Ingredients for Extreme Convection over South America – RELAMPAGO and ANDEX

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ANDEX Workshop, 22-24 October 2018
Santiago de Chile, Chile

Overview of RELAMPAGO-CACTI field campaign.

RELAMPAGO Hydrometeorology Component

How this relates to ANDEX – with Alejandro Martinez (U Antioquia, Colombia)

Overview of RELAMPAGO-CACTI field campaign.

Experimental Design Overview

RELAMPAGO: Remote sensing of Electrification, Lightning, And Meso-scale/micro-scale Processes with Adaptive Ground Observations (translates to lightning flash in Spanish and Portuguese)

Co-authors

- **RELAMPAGO**

- Steve Nesbitt, University of Illinois at Urbana-Champaign (US NSF PI)
- Adam Varble, University of Utah (US DOE CACTI PI)
- Paola Salio, University of Buenos Aires, Argentina (Argentina lead)
- Luiz Machado, INPE, Brazil (Brazil lead)
- Jeff Trapp, University of Illinois at Urbana-Champaign (US NSF Co-PI)
- Francina Dominguez, University of Illinois at Urbana-Champaign
- Angela Rowe, University of Washington
- Kristen Rasmussen, Colorado State University
- Russ Schumacher, Colorado State University
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- Jim Marquis, University of Colorado-Boulder
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- Jim Wilson, National Center for Atmospheric Research
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- Josh Wurman, Center for Severe Weather Research
- Ed Zipser, University of Utah
- Robert Houze, University of Washington/PNNL
- V. Chandrasekar, Colorado State University
- Rachel Albrecht, University of São Paulo, Brazil
- Timothy Lang, NASA Marshall Space Flight Center (US NASA/NOAA lead)
- Celeste Saulo (Servicio Meteorológico Nacional, Argentina)

- **CACTI**

- **Principal Investigator**
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- Kristen Rasmussen, National Center for Atmospheric Research
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- Ruby Leung, Pacific Northwest National Laboratory
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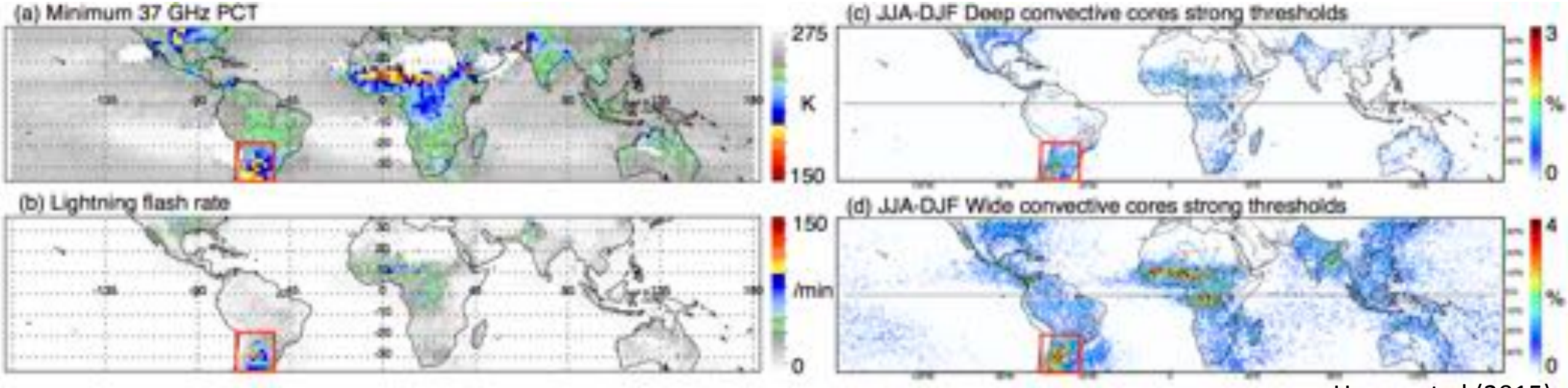
- David Romps, Lawrence Berkeley National Laboratory
- David Gochis, National Center for Atmospheric Research
- Eldo Avíla, Universidad Nacional de Córdoba
- Christopher Williams, University of Colorado-Boulder/NOAA

Southeast South America is one of the regions with the most severe storms on the planet.



Zipser et al. (2006)

Houze et al (2015)

1) the storms with the greatest vertical development of the Earth; 2) the most intense lightning flash rates by storm; 3) the highest density of hailstorms in the world. *That is why there is international interest in studying the region.*

The region has optimal conditions for the formation of Mesoscale Convective Systems

