Storm Peak Lab Cloud Property Validation Experiment : StormVEx

Daniel Cziczo

with thanks to

Jay Mace (StormVEx PI), Gannet Hallar and Ian McCubbin (DRI / SPL)

Cloud –Aerosol-Precipitation Interaction Session

Wednesday October 13, 2010

Pacific Northwest NATIONAL LABORATORY

What: Deployment of the 2nd ARM Mobile Facility and various other experiments to Steamboat Springs Colorado to operate in close coordination with instruments at Storm Peak Lab

When: Mid November 2010 – early April 2011 with periodic ‘intensive’ efforts (e.g. during mixed phase or dust events)

Why: Primary objective – Use AMF2, ‘guest’ instruments and SPL as in situ data collection platform for validation of cloud and precipitation properties retrieved by ground-based active and passive remote sensors.

StormVEx Objectives :

1. Provide a continuous correlative remote sensing and in situ data set to the ARM Archive that consists of routine ARM active and passive remote sensing measurements, with coincident in situ microphysical cloud and precipitation observations that are suitable for validation of remote sensing retrieval algorithms.

2. Produce an ACRF data set in a region of complex terrain (e.g. COPS) - a long standing goal of ARM

3. Document the *role of aerosols, both natural and anthropogenic, in cloud and precipitation processes*.

Pacific Northwest
NATIONAL LABORATORY

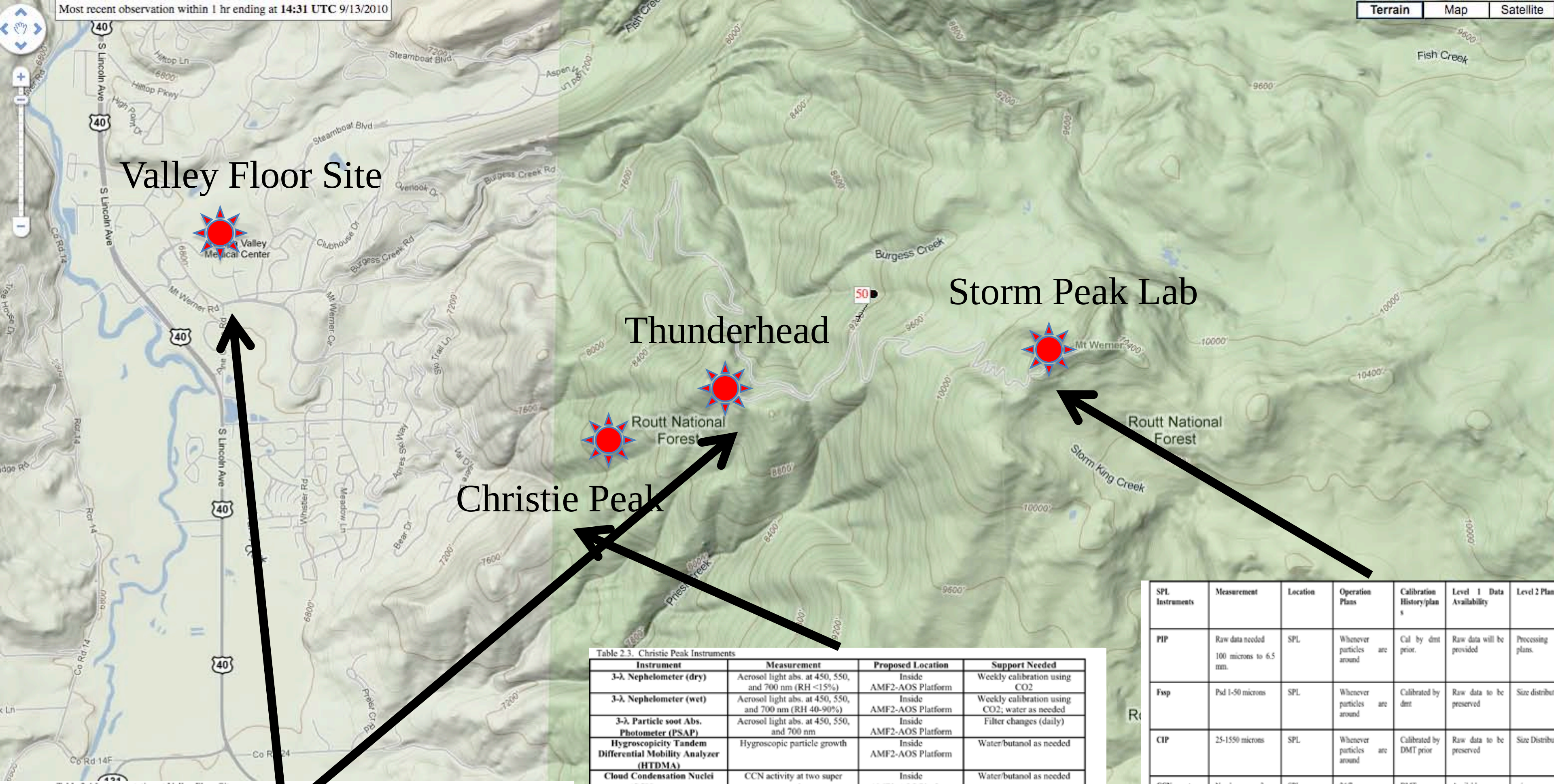


Table 2.4 Instrumentation at Valley Floor Site

Instrument	Measurement	Proposed Location	Support Needed
Radar Wind Profiler (RWP)	Winds, back scatter	East of GP Van within 20 m	Tie Downs or weights for guy wires
Ceilometer (VCEIL)	Cloud base, aerosols	East of GP Van within 10 m	Tripod tie-downs
Skyrad	Broadband SW, infrared, UV downwel. irrad	East of GP Van ~50 m Elevated Stand	Radiometer Stand tie-downs
Gndrad	Broadband SW, infrared upwelling irrad	East of GP Van ~50 m from 10 m tower	Tower
Total Sky Imager (TSI)	Cloud fraction	East of GP Van ~50 m Elevated Stand	
Balloone-borne Sounding Sys. (BBSS)	Wind, Temp, RH atmos. Profile	Helium beside GP Van Launch from field as appropriate	Helium location Access to field thru snow
Surface Fluxes (ECOR)	Heat, Mom., Water Vapor, CO2 sfc fluxes	East of GP Van ~50 m from tripod/tower	Access to inst. thru snow
Surface Met (SMOS)	10 m Winds, Temp, RH, Precip	East of GP Van ~50 m from tower	
Infra Red Sfc Temperature (IRT)	Sfc Skin Temp	East of GP Van ~50 m from tower	Height TBD
Local Data System	Instrument communication	GP Van Inside trailer	Virtual Comms to Data System
JPL 94 GHz Cloud Radar (ACR)	Scanning W-Band Radar Reflectivity	JPL Supplied Trailer	Steve Dinardo, JPL.
MMCR	Vertically pointing Ka Band Doppler Radar Spectra		
