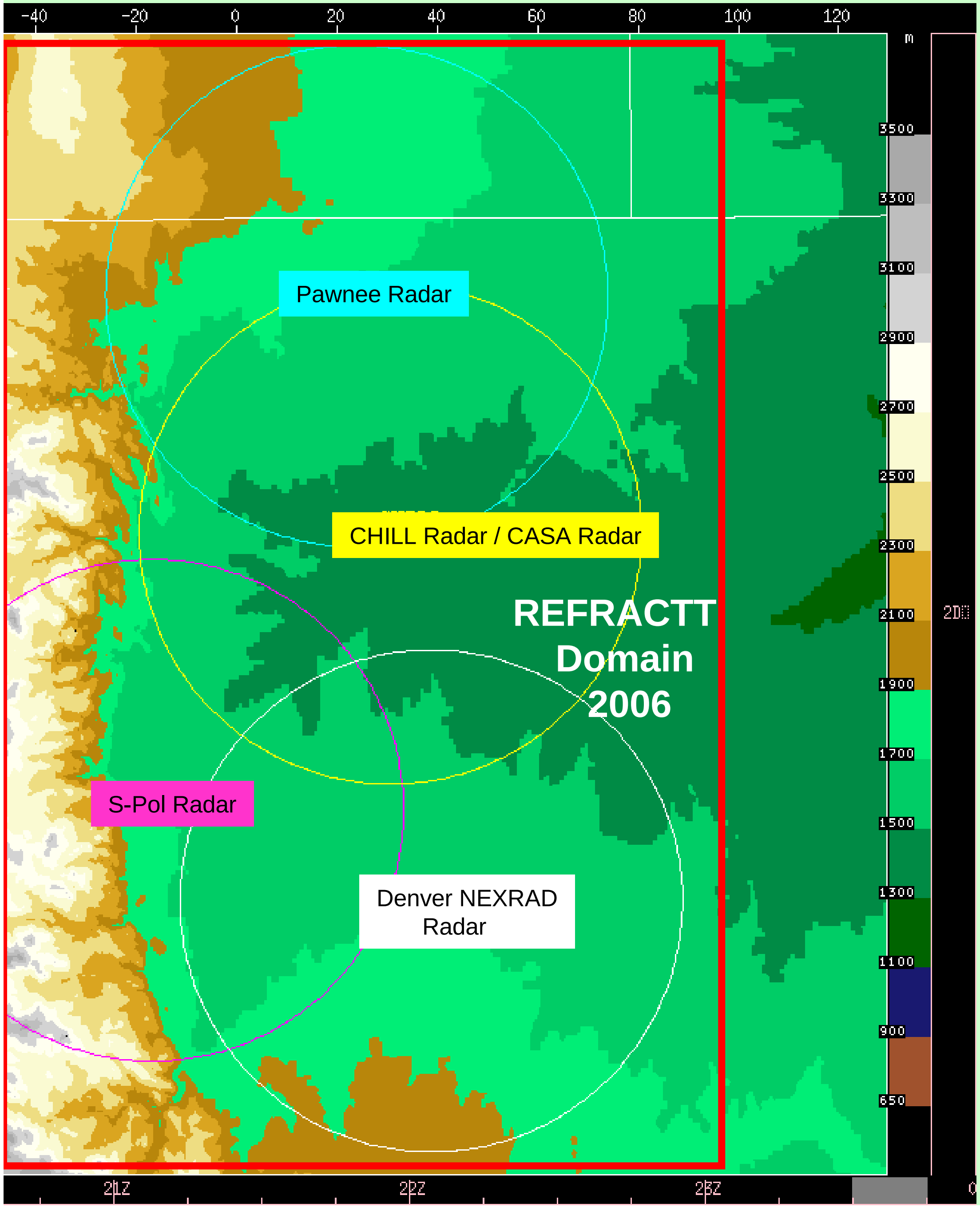
REFRACTT-2006 Results

Rita Roberts, NCAR/RAL

TAC Teleconference Briefing

1 November 2006

REFRACTT -2006



Data Sets

Radars:

- NCAR S-Pol Radar
- CSU CHILL and Pawnee Radars
- NWS NEXRAD Radar
- CASA X-band
- ENVISAT ASAR

Radiosondes:

- Mobile sounding system
- NWS Soundings

GPS receivers (20)

Radiometers

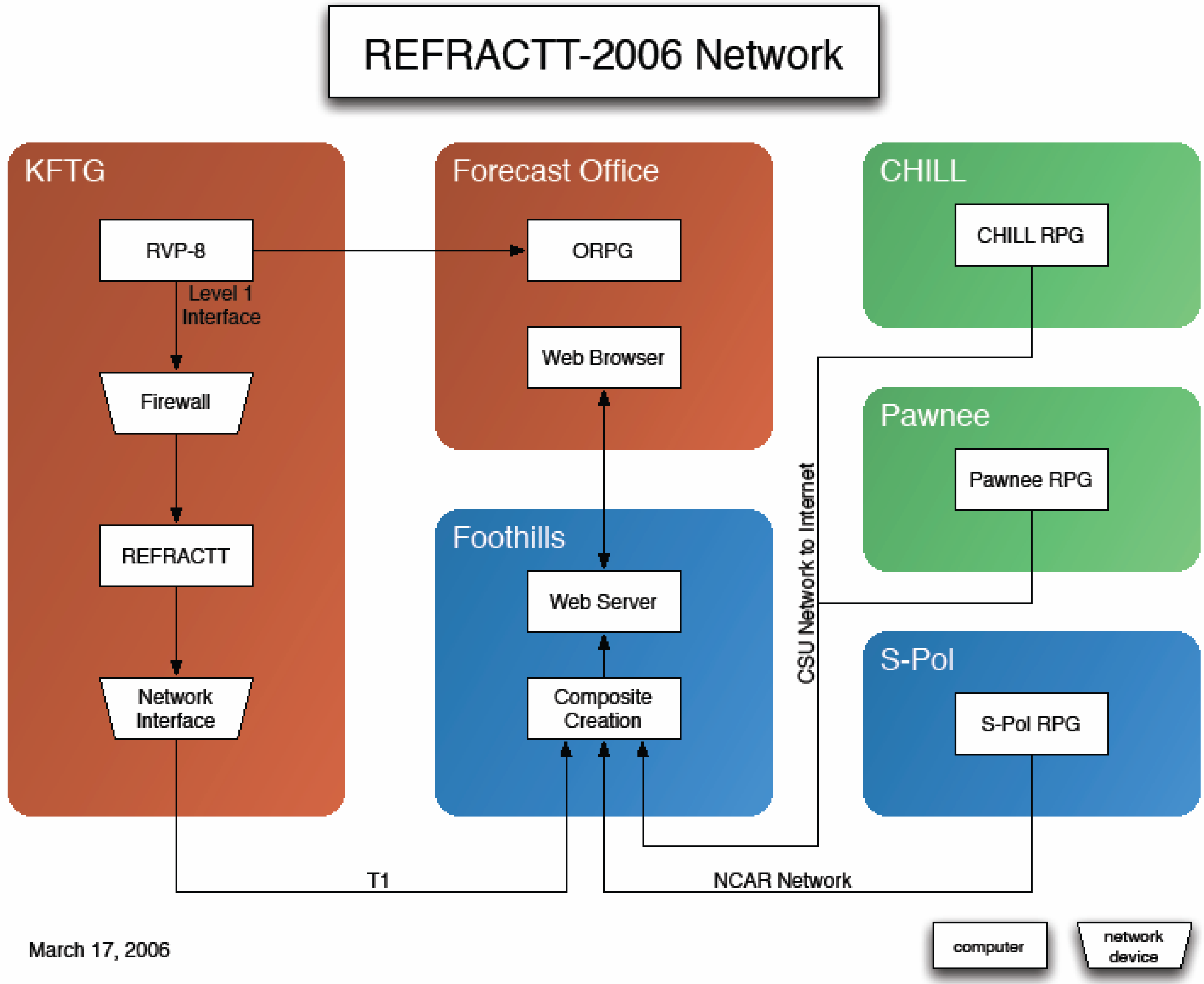
- CSU Mini-radiometers
- Radiometrics radiometer

GOES Satellite

Surface mesonet weather stations

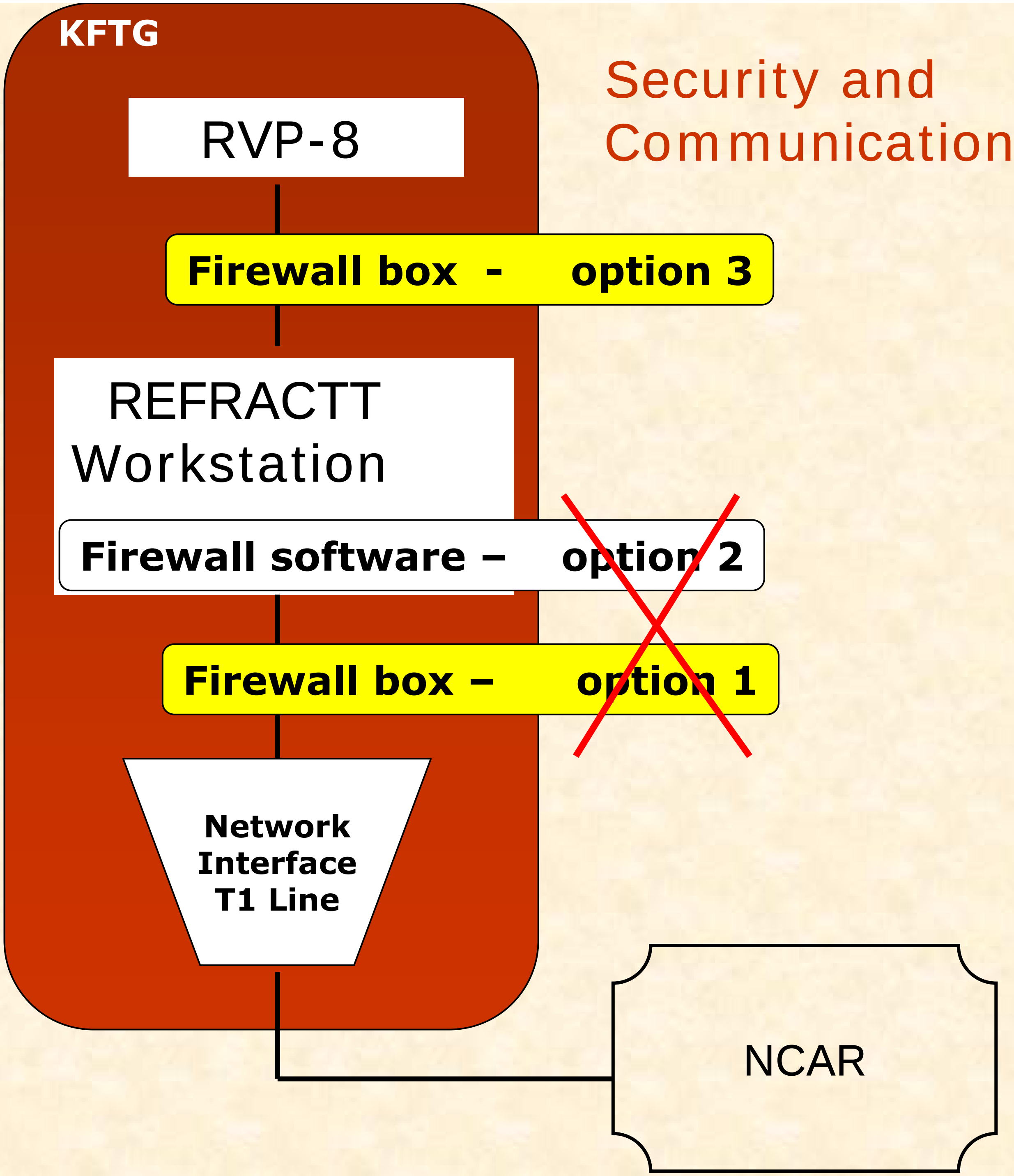
Accessing Denver FTG Data

- Tri-agency approval to access FTG received in late May.
- Security clearance testing of NCAR REFRACTT workstation done at the ROC the last week of June.



