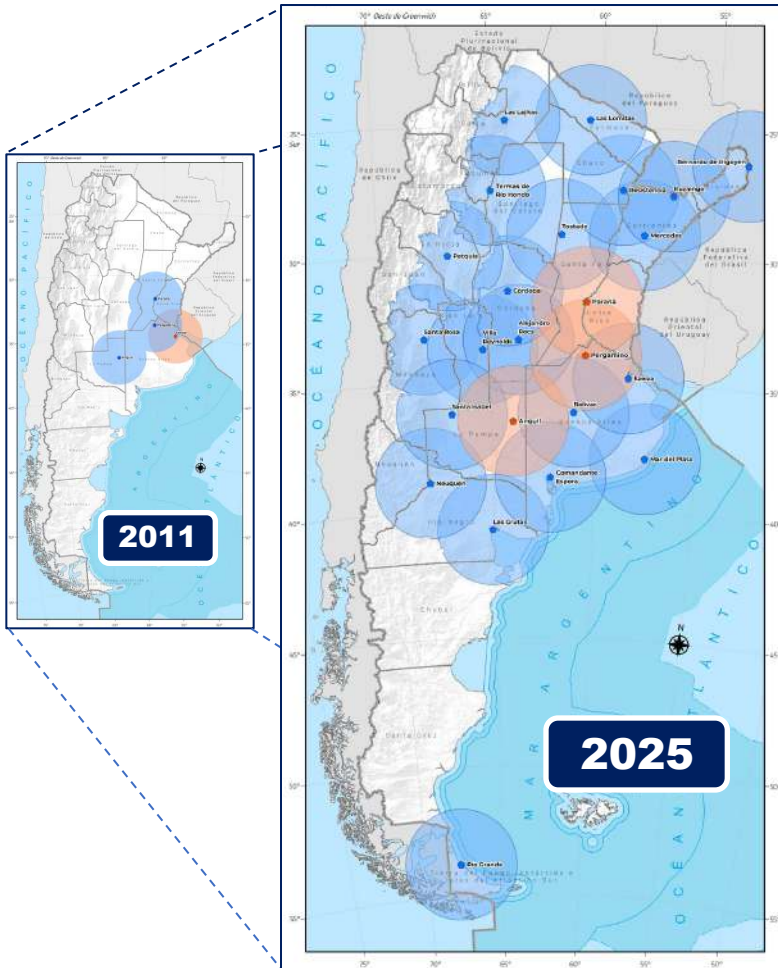**2011**

2025

SINARAME

A brief overview of the development of the Argentinian weather radar network

*Federico Renolfi * [1], Pablo Irurzun [2], Pedro Lohigorry [2] and Andrés Rodriguez [3, 4, 5]*

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The SINARAME network

A little more than ten years ago, by the end of 2011, the Argentine government promoted the creation of a unified national network of dual-polarization C-band weather radars with the beginning of *Sistema Nacional de Radares Meteorológicos* (**SINARAME**) project, managed by the *SubSecretaría de Recursos Hídricos de la Nación* (**SSRH**).

Along with the design, manufacturing, and commissioning of the new *Argentinian Meteorological Radar* (**RMA**), the first phase of this project included the development of a *Radar Operations Center* (**COP**) in Buenos Aires to have a central control system and data archive of the entire network.

RMA0, the first commissioned unit in SINARAME stage 1, is located in Bariloche near INVAP's factory. It's been dedicated to research, training and testing of new technologies since the begginings of SINARAME.

