

ARM

Aerial Facility



Jason Tomlinson & Celine Kluzek
Pacific Northwest National Laboratory
ICCAGRA Meeting
Washington DC
September 27, 2011

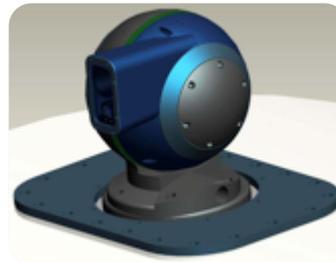
ARM Aerial Facility

- The AAF operation is multi faceted



Virtual hangar.

AAF has worked with 13 different aircraft



Instrument Operation and Development



G-1

We find the aircraft that suits the needs of the scientist!

Components of the ARM Aerial Facility



Virtual Hangar + Instrumentation + G-1

- CLASIC, Oklahoma; 6/2007
- ISDAC, Alaska; 4/2008
- RACORO, Oklahoma; 1–6/2009
- SPARTICUS, Oklahoma; 1–6/2010
- ARM Airborne Carbon Measurement Experiment, Oklahoma, 2008 - 2013
- So far worked with 13 aircraft:
 - ER-2, Lear 25, P-3 (2), B-200, CV-580, J-31, G-1, Twin Otters (3), C206, Bell 206

- Legacy (AVP, ASP)
- Recovery Act
- PI's
- Maturation Program

- PNNL since 1989
- ARM since 2010
- CARES, Sacramento, 6/2010
- CALWATER, Sacramento 2-3/2011

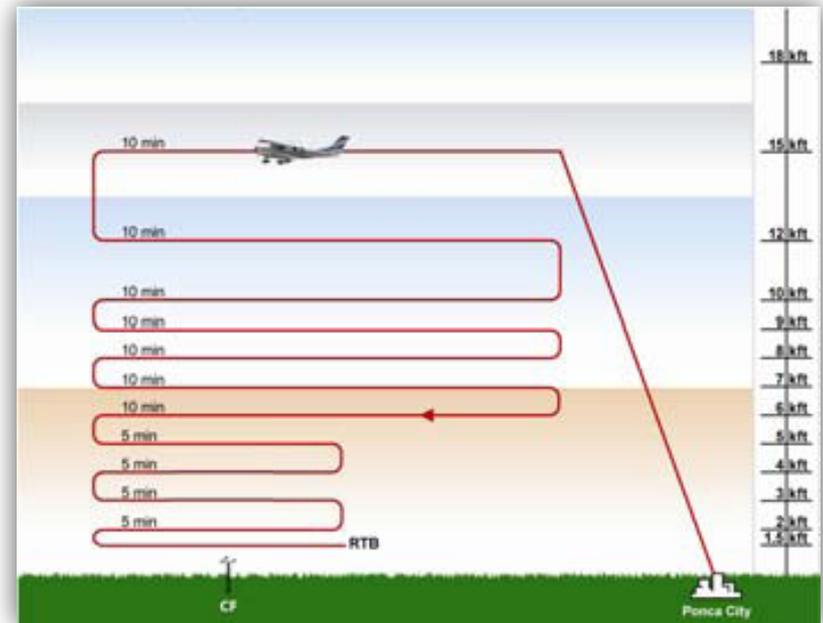
Planned

- Cape Cod 7/2012 & 2/2013
- Brazil 2x in 2014

ARM-ACME (2008-2013)

ARM Airborne Carbon Measurement Experiment (ACME)

- Routine flights over the SGP site using a Cessna 206
- Measurements of carbon cycle gases and ozone



Instrument Maturation – FY11

Workshop “Advances in airborne instrumentation for measuring aerosols, clouds, radiation and atmospheric state parameters”. U. Illinois, Fall 2008

McFarquhar G., B. Schmid, A. Korolev, J. A. Ogren, P.B. Russell, J. Tomlinson, D. D. Turner and W. Wiscombe. Airborne Instrumentation Needs for Climate and Atmospheric Research. *BAMS*, in press, Sep 2011.

- **Airborne Open Polar/Imaging Nephelometer for Ice Particles in Cirrus Clouds** - J. Vanderlei Martins, UMBC
- **Aircraft Integration and Flight Testing of 4STAR** - Connor Flynn, PNNL
- **Further Development of the HOLODEC 2 (Holographic Detector for Clouds 2) Instrument** - Raymond Shaw, Michigan Tech
- **Parameterization of Extinction Coefficient in Ice and Mixed-Phase Arctic Clouds During ISDAC** - Alexei Korolev, Environment Canada
- **The Maturation and Hardening of a Stabilized Radiometer Platform** - Anthony Bucholtz, NPS

ARRA Instrument	SPARTICUS 2010	CARES 2010	CALWATER 2011	MC3E/MACPEX 2011	TCAP 2012 & 2013	GoAmazon2014
WCM-2000			X		X	X
CSI	X		X			
AIMMS-20			X		X	X
F-FSSP				X		
CDP	X		X		X	
F-CDP				X		X
2-DS			X			X
HVPS-3			X	X		X
SMPS						
UHSAS		X	X	X	X	
CCN					X	X
SP2		X			X	
PASS-3		X				
f(RH)					X	
PILS					X	
CVI			X			
CO ₂ , CH ₄ , H ₂ O						X
CO, O ₃ , SO ₂ ,NO,NO ₂ ,NO _v					CO only	No SO ₂

