The Canadian Space Agency's Hurricane Watch Program: Supporting Research on Wind Field Retrieval from RADARSAT-1 Images

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ABSTRACT

The Canadian Space Agency's Hurricane Watch program monitors tropical cyclones worldwide and acquires RADARSAT-1 imagery to support scientific research. Space borne Synthetic Aperture Radar (SAR) gives high-resolution synoptic views of the ocean's surface without being affected by cloud cover. Surface wind fields can be computed from the sea surface backscatter patterns visible on SAR imagery. This capability, combined with the presence of fine scale storm features in SAR images, has motivated the use of RADARSAT-1 images for the study of tropical storms and cyclones. The experience of the Mission Management Office team has grown through the years, and this accounts for the increase of successful acquisitions over the last seasons. Nevertheless, capturing *eyes* and *edges* of tropical cyclones remains a challenge. This paper presents an overview of the current Hurricane Watch operations and the content of its archives. To further improve the efficiency of Hurricane Watch operations, a novel approach for conducting the program's operations is presented. We propose three operational scenarios with varying degrees of task automation based on spatio-temporal analysis. A pilot study of an extensive RADARSAT-1 coverage of the Atlantic basin was conducted during the peak of the 2006 hurricane season. In addition, RADARSAT-1's capability to capture tropical storms for the Atlantic basin in a more efficient manner was investigated by means of the simulation of an extensive acquisition plan using real 2005 operational constraints. The added efficiency of this approach was validated using hurricane best-track data and compared favorably with Hurricane Watch results.

Keywords: Hurricane Watch, RADARSAT-1, tropical cyclone, typhoon, wind field, SAR.

1 INTRODUCTION

The ability of synthetic aperture radar (SAR) to capture the ocean surface roughness patterns generated by surface winds is largely recognized [1]. This motivated initial attempts to acquire RADARSAT-1 imagery over hurricanes to study the intense wind structures hidden by the clouds in optical spectrum based sensors [2, 3,4]. In 1998, the Canada Centre for Remote Sensing (CCRS) submitted the first acquisition requests over hurricanes and successfully acquired imagery over Bonnie, Danielle, Georges and Mitch. CCRS used this imagery to investigate the visibility of tropical storm related phenomena [2]. The Canadian Space Agency (CSA) later engaged in the Hurricane Watch Program (HW), in collaboration with the CCRS and the U.S National Oceanic and Atmospheric Administration / Atlantic Oceanographic and Meteorological Laboratory (NOAA/AOML) [3,4]. The program's goal is to acquire RADARSAT-1 images of tropical cyclones to support research studies focused on wind field analysis from SAR data. The Canadian Hurricane Centre of Environment Canada and more recently the Department of Fisheries and Oceans Canada (DFO) also provided valuable support and feedback in the development of the HW initiative. In 2004, the Center for Southeastern Tropical Advanced Remote Sensing of the University of Miami (CSTARS) joined the program by making its ground receiving station available for the downlink of HW imagery. CSTARS also plays an important role by processing RADARSAT-1 data into wind field maps. CSA's Satellite Operations' Mission Management

Office (MMO) is responsible for the overall management of issues related to RADARSAT-1 data acquisitions and for the HW program [5]. RADARSAT-1, which is currently in its twelfth year of operations, has a dawn-dusk sun-synchronous orbit, with a 24-day repeat cycle, and orbits the Earth 14 times a day. The SAR on board RADARSAT-1 provides the distinct advantage of all-weather acquisition capabilities. Its C-band microwave penetrates clouds to allow the observation of the underlying ocean surface. It has been found that RADARSAT-1 images could provide valuable details about a storm's structure when it is out of range of coastal radars; for example, roll vortices in regions between the rain bands of hurricanes [3,4,6]. Large spatial extent of boundary layer rolls was first recognized in RADARSAT-1 imagery [6]. RADARSAT-1 has the proven capability to provide a synoptic view of wind fields, and unique information of fine scale details of storm morphology and structure [4,6,7,8]. Such information can contribute to the study of tropical cyclones and the study of wind field extraction methods and algorithms in situations of severe winds [9,10,11]. Since its inauguration, the HW program has been evolving through the years at the CSA level in order to collect an extensive SAR hurricane imagery dataset for scientific research.

This paper presents an overview of current operations involved in the HW program, and a summary of the content of its archives. A novel approach, based on an extensive experimental coverage of the Atlantic region, during the peak of 2006 hurricane season, is presented. We will also discuss the outcome of a 2005 extensive full season Atlantic coverage simulation that illustrates the capability of RADARSAT-1 to capture different stages of tropical storms. Finally, we will discuss possible improvements to HW procedures and future work needed to better respond to the scientific community user needs and requirements.

