Aerosol Direct Forcing at TOA and Surface Using CERES and MATCH

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It's seems impossible to evaluate critical feedbacks in climate models.
By the way, what causes anthropogenic climate change?
That's easy: Forcing!
Do we know the value of forcing?
Not for aerosols, and it's probably big.
Haven't we got new tools for that?
Yes. Let's start there.

CERES Surface and Atmosphere Radiation Budget (SARB) product

Assignment of aerosol characteristics

| MATCH aerosol type	CRS aerosol optics	scale height
dust (0.01-1.0 μm)	1. dust (0.5 μm) Tegen-Lacis	3.0 km
dust (1-10 μm)	2. dust (2.0 μm) Tegen-Lacis	1.0 km
dust (10-20 μm)	2. dust (2.0 μm) Tegen-Lacis	1.0 km
dust (20-50 μm)	2. dust (2.0 μm) Tegen-Lacis	1.0 km
hydrophilic black carbon	3. soot (OPAC)	3.5 km
hydrophobic black carbon	3. soot (OPAC)	3.5 km
hydrophilic organic carbon	4. soluble organic (OPAC)	3.8 km
hydrophobic organic carbon	5. insoluble organic (OPAC)	3.8 km
sulfate	6. sulfate (OPAC)	3.5 km
sea salt	7. sea salt (OPAC)	0.5 km

Input from MATCH (Fillmore and Collins) 15 July 2001
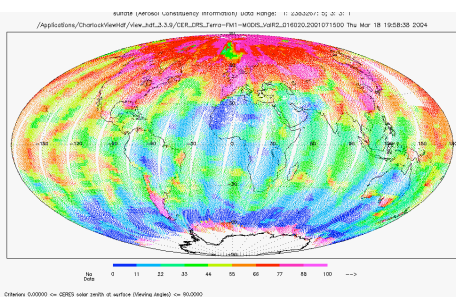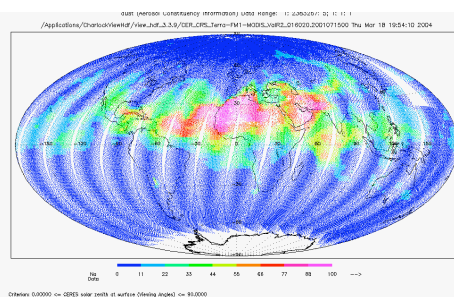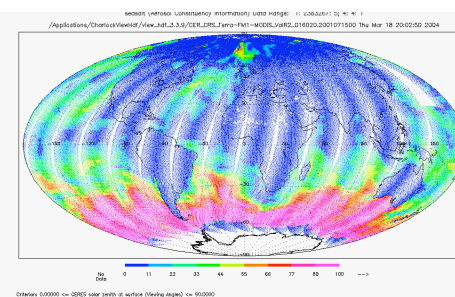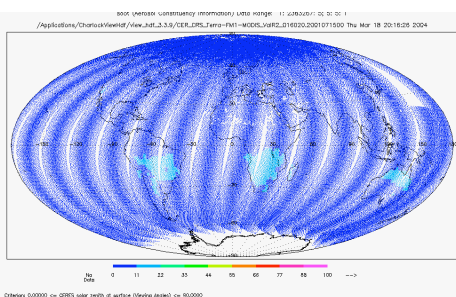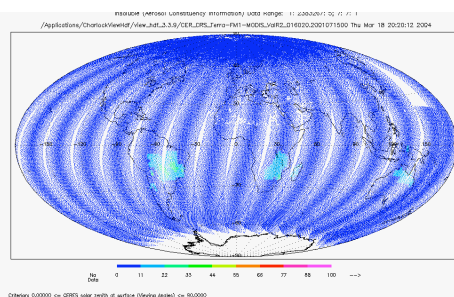
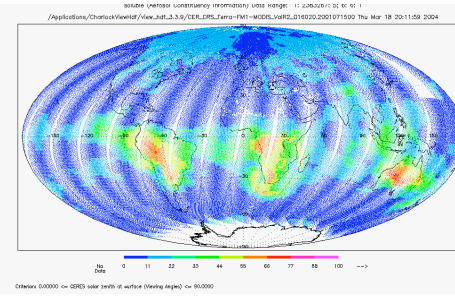

Sulfate (%)   **Dust (%)**   **Sea Salt (%)**

Soot (%)   **Insoluble organic (%)**   **Soluble organic (%)**

Untuned Terra Ed2A (ValR2) Parameters at Ground Sites

Jan-Feb-Mar-Apr-Jul-Oct 2001
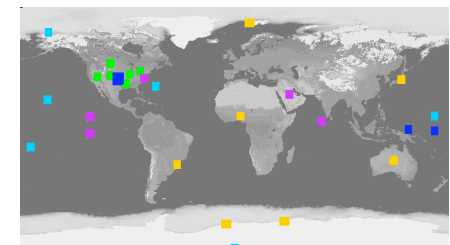
Bias = Mean (Calculation - Observation)

