NOAA/OAR Joint Hurricane Testbed

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Improved Eyewall Replacement Cycle Forecasting Using a Modified Microwave-Based Algorithm (ARCHER)

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Report Frequency: Semi-annual

1. ACCOMPLISHMENTS DURING THIS PERIOD

The milestones for this project, first described in the project proposal, are summarized in the following table. The major goals for this reporting period (Jan-June 2016) are highlighted in yellow and described in turn directly below.

Milestones/Deliverables

Milestone	Start Date	Forecasted Completion	Actual Completion	% Complete
1. Create a double eyewall module for ARCHER	July 2015	Dec 2015	Dec 2015	100%
2. Create real-time online display of ARCHER-ERC output	Jan 2016	June 2016	June 2016	100%
3. Evaluate performance of online ARCHER module display	Jan 2016	June 2016	June 2016	100%
4. Produce initial online technical documentation	Jan 2016	June 2016	June 2016	100%
5. Calibrate/validate the ERC probability product	Jan 2016	June 2016		90%
6. Finalize double eyewall ARCHER module to optimize performance	July 2016	Dec 2016		
7. Finalize online display of algorithm	July 2016	Dec 2016		
8. Complete online technical documentation	Jan 2017	June 2017		
9. Deliver ERC module for SHIPS	Jan 2017	June 2017		
10. Create real-time online text file output of ERC module for SHIPS	Jan 2017	June 2017		

Milestones 2&3. Create real-time online display of ARCHER-ERC output, and evaluate performance.

We now have an operational script to produce ERC guidance imagery from ARCHER results in real-time, linked from the original ARCHER page. The ERC guidance page includes a Hovmoller chart of ARCHER ring score, azimuthal brightness temperature and operational/forecast maximum wind. (More information on the forecasting utility of this product is described further below.) This product was on time for the 2016 North Atlantic hurricane season. Ongoing evaluation has led to several improvements in display, and helped indicate what to include in the Product Description page.

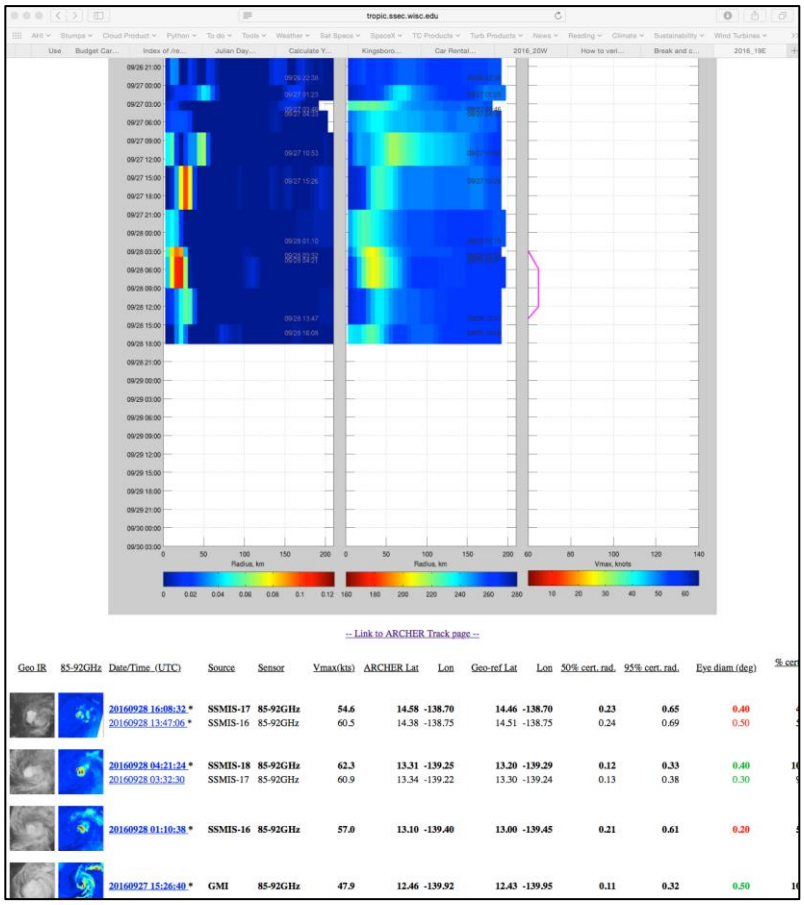

Figure 1. Screenshot of ERC guidance page for Hurricane Ulika (2016 19E).

