Improved Official Geoid Model for Israel, 2009

Hezi SARID, Omer BAR, Hsein NASR-ALDIN, Dan SHARNI, Israel

RESEARCH PROJECT for the Survey of Israel

CONTRIBUTIONS by Israel Geophysical Institute, Dr. Michael Rybakov, Dr. John Hall, Profs. Bernhard Heck and Kurt Seitz (for the late Prof. Hans-Georg Wenzel), Dr. Nikos Pavlis, Profs. Petr Vaníček and Marcelo Santos

UNDULATION PREDICTION

Undulation field relatively smooth

(7 meter over 350 km)

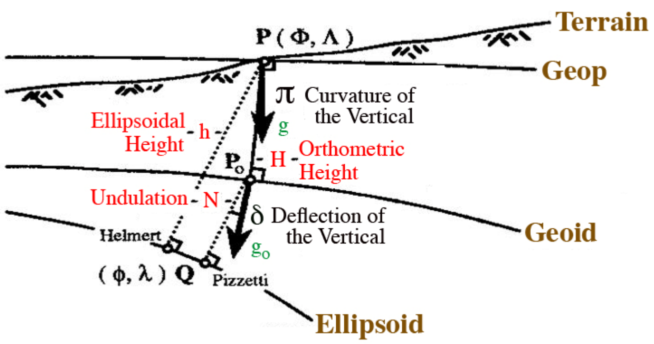
Two methods to Interpolate:

- Mathematically (kriging, GIS tools)
- Physically (gravity data)

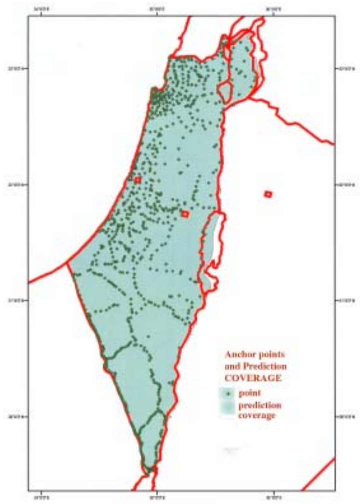
The Mathematic method requires a dense network of anchor points.

Anchor Point

Where both Orthometric Height (H) and Ellipsoidal Height (h) are known. The Undulation (N) transforms between them: $H = h - N$



ILUM 1.2 - Anchor Points



RCR process

RCR: Remove-Compute-Restore

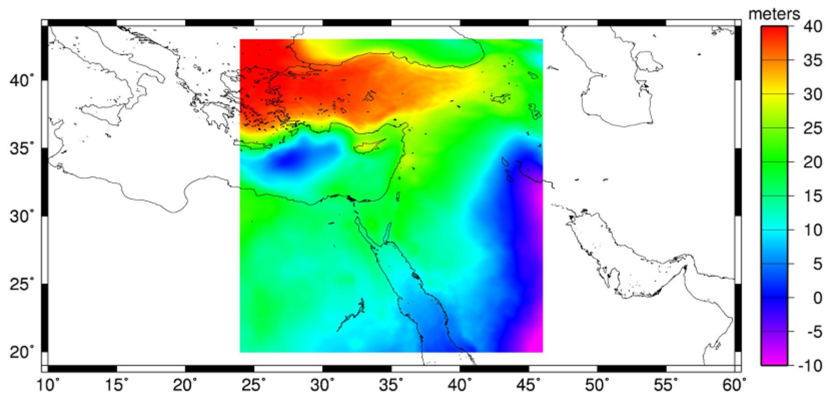
- Remove all known contributions to undulations at anchor points (global gravity model, local gravity and topographic effects) - to obtain residual undulations
- Compute: Interpolate at desired locations
- Restore by adding back all known contributions

Project DATA Sources

- Global gravity model – EGM 2008
- Bouguer gravity anomalies to 2° beyond Israel (converted to Free-Air anomalies, with DTM)
- Observed gravity in Israel, converted to Free-Air anomalies

