Remove-Restore Technique for Improving the Datum Transformation Process

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Problem Definition

- Where GPS is used extensively specially these days, The geodetic datum transformation became important issue.
- The accuracy of the coordinates of points in WGS-84 does not equal to the accuracy of the coordinates in the local datum.

Objectives

- Investigating the effect of using weighted coordinates in the transformation process.
- Investigating the effect of using modified (improved) local coordinates instead of using the local (ESA) coordinates in the transformation process.

Methodology

The computations are made in two groups:

- Group 1:is specified for the comparison between using equal weight and using weighted coordinates in the transformation process.
- Group 2:is specified for the investigation of using equal weighted coordinates, using improved coordinates, and using weighted coordinates in the transformation process.

Case study

- Data used
  - The geodetic coordinates of 34 first order triangulation stations known in the Egyptian Datum, 26 of them belong to Network I with precision 1:100,000 and 8 of them belong to Network II with precision 1:50,000.
  - 15 stations of 34 stations mentioned before belong to the High Accurate Reference Network (HARN) with precision 1:10,000,000.

Case study

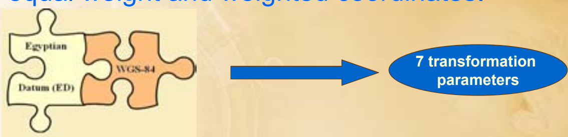
- Data used
  - Other 7 stations belong to the Egyptian Aviation project with precision 1:7000,000.
  - The other 12 stations belong to the National Agricultural Cadastral Network (NACN) with precision 1:1000,000.
  - The modified (improved) coordinates of 24 stations included in the above mentioned 34 stations known in the Egyptian datum.

Case study

- Software

Customized software using VB.NET consists of two main modules :

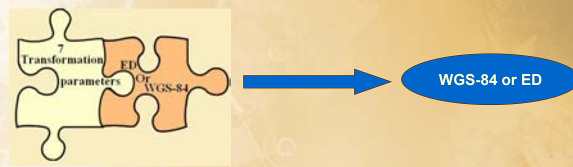
1. Module for calculating 7 transformation parameters with their standard deviation for equal weight and weighted coordinates.



Case study

- Software

2. Module for interpolating coordinates using 7 transformation parameters.

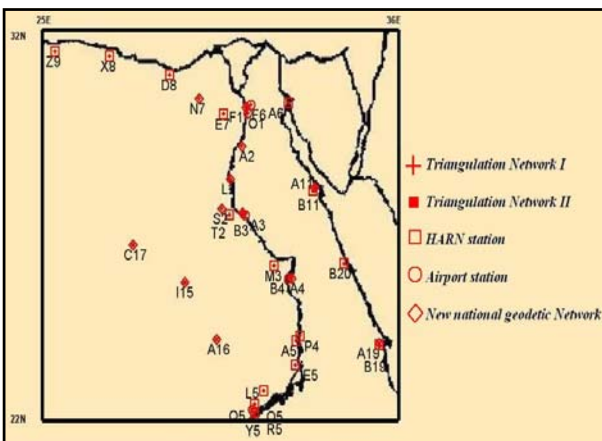


Case study

- To achieve the first target :
  - 5 solutions at this group has been done using 34,30,25,15,and 10 stations consecutively.
  - Local and WGS-84 coordinates of the mentioned 34 stations are used.
  - Seven transformation parameters are computed with their standard deviations.
  - The computations are done once with equal weight coordinates and once more using weighted coordinates.

