Gravity

An Essential Layer in Defence GIS
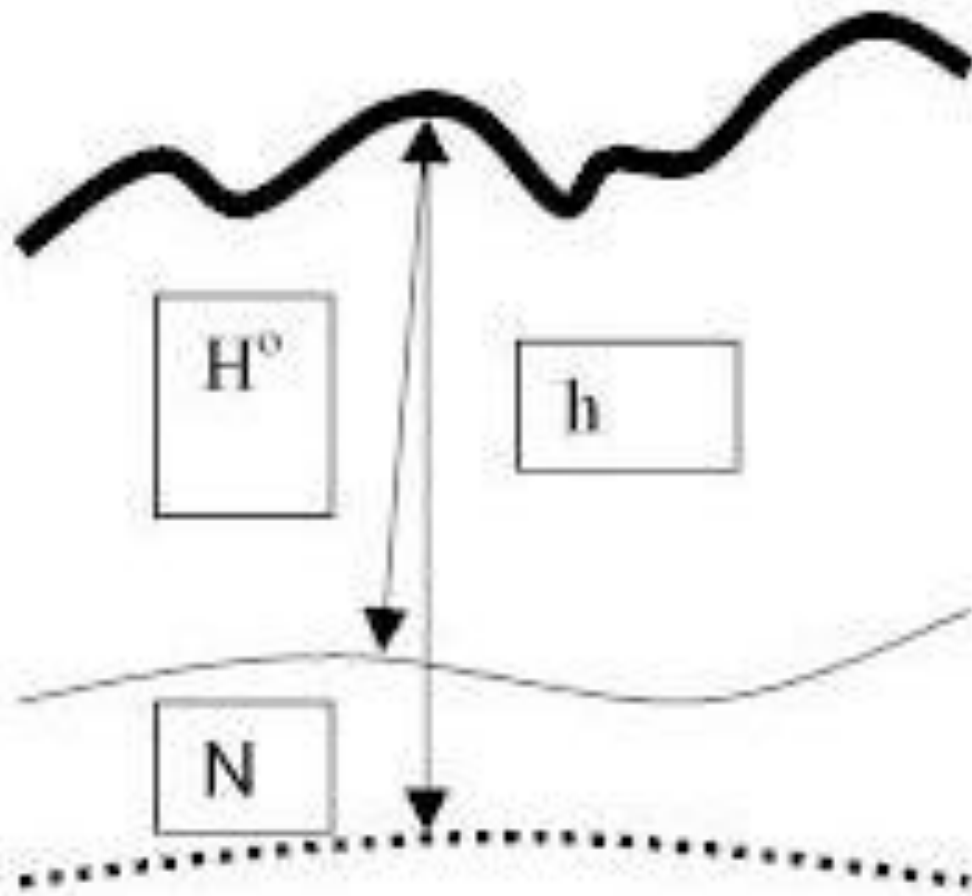
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mObiterra

SOLUTIONS (INDIA) PRIVATE LIMITED

terrain

H^o

h

geoid

N

ref. ellipsoid

Bhaskaracharya 5th Century CE in his **Surya Siddhanta**

"Objects fall on the earth due to a force of attraction by the earth. Therefore, the earth, planets, constellations, moon and sun are held in orbit due to this attraction."

Presentation Scope

- Role of Gravity in Defence Applications
- International Developments
- Indian Gravity
- Mobiterra's Investment
  - Trajectory Algorithm
  - Deriving & validating Gravity Maps
  - Plumb line
  - Comparing Gravity Models

