AEROSOL EFFECT ON CLOUDS & PRECIPITATION

The Atlantic Ocean - 4 laboratories for simultaneous study of aerosol-cloud interaction June-Aug

Pollution - interaction with clouds "plays" at >30N

Dust - interaction with clouds "performs" at 5N to 30N

Smoke - interaction with clouds is "staged" at 20S-5N

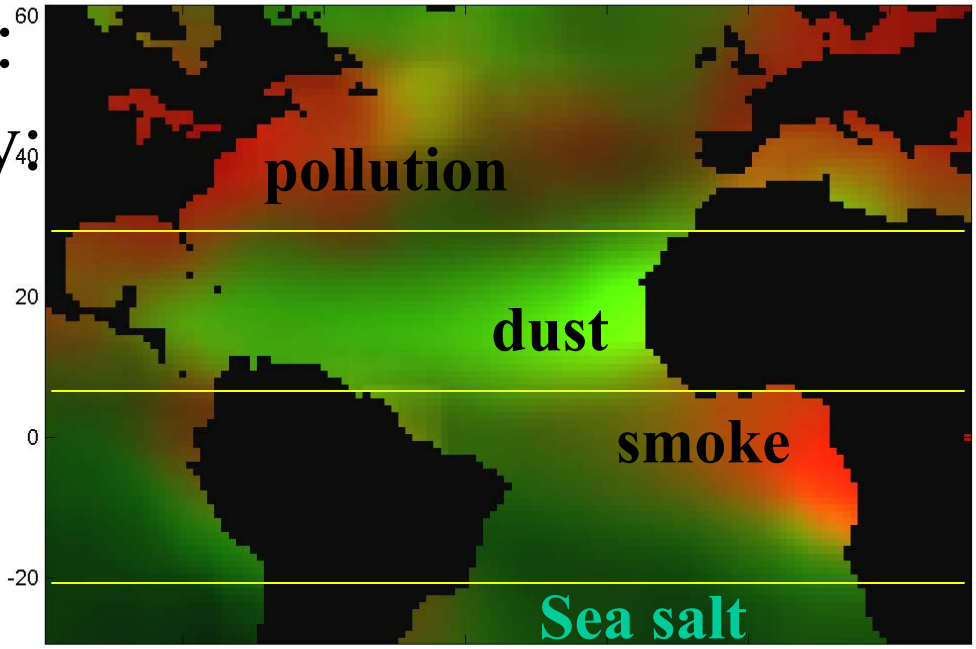
Maritime aerosol - interaction with clouds, 20S-30S

Aerosol indirect effects: The Atlantic Laboratory:

Aerosols:

Red - pollution and smoke

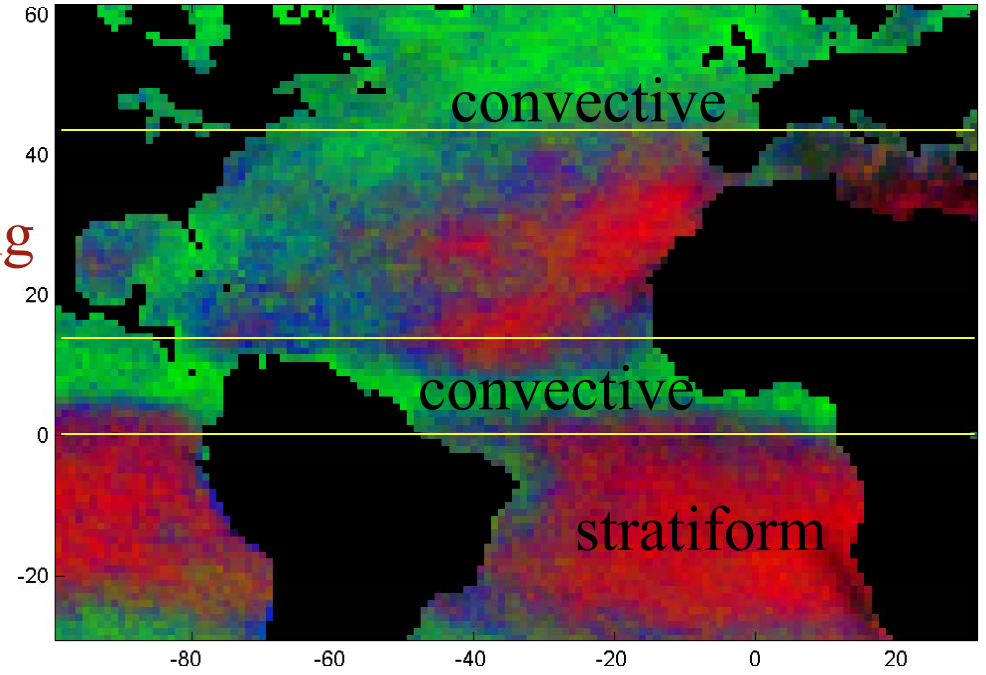
Green - dust and sea salt



Clouds:

