UFPR (1) SIRGAS (2) DGFI (3) SENESCYT (4)

TOWARDS A UNIFIED VERTICAL REFERENCE FRAME FOR SOUTH AMERICA IN VIEW OF THE GGOS SPECIFICATIONS

Andrea Galudht Santacruz Jaramillo (1) (4)
<u>Sílvio Rogério Correia de Freitas</u> (1) (2)
Laura Sánchez (2) (3)

International Association of Geodesy
IGFS

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1. SIRGAS – WG III and the SVRS

SIRGAS-WG III (Vertical datum) was established during the IAG 1997 Scientific Assembly.

Its main objectives are:

- to define a modern unified SIRGAS Vertical Reference System (SVRS);
- to establish the corresponding reference frame;
- and to transform the existing classical height datums to the new system.

1. SIRGAS – WG III and the SVRS

SIRGAS is the IAG Sub-Commission 1.3b

- SC1.3b-WG I: Reference System
- SC1.3b-WG II: SIRGAS at National Level
- **SC1.3b-WG III: Vertical Datum**

Present Objective: Establish a unified gravity-field related vertical reference system that meets the GGOS requirements on long-term stability and homogenous high-reliability.

In a first step, the unification works are directed to the South-America and in next steps for Central-America and Caribbean countries

1.1. Diagnostic of Vertical Networks in SIRGAS context

i) most of the reference levels for height datums are realized by the mean sea level registered at individual tide gauges over different periods;

ii) the vertical networks were extended over each country using mainly spirit leveling methods, in general, without corrections for the real gravity effects;

iii) they do not take into account the variation of heights and reference levels with time;

iv) vertical datums discrepancies between neighboring countries.

1.1. Diagnostic of Vertical Networks in SIRGAS context

Mainly, because the explained aspects, the vertical networks do not permit data exchange neither in continental nor in global scale, and they are not able to support practical height determination with GNSS techniques in combination with precise geoid or quasi geoid models.

2. The GGOS Specifications

Goals:

- to be the primary source for all global geodetic information and expertise serving society and Earth system science;
- to actively promote, sustain, improve and evolve the global geodetic infrastructure needed to meet Earth science and societal requirements;
- to coordinate the international geodetic Services that are the main source of key parameters needed to realize a stable global frame of reference and to observe and study changes in the dynamic Earth system;
- to communicate and advocate the benefits of GGOS to user communities, policy makers, funding organizations, and society.

3. The GGOS Global Vertical Reference System (GVRS)

GVRS Conventions

$$W_0 = Constant$$

$$-\Delta W_P = C_P = W_0 - W_P$$

The unit of length is the meter (SI)

The GVRS is a Zero Tidal System

4. The SVRS under the GGOS specifications

The proposed SVRS is based on two components: a geometrical; and a physical one.

The geometrical component corresponds to ellipsoidal heights referred to the SIRGAS datum. The physical component is given in terms of geopotential quantities (W_0 as a reference level and geopotential numbers as primary coordinates).

Its realization should:

i) refer to a unified global reference level W_0;

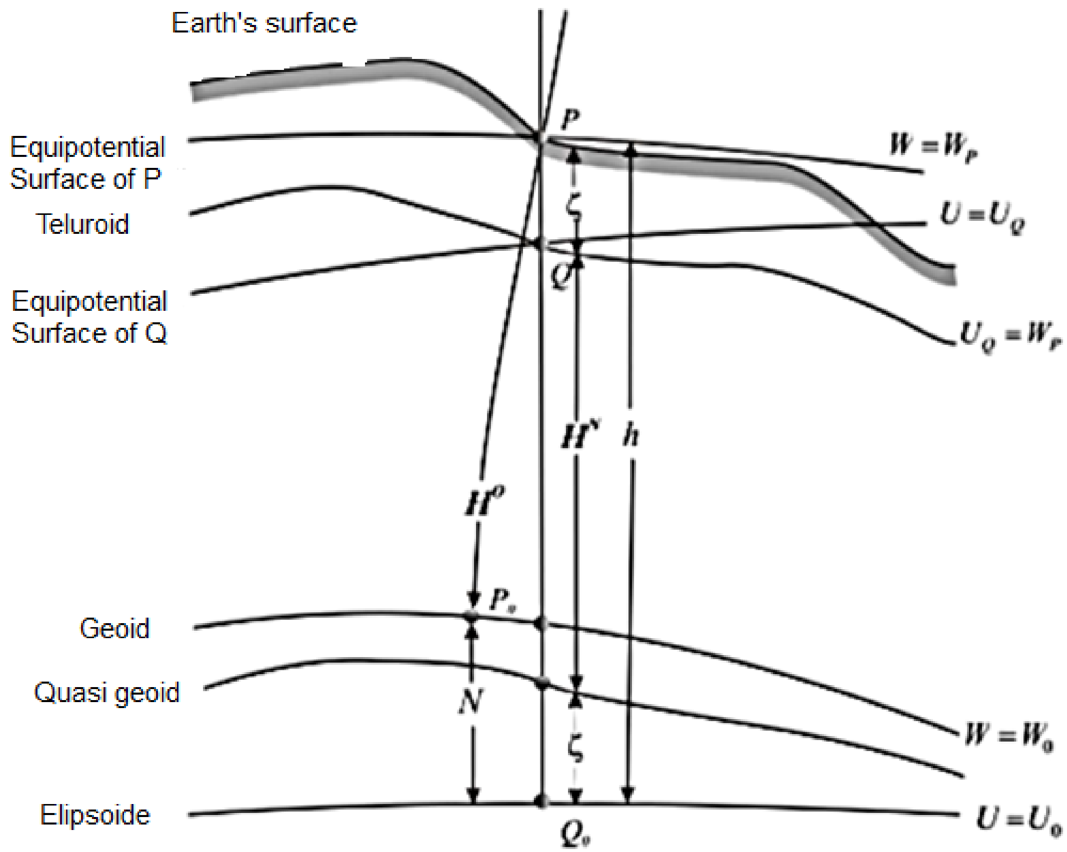
ii) be given by proper physical heights (derived from spirit leveling in combination with gravity reductions);

