Educational Innovations in Radar Meteorology

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A look back…….

A look at the present……..

A look ahead……..

Survey sent to many radar meteorologists…..

Questions asked:

1. State briefly what exposure you had to radar equipment as a graduate student, including the when/where/what. What were some of the most memorable aspects of your graduate level education in radar meteorology?

2. Briefly describe the radar educational aspects of your position at present. Do you regularly use and have access to radar equipment? What use do you make of the Internet in radar education?

3. What is your wish list for the future in terms of radar education, assuming no budget limits?

Selected responses….

Question 1 (memorable aspects of one's early education in radar…)

"Having daily contact with Speed Geotis and Pauline Austin. Using tracing paper and colored pencils to track echoes observed by the MIT radar. Using filter paper to measure drop size distributions by hand. Hearing Juerg Joss talk about early disdrometers." (R. A. Houze)

"Memorable discussions with Dave Atlas, Bernard Vonnegut, Lou Battan and Roger Lhermitte on the use of radar to assess the idea that gravitational power of settling precipitation particles provides energy for electrical breakdown. Assembling an X-band radar with Roger Lhermitte providing a valuable hands-on experience." (Earle Williams)

My interest in radar began at the University of Texas where an "old boat radar" was located on top of the Engineering building. My interested was further heightened by working with the NCAR C-bands and the NOAA airborne radars under Bob Houze's guidance at the U. of Washington. (Mike Biggerstaff)

"In 1960, assembling a AN/APS-15 antenna, AN/APS-3 radar and a Navy VE-2 PPI display, and later working with a CPS-9 radar at the Illinois State Water Survey under the guidance of Gene Mueller" (Ron Rinehart)

Selected responses….

Question 1 (memorable aspects of one's early education in radar…)

"I was exposed to CP-3, CP-4 and CHILL as a second year graduate student at the University of Chicago during the NIMROD experiment. Seeing the first ever color display of reflectivity and velocity. Having the pleasure of helping to dismantle the CP-3 antenna at the end of the project." (R. Wakimoto)

"At McGill, I worked to assemble an X-band vertically pointing radar, wrote the data acquisition code, and analyzed the data. Long hours were spent at the radar observatory where I was exposed to radar maintenance/repair needs, and could spend hours looking at displays of all sorts of weather." (F. Fabry)

Hands on experience is critical!

Exposed to hardware and engineering aspects of radars, calibration

Doing simple experiments and integrating the radar measurements with other observations

NCAR CP-3 and CP-3 mobile C-bands

The "educational workhorses" of the 70's and 80's

Radar systems developed at NOAA/ETL were also key education platforms in this era-and still are today

NCAR CP-2, the "polarimetric" centerpiece in the 80's and early 90's

Selected responses….

Question 2 (current educational activities….)

"We were very fortunate at UND to have a C-band Doppler radar as a teaching tool." (R. Rinehart)

"The DOW's are heavily used for classroom projects. Students write mini proposals to develop the research idea and take data. Formal reviews of the proposals are done and not all are funded!" (J. Wurman)

"We rely heavily on archived images of NEXRAD and other radars." (R. Wakimoto)

Excellent opportunities exist today for hands-on education, that far exceed what was available even 1-2 decades ago. However, many institutions still desire direct access to even a small "teaching" radar.

Mobile radars such as the DOW, SMART-R, U. Mass/OU and U. Miami systems can help fill this gap.

VIRTUAL CHILL-provides exposure to radar via the Internet

CSU-CHILL National Radar Facility

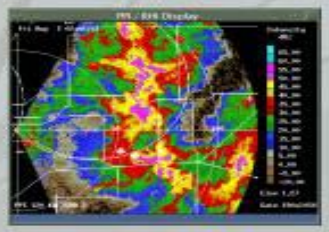
The modern-day educational and research radar

Exposure through field projects, 20 hour projects, REU projects, summer visitor program (beginning 2002).

www.chill.colostate.edu

Visiting Student Program

During the Summer of 2002, the Colorado State University CHILL Radar Facility will launch its Visiting Student Program. Two students (one in Atmospheric Science and one in Electrical Engineering) will be selected to spend 4 weeks at the facility for instruction and data collection to acquire a data set for thesis research. Students will receive support for lodging, per diem and local transportation.



