3.3 A CLIMATOLOGY OF CLOUDLINES ASSOCIATED WITH THE CHESAPEAKE AND DELAWARE BAYS

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1. INTRODUCTION

Since 1996, National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) images from over the mid-Atlantic coast of the United States have been archived by the Ocean Remote Sensing Group at the Johns Hopkins University Applied Physics Laboratory (JHUAPL). Portions of this archive can be found at http://fermi.jhuapl.edu/. Anomalous cloud lines (ACLs) are observed in many of these images. Examples of such phenomena can be seen in Figure 1, which is a one-kilometer AVHRR image from 1144 UTC, 11

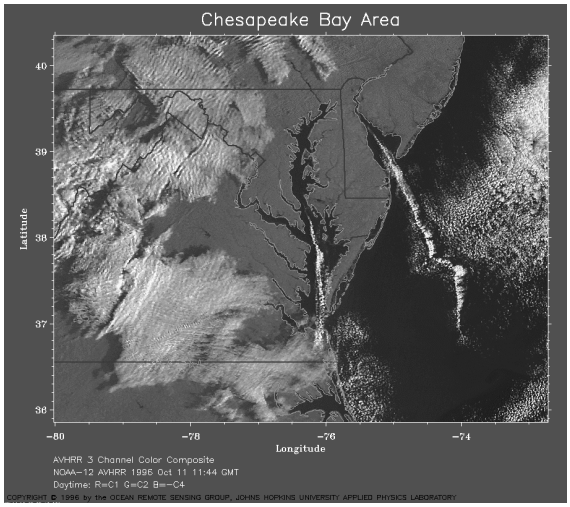

Figure 1. 11 October 1996 AVHRR image

October 1996. The image is a composite of Channels 1 (0.58 to 0.68 µm), 2 (0.72 to 1.0 µm) and 4 (10.3 to 11.3 µm). This combination of channels provided the best view of the early morning scene. ACLs can be seen protruding from the Chesapeake and Delaware Bays. The cloud lines are said to be anomalous because their appearance in the AVHRR image stands out from the ambient clouds in the same scene.

Local National Weather Service forecasters are aware of this type of event and have hypothesized that the phenomenon results from natural mesoscale soleniodal circulations, analogous to what is often observed over and downwind of the Great Lakes during cold air outbreaks. They even refer to the phenomenon as "bay effect." While this explanation is reasonable, a counter-hypothesis is that at least some of the ACLs we observe are anthropogenic, resulting from enhanced convection associated with the exhaust plumes of transiting ships. Sikora et al. (2001) discusses the merits of each of these hypotheses focusing on the cases found in Figure 1 and similarly robust cases found in Figure 2 (image specifications same as for Figure 1).

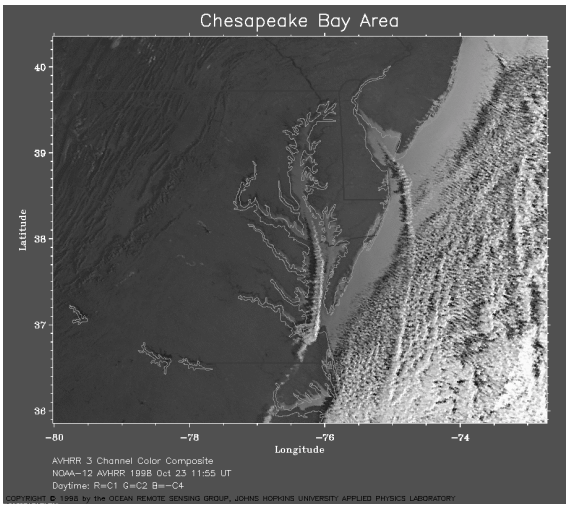

Figure 2. 23 October 1998 AVHRR image

In order to gain more insight into the morphology of ACLs, we have developed a satellite climatology of their occurrence when associated with the Chesapeake and Delaware Bays using the October 1996 to December 2000 AVHRR archive housed at JHUAPL. A corresponding climatology of the near surface meteorological conditions associated with the occurrence of ACLs has also been developed. This paper reports the preliminary results of our research.

2. PROCEDURES

Approximately 10,000 AVHRR images were manually examined yielding 135 independent occurrences of ACLs. An occurrence was documented if, in the subjective opinion of the observer, the cloud line in question was different in appearance from any ambient clouds and was associated with either the Chesapeake or Delaware Bay. There were 103 occurrences when all or a portion of an ACL was located over a particular bay. There were 32 occurrences when an ACL was found to exist completely over the open Atlantic.