iii) be associated to a specific reference epoch, i.e. it should consider the coordinate and referential changes with time.

4.1. Associated heights related to the SVRS

$$h = H^O + N$$

$$h = H^N + \zeta$$



4.2. Realization of the SVRS by the SIRGAS Vertical Reference Frame (SVRF)

Determination of W_P

Classical Form
With Leveling Networks and gravimetry

$$W_P = W_0 + C_P$$

$$C_P = W_0 - W_P = \int_0^P g\,dn$$

Modern Form
With Innovative Technologies, GGMs, GBVP

$$W_P = U_P + T_P$$

$$C_P = W_0 - W_P$$

$$U_P = U_0 + \frac{\partial U_0}{\partial h}.h$$

$$T_P = \frac{R}{4\pi}\iint_s (\delta g + \mu_1 + \mu_2 + \cdots).H(\psi)ds$$

4.3. Strategies for linking the SVRS to a GVRS

Inventory with the characteristics of the National Vertical and Gravimetric Networks = Local Strategies

Countries of South America

Local Height System 1

≠

Local Height System 2

≠

Local Height System *i*

INTEGRATION

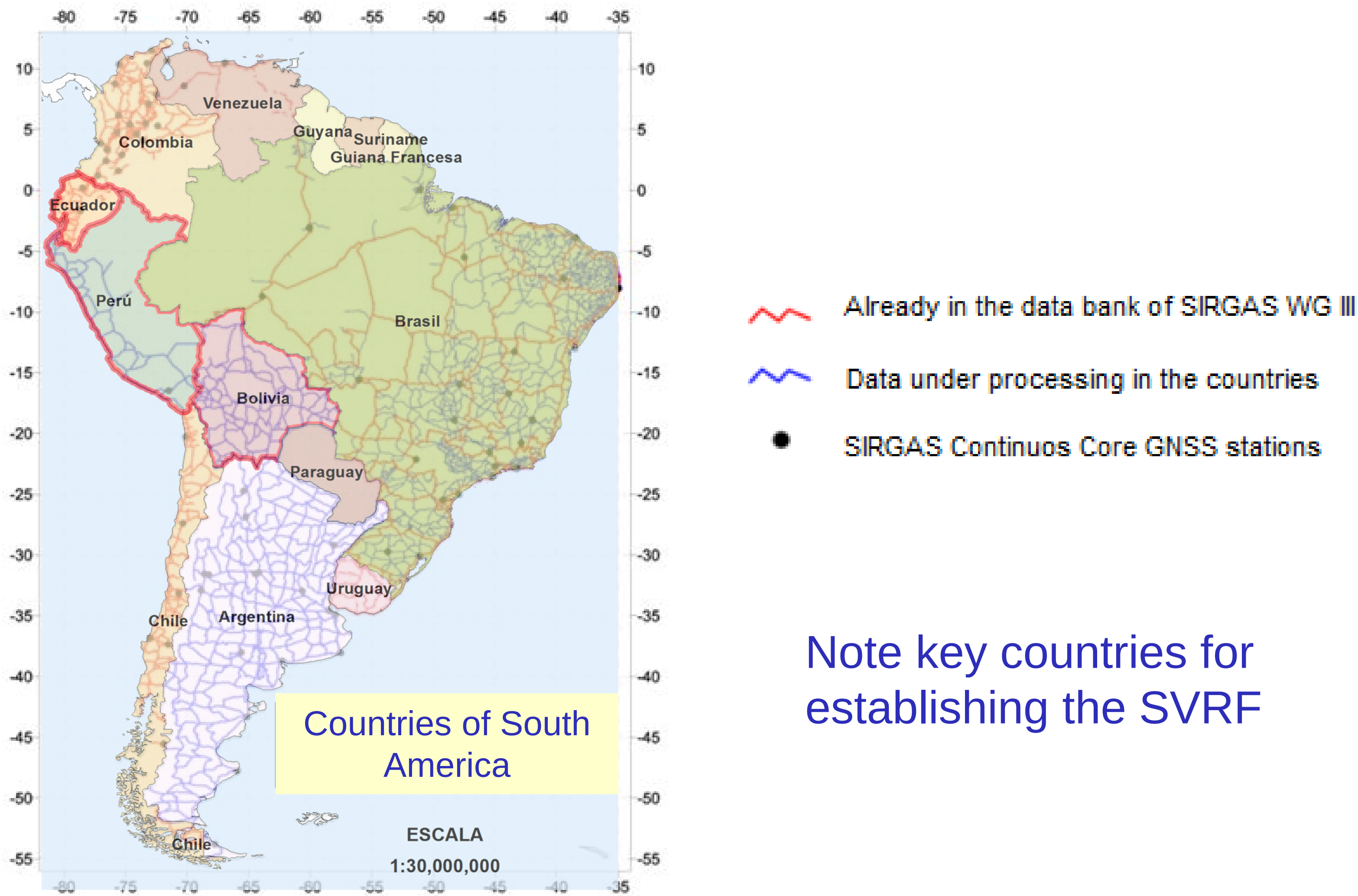
Regional Strategies

Based on the combination of classical and modern data under the GVRS/ GGOS Specifications.

