“Caribbean Test-bed for Saharan Dust Long and Short Range Transport."

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Introduction: Aerosols transport in climate models.

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Key Points:
- CMIP5 models underestimate African dust emission and transport
- The dust size distribution is biased toward small particles in CMIP5 models
- CMIP5 models do not represent coupled processes that involve African dust

Supporting Information:
- Readme
- Text S1
- Table S1
- Figure S1
- Figure S2
- Figure S3

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An analysis of aeolian dust in climate models

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Abstract Aeolian dust is a key aspect of the climate system. Dust can modify the Earth's energy budget, provide long-range transport of nutrients, and influence land surface processes via erosion. Consequently, effective modeling of the climate system, particularly at regional scales, requires a reasonably accurate representation of dust emission, transport, and deposition. Here we evaluate African dust in 23 state-of-the-art global climate models used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. We find that all models fail to reproduce basic aspects of dust emission and transport over the second half of the twentieth century. The models systematically underestimate dust emission, transport, and optical depth, and year-to-year changes in these properties bear little resemblance to observations. These findings cast doubt on the ability of these models to simulate the regional climate and the response of African dust to future climate change.

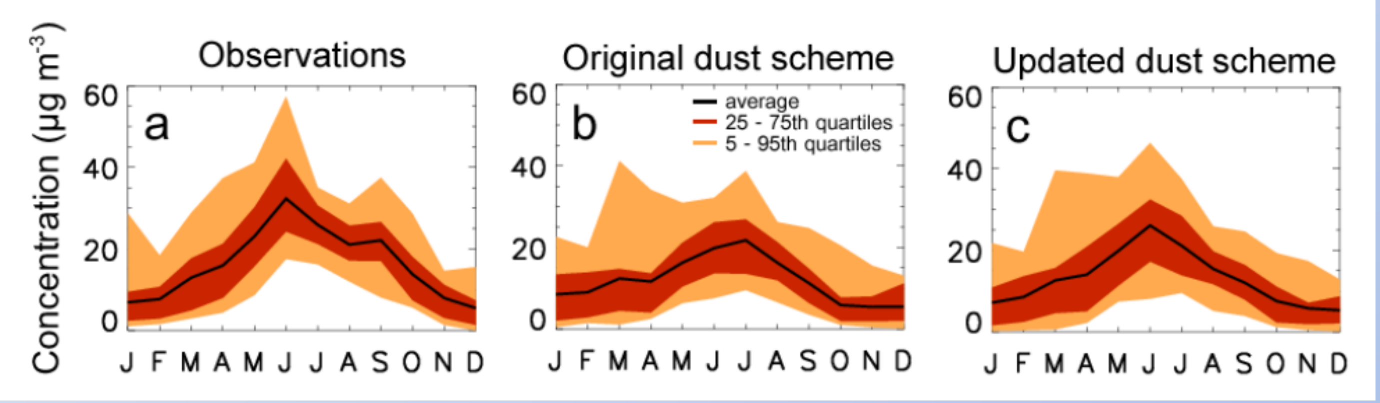
5. Conclusions

Based on the results presented here CMIP5 models are unable to capture any of the salient features of northern African dust emission and transport. The exact nature of the biases are not elucidated here but are likely to be related to a variety of sources, including the dust size distributions and atmospheric and surface processes. We conclude that there is no reason to assume that the projections of dust emission and concentration for the 21st century have any validity. Despite highlighting deficiencies in the representation of the multitude of land and atmospheric processes that govern dust emission, these results also cast doubt on the representation of other features of coupled Earth system that are affected by aeolian dust, including regional land and ocean surface temperatures [*Evan et al.*, 2009], precipitation and cloud processes [*Kaufman et al.*, 2005a; *Yoshioka et al.*, 2007], coupled equatorial processes [*Evan et al.*, 2011], and terrestrial [*Das et al.*, 2013] and oceanic biogeochemistry [*Mahowald et al.*, 2010]. It is likely that the representation of dust in climate models can be improved by increasing the number and quality of observations of dust emission and atmospheric mass concentration in order to improve understanding of the processes affecting dust emission.

<u>Introduction</u>: Aerosols transport in dynamical-chemical models.