SINARAME
Operational radar – Stage I
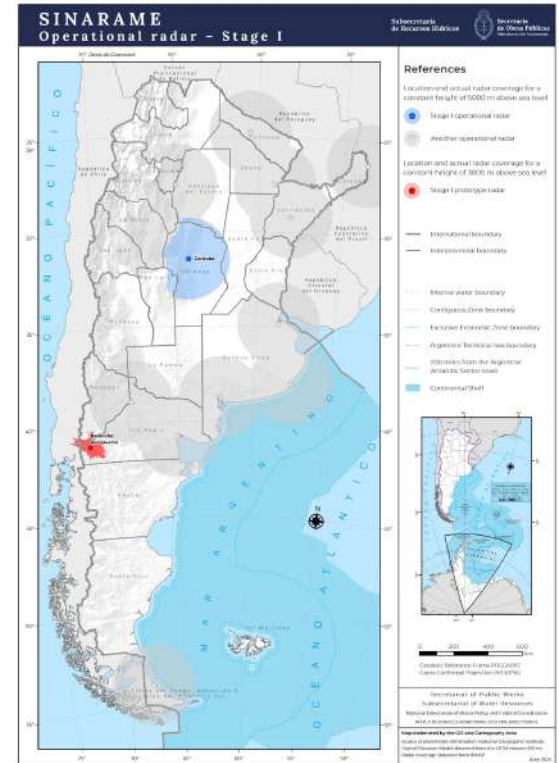
SINARAME – Center of Operations (COP)
SMN building, CABA, Buenos Aires

Images courtesy of SMN & SSRH

RMA-C320
Dual polarization C-band weather radar

The *Argentinian Meteorological Radar* (**RMA**) is a modern, dual–pol weather radar designed and manufactured entirely in Argentina by INVAP S.E.

The **SINARAME** network is currently composed of 16 C-band weather radars. The first 3 units were acquired abroad prior to the start of SINARAME project, while the newer **13** are **RMA** units.

RMA0, the first commissioned unit in phase 1 of the *SINARAME* project, is dedicated to research, testing of new technologies and personnel training.

By the end of 2025, a total of **21** *RMA* units are expected to be operational.

VIDEO !

Images © INVAP

RMA-C320
Technical specifications

| Parameter	Value
Brand and Model	INVAP RMA-C320 (Doppler, dual polarization)
Operational frequency	C-Band, 5600 - 5650 MHz (1 MHz steps)
Dual Pol transmission mode	Simultaneous transmission and reception (H + V)
System Sensitivity (ISO/DIS 19926-1:2019)	Better than -7 dBZ at 50 km with 1us pulse and for SNR=0 dB including atmospheric attenuation and radome and waveguide losses
Radome losses	0.4 dB (dry, one way)
Transmitter	Coaxial Magnetron, solid state modulator
Peak power	250 to 320 kW (10kW steps)
Pulse duration	0.5 to 2.0 us (100 ns steps)
Max duty cycle	0.001 (0.1%)
Antenna	Parabolic, center feed, 4.48 meters
Gain	45.4 dBi +/- 0.5dB @5625 MHz
Beam width @ -3dB (typical)	0.90° @5625 MHz
side lobes	Better than -27 dB
cross-pol isolation	Better than -35 dB
Receiver	Antenna mounted, over azimuth, double conversion superheterodyne
Intermediate Frequency (IF):	First: 905 MHz, Second: 70 MHz
noise figure	Better than 3 dB

Images © INVAP

RMA-C320
System composition

Antenna

Radome

Pedestal (mechanics and control software)

VIDEO !.

Images © INVAP
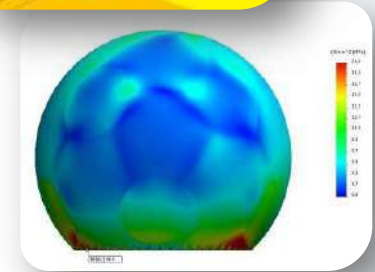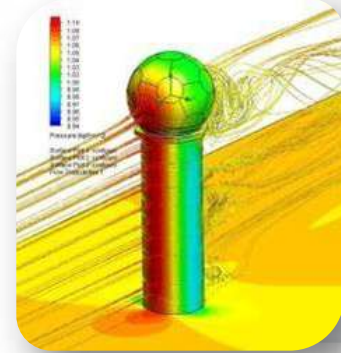
RMA-C320
# Radar assembly line