2 HURRICANE WATCH OPERATIONS

2.1 Current Hurricane Watch procedures

The Mission Management Office of the Satellite Operations directorate of CSA is responsible for the daily planning of RADARSAT-1 image requests received from the order desks. Planning is done based on established policies, procedures and guidelines. The HW operations of the program start every year around the 1st of June and end around the 30th of November. The HW specific tasks are distributed amongst the team of MMO mission planners, some mission planners being assigned to each of the four specific basins to monitor (Atlantic, Eastern Pacific, West & South Pacific and North & South Indian). The operations of HW [12] involve the daily monitoring of cyclone activity worldwide using regular bulletins issued by official regional meteorological centers (National Hurricane Center, Canadian Hurricane Center, Joint Typhoon Warning Center, Central Pacific Hurricane Center). Cyclone trajectories are imported into the Swath Planning Application software (SPA 3.1P1) and possible swaths over the center of the storm are generated in Wide ScanSAR mode (450-500 km wide swath) within a spatial and temporal buffer, to allow coping with the geographical uncertainty of the cyclone track. Submissions are made during the latest planning time frames available to allow for the latest predictions to be interpolated to the available imaging opportunity. These time frames, referred to as the *freeze* and *superchill*, respectively relate to 29 to 53 hours, and 53 to 77 hours prior to acquisitions. These delays have a huge impact on the success of acquisitions due to the greater uncertainty over the precise locations of storms that have to be interpolated or extrapolated from forecasted locations to match possible RADARSAT-1 swath timings. Due to the latitude of occurrence of tropical storms, it is not always possible to plan an acquisition with the optimal coverage in time and space in reference to the forecasted locations. Furthermore, planning opportunities can be limited due to lack of on-board recorder (OBR) availability. The HW image requests have a medium priority level which forces the program to concede in favor of higher priority level requests in cases of conflicts with images in other beam modes, or when OBR space is sparse. The unpredictable nature of cyclone trajectories, limited accuracy of forecasts, and RADARSAT-1 planning constraints make it quite challenging to successfully image a tropical cyclone's center.

After the downlink of data to the receiving facilities, trajectories are revised with latest predictions and actual location data, with interpolation to the acquisition's timing, to evaluate the success of the acquisition. We consider an acquisition successful when it captures the center of the storm: *eye hit* or its *edge*, which is approximated by a 100 km radius circle. The RADARSAT-1 data is received and archived with no processing. The station can make an intermediate stage of processing, by means of fastscan or quicklook images, available. Although varying in quality, these low-resolution images are helpful to visually validate the success in capturing the storm. Results are later reported to partners and users by way of daily email reports, a restricted access website, and post-seasonal reports.

2.2 Experimental 2006 Atlantic coverage

With the intensity of the record-breaking 2005 Atlantic basin cyclone activity, and the amount of resources that were necessary to pursue the HW operations during that time [12], the need was recognized to evaluate the feasibility of a more extensive and automated coverage of that area for future seasons. It was decided to elaborate an experimental extensive coverage of the Atlantic region during part of the peak of hurricane season 2006 to test possible improvement of procedures.

An extensive image acquisition plan was established for the period extending from September 5th (11:20 UTC; cycle: 163, orbit: 229.40284) to September 30th 2006 (23:44 UTC; cycle: 165, orbit: 251.07334). All possible Wide ScanSAR swaths that could be downlinked in real-time at CSTARS, in Miami, were generated. No data having to use the on-board recorder (OBR) were planned. This strategy allowed other projects, including the current HW, to use the OBR when resources were available. The CSTARS station is remarkably well located to monitor Atlantic tropical storms (TS), occurring in the Caribbean's, the Gulf of Mexico, and part of the east coast of Northern America. In total, the acquisition plan consisted of 103 possible ascending or descending Wide ScanSAR swaths. A script was used to automatically de-conflict the HW pilot acquisition plan with higher priority image requests registered in the Order Desk System database. During this step, the swaths were split into one-frame long segments to facilitate the resolution of daily conflicts created by incoming higher priority requests. Note that regular HW, in comparison, plans longer image segments and this is later taken into account in the analysis of the results. Requests were submitted through a batch submission tool and later planned through the regular 14 day moving planning window. Overall, 525 images were generated in the initial acquisition plan. Due to the daily de-conflicting of the acquisition plan and operational constraints, some images were either lost or abandoned. CSTARS received the remaining total 464 images shown in Figure 1.

