Dual Polarization Radar from the NWS Hydrology Perspective

An Opportunity For Communication

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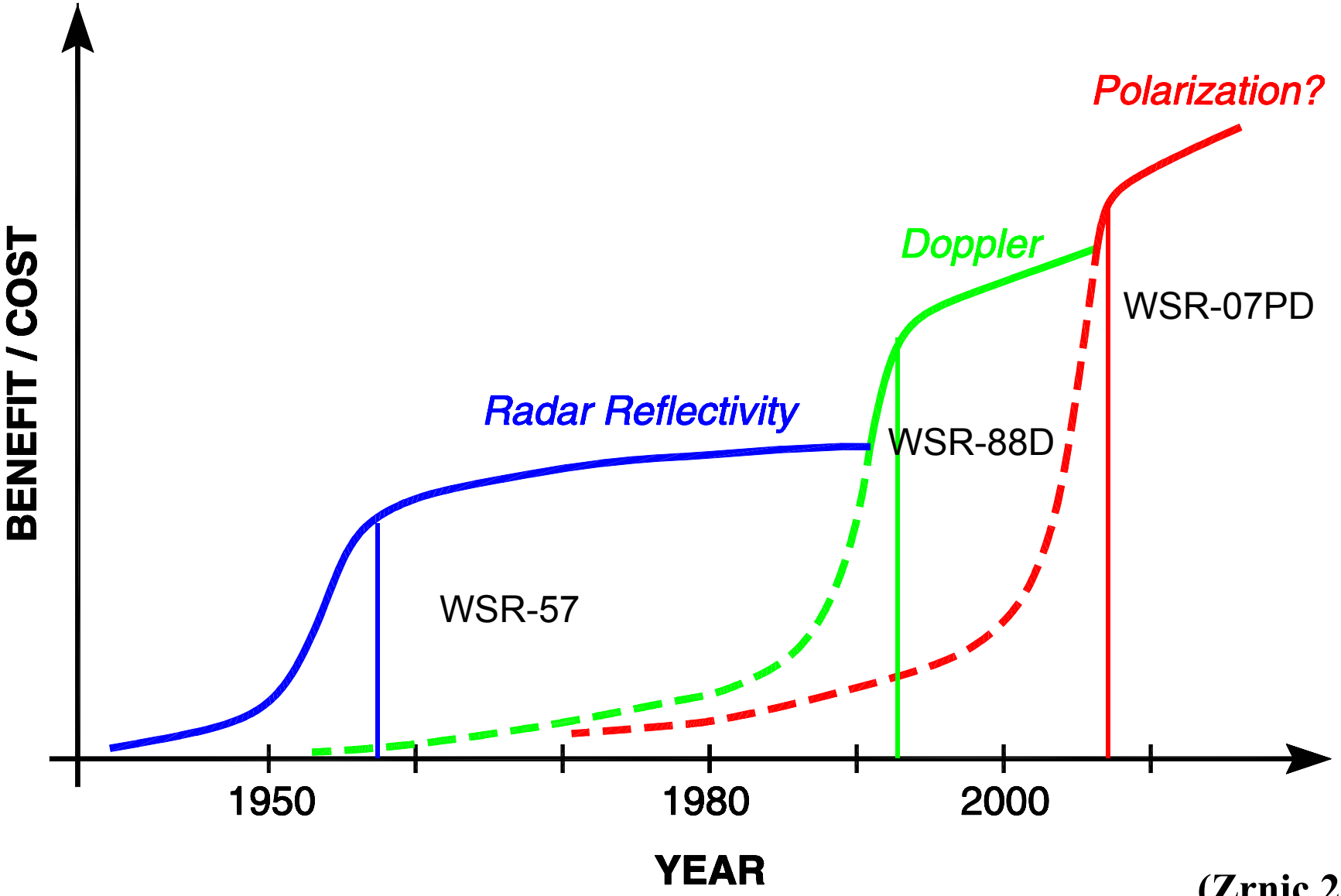
Weather Radar Technology-
Merits in Chronological Order



(Zrnic 2003)

Customers

- All users of precipitation products, especially WFOs, RFCs, emergency and water managers, etc.
- Other non-hydrologic users of reflectivity products

Benefits

- Significant improvements in rainfall estimates
  - Reduced biases and RMS errors
  - Arbitrary 53-dBZ hail cap in PPS no longer necessary
  - Reduction in bright-band overestimation
- Improved quality of base radar data
  - Bird/insect echoes can be removed
  - Less terrain blockage effects at low elevation angles
- ROC/NSSL estimate total financial benefit of $690M per year (NPMC report)

