Innovative Techniques to Improve Weather Observations

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Weather Radar Research

The What
Weather Radar Signal Processing

Time series data

Why does this pixel have this color?
What does it represent?

Meteorological variables

Weather Radar Signal Processing
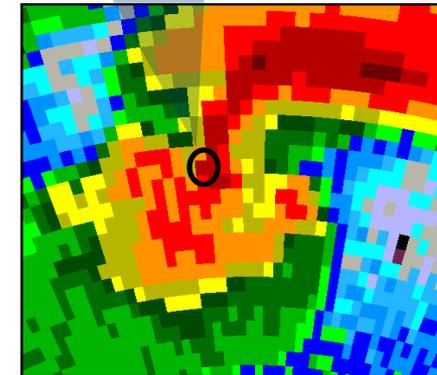
- *Smaller amounts of data*
- *Understandable*

- *Large amounts of data*
- *Unintelligible*

Separation and classification of echoes
Mitigation of sampling artifacts

NOAA Strategic Goals

- ❧ "Increase lead-time and accuracy for weather and water warnings and forecasts"
- ❧ "Improve predictability of the onset, duration, and impact of hazardous and severe weather and water events"
- ❧ "Increase development, application, and transition of advanced science and technology to operations and services"

All weather-**radar**-centric endeavors benefit

Research charters, partners, and customers

- ❧ NEXRAD Product Improvement
- ❧ Data Quality
- ❧ MPAR

Four basic needs to *improve weather observations*

- **Effective** quality control
- **Faster** updates
- **Better** accuracy
- **Greater** coverage

Improvements at the source

- Benefits carry over downstream

## Enabled by technology

- Feasible real-time implementation

BENEFITS

Data Acquisition

Product Generation
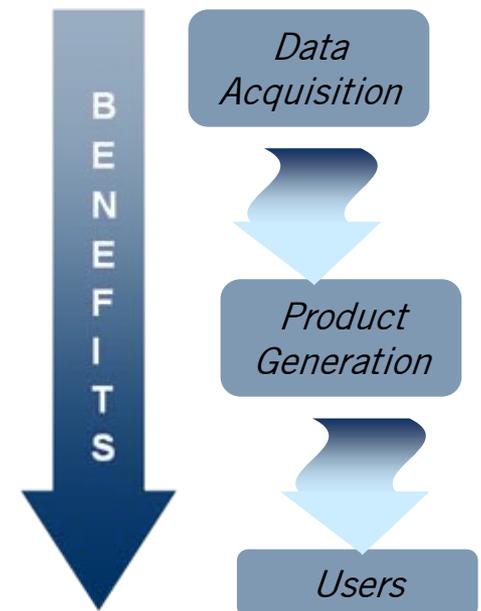
Users

Effective Quality Control
Motivation

Ground Clutter — Clutter Filter OFF

Ground Clutter & Weather — Clutter Filter OFF

NSSL's Clean-AP Filter — Clutter Filter ON

Cumulative US Wind Power Capacity

Total US wind power capacity has increased more than 6 times over the past decade

