Towards a new Canadian weather radar network and the roll-out of modern operational radar products for end-users

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Acronyms:

- CFSB: Corporate and Financial Services Branch
- CMC: Canadian Meteorological Centre
- CMOI: Implementation and Operational services
- CMOI-Radar : Implementation and Operational services - Radar team
- CWRRP: Canadian Weather Radar Replacement Program
- ECCC: Environment and Climate Change Canada
- FSII : Forecast Systems Integration and Innovation
- MSC: Meteorological Service of Canada
- URP : Unified Radar Processor

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1. Introduction:

This poster provides an overview of the ECCC's radar renewal project, including a discussion of preliminary plans for the generation and operational deployment of products to the end-users. The tools used for this deployment, as well as various examples of new radar products that will soon become available, are presented. Below are the major aspects that will be covered by this poster.

2. The current Canadian radar network:

The Canadian Weather Radar Replacement Program (CWRRP) is a seven-year infrastructure project that is intended to replace MSC's (Government of Canada's Meteorological Service of Canada) existing network of aging weather radars with modern S-Band Dual-Polarized radars. It should be noted that the previous Canadian radar network consisted of 30 radars, 28 single-polarized C-Band radars, 2 dual-polarized C-Band radar (whose dual products are used only internally) and one dual-polarized S-Band radar located in Montreal and managed by McGill University. Figure 1 shows the distribution of Canadian radars.

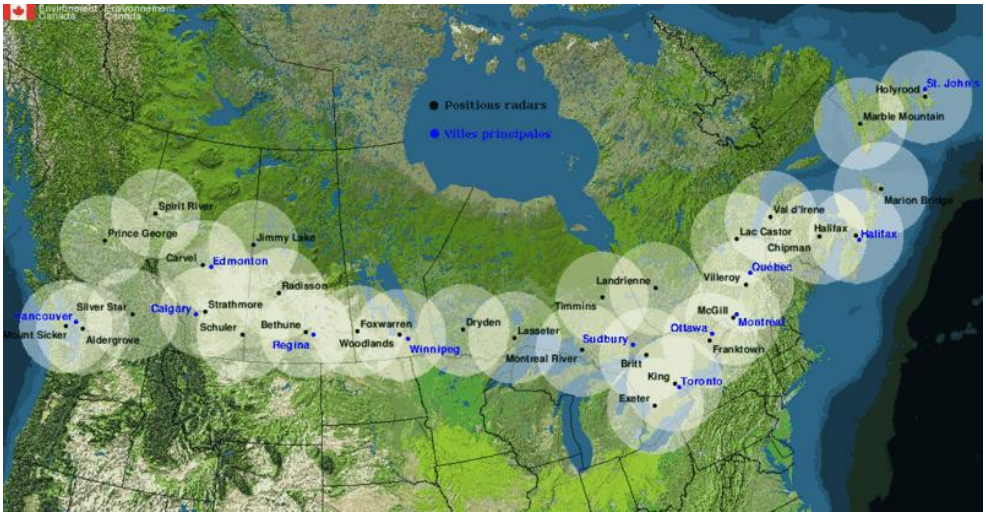


Figure 1: The previous Canadian radar network (30 C-Band radars and 1 S-Band).

3. The CWRRP project:

As of date, the CWRRP project is entering a crucial phase as the first 7 radars from of a total 32 have recently been installed, and products are already available to the public and to internal and external users (Table 1 shows the installed new S-Band radars per province). We are aiming for the installation of five (5) more by the end of 2019 to reach a total of 12 radars. As shown by figure 2, the installation rate of the dual-polarized S-band radars is about seven (7) radars per year.

