TOWARDS MODERNIZATION OF INDIAN VERTICAL DATUM- IVD2009

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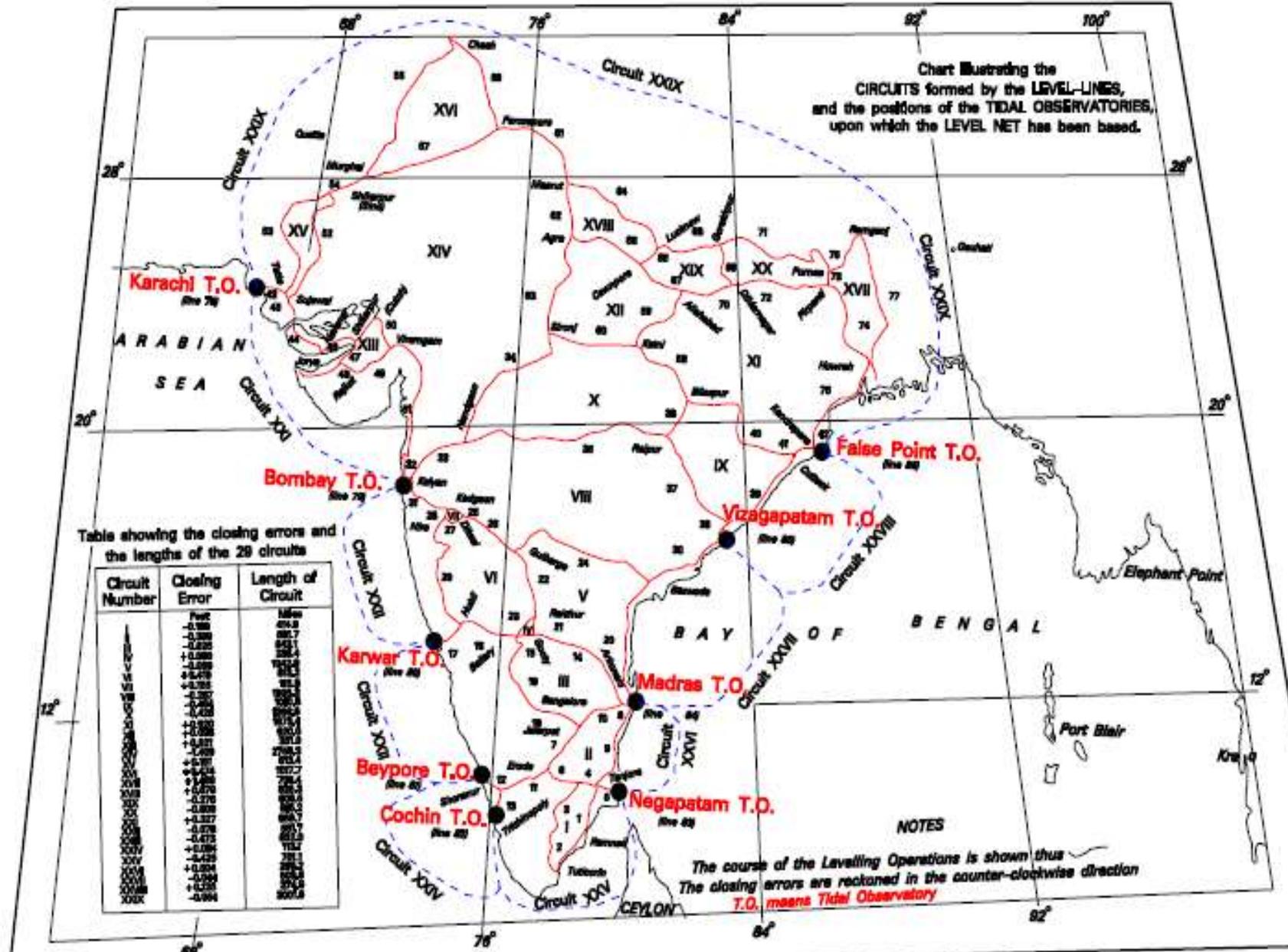
FIRST LEVEL NETWORK 1909

WHY MODERNIZATION OF IVD ?

