Environment Canada Environnement Canada

Canada

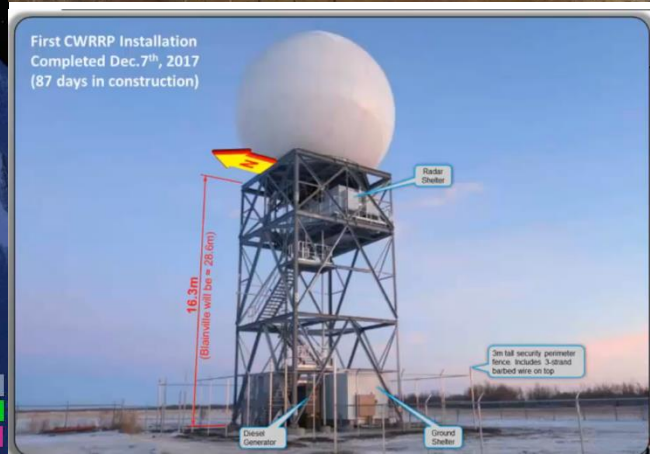
Great Lakes Operational Workshop

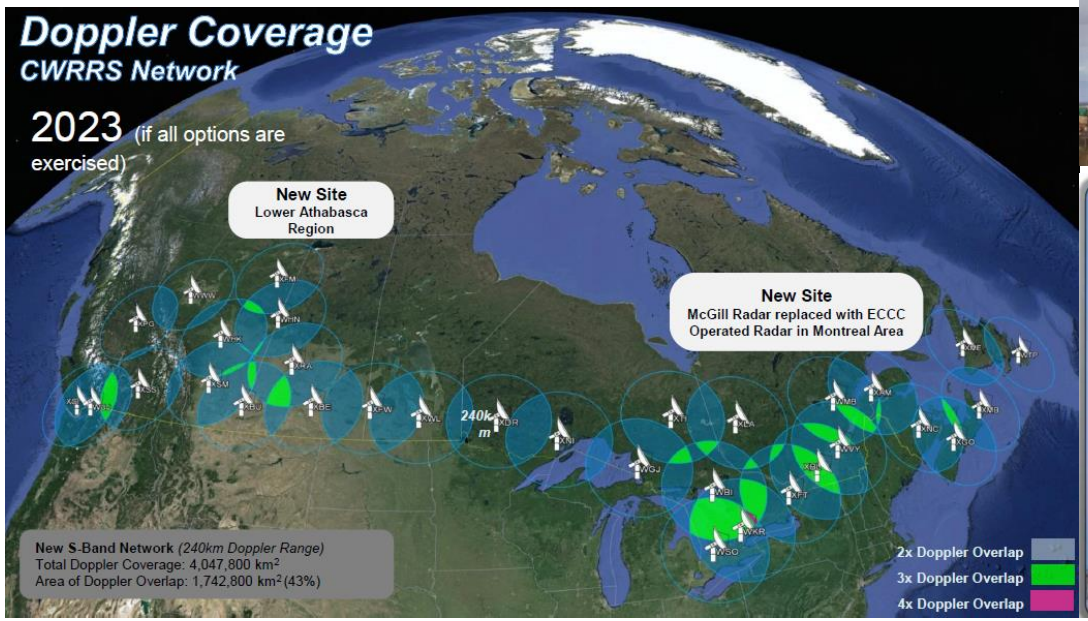
Canadian Weather Radar Replacement Project and Operational Impacts

Steve Knott
FSII/OSPC
May 1-3, 2018

Outline

- **Radar Deployment Schedule**
- **Scanning Strategies**
- **Anticipated Improvements**

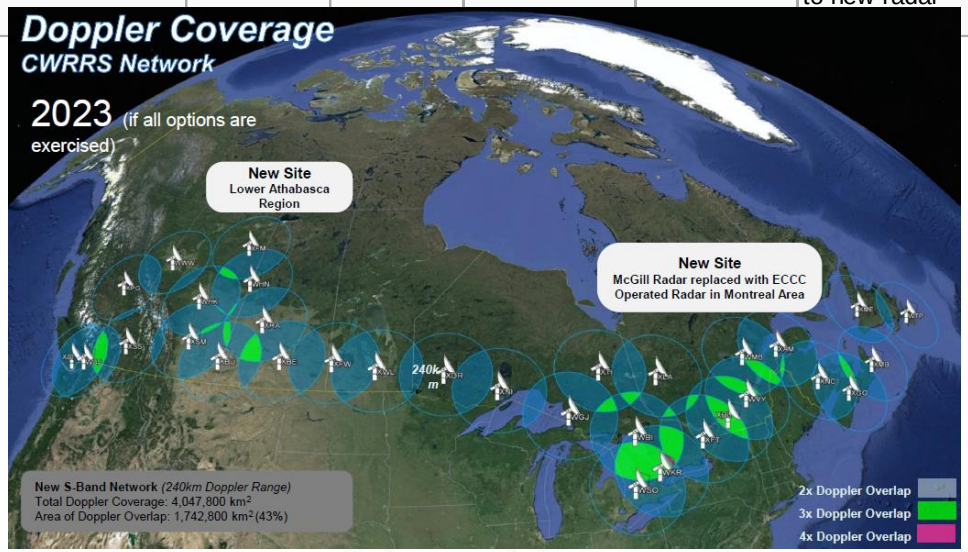




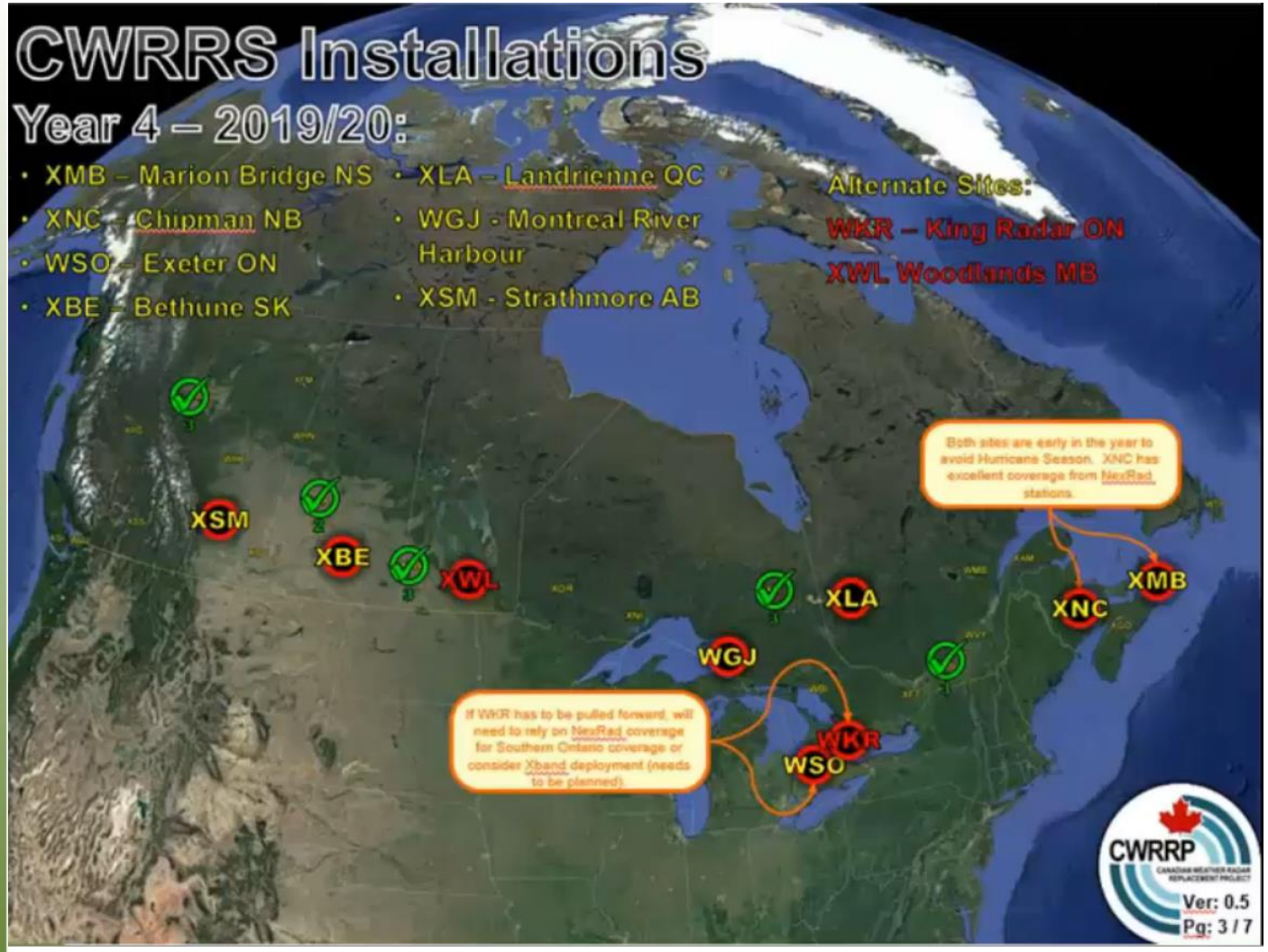
Radar Installs for 2018

Order	Site and ID	Installation Year (FY)	Status	Construction Start Date	SAT (Site Acceptance) Date	Old C-Band Radar Off Network (Estimated)	New S-Band Online (Estimated)
1	Radisson, SK "CASRA"	2017/2018	Completed	11-Sep-17	08-Dec-17	15-Oct-17	07-Feb-18
2	Blainville, QC "CASBV"	2018/2019	On track	16-Apr-18	20-Jul-18	NA (McGill radar available until Sept 30, 2018)	30-Sep-18 (data available internally by late July, but with periodic outages due to training and testing requirements on new radar)
3	Foxwarren, MB "CASFW"	2018/2019	On track	14-May-18	17-Aug-18	25-Jun-18	31-Aug-18
4	Timmins, ON "CASTI"	2018/2019	On track	11-Jun-18	14-Sep-18	23-Jul-18	28-Sep-18
5	Spirit River, AB "CASSR"	2018/2019	On track	09-Jul-18	12-Oct-18	25-Jun-18 (old radar must be decommissioned prior to new radar	26-Oct-18

1 portable x band 2018 Available for gap filling deployment

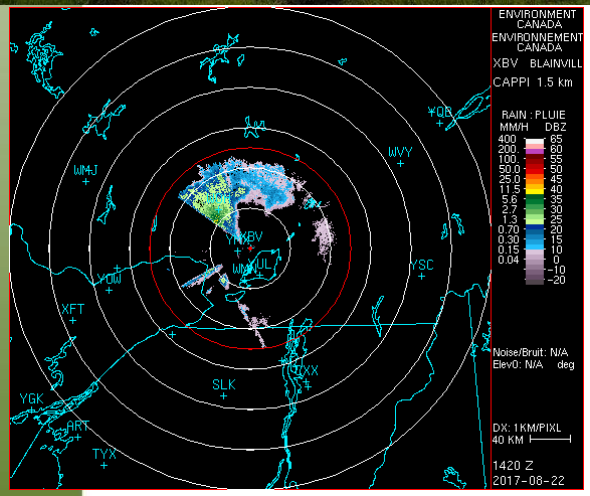


Radar installs for 2019



2 portable x-band radars available for gap filling deployment 2019

Portable X-band Deployment



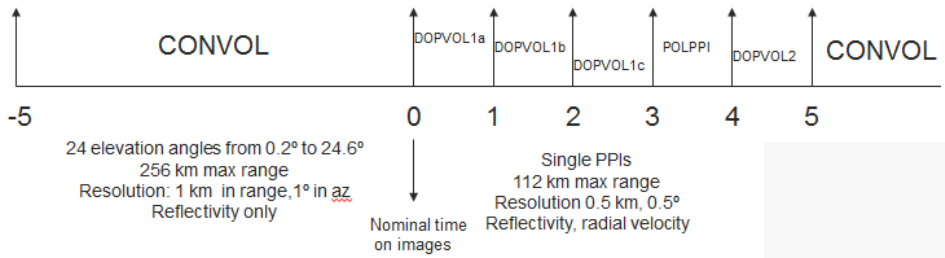
Portable x-band radar

- Originally deployed to cover anticipated gap for Montreal area
- Experienced considerable beam blockage at XBV to the west ~240-300 ^{0}
- Another deployment this Spring to cover convective area of southwestern Manitoba
- 7 scan angles every 5 minutes, reflectivity and vr
- Range = 100km (~ 60 mi), vr is 48ms-1
- Stand alone imagery, not to be fully integrated into URP software suite ie Storm cell identification or URP composites

