Weather radar data representation supporting the emergence of weather radar as a global resource

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OOM
World Meteorological Organization
Organisation météorologique mondiale

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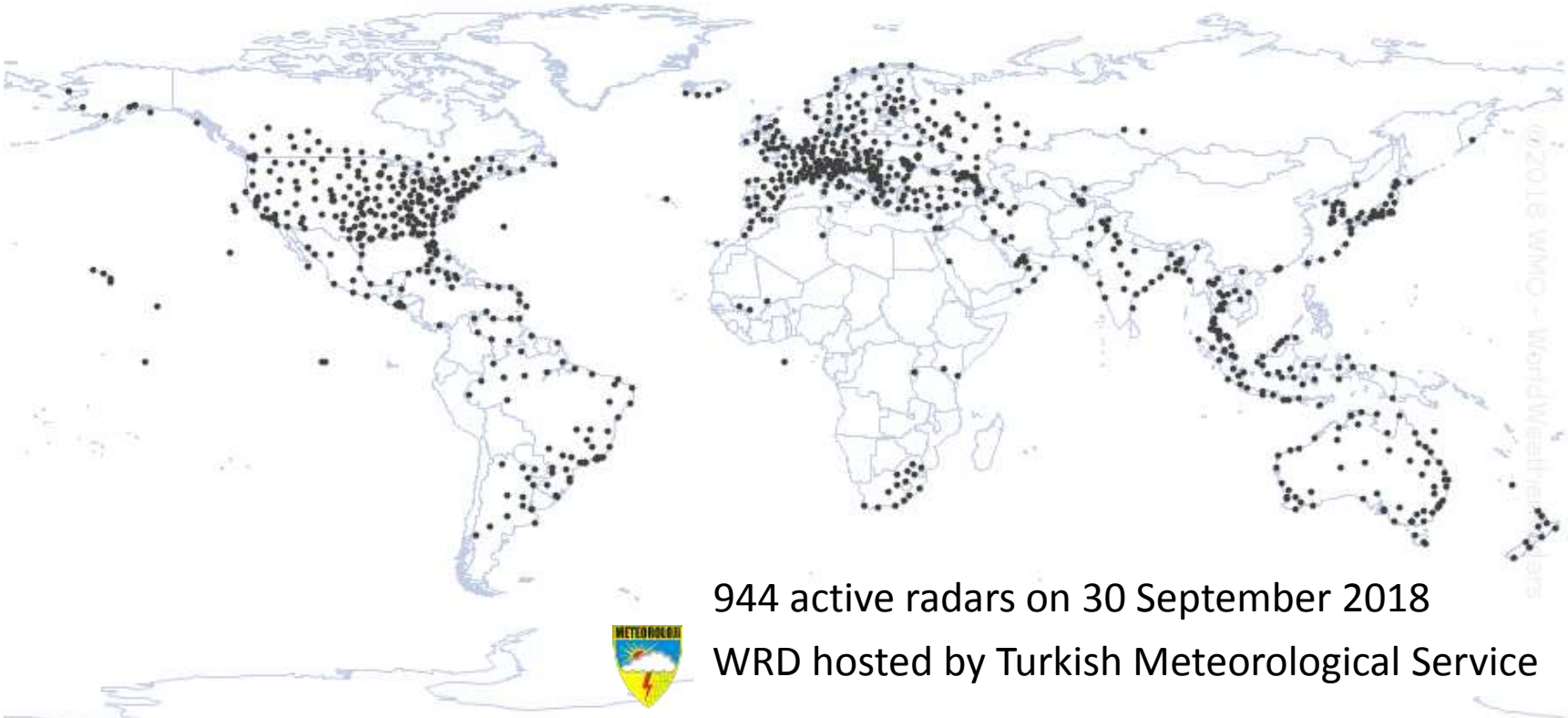
Outline

1. Weather radar – an emerging global resource
2. Weather radar data representation
3. Example for radar system quality assurance
4. Best Practices Guide to Operational Weather Radar
   - ✓ Addressing WxR data quality
5. Weather radar data exchange mechanisms
6. Next steps

WMO weather radar database – WRD



944 active radars on 30 September 2018

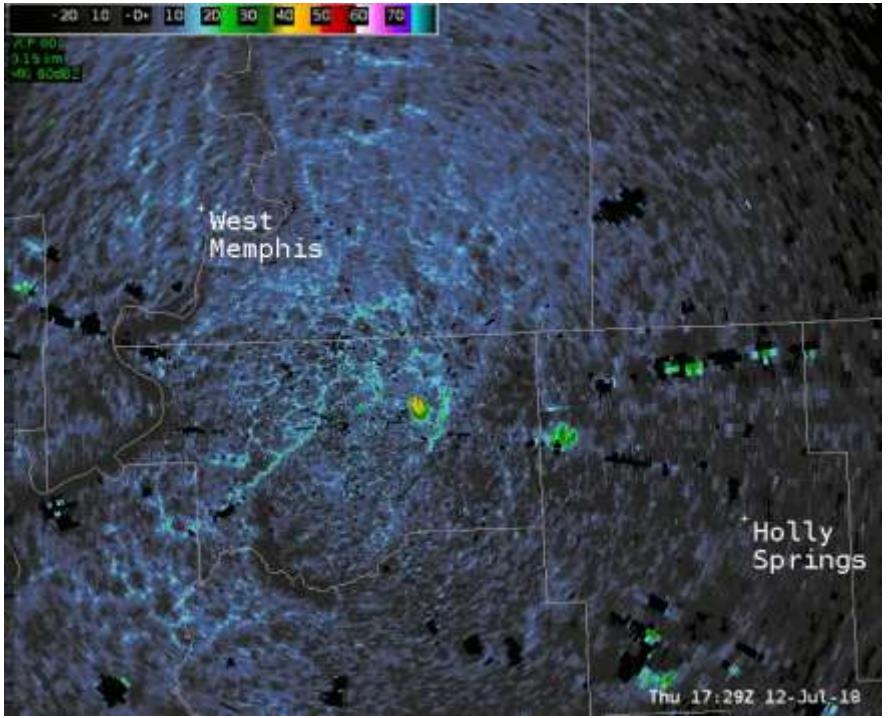
WRD hosted by Turkish Meteorological Service

Weather radar capabilities

NWS Memphis ✓
@NWSMemphis

Follow

Check out the cluster of storms from the high resolution Terminal Doppler Weather Radar (TDWR) in Southaven. You can see the converging air prior to convective initiation followed by a downburst. Low ambient wind shear leads to the near perfect symmetry of the outflow.



