# Motion Characteristics of Cloud Clearing Boundaries in the Southeast Atlantic

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ENVIRONMENT ANALYTICS

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## Background

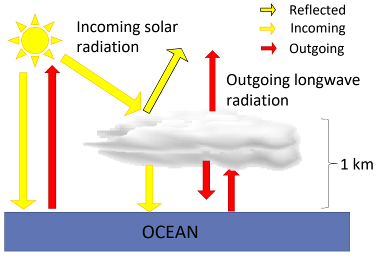



*Figure 1: Diagram showing the cooling nature of low layer clouds over the ocean.*

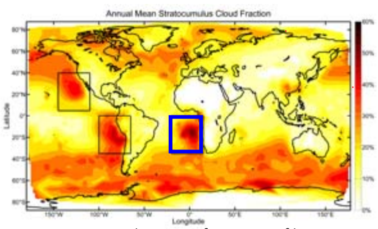



*Figure 2: Annual average frequency of low stratocumulus clouds (Hahn and Warren, 2007).*

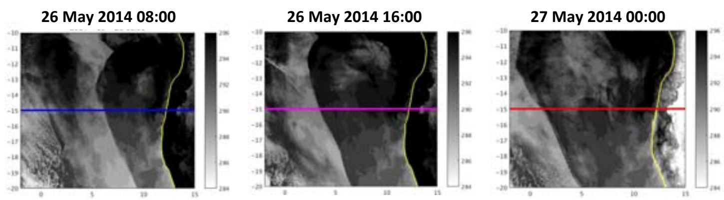
The radiative balance of the Earth can be greatly affected by variance in cloud cover. Processes that can increase or decrease the total global area of cloud cover impact the radiative balance and could offset or enhance warming from $CO_2$ increases.

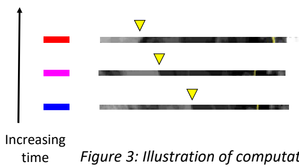
Our study focuses on the southeast Atlantic off the coast of Angola and Namibia (Fig. 2, blue box), where large decks of low clouds (tops <1.5 km in height) commonly form. Recent work has shown that vast areas of these marine low clouds can be eroded along westward-moving sharp lines 1000+ km long.

We are interested in how the speeds of these cloud-eroding lines change with distance from the coast and with latitude along the line.

## Data and Methods

Cases were chosen from a list of several hundred cloud-clearing boundaries identified using satellite imagery (NASA EOSDIS). Plots illustrating the boundary's east-west movement vs. time (Hovmoller plots) were generated across varying focus latitudes. These plots are analyzed to examine changes in speed of the boundaries as a function of distance from the coastline and latitude.



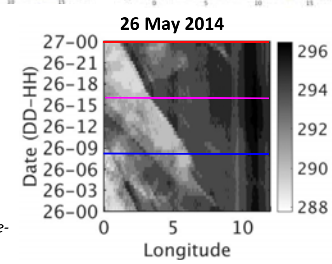




*Figure 3: Illustration of computation of Hovmoller plots. For each time, the corresponding strip at the focus latitude in the IR satellite image is placed in a longitude-time plot.*

## Image Analysis

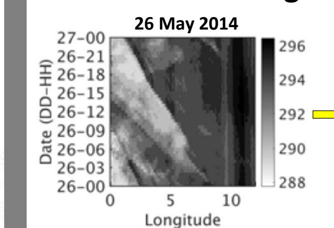



*Figure 7: Original Hovmoller plot.*

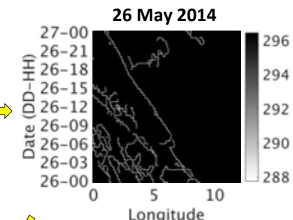



*Figure 8: Hovmoller plot after being passed to edge function that identifies visible edges and returns a binary image.*

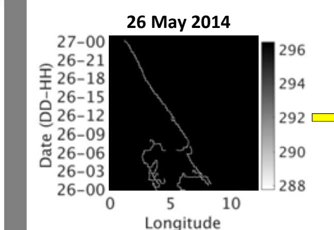



*Figure 9: Remnants of edges after image erosion to further isolate the major slope of the transitional boundary.*