REFRACTT-2006 Network
KFTG
RVP-8
Level 1
Interface
Firewall
REFRACTT
Network
Interface
Forecast Office
ORPG
Web Browser
Foothills
Web Server
Composite
Creation
CHILL
CHILL RPG
Pawnee
Pawnee RPG
S-Pol
S-Pol RPG
CSU Network to Internet
T1
NCAR Network
March 17, 2006
computer
network
device

Security and Communications Issues



Accessing Denver FTG Data

- Tri-agency approval to access FTG received in late May.

- Security clearance testing of NCAR REFRACTT workstation done at the ROC the last week of June

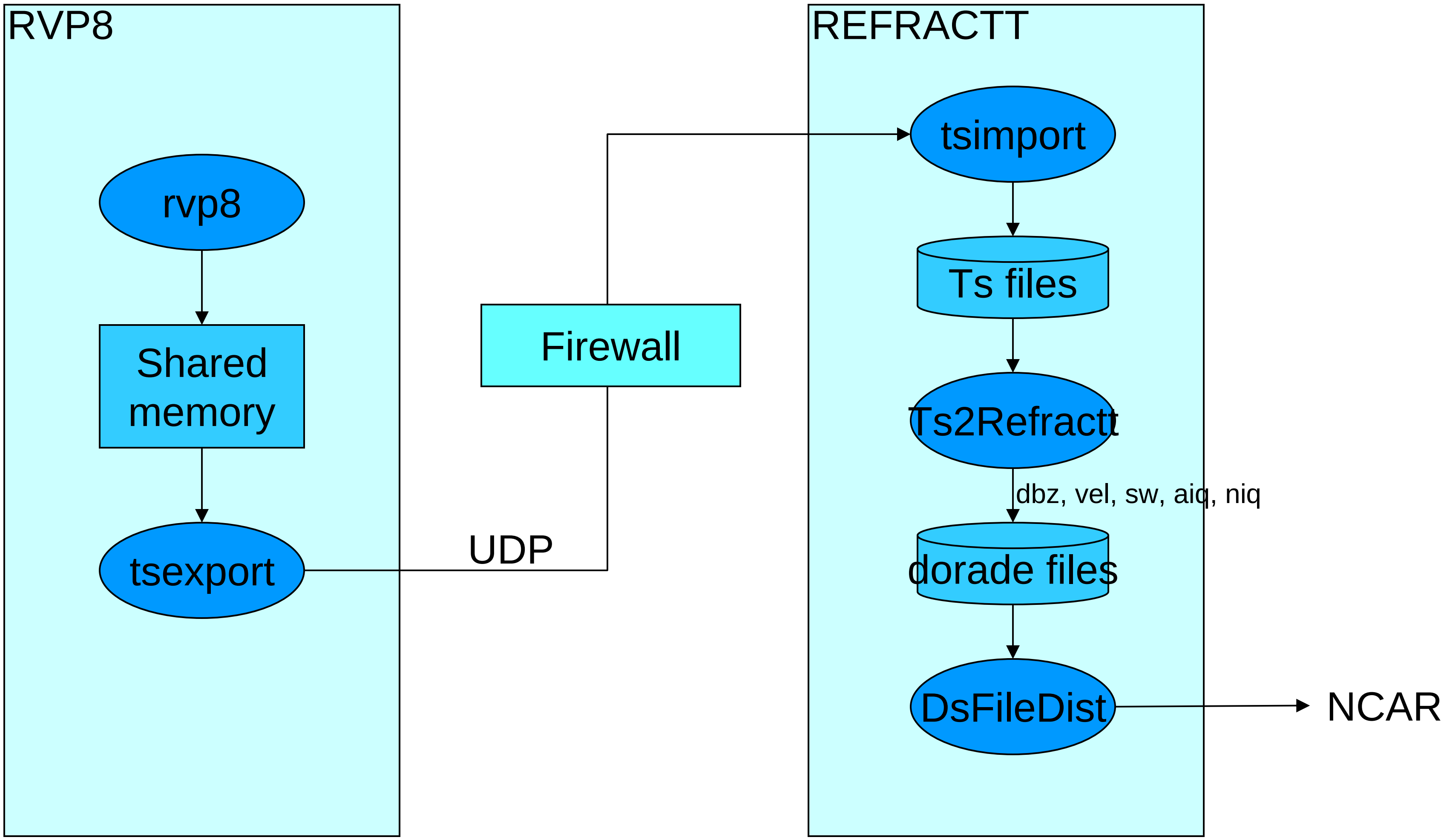
- Auxiliary workstation and GPS frequency counter hardware installed on 11 July.

- T1 Line not activated until 14 July. Data flow to NCAR ensued.

- Preliminary calibration data set collected on 29 July used for real-time FTG refractivity fields

- Better calibration dataset collected on 6 Aug

Software written by Mike Dixon and Nancy Rehak was tested on S-Pol RVP8 prior to smooth installation on the KFTG auxiliary machine



"REFRACTT" at KFTG

NCAR Workstation and Data Processing Software

Software Accomplishments

- Modification and streamlining of data ingest software for compatibility with NEXRAD ORDA system (Dixon, Rehak)
- Significant effort was directed at optimizing and transitioning Fabry's research software into operationally efficient code (Rehak, Fritz, Flanigan, Fabry)
- Protocol was defined for assignments of responsibilities by NCAR, ROC, and/or NWS WFO during FTG data flow outages (Horvat, Heimer, Hoffmeister, Ladd)
- Enabling the transfer of I and Q data from the ORDA port to the REFRACTT workstation involves the entering of a couple of commands on the command line. NWS technicians type this in during any reboot process at the radar. Would be ideal to incorporate these two commands in the future into the existing reboot software.

Accessing Denver FTG Data Involved Significant Effort By…..

Tim Crum (ROC)
Mike Dixon (NCAR/RAL)
John Heimer (ROC)
Tres Hoffmeister (NCAR/RAL)
Christina Horvat (ROC)
John Hubbert (NCAR/EOL)
Robert Ladd (Denver NWS)
Tommy Mcgehee (ROC)
NWS Technicians

Larry Mooney (Denver NWS)
Joseph Muffoletto (ROC)
Rex Reed (ROC)
Nancy Rehak (NCAR/RAL)
Rita Roberts (NCAR/RAL)
Bob Saffle (OST)
Jeff Stolte (NCAR/RAL)
TAC members
Joe VanAndel (NCAR/EOL)

REFRACTT Accomplishments

- Successfully demonstrated ability to obtain and mosaic water vapor from research and *operational* radars.

- Largest domain over which high resolution, low-level water vapor has been collected in real-time

- Data obtained from a spectrum of events:

  -stationary convergence zones,
  -gust fronts and boundary collisions
  -convection initiation,
  -rapid drying in the boundary layer, and
  -cold front passage and post-frontal convection.

- Mosaics of refractivity fields were provided in real-time to the Denver NWS forecasters for use in short term nowcasts.

Interaction with the Denver NWS WFO

- Training on the refractivity technique was conducted during two sessions of their Spring Convective Weather Workshop
- Forecaster feedback was solicited in the development of the refractivity web page produced for the NWS
- Most of communications with NWS forecasters during REFRACTT operations was via telephone, email exchanges, and a few surveys.

Real-time web page developed for NWS forecasters by Rehak

Features include:

Refractivity (*N*) and delta-*N* fields (*N*) from FTG, S-Pol and CHILL radars

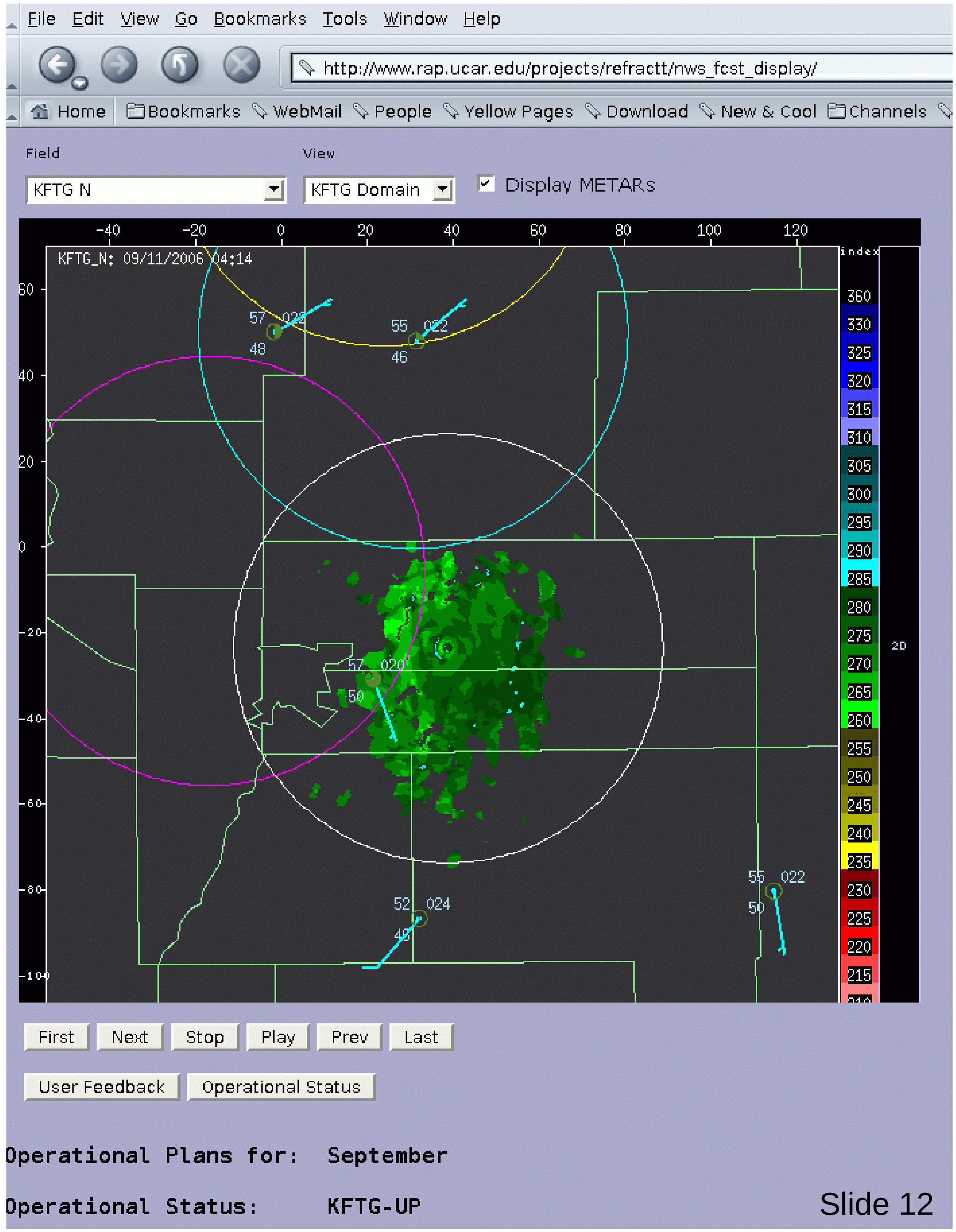
Mosaic *N* field

Mosaic dewpoint temperature field

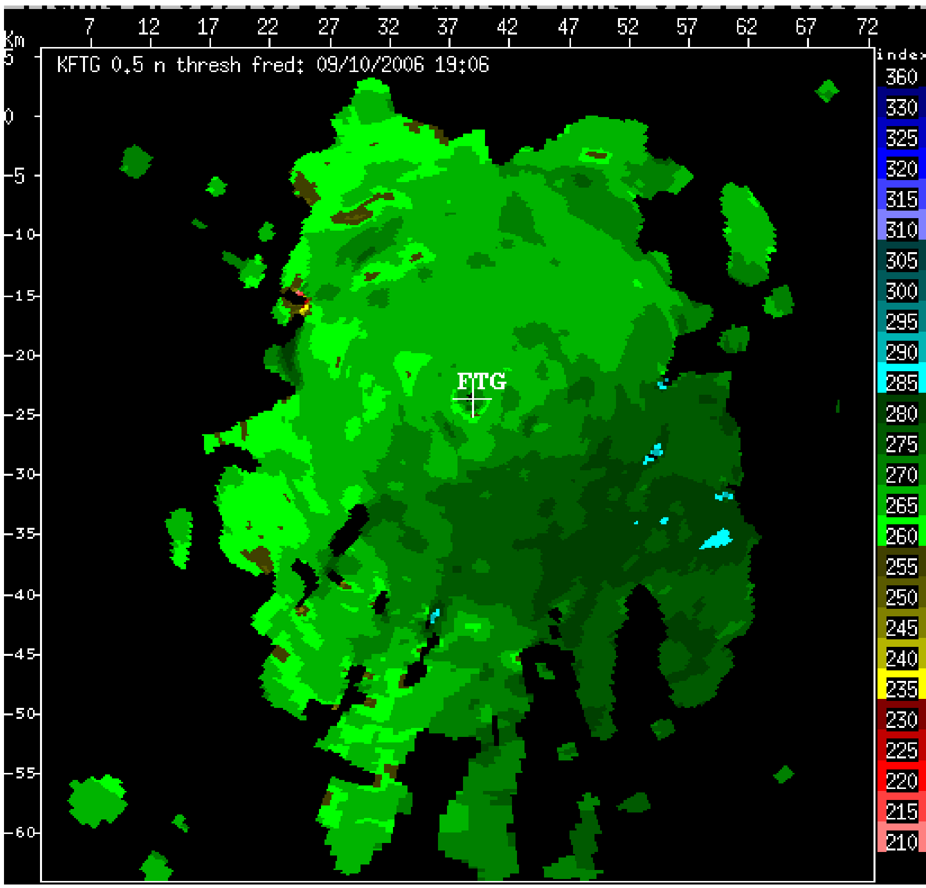
Selection of domain sizes

Display of METARS, precipitation accumulation and reflectivity

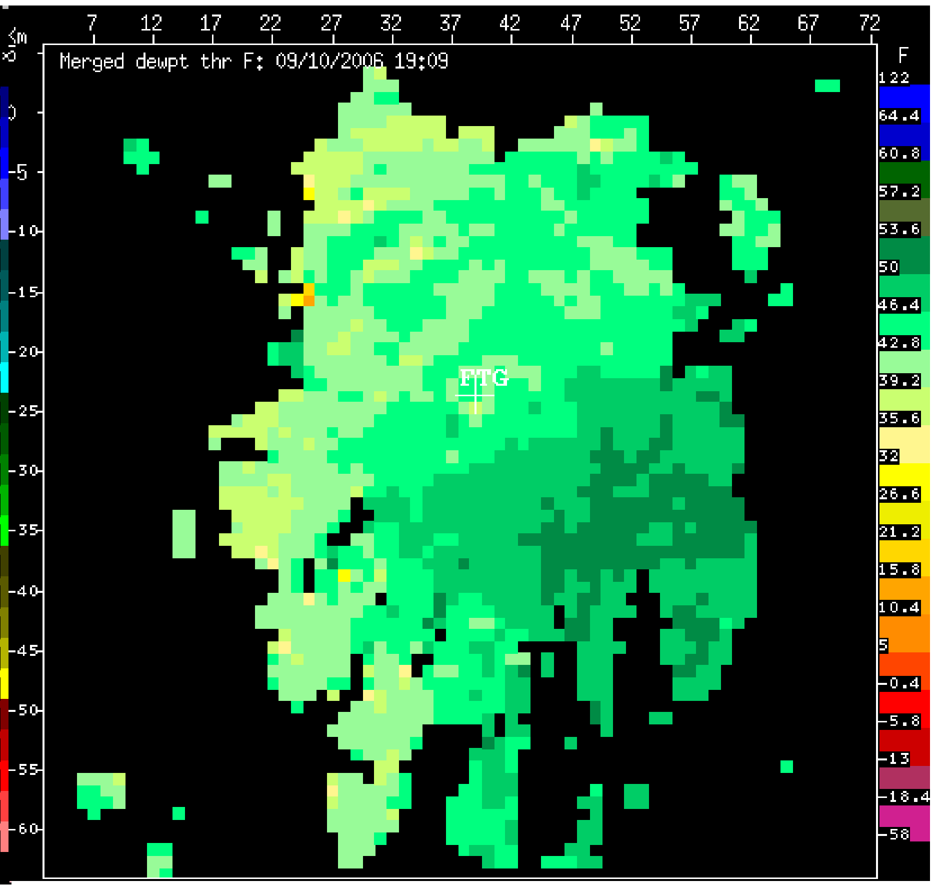
Forecaster survey form



Refractivity and Dewpoint Temperature Fields



Refractivity, *N*



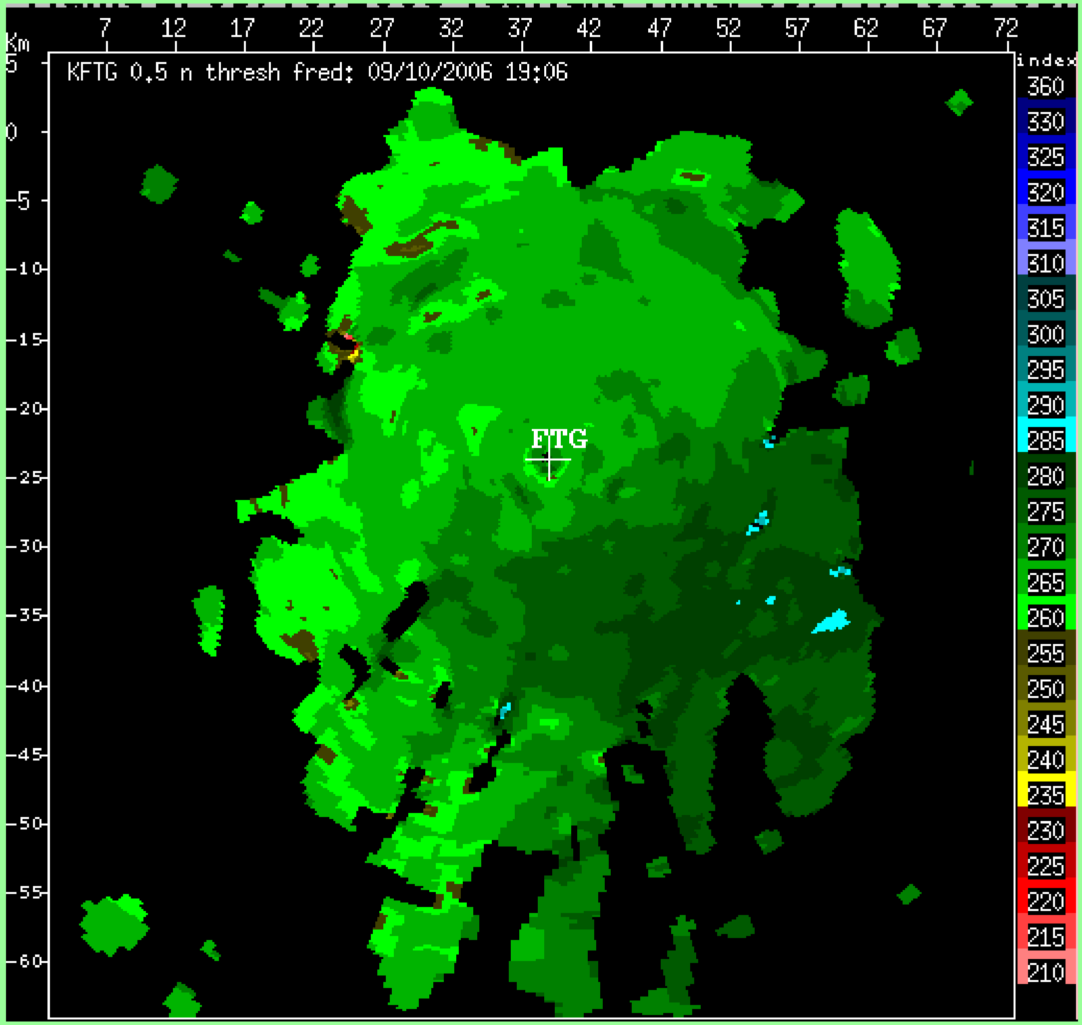
Dewpoint, T_d (^oF)

SomeHighlights from REFRACTT

- Cold frontal passage
- Stationary convergence zones
- Significant drying in the boundary layer
- Gust fronts and convection initiation
- Post-frontal, synoptically-driven convection

Radar Refractivity *N* (Water Vapor)