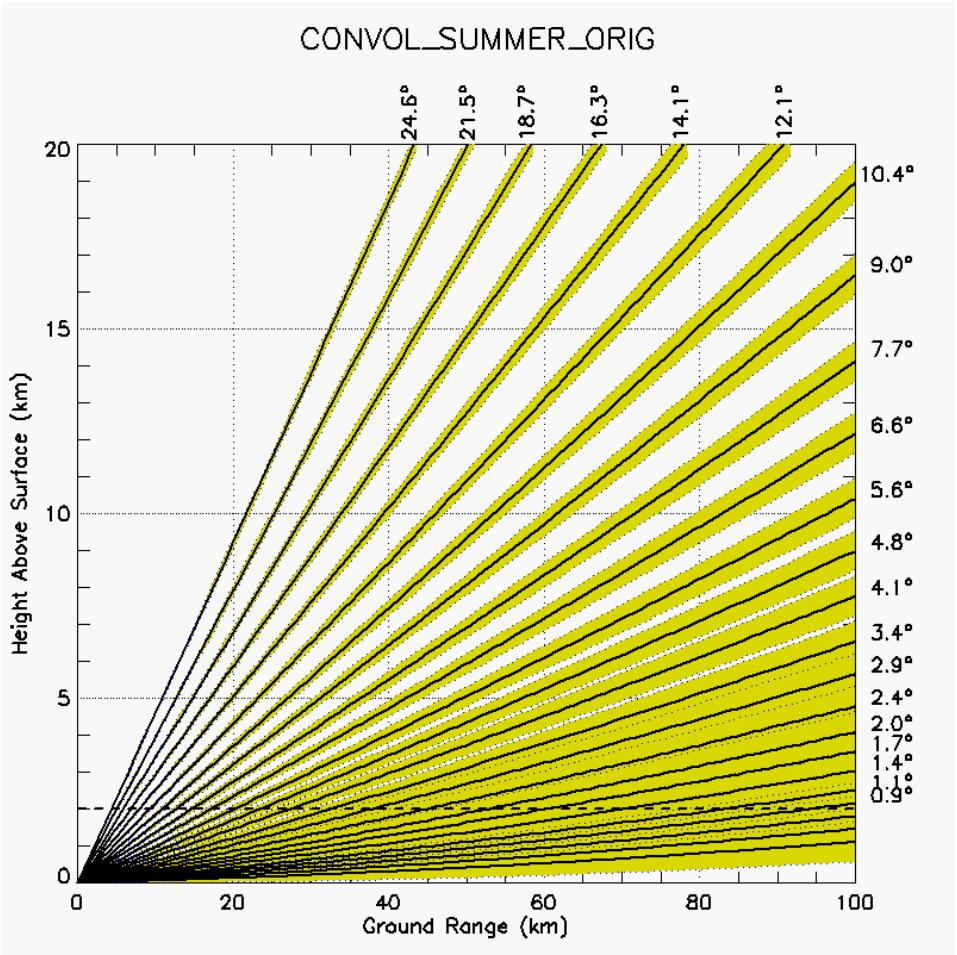
URP / NinJo XBV products available*:

- CAPPI
- MaxR
- Echo Top
- SVRWX
- WDRAFT
- VIL
- VIL Density
- VIZ
- Hail
- Hail MESH
- HAIL POSH
- CoTPPI
- BWER
- PPI - DBZ
- PPI - VR

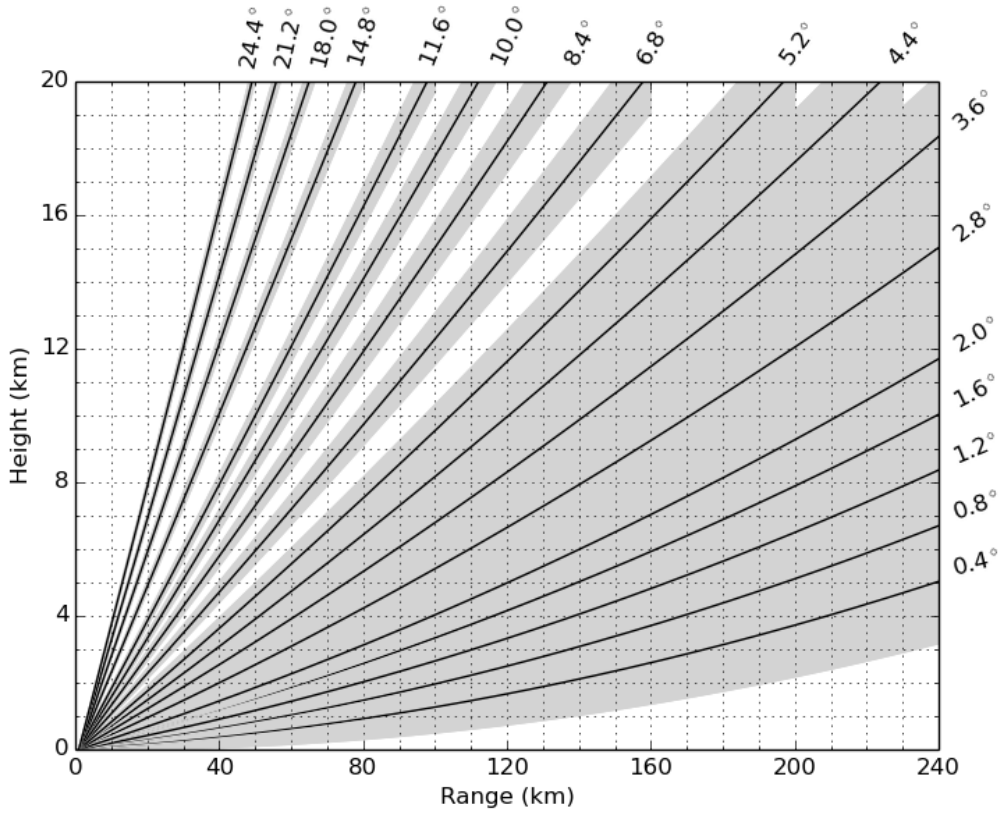
Current C band Scanning Strategy



- CONVOL and DOPVOL mode alternate every 5 minutes
- CONVOL: 5 mins for 24 reflectivity angles
- DOPVOL: 5 mins for 3 Doppler angles; LOLAA, 1.5 and 3.5
- Vr range 120km with upper bound of 48 ms-1
- Results in time increment of 10 minutes

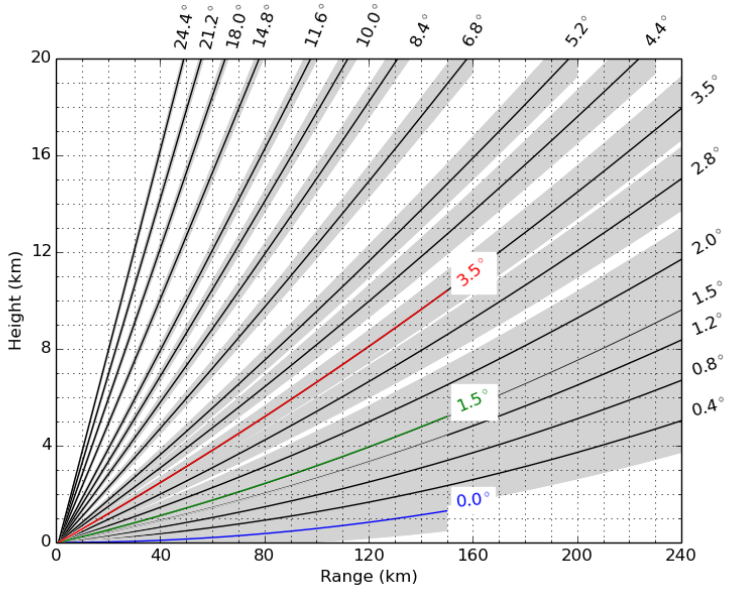


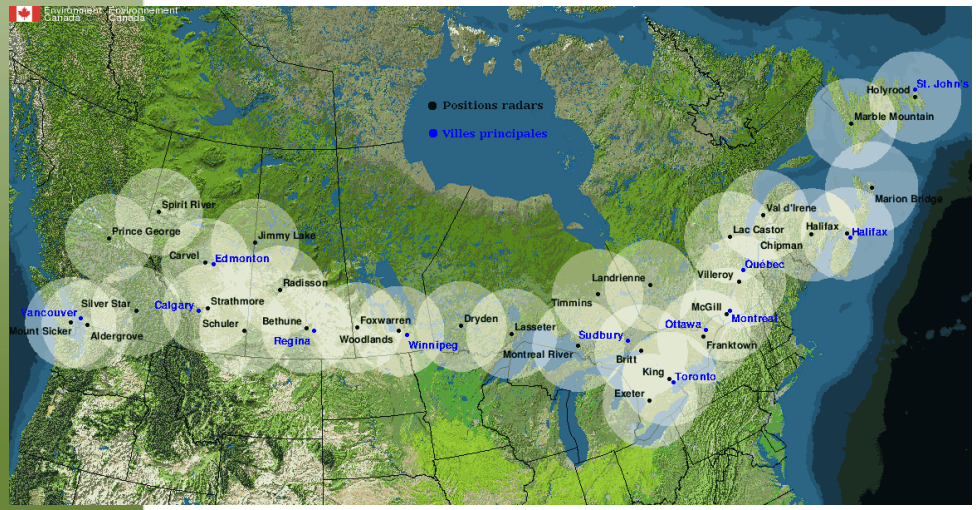
Selex: Six-minute polar volume S-band: PVOL6S



- Similar to NEXRAD ie no longer separate reflectivity and doppler modes
- Vr range 240 km
- 6 min time increment
- Polarized products
- Not Site configurable
- Potential for intermediate 3min lowest level scan may be discussed later

Radar Harmonization





- Current Canadian C-band scan strategy is time synchronized
- As the project evolves Canada's radar network to be a collage of radar frequencies and scan strategies
- New S band will utilize 6 minute x 17 elevation scan strategy
- Existing C band will remain first 5 mins: 24 reflectivity angles, then 5 mins: Doppler scan mode
- No immediate timeline for radar scan strategy harmonization

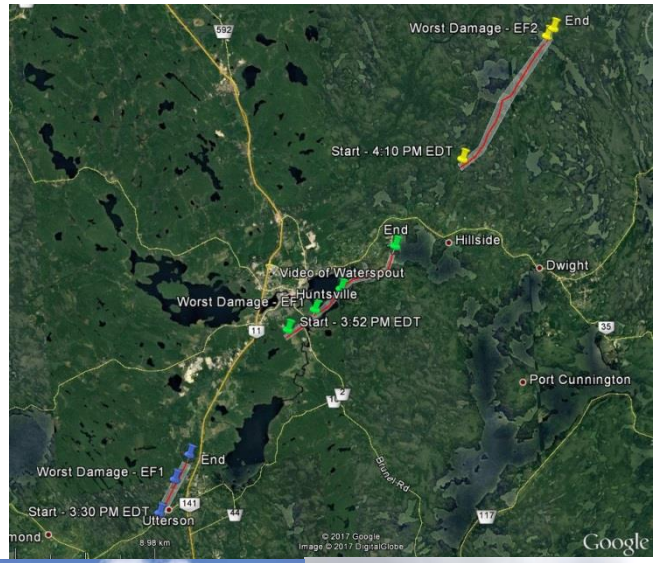
Planned URP Releases: A Recap

	Release	Date	**Requirements: High Priority** and ***Highly Desirable***
1)	URP 2.10	Deployed Jul 2017	X-band radar data integration for XBV • Existing single radar volume products • DBZ and VR PPIs
2)	URP 2.11	Target Feb 2018	Phase 1: S-band radar data integration • Existing single radar volume products • DBZ and VR PPIs • Dual pol PPI products (moved up from URP 2.12) • *Storm relative velocity for C-band* • *NEXRAD Level 2 processing* • *NUMERIC format modification for CMOI*
3)	URP 2.12	Target Oct 2018	Phase 2: S-band radar data integration • Existing precipitation accumulation products • Existing Doppler products • Composites (C, S, X-band) • *Further NEXRAD Level 2 processing & integration*
4)	URP 2.13	Target Apr 2019	Phase 3: S-band radar data integration • Existing severe weather/SCIT (S and C-bands) • New particle classification • New dual pol QPE • New/improved data quality including an enhanced PRECIP/ET product for S-band • *Change SCIT table units (deferred from URP 2.11 to coordinate with NinJo 3 release)* • *Further NEXRAD Level 2 processing & integration*