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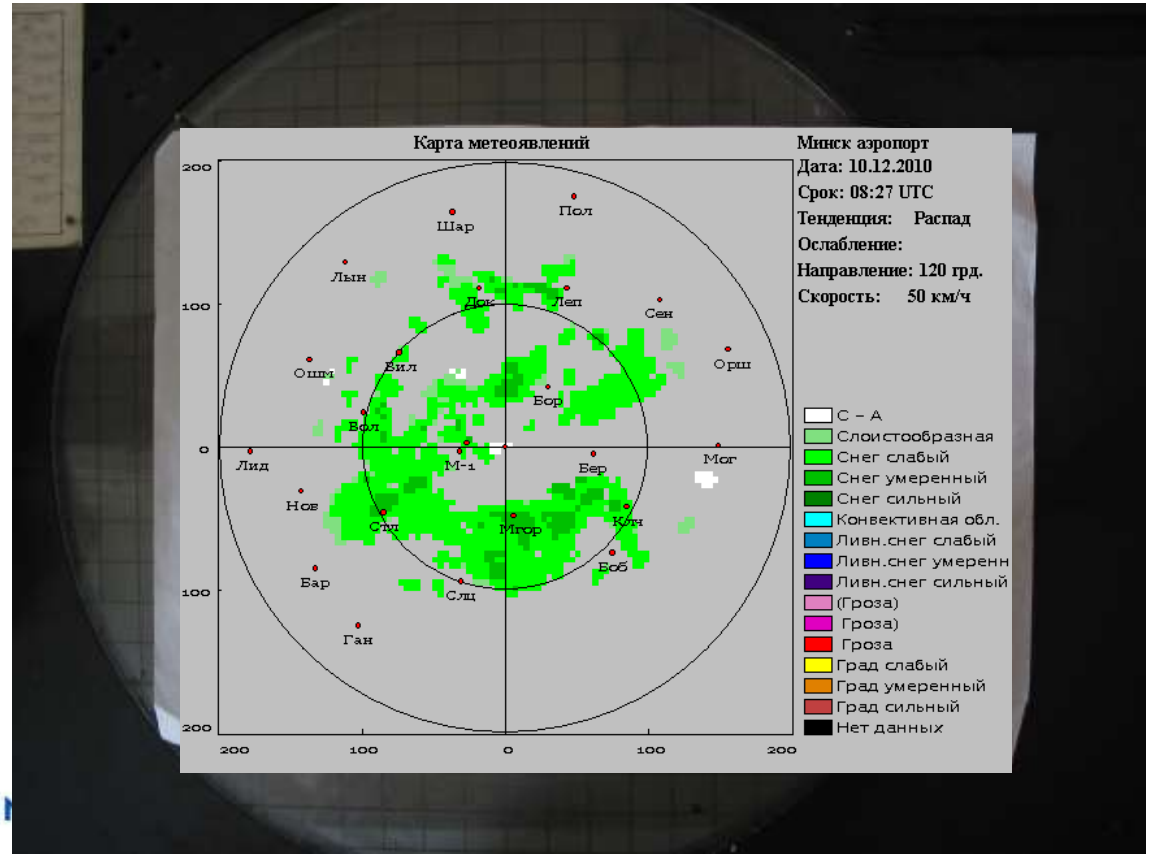
Radar-based weather message

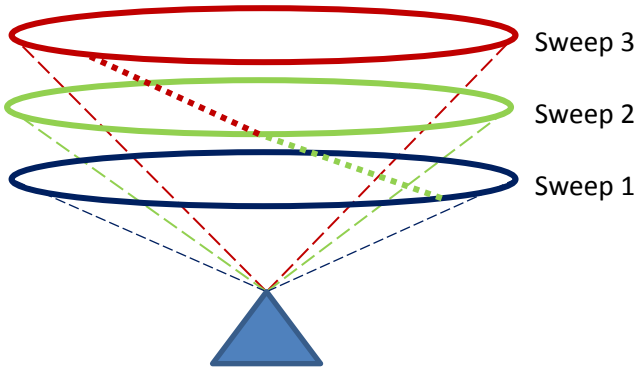


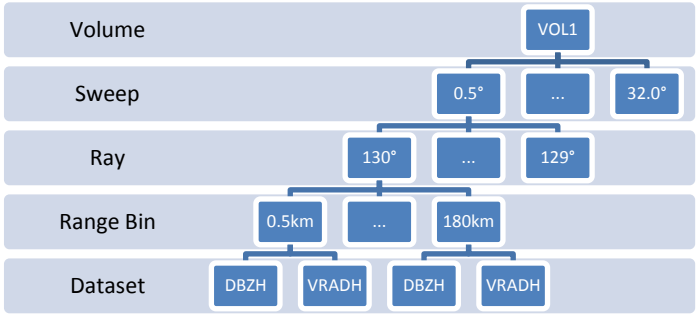
Purposes of data representation

Transmission	to facilitate data transfer from site to central facility
Production	contains all data and metadata required to derive higher-order outputs from input data
Exchange	data or product sharing but not necessarily further processing
Archive	data representation from many different (observing) systems for storage

IPET-OWR's weather radar (and lidar) radial data representation deliverables

1. Information model
2. Data model
3. File format specification
4. WMO Member guidance





Object model hierarchy

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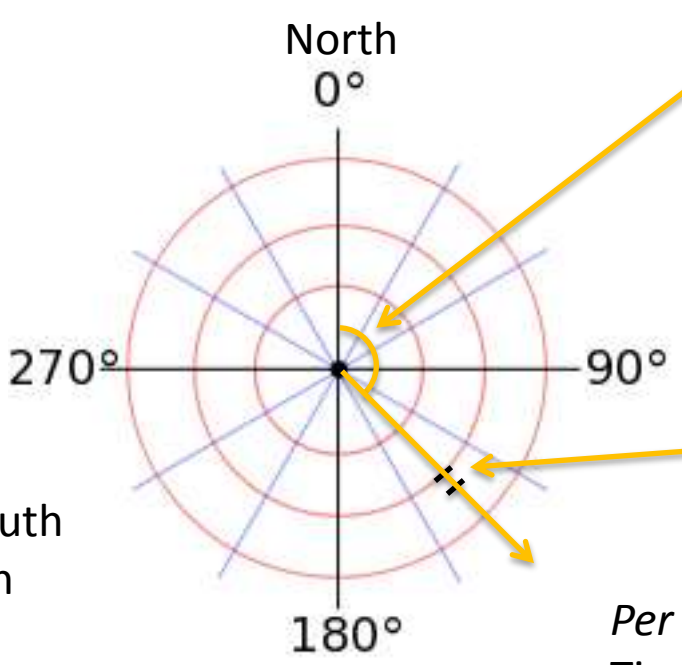
Example: horizontal beam width

1. IM: Identifier=3.2, Type=real, Unit=degrees, Accuracy=0.01
2. DM: Type=float, Encoding=float64, Definition=64-bit floating point value in IEEE 754-2008 binary64 format
3. File: *radar_parameters* sub-group, variable name = radar_beam_width_h
4. WMO Member guidance: required for exchange

Basic weather radar observation in radial/spherical coordinates

Radar site
Longitude, Latitude, Height
Geodetic datum name
WIGOS site identifier

Per sweep
Elevation angle
Number of azimuth gates
Number of range bins/azimuth
Azimuthal offset from North



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Radar quantities or “moments”

For each quantity
Dataset identifier
Quantity name
Quantity units
Special value: missing data
Special value: no signal