Case study

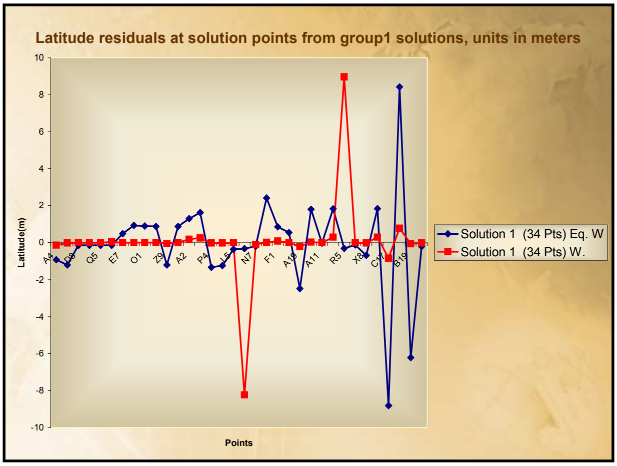
- Residuals at the stations are computed.
- 4 check points are computed in 30 stations solution and 5 check points for other solutions.

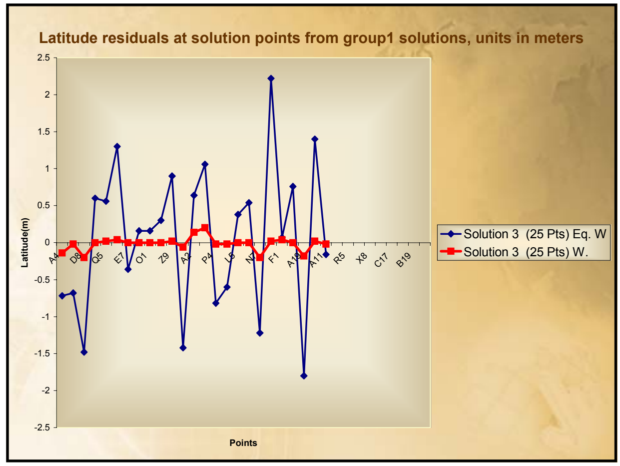


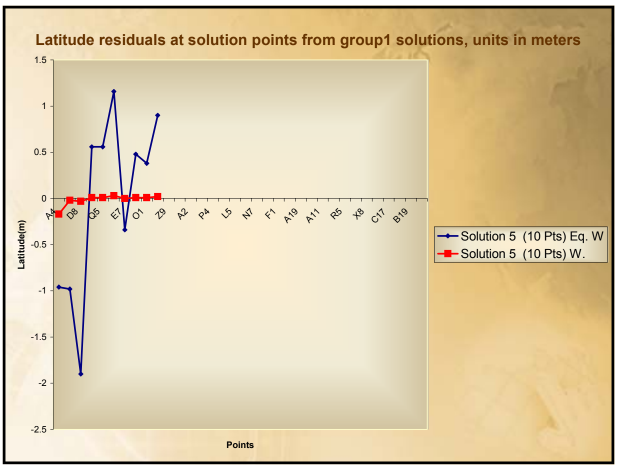
Results & Analysis

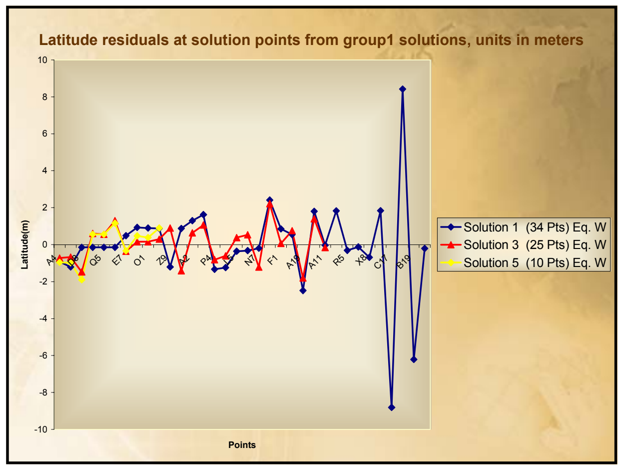
Seven parameters with their standard deviations from group 1 solutions