Examples of Past Shortcomings

- Limited Doppler Range
  - Huntsville Tornadoes - 4 Aug 2018
  - Windsor Tornadoes - 24 Aug 2016
- Attenuation issues
  - Mount Forest Heavy rain - 23 June 2017
  - Toronto Heavy Rain – 8 June 2013
- Dropped Radar Bins
  - Teviotdale EF2 – 2 Aug 2016
  - Shellbourne EF1 – 18 April 2013

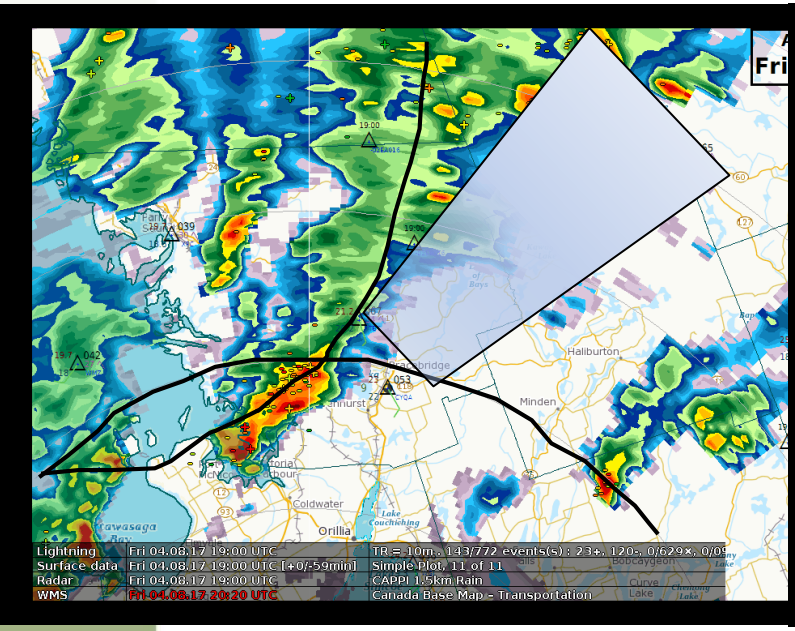
4 Aug 2017: Huntsville, ON



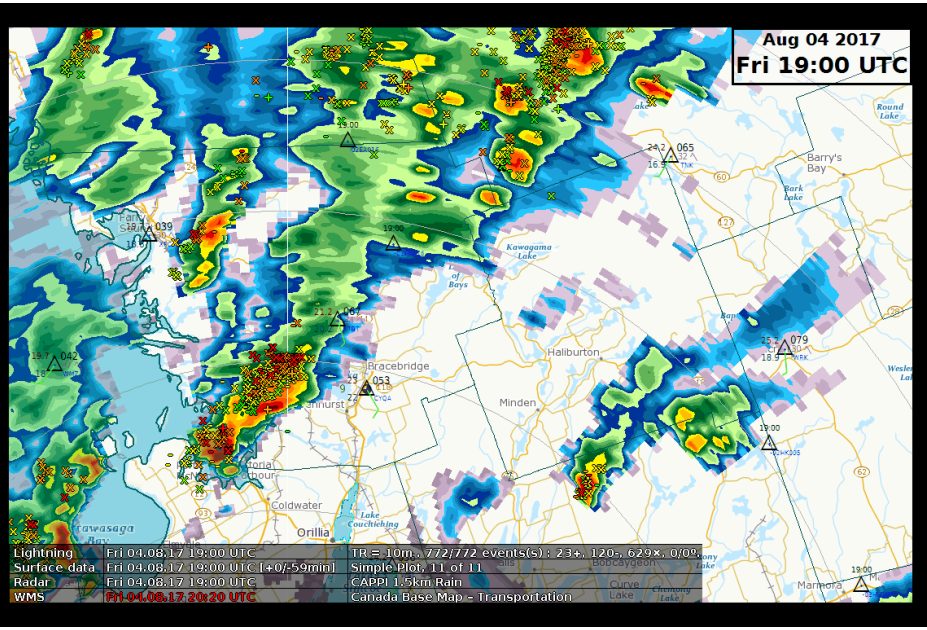
Environme
Climate C

King Radar: 1.5km Cappi

Positive and negative ltng only

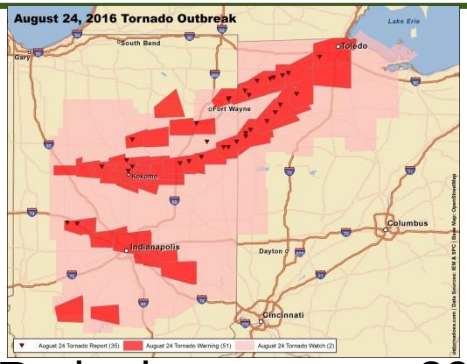


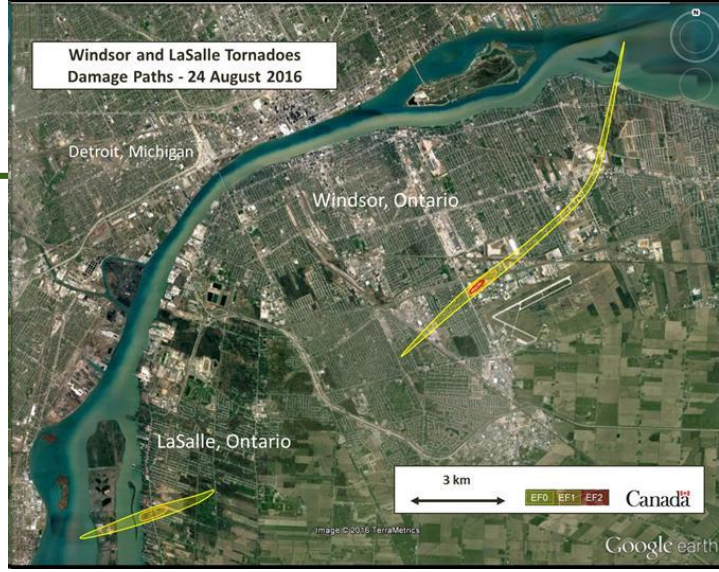
Total Lightning



- King 120km Doppler range ends at Bracebridge
- Britt radar Doppler range ended at Huntsville
- Mesocyclones not depicted for SCIT*
- At 1950z, echoes appear to transform into numerous discrete cells, later cell mergers seem likely though difficult to tell with 10 minute increments
- 3 Confirmed Tornadoes in Forested area, possible more occurred
- Selex S band will extend Doppler range, also have Dual Pol CC product at 6 min time intervals, and integrated eventually into SCIT
- At 20:10z appears to be some attenuation, at 2030z radome wetting at King further diminishes signal