Field looks much better than data collected with the A1DA recorder in 2005

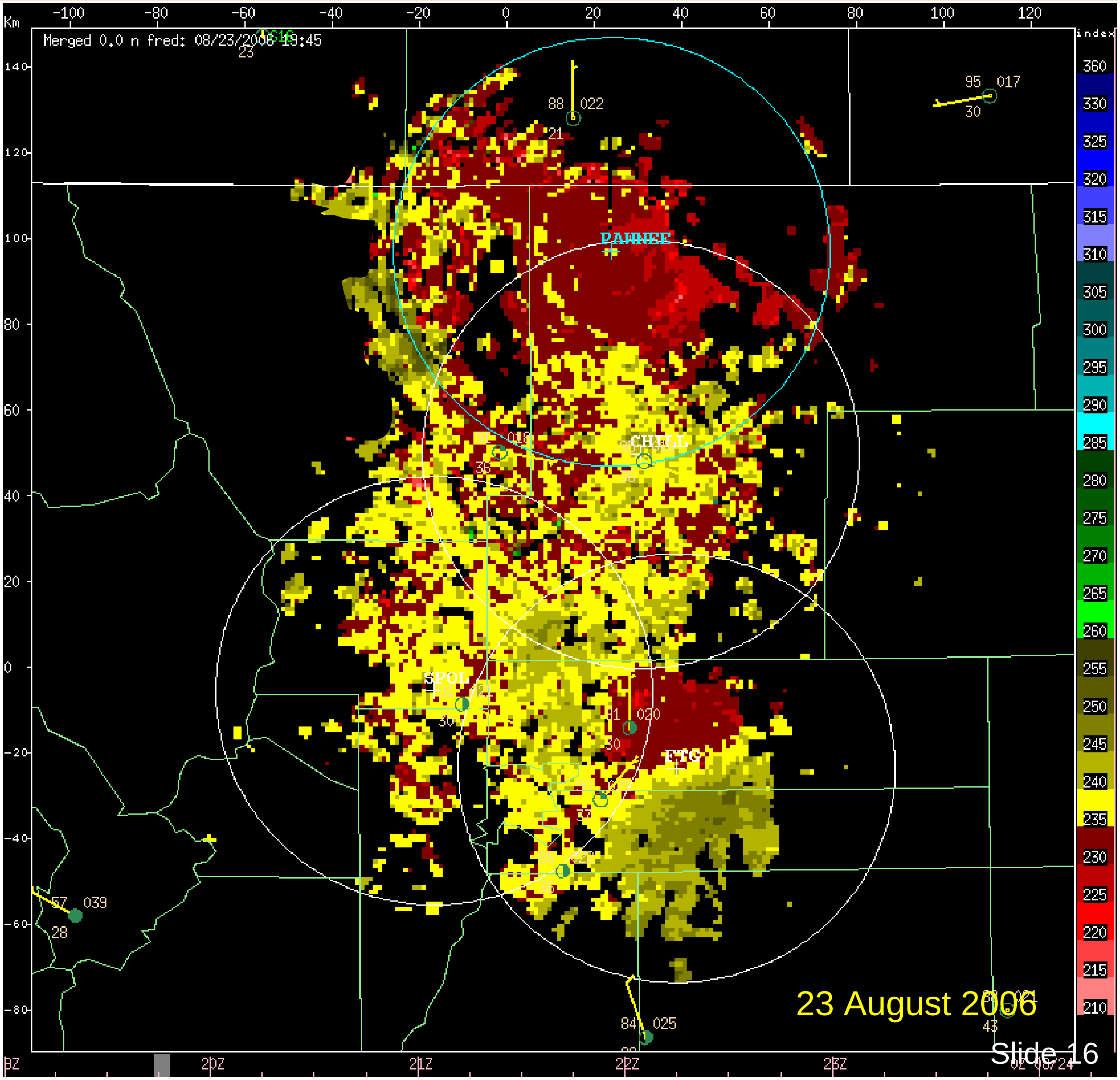


Increasing Moisture

1 g/kg change in moisture ~ 4 *N* units

Radar Refractivity Mosaic of 4 Front Range radars

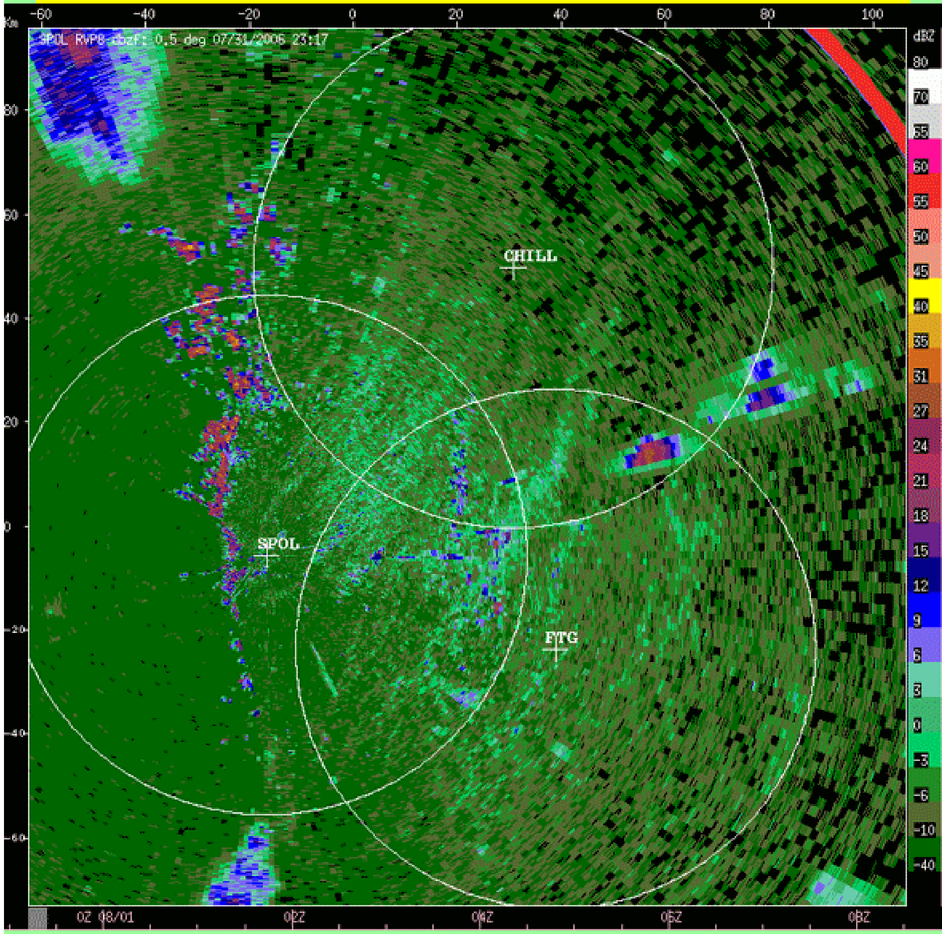
Typical variability in water vapor ~ 4-5 gm/kg



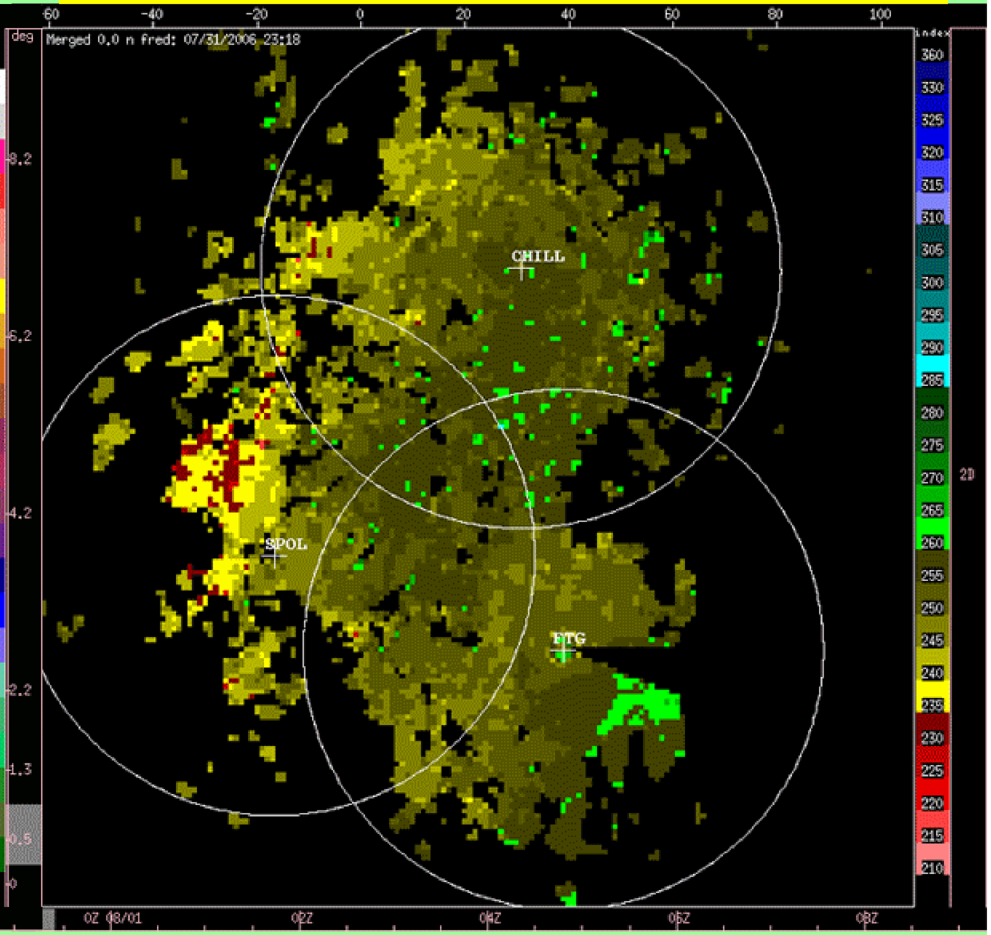
S-Pol, CHILL, Pawnne Denver NEXRAD radars

Post-Frontal Convection Triggered Along N-S Boundary
31 July – 1 August 2006

Reflectivity (Precipitation)



Refractivity (Water Vapor)