Red - low level clouds including stratiform cloudd

Green - convective clouds



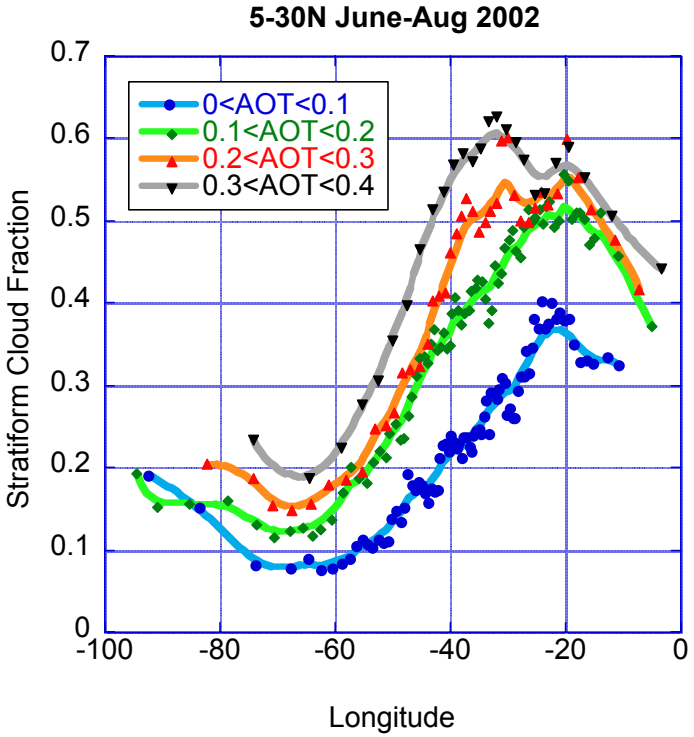
Aerosol effect on shallow clouds: Stratus and Trade Cumulus clouds

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

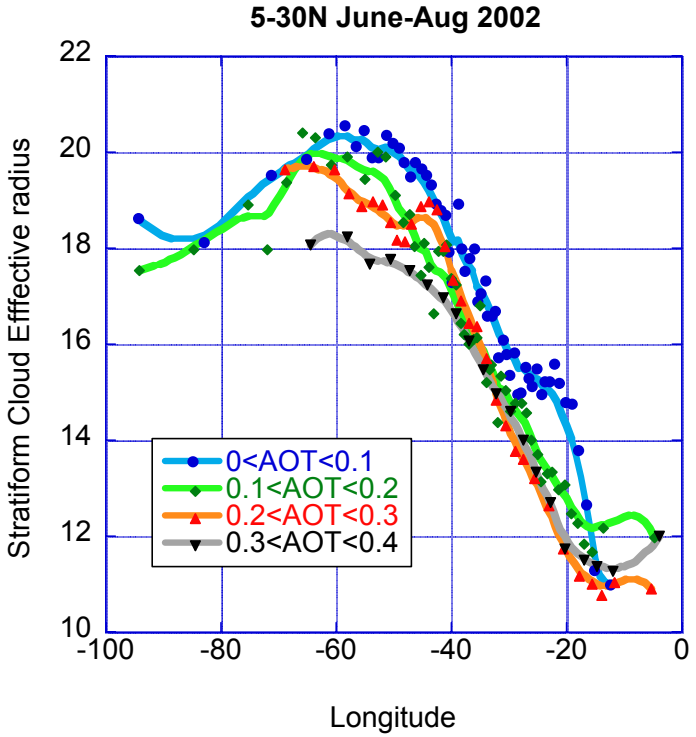
Kaufman, Koren, Remer, Rosenfeld & Rudich, 2005

Dust: 5°N-30°N

Cloud fraction



Cloud droplet size



<u>Radiative forcing (reflection of sunlight):</u>

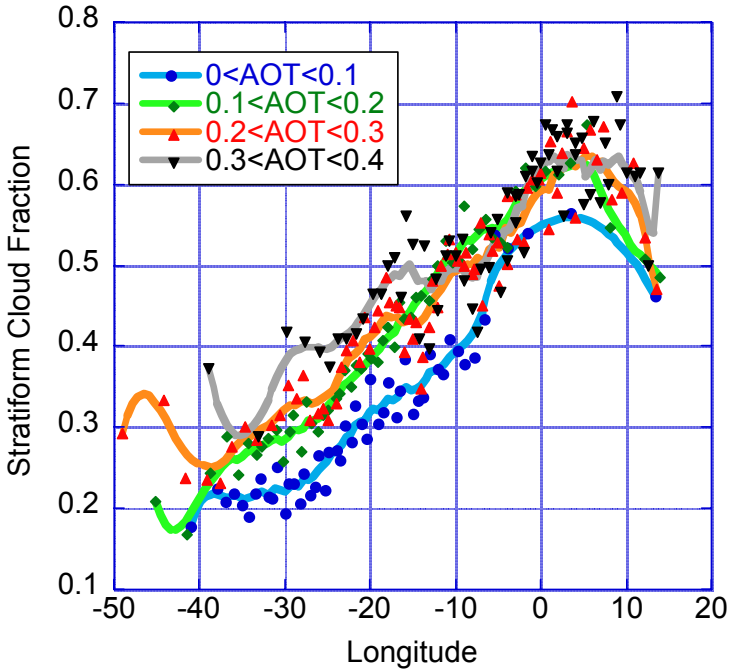
Change in cloud droplet concentration/size: -0.7W/m^2

