EPUSP

Escola Politécnica da Universidade de São Paulo

IAG

IGC INSTITUTO GEOGRÁFICO E CARTOGRÁFICO

CENEGEO

GRAVITY INFRASTRUCTURE LATIN AMERICA

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Implementation of the GGRF in Latin America
Buenos Aires, Argentina, Sept 16 - 20, 2019

OBJECTIVE

To present the gravity infrastructure in Latin America for:

1. Gravity densification and references;
2. IHRF efforts.

SUMMARY

1- Gravity Reference System – Absolute measurements;
2 – Densification Gravity Surveys;
3 – Geoid Fitting with 360 GPS/BM of IBGE in State of São Paulo;
4 – Efforts in the International Height Reference Frame (IHRF).
5 - Improvement on the DTM

IUGG2019 – IAG Recomendation

1 – IAG urges: International and national agencies and government bodies in charge of geodetic infrastructure to:

- establish a set of gravity reference stations on the national level;
- perform regular absolute gravity observations at these stations;
- participate in comparisons of absolute gravimeters to ensure their compatibility;
- make the results available open access;

IUGG2019 – IAG Recomendation

2-IAG urges: All countries to engage with IAG and concerned components, in particular the International Gravity Field Service (IGFS), in order to promote and support the implementation of the IHRF by:

- ✓ **Installing IHRF reference stations at national level;**
- ✓ **Conducting the necessary gravimetric surveys to guarantee the precise determination of the potential values;**

IUGG2019 – IAG Recommendation

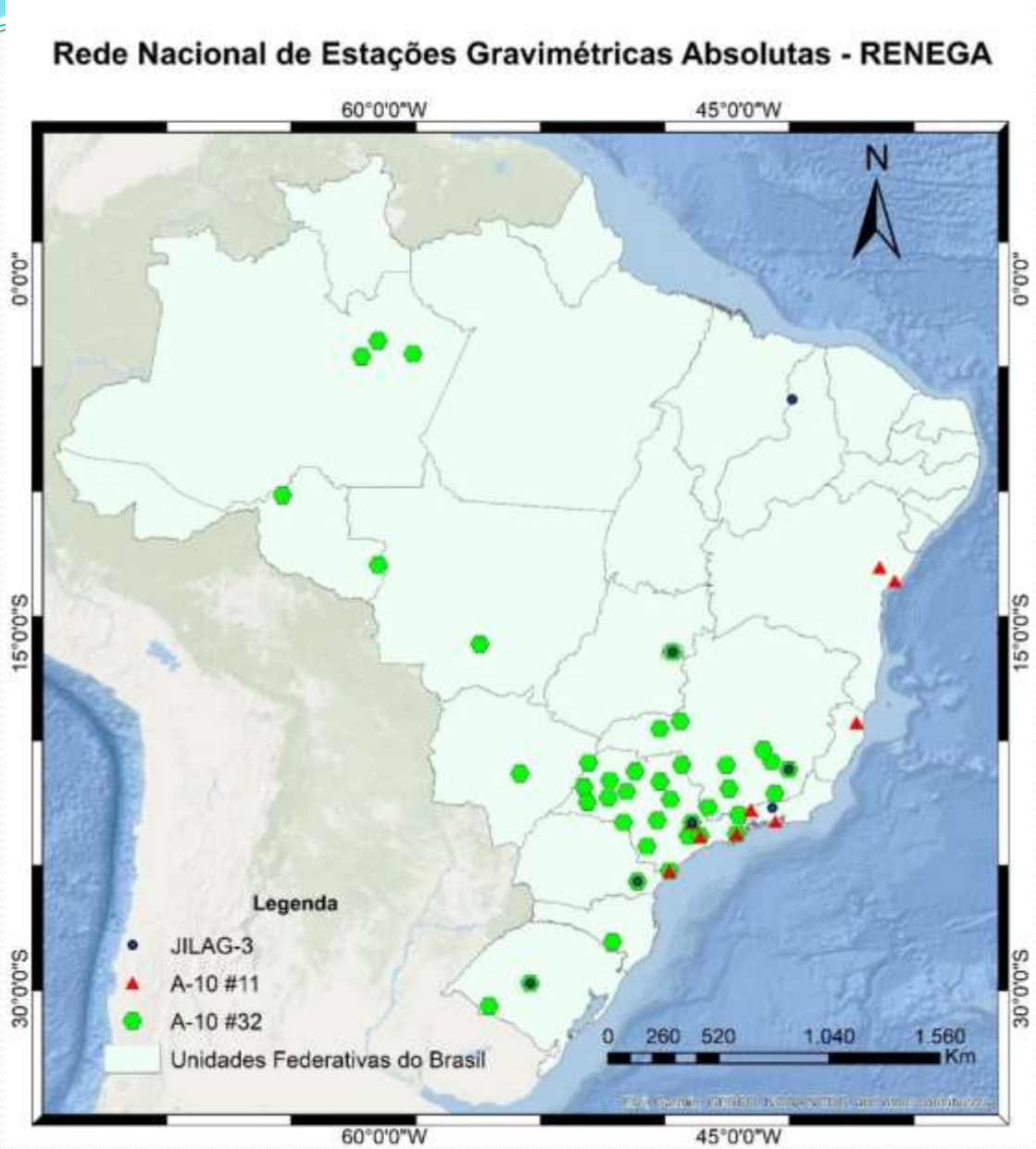
- ✓ **making data available open access;**
- ✓ **contributing to the development of analysis strategies to improve the estimation of reference coordinates and modelling of the Earth's gravity field;**
- ✓ **describing, archiving and providing geodetic products associated to the IHRF.**

Absolute gravity system established

Since 2013 our efforts in the contribution to IGRF addressed the attention to a few different countries in Latin America.

For that purpose, we had important contributions from many different organizations. In particular, from BGI/IRD in Chile, Argentina and Peru, with expected survey in Colombia.

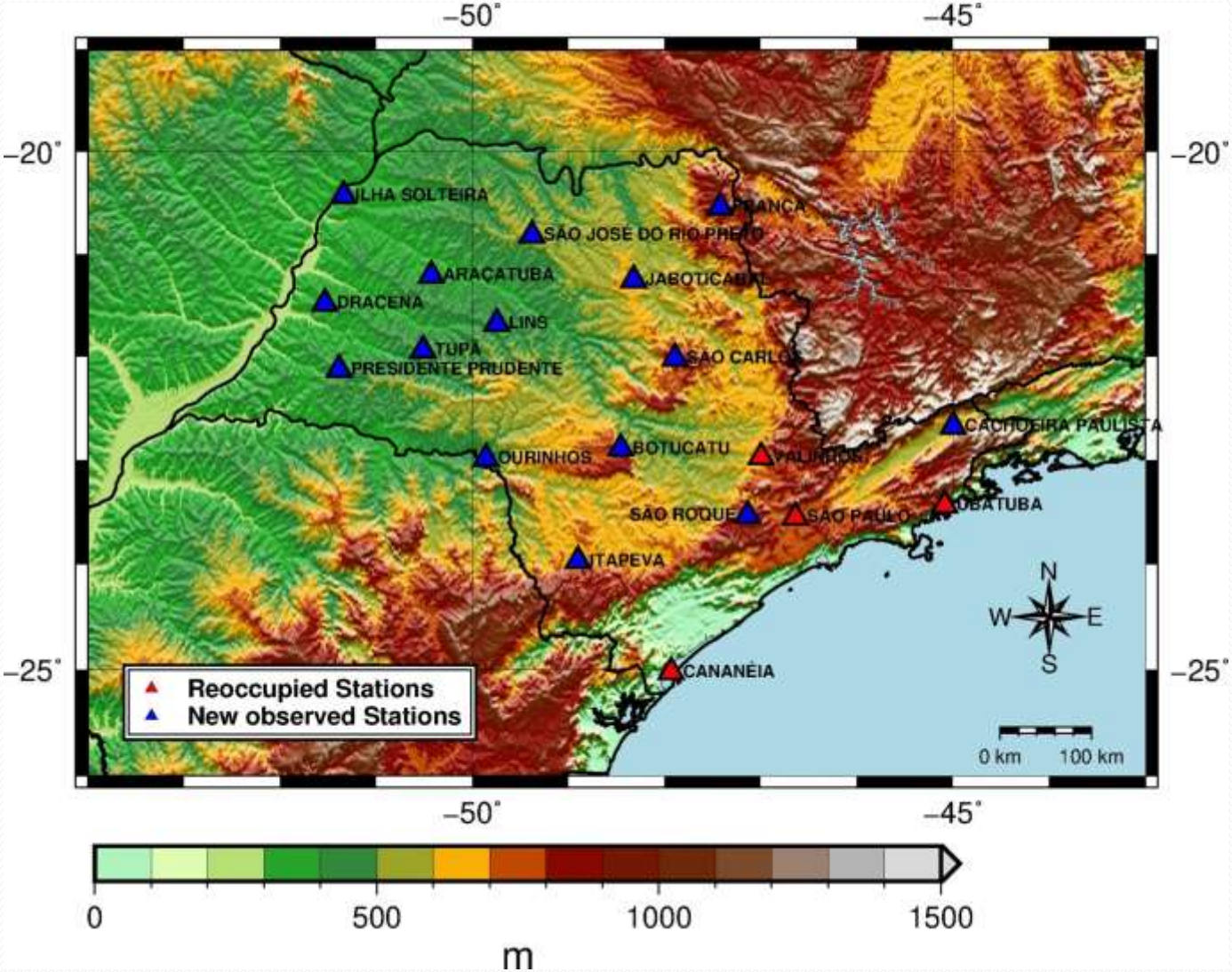
Absolute Gravity established - BRAZIL



In Brazil, **43 stations** were established along a profile that extends from Manaus to Santana do Livramento and in the state of São Paulo

