CERES/ARM Validation Experiment (CAVE)

A Web Based Tool for Radiation Transfer and Display of CERES Data Product Validation

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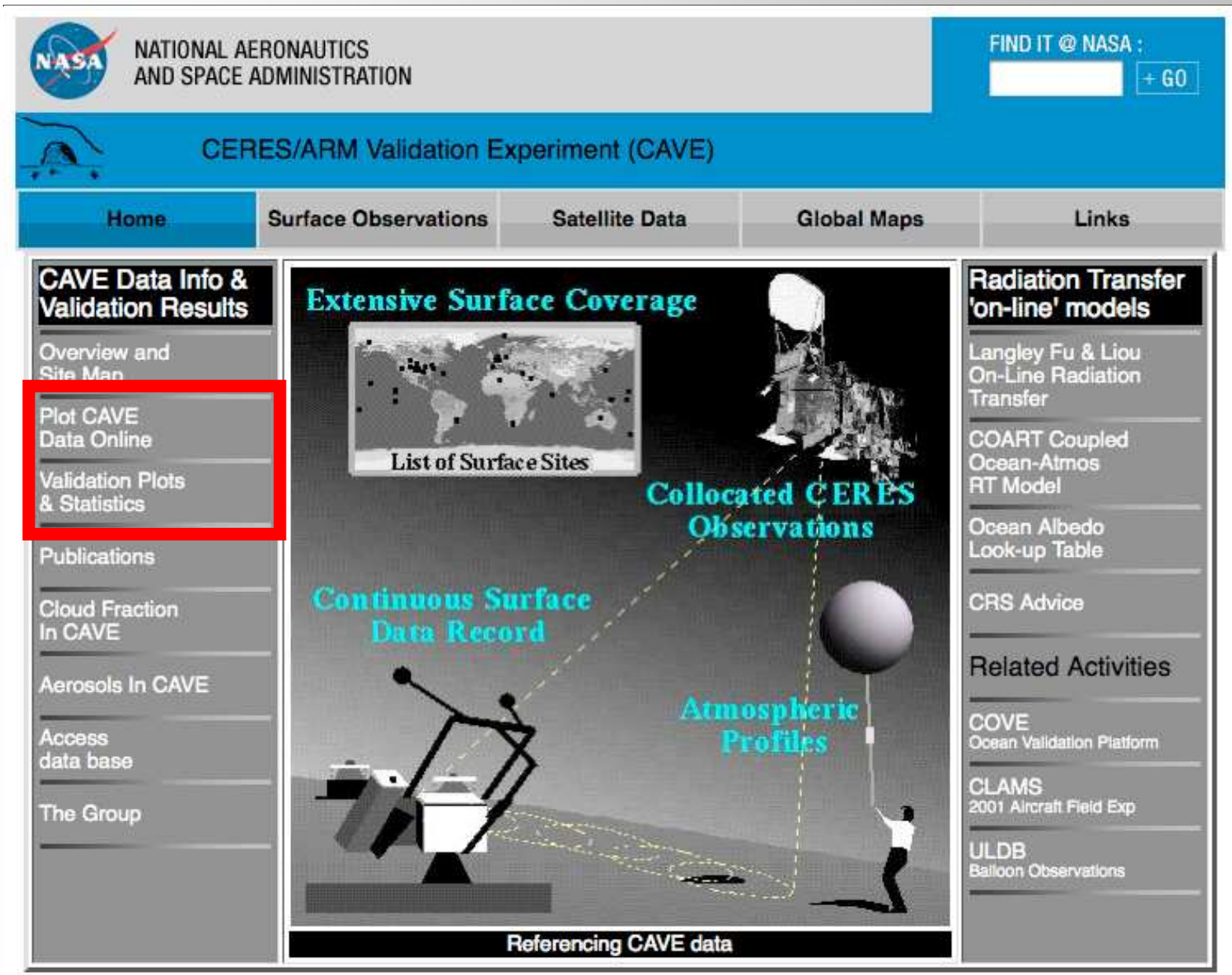
CERES Surface and Atmospheric Radiation Budget (SARB)

Fundamental tasks:

- Calculate flux profiles beneath CERES footprints (anywhere on the globe.)
- Calculate flux profile in CERES grid boxes, globally, hourly.
- Validate results at Top Of Atmosphere (TOA) and Surface.