International Efforts

- CHAMP
- GRACE
- GOCE

- Satellite only   & Combined Gravity Models

North
Latitude

40

West
Longitude

-110

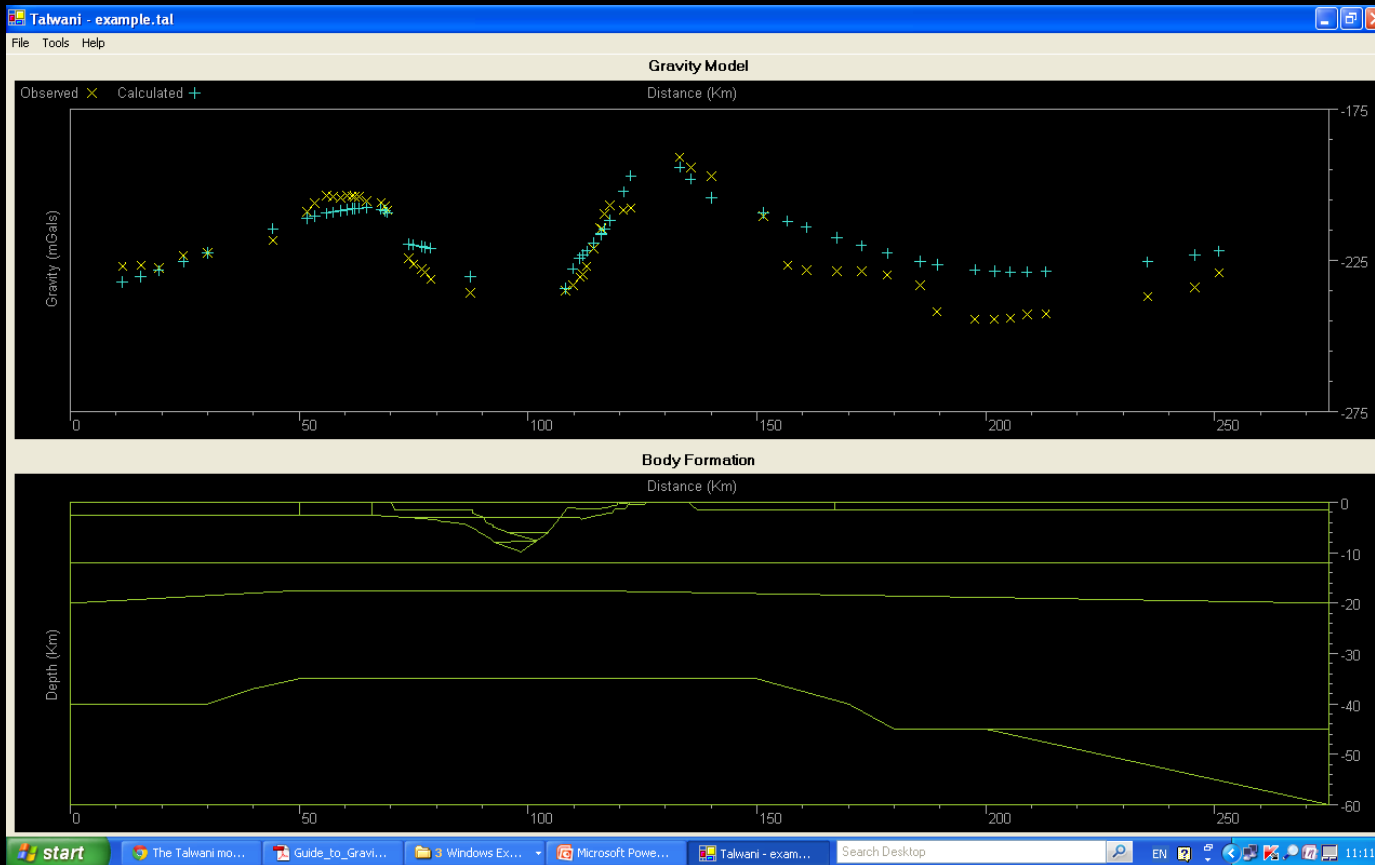-100

East
Longitude

39

South
Latitude

Search the Gravity Datase Search the Magnetic Data

Search Results
Number of Records found: 20043

27	LonNAD83	Elevngvd29m	Elevngvd88m	ObsGrvLess97
998300	-102.5003025	1375.00	1375.58	3649.90
950000	-101.3954399	0963.50	0963.89	3758.80
000000	-101.4004400	0963.50	0963.89	3758.90
341700	-105.6347289	2649.30	2650.78	3292.36
713300	-105.7718930	2696.40	2697.92	3287.78
250000	-107.5256114	2108.90	2110.45	3383.90
248300	-107.5254414	2108.90	2110.45	3383.90
930000	-105.5935577	2644.70	2646.16	3291.14
975000	-105.5980578	2648.20	2649.66	3288.16

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http://irpsrvgis00.utep.edu/repositorywebsite/Default.aspx

Interpreting Gravity Anomaly

Talwani

Indian Gravity

- G&RB, NGRI, WIHG,..
- 3500 GT Points, 17000 BMs, 35000   Gravity Stations

Source: Availability and Accessibility of Geodetic and Map data in India , M. N. Kulkarni

Impact of Gravity Anomalies on Ballistic Trajectories

- On height, range, time-of-flight of Ballistic Trajectory
  - Modifying the equations of motion with gravity anomaly

- On launch velocity
  - from the range if the angle of launch is known.
  - if the maximum height and range are known,

- On angle-of-launch
  - Affects the range.
  - If the launch velocity is known, the required angle of launch for a desired range can be calculated from the motion equations.
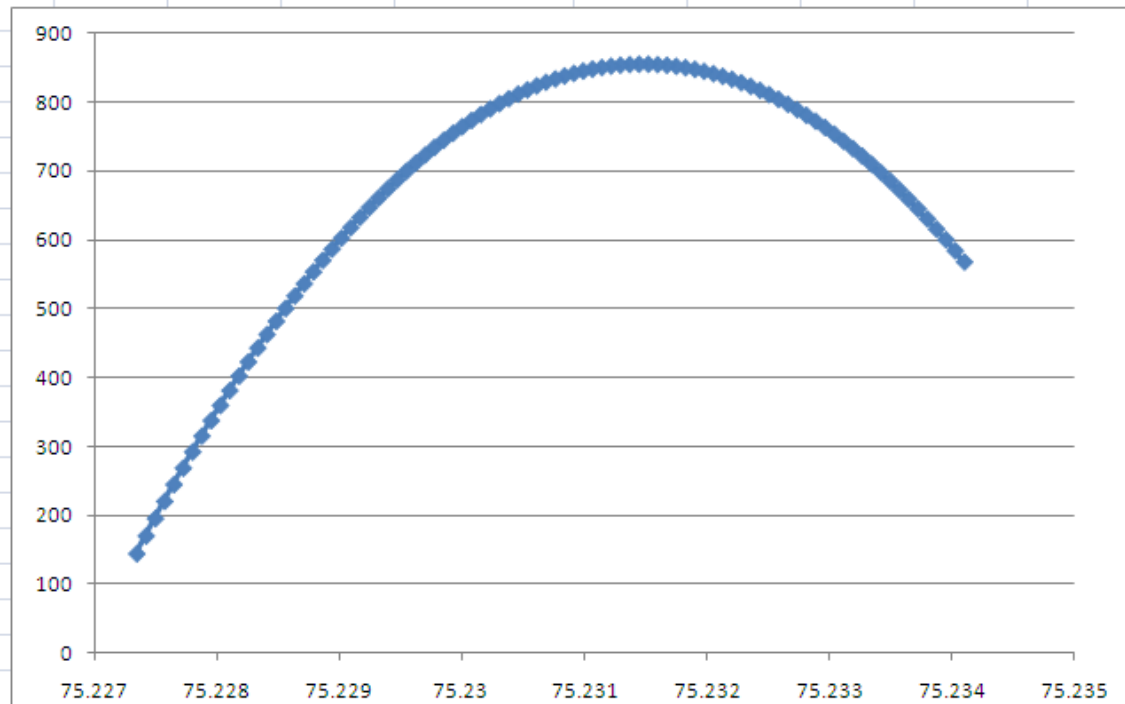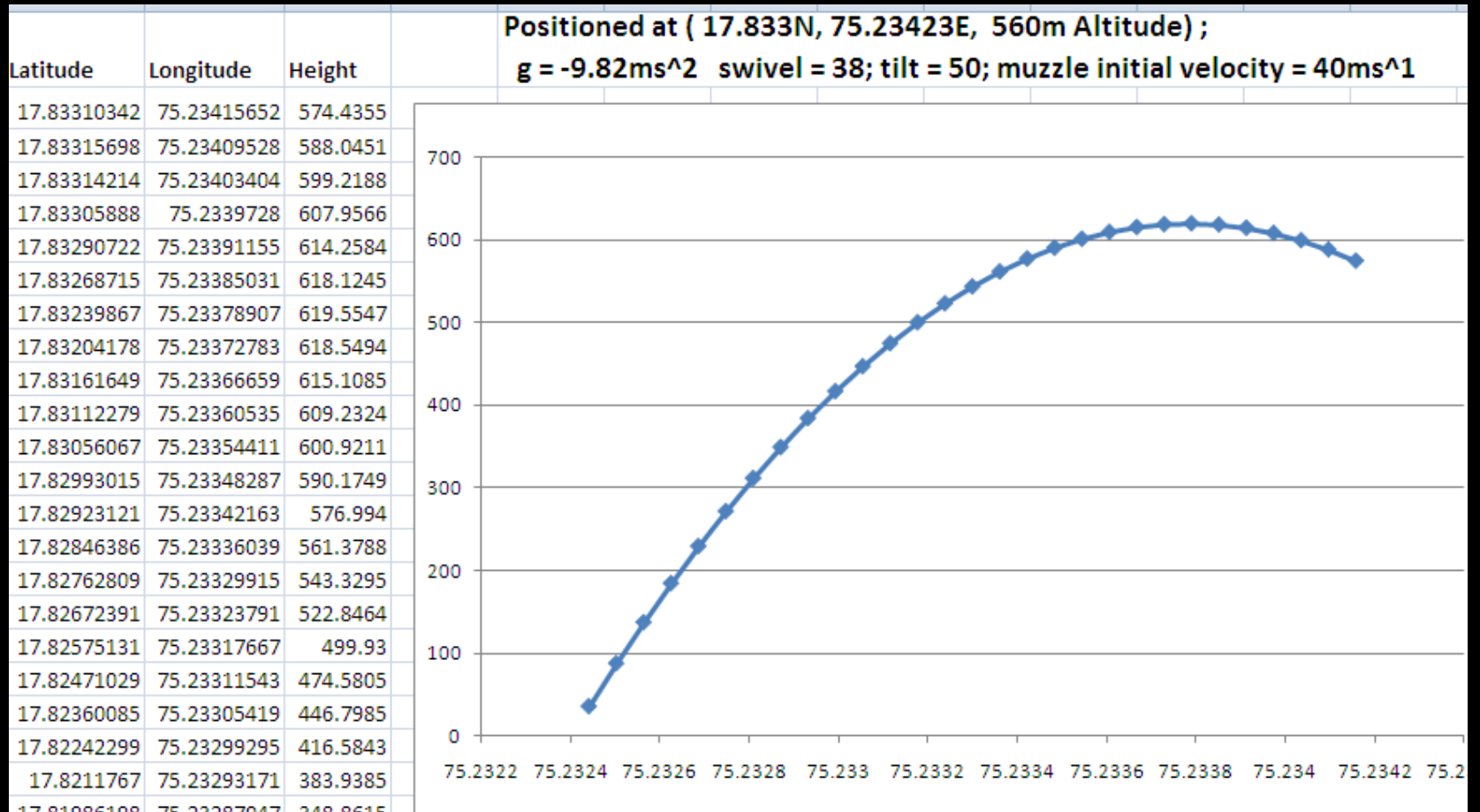
Trajectory – Variables

