# RELAMPAGO Field Program – Argentina, late 2016

## *R*emote sensing of *E*lectrification, *L*ightning, *A*nd *M*esoscale /microscale *P*rocesses with *A*daptive *G*round *O*bservations

*(RELAMPAGO translates to "lightning" in Spanish and Portuguese)*

Dan Cecil, Steve Nesbitt, Timothy Lang, Kristen Rasmussen, Patrick Gatlin

## Overview

**Who:**

*Possible Agencies and Nations Involved*: NSF, NASA, NOAA, Argentina, Brazil, Chile, Paraguay, Bolivia

*Core Science Steering Group*: Dan Cecil (NASA MSFC), Steve Nesbitt (U. Illinois), Timothy Lang (NASA MSFC), Paola Salio (U. Buenos Aires), Luiz Machado (INPE), Ernani Nascimento (U. Federal de Santa Maria), Rachel Albrecht (INPE), Kristen Rasmussen (U. Washington)

*Nascent Science Team*: Bob Houze, Ed Zipser, Dave Gochis, Patrick Gatlin, Celeste Saulo, Josh Wurman, Steve Goodman, Rich Blakeslee, Darrel Baumgardner, Graciela Raga, Yanina Garcia Skabar

*Let us know if you are interested in joining*

***What***:

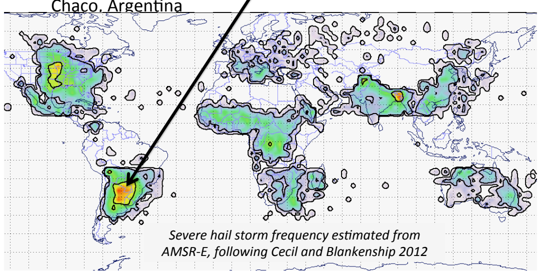
Multi-Agency, multi-national field program *to be proposed*, studying multi-scale aspects of intense, organized convective systems in subtropical South America.

***When***:

Mid-October – Mid-December 2016 is the current target

***Where***:

Region centered on about 30° S, 62° W, between Cordoba and Chaco, Argentina



*Severe hail storm frequency estimated from AMSR-E, following Cecil and Blankenship 2012*

***Why***:

Satellite evidence, including from TRMM and Aqua, indicates that the convection in this region is unique in its intense vertical structure, broad horizontal organization, and lightning production.

In this data sparse region, we do not know much about aspects of these systems including what governs their structure, life cycle, similarities and differences with severe weather-producing systems observed in the US and elsewhere, and their predictability on weather to climate timescales.

***How***:

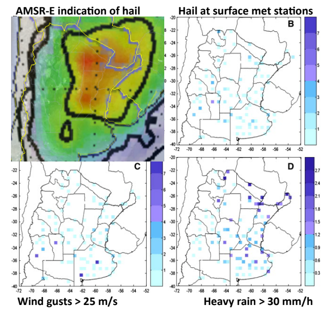
Ground-based radar, radiosondes, lightning mapping array, surface mesonet / sticknet, disdrometers, electric field mills, ER-2?

## Topics and Science Questions

### Severe weather

- Why do many storms in Northern Argentina (north of the area indicated by surface-based reports, and more heavily studied in the past) stand out as among the strongest on earth in satellite observations, without having ground-based verification or a strong reputation about the violence of these storms?
- Does the pre-convective environment for ground-truth-confirmed severe thunderstorms in South America display a loaded-gun profile? Is an elevated mixed layer (leading to early convective inhibition) also observed over Argentina in days of severe thunderstorms? If so, is there an unobserved South American dry line triggering such storms?
- Can we improve microphysical models and forecasts with new information that might be applicable within and beyond this region?