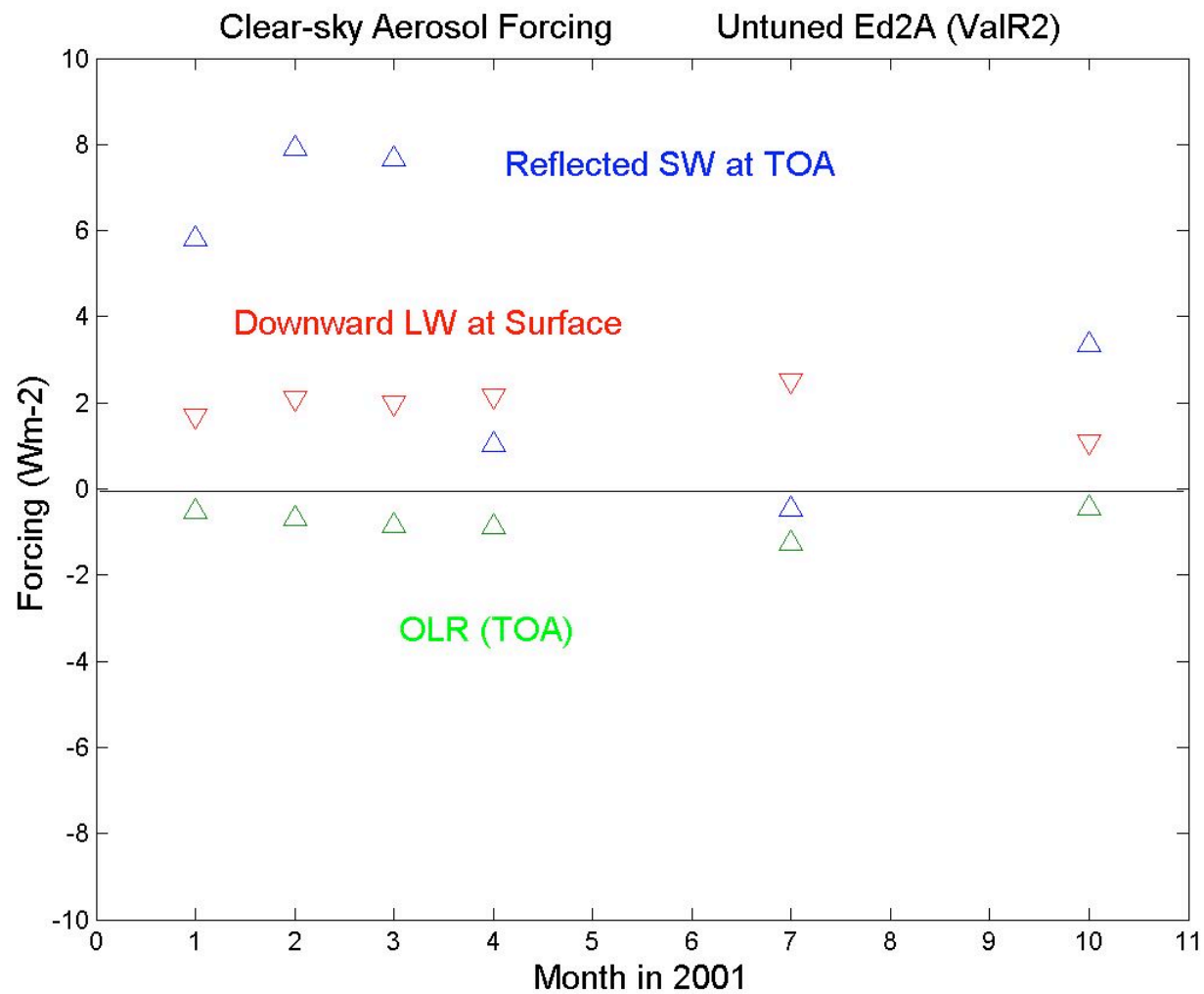Surface (SFC) observations as 30-minute (half hour) intervals

~40 CAVE sites (ARM, BSRN, SURFRAD, COVE)

AF = Aerosol Forcing = (Flux with aerosol) – (Pristine flux)

	All sky		Clear-sky (by MODIS)		
	Bias (Wm-2)	RMS (Wm-2)	Bias (Wm-2)	RMS (Wm-2)	AF (Wm-2)
LW down SFC	-5	22	-9	15	2
SW down SFC	9	82	0	25	-25
LW up TOA	1	9	0	5	-1
SW up TOA	2	28	1	6	4

Google "CERES CAVE" for access to data.

Clear-sky Aerosol Forcing   Untuned Ed2A (ValR2)

Reflected SW at TOA

Downward LW at Surface

OLR (TOA)

Forcing (Wm-2)

Month in 2001

Google "CERES CAVE" for access to data.

Aerosol forcing to reflected flux at TOA and to insolation at surface.

Computed for continental aerosol optical thickness (AOT) of 0.10 with scale height of 2 km; overhead sun and Midlatitude Summer (MLS) sounding; surface albedo spectrally flat.

Conditions						
Surface albedo	0.1	0.1	0.1	0.2	0.2	0.2
Cloud height (km)		1	1		1	1
Cloud optical depth	0	10	64	0	10	64
Fluxes and Forcings (Wm-2*)*						
Reflected Flux at TOA	152	457	815	242	486	817
Aerosol Forcing at TOA	5	0	-7	2	0	-7
Insolation at Surface	1056	630	156	1064	667	172
Aerosol Forcing at Surface	-12	-9	-2	-10	-7	-2

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Aerosol forcing is affected by surface albedo

**Aerosol forcing to reflected flux at TOA and to insolation at surface**.

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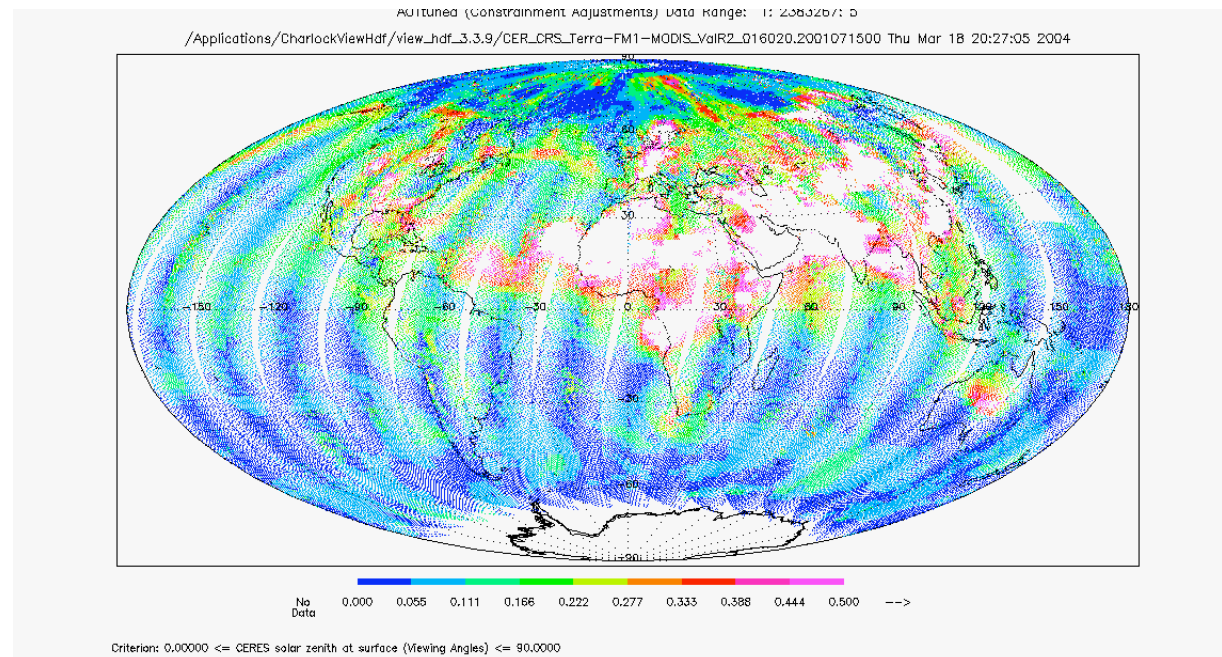Aerosol forcing is affected by cloud optical depth.