Change in cloud cover: -5.5W/m^2

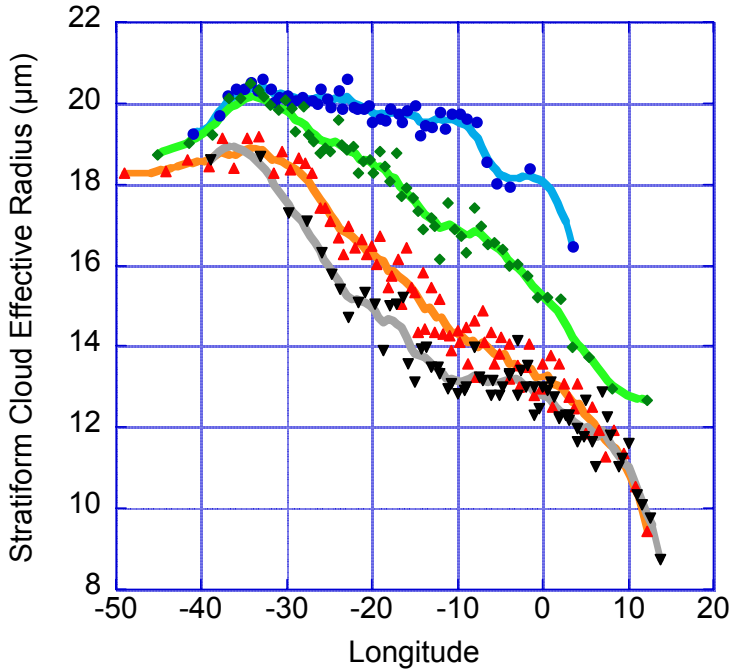
Reflection of sunlight by dust: -7.2W/m^2

Smoke: 20°S-5°N

Cloud fraction



Cloud droplet size



<u>Radiative forcing (reflection of sunlight):</u>

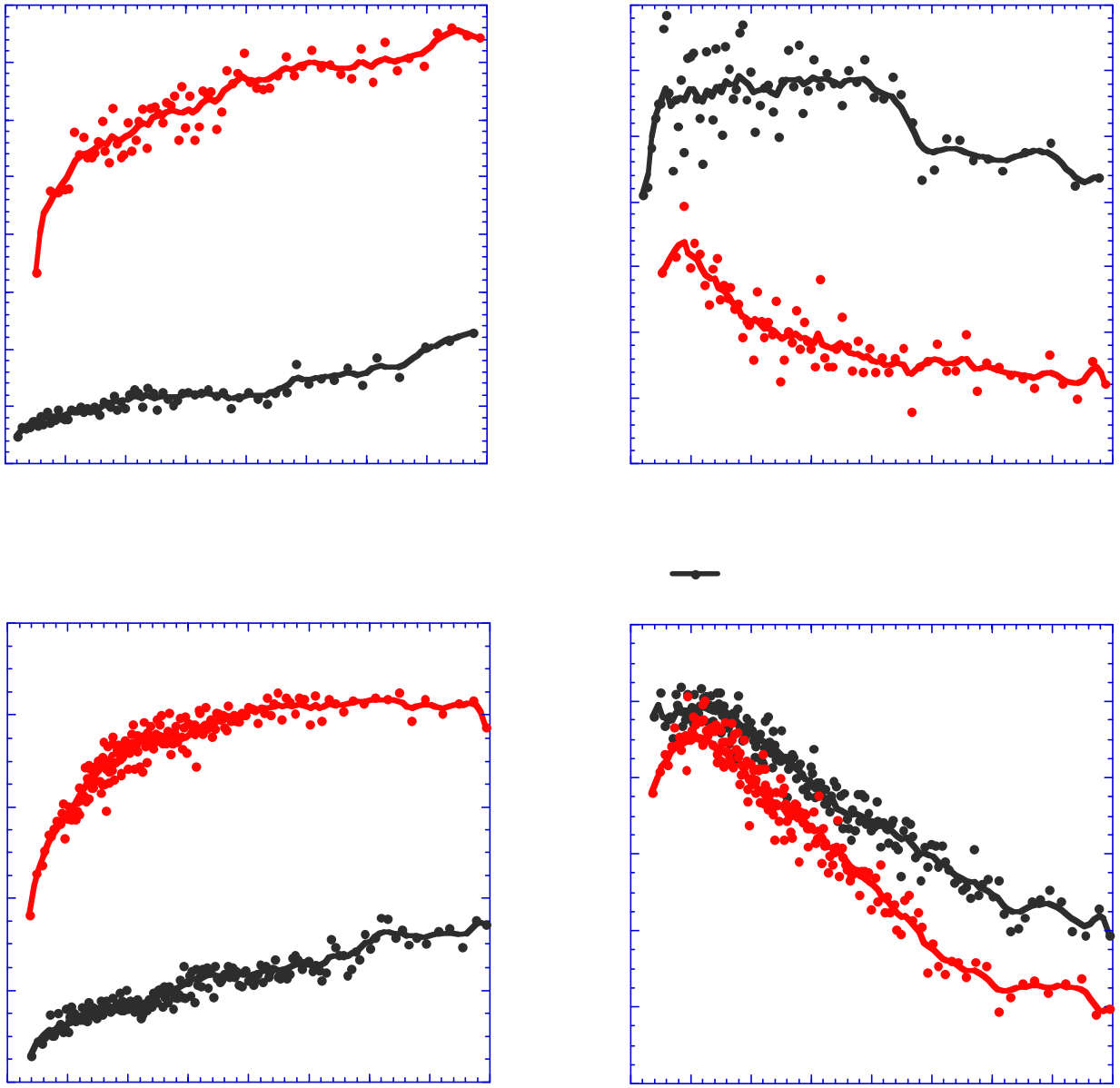
Change in cloud droplet concentration/size: -2.2W/m^2

