Forecast/Warning Tools and Techniques

WSR-88D Science and Engineering R&D Overview

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Why Do We Invest in WSR-88D R&D?

- **WSR-88D Science and Engineering R&D needed to:**
  - Improve and evolve the performance and utility of the WSR-88D network
  - Support weather enterprise through basic research, operational applications, and informing the private sector of novel technological developments
  - Provide foundation for enhancements to support tri-agency forecast and warning missions through the **Radar Product Improvement (RPI) Program**
Dual Polarization: Latest Technology Transferred to NWS

- Differences in how horizontal and vertical fields interact with particles characterized by the polarimetric variables below:
  - Differential Reflectivity ($Z_{DR} = Z_H - Z_v$)
  - Differential Phase ($\Phi_{DP}$) and Specific Differential Phase ($K_{DP}$)
  - Co-polar correlation coefficient ($\rho_{hv}$)
WSR-88D R&D Makes Forecasts and Warnings Better!

- Polarimetric capabilities across WSR-88D network make possible development of:
  - New signal processing techniques to help forecasters accurately interpret the data
  - Radar algorithms to increase warning lead times for cold and warm-season weather hazards

- Work aligned with OAR Strategic Plan Goals and NOAA R&D Vision Areas:
  - Reduces societal impacts from hazardous weather using a robust and effective research, development, and transition enterprise (Vision Areas #1 and #3)
How Do We Measure Quality and Performance?

**ROC Deliverables & Products**
Ex: Hail Size Discrimination (HSDA) & MetSignal Algorithms implemented in RPG Build 17.0

**Technical Publications**
(algorithms & upgrades for WSR-88D radars)

**Peer-Reviewed Publications**

<table>
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<th>Applications of an Expanded ZDR Scale</th>
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<td><strong>Target</strong></td>
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<td>Precipitation and clouds</td>
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<td>Dust storms</td>
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<td>Chaff</td>
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<td>Wild fire smoke</td>
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**Awards**
Alexander Ryzhkov and Dusan Zrnic: 2019 ASLI Choice Award: Best Sci & Tech Book

**Stakeholder Engagement**
Numerous interactions with domestic and international partners

**Jeff Snyder: 2019 Presidential Early Career Award for Scientists and Engineers (PECASE)**
Who Do We Collaborate with to Increase Performance?

- NSSL recognized as a domestic and international leader in radar engineering and science, with numerous collaborations resulting in:
  - Basic science advancements and associated resources supporting radar algorithm development and improvement
  - Additional support through external funding and participation in field projects

[Logos of various organizations]
How Do We Impact Stakeholder Goals & Performance?

● By developing evolutionary signal processing techniques and new diagnostic capabilities for the WSR-88D network, focusing on using dual-polarization data for improving:
  ○ Hydrometeor classification
  ○ Quantitative precipitation estimates (QPE)
  ○ Severe weather nowcasting
  ○ NWP models

● Collaborating with Radar Operations Center (ROC) to ensure NWS forecasters have knowledge, capabilities, and technologies to communicate accurate, timely, and actionable forecasts
Evolutionary Signal Processing Techniques

- Operational phase coding (SZ-2) algorithm helps **mitigate range-and-velocity ambiguity**

- Currently transferring WET/CLEAN-AP algorithm to WSR-88D to **enhance ground clutter mitigation** while minimizing its filtering of “pure” weather data

- Future: Transferring range oversampling to **improve radar-variable estimation**
Hydrometeor Classification and Winter Weather

- Tested new melting layer detection algorithm with spatially variable melting layer top and bottom

- Developing heavy snow nowcasting techniques based on polarimetric (high $K_D$) signatures aloft with over 1 hr lead time due to slow fall speed of snow
Quantitative Precipitation Estimation (QPE)

- Operational MRMS QPE algorithm based on specific attenuation (A) and $K_{DP}$
  - Less sensitive to DSD variability, attenuation, miscalibration, partial beam blockage, etc.

- Polarimetric methods demonstrated for snow QPE for the first time

Simulations based on the disdrometer snow data

The impact of the partial beam blockage caused by nearby trees is completely eliminated in the rainfall map retrieved from A

Nor’easter “Gail” on 17 Dec 2020 (KENX WSR-88D)

The polarimetric estimates of snow rate are much less sensitive to the variability of snow size distribution than the conventional S(Z) estimates
Severe Weather Research

New (Probabilistic) Tornado Detection Algorithm

- Areas of high concentration of melting hail and rain ("K_{DP} cores") identified as prime regions for downburst development

- 33.69% probability of tornado occurrence

- Hail Size Discrimination Algorithm (HSDA) made operational in 2016-2017

- Leveraging dual-polarization radar and advanced shear detection (e.g., LLSD) to provide probabilities of tornado occurrence
Research Priorities through 2025

- Supporting ROC implementation, validation, and testing of evolutionary signal processing techniques and meteorological algorithms
- Fusing additional observational platforms with existing WSR-88D network
- Validating and refining polarimetric snow QPE algorithms
- Continued synergy of polarimetric radar data and NWP for model validation and nowcasting
  - Porting over advanced polarimetric radar forward operator (PRFO) to high-resolution models for community use
Questions for the WSR-88D panel?