Scaling gain
Scaling offset

0	data	255
-32	dBZ	95

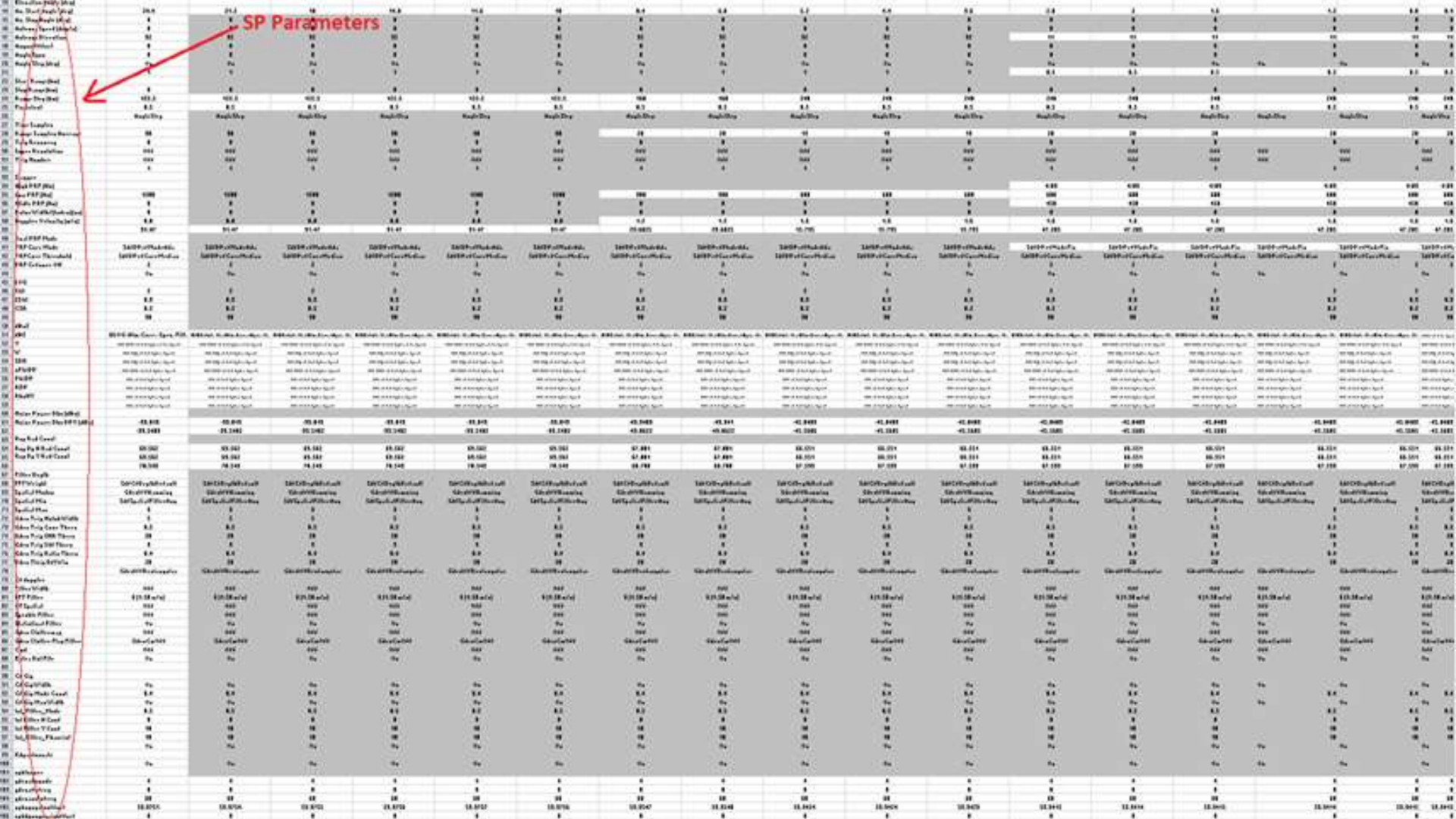
Quantities per sweep
Total power (H/V)
Radar reflectivity factor (H/V)
Radial wind velocity (H/V)
Spectral width (H/V)
Signal quality index (H/V)
Differential reflectivity
Correlation coefficient HV
Differential phase
Specific differential phase
Radar echo classification

Doppler

Dual-polarization

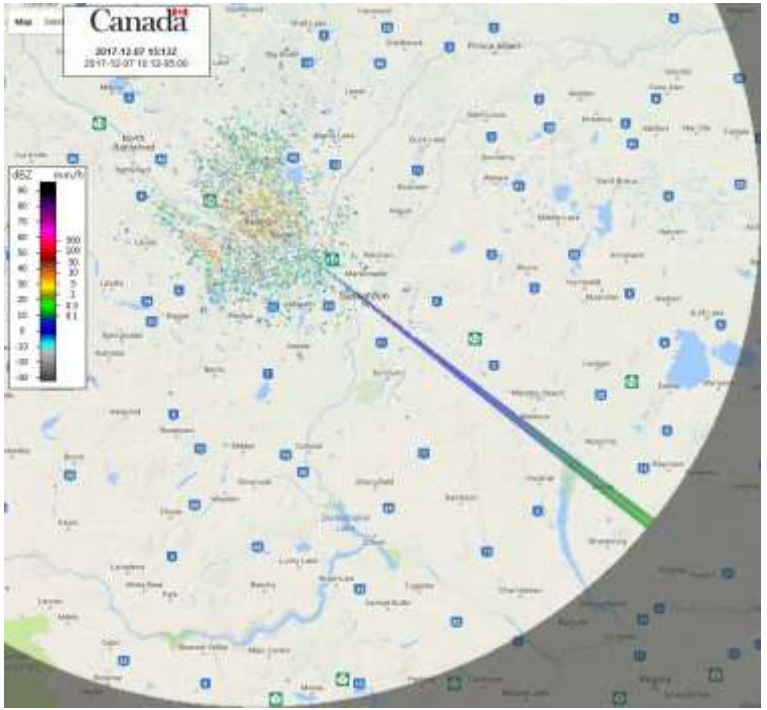
More (optional/desirable) metadata

- Calibration metadata (47 attributes)
- Ray characteristics, (12 attributes) e.g.
  - Precise read-out angles
  - Transmit power
  - Noise estimate
  - Sample size (number of pulses)
  - Pulse repetition time(s)
- Thresholds applied to quantities


SP Parameters

When metadata matters : quality assurance

- Weather radar as a radio telescope: solar signatures from operational data
- Methods evolved in Europe (NL, FI)
- 2018 Vaisala Award winners (Thursday)!
- See poster by Marco Gabella today.



Allows determination of:

✓ Antenna pointing accuracy
✓ Calibration level stability
✓ Differential reflectivity bias/offset
✓ With exchanged data!