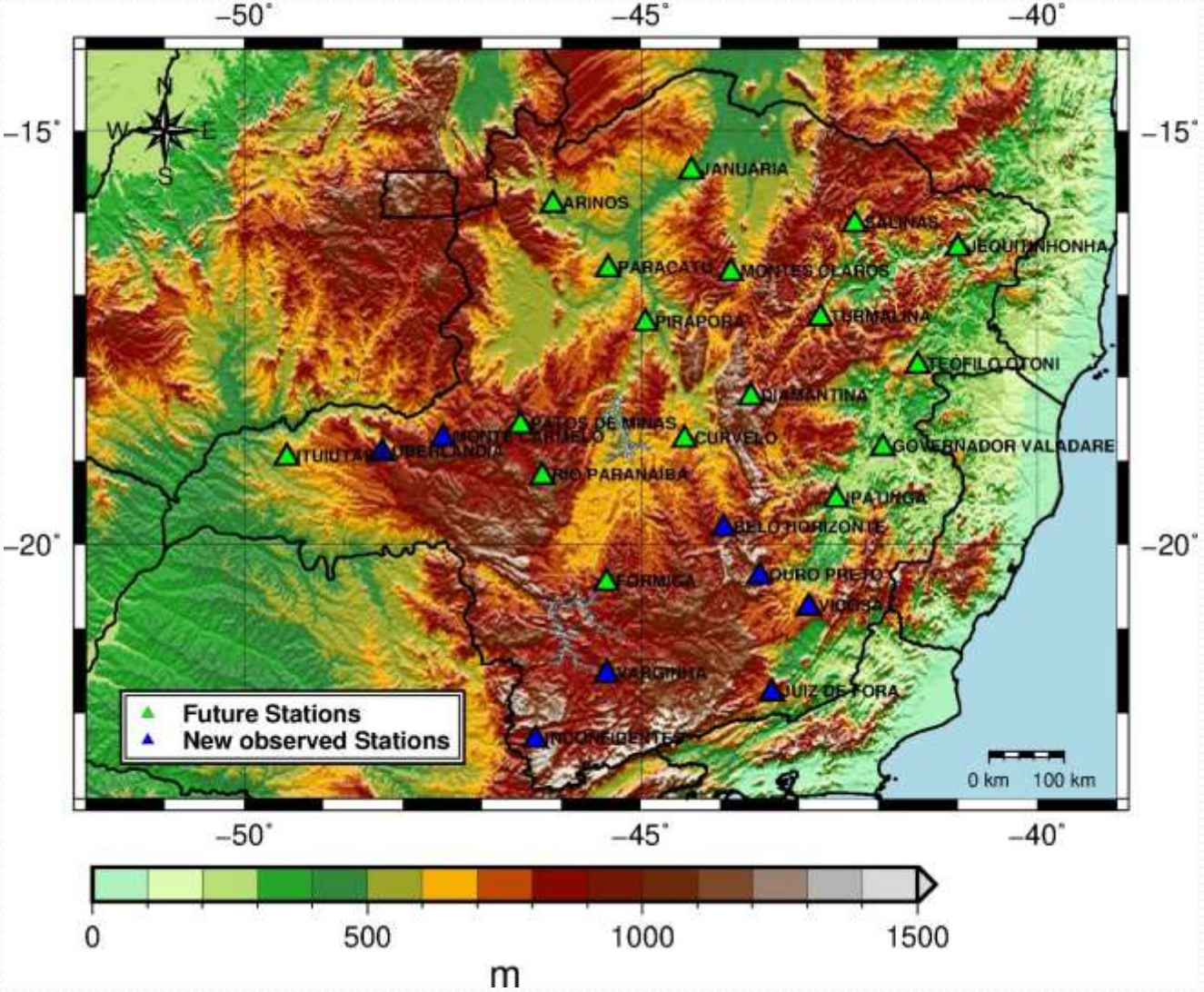
State of São Paulo - BRAZIL 2013-2017

In the State of São Paulo, **19 stations were established, 15 new and 4 reobservations**. These were measured by the ON and IFE and NGS, allowing a comparison.



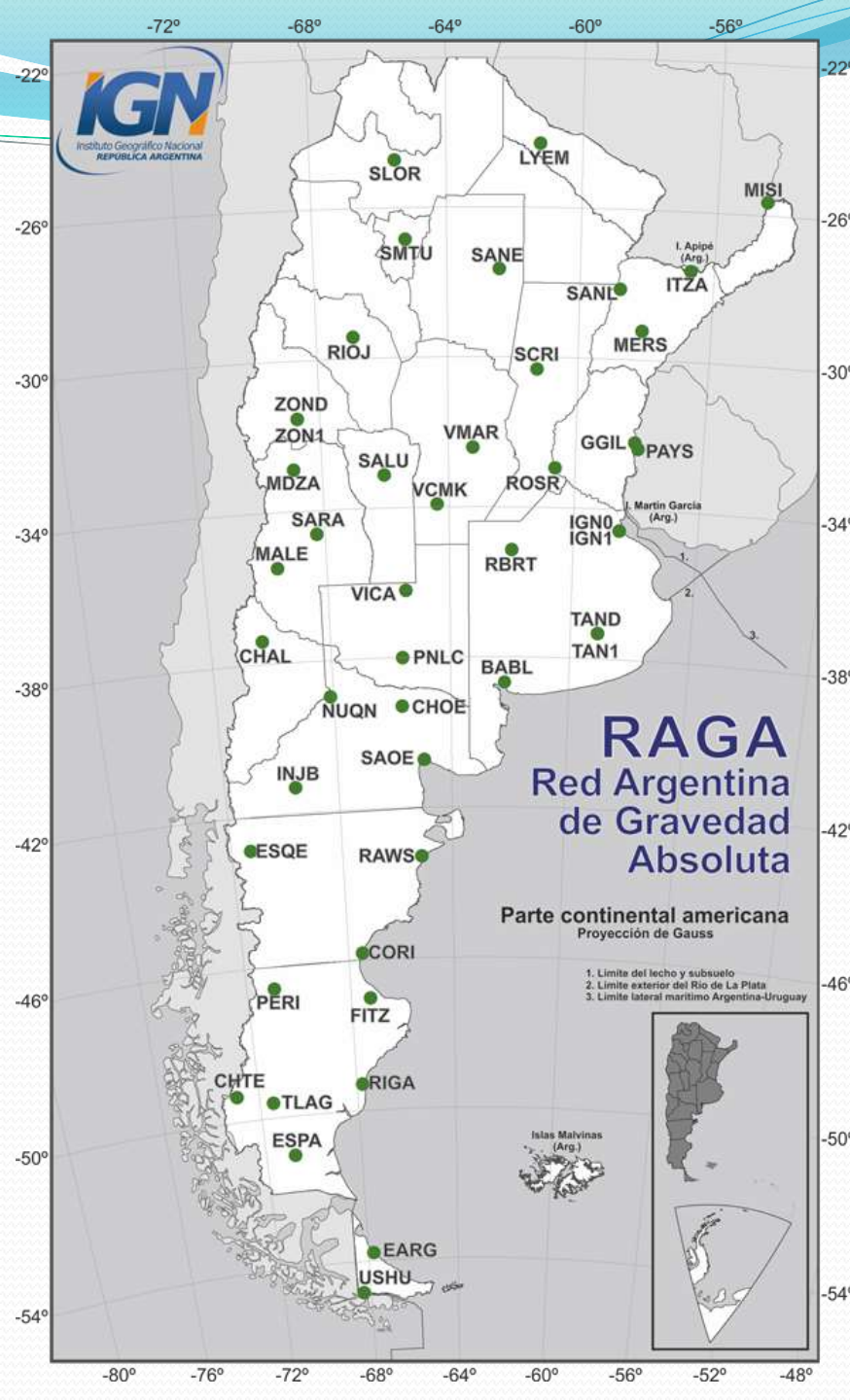
State of Minas Gerais - BRAZIL 2013-2017

In the State of Minas Gerais, **8 stations were observed, 13 to be accomplished**.



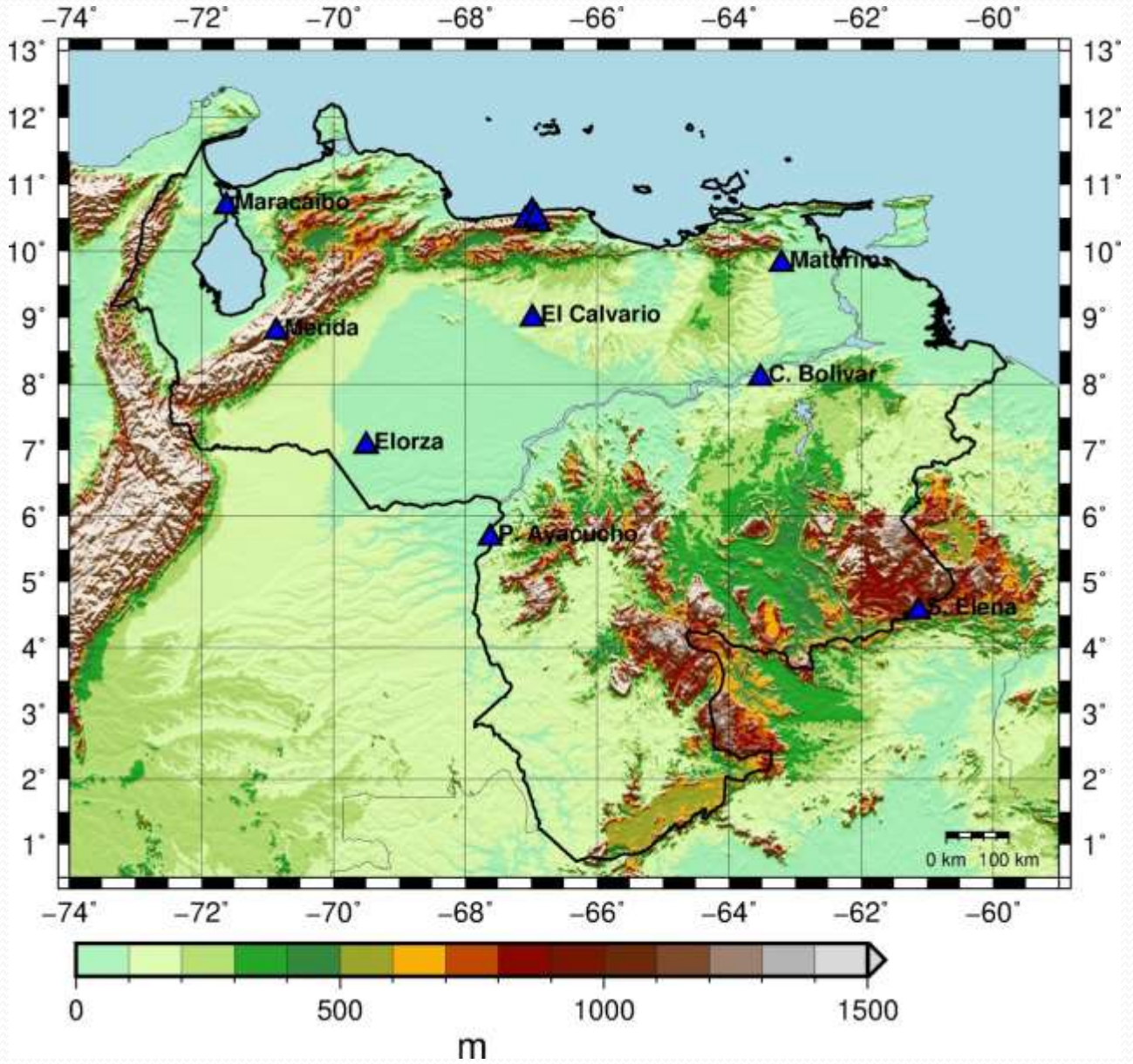
ARGENTINA
2014-2016

- The absolute gravity network of Argentina (RAGA) was established in three different campaigns.
- A total of **35 stations** were observed, three of which were also subject to measurements by BGI/IRD, which allowed a comparison.
- Work performed in cooperation with ***Instituto Geográfico Nacional*** (IGN).