Change in cloud cover: -7.0W/m^2

Reflection of sunlight by smoke: -1.8W/m^2

Meteor. Effects on the shallow clouds

AOT<0.2	30-20S	20S-5N	5-30N	30-60N	% change with AOT	Change in cloud fraction
VGRD:1000 mb NCEP	0.04	0.04	-0.15	-0.14	17	0.012
VGRD:750 mb NCEP	-0.05	-0.03	0.04	-0.13	3	0.001
VGRD:500 mb NCEP	-0.02	0.00	0.00	0.16	3	0.003
UGRD:1000 mb NCEP	0.12	0.12	0.06	0.03	17	0.014
UGRD:750 mb NCEP	0.02	-0.02	-0.05	0.15	17	0.008
UGRD:500 mb NCEP	-0.19	-0.07	-0.05	-0.14	14	0.012
Pressure vertical velocity :750 mb NCEP	0.00	0.02	0.01	-0.02	1	0.000
Pressure vertical velocity :500 mb NCEP	-0.03	-0.02	-0.03	-0.05	2	0.001
Latitude	0.08	0.11	-0.05	-0.12	17	0.013
Londitude	0.01	-0.07	-0.04	-0.01	13	0.004
MODIS Aerosol optical thickness	**0.32**	**0.16**	**0.14**	***0.26***		0.222
MODIS Aerosol Fine fraction	**-0.04**	**0.02**	**-0.08**	***-0.03***		0.025
MODIS Total precipitable Water Vapor	0.07	0.00	-0.05	0.16	14	0.005
MODIS Cloud top temperature	-0.72	-0.78	-0.59	-0.71	10	0.066

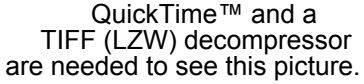


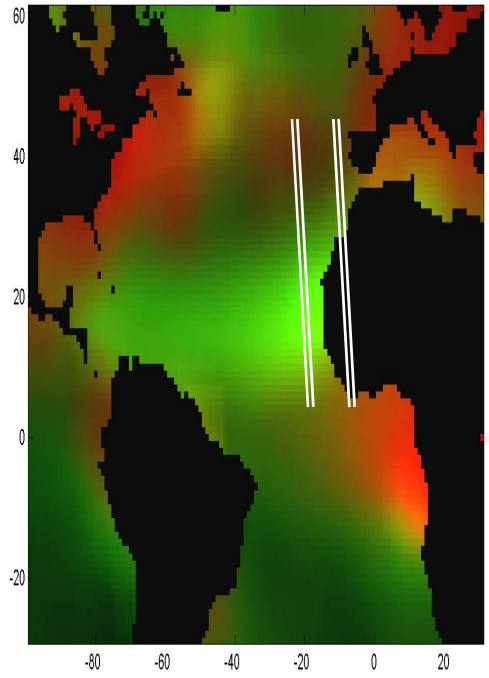
Radiative forcing w/m^2

Region and Dominant aerosol	Fract. of region	Shallow cloud cover	Range of aerosol optical thickness / average	Δcl-aer	δcl-aer	δcl-Tcl	% change in R_{eff}	% change in COT	Radiative effects (W/m^2) due to:				
									ΔN_c	$\Delta N_c + \Delta W$	$\Delta N_c + \Delta W + \Delta cl$	Total forcing TOA	ΔAbs
30°N-60°N North Atlantic Pollution	0.17	0.07	0.02-0.20 0.20-0.40 0.146	0.26 - 0.11	0.27 0.02	-0.02 -0.09	-2 -3	+41 +13	0	-1.1	-6.7	-10.2	0.7
5°˜-30°N Saharan Dust	0.26	0.11	0.02-0.20 0.20-0.40 0.155	0.25 0.12	0.12 0.11	0.12 -0.01	-7 -3	+11 -2	-0.7	-0.7	-6.2	-13.4	0.7
20°S-5°N biomass burning Smoke	0.53	0.29	0.02-0.20 0.20-0.40 0.143	0.20 0.08	0.17 0.08	0.00 -0.01	-24 -14	+34 +7	-1.9	-2.2	-9.2	-11.0	2.9
30°S-20°S Maritime aerosols	0.47	0.27	0.02-0.20 0.077	0.41	0.30	0.14	-22	+34	---	---	---	---	---

Convective Clouds

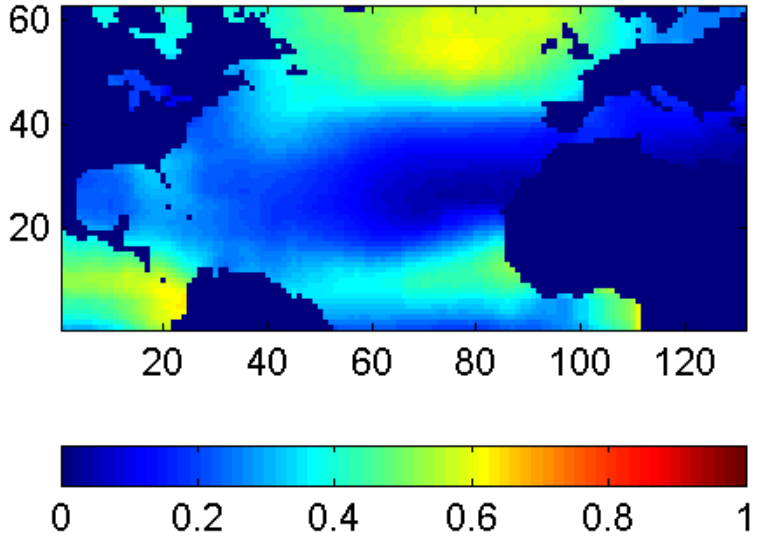
Koren,
Kaufman,
Remer,
Rosenfeld &
Rudich, 2005