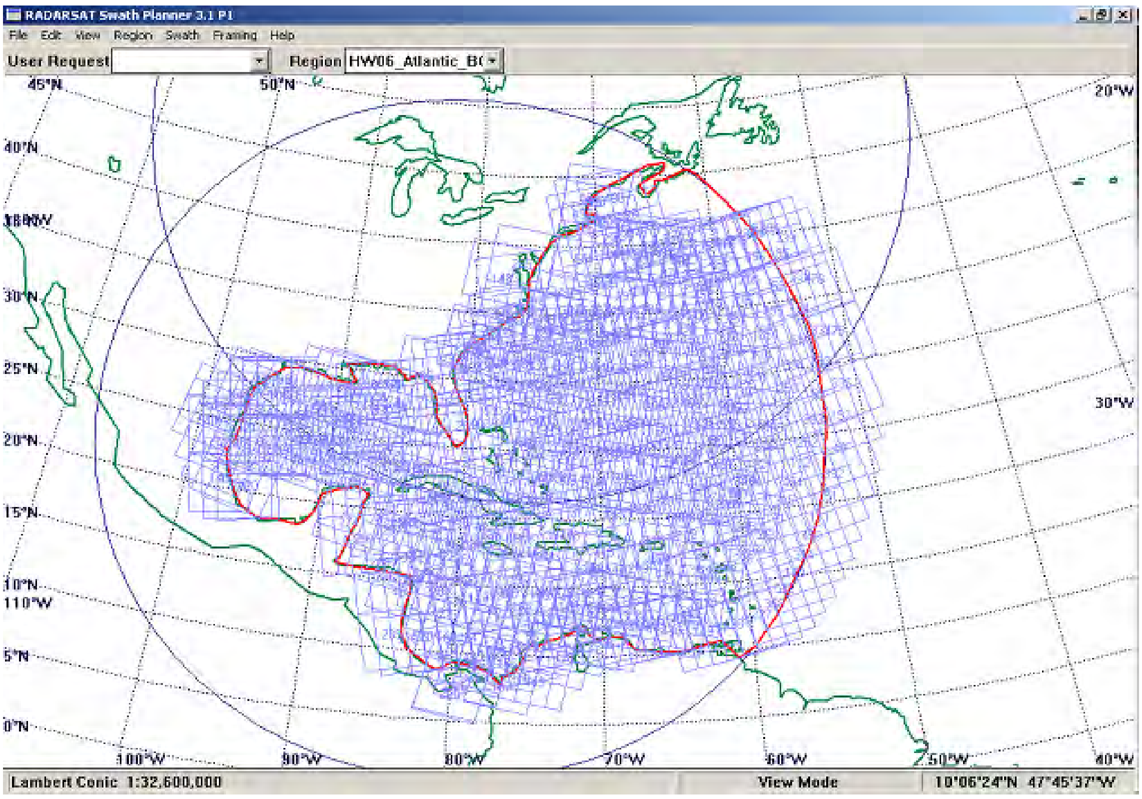

Figure 1. RADARSAT-1 experimental Atlantic 2006 peak season blanket acquisition plan with real-time downlink to CSTARS. A total of 464 Wide ScanSAR B (450 km wide swaths) frames of data were acquired from September 5th to 30th 2006. The southern circle represents the inner mask of CSTARS located in Miami (USA). The northern circle represents the Gatineau mask (Canada). Image generated with SPA 3.1 P1 software, © Copyright Canadian Space Agency, 2006.

During the experiment, four tropical storms developed into hurricanes in the region being covered (Florence, Gordon, Helene and Isaac). The acquisitions were not processed, but archived at the receiving station, and the procedure for identifying *eye* or *edge* hits contained in each image had to rely on image metadata solely. Quick-look images and wind processing maps are produced by the reception facility once potential hits are identified. The SPA software can export an acquisition plan containing the geographical coordinates of all vertexes of the polygon approximations of the regions covered by each image in a file (.exp SPA format). The vertex coordinates are in latitude and longitude. Figure 1 shows an illustration of the image polygons. A spatio-temporal analysis algorithm was developed to process the data. It takes as input the polygons and the geographical coordinates of forecasted tropical storm. Since the time of the forecast does not coincide with the one associated with the image polygon, it is important to interpolate the position of a storm at the time of acquisition of each image. A simple linear interpolation is used. To find out if an interpolated storm point is inside the corresponding polygon we used a simple ray-casting algorithm. This algorithm first computes a segment using the storm interpolated coordinates and another point which is outside the bounding box of the polygon. Then, the number of *edges* of the polygon that intercept the segment is computed. When an odd number of interceptions occurs, the interpolated point is inside the polygon; otherwise it is outside. Care must be taken to avoid duplicating the same interception when it occurs at a vertex. An *eye hit* occurs when an interpolated point is inside the polygon.

The *edge hit* is detected using the minimum distance between a point located on the edges of the polygon and the interpolated storm location. An *edge* must be outside the polygon and has a distance smaller than a 100 km to the polygon's frontiers. This is the same definition that is used by the regular HW program. The distance is computed using the great circle distance approximation (based on an average Earth radius of 6372.795 km). In order to ease computation, we marked the outline of the polygon by a set of more than a thousand points. The sampling is dense enough so that the distance is a good approximation.