Storms

Wind Farms
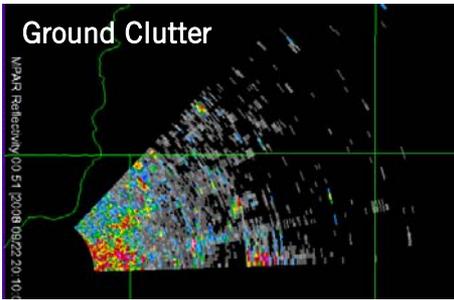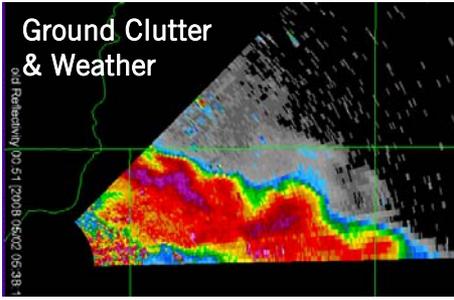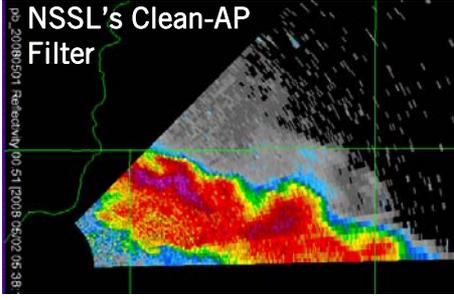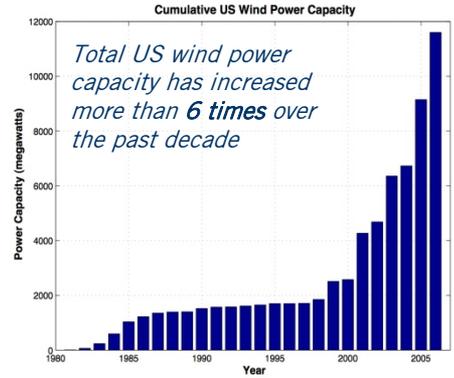
- Radar data is messy!
- Users and algorithms need clean data
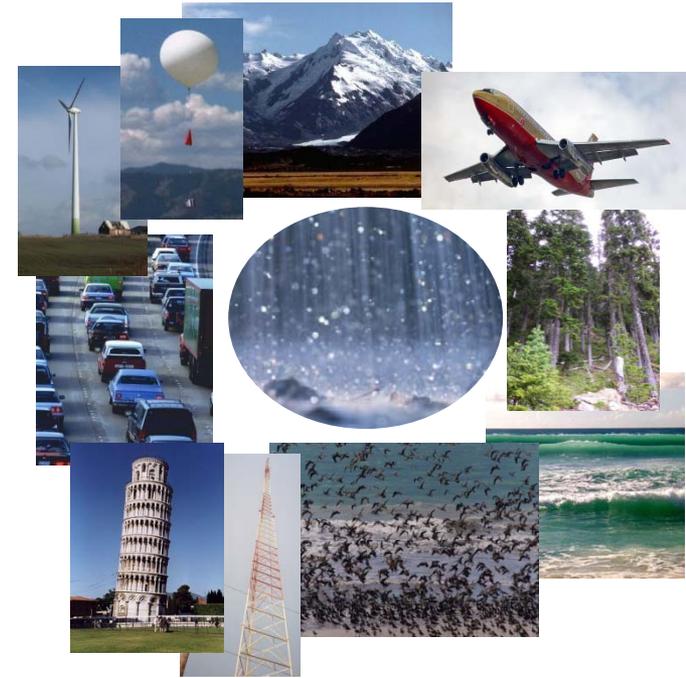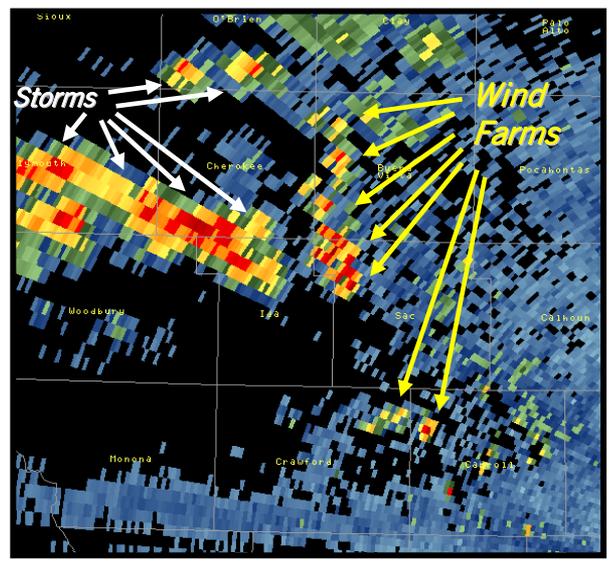
Faster update times are needed to provide forecasters a greater opportunity to see **first signs** of potentially severe weather from **quickly evolving phenomena**

2008 National Weather Service Field Survey – Part 1

2008

National Weather Service

Field Survey

Part 1: Volume Coverage Pattern Usage

---*DRAFT*---
Version 1.1
5 June 2008

(NOAA)

Which type of scanning strategy improvement do you consider most important?