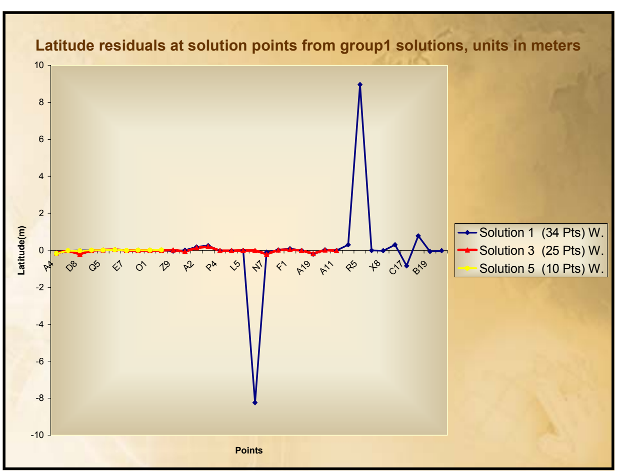
	Solution 1 (34Pts)		Solution 3 (25 Pts)		Solution 5 (10 Pts)	
	Eq. W	weighted	Eq. W	weighted	Eq. W	weighted
DX (m)	22.85 ±44.10	-3.98 ±0.02	-36.90 ±71.52	-51.29 ±0.02	-203.72 ±335.44	-201.51 ±0.04
DY (m)	82.03 ±51.57	105.42 ±0.02	118.93 ±89.12	138.42 ±0.02	266.83 ±615.75	263.87 ±0.05
DZ (m)	88.50 ±27.51	100.65 ±0.01	126.60 ±36.75	133.82 ±0.01	265.24 ±74.93	264.77 ±0.02
RX sec	-.904 ±4.87	-0.992 ±1.70	-0.677 ±7.04	-0.857 ±2.0	-0.601 ±3.42	-0.565 ±1.32
RY sec	-2.918 ±9.72	-3.563 ±2.49	-4.604 ±1.42	-4.995 ±2.83	-10.360 ±4.09	-10.316 ±1.44
RZ sec	6.847 ±1.57	7.893 ±1.06	8.822 ±2.74	9.520 ±1.31	15.089 ±1.78	14.983 ±3.01
S	-7.498 ±4.08	-6.872 ±1.52	-6.042 ±5.58	-6.203 ±1.74	-7.530 ±1.44	-7.547 ±2.7


Latitude residuals at solution points from group1 solutions, units in meters
Latitude(m)
Points
Solution 1 (34 Pts) Eq. W
Solution 1 (34 Pts) W.


Latitude residuals at solution points from group1 solutions, units in meters
Latitude(m)
Points
Solution 3 (25 Pts) Eq. W
Solution 3 (25 Pts) W.


Latitude residuals at solution points from group1 solutions, units in meters
Latitude(m)
Points
Solution 5 (10 Pts) Eq. W
Solution 5 (10 Pts) W.