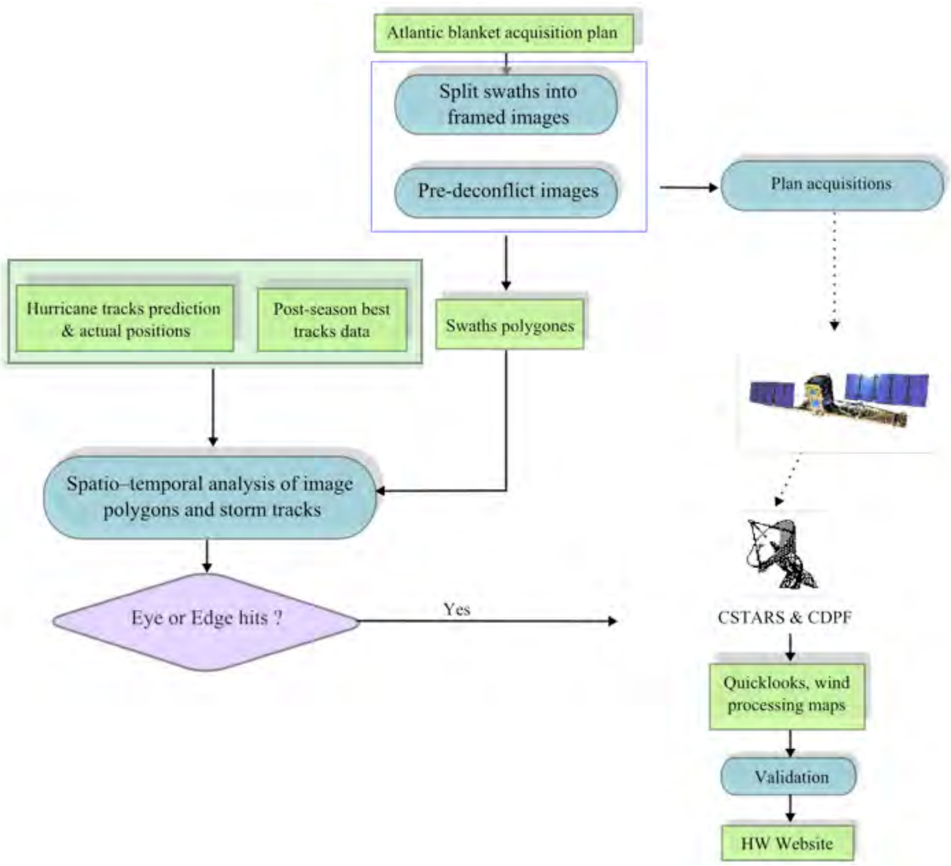

Figure 2. Schematic description of experimental algorithm used for the 2006 Atlantic peak season coverage.

Since there is incertitude in the prediction of storm location, it is useful to compute the minimum distance between an *eye hit* location and the frontier of the polygon. When it is large, the *eye* is near the center of the polygon. When it is small, it is near the frontier and can even be an *edge* in reality. Small minimum distance for an *edge* means that the center of the storm is near, but outside, the frontier of the polygon. Since there is incertitude in the predictions, it can even be an *eye* in reality. Because of the fact that interpretation of the magnitude of the minimum distance is different for *edge* and *eye*, we used *signed distances* to distinguish them in reference to the polygon vertexes. For *eyes*, we used *negative distances* and for *edges* we used *positive distances* (Figure 3). The algorithm outputs all polygons that contain an *eye* or *edge* hit, the position of the interpolated storm and minimum distance between the polygon's frontier and the center of the storm. Using the results of the algorithm, quicklooks can be requested from the reception station. The overall procedure for the blanket Atlantic coverage experiment can be viewed in Figure 2.

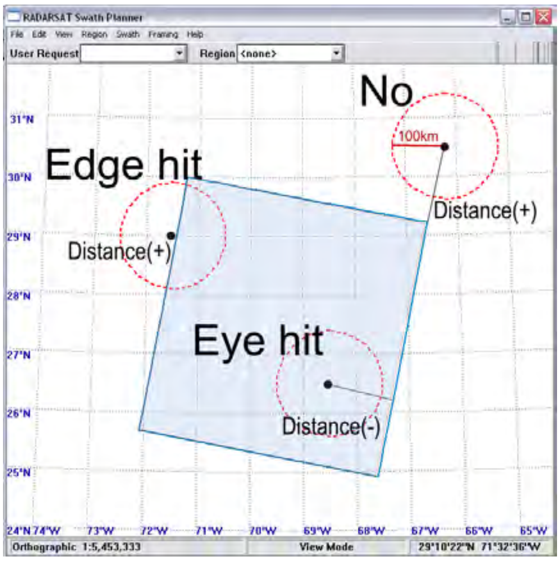

Figure 3. Examples of *eye* or *edge hits* contained in a RADARSAT-1 one frame long Wide ScanSAR B image. *Eye hit*: center of cyclone is inside the polygon. *Edge hit*: center of cyclone is outside of the swath but less than 100km from polygon segment. No hit: center of cyclone is further than 100km of polygon. Image generated with SPA 3.1 P1 software, © Copyright Canadian Space Agency, 2006.