*From Cecil and Blankenship 2012, Matsudo and Salio 2011*

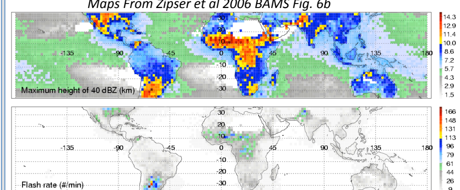



### Prediction

- Why do numerical models, from mesoscale NWP scales to climate models, have very low skill in this region? Are they missing important data for assimilation or are there missing physical processes in numerical models?
- Does the large zonal soil moisture gradient in Northern Argentina control the intensity, structure, and predictability of convective systems?
- What datasets are missing in order to provide for more accurate nowcasting and short term NWP predictions in the region?
- What are possible inferences and limits of predictability on synoptic to intraseasonal time scales for subtropical South American convection?

### Cloud microphysics/electrification

*Maps From Zipser et al 2006 BAMS Fig. 6b*




**Top**: 1% highest 40 dBZ echo tops

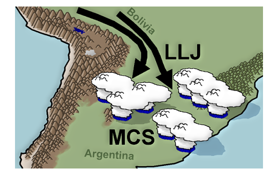
**Middle**: 1% highest lightning flash rates

**Right**: Photo of TLE above thunderstorm

- What leads to the extremely tall radar reflectivity vertical structure (e.g. high reflectivities near the homogeneous freezing temperature) of storms in the region? Is this structure due to high conditional instability, low entrainment, aerosol environments, or strong mesoscale lift? What are the implications for charging rates in these storms?
- Does the extreme vertical structure and dense ice production in these storms lead to unique drop size distributions in these storms (i.e. large drops stabilized by ice cores)?
- Does the broad structure of the systems lead to enhanced charging and lightning in the anvil and stratiform regions of the storms?
- Does the extreme structure of these storms lead to enhanced sprites/TLE production compared with the US Central Plains?

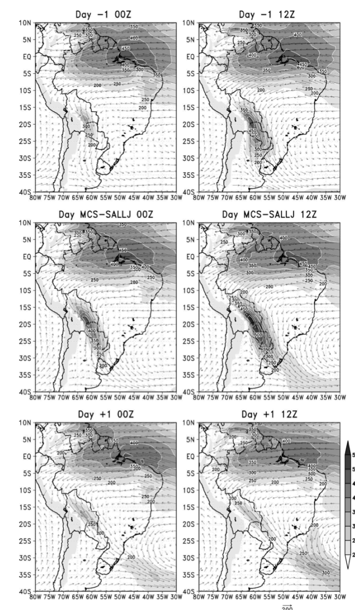
### MCS life cycle

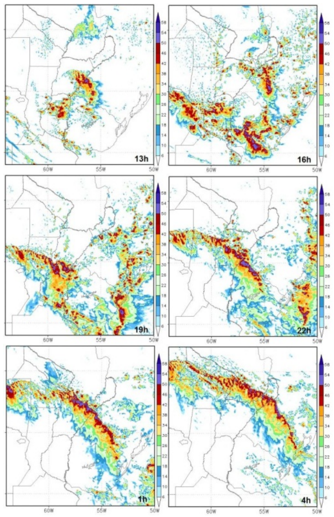
- What controls the diurnal cycle of convective system intensity (vertical structure) and mesoscale organization in the lee of the Andes?
- What is the role of microphysical and kinematic processes in leading to the upscale growth of convective clouds into MCSs and ultimately MCCs?
- Does the extreme intensity of the convection in the region impact the morphology of the convective systems (or vice versa), and how?
- Are there inferences of predictability for these processes from observations? How well do cloud resolving models and regional NWP models represent this morphology from case study to seasonal time scales?




### MCS environments

- What are the synoptic to mesoscale flow features in the region, and how do they dictate the triggering of convective systems and the environment for storms to grow upscale into MCSs?
- How does the PBL control the evolution of the LLJ and the evolution of MCSs considering different initiation times?
- How do katabatic flows near the Andes evolve and initiate large MCSs over the plains regions close to the mountains?
- The LLJ produces a strong transport of biomass aerosols between Amazonia, Paraguay and northern Argentina, plus there are dust outbreaks from the south. What is the influence of the these aerosols on the development of large convection?

