



*Division of Atmospheric Sciences*

*Science*

*Environment*

*Solutions*



## Storm Peak Laboratory during StormVEx

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**Unique, high elevation, mountain-top atmospheric research facility readily accessible under all weather conditions!!!**

# The Storm Peak Lab Cloud Property Validation Experiment

## *StormVEx*

A photograph of the Storm Peak Lab building, a multi-story structure with a wooden facade and a complex network of metal scaffolding and railings. The building is situated on a snowy mountain peak under a clear blue sky. A tall, thin tower is visible in the background. The foreground is covered in a thick layer of snow.

Project Team:

Jay Mace (PI) - University of Utah, Gannet Hallar - Desert Research Institute

Ian McCubbin - Desert Research Institute, Sergey Matrosov-CIRES University of Colorado NOAA/ESRL

Matthew Shupe - CIRES, University of Colorado and NOAA/ESRL, Brad Orr - Argonne National Laboratory

Roger Marchand - University of Washington, Rich Coulter - Argonne National Laboratory

Chuck Long - Pacific Northwest National Laboratory, Linnea Avallone - University of Colorado

Arthur Sedlacek - Brookhaven National Laboratory, Paul Lawson - Stratton Park Engineering Corporation

# The Storm Peak Lab Cloud Property Validation Experiment

## *StormVEx*

- **What:** Deployment of the Department of Energy Atmospheric Radiation Mobile Facility to Steamboat Springs to operate in close coordination with Storm Peak Laboratory
- **When:** Mid November 2010 – early April 2011
- **Why:** Primary objective – Use SPL as in situ data collection platform for validation of cloud and precipitation properties retrieved by ground-based active and passive remote sensors.

# Storm Peak Laboratory Owned and Operated by Desert Research Institute Located in Northwest Colorado on the US National Forest



# **STORM PEAK LABORATORY**

## **MISSION STATEMENT:**

*To ensure that Storm Peak Laboratory will continue to integrate climate research and education by advancing discovery and understanding within the field of aerosol, pollution, and cloud interactions.*



# Aerosol, Cloud, and Trace Gases Research and Education Facility

Located on Steamboat Springs Ski Resort

Elevation: 3220 m (10,530 ft)

Pressure: ~ 690 mb

In cloud ~25% of time in the winter

Mixed Phase Clouds

9 Person Bunkhouse

Full Kitchen, Running Water

Facility and Guest Instruments

## UPCOMING NSF ARI-R<sup>2</sup> RENOVATION:

3 New Aerosol Manifolds

New Wet Chemistry Lab

High Speed Internet Connection - 150 Mbps



# Storm Peak Laboratory Cloud Probes

OVER 400 Hours of Data (to date!) from StormVEx:

- FSSP - 0.5-45  $\mu\text{m}$
- CIP - 25  $\mu\text{m}$  to 1550  $\mu\text{m}$
- PIP - 100 $\mu\text{m}$  - 6.2mm.

Major Investment from DRI and NASA/JPL CloudSat Program:

- Probe Stand designed and machined by NCAR and coupled with sonic anemometer
- New DMT probe arms purchased for CIP and PIP



Quick look all available on  
StormVEx web site  
for CIP, PIP, and FSSP

# THANK YOU!

## The Graduate Students of StormVEx

- Betsey Berry, University of Utah
- Stewart Evans, University of Washington
- Ben Hillman, University of Washington
- Wil Mace, University of Utah
- Clinton Schmidt, University of Utah
- Carolyn Stwertka, University of Utah
- Adam Varble, University of Utah
- Christy Wall, University of Utah



Also hosted classes from University of Wisconsin, University of North Carolina at Charlottesville, and University of Colorado during StormVEx





# CAMPS

## Colorado Airborne Multi-Phase Cloud Study

L. M. Avallone<sup>1</sup>, A. G. Hallar<sup>2</sup>, G. Chirokova<sup>2</sup>

<sup>1</sup>University of Colorado

<sup>2</sup>Desert Research Institute, Storm Peak Lab

*In coordination with the DOE StormVEx field campaign*





# Summary

- December 15, 2010 to February 28, 2011
- Principal Investigator: Linnea Avallone
- Co-Investigators: Gannet Hallar, Matt Shupe, Zhien Wang
- 29 research flights totaling 98 flight hours
- Flights sampled a variety of conditions including:
  - Thick precipitating clouds
  - Mixed-phase clouds with range of ice/liquid fractions
  - Pure ice and pure liquid clouds
  - Wave clouds
  - Cumulus/convective clouds

# Instrumentation

- Wyoming Cloud LIDAR (WCL)
  - downward, upward
- Wyoming Cloud Radar (WCR)
  - upward, dual-downward
- Closed-path laser hygrometer (CLH) – total water
- DMT Cloud Droplet Probe: 2-50  $\mu\text{m}$  particles
- Particle Measuring Systems FSSP: 0.5-45  $\mu\text{m}$  particles
- Particle Measuring Systems 2D-C optical array: 100 - 800  $\mu\text{m}$
- Particle Measuring System 2D-P optical array: 200  $\mu\text{m}$  – 6.4 mm
- DMT Cloud Imaging Probe: 25-1500  $\mu\text{m}$
- DMT LWC-100
- Gerber PVM-100: liquid water
- Licor 6262: CO<sub>2</sub> and H<sub>2</sub>O vapor
- Edgetech Dewpoint Hygrometer



