Schedule

10:45-11:15 AM CACTI Overview – Adam Varble

Infrastructure Updates

11:15-11:20 AM AMF Logistics Update – Heath Powers

11:20-11:25 AM C-SAPR2 Update – Nitin Bharadwaj

11:25-11:30 AM Data Flow Update – Cory Stuart

11:30-11:35 AM Data Products Update – Scott Collis

11:35-11:40 AM Metadata – Maggie Davis

IOP Updates

11:40-11:50 AM G-1 Update – Beat Schmid

11:50-12:05 PM RELAMPAGO Overview – Paloma Borque

Discussions

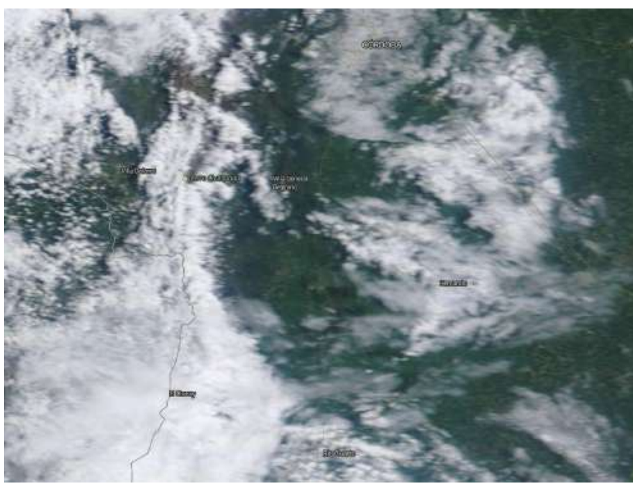
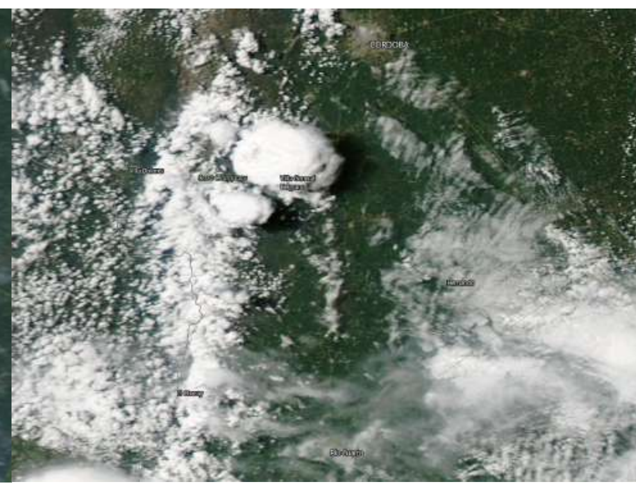
12:05-12:20 PM Discussion of coordination/communication between CACTI and RELAMPAGO during the IOP

12:20-12:35 PM Discussion of radar, G-1, and sounding observing strategy decisions

12:35-12:45 PM Extra time for further discussion



The Cloud, Aerosol, and Complex Terrain Interactions (CACTI) ARM Field Campaign


Investigators

<u>Principal Investigator</u>

Adam Varble, University of Utah

<u>Co-Investigators</u>

Stephen Nesbitt, University of Illinois

Paola Salio, Universidad de Buenos Aires

Edward Zipser, University of Utah

Susan van den Heever, Colorado State University

Greg McFarquhar, University of Illinois

Paul DeMott, Colorado State University

Sonia Kreidenweis, Colorado State University

Robert Houze, Jr., University of Washington

Kristen Rasmussen, National Center for Atmospheric Research

Michael Jensen, Brookhaven National Laboratory

Pavlos Kollias, McGill University

Ruby Leung, Pacific Northwest National Laboratory

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

Management

Ground

Kim Nitchke – AMF1 Manager

Maciej Ryzek – AMF1 Operations Lead

Nitin Bharadwaj – Radar Engineering Lead

Stephen Springston – Aerosol Systems Engineering Lead

Aircraft

Beat Schmid – AAF Manager

Jason Tomlinson – Engineering Manager

Mike Hubbell – Chief Pilot

In country management is provided by INVAP. Many others at ARM are involved in operations, engineering, instrument mentoring, data management, and communications.

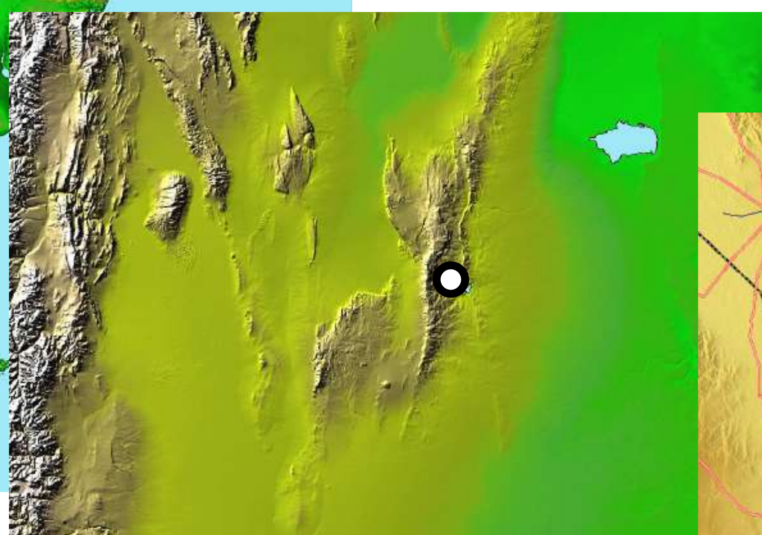
Overview

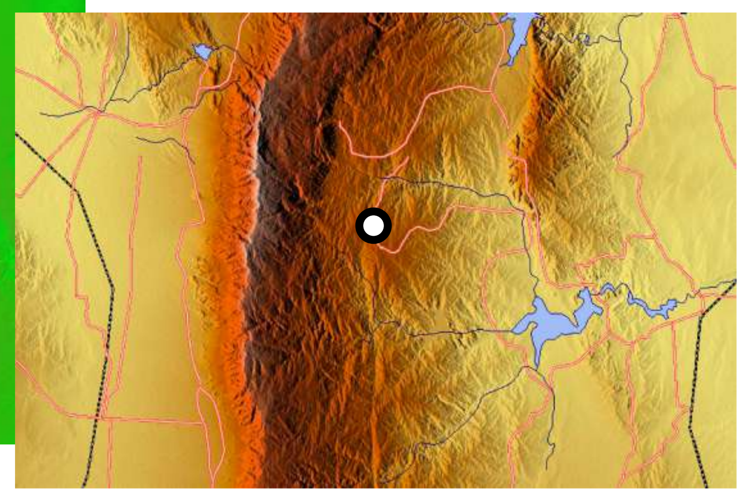
<u>Timing</u>: 1 October 2018 – 30 April 2019

<u>Location</u>: Villa Yacanto, Argentina (32.1°S, 64.75°W)

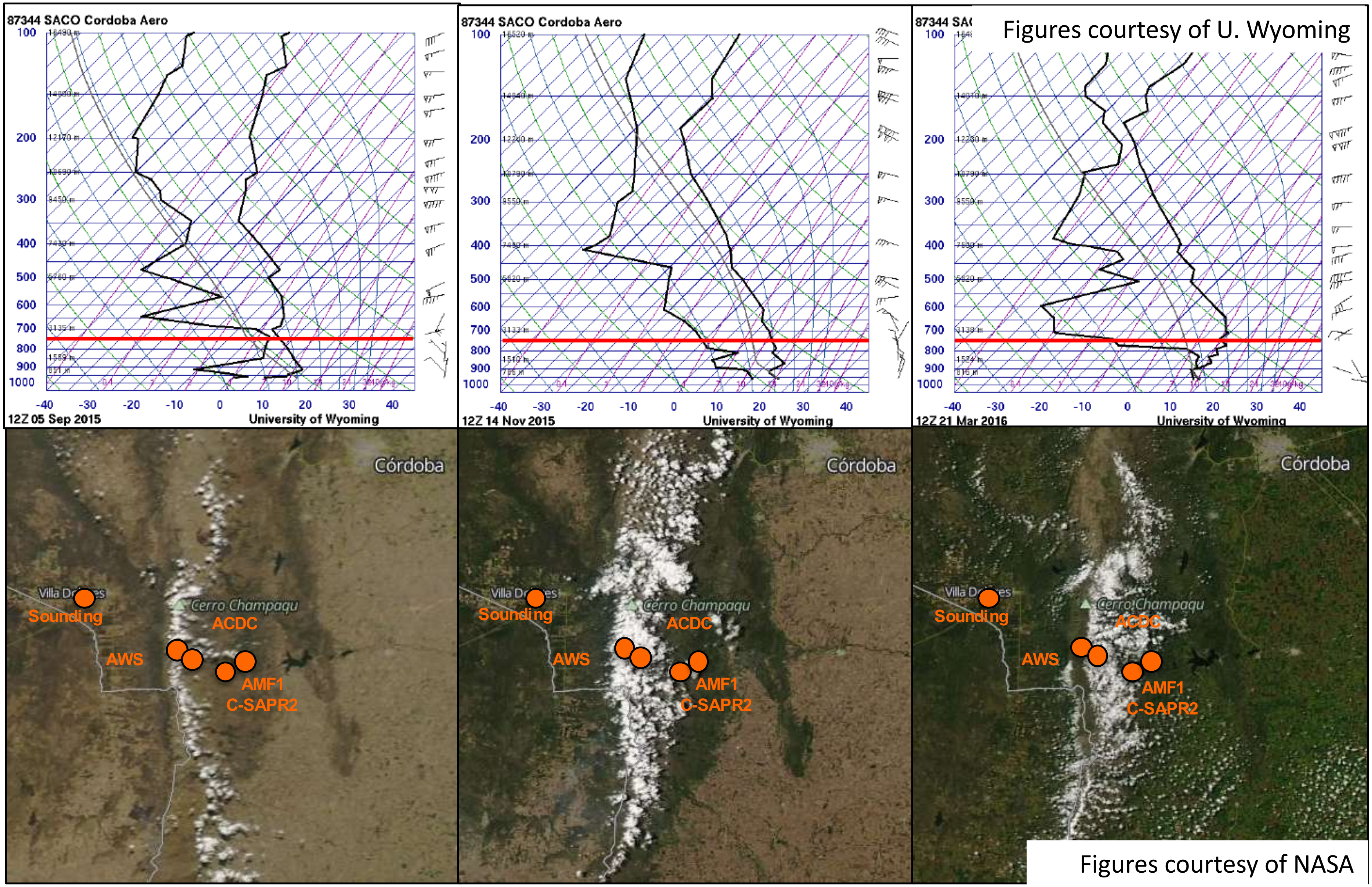
<u>Secured Resources</u>: AMF-1 (reconfigured), C-SAPR2, INP filters, APS, photogrammetry, G-1 aircraft (IOP), AWSs