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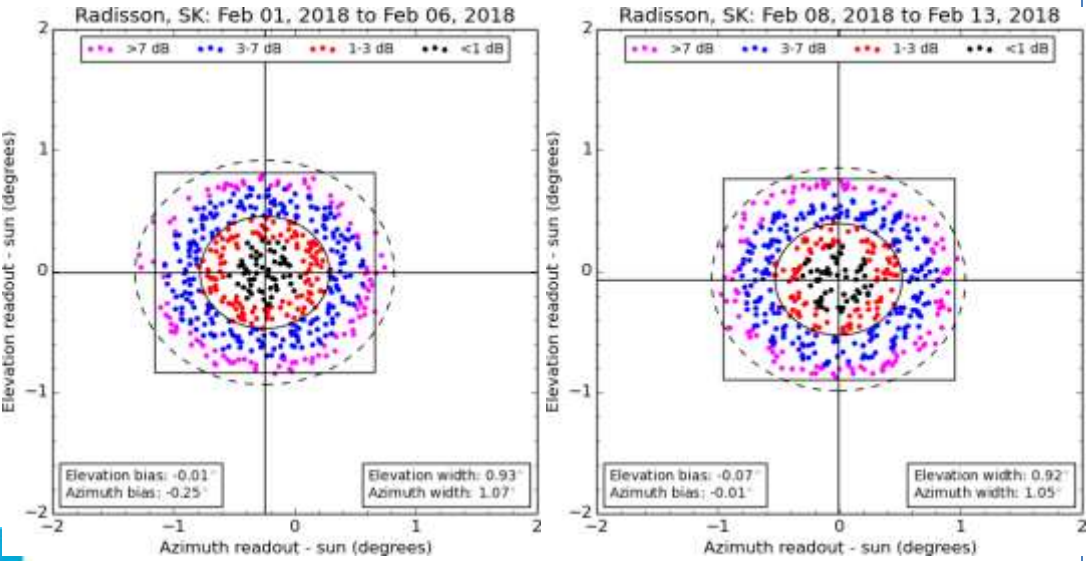
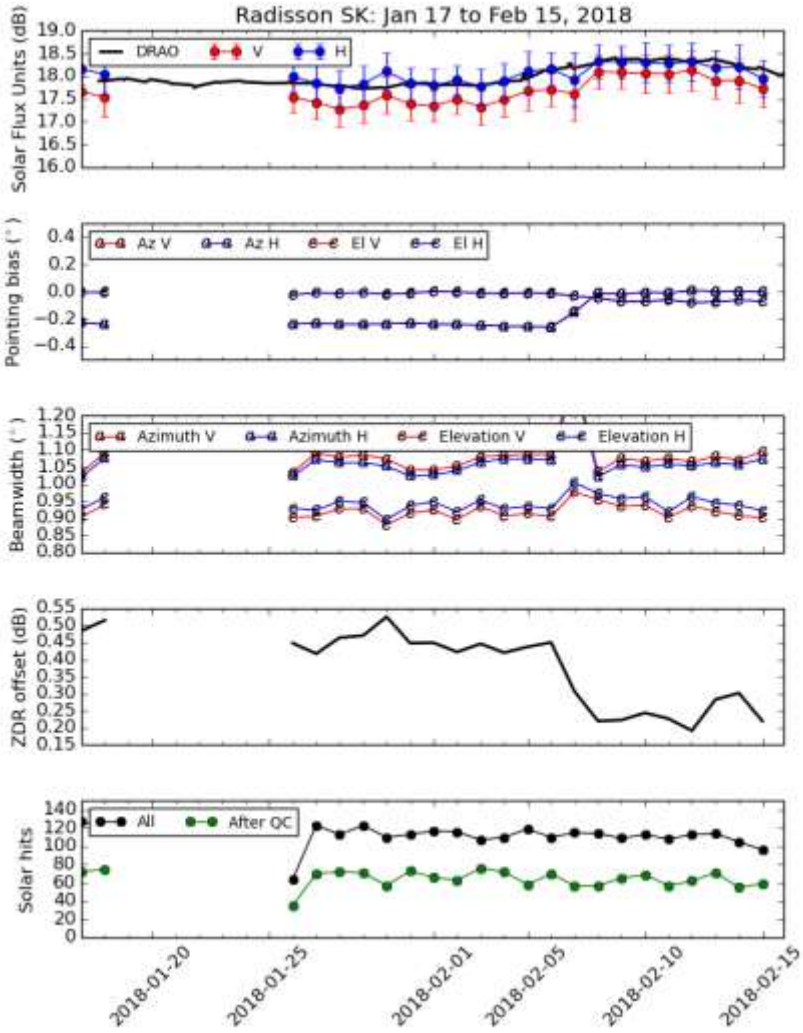
Solar monitoring

Power distributions





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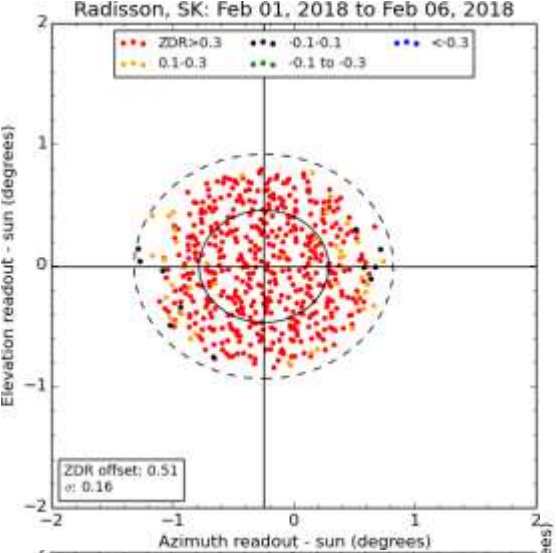
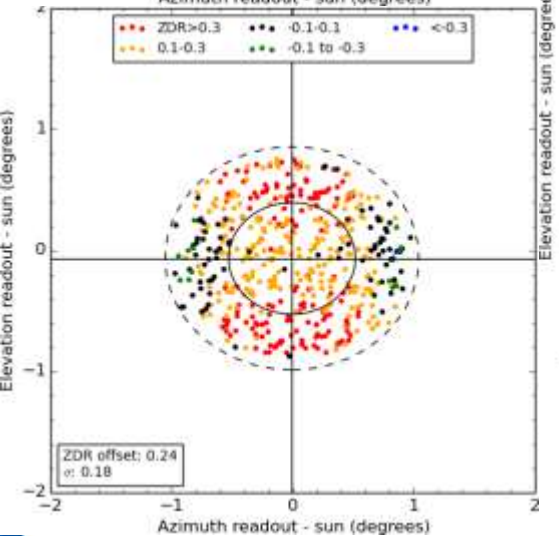
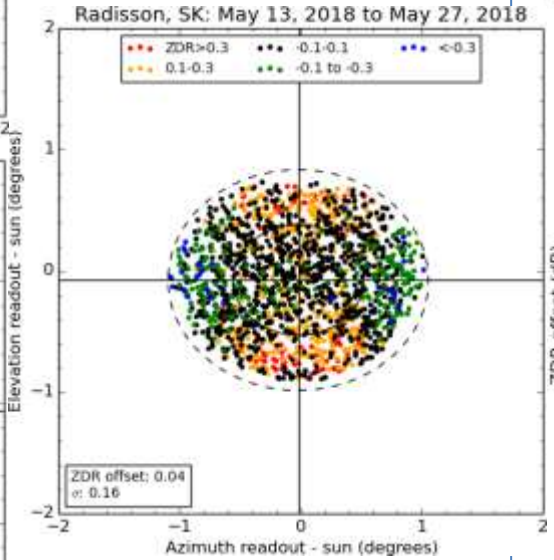
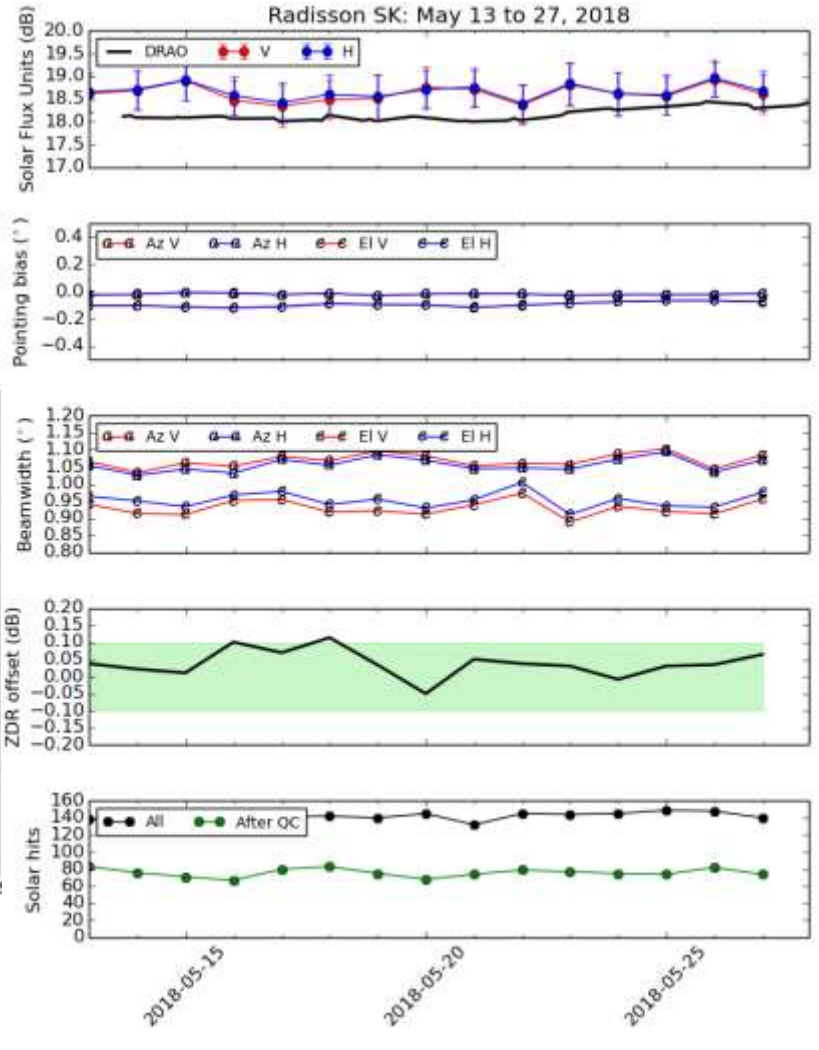
Solar Z_{DR} offset monitoring