G-1 (BMI owned, ARM base funded, PNNL based and managed, for the science community)



Aircraft Technical Information

Length: 63.75 feet (19.44 m)

Wingspan: 78.33 feet (23.88 m)

Height: 23.33 feet (7.11 m)

Cabin space: 165 square feet

External probes (PMS cans, etc.): 8

Maximum gross weight: 36,000 pounds
(16,330 kg)

Endurance with maximum fuel: 8 hours

Endurance with typical payload/fuel: 5 hours

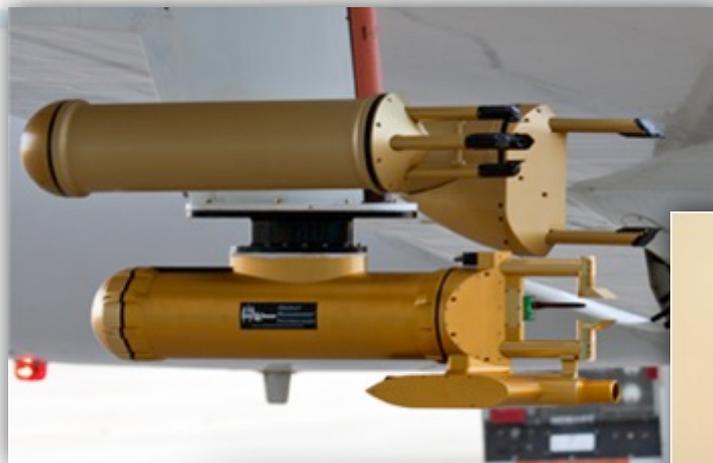
Crew capacity: 2 pilots, 3-5 scientists

Cabin payload: 4,200 pounds

Research Power: 500A @ 28 VDC (incl. 77A
@ 115 VAC, 60 Hz)

Enhanced Sampling Capability on G-1

- Wing Pylons (FAA Approved)
 - Operated 8+ cloud probes during the CALWATER project
- New Aerosol Inlet
- New Counter-flow Virtual Impactor Inlet
- New tip designs to reduce shattering artifacts for all of our cloud probes



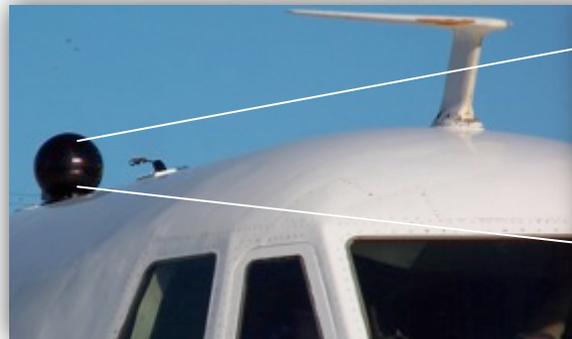
Enhanced Radiometry on G-1

■ 4STAR

Battelle
The Business of Innovation



- Completed 9 test flights
 - Sep 2010, April 2011, and August 2011
- To be used in Twin Column Aerosol Project (TCAP)
 - Direct Solar Beam and Sky-Scanning: Aerosol OD, Size Distribution, Absorption, Extinction, Cloud OD, H₂O, O₃



■ Non-moving Radiometer Package (for TCAP)

- MFR, SW, 415, 500, 615, 673, 870, 940, and 1625 nm (albedo) spectral channels
- SPN-1 unshaded SW global, broadband