GEOS-Chem model driven by MERRA re-analysis meteorology & using a new dust source activation scheme:

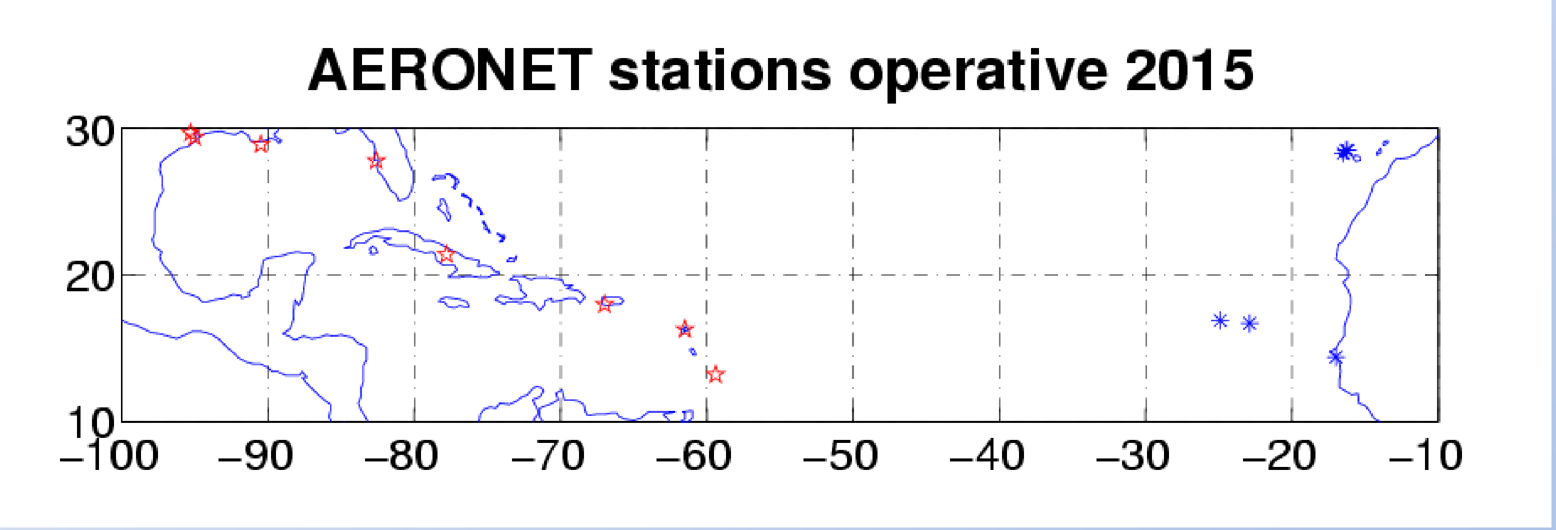
- reproduces the observed DAOD trend from 1982 to 2008.
- quantify factors contributing to this trend & observed variability



Climatological (1982 – 2008) monthly surface dust concentrations at Ragged Point in Barbados; the baseline GEOS-Chem model & GEOS-Chem model with sub-grid wind parameterization and Koven dust source map.
Black line :monthly mean; red and orange shading 25th - 75th & 5th - 95th quantiles

D. A. Ridley, C. L. Heald, and J. M. Prospero, What controls the recent changes in African mineral dust aerosol across the Atlantic? Atmos. Chem. Phys., 14, 5735–5747, 2014,doi:10.5194/acp-14-5735-2014

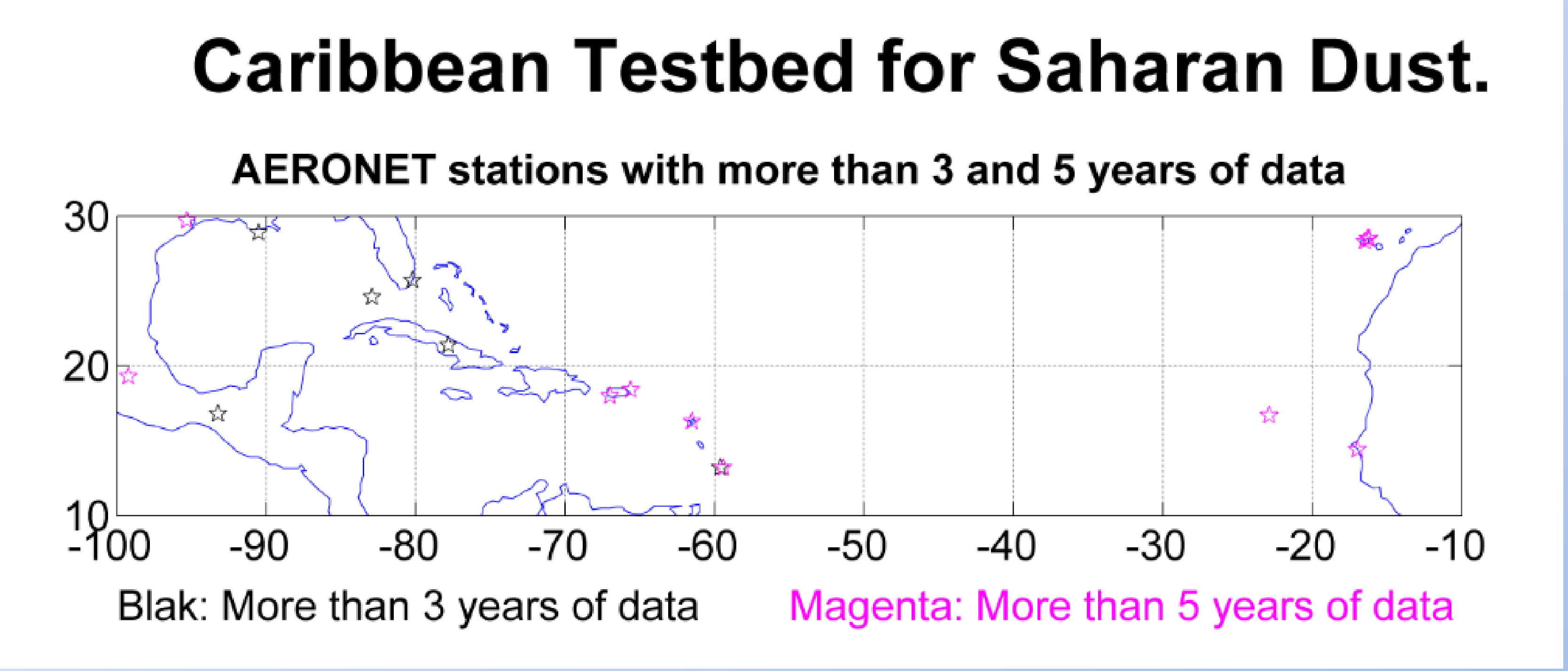
AERONET sun photometers in the region.