VENEZUELA 2016

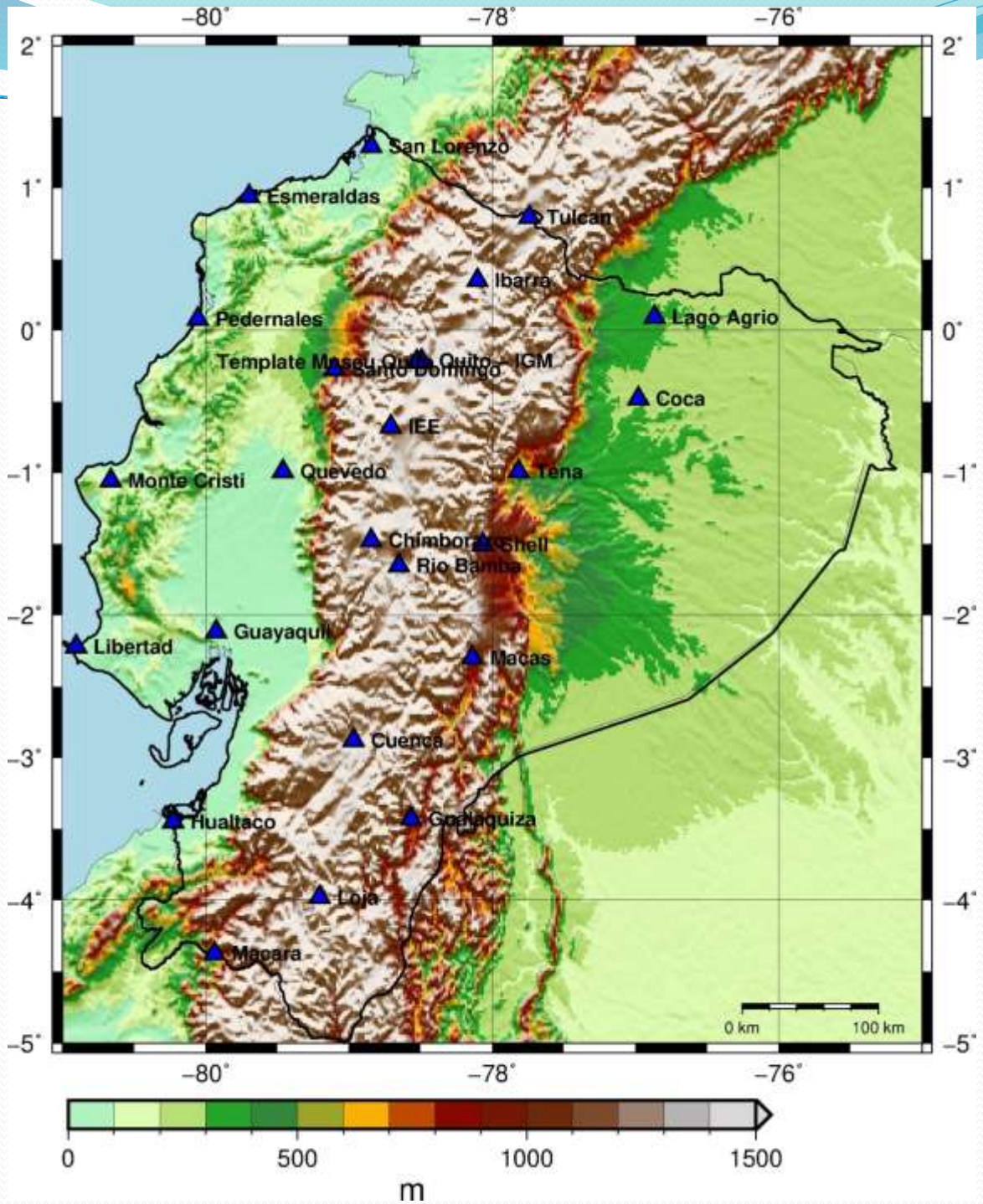
13 stations were established, selected within the possibilities of the country, by the **IGVSB (Instituto Geográfico Venezuelano Simon Bolivar).** The main problem of the country is the forest area.



ECUADOR 2017

25 stations were established homogeneously, but with the restrictions of the Amazon region.

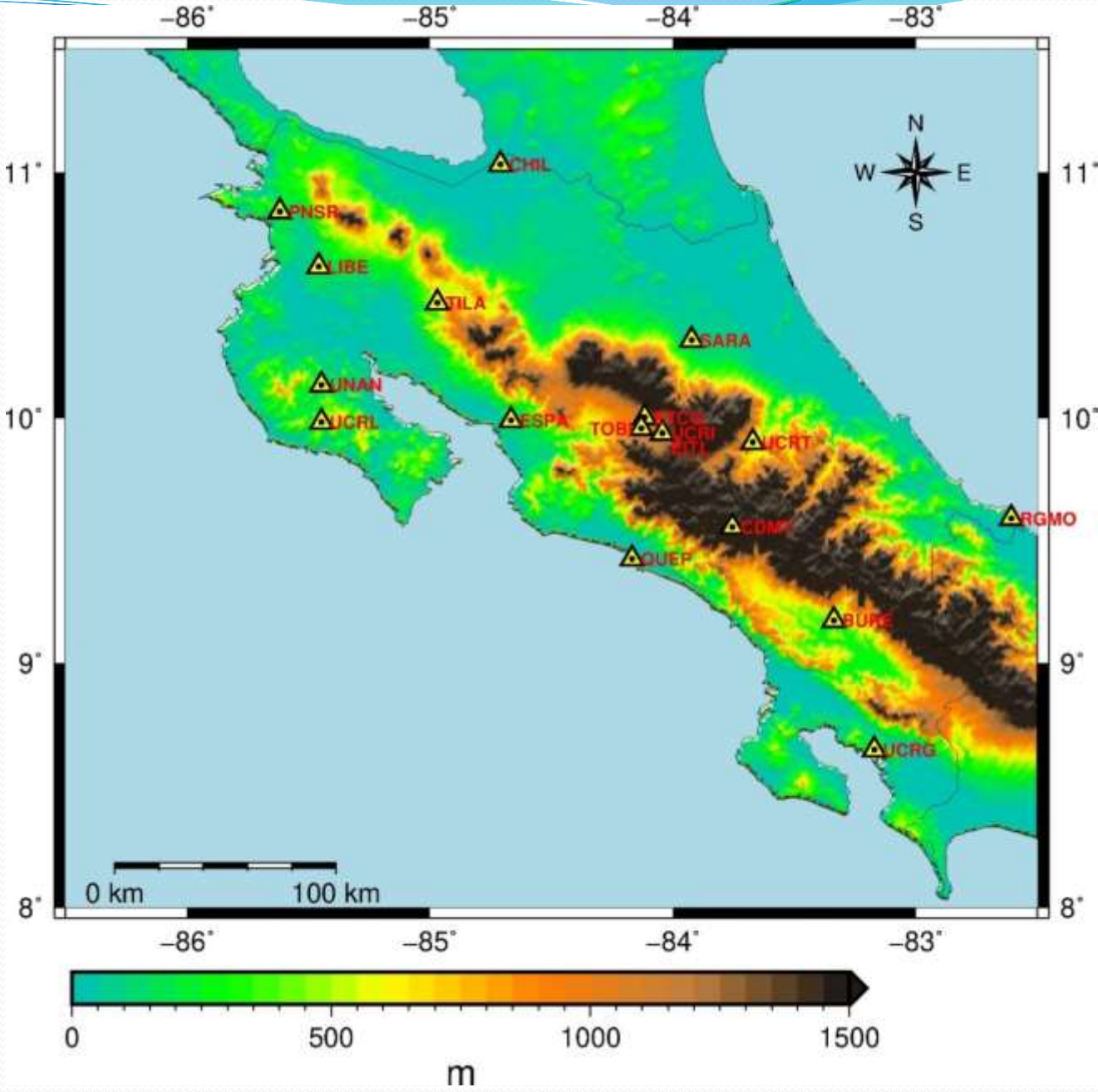
Work performed in cooperation with *Instituto Geográfico Militar* (IGM).



COSTA RICA 2019

16 stations were established, with 5 being reobserved.

Work performed in cooperation with *Universidad de Costa Rica* (**UCR**) and Instituto Geográfico Nacional (**IGN**).