Latitude residuals at solution points from group1 solutions, units in meters
Latitude(m)
Points
Solution 1 (34 Pts) Eq. W
Solution 3 (25 Pts) Eq. W
Solution 5 (10 Pts) Eq. W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Points
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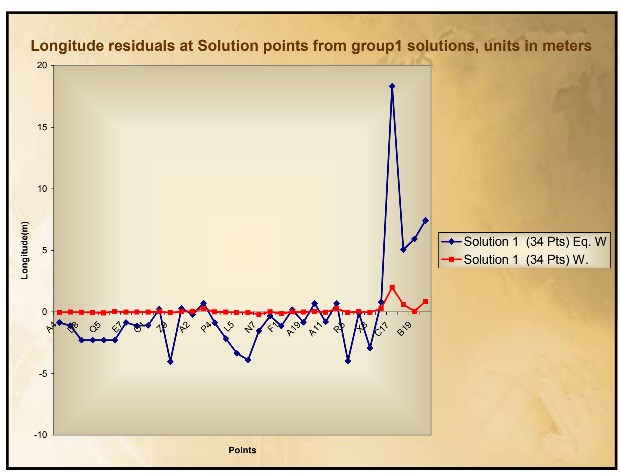
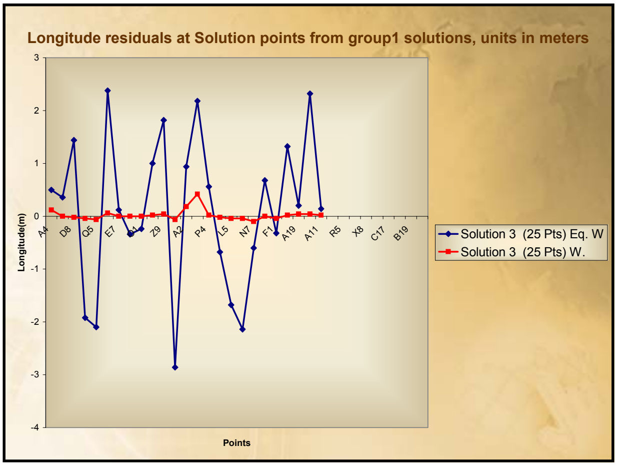
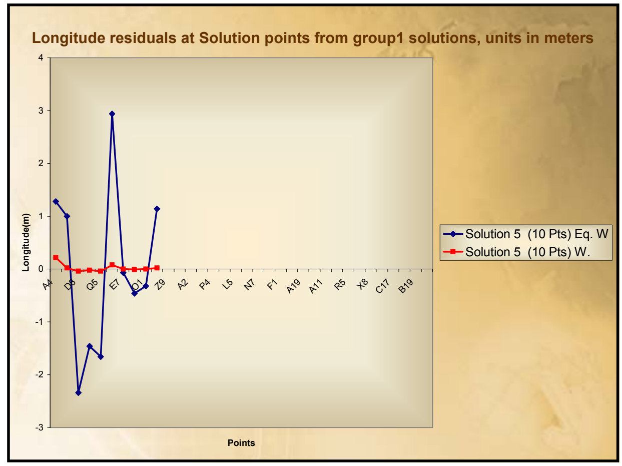
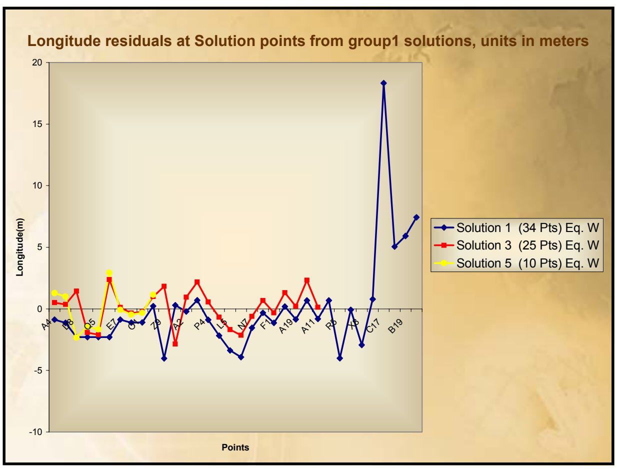
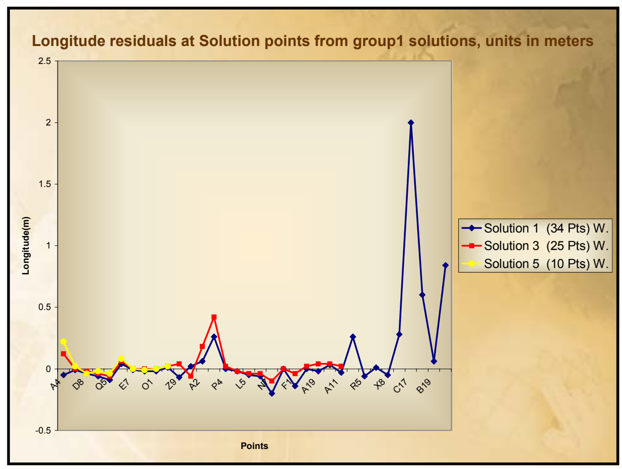
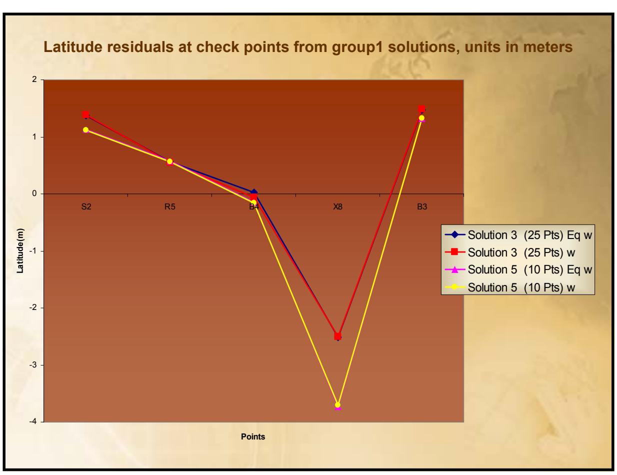

