A Comparison of MODIS and ISCCP Global Cloud Statistics

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I. Introduction

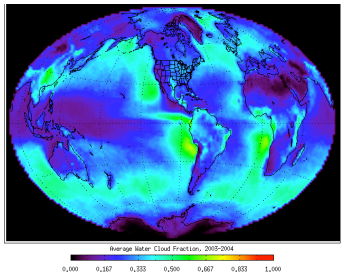
Two of the most important cloud properties in the study of Earth's climate are particle effective radius and cloud fraction. The Moderate Resolution Imaging Spectroradiometer (MODIS) provides an unprecedented opportunity to obtain measurements of these cloud properties. The International Satellite Cloud Climatology Project (ISCCP) also collects these data from a suite of weather satellites operated by several nations. MODIS data and ISCCP D1 and D2 datasets are publicly available. Since MODIS and ISCCP collect their data independently of each other, we would like to know if both datasets are finding the same general global features. In this study, we compare the cloud fraction and particle effective size from MODIS Level-3 cloud products (King et al., 2003; Platnick, et al. 2003) and ISCCP data (Rossow and Schiffer, 1991; Han et al. 1994)

II. Cloud Fraction Comparison

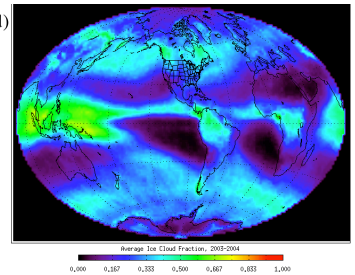
Since clouds generally reflect incoming solar radiation and trap longwave radiation emitted by Earth, knowing the fraction of global cloud coverage is crucial to understanding Earth's radiation budget. For this study, global monthly mean (Level 3) Aqua MODIS cloud fraction was obtained and averaged over a two year period. The same was done for the data obtained from the ISCCP, except it was averaged over a nineteen year period. While Level 3 MODIS data is provided on a 360° by 180° grid, ISCCP data is provided on a 144 by 72 grid. In order to do a pixel-by-pixel comparison, we interpolated the ISCCP data to a 360° by 180° grid.

Shown below is the average water cloud fraction from (a) Aqua MODIS and (b) the ISCCP D2 dataset. Even with its relatively small dataset, the MODIS image shows many of the same features as the ISCCP image. Panel (c) shows the zonal mean water cloud fraction for Terra MODIS, Aqua MODIS, and ISCCP. MODIS and ISCCP show the same features, such as the primary peak between 40°S and 60°S, the peak at the equator, and the minimum around 65°N. Panels (d) and (e) show ice cloud fraction for Aqua MODIS and ISCCP data respectively. The two images match very well equatorward of 50°N and S latitude, but show some differences outside this range. Panel (f) shows the zonal mean ice cloud fraction. MODIS and ISCCP show the same features and even about the same magnitude equatorward of 50°N and S. Poleward of these regions however, the two datasets differ greatly, with ISCCP showing much higher cloud fraction. Because MODIS and ISCCP classify clear and cloudy pixels differently and use different thresholds, and because separating ice clouds from surface ice and snow is difficult, we can expect less agreement between the two datasets near the poles than at lower latitudes.

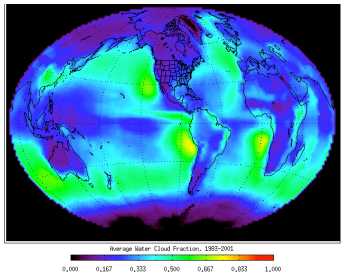
(a)



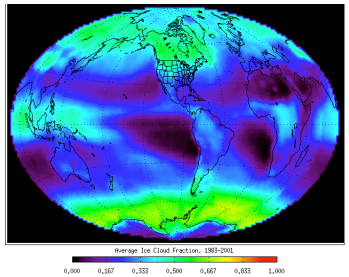
(d)



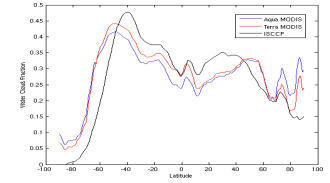
(b)



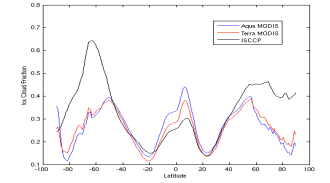
(e)



(c)



(f)

