Improvements to Near-Real-Time Cloud Detection Near the Terminator and Impact on Diurnal Trends of Cloud Properties

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Introduction

Automated cloud detection in satellite imagery near the day/night boundary known as the terminator is uniquely difficult because of the low signal-to-noise ratio in visible (VIS) channels and in the solar component of shortwave-infrared (SIR) channels. Surface features also make clear-sky VIS and SIR reflected radiance difficult to model. False cloud detections may appear near the terminator when predicted clear-sky VIS and SIR radiances are inaccurate as shown below. The retrieved cloud properties for these false detections contaminate the mean macro- and microphysical cloud properties derived over ARM sites. The extent of the contamination is quantified in this study at the ARM SGP site and the AMF site in Germany.

Methods

Use cloud fraction, mean clear T11, standard deviation of clear T11, and predicted clear-sky T11 on a 0.5-degree grid from previous images to eliminate false clouds.

Assume clear T11 are normally distributed and that mean clear T11 and mean cloudy T11 have different values.

Use predicted clear-sky T11 to account for any warming or cooling within gridboxes.

Compute confidence score to ensure that observed scene is known in terms of mostly clear (CF < 0.5) and mostly cloudy (CF > 0.5) scenes.

Apply algorithm to the daytime side of the terminator where SZA < 88.5°.

Results – Southern Great Plains, Central Facility

The Active Remote Sensing of Clouds (ARSLC) products were used to independently assess the performance of the standard and modified cloud masks near the terminator. The months of September 2004 and October 2008 were characterized by relatively low mean cloud fraction (CF < 0.5), and these months were chosen for the analysis because of the increased opportunity to reduce false cloud detections. GOES-10 and GOES-12 cloud properties were averaged within a 50-km radius of the SGP, and the ARSCL products were averaged over a 15-minute interval centered at the satellite image times. Results for the daytime and nighttime side of the terminator are also shown for comparison.

Results – Black Forest, AMF

Cloud properties were analyzed in a similar way for Meteosat-8 and 9 data over the AMF site in Germany. ARSCL products were not available so Vaisala Ceilometer (VCBL) products were used instead. However, the ceilometer lacks sensitivity to high cirrus clouds. Therefore, ice clouds with a satellite-retrieved altitude > 7 km and optical depth < 6 are excluded from this analysis. Results are shown for December 2007.

Summary

False cloud detections near the day-night terminator result from inadequate modeling of visible and SIR reflectance at high SZA. Cloud fraction and observed and predicted T11 from prior scans were used to eliminate false cloud detections near the terminator where neither daytime nor nighttime cloud detection methods can be directly applied.

Unrealistic peaks in mean cloud fraction near sunrise and sunset are eliminated using the described method. The method demonstrates skill when applied to GOES-10, GOES-11, GOES-12, Meteosat-8, and Meteosat-9 data over the SGP and AMF Black Forest sites and so appears to be fairly robust.

Cloud fraction, particle size, and top height are the most significantly impacted retrievals with percent differences ranging from 6-12%.

False alarm rates for the Meteosat retrievals over the AMF Black Forest site are higher than GOES in part because the Vaisala ceilometer lacks sensitivity to clouds higher than ~7km. A combined radar/fluor probe like ARSCL can be used in the future to produce a more complete assessment involving all cloud types.