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## Optimizing Tropical Cyclone Monitoring: RADARSAT Constellation Mission's Tropical Cyclone Acquisition Planning System (RCM-TCAPS)

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### Abstract

Since 1999, the Canadian Space Agency (CSA) has been monitoring tropical cyclones using Synthetic Aperture Radar (SAR) with the RADARSAT missions and the Hurricane Watch initiative. In 2019, the CSA launched the RADARSAT Constellation Mission (RCM), a trio of satellites that work together to provide all-weather, day-and-night imagery with global coverage, making them ideal for tracking and understanding the dynamics of tropical cyclones.

To further enhance the monitoring of tropical storms and cyclones, the CSA developed the RCM Tropical Cyclone Acquisition Planning System (RCM-TCAPS). This system uses forecasting data from authoritative weather agencies to perform automated acquisition planning and initiate RCM tasking requests for timely and more accurate storm monitoring. By combining this intelligence with RCM's global access and frequent revisit capability, the CSA provides comprehensive coverage of tropical storm events across all major oceanic basins, enabling up to twice-daily coverage based on a sun-synchronous near-polar orbit. This allows for tracking rapid changes in a cyclone's intensity and trajectory, ensuring that no significant developments are missed. Ultimately, it improves forecast accuracy and strengthens disaster response efforts.

SAR sensors offer unique advantages for monitoring tropical storms and cyclones. They capture detailed images of the ocean surface, revealing critical information about wind speeds and the overall structure of tropical cyclones. This data is invaluable for meteorologists and researchers, enabling precise analysis of storm development and progression. This initiative has enhanced the CSA's capacity to operate RCM effectively in this context, serving the Government of Canada and international users with timely SAR data that they transform into value-added products for the purposes of weather forecasting operations.

In 2024, the RCM Hurricane Watch initiative and TCAPS produced the most comprehensive annual set of SAR tropical cyclone collections ever achieved, with 461 images acquired and an 82% 'Eye Hit' success rate on average. The system is performing equally well or better for the 2025 season, creating a rich SAR data repository for current and future climate and weather forecasting science.

**Keywords:** RCM, SAR, Acquisition Planning, Tropical cyclones

### Acronyms/Abbreviations

API – Application Programming Interface  
ATCF – Automated Tropical Cyclone Forecasting System  
CHC – Canadian Hurricane Centre  
CPHC – Central Pacific Hurricane Center  
CSA – Canadian Space Agency  
ECCC – Environment and Climate Change Canada  
EODMS - Earth Observation Data Management System  
GC – Government of Canada  
HW – Hurricane Watch  
IBTraCS - International Best Track Archive for Climate Stewardship  
JTWC – Joint Typhoon Warning Center  
NCAR - National Center for Atmospheric Research  
NHC – National Hurricane Center  
NOAA – National Oceanic Atmospheric Administration  
NRCan – Natural Resources Canada

NWP – Numerical Weather Prediction  
OHS – Order Handling Subsystem  
RAL - Research Application Laboratory  
RCM - RARDARSAT Constellation Mission  
RMW - Radius of Maximum Wind  
SAR - Synthetic Aperture Radar  
SPG4 - Simplified General Perturbation 4  
STAR – Center for Satellite Applications and Research  
TC – Tropical Cyclone  
TCAPS – Tropical Cyclone Acquisition Planning System  
TCGP - Tropical Cyclone Guidance Project  
TLE – Two-line Element

## 1. Introduction

In 2019, the CSA launched the RADARSAT Constellation Mission (RCM), a trio of satellites that work together to provide all-weather, day-and-night imagery with global coverage, making them ideal for tracking and understanding the dynamics of tropical cyclones (TC). The term "tropical cyclone" is a generic reference encompassing region-specific terms such as hurricanes, typhoons, and cyclones.

SAR sensors offer unique advantages for TC monitoring, providing useful complementary information to that offered by conventional optical weather satellites (see Fig. 1). With their ability to penetrate cloud cover, SAR sensors capture detailed images of the ocean surface, revealing critical information about wind speeds and the overall structure of a TC. This data is invaluable for meteorologists and researchers, enabling precise analysis of storm development and progression.