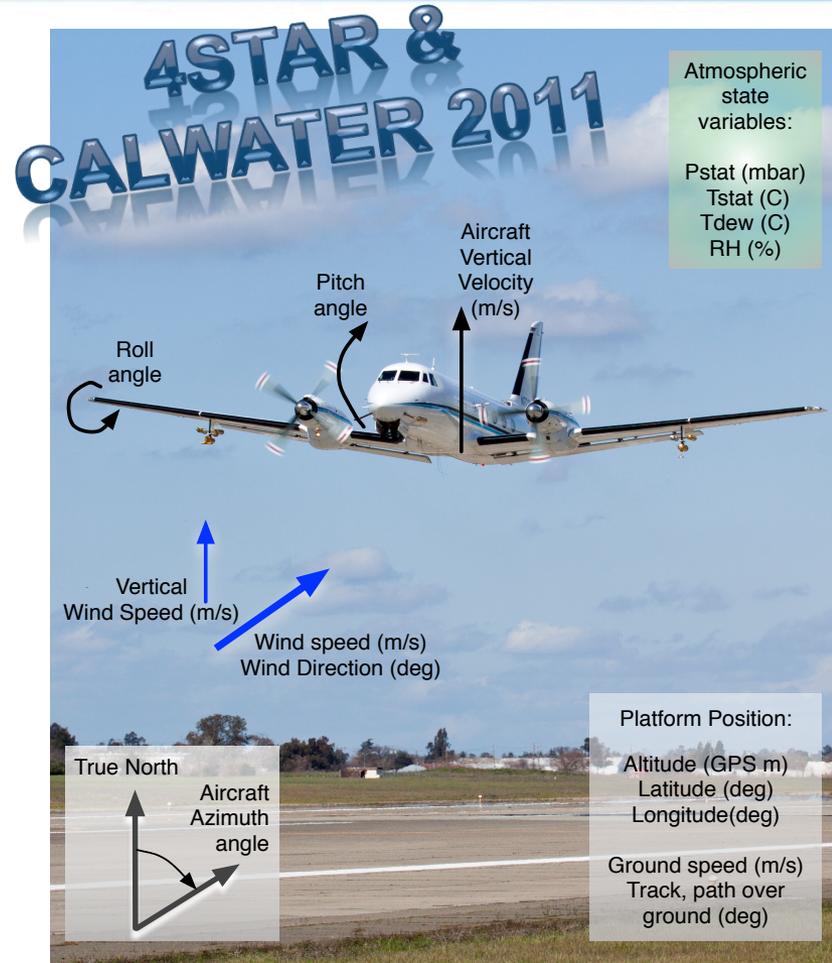


Gulfstream G1 - 1st merged data set using IWGADTS

International Working Group for Aircraft Data Telemetry System

Index	Variable Name
1	IWG1
2	Date / Time
3	Lat
4	Lon
5	GPS_MSL_Alt
6	WGS_84_Alt
7	Press_Alt
8	Radar_Alt
9	Gnd_Spd
10	True_Airspeed
11	Indicated_Airspeed
12	Mach_Number
13	Vert_Velocity
14	True_Hdg
15	Track
16	Drift
17	Pitch
18	Roll
19	Side_Slip
20	Angle_of_Attack
21	Ambient_Temp
22	Dew_Point_Temp
23	Total_Temp
24	Static_Press
25	Dynamic_Press
26	Cabin_Press
27	Wind_Speed
28	Wind_Dir
29	Vert_Wind_Spd
30	Solar_Zenith
31	Sun_Elev_AC

- Platform & atmospheric state variables at 1Hz
 - ✧ Comma delimited format
 - ✧ Including ICARTT headers
 - ✧ 2-line header (variable name and units)
 - ✧ First column is "IWG1"
- Why use the IWG1 standard format:
 - ✧ Standard between platform aircraft
 - ✧ Standard between agencies
 - ✧ Facilitates inter-agency collaboration and scientist data retrieval
- Advertised to DOE contractors



IWGADTS used in 4STAR mission August 29th-31st 2011

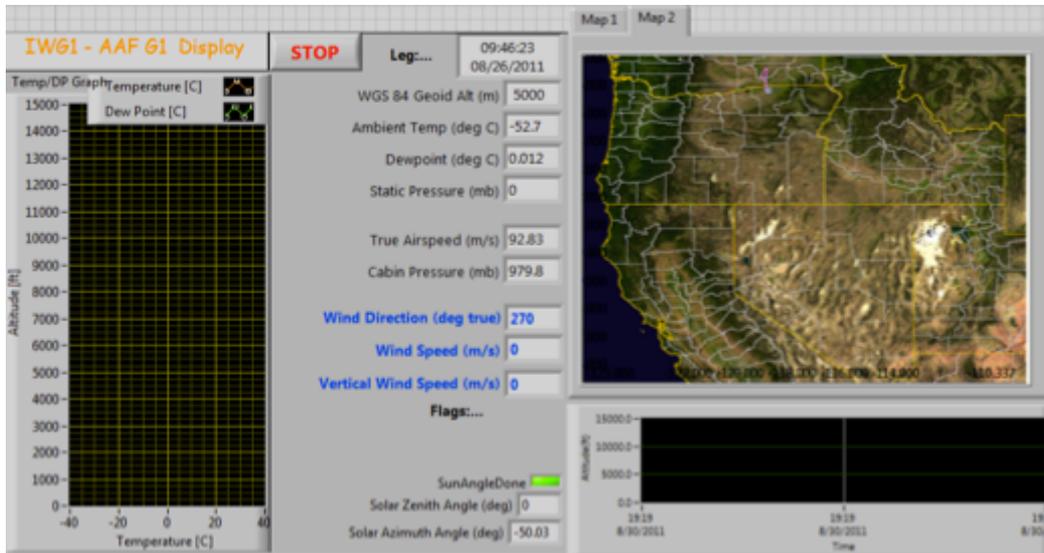
- Use IWG1 string to transmit information to 4STAR :
 - Collaboration between NASA ARC team and PNNL/DOE AAF
 - Aircraft position and altitude used to calculate sun position
 - Software equipped to receive IWG1 string Built-in LabView Sub-Vi
 - In the next campaign, use roll and pitch info to compensate the head movements
- 4STAR ready to accept IWG1 data stream from any other platform
 - ✓ Integration with P3