Scanning ARM Cloud Radar (SACR)	Scanning X and Ka Band Doppler Radar Spectra		

Table 2.3. Christie Peak Instruments

Instrument	Measurement	Proposed Location	Support Needed
3-λ Nephelometer (dry)	Aerosol light abs. at 450, 550, and 700 nm (RH <15%)	Inside AMF2-AOS Platform	Weekly calibration using CO2
3-λ Nephelometer (wet)	Aerosol light abs. at 450, 550, and 700 nm (RH 40-90%)	Inside AMF2-AOS Platform	Weekly calibration using CO2; water as needed
3-λ Particle soot Abs. Photometer (PSAP)	Aerosol light abs. at 450, 550, and 700 nm	Inside AMF2-AOS Platform	Filter changes (daily)
Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA)	Hygroscopic particle growth	Inside AMF2-AOS Platform	Water/butanol as needed
Cloud Condensation Nuclei (CCN) counter	CCN activity at two super saturations	Inside AMF2-AOS Platform	Water/butanol as needed
Condensation Particle Counter (CPC)	Particle counting >10 nm	Inside AMF2-AOS Platform	Butanol as needed
Trace Gas (Ozone)	Ambient ozone burden	Inside AMF2-AOS Platform	Monthly filter changes
Met. Data	Temp.; wind speed; wind dir.; humidity; pres.; rain fall	Inside AMF2-AOS Platform	none
Single Particle Soot Photometer (SP2)	Black Carbon mass conc. and size. Dist.	Inside AMF2-AOS Platform	Data transfers as needed
Data System	Instrument systems, data archive	Inside AMF2-AOS Platform	
Multi Filter Rotating Shadowband Radiometer (MFRSR)	Direct normal, Diffuse & Total horizontal solar irrad. @ 415, 500, 615, 673, 870, 940	Roof of AOS platform	Snow removal as needed

SPL Instruments	**Measurement**	**Location**	**Operation Plans**	**Calibration History/plans**	**Level 1 Data Availability**	**Level 2 Plan**
PIP	Raw data needed 100 microns to 6.5 mm.	SPL	Whenever particles are around	Cal by dmt prior.	Raw data will be provided	Processing plans.
Fssp	Psd 1-50 microns	SPL	Whenever particles are around	Calibrated by dmt	Raw data to be preserved	Size distribut
CIP	25-1550 microns	SPL	Whenever particles are around	Calibrated by DMT prior	Raw data to be preserved	Size Distribu
CCN counter	Number per cm3 per ss%	SPL	24/7	DMT calibration	Available upon request	n/a
SMPS (scanning mobility particle sizer	8-500nm size distribution	SPL	24/7	TSI calibration annually; Not mission critical	Available upon request	
APS (aerodynamic particle sizer)	500nm to 20 microns	SPL	24/7	TSI calibartion annually; Not mission critical		
(U)Cpc (ultra)(condensation particle counter)	Aerosol concentrtion 10 and 3 nm cutoffs	SPL	24/7	TSI calibration annually; Not mission critical		
Trace gasses (ozone and co2)		SPL	24/7	Not mission critical		
MFRSR		SPL	24/7		Cal prior	
Met	5 minute data uploaded directly to WRCC site	SPL	24/7			

Table 2.5. SPL Instrumentation

What Effect Do Aerosol Properties (Size & Composition) Have On Cloud Formation?

