Comparing CALIPSO and ground-base measurements of clouds at Camagüey.

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Introduction:

The Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) aboard the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite provides a new view of cloud properties data with high resolution around the world, especially semitransparent and optically thin clouds. Assessment of this useful data comparing with data from ground-base measurements is very important for increasing the knowledge about clouds and their representation in climate models. In this paper Cloud Optical Depth (COD) lower than 5 from level 2 version 3.01 cloud profile data of CALIPSO [2006-2014] measurements is compared with COD <5 obtained from AErosols RObotic NETwork ground-base sun photometer (AERONET)[2010-2014]. Cloud frequency was also computed for each datasets as a ratio between cloud measurements and all possible measurements made for each instrument.

Dataset and Methods:

CALIPSO:

Cloud profile dataset level 2 version 3.01 from CALIOP measurements is used. It has 5 km of horizontal resolution, having 20 km of maximum altitude. Cloud optical depth (COD) below 5 and cloud frequency is assessed from this dataset. The time period of CALIPSO data employed in this investigations spans from June 2006 until November 2014. Cloud frequency for the survey region was computed as a ratio of total cases where the cloud type is observable in the column and total column measurements.

AERONET:

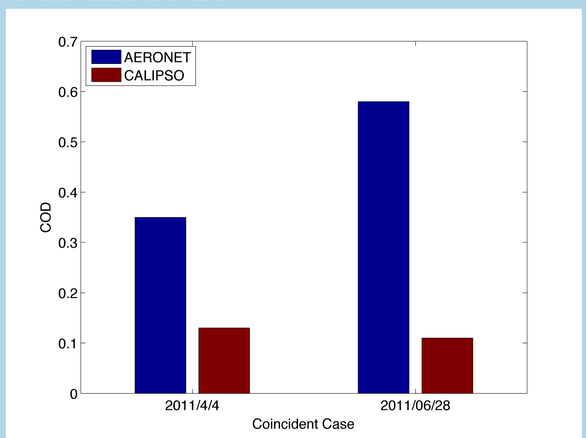
At Camaguey a Cimel sun photometer belonging the Iberian network for aerosol measurements (RIMA, in Spanish) was installed from 2008 as part of AERONET. Aerosol optical depth (AOD) is determined using Direct Sun measurements. The Direct Sun measurements are also used for screening out clouds contamination in the aerosols measurements. Thus, the AOD dataset have three quality levels the “1.0” with the raw dataset, the level “1.5” with the measurements with cloud contamination screened and the level “2.0” with the pos-calibration correction applied. The measurements of sky radiances are employed for computing other aerosols properties and Cloud Optical Depth (COD). COD is computed from the radiance measured in Cloud Mode operation, when the sun photometer is not able to make measurements of aerosols when clouds block the sun. In this stage the instrument point to the zenith to make irradiances measurements. Cloud frequency from Cimel sun-photometer dataset is computed as a ratio between the sum of all cloud mode measurements and the differences between 1.5 and 1.0 of AOD level, and all sun measurements(AOD_1.0 +COD). The AERONET data used for this investigations span from June 2010 up to August 2014.

Comparison Design:

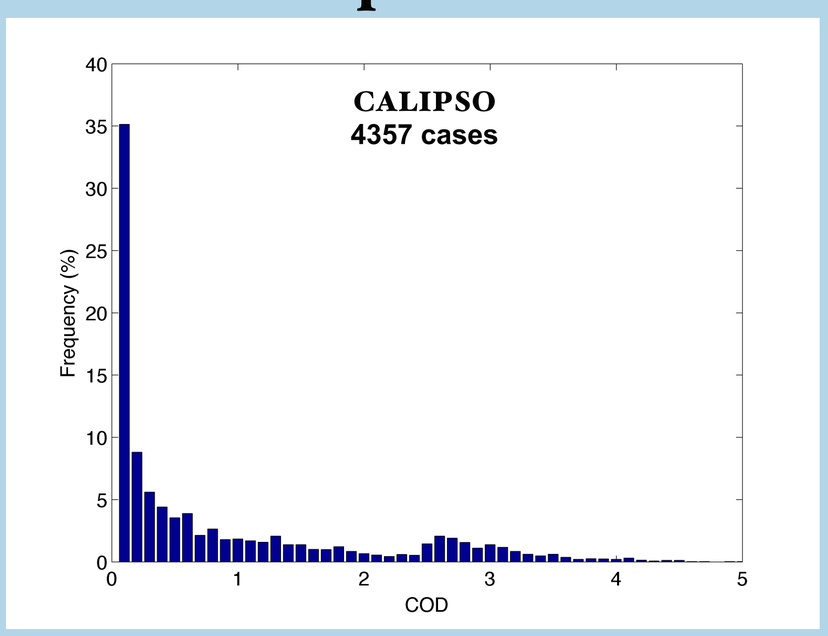
Results:

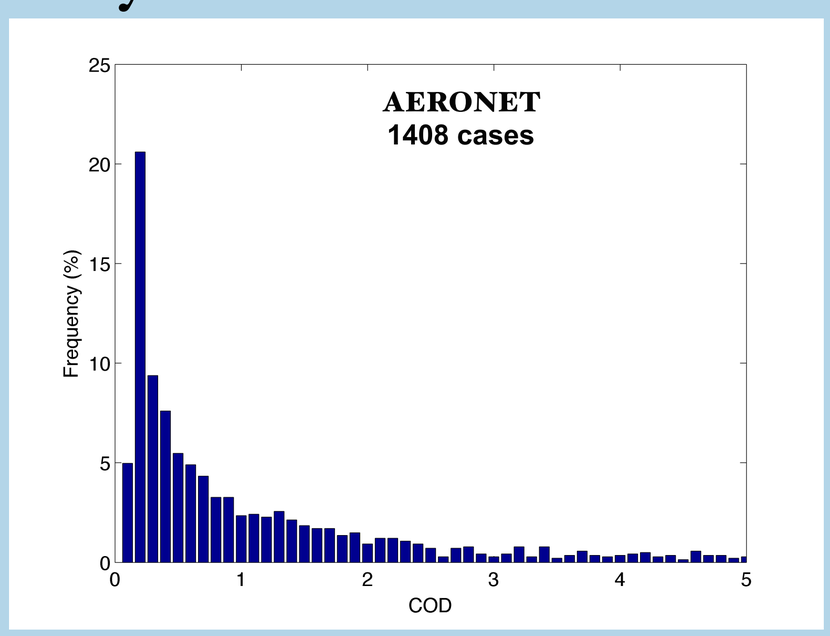
Coincident Comparison:

We look for cirrus clouds with long time duration because of the time lag between AERONET and CALIOP measurements (+ 5 hours). Therefore clouds cirrus must be observed the day before, from which AERONET COD is selected, also in the beginning of the day of CALIOP measurements there must be also cirrus cloud reported. Two COD coincident measurements were retrieved, Both coincident measurements show higher COD values for AERONET .



General Comparison: COD frequency Distribution





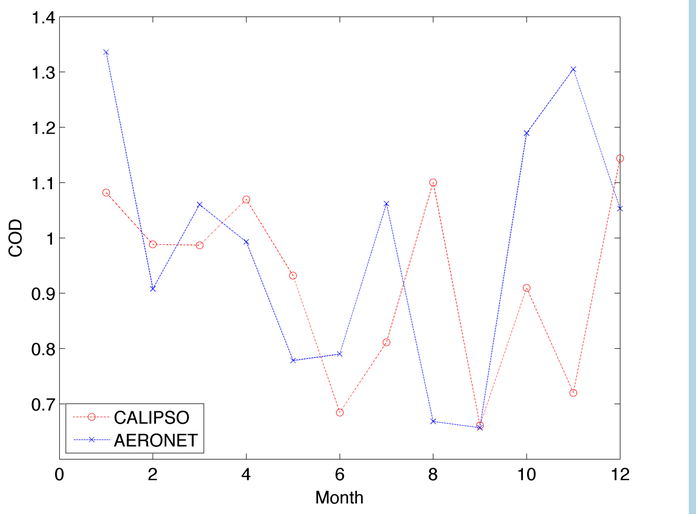
Both distributions have differences especially in the bin centered at 0.1 and 0.2 of COD value. At 0.1 CALIPSO has the maximum value with 35.1%, in this bin AERONET only has a 5 %. In contrast AERONET has the maximum placed at 0.2 with 20.6 %, in this COD interval CALIPSO has only 8%. CALIPSO COD values are most grouped to the lowest values with almost 70 % of the values correspond to COD values below 1 for CALIPSO and 66 % for AERONET.

