A 3-channel Algorithm for Retrieving Spatially and Temporally Continuous Cloud Properties Across Different Geostationary Satellite Imagers

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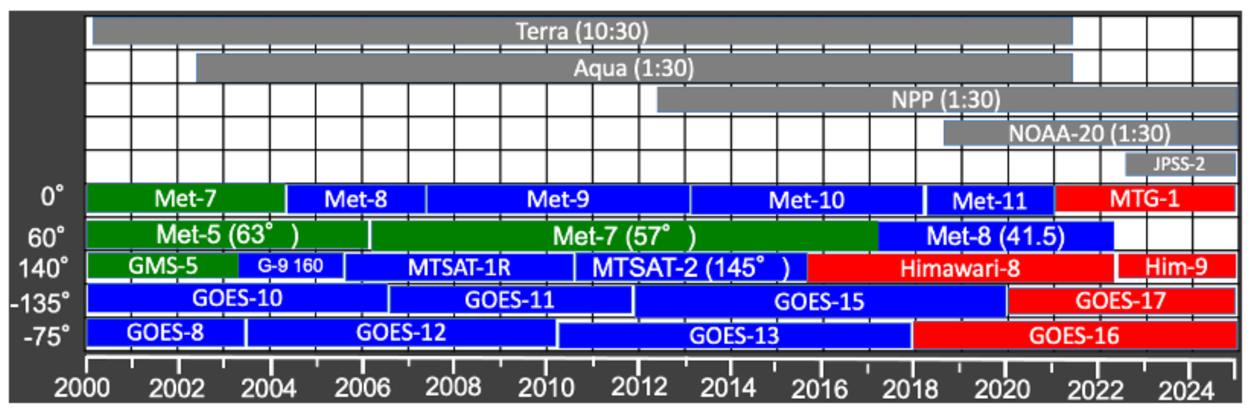
Introduction

Cloud property retrieval algorithms for passive satellite imagers are generally designed to take advantage of all the useful spectral information available for a particular satellite. This strategy optimizes accuracy and reduces misidentification and retrieval biases, particularly for modern satellites with many spectral channels. However, the application of dissimilar algorithms tailored for different satellite sensors can present a problem within the climate data record (CDR). Algorithm inconsistencies can introduce artificial trends in the CDR that are tied to instrument changes rather than physical changes, especially when older satellites with limited spectral information are included. The NASA CERES (Clouds and the Earth's Radiant Energy System) data record provides global cloud property retrievals across 23 years and more than 25 satellites. With the goal of producing a spatially and temporally continuous record of cloud properties, the CERES cloud working group has developed algorithms that use only 3 channels that are common to most geostationary satellite imagers: 0.65, 3.9, and 10.8 μm.

The CERES Data Record

The NASA CERES instruments have been providing information about the Earth Radiation Budget (ERB) since the launch of Terra in 2000. Cloud properties from co-located high spatial resolution imagers are necessary to produce data products that describe the ERB at TOA, within the atmosphere, and at the surface. CERES Edition 4 cloud properties are derived using the available spectral information from each imager, and are used to provide hourly estimates of ERB.

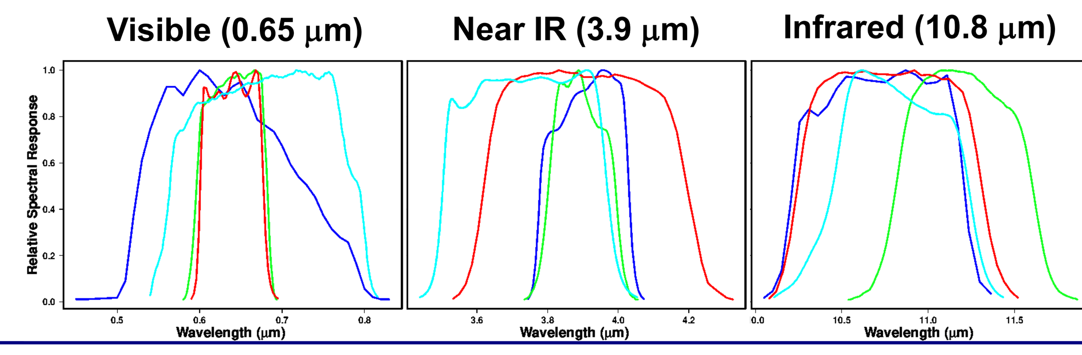


Satellite imagers included in the CERES data record, from 2000 to present.

