency.
- In any case, for every work, the surveyor had to note the nominal height of the basic bench-marks he used.

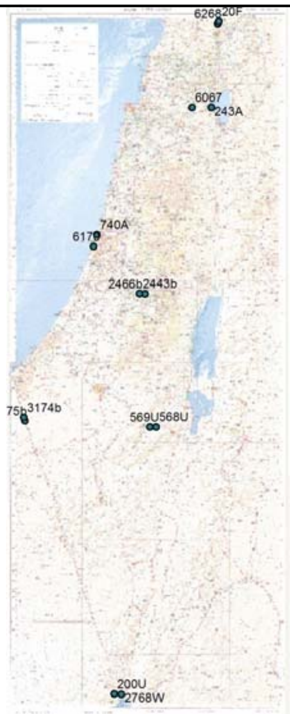
What has been changed?

- For every work the surveyor has to note the ILUM version he used (The SOI maintains every version).

Experimental results and Comparison with EGM08

- The Earth Gravity Model (EGM08)was developed by the US National Geospatial Agency by optimally combining gravitational information extracted from dedicated geopotential mapping satellite missions (CHAMP, GRACE), with data from a global gravity anomaly database at a 1´by 1´ resolution.

Experimental results (cont.)



Distribution of 7 pairs of bench-marks

Experimental results (cont.)

Height differences obtained using ILUM 1.2, EGM08 and Precise Leveling

Summary of "absolute" differences (mm):

	(ILUM 1.2 – Leveling)	(EGM08 – Leveling)
Mean:	-16	-254
RMS:	54	227
Max:	80	41
Min:	-128	-629

Experimental results (cont.)

Height differences between pairs of bench-marks

Region	benchmarks		distance (km)	height difference (m)			abs difference (ppm)	
	from	to		EGM08	ILUM 1.2	leveled	leveled minus EGM08	leveled minus ILUM 1.2
Kiryat Shmona	20F	6268	1.4	41.463	41.421	41.435	20.0	10.0
Tiberias	243A	6067	11.8	484.351	484.160	484.106	20.8	4.6
Tel Aviv	740A	6170	7.6	15.060	15.021	15.016	5.8	0.7
Nitzana	2443b	2466b	3.3	88.723	88.657	88.666	17.3	2.7
Nitzana	3174b	3175b	2.1	13.375	13.431	13.428	25.2	1.4
Dimona	569U	568U	4.0	11.521	11.432	11.466	13.8	8.5
Eilat	2768W	200U	4.4	283.303	283.191	283.211	20.9	4.5

Discussion: The need for accurate geoid

- The professional literature stress the need for a countrywide reference system for orthometric height measurements.
- Deduced orthometric heights using GNSS and geoid-model should agree with the registered heights of existing bench-marks.
- It is common to look for 1cm geoid model.
  - **Is it really achievable?**
  - **Is it really necessary?**
- Various specifications stress the need for high absolute accuracy. This need is **overemphasized**, since relative accuracy is more important.

The need for accurate geoid (cont.)

- It is suggested that the countrywide official geoid may have lower accuracy.
- For a reasonable orthometric control we usually don't need a height-differences accuracy better than 25mm for bench-marks 1km apart (25ppm).

This accuracy was achieved in all our experiments.

The need for accurate geoid (cont.)

- For special projects, surveyors will be required to establish "islands" of high accuracy orthometric heights.

Summary and Conclusions

- As of May 2007 surveyors in Israel benefit the ability to define statutory orthometric heights, even in real time, using a single GNSS receiver equipped with the Israeli official geoid undulation model (ILUM). Instead of occupying at least 4 bench-marks, they can use just one bench-mark for checking purposes only.
- Our two years experience with the three ILUM versions already released is good, and it fulfilled our expectations.
- From the Israeli surveyors' point of view, the new possibility to define orthometric heights is a great success.

Summary and Conclusions (cont.)

- As was shown with the use of EGM08, this approach can be a great advantage for other countries, especially where the vertical orthometric control is spars and in areas were establishing a leveling network is practically impossible.
- Also the developed and rich countries can benefit using this approach before computing the "perfect" geoid, because "The **best** is the enemy of the **very good**".