Selection will be based upon a project proposal submitted by students and their advisor. First year graduate students are especially encouraged to apply. We strongly encourage the participation of women and minorities in this program.

For more information about this program and application requirements, please visit out web site at

www.chill.colostate.edu/VisitingStudent

Applications are due by February 28, 2002

CSU-CHILL Radar Facility

The CSU-CHILL Facility issupported by the National Science Foundation and Colorado State University.

NSF

Colorado State University

Knowledge to Go Places

NCAR S-pol radar

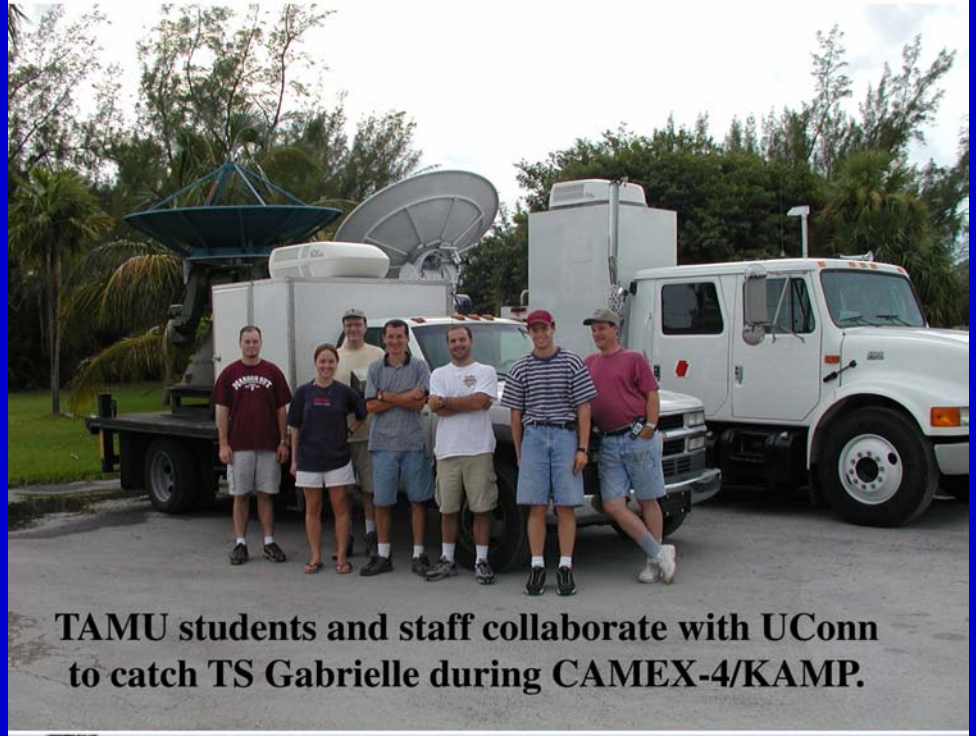
10 cm Doppler, polarimetric radar
Highly portable, six 20 ft. seatainers
Diesel generator powered
Easy set up
Peak power 1 Mw
1 degree beamwidth antenna
Suite of Doppler and polarimetric variables
Doppler measurements, polarimetric-based rainfall maps, hydrometeor identification
Internet ready
Excellent educational opportunities for both graduate (field projects) and undergraduates (e.g., REU projects)