SIRGAS WG III

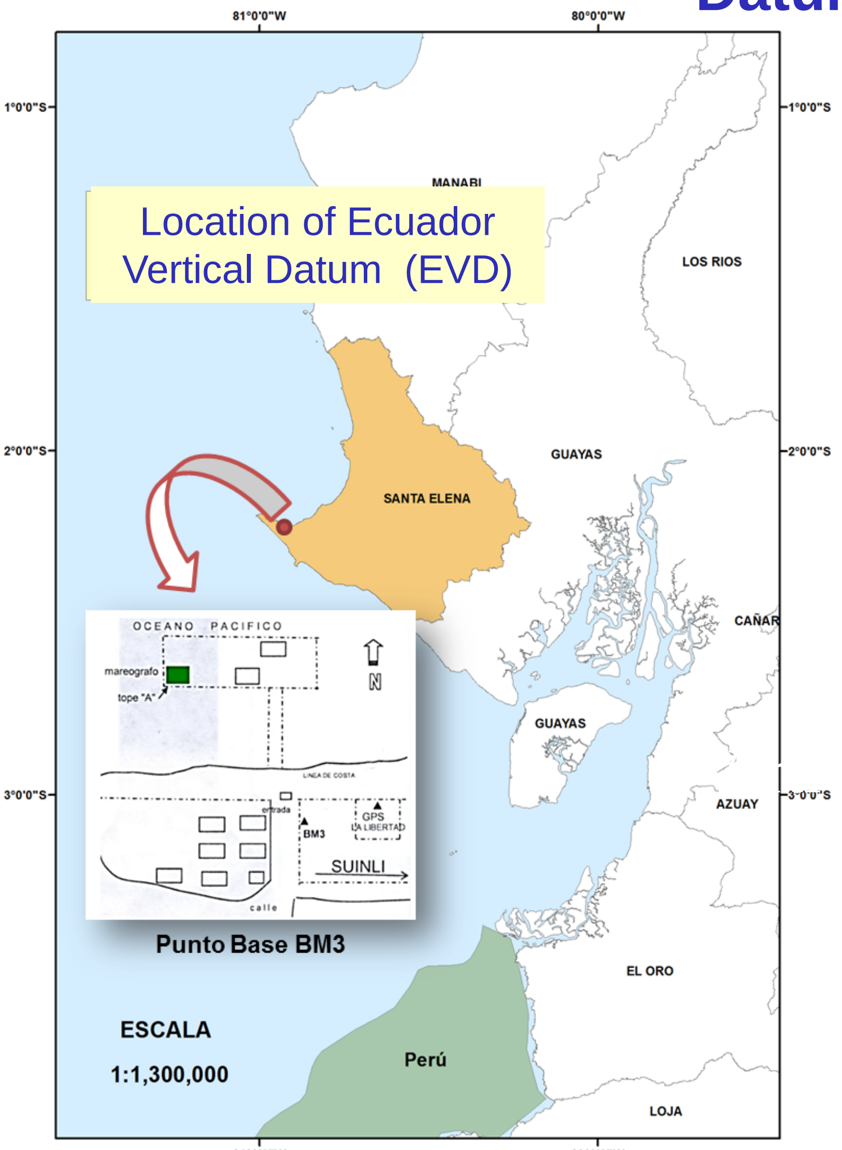
3rd IGFS General Assembly

5. Present Status of SVRF from Inventory in South-America



Note key countries for establishing the SVRF

6.1. A sample of an inventory in Ecuador – Ecuador Vertical Datum (EVD)

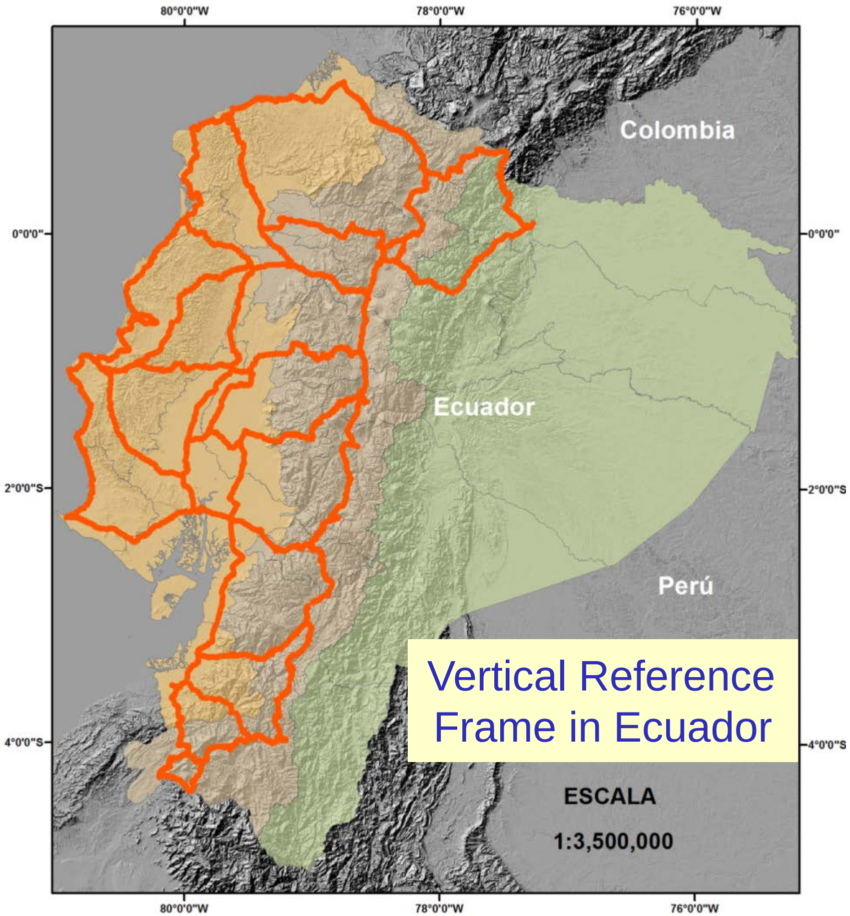


STRATEGIES FOR EVD

- Geocentric positioning of tide-gauge;
- Modelling of time evolution of MSL;
- Improving of GGM resolution by reducing omission error (e.g. by RTM and/or gravimetry densification);
- W_i determination in the datum with basis in the solution of the GBVP (free and fixed) and determination of SSTop;
- Comparison with solution from MSS model (e.g. CLS 2011);

