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



WMO OOM

World Meteorological Organization Organisation météorologique mondiale Daniel Michelson, ECCC, Canada Mark Curtis, BoM, Australia Mike Dixon, NCAR, USA Günther Haase, SMHI, Sweden Akihito Umehara, JMA, Japan

#### Inter-Programme Expert Team on Operational Weather Radars IPET-OWR

Daniel Michelson	Chair	ECCC	Canada
Hiroshi Yamauchi	Vice-Chair	JMA	Japan
Tom Kane	Vice-Chair	BoM	Australia
Paul Joe		Secretariat	WMO
Dean Lockett		Secretariat	WMO
Wai Kong		НКО	Hong Kong China
Mark Curtis		ВоМ	Australia
José Mauro de Rezende		INMET	Brazil
Pei Chong		СМА	China
Elena Saltikoff		FMI	Finland
Bernard Urban		MF	France
Andreas Becker		DWD	Germany
Theo Mammen		DWD	Germany
Akihito Umehara		JMA	Japan
Jeong-Hee Kim		КМА	Republic of Korea
SungHwa Jung		КМА	Republic of Korea
Yuri Borisovich Pavlyukov		Roshydromet	Russian Federation
Marco Boscacci		МСН	Switzerland
Marco Gabella		МСН	Switzerland
Ercan Büyükbaş		TMS	Turkey
Blake McGuire		NOAA	USA
Michael Dixon		NCAR	USA
Vlado Stojanovic		ECCC	Canada
B			

CIMO & CBS

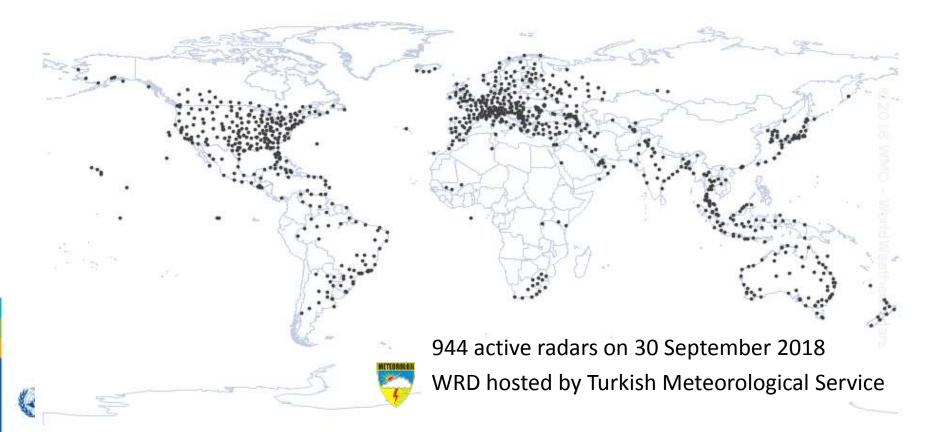


# Outline

- 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



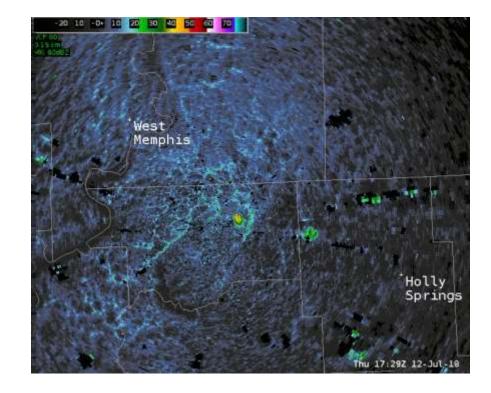
# Weather radar capabilities





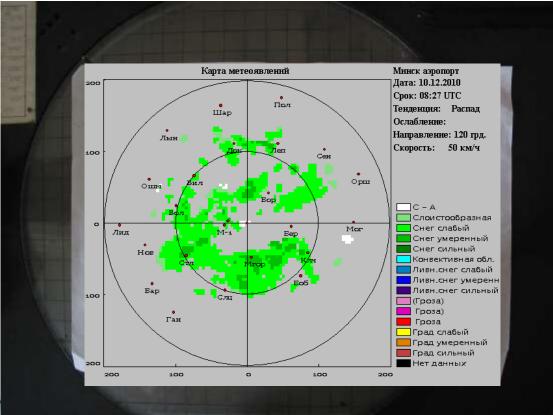


Check out the cluster of storms from the high resolution Terminal Doppler Weather Radar (TDWR) in Southaven. You can see the converging air prior to convective initiation followed by a downburst. Low ambient wind shear leads to the near perfect symmetry of the outflow.