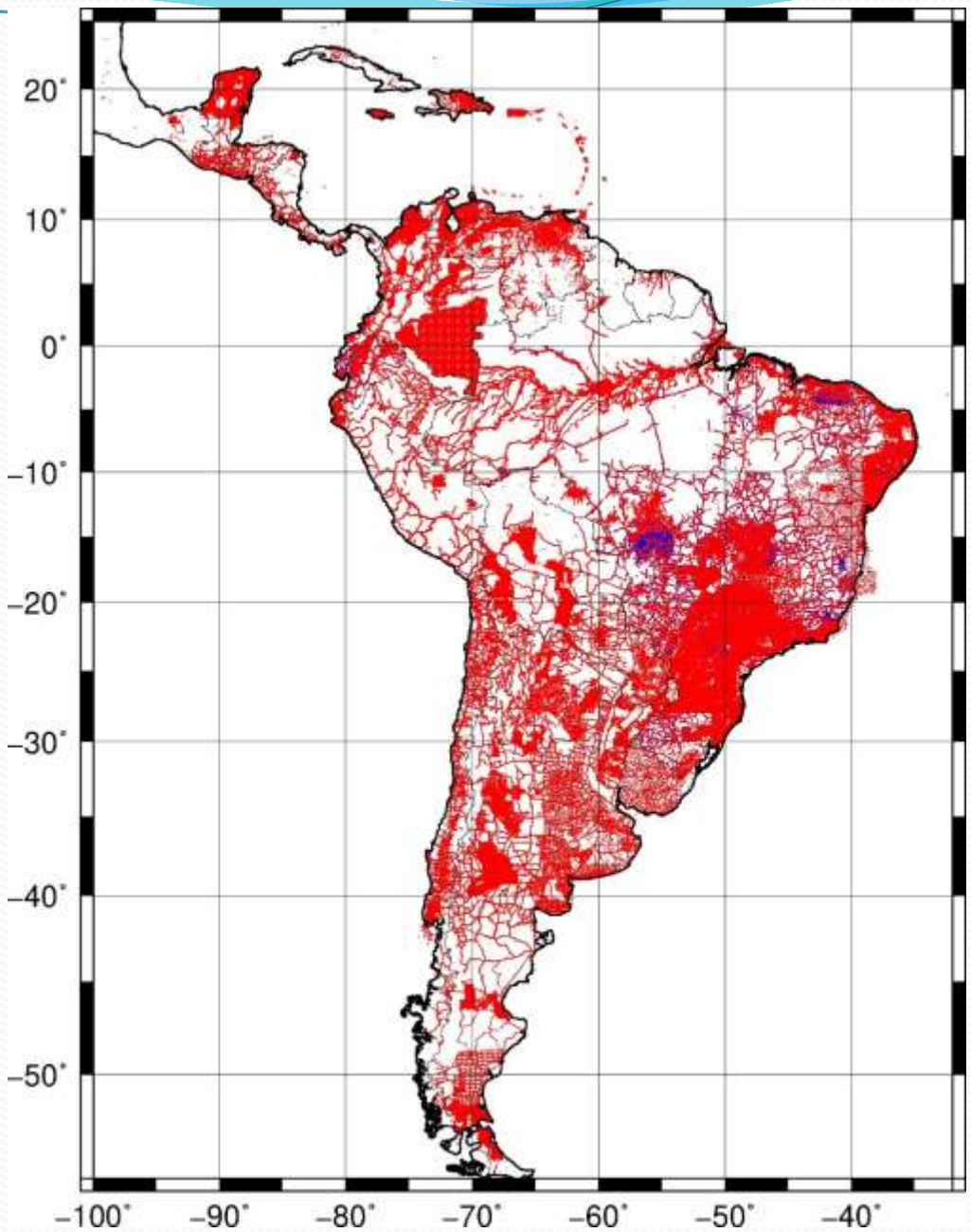
LTG/EPUSP GRAVITY DATA DISTRIBUTION

977,821
point gravity data

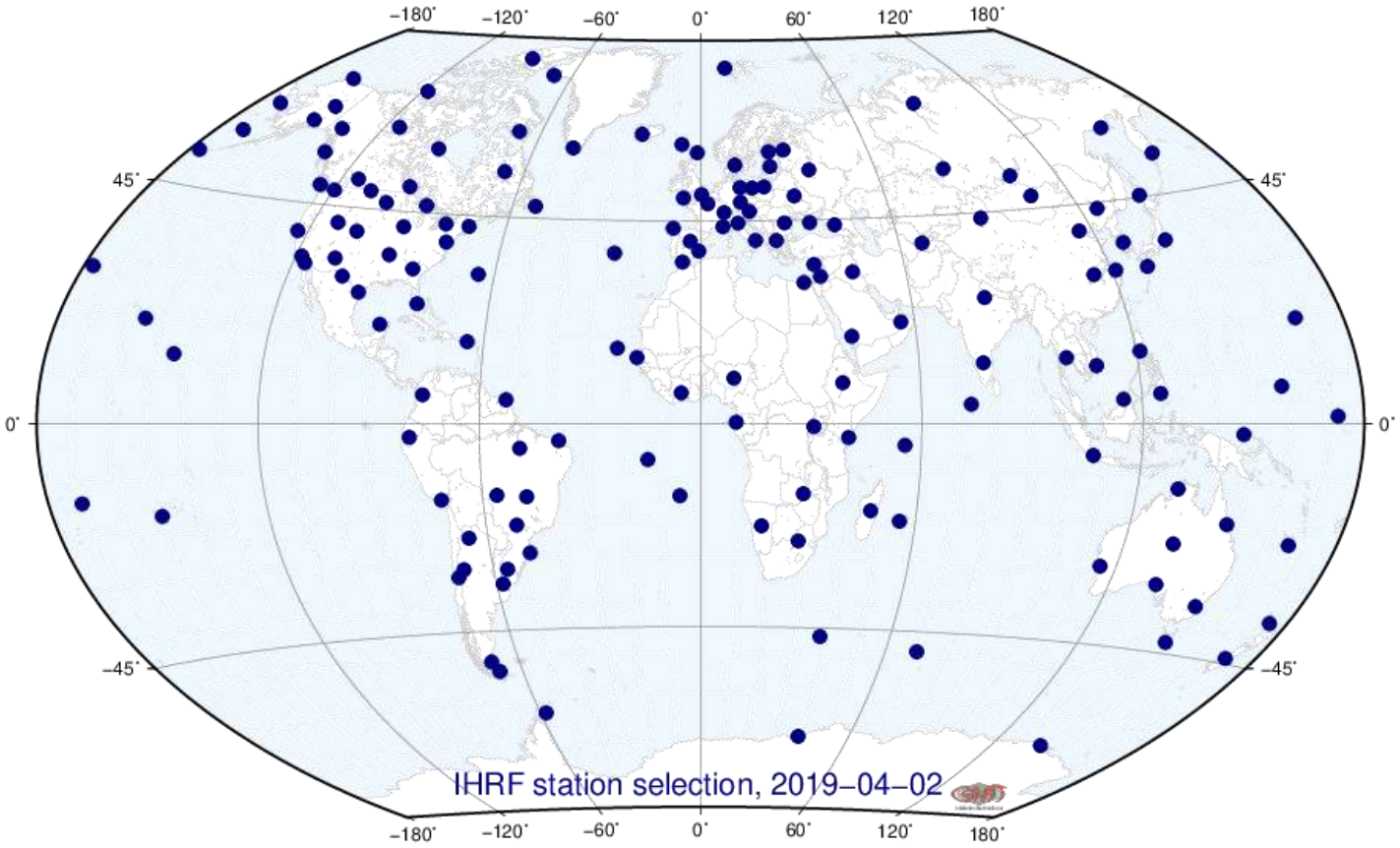
We are adding
<u>Brazil:</u>
1742 points (IBGE)

80 points (LTG)
8 points (LTG and IBGE)
around IHRF stations in SP

<u>Ecuador:</u>
259 Points (IGM)



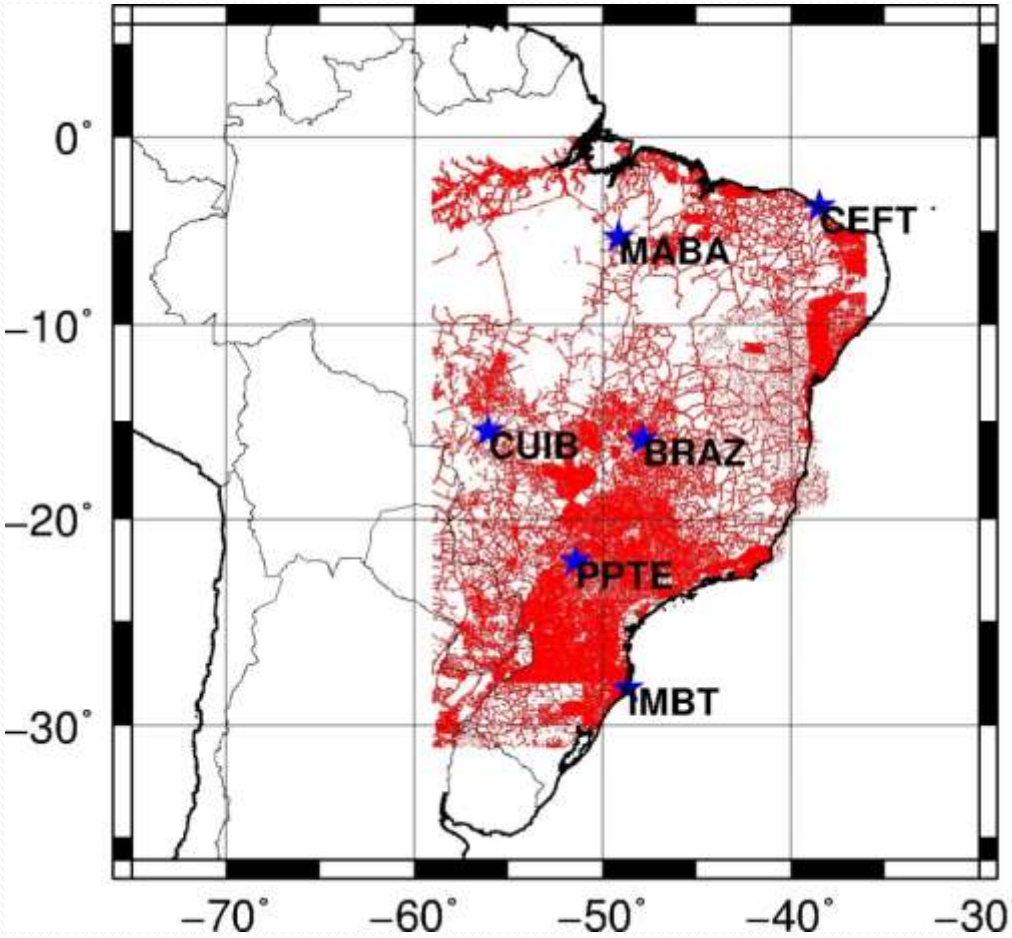
First proposal for the global IHRF reference network (~170 stations)



Terrestrial gravity data (red points) and six RBMC stations.

IHRF Stations:

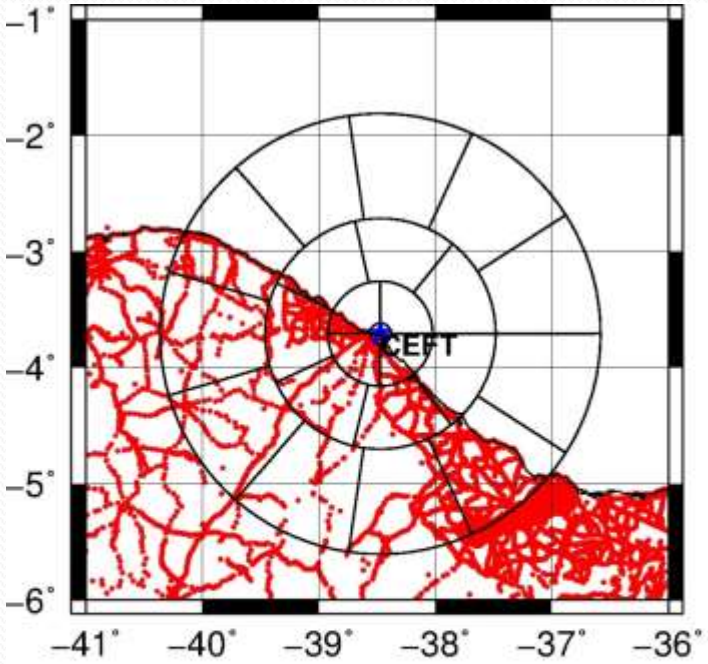
Fortaleza (CEFT)
Marabá (MABA)
Cuiabá (CUIB)*
Brasília (BRAZ)*
Presidente Prudente (PPTE)*
Imbituba (IMBT)



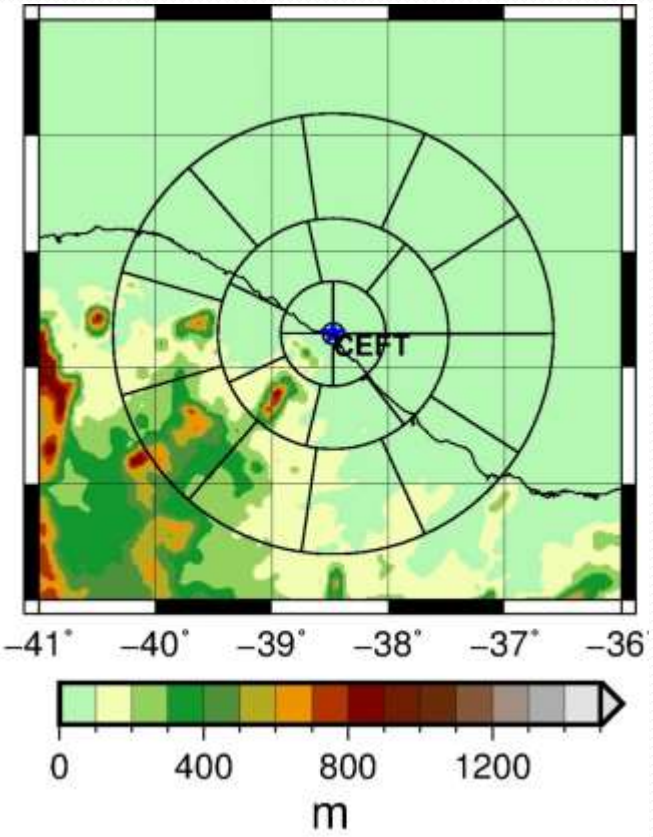
A total of 385,649 gravity points exist in the area extended from 0°S to 31°S in latitude and 59°W to 36°W in longitude.