No	Site Name	Site ID	Province	Site Acceptance Test Date	Product Online date
1	Radisson	CASRA	SK	Dec 7, 2017	Feb 7, 2018
2	Blainville	CASBV	QC	Aug 7, 2018	Sep 27, 2018
3	Foxwarren	CASFW	MB	Oct 26, 2018	Sep 27, 2018
4	Smooth Rock Falls	CASRF	ON	Oct 30, 2018	Nov 14, 2018
5	Spirit River	CASSR	AB	Mar 22, 2019	Feb 22, 2019
6	Bethune	CASBE	SK	09-13 Sept, 2019	Aug 08, 2019
7	Exeter	CASET	ON	26-30 Aug, 2019	Aug 08, 2019

Table 1: List of the installed new S-band radars

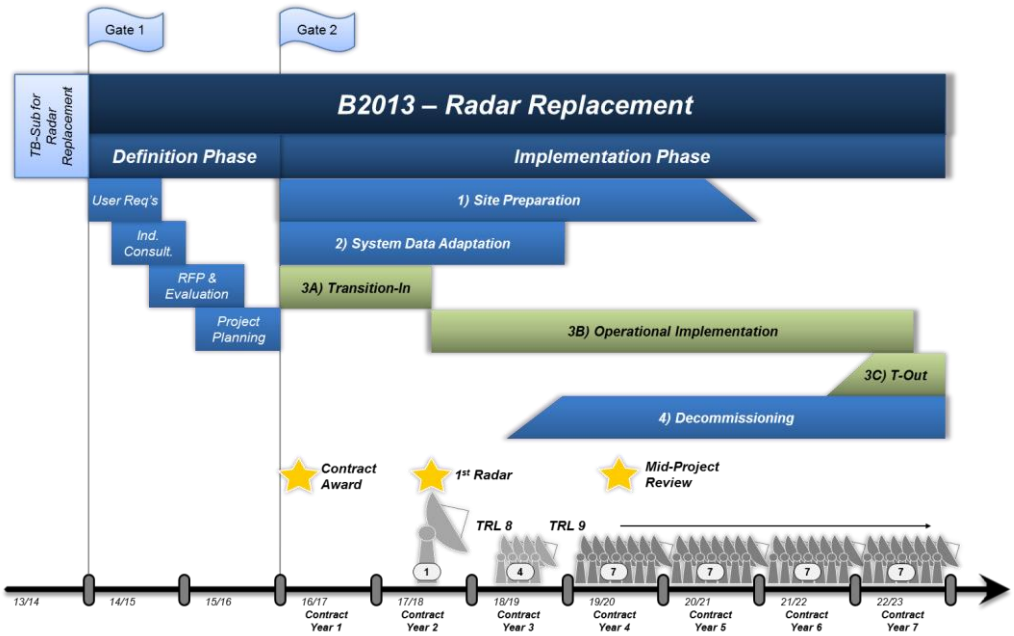


Figure 2: CWRRP radar replacement timeline (Graphic from CWRRP group).

As part of this project, many improvements for both the products and services are planned. For example, in addition to the integration of the dual-polarization technology that significantly improves the quality of existing products and allows the development of new products such as the particle classification, the Doppler range is doubled from 120 km to 240 km and the product availability changes from every 10 minutes to every 6 minutes. Furthermore, many other calibrations along with a new scan strategy are implemented with the new S-Band radars. Figure 3 shows the major features of the new S-band radars.