Data exchange

HDF5 - Groups, hierarchies, compression

NORDRAD

COST 717 OPERA

ODIM_H5 2.1 2.2 2.3, 3.0?

Data quality

2001 2003 2008 2011 2013 2014 2016-

CF Conventions 1.4, 2.0

CfRadial 1.3

Groups
Hierarchies
Data quality

Compression

netCDF v 4

Research

Data exchange

HDF5

Engagement with CBS IPET-CM on achieving official status of Member use guidance

ODIM_H5 2.2

Structure

CfRadial 2.0

Single Global Standard

CF

CfRadial 1.4

netCDF

Research

Best Practices Guide to Operational Weather Radar

A. Guide to Weather Radar Network Design
B. Guide to Weather Radar Technology
C. Guide to Weather Radar Procurement
D. Guide to Weather Radar Siting, Configuration, and Scan Strategies
E. Guide to Weather Radar Calibration, Monitoring, and Maintenance
F. Guide to Weather Radar Data Processing
G. Guide to Weather Radar Data Representation and International Exchange
H. Operational Weather Radar Glossary of Terminology

Complement to
CIMO Guide
Manual on WIGOS

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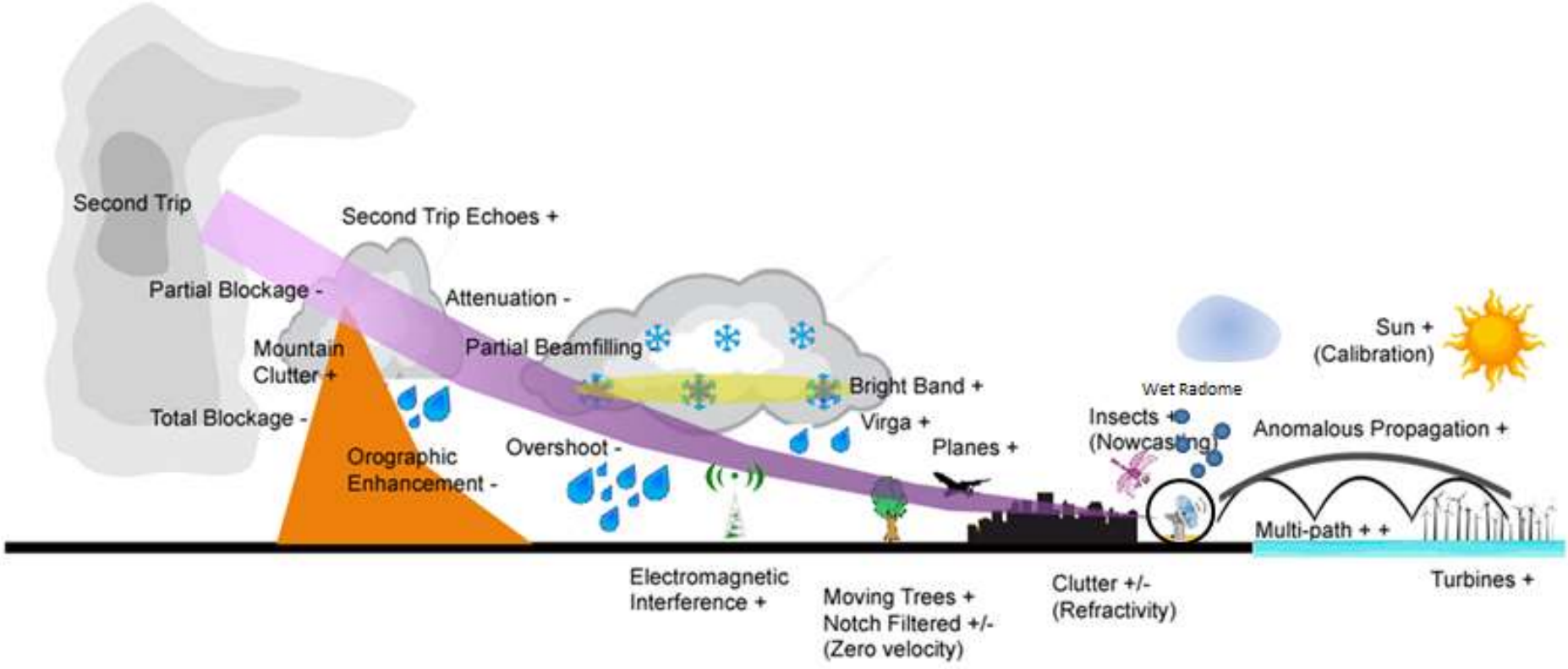
Aligned with ISO weather radar standard

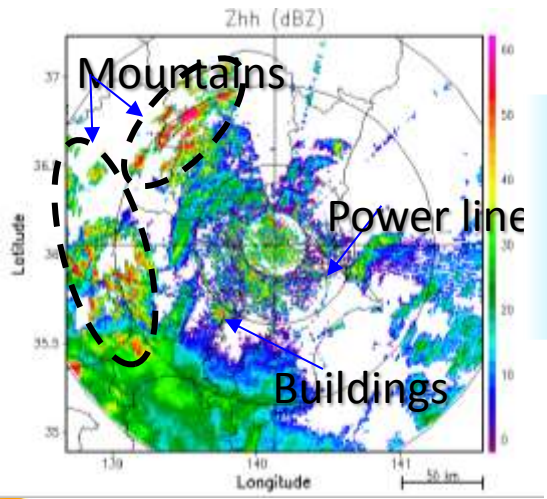
See poster!