Globally define atmosphere, aerosol, surface, and cloud properties.

CERES PRODUCT	Name	What?	Resolution Space/Time	Archived		
				Terra	Aqua	TRMM
CRS	Clouds & Radiation Swath	Radiation Transfer run on each footprint	Footprint (~20km) Instantaneous	2000/03 2009/03 Ed2 (b)(f)(g)	2002/02 2007/12 Ed2 (c)	1998/01 1998/08 Ed2 (c)
SYN	"Synoptic" SARB	Radiation Transfer run on 1 Degree Grid box	Global 1 Degree Equal Angle 3 Hourly (run hourly)	2000/03 2005/10 Ed2c	2002/07 2005/10 Ed2b	N/A

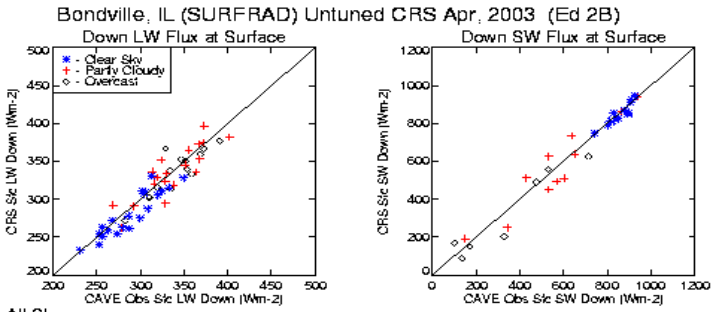


http://www-cave.larc.nasa.gov/cave/

Validation – Plots & Statistics

Detailed statistics for each surface site and groups of sites.

Time series of observations, biases, and cloud & aerosol forcings.



All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	318.7	54	-4.5	15.3	15.8	27.7	1.5
LW Up Sfc	381.2	42	9.8	18.1	20.4	--------	--------
SW Dn Sfc	633.2	30	-9.9	56.5	56.4	-276.4	-22.6
SW Up Sfc	134.1	30	-55.2	25.5	60.6	--------	--------
LW Up TOA	241.9	54	1.3	7.0	7.1	-22.1	-0.5
SW Up TOA	331.8	30	8.6	21.6	22.9	177.8	10.8

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	288.8	21	-7.6	12.5	14.3	--------	1.9
LW Up Sfc	398.9	14	15.5	19.8	24.6	--------	--------
SW Dn Sfc	857.2	12	-6.9	23.6	23.6	--------	-32.5
SW Up Sfc	180.1	12	-62.8	17.9	65.1	--------	--------
LW Up TOA	274.3	21	0.0	3.0	3.0	--------	-0.7
SW Up TOA	174.7	12	-3.8	4.1	5.5	--------	11.5

Clear Sky MODIS & L/AA

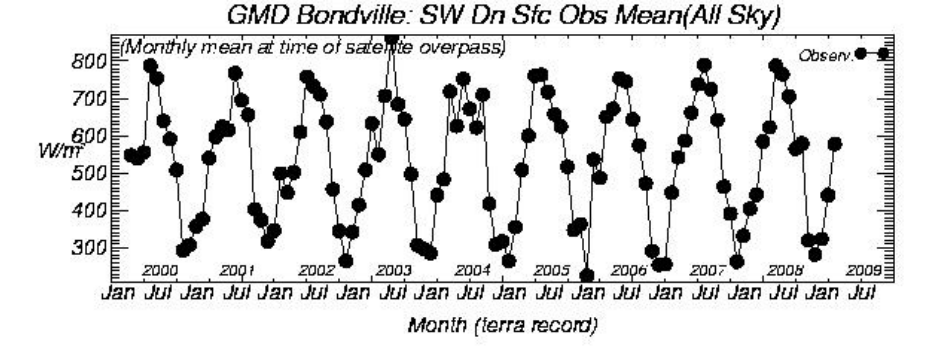
	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	291.5	5	-17.2	5.7	18.0	--------	2.2
LW Up Sfc	431.5	5	9.8	16.4	17.7	--------	--------
SW Dn Sfc	836.0	5	-13.2	20.1	22.3	--------	-32.6
SW Up Sfc	177.4	5	-69.9	14.7	71.1	--------	--------
LW Up TOA	285.5	5	-0.8	4.0	3.7	--------	-0.8
SW Up TOA	167.8	5	-5.0	4.6	6.5	--------	12.5