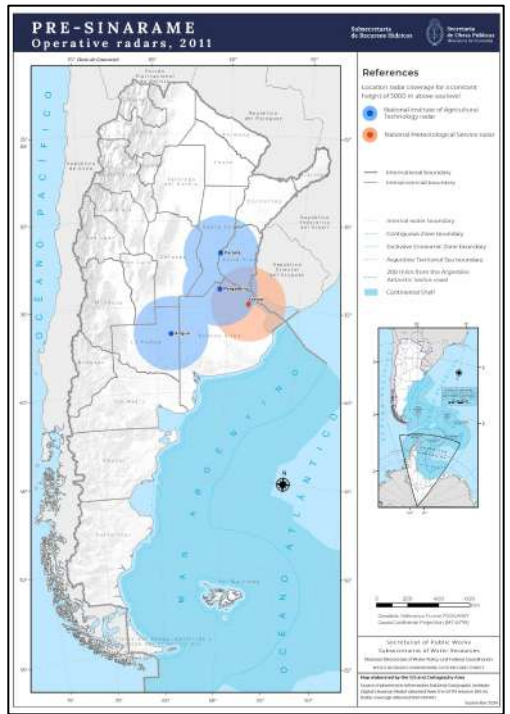Images © INVAP

The SINARAME network

Argentina's network of weather radars, *Sistema Nacional de Radares Meteorológicos* (**SINARAME**), is an ongoing, long-term, multi-stage government project.

- **Phase 1** of SINARAME project started in September 2011
  By June of 2015 RMA1 was fully operational

- **Phase 2** of the project was carried out between 2014 and 2019
  Another 10 new RMA radars were put into operation

- **Phase 3** of the project is underway, expected to finish by 2025
  Delivering a new batch of 10 RMA radars, reaching a grand total of 21 fully operative units.

The ultimate goal of **SINARAME** is to cover Argentina's surface with modern dual-pol weather radars, managed from a central location in Buenos Aires thereby enhancing hazardous weather forecast and alerts; resulting in better decision making by authorities, emergency managers and the general population.
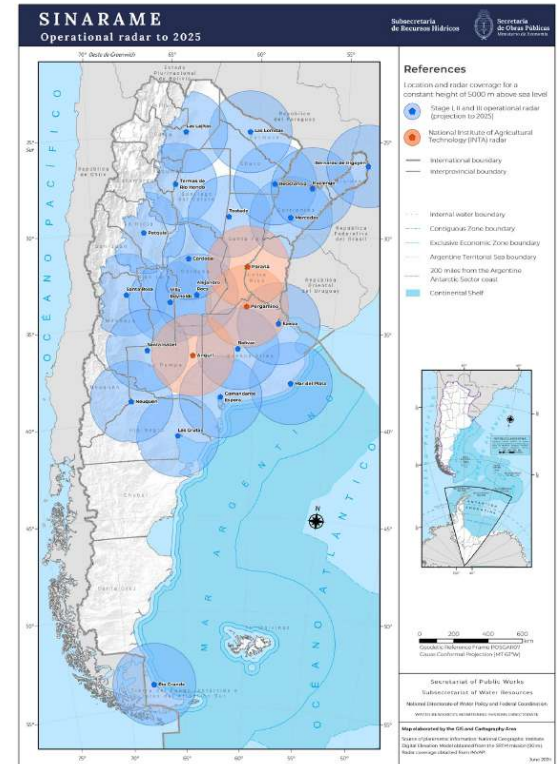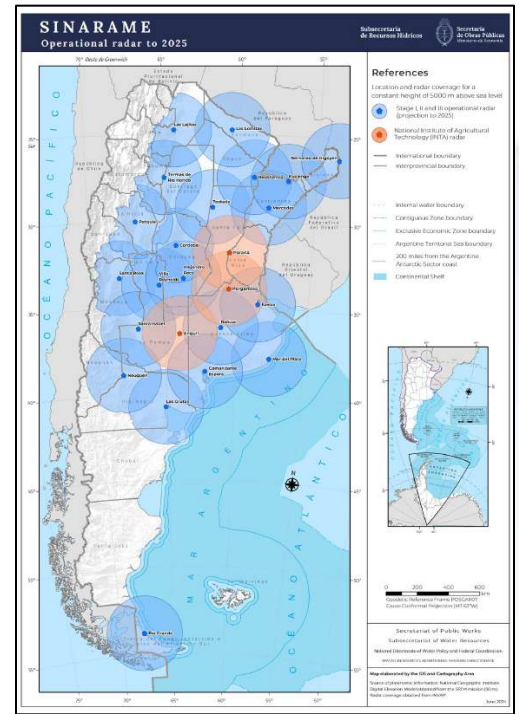

