Progress report on GNSS & SLR projects

Stan Makarchuk

Comisión Nacional de Actividades Espaciales

Claudio Brunini

Argentinean - German Geodetic Observatory

A R G E N T I N A

United Nations/Argentina Workshop on the Applications of Global Navigation Satellite Systems

Falda del Cármen, March 19 -23 2018

Introduction

This presentation reports on the progress of two idea-projects under study by the Comisión Nacional de Actividades Espaciales (CONAE) and the Argentinean-German Geodetic Observatory (AGGO).

The ideas are targeted to:

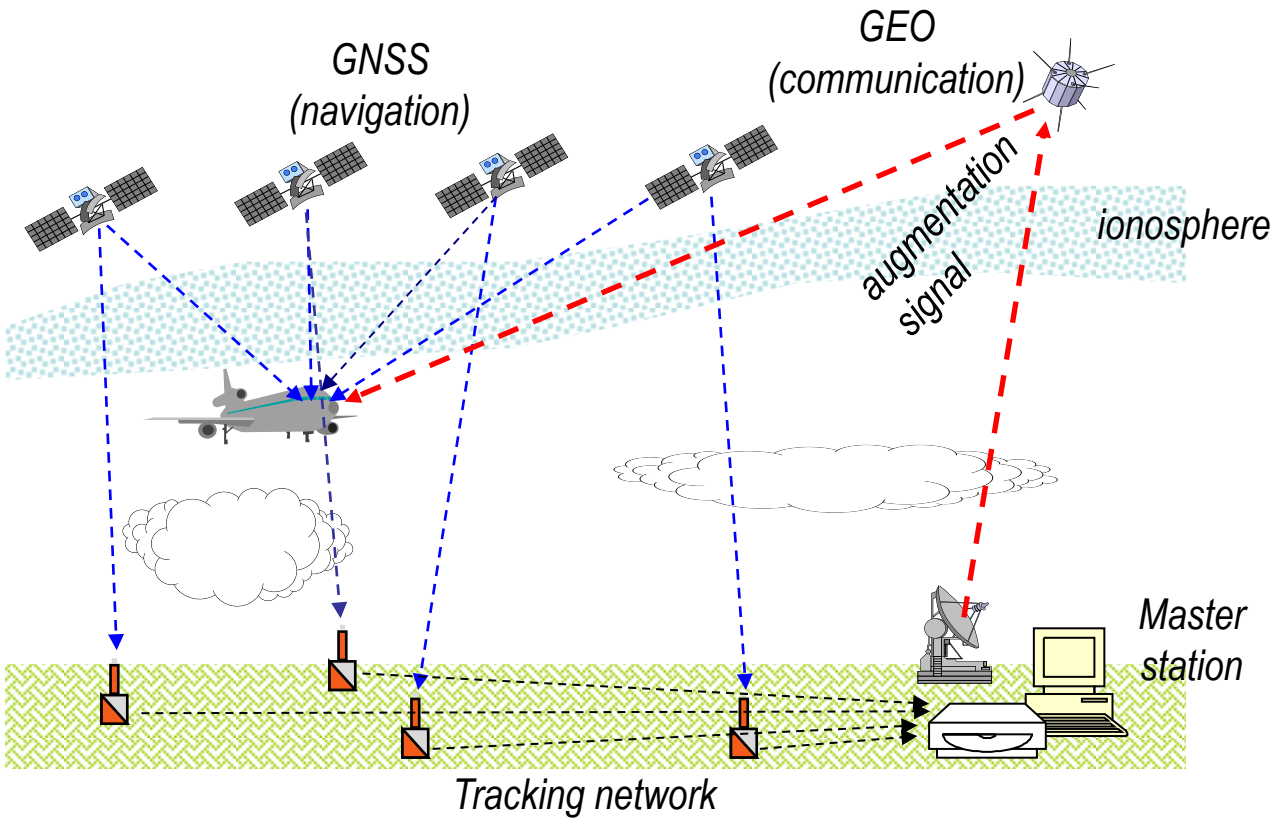
1. *Assess the feasibility of implementing a Satellite Based Augmentation System (SBAS) in Argentina (with possibility to be expanded to the CAR/SAM region) through the development, installation and operation of an experimental prototype.*
2. *Leverage the use of the Satellite Laser Ranging (SLR) technology in Argentina (and Latina America) for a variety of purposes, including:*
    a) *Use of SLR data for regional GGRF densification;*
    b) *Equipped future satellite missions with laser retro-reflectors;*
    c) *Use of SLR data for Lunar geodesy;*
    d) *Exploring quantum encrypted communication via SLR.*

GNSS Satellite Based Augmentation System (SBAS)

Are intended to augment the accuracy and Integrity of stand alone GNSS navigation for safety of life (e.g. civil aviation) and other (e.g. precision farming) applications.

