Motion Characteristics of Cloud Clearing Boundaries in the Southeast Atlantic
Spencer Rhodes, Lindsay Hochstatter, Sandra Yuter, Matthew Miller
Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC

I. Background
Recent work has shown that vast areas of marine stratocumulus can be eroded along westward-moving, sharp lines 1000+ km long. Processes that can increase or decrease the total global area of cloud cover impact the radiant balance of the Earth and could offset or enhance warming from CO2 increases. Our study focuses on the southeast Atlantic off the coast of Angola and Namibia (above, blue box), where large decks of low clouds (tops <1.5 km in height) commonly form. We are interested in how the speeds of these cloud-eroding lines change with distance from the coast and with latitude along the line.

II. Data Sources
Cloud eroding boundaries examined for this study were chosen from a list of several hundred previously identified cases. These boundary events were categorized as “sharp,” “somewhat diffuse,” or “mostly diffuse” based on subjective visual assessment. Boundaries that were 1) westward-moving, 2) more than 6 hours in duration, and 3) propagated at least 250 km were used for estimation of phase speed. Hovmoller plots were generated from half-hourly IR data, drawing data from focus latitudes of 14° to 16° S, to be passed to the speed calculation algorithm.

Data are from NASA EOSDIS including Aqua, Terra, and Suomi NPP reflectance and 4-km global merged IR.

Figure 1: Annual average frequency of low stratocumulus clouds (Hahn and Warren, 2007).

III. Calculation of Hovmoller Plots from IR Data

To get a row for each time, we average across latitudes

To refine our dataset of several hundred boundaries, we used an edge detection algorithm to calculate the speed of the boundary current. For each boundary, a Canny edge detection algorithm was run on the boundary location to determine the phase speed.

IV. Identifying Boundaries for Phase Speed Estimation

Enhanced Hovmoller for 26 May 2014

We detect boundary edges, which represent the transition from cloudy to clear, using Canny edge detection. This method requires input with sufficient contrast and a square array. To meet these constraints, we enhanced contrast by modifying brightness temperatures in reference to the absolute difference between maximum and minimum brightness temperature. We then interpolated with regard to time to obtain a square array.

V. Phase Speed Detection Results

• ”Mostly diffuse” boundary
• Edge detection threshold decreased to 0.5
• Fails westward propagation and propagation distance criteria

• ”Somewhat diffuse” boundary
• Noticeable boundary shown but not detected in whole by algorithm
• Indicates need for increased robustness

• ”Sharp” boundary
• Analyzed speed: 16.7 m/s
• Slope deviation: 0.38
• Example of case in which default edge detection threshold picks up on entire expanse of boundary

Summary
Edge detection is useful to identify cloud-eroding boundaries in Hovmoller plots. Using an edge detection algorithm to calculate the speed of the boundary currently produces good results in extremely sharp cases. The analyzed speed of a transition can vary with time and from boundary to boundary.

Future Work
• Refine input image processing and edge detection method to identify boundaries with less defined cloudiness transitions and weaker brightness gradients.
• Determine motion characteristics for our dataset of several hundred boundaries.
• Analyze distribution of motion characteristics in relation to regional environmental conditions.


Acknowledgments: Special thanks to Daniel Hueholt and Ronak Patel for their advice. This research is supported by NSF grant AGS-1556337. Travel grant provided by the NCSU Office of Undergraduate Research.