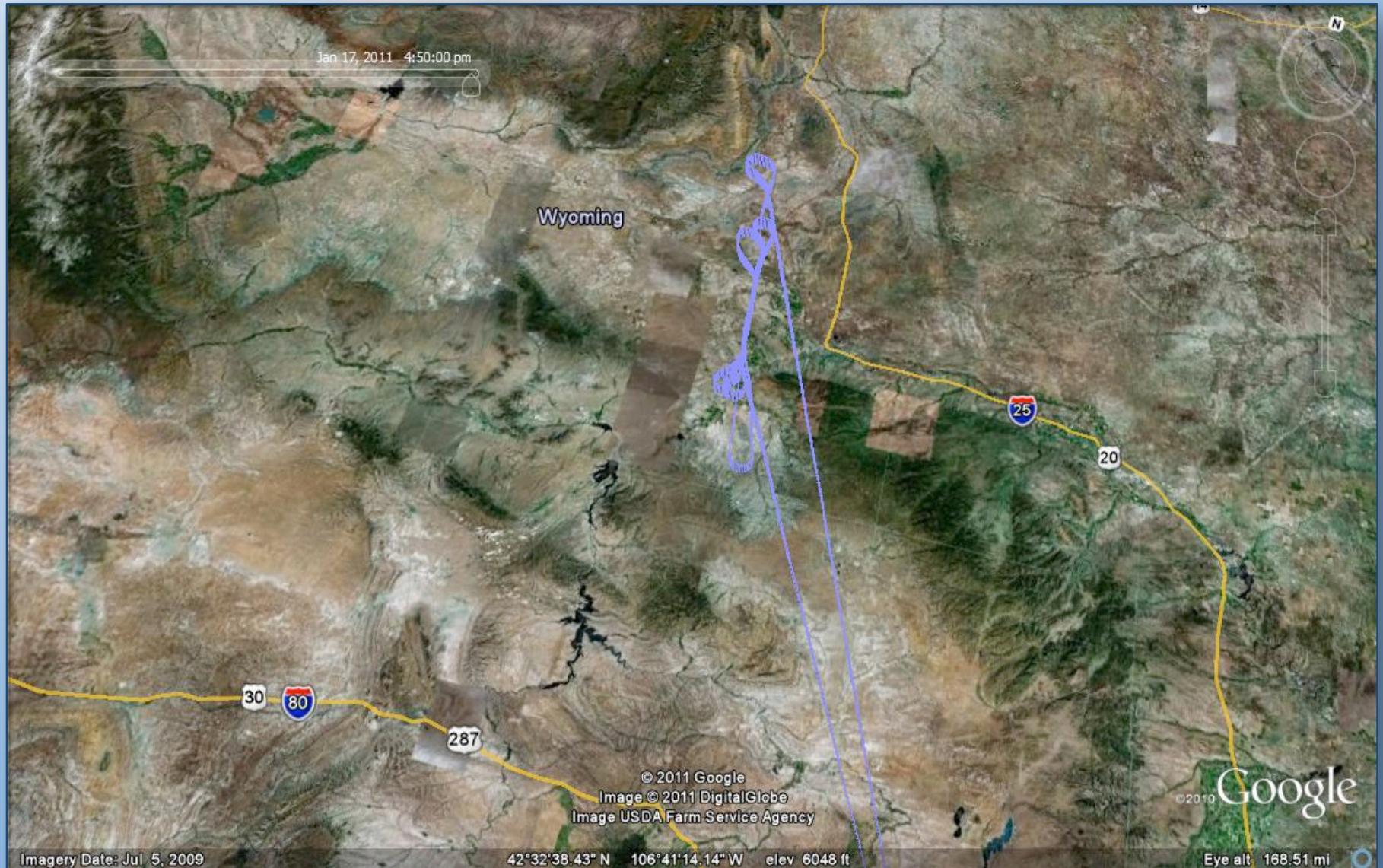
# Intercomparisons

- Three CloudSat overpasses:
  - 8 January – mixed-phase cloud at 13-16,000 ft
  - 17 January – mixed-phase cloud at 16-21,000 ft
  - 25 February – mixed-phase cloud with large dendrites at 13,000 ft
- SWACR/in situ comparisons
  - 6 February – cumulus with large ice/graupel
  - 26 February – mixed-phase clouds/moderate icing