Station	Lat.	Long.	Elev.
1.Ragged_Point	13.2	-59.4	40.0
2.Guadeloup	16.3	-61.5	0.0
3.La_Parguera	18.0	-67.0	12.4
4.Camaguey	21.4	-77.8	122.0
5.SP_Bayboro	27.8	-82.6	5.0
6.Site_CSI_6	28.9	-90.5	32.7
7.UH_Coastal_Center	29.4	-95.0	5.0
8.Univ Houston	29.7	-95.3	65.0

Station	Lat.	Long.	Elev.
1.Dakar	14.4	-17.0	0.0
2.Capo_Verde	16.7	-22.9	60.0
3.Calhau	16.9	-24.9	40.0
4.Izana	28.3	-16.5	2391.0
5.Sta_Cruz_Tenerife	28.5	-16.2	52.0
6.La_Laguna	28.5	-16.3	568.0

Caribbean Test-bed for Saharan Dust Long and Short Range Transport.

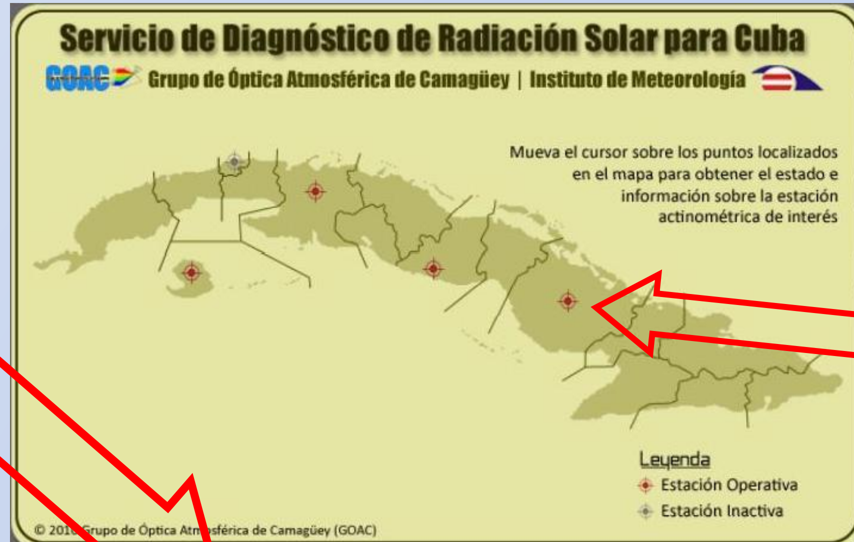


Current lidars

Caribbean	African Coast
• University Miami (MPL) • Barbados MPI Ramman lidar • Natal – Brazil (mobile)	• Izaña Observatory (MPL), Spain • La Laguna University Canary Islands, Spain

Cuban Test bed for Saharan Dust. (High resolution)

Broadband AOD:
Derived from hourly direct solar radiation measurements under NO cloud presence in the line of sight