Windsor Tornadoes24 Aug, 2016

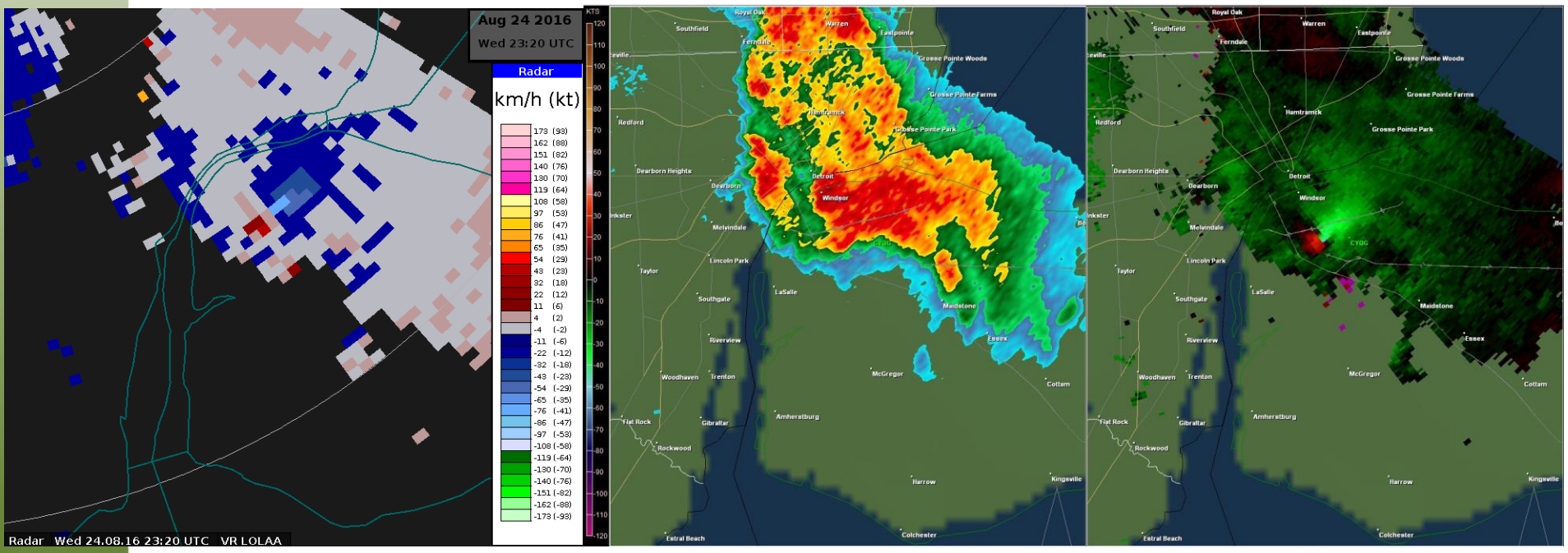




Radar images near 2020z

URP - Detroit

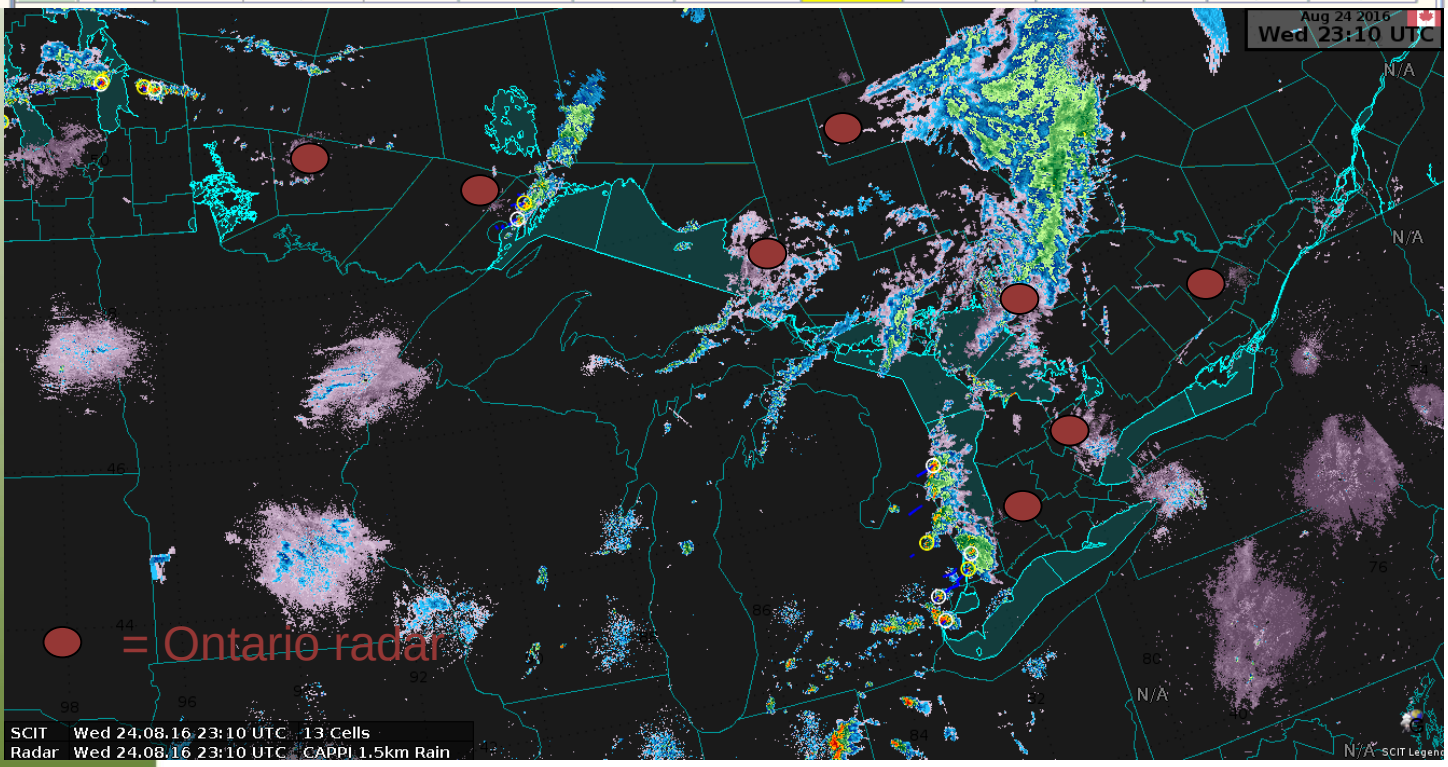
Nexrad - Detroit



Storm Cell Identification Table

Storm Cell Identification & Tracking Table

ID	RANK	BWER [km]	Meso [m/s/km]	Hail [cm]	WDRAFT [m/s]	VIL [mm]	VIL Dens [g/m3]	Max Z [dBZ]	HGT 45dBZ [hm]	Echotop [h...	Radar	Direction [°]	Speed [m/s]
1494	4.5	0	N/A	2.2	21.4	30	4.2	61.5	71	91	XTI	77.3	7.5
1462	2.9	0	N/A	0.3	14.4	12.4	2.1	56.5	51	70	WSO	52.7	12.5
1487	2.8	0	N/A	0.2	13.7	11.5	2.5	57	39	69	XWL	14.4	3.3
1490	2.4	0	N/A	0	11.6	9	1.4	56.5	38	71	XNI	66.5	10.1
1485	2.3	0	N/A	0.2	10	12	1.3	55.5	41	104	XWL	152.9	5.1
1506	2.3	0	N/A	0	8.6	8.8	1.5	53	52	79	XTI	N/A	N/A
1442	2.1	0	N/A	0	8.9	8.4	1.2	54.5	38	80	XWL	51.3	10.6
1493	2	0	N/A	0	6.5	6.5	0.9	49	56	94	XTI	65.9	14.9
1476	2	0	N/A	0	6.7	7	1.1	50.5	46	83	XTI	91.8	7
1504	2	0	N/A	0	9.1	5.8	1.1	50	42	56	WSO	N/A	N/A
[illegible]	1.9	0	N/A	0	7.8	5.1	0.9	50.5	35	64	XNI	82.7	10.1
1496	1.9	0	N/A	0	7.1	7.1	0.6	52	49	130	WSO	59.8	12.8
[illegible]	1.8	0	N/A	0	7.5	5.9	0.8	50	35	66	WSO	N/A	N/A
1503	1.7	0	N/A	0	5.8	5.8	0.8	49.5	36	85	XWL	N/A	N/A
1475	1.7	0	N/A	0	5.6	5.6	0.7	50	40	84	WSO	68.7	12
1497	1.7	0	N/A	0	4.2	4.7	0.8	50.5	41	83	WSO	56.3	14.2
1502	1.6	0	N/A	0	4.4	4.4	0.6	53	30	77	XWL	N/A	N/A



- OSPC monitors 8 Ontario radars plus several upstream US radars
- SCIT a means for Situational awareness
- Windsor Cell ID:1496 is 12th ranked and indicated as weak
-MESO is NA
- Outside of Exeter radar 120km doppler range

23 June 2017
Nocturnal Heavy rain Event

Quick Case Study

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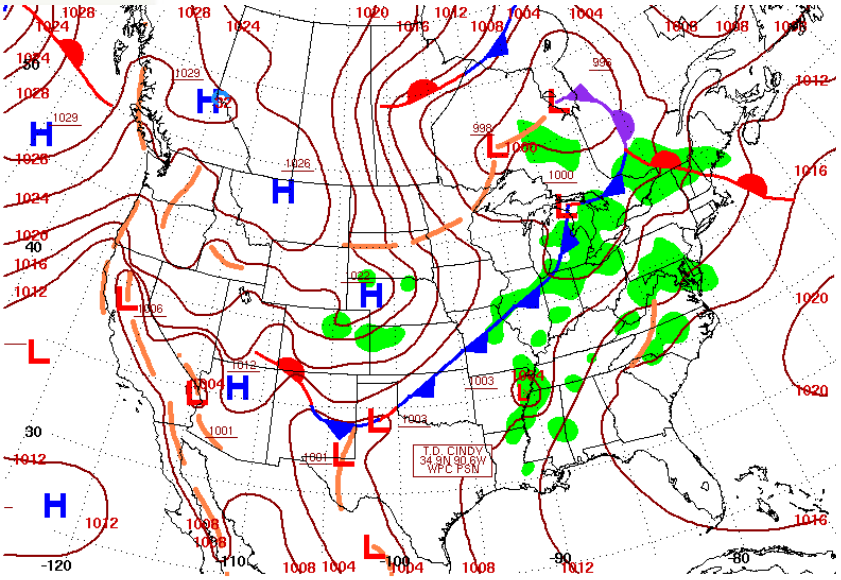
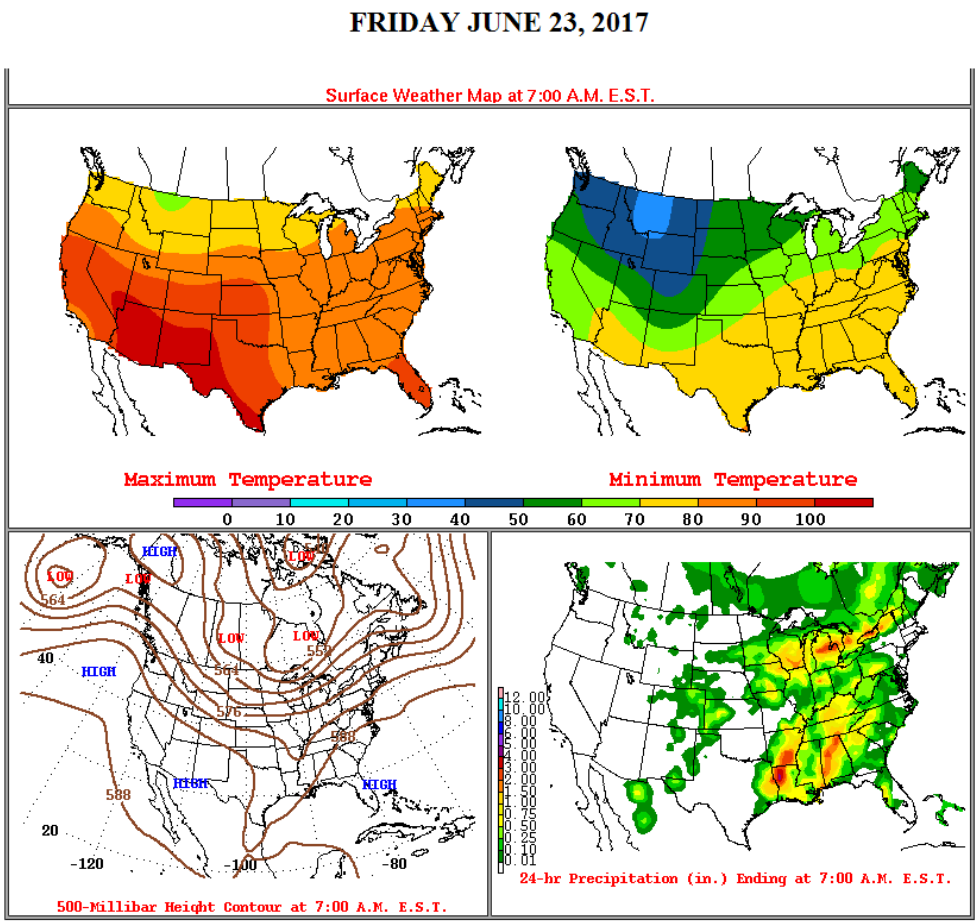
gement climatique Canada

General Synoptic pattern

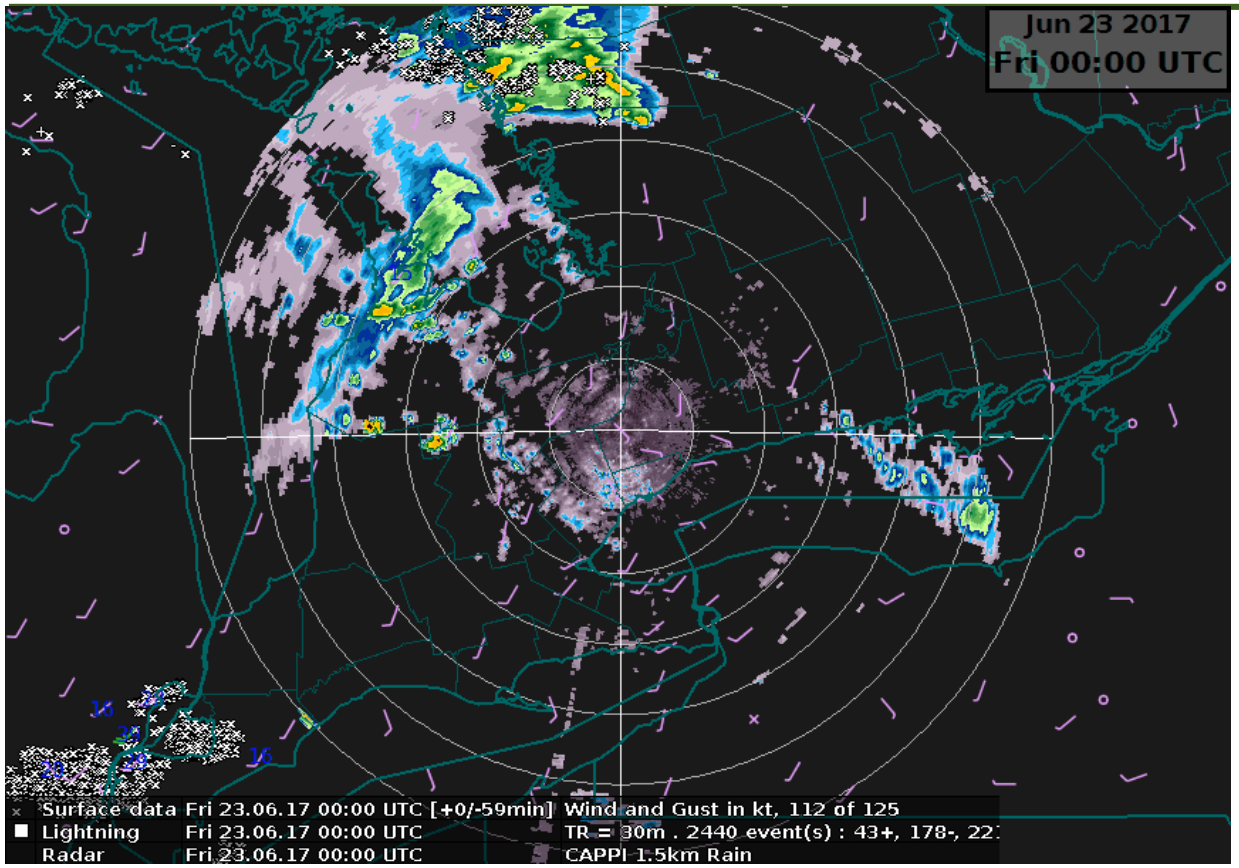
Source: Weather Prediction Center





- Significant flooding occurred over portions of southwestern Ont with a general 75-150 mm in 12 hr time frame
- Grand River Basin hard hit
- Note: These maps illustrate Synoptic situation approx 9 hrs after the onset of this Heavy rainfall Event over Swrn Ont
- Radar loop does show some outflow boundaries which appear to have setup in east-west orientation; further south of the synoptic scale front shown on the WPC analysis.