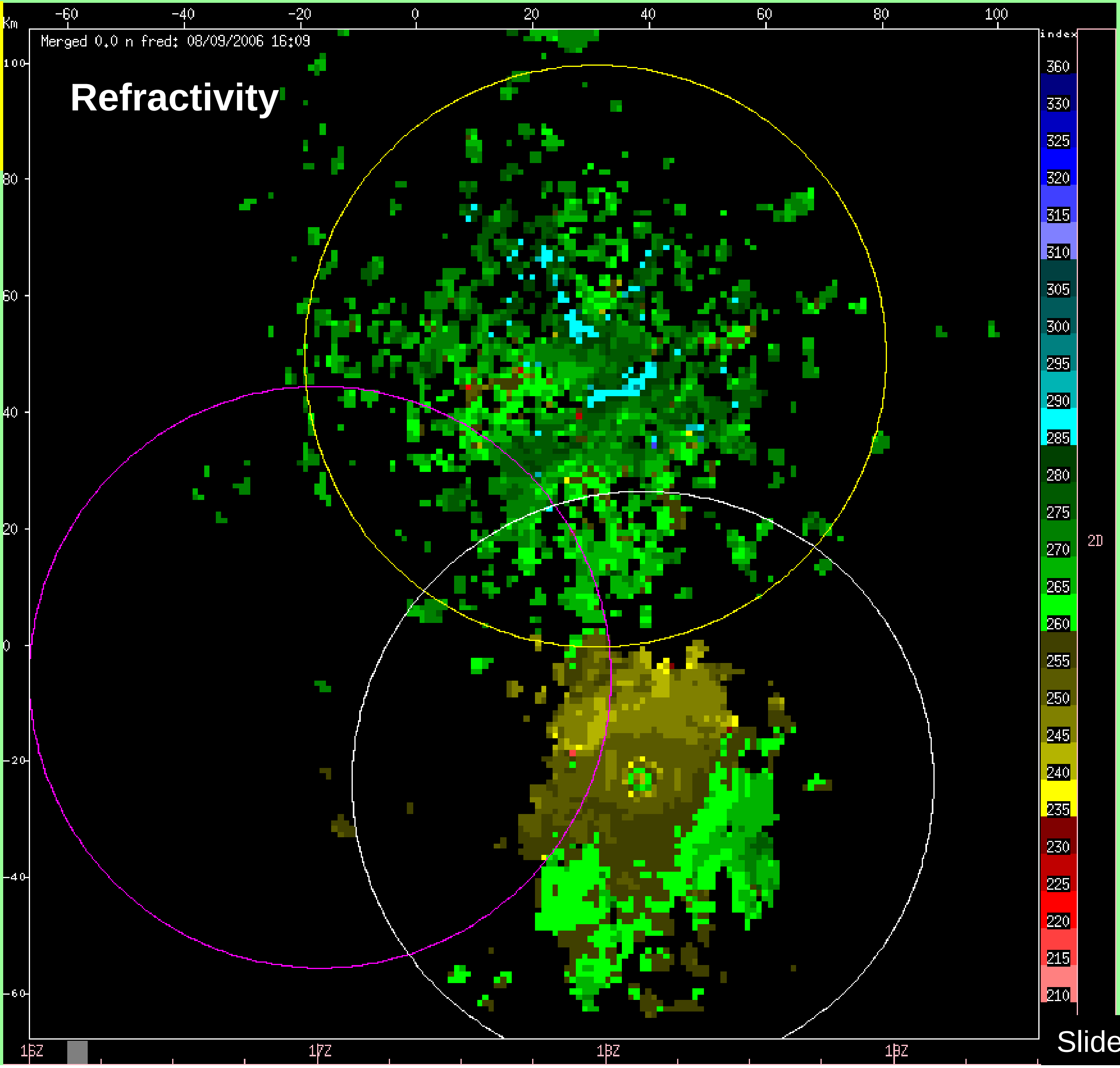


CHILL, S-Pol and WSR-88D

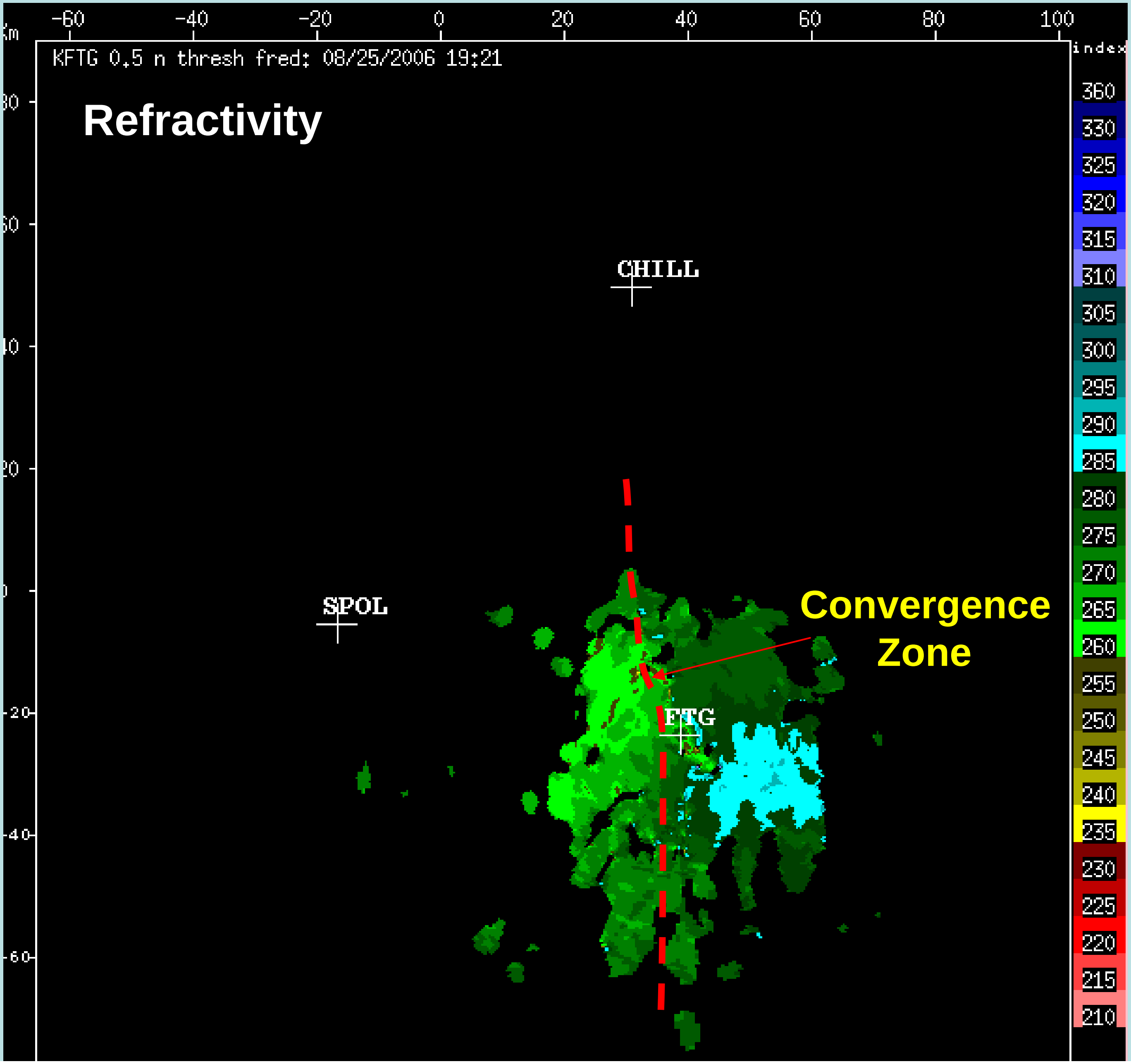
Rapid Drying in the Boundary Layer

9 Aug. 2006

CHILL and WSR-88D



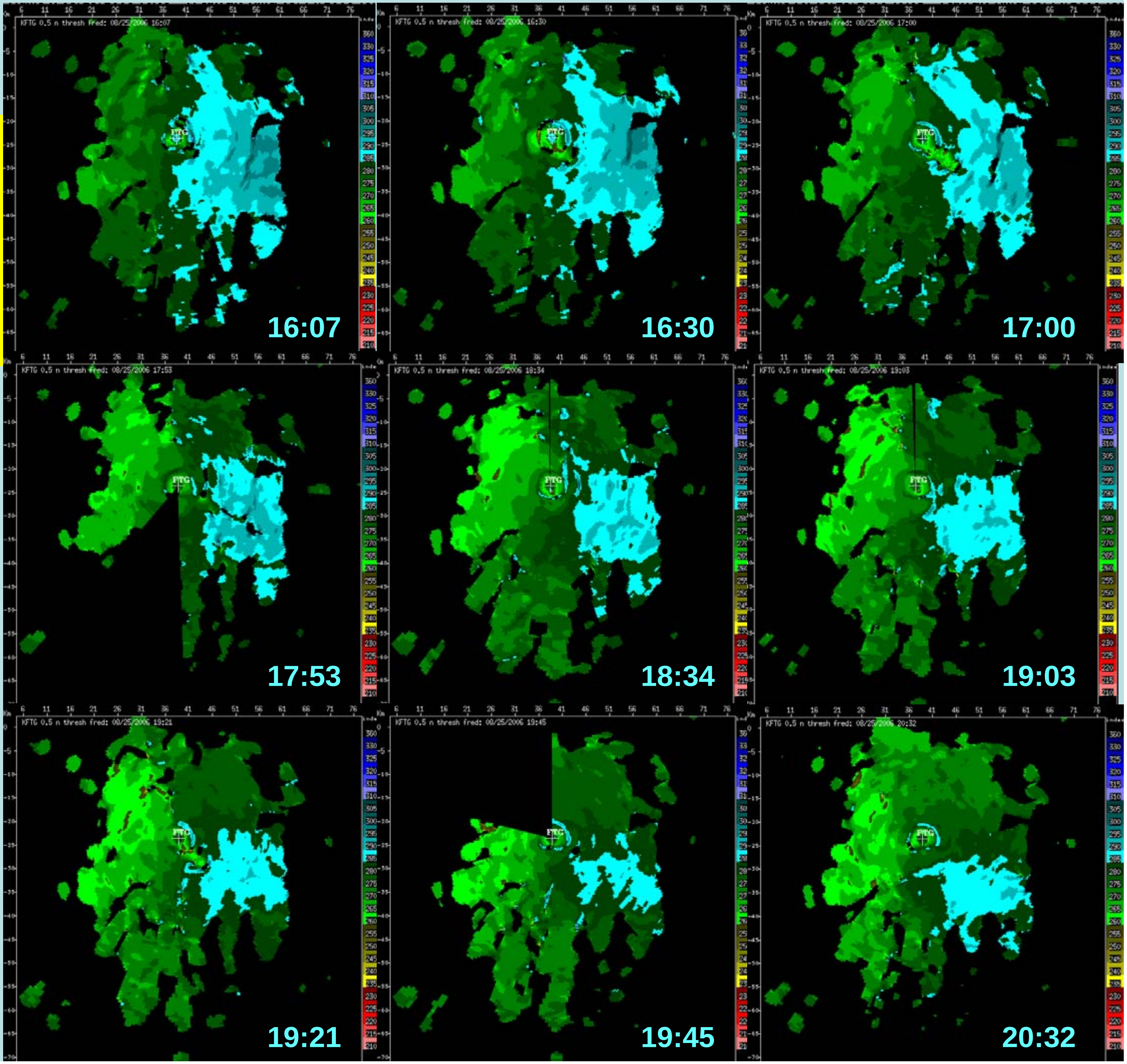
Terrain-Induced Stationary Convergence Zone
25 August 2006