Milestone 4. Produce initial online technical documentation

We have composed a short introduction to the ERC guidance product page, linked from the main ARCHER-ERC webpage. It describes the elements of the product images and offers an initial suggestion on how to interpret the trends in eyewall development to produce an ERC forecast.

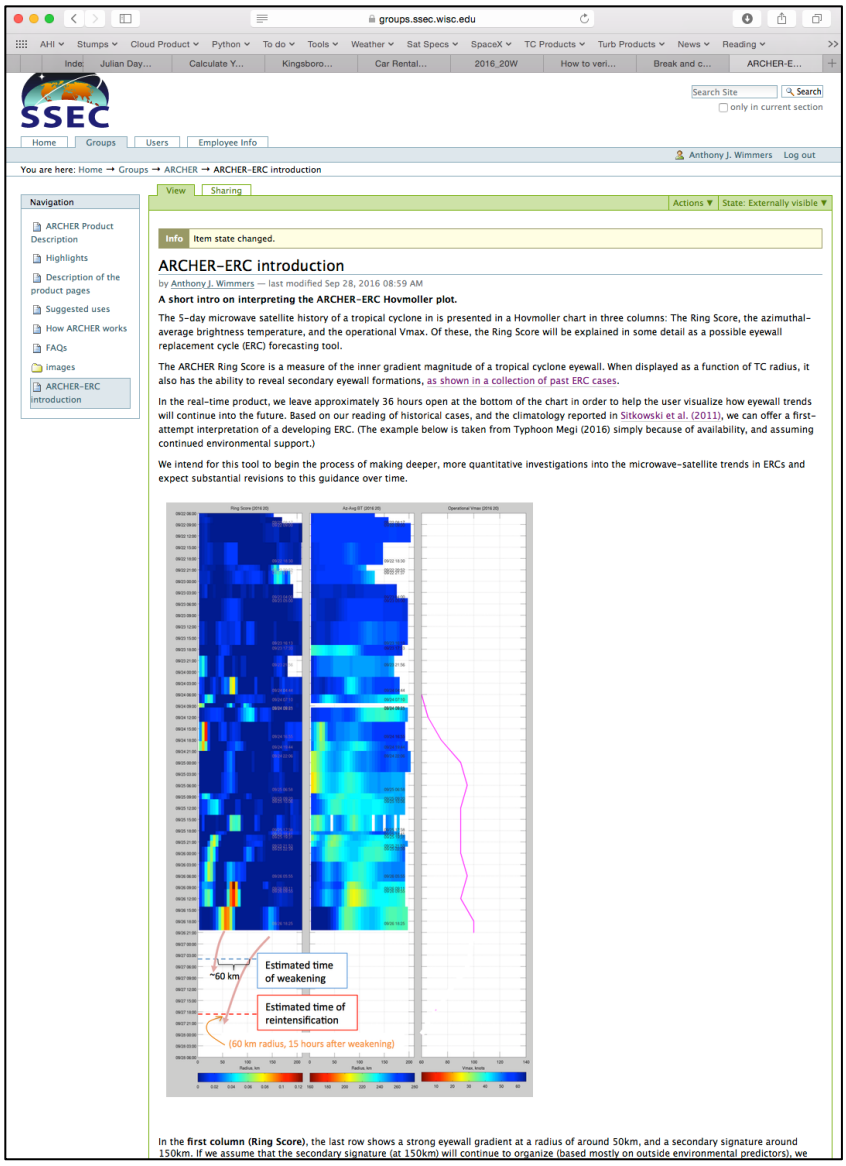

Figure 2. Screenshot of the online ARCHER-ERC Product Description.

Milestone 5. Calibrate/Validate the ERC Probability Product

We have organized the calibration dataset to develop an ERC-Probability model in a similar fashion as Jim Kossin's pERC model. Currently we have selected and organized the needed ARCHER variables to run the model, as demonstrated in the figures below, in the case of Hurricane Isabel (2003). Figure 3a shows the context of the TC intensity over the relevant time frame. Figure 3b shows the ARCHER-resolved eyewall inner radii as well as the radius of the "moat" in between. Note that these plots are not meant to follow the same feature over the whole timeframe, because often the outer eyewall transitions into the inner eyewall. Rather, these variables will be used in a probabilistic prediction of TC weakening from an ERC in an image-by-image basis. Likewise, the ARCHER Ring Score trends (Figure 3c), which are a measure of average gradient magnitude, will also be

a key factor in resolving ERC weakening probabilities. This model will be verified with Jim Kossin's dataset of aircraft-verified ERC weakening events, from Kossin and Demaria (2016).