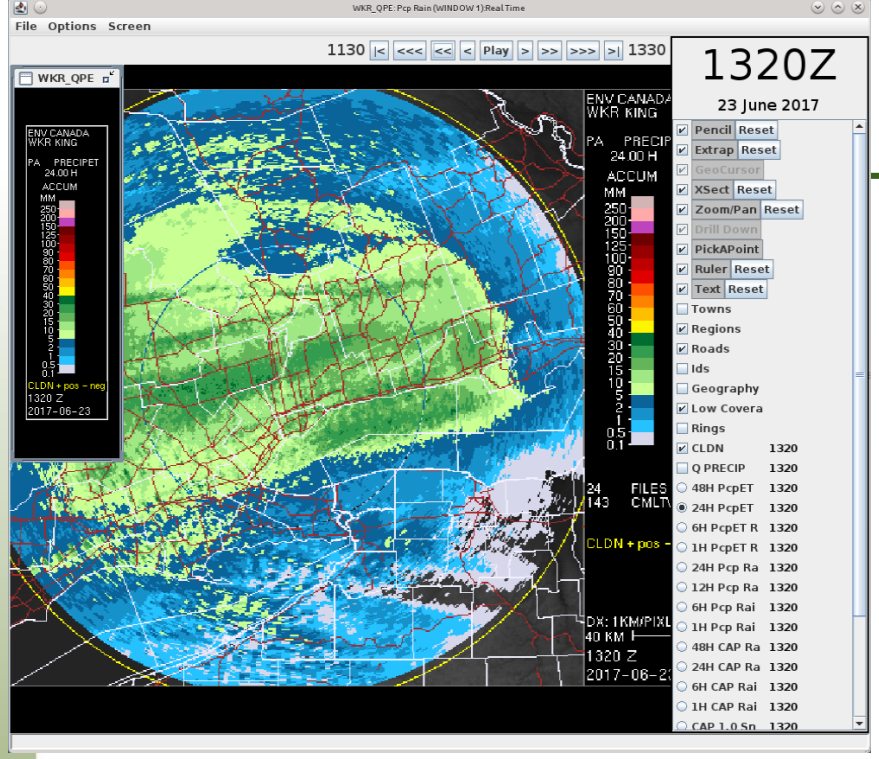
12 Hr Loop of 1.5km CAPPI
Note: Lightning is 30 min trace



Attenuation observed results in Concentration of lightning Strikes but with minimal Radar signal

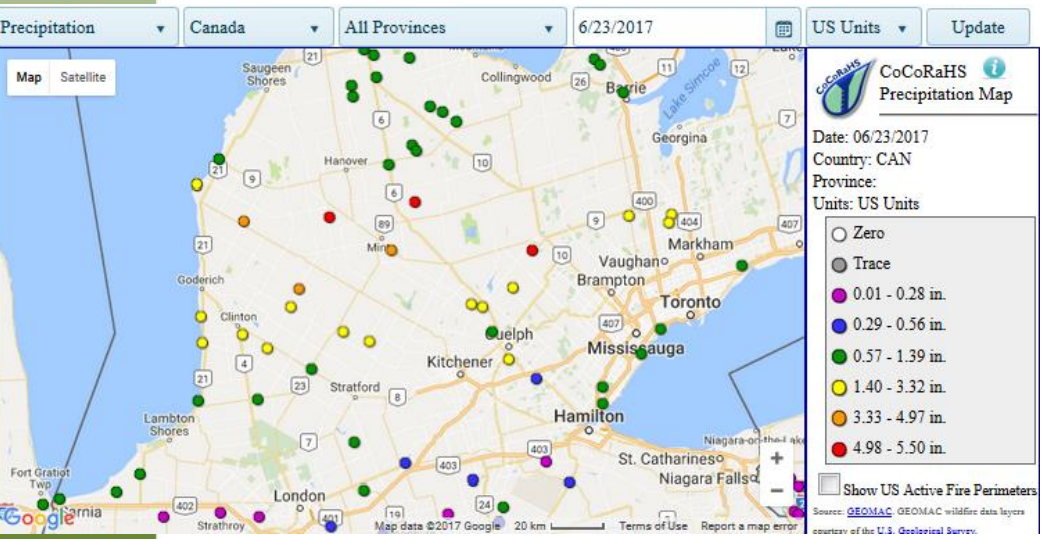
- Scattered Convection transforms into an organized east west line of Training Convection.
- King experiences significant attenuation due west
- Operations was not aware of the magnitude of the rainfall event till climate observations became available some 6 hrs after the event

CoCoRaHS and King Rain Accumulation



*Significant Attenuation and Radome Wetting at King Radar vastly underestimates Rainfall Amounts (QPE)

*King does not show any values above 40 mm



- MOUNT FOREST: 158
- MONO CENTRE: 101
- GODERICH: 91.9
- POINT PETRIE: 77.5
- COBOURG: 54.3
- TORONTO BUTTONVILLE AIRPORT: 50
- UXBRIDGE: 43.7
- ELORA: 43.4
- TORONTO PEARSON AIRPORT: 36.2
- MILDMAY: 137.4 (COCORAHS)
- ORANGEVILLE: 128 (COCORAHS)
- PALMERSTON: 121.9 (COCORAHS)
- LUCKNOW: 108.7 (COCORAHS)
- BRUSSELS: 95 (COCORAHS)
- MILFORD: 71.4 (COCORAHS)
- SCHOMBERG: 66.8 (COCORAHS)
- ELORA: 56.6 (COCORAHS)
- AURORA: 55.9 (COCORAHS)
- BAYFIELD: 51.1 (COCORAHS)

A Billion Dollar Flash Flood in Toronto – Meteorological Analysis and Operational Considerations

David Sills[1], Arnold Ashton[2], Steve Knott[2], Sudesh Boodoo[1], Joan Klaassen[1], Stéphane Bélair[1] and Helen Yang[2]

[1]Science and Technology Branch
[2]Meteorological Service of Canada

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The Event and Impacts

- 8 Jul 2013 2000-0500 UTC, worst 2020-2210

- 50-130 mm of rain across much of Greater Toronto Area, a 100-yr return period storm

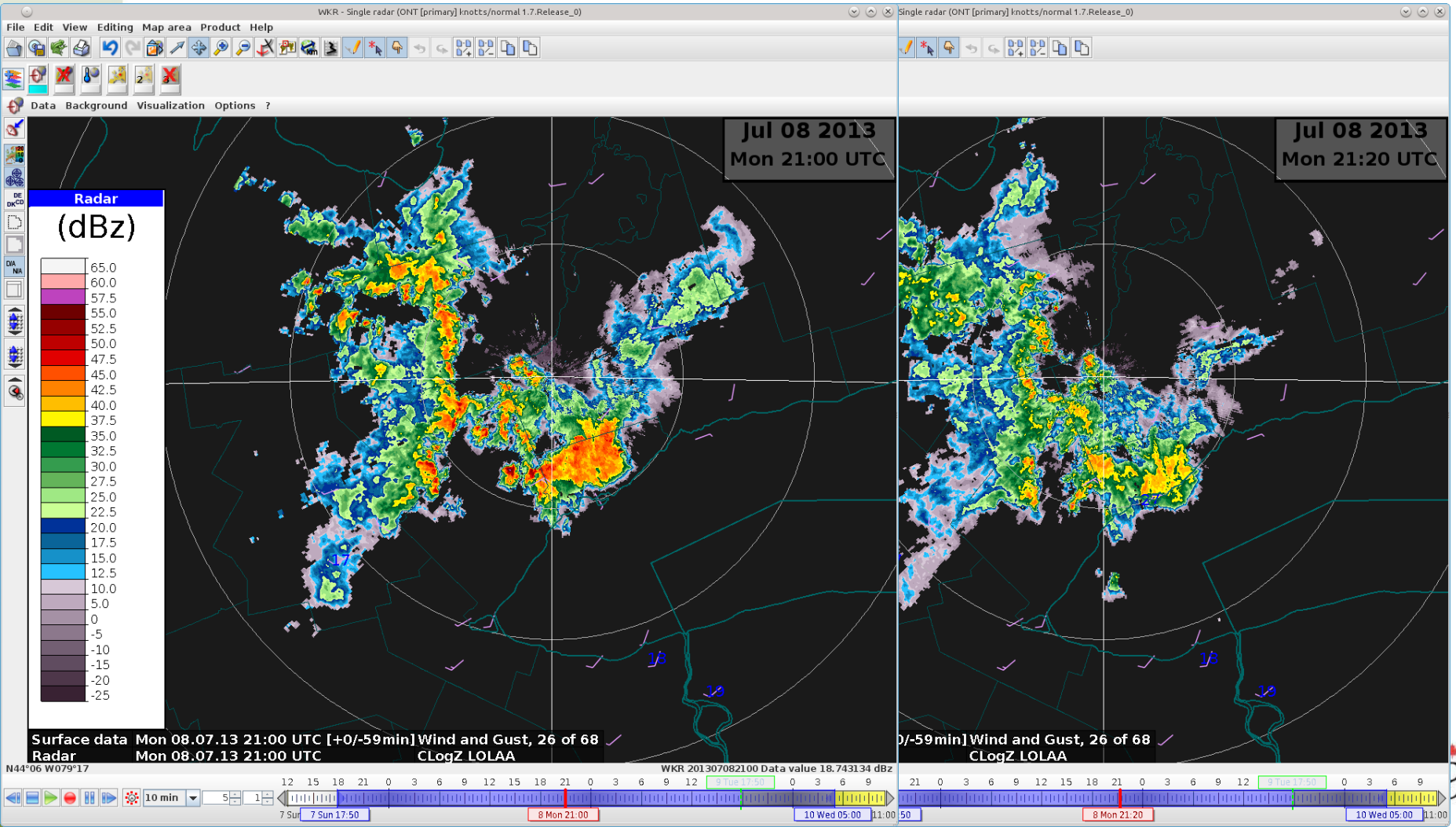
- Significant Disruption to Transportation

