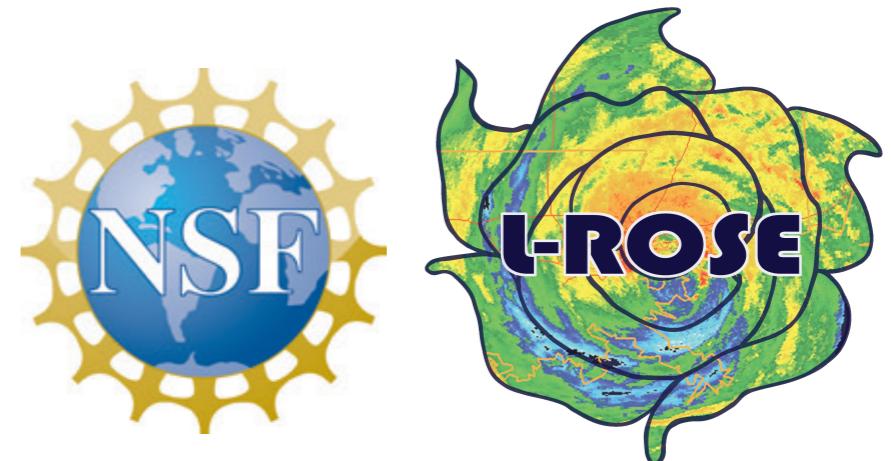


The Lidar-Radar Open Software Environment (LROSE) : Progress and Plans



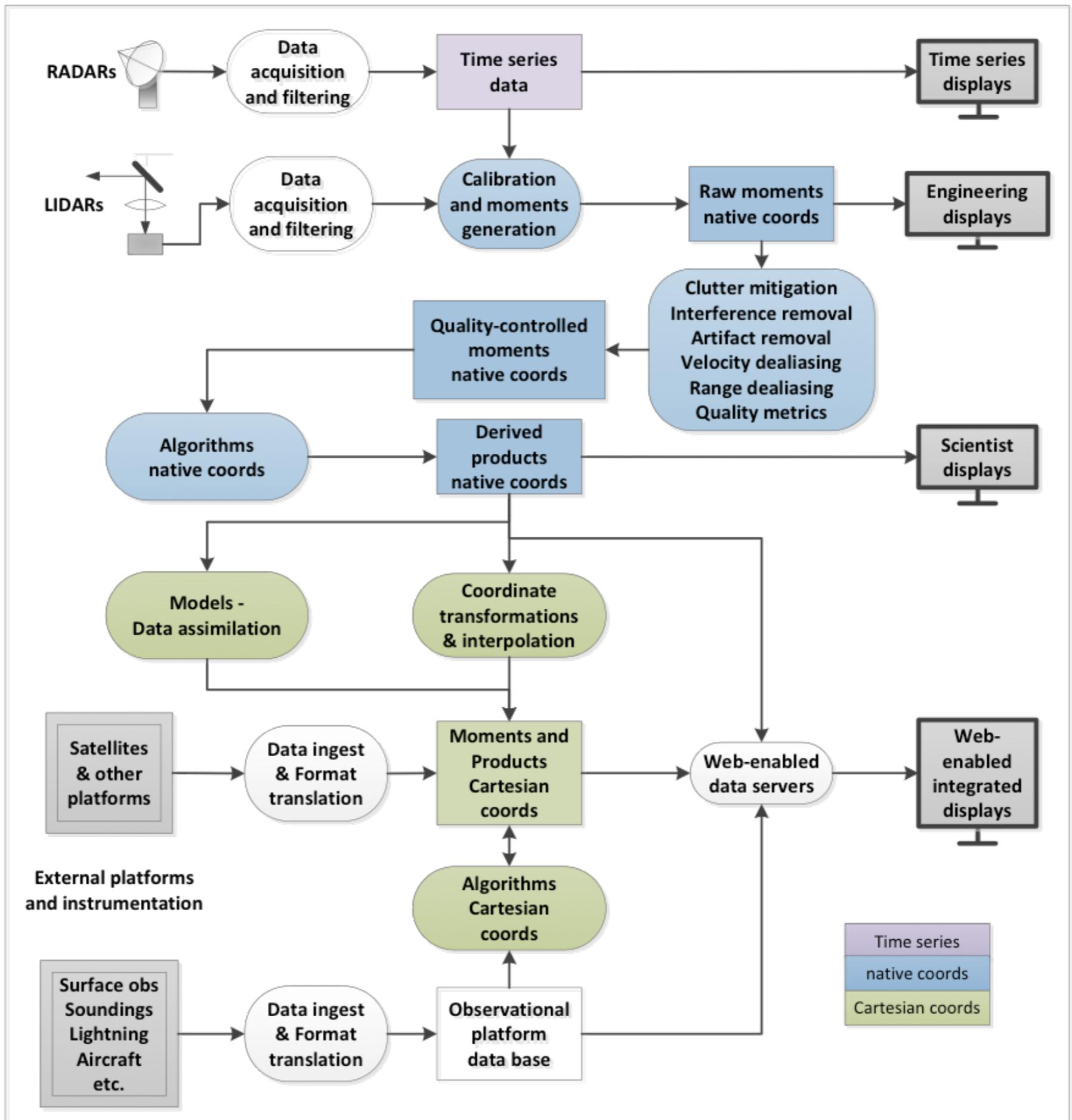
Michael M. Bell
Colorado State University

