

A Shore-Parallel Cloud Band over Lake Michigan

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1. Introduction

An outstanding example of a shore-parallel cloud band occurred over Lake Michigan on 23 February 1989 (Fig. 1). The cloud band developed in the early morning and remained nearly stationary over the center of the lake throughout the daylight hours. With the exception of the single cloud band, skies were clear over the lake.

2. Discussion

The shore-parallel cloud band event was preceded by an outbreak of arctic air over the Midwest. Cloudiness developed over Lake Michigan on 22 February as cold and strong surface winds blew over the relatively warm lake waters. As is commonly observed over the Great Lakes during wintertime arctic outbreaks, some clouds were organized in the form of wind-parallel bands (e.g., Holroyd 1971; Schoenberger 1988). During the night surface winds subsided to near calm and surface temperatures dropped to near 0°F over much of the western Great Lakes region as the center of the arctic air mass settled over the area. By sunrise on 23 February a single distinct cloud band had formed over Lake Michigan with a north-to-south orientation parallel to the major axis of the lake. The shore-parallel cloud band was well developed over the middle of the lake at 1500 UTC (0900 LST) (Fig. 1). It should be noted here that the University of Chicago cloud physics group refers to shore-parallel bands that occur over the middle of the lake as midlake bands, reserving the term "shore-parallel cloud band" to similar appearing cloud structures occurring very close to the shoreline (e.g., Braham 1983).

While overall the cloud band moved little throughout the day, the southern portion drifted slowly west-

ward. Heavy snow showers were reported when the cloud band moved over the coastline of northeastern Illinois. In fact, station CGX on the southeast side of Chicago reported several hours (1400–1700 UTC) of moderate to heavy snowfall.

Shore-parallel cloud band events are often characterized by the development of a mesoscale vortex (Forbes and Merritt 1984). In this case, however, no vortex was observed. Just prior to sunset, the cloud band began to dissipate and formation of wind-parallel clouds were evident on satellite imagery, especially over southern portions of Lake Michigan. This is in accordance with the observation of Passarelli and Braham (1981) that wind-parallel cloud bands have a tendency to form following decay of a shore-parallel band.

The shore-parallel cloud band observed on 23 February may have been the result of a convergence of nocturnal land breeze fronts originating along the eastern and western shores of Lake Michigan. From a study of lake-effect snow episodes over the Great Lakes, Passarelli and Braham (1981) find that a strong lake-land temperature difference induces a shallow land breeze that may oppose a corresponding land breeze originating from the opposite shore. Numerical simulations of lake-effect snows along the western shore of Lake Michigan by Ballentine (1982) confirm the importance of a significant lake-land thermal gradient in allowing a large transport of heat and moisture into the atmosphere from the lake. The resulting low-level wind confluence coupled with potential instability of the air in contact with the warm lake enhances vertical motion and cloudiness along a line parallel to the long axis of the lake. A typical event develops initially in a relatively tranquil synoptic scale environment and can persist for 12 hours or longer. Observed evidence for such mechanisms operating in the present case include a weak synoptic scale pressure field and a convergent surface wind component over the lake.

The mechanism involved in the maintenance of the shore-parallel cloud band reminds us of conditional instability of the second kind (CISK), a mechanism

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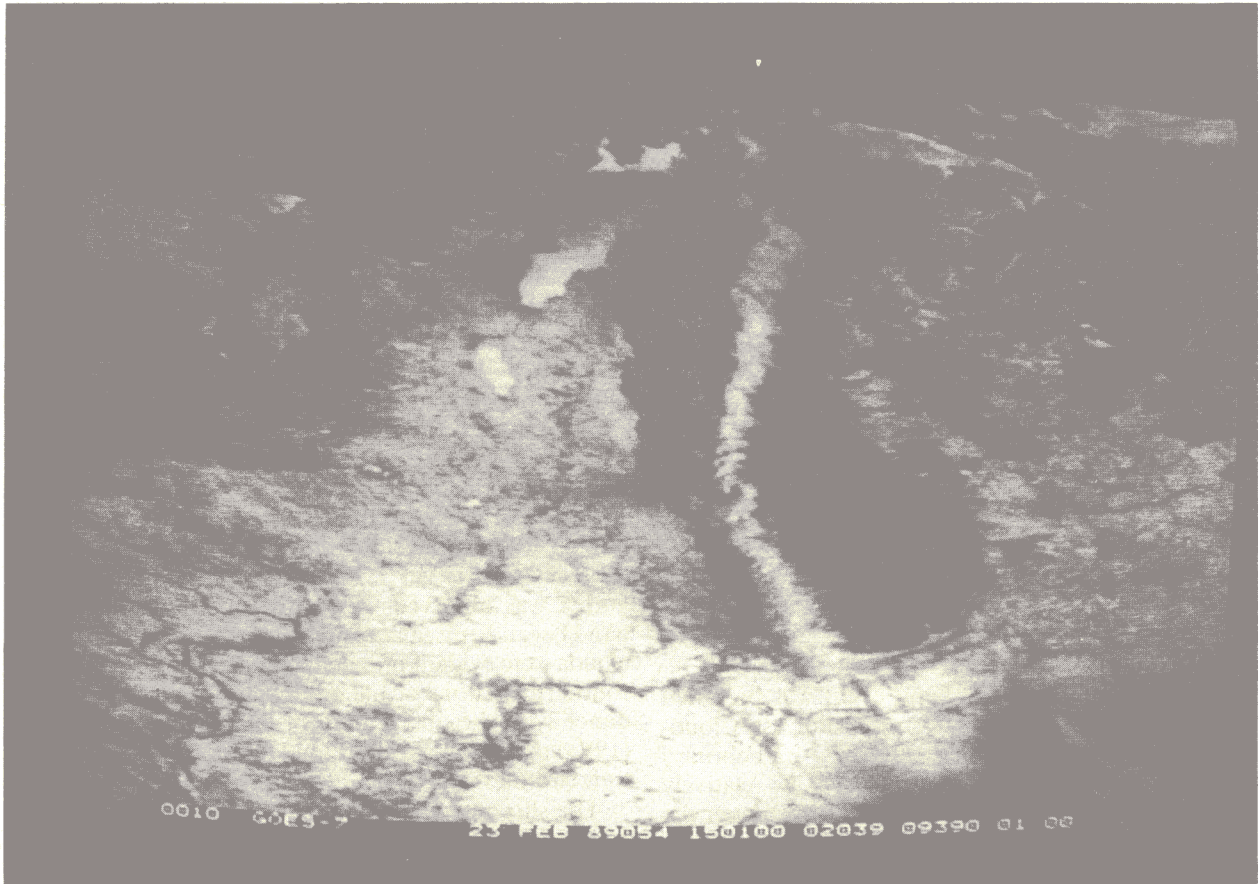


FIG. 1. One-kilometer resolution GOES visible image at 1500 UTC (0900 LST) on 23 February 1989. The image is centered over Milwaukee, Wisconsin on the western shoreline of Lake Michigan.

commonly recognized in the maintenance of tropical disturbances. The CISK mechanism is a positive feedback loop between scales of motion where the inflow of moist surface air fuels the small scale convection in the cloud band, with the convection in turn maintaining the larger scale upper-level outflow and low-level inflow. This idea of positive feedback between the convective and mesoscales in maintaining the stable state of a shore-parallel cloud band has been suggested previously by Passarelli and Braham (1981). Finally, preliminary results for the present case indicate that disruption of the feedback loop and thus dissipation of the shore-parallel cloud band is the result of warm advection at low levels over parts of the region.

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