Images © SSRH

SINARAME Project – Past, Present, near Future

Past
Sep. 2011
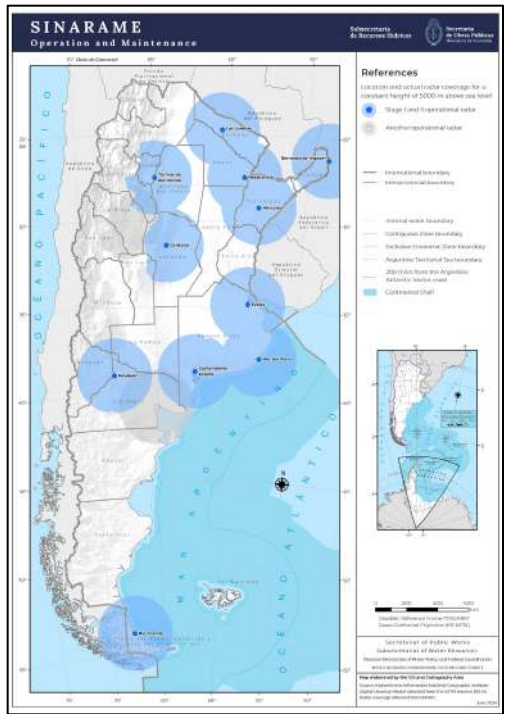
Present
Sep. 2011 ~ Jun. 2024

Future
projection for 2025

Images © SSRH

INVAP – RMA0
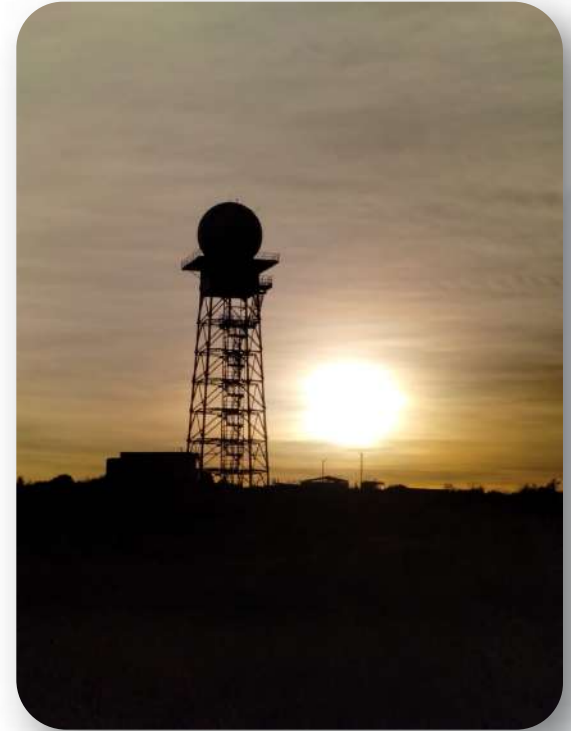## Bariloche, Río Negro

RMA 0

Images © INVAP

SINARAME – RMA1
Córdoba, Córdoba

Images courtesy of SSRH (photos by Universidad Nacional de Córdoba)