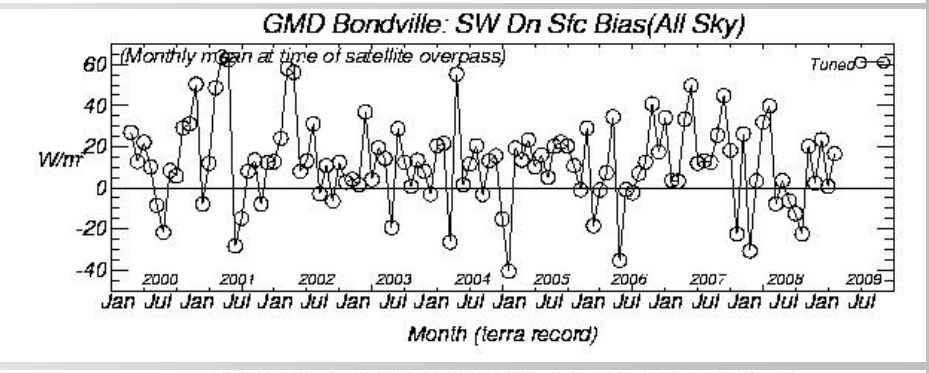
Overcast MODIS

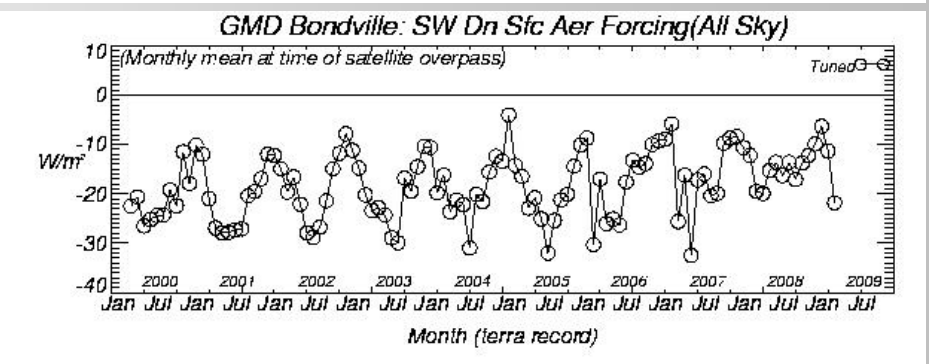
	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	339.9	14	-5.2	14.9	15.3	58.6	0.7
LW Up Sfc	359.2	12	6.0	13.5	14.2	--------	--------
SW Dn Sfc	351.0	7	-25.1	68.2	67.9	-590.8	-12.4
SW Up Sfc	75.7	7	-37.7	29.1	46.3	--------	--------
LW Up TOA	198.5	14	3.0	9.0	9.2	-51.1	-0.1
SW Up TOA	557.9	7	23.9	20.8	30.7	428.3	4.7