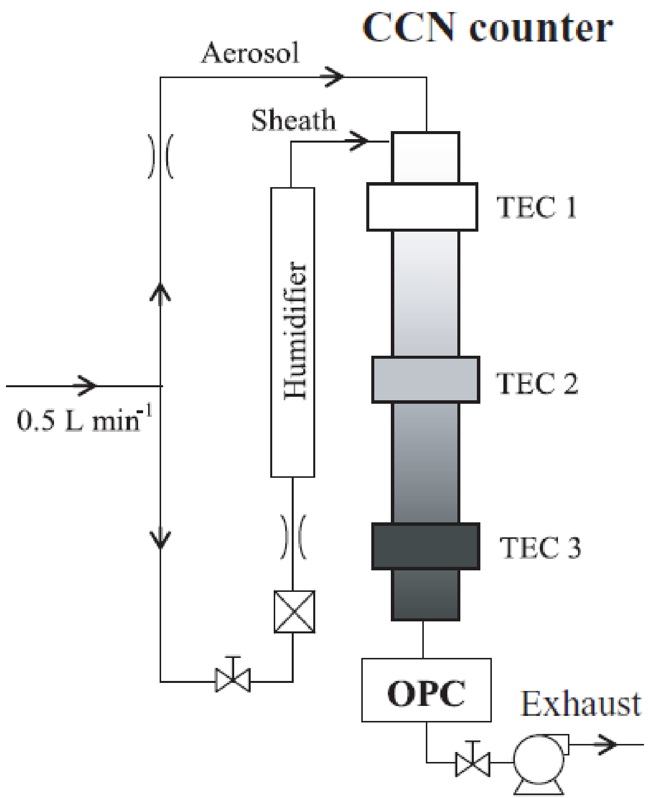
1. Laboratory Studies (… but what composition to use ?)

2. Measure in Cloud (… but what were the initiation conditions?)

3. Make an *artificial* cloud from *free tropospheric* aerosol

Droplet Formation

Cloud Condensation Nucleus Chamber

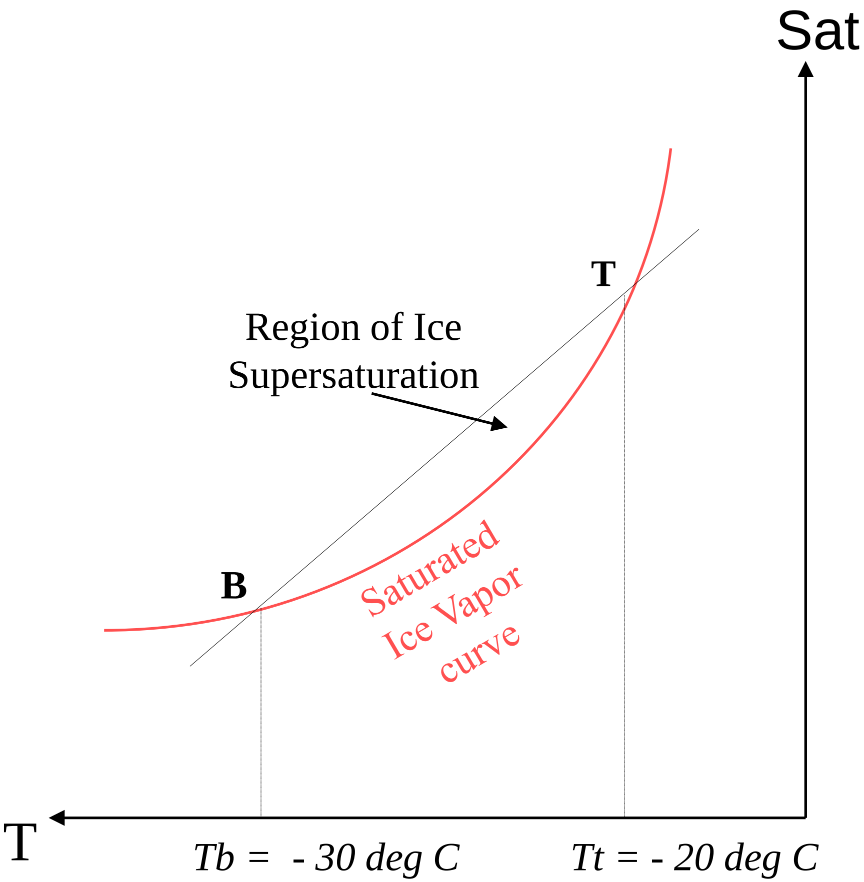


Aerosol Science and Technology, 44:861–871, 2010
Copyright © American Association for Aerosol Research
ISSN: 0278-6826 print / 1521-7388 online
DOI: 10.1080/02786826.2010.498715