Various values of Canon-length, muzzle-velocity, swing, tilt
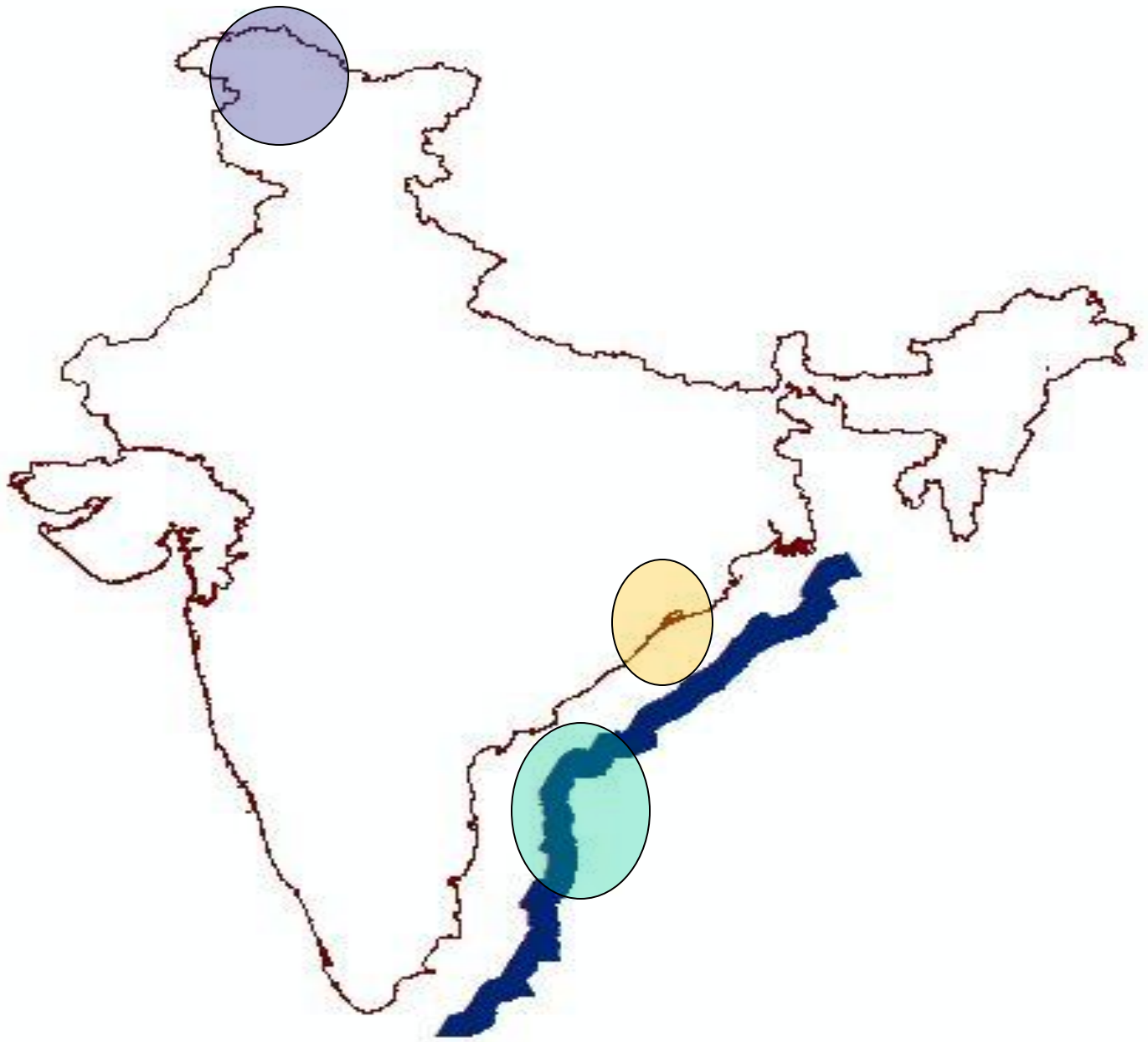Gravity: Constant and varying

case	input	check	Non-zero variables
1	tilt = 90	Vertical trajectory expected	All other than tilt, (constant g)
1g	Case 1 with varying gravity	No deviations from Case 1 trajectory	
2	swing=90; tilt=0;	horizontal trajectory expected	Muzzle-velocity, canon constant g)
2g	Case 2 with varying gravity	By-and-large horizontal, but with fluctuations expected	
3	Muzzle velocity=0	Only one epoch expected	All other than muzzle (constant g)
3g	Case 3 with varying gravity	Same as Case 3	
4	Canon-length=0;swing=90;tilt=0	The first epoch and the input position matches. This also checks the *geodetic* → *ECEF* →*geodetic* transformation.	Muzzle-velocity (constant g)
4g	Case 4 with varying gravity	Same as case 4	

75.2341009	17.83311163	567.7622
75.23402491	17.83316393	584.1458
75.23394891	17.83320271	600.0482
75.23387292	17.83322799	615.4695
75.23379692	17.83323975	630.4096
75.23372093	17.83323799	644.8686
75.23364494	17.83322273	658.8464
75.23356894	17.83319395	672.343
75.23349295	17.83315166	685.3585
75.23341696	17.83309586	697.8928
75.23334097	17.83302654	709.9459
75.23326497	17.83294371	721.5179
75.23318898	17.83284737	732.6088
75.23311299	17.83273752	743.2185
75.233037	17.83261416	753.3471
75.23296101	17.83247728	762.9946
75.23288502	17.83232689	772.1609
75.23280903	17.83216299	780.8462
75.23273304	17.83198558	789.0504
75.23265705	17.83179466	796.7735
75.23258106	17.83159022	804.0156
75.23250508	17.83137228	810.7766
75.23242909	17.83114082	817.0567
75.2323531	17.83089584	822.8557

swivel 0; tilt 45

Latitude	Longitude	Height
17.83310342	75.23415652	574.4355
17.83315698	75.23409528	588.0451
17.83314214	75.23403404	599.2188
17.83305888	75.2339728	607.9566
17.83290722	75.23391155	614.2584
17.83268715	75.23385031	618.1245
17.83239867	75.23378907	619.5547
17.83204178	75.23372783	618.5494
17.83161649	75.23366659	615.1085
17.83112279	75.23360535	609.2324
17.83056067	75.23354411	600.9211
17.82993015	75.23348287	590.1749
17.82923121	75.23342163	576.994
17.82846386	75.23336039	561.3788
17.82762809	75.23329915	543.3295
17.82672391	75.23323791	522.8464
17.82575131	75.23317667	499.93
17.82471029	75.23311543	474.5805
17.82360085	75.23305419	446.7985
17.82242299	75.23299295	416.5843
17.8211767	75.23293171	383.9385
17.81996199	75.23287047	348.8615