IOP is coincident with RELAMPAGO (NSF) field program (1 November – 15 December 2018)

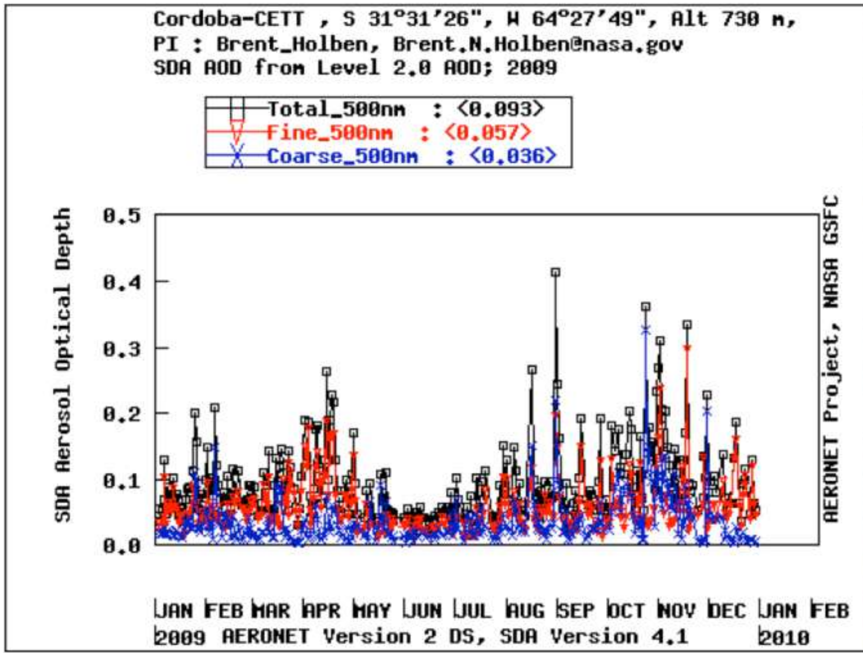


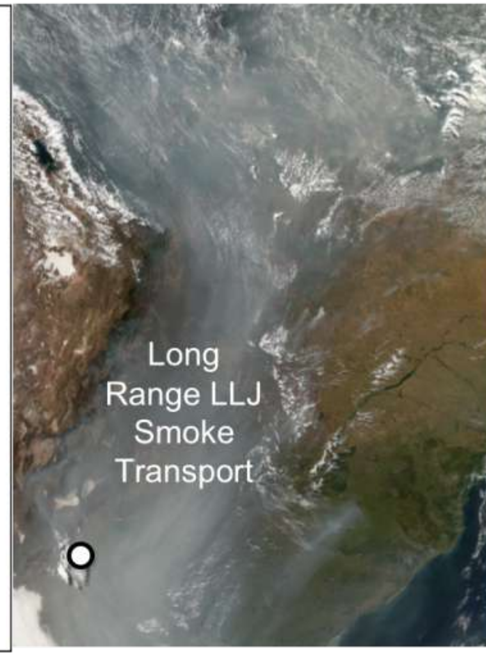


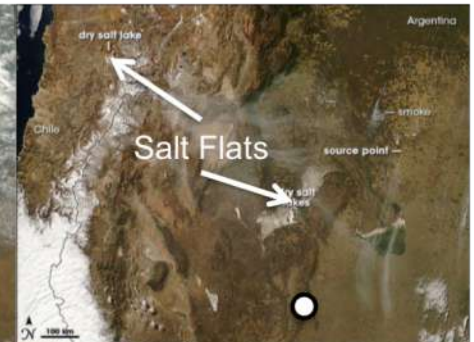
Experiment Rationale – Repeated Orographic Cumulus