- M.S.L. of all the ports was considered at the same level
- Change in MSL value

- No fore and back levelling concept , old Instruments and staves with no calibration

- Inconsistency in level network Adjustment

- No observed gravity for orthometric correction

- 95% of leveling bench marks(BMs) destroyed

- No relationship with GNSS derived positions

- Not suitable for construction of groid model of cms level accoracy

COMPARATIVE STUDY TWO EPOCHS OF MSL MEASUREMENTS

Sl. No.	TG STATION	Z_0 MSL1909	Z_0 MSL 1994	Height of TGBM Above MSL Epoch1909 (m)	Height of TGBM Above MSL Epoch 1994 (m)
		(m)	(m)	(m)	(m)
1	MUMBAI	2.5103	2.5612	4.5419	4.4910
2	MARMAGAO	1.2914	1.3009	3.1802	3.1707
3	KARWAR	1.1265	1.1613	2.9397	2.9049
4	NEW MANGALORE	0.9744	0.9160	2.7659	2.8243
5	PARADIP	1.5363	1.7200	3.0265	2.8428
6	VISAKHAPATNAM	0.8023	0.8229	1.7773	1.7567
7	CHENNAI	0.5495	0.6198	4.1472	4.0769
8	TUTICORIN	0.6483	0.6385	1.2967	1.3065

VARIATIONS IN CHART DATUM LEVEL ALONG WEST COAST OF INDIA

	MUMBAI	MARMAGAO	KARWAR	NEW MANGALORE
ELLIPSOID WGS 84	70.6832 m	83.9806 m	85.8822 m	90.1023 m
TGBM (GCP)	7.0522 m	4.4716 m	4.0662 m	3.7403 m
IMSL				0.9744 m
LMSL (1994)	2.5612 m	1.3009 m	1.1613 m	0.9160 m
IMSL (1910)	2.5103 m	1.2914 m	1.1265 m	
GGM	2.1432 m	0.8806 m	0.9222 m	0.1723 m
CD	0.0000 m	0.0000 m	0.0000 m	0.0000 m
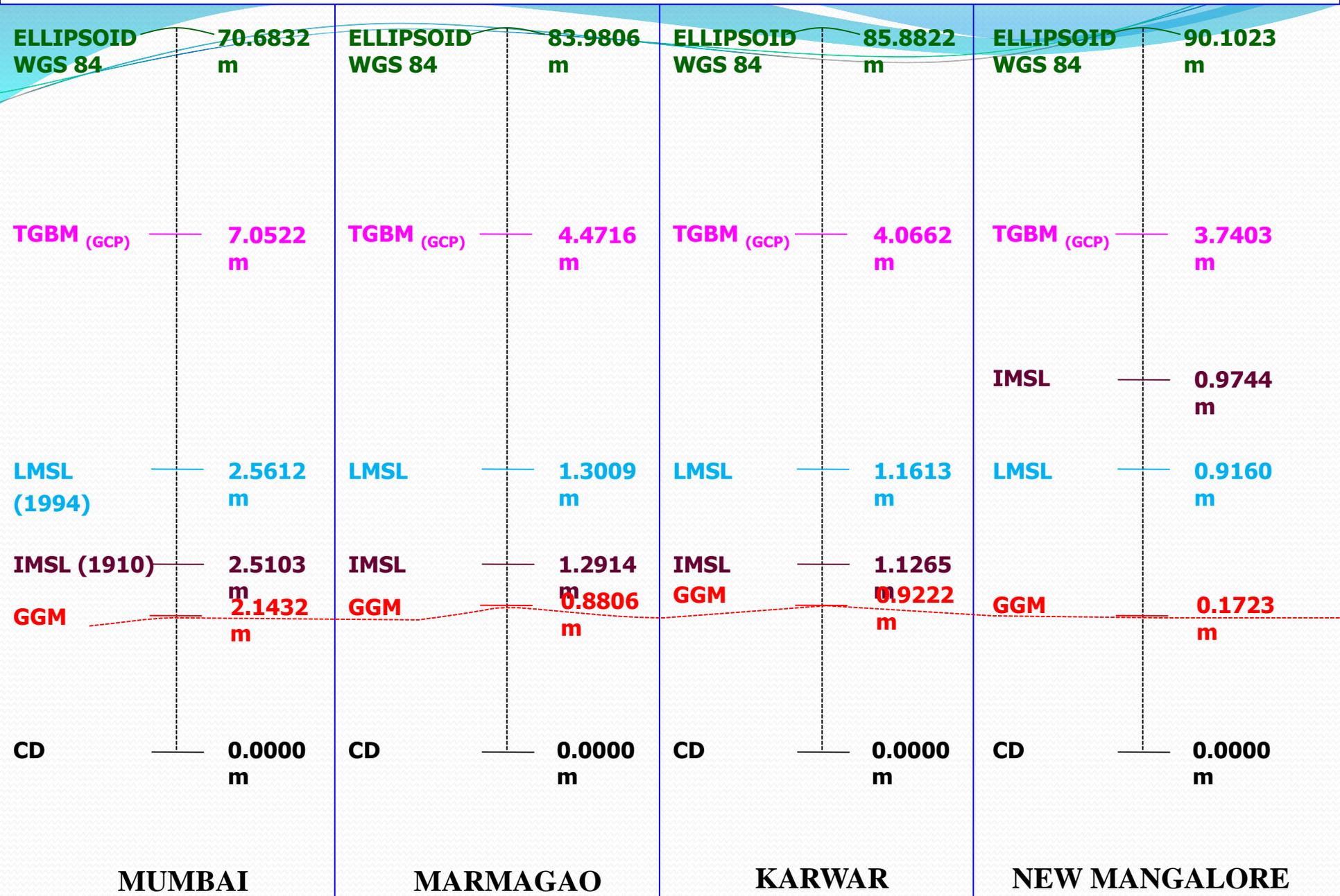
MODERNIZATION OF IVD-OBJECTIVES