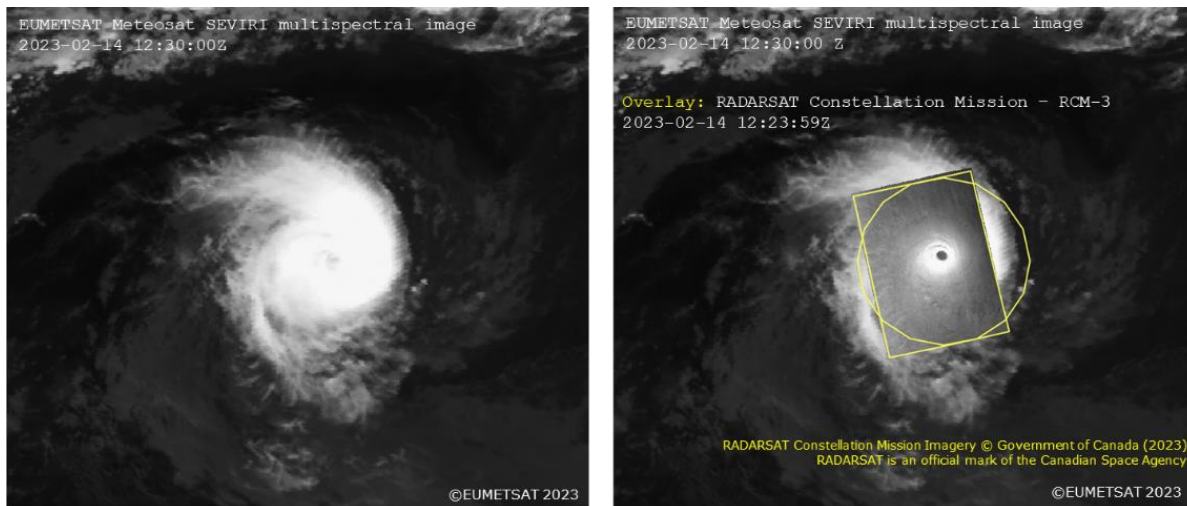


Fig.1. A comparison between a EUMETSAT Meteosat SEVIRI multispectral image acquired on 2023-02-14 12:30Z (left) and an RCM-3 Low Noise SAR image (right) acquired on 2023-02-14 12:24Z

The Government of Canada (GC) uses SAR data and RCM extensively to enhance marine surveillance and weather forecasting. The SAR Winds program of Environment and Climate Change Canada (ECCC) department provides near real-time marine wind measurements which is crucial for marine forecasters and numerical weather prediction models as described in [1]. This monitoring and the products from the SAR Winds program also benefit the Canadian Hurricane Center (CHC) during the Atlantic hurricane season as all HW acquisitions are systematically delivered to ECCC's SAR Wind program.

In recent years, significant efforts have also been made by NOAA's Center for Satellite Applications and Research (STAR) Water Surface Conditions Science Team's tropical cyclone winds program to derive operational forecast data products from SAR data as described by Jackson et al. [2]. Their products feed into operational systems such as the

Automated Tropical Cyclone Forecasting (ATCF) system used by the Joint Typhoon Warning Center (JTWC). A public web portal [3] also catalogues all their products, generated not only from RCM data but also from other sensors such as Sentinel-1 and RADARSAT-2, for the benefit of the international forecasting community. Their SAR forecast aid products offer precise location information of the TC eye feature and the 2D wind field derived from the normalized radar cross section (NRCS), including maximum winds, Radius of Maximum Wind (RMW), and wind radii (see Fig. 2).

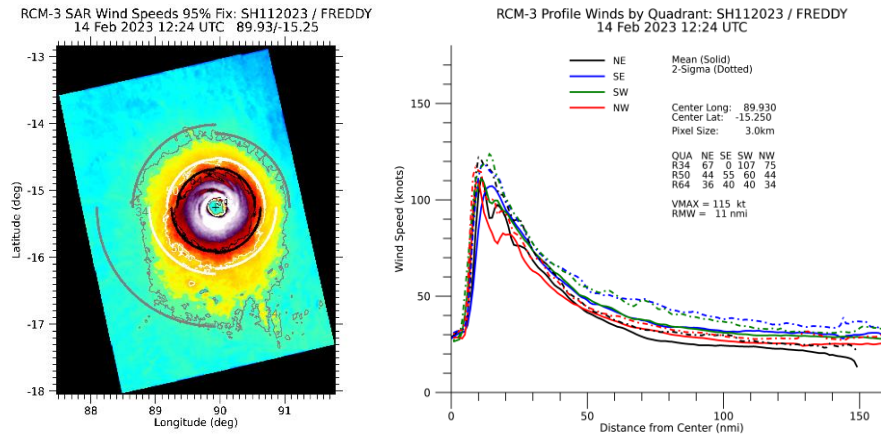


Fig. 2. SAR Tropical Wind Products from RCM created by NOAA STAR<sup>1</sup>

Since 1999, the Canadian Space Agency (CSA) has been monitoring TC events using SAR through the RADARSAT missions and the Hurricane Watch (HW) initiative [4,5]. Traditionally, the acquisition planning of SAR images was rather a manual process. It typically involved order desk operators searching on-line for official bulletins from various sources to retrieve TC track information to guide their planning. The primary focus was on the Atlantic Ocean during the active period from June 1 to November 30. Acquisition planning software allowed feasibility assessments of possible acquisition swaths to be performed based on areas manually defined from the TC tracks. The acquisition plans typically covered a 3- to 7-day range. While generally effective, this approach presented challenges when storms deviated from their original track.