Longitude residuals at Solution points from group1 solutions, units in meters
Longitude(m)
Points
Solution 1 (34 Pts) Eq. W
Solution 1 (34 Pts) W.

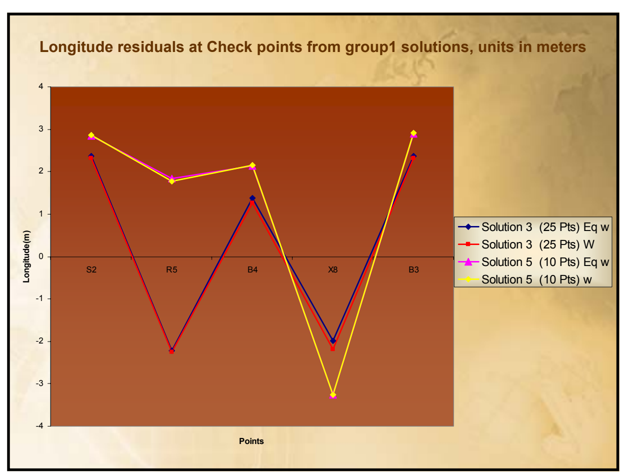

Longitude residuals at Solution points from group1 solutions, units in meters
Longitude(m)
Points
Solution 3 (25 Pts) Eq. W
Solution 3 (25 Pts) W.
A4
D8
Q5
E7
Z9
A2
P4
L5
N7
F1
A19
A11
R5
X8
C17
B19


Longitude residuals at Solution points from group1 solutions, units in meters
Longitude(m)
Points
Solution 5 (10 Pts) Eq. W
Solution 5 (10 Pts) W.
A4
D8
Q5
E7
O1
Z9
A2
P4
L5
N7
F1
A19
A11
R5
X8
C17
B19

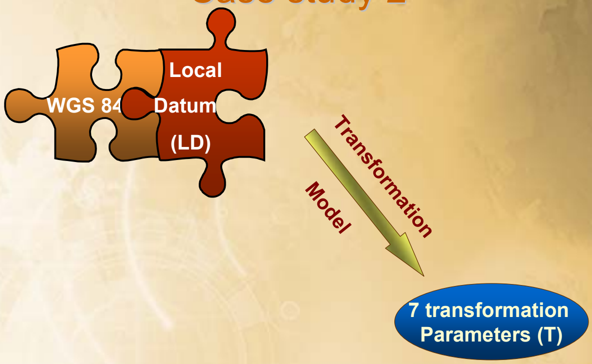

Longitude residuals at Solution points from group1 solutions, units in meters
Longitude(m)
Points
Solution 1 (34 Pts) Eq. W
Solution 3 (25 Pts) Eq. W
Solution 5 (10 Pts) Eq. W


Longitude residuals at Solution points from group1 solutions, units in meters
Longitude(m)
Points
Solution 1 (34 Pts) W.
Solution 3 (25 Pts) W.
Solution 5 (10 Pts) W.