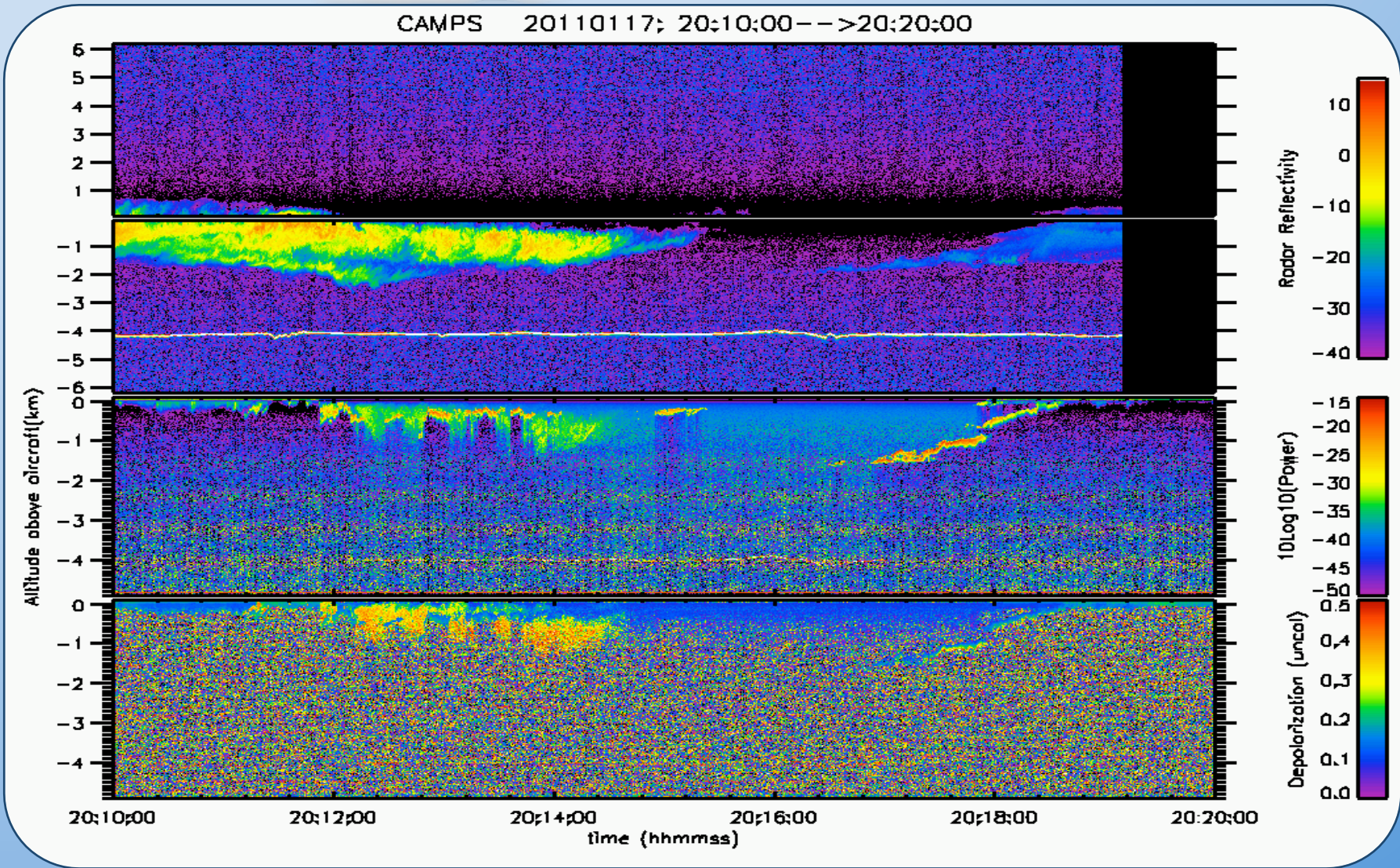
# Case Study Examples

- January 17 (RF 8) – CloudSat overpass
  - Mixed-phase clouds from 21,000 to 16,000 ft
- February 1 (RF 15) Cold and Ice formation
  - Flight through very thin clouds at 18,000 ft and -38 C. Possibly homogeneous nucleation
- February 7 (RF 19) High LWC
  - Above Storm Peak Laboratory two distinct cloud decks, upper layer cloud ~20,000 composed entirely of ice and lower cloud deck that appeared more wavelike in structure. Over the course of flight, upper deck dissipated and lower deck thickened; Lower deck, mostly liquid with a few large ice particles; we encountered high CLWC's up to  $1.0 \text{ g/m}^3$