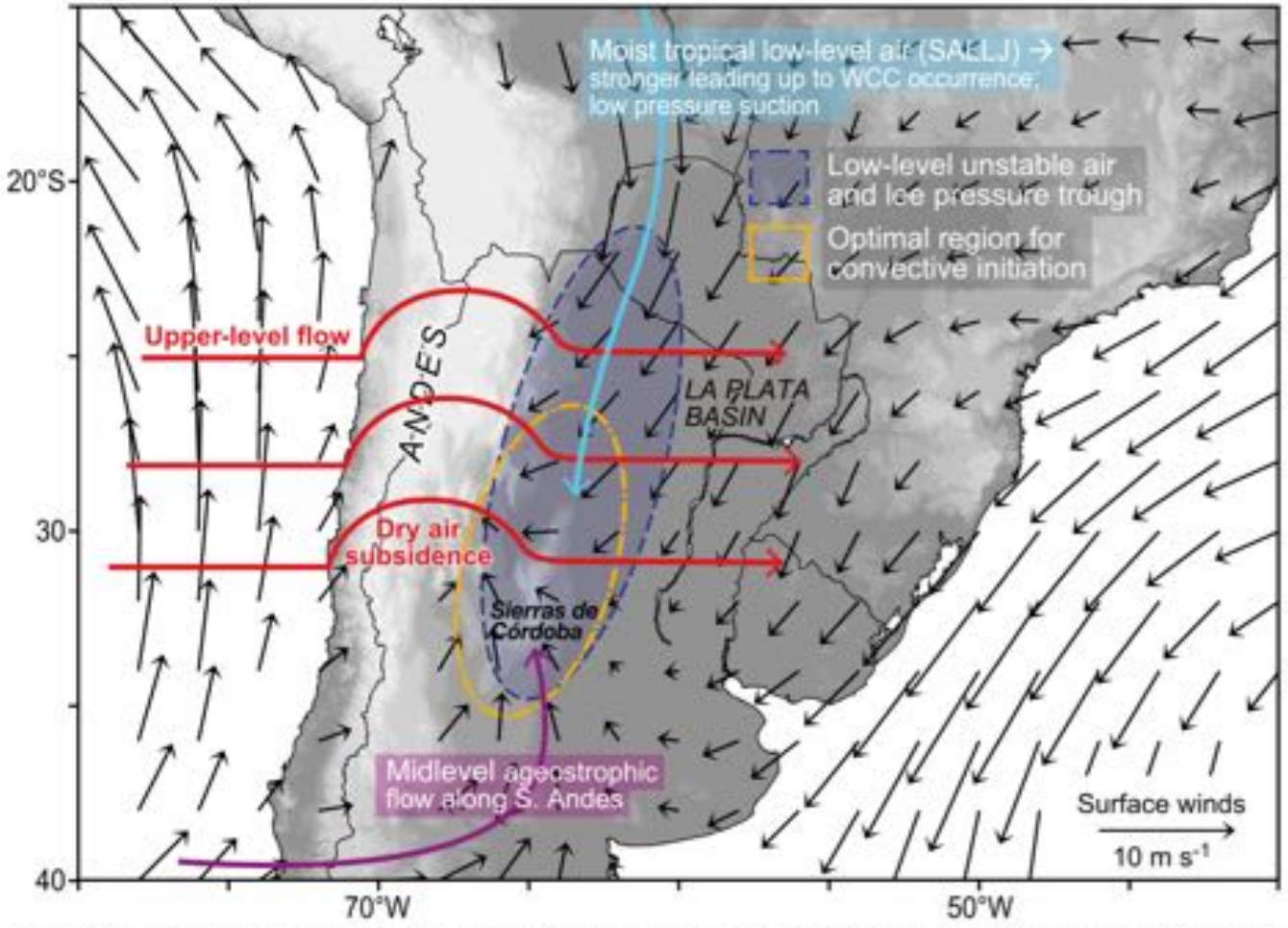
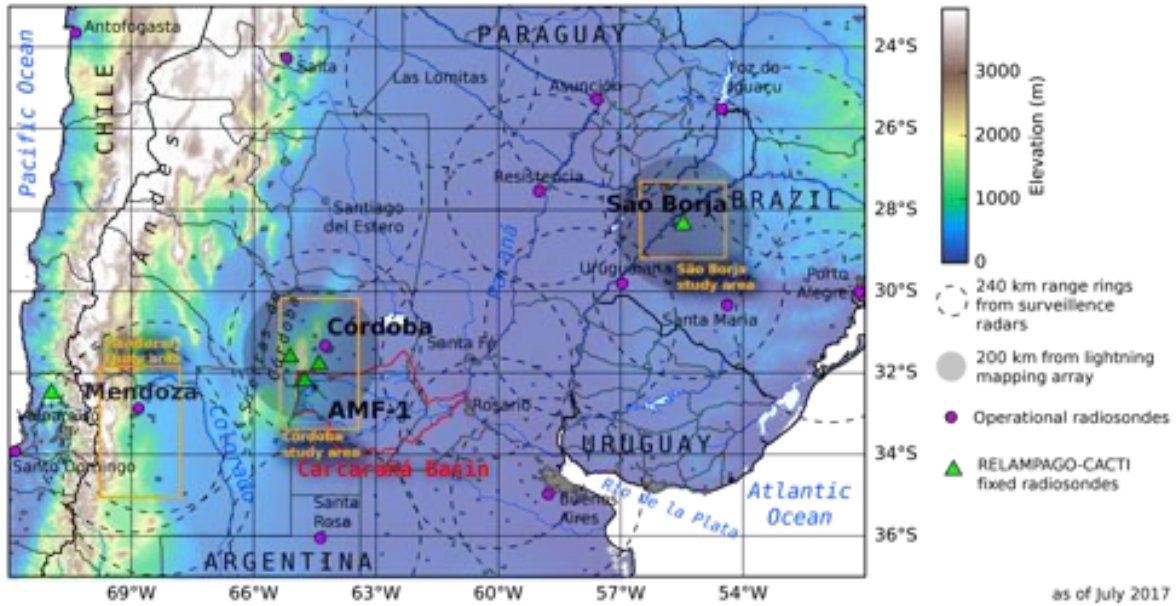


FIG. 18. Conceptual model representing the key ingredients for convective initiation in the lee of the subtropical Andes. Blue arrows and text represent low-level flow, purple arrows and text represent midlevel flow, and red arrows and text represent mid- to upper-level flow. The region highlighted in orange represents the optimal region for convective initiation. Composite surface winds ($m\,s^{-1}$) for days when a wide convective core is located in the La Plata basin regions are represented in black vectors.

- Very moist South-American Low-level jet.
- Mid-level dry air that creates a “capping” inversion.
- Mountain and valley breezes that occur in the presence of the Sierras de Córdoba or the passage of fronts.