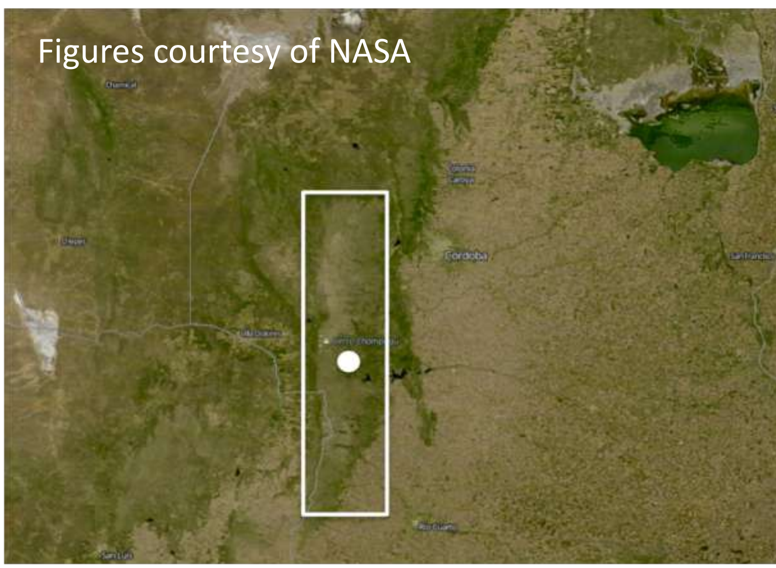


Experiment Rationale –
Variable Aerosol and Land Surface Properties

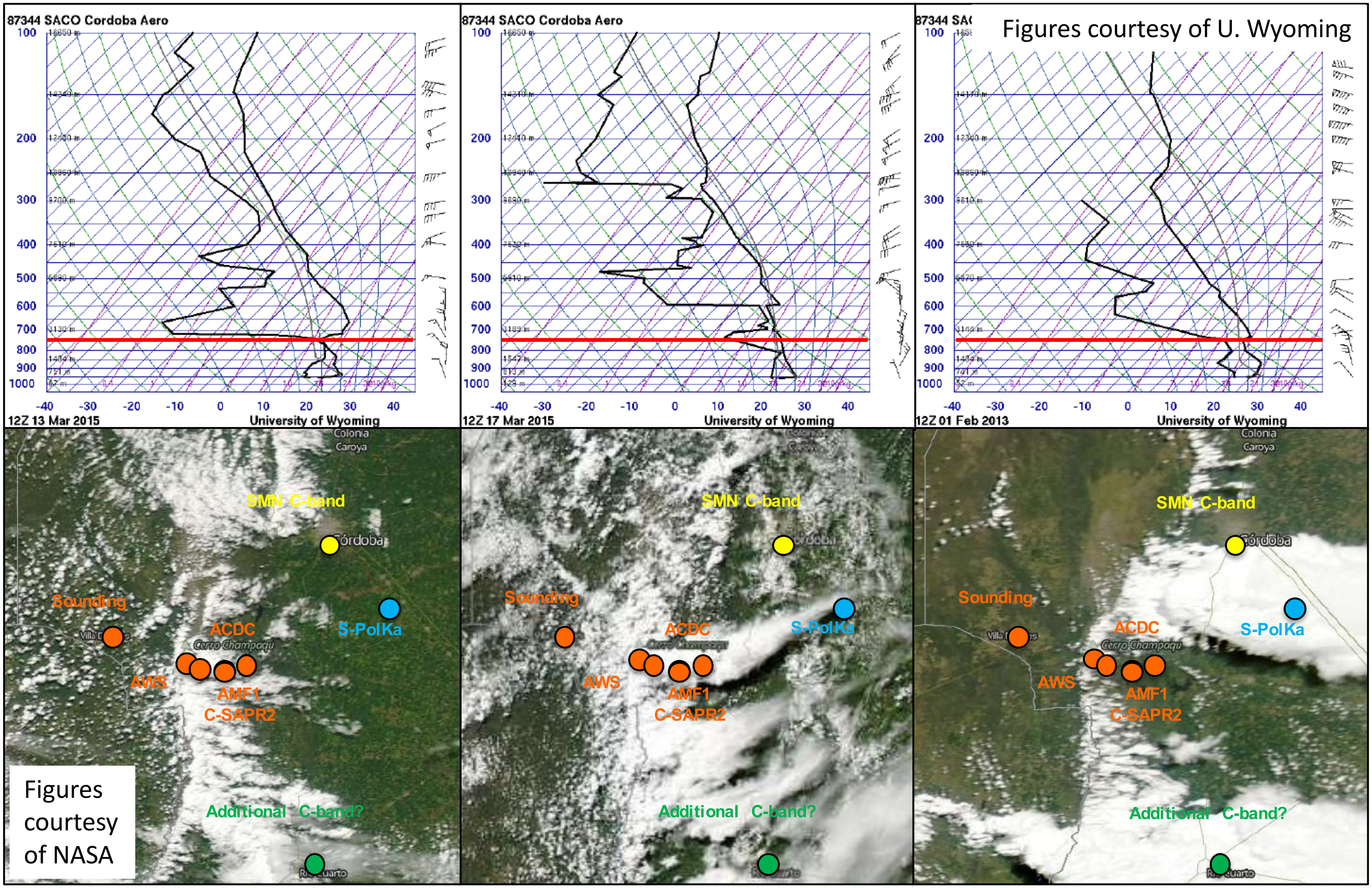








Experiment Rationale – Repeated Deep Convective Initiation

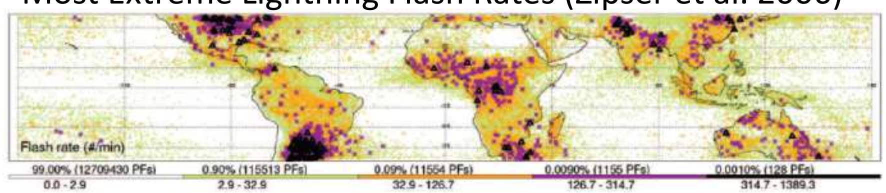


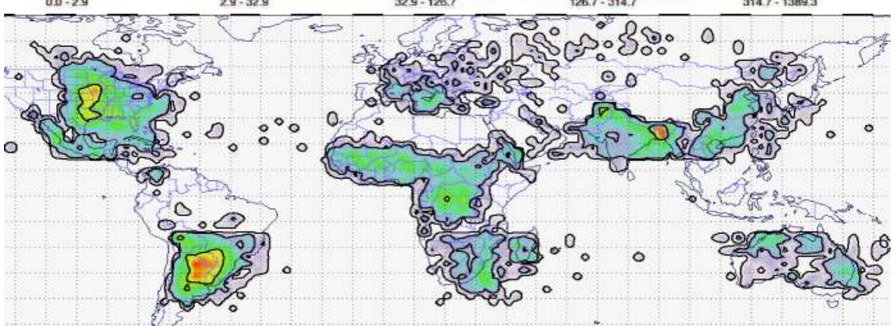
Experiment Rationale – “Extreme” Convection

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Orographic Cu	13	19	15	22	19	24	22
Orographic Sc	6	3	2	5	1	1	4
Orographic Cb	1	7	9	6	8	8	2
Overcast	2	3	6	1	7	5	4
Scattered Non-Orographic Clouds	6	2	4	4	1	0	0
Clear	4	3	3	0	0	1	3

These numbers are for the area observable by the AMF-1 (< 25 km away) from one season estimated from MODIS images.

Most Extreme Lightning Flash Rates (Zipser et al. 2006)





Severe Hail Frequency Estimated from AMSR-E (Cecil and Blankenship 2012)

The most “extreme” storm observed by TRMM occurred downstream of our proposed location. It had a **40 dBZ echo reaching 18.8 km**, a 85-GHz PCT down to 44 K, a 37-GHz PCT down to 68 K, and a **minimum IR T_b of -111.6 C**.

Experiment Rationale – Mesoscale Organization

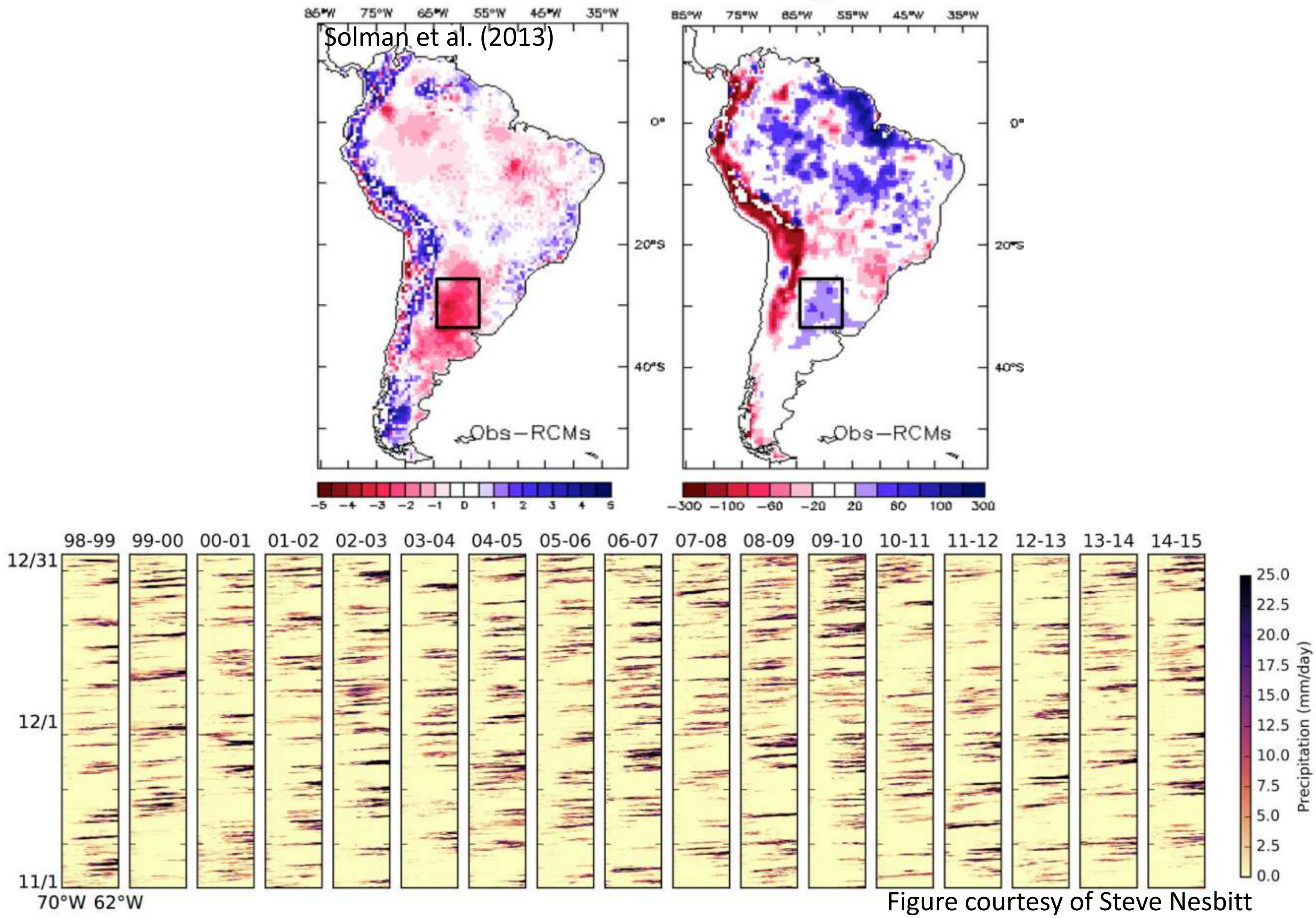
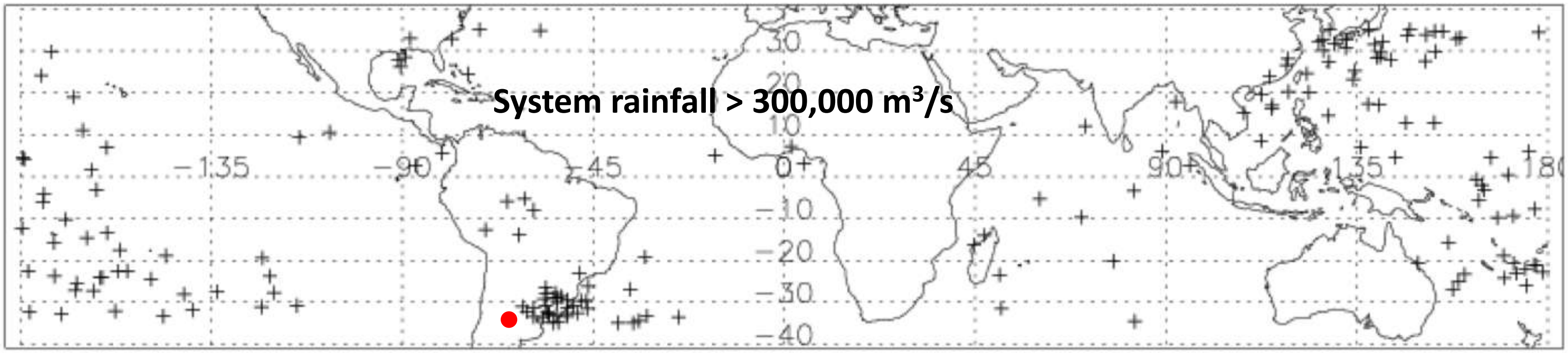
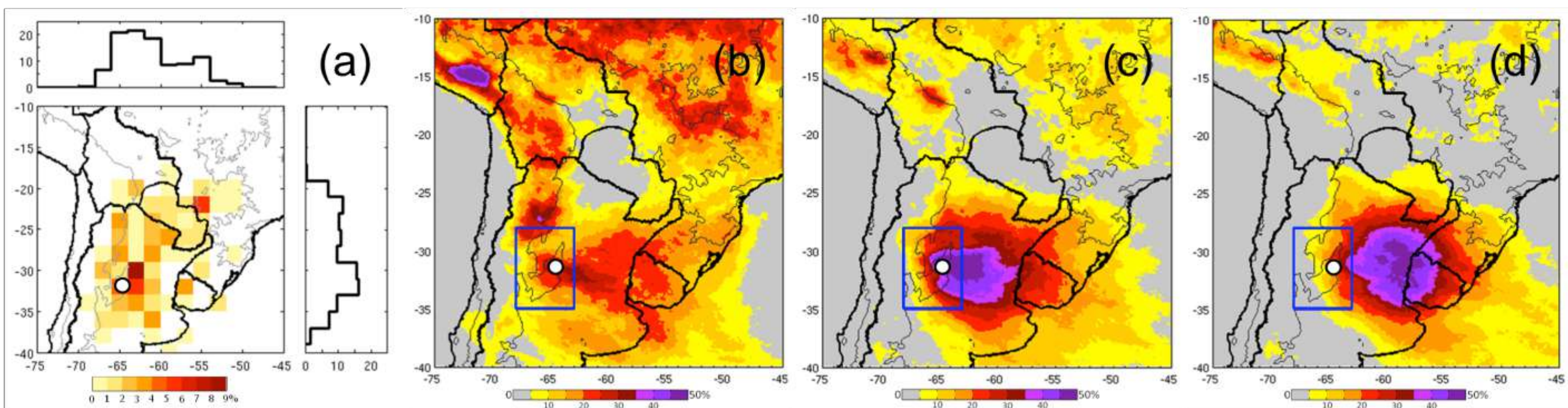