When RCM came into operation, it became clear that a more efficient acquisition planning approach was needed for TC monitoring. The mission's frequent revisit capability and extensive global coverage offered new opportunities for improvement.

Several objectives were defined to enhance the acquisition process for TC monitoring with RCM:

- Automate the collection of forecast track aids.
- Achieve consistency in acquisition planning of TC image collects.
- Significantly reduce the overhead in preparing satellite tasking requests
- Generate updated acquisition plans every day to better capture storm evolution.
- Improve the positioning of acquisitions over the storm to better capture the "eye" feature
- Ensure year-round coverage across all major oceanic basins with TC activity.
- Integrate a task management application to better track and coordinate HW RCM order submissions in a work team environment

To meet these objectives, the RCM Tropical Cyclone Acquisition Planning System (TCAPS) was developed to facilitate and automate as much as possible the satellite acquisition planning process for TC monitoring. The system aims to enhance operational efficiency and provide more accurate and consistent tracking of these events.

<sup>1</sup> Synthetic Aperture Radar (SAR) based tropical wind products were generated and provided through the STAR Water Surface Conditions Science Team's tropical cyclone winds program. See the following webpage ([https://www.star.nesdis.noaa.gov/socd/mecb/sar/sarwinds\\_tropical.php](https://www.star.nesdis.noaa.gov/socd/mecb/sar/sarwinds_tropical.php)) for more information

## 2. RADARSAT Constellation Mission Characteristics for TC monitoring

The RCM characteristics have been described extensively in Côté et al. [6,7] and Thompson [8] and what follows is a condensed description mainly focusing on features of interest to TC monitoring.

RCM was launched in 2019 and is comprised of three small satellites (1,400 kg each, compared to 2,800 kg for RADARSAT-1 and 2,200 kg for RADARSAT-2). Each spacecraft consists of a bus module and two payloads: a SAR as the primary payload and an Automatic Identification System (AIS) as secondary payload used for ship identification (see Fig. 3). The spacecrafts fly evenly spaced at 120° on the same orbit, effectively spacing them 32 minutes apart on a 96-minute orbit. The satellites operate in a sun-synchronous low-earth polar orbit at an altitude of approximately 600 km. This generally allows the constellation to monitor a TC twice a day, in both an ascending and descending orbit direction.

Each satellite provides SAR imagery in various imaging modes, ranging from 1-meter spatial resolution in Spotlight mode, to between 3 and 16 meters in Stripmap mode, and between 30 and 100 meters in ScanSAR mode (see Fig. 4). They also support single and dual polarization capabilities, along with fully polarimetric and compact polarization modes.

For TC monitoring and ocean surface wind retrieval, the target RCM imaging modes are Medium Resolution 50 m and Low-Noise imaging modes in dual-polarization. These modes offer a swath width of 350 km and can switch between four different beam positions across an accessible swath of 600 km by varying incidence angles. The Low Resolution 100 m mode can also be used. It has a swath width of 500 km but only a single beam position. More details are provided in Table 1.

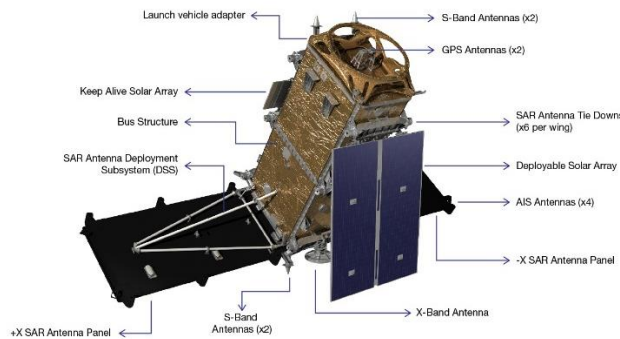


Fig. 3. The RCM Satellite

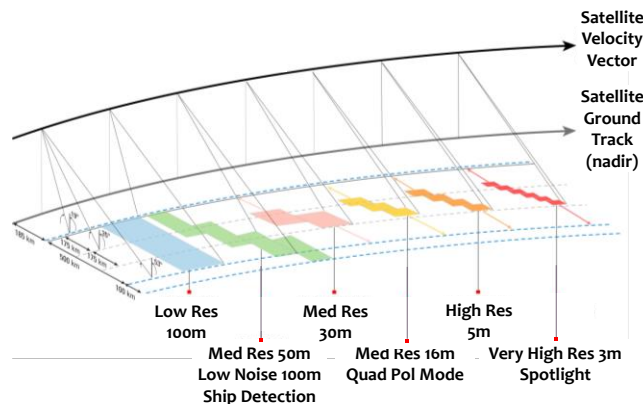


Fig. 4. The RCM Imaging Modes

Table 1. RCM imaging modes for tropical cyclone monitoring. Med Res., Low Noise, and Low Res.

