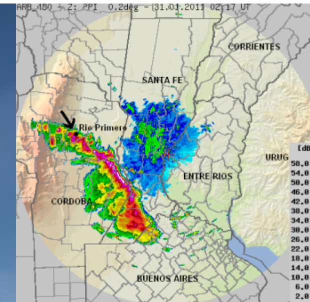
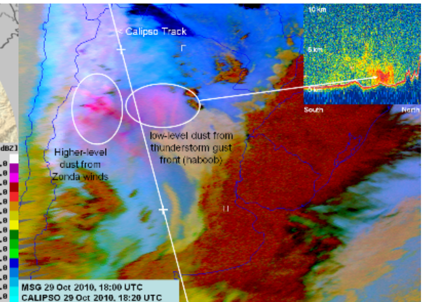
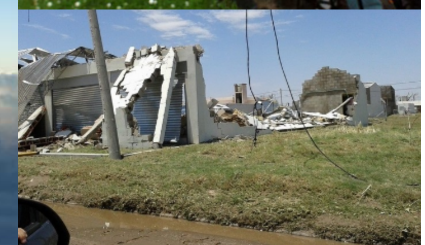






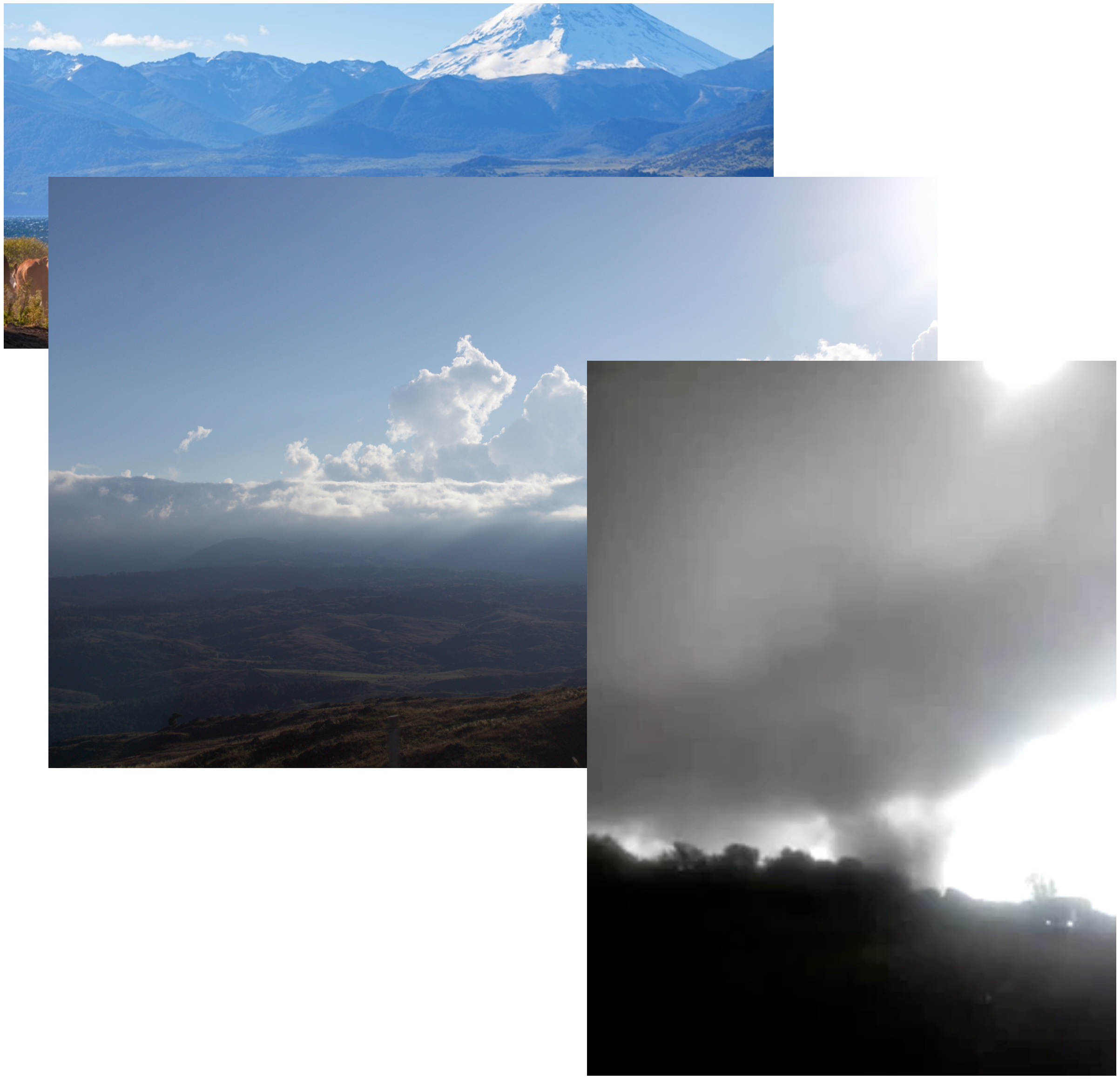
RELAMPAGO

Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations

Steve Nesbitt
Associate Professor
Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign

Motivation

- Lack of consistent, high-frequency, repeatable observations of thermodynamic, kinematic, diabatic processes, and land surface conditions where convection initiates and grows upscale. **NEXRAD and operational soundings not enough in US.** *So we do field projects!*
- In the US, where we have a great chance of doing this, <u>the precipitation climatology widespread across the plains</u> (e.g. PECAN), and the <u>terrain is complicated.</u>
- What if there existed a place where there are analogs to the US, where the precipitation climatology is reliable, and we could design a field campaign?



