# Improvements to GOES Twilight Cloud Detection over the ARM SGP

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## I. Introduction

### a) Definition of Twilight

- Here twilight is defined as when $82.0 < \theta < 87.5$, where $\theta$ is the solar zenith angle

### b) Challenges of Twilight Cloud Detection

- Very little visible reflectance
- Low water clouds have little thermal contrast with the underlying surface
- A small solar component negates the usefulness of channels near 3.7 µm

## II. Method

- Method is summarized in Figure 1
- The Visible Infrared Solar-infrared Split-window Technique (VISST) uses a version of the Clouds and the Earth's Radiant Energy System (CERES) cloud mask (CM) as the primary method of cloud detection
- Mean clear and cloudy brightness temperatures (BTs) and other statistics are calculated from the satellite observations preceding twilight
- During twilight, the CERES CM is executed as usual
- After the cloud masking is performed, these statistics and the CM results are compared to the observations for each pixel under twilight conditions
- Depending on the CM result and how well the twilight statistics match the statistics from the preceding satellite overpass, the CM is adjusted
- This statistical algorithm is supplemental to the CERES CM and is designed to detect as much cloud as possible while minimizing false cloud detections

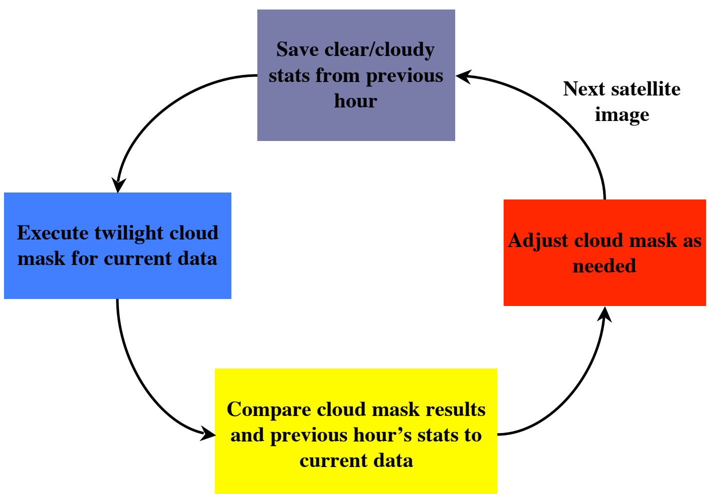


**Fig. 1.** Flowchart illustrating the new twilight cloud detection process

## III. Improved Cloud Detection over the SGP

- GOES-8 data from June to November 1998 were reprocessed over a region within a 10-km radius of the ARM SGP Central Facility using the new stats algorithm to aid cloud detection during twilight
- Table 1 shows how the new VISST cloud amounts compare to 30-minute averaged cloud amounts derived from micropulse lidar (MPL) data. Values in parentheses were obtained without using the stats algorithm

| | | ARM Cloud Amount (%) | | |
|---|---|---|---|---|
| | | ≤ 5 | 5 < CA < 95 | ≥ 95 |
| VISST Cloud Amount (%) | ≤ 5 | 60.5 (84.9) | 18.2 (29.5) | 1.7 (6.8) |
| | 5 < CA < 95 | 34.9 (12.8) | 52.3 (40.9) | 40.7 (42.4) |
| | ≥ 95 | 4.7 (2.3) | 29.5 (29.5) | 57.6 (50.8) |

**Table 1.** Comparison of VISST and 30-minute averaged cloud amounts from MPL data. Values in parentheses were obtained without use of the stats algorithm.

- An example from June 5, 1998, is illustrated in Figure 2 below
- Most of the warm low clouds over Kansas and northern Oklahoma were detected by the nighttime cloud mask at 1115 Z (not shown) but missed by the twilight cloud mask at 1145 Z (Fig. 2a)
- The stats algorithm restores much of the cloud cover (Fig. 2b) and this is easily verified by looking at an enhanced visible satellite image (Fig. 2c)
- A red circle indicates the location of the ARM site (36.62°N, 97.50°W)

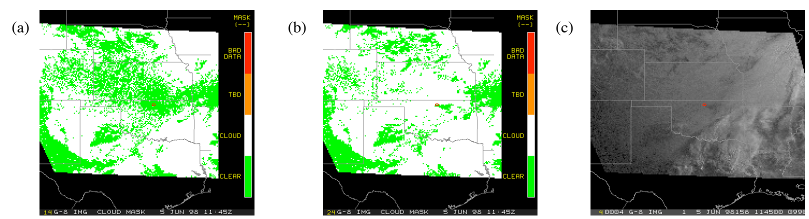


**Fig. 2.** Images of (a) the CERES cloud mask at 1145 Z, (b) the CERES cloud mask at 1145 Z after re-processing with the new stats algorithm, and (c) an enhanced GOES-8 visible image at 1145 Z.

## IV. Summary

- An algorithm has been developed to aid cloud detection during twilight hours
- Satellite observations are compared to clear and cloudy statistics from the previous satellite overpass to provide a smoother transition from the daytime to the nighttime cloud mask algorithm
- The initial results indicate that cloud detection increased by about 10% when compared to the MPL data using the new algorithm
- The statistical approach outlined here is supplemental to the CERES cloud mask and is not intended to replace a rigorous cloud mask algorithm

## V. Acknowledgments

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