| Imaging Mode      | Resolution (m) | Swath Width (accessible, km) | NESZ Spec. (dB) | Dual Polarization Mode Directions | Near and Far Incidence Angles (degrees) |         |         |         |
|-------------------|----------------|------------------------------|-----------------|-----------------------------------|---|---------|---------|---------|
|                   |                |                              |                 |                                   | Swath A                                 | Swath B | Swath C | Swath D |
| Medium Resolution | 50             | 350 (600)                    | -22             | HH+HV<br>VV+VH                    | 19.0,                                   | 27.1,   | 34.3,   | 40.6,   |
| Low Noise         | 100            | 350 (600)                    | -25             | VV+VH                             | 46.2                                    | 50.9    | 55.1    | 58.7    |
| Low Resolution    | 100            | 500 (500)                    | -22             | VV+VH                             | 19.0,<br>55.1                           | -       | -       | -       |

GC users place their image orders through the Order Handling Subsystem (OHS). RCM images are requested for various operational and R&D needs. The CSA manages order submissions for the HW initiative. These orders, formulated with desired imaging beam(s), geographical Area(s) of Interest (AOI), duration, number of AOI coverages, and revisit frequency, are aggregated by the Mission Planning Subsystem for concurrent planning and de-confliction, as orders continue to come in, leading to the preparation of satellites tasking plans, uploaded to the spacecraft via the Spacecraft Control Subsystem.

For data latency, RCM’s network of ground stations is optimized to meet 10-to-30-minute downlink-to-delivery data latency requirements over Canada and its maritime zones of interest. For international zones outside of Canada where most TC events occur, RCM provides a maximum of 2-hour downlink-to-delivery data latency.

Image acquisitions are processed into various product formats and delivered to GC users via the RCM Ground Segment. Additionally, a copy of the processed RCM image products is sent to the Earth Observation Data Management System (EODMS). This geospatial platform, provided by Natural Resources Canada (NRCan), enables the discovery and downloading of authoritative Canadian Earth Observation (EO) raster data. Users wishing to download RCM data from EODMS must create an account and comply with data access conditions. A basic public user account will allow access to a portion of the RCM data catalogue. Public users from non-federal government organizations, industry and academia wishing to access RCM image products, over and above those available to the general public on the EODMS, can apply to become vetted users.

### 3. Tropical Cyclone Acquisition Planning System (TCAPS)

TCAPS is a demonstration project in its current form. It consists of a collection of API functions that are called from a workflow scheduled to run daily. It automatically gathers information on all active worldwide TC events and uses an acquisition planning algorithm optimized for TC monitoring to generate the parameters required by an operator to create and submit a tasking request to the RCM’s OHS.

The workflow primarily runs the following steps: 1) pull TC forecast track data from weather agencies; 2) generate next-day satellite ground track data from TLE data; 3) perform acquisition planning optimized for TC monitoring; 4) provide operators with tailored order parameters to create tasking request from RCM’s OHS.

Two inputs are critical for TCAPS’ acquisition planning. The first are the TC forecast tracks that are obtained from weather bulletins which TCAPS pulls daily from authoritative weather agencies to trigger the acquisition planning when TC events are active. The second, is the satellite ground track data to know the positions and overpass timings of the RCM spacecrafts in relation to the TC location and footprints.

#### 3.1 Tropical Cyclone Forecast Track Information

TCAPS relies on public on-line advisory bulletins from authoritative weather agencies to initiate acquisition planning of image collects. These bulletins provide TC forecast tracks, predicting the storm’s path over the next 3 to 5 days. The parameters of interest for acquisition planning are the anticipated geographic positions of the storm’s central circulation feature which are provided at every 6 to 12-hour interval throughout the bulletin’s valid time range.

Weather agencies worldwide typically issue their TC bulletins at 03:00, 09:00, 15:00, and 21:00 UTC. TCAPS currently obtains new forecast data once per day, by default at 15:00 UTC, to allow for the acquisition planning, ordering and satellite tasking to occur within 36 hours prior to the start of image collects.

For the Atlantic Ocean basin, when storms are near or within Canadian waters above the 35° latitude parallel, TCAPS uses forecast tracks from the Canadian Hurricane Center (CHC) [3]. For other parts of the Atlantic basin, as well as the Eastern and Central Pacific ocean basins, TCAPS relies on data from NOAA's National Hurricane Center (NHC) and the Central Pacific Hurricane Center (CPHC) [9]. In the Southern Hemisphere, North Indian Ocean, and Western Pacific oceanic basins, TCAPS obtains forecast tracks from the JTWC public site [10].