EGM2008 Undulations

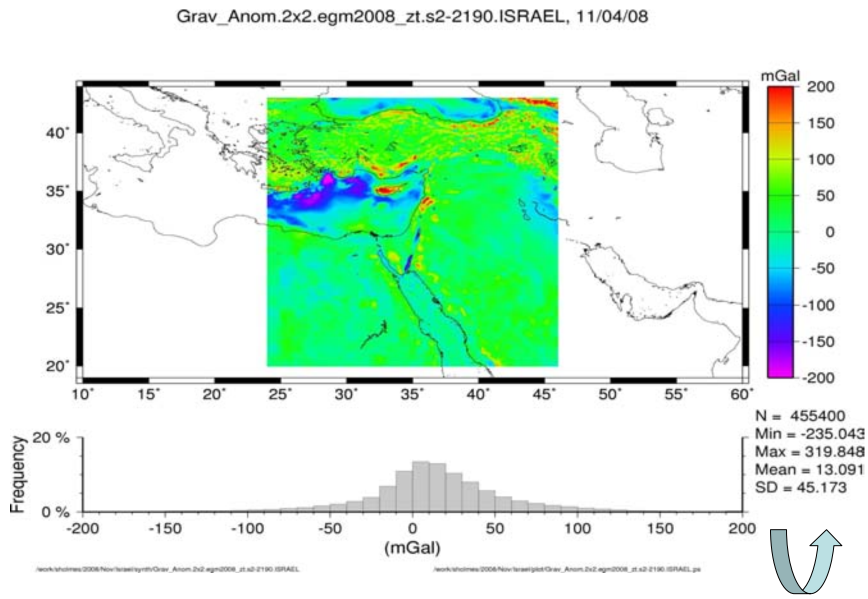
Geoid_Ht_WGS84.2x2.egm2008_tf.s0-2190.ISRAEL, 11/03/08



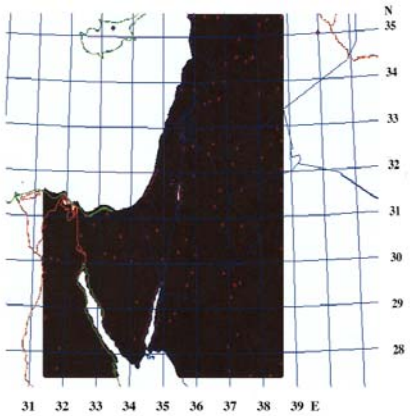
(849 Anchor points) minus (EGM2008) undulations

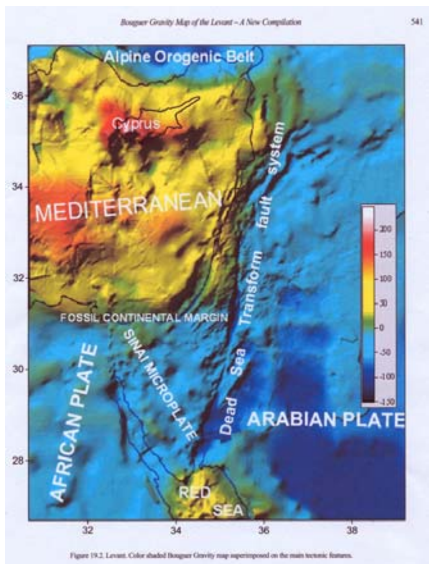
Average [m]	S. Dev [m]	Min [m]	Max[m]
-0.28	0.21	-0.99	0.35