Scanning Mobility CCN Analysis—A Method for Fast Measurements of Size-Resolved CCN Distributions and Activation Kinetics

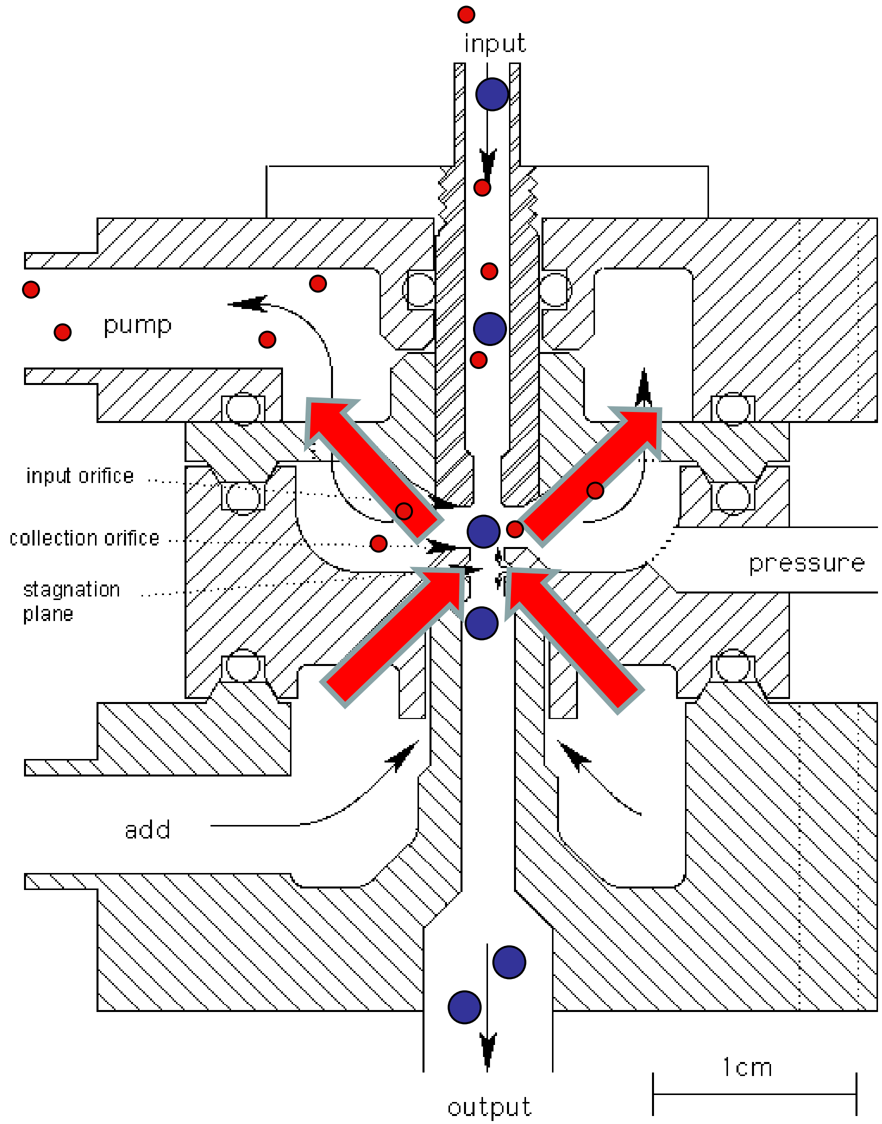
Richard H. Moore,[1] Athanasios Nenes,[2] and Jeessy Medina[1]