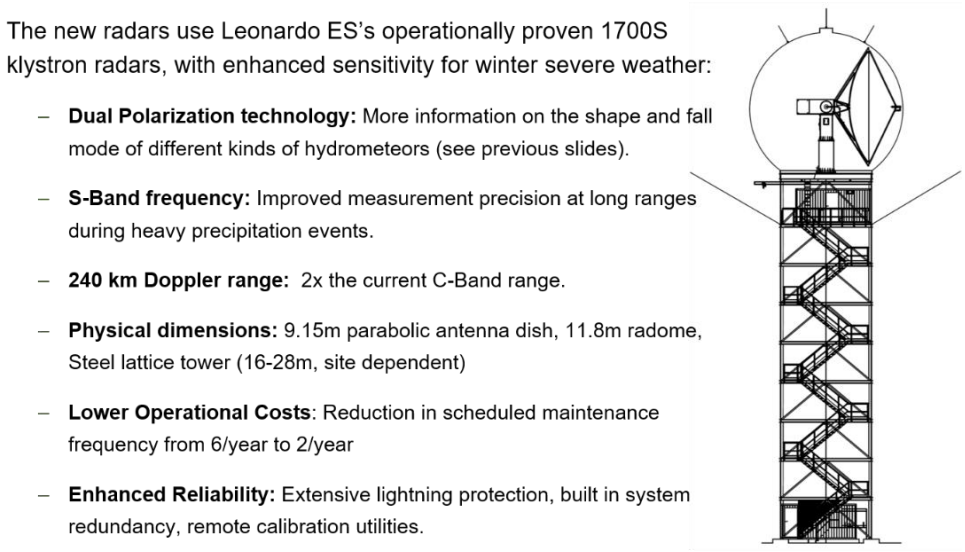


Figure 3: Technical characteristics and coverage (Graphic from CWRRP group).

For the majority of cases, the new S-Band radar is installed close to the location of the existing C-Band radar, with the exception of a few radars where the location of the radar is moved to another site (e.g. the new Blainville radar placed in new location to better serve the greater Montreal region in Quebec. When possible, MSC will continue to operate the C-Band radar during the S-Band construction where RF (Radio Frequency) safety considerations allow in order to minimize the downtimes as much as possible. The C-Band radar and its infrastructure will be decommissioned once the Site Acceptance Test (SAT) of the S-Band system is satisfied. It is important to note that raw data of the S-Band radar will be available to experts and researchers a few days before the SAT date for tests and calibration. The data will also be processed in real-time in order to allow for product evaluation and to detect any impacts users may experience.

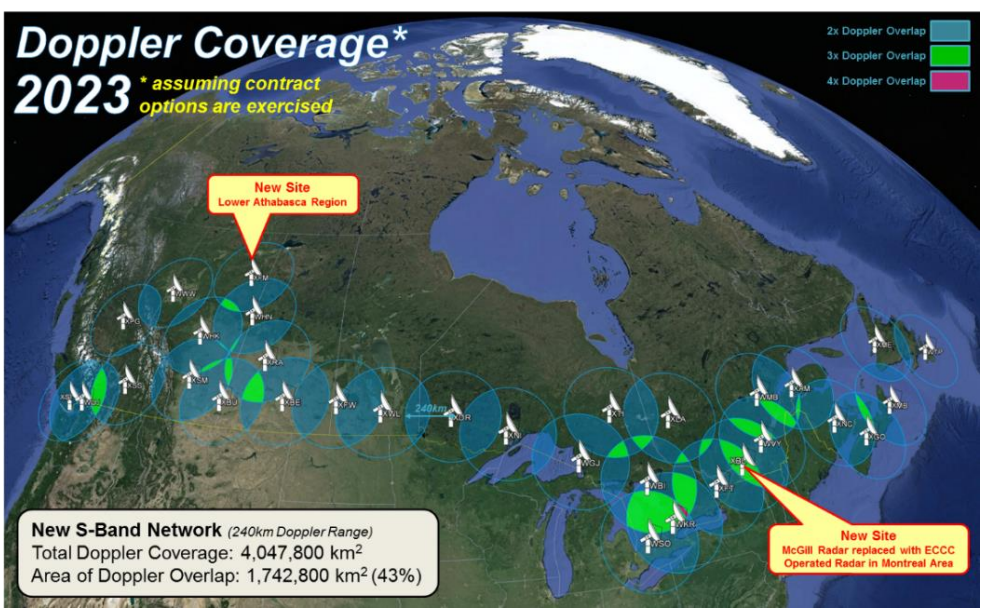


Figure 4: The future Canadian radar network and the new Doppler coverage (Graphic from CWRRP group)

4. Operational Radar processing

3.1 Mandate

The real-time generation, delivery, scientific and technical support of the radar data, for both MSC's users and external clients, is ensured by the Operational Radar Production team (CMOI-Radar) from the Canadian Meteorological Centre (CMC) Operations Division. The CMOI-Radar team represents the critical path before the radar products are disseminated to a variety of users. In fact, the CMOI-Radar team is very busy managing the data and products of the radar network and ensuring that the data and images are available to the users in various formats as well as ensuring that there is proper archiving of the operational data. There is a wide variety of clients for radar data ranging from MSC operational meteorologists and NWP systems to other national and international meteorological services. Real-time products and data are available to the clients as soon as the data available operationally.