Provides the users within a large region (e.g. a continent) with an augmentation signal via geo-satellite communication.

Existing examples are: EGNOS, BDSBAS, GAGAN, MSAS, SDCM and WAAS.

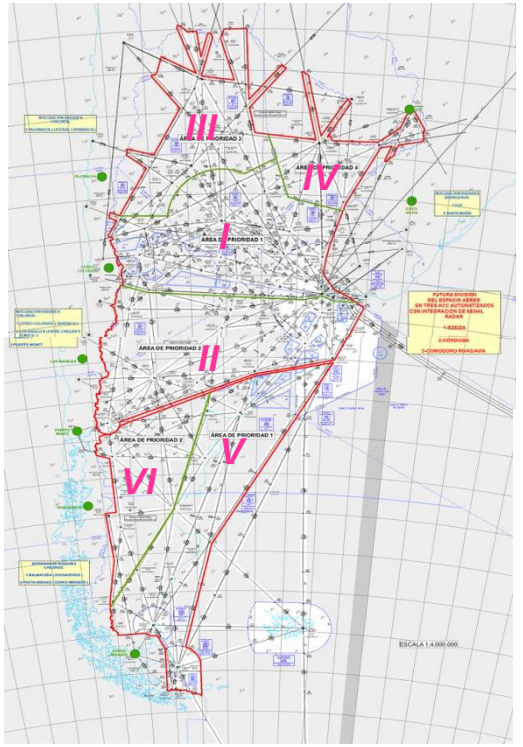


Requirements for the system

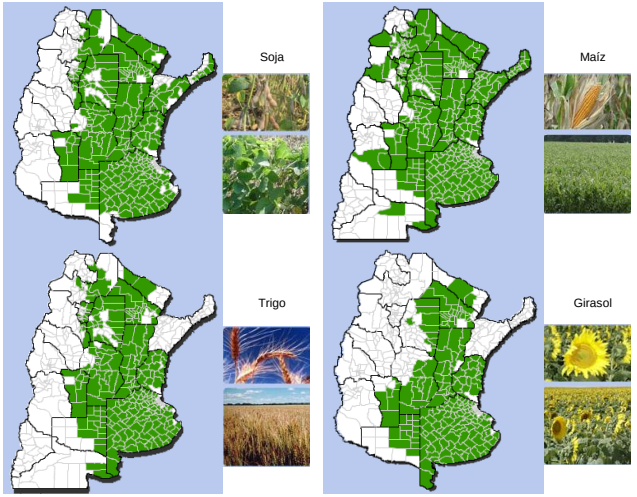
A feasibility study conducted in Argentina identified the main users in the following sectors:

- *Civil aviation (1)*
- *Agriculture (2)*
- *Fluvial transportation (Hidrovía - 3)*
- *Land administration*
- *Others (hazard mitigation, mining, petroleum, etc.)*

1)



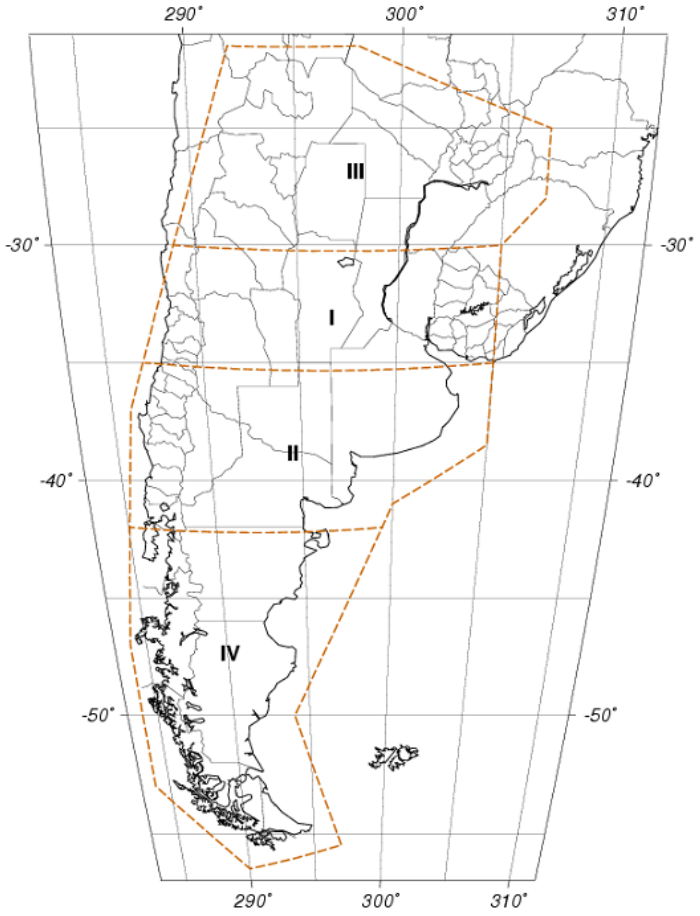
2)