Rasmussen and Houze 2016

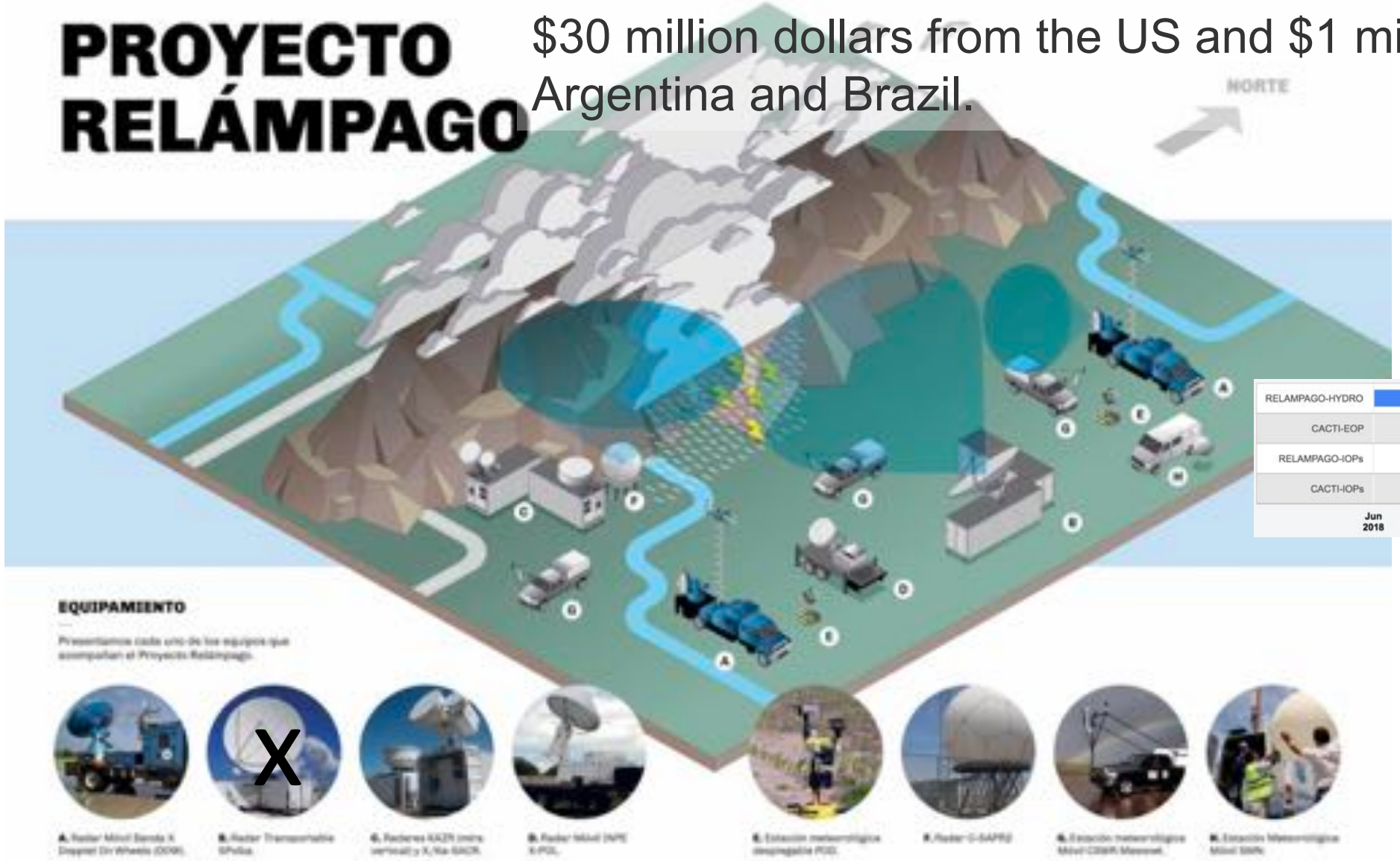


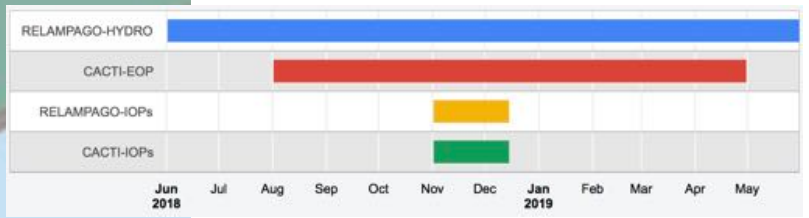
Questions to be addressed by RELAMPAGO-CACTI:

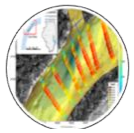
- What are the life cycles and environmental characteristics of deep, organized, high-impact weather-producing storms across this region? How does it act to set the stage for hazardous weather and extremes?
- What are the physical mechanisms that produce these storms? How do they differ from similar events in the US? What is the predictability of these storms and associated hazards?

With resources from US agencies such as the National Science Foundation (NSF), NASA, NOAA, in cooperation with agencies and institutions from Latin America for an investment amount of $30 million dollars from the US and $1 million dollars from Argentina and Brazil.

PROYECTO RELÁMPAGO







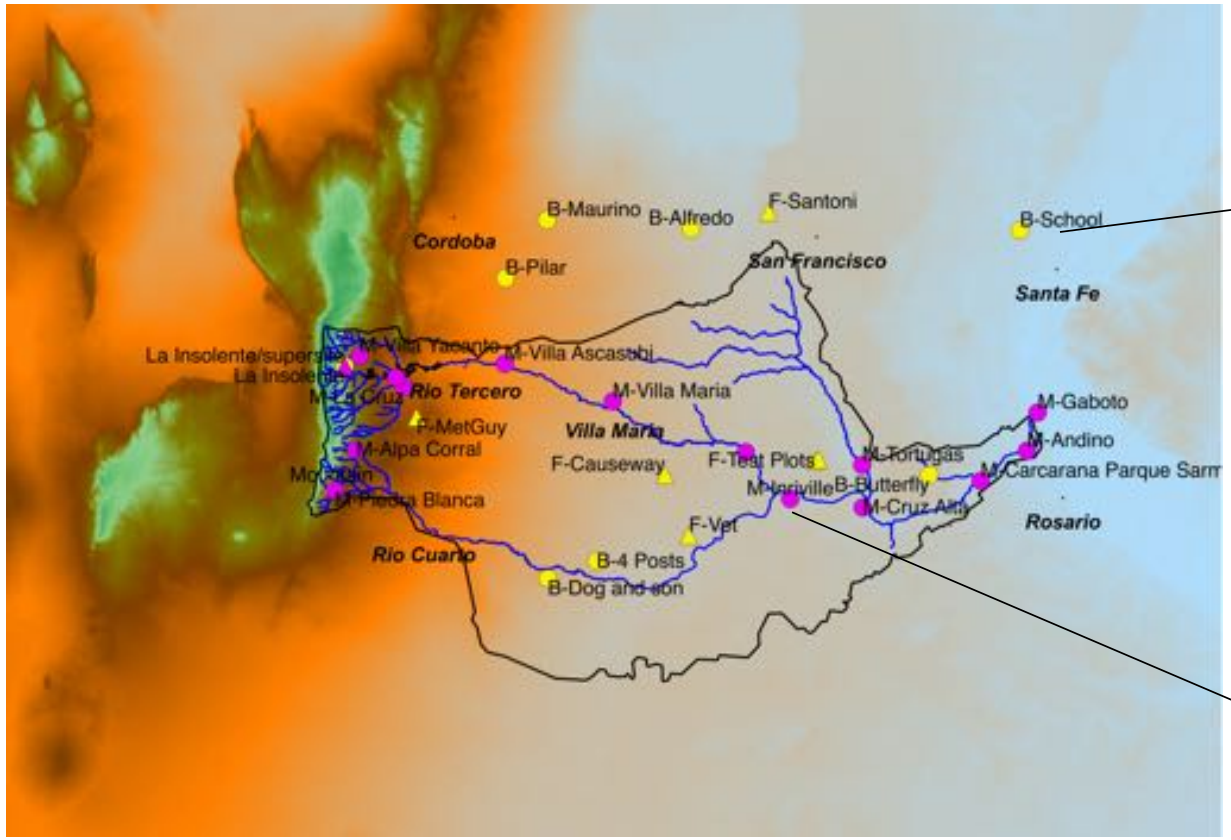
Streamflow+ADCP

RELAMPAGO Hydrometeorology Component (my part)

1. How does land cover heterogeneity (including human-modified land cover) impact initiation and growth of convective precipitation at the local and mesoscale through land-atmosphere exchanges of moisture and energy?