Beat Schmid, PNNL/DOE
and Roy Johnson, NASA Ames

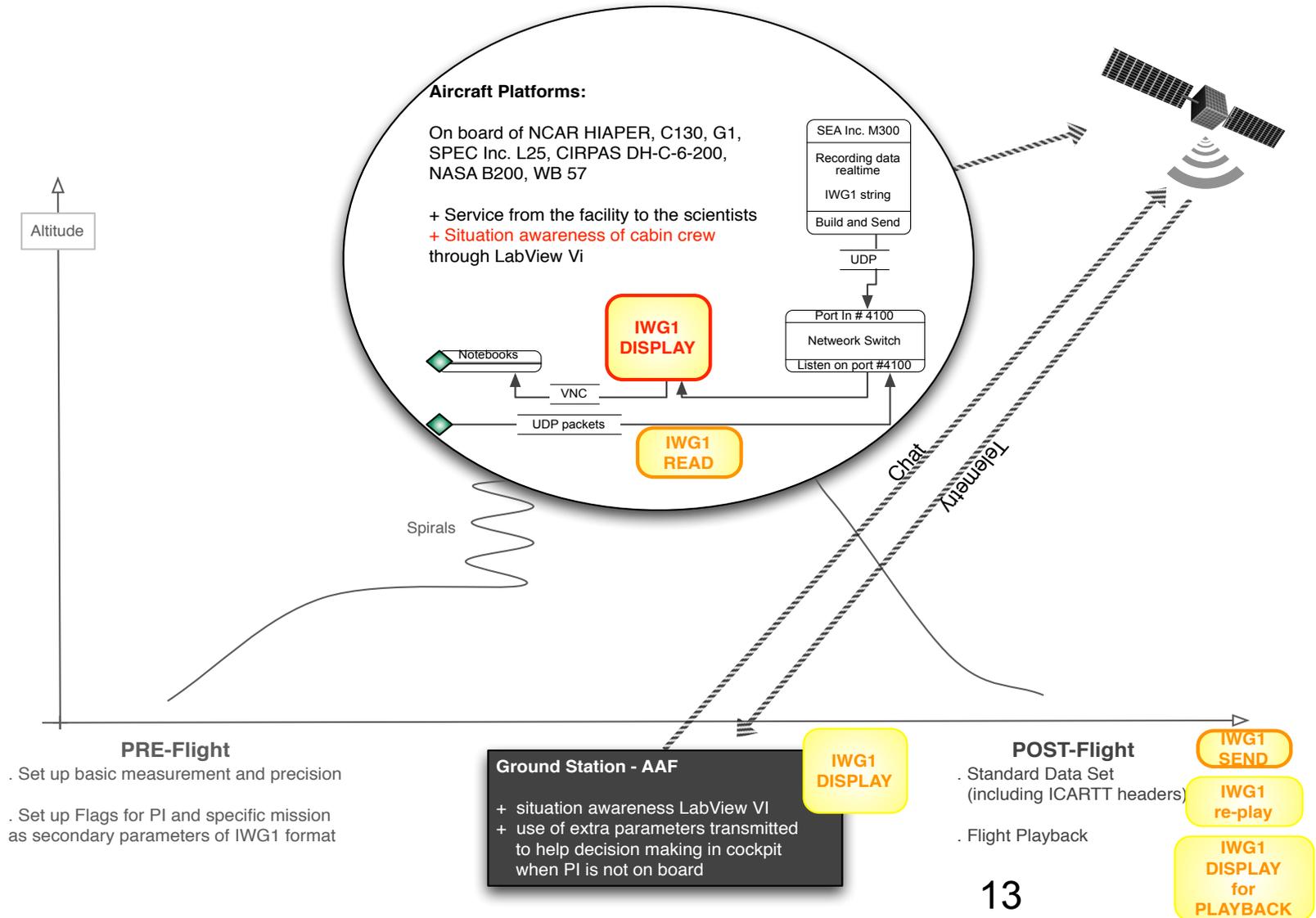
IWGADTS used in 4STAR mission August 29th-31st 2011

- Use IWG1 to display position to cabin crew
 - Map display (developed by Jason Tomlinson, PNNL/DOE)
 - Ground crew display
 - Sending mission specific parameters



Beat Schmid, PNNL/DOE and Roy Johnson, NASA Ames

IWGADTS - LabView Modules



Gulfstream G1 - 1st merged data set using **IWGADTS** *International Working Group for Aircraft Data Telemetry System*

CALWATER 2011

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11	Indicated_Airspeed
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13	Vert_Velocity
14	True_Hdg
15	Track
16	Drift
17	Pitch