Latitude residuals at check points from group1 solutions, units in meters
Latitude(m)
Points
S2
R5
B4
X8
B3
Solution 3 (25 Pts) Eq w
Solution 3 (25 Pts) w
Solution 5 (10 Pts) Eq w
Solution 5 (10 Pts) w


Longitude residuals at Check points from group1 solutions, units in meters
Longitude(m)
Points
S2
R5
B4
X8
B3
Solution 3 (25 Pts) Eq w
Solution 3 (25 Pts) W
Solution 5 (10 Pts) Eq w
Solution 5 (10 Pts) w

Case study 2



Case study

Case study 2

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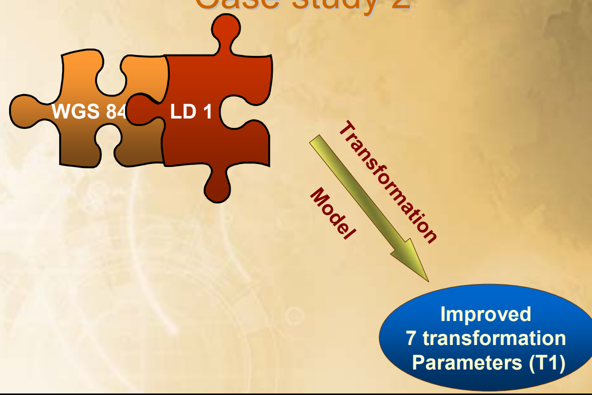
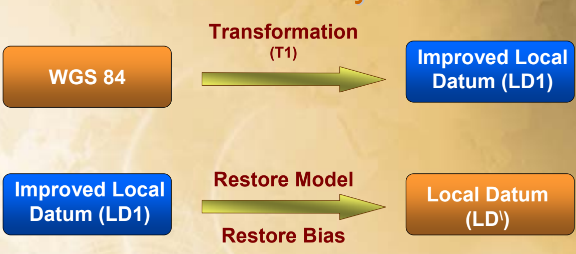


Case study 2



(LD') Homogenous with (LD)

but (LD') is more accurate

Case study 2

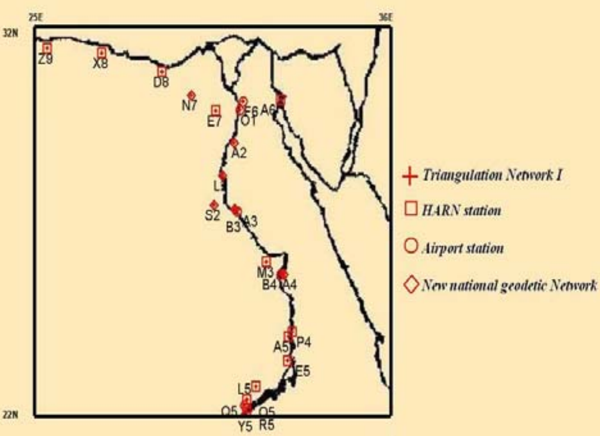
- To achieve the second target :
  - 2 solutions at this group have been done using 24 and 19 stations consecutively.
  - Local, Modified Local and WGS-84 coordinates of the mentioned 24 stations are used.
  - The local datum coordinates are modified (improved) using the way explained in [Saad and Elsayed, 2005].

Case study 2

- The improved coordinates are used with their corresponding WGS-84 coordinates to compute the transformation parameters.
- The parameters are used to transform the coordinates of the points.
- The transformed coordinates are Re-modified again to be back in ESA system of coordinates.
- Residuals at the stations are computed.
- 5 check points are used .

Case study 2

- Seven transformation parameters are computed with their standard deviations.
- The computations are done firstly with equal weight coordinates, secondly with the modified coordinates, and thirdly using weighted coordinates.
- In three cases, the residuals at solution stations are computed.