- **Determination of Geoid along Indian coast for IVD definition**

- **Determination of geo-potential value W_o for IVD**

- **Realization of IVD through a level net work at national level**

- **Transformation of observed heights of Bench Marks into geopotential numbers**

- **Adjustment of the Levelling network in terms of geopotential numbers**

- **Define the height of points in terms of Helmert's orthometric heights**

Methodology to redefine the IVD

The concept for the definition of IVD has been adopted keeping in view that a gravimetric geoid will serve as vertical datum in near future.

STEP-1. Selection of TG Ports based upon the availability of MSL Data

STEP-2. Selection of SST model for reduction of MSL to Geoid

Step-3. Adoption of (conventional) geopotential value W_0 coresponds to global mean sea level (geoid)

Step-4. Computation of geopotential value for local vertical datum(W_0^{LVD})

Step-5.Level net adjustment with respect to W_0^{LVD} of selected TG BMs.

Step-6. Defined height of each bench marks in terms of geopotential number with reference to W_0^{LVD}

Principle of Dermination of W_o^{LVD}

- **h-H-N≈l**
- $\Delta W = W_o - W_o^{LVD}$
- $W_o^{LVD} = W_o + \Delta W$
- $\Delta W \approx l.g \approx l.\gamma$

$$\hat{W}_o^{LVD} = W_o - \frac{\sum_{i=1}^{K} \frac{1}{\gamma_i}(h_i - H_i - N_i)}{\sum_{i=1}^{K} \frac{1}{\gamma_i^2}}$$
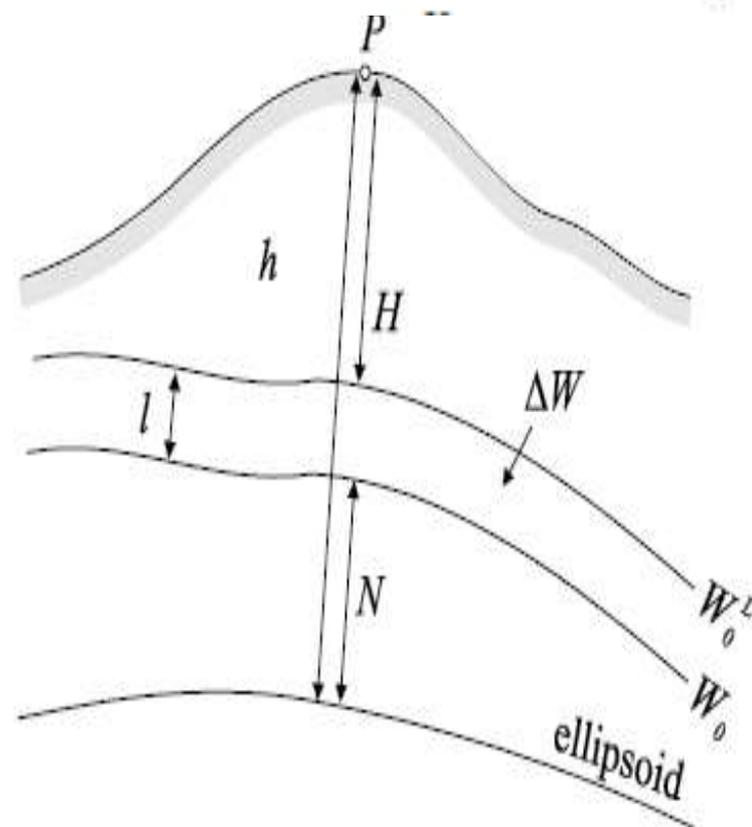
Data Requirement

