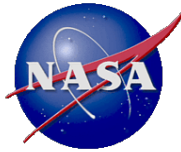




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Canadian Physical Validation Accomplishments and Network Validation Plans

David Hudak and Paul Joe

Cloud Physics and Severe Weather Section
Environment Canada

PMM Science Team Meeting, Annapolis, MD, March 18-21, 2013

Physical Validation Studies

- The quantitative characterization of frozen precipitation in cold season cloud systems has unique challenges
 - Much of the precipitation is light (≤ 0.2 mm/h)
 - High vertical resolution (≤ 150 m) is required to sample at low levels (≤ 250 m) due to strong vertical gradients.
 - A prevalence of multi-layering that frequently involve mixed phase cloud conditions.
 - the variability in solid particle shape and density over a wide variety of scales
- The Canadian CloudSat CALIPSO Validation Experiment (C3VP) in the winter of 2006/07 provided snowfall algorithm developers and satellite simulator models with a basic set of observations, physical insights and modeling simulations to use for algorithm development.
 - Huang et al. (2009); Shi et al. (2010); Molthan et al. (2012); Iguchi et. al. (2012); Skofronick-Jackson and Johnson (2011); Barker et al., (2008); Hudak et al. (2008); Szyrmer and, Zawadzki (2010); Battaglia, et al., (2010); Turk et al. (2011)



Light Precipitation Evaluation Experiment (LPVEx)

- Contributed 2 POSS units and a MRR system
- Participation in field project



Nevezorov Probe on King Air

Modified probe design for Improved airborne hot wire measurements of ice water content in clouds (Korolev et al., ICCP2008, P13.4)





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The GPM Cold Season Precipitation Experiment (2011/12)



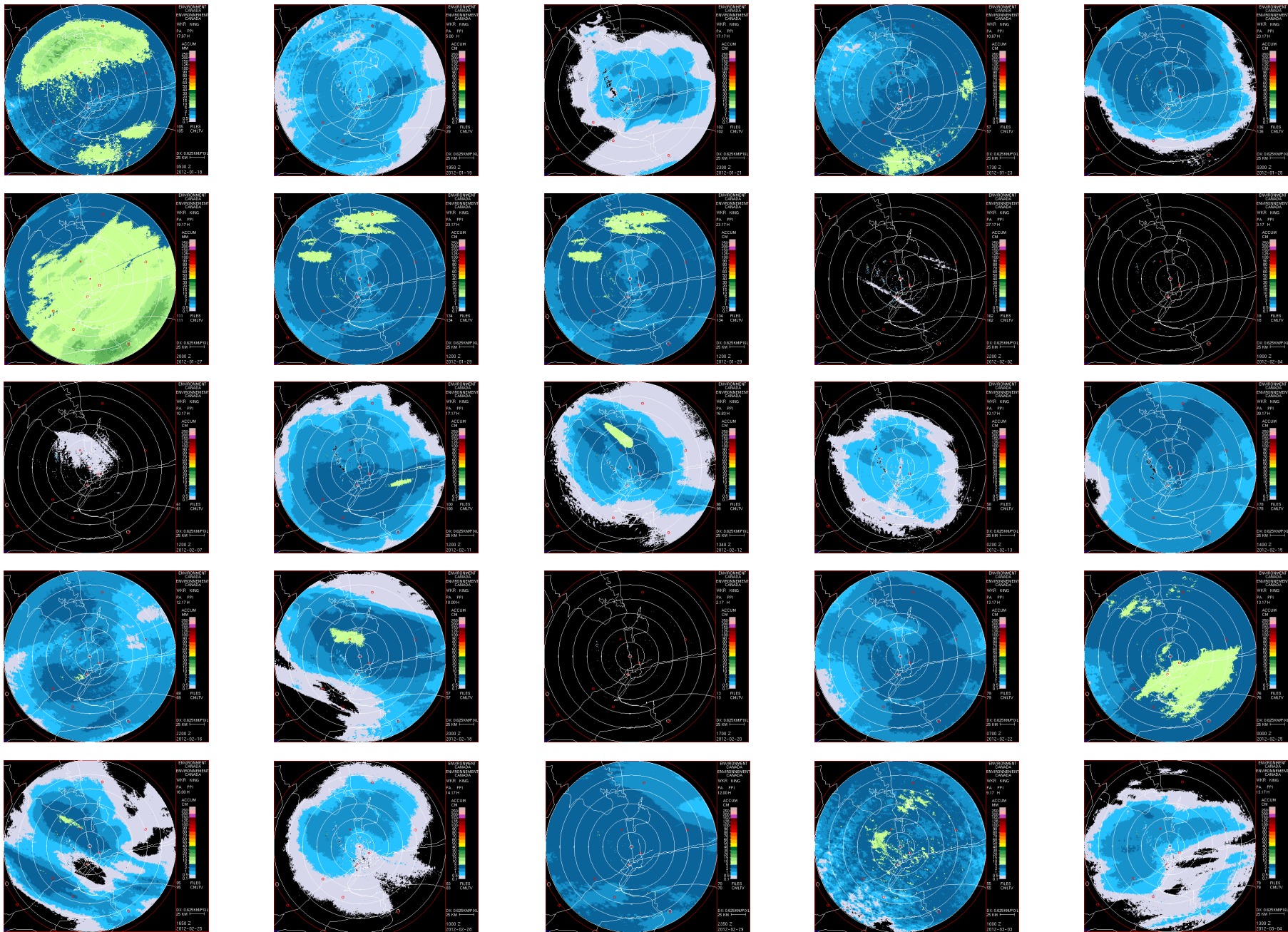
- Designed to address shortcomings in GPM snowfall retrieval algorithm with
 - in-situ data on microphysical properties in winter cloud systems
 - associated remote sensing obs
 - coordinated model simulations
- To characterize the ability of multi-frequency active and passive microwave sensors to detect and estimate falling snow.