PACIFIC OCEAN
ATLANTIC OCEAN
PERU
BOLIVIA
BRAZIL
PARAGUAY
URUGUAY
ARGENTINA
CHILE
FALKLAND ISLANDS (ISLAS MALVINAS) (Administered by U.K., claimed by Argentina)
TIERRA DEL FUEGO
PATAGONIA
PAMPAS
GRAN CHACO
ANDES
Santiago
Buenos Aires
Montevideo
Asunción
Córdoba
Rosario
Mendoza
La Plata
Mar del Plata
Bahía Blanca
Valparaíso
Concepción
Valdivia
Puerto Natales
Río Gallegos
Cape Horn
ELEVATION
metres feet
4,000 13,124
3,000 9,843
2,000 6,562
1,000 3,281
500 1,640
200 656
0 0
International boundaries
Political subdivision boundaries
Bridges
Dams
Waterfalls
Glaciers
Spot elevations in metres
Swamps and marshes
Salt flats
Sand areas
0 100 200 300 400 mi
0 150 300 450 600 km
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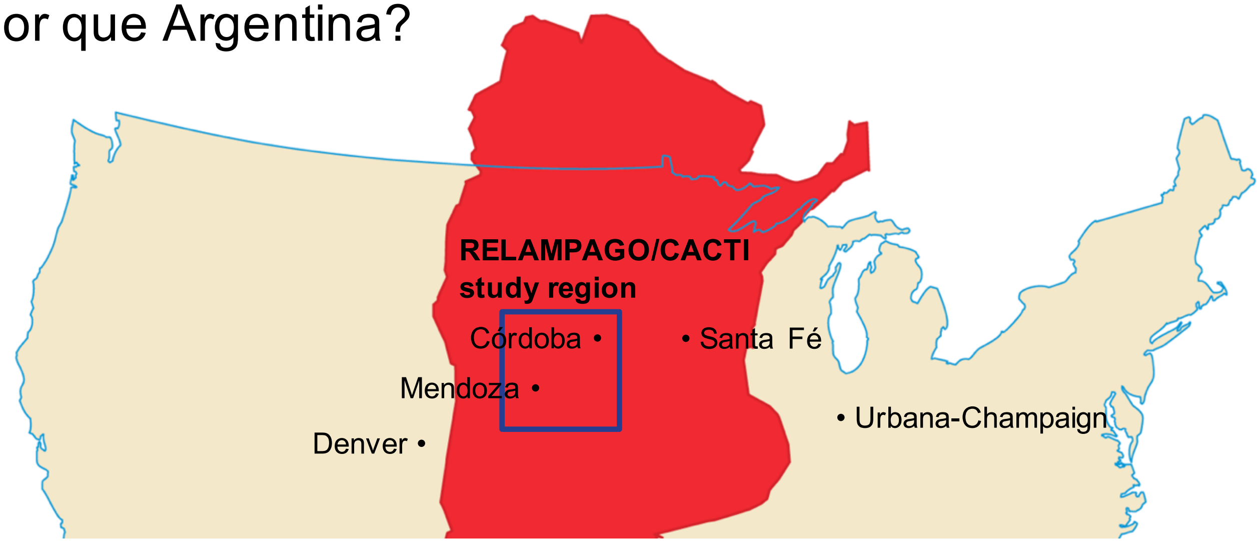
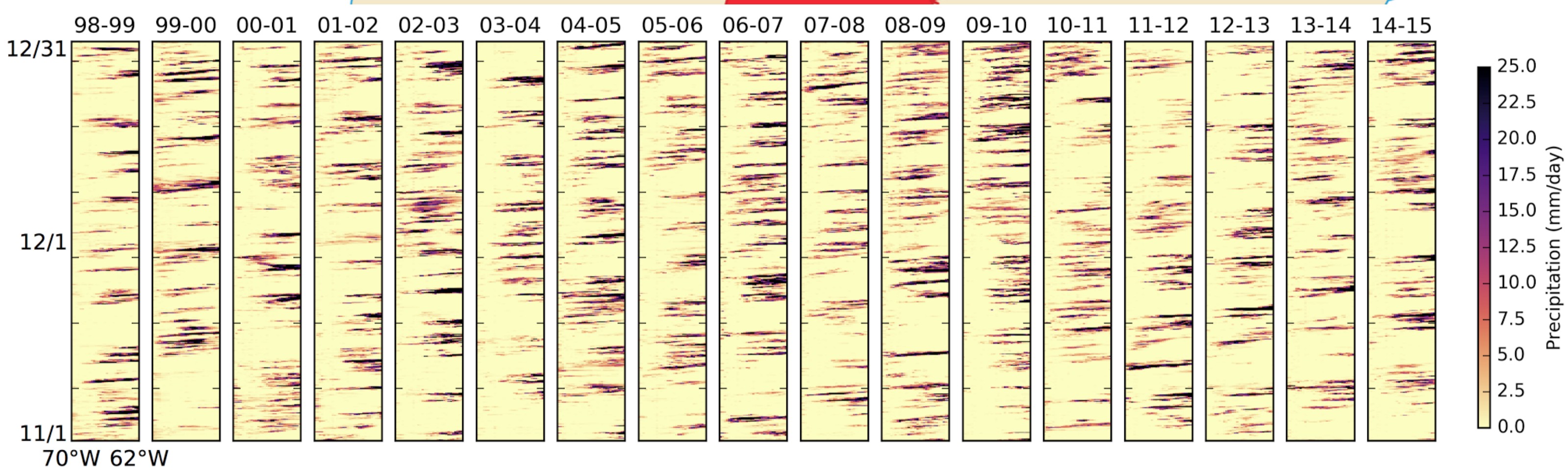
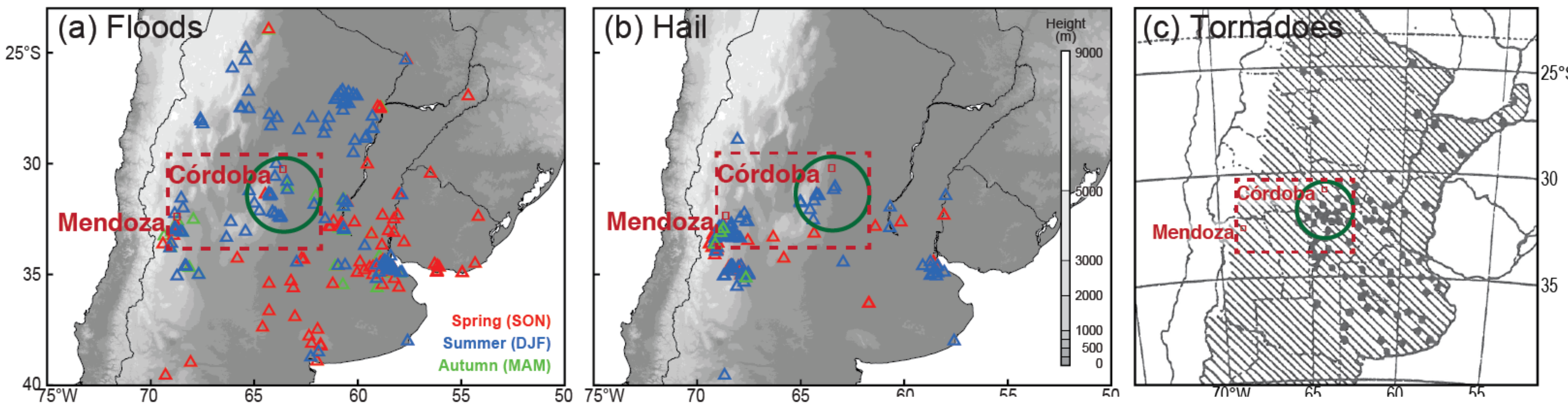
¿Por que Argentina?





TRMM 3B42 rain rate Hovmöller diagram centered on the Sierras de Córdoba during Nov-Dec

& Co.



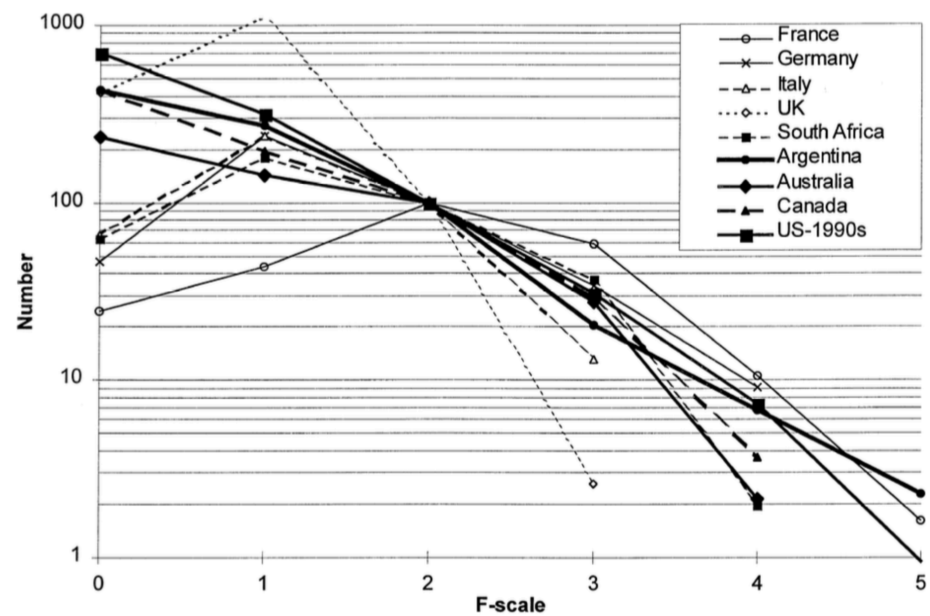
Rasmussen et al. (2014); Altinger de Schwarzkopf and Rosso (1982)