NASA N-pol radar

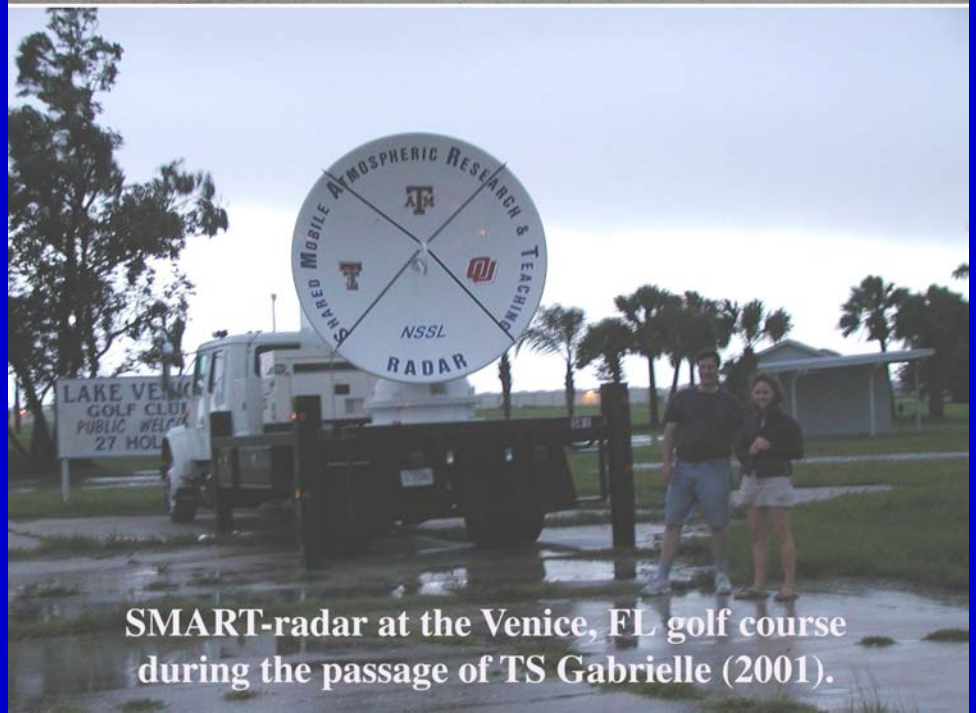
10 cm Doppler, polarimetric radar
Highly portable, four 20 ft. seatainers
Diesel generator powered
Easy set up
Peak power 50 kw
1.4 degree beamwidth antenna
Suite of Doppler and polarimetric variables
Internet ready

The era of the mobile radars-

---moving laboratories that can visit institutions that do not have their own radar systems



TAMU students and staff collaborate with UConn to catch TS Gabrielle during CAMEX-4/KAMP.



SMART-radar at the Venice, FL golf course during the passage of TS Gabrielle (2001).

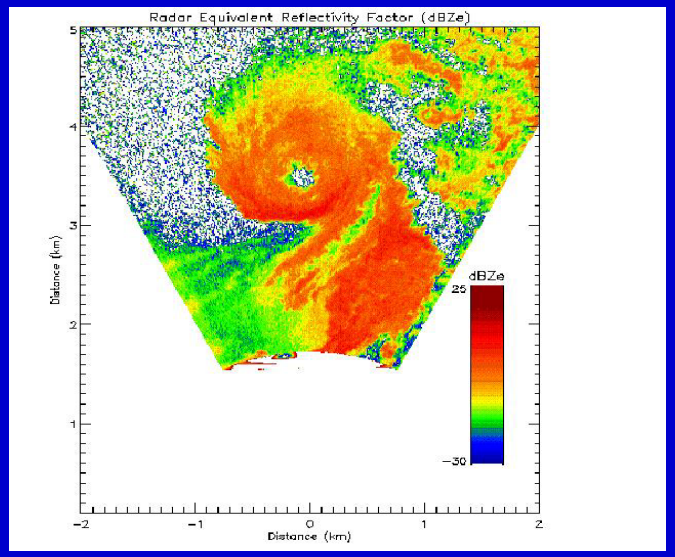
SMART-R
Shared Mobile Atmospheric Research and Teaching Radar