2.3 Simulation of 2005 season full coverage

The low 2006 tropical cyclone activity experienced during our pilot study did limit the opportunities to estimate the efficiency of a blanket regional coverage approach of the Atlantic. To overcome this reality, we simulated a full season coverage of RADARSAT-1 acquisitions over CSTARS mask using 2005 data. The acquisition plan was de-conflicted with historical RADARSAT-1 acquisitions that were registered in the Order Desk System during that season. Only rare temporary outages that randomly occur were not reproduced. The acquisition plan contained 680 Wide ScanSAR B swaths that were split into 3805 one-frame long data segments. Spatio-temporal analyses, using the same algorithm as for the 2006 Atlantic blanket coverage analysis were performed to extract *eyes* and *edges hits* contained in the simulated acquisitions. We used post-season 6-hourly 2005 best tracks data, extracted from the Historical North Atlantic Tropical Cyclone Tracks [13] dataset, from the NOAA, available from the Coastal Services Center's website (http://www.csc.noaa.gov/hurricane_tracks). This dataset contains the historical center location of all subtropical depressions (SD), tropical storms (TS), extra-tropical storms (E), tropical lows (L), waves (W), disturbances (D), subtropical storm (SS), tropical depressions (TD) and hurricanes (Saffir-Sympson scale). From this dataset, we used 796 storm center locations.

3 RESULTS

3.1 Hurricane watch archives

Table 1 shows the overall percentage of acquisitions successful in capturing tropical cyclone and tropical storm *eyes* or *edges*. It can be noted that the success rate has been increasing through the years. These positive results can be in part attributed to the ability to plan request in the latest time frame (*freeze*) since 2004, and increased mission planner's experience. Table 2 describes the *eye* and *edge* image content of the HW dataset that were collected over the years from the various regions being monitored. These HW images are not *a priori* processed, but remain as archives, in the reception facilities where they were downlinked. As for the location of these archives, 74% of all *eye hit* images and 89% of all *edge hit* images are available from Canadian reception facilities at Gatineau (GSS) or Prince Albert (PASS). This is due to the fact that Atlantic basin images are sent either real-time to CSTARS and GSS stations or recorded and later played back to PASS or GSS. As for images acquired in the Eastern Pacific, the West & South Pacific and the North & South Indian Ocean regions, the majority are recorded on the OBR and subsequently downlinked to Canadian receiving stations. Also, from Table 2 it can be observed that a fairly important number of cyclone and typhoon *eye* hit data is available for these regions. Interested users can request the data be processed from the relevant order desks in accordance to RADARSAT-1 data policies. For more information on the data archives, please contact first author.

Table 1. Seasonal success rates of Hurricane Watch acquisitions in capturing *eye*s and *edges* of tropical cyclones

Year	Number of submissions	*Eye* & *edge* number of hits	Success rate (%)
1999	33	4	12.12
2000	19	2	10.53
2001	117	21	17.95
2002	124	30	24.19
2003	55	19	34.5
2004	46	12	26.1
2005	115	83	72.2
2006	59	30	50.8

Success rates represent the percentage of acquired images that have effectively hit the center of the tropical storm/cyclone or its *edge* based on an approximated 100 km radius circle storm shape.

Table 2. E*ye* and *edge* content of Hurricane Watch archives by geographic region (N/A = details not available)

Year	Atlantic		East Pacific		West & South Pacific - North & South Indian		Totals		
	Eyes	*Edges*	*Eyes*	*Edges*	*Eyes*	*Edges*	*Eyes*	*Edges*	*Eyes + Edges*
1998	2	2	0	0	0	0	2	2	4
1999	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4
2000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
2001	7	4	6	4	0	0	13	8	21
2002	12	8	1	1	5	3	18	12	30
2003	6	3	1	1	5	3	12	7	19
2004	3	3	0	2	4	0	7	5	12
2005	21	17	11	5	21	8	53	30	83
2006	5	2	1	4	13	5	19	11	30
Totals	56	39	20	17	48	19	124	75	205

3.2 Experimental 2006 Atlantic coverage results

An illustration of the spatio-temporal relation between forecasted tropical storm centers, with their identified geographically coincidental or closest image polygons, is provided in Figure 4. The vertical line dividing the graphic delimits the potential *eye* and *edge hits*. On the left hand side are the storm centers geographically contained in an image polygon (potential *eye hits*). On the right-hand side, outside of image polygon storm centers are plotted in reference to their spatially closest image polygon intercepting the *edge*. For this dataset, the storm center locations have not yet been interpolated to the time of image acquisitions. Time lapse between storm center forecast time and image acquisitions is given in the Y-axis. In the lower left corner of the graph (R1), more probable *eye hits* with smallest spatio-temporal *signed distance* of storm center location to image polygon are plotted. In the lower left corner, on right hand side of vertical division of graph (R2), points represent potential *edge hits* with smallest spatio-temporal distances between storm center locations and image polygons. This region of the graphic could also contain misclassified *eye hits*. Inversely, *eye hits* with large time lapse and biggest signed distance could be misclassified *edges*. Some misclassification of *eyes* could be present in R4 region of the graphic and are most probable in R3. While running the *eye* and *edge hit* detection script, using interpolated storm locations at time of image acquisitions; we detected 4 *eye hits* and 9 *edge hits*. These numbers were adjusted to compensate from double hits resulting from successive images in the same continuous swath. In comparison, regular HW program captured 1 *eye* and 2 *edges* in the Atlantic for the same period, excluding hits obtained by using the OBR. All the successful images from the regular HW program were captured by the pilot study. Preliminary validation with quick-look images showed some limits in detecting *a priori eyes* and *edges* precisely because of uncertainty in storm forecast data. Some confusion in the classification of *eyes* and *edges* was observed. The 2006 simulation data will have to be reevaluated upon publishing of 2006 best tracks data by NOAA. As for the 2005 simulation, already published post seasonal best tracks data were used to detect *eye* and *edges* probable hits.