EGM2008 FA Anomalies

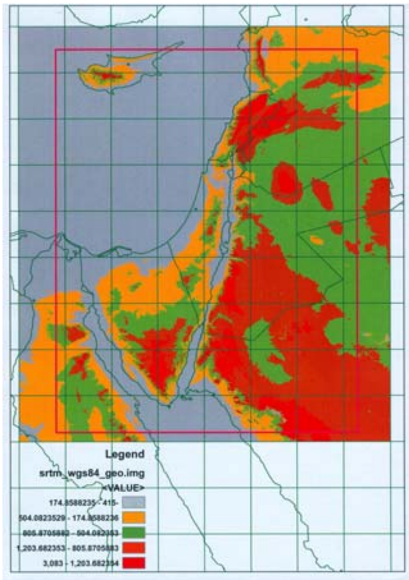


Bouguer Anomalies

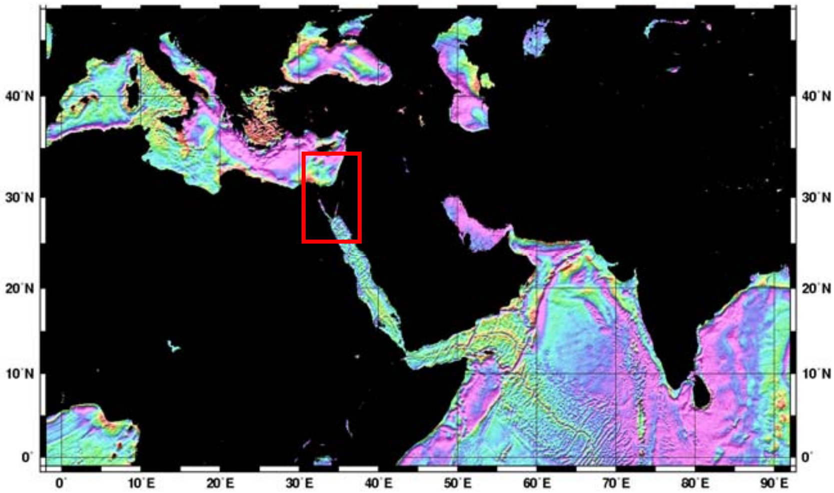




SRTM data

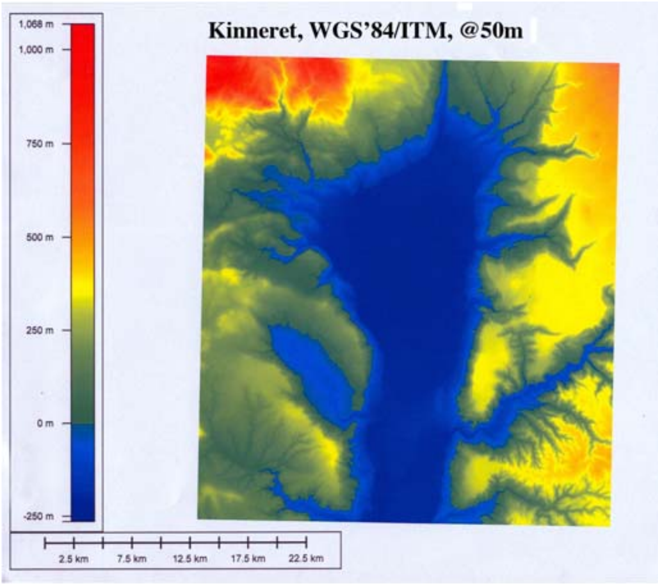


Marine Gravity

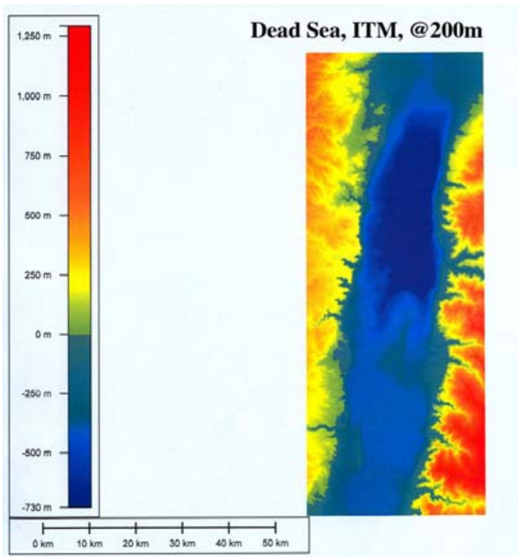


David T. Sandwell and Walter H. F. Smith, Marine Gravity Anomaly from Satellite Altimetry, Version 15.2