Sun photometer:
Belonging to RIMA & contributing to AERONET

Actinometer-Galvanometer

BAOD Diagnostic Service for Cuba

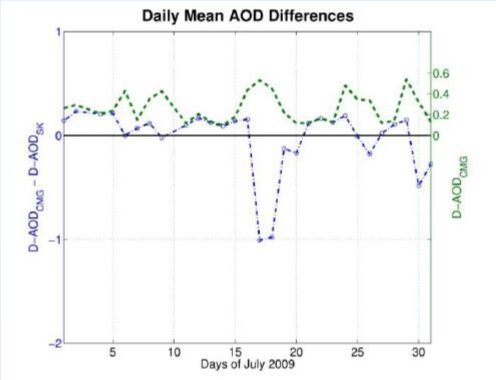
Proposals for a New Lidar Already submitted:

- Lidar Lab, Anhui Institute of Optics and Fine Mechanics, China
- NPOTayfun, Obnisnk, Russia
- NSF, Switzerland

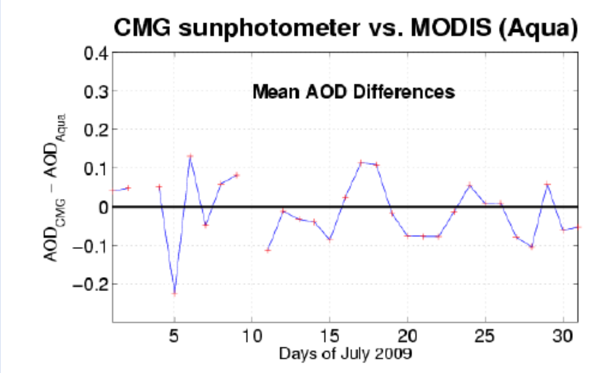
Looking for a Ceilometer

Example of long range transport study .

Sun photometer Saharan Dust AOD at Camagüey & coincident AOD from MODIS & forecasted by SKIRON show big differences.



Daily $\overline{\text{AOD}}$ differences (blue).
Daily $\overline{\text{AOD}}$ sun-photometer (green).



Daily $\overline{\text{AOD}}$ differences.

SKIRON:

- Better agreement: Daily $\overline{\text{AOD}}$ (sunphotometer) & SKIRON forecasted $\overline{\text{AOD}}$.
- SKIRON lacks of a climatological values of AOD
- SD forecasted AOD in SKIRON overestimates Camagüey measured AOD.

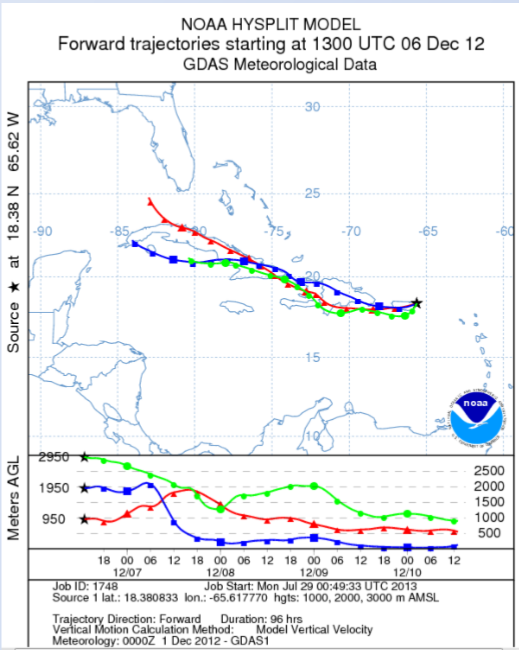
MODIS:

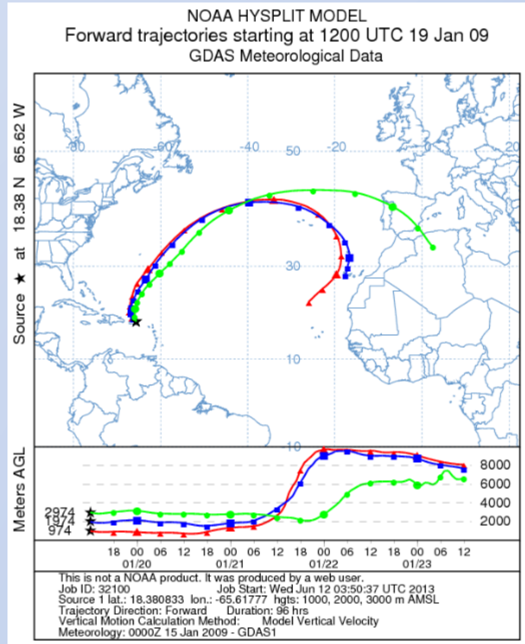
- Better agreement: Daily $\overline{\text{AOD}}$ (sunphotometer) & aerially $\overline{\text{AOD}}$from MODIS.
- Areal $\overline{\text{AOD}}$ from MODIS underestimates Camagüey measured $\overline{\text{AOD}}$.