Overcast MODIS & L/AA

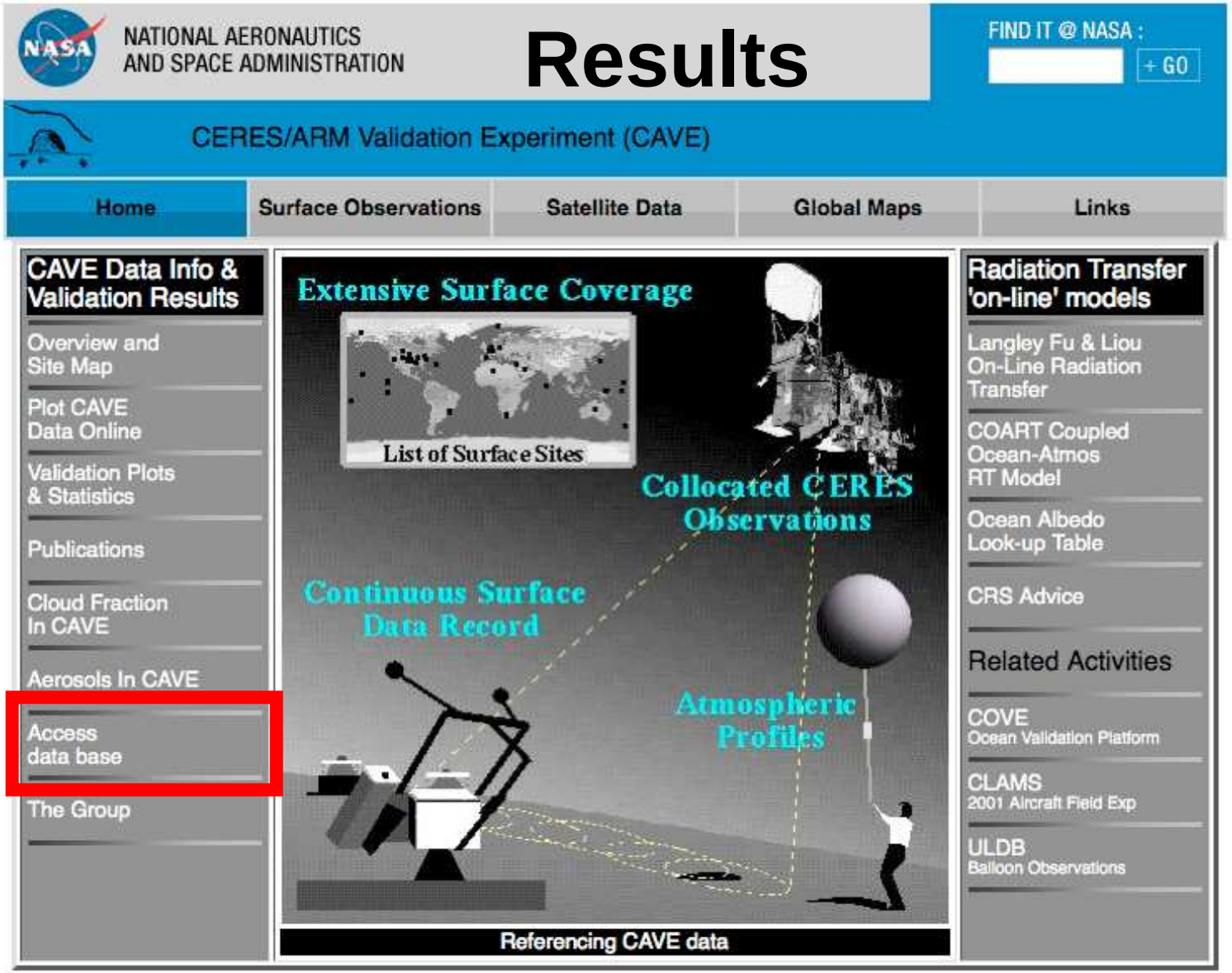
	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	333.6	4	-6.8	5.4	8.2	63.9	0.4
LW Up Sfc	361.7	4	11.3	7.9	13.3	--------	--------
SW Dn Sfc	280.5	4	-22.9	66.5	62.0	-627.0	-10.3
SW Up Sfc	59.5	4	-28.3	37.5	43.1	--------	--------
LW Up TOA	177.3	4	12.3	6.5	13.5	-62.6	-0.1
SW Up TOA	615.9	4	24.5	29.3	35.3	487.2	0.0







Access Surface Observations & SARB Results



http://www-cave.larc.nasa.gov/cave/

Available Surface Observations

Select Desired Data From the Data Base

Data Type	One Surface Site ----- Or	Grouping of Surface Sites	One Year ----- Or	All Years	Read Program
SAM SYN_UT SYN_LT CRS PROFILE	arm_E13 arm_E01 arm_E03 arm_E20 arm_E22	arm_sgp surfrad island desert polar	1998 1999 2000 2001 2002	○ yes ⊙ no	⊙ f90 ○ idl

For CRS data only, choose a satellite:
⊙ terra ○ aqua ○ trmm

Continue

Reset

Curator: David Rutan
NASA Responsible Official:
Dr. Thomas Charlock
Last updated: Dec 15, 2009

Please review your selections (or fill missing choices) before proceeding.

You have selected data from the **SAM** set of records from CAVE.

SAM is the 15 minute average surface observations.

The surface site location of the data selected is: **arm_E13.**

The year chosen for the data is: **2000**.

Please enter e-mail address:

Why do we ask, you ask?