3)

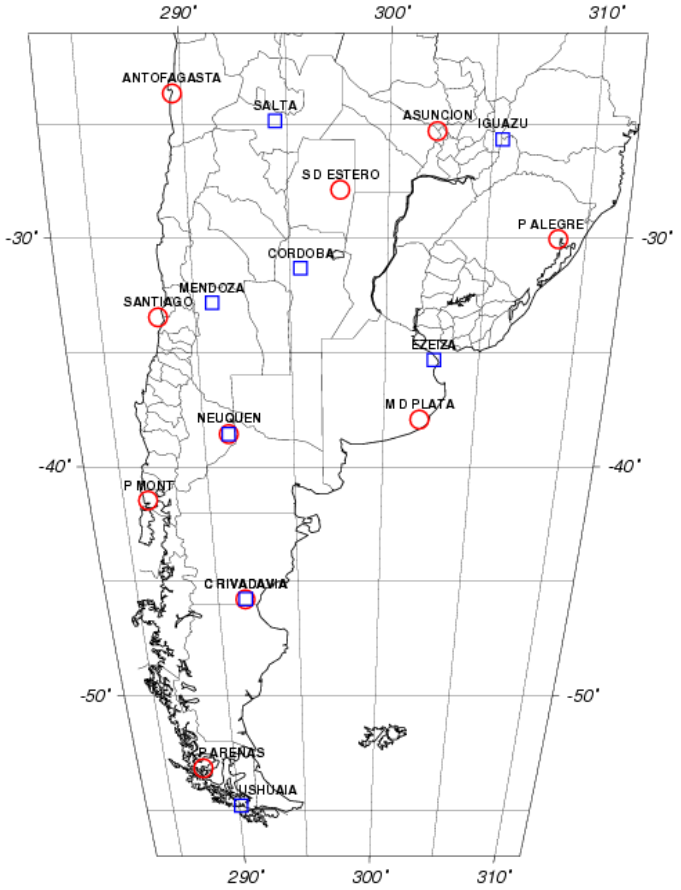
System architecture

Modular, scalable in four phases (numbered form I to IV in order of priority)



Tracking stations distributed according to ICAO criteria

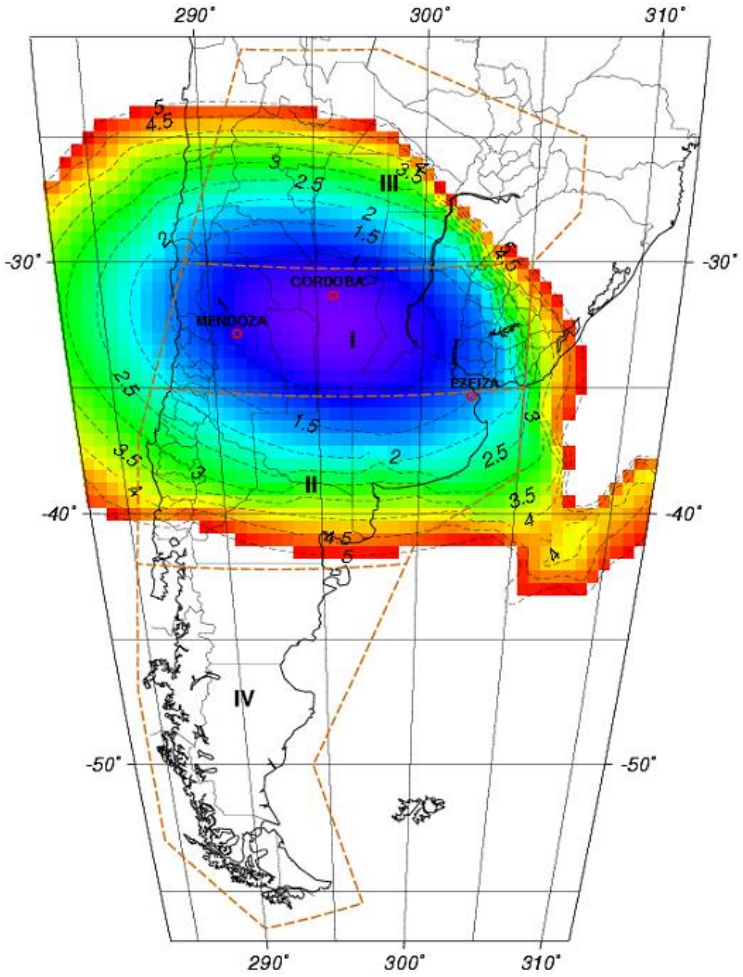
- ○ *proposed by ICAO for the SAACSA project*
- □ *proposed for this project*