Background & Discussion

- NWS GPRA Goals
  - Subjective Estimates Of Dual Pole Impact On Warning Performance

(H – High, M – Medium, L – Low, NC – No Change)

Warning Phenomena	Prob. Of Detection	False Alarm Rate	Lead Time
Tornadoes	Promising, impact TBD	Promising, impact TBD	Promising, impact TBD
Severe Weather (Hail)	H	H	M
Flash Floods	H	H	M
Winter Weather	H	H	H

Background & Discussion

- Additional Benefits To NEXRAD Agency Operations And National Economy
  - Subjective Estimates Of Dual Pole Impact (H – High, M – Medium, L – Low, NC – No Change)

Phenomena	Impact	Application
Data Quality	H	FAA ATC Systems, Wind Input For NWP, Clean Input Data For Radar Algorithms, Increased Storm Detection In Partially Blocked Areas & Due To Attenuation
Precipitation Estimation	H	River Forecasts, Water Management, Agriculture & Forecast Management, Snow Removal Management, Flash Flood Warnings
Hail Detection	M	Agriculture Management, Air Traffic Safety, Resource (e.g., Aircraft, Personnel) Protection
Rain/Snow Discrimination	H	Air Traffic Safety, Highway Safety, Power Grid Management, Snow Removal Management, Agriculture & Forest Management

Background & Discussion

- Multi-year NSSL JPOLE program funded by NOAA
  - Modified NSSL WSR-88D unit for dual polarization
  - Implemented NSSL design for simultaneous vertical/horizontal transmit/receive with WSR-88D scanning speeds
- Demonstrated NEXRAD performance improvements
  - Much improved accuracy of rainfall estimates
  - Precipitation type determination: hail, snow, liquid rain
  - Improved data quality through mitigation of problems related to calibration errors, partial beam blockage, attenuation, ground clutter and anomalous propagation
- Documentation of results in NSSL reports

(Ryzhkov 2003)

Joint POLarization Experiment (JPOLE) Objectives

April 2002 – June 2003, Oklahoma

- Evaluate engineering design (simultaneous transmission, compatibility with WSR-88D, quality of multiparameter radar data)
- Evaluate the capability for classification of meteorological and nonmeteorological scatterers , hail/rain, rain/snow discrimination
- Validate the quality of rainfall measurements using two rain gage networks: Oklahoma Mesonet and ARS Micronet
- Deliver radar variables and products (results of classification and rainfall estimation) to the Norman NWS Office for evaluation and feedback

* *And real-time delivery of digital rainfall products to Arkansas-Red Basin RFC for evaluation*

Background & Discussion

Schedule

- **Operational Development – FY04 – FY07**
  - Phase 1 – FY04
    - Define Requirements
    - Complete Program Plan/Acquisition Plan
    - Develop Statement of Objectives for Contract
  - Phase 2 – FY05-07
    - Design/Development
    - Test
- **Deploy, Maintain & Assess – FY07-09**
  - Production
  - Deployment

- *NPI Project Lead will obtain NPMC approval-to-proceed at key Program milestones*

Background & Discussion

Rough Order of Magnitude funding requirements

- **Requirements Analysis, Development and Testing(FY04 – FY07)**
  - **$6.5M**
- **Procurement (FY06 – FY08)**
  - **$26M**
    - **$125K/site**
    - **15% spares**
- **Deployment (FY07 – FY09)**
  - **$4.5M**

Agency funding:

- Fund per Agency Cost-share MOA

- DOC and DOD funding adequate

- FAA: Needs program requirements to be defined

Background & Discussion

- Economic Benefit Analysis
- Utilized "NEXRAD Technical Requirements for Precipitation Estimation and Accompanying Economic Benefits" (Hudlow, et.al., 1985)
  - Report related flash flood damage avoidance & water management to accuracy of precip estimates
- Dual Pol Improves precip estimation accuracy from 30% to (approximately) 12.5%. (Zrnic, 2003)
- Applying The Hudlow Approach Resulted In
  - Estimated annual benefit - $690M
  - Analysis Supported by NSSL; Validated by Dale Sirmans