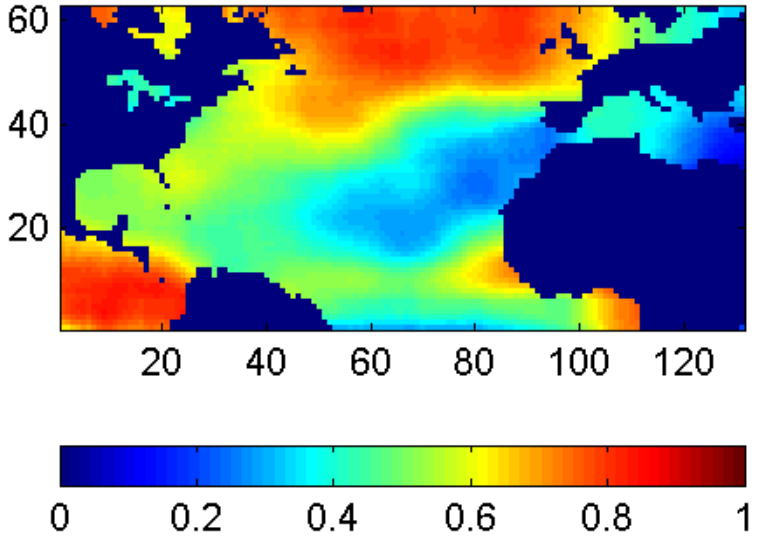
QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

