Mid-year progress report (Year 2)

Title: Integration of an Objective, Automated TC Center-fixing Algorithm Based on Multispectral Satellite Imagery into NHC/TAFB Operations

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Reporting period: 1 August 2014 – 28 February 2015

The following is a summary of the project's timeline for Year 2:

1. **Algorithm/website refinement**: Develop, troubleshoot and continue improvements to real-time ARCHER algorithm based on evaluation of 2014 hurricane season. Improve capabilities of ARCHER website and add to the product support pages (wiki) where needed.
2. **Algorithm validation**: Compile results of a validation of ARCHER using positions resolved with aircraft reconnaissance for the 2014 hurricane season.
3. **Report on progress**: Present updates on project work at 2015 IHC and confer with colleagues at NHC.

Work progress:

1. Algorithm/website refinement

We began Year 2 in August with a nominally operational ARCHER real-time algorithm and website (Figure 1), and thereafter refined it toward full capability and high reliability by September 2014 (http://tropic.ssec.wisc.edu/real-time/archerOnline/web/index.shtml). It has provided real-time center-fix forecasting assistance for nearly all of the East Pacific and North Atlantic tropical cyclones of the 2014 season using all operational real-time satellite sensors at 85-92 GHz, 37 GHz; Geostationary visible, shortwave infrared, longwave window infrared; and ASCAT ambiguities.

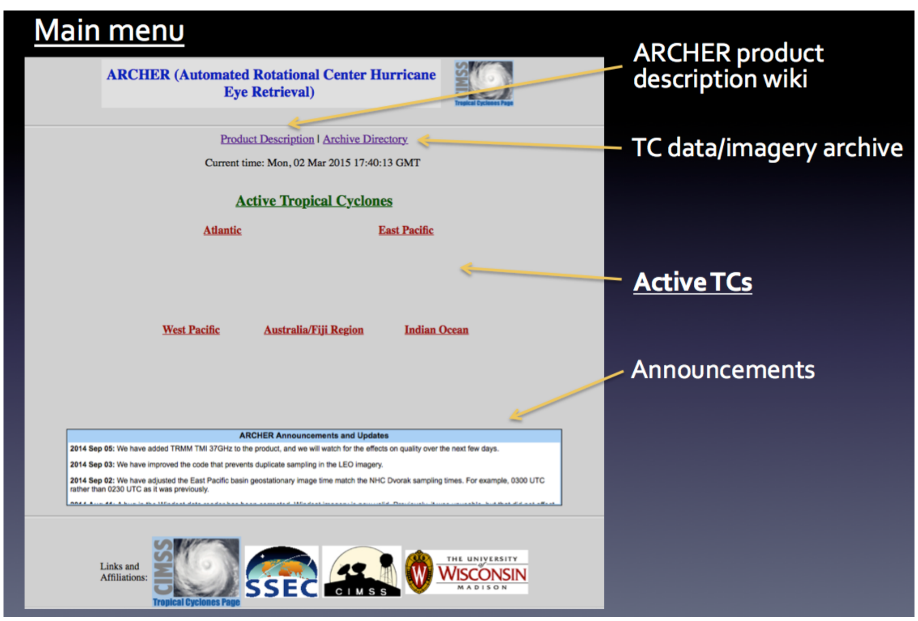
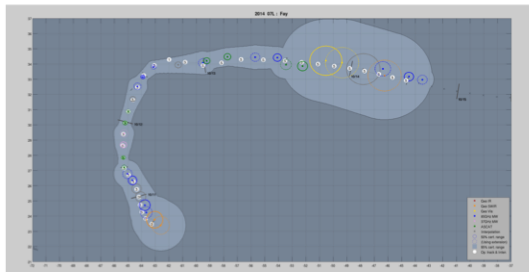


Figure 1. Screenshot of ARCHER main website.

The representation of individual storm tracks has performed on target, with an accurate and intuitive display of ARCHER center-fixes at 3-hour intervals, updated in real-time at approximately 5-minute latency. Figure 2 displays an example of the ARCHER website track guidance page, which displays a track map with the tabulated position and expected error at every satellite sensor encounter.