OHD Science Funding Support to NSSL

- $10K/yr in FY01 and FY02 (base funding)
- $60K in FY03 (NPI funding)
- $60K in FY04 (using FY03 AHPS funding)
- No funding currently identified beyond FY04
- If OHD drops support:
  - Possible delays in implementation of a polarimetric QPE algorithm on the WSR-88D
  - Some important polarimetric QPE science issues remain unresolved
  - Delays in incorporating dual-polarization into probabilistic QPE techniques

Results from NSSL Funding

- NSSL scientists (Ryzhkov et al.) have developed and evaluated a prototype next-generation WSR-88D precipitation algorithm prototype for the WSR-88D to replace PPS
- In September they delivered their FY03 annual report to us titled *"Rainfall Measurements with the Polarimetric WSR-88D Radar"*
  - Available on-line at **http://www.nws.noaa.gov/oh/hrl/papers/papers.htm#wsr88d**
  - Report was distributed to Hydromet Group and OHD management and reviewed by me, Dave K., and Edward Brandes at NCAR
- They presented two NWS seminars on Nov. 18th and met with us to discuss QPE results

(Ryzhkov 2003)

Polarimetric Rainfall Estimation:

NSSL Report Summary

- Conventional and polarimetric rainfall estimation algorithms have been validated using 108 Oklahoma Mesonet and 42 ARS Micronet rain gages during JPOLE.

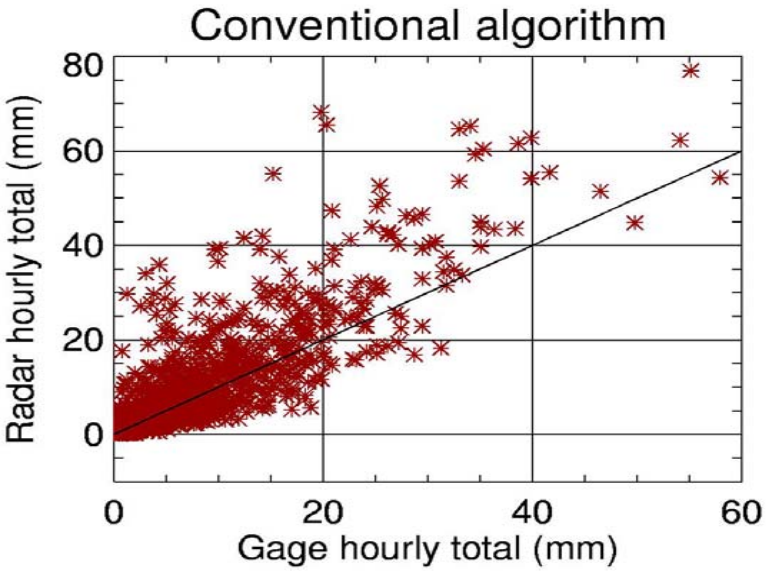
- The polarimetric QPE algorithm outperforms the conventional one in terms of bias and RMS error. The RMS error of the one-hour total estimate is reduced 1.8 times for point measurements and 3.7 times for areal rainfall estimates.

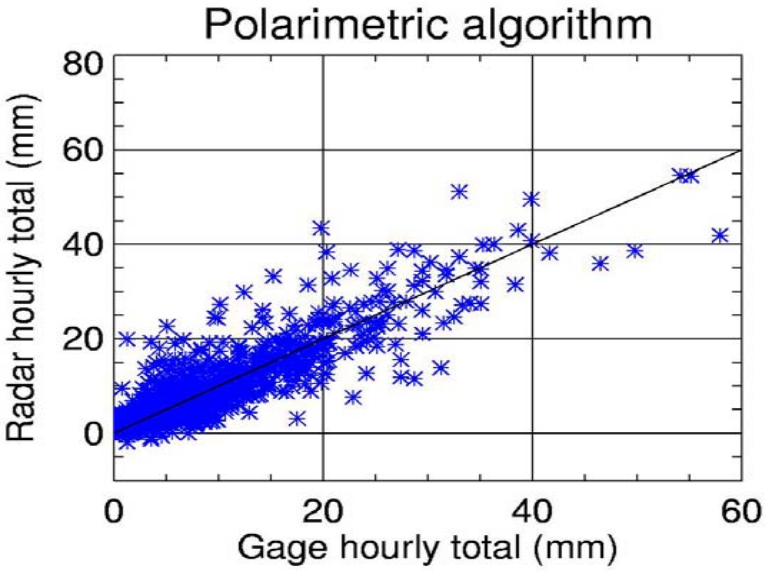
- Most significant improvement is achieved in areal rainfall estimation and in measurements of heavy convective precipitation (often mixed with hail).