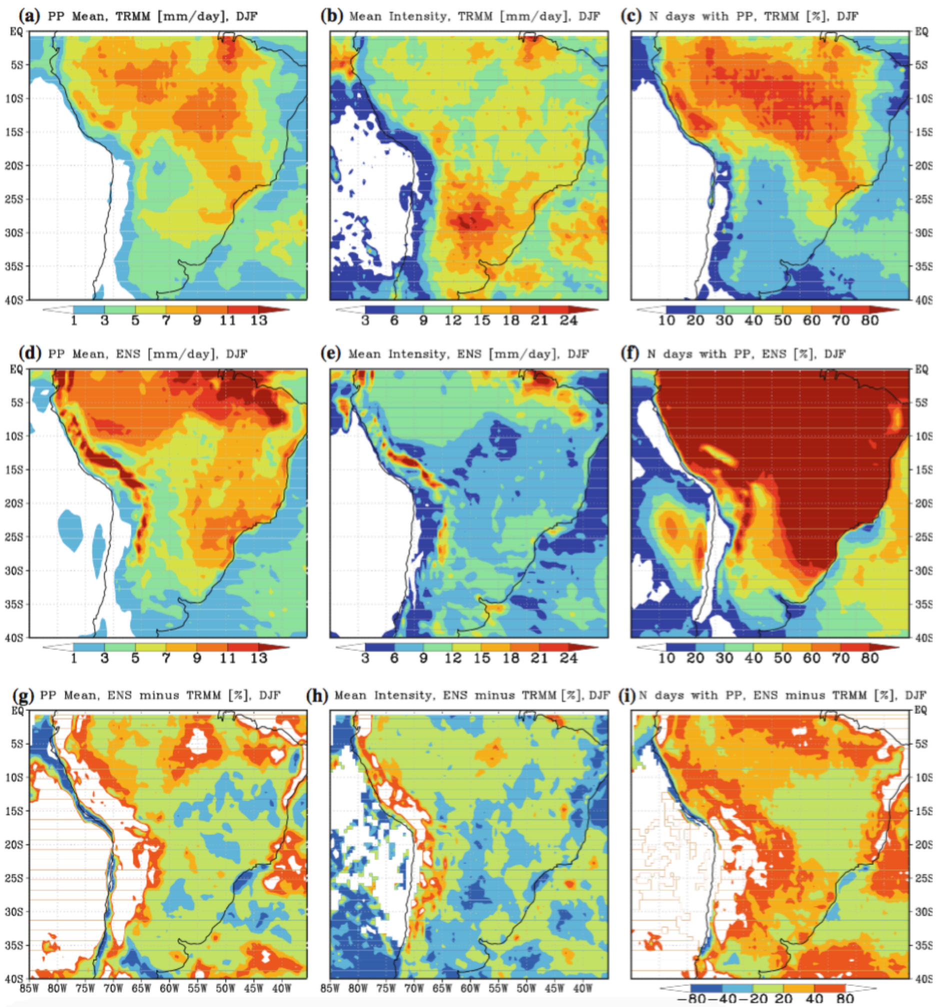
Distributions of Severe Weather in SESA

<u>Brooks and Doswell (2001)</u>

Distribution of reported tornado intensities

Argentina 1930–1979., N=368.
US 1920–1998, N=44417.

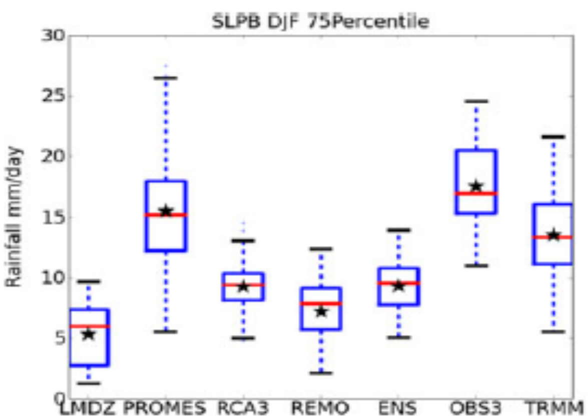




Solman et al (2013)

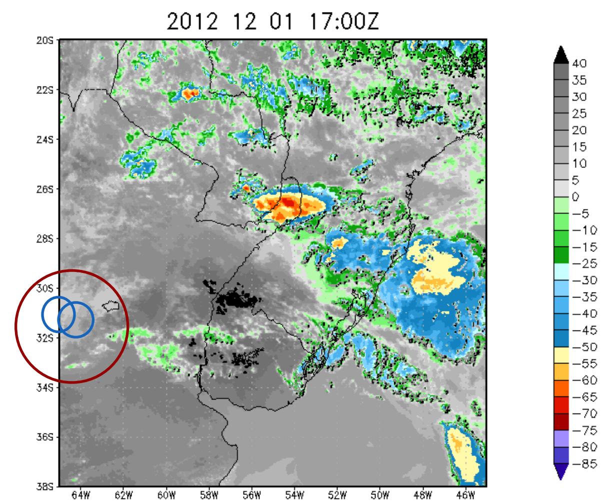
There is a large uncertainty in climate and regional models in simulating precipitation.

Carril et al (2012)



RELAMPAGO/CACTI 2018-2019 is an international project...

- to study intense continental convective systems in subtropical South America
- to understand their interactions with local and regional meteorology, aerosols, topography, and land-atmosphere interactions
- to improve severe storm hazard prediction
- to place extreme continental convection in context with regional and global climate



Science Steering Groups

CACTI

Adam Varble, U. Utah, lead scientist

<u>Co-Investigators:</u>

Eldo Avila, U. Cordoba
Paul DeMott, CSU
David Gochis, NCAR-RAL
Robert Houze, UW/PNNL
Michael Jensen, BNL
Pavlos Kollias, Stony Brook/BNL
Sonia Kreidenweis, CSU
L. Ruby Leung, PNNL
Greg McFarquhar, Illinois
Steve Nesbitt, Illinois
Kristen Rasmussen, NCAR MMM
David Romps, Berkeley/LBNL
Paola Salio, U. Buenos Aires
Christopher Williams, U. Colorado
Edward Zipser, U. Utah
Sue van den Heever, CSU

RELAMPAGO

Steve Nesbitt, Illinois (US NSF PI)
Jeff Trapp, Illinois (US NSF Co-PI)
Rita Roberts, NCAR-RAL (US NSF Co-PI)

Adam Varble, University of Utah (CACTI liason)
Paola Salio, U. Buenos Aires, Argentina (Argentina lead)
Luiz Machado, INPE, Brazil (Brazil lead)
Francina Dominguez, Illinois
Kristen Rasmussen, NCAR-MMM
Jim Wilson, NCAR-RAL
Karen Kosiba, CSWR
Josh Wurman, CSWR
Ed Zipser, Utah
Robert Houze, U. Washington
V. Chandrasekar, CSU
Rachel Albrecht, U. São Paulo, Brazil
Timothy Lang, NASA MSFC (US NASA/NOAA lead)
Celeste Saulo (Servicio Meteorológico Nacional, Argentina)

What is RELAMPAGO?

Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations

RELAMPAGO's proposed primary science questions:

1. Determine relevant environmental processes that lead to the initiation of convection near complex terrain features, and contrast the mechanisms near the Andean front and the lower mesoscale topography to the east.
2. Intensification and upscale growth of convection: Identify the kinematic, thermodynamic, and microphysical processes by which convection intensifies and grows upscale in the immediate vicinity of complex terrain features into extremely tall and broad convective systems.
3. Observe the processes by which high-impact weather events (flooding, hail, strong winds, and tornadoes) are generated in environments close to the Andes and lower mountains to the east of the Andes **in two nearby regions: the Sierras de Cordoba, and Mendoza**.

1 Nov – 15 Dec 2018.

RELAMPAGO + CACTI
Potential Contributions

NSF (US)

Deployment pool
S-PolKa
DOWs
Soundings + Expendables
Mesonet/Pods (CSWR)
DIAL LIDAR

Non-deployment pool
Hydromet measurements (RAL)
(Proposed)

NASA (US)

Disdrometers
Rain gauges
Micro-rain radars
NPOL?
ER-2?
(Proposed)

NOAA (US)

GOES-R validation
Lightning mapping array
Field mills
(Proposed)

SMN (AR)

C-Band DP op network

Mobile soundings

Enhancement of operational radiosondes

DSD + rainfall
FUNDED!

INPE (BR)

Mobile X-Band DP radar
Precip/profiling supersite
Lightning mapping array
Sticknet
S-Band DP radars downstream
(Proposed)