PMM Science Team Meeting, Annapolis, MD, March 18-21, 2013

GCPEX Deployment

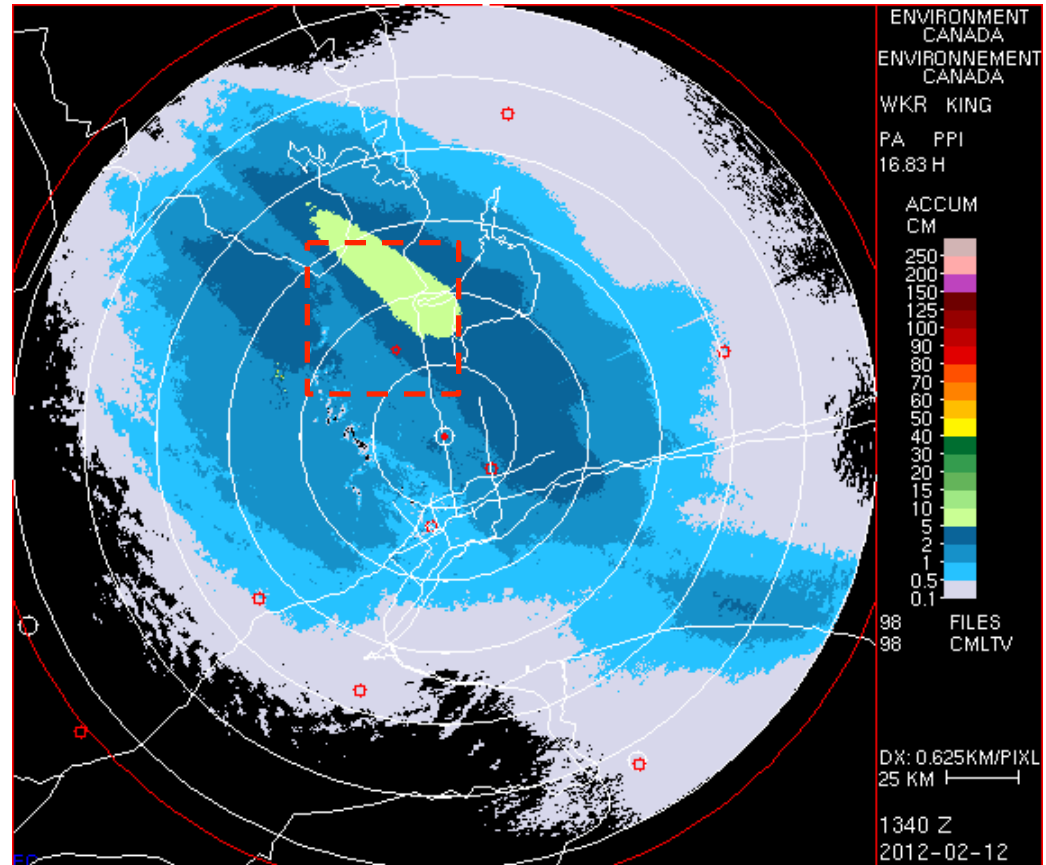


King Radar-based GCPEX Event Accumulations

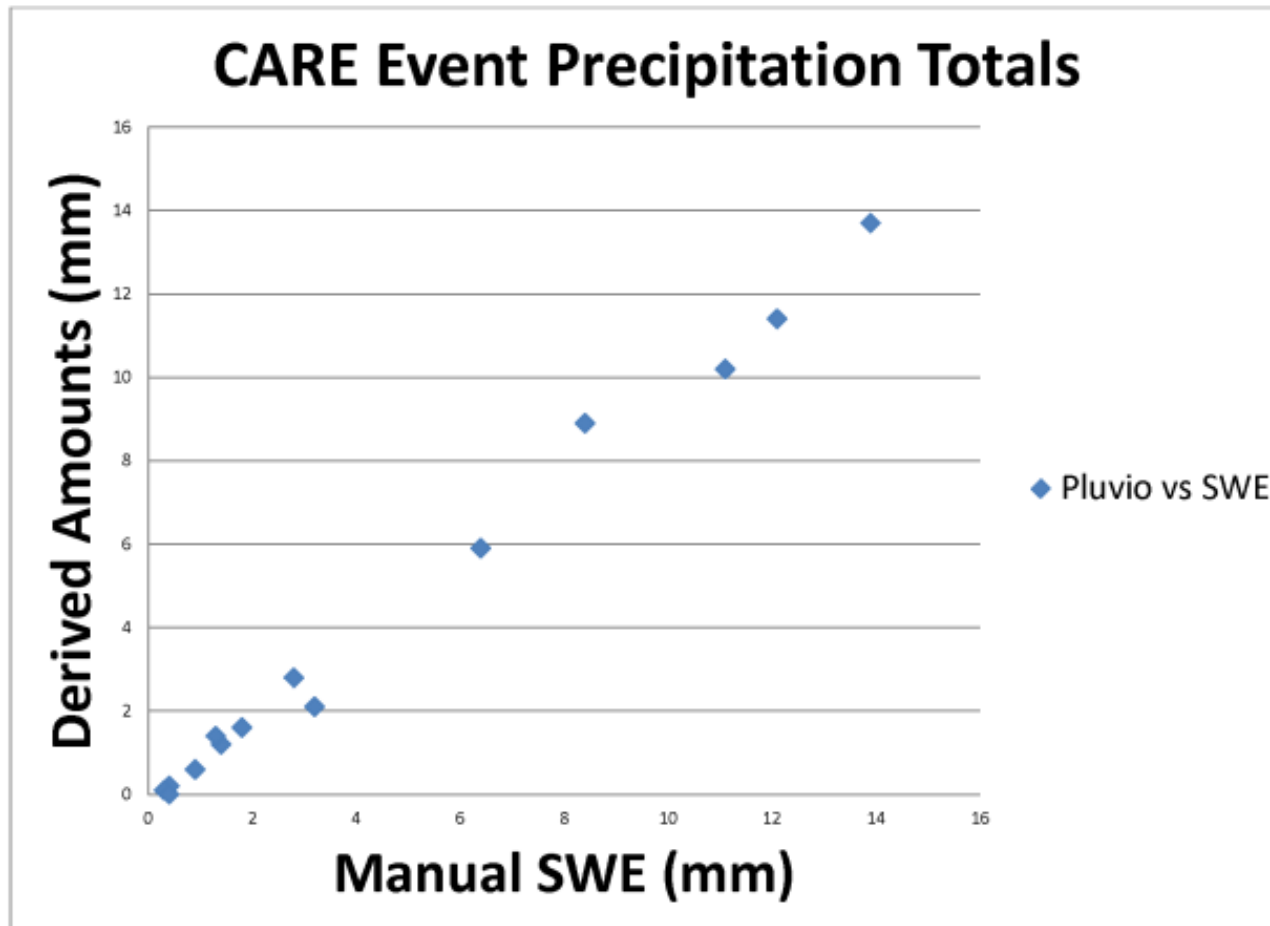


King Radar Event Accumulation

Event	13
Synoptic	Lake Effect
Pcpn Type	Snow
SWE (CARE)	1.8
Start	11-Feb-12
GMT	21:00:00
End	12-Feb-12
GMT	14:00:00



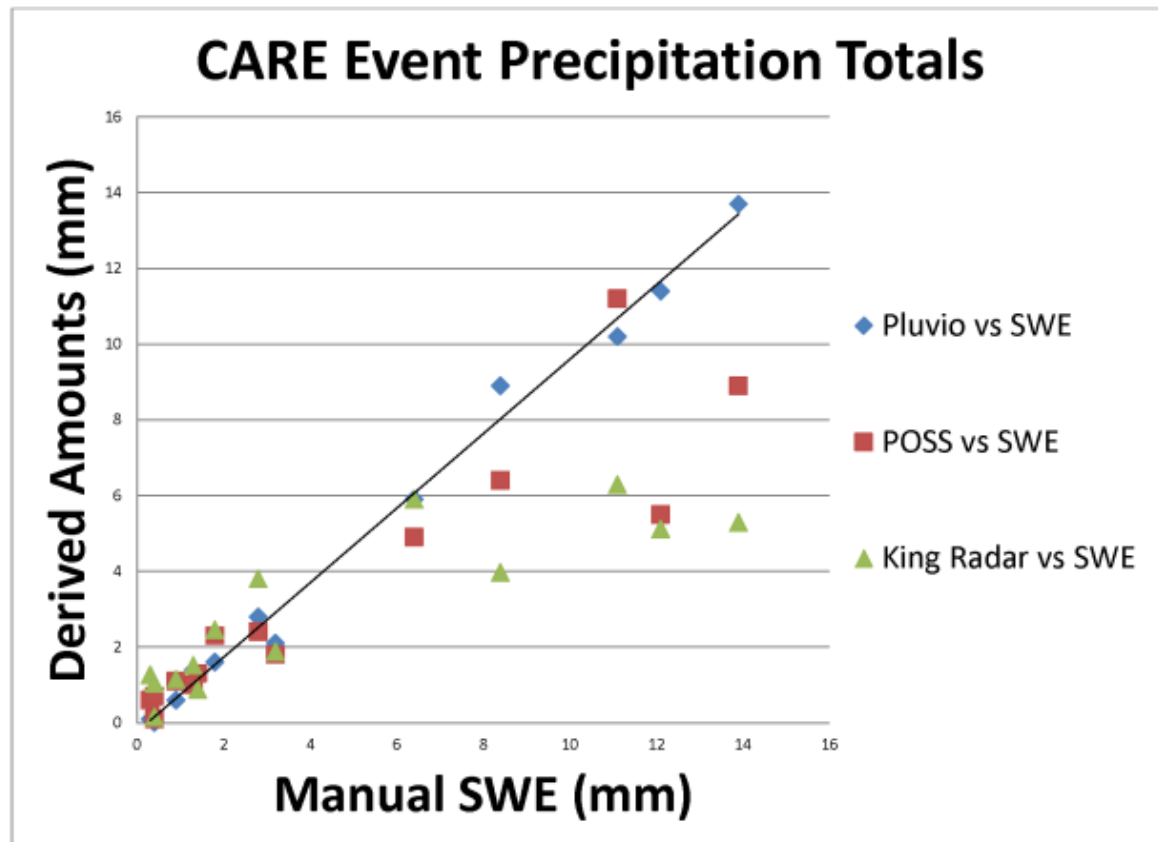
GCPEX: Pluvio 400 Matches the Manual International Reference