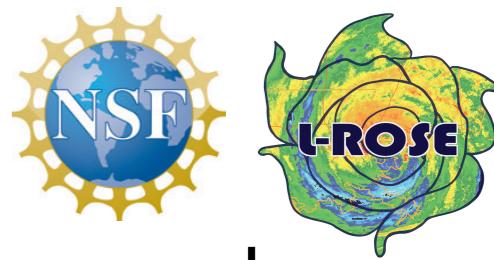


Wen-Chau Lee and Mike Dixon
NCAR



Research supported by NSF SI2-SSI Award ACI-1661663





LROSE: Lidar-Radar Open Software Environment

- LROSE is a project to develop common software for the LIDAR, RADAR and Profiler community
- Joint 4-year project between Colorado State University and NCAR Earth Observing Laboratory funded by NSF SI2-SSI
- LROSE is based on collaborative, open source development, with algorithms and techniques developed and supported by the community
- Data stored in portable data formats like CfRadial, based on UNIDATA NetCDF, following the Climate and Forecasting (CF) conventions to facilitate cooperation with PyArt, Baltrad, and data assimilation by models

nsf-lrose.github.io

NSF Radar Workshop 2012 Survey (Bluestein et al. 2015)

Radar Software Needs	Personal Research Needs	Community Needs	Total Score
NCAR-maintained centralized repository for radar software (esp. including wind synthesis) with data sets for software testing	55	41	96
Standardized software packages and toolkits (multi-platform, modular, menu-driven, easy for community to add to, ease of conversion among new and old radar data formats)	30	53	83
Training (workshops/online tutorials)	48	15	63
Ability to integrate radar and non-radar data sets	25	32	57
Open source tools and software	30	16	46
3D/4D Visualization Software (with publication quality output)	24	21	45
Next generation wind synthesis software to replace the legacy (REORDER/CEDRIC) algorithms, while maintaining current functionality	15	27	42
Common radar data format standard and a common metadata standard (e.g. CfRadial)	19	15	34
64-bit compatible real-time display software tool	19	11	30
Improved radar data quality control (solo) (Oye et al., 1995)	12	20	32
Automated quality control software	14	13	27
Detailed documentation for data products, tools, and code	18	7	25
Improved dual-polarization processing	10	12	22
Accessible variational Doppler radar assimilation and thermodynamic retrieval	7	4	11
Totals	326	287	613

April 11-12 2017 LROSE Workshop Summary

1. Six key applications were identified for initial development:
Convert, Display, QC, Grid, Echo, and Winds
2. Good documentation, ease of use, and starter kits were emphasized as crucial aspects for software adoption, not just the availability of code or algorithms
3. Community contributions beyond code such as discussion forums, how-to videos, and tutorials will help build user base
4. Focus on high-quality, well-tested, well-maintained and well-documented key applications as ‘building blocks’, allowing users to assemble trusted, reproducible workflows to accomplish more complex scientific tasks