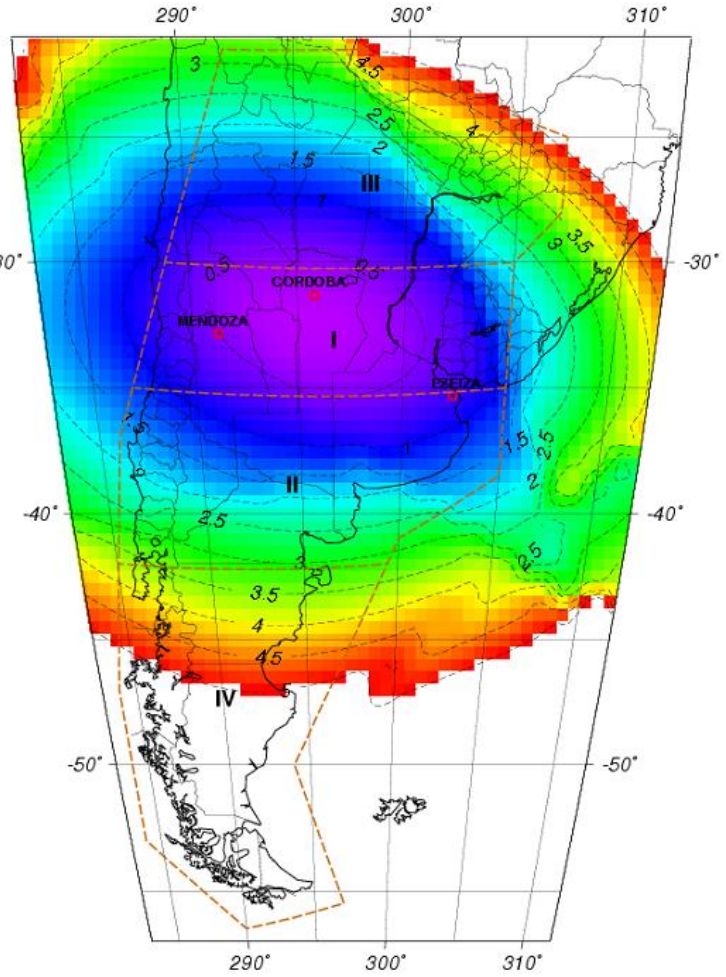
Error assessment (simulation) under worst case scenarios

Phase I (3 RIMs)

Vertical error [m]



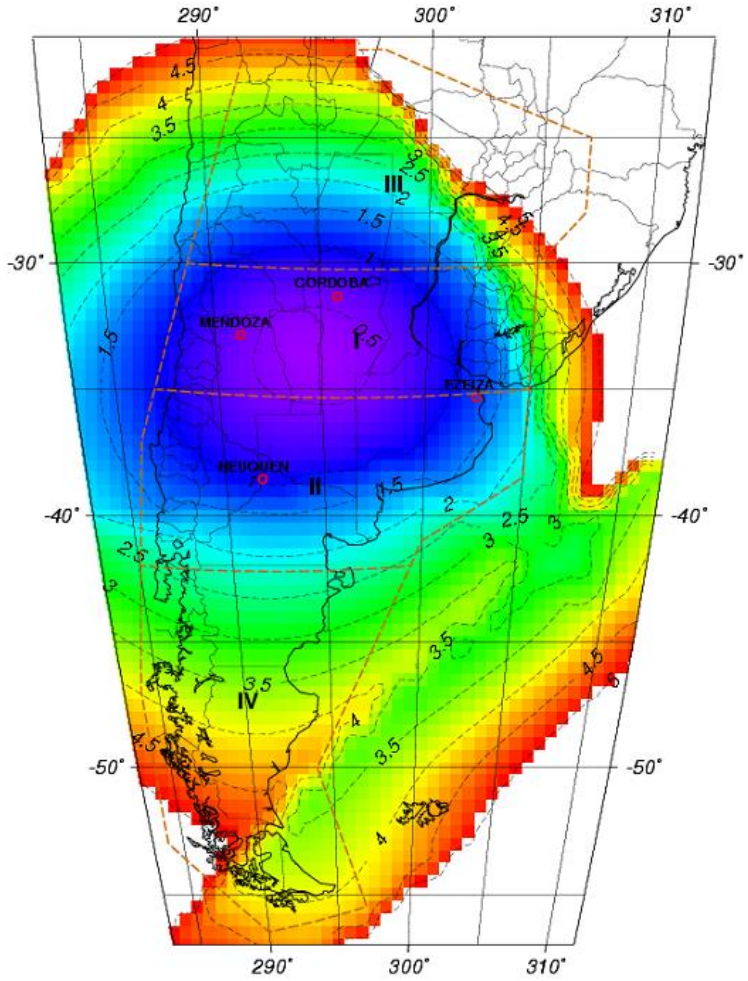
Horizontal error [m]