- The polarimetric method is more robust with respect to radar calibration errors, beam blockage, attenuation, DSD variations, and presence of hail than the conventional R(Z) method.

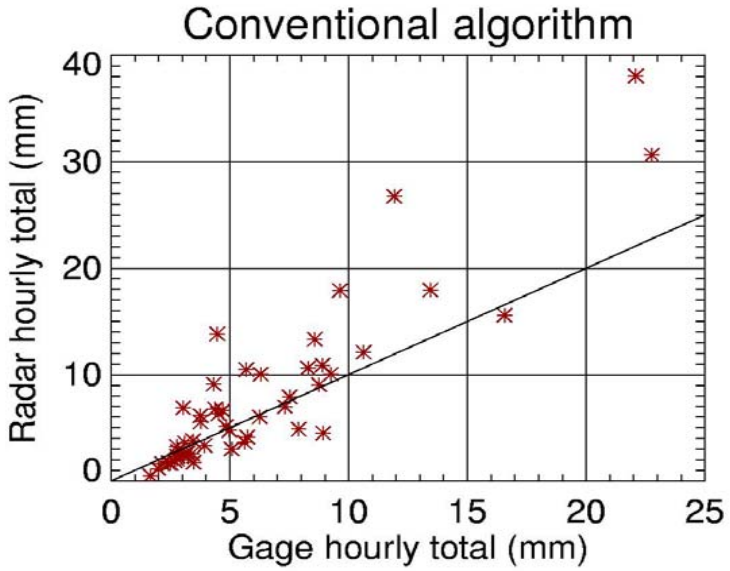
Polarimetric Rainfall Estimation