Texas A&M, Texas Tech, Univ. of Okla, NSSL

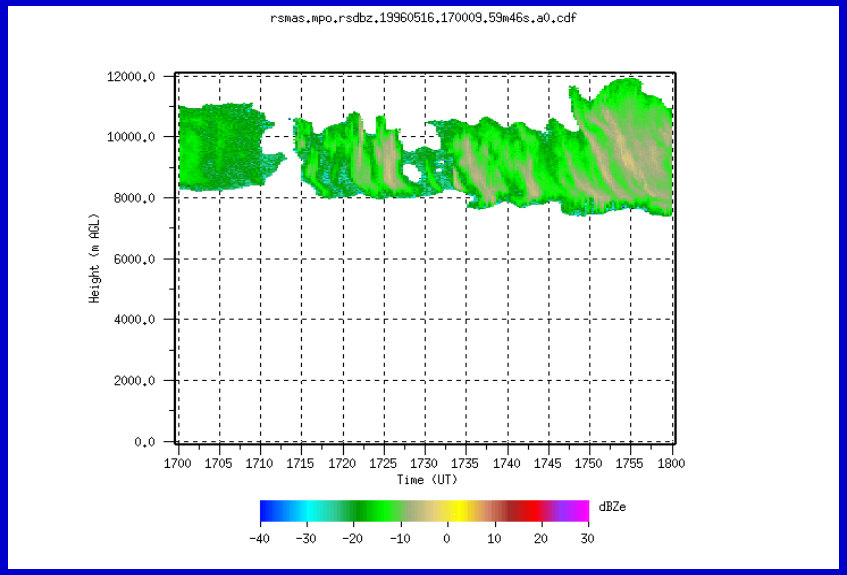
Seminole Mobile C-band ready soon

OU DOW's—mobile X-band Doppler radars

UMASS/MIRSL-OU 95 GHz Mobile Doppler



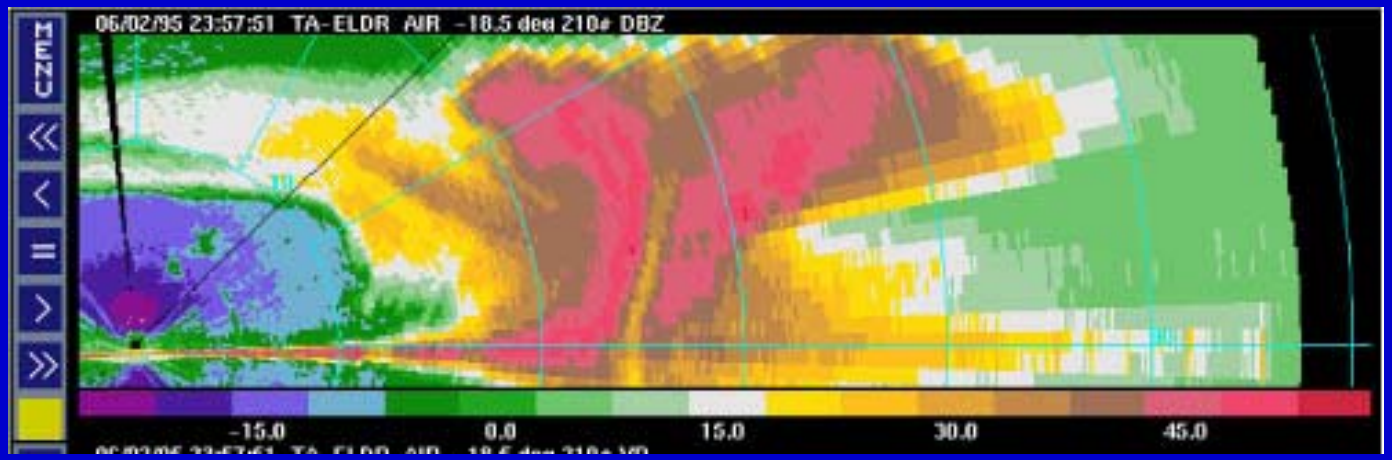
U. Of Miami 94 GHz portable Doppler radar



NCAR/NSF ELDORA X-band airborne Doppler radar

NOAA P-3 airborne Doppler radars

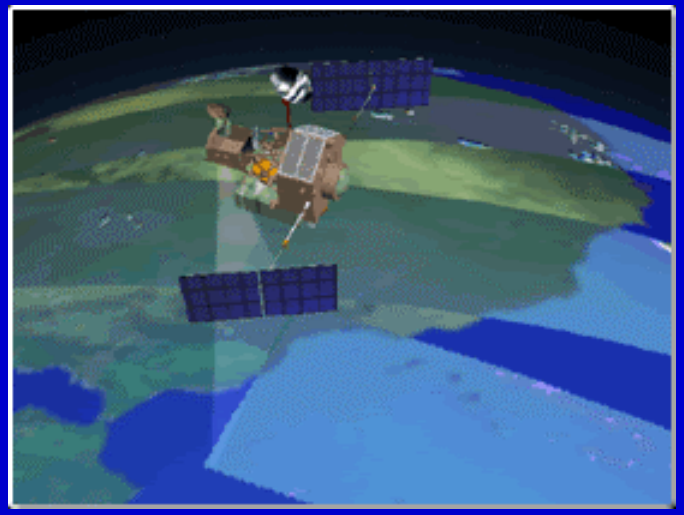
NASA ER-2 EDOP radar



Shipborne radar---R/V Ronald H. Brown

❑Instruments

- Radar (Scanning C-band Doppler; Vertically pointing Ka-band Doppler)
- Rawinsonde
- 915 MHz wind profiler
- DIAL/Mini-MOPA LIDAR
- Multi-spectral radiometers
- Air-sea flux system
- Meteorological observation (T,RH, P), rain gauges and ceilometer
- Oceanographic measurements including SST, CTD and ADCP