And if this were indirect forcing, we'd have to account for vertical velocity, too.
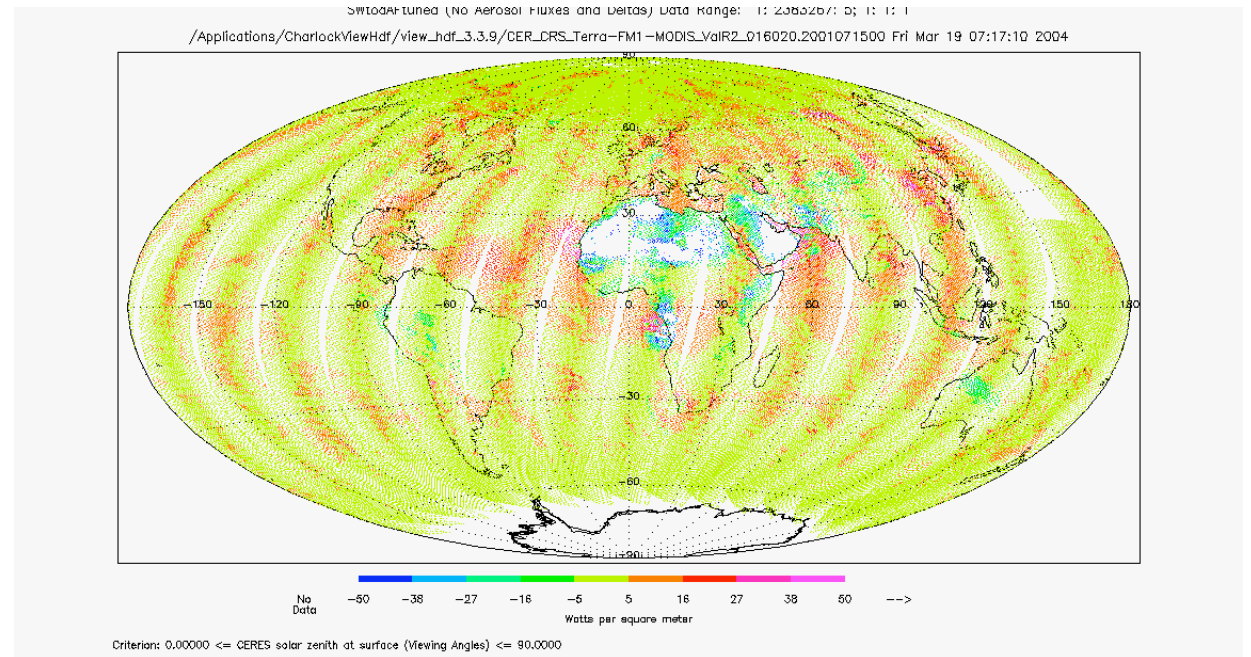
Scale 0.0 - 2.0