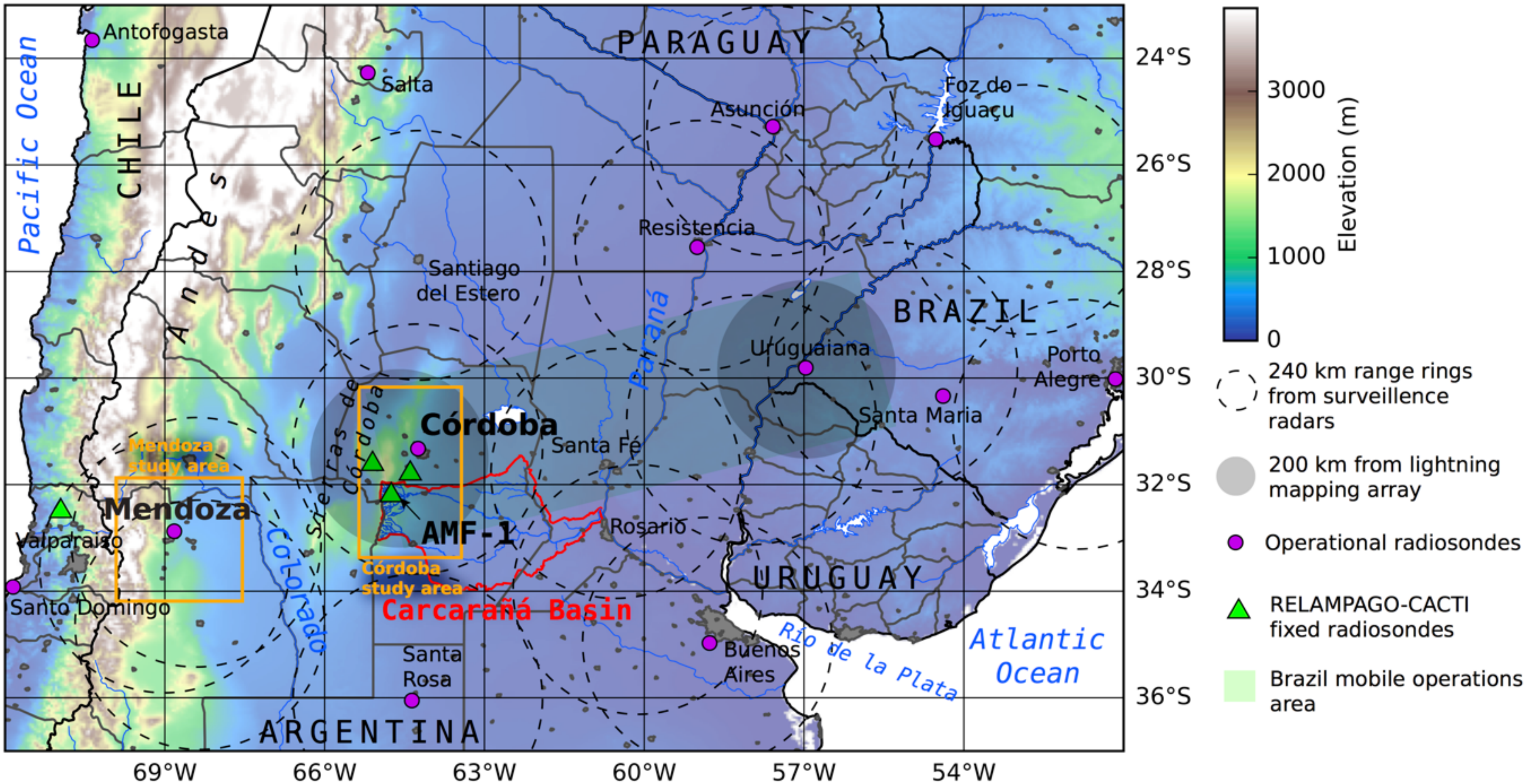
CONyCET (CH)

Sounding sites
(Proposed)

DOE (US)
CACTI

AMF-1 (cloud/profiling suite, aerosol measurements)
C-Band DP Radar?
G-I microphysical and aerosol aircraft)?

RELAMPAGO-CACTI broad study domain



Radars to complement CACTI observations

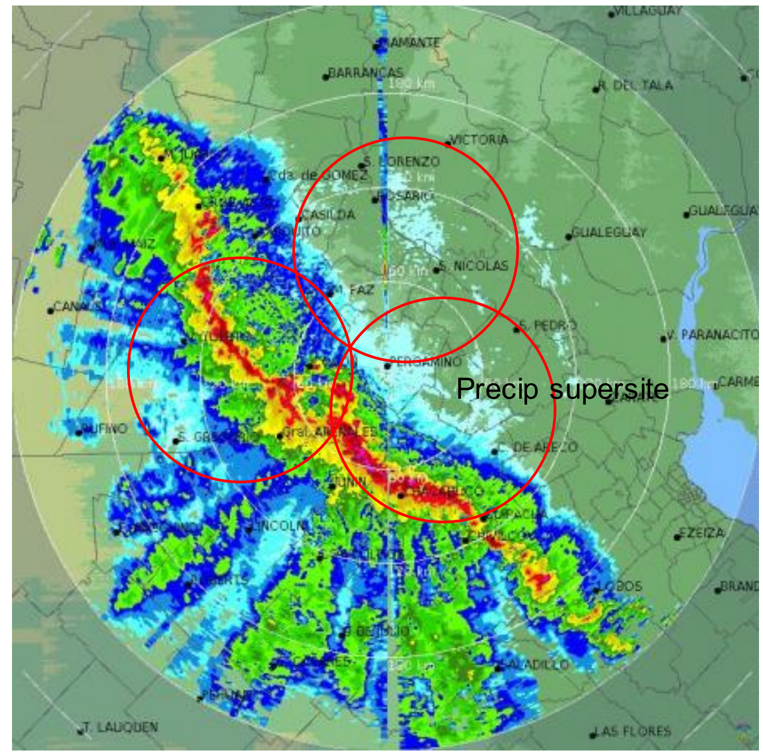
AR Existing + SIRANAME Network: Critical for surveillance. <u>Need to demonstrate consistent calibration</u>.

S-PolKa: 4-D distribution of precipitation, microphysics, cloud liquid water, moisture

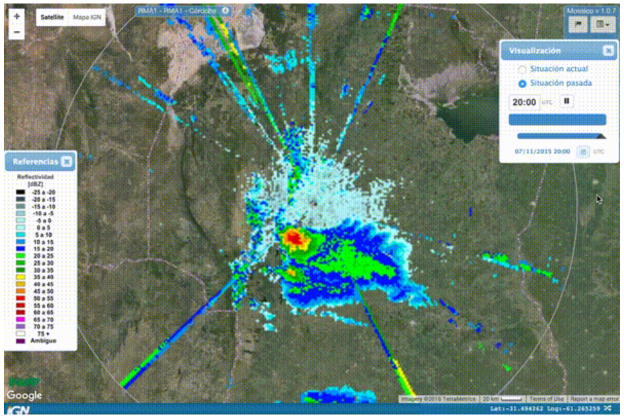
3 DOW radars: Dual-pol, dual-Doppler kinematics, low level structures

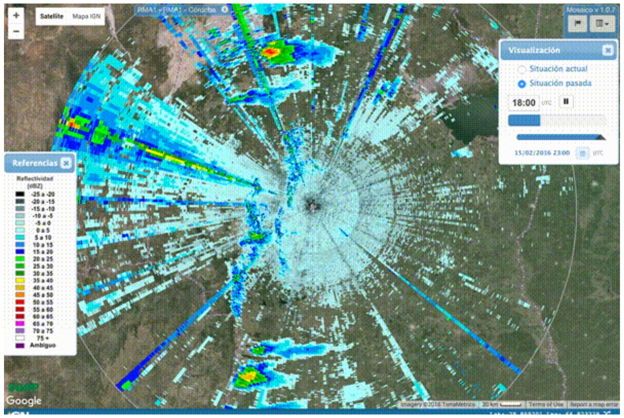
Brazil X-Pol mobile radar: Lagrangian tracking of systems

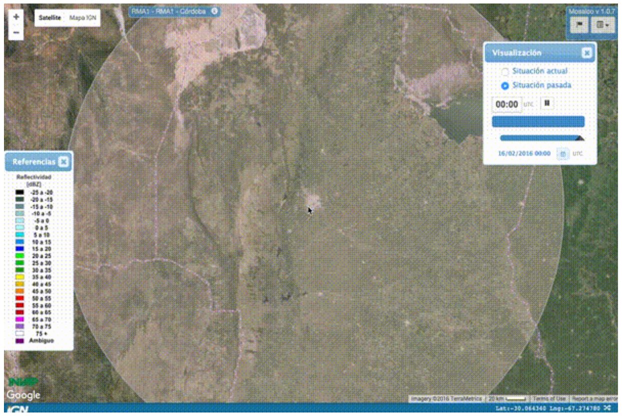
These radars will compliment each other, allowing the objectives of each radar to be fully accomplished without sacrificing measurement capabilities.