Polar-orbiting imagers
Geostationary imagers with:
2 channels 5 channels 16 channels

CERES Edition 5 cloud property retrievals will use the 3 spectral channels that are common to most of the instruments shown above. Differences in instrument SRF are accounted for in all clear-sky predictions and cloud models, allowing for an identical retrieval algorithm to be applied to all instruments.

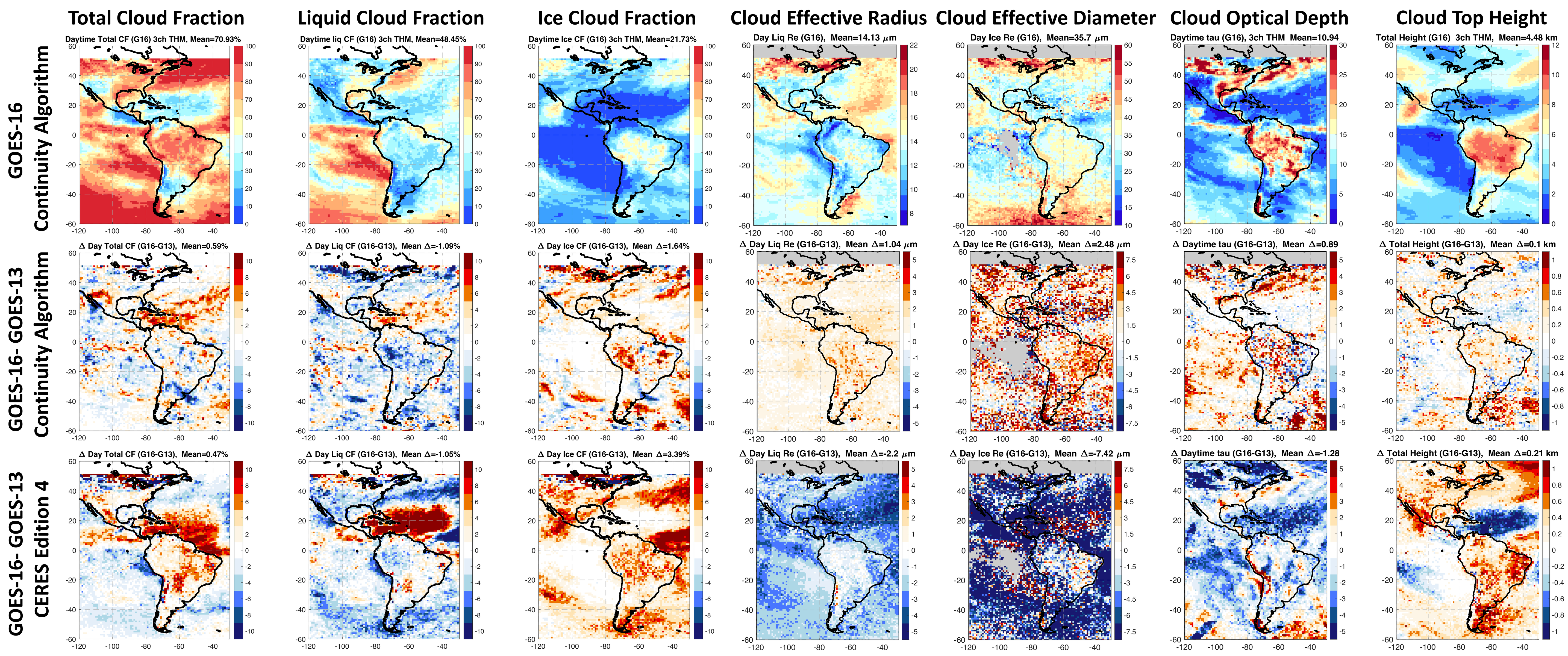
GOES-8 like instruments (GOES 8-15)
MTSAT like instruments (MTSAT 1-2)
GOES-16 like instruments (GOES 16-18, HIM 8-9)
MSG Seviri like instruments (MET 8-11)



