Year 1 Progress Report

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 2013 – 31 July 2014

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

1. **Dataset development**: Compile an archive of NHC forecasts, satellite imagery, aircraft data and manual position fixes for a 2005-2012 dataset of North Atlantic tropical cyclones
2. **Algorithm refinement**: Adapt the center-fixing algorithm, ARCHER, to the test period dataset in a simulated real-time mode
3. **Algorithm evaluation**: Verify/validate the ARCHER center-fixing performance
4. **Real-time testing:** Ready the updated ARCHER algorithm for real-time testing in the 2014 North Atlantic hurricane season (this was added to the revised timeline)

Work Progress:

We are pleased to report that we have met all of the objectives for Year 1 on schedule. In addition, extra time allowed for us to complete the ARCHER instructional material before the ASO hurricane season when they would do the most good, so we have met the objectives of this Year 2 deliverable ahead of schedule as well.

The Year 1 mid-year report has already described the completion of the first three objectives listed above (1: Dataset development, 2: Algorithm refinement and 3: Algorithm evaluation). This report will briefly discuss the one follow-up task that was addressed in the mid-year review (Comparison of ARCHER and SAB/TAFB center-fixes), report on the completion of objective #4 (Real-time testing), and summarize the delivery of the ARCHER instructional material.

Comparison of ARCHER to SAB/TAFB center fixes

The mid-year report showed the results of the ARCHER validation during the 2012 time period, using the NHC best track as a "truth" dataset. Here we add a comparison of the ARCHER accuracy relative to their SAB/TAFB center fixes. The results are categorized by performance during tropical depression / tropical storm intensities, Category 1, and Category 2-5. The tropical depression / tropical storm column (TD-TS) is the most important, because this is where the most assistance can be offered to analysts and forecasters. Performance is also separated between "Real-time" (using only the data available at the valid time), and "Near-real-time" (using data available several hours before and after the valid time). Both versions are important for interpreting the performance of an algorithm that updates the recent track history with new information as it arrives.

From a straight comparison of average error (Tables 1 and 2) the SAB/TAFB positions are more accurate than ARCHER positions, as expected, by 30-40% on average.

Table 1. Average error of ARCHER combined-sensor center-fix w.r.t. the NHC Best Track (2012 NATL dataset).

	TD – TS (N=476)	Cat 1 (N=69)	Cat 2-5 (N=36)
Real-time	51 km	32 km	19 km
Near-real-time	42 km	30 km	17 km

Table 2. Average error of SAB/TAFB position (2012 NATL dataset).

	TD – TS	Cat 1	Cat 2-5
SAB / TAFB	34 km / 34 km	22 km / 26 km	12 km / 12 km

However, ARCHER was not designed to substitute for a skilled forecaster. Rather, it serves to complement and accelerate the forecasting process, and also to highlight information that may not receive proper notice. To evaluate the helpfulness of ARCHER in this regard, we examine the percentage of ARCHER center-fixes that improve on the SAB/TAFB fixes (Table 3).

Table 3. Percentage of cases in which ARCHER had lower error than the corresponding SAB/TAFB position (2012 NATL dataset).

	TD – TS	Cat 1	Cat 2-5
Real-time	32% / 36%	36% / 36%	21% / 26%
Near-real-time	40% / 41%	36% / 39%	26% / 21%

These results show that although ARCHER is usually less accurate than a skilled forecaster, it would very likely add skill on a regular basis when included in operations. Note also several other factors not included in this analysis, each of which fall in ARCHER's favor:

1. ARCHER includes an expected error estimate with every center-fix, so the forecaster knows in advance which results are likely to be more/less accurate than normal.
2. As of summer 2014, ARCHER includes 37 GHz imagery, which the 2012 validation does not. This alone appears to have improved the multi-sensor accuracy of ARCHER by 20-25%.
3. As of summer 2014, ARCHER includes low-latency microwave imagery from the GPM Microwave Imager (GMI), which has further reduced the ARCHER error in real time and near-real-time.

Real-time testing

Since June 30, we have maintained an online site (http://tropic.ssec.wisc.edu/real-time/archerOnline/web/index.shtml) with a number of real-time supporting products for each tropical cyclone identified by the NHC or the JTWC. (Observations of tropical cyclones outside the purview of the NHC is a useful fringe benefit, and also has greatly accelerated the troubleshooting process for this project.)