Spaceborne radars, e.g. NASA/TRMM provide educational opportunities

Our challenge is to identify ways to actively involve these diverse facilities in the formal educational setting. REU projects and field programs are excellent venues, but they only allow a fraction of the students in our discipline to be exposed to instrumentation, and for relatively short periods of time. These efforts typically involve NSF facilities only. Need to identify mechanisms whereby students and faculty can gain access to non-NSF facilities as well. Need to provide mechanisms to provide students hands-on experience for prolonged periods.

R/V Brown is essentially a floating classroom!

Today's radar meteorology course emphasizes both "meteorological" and "engineering" aspects of the field----

Electromagnetic concepts, Doppler principles

Scattering matrix, Rayleigh-Gans approximation, Mie scattering

Radar systems, range equation, Mueller and covariance matrices

Dual-polarization variables, wave propagation in precipitation media

Doppler radar signal theory

Engineering principles, transmitters, receivers, antennas

Signal processing techniques

Ray propagation and anomalous propagation

Syllabus, continued:

Doppler radar techniques, single and multiple Doppler and applications

Polarimetric radar observations, hydrometeor identification techniques, rainfall estimation, cloud and precipitation physics

Profilers, lidars, cloud radars, spaceborne radars, shipborne platforms

Real time observations of meteorological phenomena

NEED TO CONTINUE TO DEVELOP JOINT COURSES IN RADAR METEOROLOGY OFFERED BY ATMOSPHERIC SCIENCE AND ELECTRICAL ENGINEERING FACULTY

INTERNET and EDUCATION

Internet technology allows radars to be brought to the classroom in an interactive manner.

In particular, CSU has embarked on a major initiative called VCHILL, aimed at bringing the CSU-CHILL NSF Facility closer to research and educational institutions, in a virtual sense.

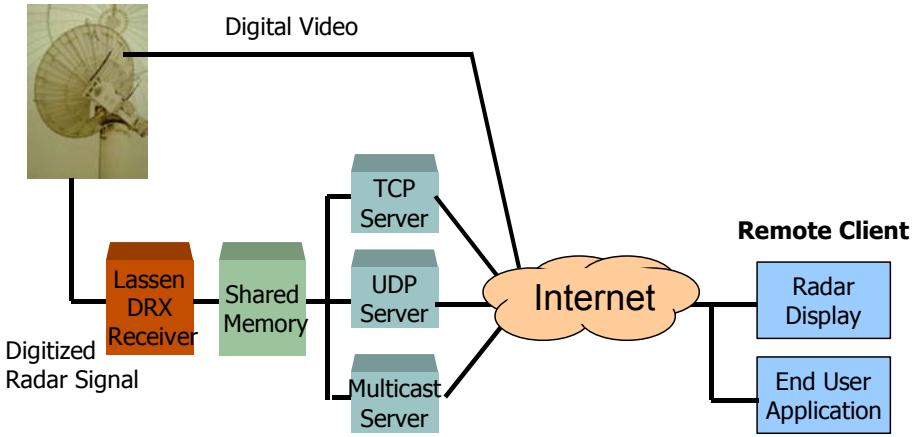
VCHILL enables real time operation of the radar distributed over the Internet—active users need not be physically located at the Facility.

This figure illustrates the VCHILL concept, allowing students to see live data and direct data acquisition from their remote classrooms.

VCHILL Concept

Remote user sees the rotating beam of the antenna in real time

Architecture of VCHILL



Allows transmission of high bandwidth digitized data to allow remote processing of the data stream

Two-way video conferencing is supported to allow on-line experiments in the remote classroom.

Video Conferencing for class room demonstration