Site and data quality



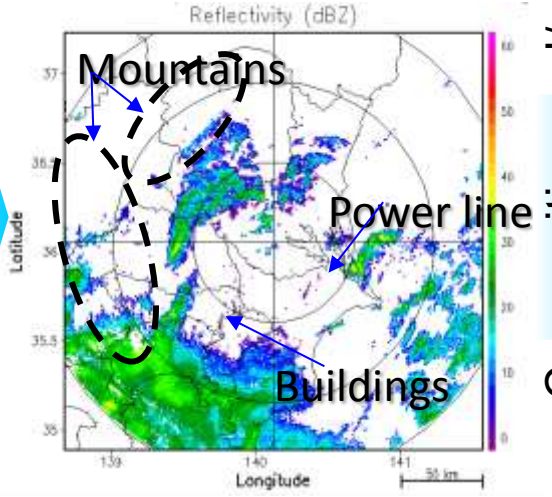
From basic data to Quantitative Precipitation Estimation

Raw moment data



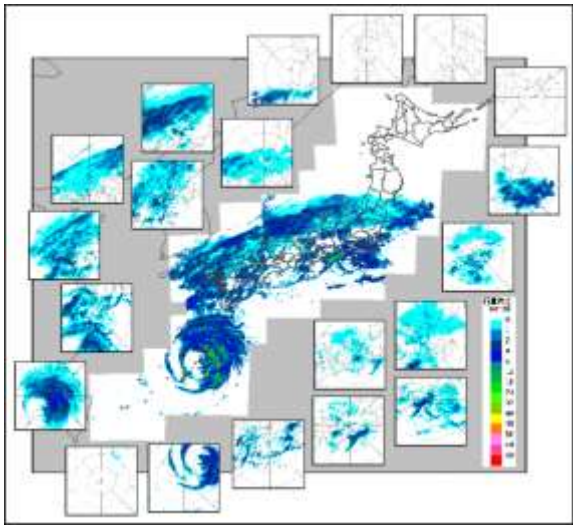
Quality Control

QC:ed moment data



Compositing and/or
Higher order processing

Radar data product



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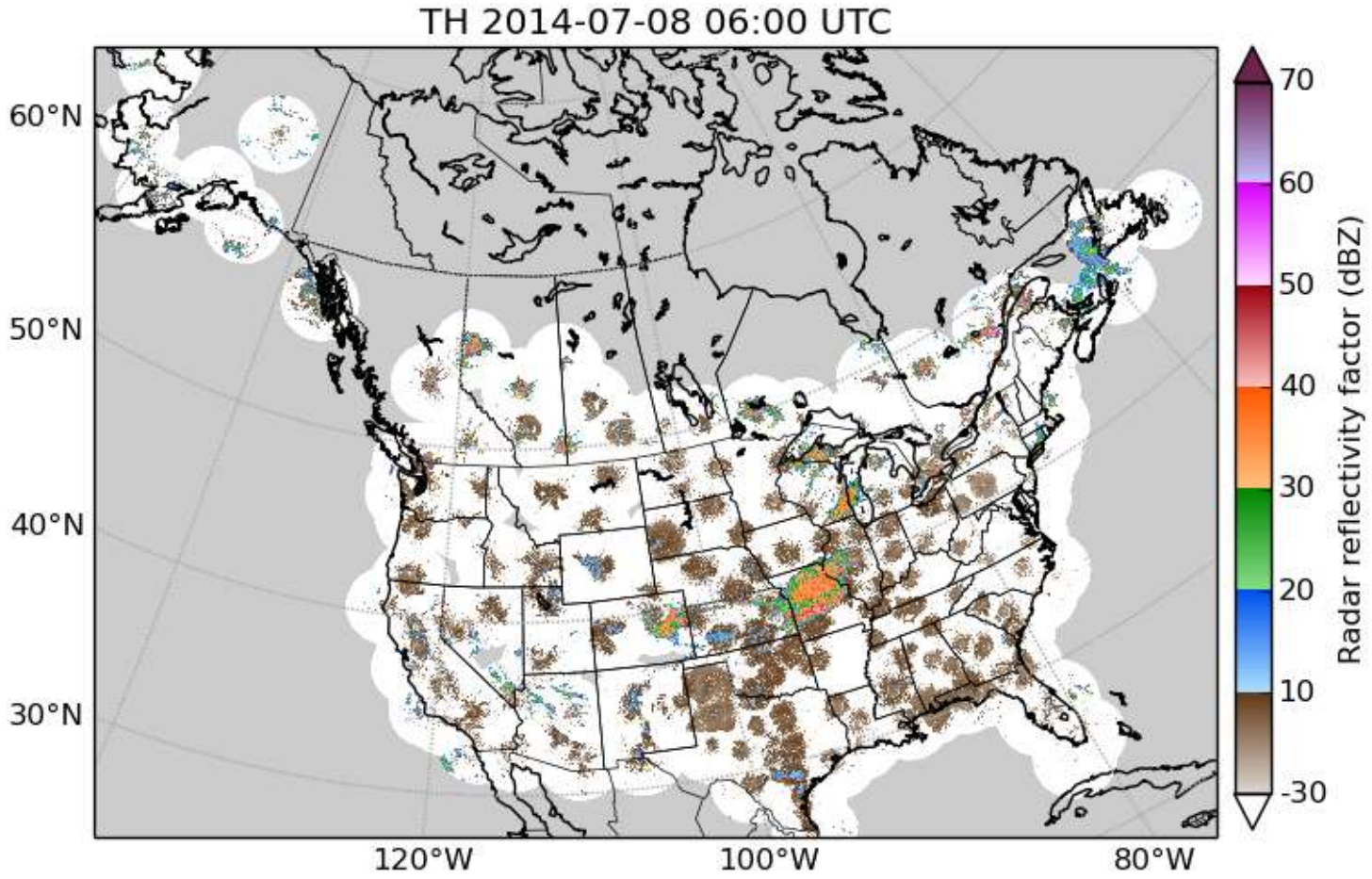
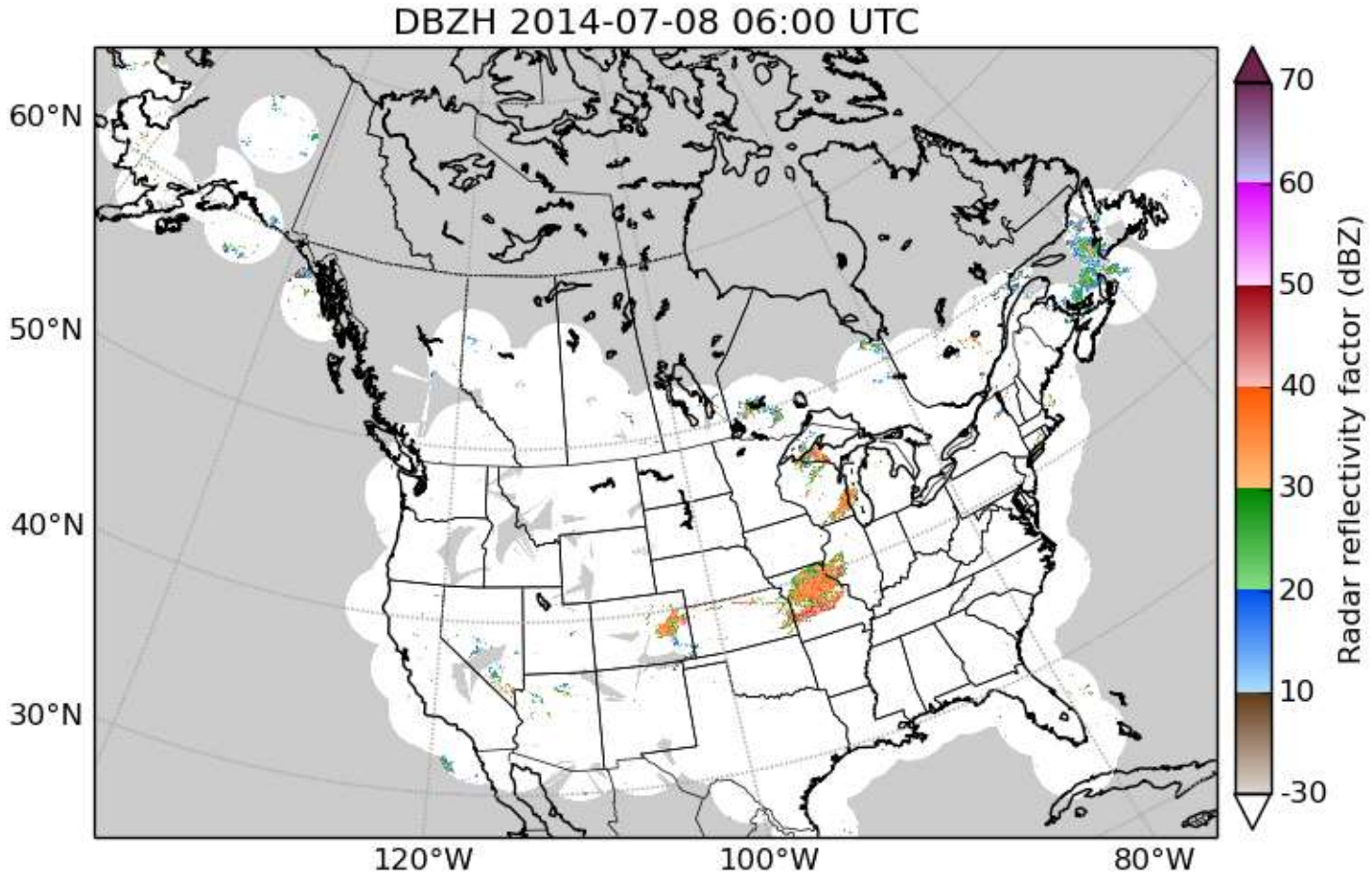
Japan Meteorological Agency