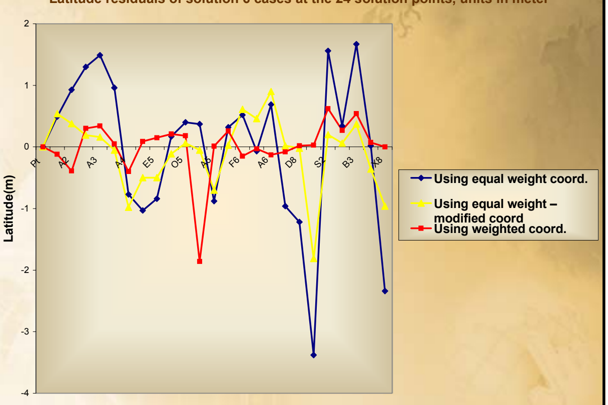


Results & Analysis

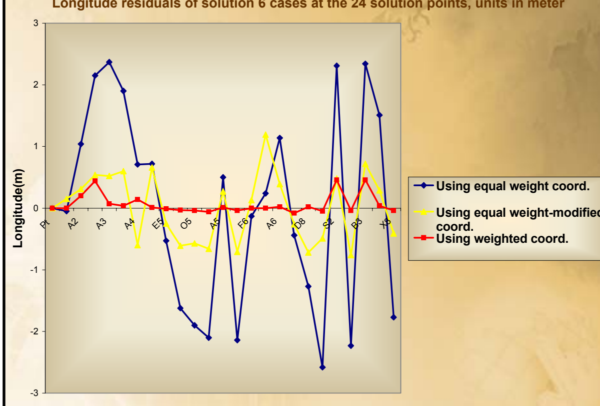
Seven parameters from the three cases of solution 6, using all 24 points.

Parameter	Using equal weight coord.	Using equal weight – modified coord.	Using weighted ESA coord.
DX (m)	-62.543 ± 92.78	-93.127 ± 61.97	-62.561 ± 0.02
DY (m)	167.819 ± 123.76	157.664 ± 71.58	168.112 ± 0.02
DZ (m)	128.524 ± 39.40	115.449 ± 40.39	128.338 ± 0.01
RX (sec)	-1.394 ± 7.418	-2.414 ± 1.143	-1.404 ± 3.770
RY (sec)	-5.049 ± 1.740	-5.838 ± 1.751	-5.047 ± 8.848
RZ (sec)	10.400 ± 3.836	9.940 ± 2.599	10.406 ± 1.946
S	-6.3633 ± 5.343	-1.0440 ± 4.703	-6.3693 ± 2.717

Latitude residuals of solution 6 cases at the 24 solution points, units in meter



Longitude residuals of solution 6 cases at the 24 solution points, units in meter

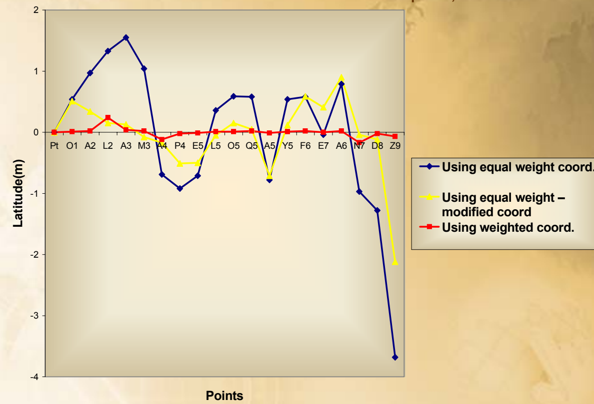


Results & Analysis

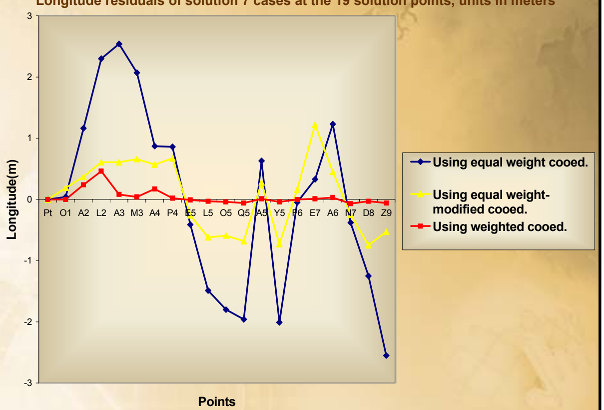
Seven parameters from the three cases of solution 7, using 19 points