The real-time supporting products include:

- The ARCHER summary table, in html and text format (for automated ingestion into the NMAP2 framework);
- The ARCHER track image (Figure 1), which visually summarizes the ARCHER-derived optimal storm track with the corresponding forecast center's forecast/analysis track included for reference;
- Diagnostic plots for each satellite source image, to guide the user through the ARCHER centering process; and
- Comparison plots, which shows the collection of ARCHER center-fixes for each 3-hour window.

Each of these components is explained in greater detail in the online supporting wiki page: https://groups.ssec.wisc.edu/groups/archer/description-of-the-product-pages.

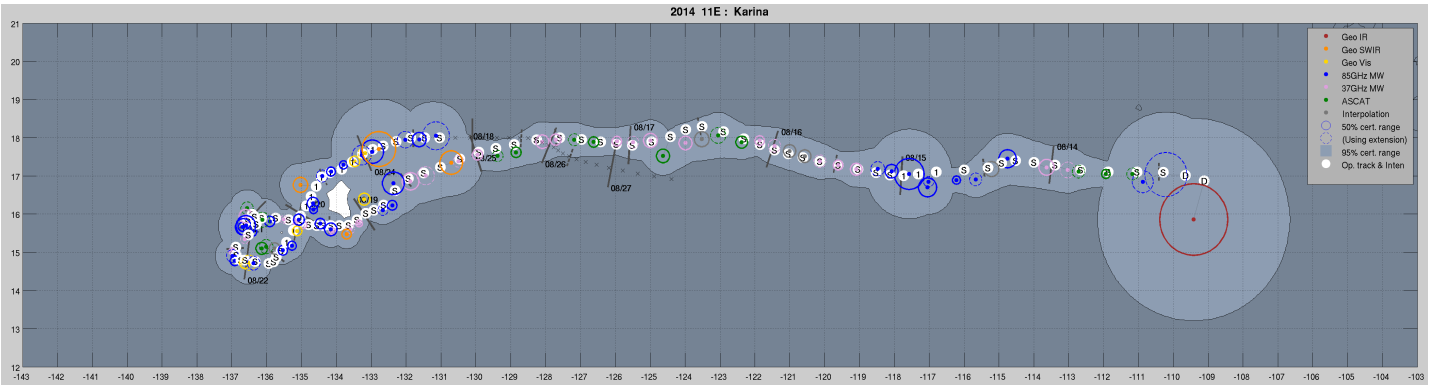

Figure 1. ARCHER-derived track image for Hurricane Karina (2014), valid at 24 August 1748 UTC. Data is spaced at three-hour intervals. Data sources are indicated in the legend. Colored circles indicate the 50% certainty range for the associated center-fix, and the light shaded zone indicates the combined 95% certainty range of the satellite-based track. The NHC forecast/analysis track, for independent reference, is shown as white disks with the intensity written inside as D, S, 1, 2, 3, 4 or 5.

Real-time products have been operating smoothly and the troubleshooting process has required very little interruption of service.

ARCHER Instructional Material

We have compiled several wiki-format webpages of instructional material, linked from the main page of the ARCHER website: https://groups.ssec.wisc.edu/groups/archer/archer-product-description. It is designed to give an overview of the ARCHER system and forecasting process in the course of a 5-20 minute read (depending on the user's time commitment). We will revise as necessary as we receive feedback from the users at NHC.

Year 2 Timeline:

The next year will bring continued refinements and additions to the product as we work with NHC to optimize the role of ARCHER in making the forecasting process more timely, accurate and reliable:

September 1 - November 30, 2014

- Continue improvements, additions and troubleshooting to the experimental real-time ARCHER forecasting support website.
- Provide continued support for JHT project of Haiyan et al.

December 1 - February 28, 2015

- If appropriate, revise the ARCHER algorithm to incorporate opportunities for improvement that emerged during the hurricane season. Include feedback on real-time algorithm performance from NHC/JHT partners.
- Add to the product support pages (wiki) where needed.

March 1 - May 31

- Present results at the 2015 IHC.
- Continue improvements to ARCHER forecasting support website.
- Prepare mid-year report, with product performance metrics for the 2014 season.
- Mid-year report due (March 31st)

June 1 - August 31

- Complete follow-up work from ideas generated at the 2015 IHC
- Continue improvements to ARCHER forecasting support website.
- Final report due (Aug 31st)

Deliverables: Optimized ARCHER forecasting support website, formatted online data, presentation at 2015 IHC.