SINARAME – RMA12
Las Grutas, Río Negro

Images courtesy of SSRH (photos by INVAP)
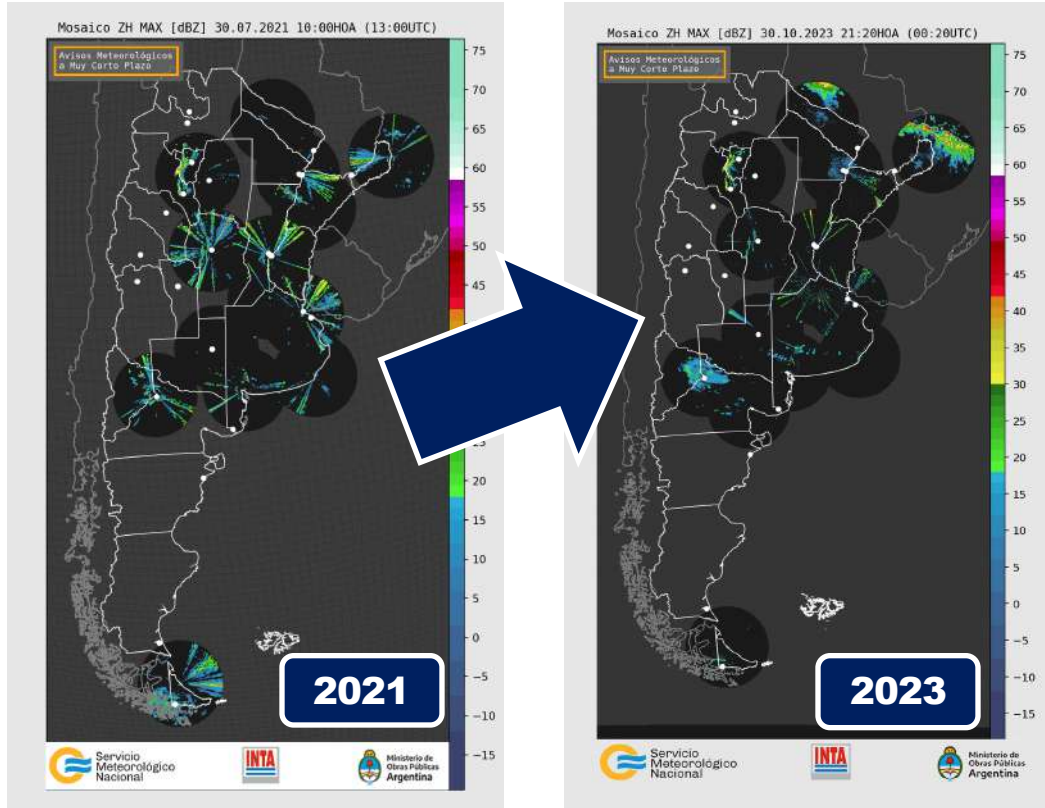
SINARAME - RMA
On site radar assembly sequence

Images courtesy of SSRH (photos by INVAP)

Radio frequency interference filtering

Mosaico ZH MAX [dBZ] 30.07.2021 10:00HOA (13:00UTC)

2021

Mosaico ZH MAX [dBZ] 30.10.2023 21:20HOA (00:20UTC)

2023

All **SINARAME** radars are affected, to a greater or lesser extent, by *Radio Frequency Interference* (**RFI**) contamination.

Different mitigation alternatives were explored, with limited success, such as:
- Tuning the radar on different operating channels within the band reserved for weather radars (5600 to 5650 MHz).
- Installation of narrowband analog filters at the input of the receivers.
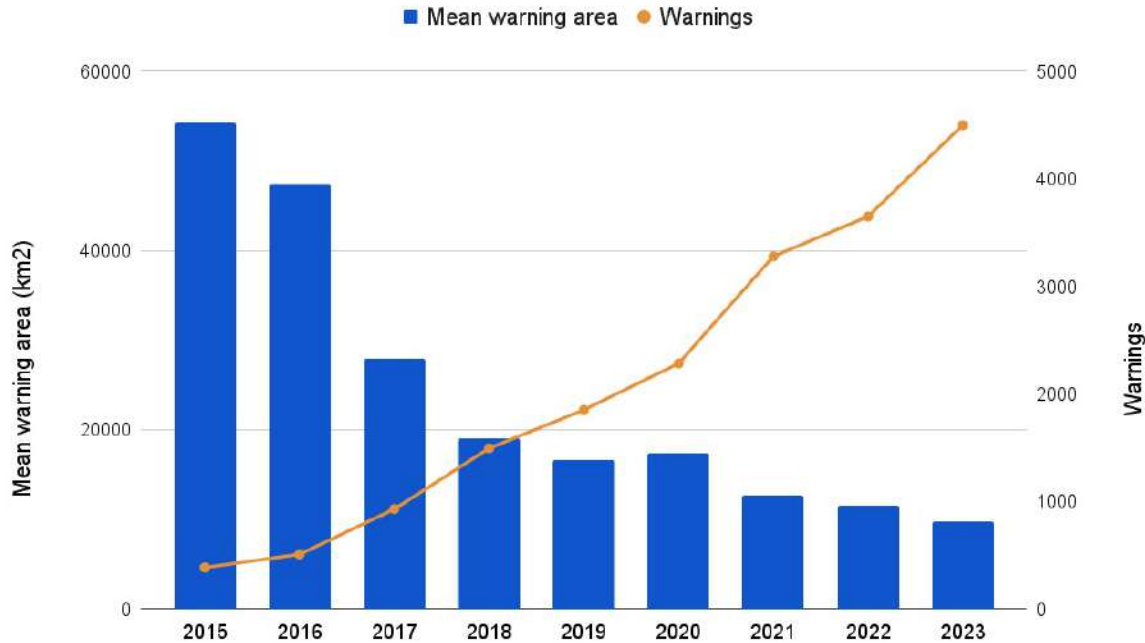
And others more effective but quite expensive to implement and sustain in the long term, such as:
- Hunting down interference sources and requesting that they be modified to work outside the reserved band.