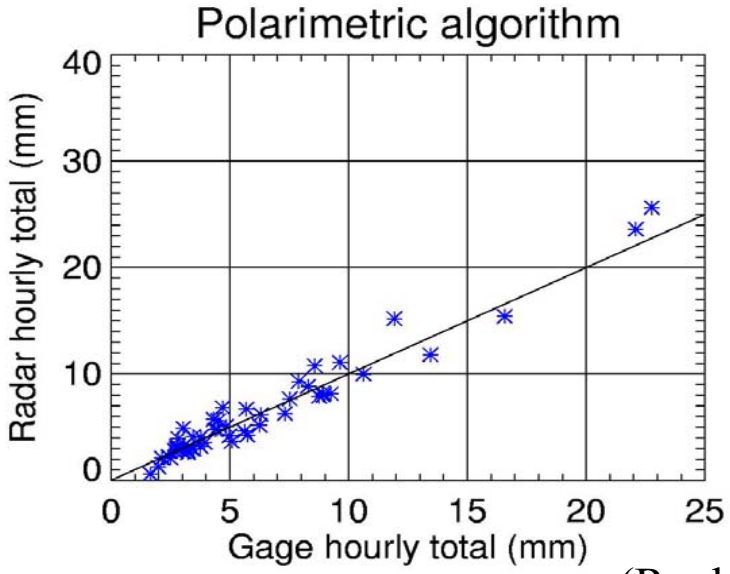
Point Estimates





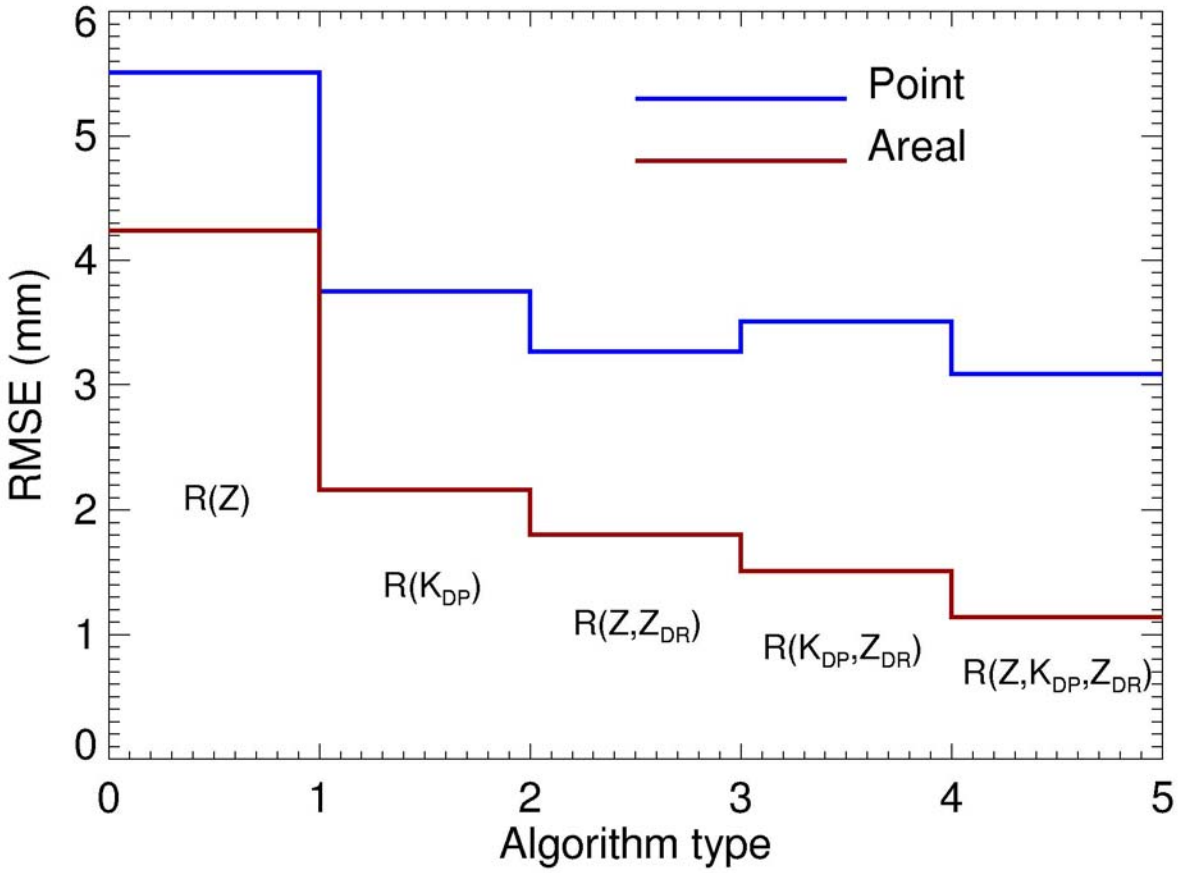
Areal Estimates





(Ryzhkov 2003)

RMS errors of point and areal estimates of rain for different radar rainfall estimation algorithms



(Ryzhkov 2003)