Pluvio 400 precipitation gauge



GCPEX: POSS and Radar Underestimate due to VPR effects.

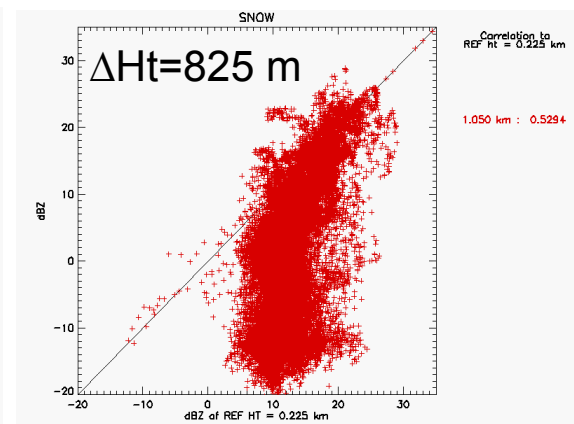
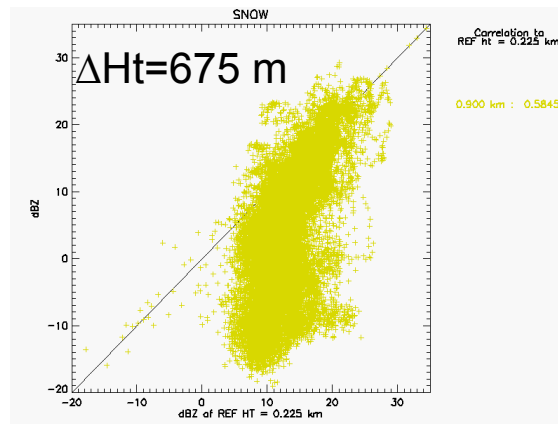
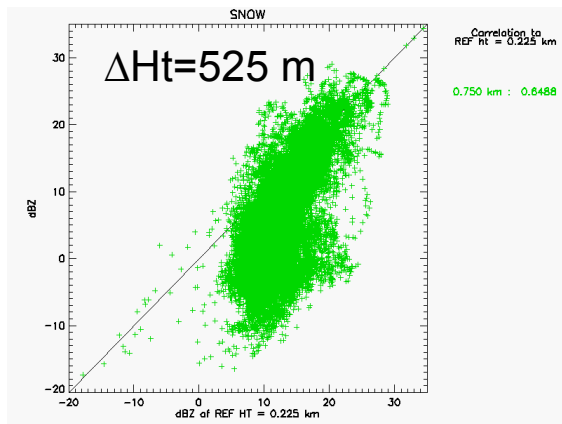
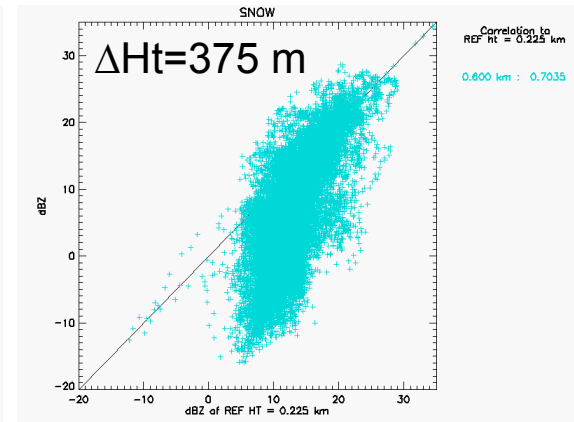
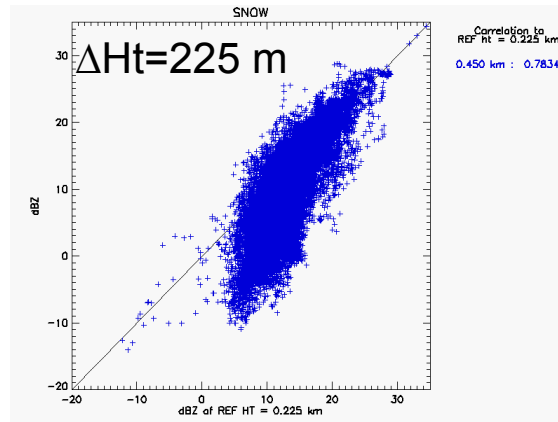
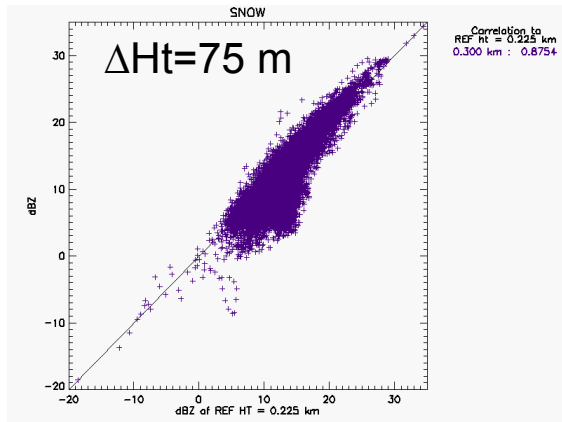


Pluvio 400, POSS, King radar



C3VP: Light precipitation reflectivities aloft evaporate on the way down to the surface.

Ze aloft (vertical axis) vs Ze near surface (horizontal axis)



GCPEX Summary

- 25 events during the 7 week field project
 - 3 mixed precipitation; 2 rain; 2 clear air
 - 18 snow
 - 13 synoptic (3 frontal, 4 cyclones, 6 upper air); 5 lake effect
- Aircraft coordination excellent (6 with 2 a/c, 3 with 3 a/c)
 - 14 DC-8; 10 UND Citation; 6 Convair-580
- Next Steps
 - Detailed precipitation type analysis
 - Extrapolation of scanning radar data to surface
- Valuable data collected for
 - GPM algorithm development
 - EC and US NWS dual polarization radar precipitation algorithms



WMO-Solid Precipitation Intercomparison Experiment (WMO-SPICE)

