Simple Model for Improving the Accuracy of the Egyptian Geodetic Triangulation Network

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Problem Definition

- The recent applications such as plate boundary , earthquakes, determination, studying the sea surface topography and its variation with time, the computation of the orbits of the artificial geodetic earth satellites, and improving the knowledge of the earth's gravity field require very high accuracy for the network coordinates.

Objectives

- Defining the bias in the network using the available precise coordinates (GPS), at some stations of the Egyptian triangulation network.
- To establish a correction model to improve the accuracy of the local network without readjusting the network.

Methodology

- illustrating the differences between the coordinates of the Egyptian datum and WGS-84 over the territory of Egypt, the differences in latitudes and longitudes at the available stations are computed.
- Investigating the bias in the local coordinates of the Egyptian datum, WGS-84 coordinates are changed to their corresponding coordinates in the Egyptian local datum by using the well known datum shift equations.

Methodology

$$\partial\varphi = (\cos\varphi_{i.p}\cos\varphi + \sin\varphi_{i.p}\sin\varphi\cos\Delta\lambda)\partial\varphi_{i.p} - (\sin\varphi\sin\Delta\lambda\cos\varphi_{i.p})\partial\lambda_{i.p} + (\sin\varphi_{i.p}\cos\varphi - \cos\varphi_{i.p}\sin\varphi\cos\Delta\lambda)((\delta h / a) + (\delta a / a) + \sin 2\varphi_{i.p} * \delta f) + 2\cos\varphi(\sin\varphi - \sin\varphi_{i.p})\delta f$$

$$\cos\varphi\,\partial\lambda = (\sin\varphi_{i.p}\sin\Delta\lambda)\,\partial\varphi_{i.p} + (\cos\Delta\lambda\cos\varphi_{i.p})\,\partial\lambda_{i.p} - [(\cos\varphi_{i.p}\sin\Delta\lambda) * (\delta h / a) + (\delta a / a) + \sin 2\varphi_{i.p} * \delta f)]$$

Methodology

Where :

- φ and λ : the latitude and longitude of the point to be shifted in the old datum.
- $\varphi_{i.p}$ and $\lambda_{i.p}$ are the latitude and longitude of the Initial Point in the old datum
- $\delta\varphi_{i.p} = \varphi_{i.p\ new} - \varphi_{i.p\ old}$ $\quad \delta\lambda_{i.p} = \lambda_{i.p\ new} - \lambda_{i.p\ old}$
- $\delta a = a_{new} - a_{old}$ $\quad \delta f = f_{new} - f_{old}$

Methodology

- $\delta a = a_{new} - a_{old}$ $\delta f = f_{new} - f_{old}$
- $\Delta\lambda = \lambda_{point} - \lambda_{i.p}$ $\delta h = h_{new} - h_{old}$

•$\partial\varphi$ to be added to WGS-84 latitude to produce the local datum latitude.

•$\partial\lambda$ to be added to WGS-84 longitude to produce the local datum longitude.

Methodology

❑Steps to achieve the first goal:

1. Get the original coordinates and name them (LD).
2. Compute WGS-84 shifted coordinates and name them (LD-1).
3. Compute the **bias** ($\Delta\varphi$, $\Delta\lambda$) and their resultant between (LD) and (LD-1) coordinates.

Methodology

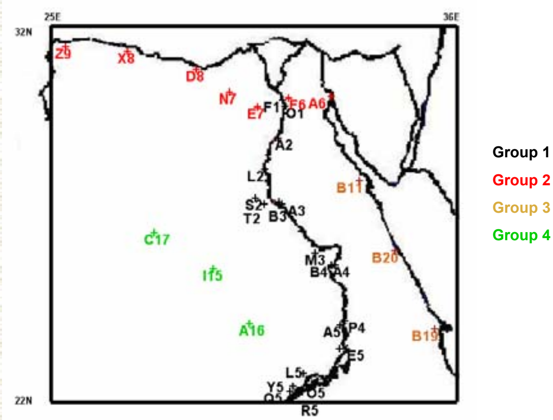
❑The available stations are divided into four groups

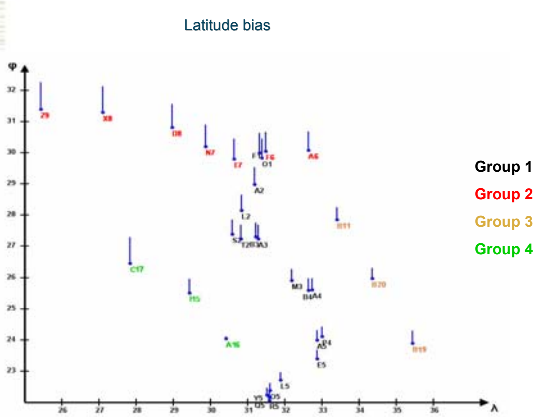
▪**Group 1** starts from the Initial point F1 in the North and goes to the South beside the Nile, its points belong to Network I.

