Prospectus for a

CHEM/CLOUD EXPERIMENT

Using Multiple Doppler Lidars in Huntsville, Alabama

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Working Group on Space-Based Lidar Winds
Frisco, Colorado, June 29 July 1, 2004

Cumulus Cloud over Killen, Alabama, photographer Barry Mahoney,
Huntsville NWS Photo Gallery, http://www.srh.noaa.gov/hun/photos/clouds.html

CHEM/CLOUD PROSPECTUS

Contents

- OVERVIEW
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- SUMMARY AND CONCLUSIONS

Keel Mountain, Gurley, Alabama, ~2:00PM CDT, June 19, 2004
Cloud base altitude ~4,000 feet, Cloud base temperature 65-69 F
Winds at surface NNW 10-15 MPH, Winds aloft NW 15-20 MPH
Photo and observations courtesy of Isaac Jones, hang glider pilot

CHEM/CLOUD PROSPECTUS

Overview

GOALS:

- improved modeling of vertical transport and chemical process associated with non-precipitating (or shallow precipitating) cumulus clouds

FOCUS:

- humid continental boundary layer over the southeastern United States

APPROACH:

- coordinated remote sensing of clouds, winds, aerosols, trace gases
- identification and parameterization of correlated satellite observables
- Large Eddy Simulation (LES) modeling and mesoscale modeling (MM5/Models-3/CMAQ) of meteorology and chemistry

Keel Mountain, Gurley, Alabama, June 19, 2004, courtesy of Isaac Jones

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Science Questions

How deep are the convective roots of non-precipitating clouds?

What are the characteristic structures of these convective roots?

What are the life cycle relationships between clouds and roots?

How do clouds and their roots interact with adjacent clouds, and with land surface effects, including orography and soil moisture?

What are the effects of cloud-driven circulations on the entrainment of water vapor, aerosols, and trace gases into cloud bases?

What are the effects of the entrained trace materials on cloud properties?

Can we quantify the exchange processes and the mass & energy fluxes between the PBL and the Free Troposphere throughout the diurnal cycle?

Do clouds and their convective roots exhibit satellite-observable signatures that could be used to improve cloud parameterizations (dynamic, chemical, microphysical) in chemical transport models?

