Mid-year progress report (Year 1)

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

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Reporting period: 1 August 2015 – 28 February 2016

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

1. **Create a "double eyewall module"** for ARCHER.
2. **Create real-time online display** of ARCHER ERC output, and evaluate its performance.
3. **Calibrate/validate the ERC probability product** using historical cases.
4. **Begin development of ERC module for SHIPS** (forecasting intensity and RMW size).

Work progress:

1. Double eyewall module

Before the start of this project, the ARCHER algorithm used a "Ring Score" measurement to provide a form of fine-scale center-fixing guidance in Cat 1-5 TCs in 85-92 GHz satellite imagery. The Ring Score is approximately an azimuthal average of brightness temperature image gradients in the radial direction, which provides an effective pattern-matching signal for finding the center of an eyewall. As part of this project, we have unfolded this approach into an enhanced eyewall-detection signal. Our new experimental ARCHER algorithm includes output for Ring Score as a function of radius from the center-fix, so that this new array of values can be analyzed for secondary maxima that indicate either a developed or emerging secondary eyewall (Figure 1).

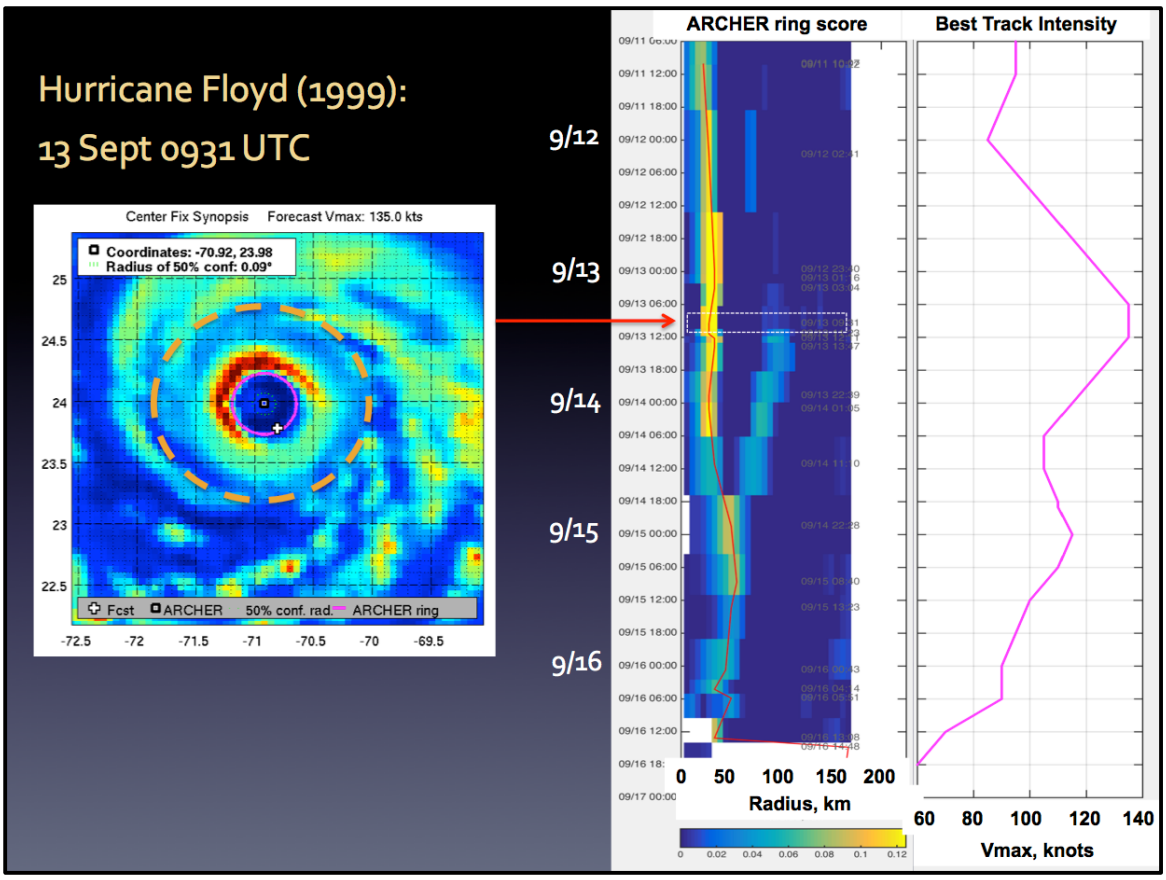

Figure 1. Left: 85-92 GHz microwave image of Hurricane Floyd (1999) with a magenta ring at the maximum ARCHER Ring Score, and a dashed orange ring at the secondary maximum. Center: Hovmöller diagram of ARCHER Ring Score with time for Hurricane Floyd. Right: NHC Best Track intensity at matching times.

The Hovmöller plot from Figure 1 shows that an eyewall replacement cycle (ERC) is readily apparent in the time series of Ring Scores. (This was not as evident in the comparisons we made with azimuthally-averaged brightness temperature.) The primary eyewall forms a column of maximum Ring Score values at radii normally at less than 75 km. The secondary eyewall emerges as a second branch of lower Ring Score values at higher radii, which ultimately contracts and converges with the primary eyewall after 24-48 hours.