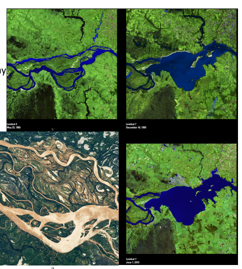




## Hydrology

The La Plata Basin is important to the agriculture, hydroelectric power, and transportation in the region. Floods and droughts have obvious impacts. Influence of land-atmosphere interaction is not well understood.

LandSat before-after imagery of reservoir at Yacyreta power station on Paraguay River (from USGS), and ISS photo of Parana River floodplain



Right: Time series of Parana River discharge at Corrientes, Argentina, from Depetris (2007). Major flood events generally correspond with El Nino, but overall discharge level has increased in recent decades.

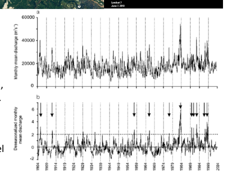
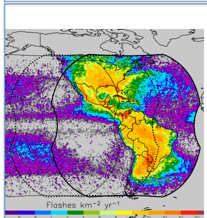


Figure 3. a: Monthly mean discharge time series (1904-2004) for the Parana River at the city of Corrientes gagging station (~1200km from the mouth). b: Same time series after deseasonalization (see text for explanation). The broken line corresponds to two standard deviations from the mean; arrows identify the occurrence of significant El Niño events.

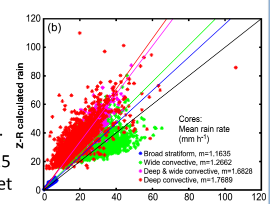
## Satellite Cal-Val



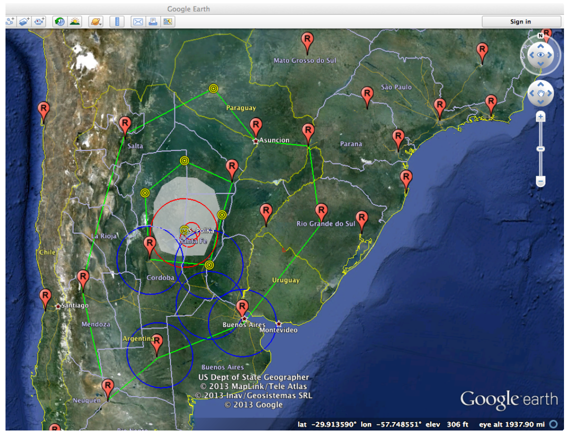
Potential to contribute to calibration – validation for GOES-R, JPSS, NPP, GPM.

***Left***: GOES-R Lightning Mapper field of view projected on LIS-OTD lightning climatology. GOES-R is to launch late 2015, with an initial check-out period stationed at 105 W, then moving to 75 W or 137 W.

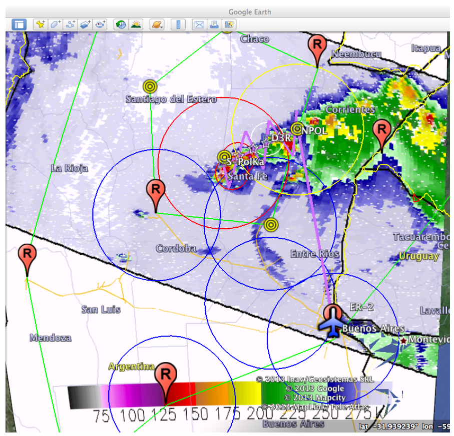
***Right***: TRMM PR Radar-derived rain rates in South America from 2A25 algorithm vs traditional Z-R estimate. See Poster 209 by Rasmussen et al. Tuesday.




# Observational Strategy



Observational assets from operational agencies or to be proposed from NSF and international partners.



TRMM 85 GHz H brightness temperature overlaid, with example ER-2 flight track in purple. TRMM image from 1550 UTC 23 Nov 2009.