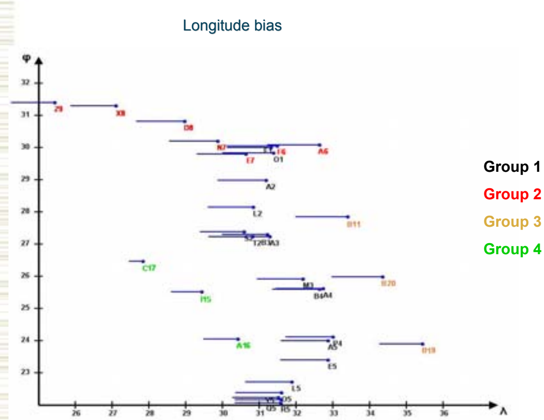
▪**Group 2** includes the stations in the East-West direction, they belong to Network I.

▪**Group 3** includes three points in the Eastern Desert and belongs to Network II.

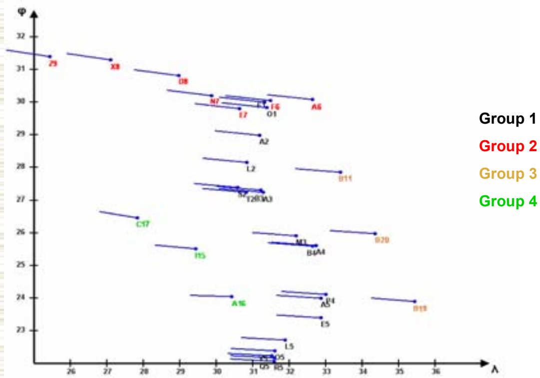
▪**Group 4** contains three points in the Western Desert and belongs to Network II.







Resultant bias



Methodology

- Steps to achieve the second goal:

1. Modeling the obtained bias in latitudes ($\Delta\varphi$) and longitudes ($\Delta\lambda$) using 1st, 2nd, and 3rd order polynomials and the best fitting polynomials are chosen.
2. The obtained polynomials are then applied to the coordinates of the points in (LD) to obtain their corresponding coordinates in (LD-1)

Methodology

The used polynomials were as follows:

$\Delta\varphi = a_0 + a_1 L + a_2 \alpha$ (1st order)

$+ a_3 L^2 + a_4 L\alpha + a_5 \alpha^2$ (2nd order)

$+ a_6 L^3 + a_7 L^2\alpha + a_8 L\alpha^2 + a_9 \alpha^3$ (3rd order)

$\Delta\lambda = b_0 + b_1 L + b_2 \alpha$ (1st order)

$+ b_3 L^2 + b_4 L\alpha + b_5 \alpha^2$ (2nd order)

$+ b_6 L^3 + b_7 L^2\alpha + b_8 L\alpha^2 + b_9 \alpha^3$ (3rd order)

Where: $\Delta\varphi$ and $\Delta\lambda$ are in meters,

(L): The distance of the point from the initial point F1 (m).

(α): The azimuth of the line between the point and F1(°)

Latitude, Longitude residuals of the fitting polynomials for Group1 (North-South direction)-solution points.