Starting in 2024, TCAPS also began planning satellite image collections for "invest" areas, which are regions monitored by meteorologists for potential TC development. Forecast tracks for these areas are not publicly available as advisory bulletins but can be found in specialized data sources like "a-deck" files from the ATCF system [11] used by agencies such as JTWC and NOAA. These files include forecast aids from a variety of weather prediction models, but TCAPS prioritizes consensus models like CONW or TVCN [12], which combine multiple operational and experimental model forecasts for more reliable predictions. NOAA provides access to its ATCF "a-deck" files for the Atlantic, Central, and Eastern Pacific basins via its public FTP site [13]. ATCF files for the Southern Hemisphere, North Indian, or Western Pacific basins are generally not publicly available from the JTWC. Instead, for those basins, TCAPS utilizes ATCF "a-deck" files from the Research Application Laboratory (RAL) Tropical Cyclone Guidance Project (TCGP) of the National Center for Atmospheric Research (NCAR) [14] which also offers "a-deck" files of TC forecast guidance aids derived from a variety of operational and experimental forecast models. The ATCF "a-deck" files from the providers listed above are also issued at 03:00, 09:00, 15:00, and 21:00 UTC and TCAPS is currently configured to pull the 15:00Z "a-deck" files daily for its next day planning.

### *3.2 Satellite Ground Track Data*

TCAPS uses the Skyfield Python package [15] to generate satellite ground tracks. It predicts the position of an Earth satellite using the standard SGP4 orbital elements provided in TLE files, which are available from various public on-line catalogs [16,17]. TCAPS generates ground tracks on a daily basis in preparation for next day acquisition planning. The positional accuracy is within 1 to 2 kilometers, but very high positional accuracy is not necessarily required since the goal is to obtain the general position and orbit timings of the satellites over storm systems that are generally in the 300 to 500 km in diameter range.

### *3.3 Acquisition Planning and Ordering*

TCAPS aims to plan single satellite acquisitions optimally aligned over the central circulation features of the storms (i.e. the "eye feature" or the RMW) using the imaging modes listed in Table 1. When the RCM satellite images are well aligned with the storm system, they can cover the storm's wind field effectively, ranging from 350 km to 500 km in both across- and along-track directions of the satellite's path. The planning aims for at least 50% coverage of the storm area. Even if only part of the storm's wind field is covered, it can still be very useful for weather forecasters, especially if the eye feature is captured to help determine the RMW. The acquisition planning algorithm is further detailed in Figure 5.

Acquisition planning in TCAPS is triggered daily at 15Z, 36 hours before the start of the next 24-hour RCM imaging period and converges quickly (within 5 minutes) onto possible TC image collect opportunities. For each active storm, TCAPS then creates tickets to a web-based visual task management application with all the necessary details about the planned image acquisitions for an order desk operator to issue a tasking request to the RCM's OHS using predefined ordering parameters. The task manager application allows a better organization of tasks, allowing operators to assign tickets to themselves or to other colleagues, thereby facilitating coordination and progress tracking for HW image collect requests.

The time required for an operator to create and submit a tasking request to the RCM's OHS assisted by TCAPS-generated parameters is typically between 5 and 10 minutes. However, operators are allotted 6 working hours per workday, based on their availability after 15Z to fulfill and close all requests. On average, there is at least one active storm every day, but this number can rise to as many as 5 or 6 storms per day during peak season for TC activity. Future work will investigate automatic order submissions to the RCM OHS. On the routine ordering timeline, this

adjustment would reduce the order submission lead time to 14 hours before the start of the imaging period. RCM’s fast tasking capabilities could also be explored for late replanning of the image collects to accommodate sudden changes in the storm forecasts. This would effectively allow a change to the acquisition plan up to 5 hours prior to the image collect.

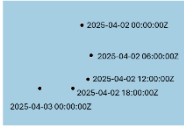

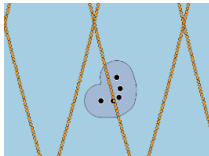
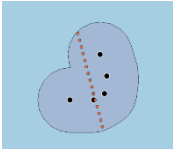
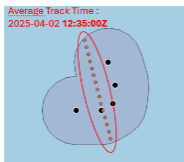
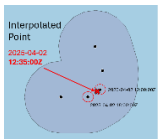
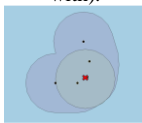
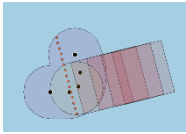
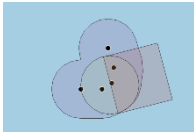
| 1  | 2   | 3   | 4  | 5   |
|--|---|---|--|---|
| <p>Obtain the forecast track data and extract the latitude/longitude of the TC path positions provided at 6 or 12 hour intervals.</p>                           | <p>Create a buffer zone with a 175 km radius around the TC forecast path.</p>    | <p>Generate RCM ground tracks as latitude/longitude points with timestamps spaced every 5 seconds along the orbit for the next-day acquisition plan</p>    | <p>Create a subset of ground track points by performing a spatial intersection with the TC path buffer zone from step 2.</p>   | <p>Calculate the mean RCM overpass time by averaging the timestamps in the ground track subset from step 4.</p>    |
| 6  | 7   | 8   | 9  | 10  |
| <p>Identify the two nearest forecast track positions to the mean RCM overpass time from step 5 and interpolate a new latitude/longitude position for it.</p>  | <p>Create a circular buffer around the interpolated position, with a 175 km radius (i.e. 350 km diameter to represent roughly a 350 km swath with).</p>  | <p>Generate all possible image acquisition footprint geometries calculated using the ground track as an anchor point and then deriving footprints based on the sensor look-direction, incidence angle, and imaging swath width characteristics.</p>  | <p>Perform a spatial intersection of the acquisition footprints with the buffer zone of the interpolated storm position from step 7. Only keep footprints with at least 50% coverage. Verify against RCM standard orders for possible acquisition sharing and match the imaging mode if possible.</p>  | <p>Summarize all of the input parameters required to task RCM for an optimal image collect over the storm.</p> <ul style="list-style-type: none"> <li>- Acquisition:                             <ul style="list-style-type: none"> <li>- start time</li> <li>- end time</li> <li>- imaging mode</li> <li>- swath position</li> <li>- spacecraft</li> </ul> </li> <li>- Area of Interest</li> <li>+ other default order parameters for TC monitoring</li> </ul> <p>Create ticket for order desk operator with all of the necessary ordering parameters attached</p> |