Assessing Intra-Satellite Continuity in Cloud Properties

Temporal Continuity Between Modern and Legacy Satellites: GOES-16 and GOES-13

GOES-16 and GOES-13 simultaneously viewed the same GOES-East domain from Dec 14-Dec 31, 2018. To minimize the impact of instrument spatial resolution differences, the visible and IR data for both are averaged to 4 km resolution, then subsampled to 8 km for comparison with CERES Edition 4 products.

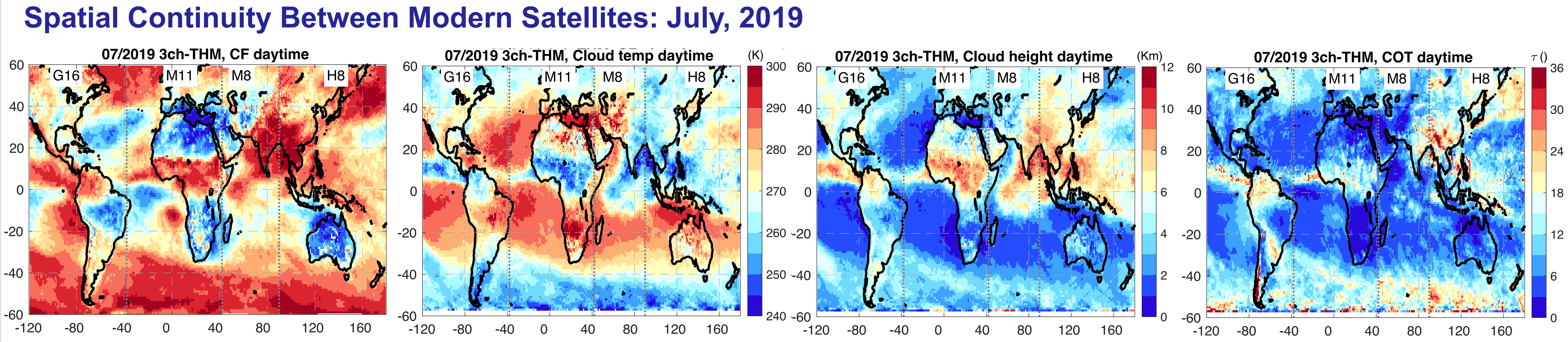


All retrieved cloud properties show better continuity between GOES-13 and GOES-16 with the new algorithm than was the case for CERES Edition 4.

Regional biases in cloud fraction are reduced, but some still exist, particularly over the Caribbean. This is especially apparent for liquid cloud fraction.

There is significant improvement in the continuity of cloud optical depth, height, and particle size, and regional differences are now minimized.