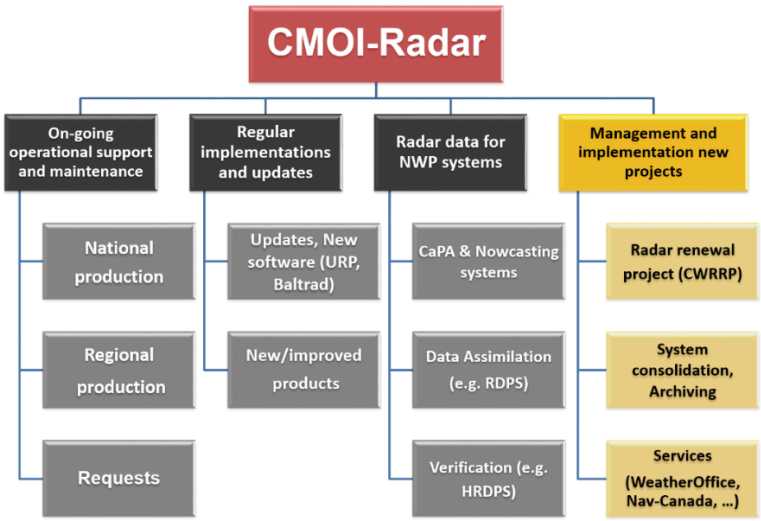


Figure 5: Mandate of the CMOI-Radar production team

3.2 Process and collaboration with key partners

The successful deployment of the new radars relies on the collaborations of key partners within MSC. For each new radar, several ECCC groups are involved to ensure the delivery of radar products for operational use. The first step of the process is the completion of the new S-band radar installation, calibration and signal-processing configuration by the CWRRP group. Then starts a test period where the system is configured with a six-minute complete scan, 17 elevation angles and a polarized volume scan strategy defined by the ECCC radar scientists. The experimental data is sent to the radar scientists and to the downstream processing application groups. These groups include research (Science and Technology), Forecast Systems Integration and Innovation (FSII) – the owner of Unified Radar Processor (URP)[2], Corporate and Financial Services Branch (CFSB) – the developer

[2] URP is ECCC's primary radar processing system. It takes real time data from multiple radars and makes products for many types of users. Data products go to other components of our weather processing system and to some external users.

of URP software and finally?, the CMOI-Radar production group. Thus, tests and validations are performed during this period, which may last a few weeks, to examine the quality of the products and report any issues to the CWRRP group. After a proper data evaluation period and after the successful completion of SAT, the new radar will be declared operational. From there, the CMOI-Radar group proceeds with the operationalization of the products while updating the technical and scientific documentation and communicating with the various users, clients and partners.

3.2 Processing and products

The processing of the raw radar data is done using several software systems. The most important is the Unified Radar Processor (URP), which is our primary radar processing system. It takes real time data from multiple radars and generates products for many users. Data and products are sent to other components of the weather processing system and to external users as well. Graphical products are sent to forecasters and to the ECCC's public web site. The regional forecast offices run different configurations of the URP software that focus especially on severe weather while CMC runs a version targeting national or continental scales and is referred as National-URP. The URP receives data from Canadian and American (NOAA) weather radars Radar products are generated every 10 minutes for the C-band radars and every 6 minutes for the S-Band radars.