# January 17, 2011 (RF 8)



# Jan 17 (RF 8): Radar & Lidar



20:10:00

20:13:00

20:16:00

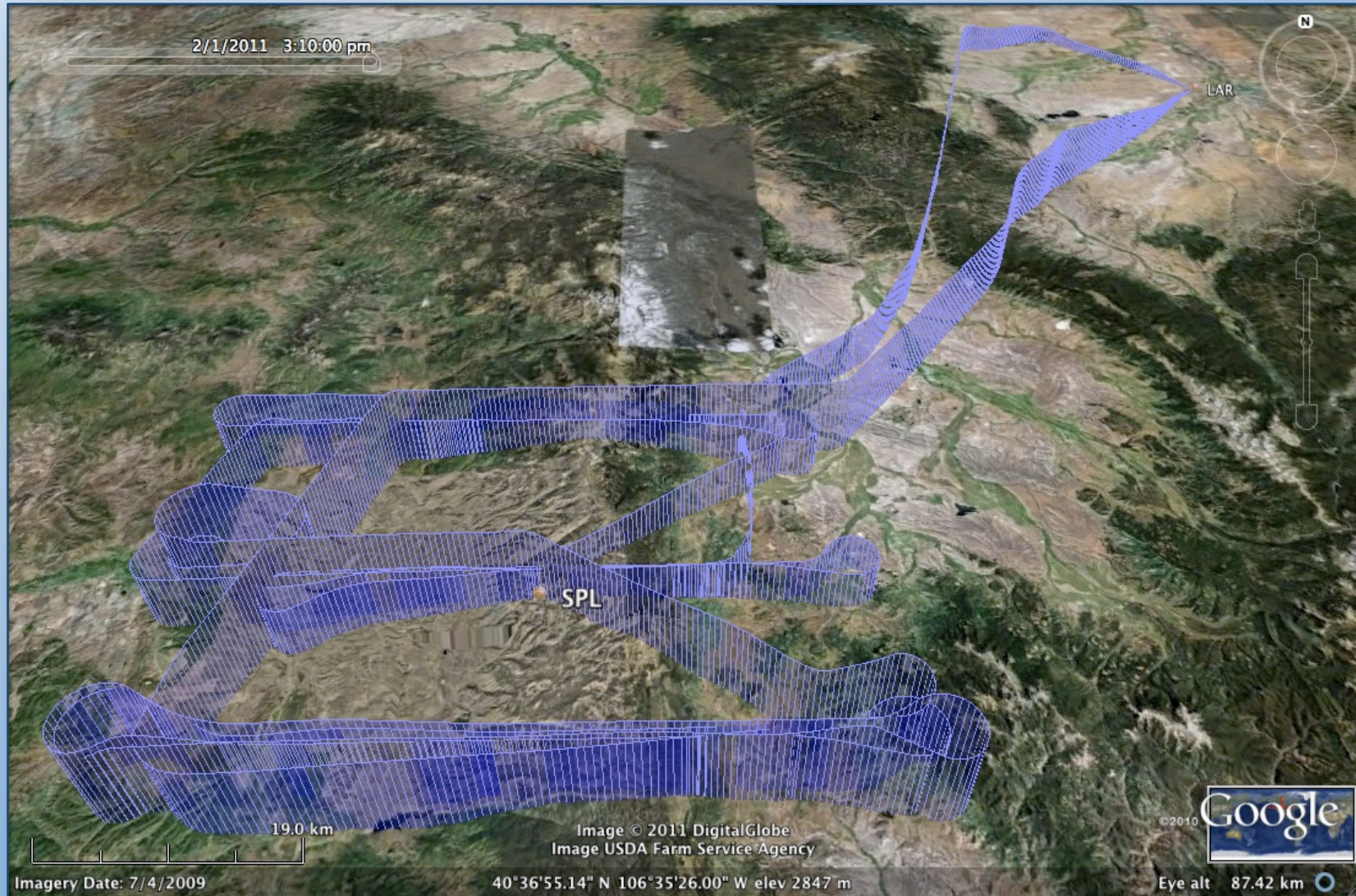
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20:22:00