Fortaleza (CEFT)

GRAVITY DISTRIBUTION



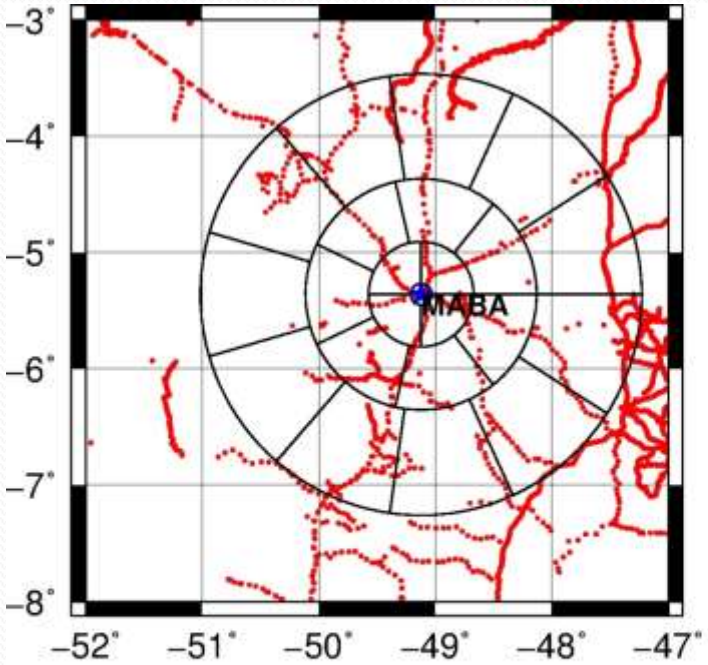
TOPOGRAFY



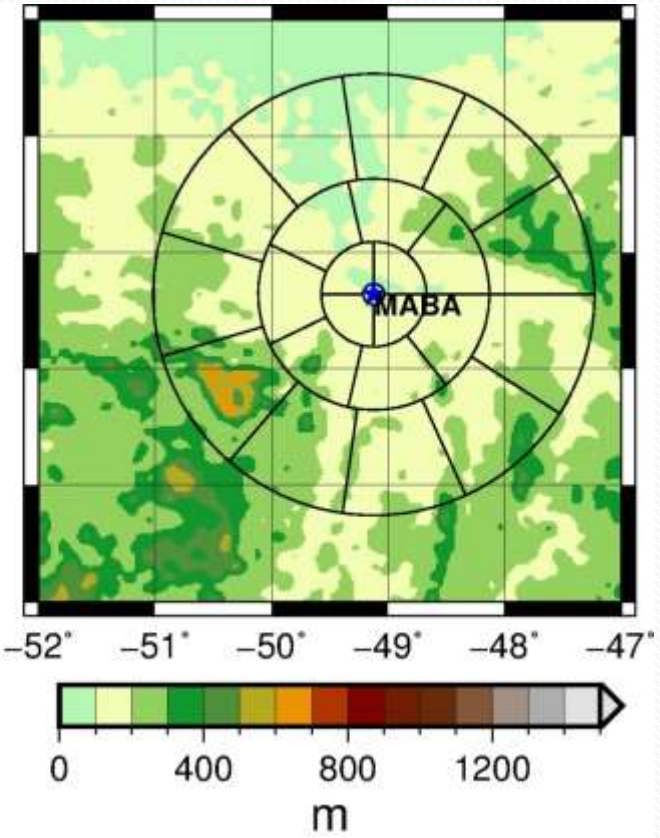
Stations	Distance	H mean	N. of points
CEFT	10 km	18,00	39
	10 km a 50 km	26,49	571
	50 km a 110 km	49,33	1069
	110 km a 210 km	72,93	4397
TOTAL OF POINTS			**6076**

Marabá (MABA)

GRAVITY DISTRIBUTION



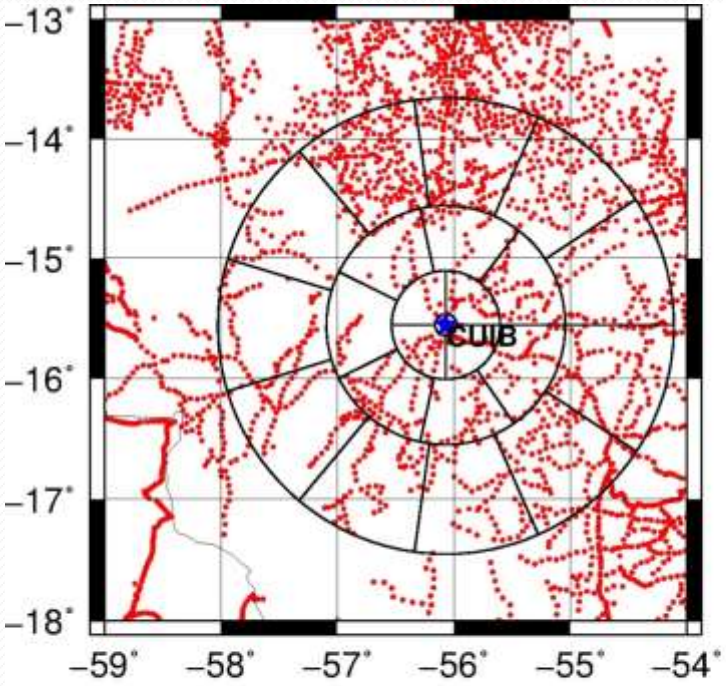
TOPOGRAFY



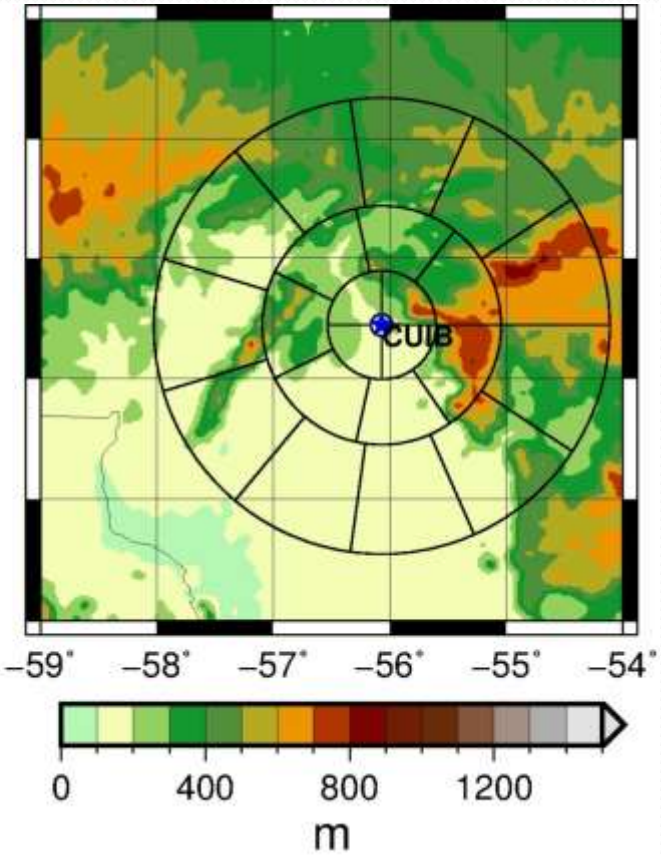
Stations	Distance	H mean	N. of points
CEFT	10 km	107,36	18
	10 km a 50 km	116,85	109
	50 km a 110 km	155,31	192
	110 km a 210 km	151,91	1015
TOTAL OF POINTS			**1334**

Cuiabá (CUIB)

GRAVITY DISTRIBUTION



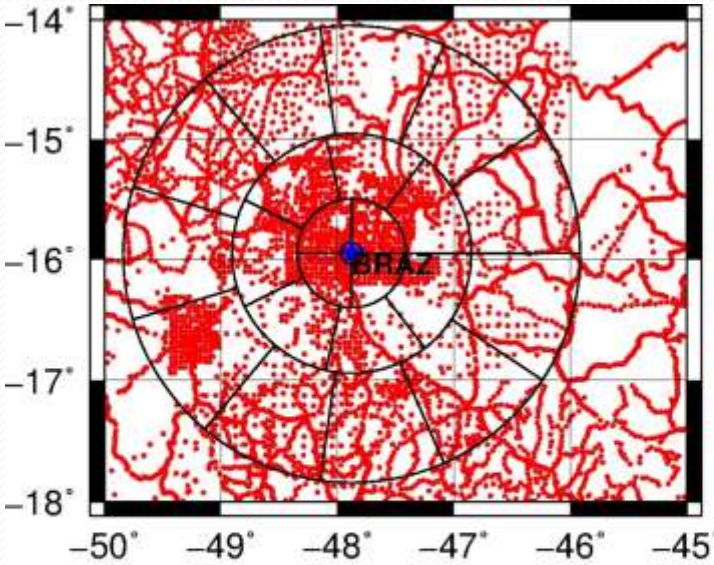
TOPOGRAFY



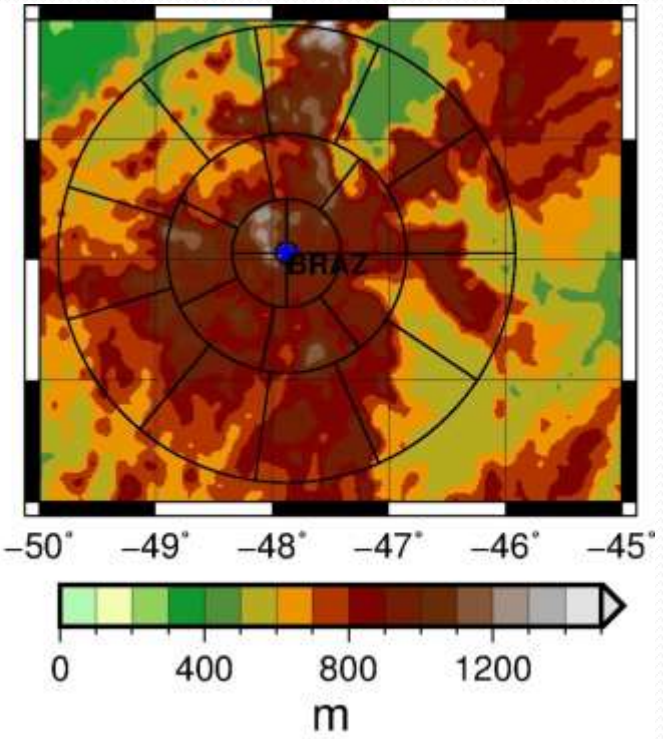
Stations	Distance	H mean	N. of points
CEFT	10 km	172,61	8
	10 km a 50 km	274,64	69
	50 km a 110 km	324,03	236
	110 km a 210 km	361,45	974
TOTAL OF POINTS			**1287**