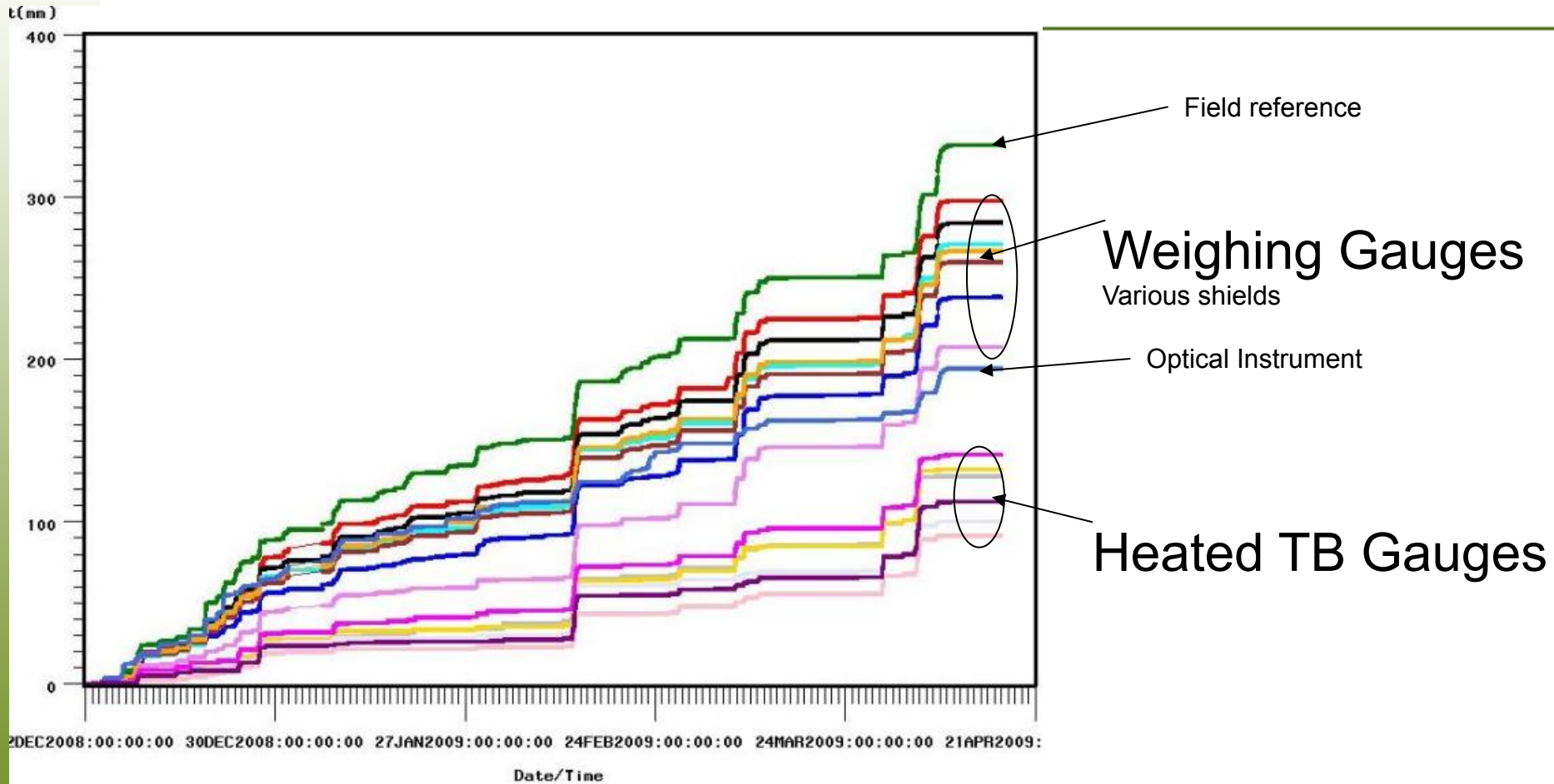
- Initiative of Commission for Instruments and Methods of Observation
- Global Cryosphere Watch (GCW) *Demonstration Project*: impact of automation on the measurement of solid precipitation;
- IOC: Canada (Nitu, Chair), China, Germany, Italy, New Zealand, Russia, Switzerland, USA.
- Multi-year (start 2012), multi-site field experiment,
 - **Canada**
 - **Finland**
 - **Japan**
 - **Norway**
 - **Russia**
 - **Poland**
 - **Switzerland**
 - **USA**
 - **Australia**
 - **Chile**
 - **New Zealand**



WMO SPICE MAP



Tipping Bucket gauges (60%) underestimate snowfall compared to weighing gauges (40%).



- Legends:
- Belfort FP Precip Amount
 - Geonor H1 Precip Amount
 - Geonor H3 Precip Amount
 - Pluvio 1 HK Precip Amount
 - Pluvio 2 HL Precip Amount
 - PWD22 H1 Precip Amount
 - All Weather Heated TBRG GC
 - CAE Heated TBRG GG
 - Hydrological Service Heated TBRG GH
 - VRG HF Precip Amount
 - Geonor H2 Precip Amount (DFIR)
 - Pluvio 1 HJ Precip Amount
 - Vaisala Heated TBRG GE
 - All Weather Heated TBRG GI
 - Hydrological Services Heated TBRG GB

SPICE Objectives

- To recommend appropriate automated field reference system(s) for the unattended measurement of solid precipitation in a range of cold climates and seasons
- Development and validation of systematic bias adjustments as a function of wind, temp, and precipitation type.
- To provide guidance on the performance of modern automated systems for measuring:
 - total precipitation amount in cold climates for all seasons, especially when the precipitation is solid,
 - snowfall (height of new fallen snow), and
 - snow depth.
- *Encourage remote sensing algorithm development*