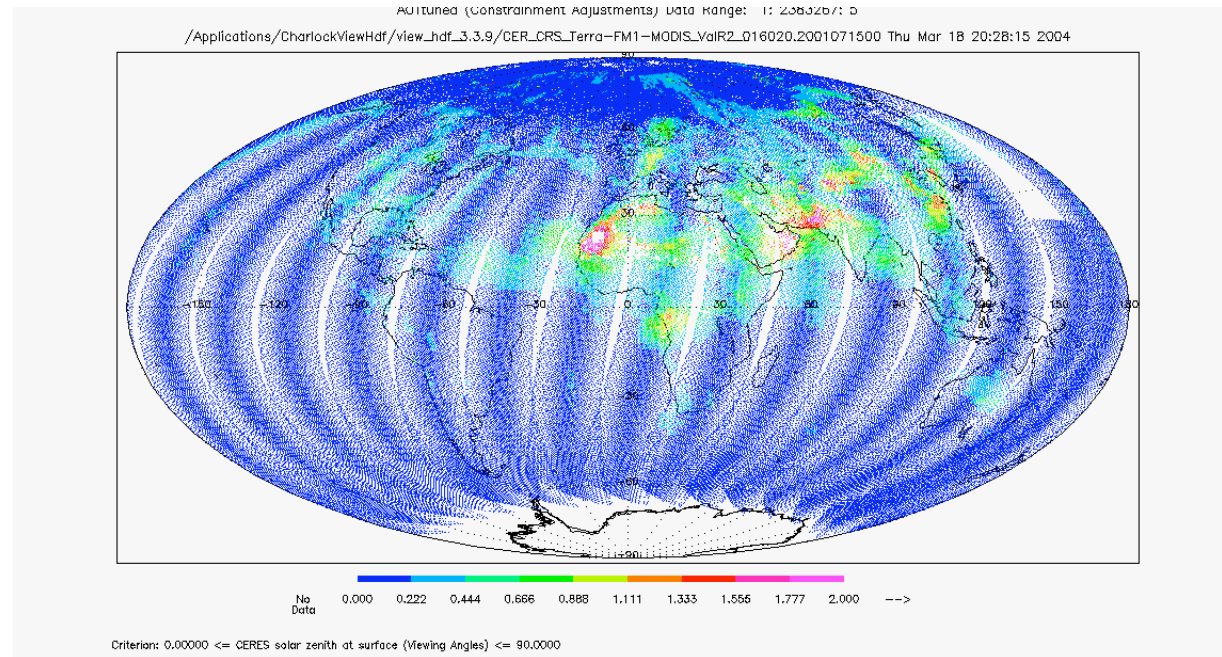
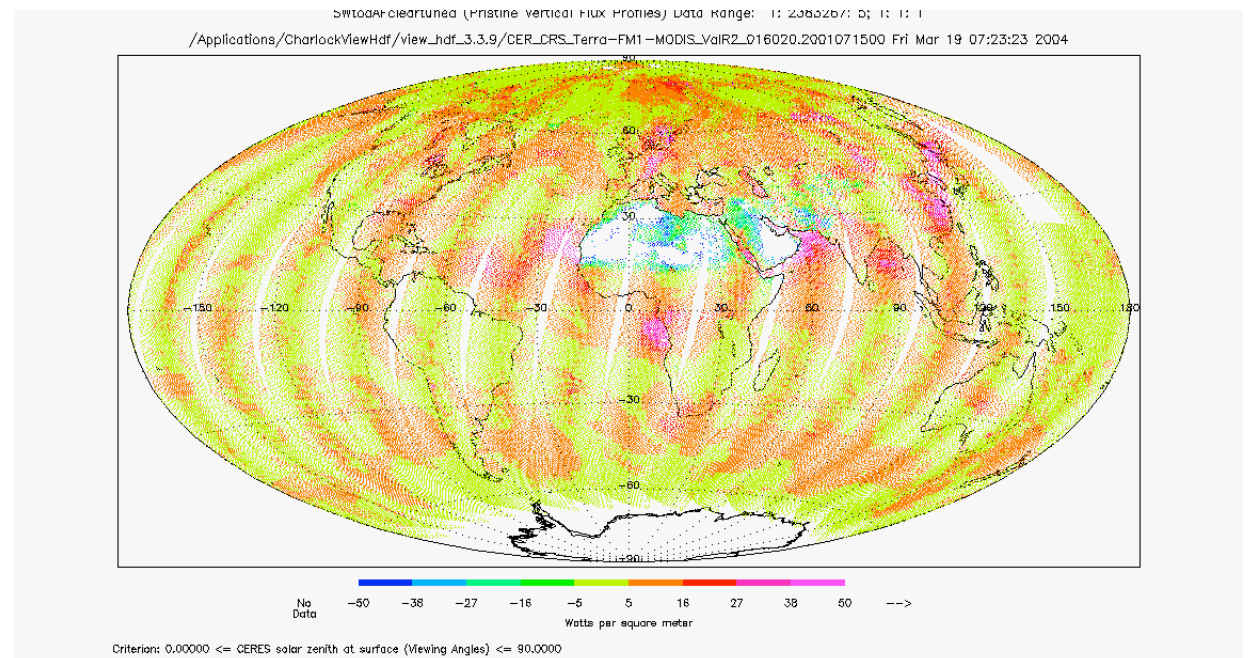Initial aerosol optical thickness AOT on 15 July 2001
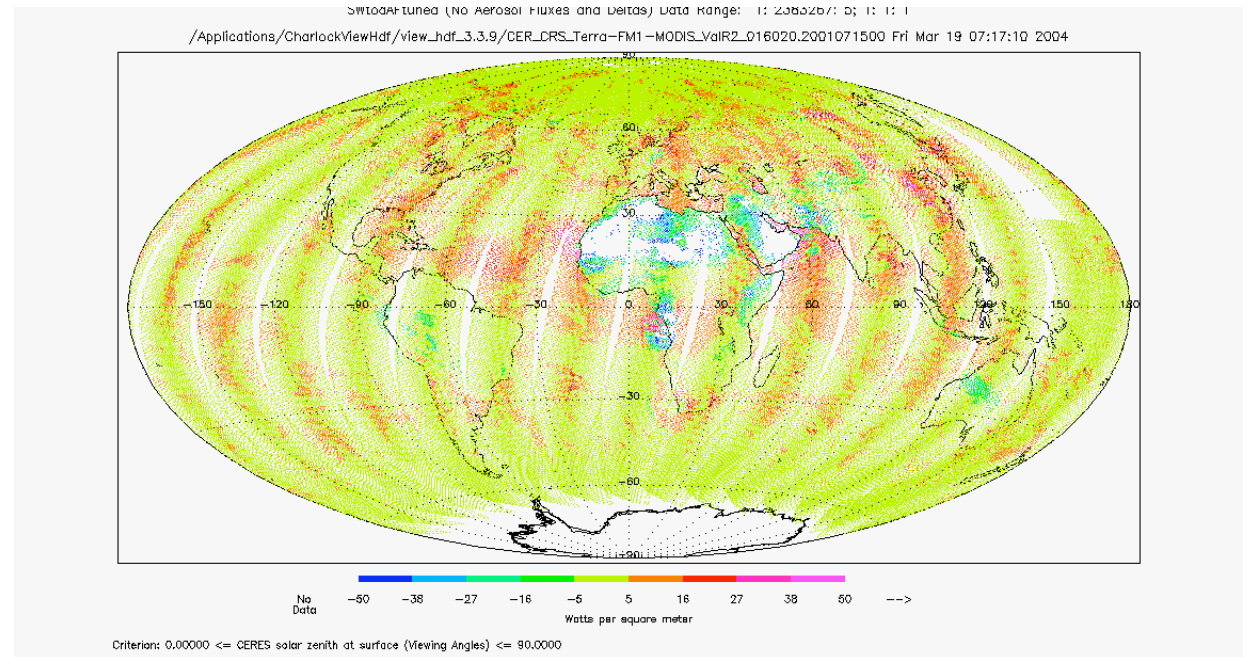