Fig. 5. TCAPS Acquisition Planning Algorithm for TC Monitoring

#### 4. Results and Discussion

Between 2020 and 2022, acquisition planning for TC monitoring on RCM was manually performed by an operator. The introduction of TCAPS in 2023 automated this process, leading to a significant increase in the number of images acquired per year. The average number of acquisitions covering storms annually rose from 65 when planned manually to 436 with TCAPS. Automation also improved global storm monitoring coverage, increasing it from 26% to 91% of total storms occurring worldwide. The breakdown by year is provided in Table 1.

Consequently, TCAPS significantly streamlined the acquisition planning and ordering process for TC monitoring, reducing much of the overhead associated with traditional methods. This enhancement facilitated a richer collection of RCM data, ensuring consistent and reliable monitoring throughout the year for nearly every storm (see Fig. 6). However, it is important to note that some storm systems are short-lived, and the 36-hour lead time required for acquisition planning and ordering may have prevented the capture of images for these storms. In 2024, TCAPS began

planning images during the early “invest” stage. This adjustment allowed early detection of storms, including weaker ones that can dissipate quickly, and resulted in a higher number of storms being monitored throughout the year.

Table 1. Number of storms monitored by CSA Hurricane Watch

| Year | Number of Storms Monitored | Number of Storm Occurrences* | Monitoring Percentage | Total Number of Acquisitions | Acquisition Planning Method |
|------|----------------------------|------------------------------|-----------------------|------------------------------|-----------------------------|
| 2020 | 17                         | 93                           | 18%                   | 26                           | Manual                      |
| 2021 | 32                         | 86                           | 37%                   | 129                          |                             |
| 2022 | 17                         | 78                           | 22%                   | 39                           |                             |
|      |                            |                              | Avg.: 26%             | Avg.: 65                     |                             |
| 2023 | 67                         | 75                           | 89%                   | 411                          | Automated (TCAPS)           |
| 2024 | 83                         | 89                           | 93%                   | 461                          |                             |
|      |                            |                              | Avg.: 91%             | Avg.: 436                    |                             |

\*Note: for storm occurring in the North Atlantic, North and South Indian, Southern Hemisphere ocean basins