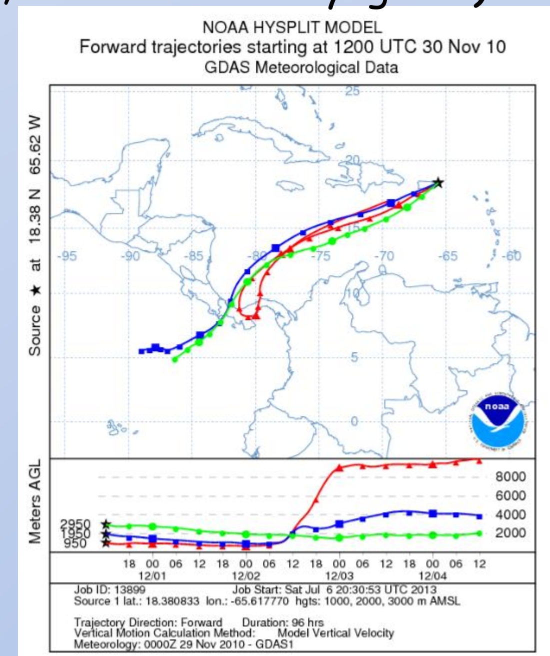
Antuña, J.C., V. Cachorro, R. Estevan, Á. de Frutos, B. Barja, Y.Benouna, B. Torres, D. Fuertes, R. González, C.Toledano, G. Kallos, S. Cristos, 2012, Characterizing aerosol optical depth measurements and forecasts of Saharan dust events at Camagüey, Cuba, during July 2009, *Opt. Pura Apl.* **45** (4), pp. 415-421

Example of short range transport study .

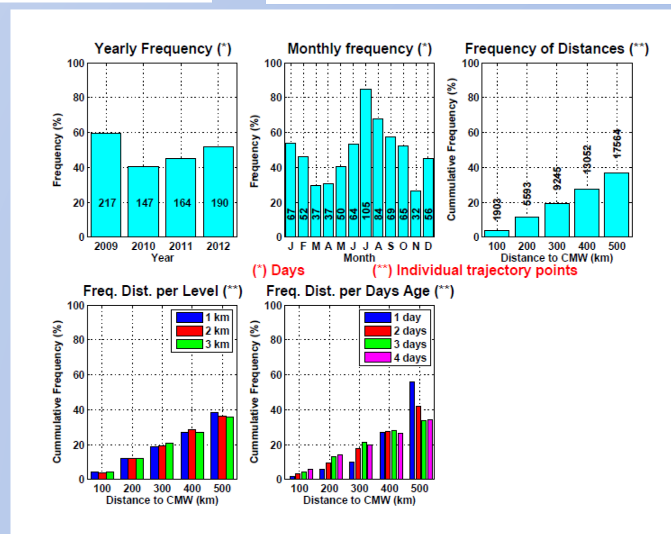
(In progress: cooperation with Dr. Olga Mayol-Bracero, Univ. PR at Mayaguez.)