- Other 8%
- No New VCPs 4%
- Better Range Unfolding 16%
- Elevation Angles Below 0.5 deg 10%
- Faster VCPs 25%
- More Frequent Low Elevation Scans 37%

62%

Courtesy of Randy Steadham (ROC)

Super-Resolution

Legacy Resolution
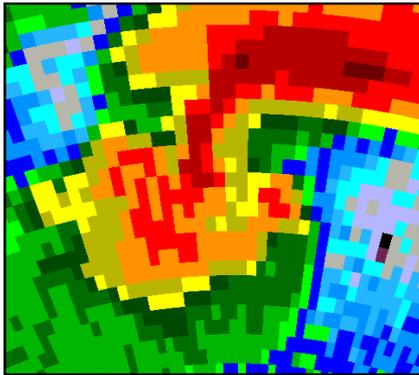
Super-Resolution
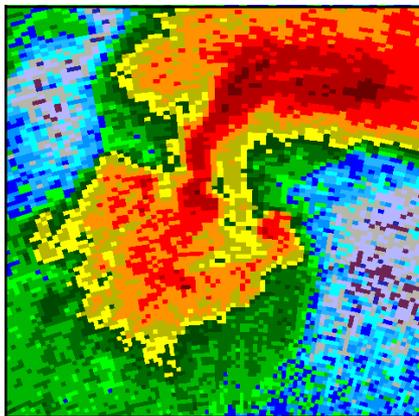
*Tornado outbreak in Oklahoma City, 9 May 2003 from Curtis et al (2003)*