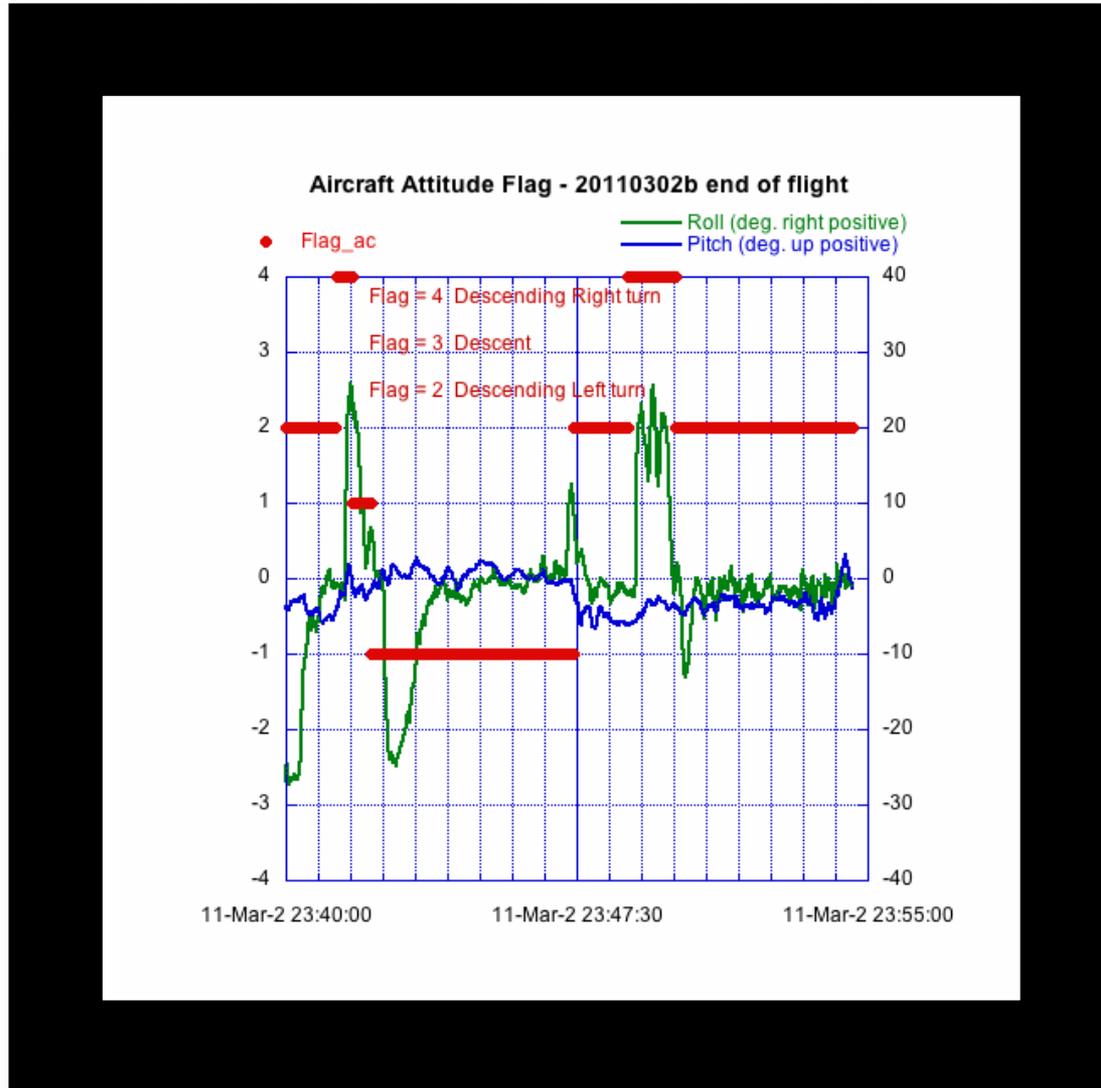
34	Flag_qc
35	Flag_ac
36	Flag_inlet
36	Flag_in_cloud
37	Flag_cloud_phase

- Using secondary parameters for mission specific **FLAGS** (at the end of the string)
 - Initial level a1 data processing: QC flag
 - ◆ Aircraft flight attitude Flag
(John Hubbe, PNNL/DOE)
 - Inlet position between CounterFlow virtual Impactor for cloud study CVI) or Isokinetic Inlet Flag
 - ◆ Cloud Flag (IN or OUT)
 - Cloud PHASE flag to be derived
(Jennifer Comstock, PNNL/DOE)

Gulfstream G1 - 1st merged data set using *IWGADTS* International Working Group for Aircraft Data Telemetry System

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Gulfstream G1 - 1st merged data set using **IWGADTS** *International Working Group for Aircraft Data Telemetry System*