Scale 0.0 - 0.5

Aerosol forcing to SW at TOA
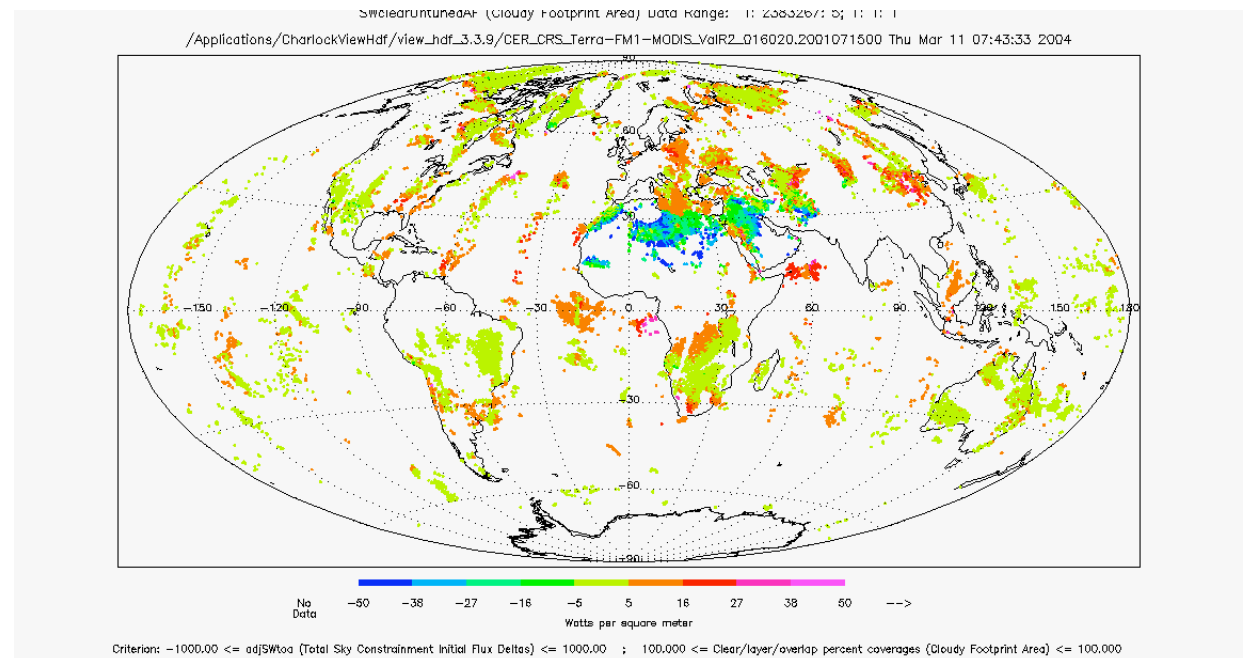**All sky**
scale -50 to 50 Wm-2

Aerosol forcing to SW at TOA
Theoretically clear sky
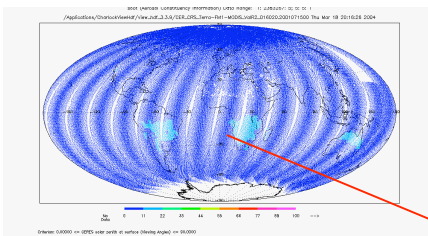scale -50 to 50 Wm-2

Aerosol forcing to SW at TOA
All sky
scale -50 to 50 Wm-2

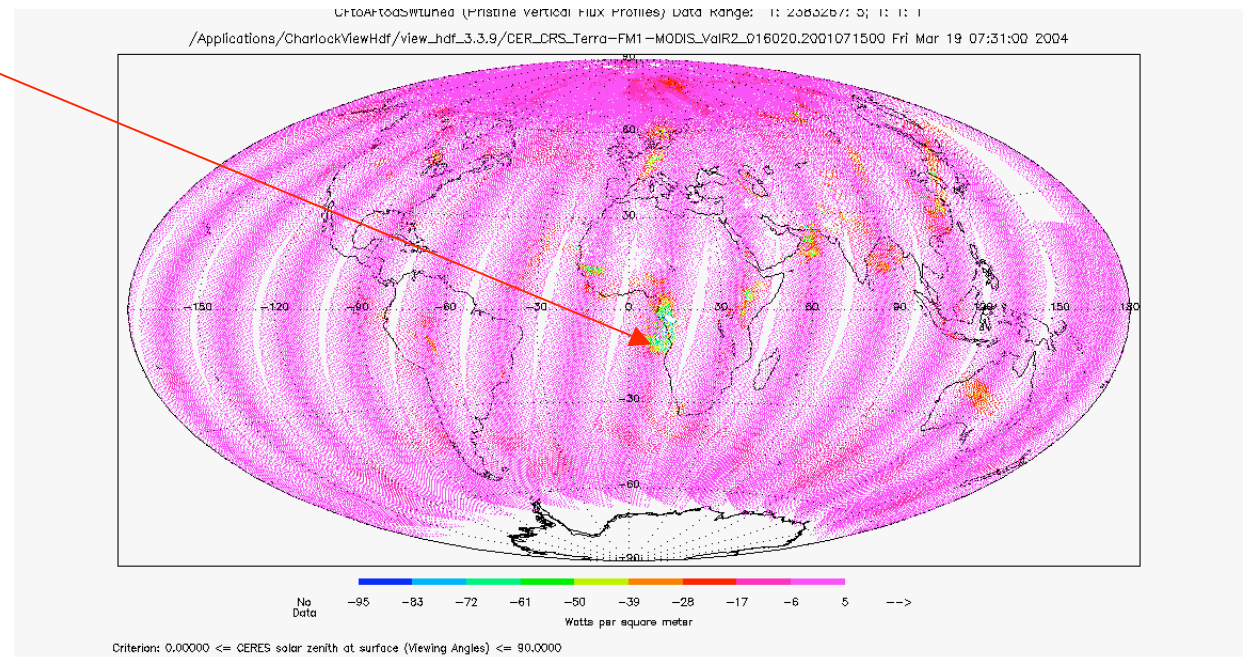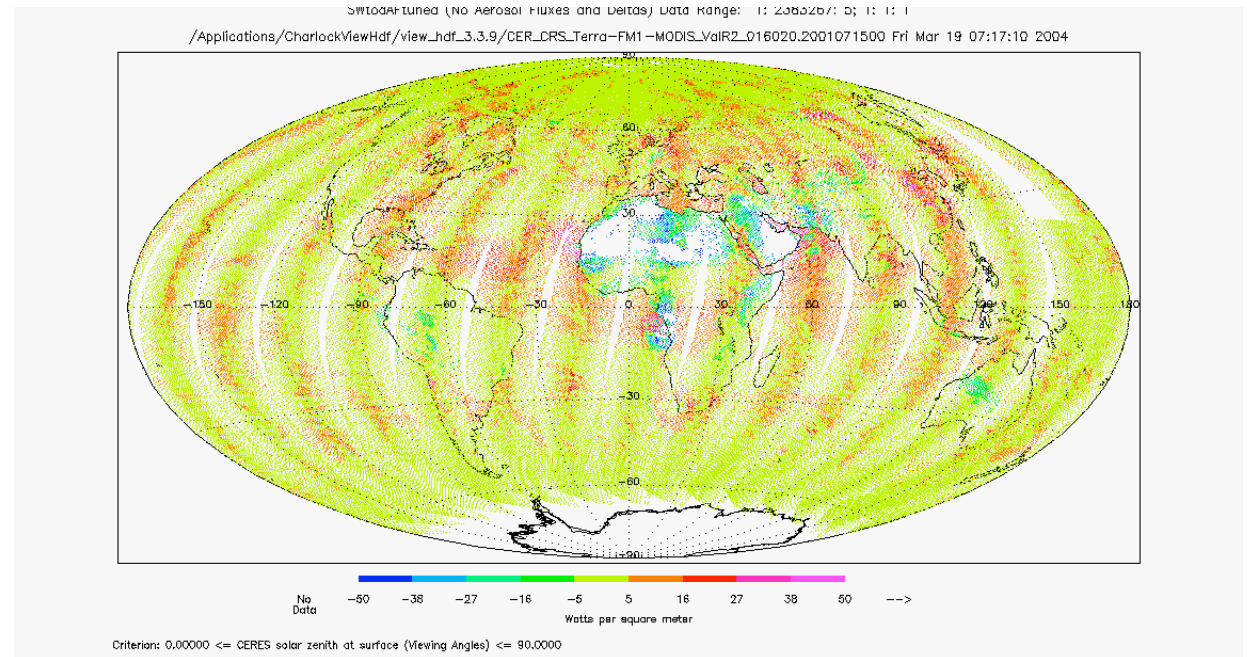Aerosol forcing to SW at TOA
MODIS screened clear sky
scale -50 to 50 Wm-2