Once the satellite climatology was completed, we then complied corresponding near-surface meteorological characteristics of the ACLs. Data from C-MAN CHLC2 (36.90 N, 75.71 W) were used to develop the near surface meteorological climatology of Chesapeake Bay ACLs. Data from NOAA buoy 44009 (38.46 N, 74.70 W) were used to develop the near-

surface meteorological climatology of Delaware Bay ACLs.

3. RESULTS

Table 1 shows the number of independent

TABLE 1

Location	Events
Both Bays	37
Chesapeake Only	25
Delaware Only	36

Table 1. Location of ACL events

events of ACLs broken into three groups. There were 37 independent events when ACLs were associated with both the Chesapeake and Delaware Bays (e.g., Figures 1 and 2). There were 25 independent events when an ACL was only associated with the Chesapeake Bay. There were 36 independent events when an ACL was only associated with the Delaware Bay.

Figure 3 shows the total number of independent

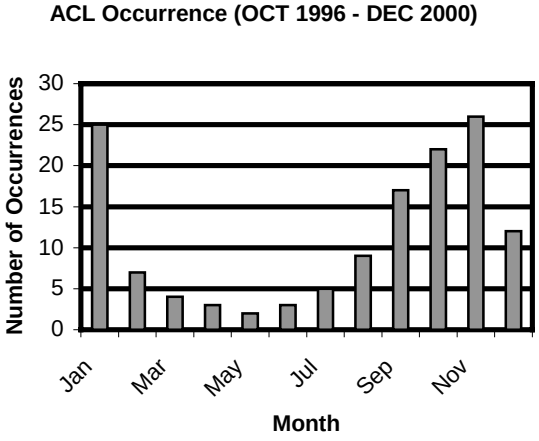

Figure 3. Total ACL occurrence per month

occurrences per month from October 1996 to December 2000. ACLs are more frequent during the cold season and less frequent during the warm season.

Figure 4 shows bay-specific ACL occurrence for the October 1996 to December 2000 time period. During the cold season, ACLs are more frequently associated with the Delaware Bay while the opposite is true during the warm season.

Table 2 shows the corresponding near-surface meteorological characteristics for Chesapeake Bay and Delaware Bay ACL occurrences. Overbars denote mean values. Positive *u* is directed down bay (139^o for the Delaware Bay and 184^o for the Chesapeake Bay)

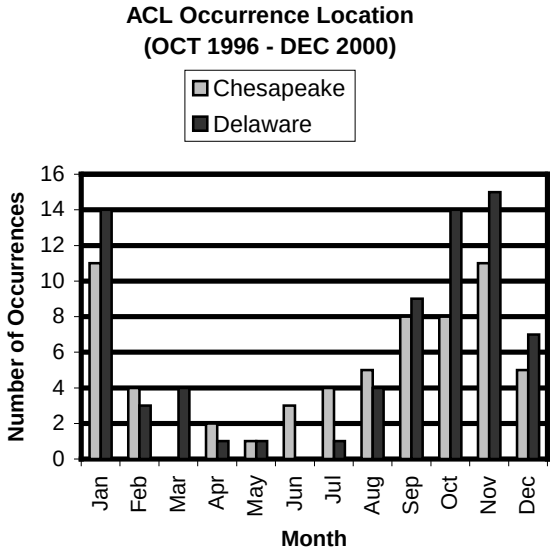

Figure 4. Bay-specific ACL occurrence

TABLE 2

	Chesapeake	Delaware
$\overline{u}$ (m/s)	8.1	8.8
σ_u (m/s)	4.9	4.2
$\overline{v}$ (m/s)	2.3	-0.1
σ_v (m/s)	4.5	3.3
$\overline{\Delta T}$ (K)	-5.7	-6.6
$\sigma_{\Delta T}$ (K)	4.2	3.5

Table 2. Near-surface meteorology for ACLs

and positive *v* is directed 90^o to the left of positive *u*. ΔT is the air-sea temperature difference.

ACL occurrences are generally associated with larger down-bay wind components than cross-bay wind components for both bays. This is truer for Delaware Bay ACLs. However, the orientation of the Delaware Bay is much more constant than that for the Chesapeake Bay. Therefore, this finding may be the result of our choice of orientation for the Chesapeake Bay coordinate system.

ACL occurrences are also generally associated with negative ΔT s, the magnitude of $\overline{\Delta T}$ being slightly larger for Delaware Bay ACLs.

4. REFERENCES

Sikora, T. D., G. S. Young, E. E. O'Marr, and R. F. Gasparovic, 2001: Anomalous Cloud Lines Over the mid-Atlantic Coast of the United States. *Can. J. Rem. Sens.*, In press.