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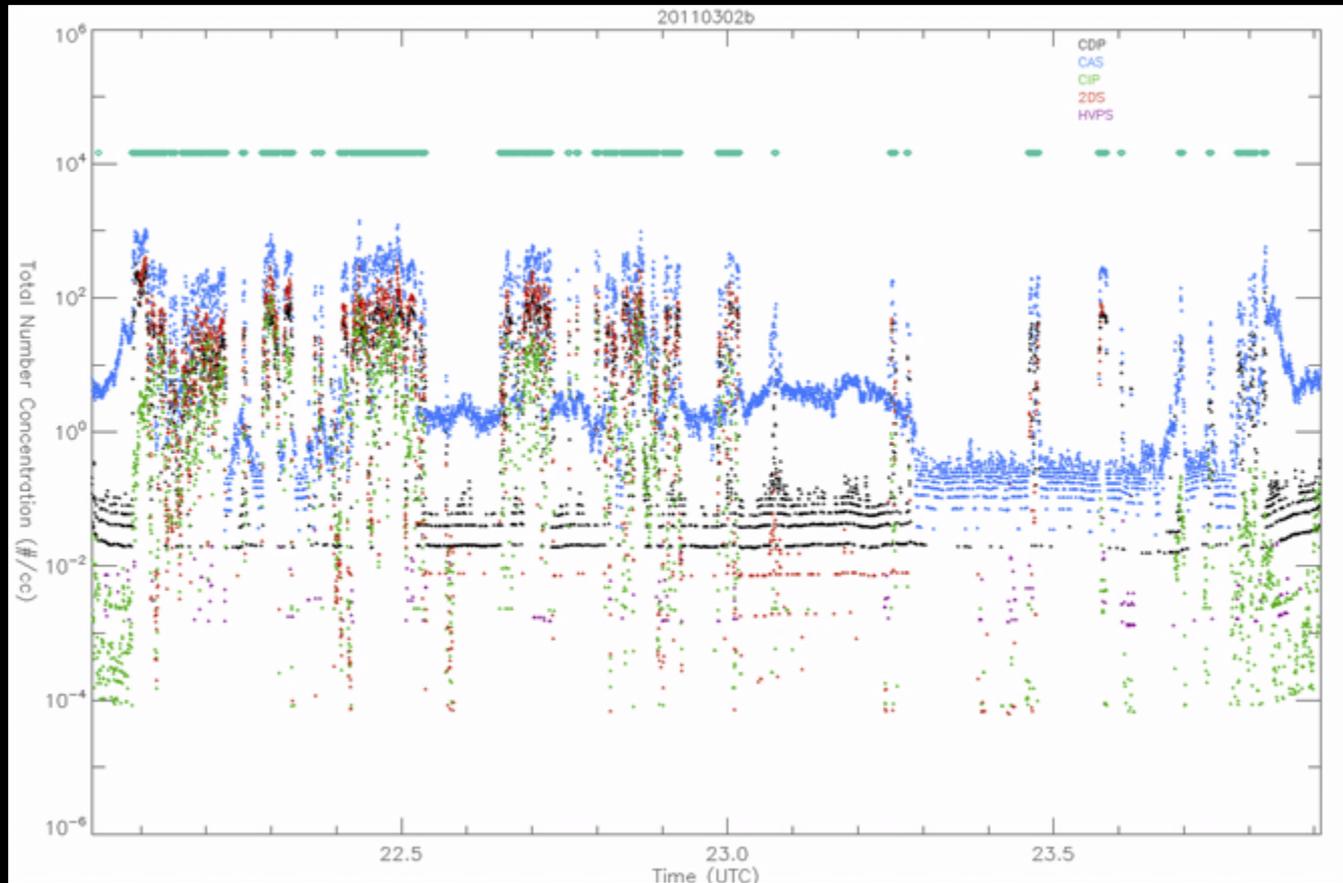
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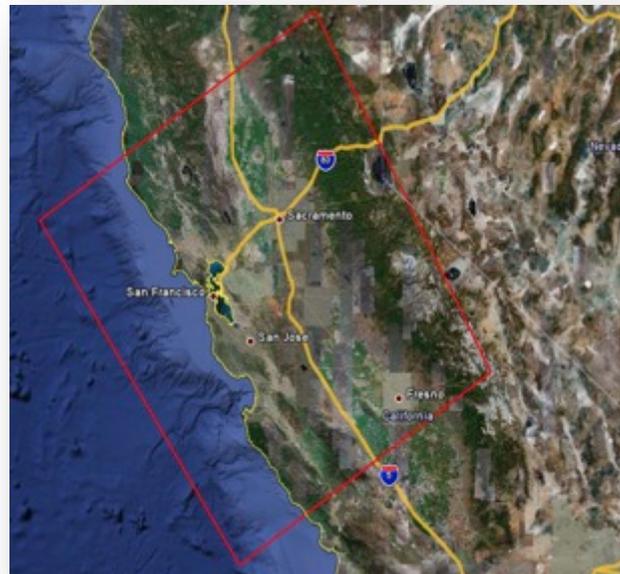
Gulfstream G1 - 1st merged data set using **IWGADTS** *International Working Group for Aircraft Data Telemetry System*

