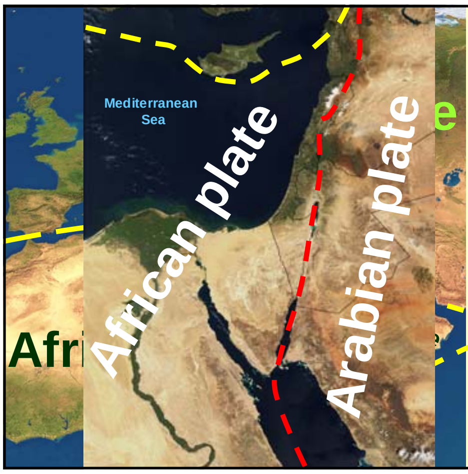

Vertical Movements in the Carmel Mountain

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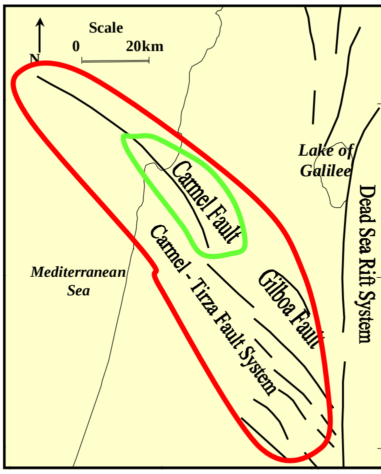
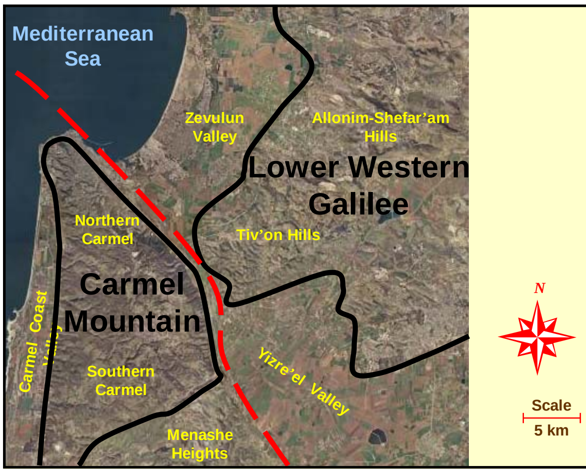


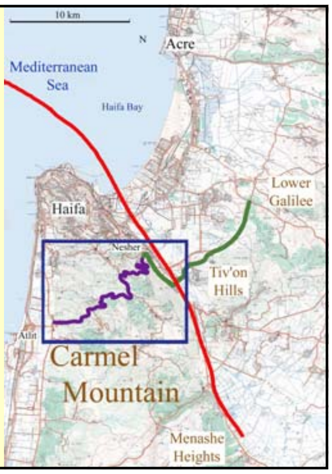
The Dead Sea Rift and the Carmel-Tirza Fault System

The research tools

- GPS Measurements
- Precise Leveling



Precise Leveling



GPS Measurements

- 1990 The Carmel network establishment
- 1994 Undulation Project
- 1999 An additional measurement of the network
- 90s G1 Network- the geodynamic network of Israel

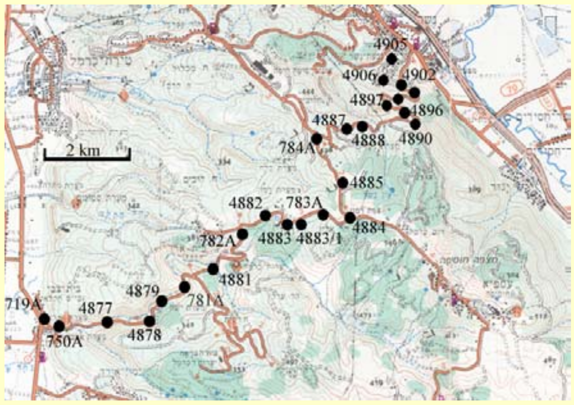
Mathematical models

Linear modal:

$$x_i = x_0 + \dot{x}(t_i - t_0)$$

Quadratic modal:

$$x_i = x_0 + \dot{x}(t_i - t_0) + \frac{\ddot{x}}{2}(t_i - t_0)^2$$



Choosing the datum points

$$H_0 : \dot{x}_1 = \dot{x}_2 = ... = \dot{x}_r = 0$$

$$H_1 : \dot{x}_1 \neq 0 \,\|\, \dot{x}_2 \neq 0 \,\|\, ... \,\|\, \dot{x}_r \neq 0$$

We will reject Ho with a confidence level of $1-\alpha$ if

$$\frac{|\dot{x}_1|}{\sigma_1} > Z_{1-\frac{\alpha}{2}} \,\|\, \frac{|\dot{x}_2|}{\sigma_2} > Z_{1-\frac{\alpha}{2}} \,\|........\|\, \frac{|\dot{x}_k|}{\sigma_k} > Z_{1-\frac{\alpha}{2}}$$

Adjustment computation

$$\begin{bmatrix} L_1 \\ L_2 \\ \vdots \\ \vdots \\ L_k \end{bmatrix} - \begin{bmatrix} V_1 \\ V_2 \\ \vdots \\ \vdots \\ V_k \end{bmatrix} = \begin{bmatrix} A_1 & 0 & 0 & \cdots & 0 \\ 0 & A_2 & 0 & & 0 \\ \vdots & & \ddots & & \vdots \\ 0 & 0 & & \ddots & 0 \\ 0 & 0 & 0 & \cdots & A_k \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ \vdots \\ X_k \end{bmatrix}$$

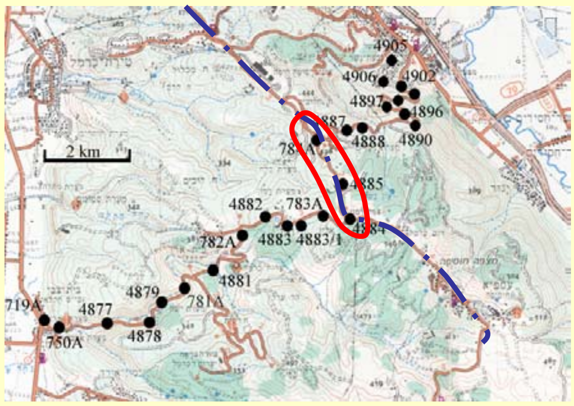
Datum Transformation

Helmert matrix with a single defect:

$$H^T = \begin{bmatrix} 1 & 1 & \cdots & \cdots & 1 \end{bmatrix}$$

The Jacobian matrix:

$$J = I - H\left(H^T P_X H\right)^{-1} H^T P_X$$



Results

model	linear modal						quadratic modal			
period	1987-1992		1991-2003		1987-2003		1987-2003			
point	velocity	$1.96\sigma_{\dot{x}}$	velocity	$1.96\sigma_{\dot{x}}$	velocity	$1.96\sigma_{\dot{x}}$	velocity	$1.96\sigma_{\dot{x}}$	acceleration	$1.96\sigma_{\dot{x}}$
750A	**-5.623**	1.161	**1.290**	0.462	-0.188	0.354	**-7.649**	1.555	**0.886**	0.182
4877					-0.248	0.336				
4878	**-4.833**	1.071	**1.244**	0.428	-0.110	0.313	**-6.630**	1.436	**0.780**	0.168
4879	**-4.815**	1.033	**1.227**	0.417	-0.120	0.304	**-6.602**	1.388	**0.776**	0.162
781A	**-4.339**	0.975	**1.107**	0.396	-0.114	0.288	**-5.963**	1.311	**0.700**	0.153
4881	**-3.631**	0.849	**0.913**	0.351	-0.112	0.256	**-5.005**	1.146	**0.585**	0.134
782A	**-2.839**	0.744	**0.865**	0.313	0.021	0.229	**-3.982**	1.009	**0.478**	0.117
4882	**-1.649**	0.540	**0.607**	0.244	0.071	0.185	**-2.381**	0.741	**0.293**	0.086
4883	**-0.528**	0.484	**0.389**	0.219	0.141	0.166	**-0.852**	0.663	**0.119**	0.077
48831	-0.283	0.403	**0.208**	0.184	0.078	0.137	-0.443	0.555	0.064	0.064
783A	-0.171	0.308	**0.226**	0.143	**0.119**	0.099	-0.295	0.427	**0.051**	0.051
4884	-0.136	0.213	**0.107**	0.102	0.040	0.068	-0.212	0.296	0.031	0.036
4885	0.015	0.160	-0.030	0.074	-0.017	0.050	0.029	0.222	-0.006	0.027
784A	0.121	0.288	-0.077	0.132	-0.023	0.088	0.182	0.399	-0.025	0.048
4887	-0.221	0.558	-0.237	0.252	**-0.229**	0.176	-0.215	0.770	-0.002	0.091
4888	-0.552	0.600	**-0.275**	0.271	**-0.341**	0.189	-0.637	0.828	0.035	0.098
4890	**-1.034**	0.733			**-0.823**	0.462				
4897	**-0.870**	0.807	0.071	0.311	**-0.524**	0.474	-0.531	0.950	0.059	0.113
4900	**-1.286**	0.898	0.200	0.359	**-0.533**	0.491	-1.117	1.095	0.129	0.130
4902	**-1.538**	0.956			**-0.785**	0.590				
4906	**-1.404**	1.011			-0.651	0.676				
4905	**-1.201**	1.057	0.329	0.385	-0.503	0.683	-0.892	1.173	0.120	0.139

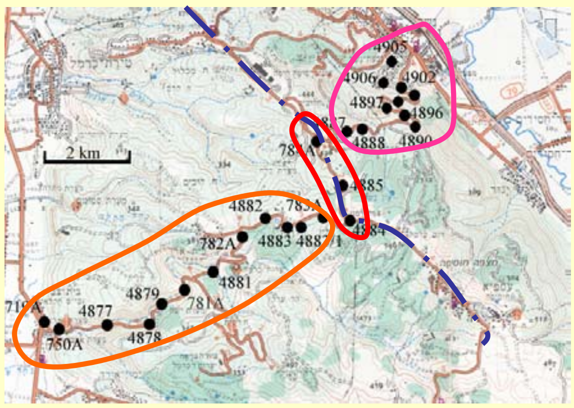
Solution and accuracy

$$\dot{X}_{new\_datum} = J\dot{X} \qquad \Sigma_{\dot{X}_{new\_datum}} = J\Sigma_{\dot{X}} J^T$$

$$\ddot{X}_{new\_datum} = J\ddot{X} \qquad \Sigma_{\ddot{X}_{new\_datum}} = J\Sigma_{\ddot{X}} J^T$$

Conclusions

- The monitoring based on 23 points that are scattered the Carmel Mountain’s breadth and basically includes 3 measuring cycles.
- The simultaneous solution indicates stability of the western slopes relatively to the mountains exterior and moderate rising of the mountain's exterior at a rate under 1 mm per year compared to the eastern slopes.



- Despite the importance of the simultaneous solution, it includes the loss of much valuable information, therefore solutions were arrived at with the use of two intersects on the time axis.
- From the analysis of these solutions, it is seen that in the first period, the Carmel ridge has risen at a rate of up to 6 mm a year with regard to its western slopes and at a rate of approximately 2 mm a year compared to the eastern slopes. Analysis of the second period's results indicates that the ridge's center does not rise, and even sinks at a rate of 1 mm per year compared to the western slopes.