250 m

250 m

1 km

250 m

1/8

250 m

0.5 deg *1 deg* *0.5 deg*

Range Oversampling

Reflectivity

Legacy
No Oversampling

Reflectivity

Evolutionary
Oversampling & Whitening
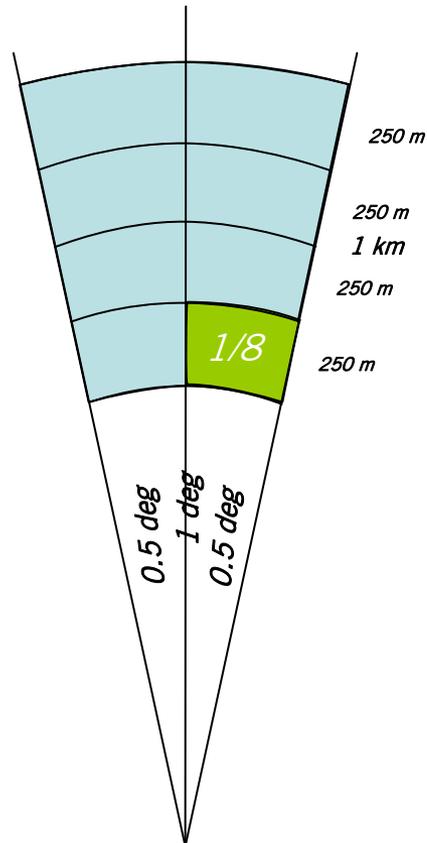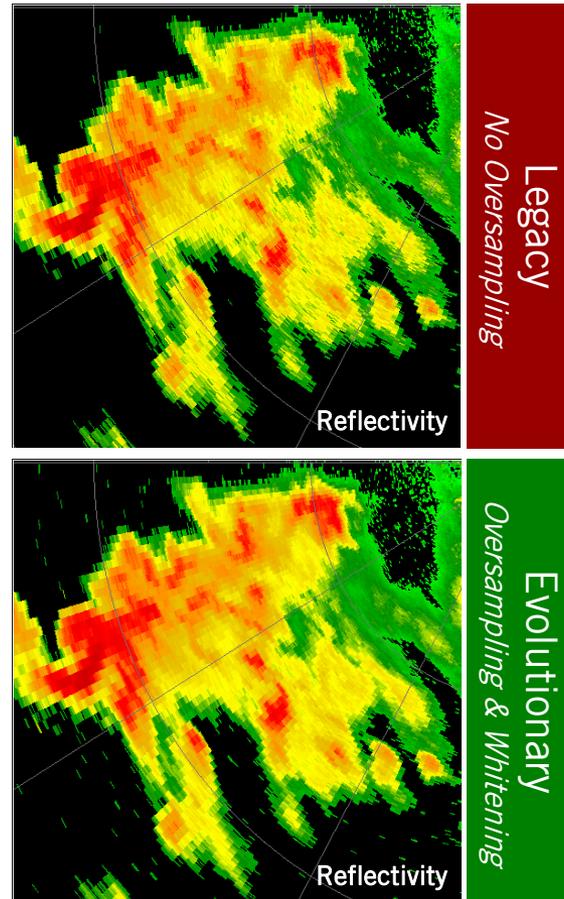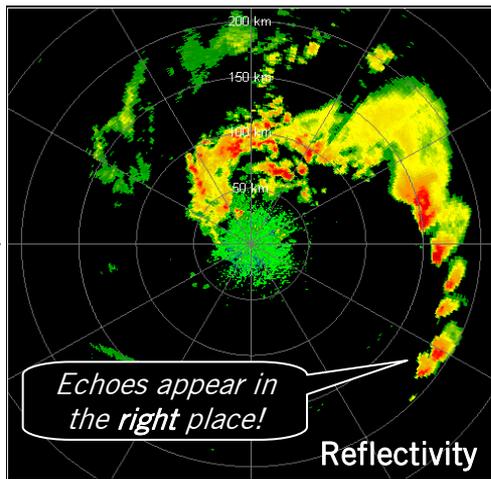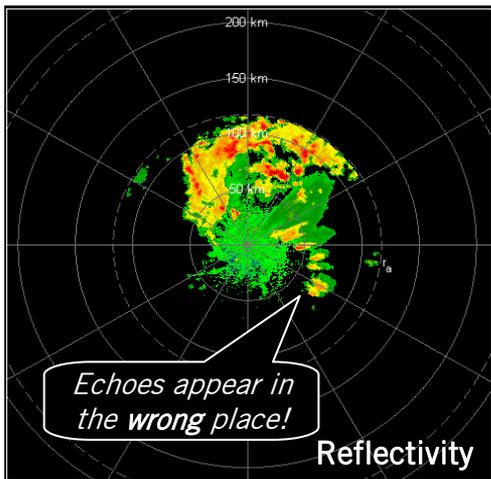
Where is the storm?
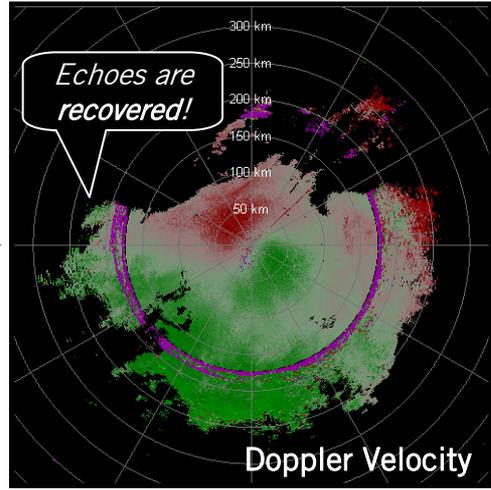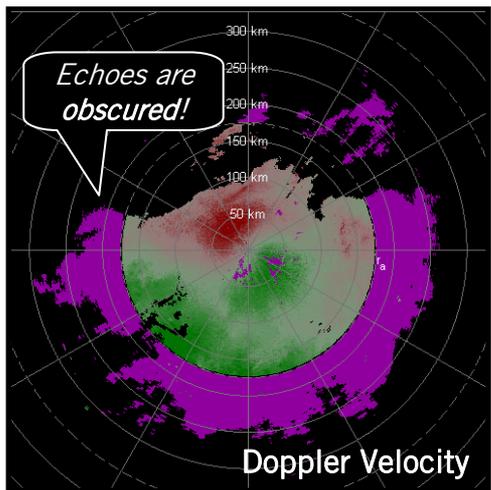
Surprised by strong winds?