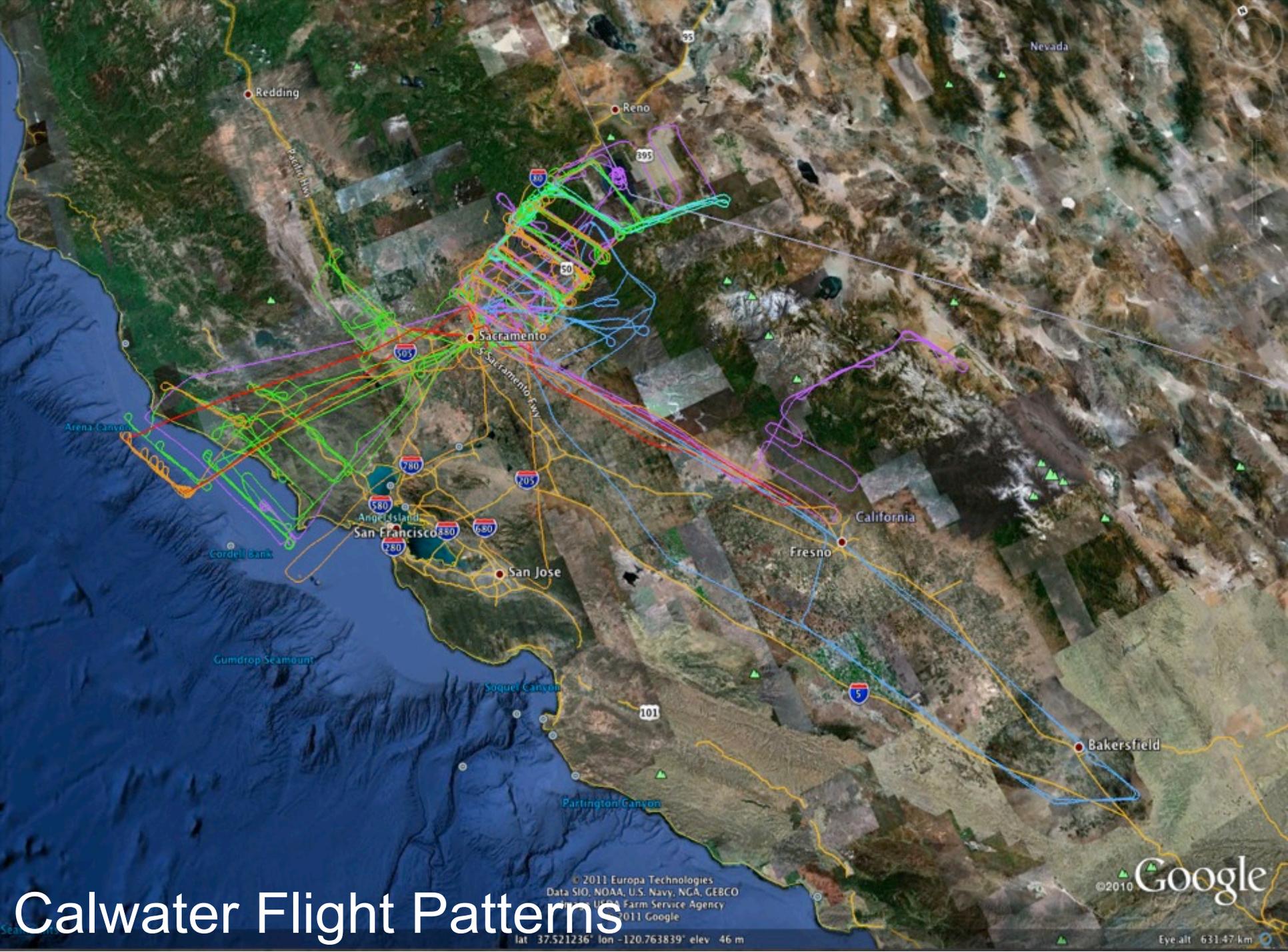
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- Investigated the effects of anthropogenic emissions on winter precipitation in the California Central Valley and Sierra Nevada mountain range
 - PI: K. Prather, UCSD
- 81 hours (incl. transit and test)
 - 28 flights, 70 hours on station
 - Feb 1 to March 7, 2011
- Atmospheric state, LWC/TWC, cloud microphysics, aerosols, and gases
 - First project for the 2D-S, HVPS-3, CSI, AIMMS-20, WCM, and CVI.





Calwater Flight Patterns

© 2011 Europa Technologies
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Imagery © 2011 Google
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lat 37.521236° lon -120.763839° elev 46 m