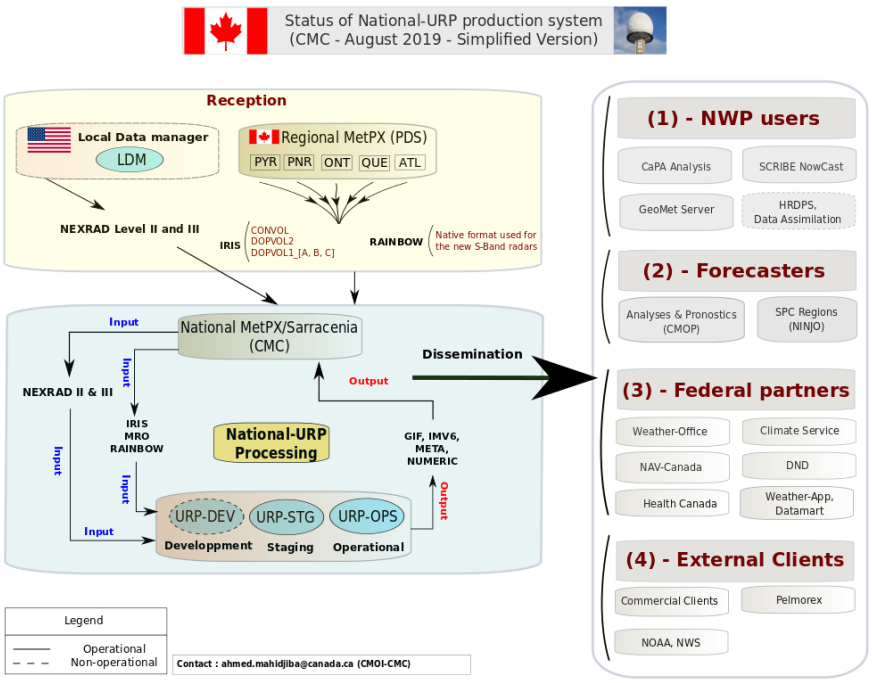


Figure 6: Data-flow of the National-URP production system at CMC.

URP runs on a Linux platform. In real-time operations, these are either moderately high-end dedicated servers or virtual machines. URP can also be run on desktop computers in test mode for research or development purposes. The individual components of URP can be run as stand alone programs. As a result, reprocessing for case studies or special products can be done using customized

"shell scripts" to merge a sequence of processing stages without requiring the entire real-time infrastructure. Furthermore, URP can be set up to use archive data or to test operational configurations using historical data. Figure 6 illustrates the complete production chain using the URP software; from reception of raw data to the dissemination of final products to the different users and clients. This figure only illustrates the National-URP production system described above. Figures 7-9 illustrate many examples of URP products.

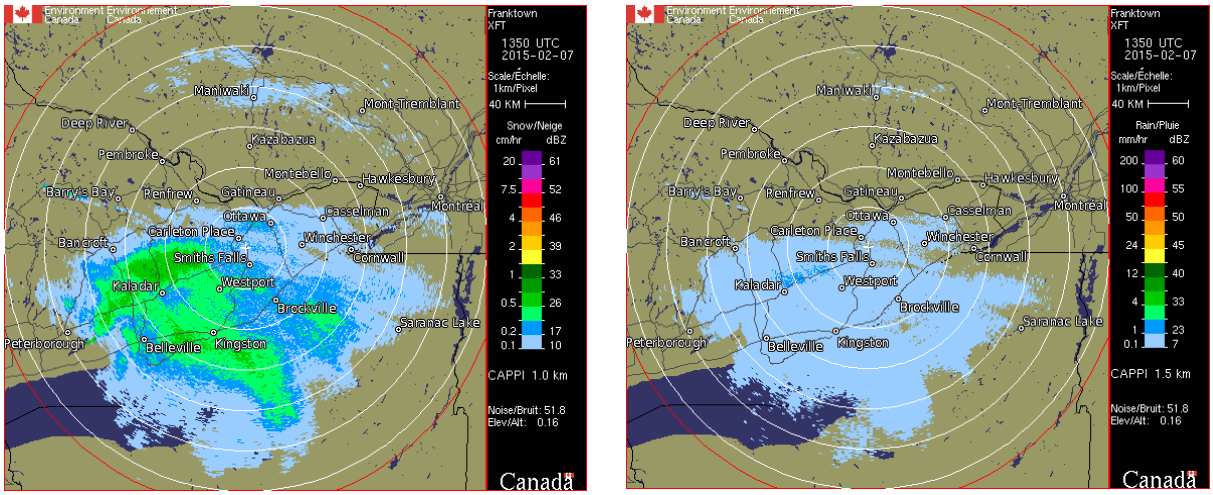


Figure 7: The Constant Altitude Plan Position Indicator (CAPPI) product (developed by McGill university) is a 2-D representation of the 3-D volume scan data. A horizontal slice is taken through the data at constant height. The CAPPI is generated by using the nearest range bin to the selected height, for low altitudes. At larger? ranges, the data is taken from the lowest elevation angle and therefore as range increases, the height of the data increases.