Track guidance page **Fay (2014)**



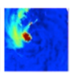
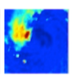
Geo IR	85-92GHz	Date/Time (UTC)	Source	Sensor	Vmax(kts)	ARCHER Lat	Lon	Geo-ref Lat	Lon	50% cert. rad.	95% cert. rad.	Eye diam (deg)	% cert. of eye
		20141011 14:51:46	GMI	85-92GHz	60.0	28.07	-65.19	28.04	-65.18	0.28	0.79	0.50	29.7
		20141011 14:51:46	GMI	37GHz	60.0	27.92	-65.24	27.89	-65.24	0.23	0.66	0.25	***
		20141011 14:45:00	Geo	Vis	60.0	***	***	***	***	***	***	0.15	***
		20141011 14:45:00	Geo	NearIR	60.0	27.71	-66.40	27.71	-66.40	0.90	2.53	0.30	***
		20141011 14:45:00	Geo	IR	60.0	27.84	-66.18	27.84	-66.18	3.36	9.49	0.10	0.9
		20141011 14:39:00 *	**Metop-B**	**ASCAT**	**60.0**	**27.82**	**-65.36**	**27.84**	**-65.36**	**0.12**	**0.33**	***	***
		20141011 13:48:00 *	Metop-A	ASCAT	60.0	27.65	-65.36	27.90	-65.38	0.12	0.34	***	***
		20141011 11:45:00	Geo	Vis	59.6	***	***	***	***	***	***	0.05	***
		20141011 11:45:00	Geo	NearIR	59.6	26.53	-64.34	26.53	-64.34	3.36	9.49	0.50	***
		20141011 11:45:00	Geo	IR	59.6	***	***	***	***	***	***	0.35	***
		20141011 10:54:04	SSMIS-17	85-92GHz	58.2	27.31	-64.92	27.45	-64.98	0.36	1.02	0.75	8.9
		20141011 08:45:00	Geo	NearIR	54.6	25.84	-64.39	25.84	-64.39	0.83	2.36	0.10	***

Figure 2. Example of Track Guidance page for Hurricane Fay (2014).

A detail of the ARCHER-resolved track for Hurricane Fay (Figure 3) gives an example of the algorithm performance. At each 3-hour timestep, the algorithm selects the results of the satellite sensor with the lowest expected error. Over the approximately 48-hour timeframe of Figure 3, this resolved track takes from the results of 85-92 GHz, 37 GHz, and ASCAT sensors, showing the clear advantage of an algorithm that can interpret the relative importance of multi-satellite retrievals with time.

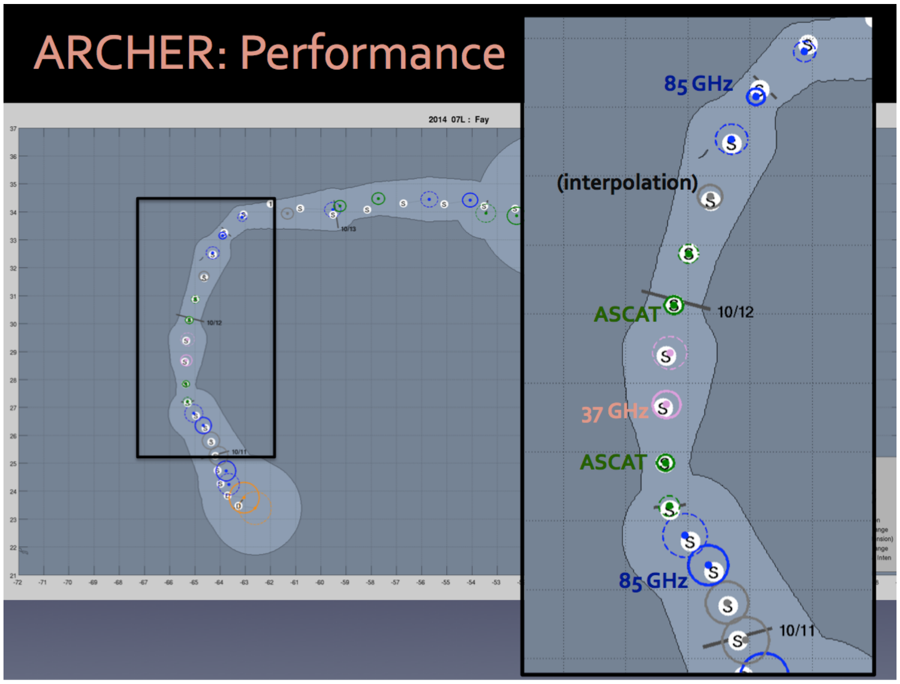


Figure 3. Example of ARCHER track-visualization display for Hurricane Fay (2014).

Another important part of the real-time ARCHER functionality is the online text output of center-fixes, which has allowed the NHC to incorporate this output into NMAP2 and overlay this data on customized visualizations (Figure 4).