Ice Nucleation
Compact Ice Chamber



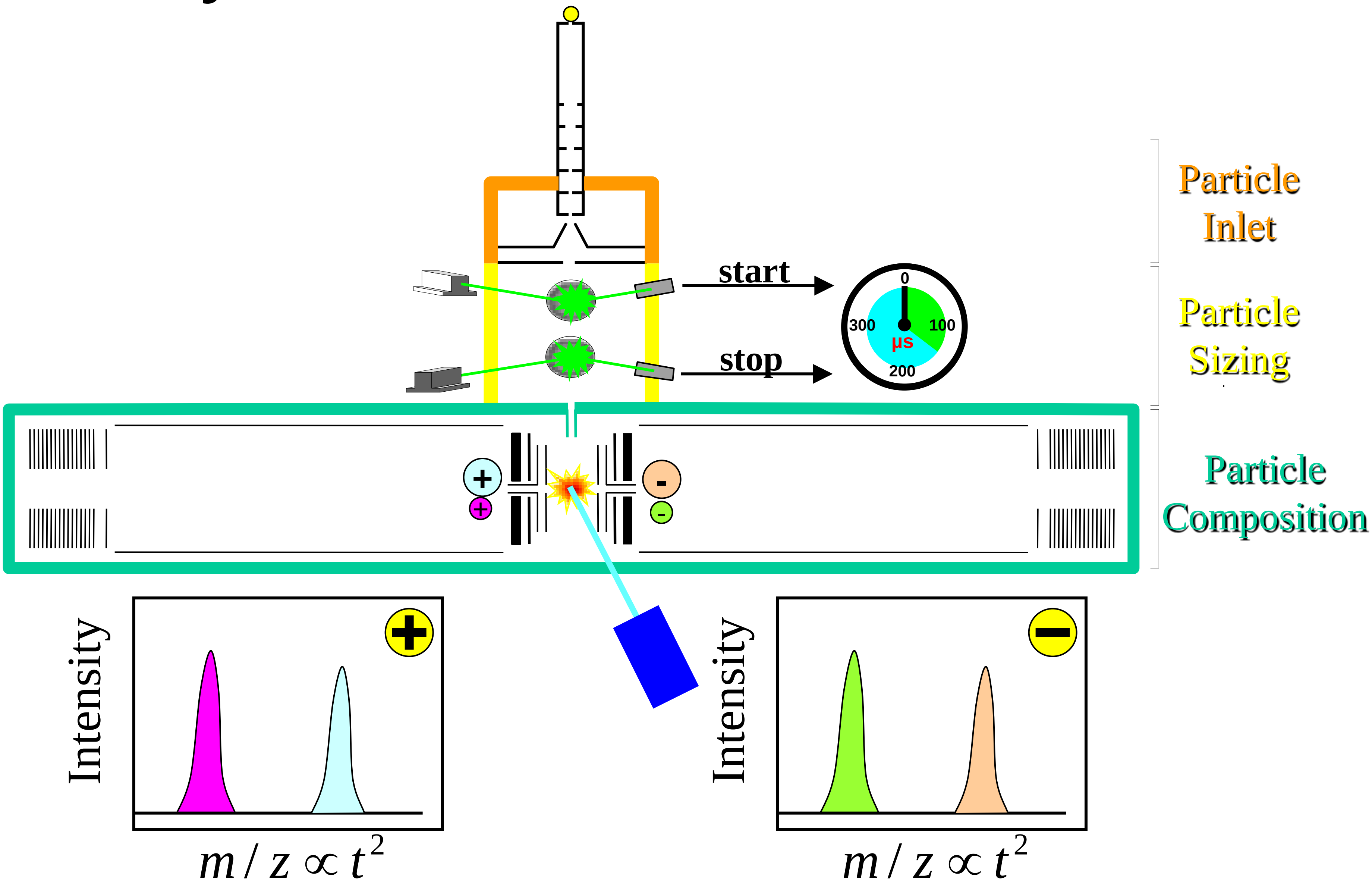
Relationship between the saturation vapor pressure over ice and temperature.

Key Step : Counterflow Virtual Impaction



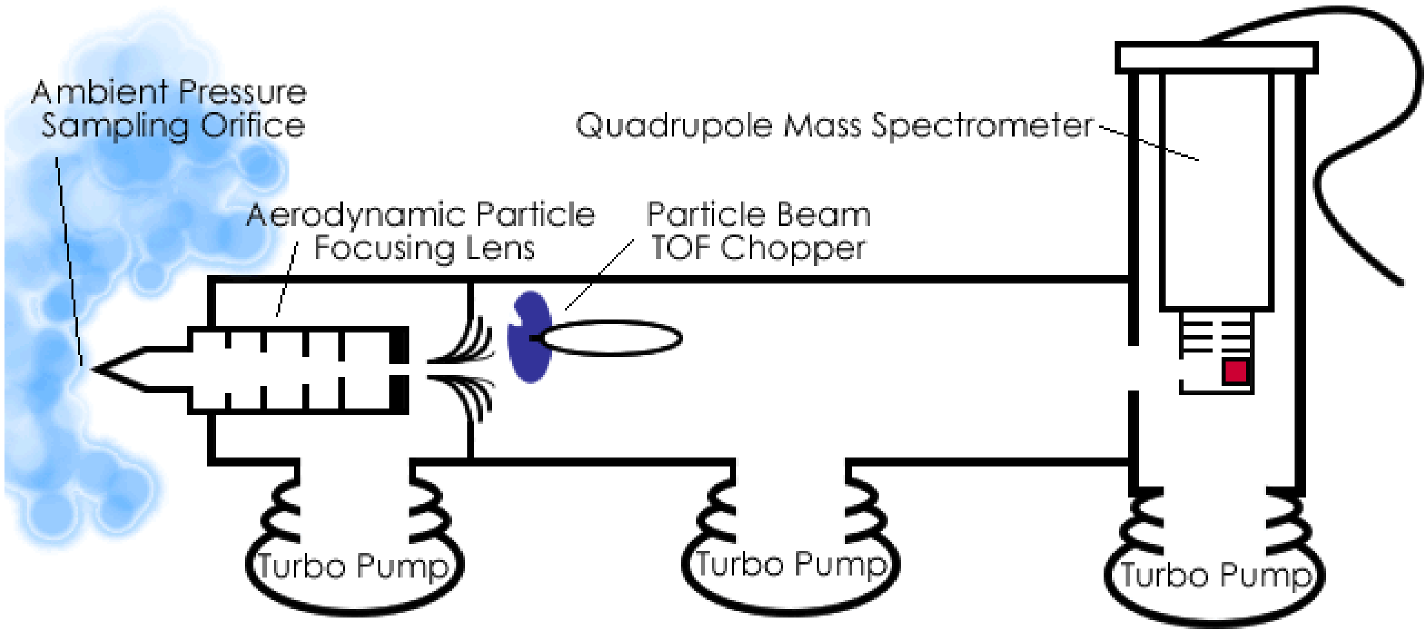
Design and Performance of a Pumped Counterflow Virtual Impactor, Boulter, Cziczo et al., AS&T, 2006.