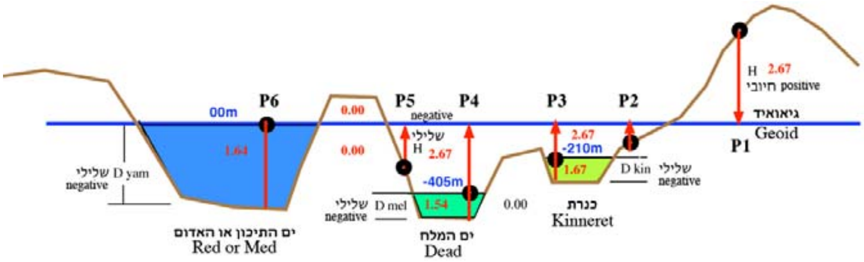
Kinneret DTM



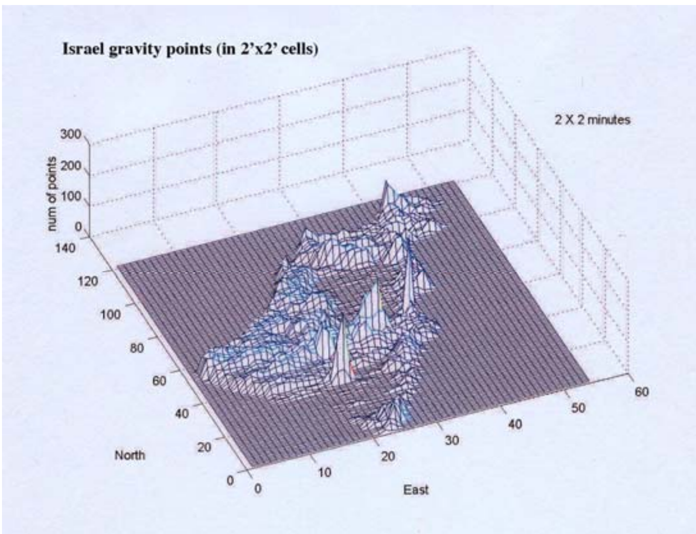
Dead Sea DTM



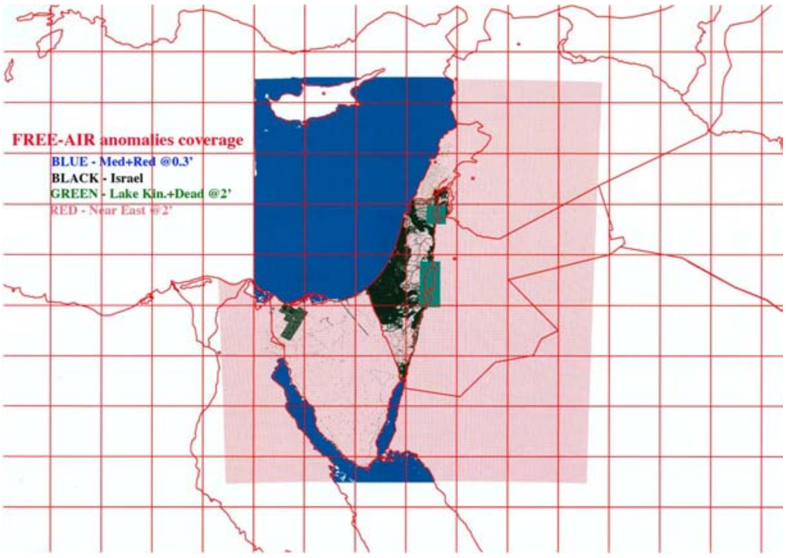
FA from BOU Anomalies



Israel Gravity



FA Area Coverage

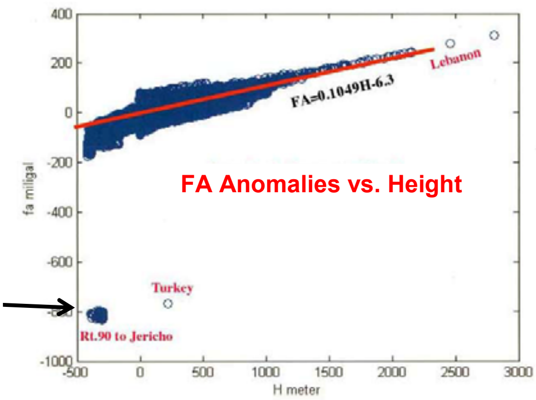


Gridding Free-Air anomalies

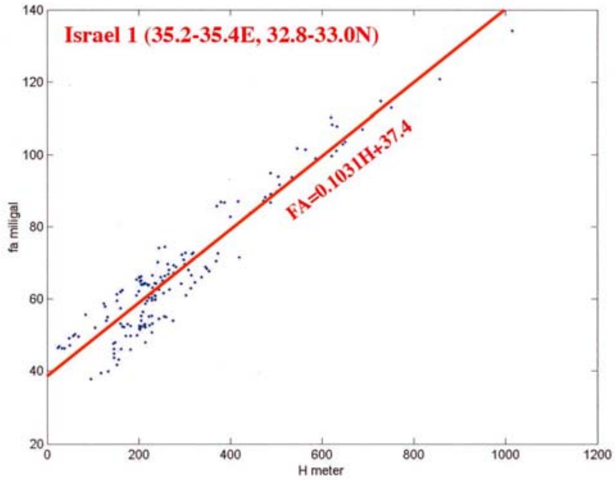
Problem: Discrete points, with area "holes"

Solutions: Correlations (Surface fitting - or height-correlations)

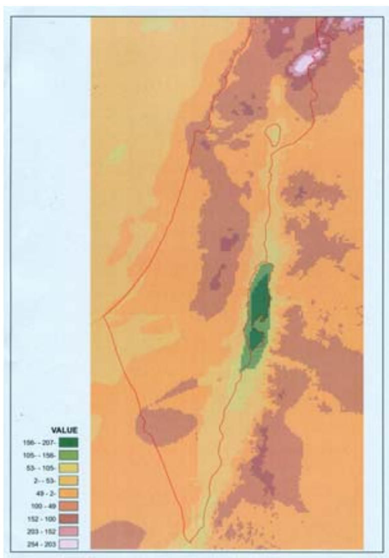