Infrastructure

NetCDF data support layer

Data servers for display applications

Higher-level language bindings for C++ library classes

Higher-level language native data handling library

Portability layer

Open source software distribution mechanism

Displays

ASCOPE for spectral radar I/Q time series

BSCAN for vertically pointing data

Low-level viewer and editor for polar data

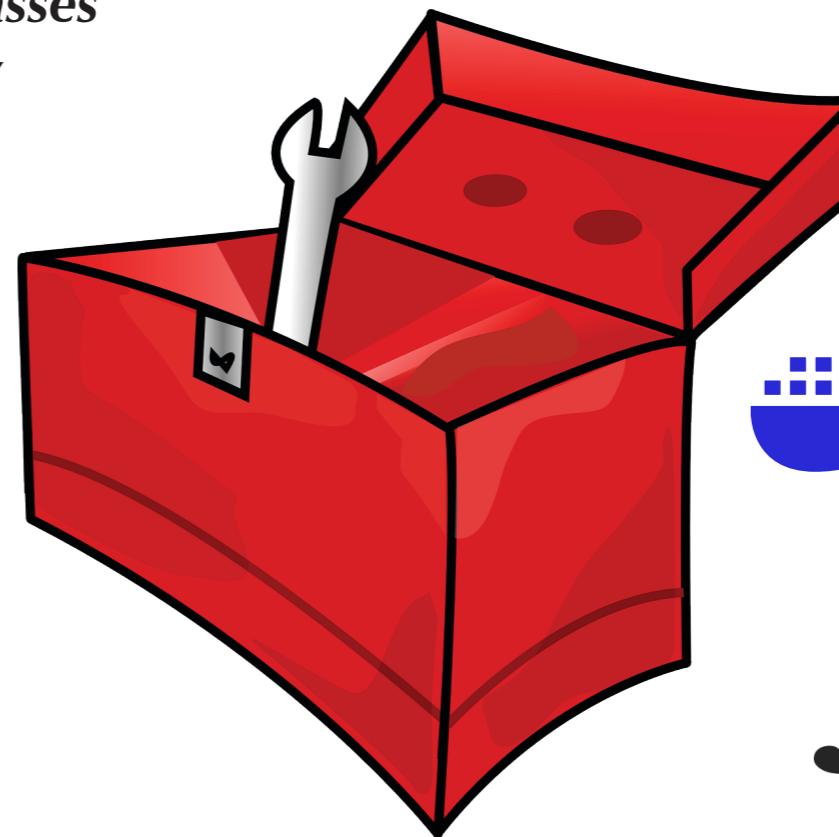
Platform-independent viewer for data integration

Display and editor tool for profiler data

Core Suite Algorithms

Well-tested, published algorithms

Common tasks and widely used tools



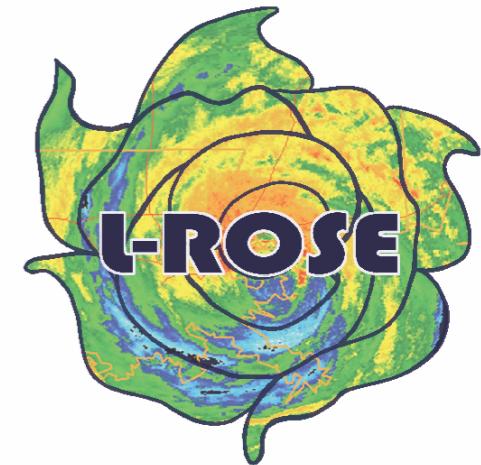
Community Algorithms

Specialized software toolsets

Configurable modules for different instruments and science goals

Partner-maintained packages (DOE PyArt, BALTRAD, and others)