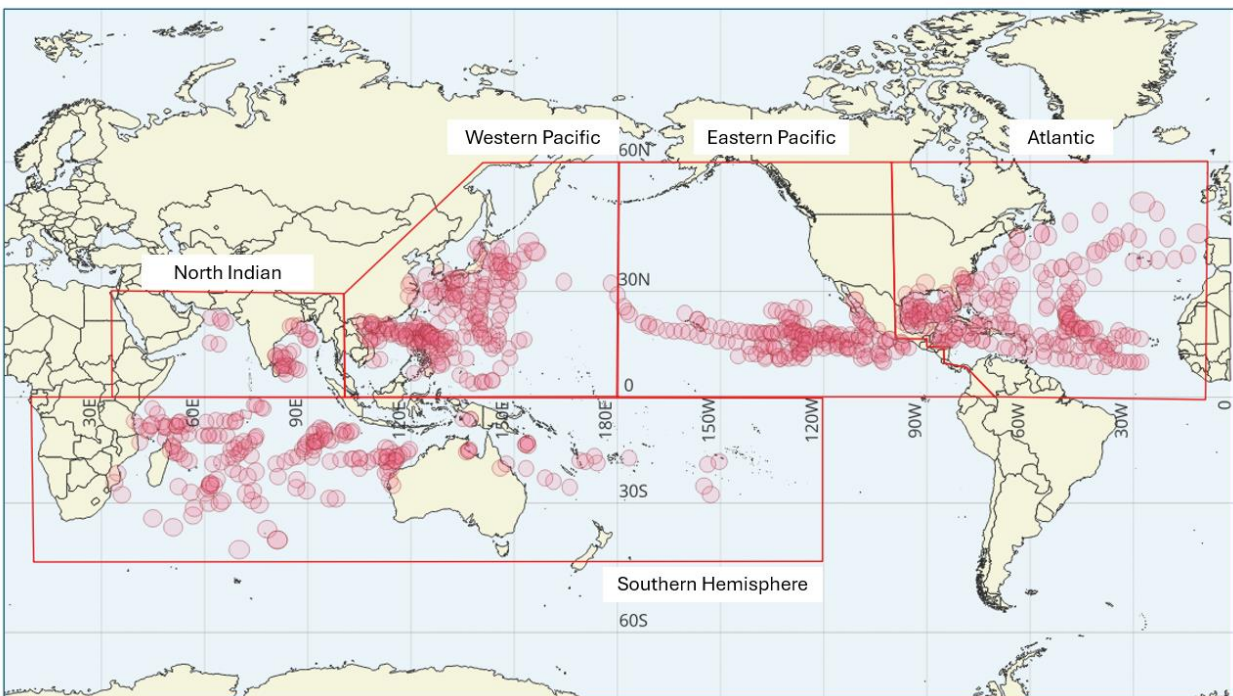


Fig. 6 Location of RCM Requested Image Collects in 2024 for TC Monitoring

To evaluate the quality of coverage for TC events, the International Best Track Archive for Climate Stewardship (IBTrACS) [18, 19] was utilized to assess the acquisition planning quality of both manual and TCAPS methods. The IBTrACS dataset integrates recent and historical TC data from various agencies, creating a unified, publicly accessible best-track dataset. As detailed in Arsenault [20], this comparison allowed to objectively assess and categorized the collected images into three storm coverage classes: Partial to Good, Good, and Very Good. The results are presented in Table 2.

Table 2. Effectiveness of ‘Eye Hit’ storm coverage \*

| Year | <i>Partial to Good</i><br>[likely edge hit] | Good<br>[potential eye hit] | Very Good<br>[likely eye hit] | Total Number of<br>Acquisitions | Acquisition<br>Planning<br>Method |
|------|---|-----------------------------|-------------------------------|---------------------------------|-----------------------------------|
| 2020 | 3 [12%]                                     | 9 [35%]                     | 14 [54%]                      | 26                              | Manual                            |
| 2021 | 23 [18%]                                    | 32 [25%]                    | 74 [57%]                      | 129                             |                                   |
| 2022 | 10 [26%]                                    | 9 [23%]                     | 20 [51%]                      | 39                              |                                   |
| 2023 | 53 [13%]                                    | 133 [32%]                   | 225 [55%]                     | 411                             | Automated<br>(TCAPS)              |
| 2024 | 23 [5%]                                     | 61 [13%]                    | 377 [82%]                     | 461                             |                                   |

\* Note: for storm occurring in the North Atlantic, North and South Indian, Southern Hemisphere ocean basins

The coverage quality between the manual approach performed up to 2022 and those with the automated TCAPS approach obtained in 2023 is comparable. However, in 2024, a significant increase in performance was observed in the Very Good category, rising from 55% to 82%. This improvement resulted from an experiment conducted throughout the year to re-adjust the HW orders, as necessary depending on the latest forecast, shortly before the routine order cutoff, using updated forecast TC tracking issued at 06Z. This adjustment reduced the lead time from 36 hours to 21 hours prior to image acquisition. It demonstrates that significant gains in coverage quality could be achieved by further reducing the order submission latency prior to image collection by re-adjusting TCAPS daily run time and re-organizing operator schedules to be available for submission of orders in the hour preceding routine order cut off time.

## 6. Conclusions

This work highlights the significant advancements in automating acquisition planning for TC monitoring with RCM using TCAPS. In 2024, iterative improvements were made to utilize forecast data from the 'INVEST' stage. This adaptation increased the success rate of early storm detection and effectively improved RCM coverage of TC events from their formation to their dissipation.

In 2023 and 2024, the HW initiative and the RCM achieved an unprecedented level of SAR TC collections across all major oceanic basins typically monitored for TC events. The significant contributions of RCM to the TC forecast community were recently highlighted at the WMO Fourth International Workshop on Satellite Analysis of Tropical Cyclones (IWSATC-4) [21] held in December 2024. Furthermore, the CSA is collaborating with other agencies within the International Coordination Group of Spaceborne SAR Missions (ICGS-SAR) to understand current tasking schemes and coordinate with the WMO regarding requirements and tasking of SAR missions for ocean wind measurements and TC monitoring.

Looking ahead to 2025, the monitoring of TC events with RCM will continue and efforts to transform TCAPS from a demonstration project to an operational application will be pursued. SAR data offer unique advantages for monitoring tropical storms systems, capturing detailed images of the ocean surface that reveal critical information about wind speeds and the overall structure of a TC. This data is becoming increasingly invaluable for meteorologists and researchers, enabling precise analysis of storm development and progression. The HW initiative has enhanced the CSA’s capacity to operate RCM effectively in this context, serving the GC and international users with timely SAR data, which they transform into value-added products for weather forecasting operations. Additionally, it creates a rich SAR data repository for current and future climate and weather forecasting science.