Positioned at (17.833N, 75.23423E, 560m Altitude) ;

g = -9.82ms^2   swivel = 38; tilt = 50; muzzle initial velocity = 40ms^1
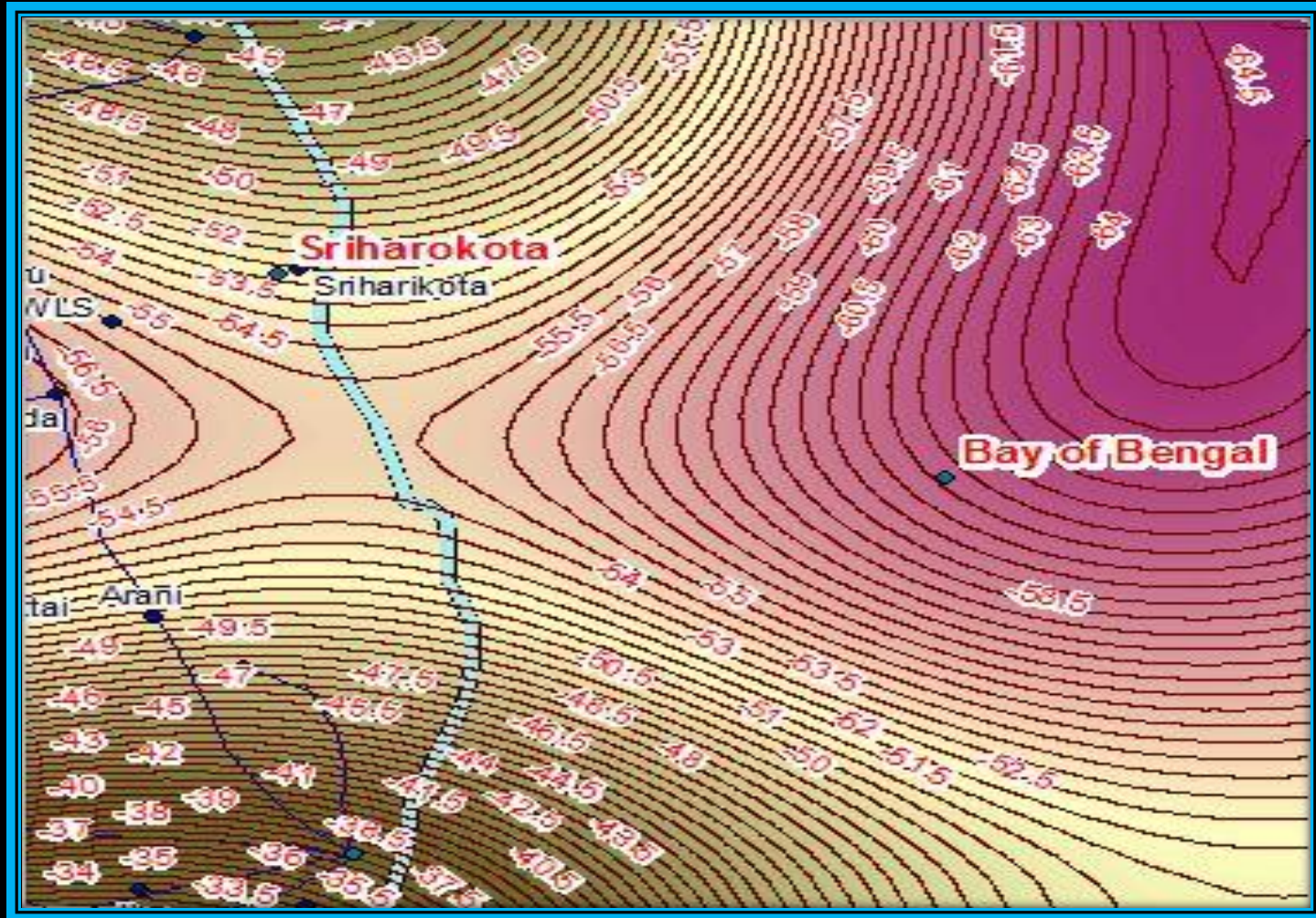
$$\text{Gravity} = f(X, Y, Z, t)$$

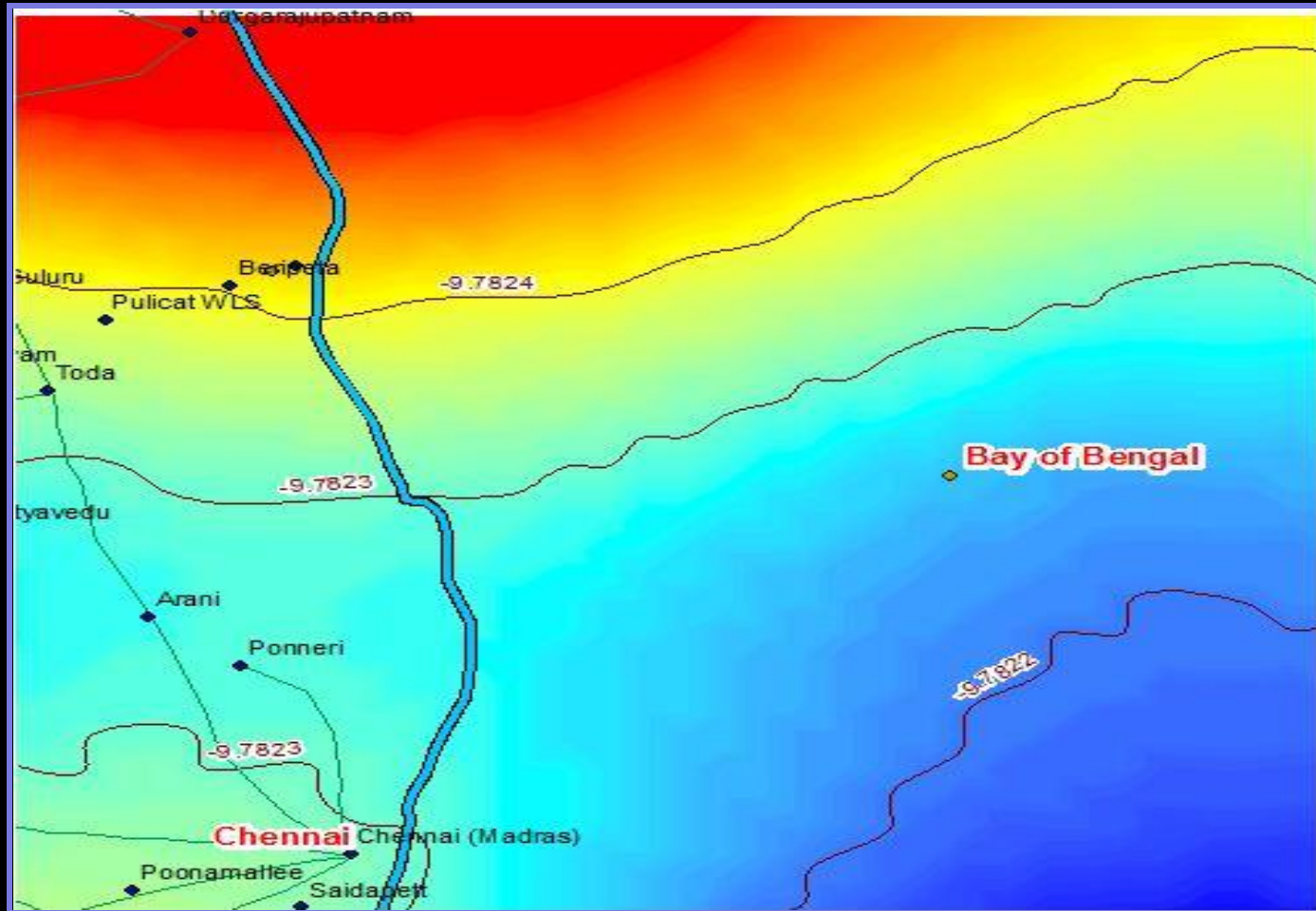# Gravity Anomaly Contour Interval = 0.5 mGal