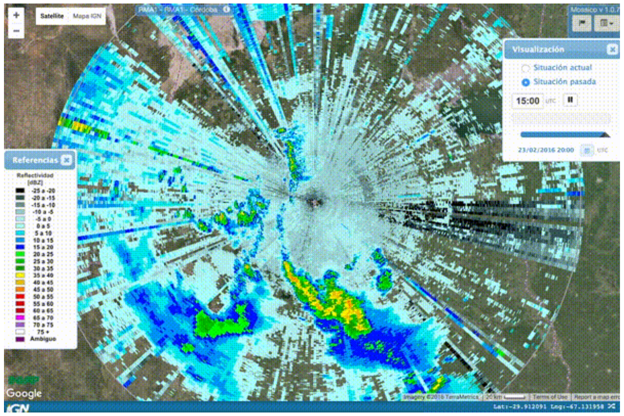


4 cases from 2015-16 warm season
Córdoba INVAP Dual-pol C-Band radar
Installed April 2015





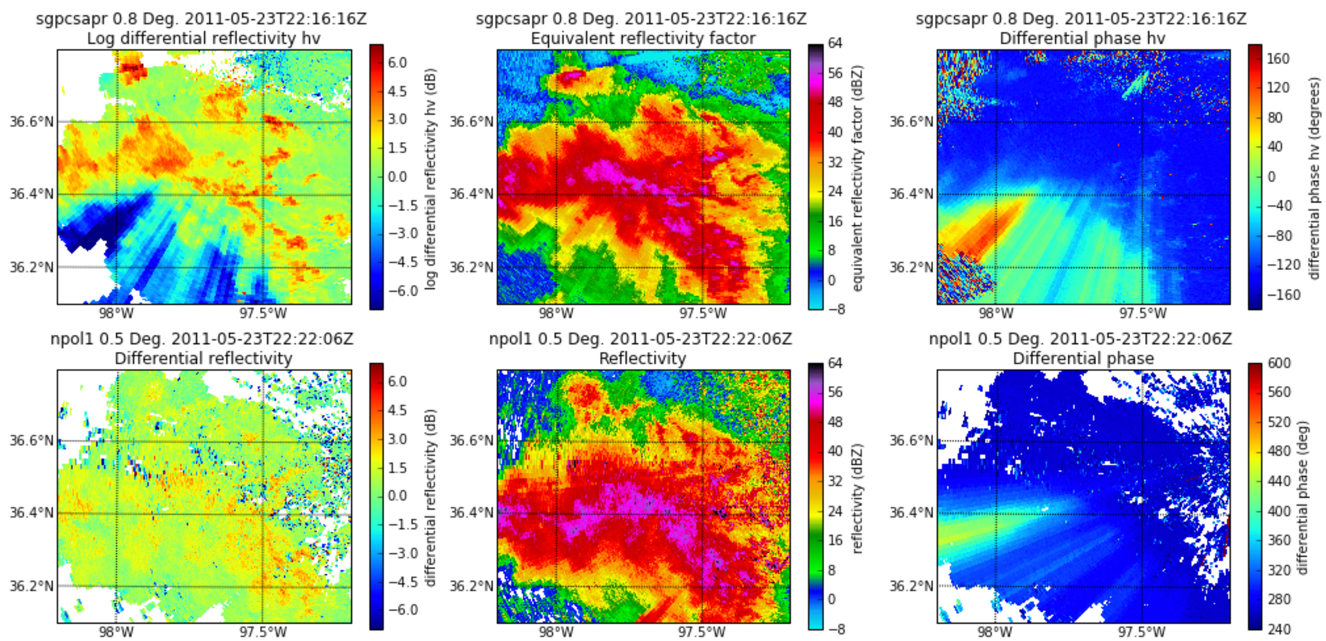




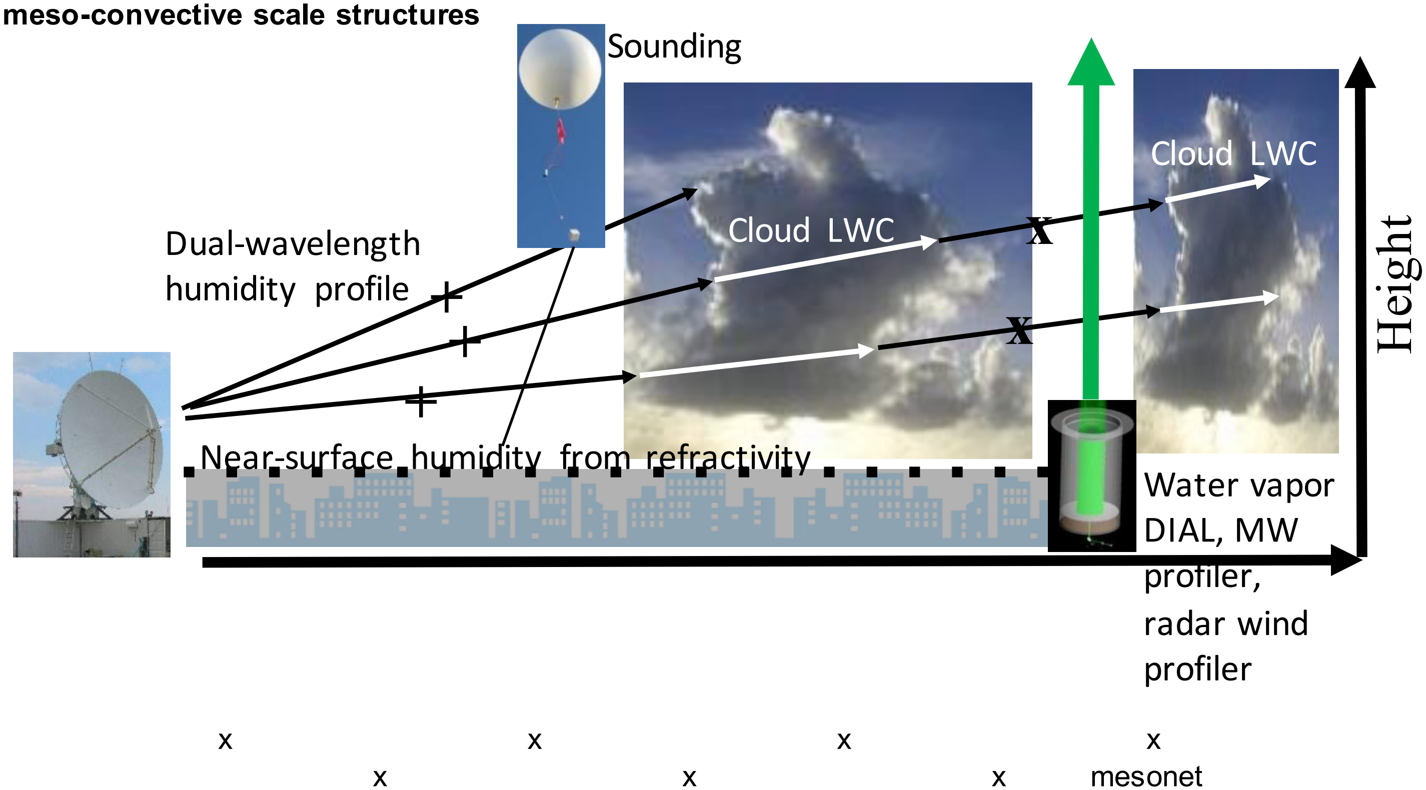
Why do we need NSF radars to accomplish these science objectives?

- Dual-Doppler scanning requires good low-level coverage and coordinated sector scans, which take away from microphysical scans (RHIs, volume scanning), mobile X-Bands (DOWs) can do this in a network configuration to mitigate attenuation
- C-band Argentinian radars,, and CSAPR-2 will suffer from attenuation and backscatter differential phase effects, plus we will lack operational control
- S-PolKa can help with calibration and algorithm development for C-Band radars, **critical in hail, large drops, and heavy precipitation**