LROSE Convert



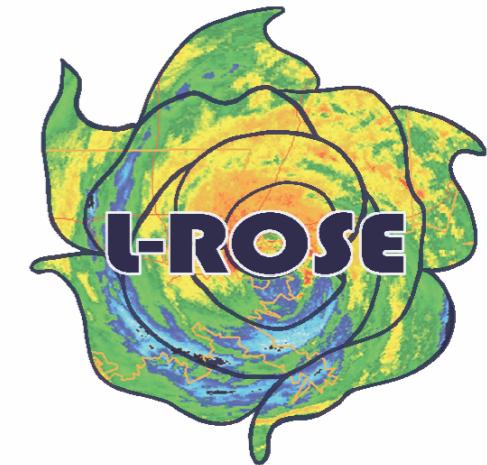
- **RadxConvert** (*mature prototype*)

- Convert to/from CfRadial netCDF format

Type	Notes	Type	Notes
D3R	Read-only	NEXRAD Level 2	Read-write
DOE	Read-only	NEXRAD Level 1,3	Read-only
DORADE	Read-write	NOXP	Read-only
EEC-Edge	Read-only (work in progress)	NSSL-MRD	Read-only
FORAY	Read-write	ODIM-H5	Read-write (work in progress)
Gamic	Read-only	RAPIC	Read-only
Gematronik Rainbow	Read-only (writeable with python script)	SIGMET Raw (Vaisala)	Read-only
HSRL (LIDAR)	Read-only	TDWR	Read-only
HRD (Hurricane Research Division)	Read-only	TWOLF	Read-only
Leosphere (LIDAR)	Read-only	UF	Read-write
CfRadial-1	Read-write	CfRadial-2 (WMO)	Read-write (work in progress)

- **RadxBUFR** (*in development*) for GSI data assimilation

LROSE Display



1. **Soloii** (*legacy*) has been ported to Docker

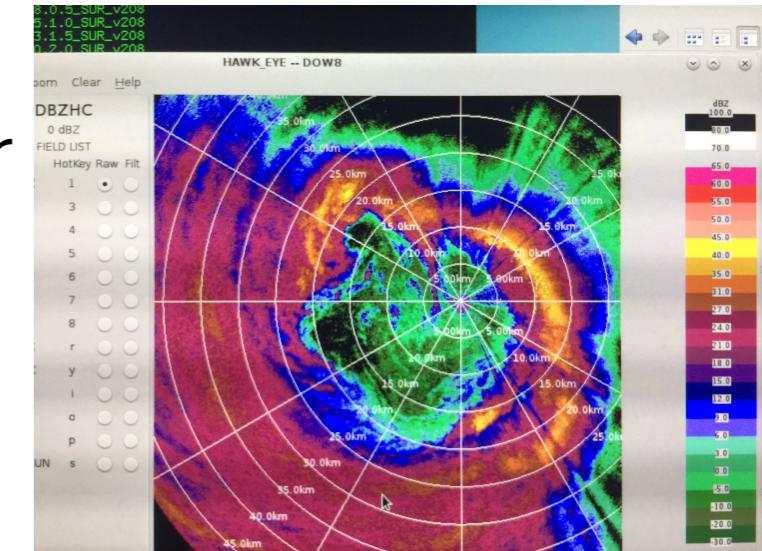


★ Download Docker and soloii_docker script. **Go!**

2. **HawkEye** (*in development*)

- Engineering and real-time display suitable for both scanning and vertically pointing radars. New research capabilities will be added

