<table>
<thead>
<tr>
<th>Time</th>
<th>Session Description</th>
<th>Presenter(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:45-11:15 AM</td>
<td>CACTI Overview</td>
<td>Adam Varble</td>
</tr>
<tr>
<td>11:15-11:20 AM</td>
<td>AMF Logistics Update</td>
<td>Heath Powers</td>
</tr>
<tr>
<td>11:20-11:25 AM</td>
<td>C-SAPR2 Update</td>
<td>Nitin Bharadwaj</td>
</tr>
<tr>
<td>11:25-11:30 AM</td>
<td>Data Flow Update</td>
<td>Cory Stuart</td>
</tr>
<tr>
<td>11:30-11:35 AM</td>
<td>Data Products Update</td>
<td>Scott Collis</td>
</tr>
<tr>
<td>11:35-11:40 AM</td>
<td>Metadata</td>
<td>Maggie Davis</td>
</tr>
<tr>
<td>11:40-11:50 AM</td>
<td>G-1 Update</td>
<td>Beat Schmid</td>
</tr>
<tr>
<td>11:50-12:05 PM</td>
<td>RELAMPAGO Overview</td>
<td>Paloma Borque</td>
</tr>
<tr>
<td>12:05-12:20 PM</td>
<td>Discussion of coordination/communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>during the IOP</td>
<td></td>
</tr>
<tr>
<td>12:20-12:35 PM</td>
<td>Discussion of radar, G-1, and sounding observing strategy</td>
<td></td>
</tr>
<tr>
<td>12:35-12:45 PM</td>
<td>Extra time for further discussion</td>
<td></td>
</tr>
</tbody>
</table>
The Cloud, Aerosol, and Complex Terrain Interactions (CACTI) ARM Field Campaign
Investigators

**Principal Investigator**
Adam Varble, University of Utah

**Co-Investigators**
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 Avila, 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

**Timing:** 1 October 2018 – 30 April 2019

**Location:** Villa Yacanto, Argentina (32.1°S, 64.75°W)

**Secured Resources:** 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)

Courtesy NASA
Experiment Rationale – Repeated Orographic Cumulus

Figures courtesy of NASA

Figures courtesy of U. Wyoming
Experiment Rationale – Variable Aerosol and Land Surface Properties

Figures courtesy of NASA
Experiment Rationale –
Repeated Deep Convective Initiation

Figures courtesy of NASA

Figures courtesy of U. Wyoming
Experiment Rationale – “Extreme” Convection

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Orographic Cu</td>
<td>13</td>
<td>19</td>
<td>15</td>
<td>22</td>
<td>19</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>Orographic Sc</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Orographic Cb</td>
<td>1</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Overcast</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Scattered Non-Orographic Clouds</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clear</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

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)

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.

Severe Hail Frequency Estimated from AMSR-E (Cecil and Blankenship 2012)
Experiment Rationale – Mesoscale Organization

Solman et al. (2013)

Figure courtesy of Steve Nesbitt
Experiment Rationale – “Extreme” Organization

System rainfall > 300,000 m³/s

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 Nephelometer), Growth (Nephelometers), composition (ACSM), CO/N2O/H2O/O3, SP2 (IOP only)

Not included: PTRMS, NOx/NOy/SO2

**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

Met Stations
~1900, 2700 m

AMF1
1140 m

Stereo Cameras
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).
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-RELAMAPAGO Resources

Figure courtesy of Steve Nesbitt
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 (Nephelometer), composition (SP2, INP filters, mini-SPLAT II), trace gases (CO, N2O, H2O, O3, SO2)

**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

Most common cloud location, but clouds will vary in horizontal extent and depth, at times extending to the east of the AMF1 site.
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

Most common cloud location, but clouds will vary in horizontal extent and depth, at times extending to the east of the AMF1 site.
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.

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

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.
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

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