The method for measuring the secondary eyewall position and intensity in 85-92 GHz imagery is still being refined, and will be presented in the Year 1 progress report. We have found that some signal filtering is helpful to remove spurious peaks in Ring Score and keep a more consistent trend with time.

2. Real-time online display

The elements of the ARCHER Ring Score (Figure 1) are also appropriate for an online graphical display. We have prepared the algorithm for displaying an updated Hovmöller diagram in real-time (Figure 2). As seen in Figure 2, the trends in Ring Score reveal the tendency and rate of secondary eyewall contraction, which help indicate the timing of the ERC. Preliminary diagnostic variables that will be shown together with this data are being finalized in tandem with the probabilistic model.

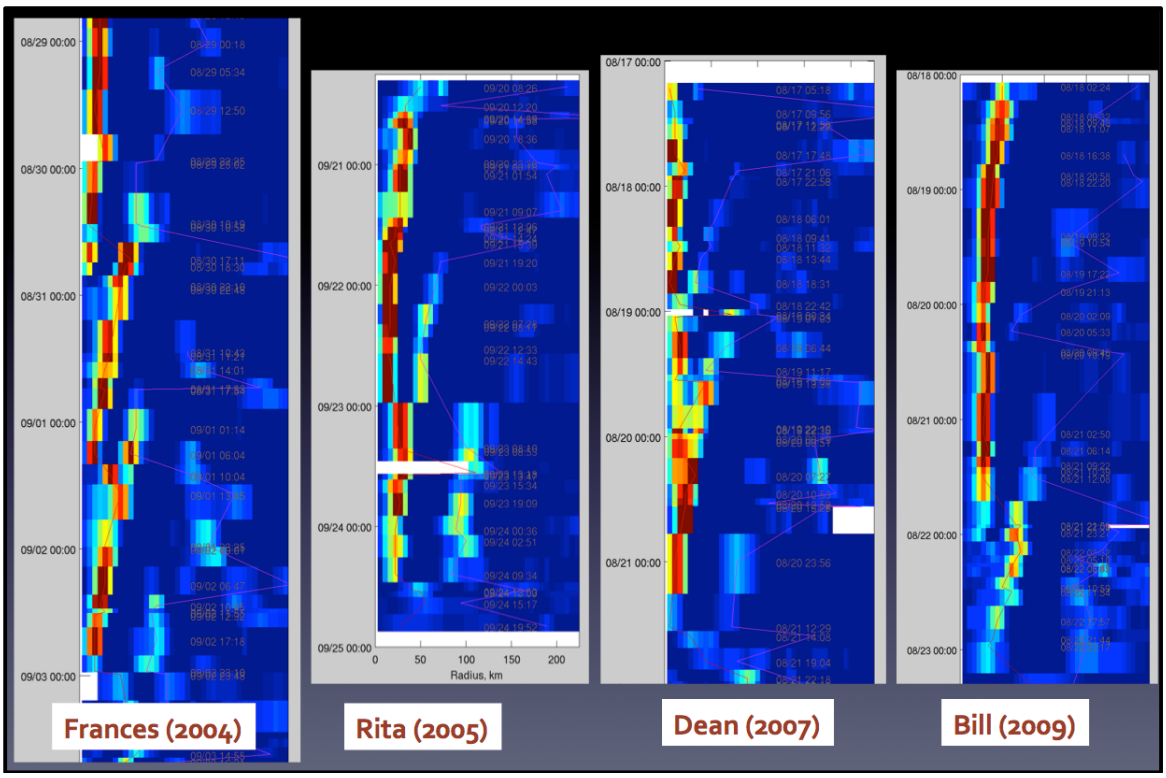

Figure 2. Hovmöller diagrams of ARCHER Ring Score with time for North Atlantic hurricanes Frances, Rita, Dean and Bill. Two complete ERCs are revealed for Frances and Dean.

3. Calibrate/validate the ERC probability product

We have constructed a database of North Atlantic 85-92 GHz imagery from 1999 to 2011, from all cases where the TC maximum sustained wind is >= 85 knots. This captures 83 ERC events total. We have also included a subjective determination of the three phases of ERC, in order to calibrate our image-based diagnostics to the ERC timing (Figure 3).