Monthly General Comparison

Month		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lineal Regression	M (slope)	0.32	0.48	0.36	0.78	0.39	0.78	0.83	0.66	0.73	0.57	0.39	0.32
	N (intersect)	1.35	1.04	1.28	0.44	1.22	0.44	0.33	0.68	0.55	0.85	1.22	1.35
	Correlation Coefficient	0.20	0.41	0.23	0.75	0.30	0.50	0.53	0.65	0.58	0.50	0.16	0.45
Maximum frequency location	AERONET	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	CALIPSO	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Absolute mean differences of COD Distribution	At 0.1	-32.0	-25.3	-32.6	-13.9	-29.4	-33.7	-30.4	-17.4	-28.1	-22.0	-41.8	-32.0
	At 0.2	7.3	14.5	14.5	7.3	21.9	11.5	9.9	12.2	16.8	12.9	8.5	7.3
	Total	2.0	1.7	2.2	1.3	2.2	2.1	1.9	1.8	1.8	1.6	1.9	2.0
Test-student hypothesis at 5 %		0	0	0	0	0	0	0	1	0	1	1	0
CALIPSO cases		175	112	173	286	207	605	553	636	512	536	376	186
AERONET cases		170	145	122	148	115	86	71	59	65	110	195	122

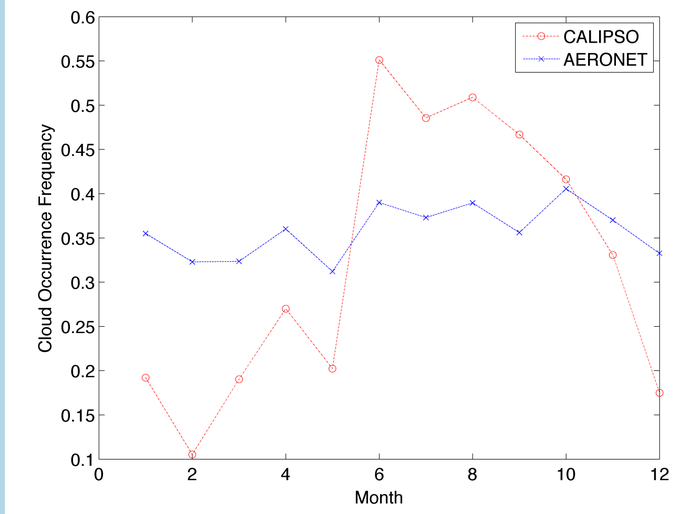
COD datasets have not good match in almost all the months of the year, only on April there is a good agreement with the slope nearest to 1 and y intersect close to 0. In April the lowest mean difference between both dataset COD distributions is also found out with 1.3 %. In this month the Spearman correlation coefficients is the highest with 0.75. It is also important to note, there are 3 months of the year where there are significant statistical differences at 5 % between both datasets (August October and November). The worst agreement between both datasets was found in November with the lowest correlation coefficient.

Mean Annual Cycle: COD



Both datasets do not clearly show a seasonal behavior, maximum values for AERONET (CALIPSO) are placed at January (December) with 1.33 (1.1). Opposite, the minimum mean values are placed in September with 0.65 (0.66). The higher differences between mean values of both COD datasets are found out in January, July, October and November with values between 0.28 and 0.58. The lower differences in mean values are placed in Mars, April and September with differences being below 0.07.

Cloud Occurrence Frequency



In general annual cloud occurrence cycles agree between both datasets, showing the pattern of the cloudiness characterizing the region and seasonality. There is seasonal behavior where the higher values are found at months in the rainy season exclusively since June to October, this seasonality is more appreciated in the CALIPSO cloud frequency. The minimum frequency value for CALIPSO (AERONET) is placed on February (March), the maximum in June (October). The decreasing in July due to the summer drought is also shown..

Conclusions:

Coincident comparison between AERONET and CALIOP COD datasets was made obtaining only two cases with higher values for AERONET COD. General comparison of COD distribution shows differences especially in the bin centered at 0.1 and 0.2. Both COD datasets have significant statistical differences at 5 %. Monthly general comparison shows differences along of the year; April is the month with best agreement. There are also differences between annual cycles of COD mean values where there is not clearly seasonal behavior. In general annual cloud occurrence frequency cycles agree between both datasets, showing the pattern of the cloudiness characterizing the region and seasonality. This seasonality is more appreciated in the CALIPSO cloud frequency.

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