2. How have changes in land cover affected the partitioning of rainfall between infiltration/runoff and the residence times of soil moisture and groundwater in the Carcara Basin's terrestrial system?

The RELAMPAGO-HYDROMET team installed most of their instrumentation in May of 2018.



Yellow are NCAR-EOL 10meter towers. (15)

Magenta are NCAR-RAL 3 meter towers. (15)

These instruments will stay for one year.

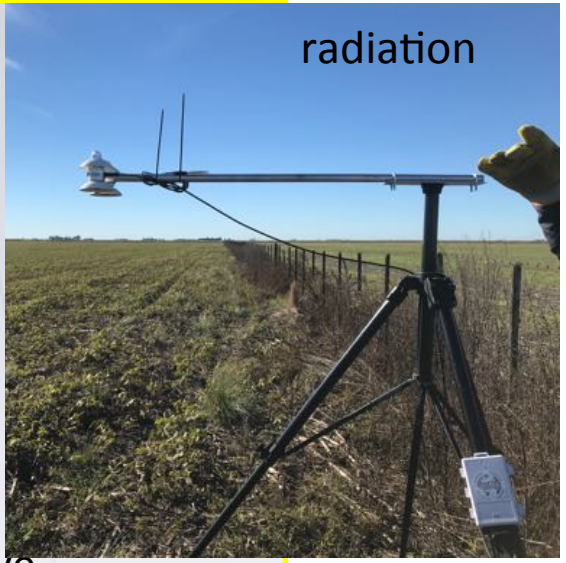
LEAD: NCAR-EOL

EOL Towers Measure

- Precipitation
- Temperature
- Relative Humidity
- Pressure
- Wind speed
- Leaf wetness
- Incoming/outgoing short/longwave radiation.
- Near-surface soil moisture
- Near-surface soil temperature
- Near-surface soil heat flux
- Near-surface soil heat capacity

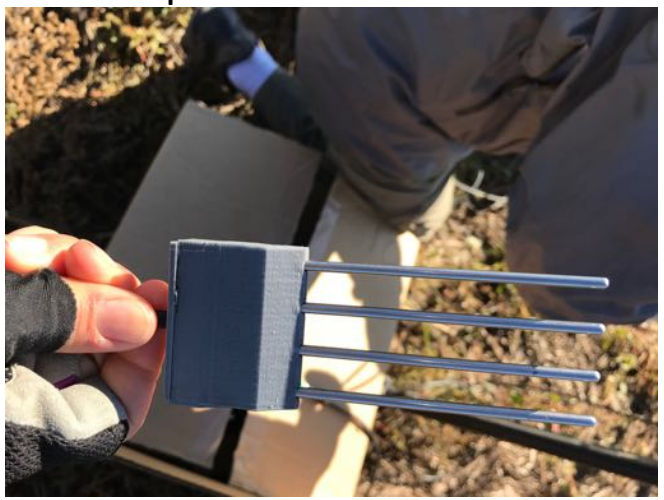
- SEVEN towers have eddy covariance instruments to measure
- Latent heat flux
- Sensible heat flux
- Momentum flux
- Carbon flux