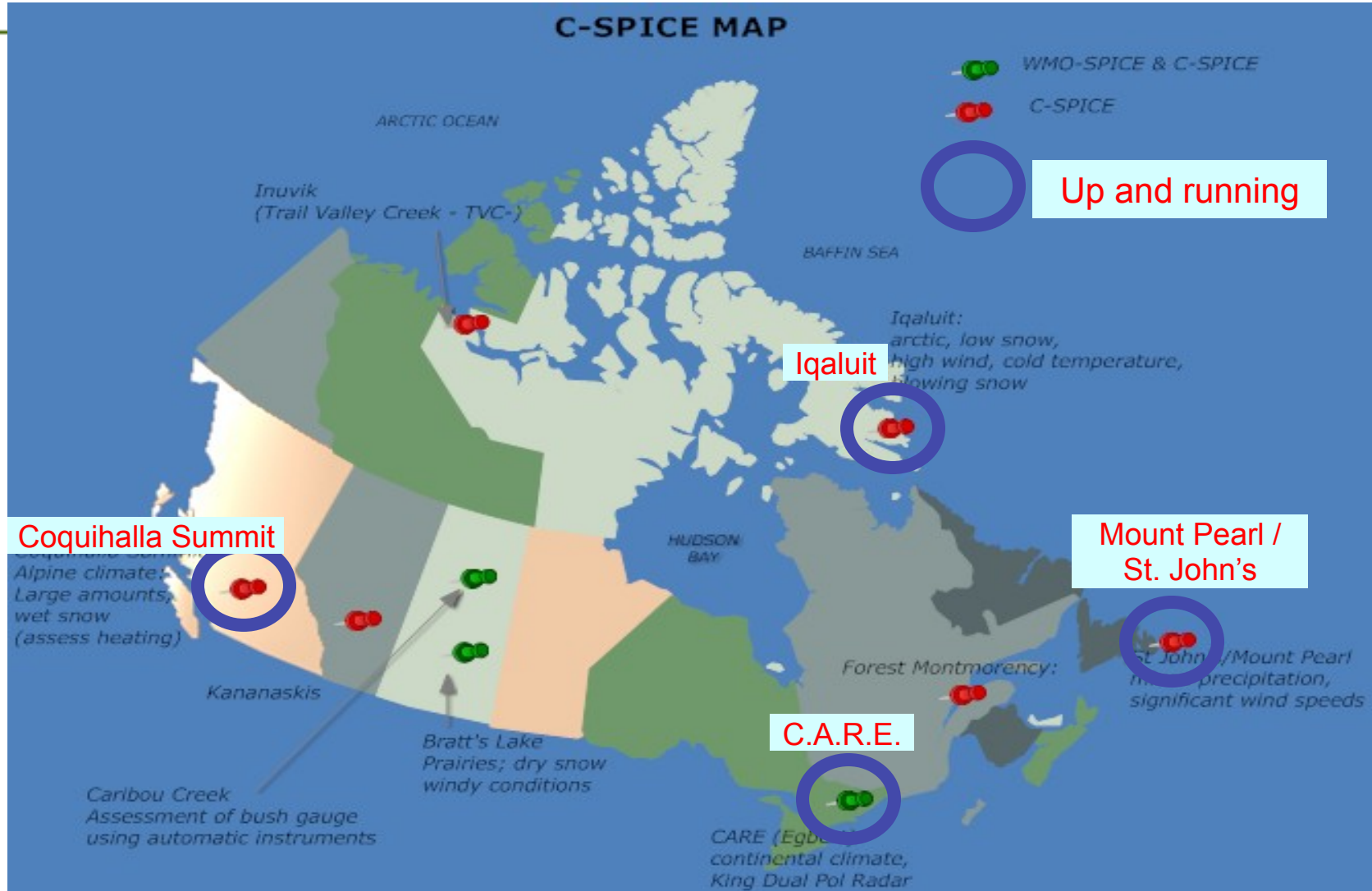


C-SPICE Objectives

- The focus of C-SPICE is on reducing the temporal scale of the observations from the daily to the minutely scale.
 - metrics and analysis techniques for smaller scales need to be developed and validated.
 - higher sensitivity or lower thresholds are needed.
- Scientific questions to address:
 - broad range of weather/climate conditions
 - evaluation of new technology for greatest sensitivity and accuracy
 - linkage to radar and remote sensing research and applications
 - understand the source of errors in precipitation observations for generalization
 - Retrieval of precipitation type, intensity and amount: development of multi-parameter algorithms;
 - Impact of environment;
 - Heating methods;
 - Snow on ground



C-SPICE sites



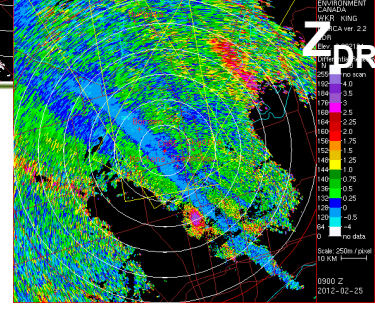
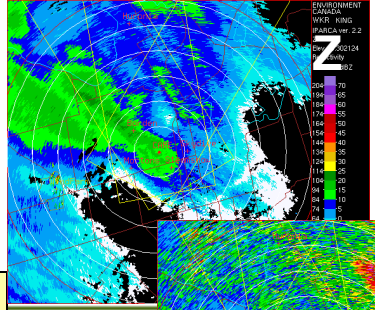
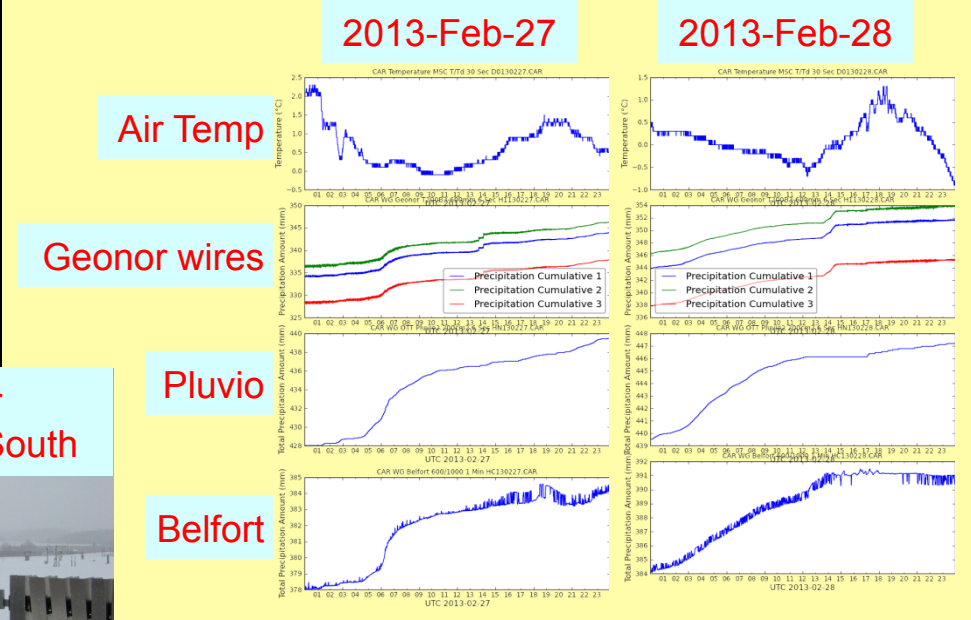
CARE

Continental climate with lake-effect snowsqualls
 (GCPEX 2012 was conducted here)
 Under coverage of EC King dual-pol C-band radar

19, 37, and 89 GHz
 (dual-pol) radiometers



Belfort Double Alter
 2013-Feb-27, Looking South



Belfort Double Alter
 2013-Feb-28, looking North



CARE Configuration (1)

- **Studies of References:**
 - DFIR + manual gauge (WMO SPICE);
 - DFIR + Geonor, CRN heater (WMO SPICE);
 - Pluvio2: Single Alter + unshielded, standard heating
 - Geonor 600 mm: Single Alter + unshielded, CRN heating, (WMO SPICE)
- **Double Shields:**
 - Belfort Double Alter (30% porosity);
 - Canadian Double Alter (50% porosity).
- **Studies of Heating:**
 - Geonor with CRN heating;
 - Geonor with manufacturer hardware and customized adjustable control;
 - Pluvio2
- **Other weighing gauges being assessed:**
 - Geonor 1500 mm
 - Belfort 3000
- **Develop adjustment curves** representing the MSC operational network setup:
 - Geonor 600 mm, Single Alter shield, unheated (standard installation);
 - Pluvio1 unheated with Tretyakov Shield;
 - Nipher gauge (manual obs).
- **Emerging technologies:**
 - FD12P
 - Parsivel2
 - FS11P
 - PWS 100 (Campbell Scientific)
 - PWD22
 - Theis LPM
 - OSI AWI430 (DND)
 - POSS
 - LUFFT
 - Hot plate;



CARE Configuration (2)

- **Snow on the Ground**
 - manual/webcam ruler (25 points)
 - GMON/CS725: SWE
 - Manual SWE measurements (snow density), SR50AH (SD)
 - Jenoptik laser (SD)
 - USH-8 (SD)
 - NAST (TBD)
 - Snow Drift sensors (IAV FlowCapt)
 - Radiometers – (19, 37, and 89 GHz)
 - Periodic snow survey
- **Intercomparison Sensors (provided by Manufacturers for WMO SPICE)**
 - Droplet Measurement Technologies
 - Various heated Tipping Buckets (including TB3)
- **Ancillary measurements:**
 - **Precipitation/Snow Video Imager II (NASA)**
 - 2D Video Disdrometer: to be added
 - High Speed Camera: image processing software for the trajectory analysis of the snow particles
 - 3D Wind inside and outside shields;
 - Temperature, Humidity, Pressure;
 - Wind Speed and Direction: 2, 3, 10 m
 - Visibility; Sky conditions; Ice Accretion.
 - Microwave Rain Radar (MRR); to be added
 - GEM Model Profiles and precip types;
 - King Radar C-band dual-pol scanning radar
 - WEBCAMs;