clean



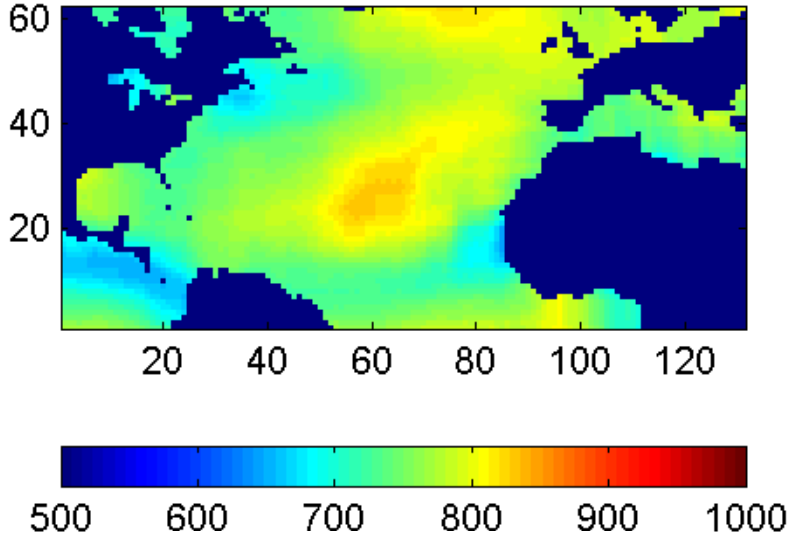
Cloud fraction

hazy



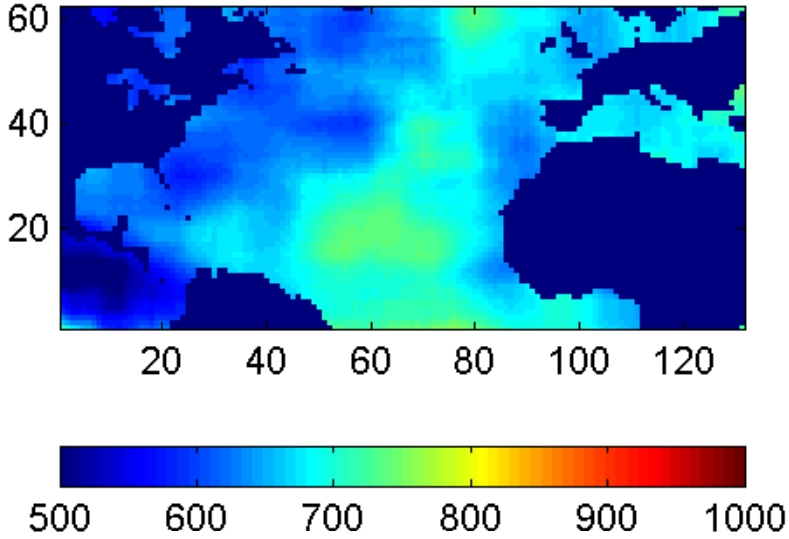
Cloud fraction

clean

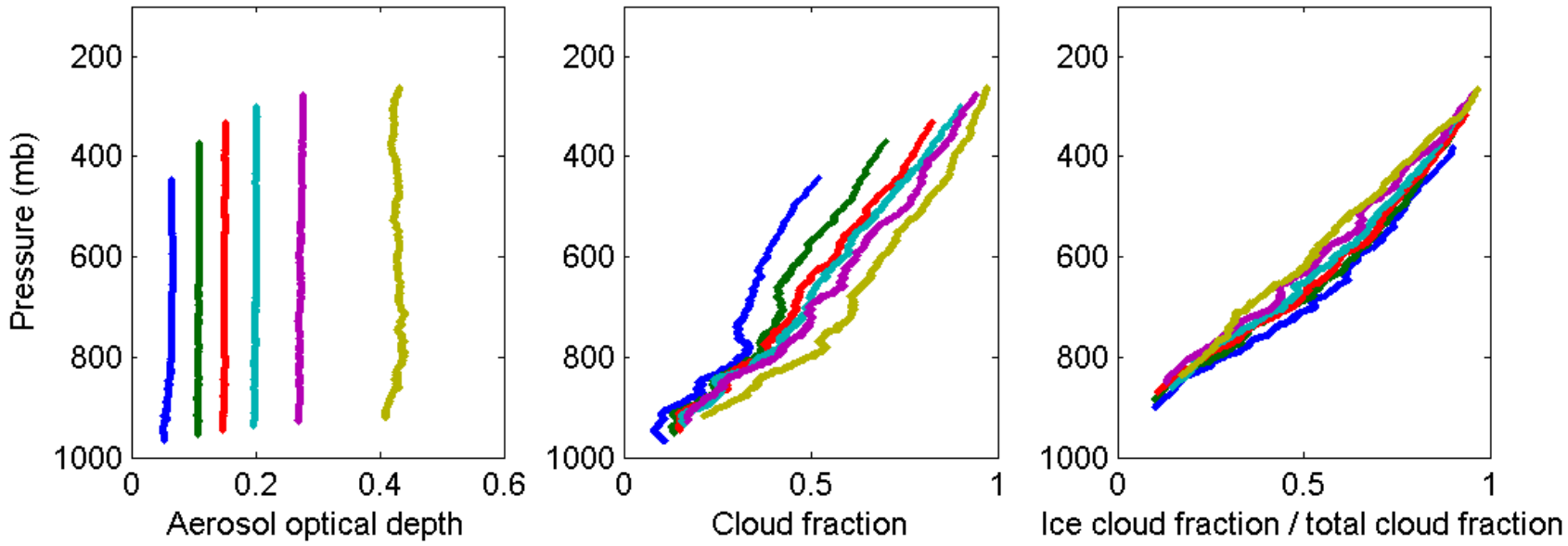


Cloud top pressure

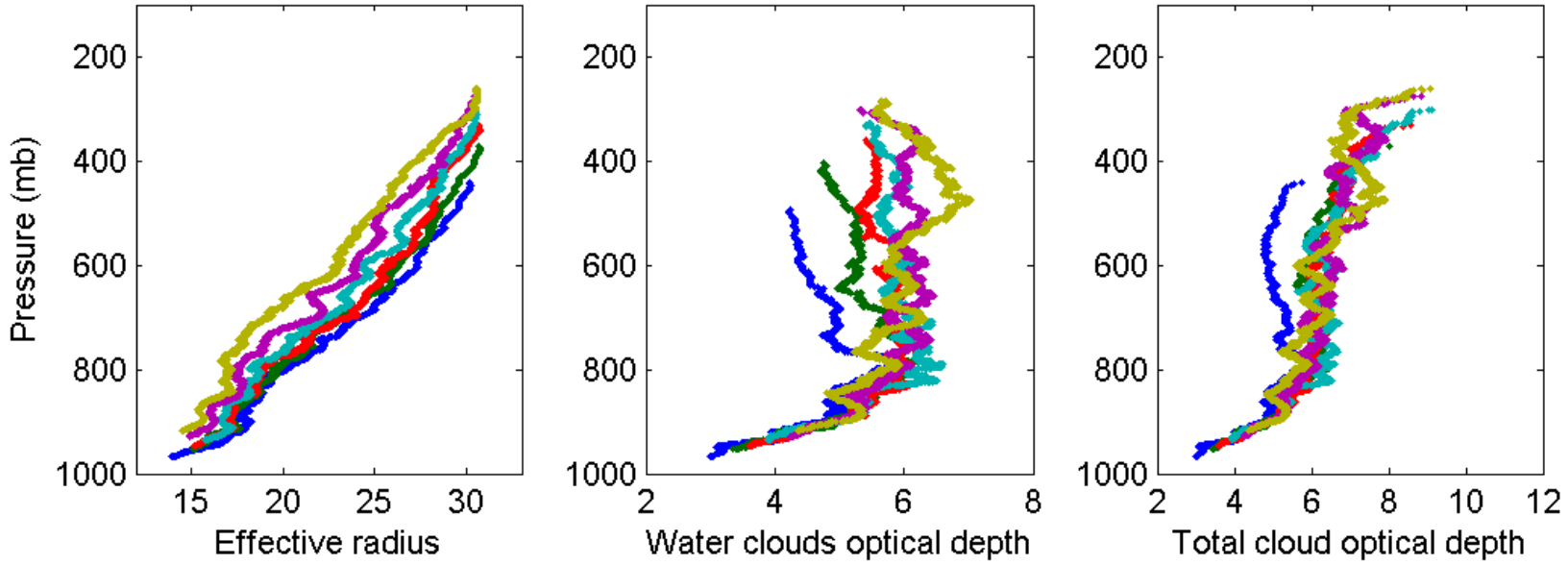
hazy



Cloud top pressure


Pressure (mb)
200
400
600
800
1000
0
0.2
0.4
0.6
Aerosol optical depth
0
0.5
1
Cloud fraction
Ice cloud fraction / total cloud fraction