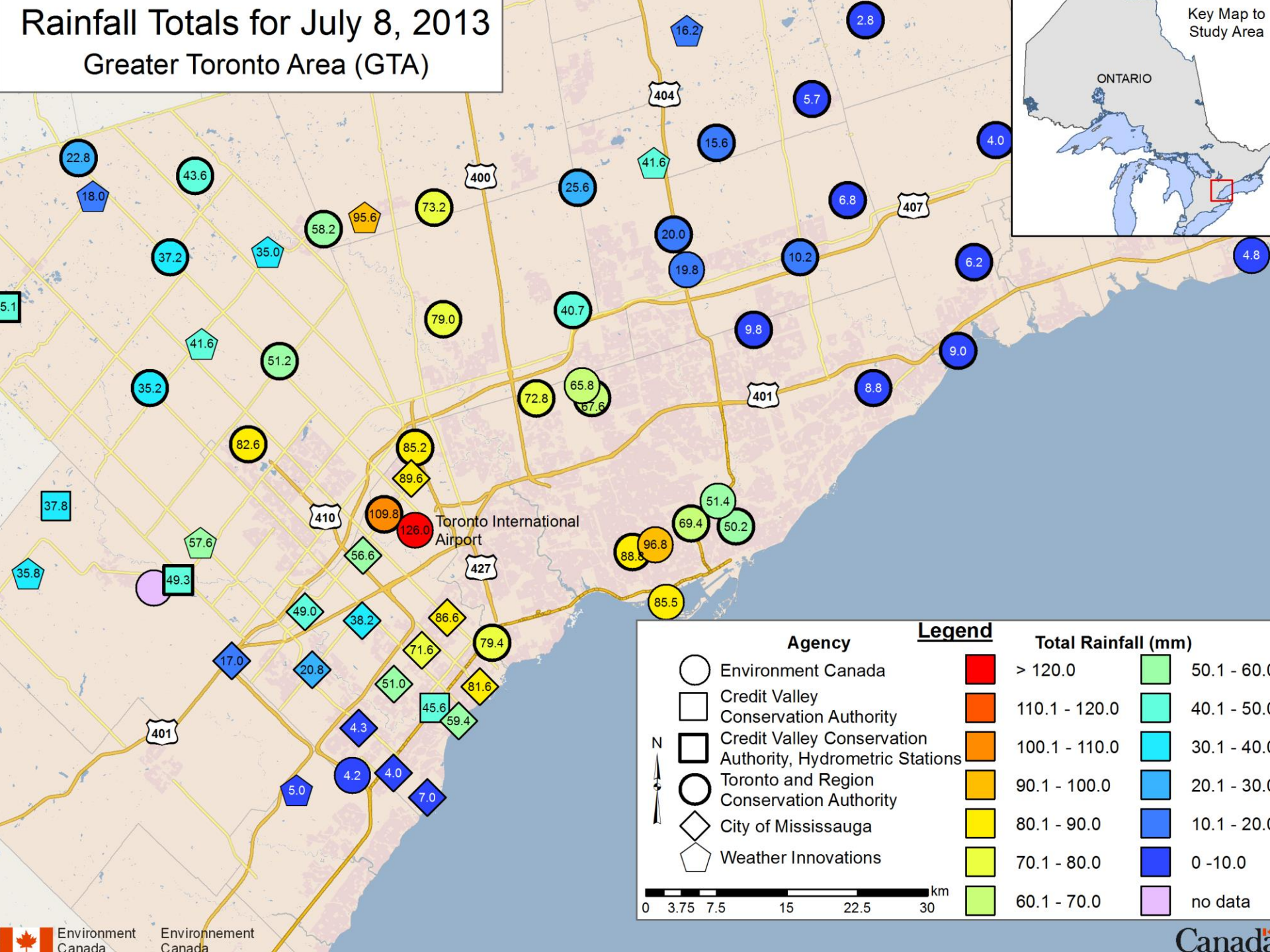
- $850M+ in insured losses, and with uninsured losses surely *more than $1B*, exact cost unknown

- *The costliest natural disaster in Ontario history!*

8 July 2013

At 2100z the main storm has moved over the GTA, however just after 2100z some cells move over King city radar and significantly reduce the Reflectivity values of the Rain. This is caused by a combination of Radome wetting and attenuation, the drop is significant and was noticed by meteorologists on shift




Rainfall Totals for July 8, 2013
Greater Toronto Area (GTA)
Key Map to Study Area
ONTARIO
Toronto International Airport
Legend
Agency
Environment Canada
Credit Valley Conservation Authority
Credit Valley Conservation Authority, Hydrometric Stations
Toronto and Region Conservation Authority
City of Mississauga
Weather Innovations
Total Rainfall (mm)
> 120.0
110.1 - 120.0
100.1 - 110.0
90.1 - 100.0
80.1 - 90.0
70.1 - 80.0
60.1 - 70.0
50.1 - 60.0
40.1 - 50.0
30.1 - 40.0
20.1 - 30.0
10.1 - 20.0
0 -10.0
no data
N
0 3.75 7.5 15 22.5 30 km
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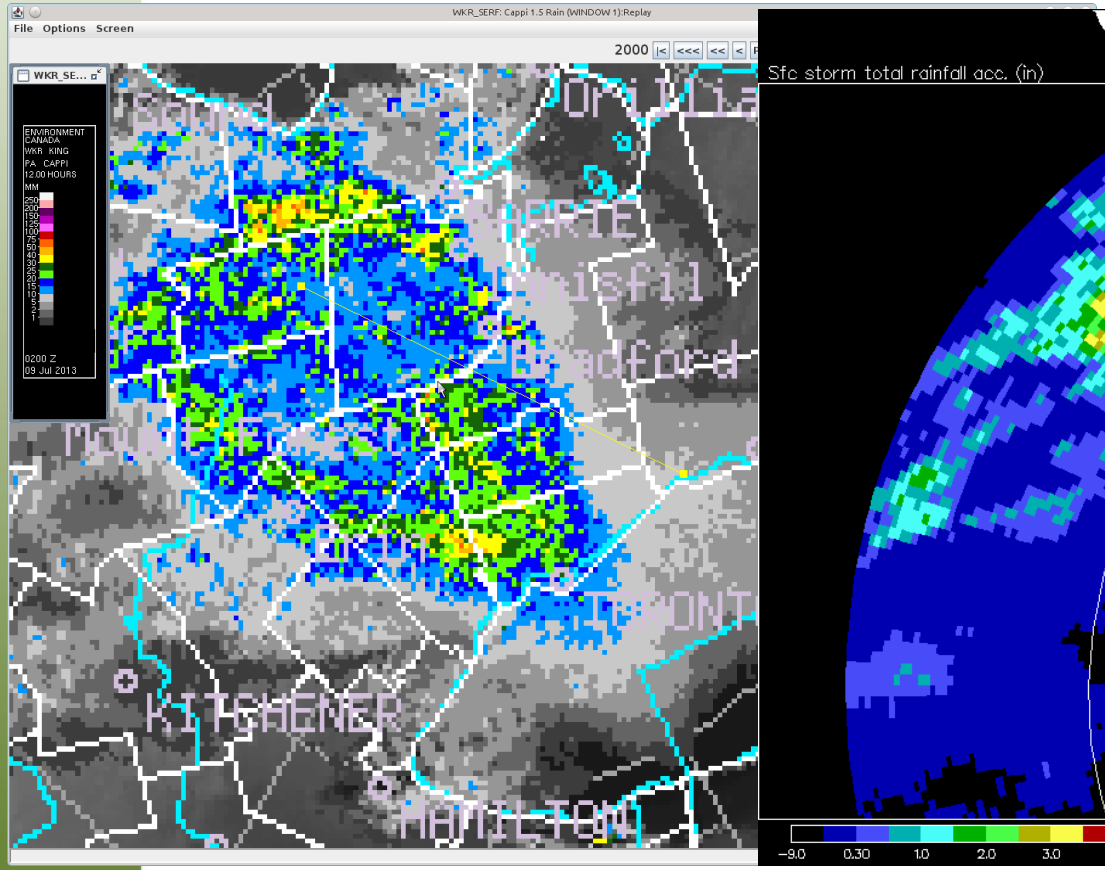
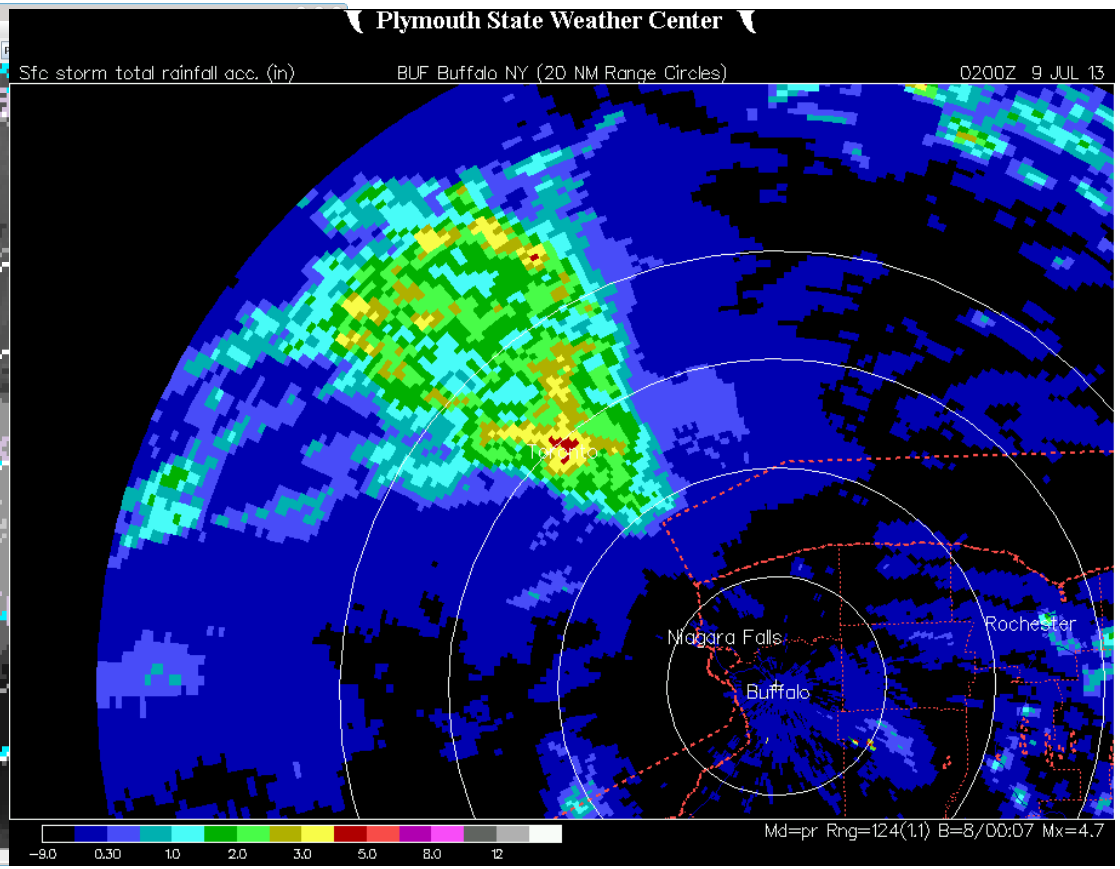
8 July 2013: Toronto Urban Flood