The flight track sketched here is 1200 n mi – about 3 hours - assuming a base in Buenos Aires, with transects across intense convective cells in a line, and a straight leg across disdrometer network. Research radar would scan RHI to coincide with this leg. Dropsondes could be released on the inflow side of each leg, and a separate dropsonde pattern could be conducted first to characterize environment while ER-2 gains altitude. Note that population density is quite low in much of northern Argentina.

**Desired observational platforms (see maps)**

**Red balloons** are operational radiosonde sites.

**Yellow bullseyes** are radiosonde sites to be proposed from NSF and/or international partners.

**Solid green lines** mark inner and outer sounding arrays.

~8 sondes per day, per site during intensive observing periods when strong, organized convection is expected.

**Blue circles** are 200 km range from operational C-band dual-polarization radars to be installed in Argentina by 2014.

**Red circles** are 200 km range from S-PolKa radar to be requested from NSF, and 50 km range from two dual-pol Doppler On Wheels (DOW) to be requested from NSF. DOWs likely would pre-deploy to set locations based on forecasts, instead of actively chasing storms.

**White shading** is lightning mapping array domain, to be proposed from Brazil.

**Yellow circles** (in figure at right) are 200 km range and 50 km range from potential NPOL and / or D3R radar locations.

**Gray stars** (in figure at right) are possible locations for disdrometers / rain gauges.

**Airplane symbol** (in figure at right) marks possible base for ER-2 in Buenos Aires. Some contribution to ER-2 costs possible from NOAA, in support of GOES-R, NPP, JPSS cal-val.

*Desirable ER-2 payload options*:

Precipitation radar (EDOP, EXRAD, HIWRAP, or similar)

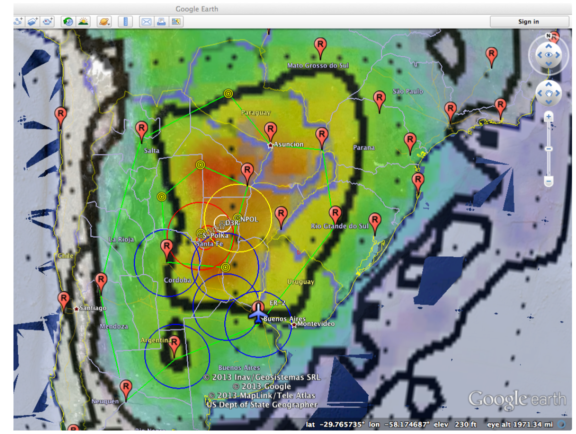
Microwave radiometer / sounder (AMPR, CoSMIR, or similar)

Lightning / electrification package (GLM Airborne Simulator)

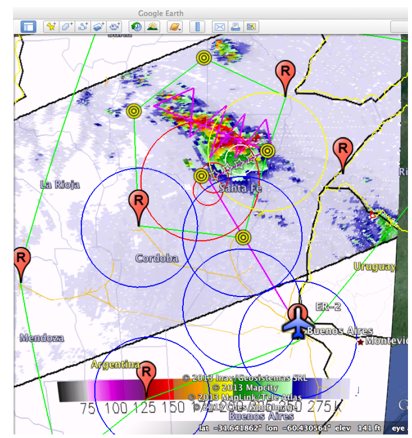
Dropsondes

Interferometer and microwave spectrometer sounders (S-HIS, NAST-I, NAST-M) for NPP/JPSS cal-val.

*Not shown*: mobile mesonet / sticknet, ground-based electric field mills, high-speed video camera (for lightning), mobile sounding facility / PIBAL, aerosol / thermodynamics UAV



Potential NASA assets added. Background shading is AMSR-E based severe hail climatology from Cecil and Blankenship (2012). The location of the satellite-indicated storm maximum in Chaco state (northern tip of inner sounding array) has limited infrastructure, making it unlikely to place a radar there.



TRMM 85 GHz Polarization Corrected Temperature overlaid on experimental design, with example ER-2 flight track in purple. TRMM image is from 1913 UTC 02 Dec 2006.

The flight track sketched here is 1750 n mi – about 4.5 hours - assuming a base in Buenos Aires, with transects across intense convective cells in a line, and a straight leg across disdrometer network.