Range: - 65 to -32 mGal

Acceleration Due to Gravity

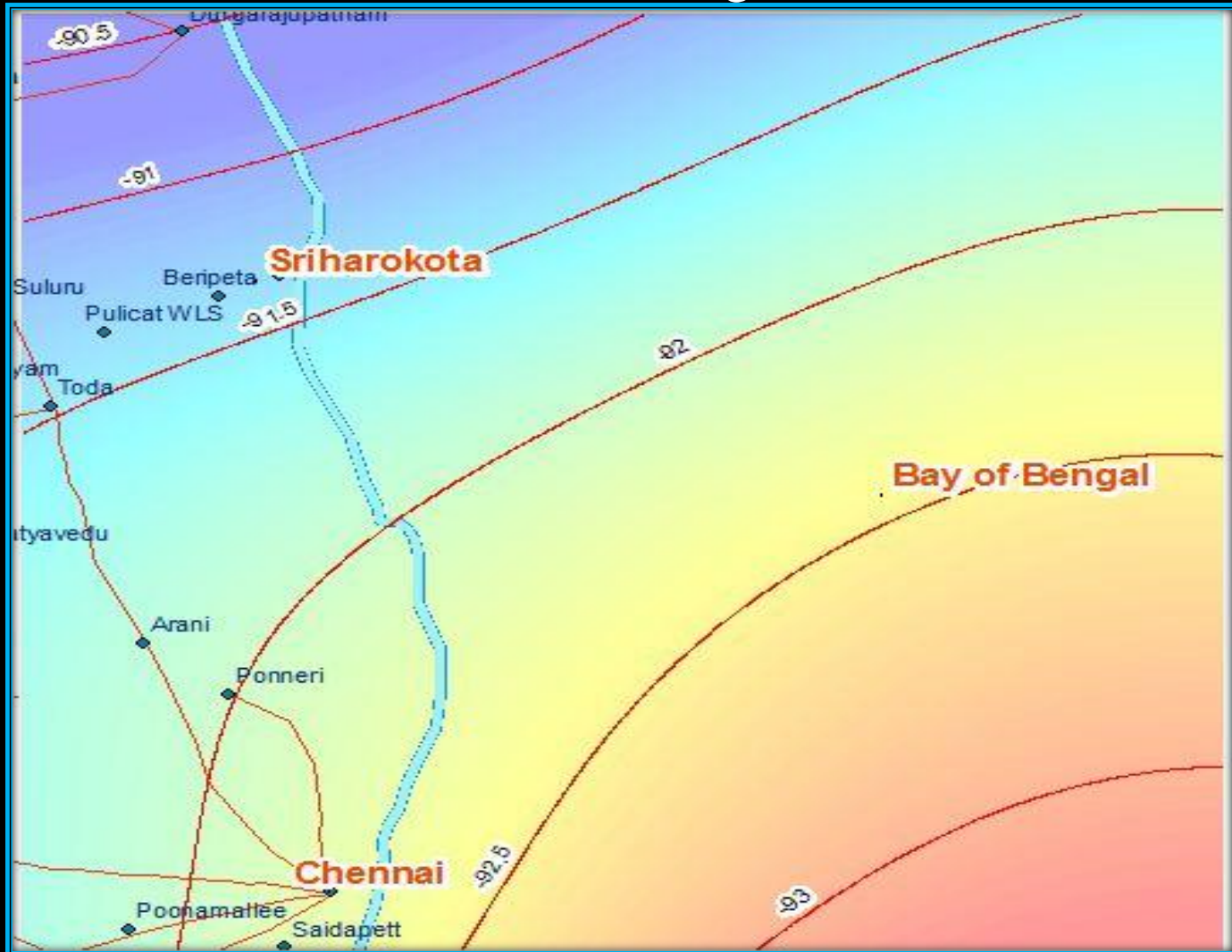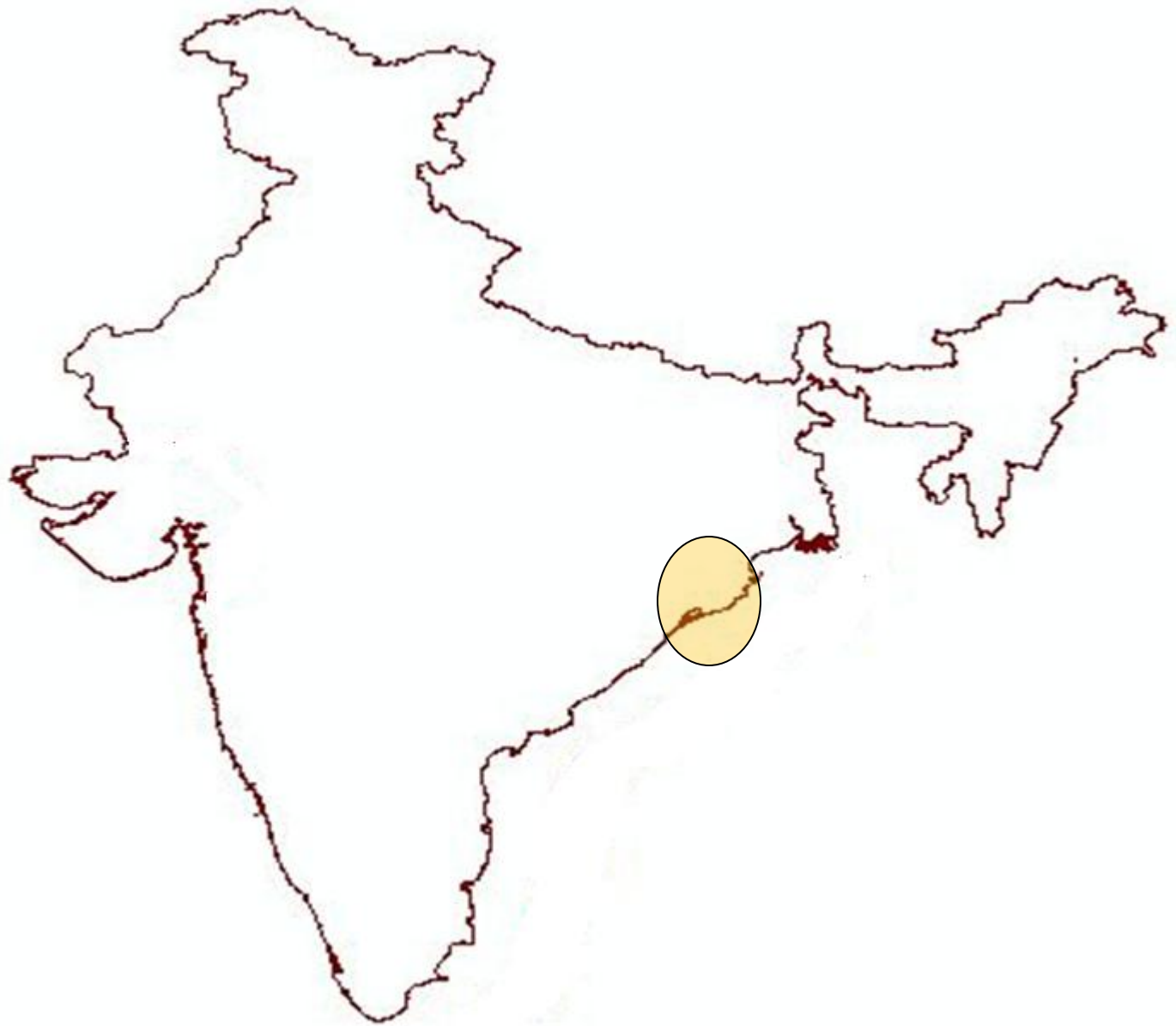Contour Interval = 0.0001m/sec^2