Some Unresolved QPE Science Issues Regarding Dual Polarization Radar

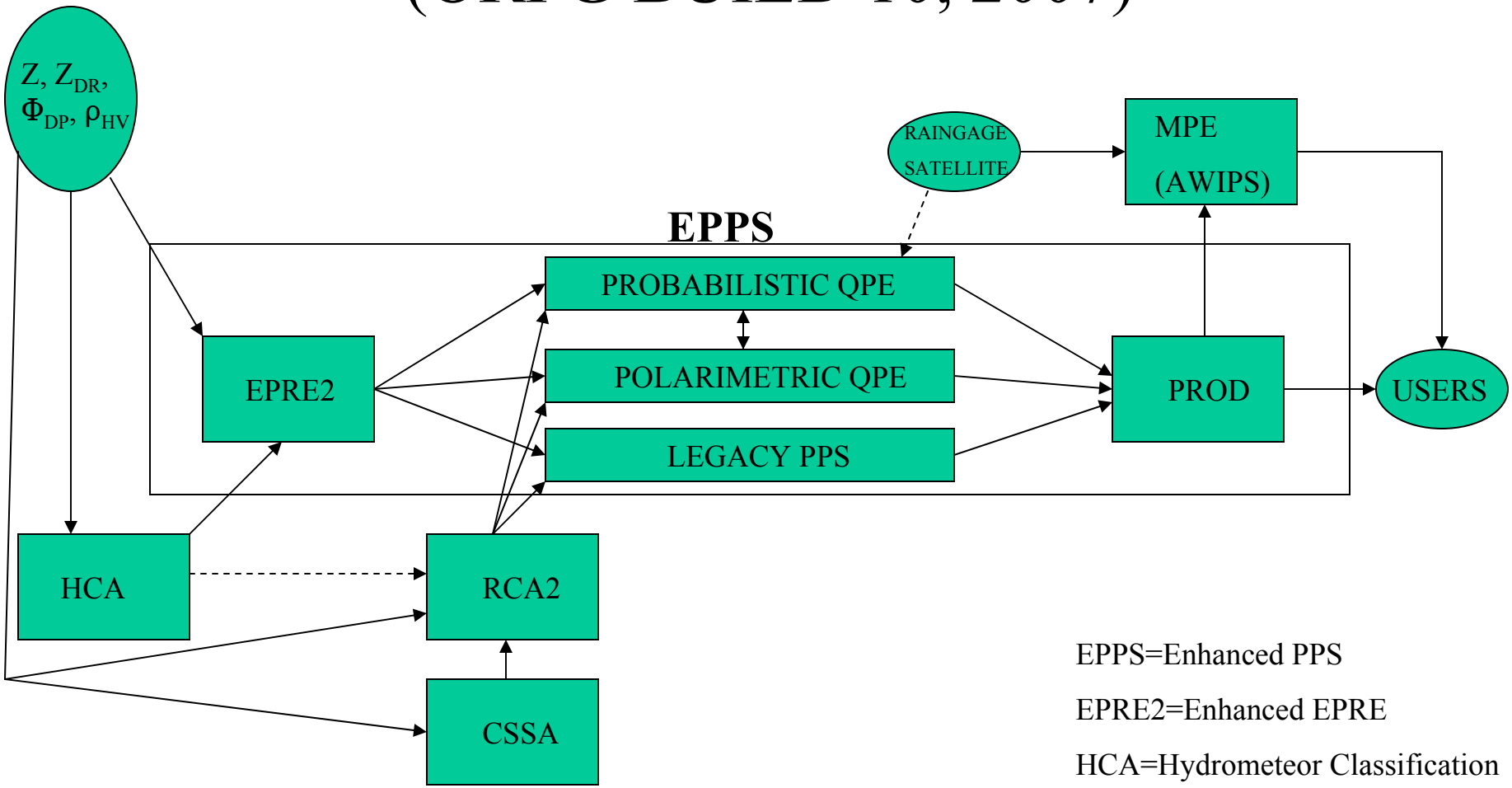
- Evaluation of QPE algorithm performance outside of Oklahoma (NSSL will work with NCAR scientist; expedite upgrade of Des Moines and/or Davenport, IA WSR-88Ds)
- Evaluation of the benefits and use in cold season (i.e., when radar beam is at or above the freezing level)
- Development of polarimetric quantitative snowfall estimation techniques (vs. existing Z-S techniques in SAA)
- Quantifying and characterizing total QPE errors (in coordination with the Probabilistic QPE project)
- Integration of the NSSL Hydrometeor Classification Algorithm (HCA) into the proposed QPE algorithm
- Robustness of attenuation and differential attenuation corrections to Z and Z_{DR}

Some Unresolved Programmatic Issues Regarding Dual Polarization Radar QPE

- Integration of new polarimetric radar QPE algorithm & products with existing PPS, MPE, and RCA algorithms
  - U. Iowa/NSSL report to OHD…received last week…discusses an initial plan
- Integration of polarimetric radar QPE algorithms with new probabilistic QPE (PQPE) algorithms also under development
  - These 2 QPE development projects are coordinated together
  - U. Iowa/NSSL report discusses an initial plan
- Quantifying benefits to NWS hydrologic forecast services
  - U. Iowa/NSSL report discusses two possible approaches
- Flexibility of the new QPE algorithms to adapt to local conditions and climates
- Education of our users on strengths and weaknesses in coordination with NSSL and ROC Training Branch

Fig. 6

POLARIMETRIC ERA (ORPG BUILD 10, 2007)



EPPS=Enhanced PPS

EPRE2=Enhanced EPRE

HCA=Hydrometeor Classification Algorithm

RCA2=Enhanced RCA

Staff Resources

- OHD:
  - Fulton, Kitzmiller – review and planning for current efforts
  - Increased involvement in QPE science now and when first operational units are fielded
- NSSL:
  - Ryzhkov, Zrnic, Giangrande, Schuur

Call to Action

Polarimetric Radar Deployment in NWS is Rapidly Approaching

- Need to continue to support NSSL QPE algorithm development and evaluation
  - Some science issues remain unresolved
- Continue coordinated planning for integration of new algorithm into existing PPS and MPE techniques
  - Pencil in polarimetric precipitation algorithm implementation in ORPG Build 10 schedule
- Support expedited delivery of NWS polarimetric radar upgrade for Davenport, IA and/or Des Moines, IA WSR-88Ds for beta-testing of new algorithms
  - Requested by Prof. Krajewski of Univ. of Iowa and Dr. Zrnic of NSSL in their recent PQPE report to OHD