# Radar-based weather message





# Purposes of data representation

Transmission

Production

Exchange

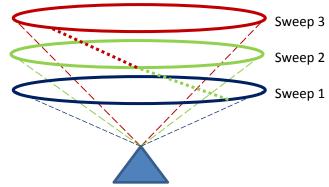
Archive

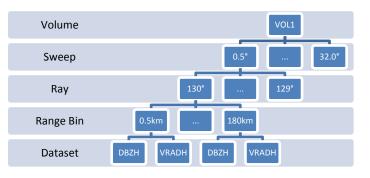
to facilitate data transfer from site to central facility contains all data and metadata required to derive higher-order outputs from input data data or product sharing but not necessarily further processing data representation from many different (observing) systems for storage



# 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

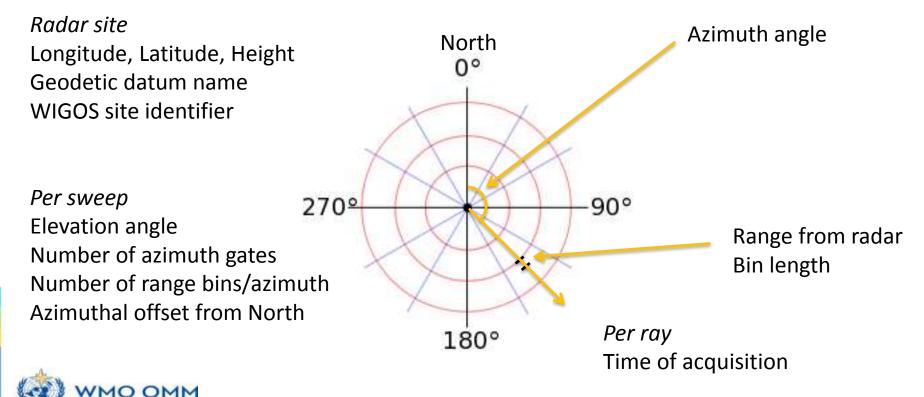


# Example: horizontal beam width

- 1. IM: Identifier=3.2, Type=real, Unit=degrees, Accuracy=0.01
- 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 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
the way on an		

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 · Dual arization Correlation coefficient HV Differential phase Specific differential phase Radar echo classification