Brasília (BRAZ)

GRAVITY DISTRIBUTION



TOPOGRAFY

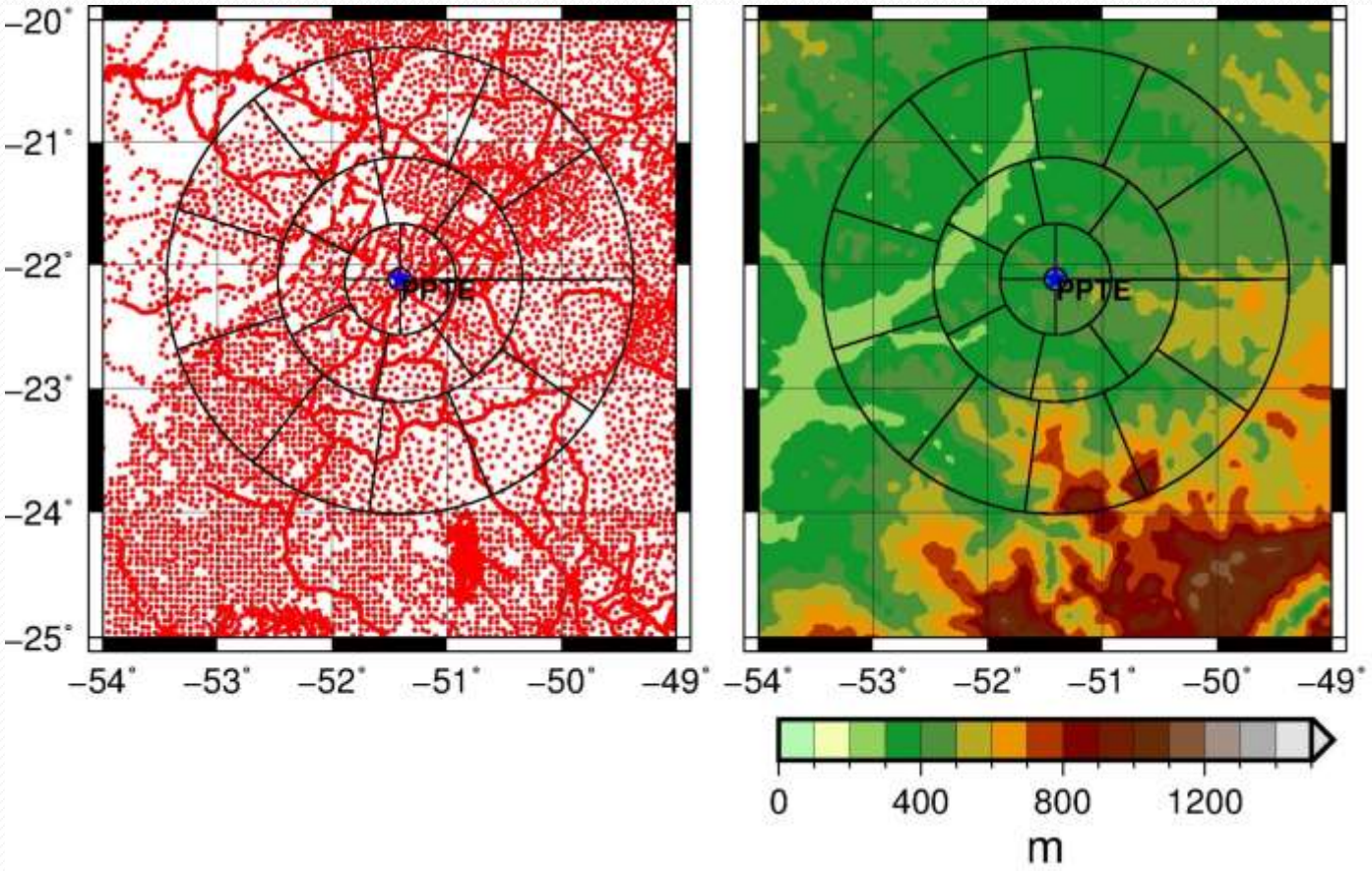


Stations	Distance	H mean	N. of points
CEFT	10 km	1109,04	53
	10 km a 50 km	1023,14	440
	50 km a 110 km	899,38	872
	110 km a 210 km	721,75	2123
TOTAL OF POINTS			**3488**

Presidente Prudente (PPTE)

GRAVITY DISTRIBUTION

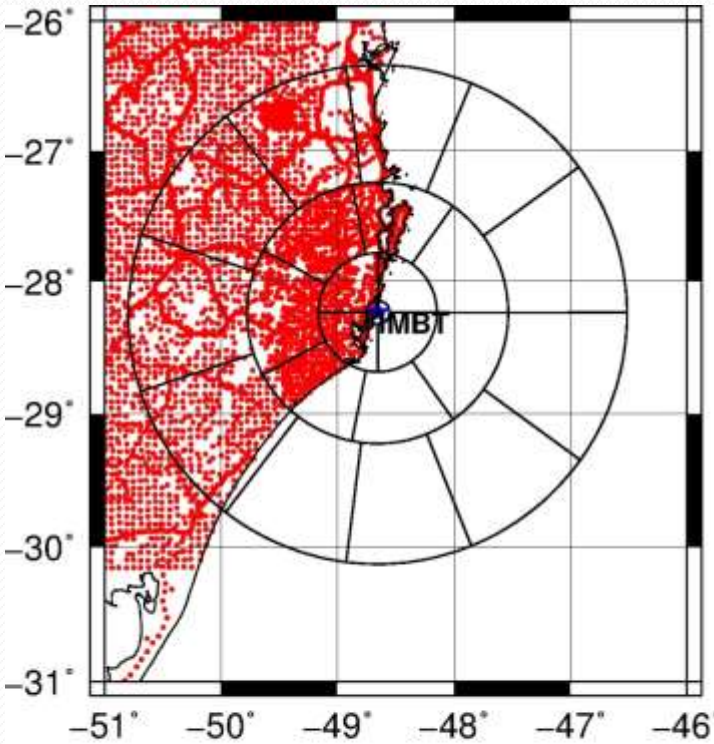
TOPOGRAFY



Stations	Distance	H mean	N. of points
CEFT	10 km	445,67	59
	10 km a 50 km	433,56	418
	50 km a 110 km	408,85	1447
	110 km a 210 km	442,52	3903
TOTAL OF POINTS			**5827**

Imbituba (IMBT)

GRAVITY DISTRIBUTION



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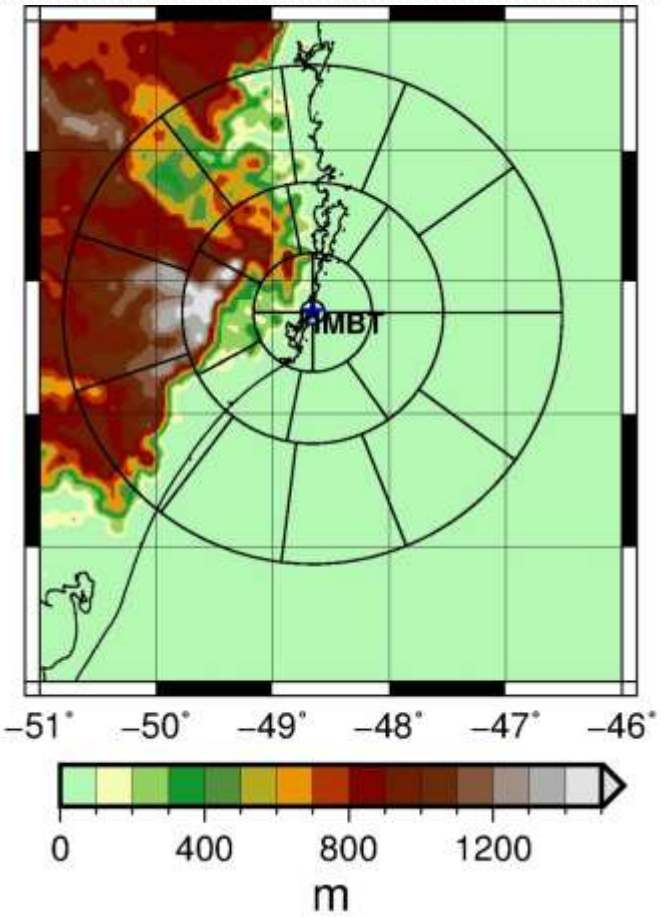
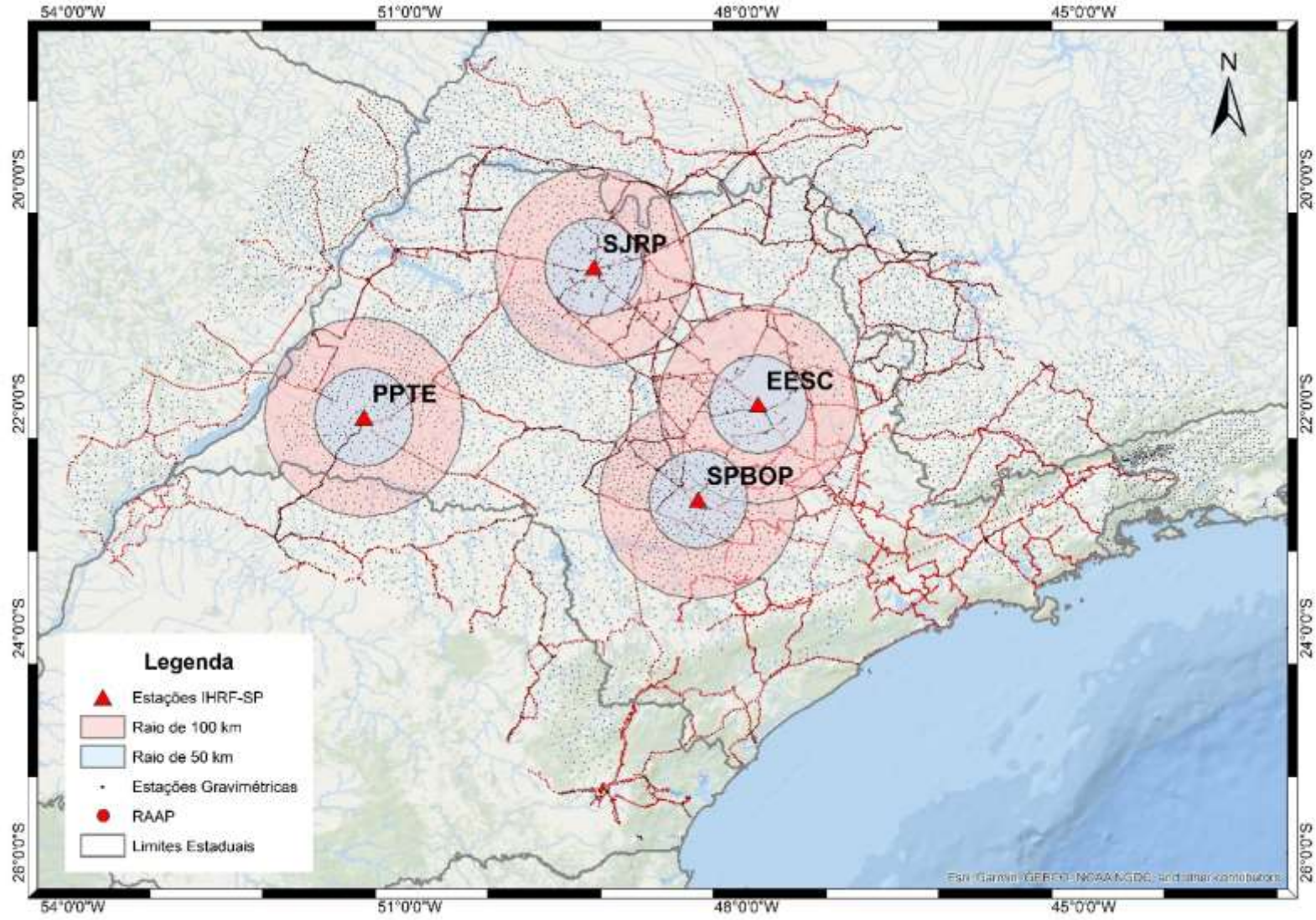