photo courtesy of Isaac Jones

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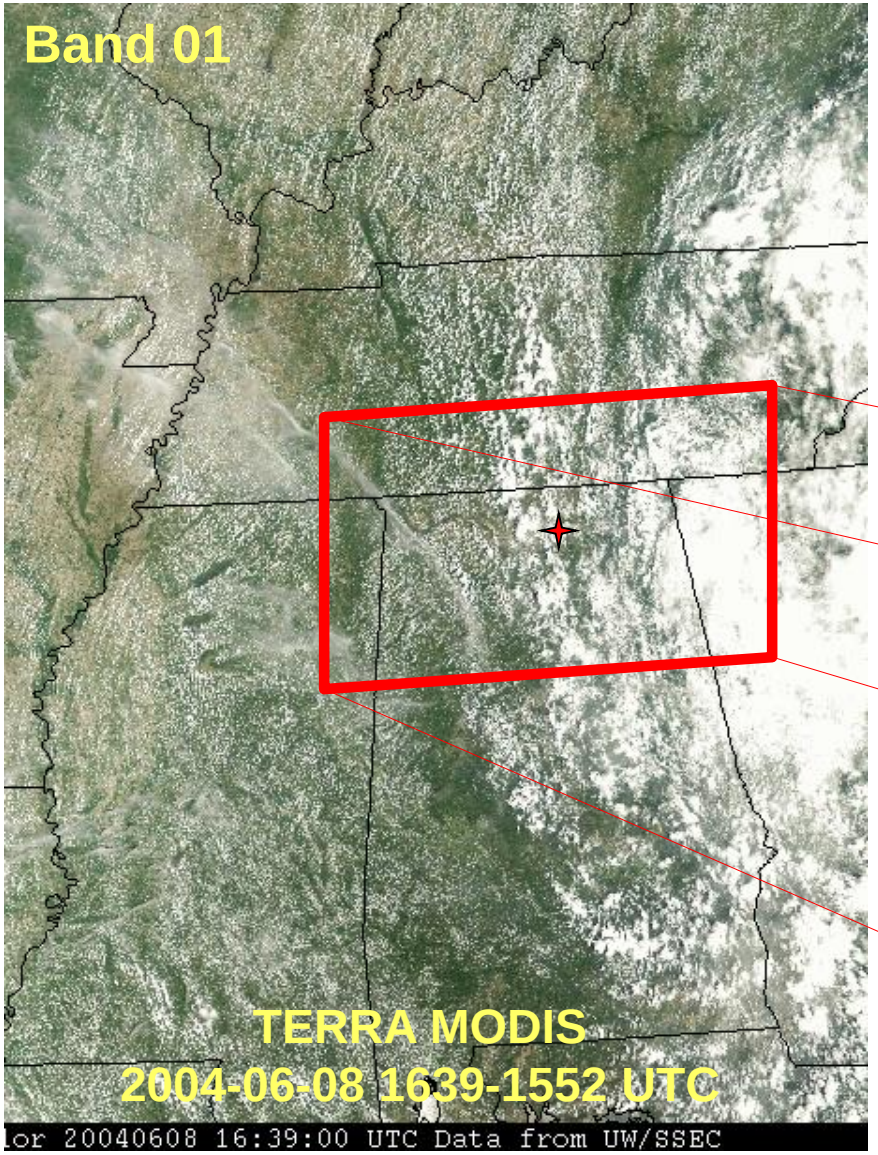
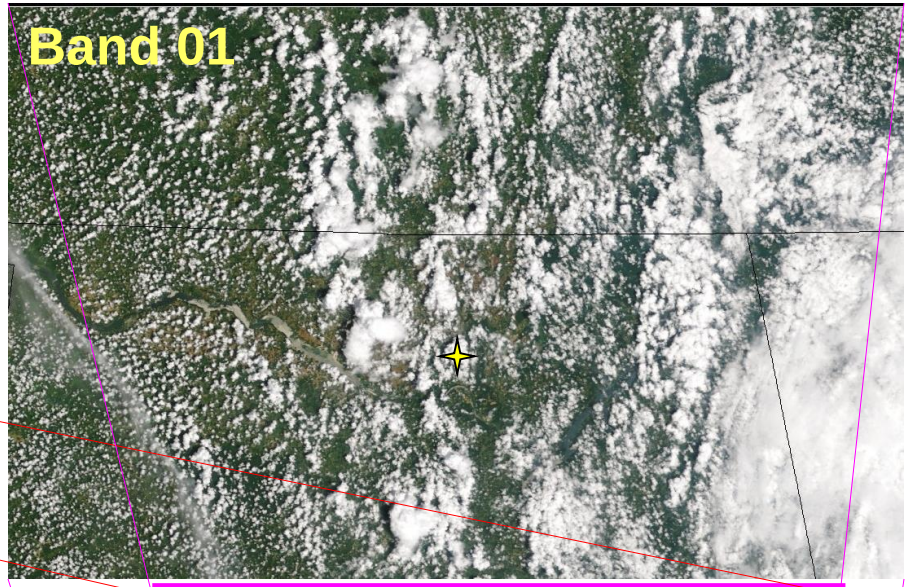
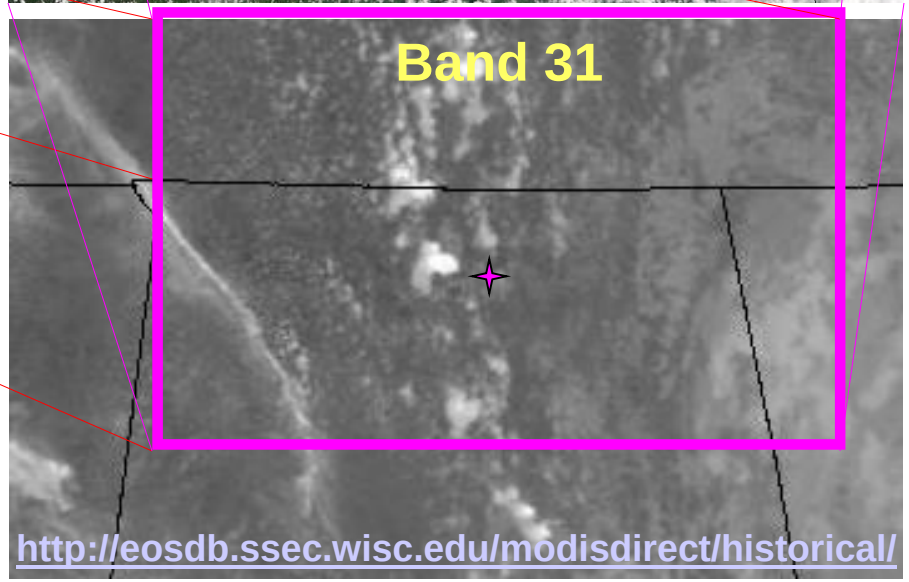
Meteorological Target: Humid Continental Boundary Layer
Capped by Fair Weather Cumulus Clouds over the Southeastern US