# 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

🤕 wmo омм

	Constant Con	A Character	Police Regils     Police Regils     Police Regils     Police Regils     Police Regils     Police     Poli	R Rated Good R Rate Stational R Rate Stational	11 (H) 12 (F) 13 (F) 14 (F)	1120 2	Gurth Jud     Gurth Jud     Gurth Halphal     Gurth Alphal     Gurth Halphal     Gurth Halphal     Gurth Halphal	a tay tay and a tay and a tay		
i.	· ·····	Baattik sengto Bill And Bill And Bill Bill And Bill Bill And And Bill And And And Bill And And And And And And And And And And	Secondaria Gold Manada Marina Santa M M M M M M M M M M M M M M M M M M M	Di SU Di SU Di SU Di SU		i.	100 - 27 alaria International	÷	L in and the second	1
: 	1313-001 1	ta in ta in ta in in in in in in in in in in in in in	Lindolayddiatad Shedrifaania Safadalifiadaa Safadalifiadaa Safadalifiadaa Safadalifiadaa Safadalifiadaa Safadalifiadaa Safada Safadalifiadaa Safadaa S	10.142 91.542 74.347		23 e	Later of Later	•	8 10.1 15 814/10-10	SP
	1212 1	AP SPL Status SPL Status SP	DHDD-yddiolaeth Telefoldiolaeth Hittaricaeth	6.00 6.00 9.00		4 - 22.0	AND	•••••	41.1 11 11 11	Paramet
i.	1222-1112 1	in anthe standards	Deconverting Schedulensing Schedulensing Schedulensing H H H H H H H H H H H H H H H H H H H	0.07 0.07 0.07	Harden Kallen Handen H		AND CONTRACTOR	•-11-	-	ers
i	2 244-2722	And the standard High Hards High Hards	Section and a section of the sector of the s	0.00 0.00 0.00	Billion C. Berther Age & Without C. Berther		AND	•••••	ulta 13 Kapitha	1
	1 200-002	Martin Angle 19. Martin 19. Marto	SetSHadderadi Godriftaadig Galadidiaadig Galadididiadig Ki Ki Ki Ki Ki Ki Ki Ki Ki Ki Ki Ki Ki	10.361 10.361 10.361	PERIOD C. Backson, April The Period C. Backson, April The Period Control of Control The Period Control of Control of Control The Period Control of Control of Control The Period Control of Control of Control of Control The Period Control of Control of Control of Control of Control The Period Control of Con	11 *	Inter-structures	•••••	HI.A HI Naph Day	
i. une	1212-112 1	Art Bill Barlot Will Barlot Will Will Gild Cartt Star Star Star Star Star Star Star	Michael Hickellands Hitchellands Hitchellen Hit Hit Hit Hit Hit Hit Hit Hit Hit Hit	54	Hand to the Loc day to sense the space of the sense the space of the sense to the space of the sense to the space of the sense of the sense the sense of the sense of the sens		Marine Salation States		and the	1t-
i	1 141-2121		International In	2.00 2.00 0.00	Harrison and Anna Anna Angela Martingan		ini i i i i i i i i i i i i i i i i i i		11 11 11	3
	2 200-2222		Tarton-philosofie Michael Michael Michael Michael Michael Michael Mi Mi Mi Mi Mi Mi Mi Mi Mi Mi Mi Mi Mi	85.00v 85.00v 85.00v	Harrison and Angele and Angele and Harrison and Harris	DD #	HI Li U.S. Lister of Laboratory Lister of Carolination	-11-	i.	3at-
i in ikinos	1212-111 1		Michigathiot adi Bolication Internation Internation Internation Internation	8.01 8.01 9.00	Alline C. Backer, April 1997 - The Control of State 1997 - State State 1997 - State State 1997 -		UN SI SI SI SI SI SI SI SI SI SI SI SI SI	-11-	in 13 Nations	
	1 111-111		Safety Sectors Secto	11.11. 11.11. 12.11.			in i i i i i i i i i i i i i i i i i i		in jan ki Kadelbar	2
i.	1212-111 1		Hatting Shared	8.8+ 8.00 9.00			internation			
i	1 141-2729		International Control Advances United Advances International Internation	11.000 11.000	Particular A. Backer Age of Particular Control of Control Particular Control of Control of Control of Control Particular Control of Control of Control of Control of Control Particular Control of Control of Control of Control of Control of Control Particular Control of Contro		u e as latteresta			
: 	1 144-5151		Michigality Statistication Statistication Lifestatistication 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	60,004 16,004 16,004	and respectively.	4 - 10 a	u e m latterate	-11-		36
3		Sherikala URBala Sherikala Sherikala Sherikala Sh	ABCORGANISTICA Adole Villandon ABCORGANISTICA			*	un cut			*
4	· · · · · ·	the fillent to the second seco	Hotelsteinen Hotelsteinen Hotelsteinen Hotelsteinen Hotelsteinen Hotelsteinen Hotelsteinen	1.10×	Contraction of the second seco			:=	1. 	·····¢
	, , , , , , , , , , , , , , , , , , ,	1 211/131	STATISTICS IN	8.0* 8.0* 8.0* 8.0*		* 101 ×	10.01			,

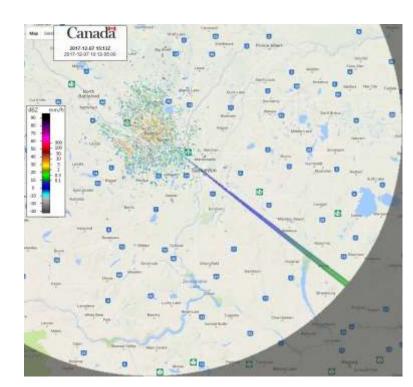
### When metadata matters : quality assurance

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

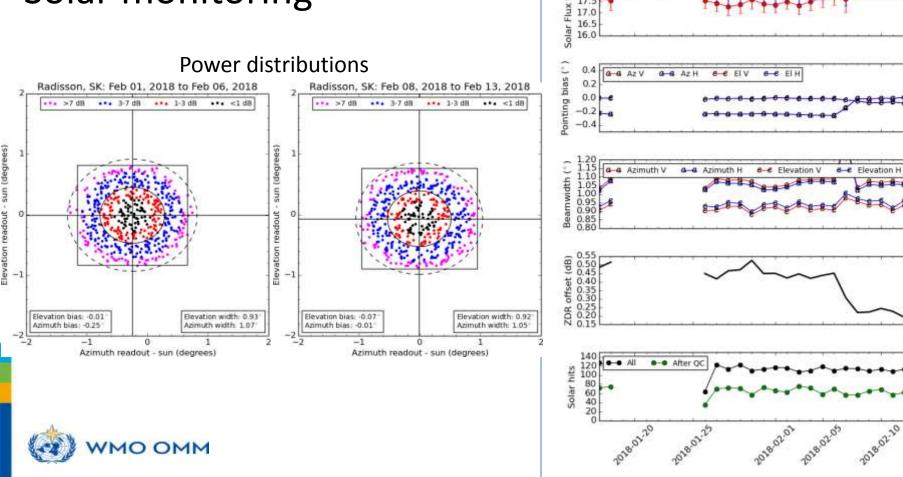
#### Allows determination of:

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





### Solar monitoring



(gp) 19.0

Units 18.0 17.5

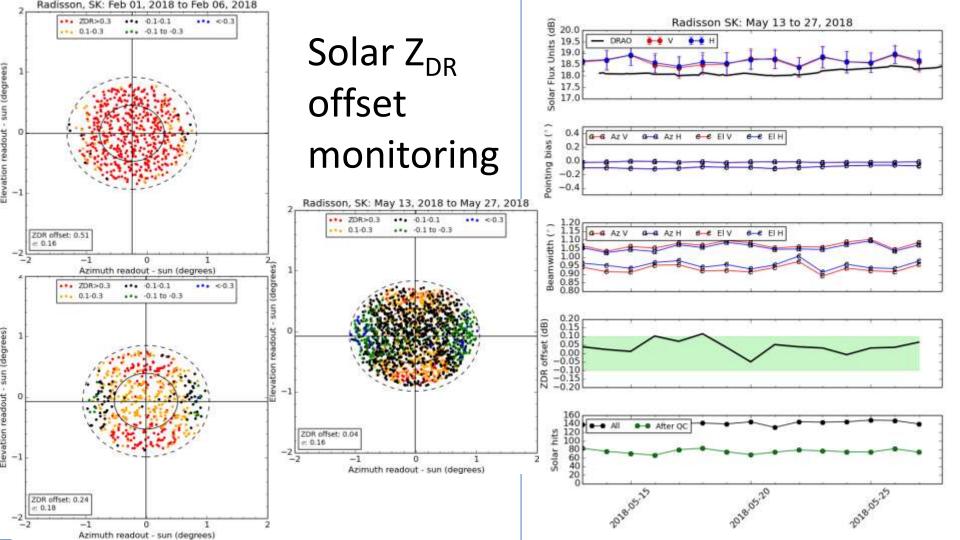
18.5

Radisson SK: Jan 17 to Feb 15, 2018

• • V

н 🔶

DRAO





HDF5 - Groups, hierarchies, compression

#### NORDRAD

net

	COST 717	OPERA ODIM_H5 Data quality	2.1		2.2	2.3	8, 3.0?
2001	2003	2008	2011	2013	2014	<b>2016</b> -	
(	CF Conventions					1.4,	2.0
			CfRadial	1.3		Groups Hierarchi Data qual	
CDF		Compression v 4	esearch				·



Data exchange

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



Structure

CF

### CfRadial 1.4

CfRadial 2.0 Single Global Standard





### 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

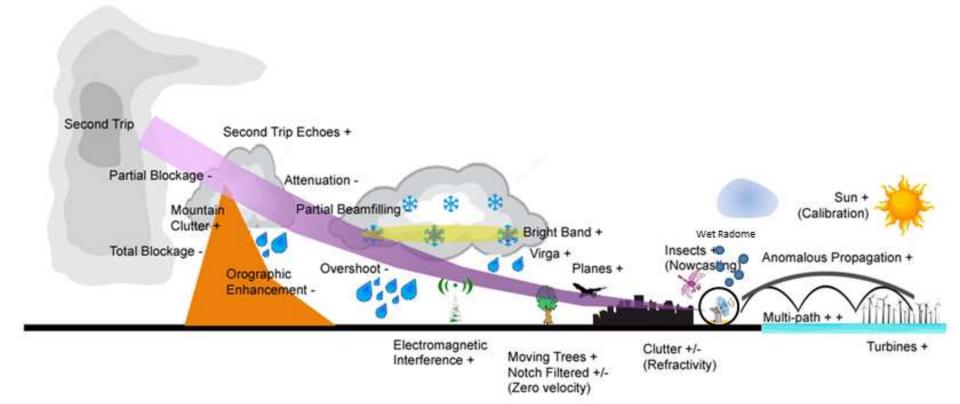
*Complement to* CIMO Guide Manual on WIGOS