20:25:00

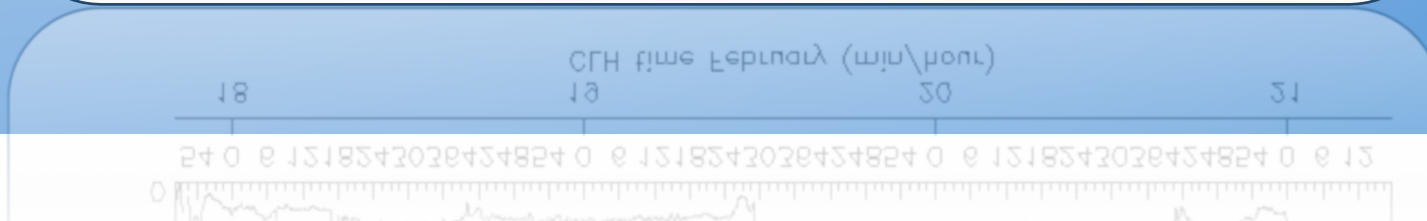
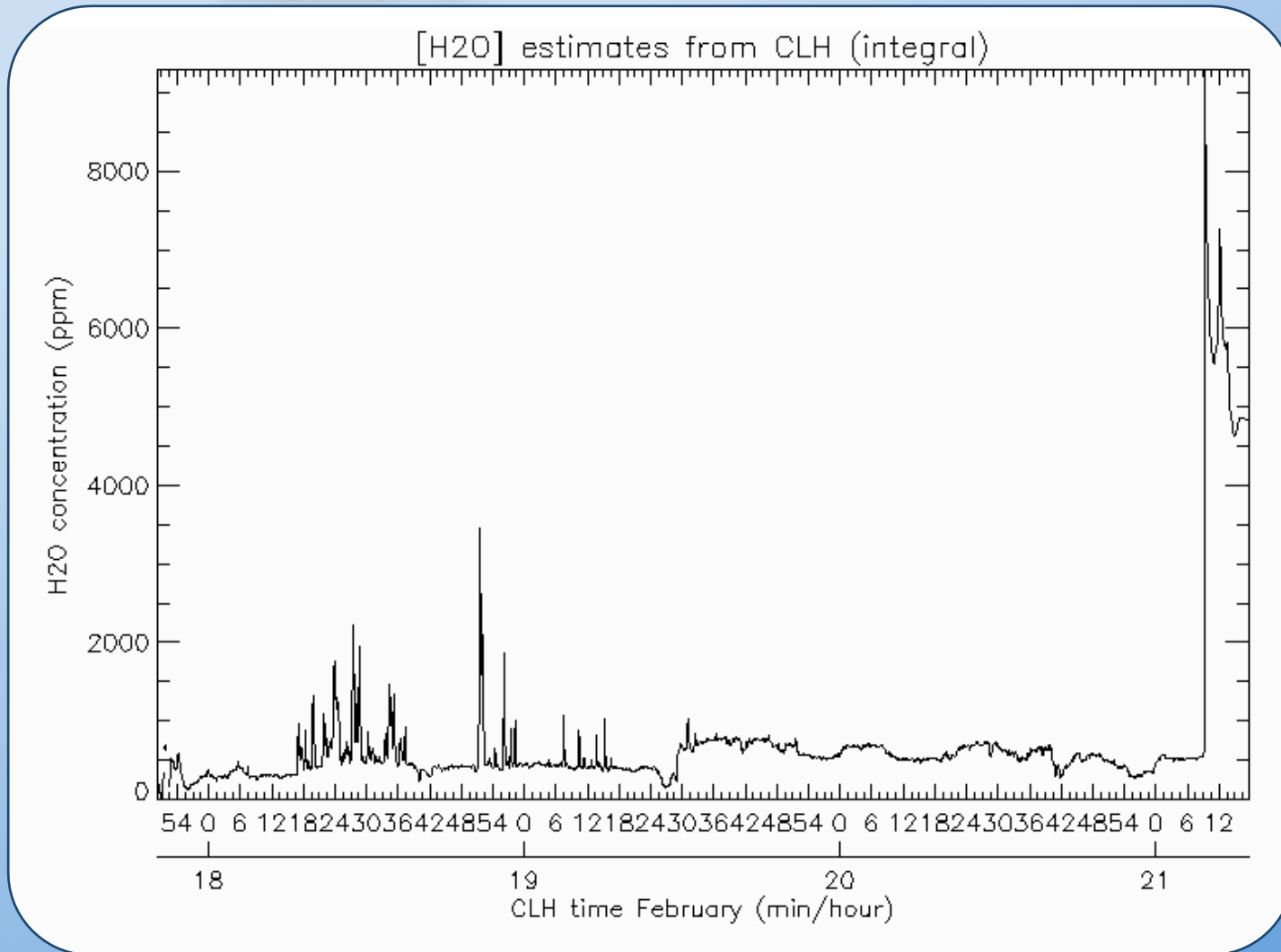
0.0  
0.1  
0.2  
0.3  
0.4  
0.5  
0.6