courtesy of: Stephanie Haines, UAH ATS; and SSEC, University of Wisconsin

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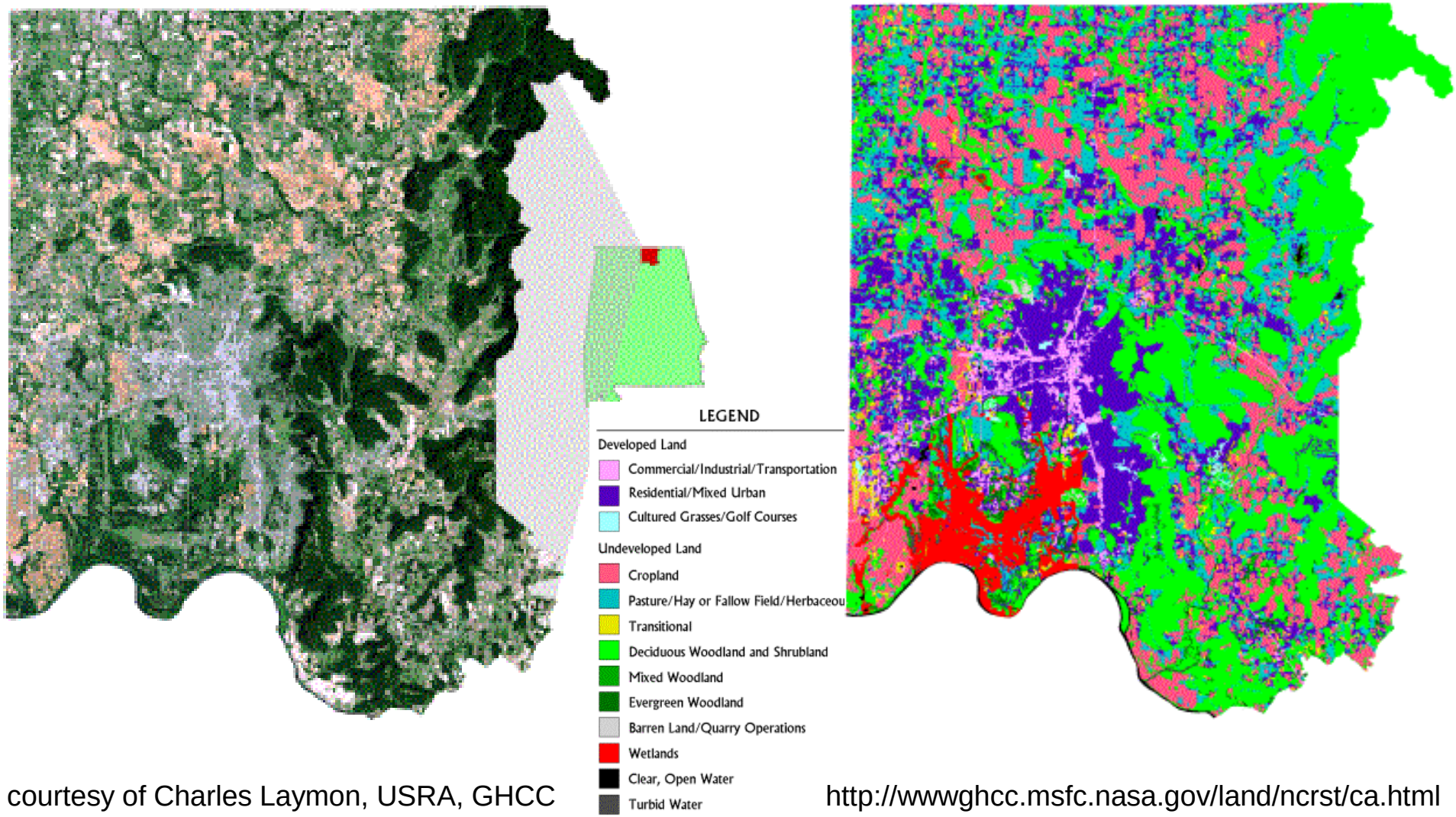
Geographical Setting: Madison County, Alabama
Centered on RAPCD Site in Huntsville