Stations	Distance	H mean	N. of points
CEFT	10 km	15,57	49
	10 km a 50 km	102,23	278
	50 km a 110 km	386,62	1038
	110 km a 210 km	590,64	2261
TOTAL OF POINTS			**3626**

IHRF - SP

4 stations were considered for the state of São Paulo.



Geoid model - state of São Paulo

Geoid fitting to the GPS/BM (360 points) from IBGE

Accuracy intervals:

GPS 0.001 m ≤ SD ≤ 0.048 m

(In most points, SD are between 0.01 and 0.02 m)

Benchmark 0.03 m ≤ SD ≤ 0.09 m

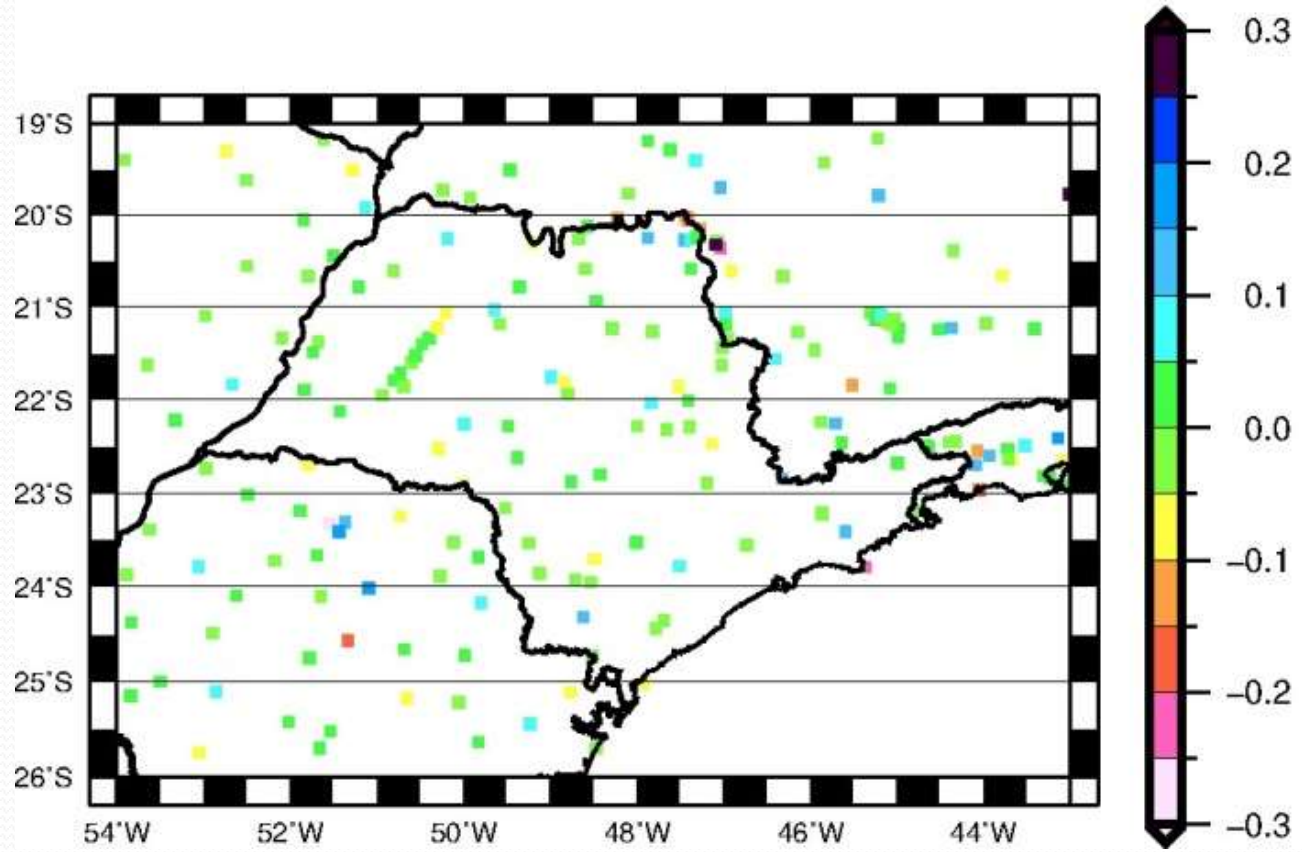
(In most points, SD are between 0.06 m and 0.07 m)

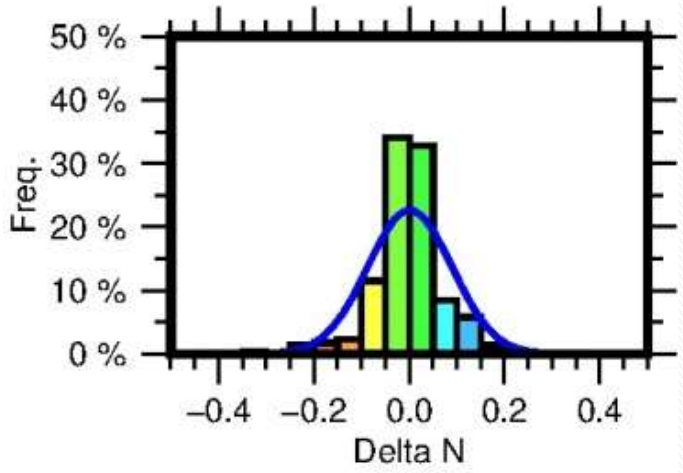
Two techniques:

a) 4-parameters (datum shift) (systematic component removed) + Least squares collocation (Kriging);
b) Weighted mean.

Should it be done?

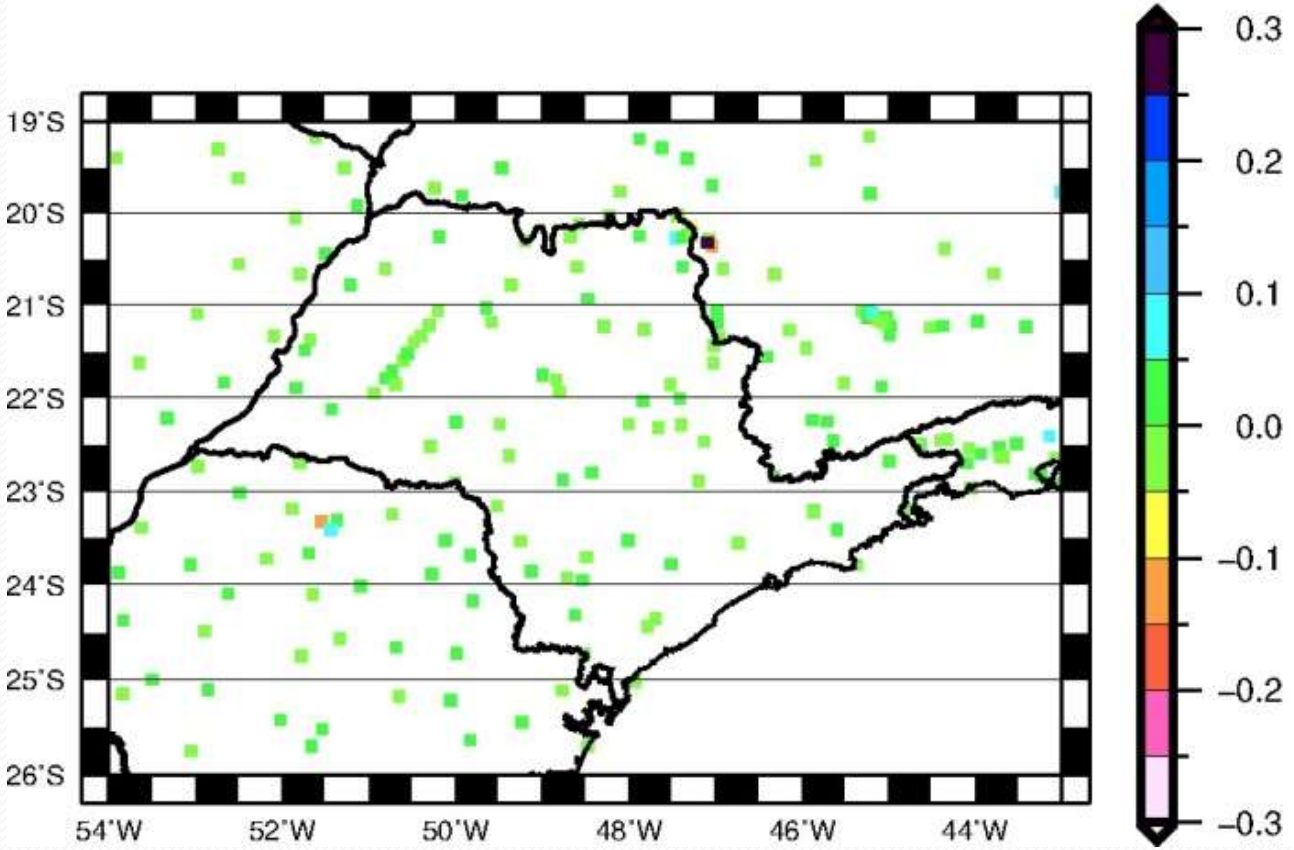
N GPS/Benchmark – N Geoid model (m)
4–parameters + Least squares collocation