Observed Gravity Error →



FA Anomaly vs. Height



FA Anomalies at 1’



Test Area

Remove – Restore process

At anchor points:

• Remove all known contributions to observed undulations (N) (global model EGM2008; Stokes integration; Indirect Effect, I.E.)

- Obtain residual undulations; develop to a surface.

At desired points:

Predict residual undulations from the surface (P.R.U.)

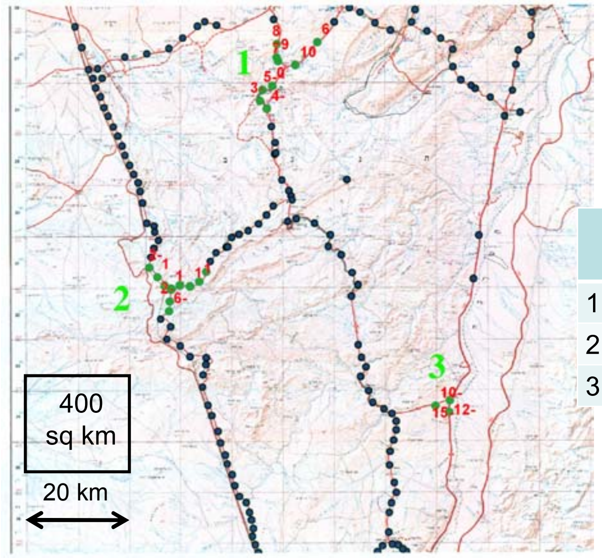
• Restore all known contributions

- Obtain predicted undulations (P.U.)