- TEN towers have disdrometers

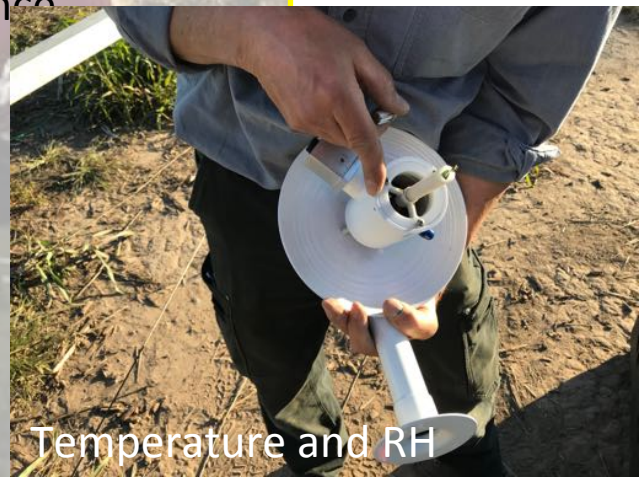


radiation

Soil temperature



Eddy Covariance



Temperature and RH

Precipitaiton

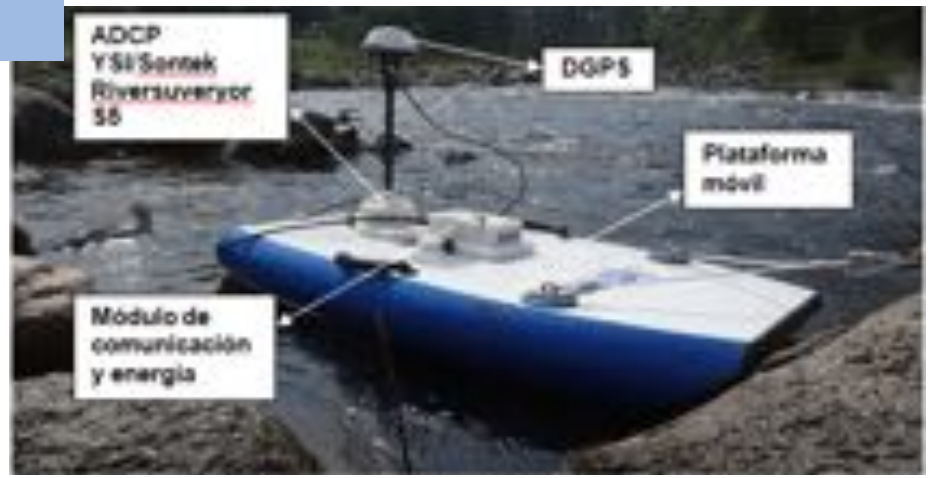
Soil Moisture

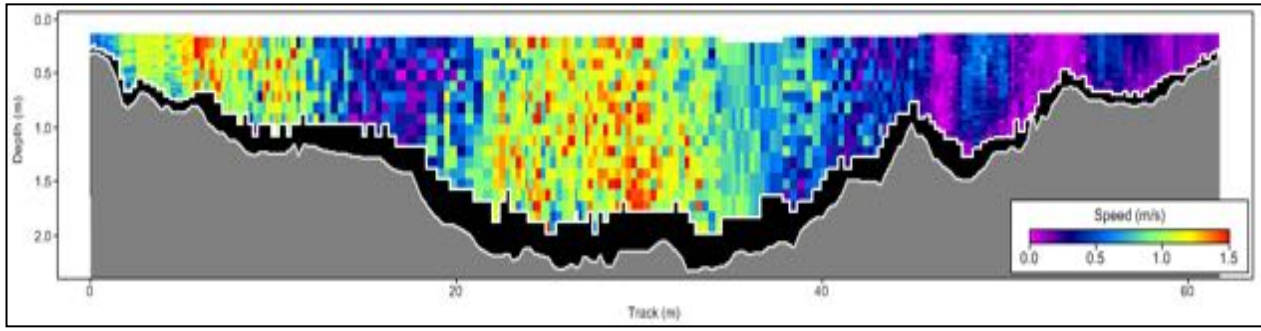
LEAD: NCAR-RAL

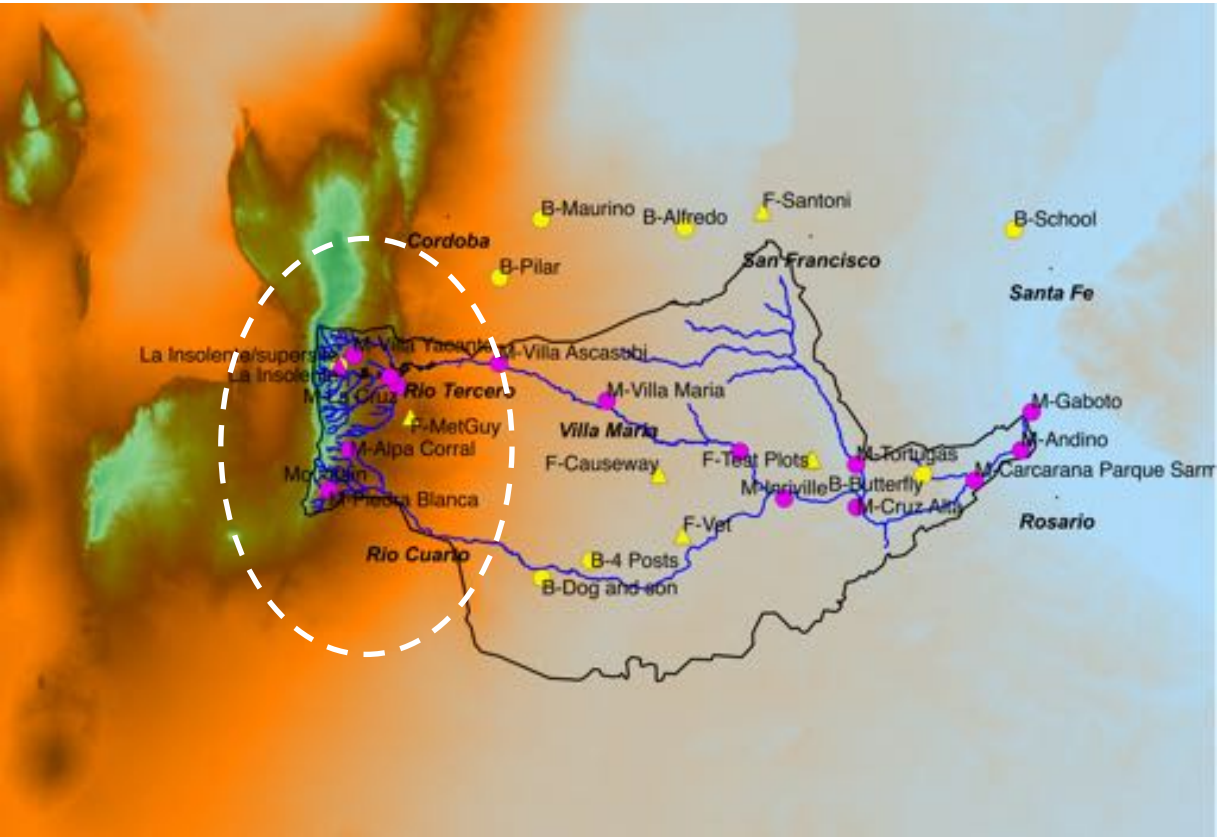
RAL Towers Measure

- Precipitation
- Temperature
- Relative Humidity
- Pressure
- Wind speed
- Leaf wetness
- Incoming shortwave radiation.
- Leaf wetness sensor
- 5cm and 25cm soil moisture
- 5cm and 25cm soil temperature

In addition, during the RELAMPAGO campaign, we will measure streamflow in the upper basin.