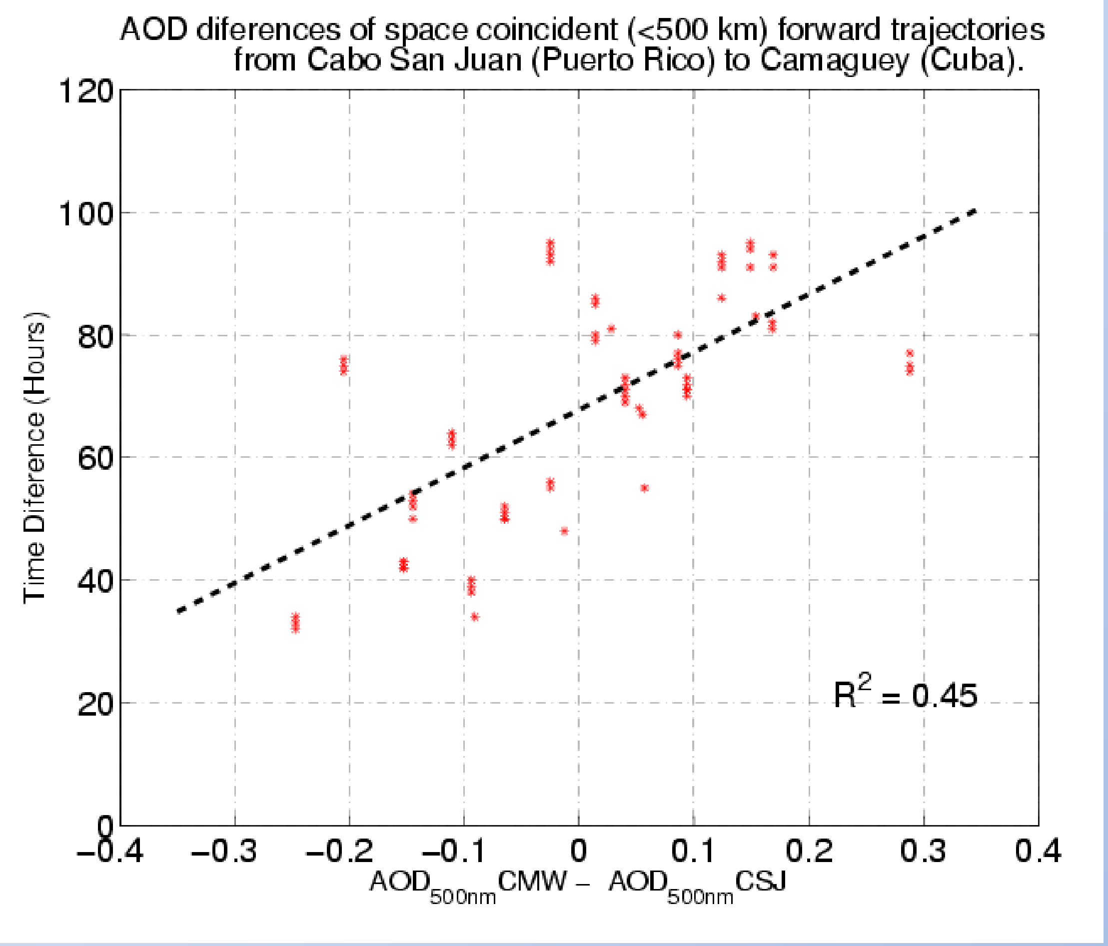




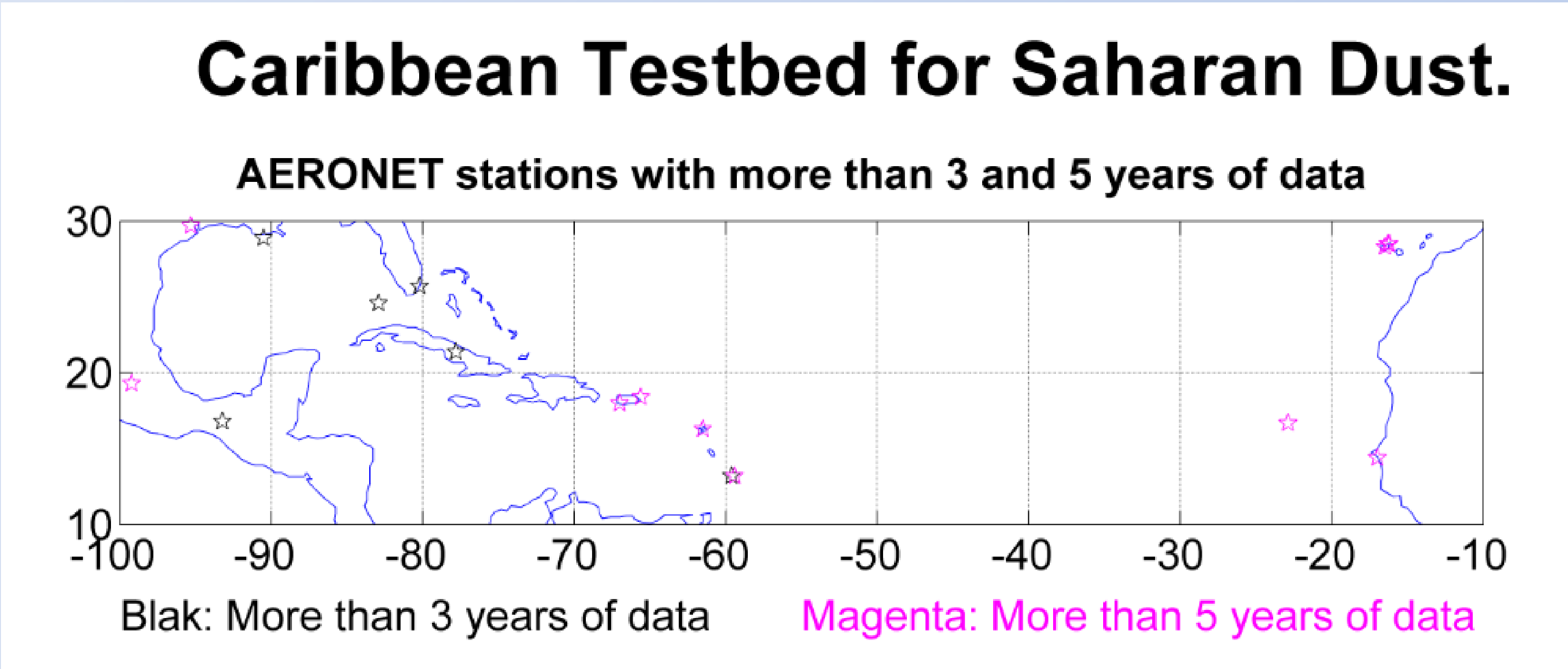
Coincidence of forward trajectories points from Cabo San Juan (Puerto Rico) with a 500km radius around Camagüey, Cuba.