Denver WSR-88D

Denver WSR-88D Refractivity Fields

Evolution of moisture along the stationary convergence zone



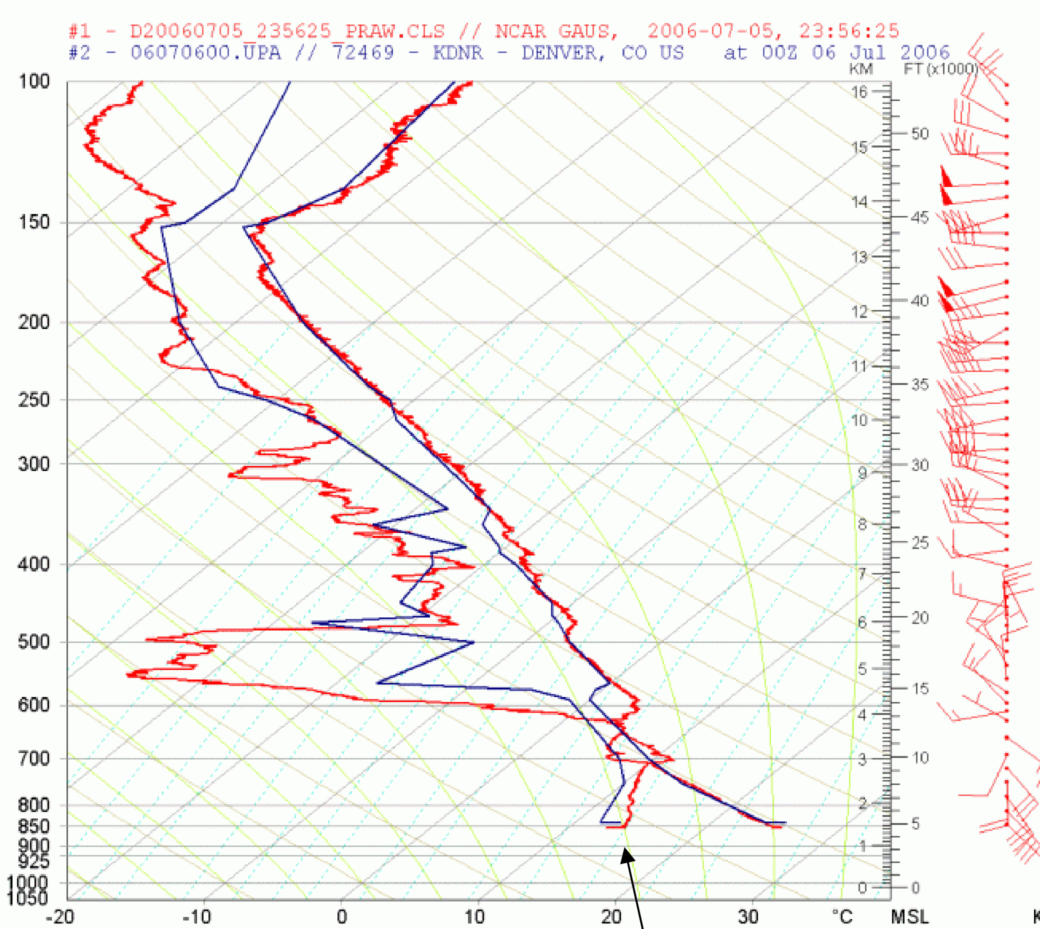
25 August 2006

16:07-20:32 UTC

~30 min intervals

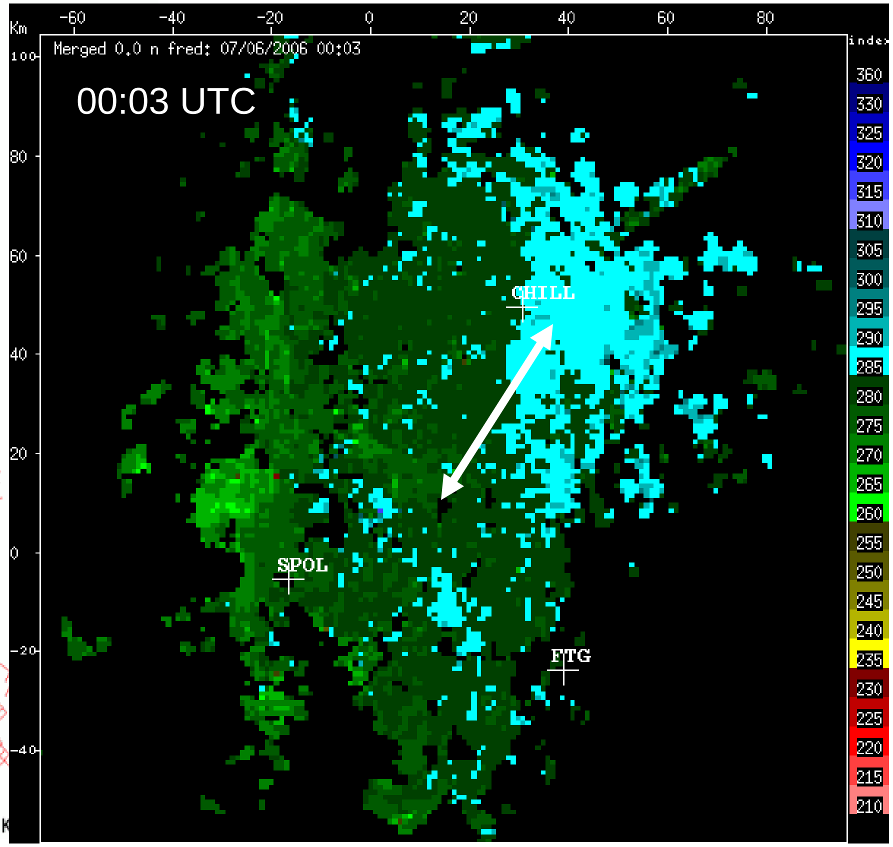
Denver WSR-88D

Data for Numerical Modeling Sensitivity Studies, Data Assimilation and Automated Thunderstorm Nowcasting Systems



2 g/kg change in moisture over depth of boundary layer

Refractivity



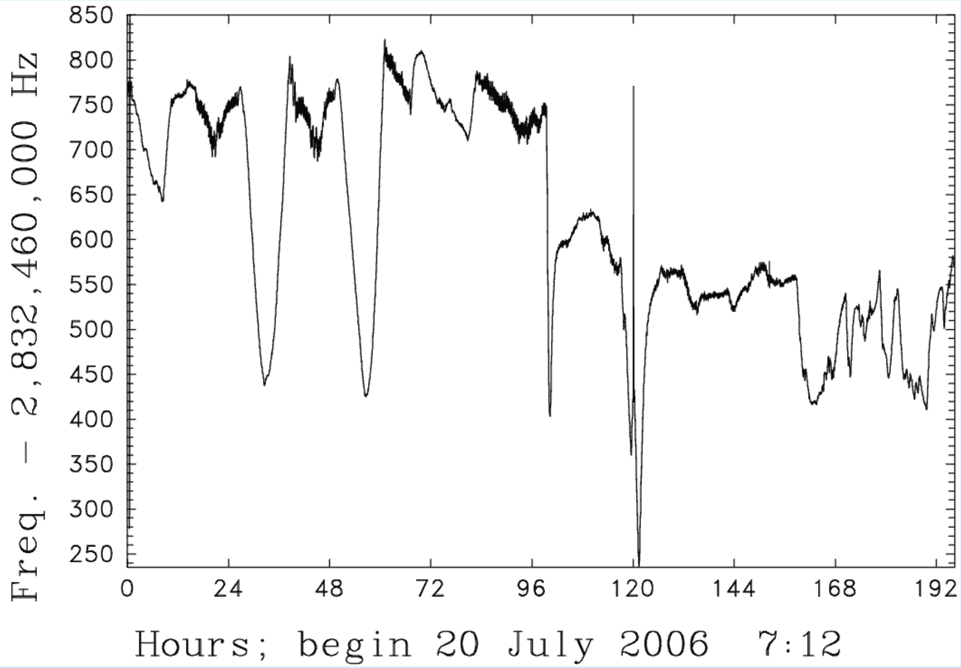
~2 g/kg change in 2-D field

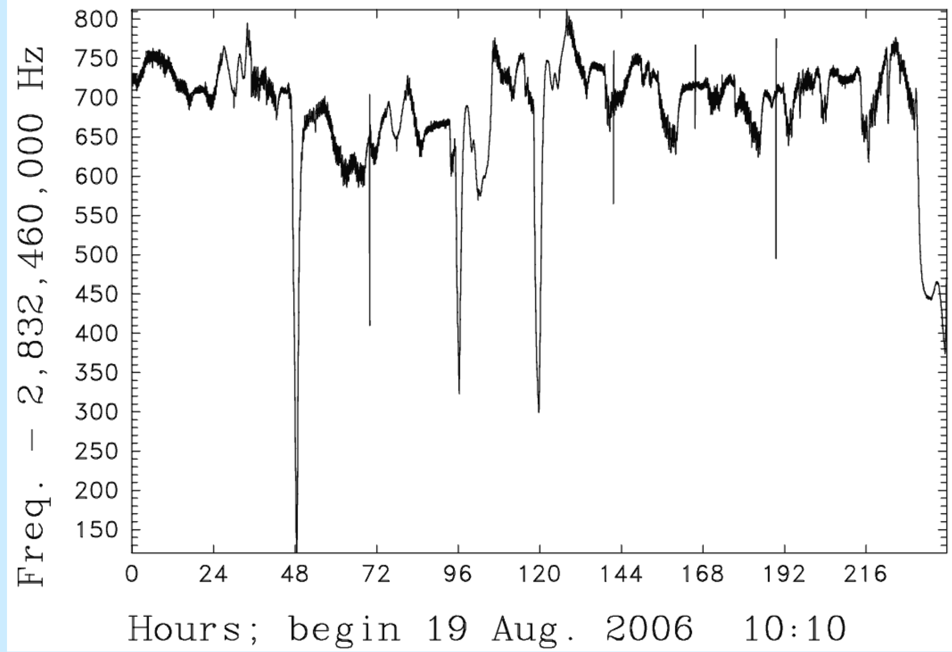
Outstanding Issues

- Stability of the transmitter frequency

Transmitter Stability – Initial Results

Courtesy: John Hubbert, NCAR/EOL





From a month of testing, it appears that the transmitter frequency is not drifting as much as spec-ed (15 kHz/yr vs. maximum allowed for N to work: 3 kHz).

→ Good news, but test duration was limited.

Outstanding Issues

- Stability of the transmitter frequency
- Refractivity collected in simultaneous H &V transmit mode

Testing and Impact of Simultaneous H&V mode on Refractivity (Hubbert, Fritz, Chandra)

<u>NEXRADS will operate in simultaneous H&V polarization transmit mode with simultaneous H&V receive</u>

- S-Pol collected data in H-mode using the VIRAC processor and in simultaneous H&V mode using RVP8

- CHILL radar typically collected refractivity data in V-mode

- During August, CHILL's scanning strategy was modified to allow collection of 0.0 deg scans in the following sequence

  scan 1: V-mode

  scan 2: Simultaneous H&V mode (warm-up)

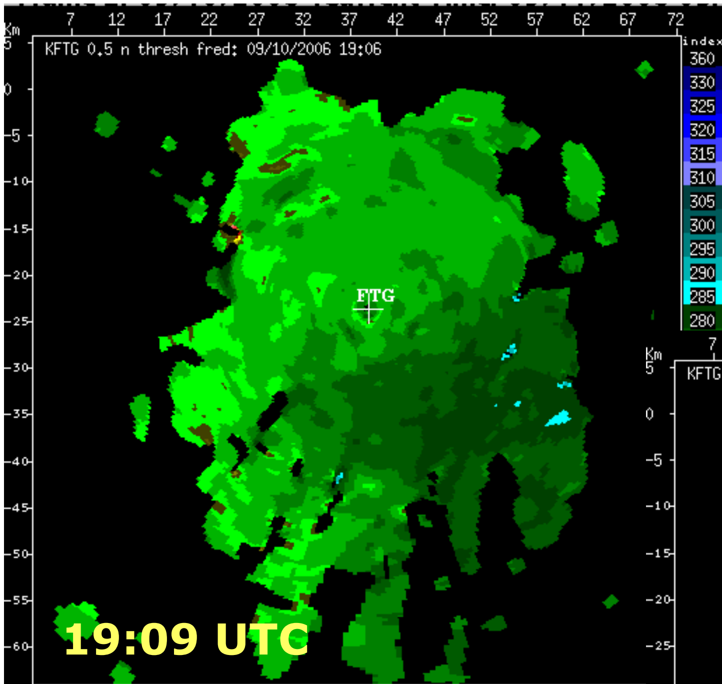
  scan 3: Simultaneous H&V mode

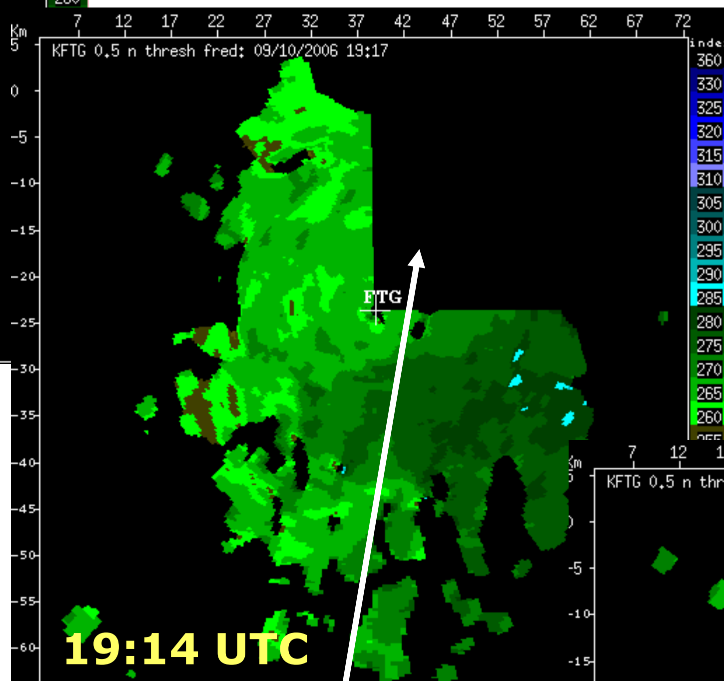
- Efforts were made to collect calibration data in simultaneous H&V mode

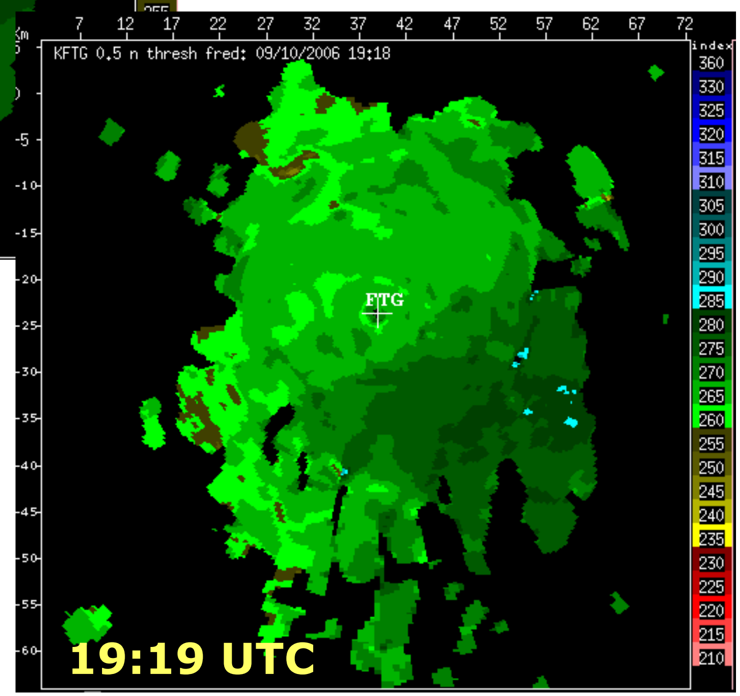
- Analysis and evaluation is ongoing

Outstanding Issues

- Stability of the transmitter frequency
- Refractivity collected in simultaneous H &V transmit mode
- Data transfer protocol

