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Development of Geoid Model-A case study on Western India

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SURVEY OF INDIA

DEHRADUN (INDIA)

Height ?

- The word 'height' has no singular meaning.
- Height may be defined as the distance measured along normal, between a point and the base (reference surface).
- We need a reference surface which is associated to gravity field of the earth.
- For practical purposes, the heights should fulfill water flow criteria i.e. Water flow from higher to lower level.

Ellipsoid as height Datum ?

- Ellipsoid is a mathematical or geometrical surface with NO practical association to actual gravity of the earth.
- Height above ellipsoid are only geometrical.
- Not necessarily fulfill the criteria of water flow.
- Water flow criteria is satisfied by Geoid referenced heights.

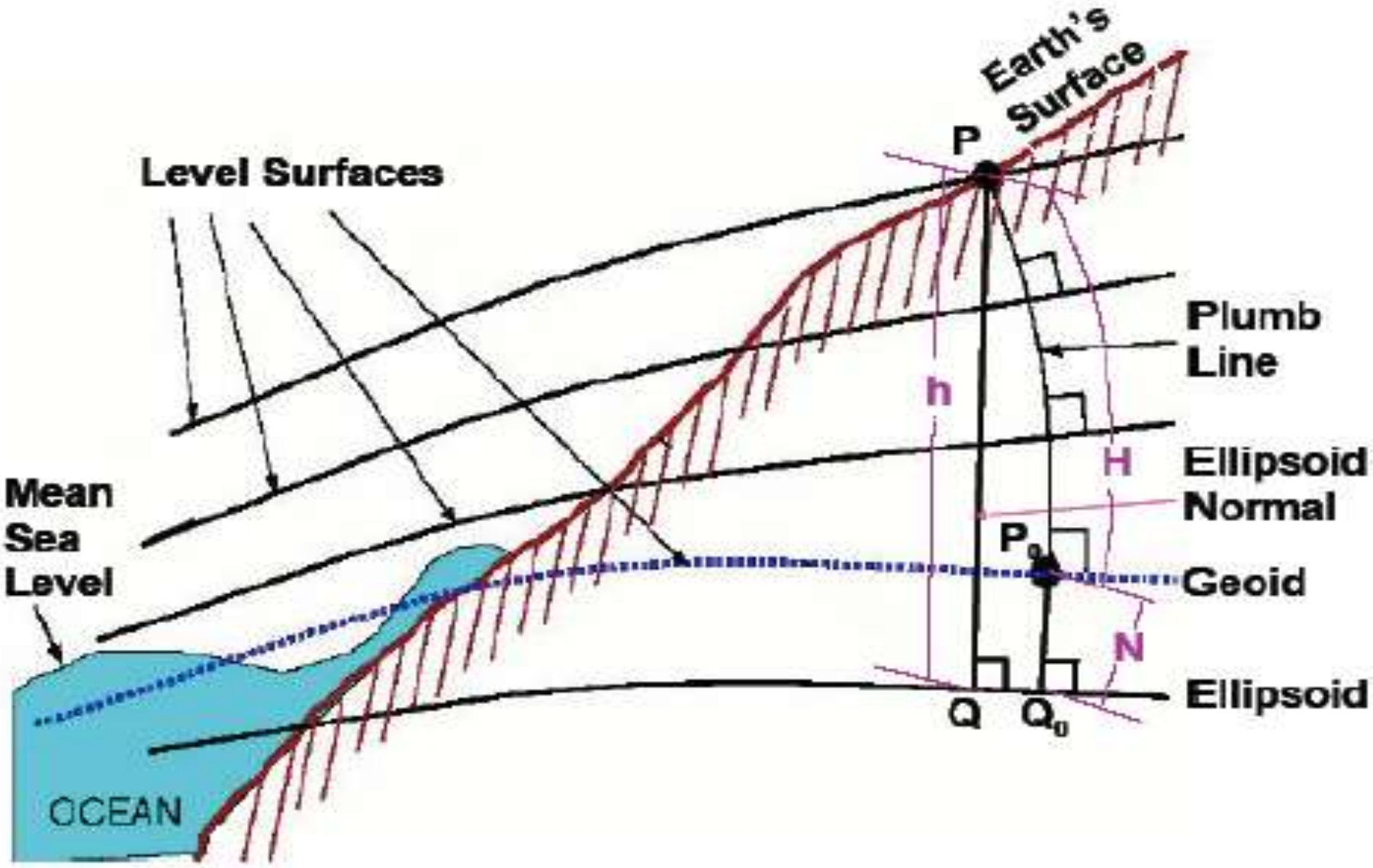
Geoid / MSL

- Geoid is an equi-potential surface of Earth's gravity field. It is closely approximated by MSL (Mean Sea Level) neglecting long term effect of sea surface topography (SST).