Space coincident forward trajectories.



Caribbean Test-bed for Saharan Dust Long and Short Range Transport.



Current lidars

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Solar Radiation:

Estación Actinométrica Tipo Yanishevskii.

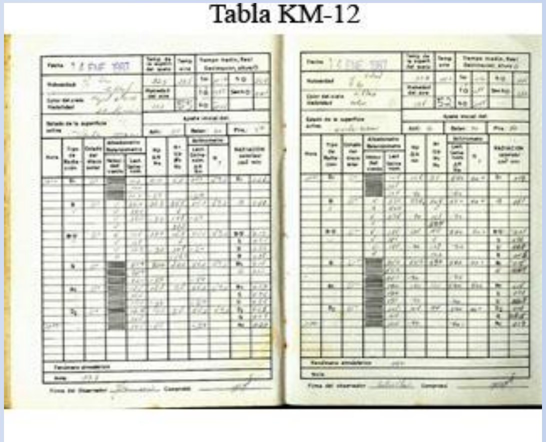
Actinómetro

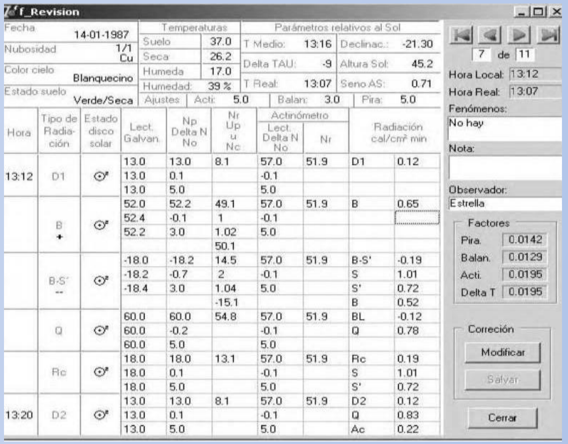
Balanzómetro

Piranómetro

Galvanómetro

Rescate de Datos.