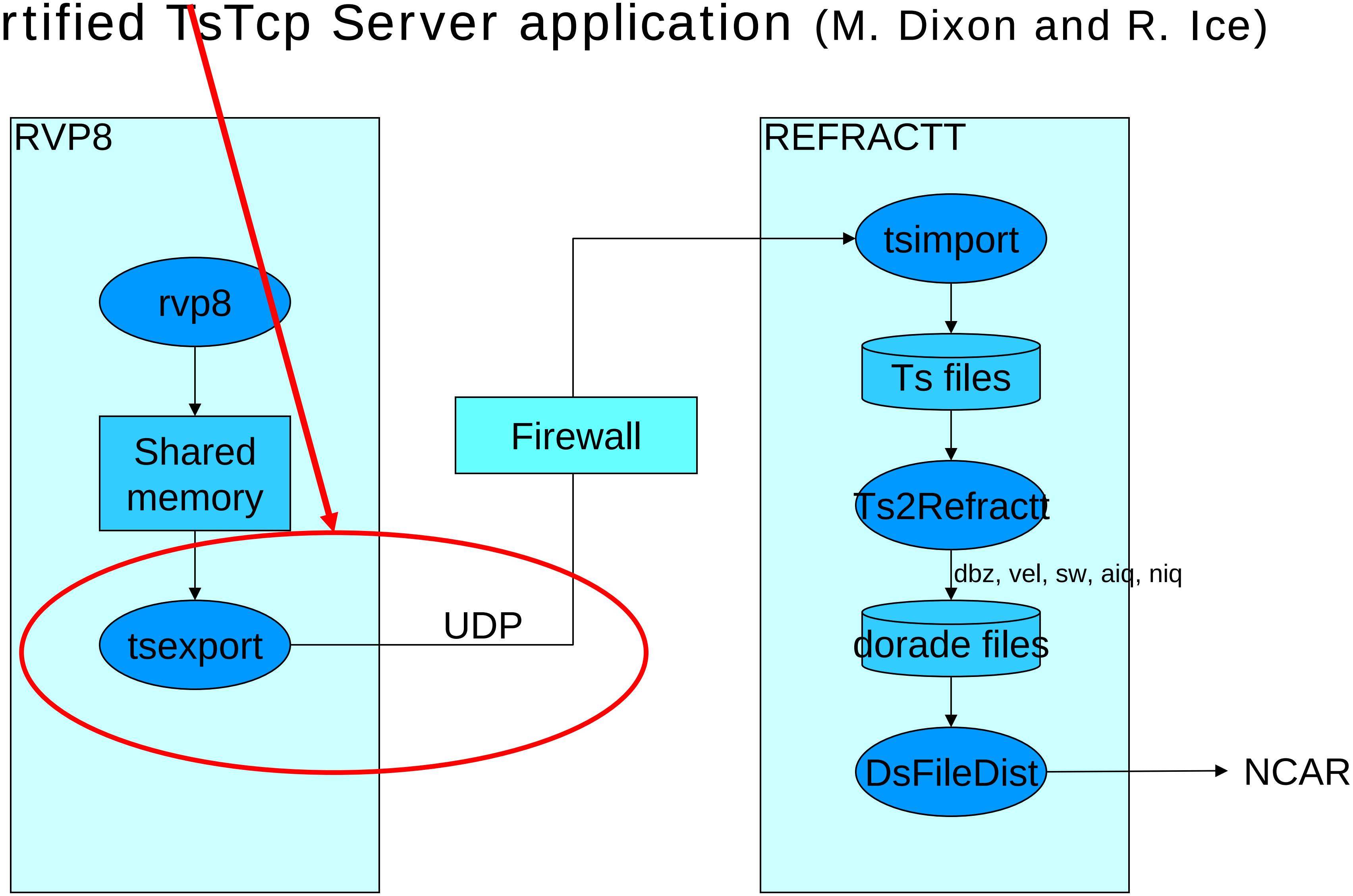






UDP is the current protocol but not very reliable, resulting in dropped sectors in almost every other volume of FTG data.

Solution: Replace tsexport/UDP functionality with a certified TsTcp Server application (M. Dixon and R. Ice)



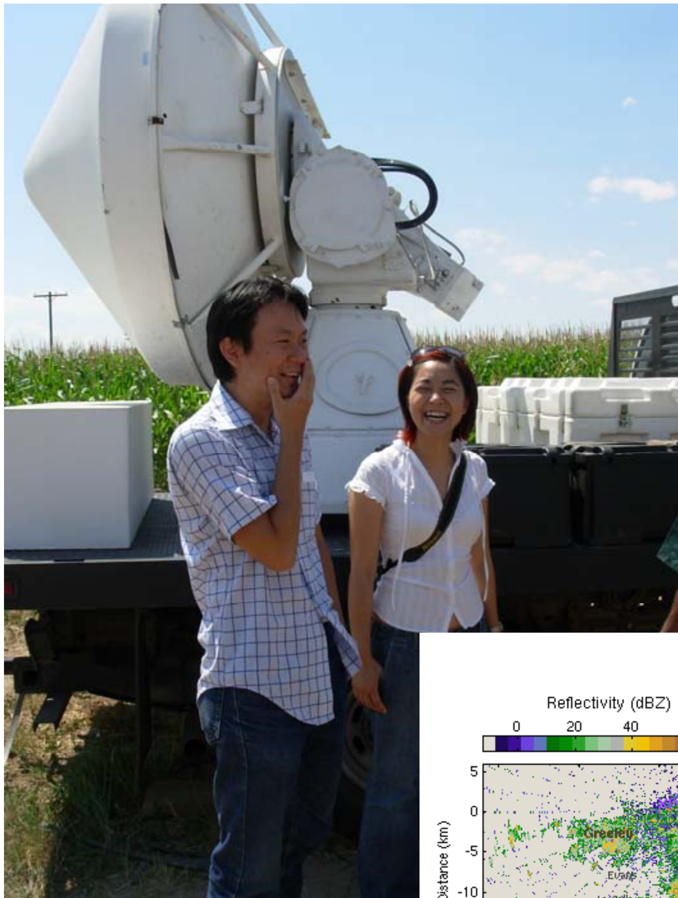
“REFRACTT” at KFTG

Outstanding Issues

- Stability of the transmitter frequency
- Refractivity collected in simultaneous H &V transmit mode
- Data transfer protocol
- How to include ingest of real-time surface station data (for refractivity-derived dewpoint temperature fields) somewhere in the process
- Comparison and evaluation of S-Band/X-band retrieved refractivity fields.

CHILL S-Band and CASA X-band Studies

Jason Fritz (CSU) and Boon Cheong (OU)



CASA X-band refractivity fields during REFRACTT

25 July 2006, Greeley Colorado

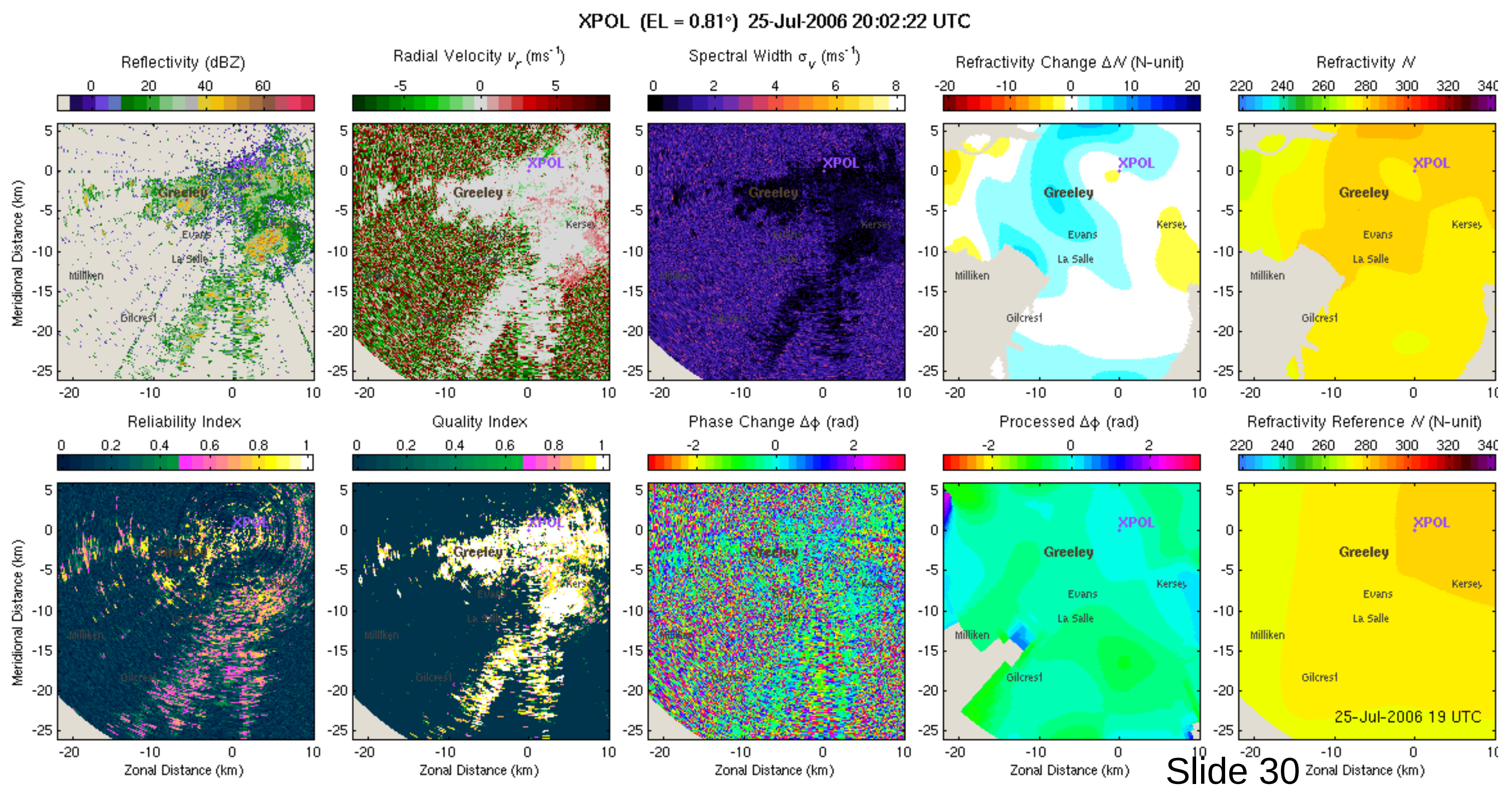


Figure courtesy of Bob Palmer

Outstanding Issues

- Stability of the transmitter frequency
- Refractivity collected in simultaneous H &V transmit mode
- Data transfer protocol
- How to include ingest of real-time surface station data (for refractivity-derived dewpoint temperature fields) somewhere in the process
- Comparison and evaluation of S-Band/X-band retrieved refractivity fields.
- Obtaining reasonable calibration and target ID data for all radars in summer time. Why do this?