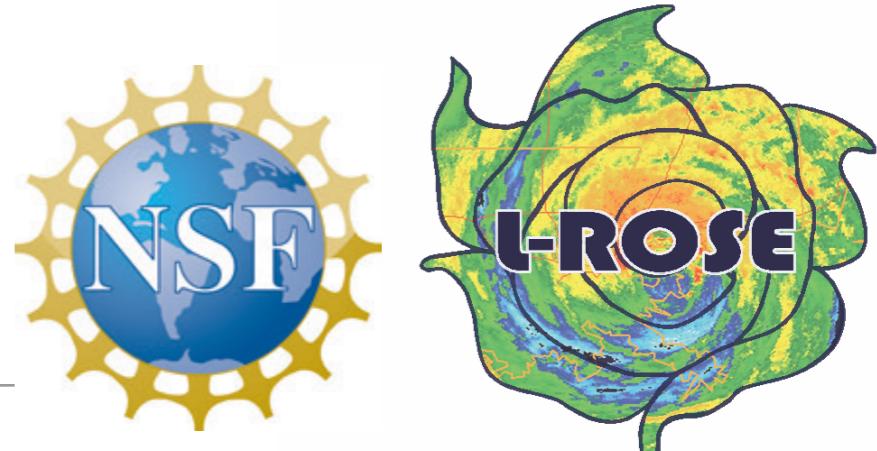
3. **Jazz** (*in development*)



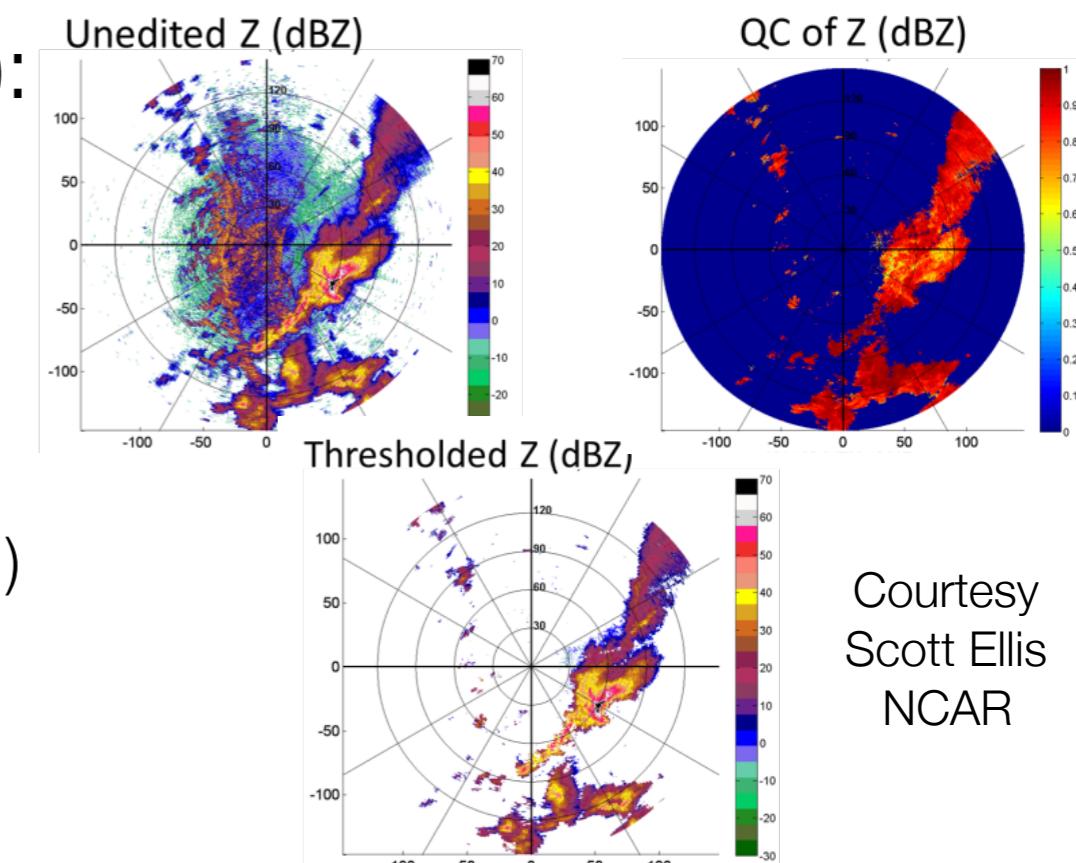
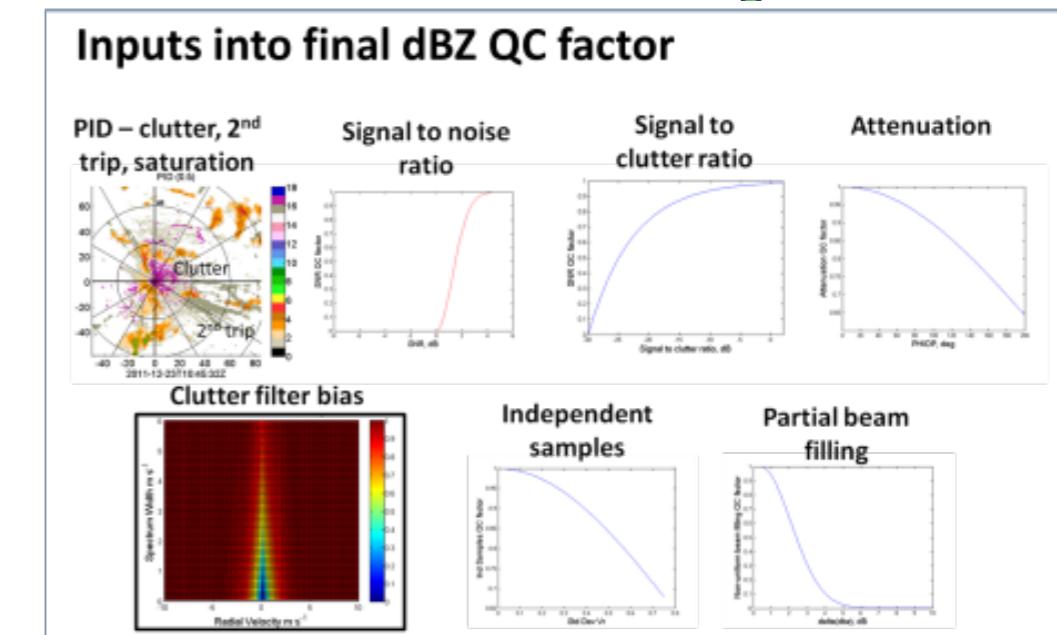
Courtesy Karen Kosiba, CSWR