The best approach, so far, has been INVAP's development of a real time RFI digital filter and deployment of the software update to all SINARAME RMA radars.

Images © SMN

Early warnings system evolution

Argentina's national weather service, *Servicio Meteorológico Nacional* (SMN) has significantly enhanced its severe weather warning capabilities through the utilization of the SINARAME radar information.

Since the expansion of the network, the SMN has experienced a substantial increase in the number of storm-based severe weather warnings (ACP) issued.

This increase in ACPs is explained by both the greater coverage of the radar network and by an increase in the number of personnel and better on-site training of forecasters, taking advantage of the large amount of radar data now available.
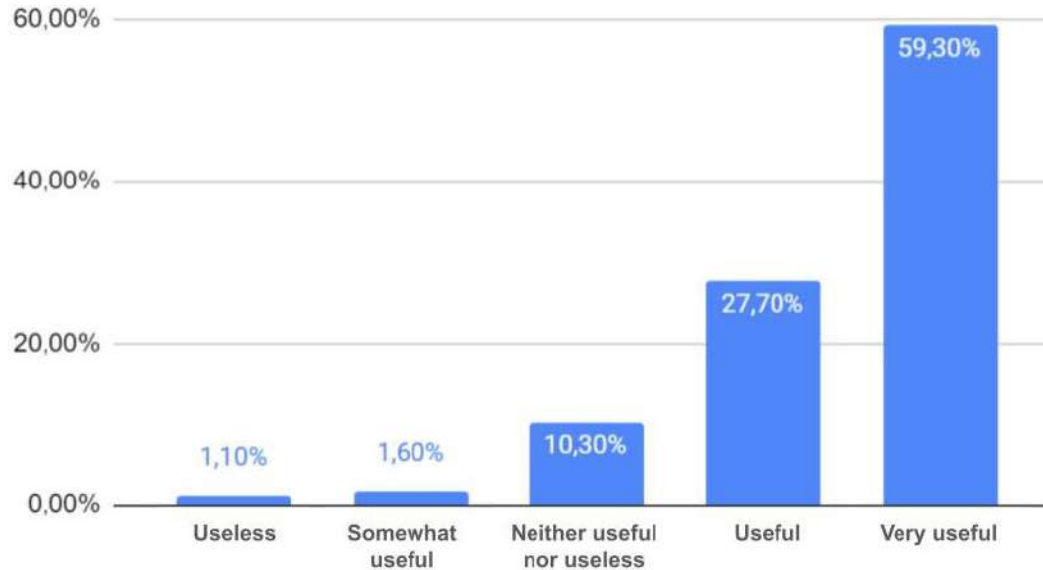
Additionally, the average area of ACPs has decreased through the years, reflecting an improvement in the resolution of the alerts.

Verification methodologies are being developed to assess the effectiveness of ACPs.

Preliminary results align well with feedback from primary users, suggesting that these warnings are valuable tools for public safety.