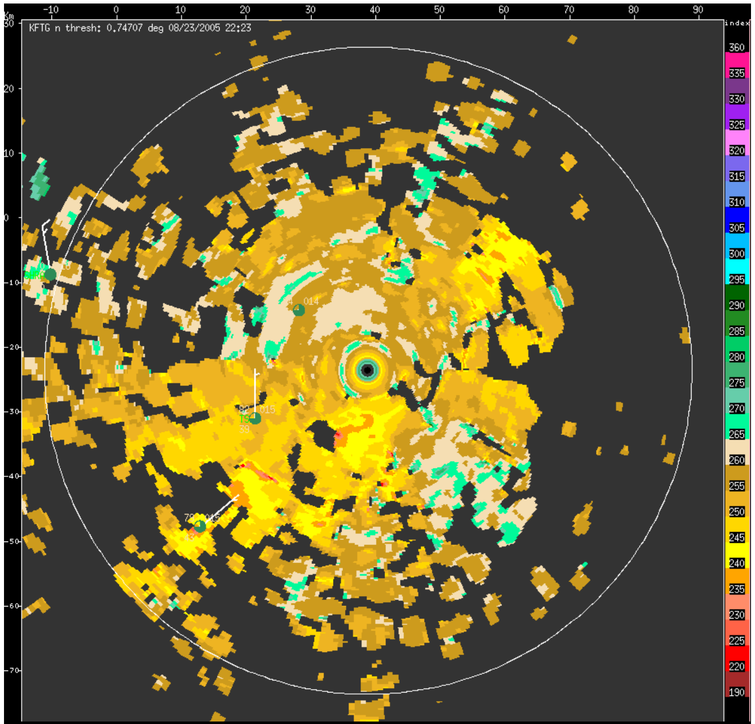
Fields Obtained

1) Refractivity N near the surface

from which we may derive dew point if temperature and pressure are known.

It is an absolute measurement.

Requires initial calibration.

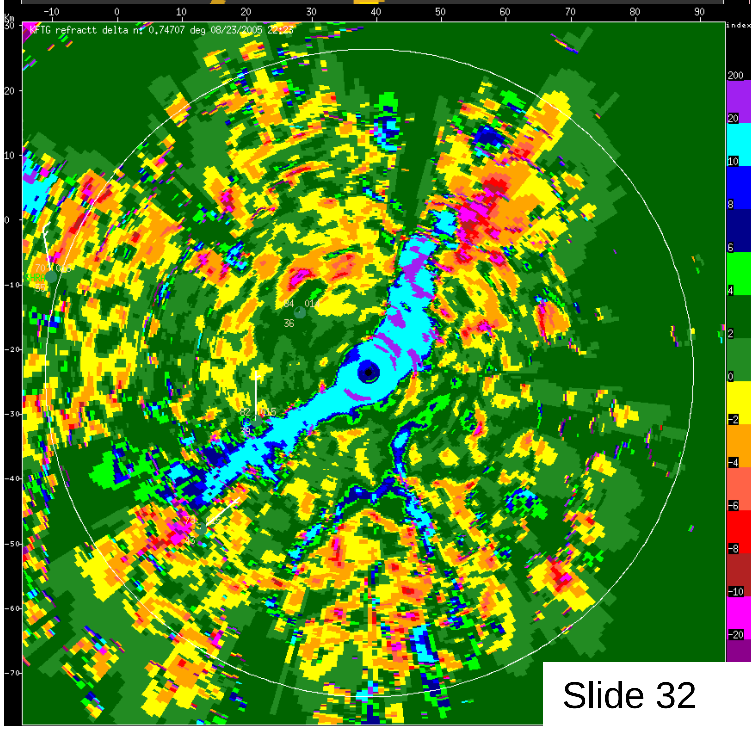


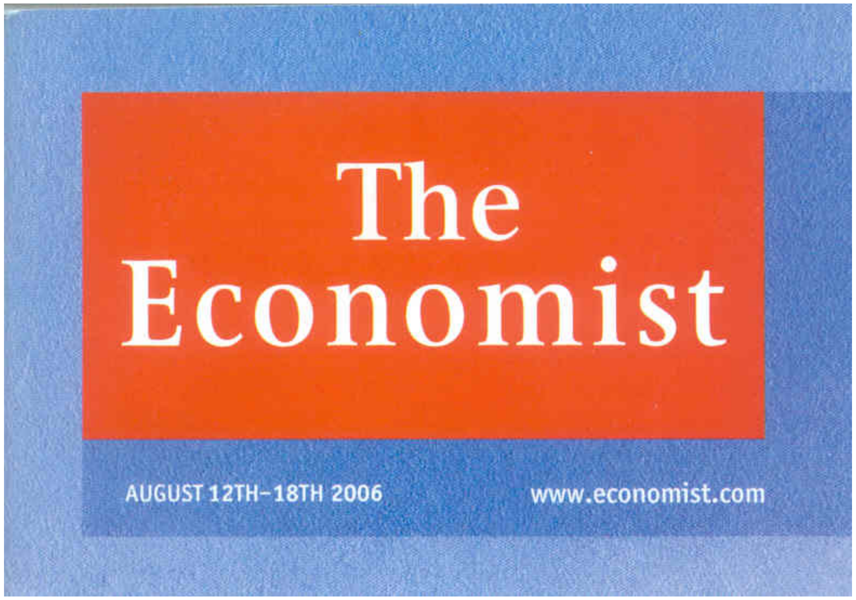
2) **Short-term change in refractivity ΔN/Δt**

where short term is anything from 5-minutes to an hour.

Relative measurement, good for highlighting moving boundaries.

No calibration required beyond the identification of ground targets.





Weather forecasting

Riders on a storm

How to detect thunderstorms before they happen

THUNDERSTORMS are notoriously unpredictable, as many a drenched picnicker can attest. Although meteorologists know what conditions favour their formation, they are hard-pressed to say exactly where a storm will occur until it is almost too late.

One reason is that the radars used to track storms can detect water in the atmosphere only once it has condensed into clouds or raindrops, and thus reflects the beam. By the time that happens, a storm is imminent. It would be better if there were some way to see atmospheric water while it is still vapour, before raindrops form.

Rita Roberts, of the National Centre for Atmospheric Research, in Colorado, and Frederic Fabry, of McGill University in Canada, think they have found out how to do this. Their method exploits the fact that water vapour changes the speed at which radar waves travel though air. That enables use to be made of what was previously just irritating noise—the part of a radar beam that is reflected not from raindrops, but from fixed objects such as buildings.

Since the distance from any given radar to each of these reflective surfaces (which may be as much as 50km, or 30 miles, away) is known precisely, the time it takes a beam to get there and back is a measure of how much water vapour it contains. With only one radar, this measure is not very informative, but the researchers' method uses four, pointing in different directions through the same air-mass.

Combining the signals from all four radars using some newly designed software means that the water content of the atmosphere can be sampled at points 4km apart. The existing system in America, which relies on weather balloons, samples points about 150km apart. The result is that incipient storms can be detected several hours before they burst, and picnickers need never be drenched again.

IMPACTS OF REFRACTT:

- ***First important step toward addressing national need for high resolution water vapor***
- ***Widespread coverage in media***
- ***NOAA/NWS Managers considering implementing technique on national network of NEXRADs (Sept. 11th)***
- ***Briefing given to NEXRAD PMC (Oct. 4th)***

Near Term Activities

- ***Scientific analysis of REFRACTT data planned including:***

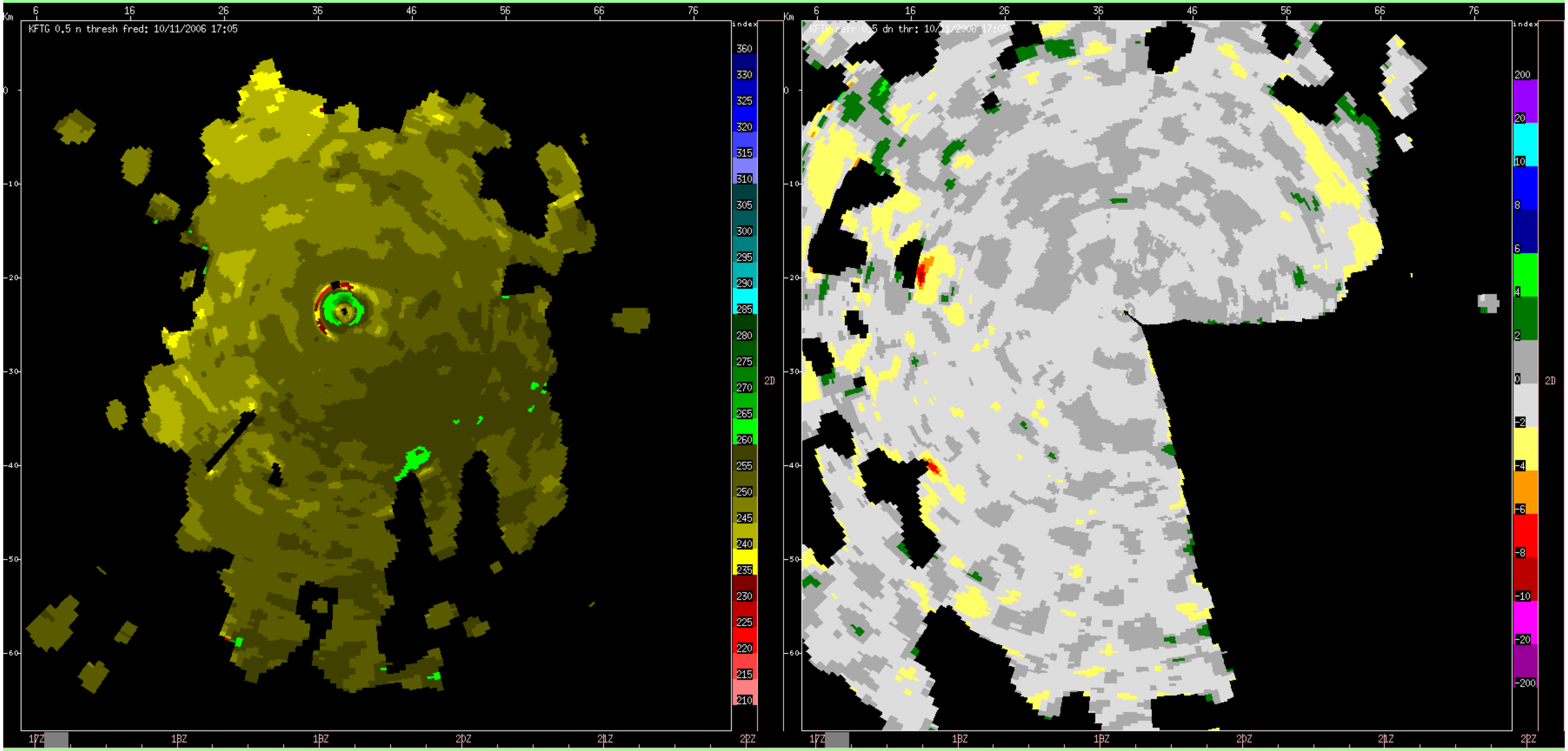
  -Sensitivity of CI, storm and boundary layer evolution to small scale (few km) variations in water vapor

  - Improved scientific methodology for combing water vapor from multiple platforms (radar, soundings, radiometers, GPS) to produce 3-D maps of water vapor

- ***Assimilation of the larger domain of water vapor into VDRAS and WRF 3DVar for improved QPF***

- ***Discusssions underway for possible FY07 winter and summer refractivity collection using the Denver NEXRAD radar and the ROC NEXRAD? Funding is needed.***

Cold Frontal Passage through Denver NEXRAD radar
11 October 2006



Where Do We Go From Here?

What are the next steps for implementing this on the NEXRADS?

Who will take on this effort to move the technique into operations?

Will the TAC be involved in these future efforts?