Aerosol forcing to SW at TOA
All sky
scale -50 to 50 Wm-2
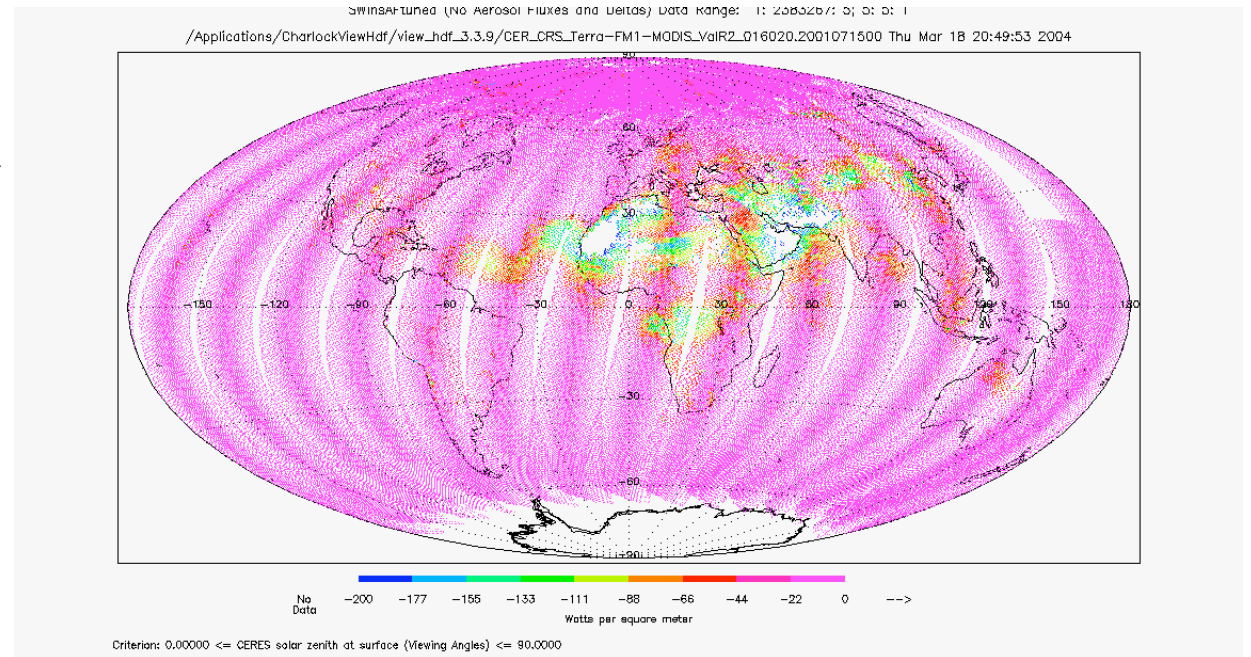

Soot (%)

Cloud Impact on Aerosol
forcing to SW at TOA
scale -95 to 5 Wm-2

Cloud imact on forcing =
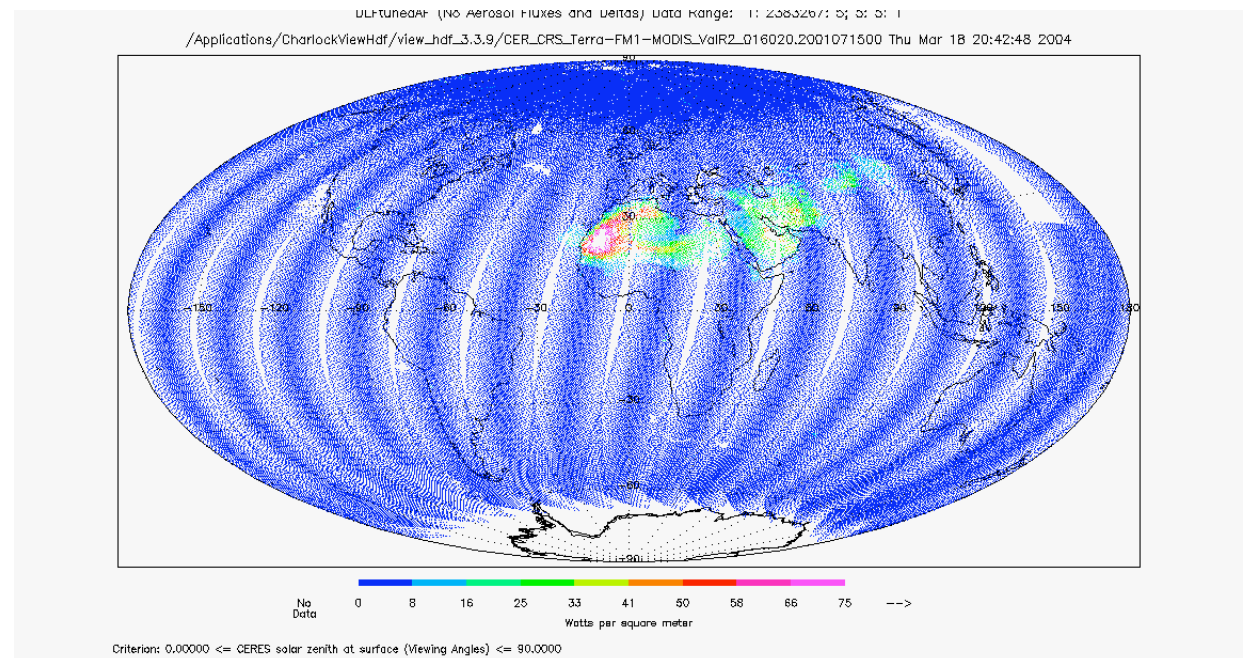   All sky forcing
                - Theoretical clear forcing