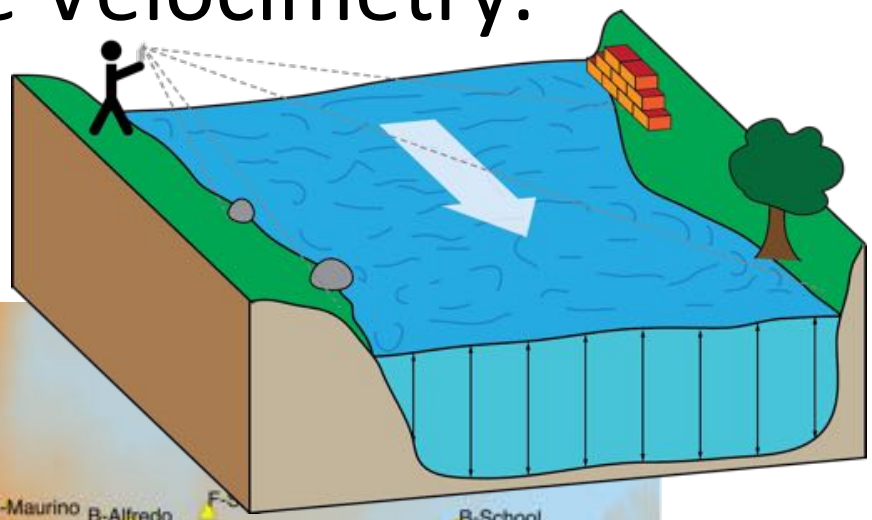


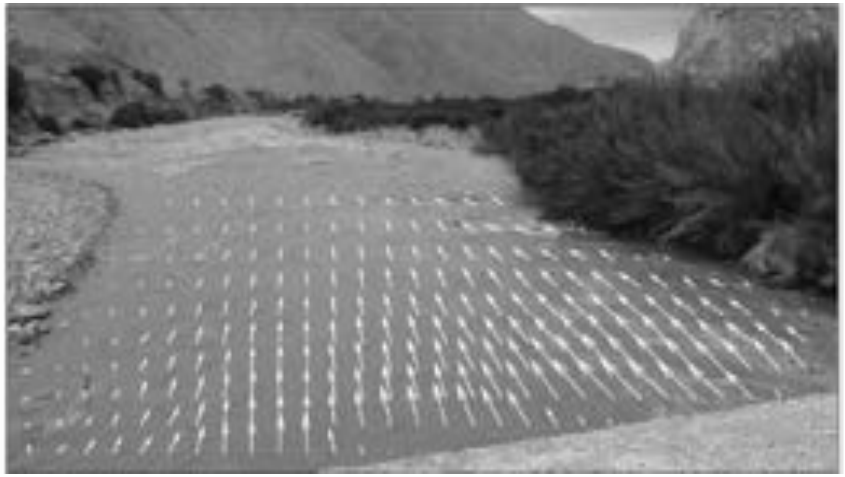


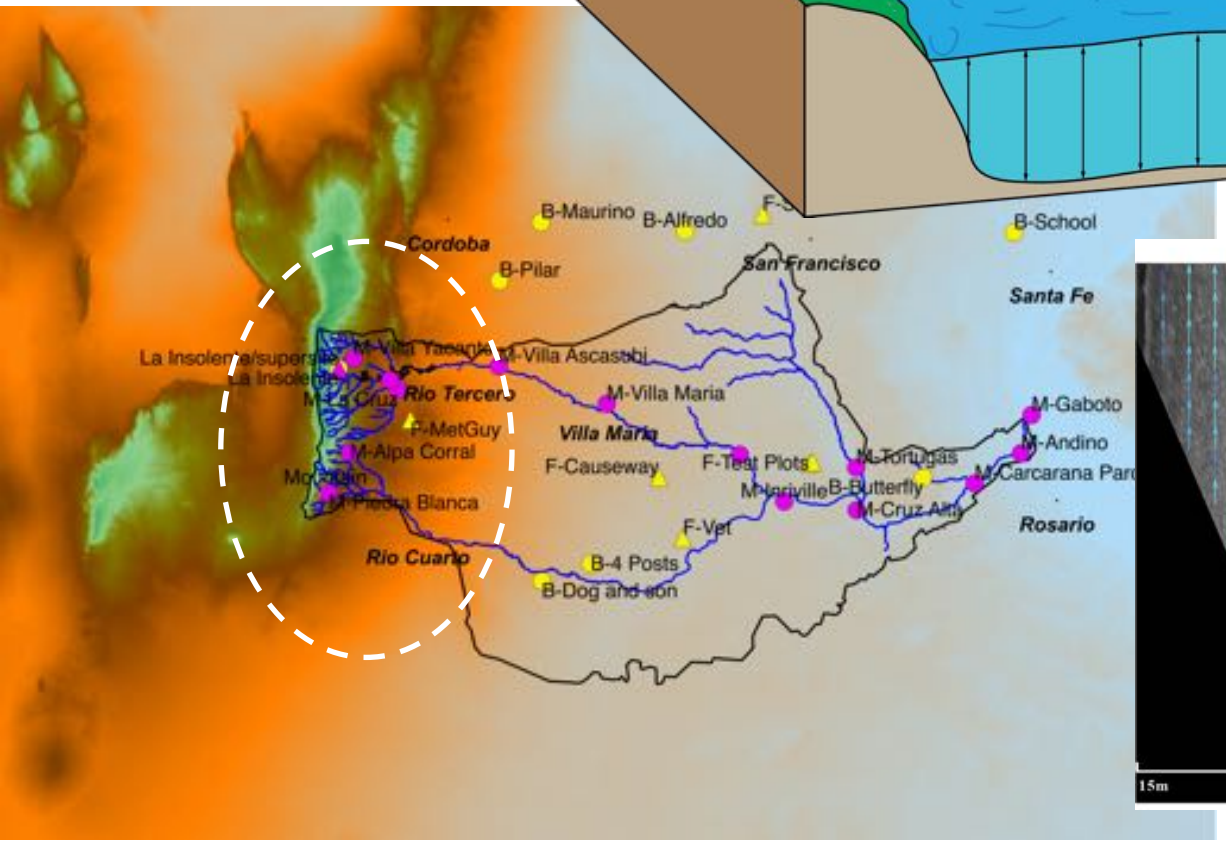


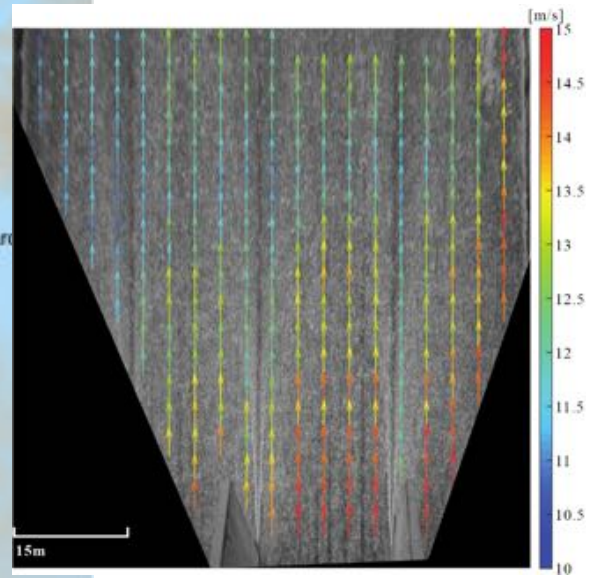
We will use an Acoustic Doppler Current Profiler (ADCP)

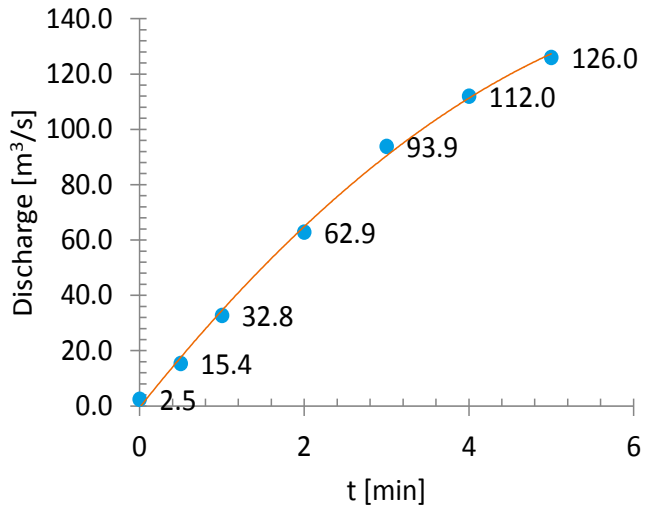
At the highest streamflow volumes, we will use Large-Scale Particle Image Velocimetry.