Figure courtesy of Steve Nesbitt

Experiment Rationale – ”Extreme” Organization





Vidal and Salio (2014)

Science Question #1

How are the properties and lifecycles of orographically generated boundary layer clouds, including cumulus humulis, mediocris, congestus, and stratocumulus, affected by environmental kinematics, thermodynamics, aerosols, and surface properties? How do these clouds types alter the lower free troposphere through detrainment?

- Measure the scales and velocities of individual cloud updraft and downdrafts including how they evolve in time, and relate these to measurements of cloud microphysical and macrophysical features.
- Investigate the ways in which aerosol properties and cloud dynamics impact precipitation and ice initiation in a growing congestus cloud including the ways that these initiations impact subsequent cloud and precipitation evolution.
- Explore the predictability of cloud coverage, depth, and radiative properties given large-scale environmental conditions.
- Investigate the impacts of mesoscale circulations and land surface interactions on local environmental conditions and cloud lifecycles.
- Quantify cloud effects on the environment.

Science Question #2

How do environmental kinematics, thermodynamics, and aerosols impact deep convective initiation, upscale growth, mesoscale organization, and system lifetime?

How are soil moisture, surface fluxes, and aerosol properties altered by deep convective precipitation events and seasonal accumulation of precipitation?

- Quantify the mechanisms that transition congestus to deep convection while relating deep convective dynamical motions to microphysical signatures and macrophysical characteristics of the clouds and precipitation.
- Investigate the predictability of deep convective cloud and precipitation properties including mesoscale organization given knowledge of large-scale environmental conditions, and determine the mechanisms most important for continued growth and/or organization of deep convection. This includes the ways in which cold pool properties depend on environmental and precipitation characteristics.
- Investigate the impact of deep convective precipitation on boundary layer aerosol and cloud properties through alteration of surface conditions across a range of timescales from hourly to seasonally.

AMF-1/C-SAPR2/Guest Instrumentation

Land Surface/PBL

Soundings, Surface Met, ECOR, SEBS, AERI, Doppler Lidar, SODAR, AWSs

Free Troposphere

Soundings, Microwave Radiometers, RWP

Aerosols

MPL, Doppler Lidar, MFRSR, Sun Photometer, Size Distribution (UHSAS, SMPS, APS), CCN, UCPC, CPC, INP Filter Collections, Extinction (PSAP, Aethelometer, Ambient Nepholometer), Growth (Nepholometers), composition (ACSM), $CO/N_2O/H_2O/O_3$, SP2 (IOP only)

Not included: PTRMS, $NO_x/NO_y/SO_2$

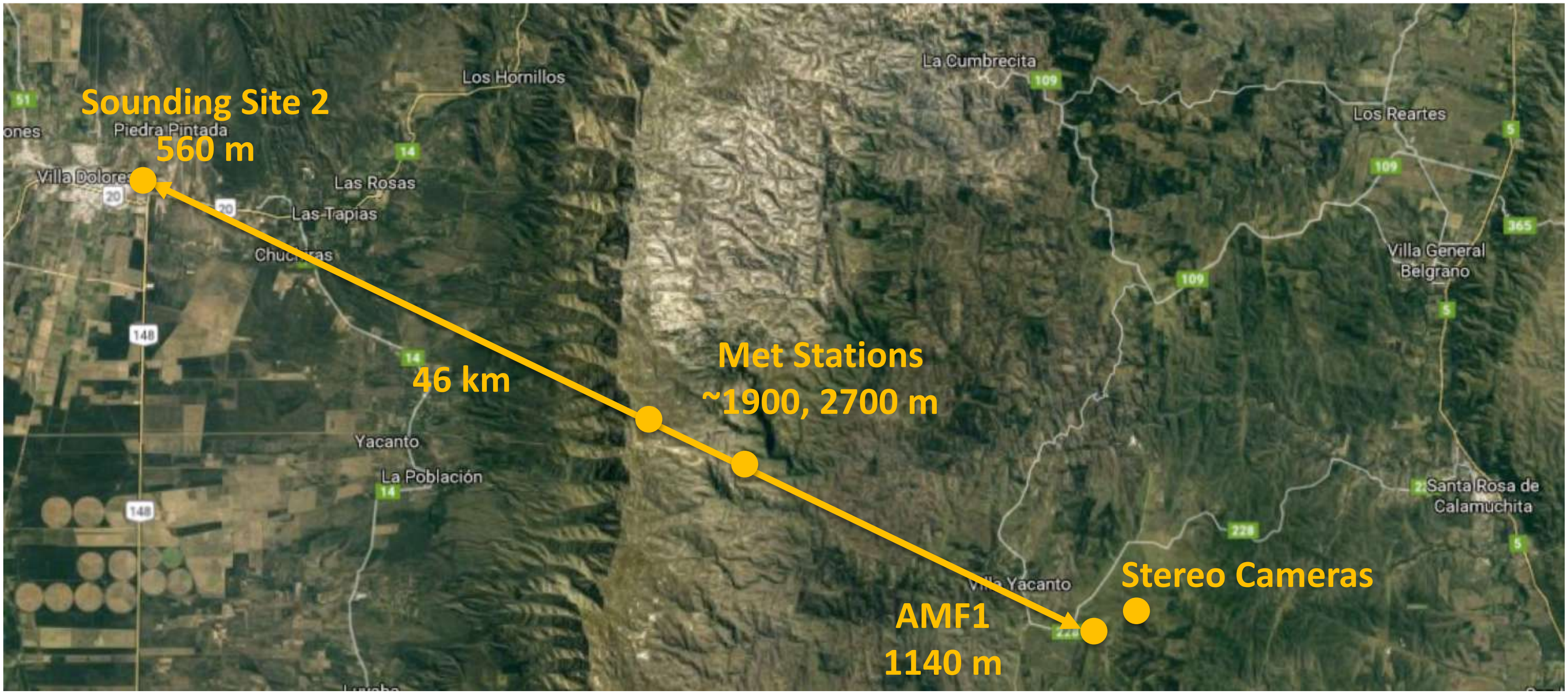
Clouds/Precipitation

X/Ka-SACR, C-SAPR2, KAZR, RWP, ACDC, Ceilometer, TSI, Microwave Radiometers, Laser Disdrometer, Tipping Bucket and Optical Rain Gauges