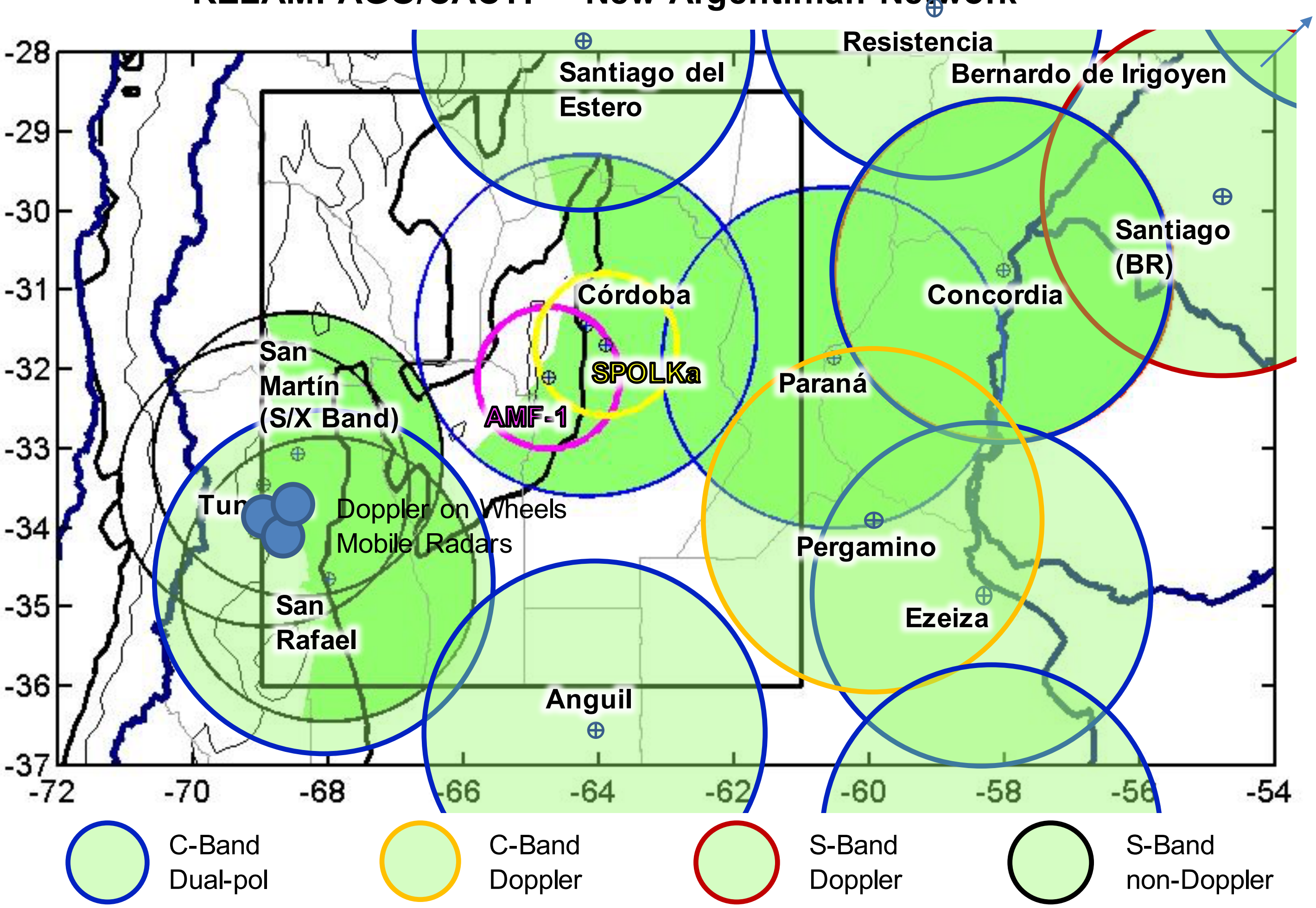
Case from MC3E Oklahoma – Top row S-Band, Bottom row C-Band



Moisture observations from new remote sensing observations and traditional observations to examine moisture variability, convective initiation and meso-convective scale structures

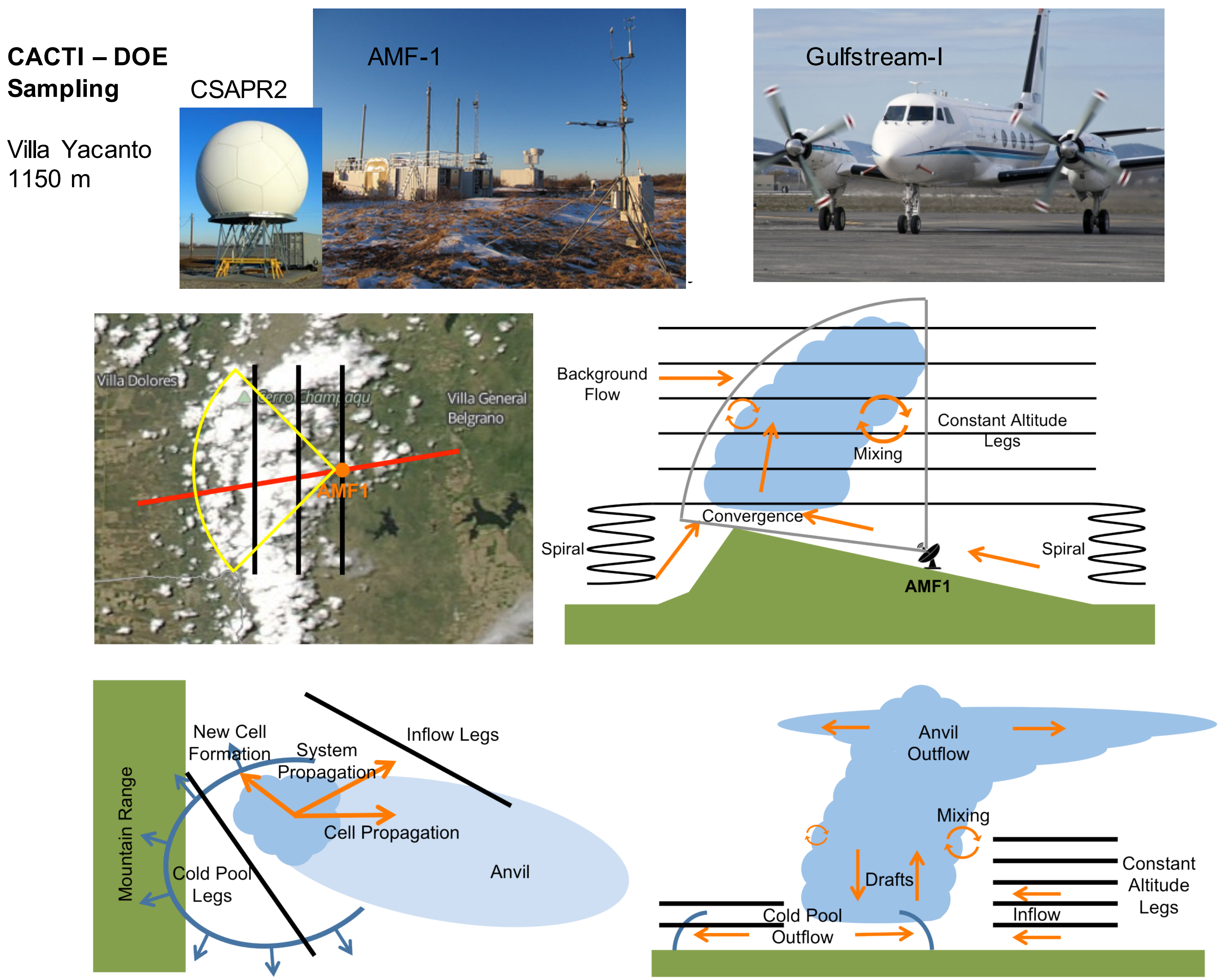


RELAMPAGO/CACTI + New Argentinian Network



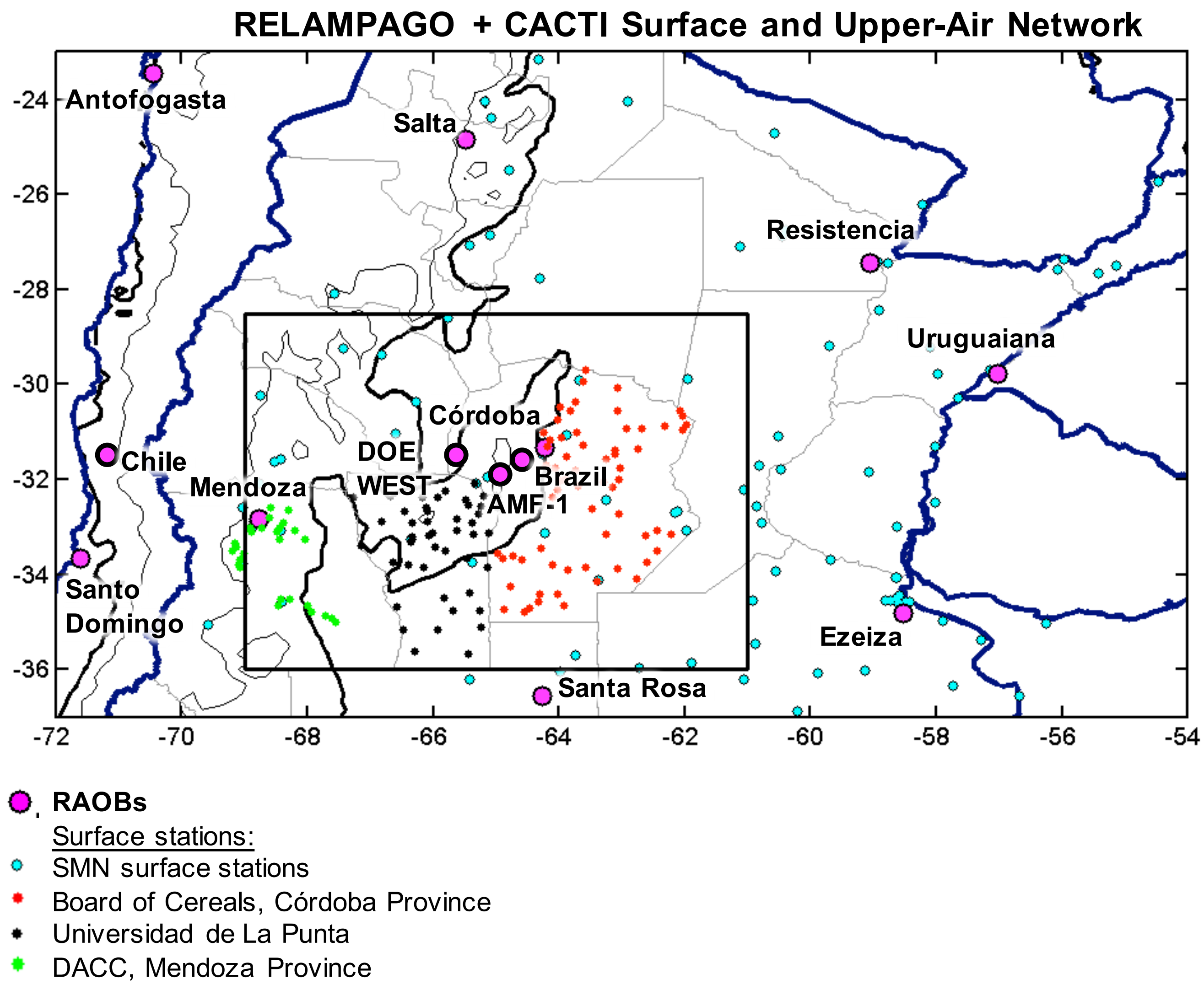
0.5° beam blockage for existing radars indicated by white areas within range rings