CAVE is funded by the NASA Earth Observing System (EOS) project, and it is important we document use of CAVE data. We ask for your email address to track data usage, we do not maintain nor disseminate it.
Should you publish using CAVE data please adhere to the instruction given at Referencing CAVE data. Copies of reprints, reports etc. would also appreciated and can be sent to: David Rutan.

If the above information is correct press the **Request** data button below.

Request

Available Parameters			Monthly	
Parm#	#obs/month	Parameter_label (units) avail.	Min	Max
1	2976	Cos(Sol Zen Ang) (-----) (yes)	-0.576	0.972
2	2536	LW Flux Dowm (W/m*m) (yes)	370.6	488.0
3	2840	LW Flux Up (W/m*m) (yes)	412.9	611.1
4	2866	SW Global Down (W/m*m) (yes)	0.000	1036.1
5	2868	SW Global Up (W/m*m) (yes)	0.000	204.9
6	2854	SW Direct Horzontal(W/m*m) (yes)	-0.001	858.7
7	1902	SW Diffuse Down (W/m*m) (yes)	0.000	557.1
8	1889	Total SW Dn,Dir+Dif(W/m*m) (yes)	-0.001	1011.3
9	2858	Temp Surface Air (Deg C) (yes)	14.8	41.9
10	2889	Sfc Pressure (mb) (yes)	970.9	983.2
11	2889	Sfc Wind Speed (m/s) (yes)	0.268	10.0
12	2889	Sfc Wind Dir (+degN) (yes)	6.4	339.8
13	2862	Sfc Rel Humidity (%) (yes)	20.4	99.9
14	1394	Cloud Fract (SWFA) (0-1) (yes)	0.000	1.000
15	132	Aeronet AOD Lev 2.0 340nm (yes)	0.179	0.752
16	132	Aeronet AOD Lev 2.0 380nm (yes)	0.161	0.691
17	132	Aeronet AOD Lev 2.0 440nm (yes)	0.128	0.609
18	132	Aeronet AOD Lev 2.0 500nm (yes)	0.113	0.518
19	132	Aeronet AOD Lev 2.0 670nm (yes)	0.073	0.351
20	132	Aeronet AOD Lev 2.0 870nm (yes)	0.052	0.234
21	132	Aeronet AOD Lev 2.0 1020nm (yes)	0.027	0.187
22	131	Aeronet Precip Wat (cm) (yes)	2.850	5.2
23	0	SMOS Precip. Total (mm) (no)	******	******
24	2641	MWR Precip Water (cm) (yes)	2.633	6.9
25	578	MWR Liq.Wat Path (g/m**2) (yes)	1.078	1107.3
26	2642	MWR %WetWindo(0-dry,1-wet) (yes)	0.000	1.000
27	2641	23 Ghz Tb (Deg K) (yes)	42.7	152.1
28	2642	31 Ghz Tb (Deg K) (yes)	20.5	239.0
29	812	MWR Cloud Fraction (0-1) (yes)	0.000	1.000
30	265	Ceil Cld Base Hgt 1(m) (yes)	278.0	7457.1
31	1	Ceil Cld Base Hgt 2(m) (yes)	1527.8	1527.8
32	0	Ceil Cld Base Hgt 3(m) (no)	******	******
33	2974	MPL Cloud Base Hgt (m) (yes)	0.000	14061.

Available CERES CRS Values

For footprints < 25km from surface site

Select Desired Data From the Data Base

Data Type	One Surface Site ----- Or	Grouping of Surface Sites	One Year ----- Or	All Years	Read Program
SAM SYN_UT SYN_LT CRS PROFILE	arm_E13 arm_E01 arm_E03 arm_E20 arm_E22	arm_sgp surfrad island desert polar	1998 1999 2000 2001 2002	○ yes ⊙ no	⊙ f90 ○ idl

For CRS data only, choose a satellite:
⊙ terra ○ aqua ○ trmm

Continue

Reset

Curator: David Rutan
NASA Responsible Official:
Dr. Thomas Charlock
Last updated: Dec 15, 2009

Please review your selections (or fill missing choices) before proceeding.

You have selected data from the **CRS** set of records from CAVE.

CRS is the CERES satellite data product where the CERES footprint fell within 25km of the selected surface site

The surface site location of the data selected is: **arm_E13.**

The year chosen for the data is: **2000.**

Please enter e-mail address:

Why do we ask, you ask?