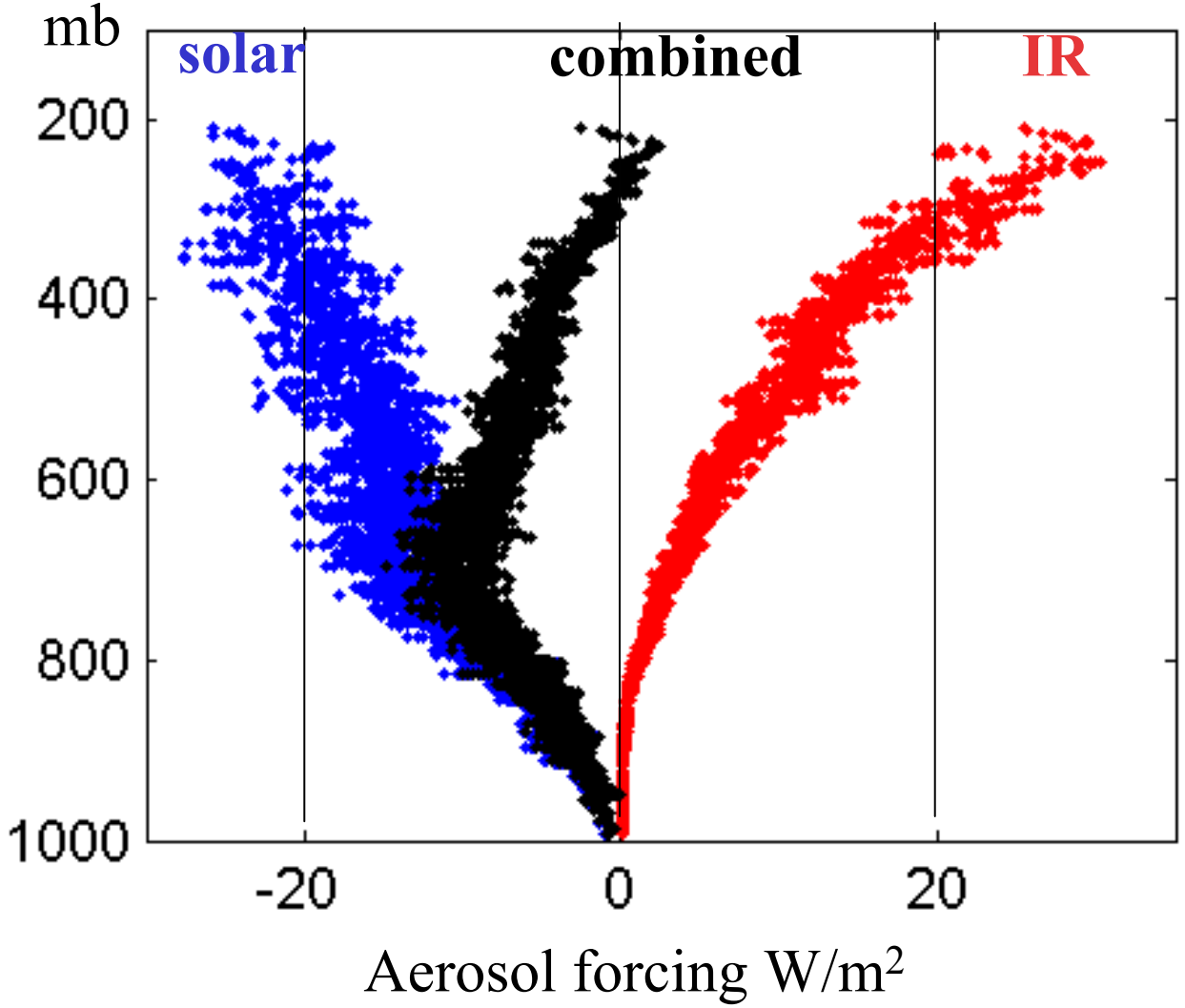
15°N-45°N

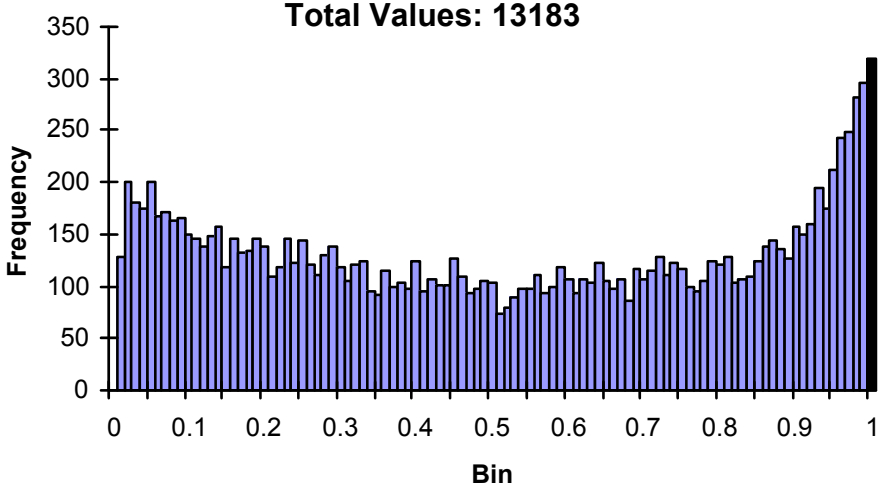

Pressure (mb)
200
400
600
800
1000
15
20
25
30
Effective radius
2
4
6
8
Water clouds optical depth
10
12
Total cloud optical depth