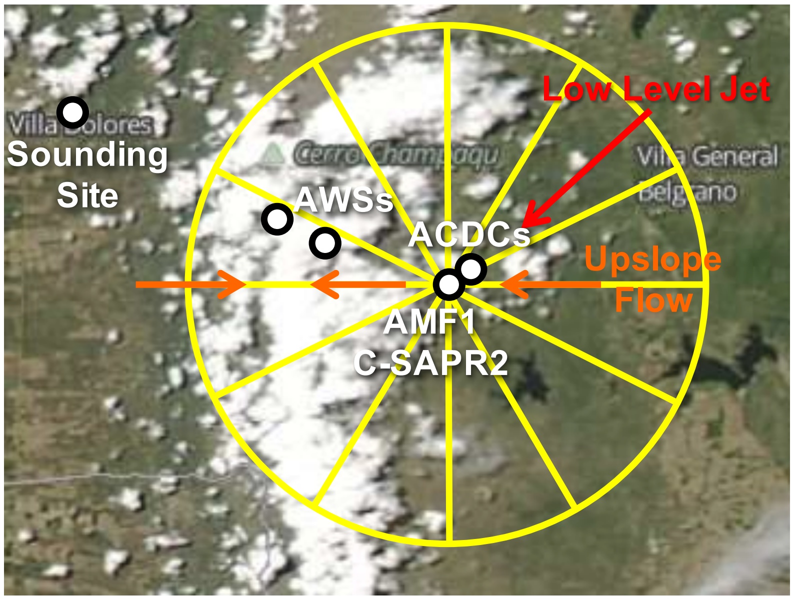
Radiation

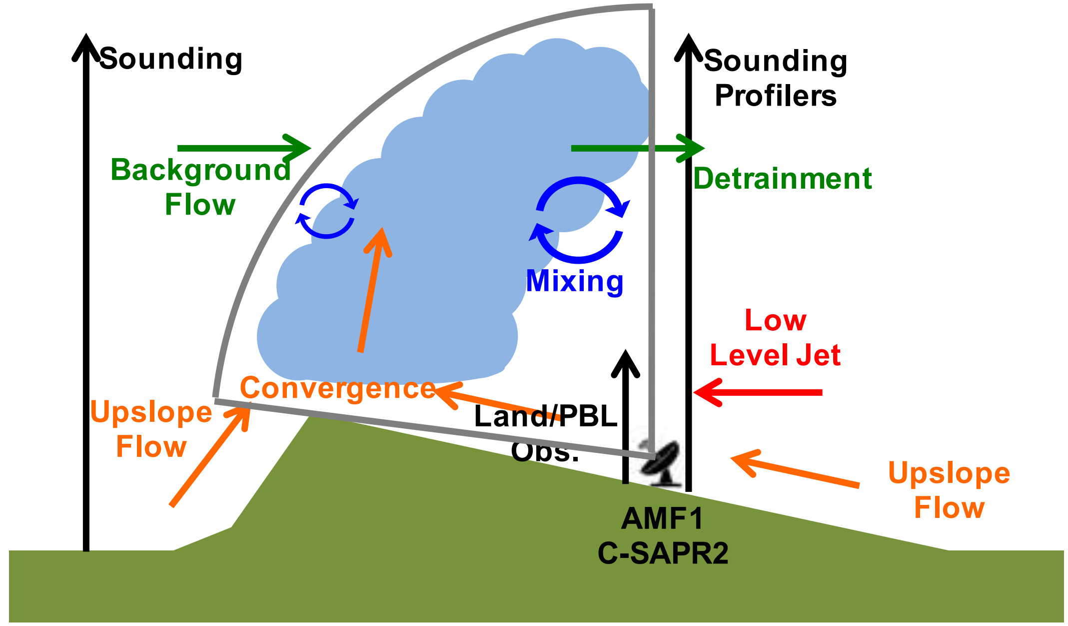
Microwave Radiometers, AERI, MFRSR, Ground/Sky Radiometers

Siting


Sounding Site 2
560 m
46 km
Met Stations
~1900, 2700 m
Stereo Cameras
AMF1
1140 m
Los Hornillos
La Cumbrecita
Los Reartes
Piedra Pintada
Villa Dolores
Las Rosas
Las Tapias
Villa General
Belgrano
Yacanto
La Población
Villa Yacanto
Santa Rosa de
Calamuchita

Measurement Strategy – AMF Vicinity



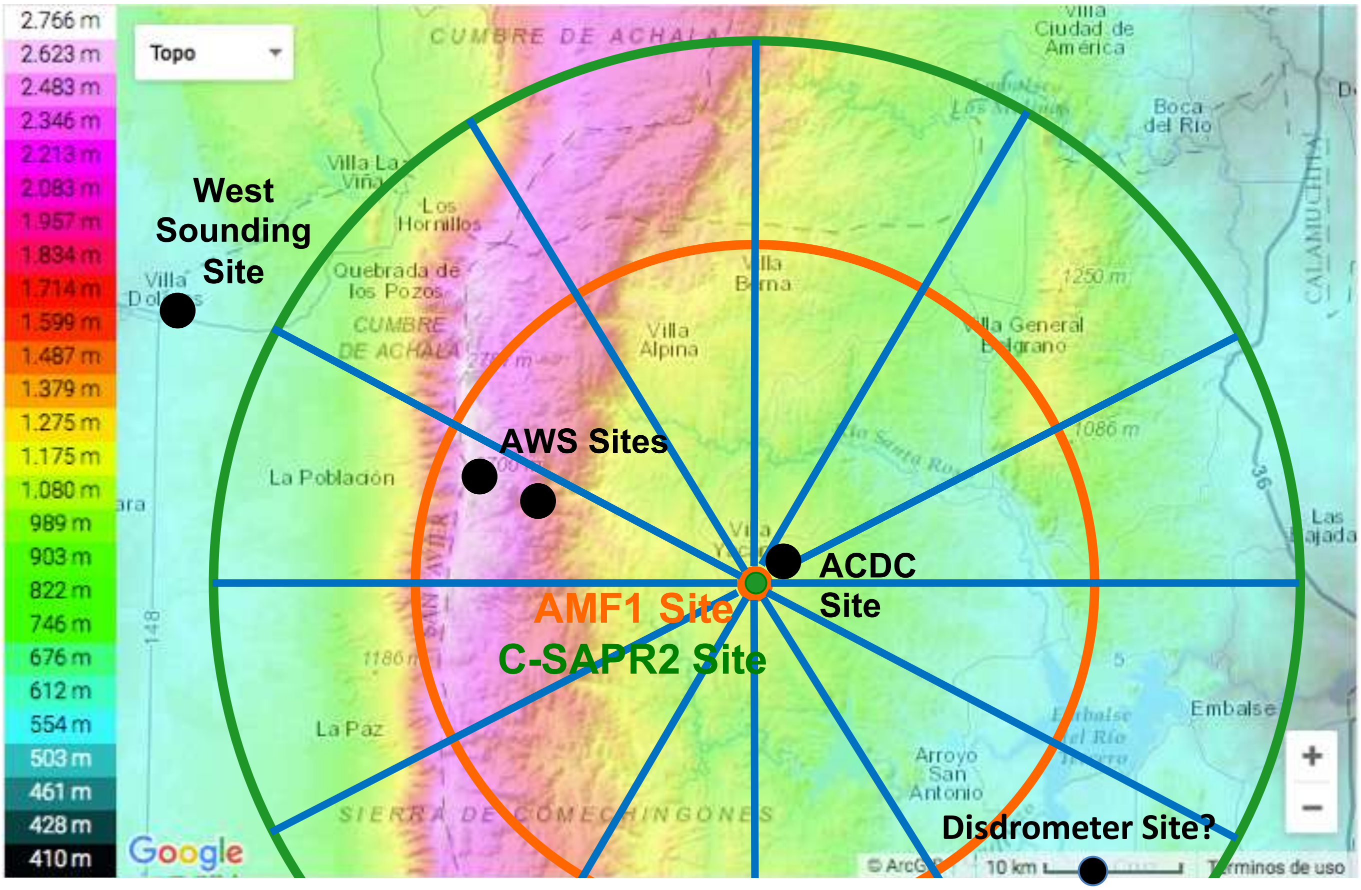


Strategy is to measure interactions between all local environmental variables with clouds and precipitation

Measure the cloud base inflow properties with in situ/remote sending measurements of clouds, precipitation, and cloud-detrained air in the free troposphere

Operations will be limited to daytime (9 AM to 9 PM local – 12Z to 0Z) with 4-7 AMF site soundings (every 2-4 hours) and 2-3 upstream soundings (every 4-6 hours)

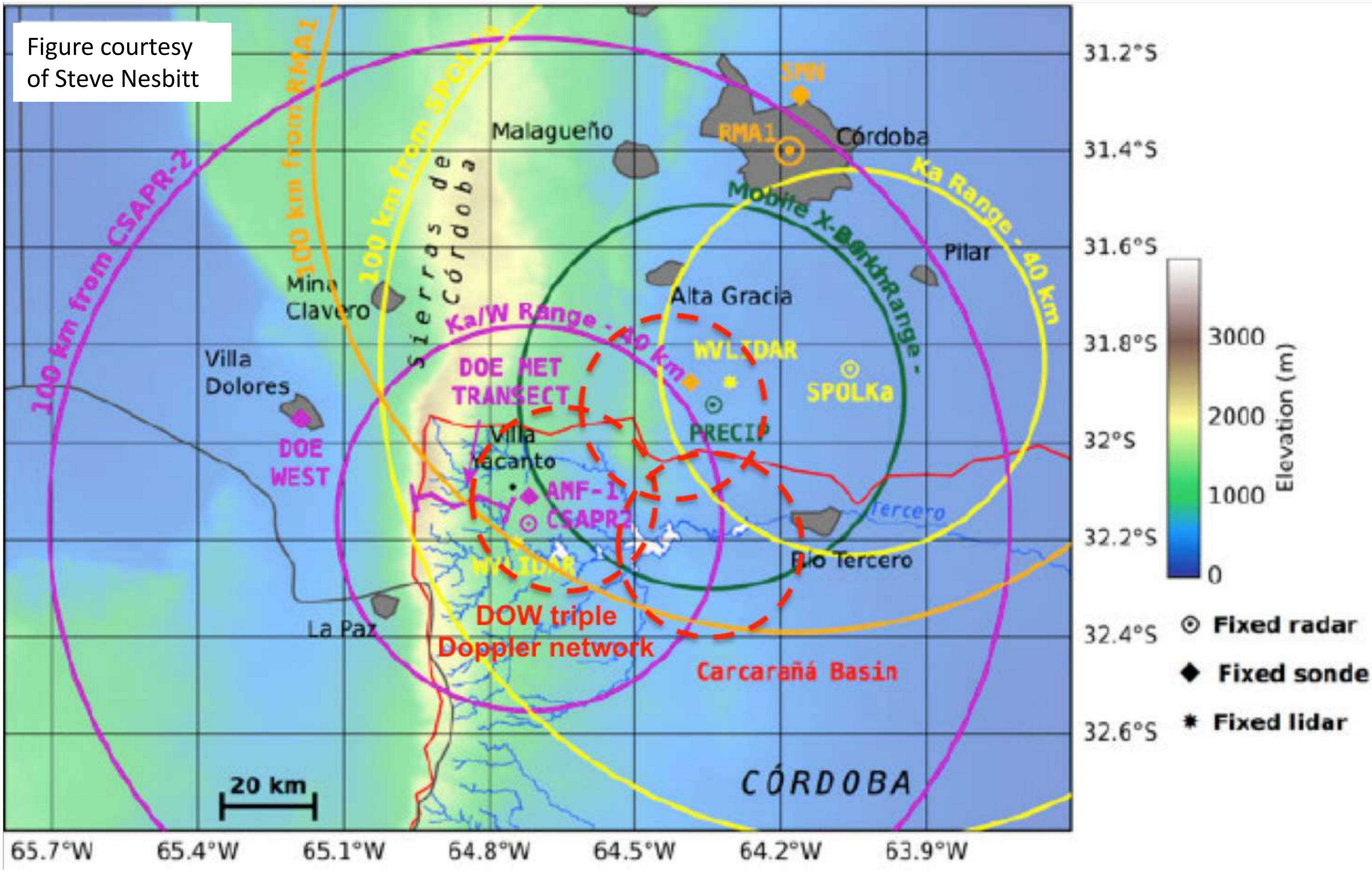
Radar Scanning Strategy



We need to come to agreement on C-SAPR2 scans to be tested at the SGP site in April-May. As of now, I am thinking of a mix of 360-deg surveillance scans and horizon-to-horizon RHIs (multiple in a row to get time rate of change information at high vertical resolution).