- MSL heights are provided by spirit levelling which is tedious, time consuming & expensive.

Geoid Model

$$h = N + H.$$



Why do we need a geoid model?

- It will save **time & money** of spirit levelling.
- Help in Reducing the time of completion of Engineering & Development projects.
- Will also help scientific community.

DATA REQUIREMENT

- Free air gravity anomaly (FA) in and around the area of interest.
- A suitable Global Geo-potential Model (GGM) like EGM96 etc.
- A high-resolution digital elevation model (DEM) like SRTM etc. for computation of terrain effects.
- Well distributed data of **N** i.e. GNSS observations on Bench Marks in the area.

Overview of Methodology

- **Widely adopted RCR (Remove-Compute-Restore) method has been used to develop Geoid Model**

REMOVE STEPS

Residual FA, $\Delta g_{res} = \Delta g_{FA} - \Delta g_{TC/RTM} - \Delta g_{GGM}$

COMPUTE STEPS

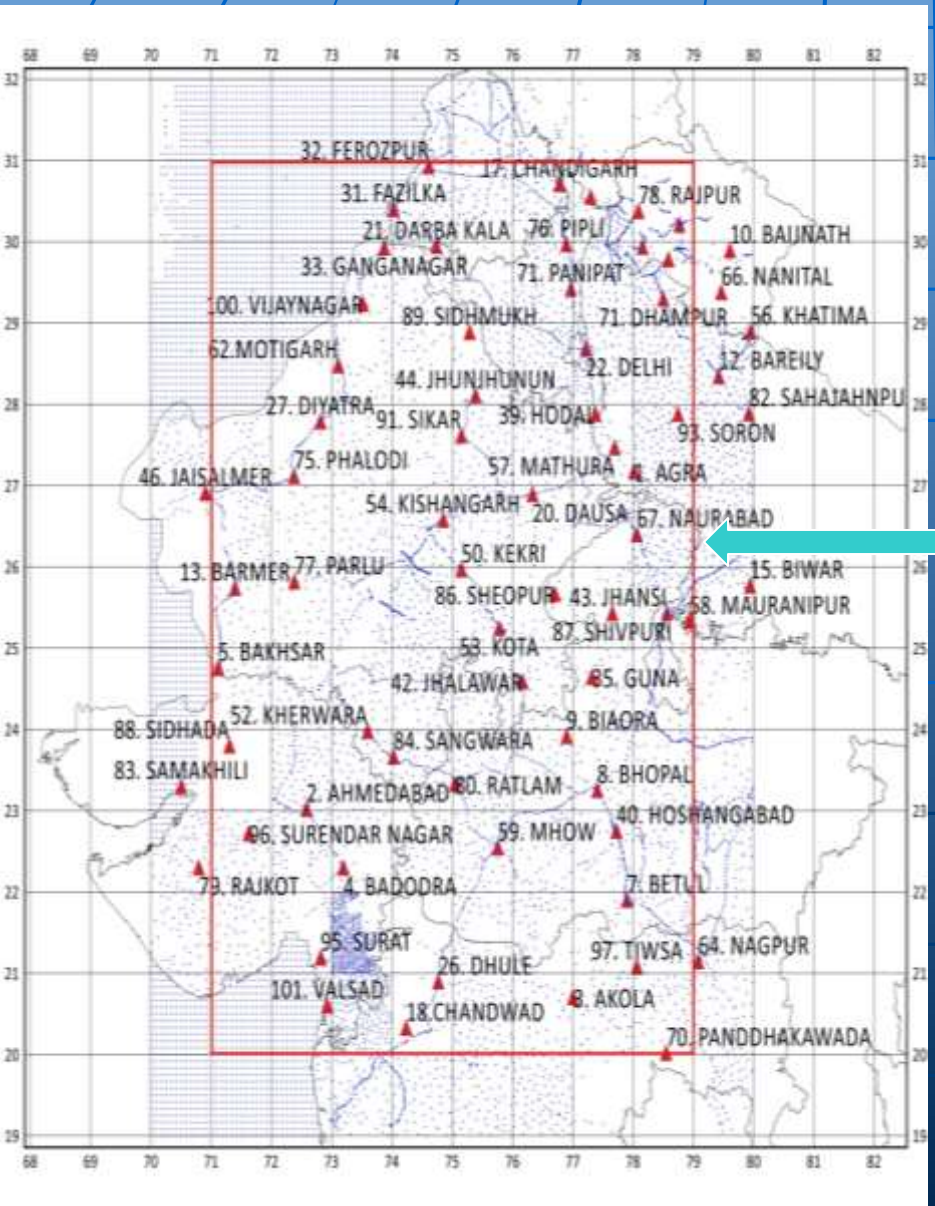
$$N_{res} = \frac{R}{4\pi\gamma} \iint_{\sigma} \Delta g_{res} S(\psi) d\sigma$$