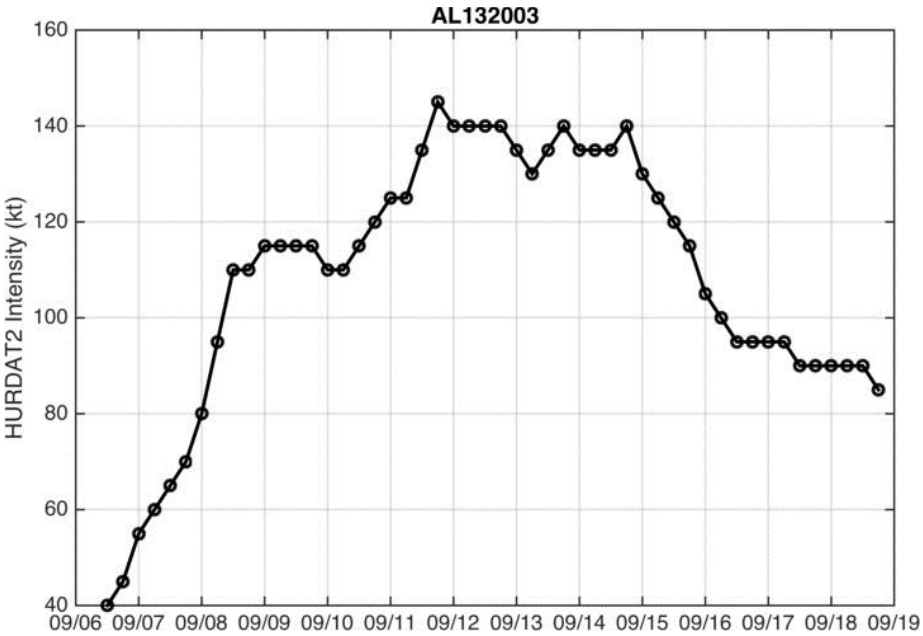

Figure 3a. Time series of HURDAT2 intensity for Hurricane Isabel (2003).

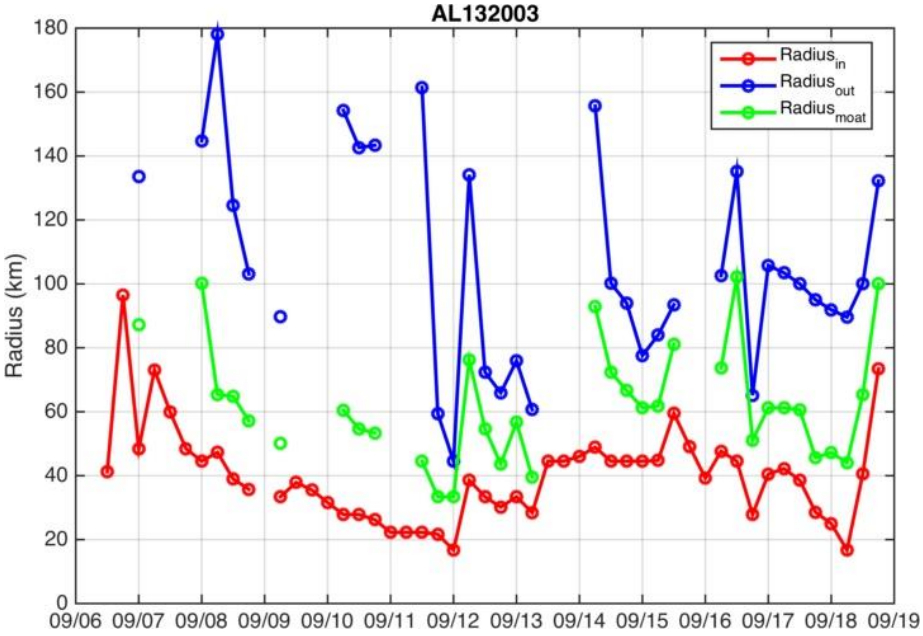

Figure 3b. Time series of radius of the ARCHER-resolved inner eyewall (red), outer eyewall (blue) and "moat" (green).