- Java-based integrating display under active development (next generation to Zebra and CIDD)

LROSE QC



1. **RadxQC** (*in development*): Remove AP & sea clutter, RF interference, chaff
2. **RadxModelQC** (*in development*): Compute QC factor for automated editing
3. **AirborneRadarQC** (*in development*): Airborne navigation corrections and automated editing (Cai et al. 2017)
4. **JamesDealias** (*mature prototype*): 4D velocity dealiasing (James & Houze 2011)



LROSE Grid



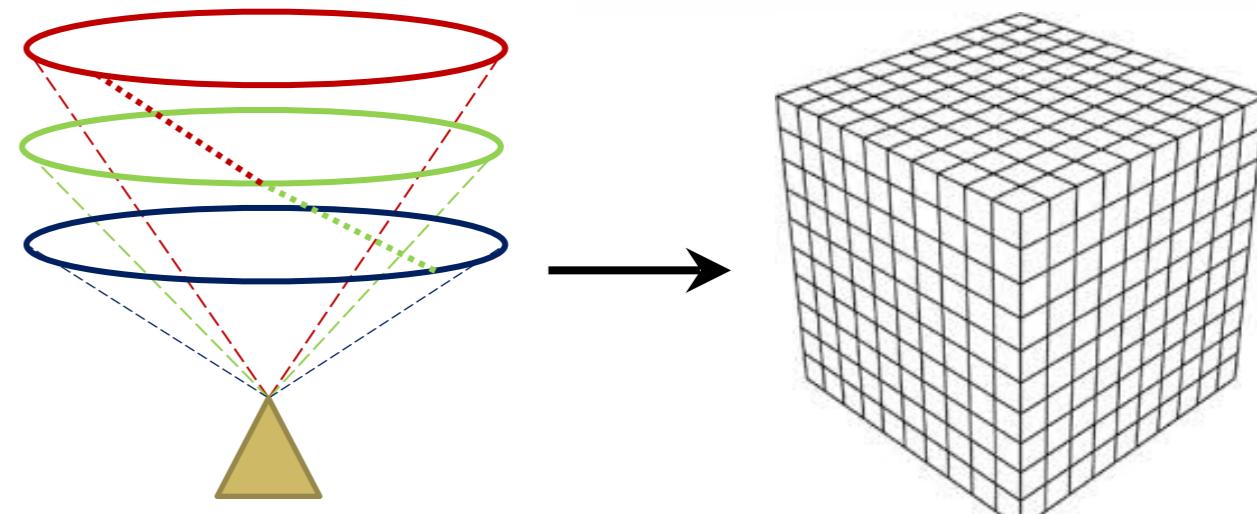
1. **Radx2Grid** (*mature prototype*)