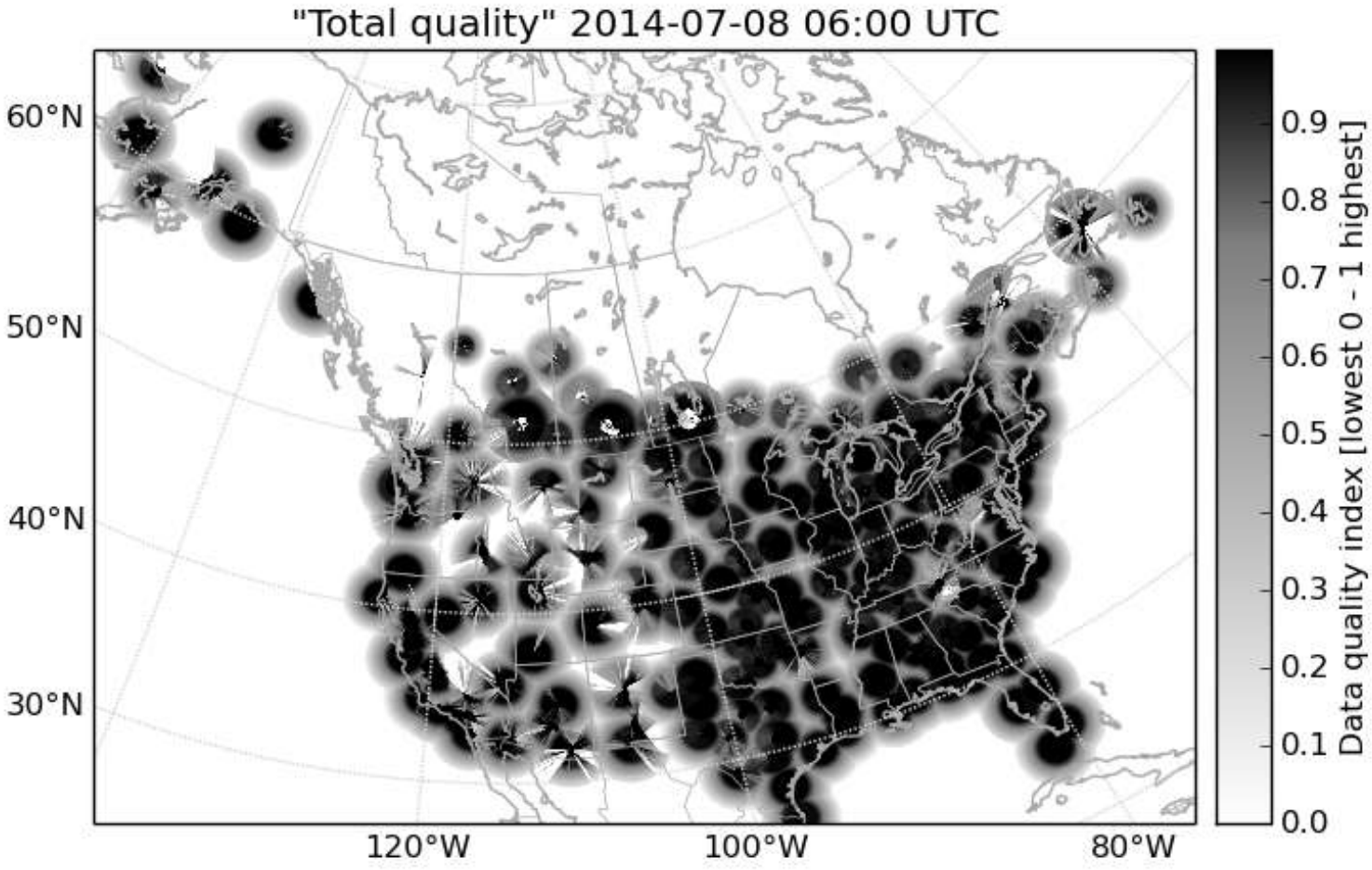
Representing data quality: No quality control



Representing data quality: Quality controlled



Representing data quality itself



Monitoring the impact of radar QC

- Uncorrected (TH) and quality controlled (DBZH) radar reflectivities matched with surface **precipitation occurrence** observations (airport METAR)
- Contingency table statistics:
  POD, FAR, CSI, ETS, TS, PC, PSS, HSS
- Identify an entire radar network as a unit
- IPET-OWR to consider such approaches as best practices