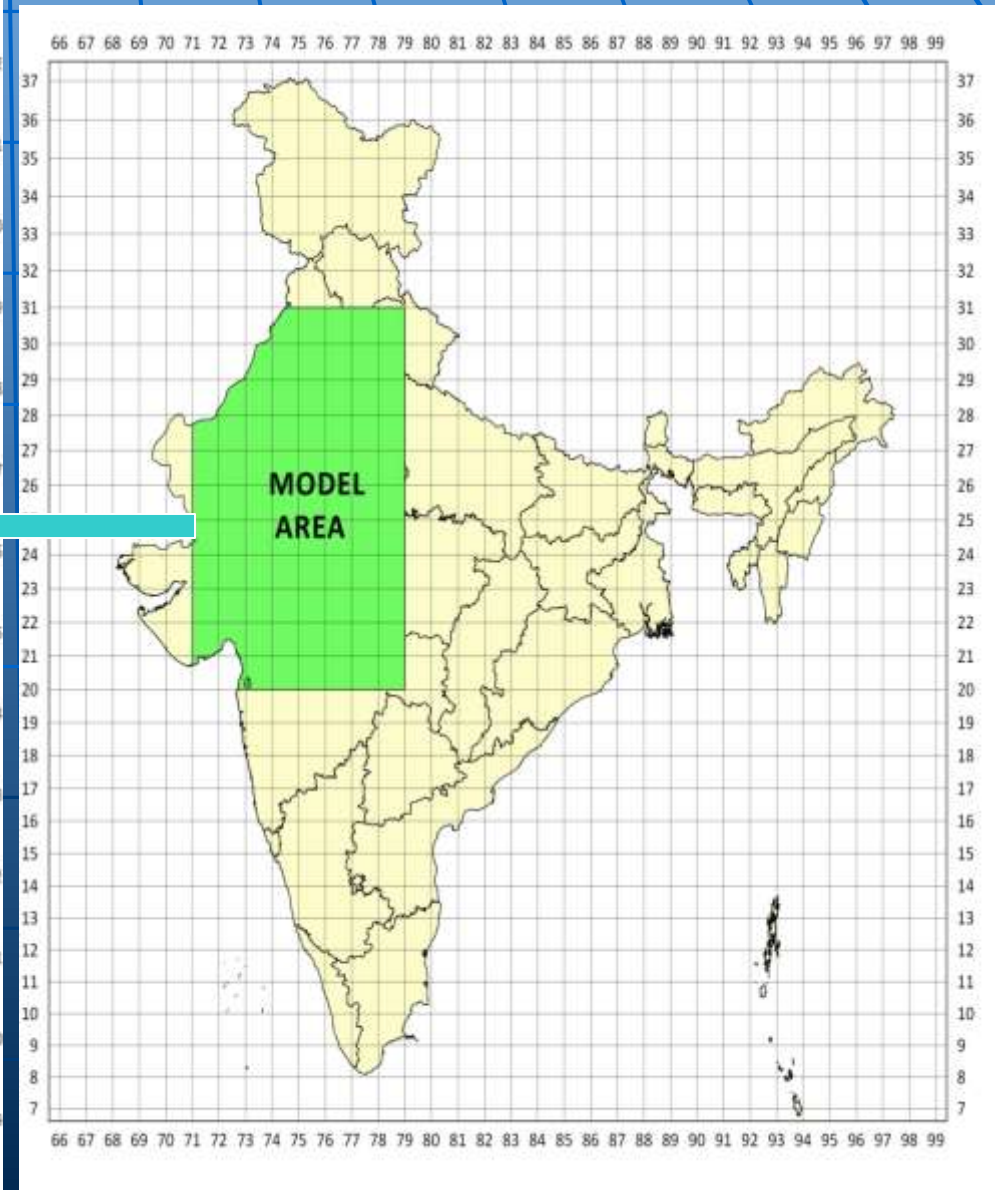
Stokes formula with optimized Kernel

RESTORE STEPS

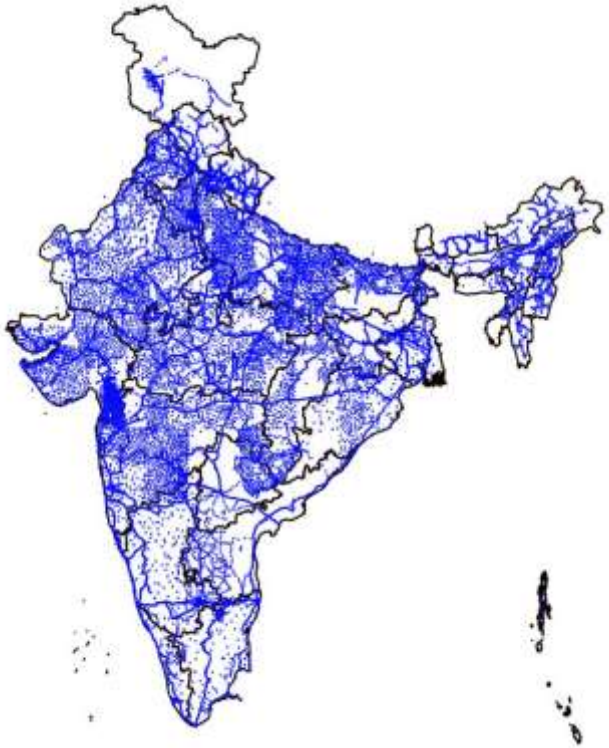
$$N_{gravimetric} = N_{res} + N_{GGM} + N_{terrain}$$

Study Area

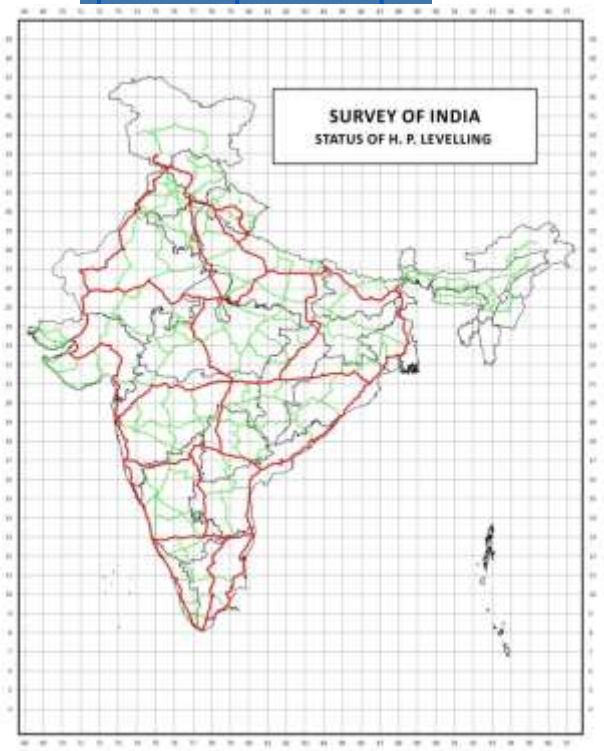

32. FEROZPUR
12. CHANDIGARH
31. FAZILKA
78. RAJPUR
21. DARBA KALA
76. PIPLI
10. BAIJNATH
33. GANGANAGAR
71. PANIPAT
66. NANITAL
100. VIJAYNAGAR
89. SIDHMUKH
71. DHAMPUR
56. KHATIMA
62.MOTIGARH
22. DELHI
12. BAREILY
44. JHUNJHUNUN
82. SAHAJAHNPU
27. DIYATRA
91. SIKAR
39. HODAL
93. SORON
75. PHALODI
57. MATHURA
4. AGRA
46. JAISALMER
54. KISHANGARH
20. DAUSA
67. NAURABAD
50. KEKRI
13. BARMER
77. PARLU
15. BIWAR
86. SHEOPUR
43. JHANSI
58. MAURANIPUR
87. SHIVPURI
5. BAKHSAR
53. KOTA
42. JHALAWAR
85. GUNA
52. KHERWARA
9. BIAORA
88. SIDHADA
84. SANGWARA
83. SAMAKHILI
8. BHOPAL
2. AHMEDABAD
80. RATLAM
40. HOSHANGABAD
96. SURENDAR NAGAR
59. MHOW
79. RAJKOT
4. BADODRA
7. BETUL
95. SURAT
97. TIWSA
64. NAGPUR
26. DHULE
101. VALSAD
8. AKOLA
18.CHANDWAD
70. PANDDHAKAWADA