- 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

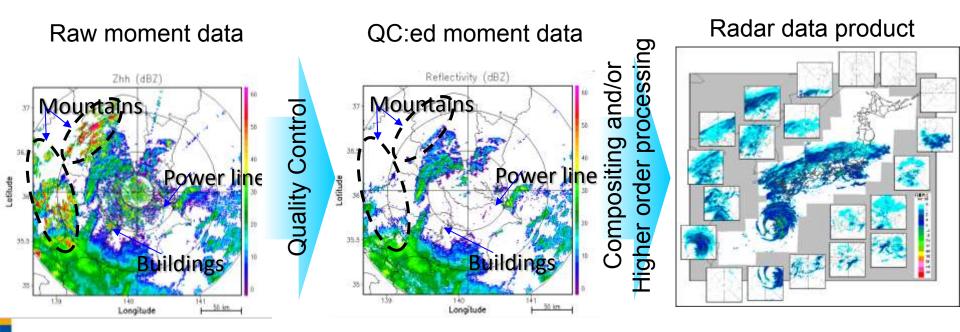
Aligned with ISO weather radar standard

See poster!

# Site and data quality



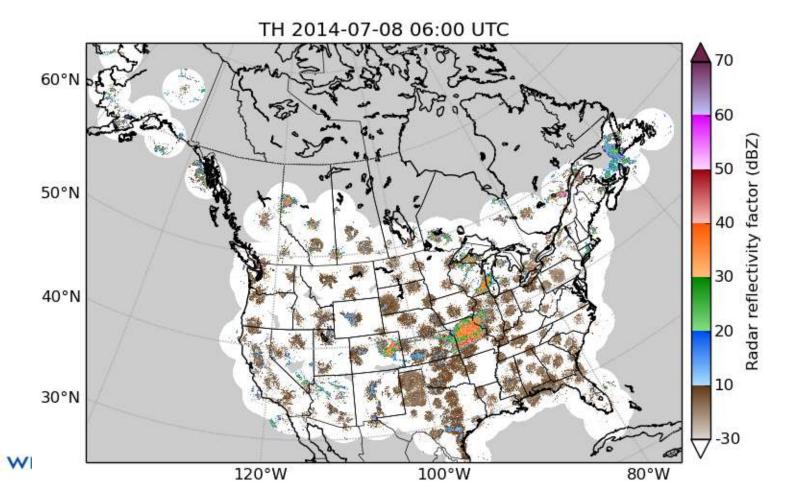
### From basic data to Quantitative Precipitation Estimation