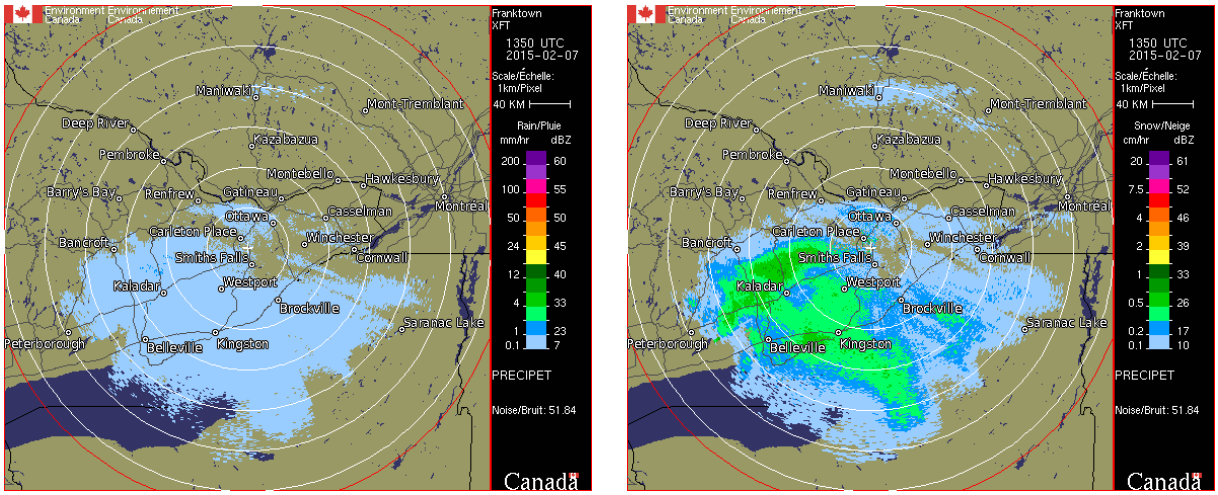
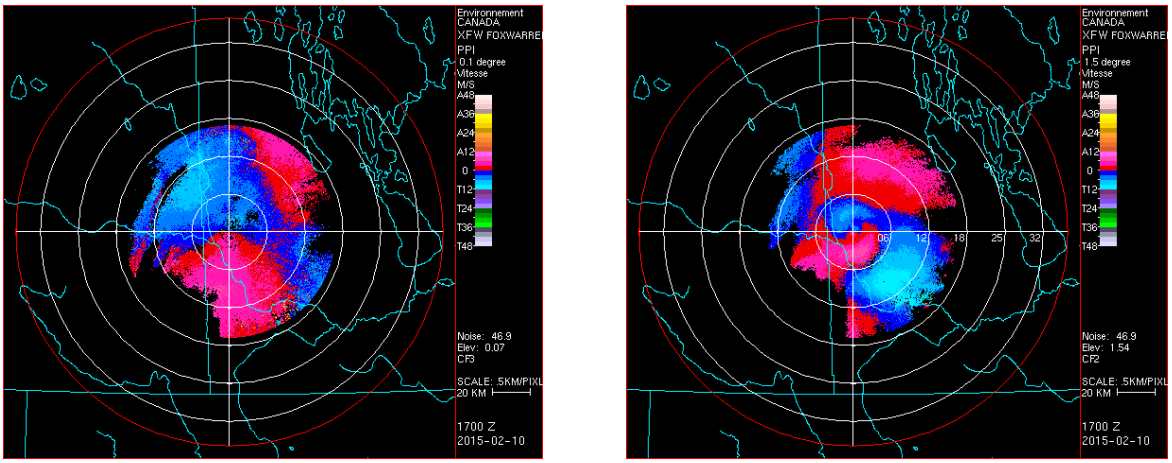
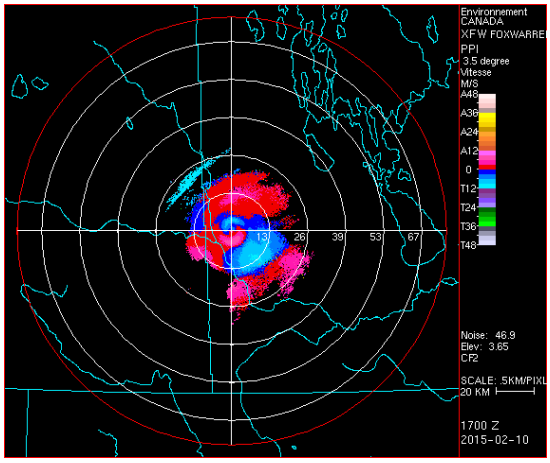