SACR will likely be primarily RHIs with mode based on expected conditions (clouds to west all day or clouds extending overhead) with potential PPIs for context.

Combined CACTI-RELAMPAGO Resources



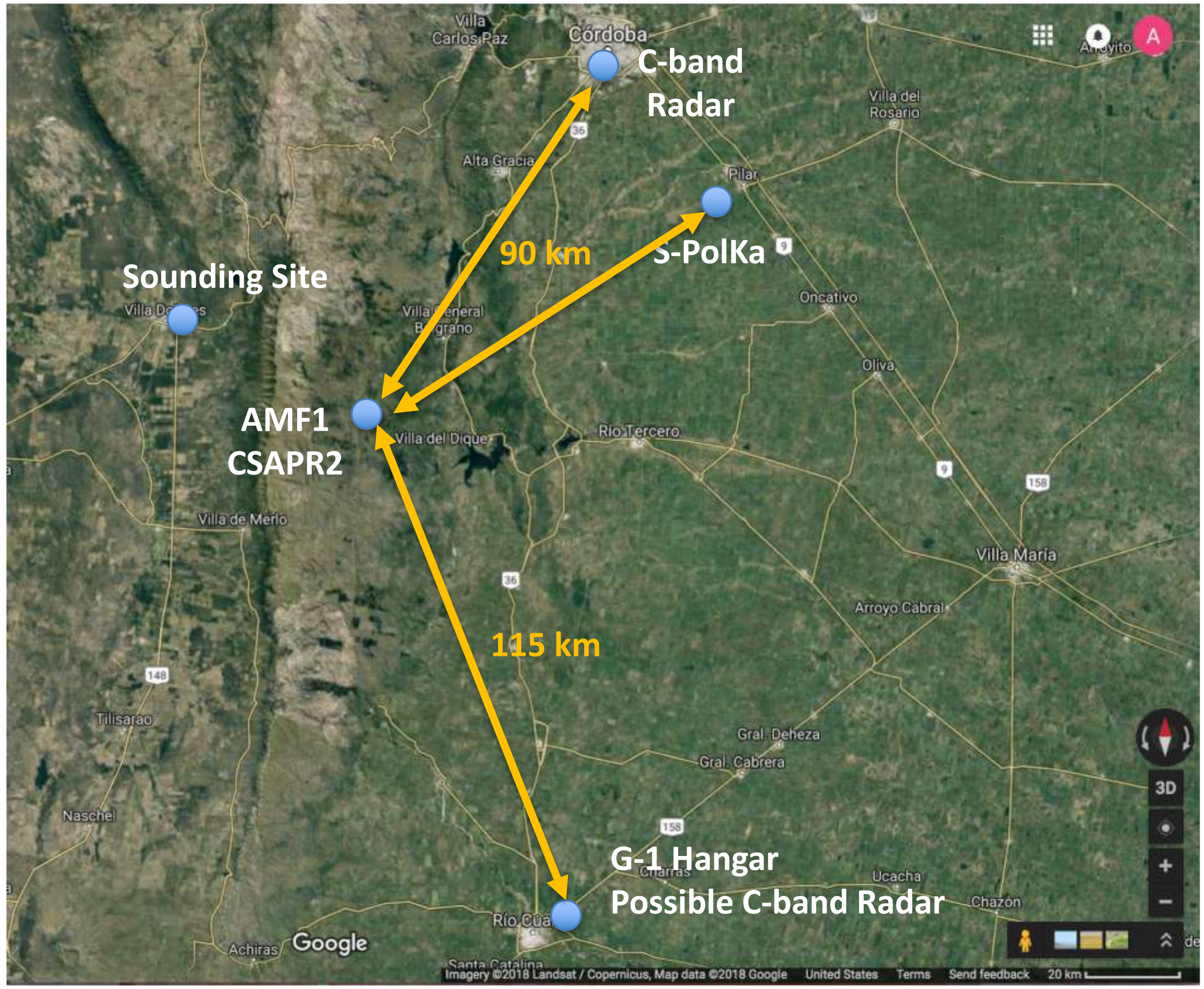
G-1 Operations

Operating out of Rio Cuarto Airport

No limit on total flight hours
Limited by crew rest

Likely limited to a single flight on any given day
~4-hour flight time

Limited to altitudes below ~21,000 feet



G-1 Instrumentation

Atmospheric State

Aircraft position/motion (multiple), temperature (3), humidity (4), pressure, winds, video camera

Aerosols/Gases

Isokinetic inlet and CVI (droplet residuals)

Particle concentration (UCPC, CPCs (1 behind isokinetic inlet, 1 behind CVI)), size distribution (SMPS, PCASP, CAPS, OPC, UHSAS?), CCN (dual-SS), absorption (PSAP, STAP), scattering (Nepholometer), composition (SP2, INP filters, mini-SPLAT II), trace gases (CO, N_2O, H_2O, O_3, SO_2)

Clouds/Precipitation

Condensate (WCM-2000, Hotwire, PVM-100A), size distribution (HVPS-3, 2D-S, F-CDP, CIP), particle images (CPI)

G-1 Flight Scenarios

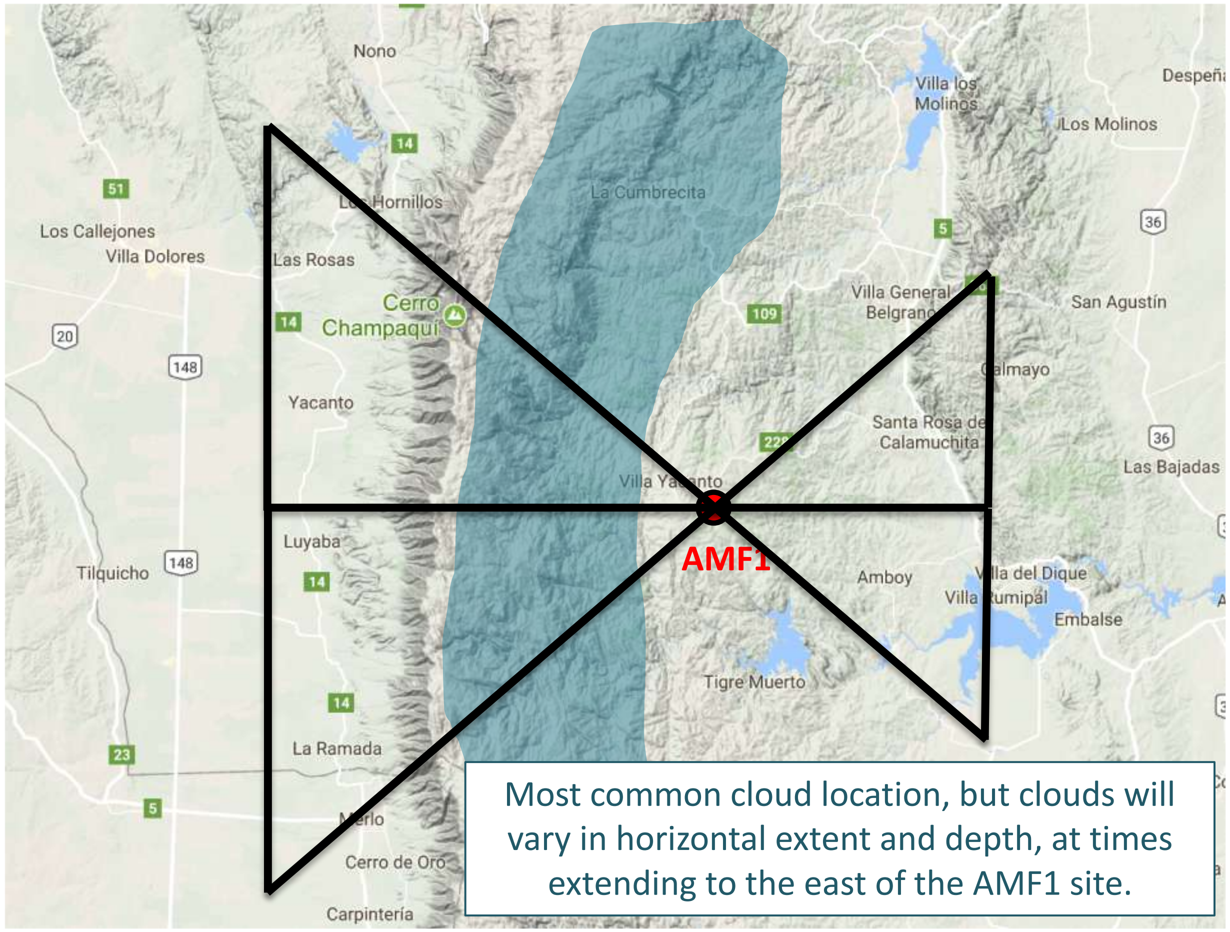
There are 3 possible flight scenarios:

1. Orographic cumulus cloud sampling – in cloud, upstream of cloud, and downstream of cloud within range of SACR measurements
2. Environmental sampling in the vicinity of growing orographic congestus clouds and initiating cumulonimbus cloud – outside of cloud sampling environmental conditions both upstream and downstream
3. Environmental sampling in the low-mid level inflow and outflow of mesoscale convective systems – outside of cloud, but possibly within stratiform precipitation focused on characterizing low level jet and cold pool structure

Scenario 1 Goals

- Measure aerosol properties in and out of orographic clouds, connecting them to measurements at the AMF-1 site to study the aerosol life cycle from below cloud base to in cloud to out of cloud aloft
- Measure possible initiation of precipitation via collision-coalescence or ice nucleation and relate these measurements to aerosol properties and cloud macroscale properties
- Use measurements of hydrometeors and winds to fine tune radar retrievals of cloud properties
- Measure the impact of clouds on mid-troposphere thermodynamic and kinematic properties that impact subsequent cloud growth

G-1 Measurement Strategy



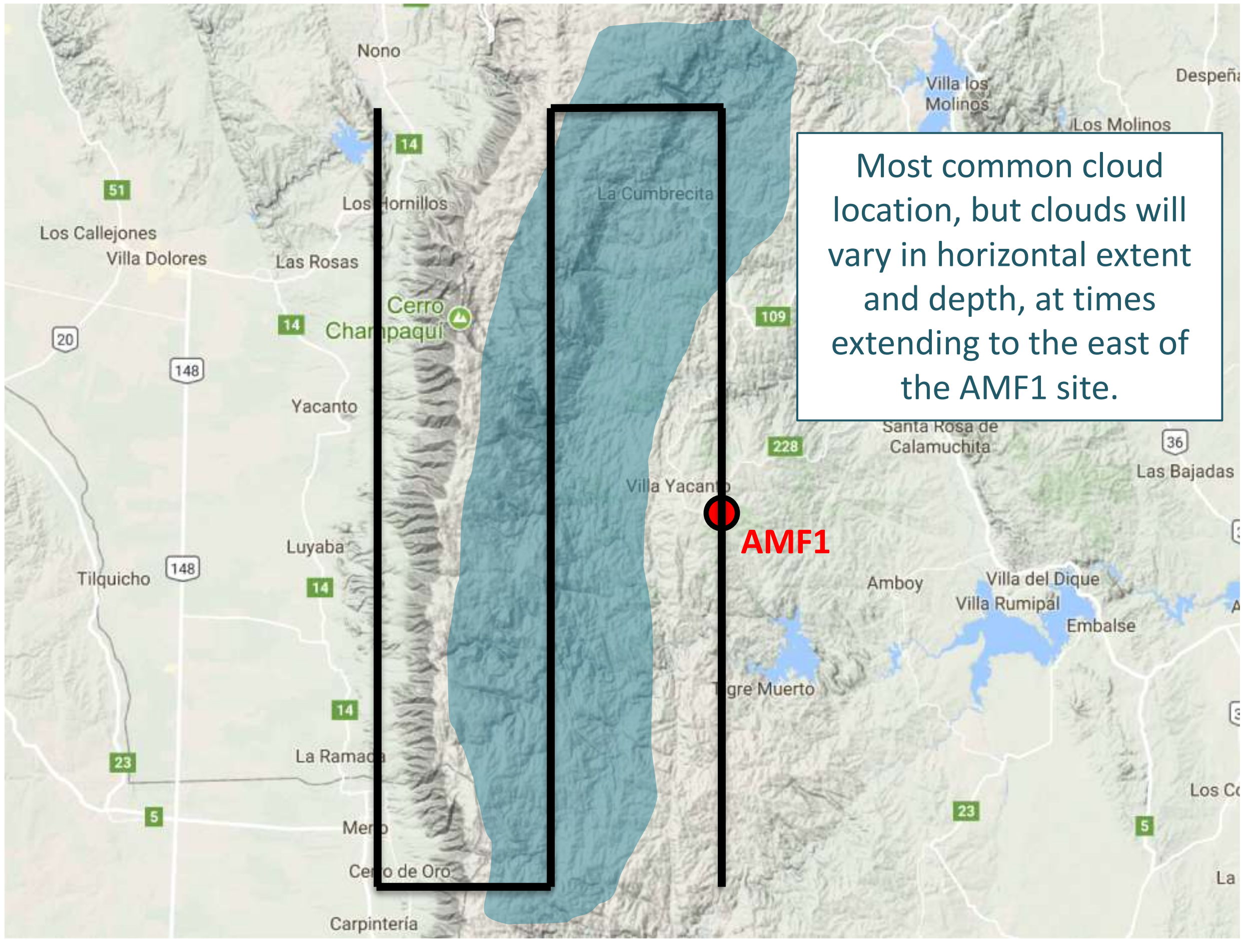
Timing: Mid morning to early afternoon

Patterns: Constant altitude radials over the AMF1 in a bowtie pattern matching RHI scans by the SACR

Vertical spiral over the AMF1 if sufficiently deep clouds are present over the site

Altitudes: Every 200-500 m depending on the situation from 3300 m up to 6500 m

G-1 Measurement Strategy



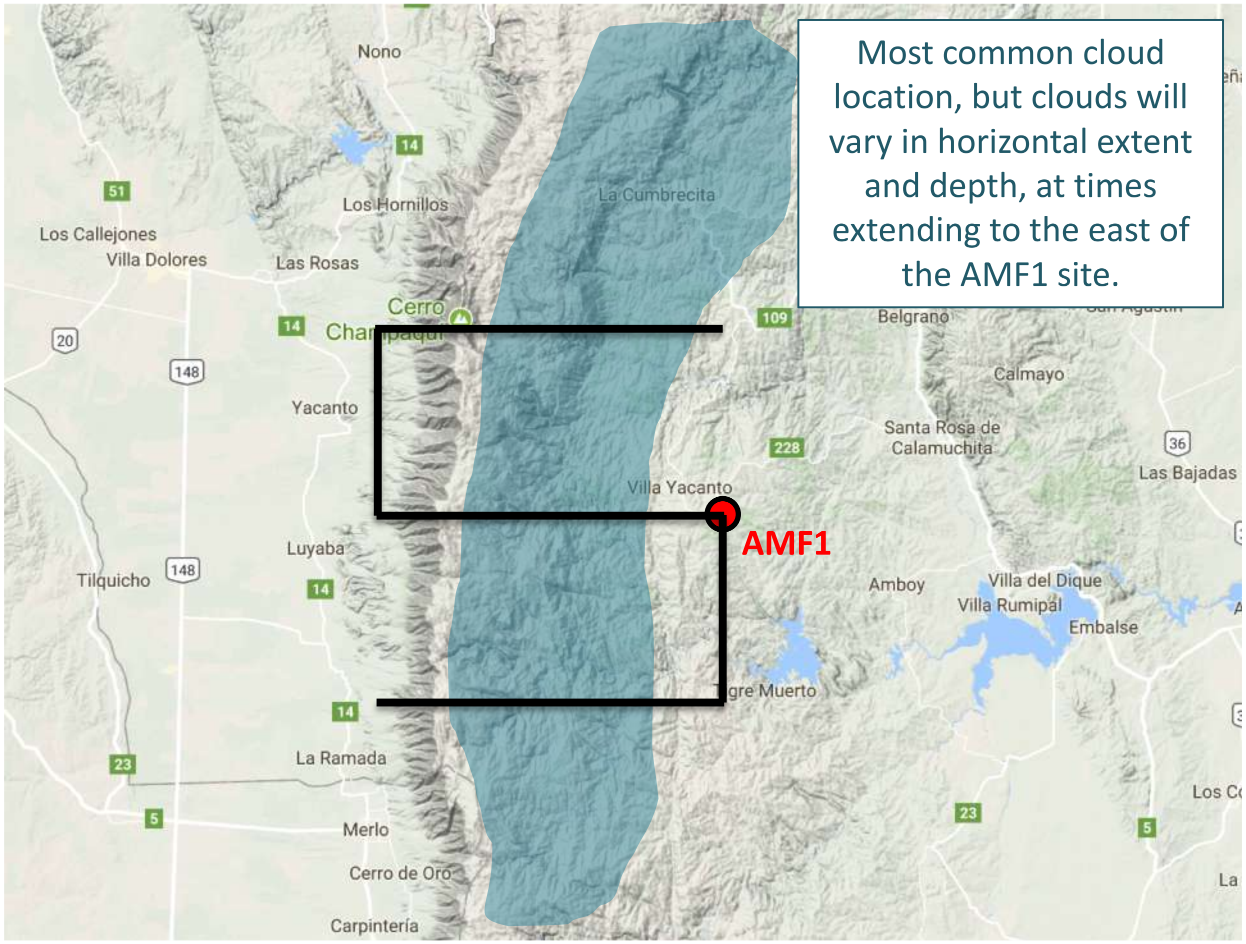
Timing: Mid morning to early afternoon

Patterns: North-south, constant altitude legs with PPI scans by the SACR

Vertical spiral over the AMF1 if sufficiently deep clouds are present over the site

Altitudes: Every 200-500 m depending on the situation from 3300 m up to 6500 m

G-1 Measurement Strategy



Timing: Mid morning to early afternoon

Patterns: East-west, constant altitude legs with PPI and RHI scans by the SACR

Vertical spiral over the AMF1 if sufficiently deep clouds are present over the site