pseudo-true color image

false-color land use image



courtesy of Charles Laymon, USRA, GHCC

http://wwwghcc.msfc.nasa.gov/land/ncrst/ca.html

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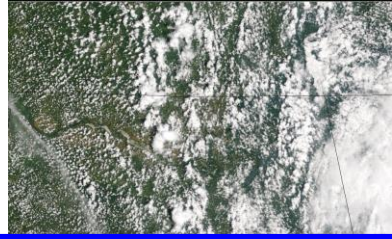
Instrumentation: Needs and Status



WIND SENSORS

- ❑ multiple Doppler lidars
- ✓ multiple Doppler sodars
- ✓ multiple Doppler radars
- ✓ 915 MHz microwave profiler
- ✓ mobile probes, 10-m met tower

TRACE CONSTITUENT SENSORS

- ✓ ozonesondes, ozone DIAL
- ✓ aerosol/cloud lidars, ceilometer
- ✓ radiometer (water vapor, temp, LWC)
- ❑ Raman lidar (water vapor, clouds)
- ❑ DOAS, FTIR solar tracker

SATELLITE-BASED SENSORS

- ✓ GOES (IR skin temp, VIS/IR cloud)
- ✓ AQUA: MODIS (clouds), MOPITT (CO, CH_4), -AIRS (temp, H_2O)
- ❑ AURA: OMI (O_3, NO_2, $HCHO$), TES(O_3, CO)
- ❑ CALIPSO: aerosols, clouds

INSTRUMENT COORDINATION

- ❑ multiple digital cameras
- ❑ intelligent sensor web

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Multi-Scale Modeling: Needs and Status

MICROSCALE
lower troposphere

LARGE EDDY SIMULATION (LES)

❑ merge

PBL
✓ dynamics
✓ gas chemistry
✓ thermodynamics
❑ aerosol processes

CLOUD
✓ dynamics
✓ microphysics
✓ thermodynamics
❑ chemistry

initial conditions & boundary conditions
✓ IC ✓ BC

MESOSCALE
full troposphere

with

SATELLITE DATA ASSIMILATION

❑ clouds
✓ sfc

✓ clouds
✓ J*

METEOROLOGY
(MM5 with 4DDA)