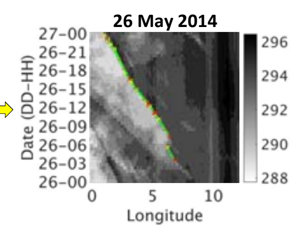
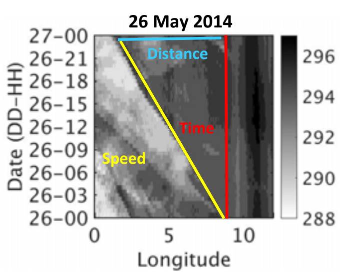



*Figure 10: Identification of longest edge in the image superimposed on original grayscale plot. Once refined, this process will automate calculation of the speed of the cloud-eroding boundary.*

## Assessing Cloud-Clearing Boundary Speed at Different Latitudes



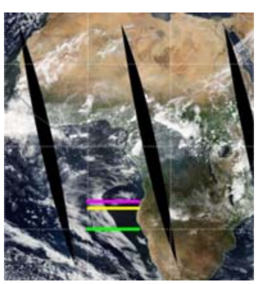



*Figure 4: Hovmoller plot of a single day showing how speed will be calculated (left) and the location of the following Hovmoller plots' focus latitudes superimposed on NASA EOSDIS satellite imagery (right). Along the yellow line at -15 °S, we estimate speed by taking the total distance traveled (~7.5 degrees of longitude, or 806 km) divided by time taken to travel (24 hours) to obtain a speed of ~33 km/hour.*

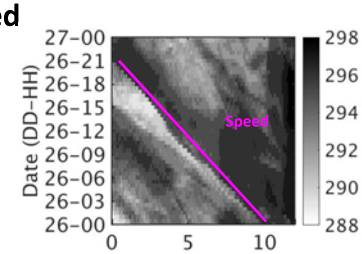



*Figure 5: As in Figure 4, except with focus latitude shifted northward by 2.5 degrees to -12.5° S.*

The slope/speed of the transition from clear to cloudy at -12.5° S is faster (as indicated by the more gradual slope) compared to at -15° S. This boundary traverses 9 degrees of longitude in approximately 21 hours, or ~46 km/hr. Towards the middle of the time period, the transition line speeds up (the divot beneath the speed line).

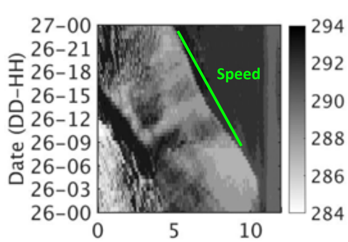



*Figure 6: As in Figure 4, except with focus latitude shifted southward by 5 degrees to -20° S.*

The portion of the cloud-eroding line at -20° S traverses roughly 4 degrees longitude in 14 hours, or ~21 km/hr. At around 09 UTC, the clearing line speeds up and then slows back down (the curve in the slope).

## Summary

A Hovmoller diagram is an excellent tool to visualize the motion of a cloud-eroding boundary. The analyzed speed of a transitional boundary is not uniform across the entire expanse. Different portions of the boundary may move faster or slower and can vary with time.

## Future Work

- Refine the image analysis process to automatically identify the cloud-clearing boundary and estimate its speed.
- Determine motion characteristics for several hundred boundaries.
- Analyze distribution of motion characteristics in relation to regional environmental conditions.

*QR code for web link to movie showing regional view of a westward moving cloud-eroding boundary.*

**Reference**: Yuter, S. E., Hader, J. D., Miller, M. A., & Mechem, D. B. (2018). Abrupt cloud clearing of marine stratocumulus in the subtropical southeast Atlantic. *Science*. doi:10.1126/science.aar5836. Special thanks to Luke Allen, Daniel Hueholt, Levi Lovell, and Ronak Patel. This research is supported by NSF grant AGS-1656237.