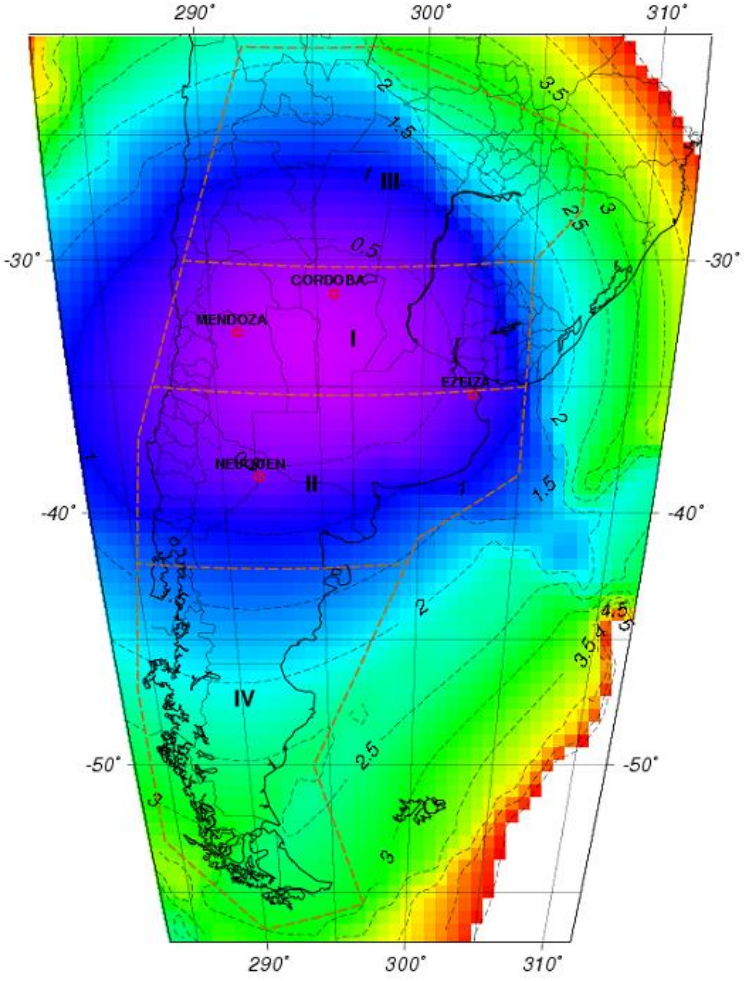
Error assessment (simulation) under worst case scenarios

Phase II (4 RIMs)

Vertical error [m]



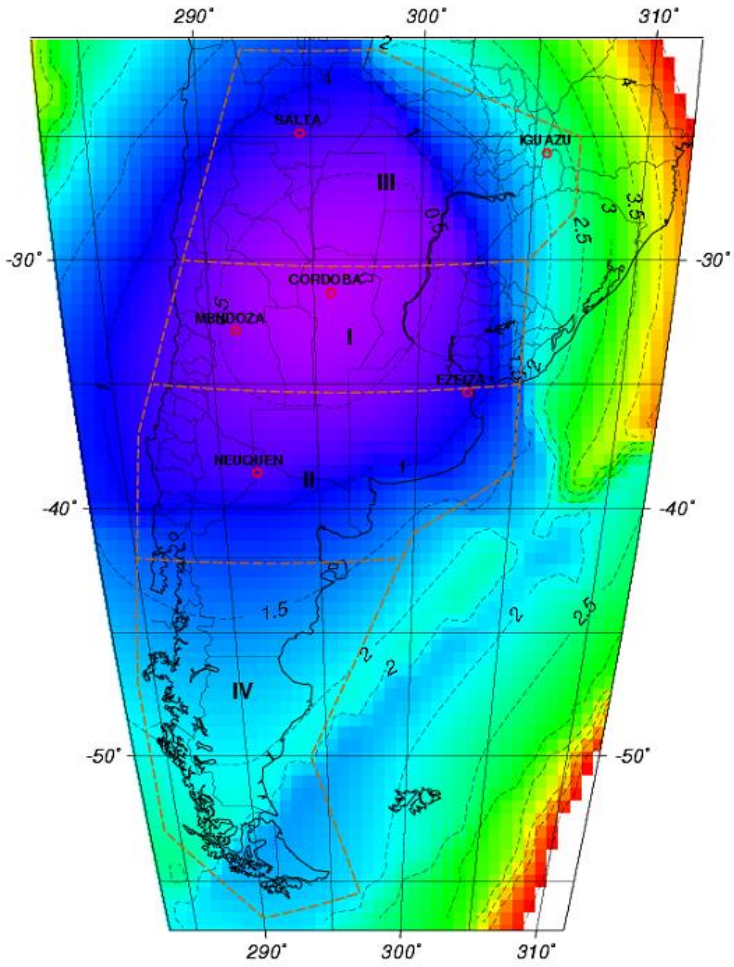
Horizontal error [m]