Bratt's Lake, SK

- Prairie Environment, Flat terrain, Focus on heating
- Blowing snow



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Caribou Creek, SK

Bush gauge is the primary reference

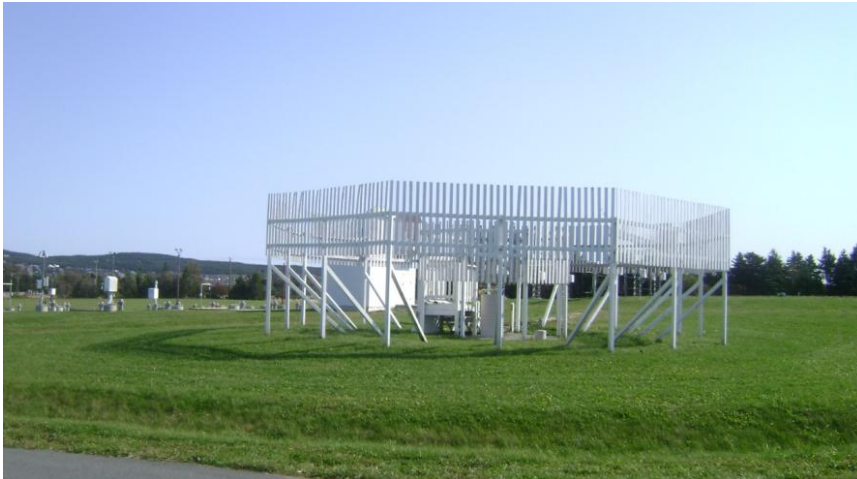
- Focus on assessing the bush gauge reference (primary) vs Double Fence International Reference (secondary) using an automatic gauge:



Mount Pearl (St John's)

Maritime climate

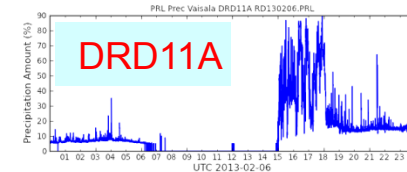
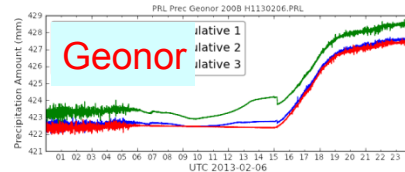
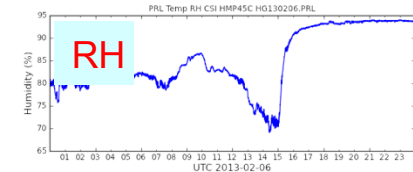
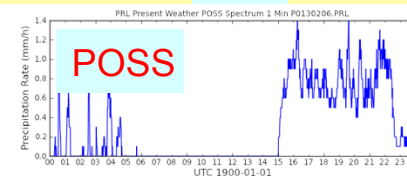
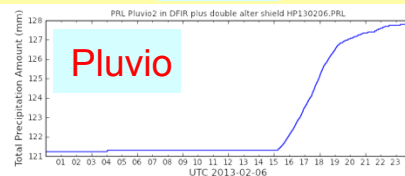
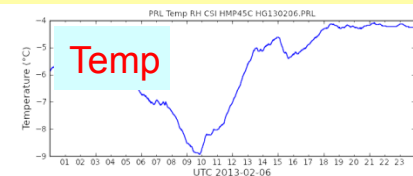
Focus: Impact of mixed precipitation type, strong winds;



2013-Feb-06

accum

rate



Coquihalla Summit Standard Climate Reference Network Gauge Heating doesn't work here.



Summer Snow Pack Analyzer



Canada

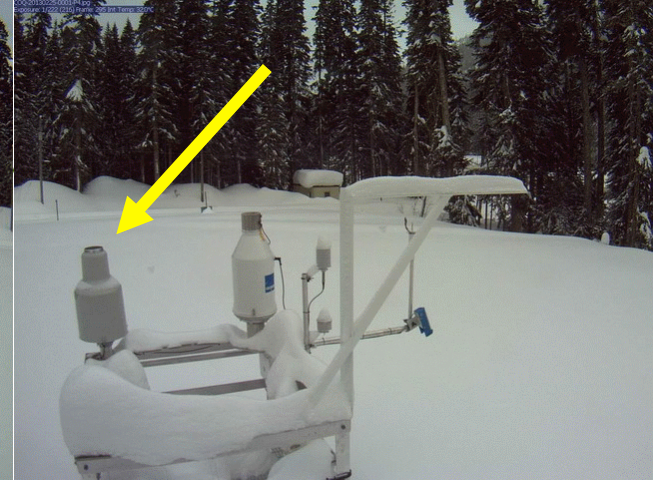
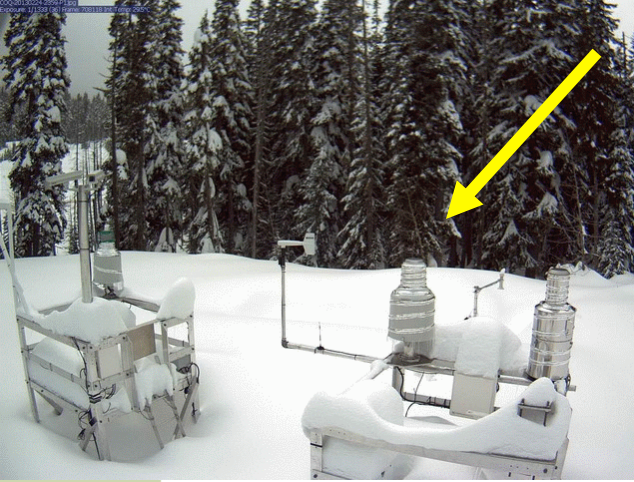
Canada

Alpine climate
Measurement of wet, heavy
precipitation;
Heating of gauges

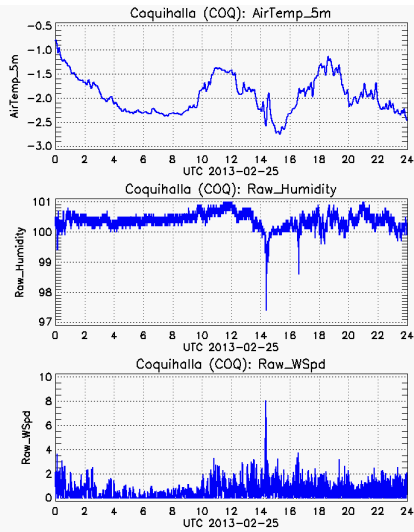


Canada

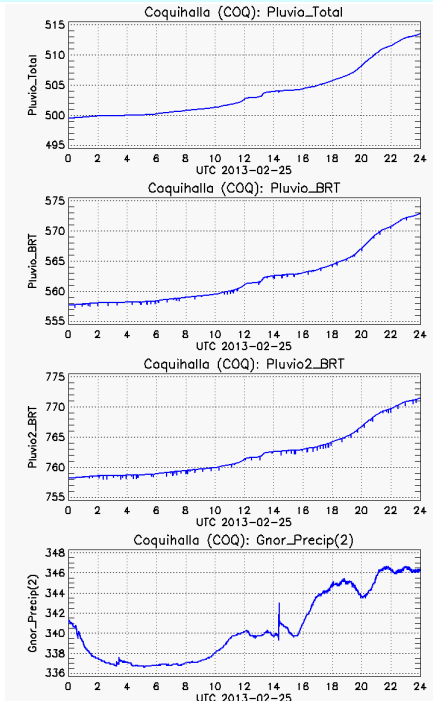
Coquihalla Summit



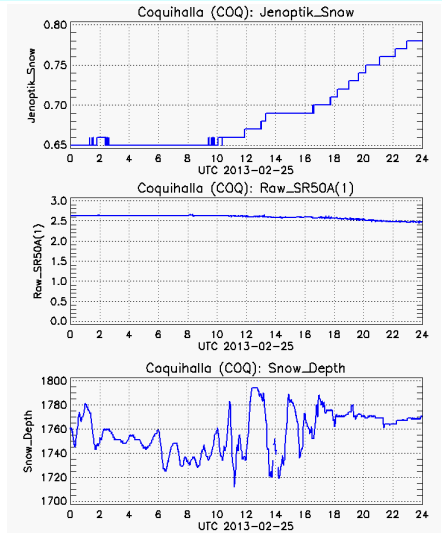
Met sensors



Differently heated collectors (Pluvia, Geonor)