Phase Coding
Mitigation of Range and Velocity Ambiguities

Initial research
- Sponsored by NWS's Radar Operations Center
- Collaboration with NCAR

Proof of concept
- Supported by KOUN upgrades

Technology transfer
- Integrated SZ-2 into signal processing pipeline

Support
- Operational issues
- Refinements

Evolution
- Other phase codes
- Other techniques

Purple denotes unrecoverable data

Doppler Velocity
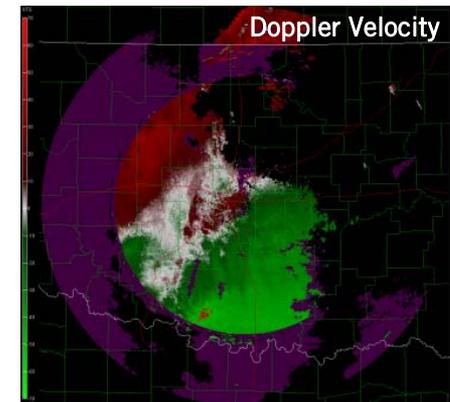
Legacy
No Phase Coding

Doppler Velocity
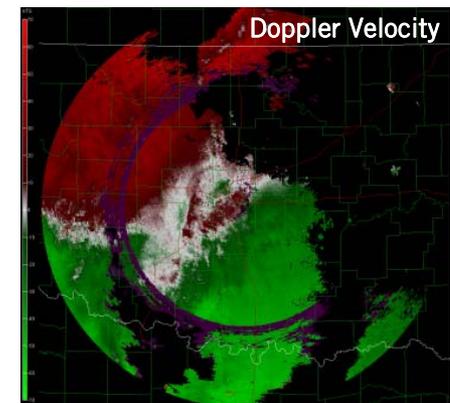
Evolutionary
Phase Coding

PAST

PRESENT

FUTURE

Phase Coding Performance
An Operational Example
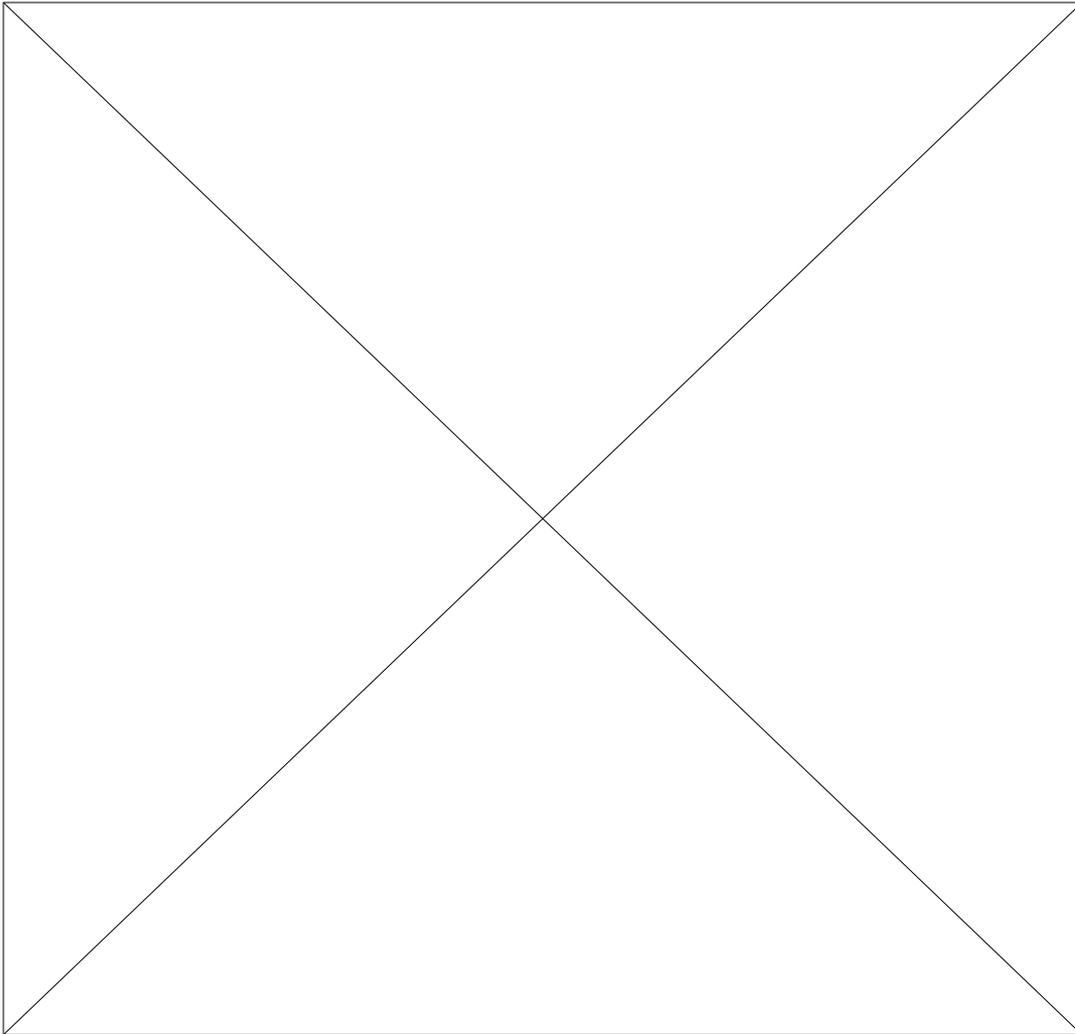
KTLX radar in Oklahoma City
30 Mar 2007,
0.5 deg elevation