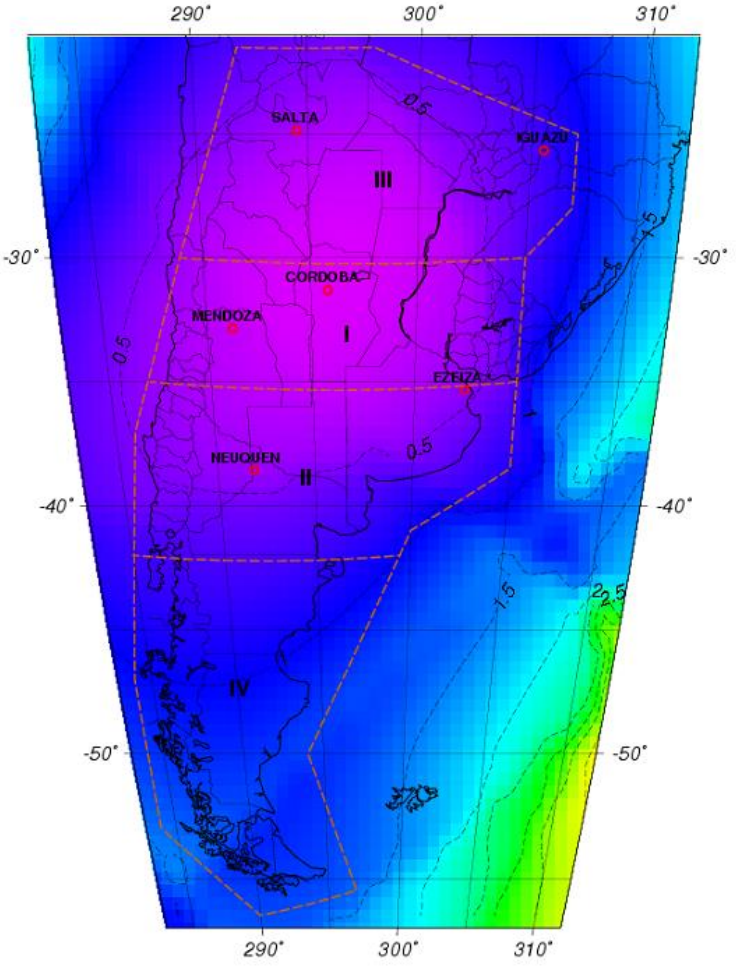
Error assessment (simulation) under worst case scenarios

Phase III (6 RIMs)

Vertical error [m]



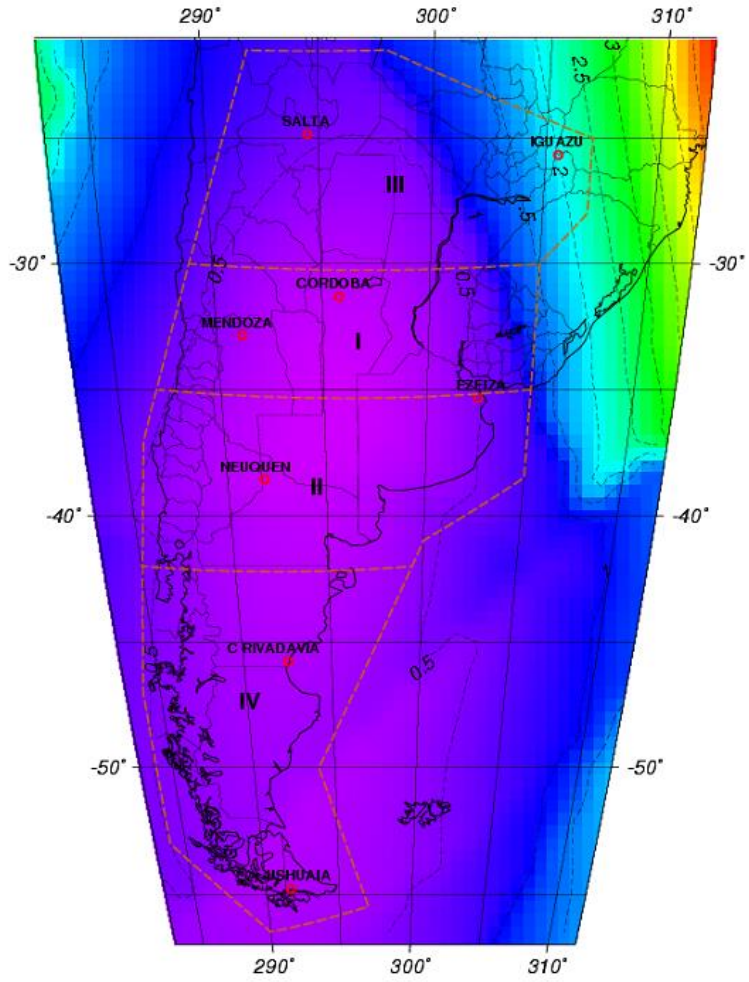
Horizontal error [m]