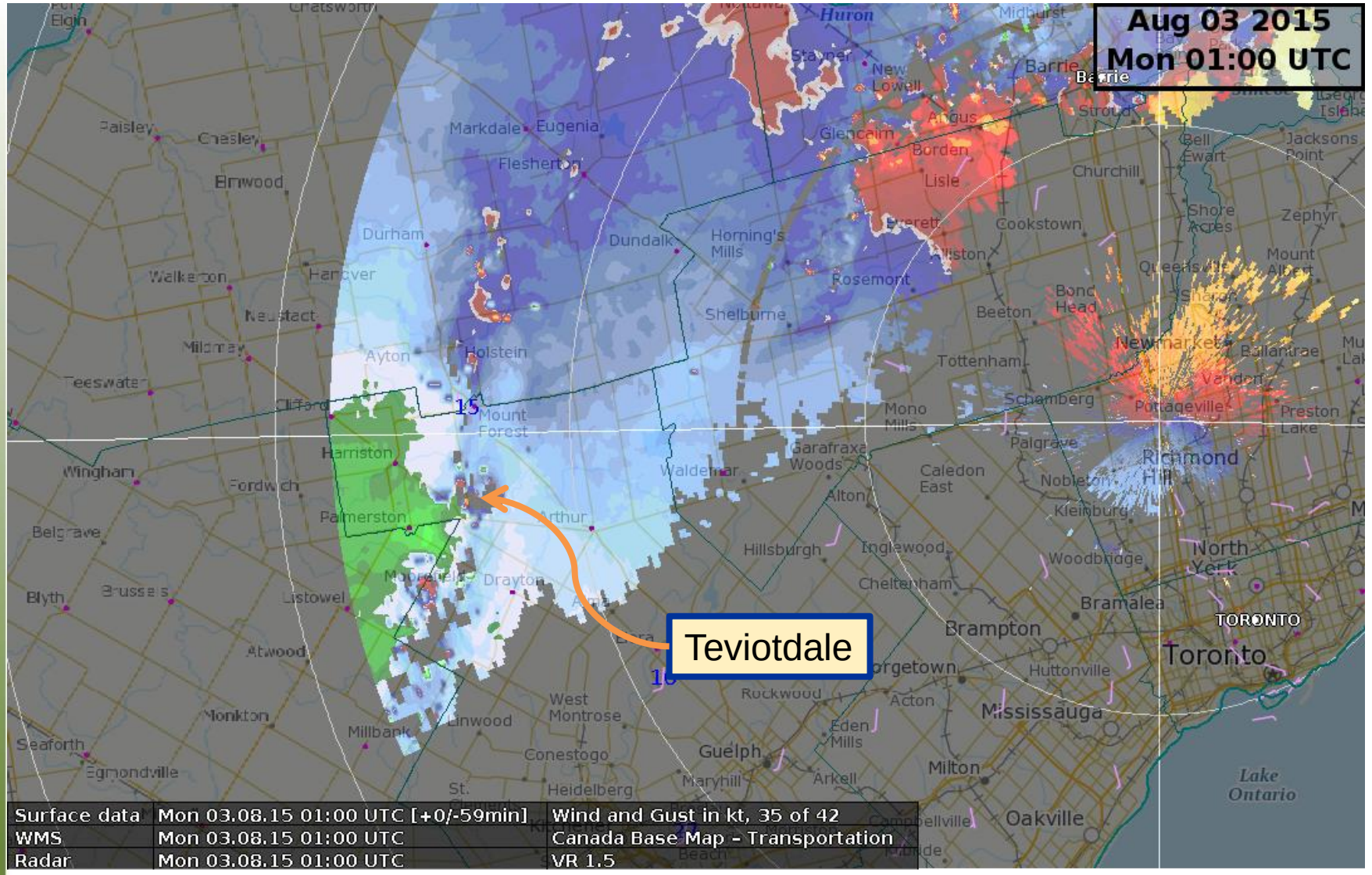
- King radar Pcpn Accum: Actual measured rainfall amounts were 126 mm at Pearson airport, 85 mm at Toronto island airport and 93 mm Toronto downtown. Rainfall estimates from King were on the order of 40-50 mm, a significant underestimation.

Buffalo Rainfall Estimates: Although it is difficult to get an exact sense of the geography over the GTA, especially since the background geography only shows the American portion of lake Ontario, Buffalo's S band radar showed maximum values of 4 to 5 inches or 100-125 mm, this is much closer to what was measured in the GTA.





Dropped Radar Bins near Mesocyclone Teviotdale, Ontario –Confirmed EF2



Teviotdale confirmed EF2 tornado ~ 9:00pm

Environment and Climate Change Canada / Environnement et Changement climatique Canada

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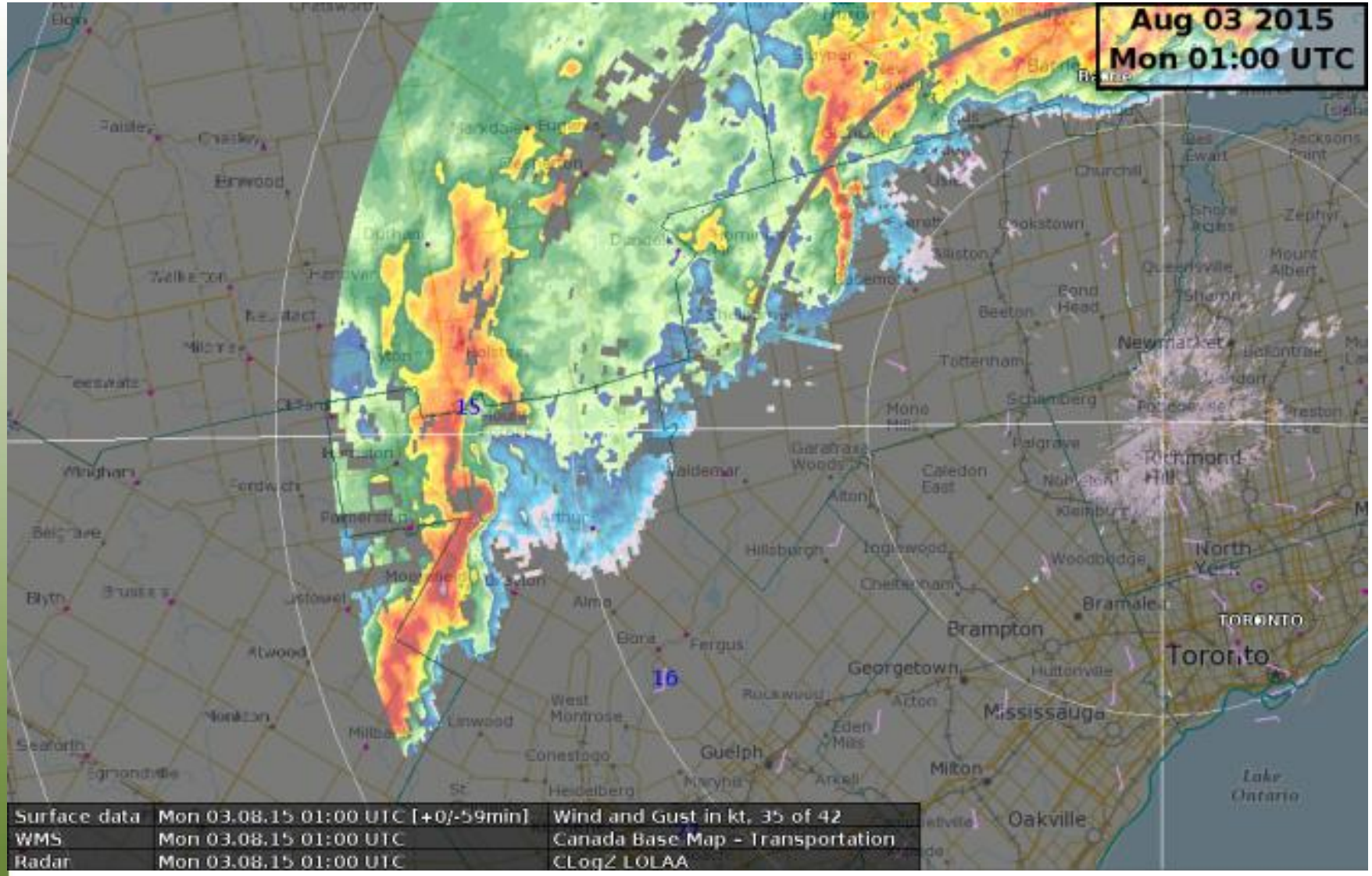
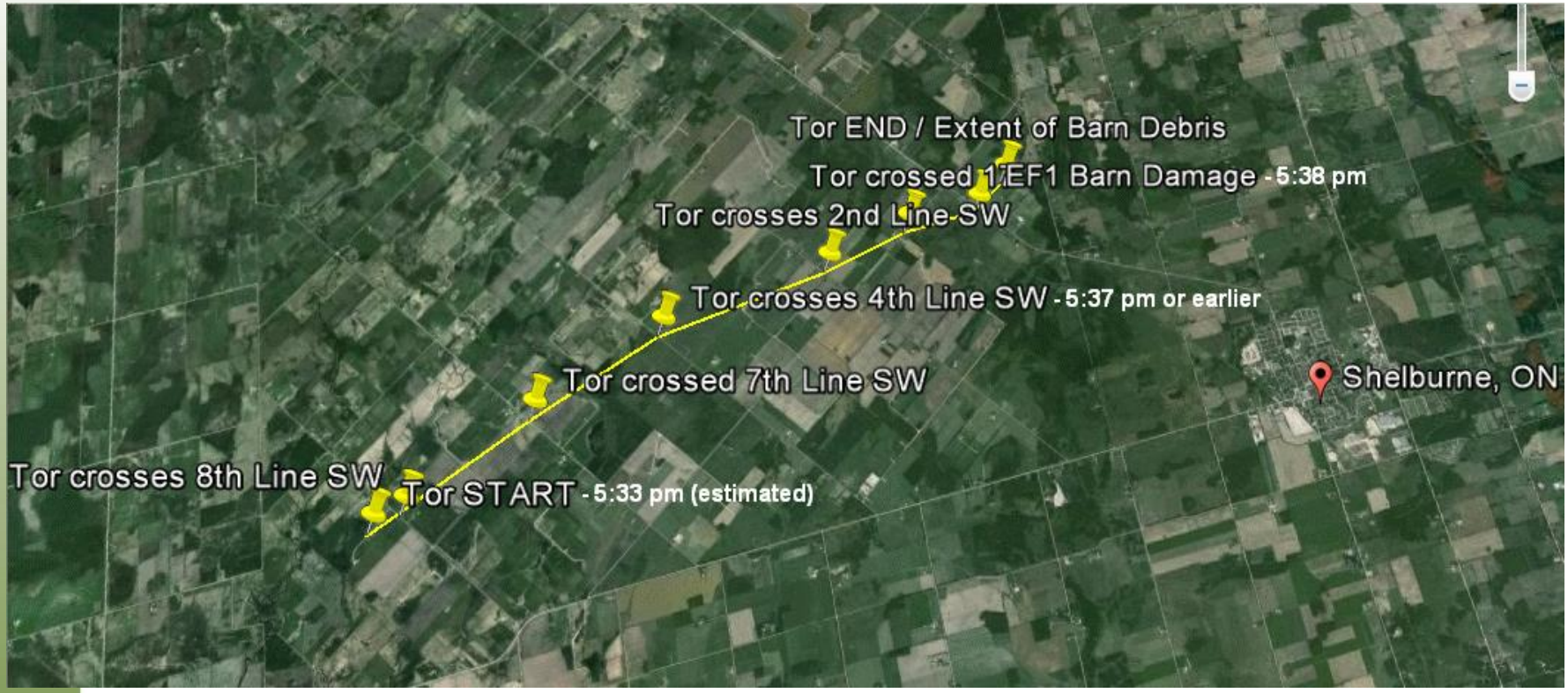
Teviotdale, Ontario –Confirmed EF2