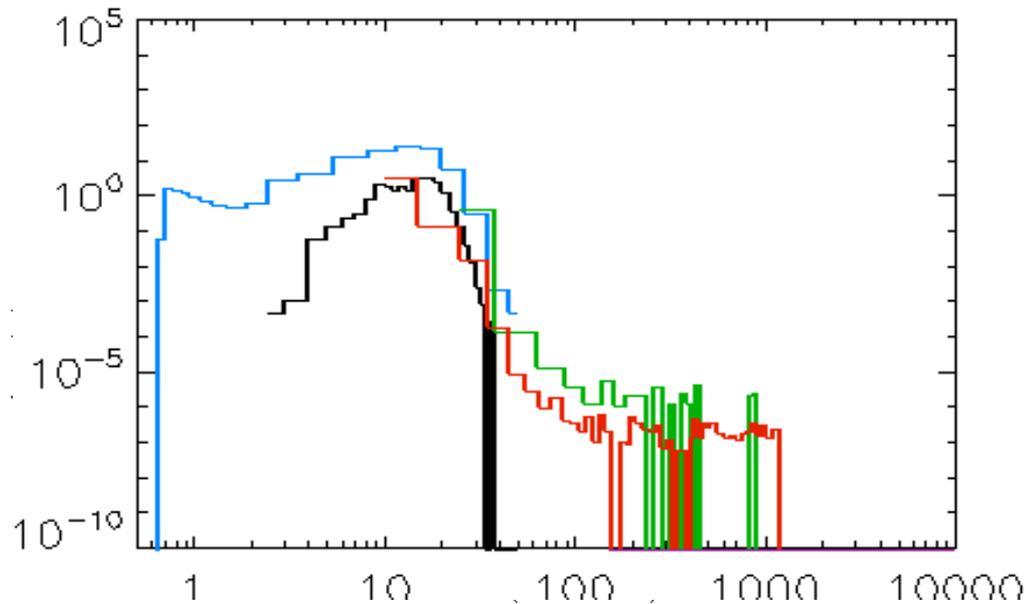
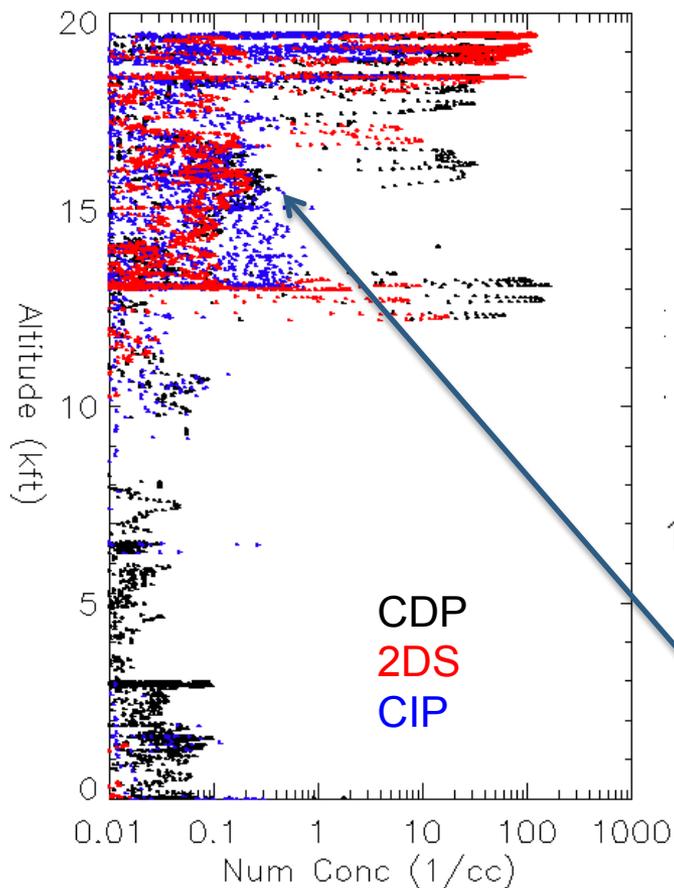
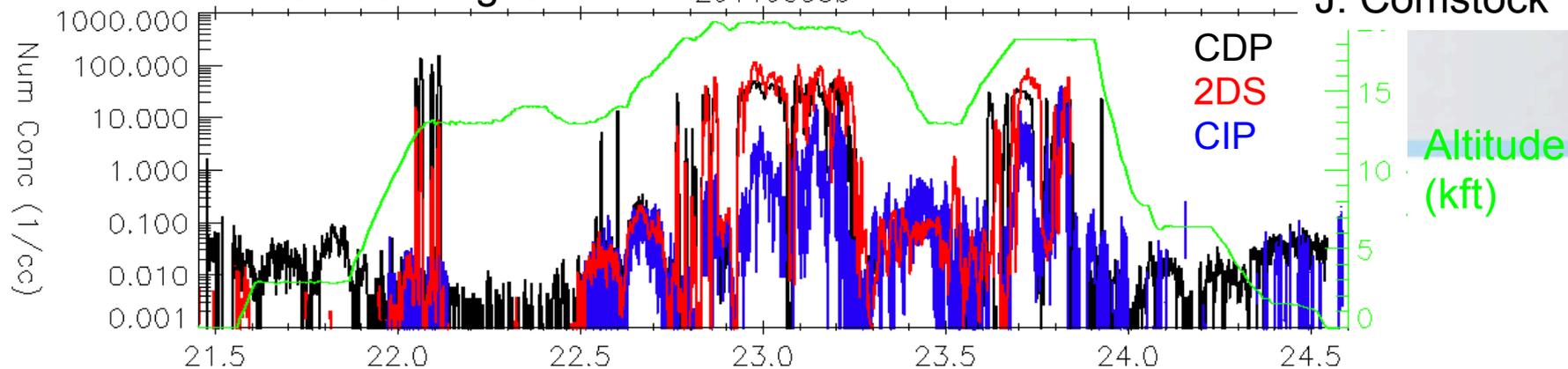
© 2011 Google

Eye alt. 631.47 km

Afternoon Flight

20110305b

J. Comstock



Cloud signal corresponds with morning aerosol layer

FY12 TCAP – Twin Column Aerosol Project

- PI: Carl Berkowitz/Larry Berg (PNNL)
- Location: Cape Cod, MA
 - Barnstable Municipal Airport in Hyannis, MA.
- Mission Dates
 - IOP1: July 6-30 , 2012
 - IOP2: 3 weeks in February, 2013
- Payload
 - Aerosols, clouds, radiation and gases
 - NASA B-200 (HSRL, RSP)



AAF Campaigns FY 13 -14

■ FY13

- Cessna Flights over SGP

■ FY14 GoAmazon

- PI: Scott Martin (MIT)
- Two Deployments for the G1
 - G-1 Jan/March 2014
 - G-1 Aug/Oct 2014
- AMF and MAOS



Summary

- AAF has made huge strides in adding cloud microphysical measurements as an area of expertise
 - Successfully completed CALWATER with a solid data set
- FY12 budget is flat (=FY11)
 - Focus on adding radiometric measurements to the aircraft during FY12
 - Continue Testing ARRA instrumentation
 - TCAP
- Aircraft is available for work the next 2 years!

More Information

ARM



<http://www.arm.gov>

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ARM Aerial Facility



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