MODEL
AREA

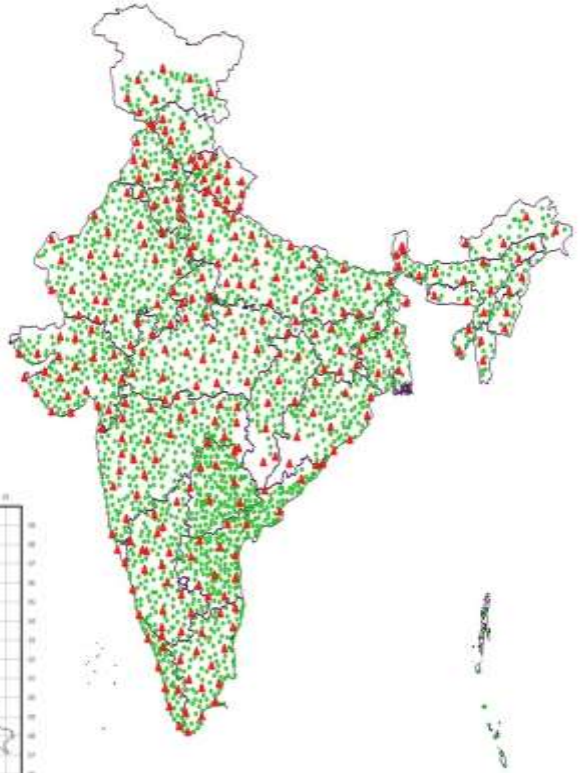
Data Available with Survey of India



Gravity coverage



Spirit Levelling data



Ground Control Points

Selection of GGM

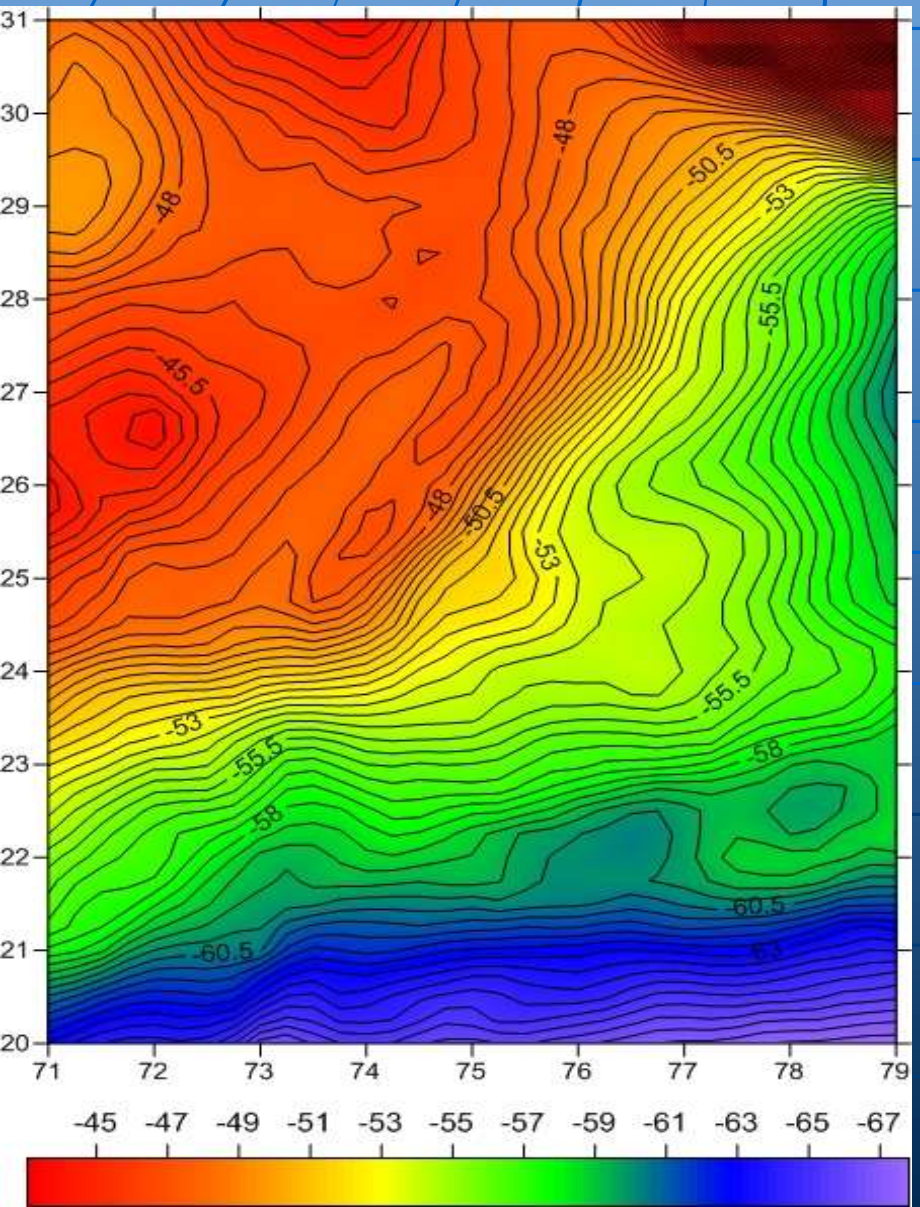
Global geo-potential model plays a very important role in development of regional geoid.