Required	Availability
Local Gravimetric Geoid	Not available
Local SST Model	Not available, Global SST Models to be used
Global Geopotential Model	Available
GNSS Observation on Tidal Stations	Available only on 8 Tidal ports
Tidal data for 19 years on all the tidal ports	Available only for 8 Tidal Stations
Dense levelling Network	A skeleton Network of 29 levelling lines with 11 circuits are available
GNSS CORS Network at Tidal Stations for Vertical ground motion corrections	Not available
Global conventional value *Wo*	IERS (2010) global value *Wo* = $62636856.00 \text{m}^2/\text{s}^2$

Evaluation of SST Models

DTU15 Mean Dynamic Topography

DTU10 Mean Dynamic Topography

DTU13 Mean Dynamic Topography
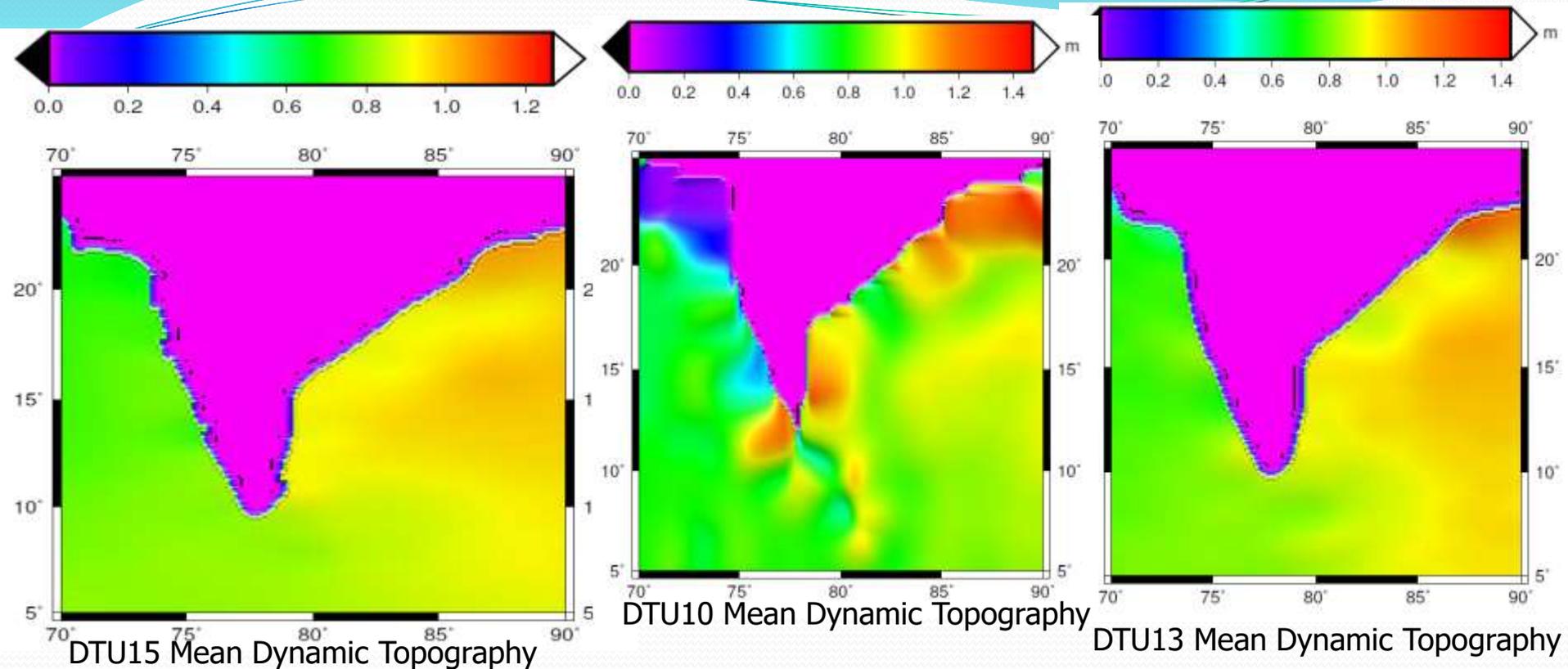
Sl. No.	SST Model	West Coast Δh (GGM and LVD) (A) m	East Coast Δh (GGM and LVD) (B) m	Difference (B)-(A) m
1	DTU10	-0.352	-0.354	-0.002
2	DTU13	-0.387	-0.312	0.075
3	DTU15	-0.377	-0.316	0.061
4	With out SST	0.452	0.651	0.199