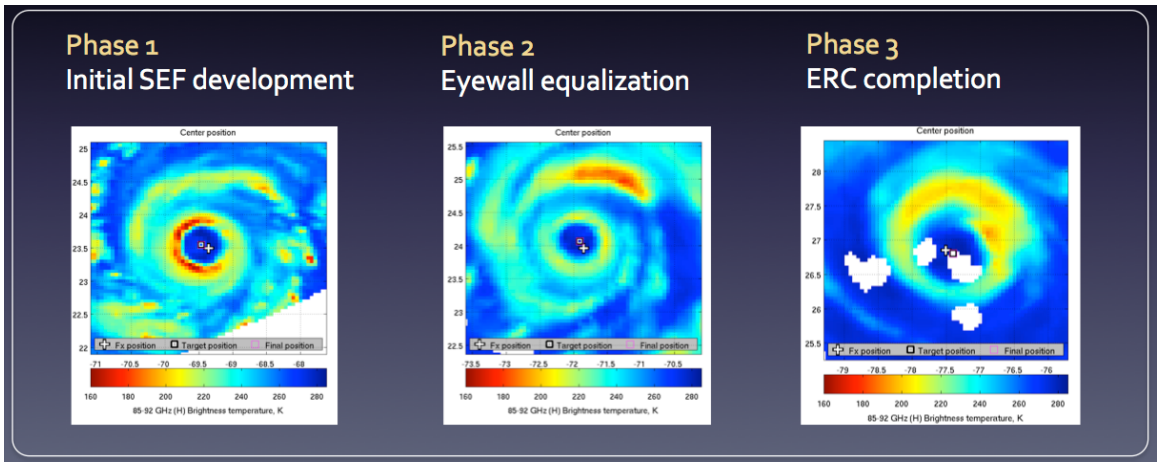

Figure 3. Examples of the three phases of ERC development evident in 85-92 GHz microwave imagery.

Jim Kossin is continuing work to utilize Ring Score data from ARCHER to improve the automated prediction of ERCs first developed in the pERC model. The evolution of ring score peaks (maxima and minima) has been found to be the key to constructing a microwave-based, probabilistic forecast of ERC (Figure 4).

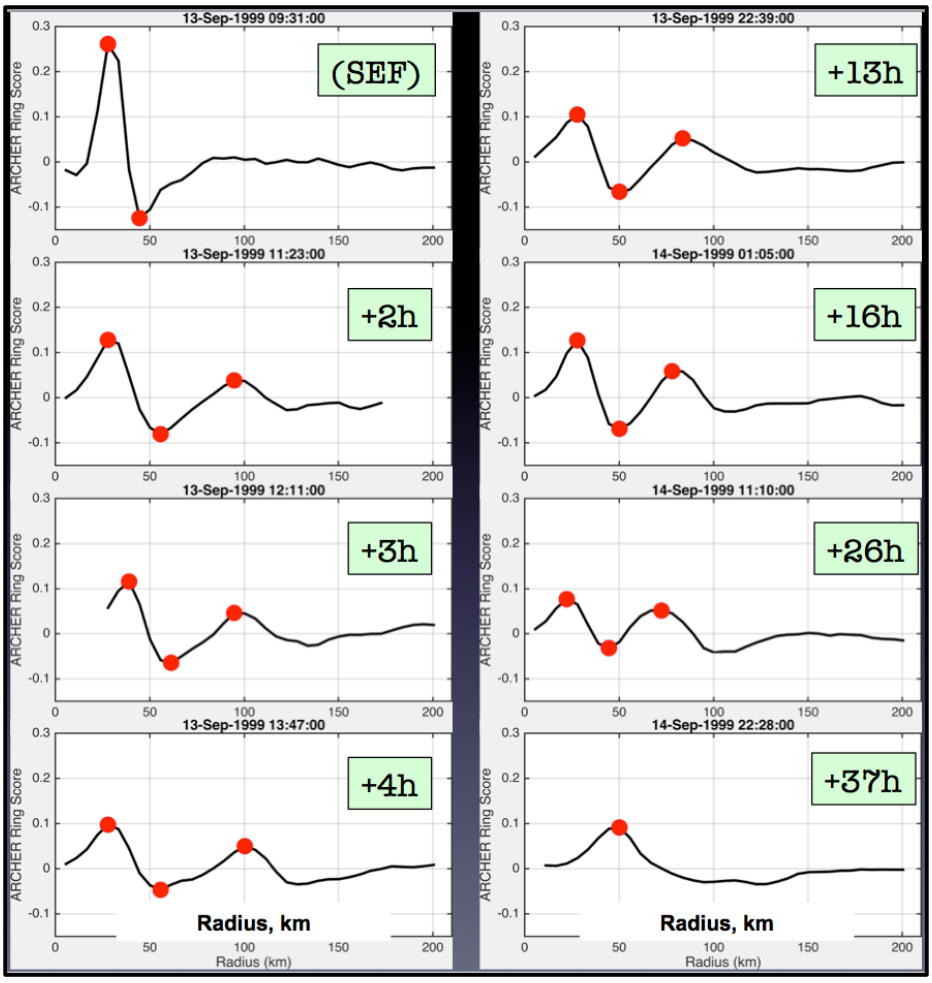

Figure 4. Evolution of maxima and minimum Ring Scores during the ERC of Floyd (1999). Note the decrease in peak-to-peak differences over time in addition to the decrease in horizontal separation. These trends will soon be characterized to improve the probabilistic ERC model.

4. Begin development of ERC module for SHIPS

We expect to begin this phase of the project later in Year 1, after the cal/val of the probabilistic model is more mature. In the meantime, Jim Kossin is transitioning the E-SHIPS and pERC models into operations at the NHC, which will allow for a smoother pathway for this project afterwards.