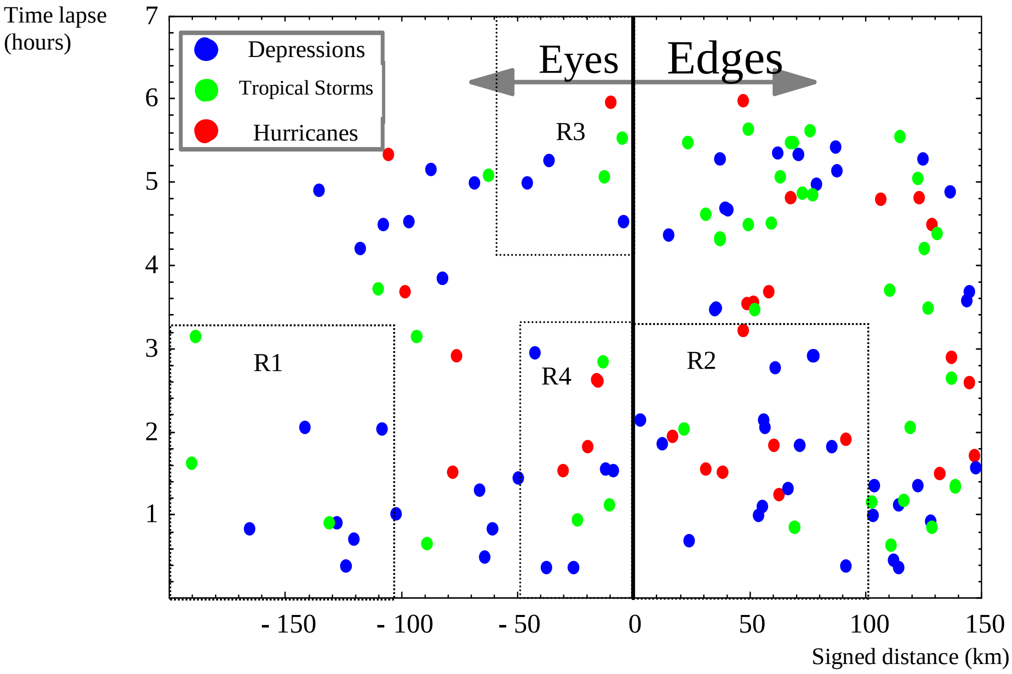

Figure 4. Spatio-temporal relation of estimated tropical storm *eye* or *edge* potential hits, computed from 2006 peak season Atlantic coverage, to their corresponding image polygons. In X-axis is the signed distance of identified *eye* or *edge* hits to their corresponding closest image polygon vertex. Time lapse between initial forecasts, without interpolation, and time of acquisition of images is in Y-axis. R1: probable *eye hits*. R2: probable *edge hits* or misclassified *eyes*. R3: estimated region of most probable misclassification of *eyes*. R4: potential confusion between *eye* and *edge hits*.

3.3 Results of simulated 2005 season full coverage

An example image acquired through the current HW procedures during hurricane season 2005 is shown in Figure 5. It shows the HW image polygon and one of the image polygons from the simulated 2005 coverage. The interpolated position of DENNIS is shown with a circle approximation of its extent. HW captured the *eye* of hurricane DENNIS at category 1 stage. CSTARS processed a wind field map (Figure 6) and a quick-look was made available (Figure 7). Our algorithm successfully detected the *eye* hit with image polygon metadata, and best tracks data. Table 3 shows a comparison of the full 2005 Atlantic blanket coverage simulated acquisition results, computed with historical best tracks data, and the current 2005 HW results [12]. All current 2005 HW *eyes* or *edges* were captured and correctly identified within the simulation, except those having used the OBR (not shown in Table 3: 3 *eyes*, 1 *edge*). This validates the efficiency of our detection script. The *eye* and *edge* captures of hurricane stages are about the same, but there is significantly more captures of tropical storms. We show tropical depressions, although at this stage of storm development, current HW does not plan acquisitions. These results are a demonstration of the potential of an extensive acquisition approach over the Atlantic basin, and show the type of tropical storm stages that could be imaged through an intense season like season 2005. Although such an extensive coverage does imply resources, it remains inside the guidelines of RADARSAT-1 operations.