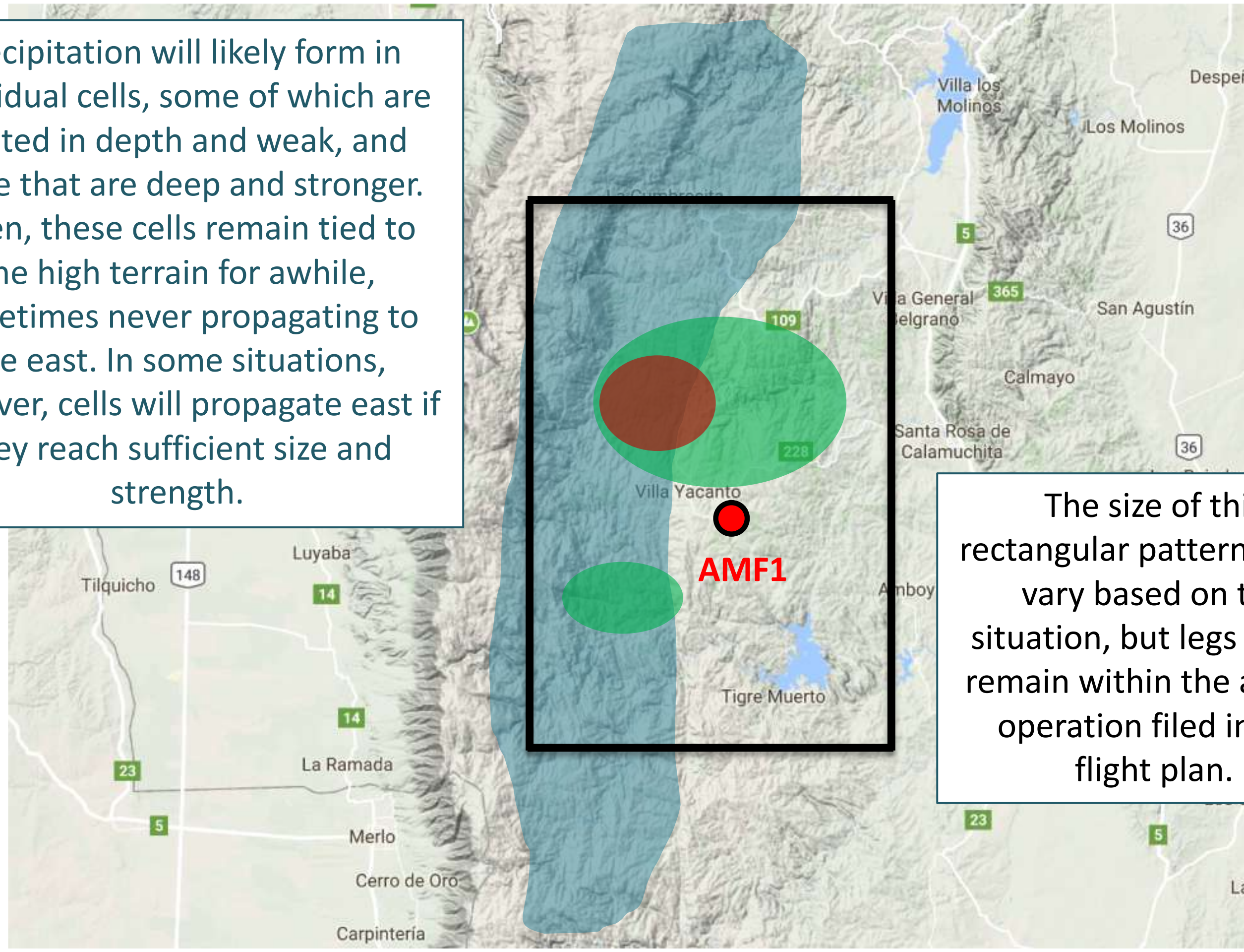
Altitudes: Every 200-500 m depending on the situation from 3300 m up to 6500 m

Scenario 2 Goals

- Measure the variability in thermodynamic, kinematic, and aerosol conditions that are impacting variability in cumulus cloud top height and deep convective initiation
- Measure the time evolution of environmental conditions as convective clouds grow and decay

G-1 Measurement Strategy

Precipitation will likely form in individual cells, some of which are limited in depth and weak, and some that are deep and stronger. Often, these cells remain tied to the high terrain for awhile, sometimes never propagating to the east. In some situations, however, cells will propagate east if they reach sufficient size and strength.



The size of this rectangular pattern would vary based on the situation, but legs would remain within the area of operation filed in the flight plan.

Timing: Early to late afternoon

Patterns: Constant altitude legs upstream and downstream of initiating deep convection within range of C-SAPR2 radar

Altitudes: Every 100-500 m depending on the situation from 3300 m up to 6500 m

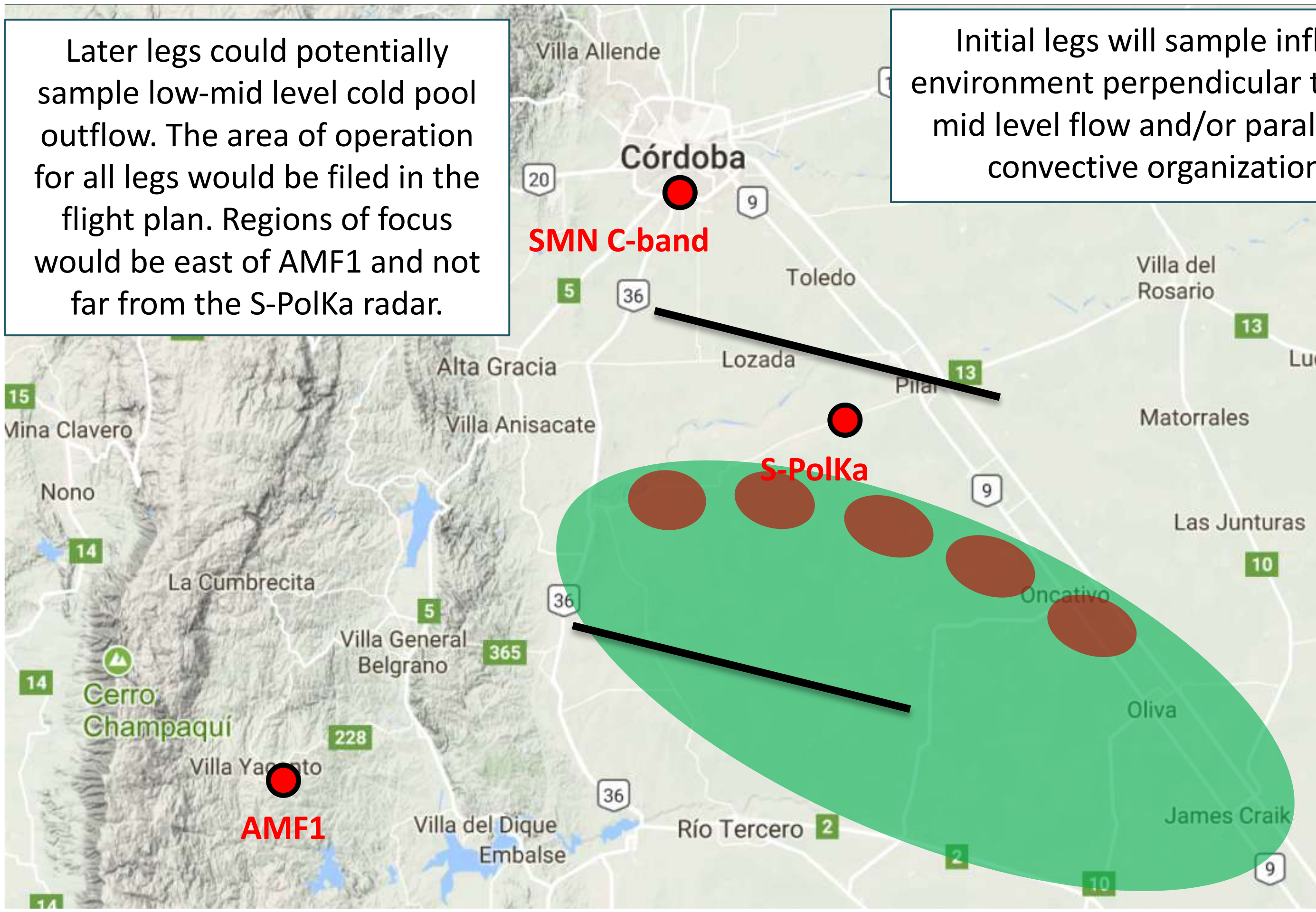
Scenario 3 Goals

- Measure the thermodynamic, kinematic, and aerosol properties of inflow and outflow mesoscale circulations that greatly impact mesoscale convective upscale growth, including the low level jet that feeds convection and cold pools that exit it and interact with vertical wind shear to initiate further deep convection

G-1 Measurement Strategy

Later legs could potentially sample low-mid level cold pool outflow. The area of operation for all legs would be filed in the flight plan. Regions of focus would be east of AMF1 and not far from the S-PolKa radar.

Initial legs will sample inflow environment perpendicular to low-mid level flow and/or parallel to convective organization.



Timing: Late afternoon to evening

Patterns: Constant altitude legs perpendicular to convective inflow and cold pool winds within range of S-PolKa

Altitudes: As low as possible up to the 3000-6000 m every 200-1000 m depending on the situation, remaining at safe distances away from deep convection

Open Questions

- Observing Strategies
  - Soundings
  - Scanning radars
  - G-1 flights
  - Science Plan to be updated
- Coordination between RELAMPAGO and CACTI operations