• Example:

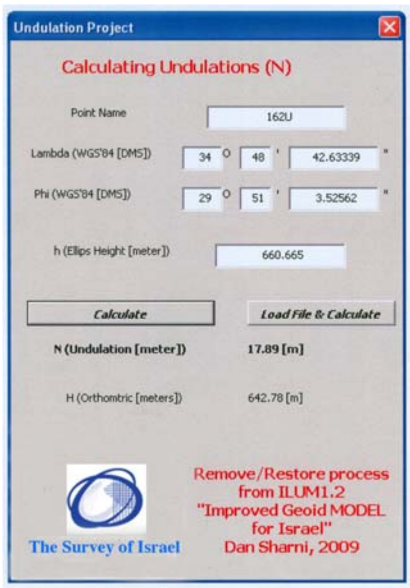
EAST	NORTH	H	P.R.U.	EGM08	Stokes	I.E.	P.U.	N	Diff.
34.963	32.283	53.52	-0.652	19.984	0.391	0.000	19.723	19.674	-0.049

Test Results

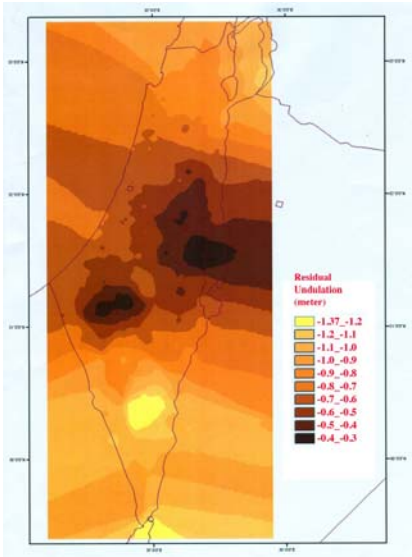


	Area (km sq)	Min (cm)	Max (cm)
1	500	-3	10
2	200	-6	1
3	800	-15	-10

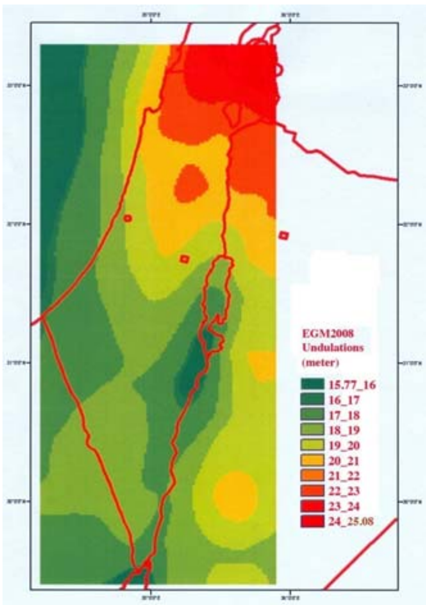
Customer Interface



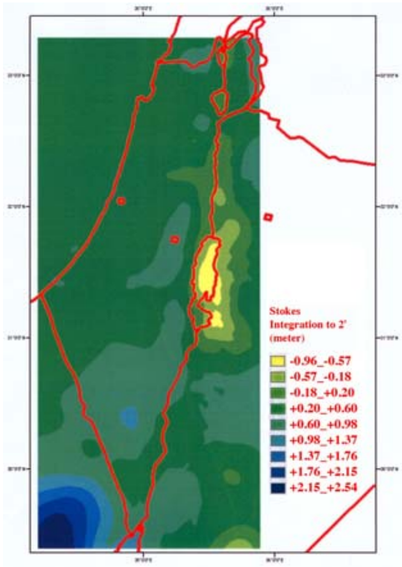
Residual Undulation



EGM2008 Undulation



Stokes Integration



Geoid for Israel

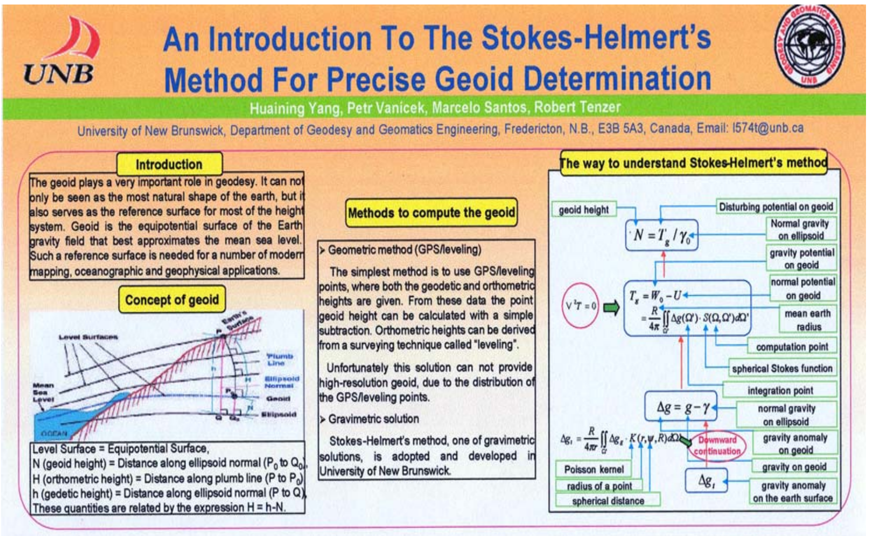
Geoid from LEVELING and GPS – or from GRAVITY.

LEVELING in Israel: MSL not accurate
Tie from the Net is tenuous