Aerosol forcing to SW **insolation**
All sky
scale -200 to 0 Wm-2

Aerosol forcing to
LW down at surface
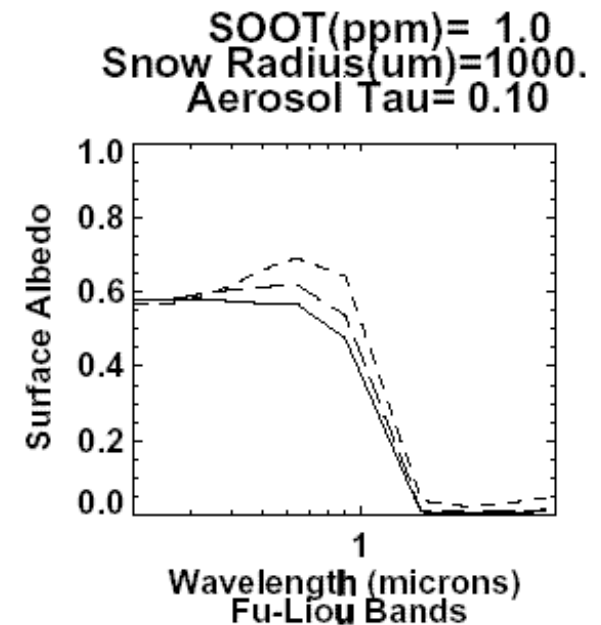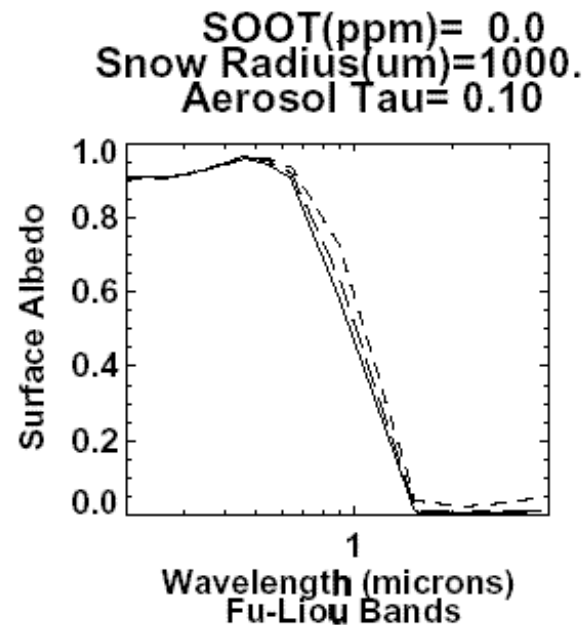All sky
scale 0 to 75 Wm-2

Aerosols that fall down
are not "dead on arrival."
If they land on snow,
they may continue to
vex us.

Arctic concentration
    of soot 0.1 ppm??

Lower panels have large
snow grains which are
more typical of NH.
They are more easily
affected by soot.

Results from Jin model.

SOOT(ppm)= 0.0
Snow Radius(um)= 50.
Aerosol Tau= 0.10

SOOT(ppm)= 1.0
Snow Radius(um)= 50.
Aerosol Tau= 0.10

SOOT(ppm)= 0.0
Snow Radius(um)=1000.
Aerosol Tau= 0.10

SOOT(ppm)= 1.0
Snow Radius(um)=1000.
Aerosol Tau= 0.10

Surface Albedo

Wavelength (microns)
Fu-Liou Bands
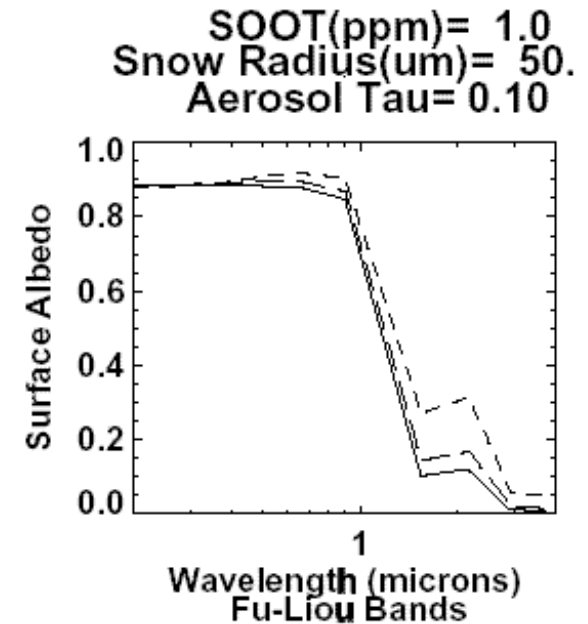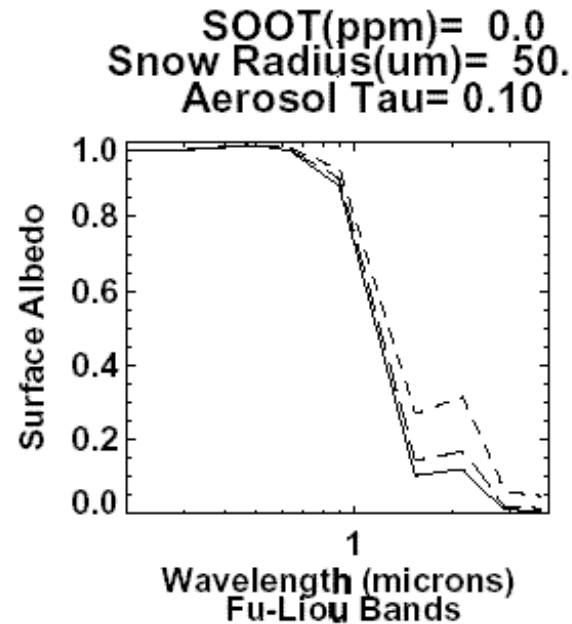
COSSOL :Solid =0.7 , LongDash=0.5 , ShortDash=0.2