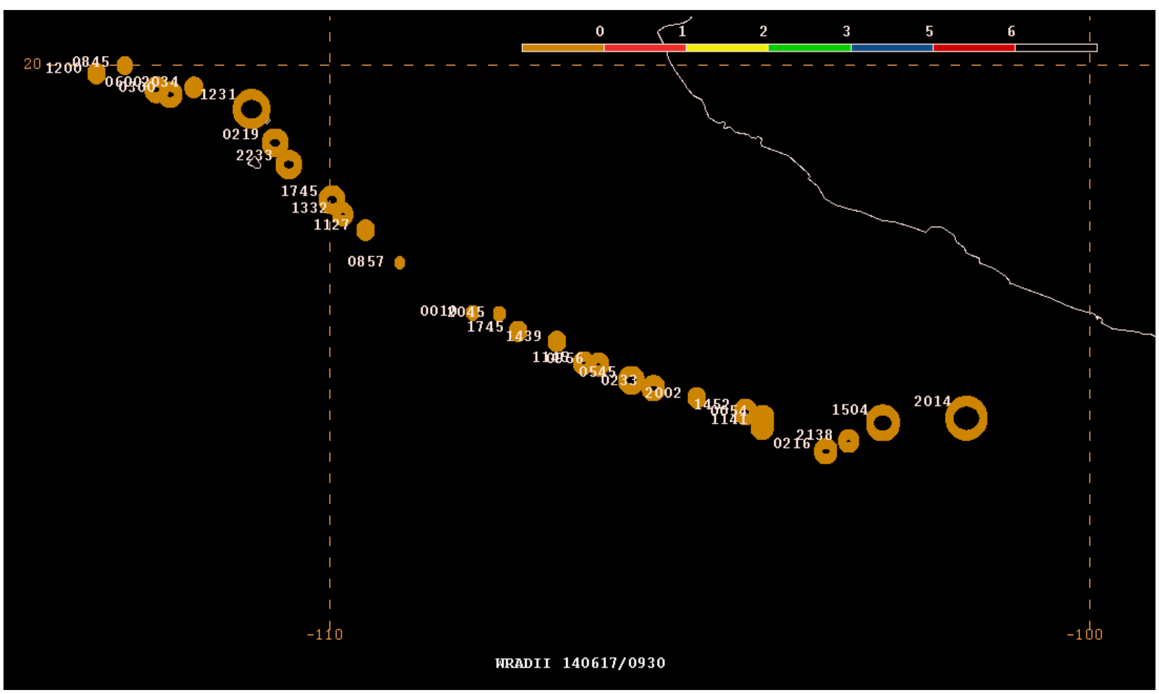


Figure 4. Example of NMAP2 display of Hurricane Christina (2014) using real-time, online ARCHER results.

Each satellite image analysis from ARCHER also links to a diagnostic image on the website, allowing forecasters to interrogate the ARCHER result to verify the accuracy (Figure 5).