Required Measurement	W-band	Ka-band	X-band	C-band	S-band	Profilers	OR
Bragg scatter (boundaries, elevated moisture variations)					SPOLKa		OR1 OR3
3-D kinematics (multi-Doppler analysis or assimilation)			DOW6 DOW7 DOW8				OR1 OR3 OR6
Vertical air motion (using Bragg scatter)						RWP	OR1 OR6
Velocity-azimuth display wind profiles	WSACR	KaSACR	DOW6 DOW7 DOW8 XPOL	CSAPR2 RMA			OR1
Quasi-vertical profiles in precipitation	WSACR	KaSACR	DOW6 DOW7 DOW8 XPOL	CSAPR2 RMA	SPOLKa		OR1 OR2 OR3 OR6
Non-precipitating clouds		KaSACR KaZR					OR2 OR3
Light rain	WSACR WACR	SPOLKa KaSACR KaZR	DOW6 DOW7 DOW8 XPOL		SPOLKa	RWP	OR2
Moderate rain		SPOLKa KaSACR KaZR	DOW6 DOW7 DOW8 XPOL		SPOLKa	RWP	OR2
Heavy rain		SPOLKa			SPOLKa	RWP	OR2
Hail, hail mixed with rain					SPOLKa	RWP	OR2
Water vapor (refractivity)				CSAPR2 RMA	SPOLKa		OR1
Water vapor (dual-wavelength)		SPOLKa KaSACR		CSAPR2	SPOLKa		OR1
Cloud water		SPOLKa KaSACR		CSAPR2	SPOLKa		OR2 OR3
Hydrometeor ID			DOW6 DOW7	CSAPR2	SPOLKa		OR2 OR3 OR6
Multi-wavelength retrievals (using dual wavelength ratio, polarization)	WSACR	SPOLKa KaSACR		CSAPR2	SPOLKa		OR2 OR3 OR6
Microphysical retrievals (using single or multi-wavelength Doppler spectra)	WSACR WACR	KaSACR KaZR		CSAPR2		RWP	OR2 OR3 OR6


CACTI – DOE Sampling
Villa Yacanto 1150 m
CSAPR2
AMF-1
Gulfstream-I
Villa Dolores
Cerro Champaqui
Villa General Belgrano
AMF1
Background Flow
Mixing
Constant Altitude Legs
Convergence
Spiral
Spiral
AMF1
Mountain Range
New Cell Formation
System Propagation
Inflow Legs
Cell Propagation
Anvil
Cold Pool Legs
Anvil Outflow
Mixing
Drafts
Constant Altitude Legs
Inflow
Cold Pool Outflow

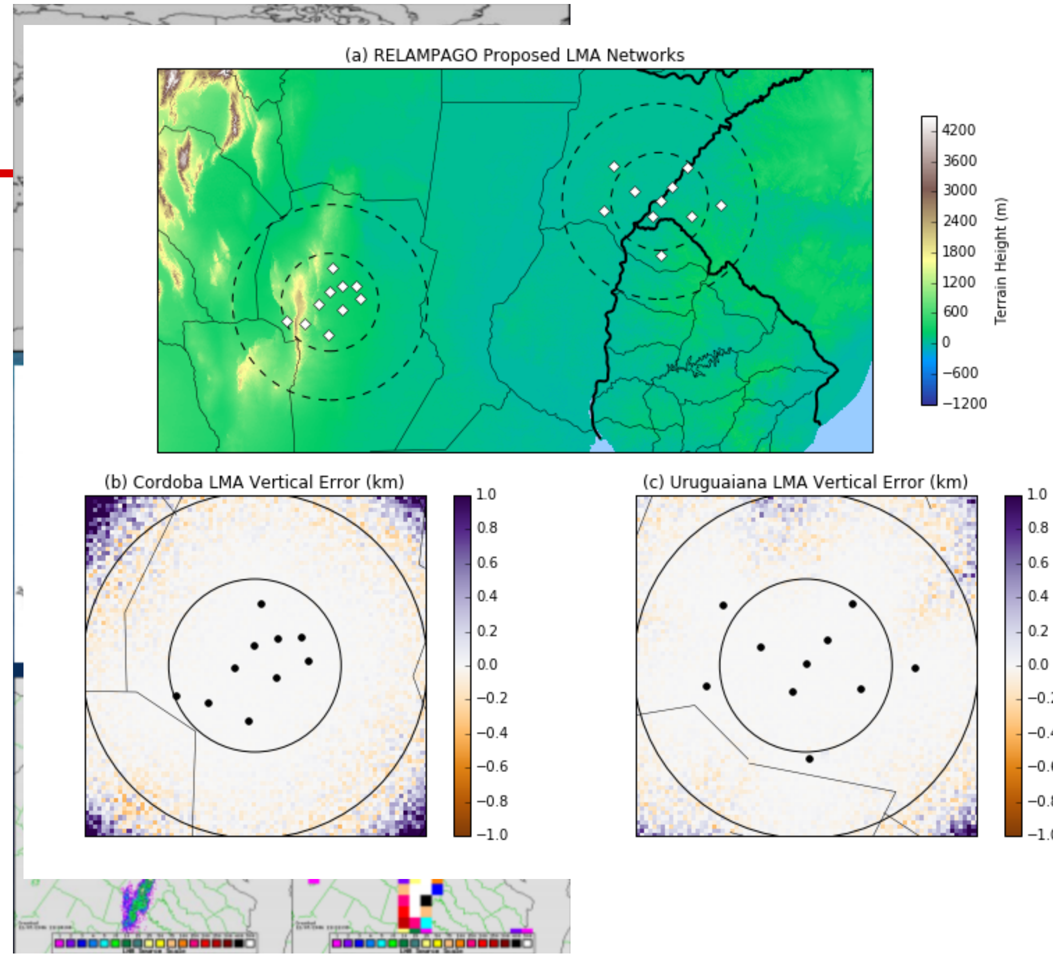
Radiosonde Facilities in RELAMPAGO

Institution	System Type	Mobile vs. Fixed (location)	Nominal Release Frequency: RELAMPAGO-IOP	Nominal Release Frequency: CACTI-EOP
SMN	Vaisala RS90 + IMET	Fixed: Córdoba, Mendoza/ (Resistencia, Santa Rosa, Ezeiza, Salta)	8 x day/(2 x day)	2 x day
SMN	Vaisala RS90	Portable: Alta Gracia	1 x hr	
SMN	Vaisala RS90	Mobile	1 x hr	
DOE	Vaisala RS92	Fixed: Villa Yacanto/ (Villa Dolores)	IOP: 8 x day/(2 x day)	2 x day
Chile	Vaisala RS92	Fixed*: Santo Domingo, Antofogasta	2 x day	2 x day
Brazil	Vaisala RS92	Fixed: Uruguaiana	2 x day	2 x day
CSWR	GRAW (x 2)	Mobile	1 x hr	
CSU	MW41 Digicora	Mobile	1 x hr	
UIUC	IMET (x 3)	Mobile	1 x hr**	