Parameter	Using equal weights	Using equal weights – modified coord.	Using weighted ESA coord.
DX (m)	89.076 ± 76.47	-118.743 ± 76.08	-88.832 ± 0.02
DY (m)	186.685 ± 90.25	175.863 ± 89.79	186.714 ± 0.03
DZ (m)	152.199 ± 48.35	138.827 ± 48.11	151.82 ± 0.01
RX (sec)	-1.296 ± 1.453	-2.329 ± 1.446	-1.305 ± 2.21
RY (sec)	-6.012 ± 2.106	-6.787 ± 2.095	-6.001 ± 1.01
RZ (sec)	11.280 ± 3.256	10.7774 ± 3.240	11.276 ± 1.57
S	-6.4099 ± 5.848	-1.1350 ± 5.819	-6.413 ± 1.84

Latitude residuals of solution 7 cases at the 19 solution points, units in meters



Longitude residuals of solution 7 cases at the 19 solution points, units in meters

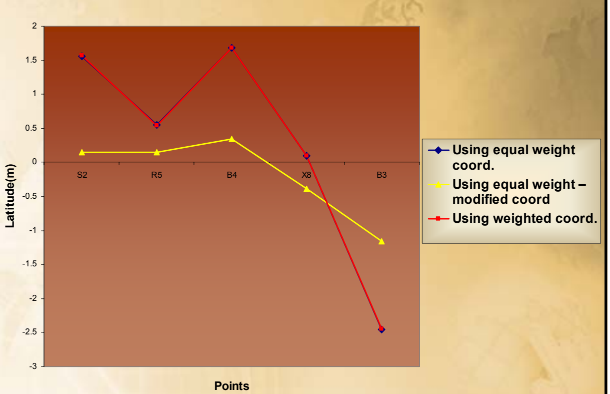


Results & Analysis

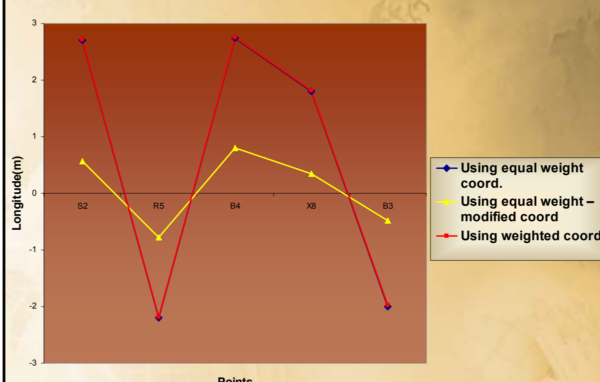
Latitude and longitude residuals at 5 check points from solution 7 cases, , units in meters

	Using equal weight coord.		Using equal weight – modified coord		Using weighted ESA coord.	
Pt	Lat res	Long res	Lat res	Long res	Lat res	Long res
S2	1.56	2.70	0.15	0.57	1.57	2.72
R5	0.55	-2.20	0.15	-0.78	0.54	-2.19
B4	1.68	2.74	0.34	0.80	1.68	2.75
X8	0.10	1.80	-0.39	0.35	0.10	1.81
B3	-2.45	-2.00	-1.16	-0.48	-2.44	-1.97
mean	1.27	2.29	0.43	0.60	1.26	2.29
St Dv	0.94	0.42	0.42	1.2	0.94	0.43

Latitude residuals at 5 check points from solution 7 cases, units in meters



Longitude residuals at 5 check points from solution 7 cases, units in meters



Conclusion

- **With respect to the first objective:**
  - ✓ Using weights improved the precision of the transformation parameters and improved also the residuals of the solution points significantly.
  - ✓ In the same time, using weights did not improve the residuals at the check points and the residuals at those check points were almost the same as in the case of using equal weighted coordinates.

Conclusion

- **With respect to the second objective:**
  - ✓ The transformation process was done in more accurate atmosphere.
  - ✓ The obtained latitude residuals were one **third** their corresponding values in the case of using ESA coordinates.
  - ✓ The obtained longitude residuals were one **fourth** their corresponding values in the case of using ESA coordinates.
  - ✓ This process is named here (remove – transform – restore).

Thank You