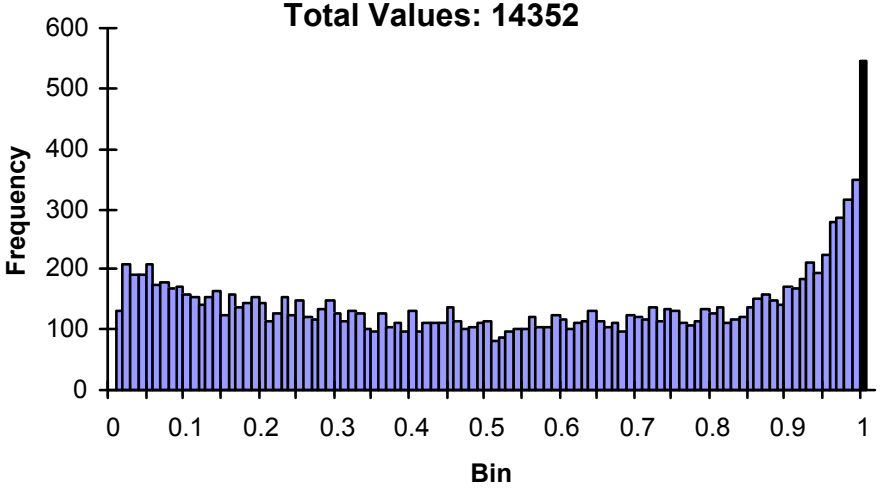
Parameter \ change in cloud fraction	Independent effect on change in the cloud fraction water clouds	ice clouds	Effect on cloud fraction correlated wit the change in aerosol water clouds	ice clouds
Cloud top pressure	**0.09**	**0.77**	0.02	**0.13**
Latitude	**0.14**	0.04	-0.01	0.00
Longitude	0.02	0.06	0.00	-0.01
Aerosol optical depth (AOD)	**0.23**	**0.09**	**0.23**	**0.09**
Aerosol fine fraction	0.07	0.04	-0.02	-0.01
Total precipitable water vapor	0.02	0.00	0.01	0.00
Meridional wind:1000 mb	**0.14**	0.04	-0.01	0.00
Meridional wind:750 mb	0.07	0.02	0.01	0.00
Meridional wind :500 mb	0.02	0.02	0.00	0.00
Zonal wind:1000 mb	**0.12**	**0.09**	-0.01	0.00
Zonal wind:750 mb	0.04	0.05	0.00	0.00
Zonal wind: 500 mb	0.03	0.04	0.00	0.00
Pressure vertical motion 750 mb	0.05	0.04	0.00	0.00
Pressure vertical motion 500 mb	0.02	0.01	0.00	0.00
change in pressure due to aerosol			0.02	**0.19**
Total change in cloud cover due to aerosol			**0.23**	**0.27**

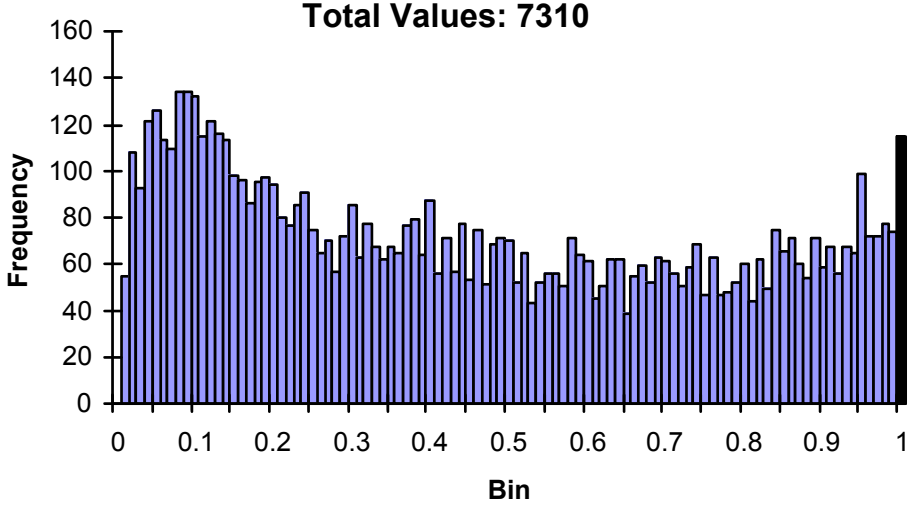
Solar: Increase in COT
Increase in cloud cover

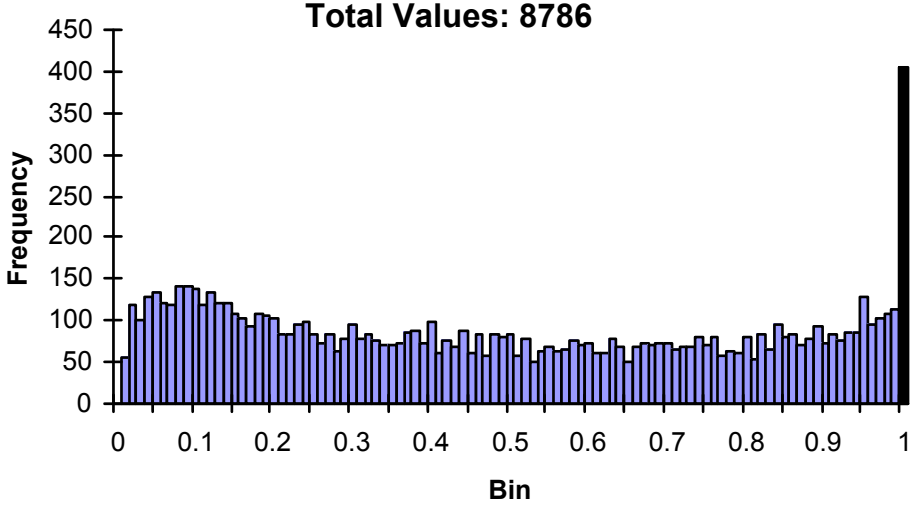
IR: Increase in cloud height
Increase in cloud cover











Bremann, Kaufman, Koren and Rong-Rong, IEEE 2005