# February 1, 2011 (RF 15)

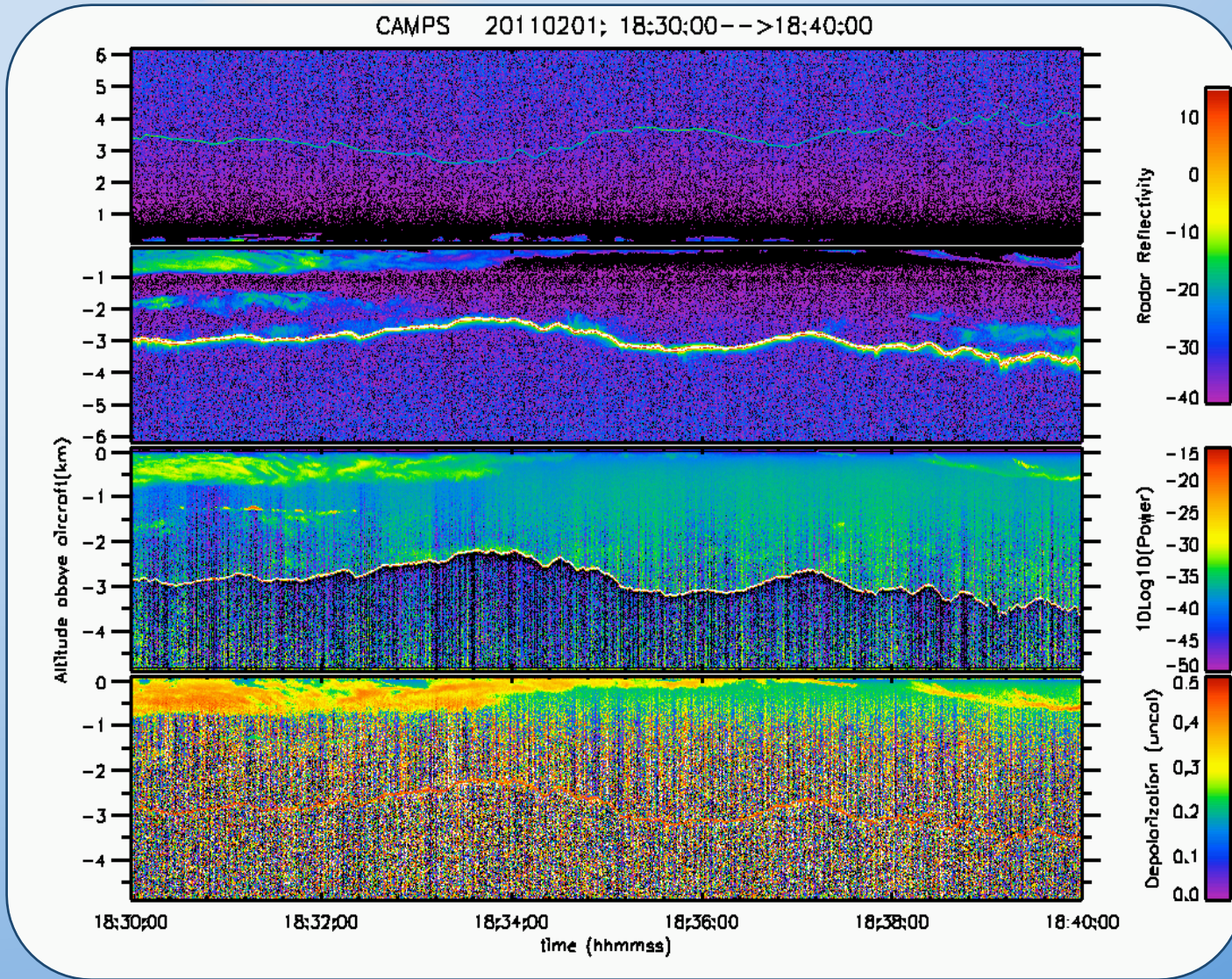




# Feb 1 (RF 15): Total Water



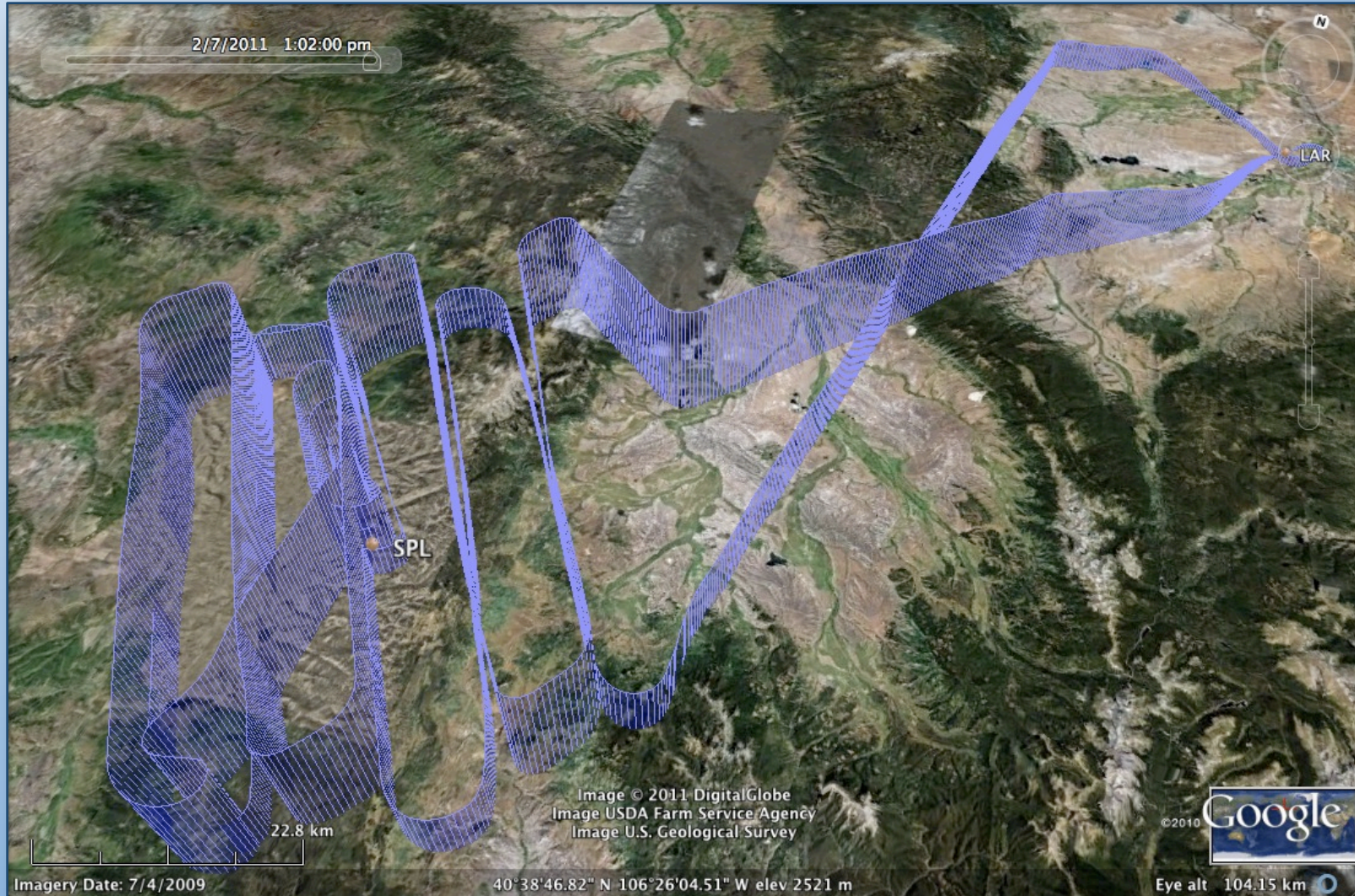