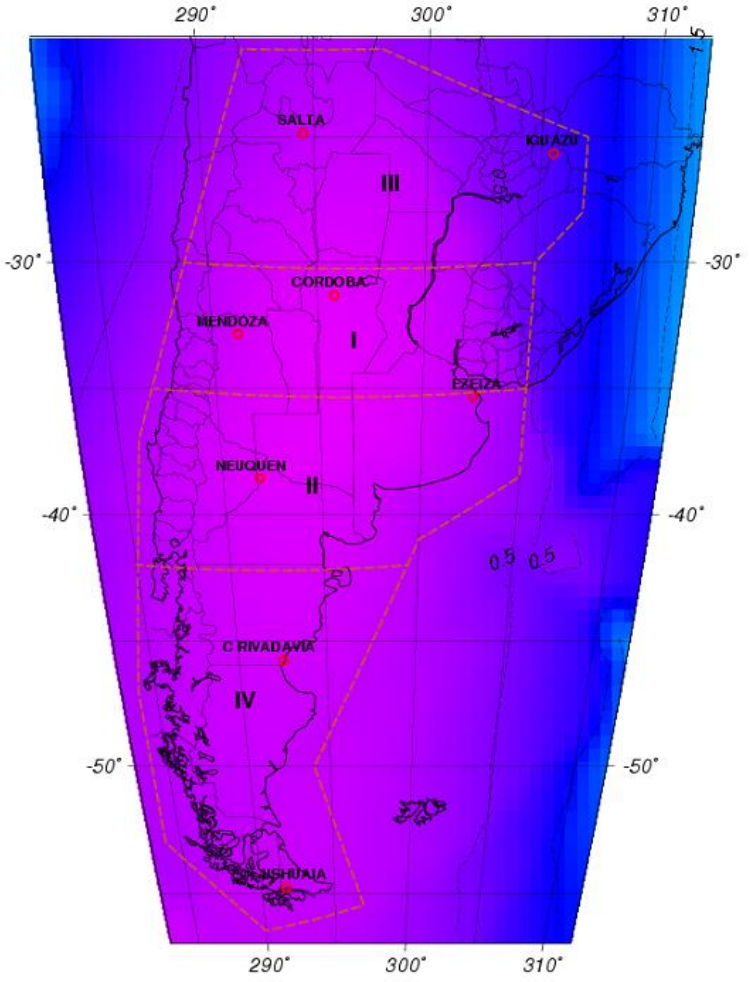
Error assessment (simulation) under worst case scenarios

Phase IV (8 RIMs)

Vertical error [m]



Horizontal error [m]



Satellite Laser Ranging (SLR)

Similar to GNSS from the point of view that determines satellite ranges based on electromagnetic signals.

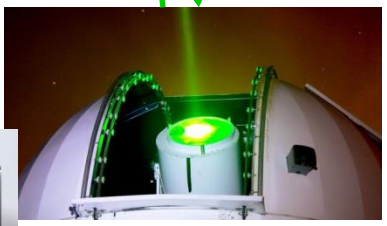
Different from GNSS because:

- *signals are laser pulse (optical signals), instead of modulated microwave carriers;*
- *measurements are double-way (no need a clock on the satellite but only in the tracking station).*

Complementarily to GNSS, SLR allows improving:

- *satellite orbits (for satellites equipped with reflectors);*
- *origin and scale of the GGRF.*

range =
speed of light × ½ travel time



precise clock only in the station

SLR in Latin America

Presently, there are 4 SLR stations in Latin America:

- *Arequipa, Peru-USA, since 1965;*
- *San Juan, Argentina-China, since 2005;*
- *Brasilia, Brazil-Russia, since 2014;*
- *AGGO, Argentina–Germany, under commissioning.*

Until now, the Latin American community has only been involved in the maintenance and operation of the tracking stations.