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Should you publish using CAVE data please adhere to the instruction given at Referencing CAVE data. Copies of reprints, reports etc. would also appreciated and can be sent to: David Rutan.

Single Satellite Flux (SSF) Data
1 – Julian Day
2 – Fraction Julian Day
3 - Sat Radius from Earth Center (km)

Includes CERES observations & Cloud Properties

Radiation Transfer I/O & Results
292 – PAR (Wm-2)
293 – Direct/Diffuse Ratio (-)
294 – Corrected Initial Surface Albedo (-)

Calculated Fluxes at 5 atmospheric levels.

Derived Variables (Not on official CRS)
455 – Monthly 15min time index (1-2976)
456 – Local Time
457 – Footprint distance from surface site (km)

Other … such as forcings.

515 – Glint Angle (deg)

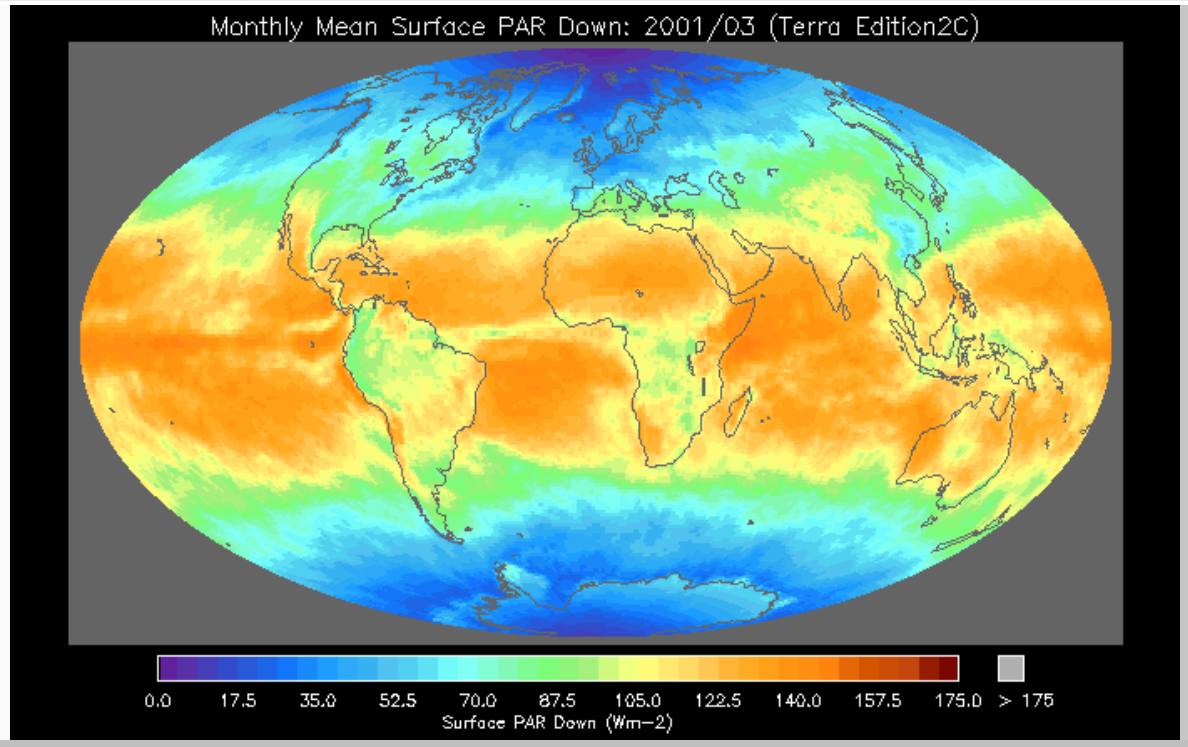
Figure 1. Graphic showing Surface Aerosol Meteorology (SAM) file structure.