# Feb 1 (RF 15): Radar & Lidar



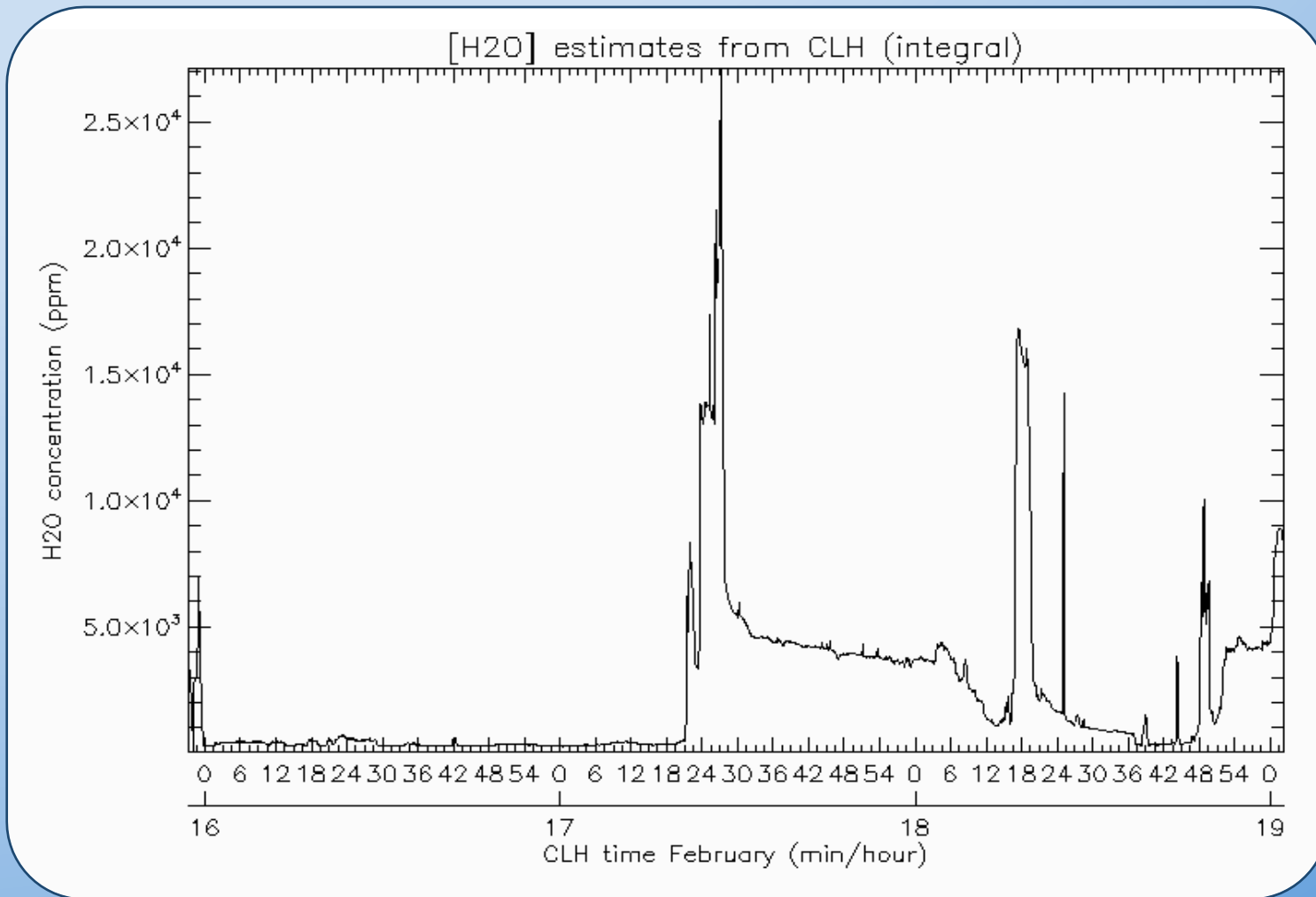
18:20:00 18:23:00 18:26:00 18:29:00 18:32:00 18:35:00