DATA USED FOR COMPUTATION OF MEAN SEA LEVEL FOR 19 YEARS

W_0^{LVD} values for IVD2009

Sl. No.	Station	W0 (GGM)						62636856
		1	2	3	4	5	6	Average
		EGM08	Eigen6c3stat	Eigen6c4	geco	goco05c	xgm2016	
1	MUMBAI	62636861.04	62636860.00	62636859.84	62636860.63	62636859.52	62636860.64	62636860.28
2	MARMAGAO	62636860.33	62636860.34	62636860.05	62636860.14	62636860.39	62636859.74	62636860.17
3	KARWAR	62636863.35	62636861.82	62636861.45	62636861.87	62636861.81	62636860.48	62636861.80
4	NEW MANGALORE	62636856.23	62636856.23	62636855.96	62636856.44	62636856.93	62636857.47	62636856.54
5	PARADEEP	62636861.12	62636861.15	62636862.03	62636861.01	62636860.98	62636861.16	62636861.24
6	VISAKHAPATTNAM	62636859.80	62636858.55	62636858.93	62636859.57	62636858.70	62636859.62	62636859.20
7	CHENNAI	62636857.77	62636859.42	62636858.97	62636859.20	62636860.79	62636859.14	62636859.22
8	TUTICORIN	62636854.65	62636856.90	62636856.46	62636856.80	62636857.48	62636858.06	62636856.72
							Average	62636859.40

Lay out of scheme of Levelling Network

No. of circuits   11

**Total distance
19,450 lin. km.**

**Max. closing error of
Circuits
0.2504 gpu**

REDEFINITION OF
INDIAN VERTICAL DATUM
REFERENCES

Levelling Line	....	
T.O. (Tidal Observatory)	....	▲
Circuit No.	....	VIII

ARABIAN
SEA

BAY
OF
BENGAL

INDIAN   OCEAN

SUMMARY OF CIRCUITS		
Circuit	Circuit	Closing Error
Number	Length(km)	∑△H(m)	∑△GPU
I	2196.2692	-0.0176	0.0379
II	1700.4808	-0.0381	-0.0084
III	1995.4320	0.1814	0.0953
IV	2198.5096	-0.1724	-0.1177
V	2824.8694	-0.1590	-0.1176
VI	2721.8246	0.1783	0.0812
VII	3215.4808	0.0615	-0.0362
VIII	2722.3872	-0.1225	-0.9537
IX	4080.4485	0.0582	0.2504
X	3407.8678	-0.0499	-0.0302
XI	1865.5941	-0.0390	0.0010

GEO POTENTIAL NUMBER ADJUSTMENT FOR INDIAN VERTICAL DATUM 2009

- NO. OF OBSERVATIONS :-   41
- NO. OF STATIONS/B.Ms. :-   32
- NO. OF STATIONS/B/Ms. HELD FIXED :- 8

MAX RESIDUAL	MIN RESIDUAL	SD	RMSE	NO. OF PASSED LINES IN 4√k	% OF PASSED LINES IN 4√k	NO. OF PASSED LINES IN 6√k	% OF PASSED LINES IN 6√k
0.1251102	-0.1041327	0.05510625	0.0570706	36	87.80	39	95.12

CONCLUSIONS

- IVD2009 will provide an authoritative height system to avoid confusion

- Users can obtain heights above the Geoid or a level equipotential) surface close to it

- It will help the users to compute the local instantaneous sea level in terms of the national vertical datum

- To provide the ability to correlate the local level (equipotential) surface and global ellipsoidal and geopotential surfaces

- IVD2009 will provide a reliable frame for consistent analysis and development of gravimetric Geoid model for India.

- It will support unification of multiple vertical datums and authoritative transformations of heights to an acceptable and defined accuracy

THANK YOU

Any Question Please?