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## References

- [1] S. Khurshid, M. Arkett, K. Warner, S. Kaya, Operational National SAR Winds System Current & Future Activities, International Workshop on Measuring High Wind Speeds over the Ocean, United Kingdom, 2016, 15-17 November.
- [2] C. R. Jackson, T. W. Ruff, J. A. Knaff, A. Mouche, C. R. Sampson, Chasing cyclones from space, *Eos*, 102 (2021), <https://doi.org/10.1029/2021EO159148>, (accessed 31.03.25).
- [3] NOAA STAR, Synthetic Aperture Radar (SAR) based tropical wind products, [https://www.star.nesdis.noaa.gov/socd/mecb/sar/sarwinds\\_tropical.php](https://www.star.nesdis.noaa.gov/socd/mecb/sar/sarwinds_tropical.php), (accessed 31.03.25).
- [4] S. Iris, G. Burger, RADARSAT-1: Canadian Space Agency Hurricane Watch program, IEEE International Geoscience and Remote Sensing Symposium (IGARSS'04), Anchorage, AK, USA, 2004, 20-24 September.
- [5] S. Banal, S. Iris, R. Saint-Jean, The Canadian Space Agency's Hurricane Watch Program: Supporting Research on Wind Field Retrieval from RADARSAT-1 Images, OceanSAR, St. John's, NL, Canada, 2006, 23-25 October.
- [6] S. Cote, M. Lapointe, D. De Lisle, E. Arsenault, M. Wierus, The RADARSAT Constellation: Mission Overview and Status, *EUSAR 2021; 13th European Conference on Synthetic Aperture Radar*, 2021, 29 March -1 April.
- [7] S. Cote, M. Lapointe, P. -P. Vezina, E. Arsenault, C. Casgrain, A. Boyer, Status of the RADARSAT Constellation Mission in the Third Year of Operation, *EUSAR 2022; 14th European Conference on Synthetic Aperture Radar*, Leipzig, Germany, 2022, 25-27 July.
- [8] A. A. Thompson, Overview of the RADARSAT Constellation Mission, *Canadian Journal of Remote Sensing*, 41[5], (2015) 401–407. <https://doi.org/10.1080/07038992.2015.1104633>.
- [9] CHC, Canadian Hurricane Centre Hurricane Tracks, <https://dd.weather.gc.ca/trajeciores/>, (accessed 31.03.25).
- [10] JTWC, Joint Typhoon Warning Center Tropical Warnings, <https://www.metoc.navy.mil/jtwc/jtwc.html>, (accessed 31.03.25).
- [11] C. R. Sampson, A. J. Schrader, The Automated Tropical Cyclone Forecasting System (version 3.2). *Bull. Amer. Meteor. Soc.*, 81, (2000), 1231–1240.
- [12] NOAA, NHC track and intensity models, <https://www.nhc.noaa.gov/modelsummary.shtml>, (accessed 31.03.25).
- [13] NCAR – RAL, Tropical Cyclone Guidance Project, <https://hurricanes.ral.ucar.edu/realtime/current/>, (accessed 31.03.25).
- [14] NOAA, Public FTP ATFC file, <https://ftp.nhc.noaa.gov/atcf/>, (accessed 31.03.25).
- [15] B. Rhodes, in SkyField, Elegant Astronomy for Python, <http://rhodesmill.org/skyfield/>, (accessed 31.03.25).
- [16] Celestrak, Two-Line Element Sets, <https://www.celestrak.com>, (accessed 31.03.25).
- [17] Space-Track, Two-Line Element Sets, <https://www.space-track.org>, (accessed 31.03.25).
- [18] K. R. Knapp, M. C. Kruk, D. H. Levinson, H. J. Diamond, C. J. Neumann, The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying tropical cyclone best track data. *Bulletin of the American Meteorological Society*, 91, (2010) 363-376. doi:10.1175/2009BAMS2755.1.
- [19] J. K. Gahtan, R. Knapp, C. J. Schreck, H. J. Diamond, J. P. Kossin, M. C. Kruk, International Best Track Archive for Climate Stewardship (IBTrACS) Project, Version 4r01. last3years. NOAA National Centers for Environmental Information. doi:10.25921/82ty-9e16. (accessed 31.03.25).

- [20] E. Arsenault, Hurricane Watch Initiative - Annual Report RCM Acquisitions for Year 2024, Canadian Space Agency, 2024.
- [21] WMO, Fourth International Workshop on Satellite Analysis of Tropical Cyclones (IWSATC-4) <https://community.wmo.int/en/meetings/fourth-international-workshop-satellite-analysis-tropical-cyclones-iwsatc-4-0/>, (accessed 31.03.25)