0.0  
0.1

# February 7, 2011 (RF 19)



# Feb 7 (RF 19): Total Water

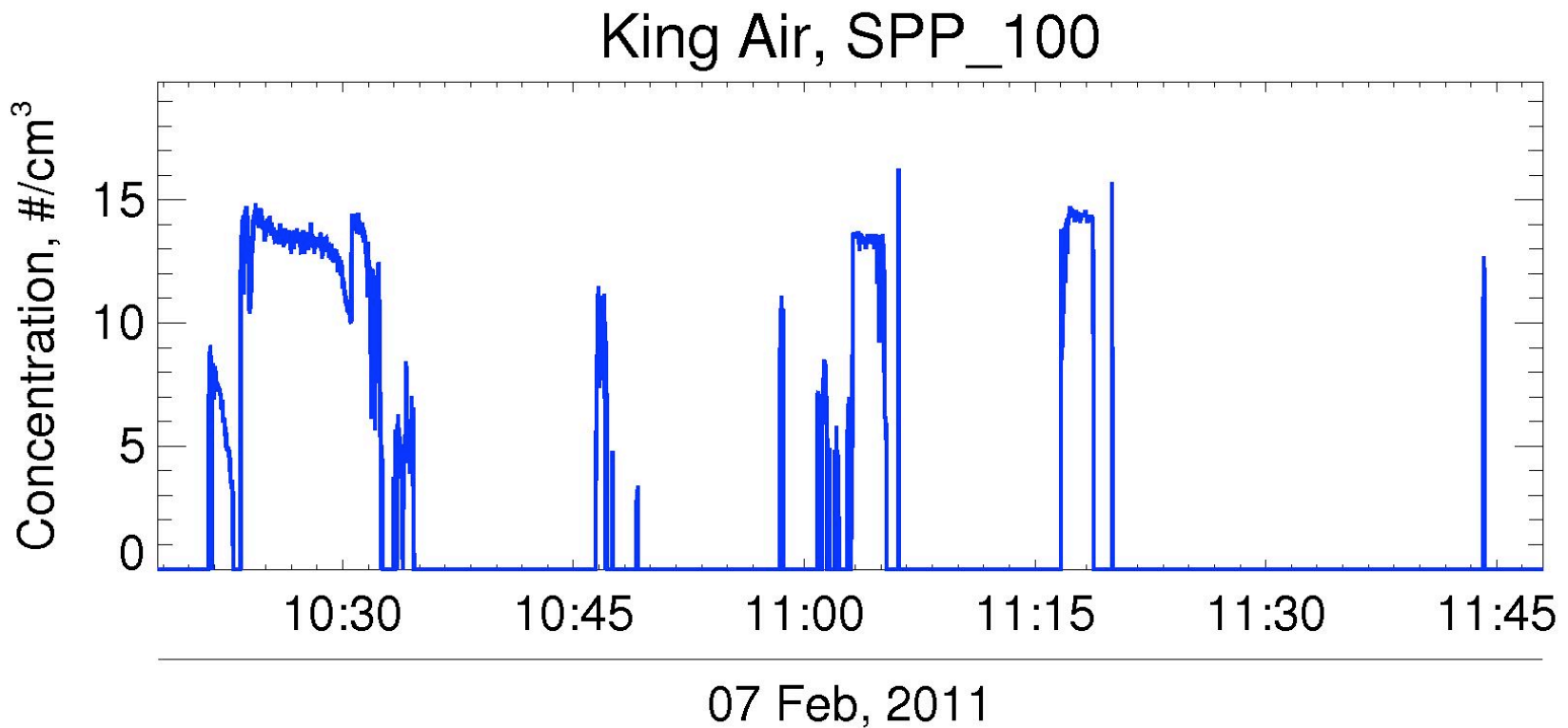


CLH time February (min/hour)

16 17 18 19

0 6 12 18 24 30 36 42 48 54 0 6 12 18 24 30 36 42 48 54 0 6 12 18 24 30 36 42 48 54 0

# February 7 (RF 17)



# Scientists onboard

- Education Experiences
  - Four graduate students
    - Sam Dorsi & Anna Luebke, University of Colorado
    - Patrick Campbell & Brittini Emery, University of Wyoming
  - Three undergraduate students  
Funded by NSF Opportunity for Enhancing Diversity
    - Erica Strom, University of Wisconsin
    - Dimauro Edwards, Stony Brook University
    - Aaron Piña, Texas A&M
- Students helped with flight planning and operated instruments during flight



# Acknowledgements



- NSF LAOF and PDM for funding
- University of Wyoming King Air team: Larry Oolman, Jeff French, Brent Glover, Nick Mahon, Don Lukens, Perry Wechsler, Matt Burkhardt, Bo Liu, Sam Haimov
- Pilots Ahmad Bandani and Brett Wadsworth
- Forecasting and Cloud Sat prediction assistance from Jay Mace, Roger Marchand, Matt Shupe and Ian McCubbin



**THANK YOU  
FOR YOUR  
ATTENTION!**



# Storm Peak Laboratory

for atmospheric science  
<http://stormpeak.dri.edu>