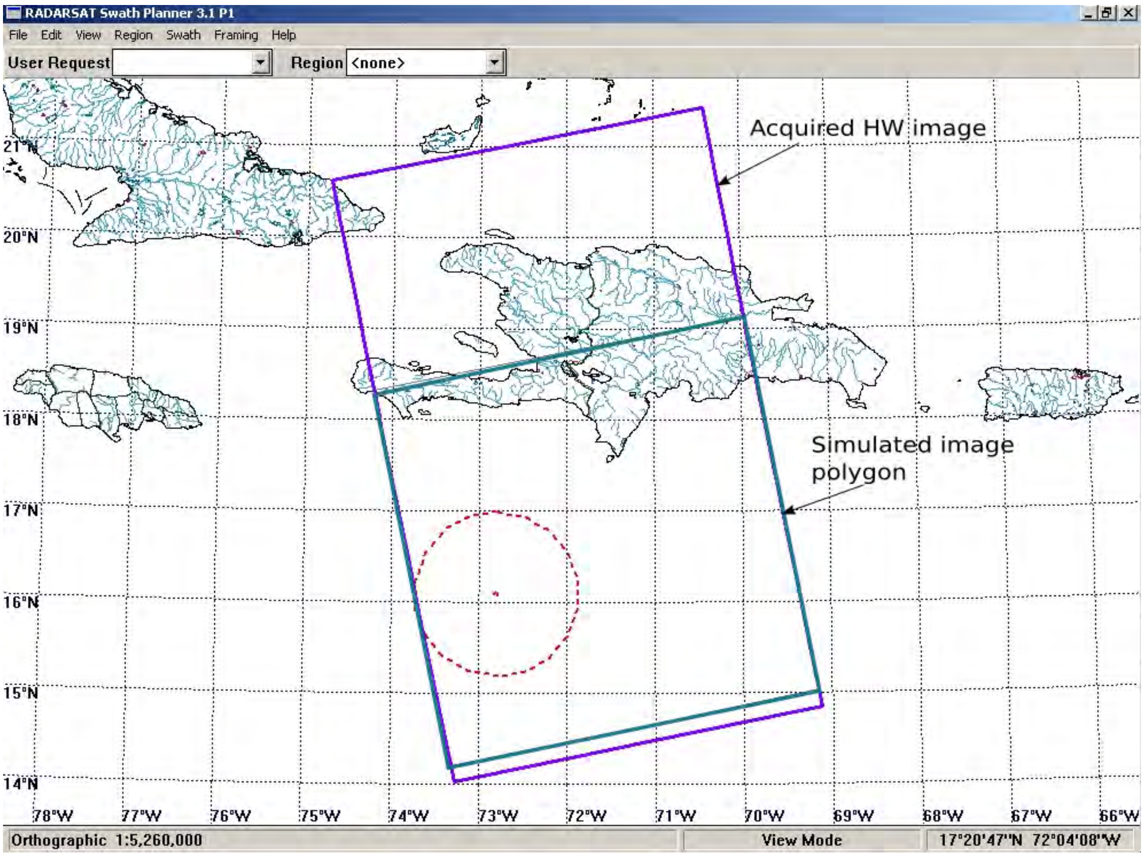

Figure 5. Acquired HW ascending Wide ScanSAR B RADARSAT-1 image polygon, and simulated image polygon. Hurricane Dennis captured at 22:54 UTC on 06 July 2005 near Hispaniola island, category 1 Saffir-Simpson scale at time of acquisition. *Eye hit* detected by analysis script with shortest distance to swath vertex of 99.39 km and interpolated center location at Lat. 16.09ºN, Long. 72.8ºW. SPA 3.1P1. © Copyright Canadian Space Agency, 2006.

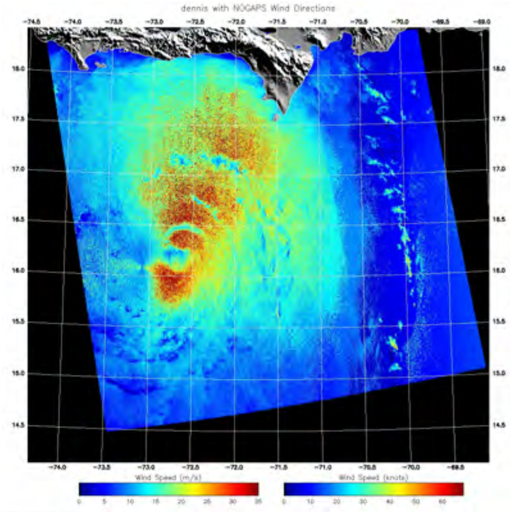

Figure 6. Wind field map processed by CSTARS of hurricane Dennis captured at 22:54 UTC on 06 July 2005.

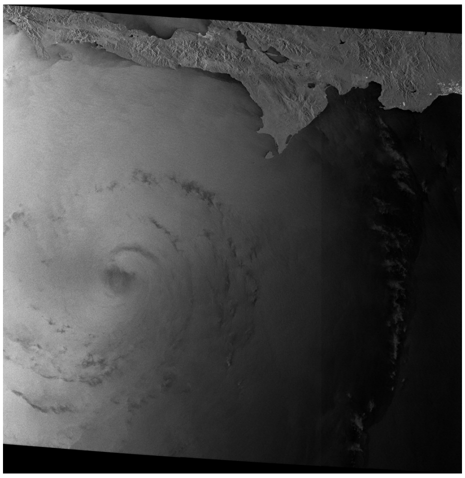

Figure 7. Ascending Wide ScanSAR B quick-look RADARSAT-1 image of hurricane Dennis captured at 22:54 UTC on 06 July 2005, © Copyright Canadian Space Agency, 2005.