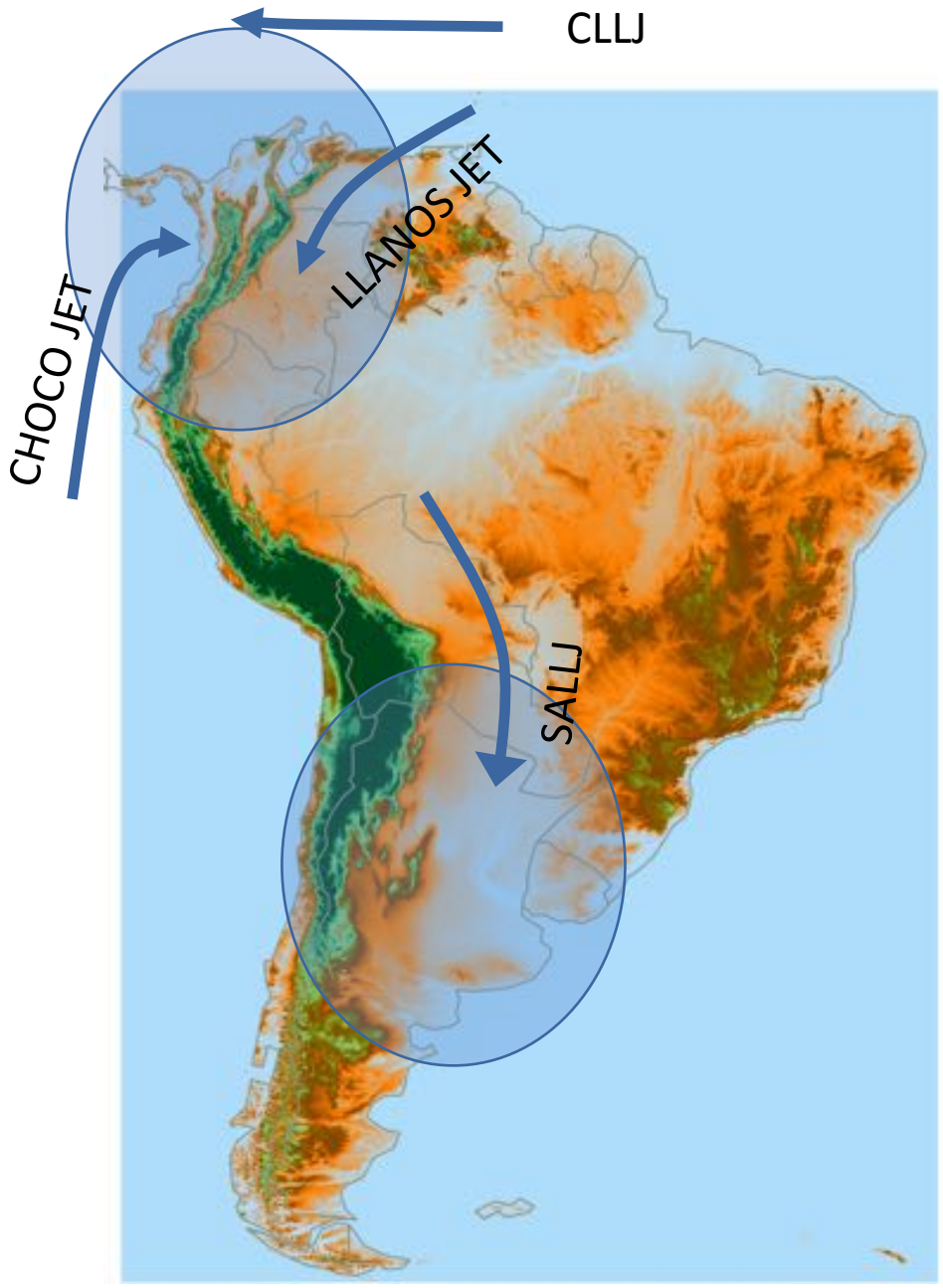








How this relates to ANDEX
(in collaboration with Alejandro Martinez from the Universidad de Antioquia, Colombia).



Alarmas se activaron en Mocoa desde las 10:30 de la noche

NACIÓN

Alarmas se activaron en Mocoa desde las 10:30 de la noche

Equipos de socorro se trasladaron desde las poblaciones aledañas en la noche de este viernes a atender la tragedia. El panorama es devastador.

Argentina in mourning as floods kill 54

By Agence France-Presse
Thursday, April 4, 2013 7:07 EDT

4 16 0

Argentina's government declared three days of national mourning from Wednesday after massive flooding killed 54 people in Buenos Aires and the nearby university city of La Plata.

Complex Topography

Extreme Hydrometeorological Events

Low-level jets

Intense convection

Important land-atmosphere interactions

This is an example of an MCS that developed southern Colombia that resulted in catastrophic flooding.

Semana | NACIÓN | OPINIÓN | ECONOMÍA | VIDA MODERNA | GENTE | CULTURA | MUNDO | TECNOLOGÍA | EDUCACIÓN | DEPORTES | SOSTENIBILIDAD | FOROS SEMANA | EDICIÓN IMPRESA