Range   -9.78264 to -9.78214 m/sec^2

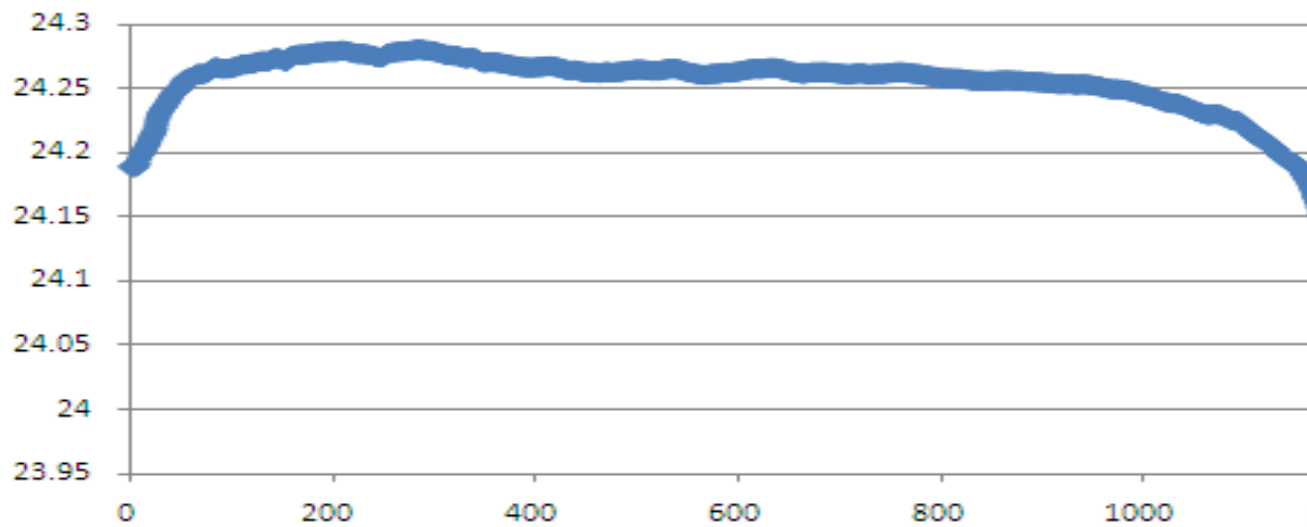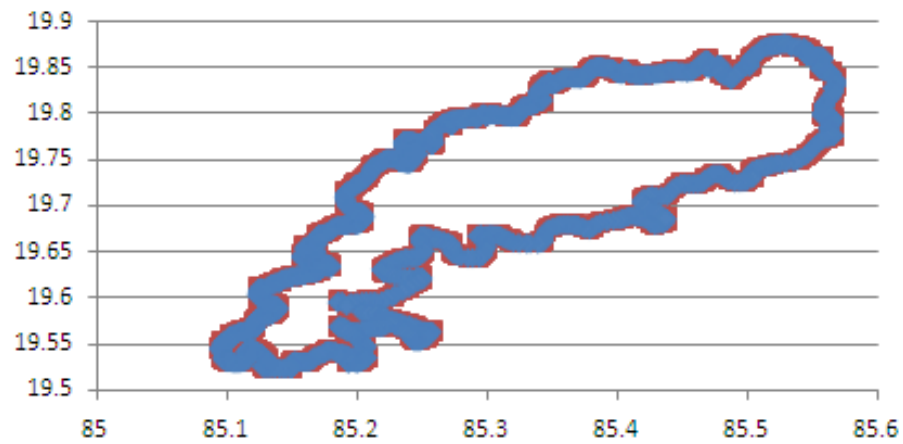# Geoid Height Contour Interval = 0.5m
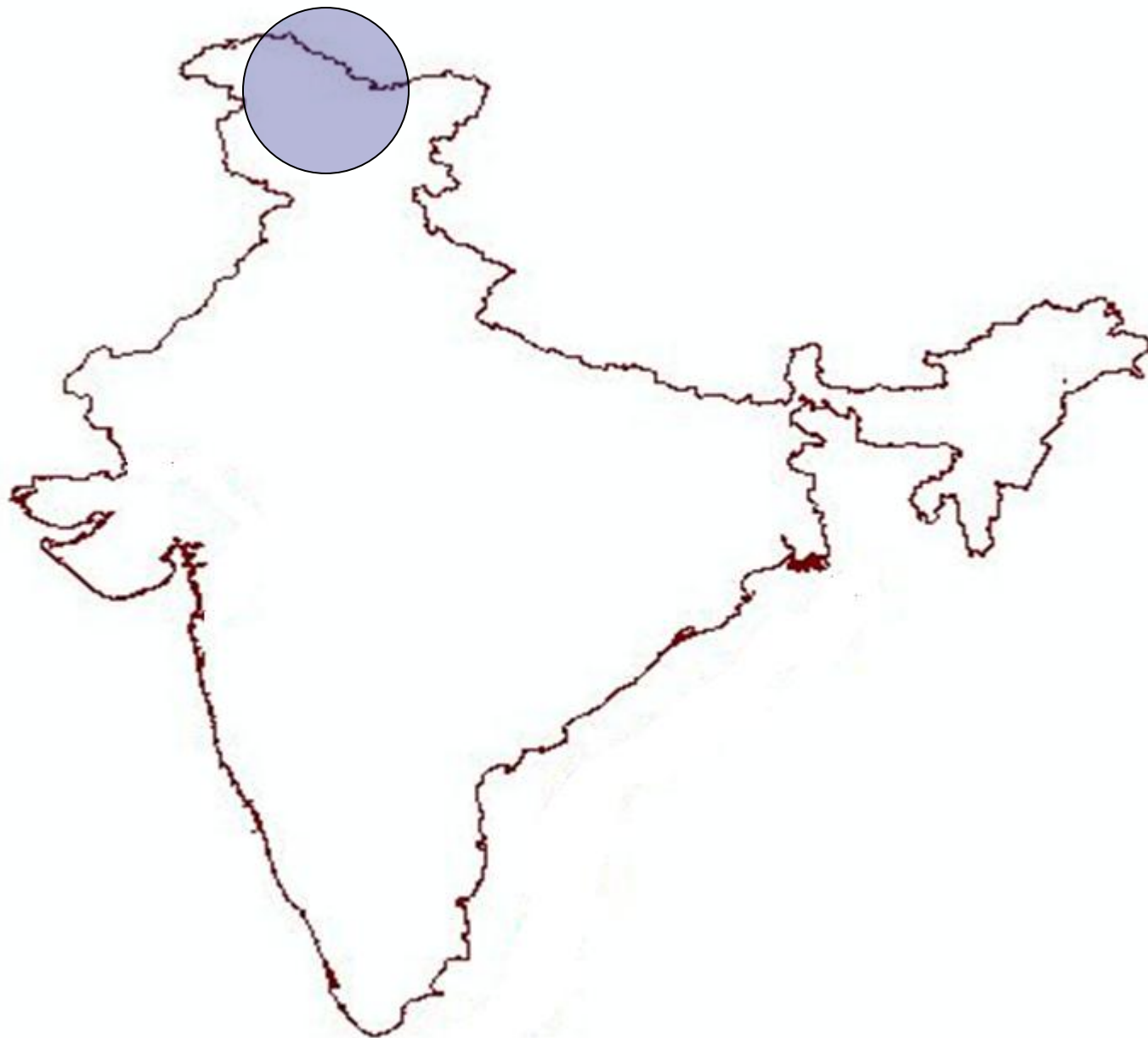## Range: -90.329 to -93.369m