Analysis of Cloud Elements : SPMS



Courtesy of D. Gross

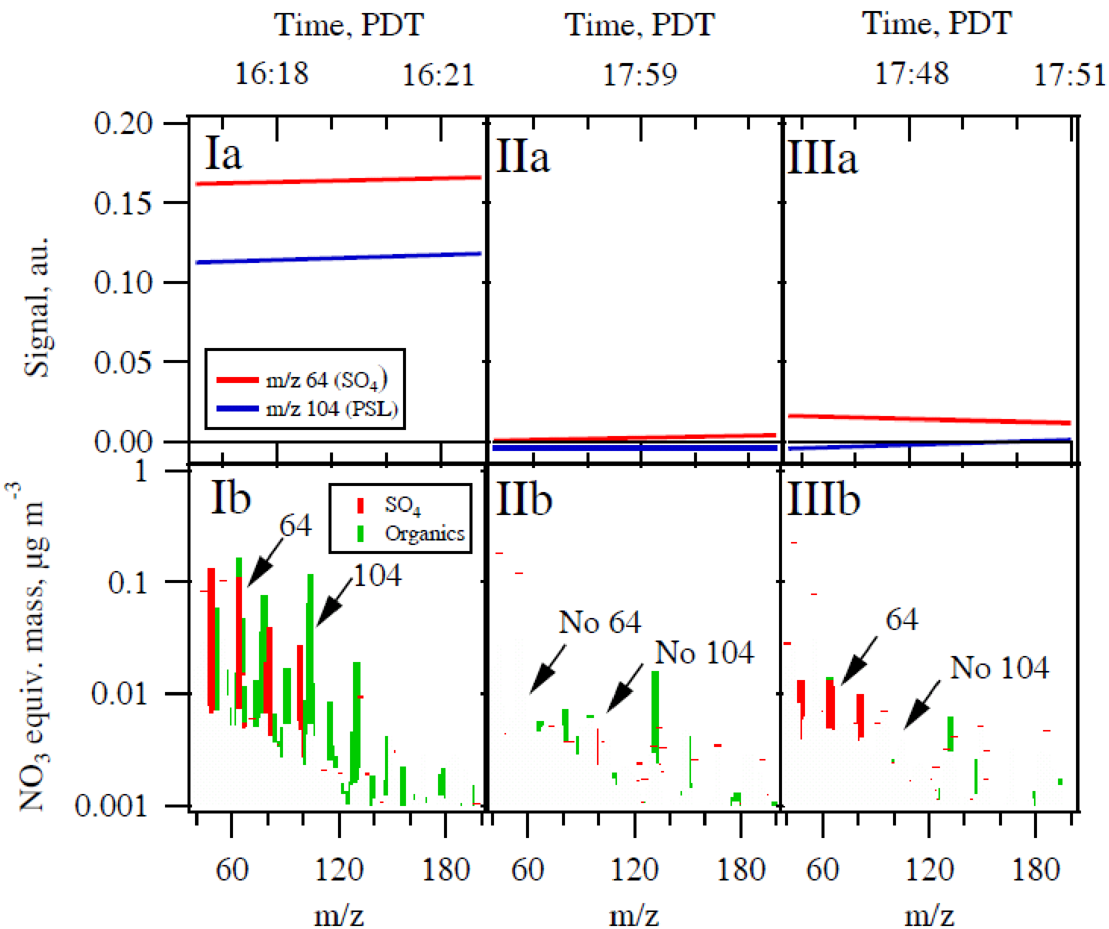
Analysis of Cloud Elements : AMS



- The choice of analytical technique critically depends on what is being observed.
- e.g. ice nuclei are largely mineral dust which is not visible to AMS whereas CCN can activate at sizes below SPMS thresholds

Animation of the Aerodyne AMS. Credit: Matt Thyson (Lexington, Massachusetts) and Jose Jimenez