Observations over 50+ years
No proper Orthometric Correction
Not all loops included
No simultaneous Adjustment
(Hierarchic forcing of 2nd degree into 1st)

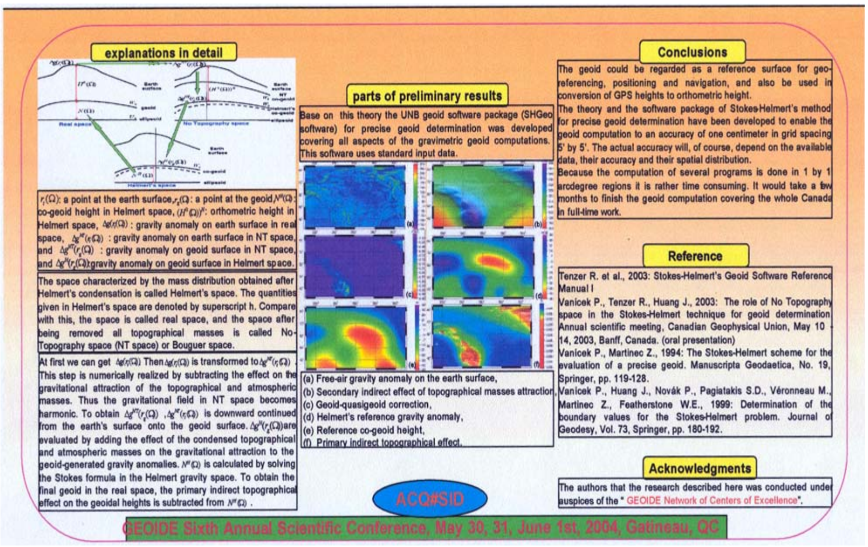
GPS (for Elevations) in Israel:
Not same epochs as leveling (obviously)
Short-period observations

GRAVITY: UNB Geoid Program Suite
(modified Stokes-Helmert procedure)
EGM2008

UNB Geoid - 1



UNB Geoid - 2



Improved Geoid for Israel: SUMMARY

- The Remove & Restore process was proved significant (few cm prediction accuracy)
- The developed software can be easily adapted to updated data
- The Geoid from the UNB-program-suite will be tested and applied to Israel