$$SSTop = (W_0 – W_i) / \gamma_I$$

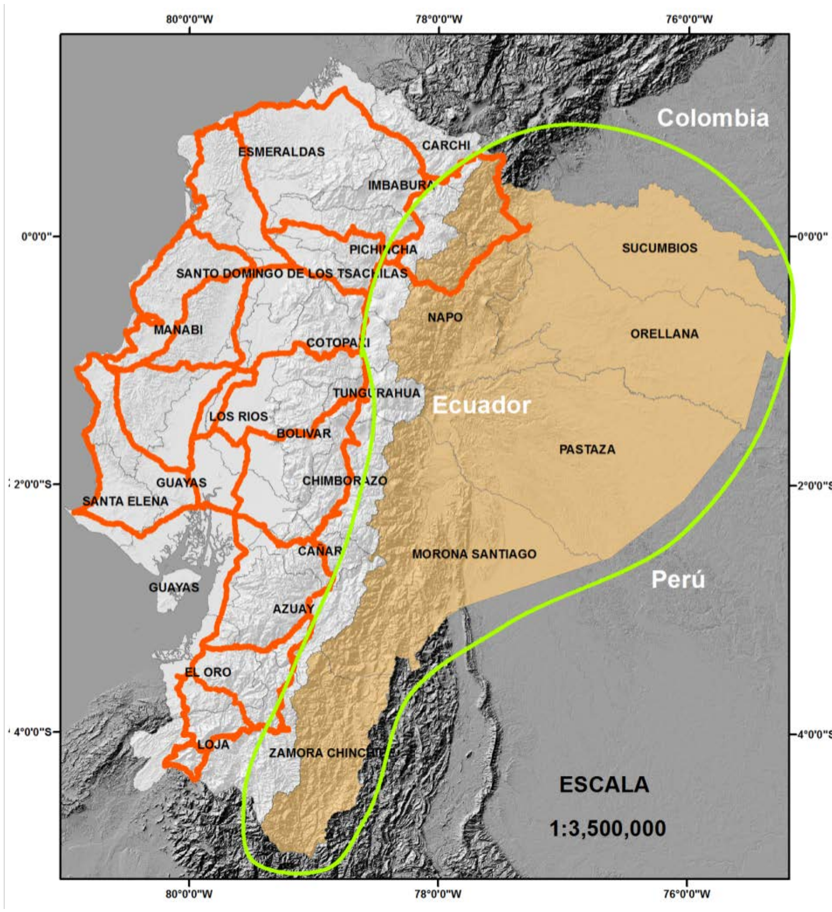
6.2. A sample of an inventory in Ecuador – Ecuador Vertical Reference Frame (EVRF)



Focus: Leveling + GNSS L1/L2 + Gravimetry

STRATEGIES	
	• Analysis of leveling errors in row leveled heights and gravity data distribution; • Densification of leveling lines in borders and Amazonian regions; • Determination of geopotential numbers differences; • Network adjustment in view of geopotential numbers differences; • Determination of geopotential numbers related to the EVD and the GVRF; •Determination of offsets in border connections.

6.3. A sample of an inventory in Ecuador – Ecuador Gravity Frame (EGF)



FOCUS: Leveling + GNSS L1/L2+ Gravimetry

STRATEGIES	• Adjustment of EGF with basis in the absolute gravity stations; • Gravity densification along with leveling lines + GNSS for generating geopotential numbers in a GVRF; • Gravity interpolation along with leveling lines; • Gravity measurements + GNSS in regions without leveling lines for generating gravity disturbances and geopotential numbers in a GVRF; • Determination of convertion parameters (EVRF ⇔ GVRF) .

7. Synthesis of meta-data analysis for building SVRF

EVD	• Geocentric positioning of tide gauge; • *Wi* determination; • W_0 by improving GGM; • MSS evolution analysis	• Realization of NVRF with basis in geopotential numbers; • Evaluation of National Vertical Reference Frames (NVRF) and their relationship with neighboring ones; • Proposition for linking to a GVRF with basis in geopotential numbers; • Determination of convertion parameters (NVRF ⬄ GVRF); • Densification of NVRF with basis in leveling and/or new methodologies.	• All heights in theSouth American NVRF refered to the same GVRF
EVRF	• Analysis of leveling lines; • Densification of leveling; • Determination of geopotential numbers diferences and adjust.; • Determination of geopotential numbers related to the EVD and the GVRF; • Determination of offsets in borders connections.		
EGF	• Adjustment of EGF; • Gravity densification along with leveling lines + GNSS; • Gravity interpolation along with leveling lines; • Gravity measurements + GNSS in regions without leveling;		
Without Information	• Global Models; • New local measurements; • and new orbital sensors data.		

8. SUMMARY

- Some steps are considered as fundamental for establishing the SVRF under GVRF/GGOS. The most important is related with the construction of a consistent SIRGAS WG III data bank with data provided by all member-countries;
- As a case study, EVD, EVRF and EGF were inventoried by using available meta-data and other descriptors;
- Similar study must be done in several countries in South and Central America for understanding heterogeneities related to the NVRF and the essentials complementary actions for establishing the SVRF under the SIRGAS – WG III umbrella;
- The use of modern data sources based on satellite surveying systems are considered essentials for facing the poor data availability in SIRGAS countries.