Shoreline Condition
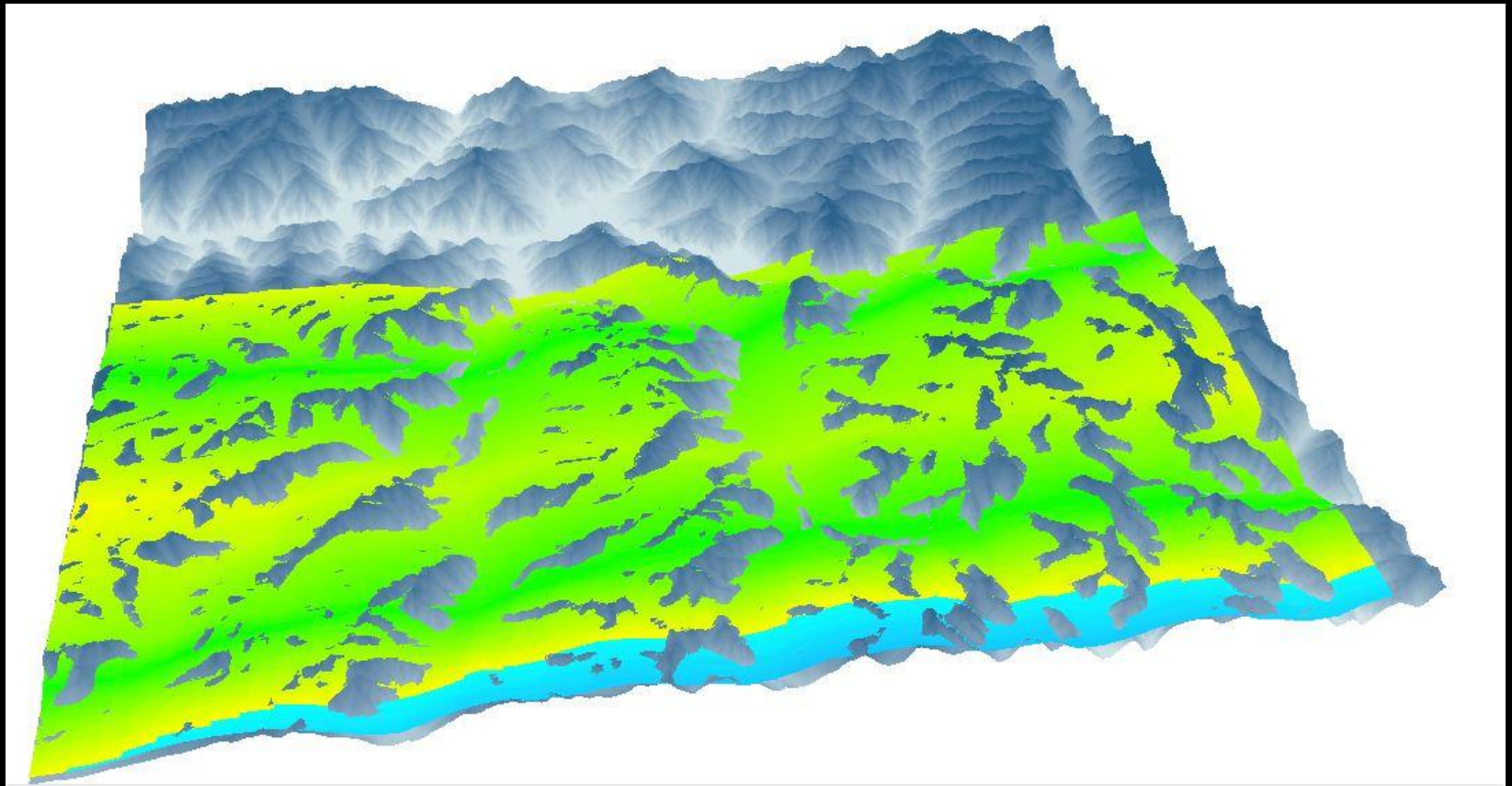
Chilika lake: 60km x 20km
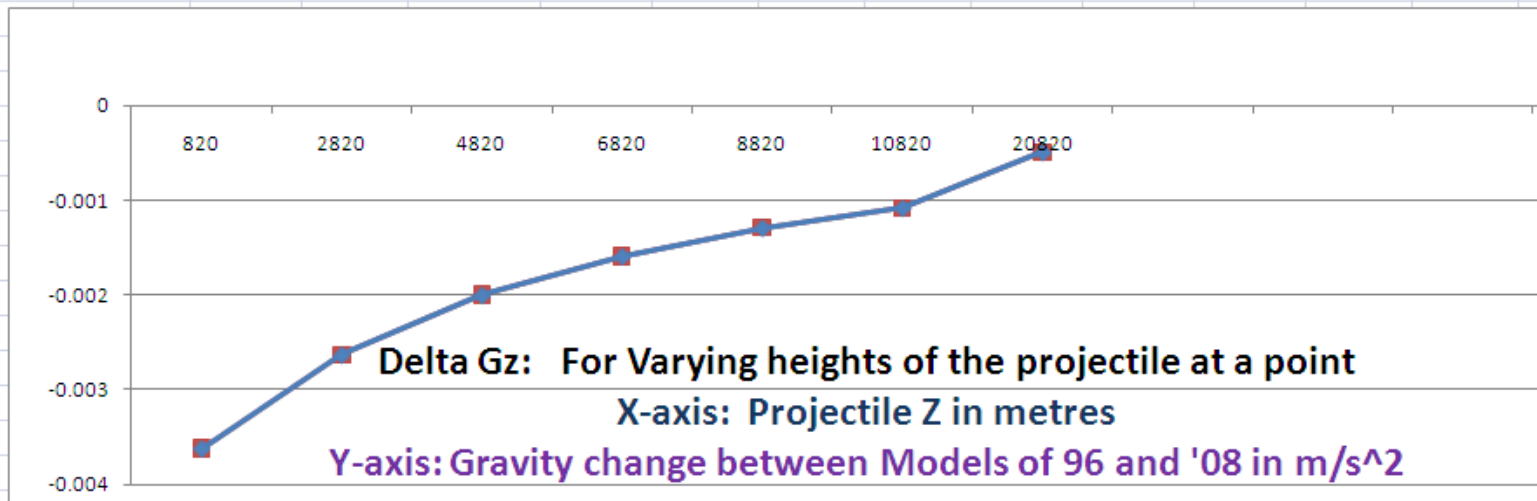
Chilika Water Outline