Spatial Continuity Between Modern Satellites: July, 2019

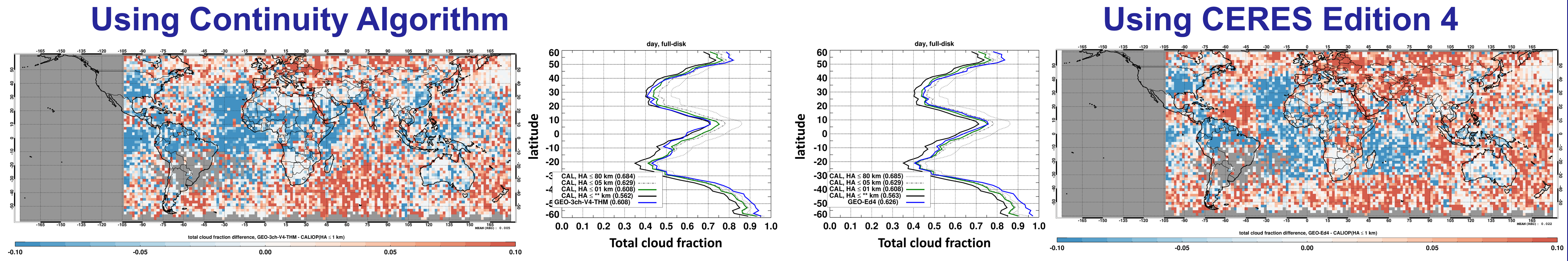


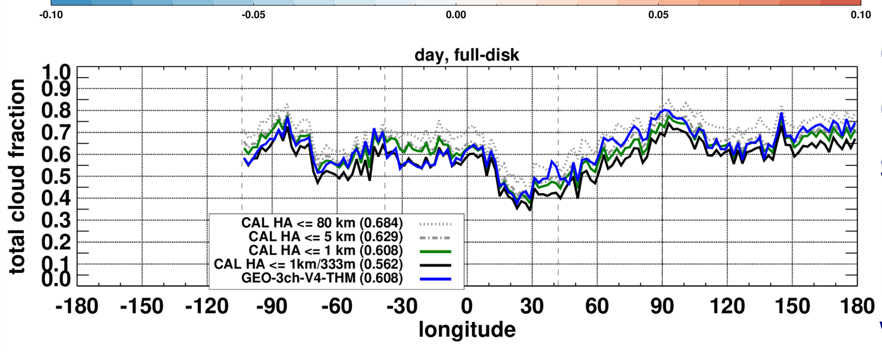
Daytime cloud fraction, temperature, height and optical depth are smooth and continuous across satellite boundaries. Improvement over CERES Edition 4 (not shown) is primarily due to improved accounting for satellite-specific instrument response functions in all clear-sky predictions (including atmospheric absorption and overhead albedo), as well as the introduction of satellite-specific cloud reflectance models.

Algorithm Accuracy vs. Legacy Algorithms

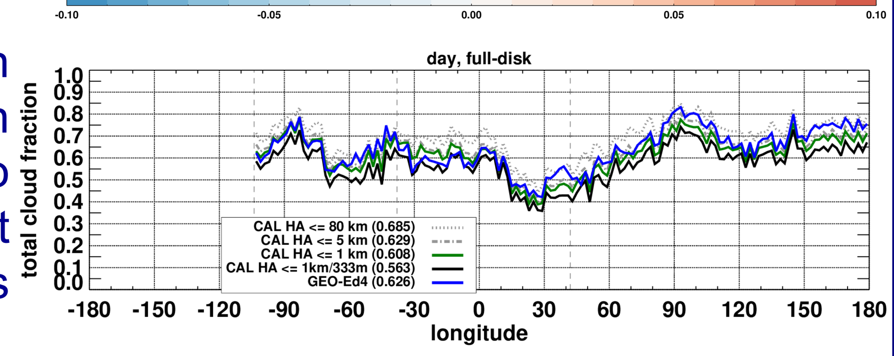
Daytime Cloud Fraction vs. CALIPSO

Using Continuity Algorithm | **Using CERES Edition 4**





Cloud fraction agreement with CALIPSO is similar to Edition 4, with some improvements (likely due to better clear-sky prediction). Agreement may be slightly deteriorated in regions where cirrus is prevalent.



Conclusions

Cloud property retrievals achieve maximum accuracy by using all the relevant spectral information available for a particular satellite. This method poses a problem for the climate data record, when satellite and retrieval algorithm differences introduce discontinuities in retrieved cloud properties. By correctly accounting for specific instrument spectral response and applying a consistent algorithm across the entire record, we can improve spatial and temporal continuity in cloud properties and better assess long term trends.

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