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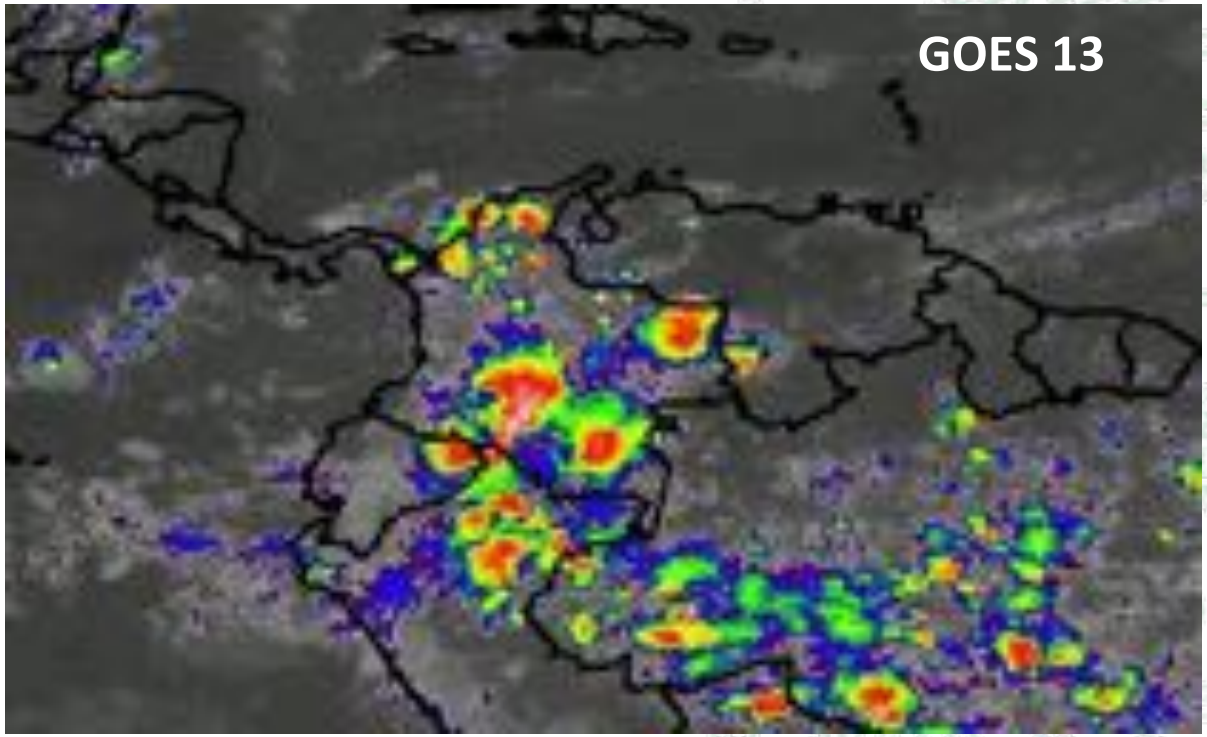
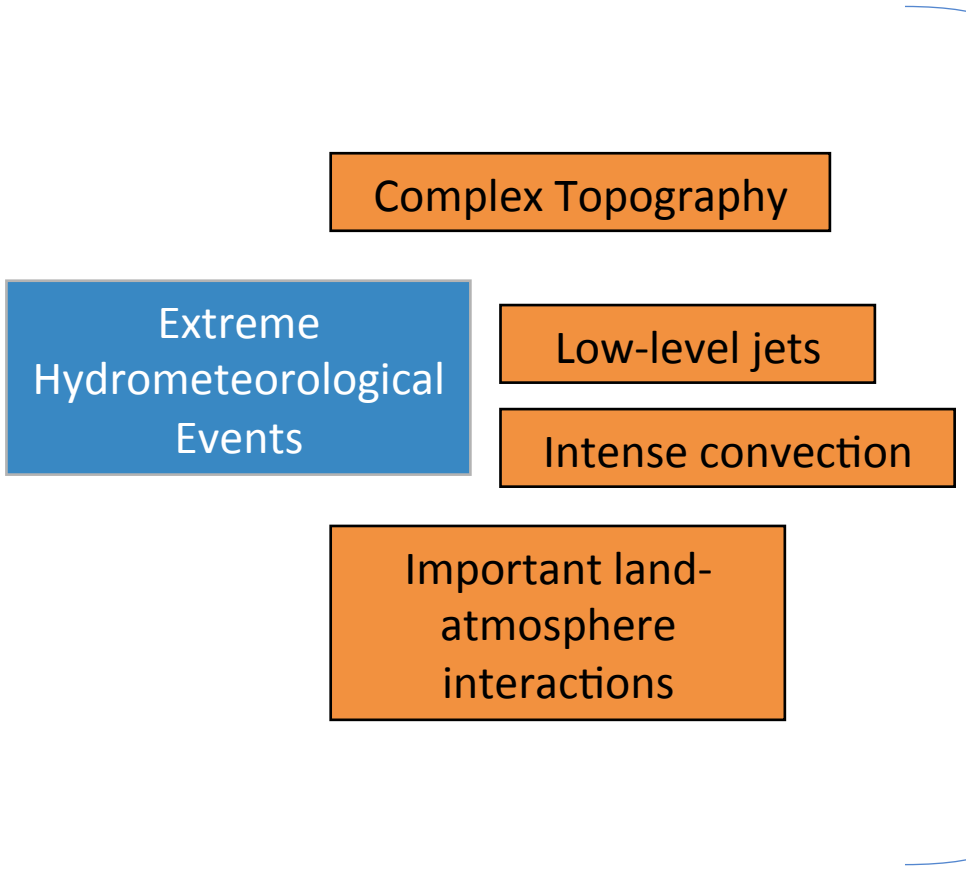
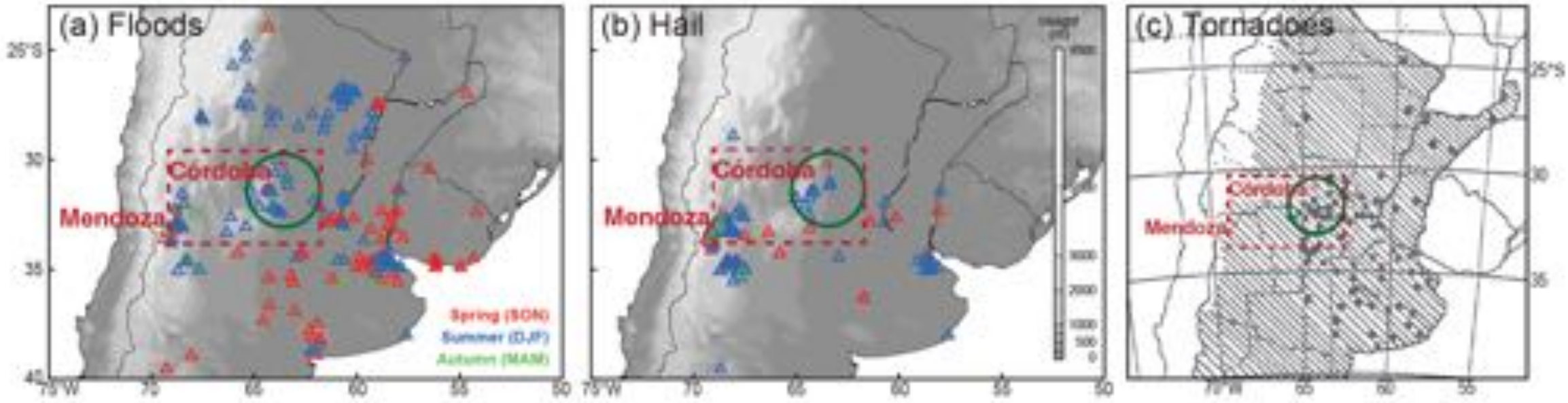


Daniel Espinosa y Alejandro Martinez
Estudiante Ingeniería Ambiental



Can we design an observational + modeling experiment to better understand these interactions and improve the predictability of extreme convection and resulting impacts?



Rasmussen et al. (2014)

Altinger de Schwarzkopf and Rosso (1982)

The result are very strong hydrometeorological impacts:

- Flooding events cover the region of subtropical South America north of 40°S.
- Hail near the complex terrain near the Sierras de Córdoba
- Tornadoes are produced east of the Sierras de Cordoba and the Pampas to the east.

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https://mediaspace.illinois.edu/media/t/1_3ov58vt6

The data is available to view at:

https://archive.eol.ucar.edu/docs/isf/projects/RELAMPAGO/isfs/qcdata/