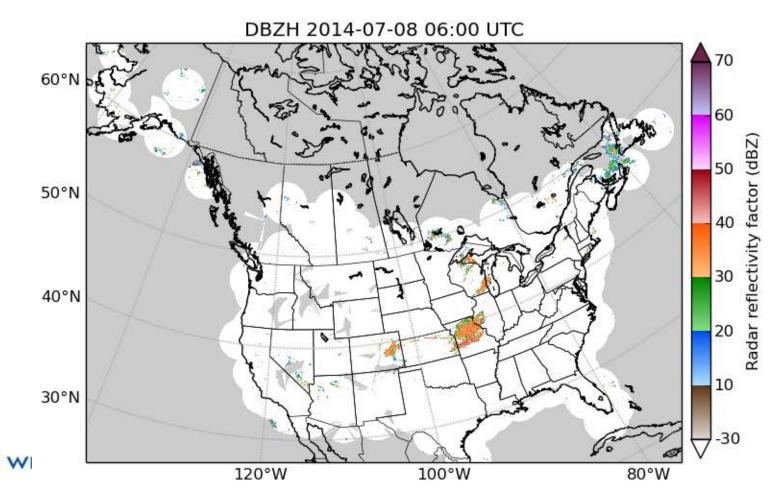


Japan Meteorological Agency

### Representing data quality: No quality control

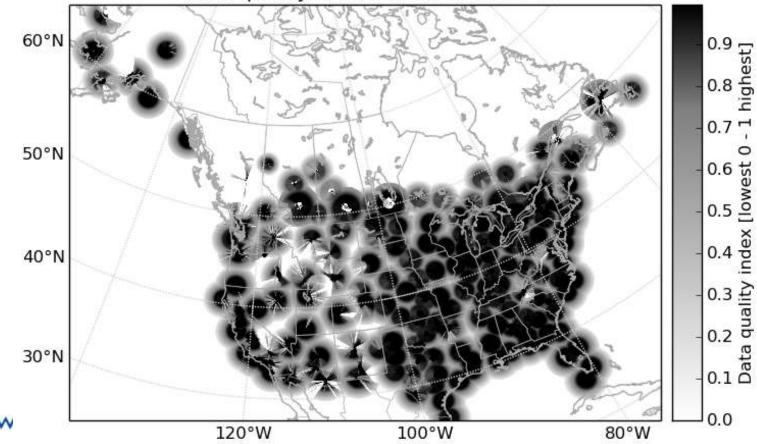


### Representing data quality: Quality controlled



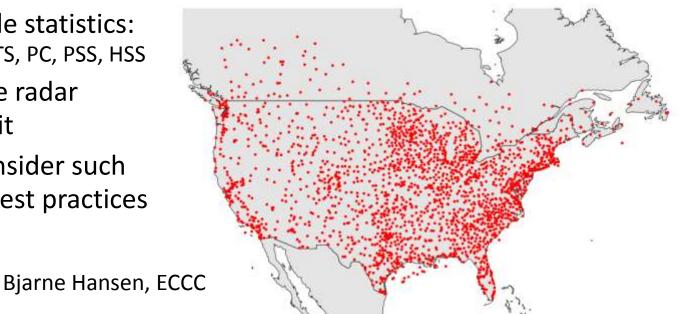
## Representing data quality itself

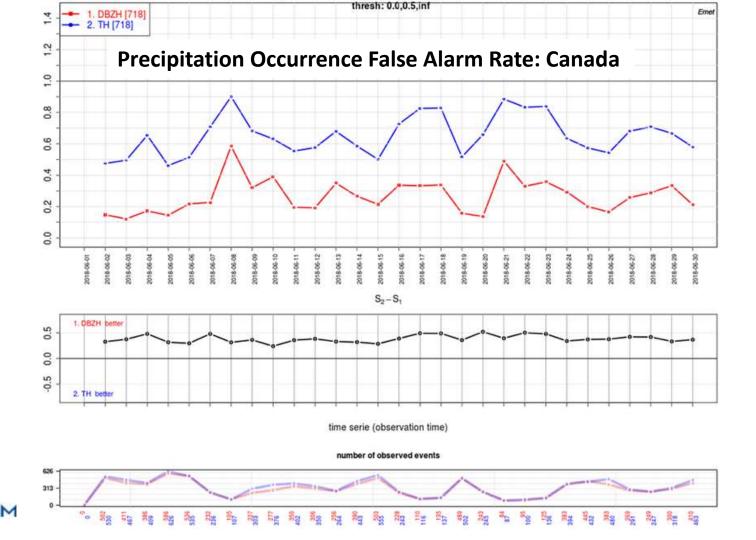
"Total quality" 2014-07-08 06:00 UTC

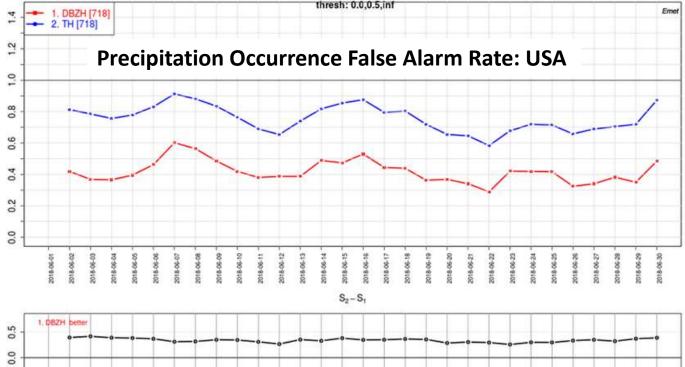


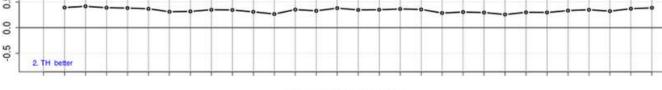
# Monitoring the impact of radar QC

- 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



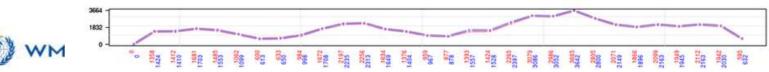






time serie (observation time)

number of observed events



# 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"

(a) wmo омм

WEATHER CLIMATE WATER TEMPS CLIMAT EAU



WMO OOM

World Meteorological Organization Organisation météorologique mondiale

# Thank you Merci