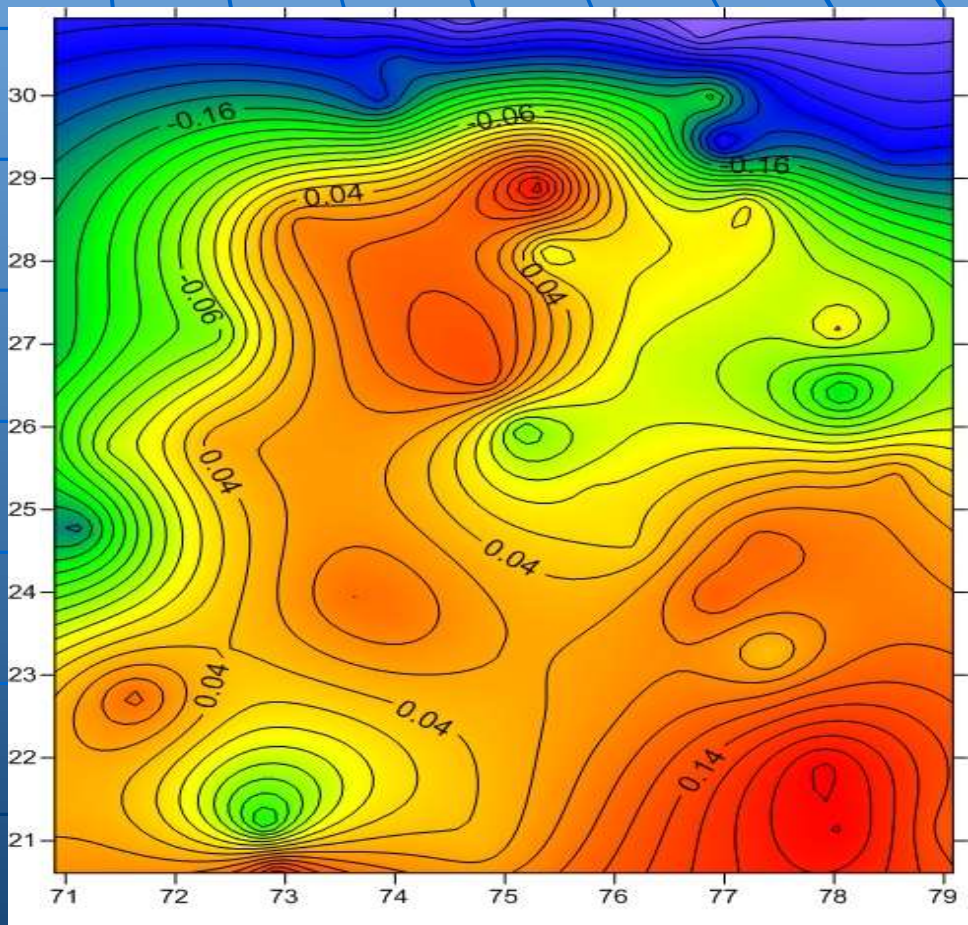
Sl. No.	Global Gravity Model	Min	Max	Mean	RMSE
1	XGM 2016 (degree 719)	-0.730	2.185	0.858	0.928
2	GOCO05C (degree 720)	-0.808	2.232	0.846	0.924
3	GGM05C (degree 360)	-0.737	2.225	0.832	0.914
4	GECO (degree 720)	-0.699	2.246	0.859	0.931
5	EIGEN6C4 (degree 720)	-0.696	2.260	0.871	0.939
6	EIGEN6C3STAT (degree 720)	-0.678	2.227	0.879	0.947
7	EGM08 (degree 720)	-0.828	2.248	0.894	0.968
8	EGM08GOCE5 (degree 720)	-0.797	2.331	0.868	0.957