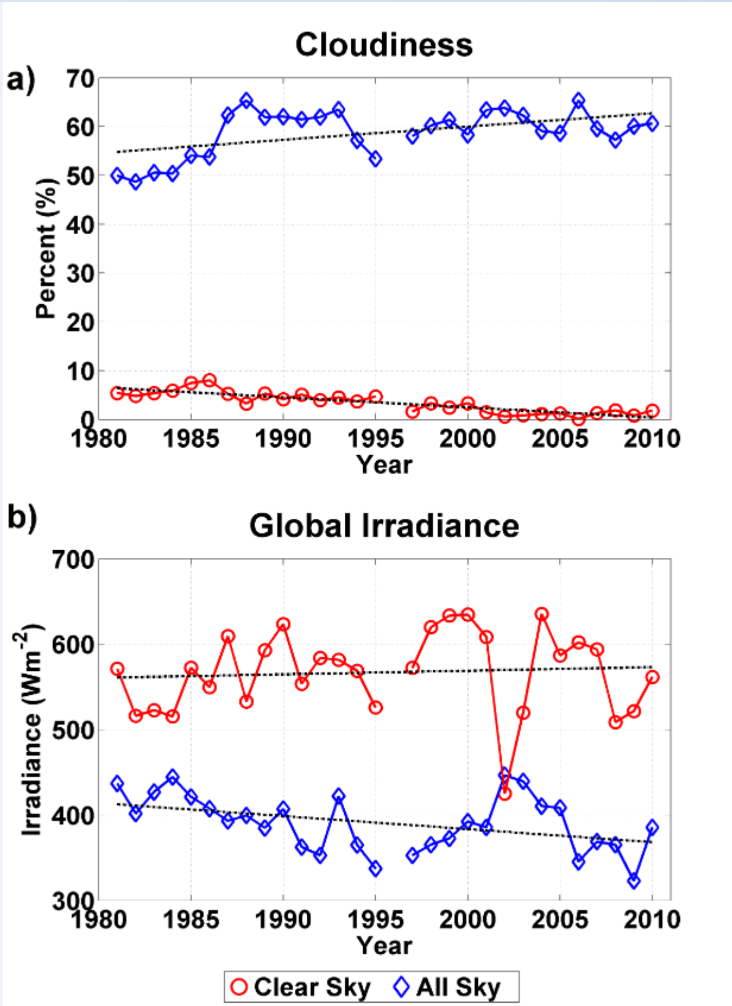


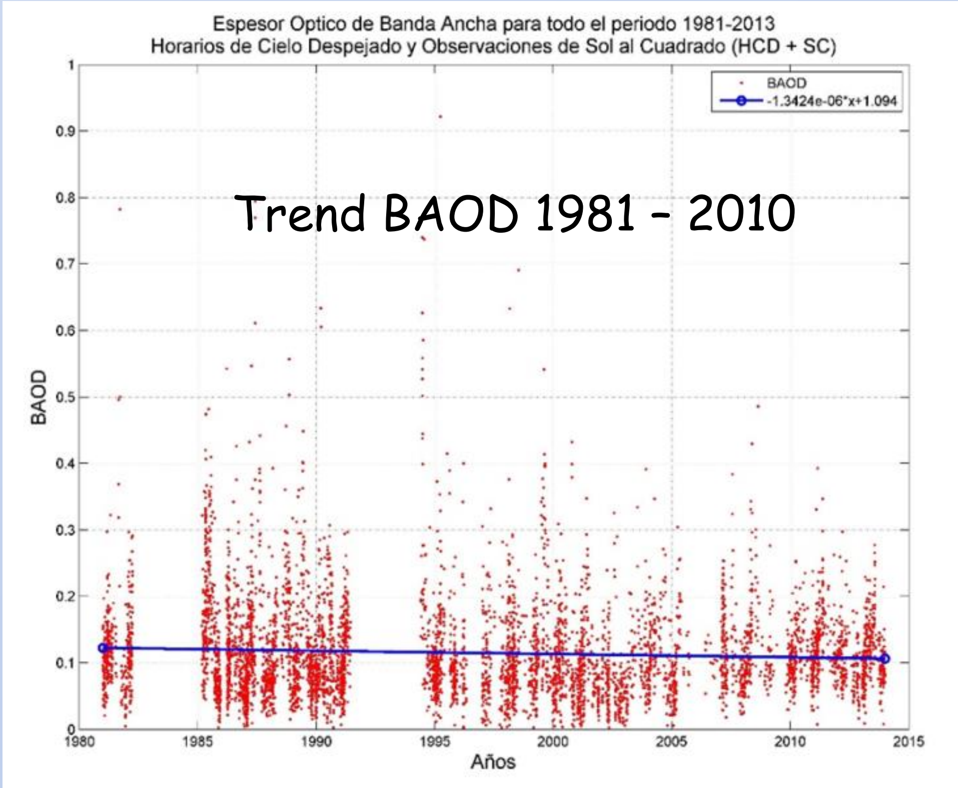
Hora	Tipo de Radiación	Estado disco solar	Lect. Galvan.	Np Delta N No	Nr Up u Nc	Actinómetro Lect. Delta N No	Actinómetro Nr	Radiación cal/cm² min	
13:12	D1	⊙	13.0	13.0	8.1	57.0	51.9	D1	0.12
			13.0	0.1		-0.1			
			13.0	5.0		5.0			
	B +	⊙	52.0	52.2	49.1	57.0	51.9	B	0.65
			52.4	-0.1	1	-0.1			
			52.2	3.0	1.02	5.0			
					50.1				
	B-S' --	⊙	-18.0	-18.2	14.5	57.0	51.9	B-S'	-0.19
			-18.2	-0.7	2	-0.1		S	1.01
			-18.4	3.0	1.04	5.0		S'	0.72
					-15.1			B	0.52
	Q	⊙	60.0	60.0	54.8	57.0	51.9	BL	-0.12
			60.0	-0.2		-0.1		Q	0.78
			60.0	5.0		5.0			
	Rc	⊙	18.0	18.0	13.1	57.0	51.9	Rc	0.19
			18.0	0.1		-0.1		S	1.01
			18.0	5.0		5.0		S'	0.72
13:20	D2	⊙	13.0	13.0	8.1	57.0	51.9	D2	0.12
			13.0	0.1		-0.1		Q	0.83
			13.0	5.0		5.0		Ac	0.22

Observaciones realizadas desde 1970 al 2010. En peligro de perdida total por deterioro del soporte informativo (papel).

Antuña, J.C., A. Fonte, R. Estevan, B. Barja, R. Acea, and J.C. Antuña Jr., 2008, Solar Radiation Data Rescue at Camagüey, Cuba. *Bull. Amer. Meteor. Soc.*, 89, 1507–1511.

Results: Cloudiness, global irradiance & Broadband AOD trends.





	Clear Sky (0-3)	All (0-10)
Cloud Cover	-2.1 (100%)	2.7 (99%)
Global Irradiance	8.6 (84%)	-17.3 (99%)
Broadband AOD	-4.9×10^{-3} (99%)	------

Trends 1981 – 2010:
H (Wm^{-2} $decade^{-1}$),
Cloud Cover (% $decade^{-1}$)
BAOD ($decade^{-1}$)
Significance level parenthesis

POSSIBLE BRIGHTENING DIMMING

INSMET

Muchas Gracias.

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