Ocean Albedo Chlorophyll Sensitivity
SZA= 0 :: July_Clim minus Chl=0.1(mg/m^3)

CHL Forced Band 7 Albedo

-0.010 -0.006 -0.002 0.002 0.006 0.010
CHL Forced Band 7 Albedo

N=	36548.	Mean	(StdDev)
Longitude		190.91(	100.68)
Latitude		4.77(	39.81)
CHL Forced Band 7 Albedo		-0.00(	0.00)

CHL Forced Band 8 Albedo

-0.010 -0.006 -0.002 0.002 0.006 0.010
CHL Forced Band 8 Albedo

N=	36548.	Mean	(StdDev)
Longitude		190.91(	100.68)
Latitude		4.77(	39.81)
CHL Forced Band 8 Albedo		-0.00(	0.00)
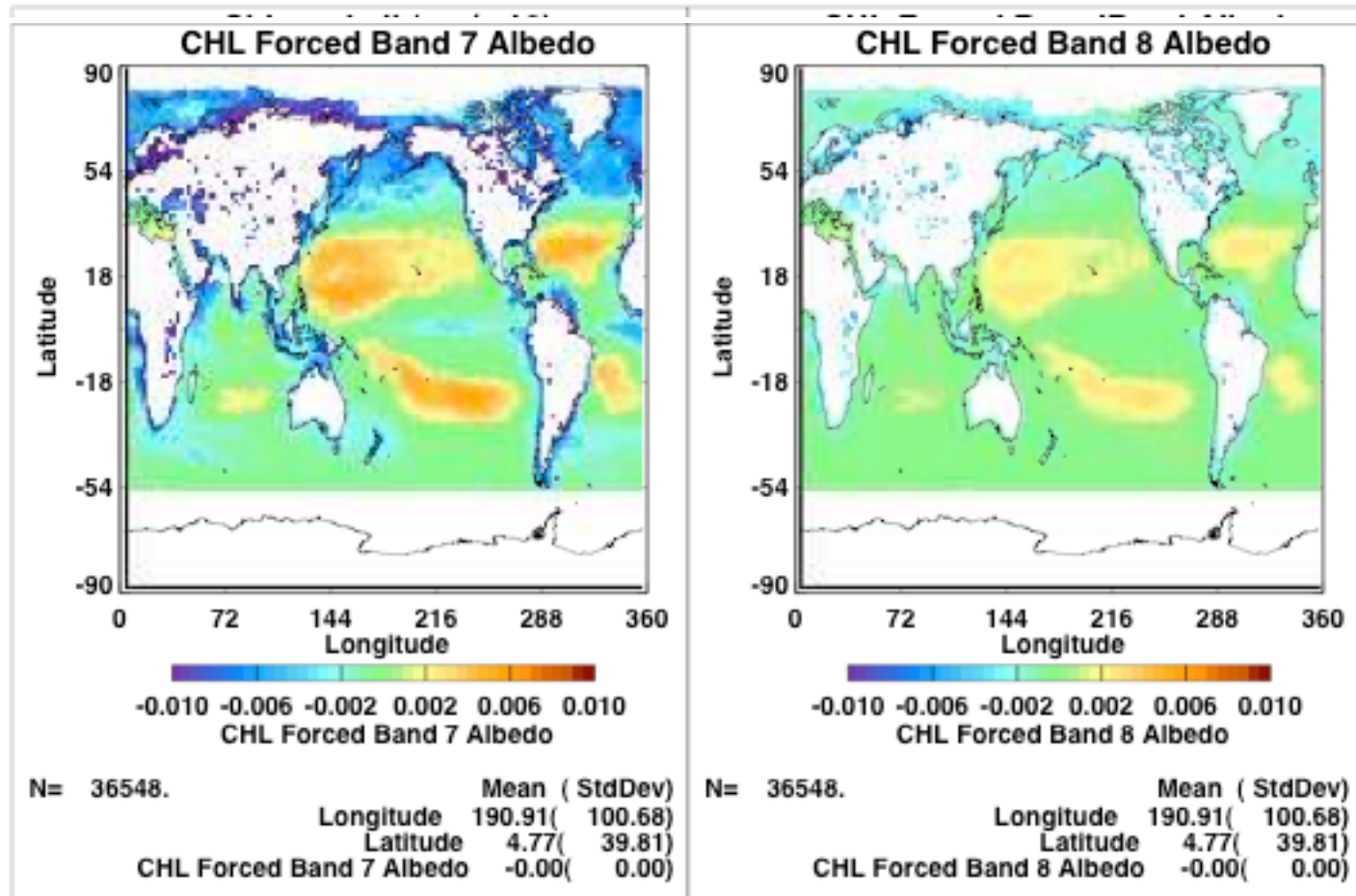
Comments

CERES SARB fluxes show promise. Despite the dusty failings, some components of aerosol forcing can be used already.

Direct aerosol forcing and surface albedo forcing could be assessed with a major effort. This would involve modeling (i.e., MATCH), repeated reprocessing, and comparison with surface measurements (which would themselves require an advance), as well as satellite data.

If solid radiative forcings are not obtained by some means, cause and effect in anthropogenic climate change simply cannot be uncorked.