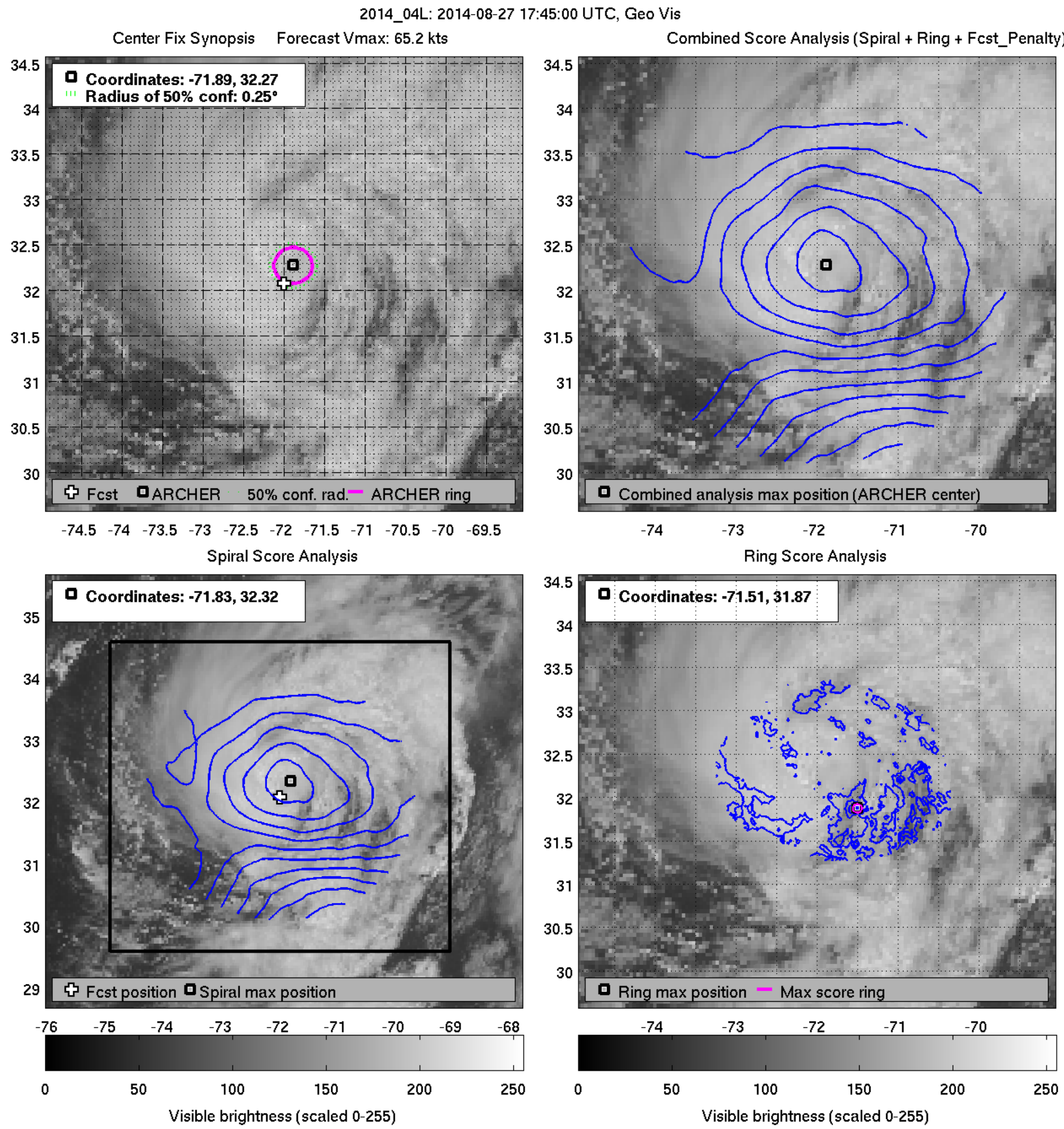


Figure 5. ARCHER single-image diagnostics for a GOES-East Visible channel analysis, showing the components of the ARCHER algorithm: the center-fix synopsis, combined score analysis, spiral score analysis and ring score analysis.

We have been busy in the first half of this year troubleshooting and analyzing the page for areas of improvement. Among these efforts have been the modifications to improve the readability of the graphics, improving the rules for interpolation of position and prevention of duplicate results (from duplicate sampling in LEO data).

As we apply the real-time ARCHER algorithm and website to other basins active during the Northern Hemisphere winter, we have seen that the software has run for months without an interruption in service, indicating that the performance will be solid in the 2015 East Pacific / North Atlantic hurricane season.

Finally, we have continued to make minor revisions to the online instructional material, provided in a set of wiki pages linked from the ARCHER website (https://groups.ssec.wisc.edu/groups/archer/archer-product-description), and will continue to revise the site as needed.

2. Algorithm validation

We will extend the validation performed in Year One with data from the 2014 season in the coming months, now that the 2014 Best Track has been released. We look forward to new results that incorporate 37 GHz imagery and low-latency GMI data for the first time.

3. Report on progress

An update was presented at the 2015 IHC meeting in Jacksonville/Miami, and we discussed the progress of the project with our colleagues at NHC. We agreed to give priority to some recent ideas that were discussed, and will try to address these in the remaining time of the project: 1) Incorporate RapidSCAT ambiguities, 2) If time allows, revise the ARCHER algorithm to re-ingest data from 6 hours before a TC is declared, in order to increase the satellite data density at this time, and 3) Improve ARCHER performance by increasing the resolution of the Visible channel input data, and. Item #3 originated with feedback from Jack Beven concerning the idiosyncratic behavior of ARCHER on visible channel imagery. The tendency for ARCHER to use both large-scale and small-scale patterns to resolve rotation is effective with most forms of imagery, but tends to cause more errors with the visible channel when large, asymmetric cloud gaps appear. We concluded that the systematic error would likely be reduced if we use a higher-resolution input image.