Snow on the ground (Jenoptik, SR50A, Sommer)



Iqualiut

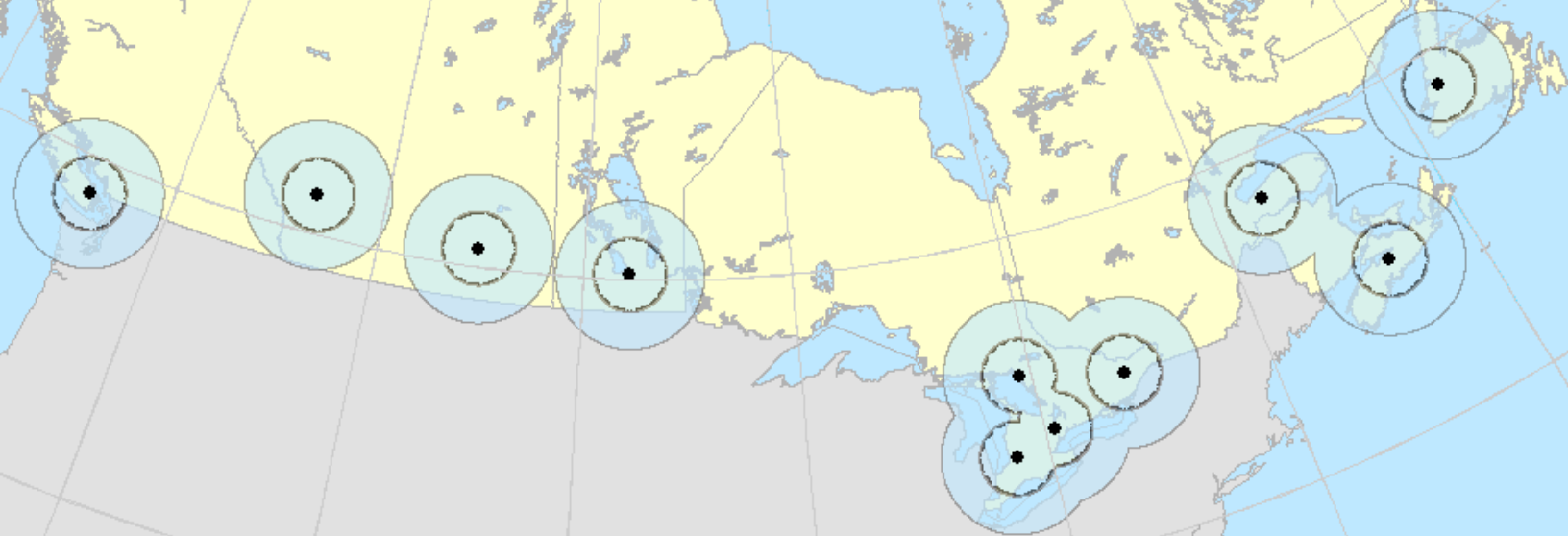
Study of precipitation in the Arctic Environment
Deploy Ka Band Scanning Radar