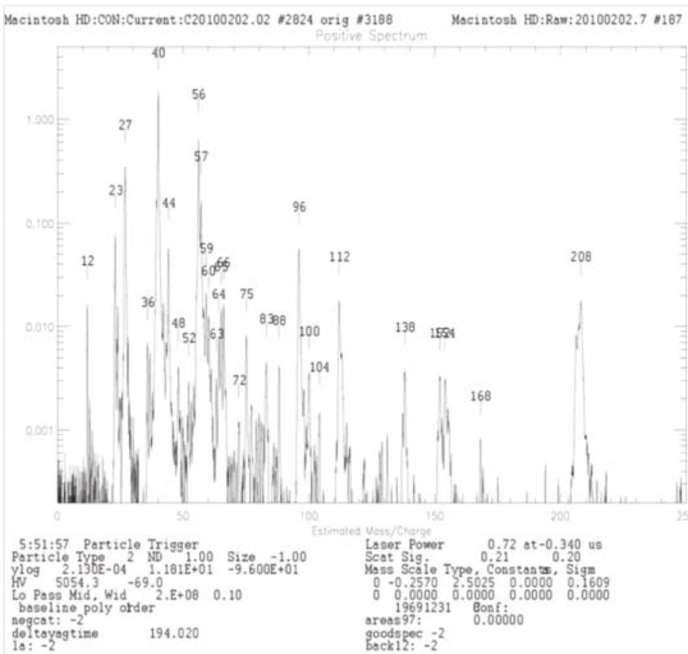
Salient Results : CCNC

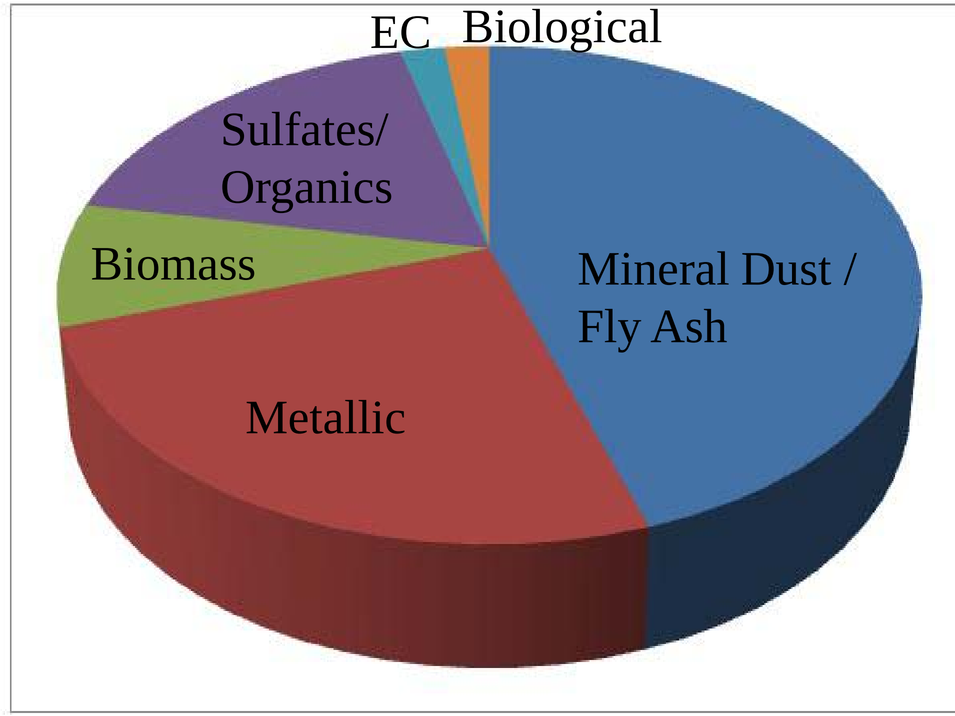


• Proof of concept : Separation of droplets from unactivated due to composition effects

• *Preliminary* Results : Organics preferentially in the unactivated phase

Salient Results : CIC





• Ice nuclei are, on average, large than typical with special composition enhanced in mineral dust and anthropogenic particles (metals).

Particle analysis by laser mass spectrometry (PALMS) studies of ice nuclei and other low number density particles

Daniel J. Cziczo[a,*], David S. Thomson[b,c], Thomas L. Thompson[b], Paul J. DeMott[d], Daniel M. Murphy[b]

Unpublished Data, SPL
e.g. DeMott, Ice Nucleation Tutorial


Questions ?

Valley Floor Site – Everything too big and heavy to get to Thunderhead…

Table 2.4 Instrumentation at Valley Floor Site

Instrument	Measurement	Proposed Location	Support Needed
Radar Wind Profiler (RWP)	Winds, back scatter	East of GP Van within 20 m	Tie Downs or weights for guy wires
Ceilometer (VCEIL)	Cloud base, aerosols	East of GP Van within 10 m	Tripod tie-downs
Skyrad	Broadband SW, infrared, UV downwel. irrad	East of GP Van ~50 m Elevated Stand	Radiometer Stand tie-downs
Gndrad	Broadband SW, infrared upwelling irrad	East of GP Van ~50 m from 10 m tower	Tower
Total Sky Imager (TSI)	Cloud fraction	East of GP Van ~50 m Elevated Stand	
Balloone-borne Sounding Sys. (BBSS)	Wind, Temp, RH atmos. Profile	Helium beside GP Van Launch from field as appropriate	Helium location Access to field thru snow
Surface Fluxes (ECOR)	Heat, Mom., Water Vapor, CO2 sfc fluxes	East of GP Van ~50 m from tripod/tower	Access to inst. thru snow
Surface Met (SMOS)	10 m Winds, Temp, RH, Precip	East of GP Van ~50 m from tower	
Infra Red Sfc Temperature (IRT)	Sfc Skin Temp	East of GP Van ~50 m from tower	Height TBD
Local Data System	Instrument communication	GP Van Inside trailer	Virtual Comms to Data System
JPL 94 GHz Cloud Radar (ACR)	Scanning W-Band Radar Reflectivity	JPL Supplied Trailer	Steve Dinardo, JPL.
MMCR	Vertically pointing Ka Band Doppler Radar Spectra		
Scanning ARM Cloud Radar (SACR)	Scanning X and Ka Band Doppler Radar Spectra		