✓ sfc energy balance

✓ radiation

PBL and cloud
✓ dynamics
✓ thermodynamics

AIR QUALITY
(Models-3/CMAQ)

trace gas
✓ emission
✓ transport
✓ chemistry

✓ aerosol processes
✓ cloud processes

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Experiment Plan

INSTRUMENT DEPLOYMENT

- Core: RAPCD (lidars [Doppler, aerosol, Raman, ozone], FTIR, DOAS, sondes)
  MIPS (sodars, profiler, ceilometer)
- Network: multiple Doppler lidars, multiple triangular arrays, SW-NE
- Boundary: multiple Doppler radars

INSTRUMENT OPERATION

- highest priority during diurnal PBL stability transitions
- all systems on standby or routine operation during designated periods
- FTIR, chemistry lidars, run routinely to characterize trace constituents
- cameras & Doppler radars identify promising clouds, notify network
- all sensors monitor target clouds that traverse their domain
- modify as needed, based on wind direction, targets of opportunity

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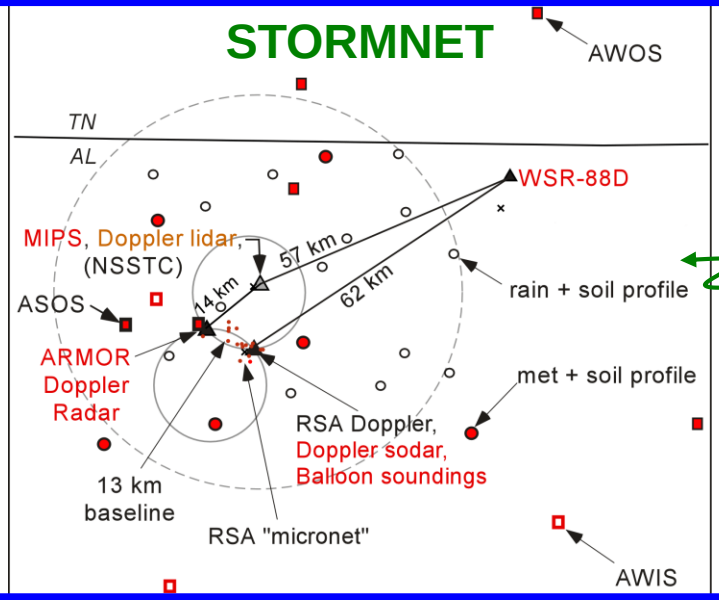
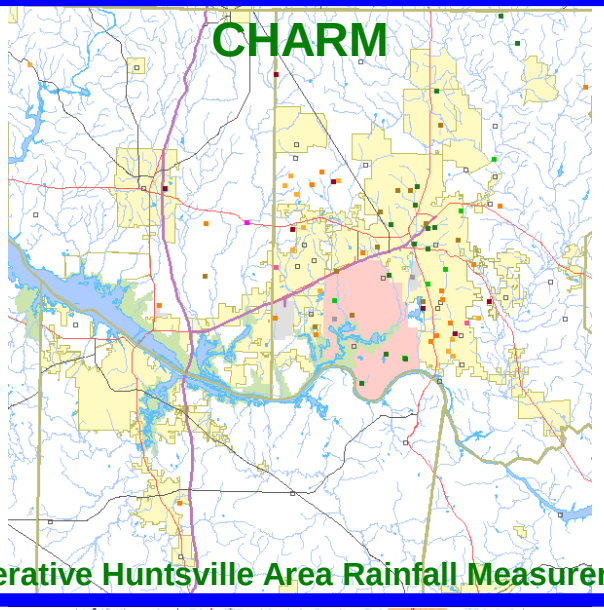
Network Maps