'GGM05C', the best fitting model in the area of interest, has been selected for considering the effect of long wavelength.

Gravimetric Geoid

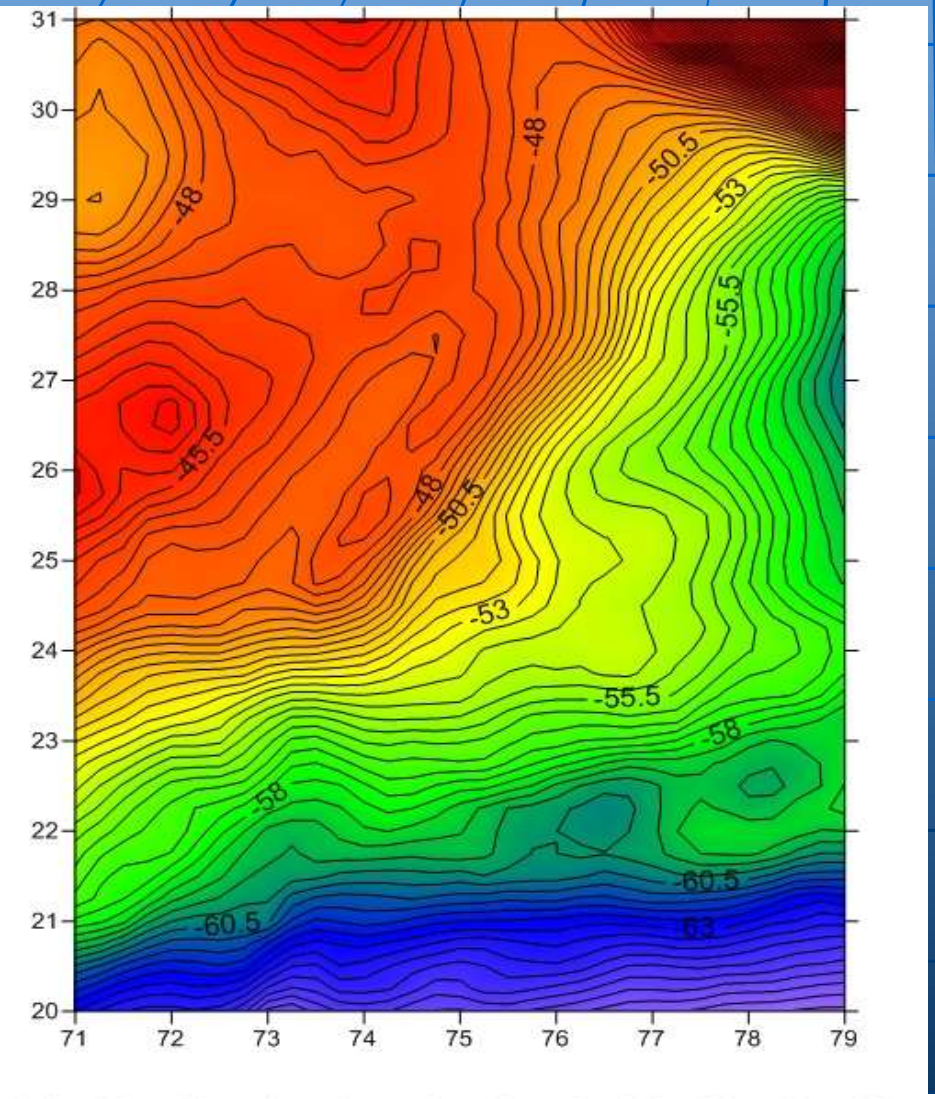
Residual of Gravimetric N & GNSSBMs



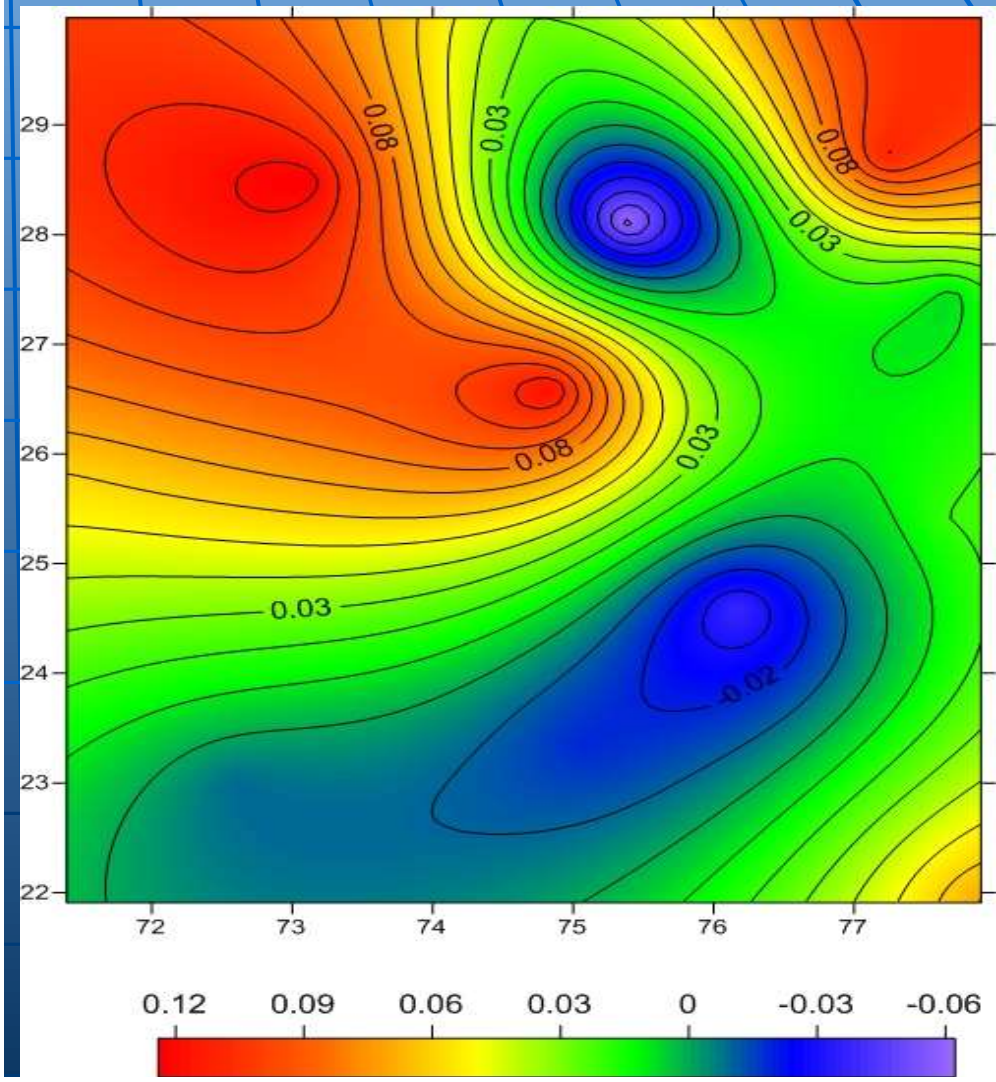


Minimum Difference	Maximum Difference	Mean	RMSE
-0.346	0.226	-0.005	0.136

Final Hybrid Geoid



Residual of Hybrid N & test points



Minimum Difference	Maximum Difference	Mean	RMSE
-0.064	0.125	0.039	0.072

Conclusion

- It will definitely facilitate GNSS user of any community to derive faster & cheaper MSL heights.
- It will help in connecting the vertical datum of island like Andaman etc. with main land.
- More data collection for development of precise Geoid Model is already under way.
- The Survey of India is releasing beta version Geoid Model for entire India very shortly.

Thanks