Figure 8: PRECIP-ET is a 2-D product designed to show the precipitation close to the ground, by using Doppler technology to process echoes within 113 km from the radar site. Doppler technology allows for a better resolution of the precipitation echoes and also provides the ability to detect the movement of precipitation from the radar perspective (i.e. are the hydrometeors moving towards or away from the radar and associated velocity). Beyond the 113 km limit, the echoes are displayed using a CAPPI . See above for more details on the CAPPI (Figure 8).



(a) **(b)**



(c)

1. **Figure 9:** The radial velocity (VR) product is a two-dimensional field. It is derived from the Doppler scan: **(a) DOPVOL1_A VR:** is a low level, high quality Doppler scan to about 110 km, which best shows the horizontal changes of the motion patterns. DOPVOL1_A provides interesting information of the horizontal spatial distribution of targets, **(b)- DOPVOL1_B VR:** B is a low-mid level, high quality Doppler scan to about 110 km and **(c)- DOPVOL1_C VR:** is an upper-mid level, high quality Doppler scan to about 110 km which best shows the changes with height. DOPVOL1_C is better if one is interested in the changes with height near the radar.

In order to meet the external client needs for raw radar data, a conversion[3] to more standard format is required and raw data is converted to the ODIM_H5 format. Contingency products have been developed and implemented by the CMOI-Radar team to ensure continuous availability of the radar products. For example, a contingency product can be generated using Canadian and American radars close to a missing radar. This contingency product is used by the ECCC's public web site and is also sent to many other users. .

[3] The conversion is done by Baltrad software from the RAINBOW native format to ODIM_H5 format

The CMOI-Radar team works closely with the NWP and data assimilation teams in order to integrate the new S-Band radars data into their systems. For example, the radar products are used to feed operational systems such as the Regional Deterministic Precipitation Analysis (RDPA) and the Integrated Nowcasting System (INCS). CMOI-Radar also provides high-resolution composites to the Data Assimilation system as part of the Radar Data Integration Project in the MSC's Regional NWP Systems. This project is in development mode.

The CMOI-Radar team deals with the technical and scientific documentations to support the users and clients. This team also needs to deal with various requests to either add or calibrate the new S-Band radar products or to answer radar related questions from clients. The CMOI-Radar's work also focuses on change management in order to deal with the various changes to the Canadian radar network and to preserve the integrity of the production systems.

5. Conclusion

The Canadian Radar Replacement Project has already achieved an appreciate progress by installing 7 radars out of a total of 32. Basic products, including raw data, are already operational and sent to all ECCC users and clients in real time. By the end of 2019, 5 more S-band radars will be installed and made available to our various partners and users. Our experts have already begun work on integrating quality control algorithms to remove the non-meteorological echoes and to make new products such as particle classification product and others available to the public and expert users.

This first phase of this project was also very beneficial to run our various deployment procedures and especially to establish a robust and fluid collaboration between the different groups involved in this project. Many good practices have also been developed and made available to these groups. Our operational support including the appropriate documentation has also been updated and greatly improved.

References

1. Radar production team (CMOI-Radar) internal documentation
2. Internal CWRRP (Canadian Weather Radar Replacement Program) project documentation
3. Internal Technical URP software documentation