STORMNET



existing

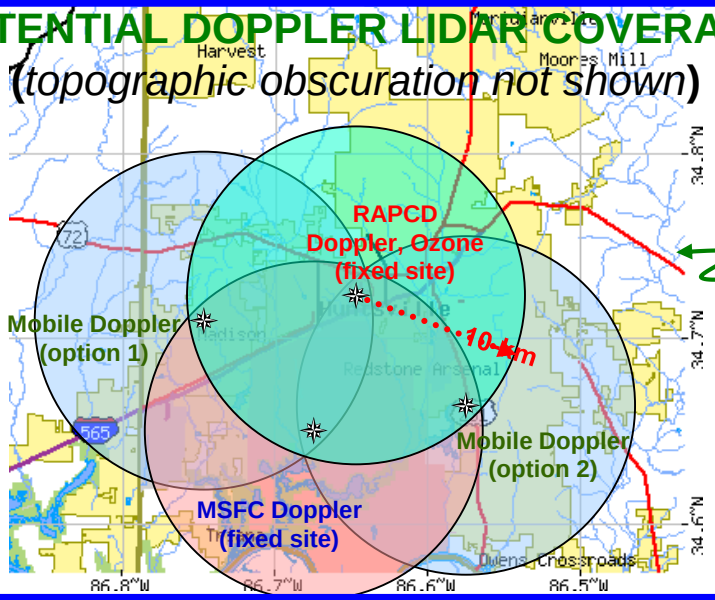
CHARM



Cooperative Huntsville Area Rainfall Measurements

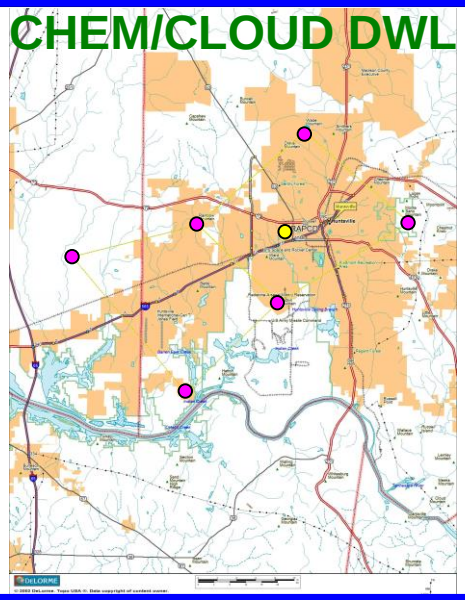
POTENTIAL DOPPLER LIDAR COVERAGE

(*topographic obscuration not shown*)



concepts

CHEM/CLOUD DWL



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Guest Instrument Accommodations at NSSTC

GROUND-LEVEL

- **five power/Internet stations, manage at least five trailers**
- **two in graveled lot with security fence, others on grassy knoll**

LABORATORY

- **two Newport optical benches, RS-4000, 4 ft x 8 ft x 8 in, I-200 isolators**
- **four optical chimneys, 36 in x 36 in, motorized hatches, rain sensors**
- **120VAC, 208VAC single-phase, 208VAC three-phase, Internet**

ROOFTOP

- **main roof: 42 ft x 42 ft utility platform; electrical power, Internet**
- **penthouse roof: telescope pier, 21 in x 21 in, anchor on penthouse floor**

photo courtesy of Isaac Jones

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Programmatic Issues

SPONSORSHIP

- approach multiple agencies

PARTICIPANTS

- identify interested researchers

PROPOSED SCHEDULE

- develop white paper after Frisco meeting
- exploratory mini-experiment, spring 2005
- intensive experiment, spring 2007

courtesy of Isaac Jones

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Summary and Conclusions

APPLICATIONS

- air pollution assessments
- ground-truth for satellite-based sensors
- urban- to regional-scale climate modeling
- regional- to global-scale climate modeling
- tactical-scale tracer models for national security

OPPORTUNITIES

- demonstrate maturity of Doppler wind lidars
- invite further discussions with interested parties

photo courtesy of Isaac Jones