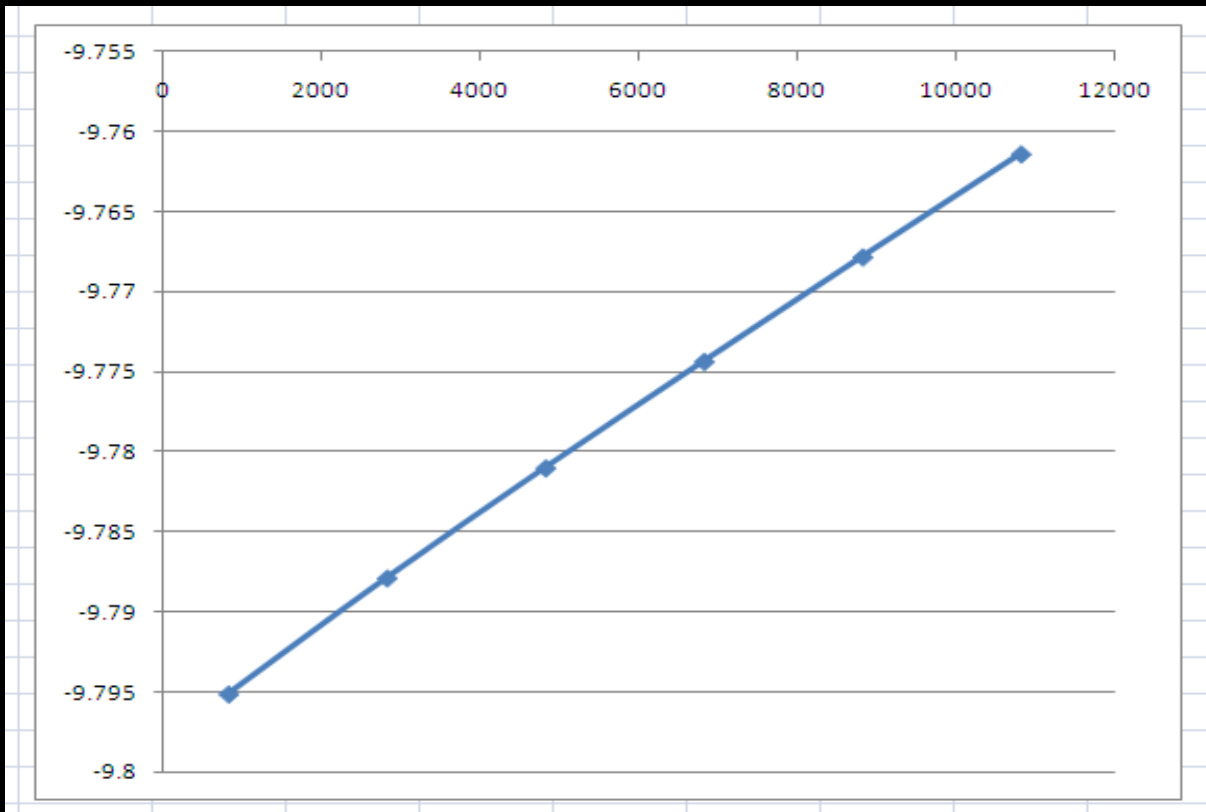# Gravity Anomaly Map of Kargil Environs overlaid on the Terrain Model

Comparing 96 & 2008 Gravity Models

Everest with Varying Z			Model2008 Gx,Gy, Gz			Model 96 Gx, Gy, Gz			delta Gx	delta Gy	delta Gz	N-96	N-08
27d59'17N	86d55'32E	820	0.0001	0.00134	-9.79513	-0.00038	0.00087	-9.79151	0.00124	0.00047	-0.00362		
27d59'17N	86d55'32E	2820	0.00009	0.00122	-9.78788	-0.00033	0.00086	-9.78525	0.00113	0.00036	-0.00263		
27d59'17N	86d55'32E	4820	0.00006	0.00114	-9.781	-0.00029	0.00086	-9.779	0.00108	0.00028	-0.002		
27d59'17N	86d55'32E	6820	0.00002	0.00108	-9.77435	-0.00025	0.00085	-9.77276	0.00106	0.00023	-0.00159	-28.7437	-28.4947
27d59'17N	86d55'32E	8820	-0.00001	0.00103	-9.76782	-0.00021	0.00084	-9.76653	0.00104	0.00019	-0.00129		
27d59'17N	86d55'32E	10820	-0.00003	0.001	-9.76139	-0.00018	0.00083	-9.76031	0.00103	0.00017	-0.00108		
27d59'17N	86d55'32E	20820	-0.00004	0.00088	-9.72983	-0.00004	0.00076	-9.72934	0.00092	0.00012	-0.00049		
			Average Gz	-9.77106			-9.77106						
			StanDev Gz	0.046174			0.046174						

Delta Gz: For Varying heights of the projectile at a point
X-axis: Projectile Z in metres
Y-axis: Gravity change between Models of 96 and '08 in m/s^2

Altitude Vs Acceleration of Gravity

Space curve

In Conclusion

- Indian Defence Systems are *into* GIS.
- Gravity needs to be part of D-GIS
  - Improved positioning & deployment
  - Discreet use of weaponry
- *Gravity forms part of core GeoInt*

Discussion

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