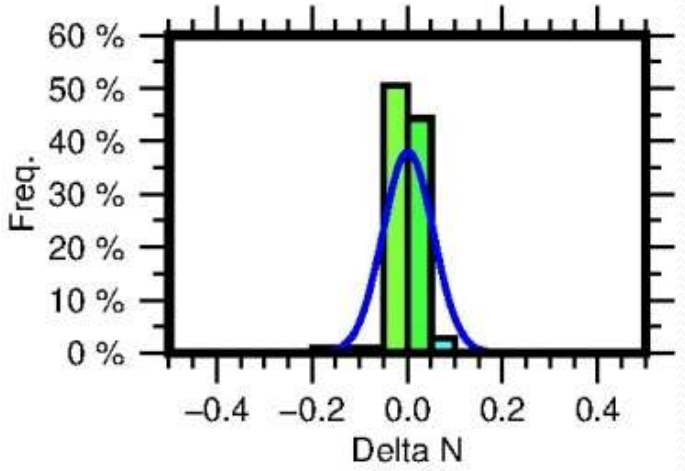




Mean	0.00
Median	−0.00
Standard desviation	0.09
RMS	0.09
Positive maximum value	0.66
Negative maximum value	−0.33

N GPS/Benchmark – N Geoid model (m)
Weighted mean

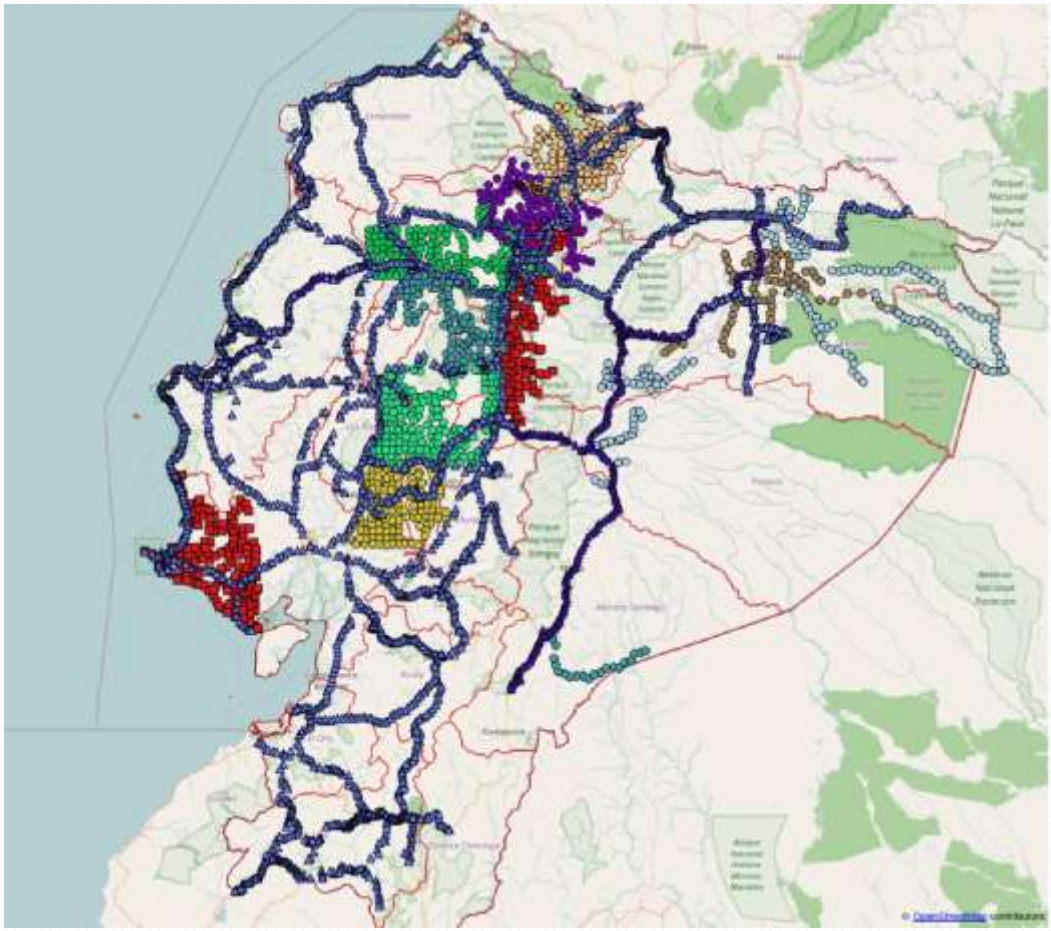




Mean	0.00
Median	−0.00
Standard desviation	0.05
RMS	0.05
Positive maximum value	0.65
Negative maximum value	−0.20

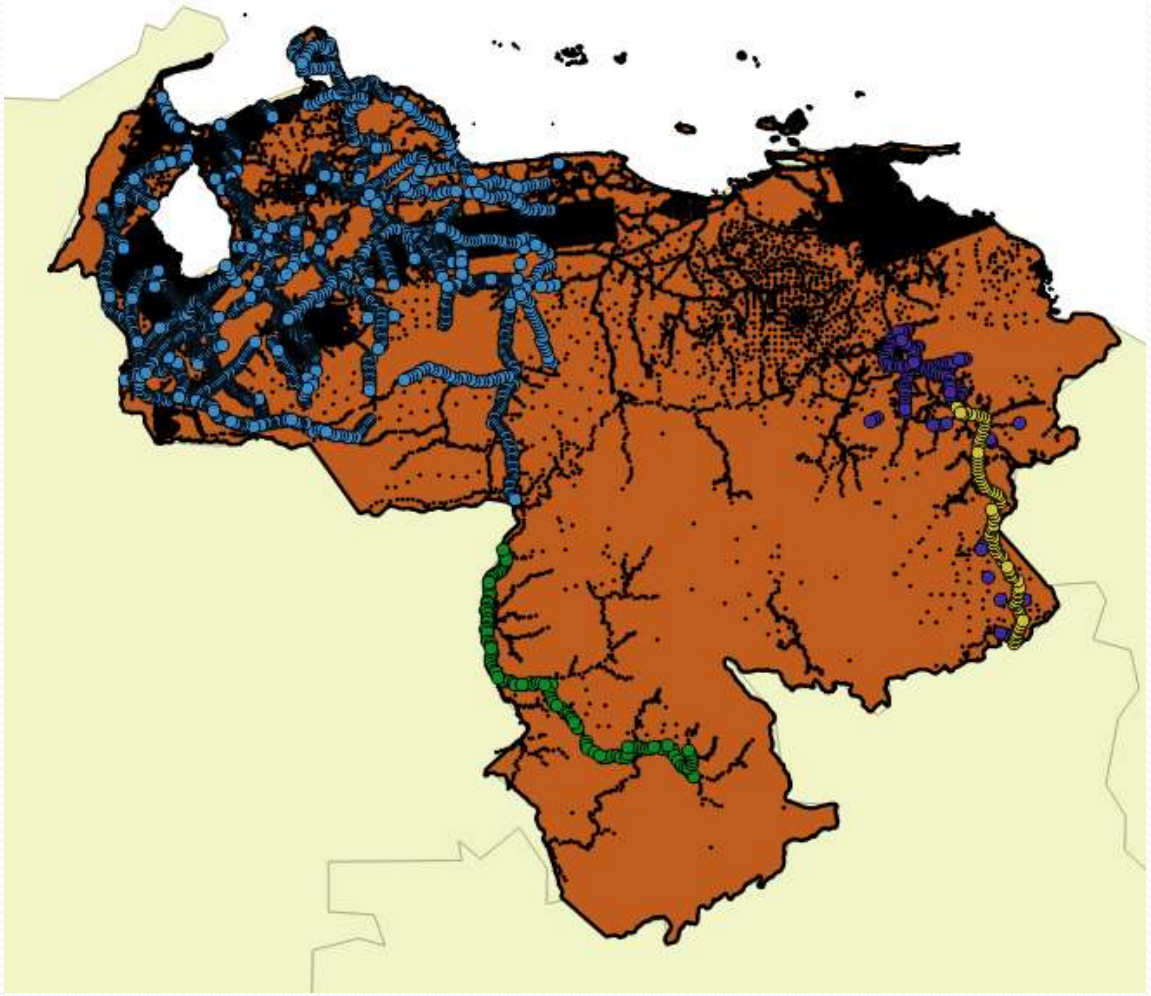
IHRF – Ecuador.

Surveys were undertaken at the tide gauge by IGM, recently. A second option is Cuenca where some surveys have been already established. It is needed to be completed.



IHRF - Venezuela

For IHRF the station in mind is Merida. But there is an attention to El Calvario. In both cases there is an absolute measurement.



DTM – Digital Terrain Model in Latin America.

SRTM/ALOS

An effort has been done in the past at LTG for the use and improvement of SRTM in Latin America. At the moment, we are working with new models, like ALOS.

Conclusion

It is fundamental to work in a strictly collaboration in order to improve the infraestructure for GGRF in Latin America. We have very good examples of efforts and these examples must propagate.

Acknowledgment

THANK YOU TO ALL INSTITUTIONS, UNIVERSITIES AND COMPANIES THAT COOPERATED FOR GEODETIC RESEARCH AND SURVEYS IN LATIN AMERICA. THE COLLABORATION OF NORTH AMERICA AND EUROPE IS ALSO FUNDAMENTAL, IN MANY CASES.

Between many names I would like to mention at least: IBGE (Brazil), IGC (São Paulo), IGMs (Chile, Ecuador), IGCSB (Venezuela), IGN (Argentina, Costa Rica), Universities (Argentina, Venezuela, Costa Rica), NGA/USA, Politecnico de Milano/ISG (Italy), BGI/IRD (France).

Thank you!

Crossing Orinoco River (VEN)

Cerro de La Muerte (CR)

Floating down the Madeira River (BRA)

Near Cotopaxi Volcano (ECU)

Vehicle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Vehículos y Equipo de trabajo de campo