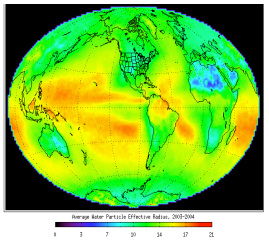


III. Effective Particle Radius Comparison

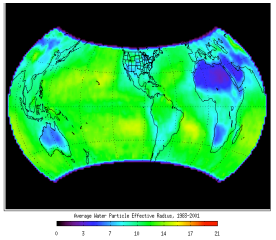
The cloud effective particle radius (EPR) is an important microphysical property in the parameterization of clouds. The cloud EPR is an average over the distribution of particle sizes within a cloud. The Advanced Very High Resolution Radiometer (AVHRR), aboard the NOAA-9 and NOAA-10 satellites, has acquired global long-term EPR measurements. These measurements are available from the ISCCP D1 dataset at a resolution of 2.5° by 2.5°. Since global monthly mean MODIS data has a resolution of 1° by 1°, we interpolated the ISCCP data to a final grid size of 360° by 180° in order to make a pixel-by-pixel comparison. Furthermore, the ISCCP only provides cloud EPR retrievals between 50°N and 50°S latitude.

Shown below are global images of water cloud EPR obtained by (a) MODIS and (b) ISCCP. Panel (c) shows the zonal mean water cloud EPR for each of the seasons. MODIS and ISCCP both show minima in EPR over northern and southern Africa, Australia, eastern Asia, and the central United States, but they disagree over the magnitude of these minima. In fact, panel (c) shows that MODIS frequently finds larger EPR values than the ISCCP, sometimes by as much as 5-7 μm. Previous studies discovered larger water cloud droplets over marine environments than over land. Both the MODIS and ISCCP data show larger cloud EPR over the Southern Hemisphere, which is covered by much more water than the Northern Hemisphere. It should be noted that the sharp drop in EPR around 50° north and south latitude in the ISCCP data is merely due to interpolation near the boundary of the dataset and is not representative of the data.

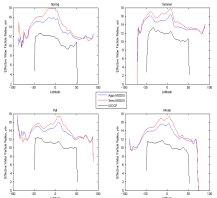
(a)



(b)

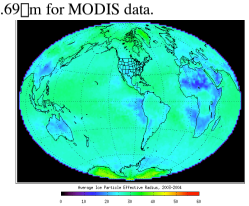


(c)

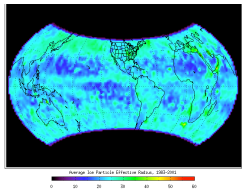


The images below are ice cloud EPR obtained from (d) Aqua MODIS and (e) ISCCP. Panel (f) shows the zonal mean ice cloud EPR for each of the seasons. Again, the ISCCP and MODIS curves differ by as much as 7μm, with MODIS reporting mostly higher values. Only in the fall do the two datasets show some of the same trends. However, MODIS and ISCCP did find similar relationships over land and ocean environments. In the Northern Hemisphere, the mean ice cloud EPR over the ocean was slightly larger than the EPR over land. Conversely, in the Southern Hemisphere, the mean ice cloud EPR over land was slightly higher than over the ocean. The magnitude of this difference was between 0.24μm - .75μm for ISCCP data and between 1.22μm and 4.69μm for MODIS data.

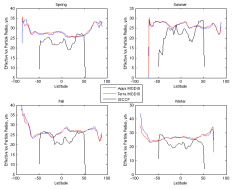
(d)



(e)



(f)



IV. Summary

MODIS and ISCCP cloud fraction show the same trends and magnitude for both water and ice clouds. The only major exception is near the poles where it is difficult to distinguish clouds from surface snow and ice. The ISCCP has nearly twenty years of data, while Terra MODIS is restricted to five years. This likely accounts for many small differences in both cloud fraction and effective particle radius. It does not seem likely that the different wavelengths used to retrieve cloud EPR explains the disparity here. MODIS uses the 2.1μm channel, which we expect to penetrate deeper into the cloud than AVHRR's 3.7 μm channel. Other studies found that cloud EPR increases with height in nonprecipitating clouds, and therefore we expect MODIS to find smaller EPR values than AVHRR. In fact, we found the opposite situation; MODIS values are generally larger than AVHRR. Instead, it seems more likely that the different cloud mask algorithms generate different cloud fraction and cloud EPR results. Despite these differences, MODIS and ISCCP show similar global trends.

V. References

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King, M. D., W. P. Menzel, Y. J. Kaufman, D. Tanre, B. C. Gao, S. Platnick, S. A. Ackerman, L. A. Remer, R. Pincus, and P. A. Hubanks, 2003: Cloud and aerosol properties, precipitable water, and profiles of temperature and humidity from MODIS. IEEE Trans. Geosci. Remote Sens., 41, 442-458.

Platnick, S., M. D. King, S. A. Ackerman, W. P. Menzel, B. A. Baum, J. C. Riedi, and R. A. Frey, 2003: The MODIS cloud products: Algorithms and examples from Terra. IEEE Trans. Geosci. Remote Sens., 41, 459-473.

Rossow, W. B., and R. A. Schiffer, 1991: ISCCP cloud data products. Bull Amer. Meteor. Soc. 72, 2-20.