Table 3. Number of *eye* and *edge hits* computed on 2005 simulated extensive Atlantic coverage compared to validated current Hurricane Watch program results.

Type of storm	*Eye hit*		*Edge hit*	
	Simulation	HW	Simulation	HW
Hurricane category 1	7	4	5	1
Hurricane category 2	2	2	1	1
Hurricane category 3	1	1	0	1
Hurricane category 4	3	2	2	1+1*
Hurricane category 5	1	1	3	1
Tropical Storm	18	7	24	10
Tropical Depression	6	1	10	0
Total	38	18	45	16

* Hits outside the 100 km radius metric, but visible cyclone features in quick-look image. Simulation numbers were adjusted to compensate from double hits resulting from successive images in the same continuous swath.

4 DISCUSSION

Based on the results of the experiments, we propose three HW scenarios of varying automation level and geographic focus. The scenarios are:

1) Automating the full season coverage of basins where HW partners have agreed to process the imagery (CSTARS, GSS). Extensive acquisition plans, like the simulated 2005, could be generated, de-conflicted, and planned periodically, either on a bi-weekly or a monthly basis. The remaining efforts could then be focused on acquisitions outside the regions covered by the stations' masks. Looking at Figure 1, we see that a large part of the Atlantic basin and part of the East Pacific basin near the southern Coasts of Mexico could be covered.

2) Same above-mentioned scenario but for the peak of the Atlantic hurricane season only. Regular HW procedures would continue to be applied to other regions. This would represent a smaller acquisition plan than the full season coverage, closer to the pilot 2006 coverage.

3) Rather than covering regions with spatially extensive acquisition plans, integrate the methods developed to spatially and temporally analyze the swaths with forecasted cyclone and tropical storm center coordinates to

efficiently plan HW image acquisitions in all monitored regions. A complete extensive season coverage plan would be simulated *a priori*, and optimal images to plan would be automatically detected with consideration of a specified temporal and spatial buffer. This would be carried out automatically by continuously analyzing the acquisition plan with forecasts as they are issued. This procedure has the potential to reduce the manual swath generating operations in the SPA. This automation would also be integrated in scenarios 1 and 2 outside extensive coverage areas.

Experiments and simulations of new approaches have been held in order to prepare the way for the next HW operations, which might benefit from hybrid quasi-operational procedures for planning acquisitions for specific regions of interest. The automation of planning strategies in the most tropical cyclone prone areas in peek season might permit concentrating mission planners efforts on regions where the system's resources for planning are more limited, or storms in a more early stage of development. Furthermore, a faster way to extract the information about an image's success might eventually allow for the near real-time processing of images having hit the target, for delivery to interested users. For now, the impacts of the implementation of each scenario need to be further studied with respect to the workload induced on CSTARS, GSS stations and CSA resources. Moreover the experiments have also been presented as an attempt to demonstrate RADARSAT-1's capability in capturing such geographically dynamic phenomena as tropical cyclones and tropical storms. We believe that with the combination of other polar orbiting SAR sensors (ENVISAT, ALOS, RADARSAT-2, RADARSAT-C), a more complete monitoring system could be built. Such a multi-satellite system could have the capability of a more temporally extensive coverage, with combined higher monitoring opportunities.

5 CONCLUSION

At the current time, HW program continues to aim at capturing cyclonic events with RADARSAT-1 imagery to support scientific research. The data is not yet used in an operational manner by meteorological agencies involved in the forecasting of tropical cyclones. Some recent demonstrations have illustrated the value added by blending RADARSAT-1 fine scale details of surface wind fields, with larger scale wind and model data [14]. Although the use of SAR data for wind applications remains an active area of research, we believe scientists are playing an important role in bringing SAR data into the field of meteorological modeling and forecasting. The automation of some of the tasks involved in HW for the purposes of the experiments over the Atlantic region, have shown the potential of integrating some of these methods into the current HW procedures for improving overall efficiency. Precise forecasts and validated data are still our primary source of input information in our daily monitoring activities and are crucial in such time sensitive image acquisition situations. Validated data of tracks positions at post-acquisition period would also become critical to identify which scenes to process in near real-time and deliver to scientists for analysis. Future work will focus on feasibility and implementation studies of the improved HW working scenarios to fully exploit RADARSAT-1's capability, and prepare for the upcoming integration of RADARSAT-2 into HW operations. With the growth of the MMO team experience in monitoring and tracking tropical cyclones, a fairly rich dataset has been built over the years. This dataset contains a variety of *eye* and *edge* images, from different regions of the world, with different storm stages, and morphological characteristics. The data gathered over the years has contributed to many studies on wind field extraction methods from SAR imagery. In the hope of continuing to support wind field and hurricane studies, CSA is currently evaluating the feasibility of a project initiative to facilitate the access of the international scientific community to the Hurricane Watch RADARSAT-1 dataset, by the provision of a large volume of processed HW images.

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