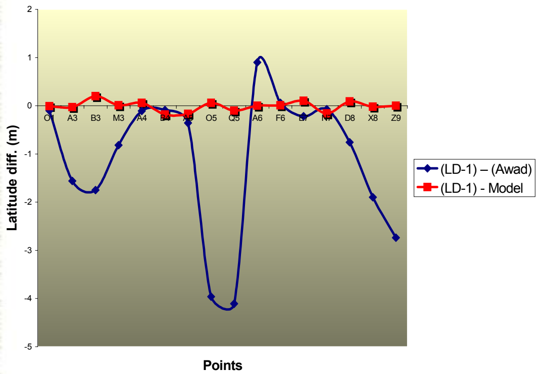
point	Azimuth (Deg)	Dist (km)	Latitude Residuals (m)			Longitude Residuals (m)		
Solution Points			1 st order	2nd order	3rd order	1 st order	2nd order	3rd order
O1	161	19.8	0.26	-0.02	-0.01	-1.32	0.01	0.01
A2	186	112.0	-0.64	-0.01	0.03	-1.12	-0.14	-0.04
L2	193	209.5	-0.34	0.09	-0.06	0.20	0.15	0.07
S2	194	298.6	0.16	-0.06	0.04	0.71	-0.12	-0.06
A3	180	306.7	0.66	-0.09	-0.03	0.98	0.21	0.04
M3	169	459.5	0.66	0.17	0.01	1.06	-0.10	-0.01
A4	164	505.0	-0.04	0.06	0.06	1.06	-0.03	-0.09
A5	167	681.1	-0.84	-0.27	-0.17	0.59	0.17	0.27
E5	168	747.2	-0.71	0.10	0.09	-0.06	-0.02	-0.15
L5	176	808.2	0.11	-0.01	0.07	-0.53	-0.33	-0.14
O5	178	843.2	0.27	0.01	0.06	-0.51	-0.07	0.03
Q5	179	859.5	0.20	-0.14	-0.10	-0.55	-0.01	0.04
R5	178	877.9	0.25	0.17	-0.01	-0.51	0.29	0.03
Abs sum			4.68	1.2	0.74	9.2	1.65	0.98
Iavgl			0.36	0.09	0.06	0.70	0.12	0.07
Stdv			0.25	0.07	0.04	0.36	1.14	0.07

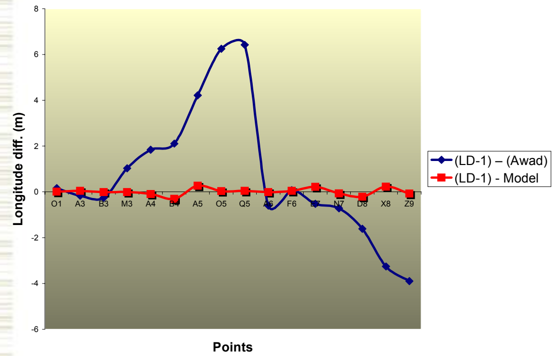
Latitude, Longitude residuals of the fitting polynomials for Group1 (North-South direction)-Check points.

point	Azimuth (Deg)	Dist (km)	Latitude Residuals (m)			Longitude Residuals (m)		
Check Points			1 st order	2nd order	3rd order	1 st order	2nd order	3rd order
B3	182	299.7	0.75	0.05	0.20	0.90	0.17	-0.01
B4	165	504.7	-0.13	-0.14	-0.18	0.80	-0.30	-0.30
P4	165	672.0	-0.91	-0.10	0.07	0.77	0.35	0.30
Y5	178	867.1	0.22	0.08	-0.02	-0.52	0.17	0.03
Abs sum			2.01	0.37	0.47	2.99	0.99	0.64
Iavgl			0.50	0.09	0.11	0.74	0.24	0.16
Stdv			0.33	0.03	0.07	0.13	0.07	0.14

Latitude, Longitude residuals of the fitting polynomials for Group2 (East-West direction)-solution points.

point	Azimuth (Deg)	Dist (km)	Latitude Residuals (m)		Longitude Residuals (m)	
Solution Points			1 st order	2nd order	1 st order	2nd order
F6	70	17.3	0.39	0.01	0.90	0.17
O1	161	19.8	0.52	-0.03	0.80	-0.30
E7	252	68.7	0.37	0.10	0.77	0.35
A6	85	128.4	-0.82	0.00	-0.52	0.17
N7	279	140.3	-0.31	-0.16	2.99	0.99
D8	292	242.4	-0.40	0.09	0.74	0.24
X8	290	427.9	-0.36	-0.02	0.13	0.07
Z9	285	584.3	0.61	0.00	0.90	0.17
Abs sum			3.78	0.41	0.80	-0.30
Iavgl			0.47	0.05	0.77	0.35
Stdv			0.02	0.00	-0.52	0.17





Conclusion

- ✓Using a model with suitable polynomial provides correction for the bias in the Egyptian triangulation networks in an easy way.
- ✓More points with high accurate WGS-84 coordinates are needed to assure those results and to make them more realistic.

THANK YOU