Note: 4 Radar and 5 Frequencies!

Christie Peak – ARM Aerosol Observing System

Table 2.3. Christie Peak Instruments

Instrument	Measurement	Proposed Location	Support Needed
3-λ Nephelometer (dry)	Aerosol light abs. at 450, 550, and 700 nm (RH <15%)	Inside AMF2-AOS Platform	Weekly calibration using CO2
3-λ Nephelometer (wet)	Aerosol light abs. at 450, 550, and 700 nm (RH 40-90%)	Inside AMF2-AOS Platform	Weekly calibration using CO2; water as needed
3-λ Particle soot Abs. Photometer (PSAP)	Aerosol light abs. at 450, 550, and 700 nm	Inside AMF2-AOS Platform	Filter changes (daily)
Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA)	Hygroscopic particle growth	Inside AMF2-AOS Platform	Water/butanol as needed
Cloud Condensation Nuclei (CCN) counter	CCN activity at two super saturations	Inside AMF2-AOS Platform	Water/butanol as needed
Condensation Particle Counter (CPC)	Particle counting >10 nm	Inside AMF2-AOS Platform	Butanol as needed
Trace Gas (Ozone)	Ambient ozone burden	Inside AMF2-AOS Platform	Monthly filter changes
Met. Data	Temp.; wind speed; wind dir.; humidity; pres.; rain fall	Inside AMF2-AOS Platform	none
Single Particle Soot Photometer (SP2)	Black Carbon mass conc. and size. Dist.	Inside AMF2-AOS Platform	Data transfers as needed
Data System	Instrument systems, data archive	Inside AMF2-AOS Platform	
Multi Filter Rotating Shadowband Radiometer (MFRSR)	Direct normal, Diffuse & Total horizontal solar irrad. @ 415, 500, 615, 673, 870, 940	Roof of AOS platform	Snow removal as needed

SPL Instruments	Measurement	Location	Operation Plans	Calibration History/plans	Level 1 Data Availability	Level 2 Plans
PIP	Raw data needed 100 microns to 6.5 mm.	SPL	Whenever particles are around	Cal by dmt prior.	Raw data will be provided	Processing in plans.
Fssp	Psd 1-50 microns	SPL	Whenever particles are around	Calibrated by dmt	Raw data to be preserved	Size distributions
CIP	25-1550 microns	SPL	Whenever particles are around	Calibrated by DMT prior	Raw data to be preserved	Size Distributions
CCN counter	Number per cm3 per ss%	SPL	24/7	DMT calibration	Available upon request	n/a
SMPS (scanning mobility particle sizer	8-500nm size distribution	SPL	24/7	TSI calibration annually; Not mission critical	Available upon request	
APS (aerodynamic particle sizer)	500nm to 20 microns	SPL	24/7	TSI calibartion annually; Not mission critical		
(U)Cpc (ultra)(condensation particle counter)	Aerosol concentrtion 10 and 3 nm cutoffs	SPL	24/7	TSI calibration annually; Not mission critical		
Trace gasses (ozone and co2)		SPL	24/7	Not mission critical		
MFRSR		SPL	24/7		Cal prior	
Met	5 minute data uploaded directly to WRCC site	SPL	24/7			

Table 2.5. SPL Instrumentation

Storm Peak Lab Instrumentation consists primarily of in situ aerosol, cloud, and precipitation probes

Additional instruments include SPEC CPI and 2DS

Table 2.7 Other Guest Instruments at SPL

P.I.	Institution	Name of Instruments	Dates of Deployment
Dan Cziczo	PNNL	Ice Nucleation Chamber, Counter-Flow Virtual Impactor, PALMS, Aerosol Mass Spectrometer	January 3 – February 18 April 1 – May 15
Paola Massoli	Aerodyne	CAPS, aerosol extinction	October 15 – May 15
Tim Garrett	University of Utah	HYVIS, snowflake probe	Participation uncertain
Art Sedlacek	Brookhaven National Lab	SP2	October 15 – May 15
Larry Berg	PNNL	PSAP, TSI Nephelometer	October 15 – May 15
Chuck Long	PNNL	Basic Radiometer System (RadSys)	October 15 – May 15
Chuck Long	PNNL	Hemispheric Sky Imager	October 15 – May 15