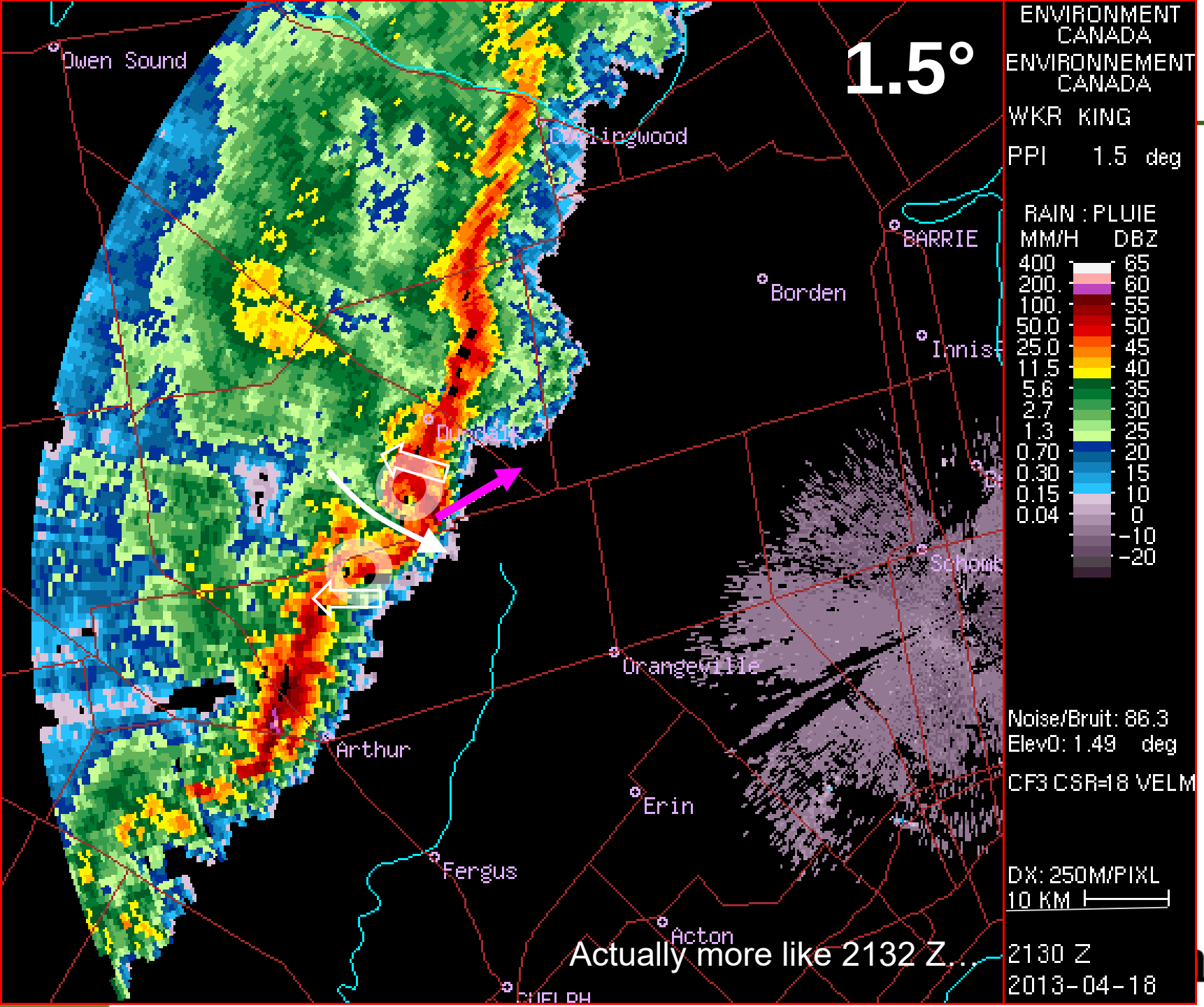


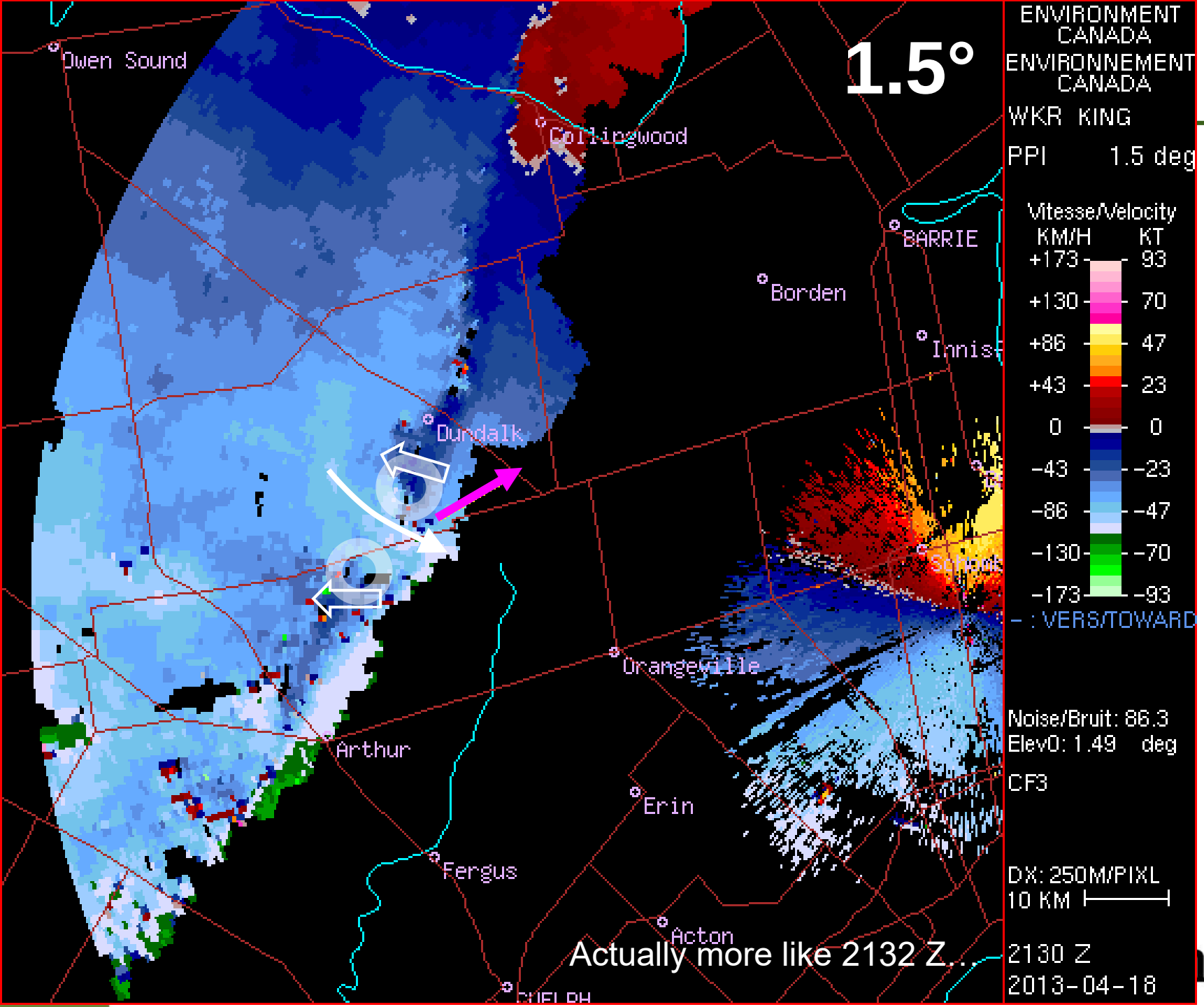
Teviotdale confirmed EF2 tornado ~ 9:00pm

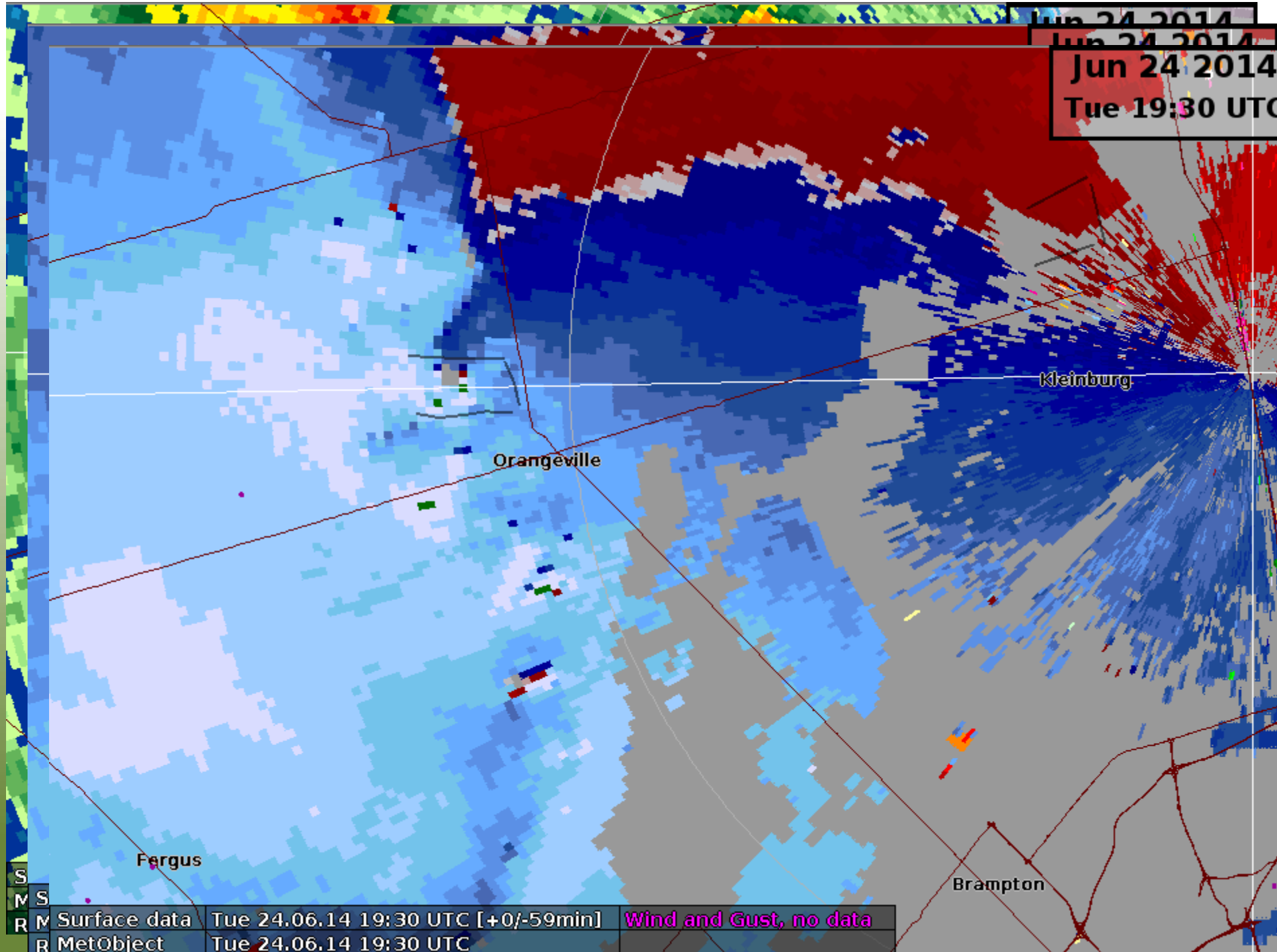
18 Apr 2013 EF1 @ Shelburne



- Occurred at leading edge of small bowing segment along QLCS – rain-wrapped!
- 10 km track beginning 2133 UTC - reports


1.5°
ENVIRONMENT CANADA
ENVIRONNEMENT CANADA
WKR KING
PPI 1.5 deg
RAIN : PLUIE
MM/H DBZ
400 65
200. 60
100. 55
50.0 50
25.0 45
11.5 40
5.6 35
2.7 30
1.3 25
0.70 20
0.30 15
0.15 10
0.04 0
-10
-20
Owen Sound
Collingwood
BARRIE
Borden
Innisfil
Dundalk
Schomberg
Orangeville
Arthur
Erin
Fergus
Acton
GUELPH
Noise/Bruit: 86.3
Elev0: 1.49 deg
CF3 CSR=18 VELM
DX: 250M/PIXL
10 KM
2130 Z
2013-04-18
Actually more like 2132 Z...


1.5°
ENVIRONMENT CANADA
ENVIRONNEMENT CANADA
WKR KING
PPI 1.5 deg
Vitesse/Velocity
KM/H KT
+173 93
+130 70
+86 47
+43 23
0 0
-43 -23
-86 -47
-130 -70
-173 -93
- : VERS/TOWARD
Noise/Bruit: 86.3
Elev0: 1.49 deg
CF3
DX: 250M/PIXL
10 KM
2130 Z
2013-04-18
Owen Sound
Collingwood
BARRIE
Borden
Durdalk
Orangeville
Arthur
Erin
Fergus
Acton
Actually more like 2132 Z...


Jun 24 2014
Tue 19:30 UTC
Kleinburg
Orangeville
Fergus
Brampton
Surface data
Tue 24.06.14 19:30 UTC [+0/-59min]
Wind and Gust, no data
MetObject
Tue 24.06.14 19:30 UTC

Summary

- The CWRRP is a 7 year infrastructure program which will phase in 20 new S band radar systems with 13 additional options from SELEX
- S band radar scan strategy will result in 17 angles every 6 minutes, with a lowest angle near 0.4 degrees, and increased radial velocity range of 240 km.
- There will be a phased approach taken for the development of MSC's internal radar viewing software
  - Dual Polarized products ready upon deployment, but Dual Pol QPE and Particle Classification not likely until Spring of 2019
  - Integration of S band data into Storm Cell Identification Table not likely until Spring of 2019
- It is anticipated that the S band Dual Pol radars will be a significant improvement to detecting Summer Convective Weather as well as phase issues for Winter synoptic scale storms.