Notice **switch** of scanning strategies:
from **VCP 12** (phase coding **OFF**)
to **VCP 212** (phase coding **ON**)
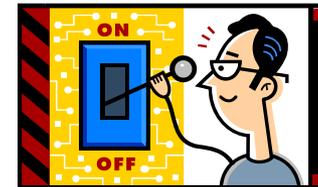
Courtesy of Jami Boettcher (WDTB)

Quality and Performance
Are we doing things right?

Performance

- ﹀ Technology transfer
    - ﹀ Phase Coding, Super Resolution, Staggered PRT, Dual Polarization, etc.
- ﹀ Teaching and advising

Quality

- ﹀ Publications
    - ﹀ OAR Outstanding Scientific Paper Award
- ﹀ Technical reports
- ﹀ Theses and dissertations
- ﹀ US Patent
- ﹀ NEXRAD T$_{echnical}$ A$_{dvisory}$ C$_{ommittee}$ endorsement
- ﹀ Awards
    - ﹀ NOAA's Bronze Medal Award
- ﹀ User satisfaction
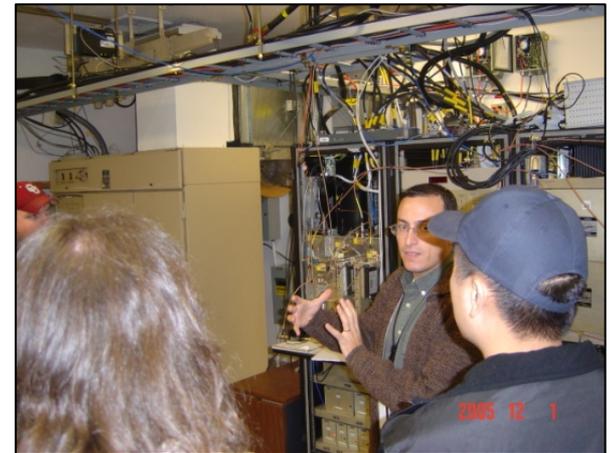
OU students are exposed to the latest technology

Present and Future Trends
Our strategy for success

The path ahead
- Technology transfer (NEXRAD)
- Evolutionary techniques (NWRT)
- Future radar technologies (MPAR)

Synergistic connections
- NEXRAD Data Quality team
- Collaboration with the ARRC (Atmospheric Radar Research Center)

Challenges
- Hiring and retaining EE's

Conclusions

Developing techniques to **improve weather observations**

- Improvements at the source
  - Driven by four basic needs
- Benefits carry over to all radar-centric applications

Demonstrated successful **technology transfer**

- Synergistic collaborations
- User satisfaction

Performing **cutting-edge research**

- Evolutionary techniques
- Future technologies

Questions?