1. 3-D Cartesian grid (x, y, z)

2. Cartesian PPIs (x, y, elev)

3. Regular polar grid (range, az, elev)

- Recent development has streamlined options in the parameter file for typical use cases.



2. **Sprint & Reorder** (*legacy to be ported to Docker*)

- Functionality available in Radx2Grid and FRACTL



1. **RadxPartRain** (*mature prototype*): NCAR PID, Precip rate
2. **ConvStrat** (*mature prototype*): Convective-stratiform partition
3. **RadxBeamBlock** (*mature prototype*): Beam blockage identification
4. **QPEVerify** (*mature prototype*): Precipitation verification
5. **RadxQpe** (*in development*): QPE application
6. **Refract** (*mature prototype*): Refractivity calculations



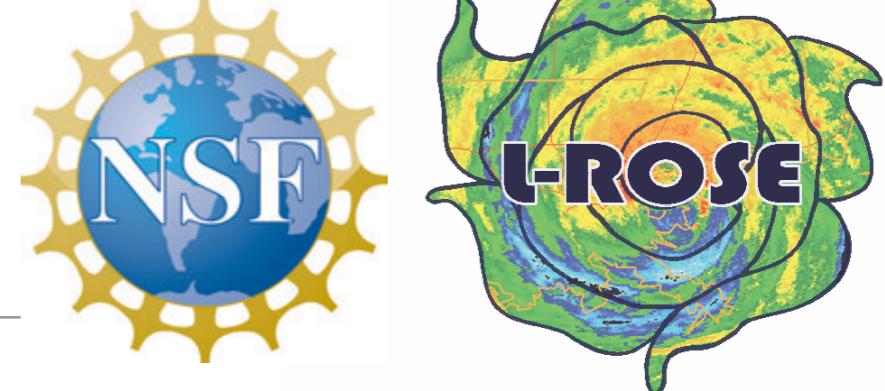
1. *Multi-Doppler*

1. **FRACTL** (*in development*): Fast Reorder and Cedric Technique in LROSE. Highly optimized classic dual-Doppler solver
2. **SAMURAI** (*mature prototype*): Spline-based 3DVAR technique
(Bell et al. 2012)
 - Inter-comparison with PyArt MultiDopp, HRD, and others underway

2. *Single Doppler*

1. **RadxEvad** (*mature prototype*): Enhanced VAD (Matejka & Srivastava 1991)
2. **VORTRAC** (*mature prototype*): GVTD (Jou et al. 2008)

LROSE Release Schedule



- **Latest Beta released 2 January**
- **First Release “Blaze” by 31 March**
- Each tool will be released with documentation and starter kits
- March 31: Initial release of core tools:
RadxConvert, RadxBufr, RadxPrint, Radx2Grid, HawkEye
- June 30: 'QC' tools: RadxCheck, RadxBeamBlock, RadxFilter
- Sept 30: 'Echo' tools: RadxPartRain, RadxQpe
- Dec 31: 'Wind' tools: SAMURAI, VORTRAC, FRACTL, RadxEvad

Get involved @ nsf-lrose.github.io



1. LROSE focused on building radar and lidar community software tools through open source development
2. Focus on high-quality, well-tested, well-maintained and well-documented key applications as ‘building blocks’, allowing users to assemble trusted, reproducible workflows to accomplish more complex scientific tasks
3. Source code and several mature prototypes are available now, formal release of “Blaze” software tools in coming months announced via LROSE mailing list