Images © SSRH

Early warnings system evolution

To what extent is the ACP information useful to you for making decisions in advance?

Useless	Somewhat useful	Neither useful nor useless	Useful	Very useful
1,10%	1,60%	10,30%	27,70%	59,30%

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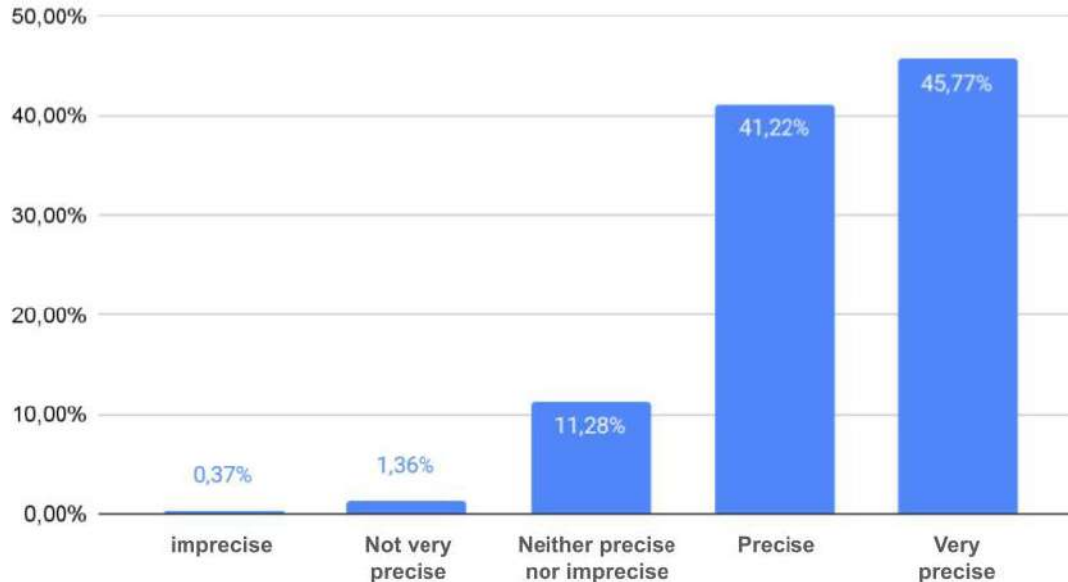
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Images © SSRH

Early warnings system evolution

How would you qualify the precision of the ACP?

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Images © SSRH

SINARAME challenges

Past

- Argentina is a big country, ranked number 8 in surface (7 if not counting Antarctica) but not a very wealthy one, so to be able to cover all of its surface, a long term plan is mandatory.

- Argentina expands trough many parallels, so it exhibits a wide range of climates, this imposes additional challenges for proper calibration / parametrization of several algortihms.

- This long term proyects goes beyond a tipical presidential administration mandate, so close collaboration troughout all the involved institutions and personel retention politics are key for the long term operation and evolution of the system.

- Proper mantenice is required to ensure optimal performance of the radars and also to maximaze the life of the sensors.

Future

- Expand the network, thus improving the coverage over Argentina's large surface and also increasing the radar density.

- Reach out remote locations, in less populated areas with poor or non-existent:
  - internet communication,
  - electric power supply,
  - access roads.

- Strengthen collaboration with neighbor countries, exchanging data to build together a continent level radar composite.

- Keep improving the signal processing software of the RMA radars, to get even better data quality by means of superior filters and novel algorithms.

Acknowledgments

SINARAME project is being executed by INVAP in close collaboration with the following institutions:

- **SSRH** *Subsecretaría de Recursos Hídricos* , the institution that provides funds for and manages the SINARAME project.

- **SMN** *Servicio Meteorológico Nacional*, Argentina's National Meteorological Service and the principal user of the network data.

- **FAMAF** *Facultad de Matemática, Astronomía, Física y Computación* de la *Universidad Nacional de Córdoba* (**UNC**).

- **EXACTAS** *Facultad de Ciencias Exactas y Naturales* de la Universidad de Buenos Aires (**UBA**).

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Thanks for your attention
Questions ?

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