A project is being considered for extracting more benefits from these stations.

Implemented actions

First actions were directed toward the establishment of a Latin American Regional SLR forum and training peoples in processing SLR data.

A dedicated school was developed during the last SIRGAS Symposium held in Mendoza, Argentina, in November 2017 (see www.sirgas.org)

The School was conducted by a German expert (Daniela Thaller, from BKG) and attended by 43 participants from 9 countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Peru, Uruguay and Venezuela.

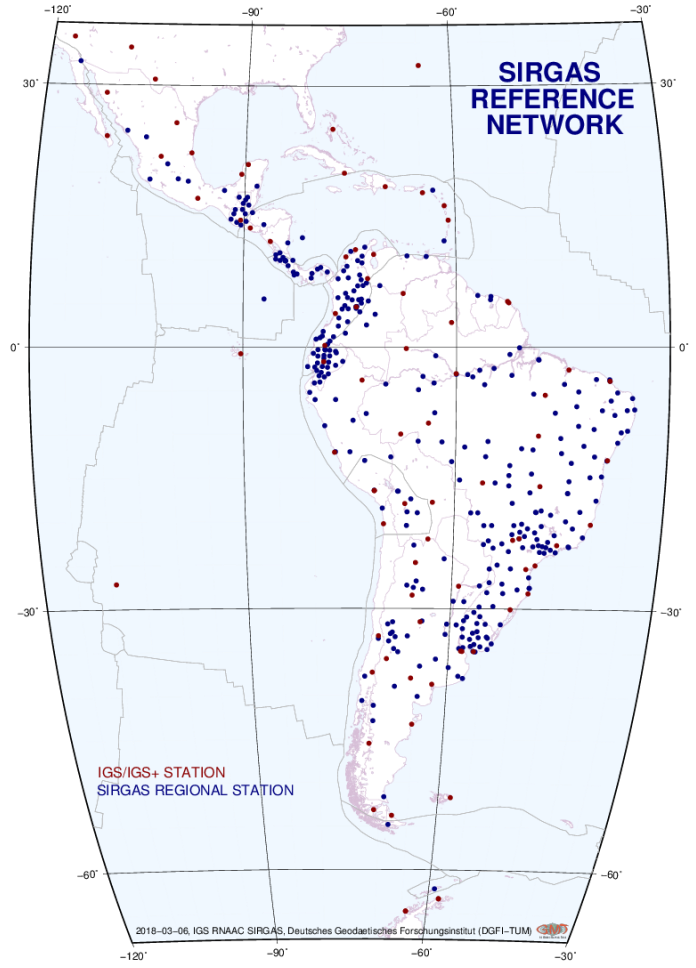
Implemented actions

All the national reference frames in Latin America relies on a regional densification of the ITRF, namely, SIRGAS.

SIRGAS reference frame is collaborative computed by 10 analysis centers run by institutions in Argentina, Colombia, Costa Rica, Chile, Ecuador, Germany, Mexico, Uruguay and Venezuela.

Until now, only GNSS measurements are used for SIRGAS computations (as well as for national reference frames computations).

Actions are in progress in Argentina and Brazil to include SLR measurements for the realization of SIRGAS (and the national reference frames).



Actions under consideration

- *Install laser retro-reflectors in future satellite missions that require precise orbit determination, including:*
  - *Developing the necessary technology for the satellite segment;*
  - *Developing orbital processing capabilities based on SLR data.*
- *Use of SLR data for Lunar geodesy:*
  - *Deploy SLR reflectors panel in the Moon, in partnership with other agencies;*
  - *Upgrade the AGGO's SLR system to reach the Moon.*
- *Exploring Encrypted Quantum Communication via SLR.*
  - *Reproduce the experiment performed recently by Chinese and Austrian scientists, who were able to transfer quantum information between Beijing and Vienna using SLR systems and the Chinese satellite "Micius".*
  - *Assessing the suitability of the AGGO's SLR system for the experiment, in partnership with the Chinese National Space Agency /China Academy of Sciences.*

Final words

Two activities framed in the peaceful use of space-based technologies in benefit of society are being explored for its potential development:

1. *Assessment of the feasibility of an SBAS implementation:*
    - *Preliminary studies have been conducted and simulation test have been performed*
    - *Results are encouraging and promissory.*
2. *Leverage the use of SLR in the region:*
    - *Activities are already on the way for including SLR data in the realizations of SIRGAS and national reference frames.*
    - *Possibilities are being explored for:*
        - *Installing laser retro-reflectors in Argentinean satellites;*
        - *Use of SLR for Lunar geodes;*
        - *Use SLR for quantum encrypted communication.*