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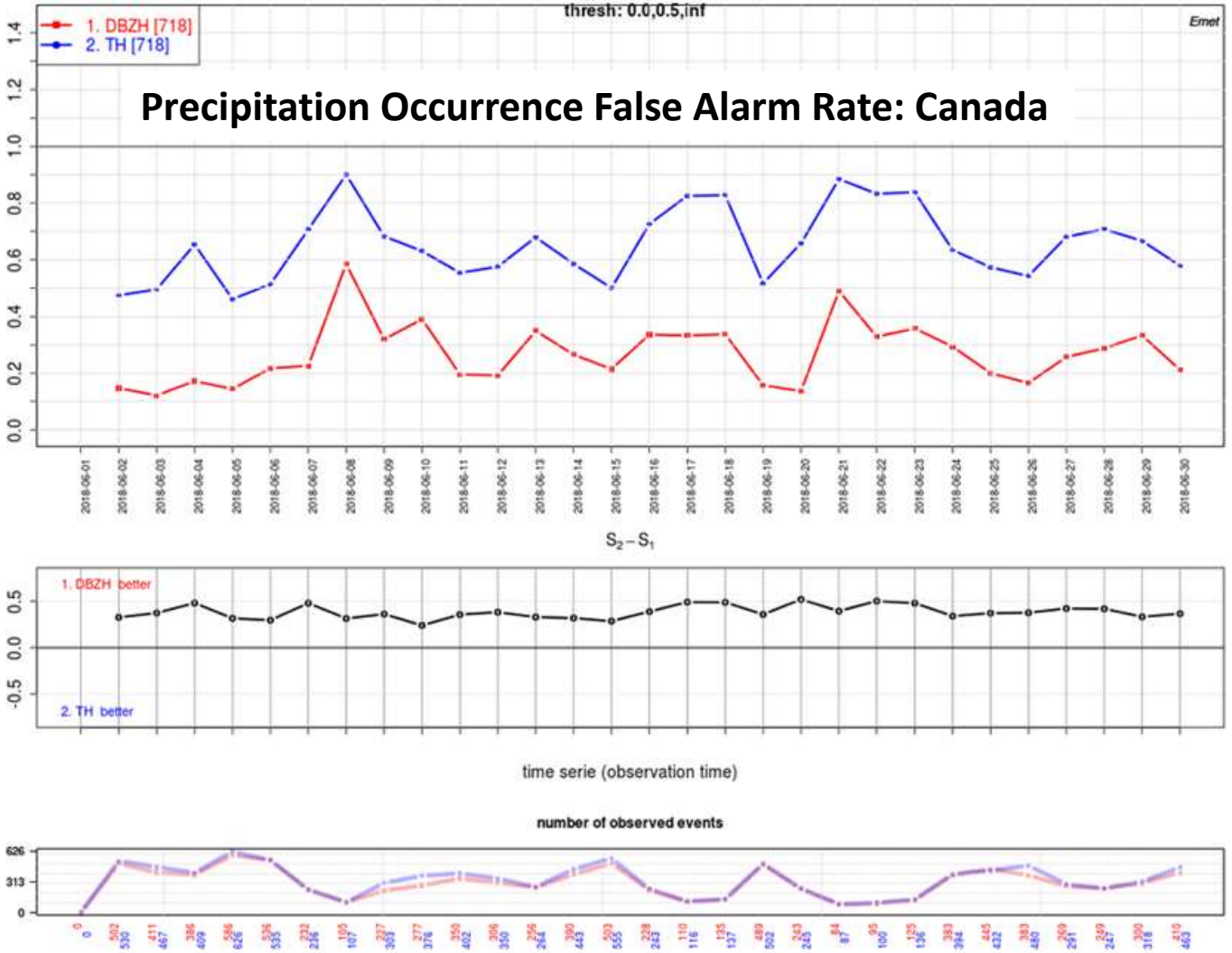
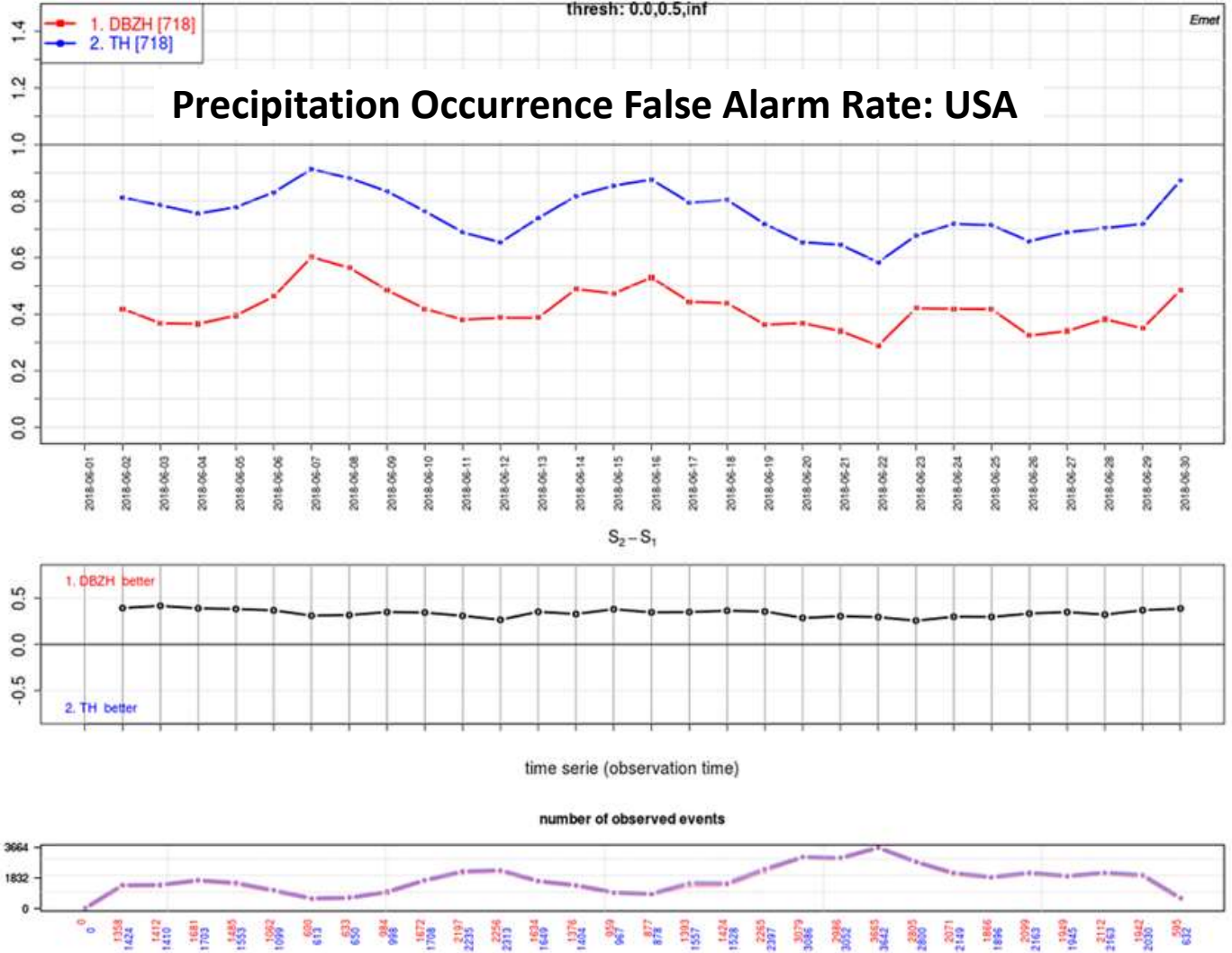
Bjarne Hansen, ECCC

Precipitation Occurrence False Alarm Rate: Canada



Precipitation Occurrence False Alarm Rate: USA



Weather radar data exchange mechanisms

Recommendations from IPET-OWR

1. Avoid FTP due to security vulnerabilities.
2. Active exchange is preferable to passive exchange because active allows greater control.
3. Next generation WMO data exchange mechanisms should be designed to accommodate weather-radar payloads using data representations proposed by IPET-OWR.
4. Members should use such exchange mechanisms with weather radar data.
5. Private networks can provide alternatives to the Internet.
6. Alternative/redundant routing mechanisms should be considered.
7. Crowdsourcing can yield data exchange solution(s).

Next steps

- Create reference Open Source software to read/write CfRadial 2.0
- Follow through with IPET-CM on official status of WMO Member use of CfRadial 2.0
- Finalize and publish first edition of the Best Practices Guide to Operational WxR, Parts A-C, G
- Continue to prepare and publish BPG Parts D-F, H
- Continue engagement with ISO on joint WxR standard
- Demonstrate best practices through engagement in e.g. field campaigns
- Continue to support WMO's Members as WxR emerges as a global resource providing "fit for purpose measurements"

Thank you
Merci

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