Canada Radar Network - 98A - 2011

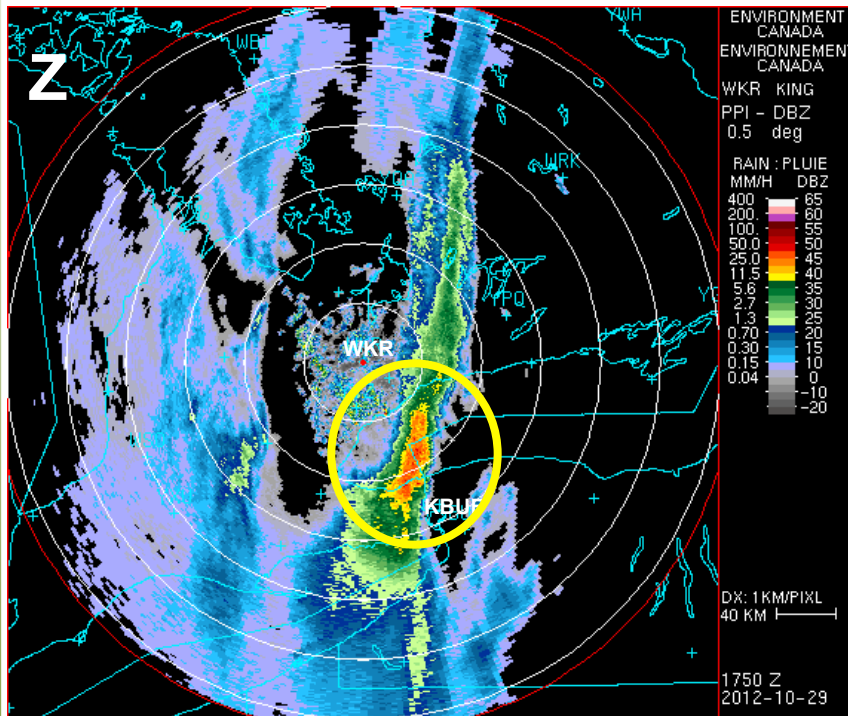
Radar Type

- 98A

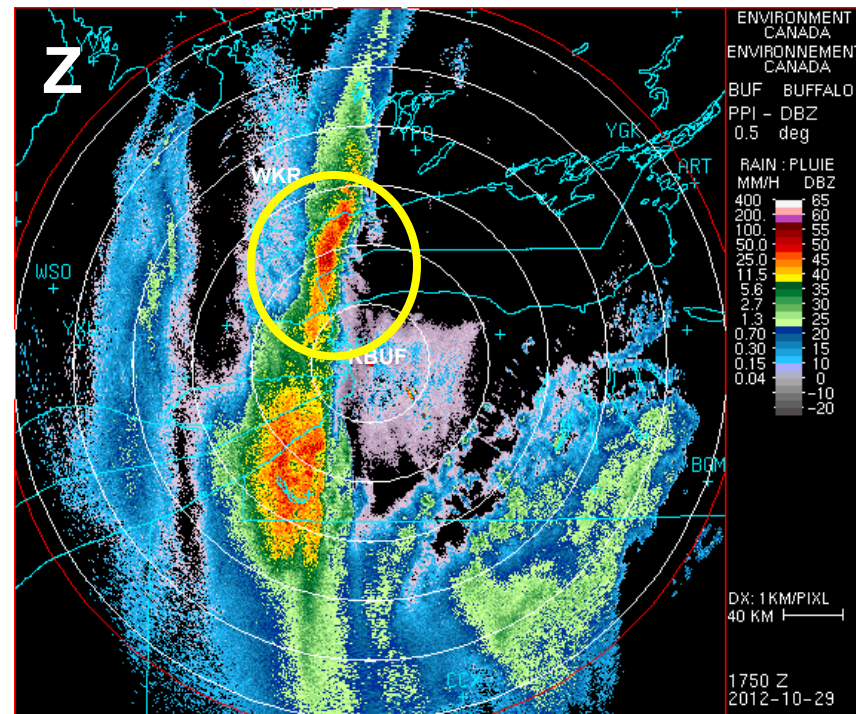


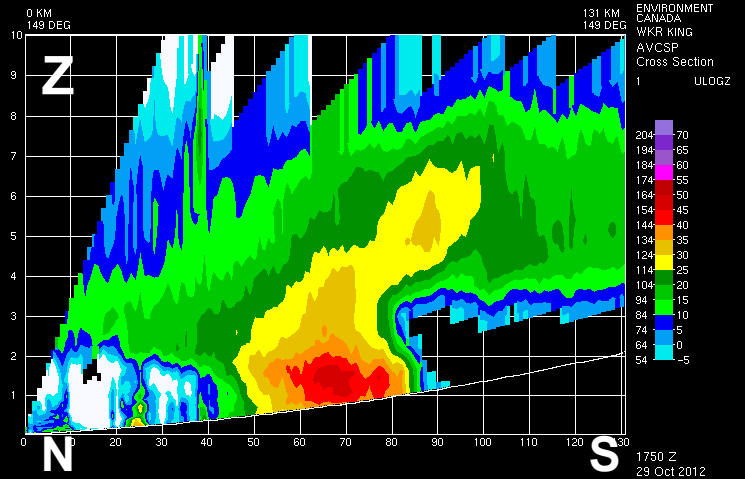
Network Validation – EC and NEXRAD

King Radar 0.5° PPI



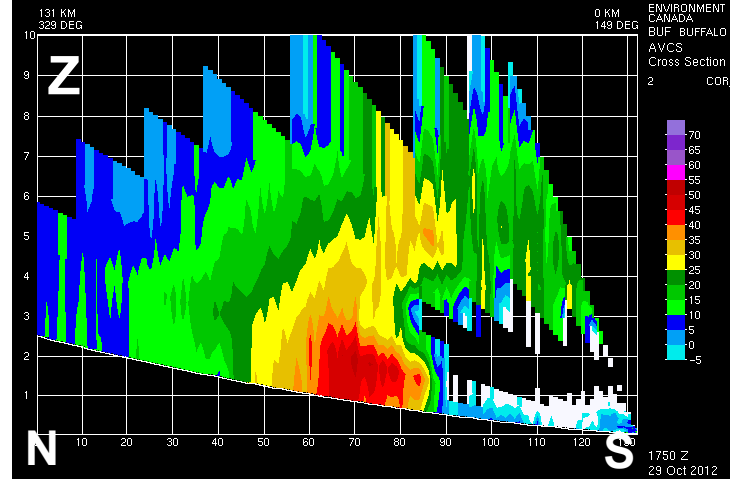
Buffalo Radar 0.5° PPI



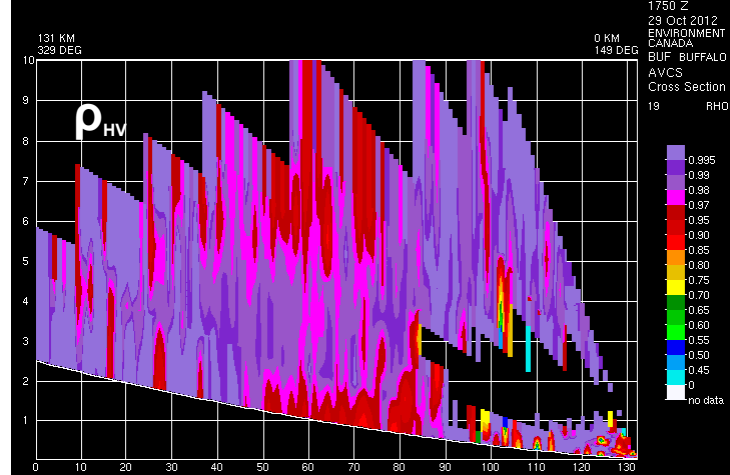
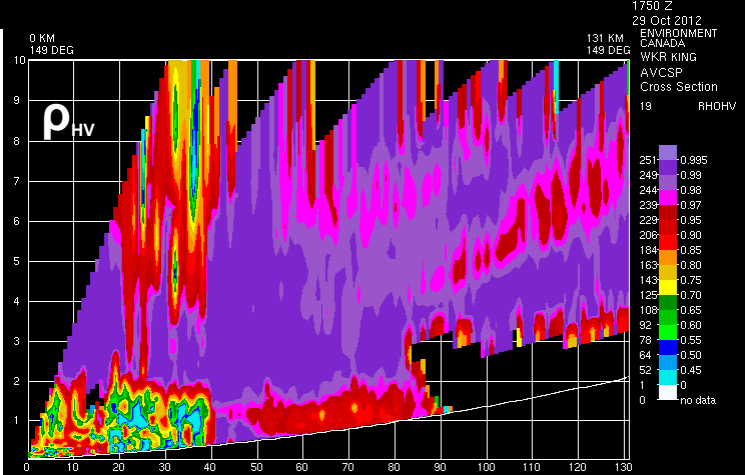
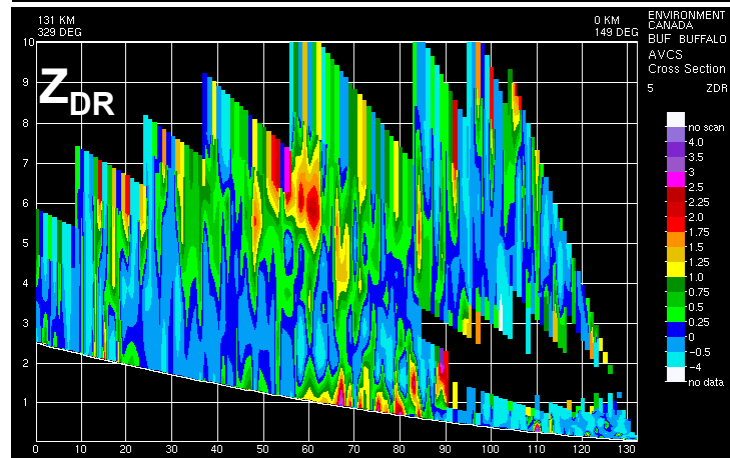
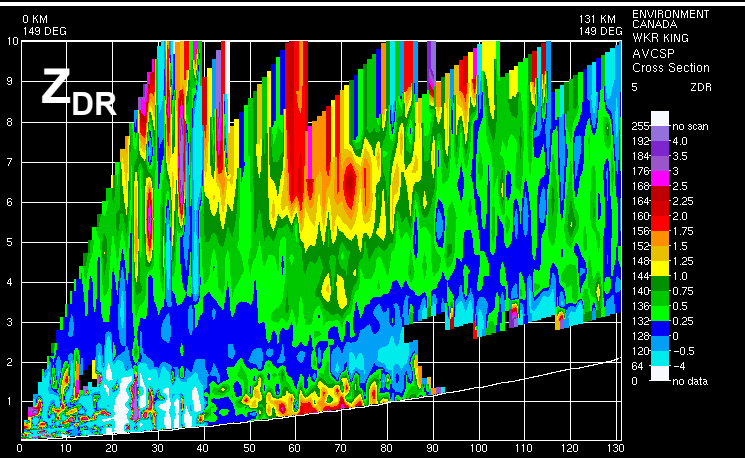
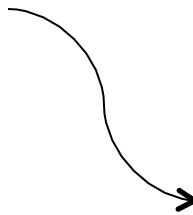


Radar X-sctns

King City



Buffalo



Network Summary

- Partnership between EC and NASA for C-SPICE to produce network validation for a variety of winter environments across Canada
- EC radar network renewal to add 10 dual polarization radars by 2016
- Synergy between EC and NEXRAD radars near US Canada border (S-band vs C-band)





Thank You!



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