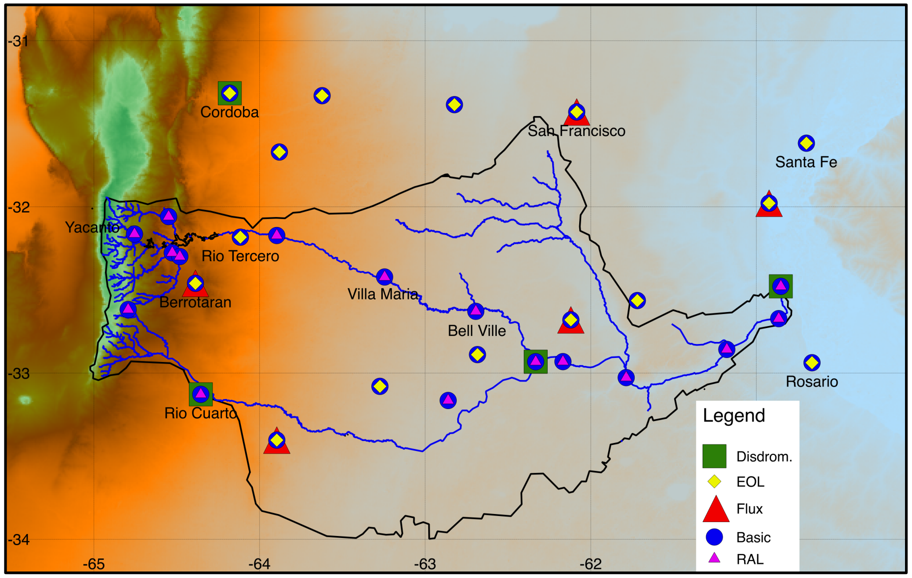

RELAMPAGO + CACTI Surface and Upper-Air Network
Antofogasta
Salta
Resistencia
Uruguaiana
Córdoba
DOE
WEST
Brazil
AMF-1
Chile
Mendoza
Santo
Domingo
Ezeiza
Santa Rosa
-24
-26
-28
-30
-32
-34
-36
-72
-70
-68
-66
-64
-62
-60
-58
-56
-54
RAOBs
Surface stations:
SMN surface stations
Board of Cereals, Córdoba Province
Universidad de La Punta
DACC, Mendoza Province

Lightning in RELAMPAGO

- GOES-R/S GLM validation and science
- Demonstrate use of real time lightning information for nowcasting
- Documents thunderstorm environments, allowing investigation of link between pre-storm environment and subsequent electrification (e.g., anomalous/inverted charge structures common in dry, high-cloud-base environments)
- Provides validation dataset for thunderstorm electrification models



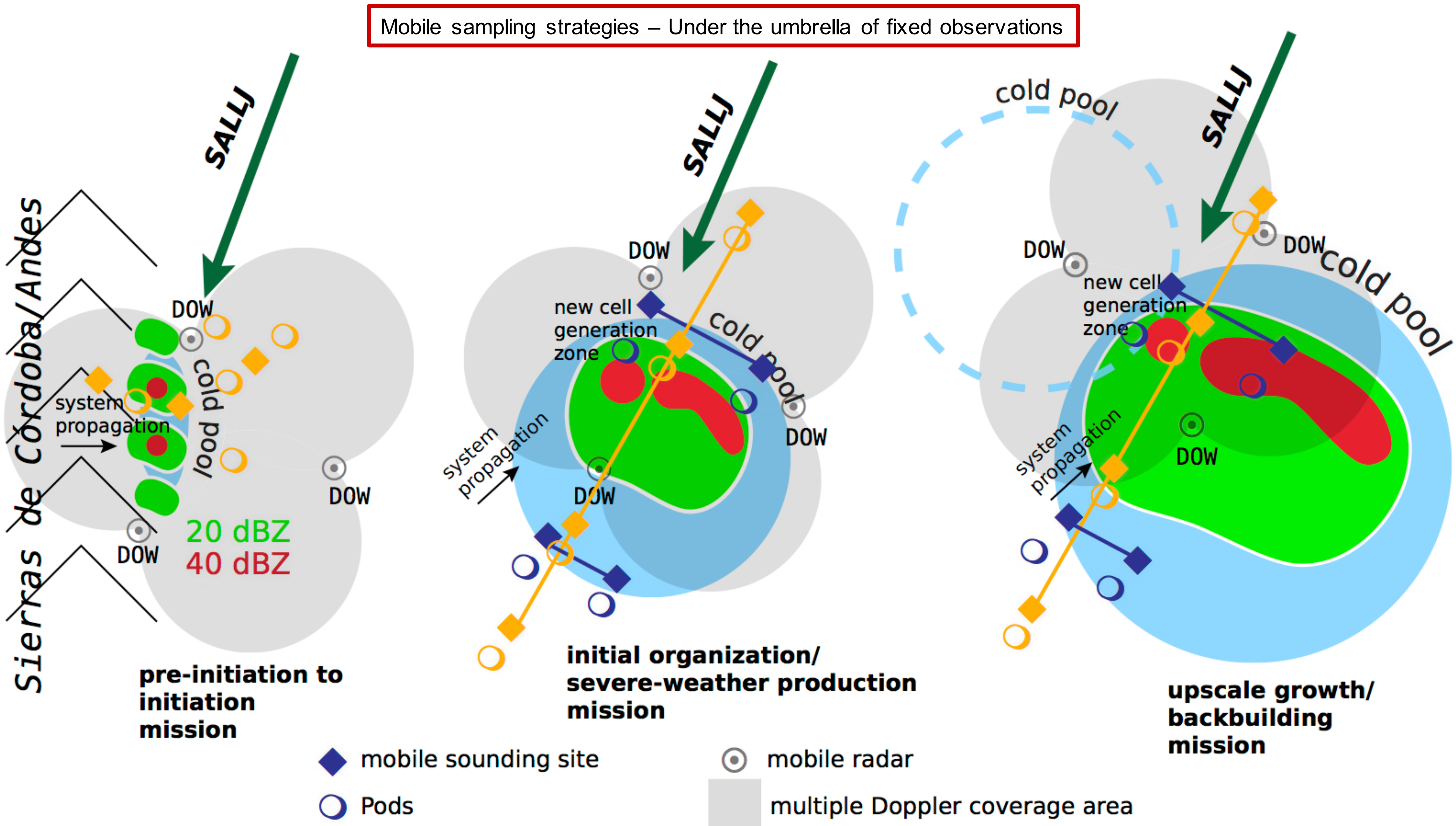
Courtesy S. Goodman



RELAMPAGO Hydrometeorology Extended Observing Period (~1 year)

"What is the role of the land surface in modulating the observed variability of heavy precipitation and flooding in the Carcarañá River Basin? "

- Precipitation gauges
- Surface flux towers
- Meteorological stations
- Streamflow observations
- Groundwater observations


Mobile sampling strategies – Under the umbrella of fixed observations
Sierras de Córdoba/Andes
SALLJ
DOW
cold pool
system propagation
20 dBZ
40 dBZ
pre-initiation to initiation mission
SALLJ
DOW
new cell generation zone
cold pool
system propagation
initial organization/ severe-weather production mission
SALLJ
cold pool
DOW
new cell generation zone
system propagation
upscale growth/ backbuilding mission
mobile sounding site
Pods
mobile radar
multiple Doppler coverage area

RELAMPAGO+CACTI
International Endorsements

- June 2013. WMO World Weather Research Programme (WWRP) – JSC endorsement in June 2013

- August 2014. Steve and Paola were invited to present RELAMPAGO during Nowcasting working group sessions before the WWRP-OSC

- August 2014. Steve, Celeste Saulo, and Paola went to WWRP-OSC in Montreal August 2014 and RELAMPAGO was included as an experiment of High Impact Weather Project together with T-NAWEX. RELAMPAGO will focus on heavy precipitation storms/flooding under HIWEATHER project.

- RELAMPAGO is a Forecast Demonstration Project and Research Demostration Project recommended by the WMO Nowcasting and Mesoscale Numerical Modeling Group.

- RELAMPAGO is seeking endorsement from the GEWEX Hydroclimatology Panel; has received positive feedback so far

Science and societal impact

Much research has been done on US Great Plains organized convection, impact?

We believe that addressing RELAMPAGO/CACTI objectives will not only help the community gain a better perspective on extreme convection globally, as it differs in its characteristics and forcing from region to region.

The knowledge gained from RELAMPAGO/CACTI will improve understanding, models, and high impact weather and climate prediction around the world.

Tailor existing and develop new tools for emergency management for HIWeather informed by the user community

hombre protegiendo su auto de granizo

¡Gracias!
¿Preguntas?

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