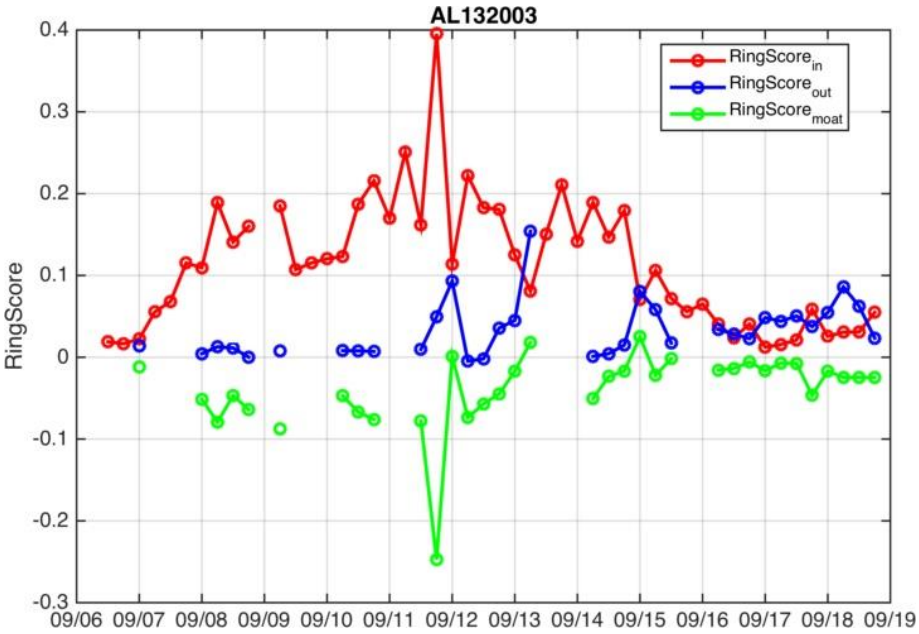

Figure 3c. Time series of radius of the eyewall ARCHER ring score (red), outer eyewall score (blue) and "moat" score (green).

During the next reporting period, the project plan is to observe the performance of our online tools, incorporate feedback from our colleagues at the NHC, and incorporate improvements where appropriate. We will also finish the previous goal of cal/val for the ERC Probability product.

2. PRODUCTS

As described in Section 1, we have developed the following deliverables/products during this reporting period:

a. The ARCHER-ERC real-time graphical guidance webpage. The main page is at http://tropic.ssec.wisc.edu/real-time/archerOnline/web/index_erc.shtml
b. The ARCHER-ERC Product Description page, at https://groups.ssec.wisc.edu/groups/archer/archer-erc-introduction
c. The ERC-Probability model algorithm, which is in progress

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

As this is a fairly small project, we have kept the activity limited to the three original participants – Anthony Wimmers, Derrick Herndon and Jim Kossin. We have provided regular updates to our colleagues at the NHC.

4. IMPACT

The expected impact of this project is to improve the forecasting accuracy for intense hurricanes in one of the current areas of need for the NHC: understanding and predicting eyewall replacement cycles. We attempt to do this using an automated analysis of eyewall (and developing eyewall) sizes and trends from 85-92 GHz microwave imagery. The information is organized into real-time online graphics and we will soon have an associated probabilistic model. These new tools under development will offer a more rigorous analysis of a phenomenon that requires greater understanding and analysis to provide adequate warning during weather-related emergencies.

5. CHANGES/PROBLEMS

No changes to the original project design are currently necessary. The work for Milestone 5 is proceeding a little more slowly than planned, but it is still progressing as expected.

6. SPECIAL REPORTING REQUIREMENTS

Here we address the three special reporting requirements that apply to this JHT project. If other special requirements also need to be addressed, please let us know.

a. Project Readiness Level: The online tools (Milestones 2 and 3) can be considered "RL 7: Prototype system." (This is 7 of 8). These tools are currently working in an operational environment in a demonstration phase and user documentation is online and ready for feedback. The ERC-Probability model is at the stage of "RL 2: Applied Research." After cal/val, we will continue to bring this model to real-time mode toward a Readiness Level 7.

b. Transition to Operations Activities: In preparation for transition to operations, we are testing the final products in real time and continue to explore options for recoding the full ARCHER system into a format that is compatible with the NHC system.

c. Testbed Approval: The decision to transition to operations will occur after the close of the project, in late 2017.

7. BUDGETARY INFORMATION

We are currently on budget and our planned expenditures are as expected. Our proposal stated that the product development should proceed quickly by following the development pathways of the original ARCHER project and the pERC model. This has gone as expected.

8. PROJECT OUTCOMES

The anticipated outcome of this project is a new system to automatically analyze near real-time microwave imagery of hurricanes and provide comprehensive forecaster guidance on the potential for an upcoming eyewall replacement cycle. This guidance will take the form of an online graphical depiction of the relevant image characteristics, and a probabilistic model using microwave image information in the same fashion as the pERC model.

REFERENCES

Kossin, J. P., and M. DeMaria, 2016: Reducing operational hurricane intensity forecast errors during eyewall replacement cycles. *Wea. Forecasting*, 31, 601-608.