Access SYN Results

http://www-cave.larc.nasa.gov/cave/

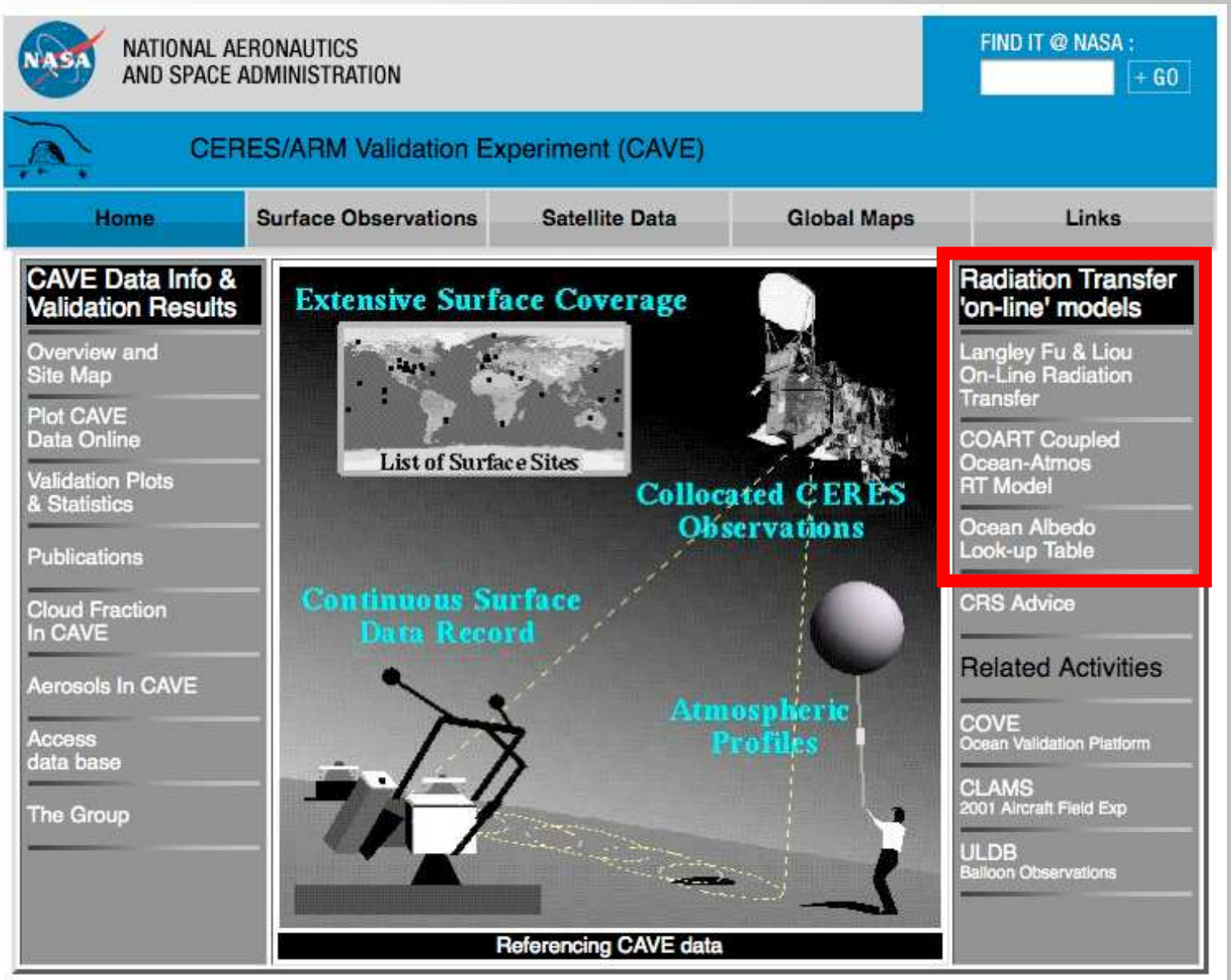
Monthly Mean Maps (Subset of AVG)

Top Of Atmosphere	SW Down		SW Up			LW Up	Albedo(%)	
Surface	SW Down		SW Up		LW Down	LW Up	Albedo(%)	
At 500mb	SW Down		SW Up		LW Down	LW Up		
Total sky, No Aerosols	SW Down Sfc		SW Up Sfc		LW Down Sfc	LW Up Sfc	SW Up TOA	LW Up TOA
Additonal SW Surface Parameters	Total PAR	Direct PAR	Diffuse PAR	Total UVA	Direct UVA	Diffuse UVA	Erythemal UVB	UV Index



ASCII version of map can be downloaded

Radiation Transfer Models On-Line



http://www-cave.larc.nasa.gov/cave/

Fu/Liou/Charlock/Kato/Kratz/Rose (FLCKKR)

Radiation Transfer Model

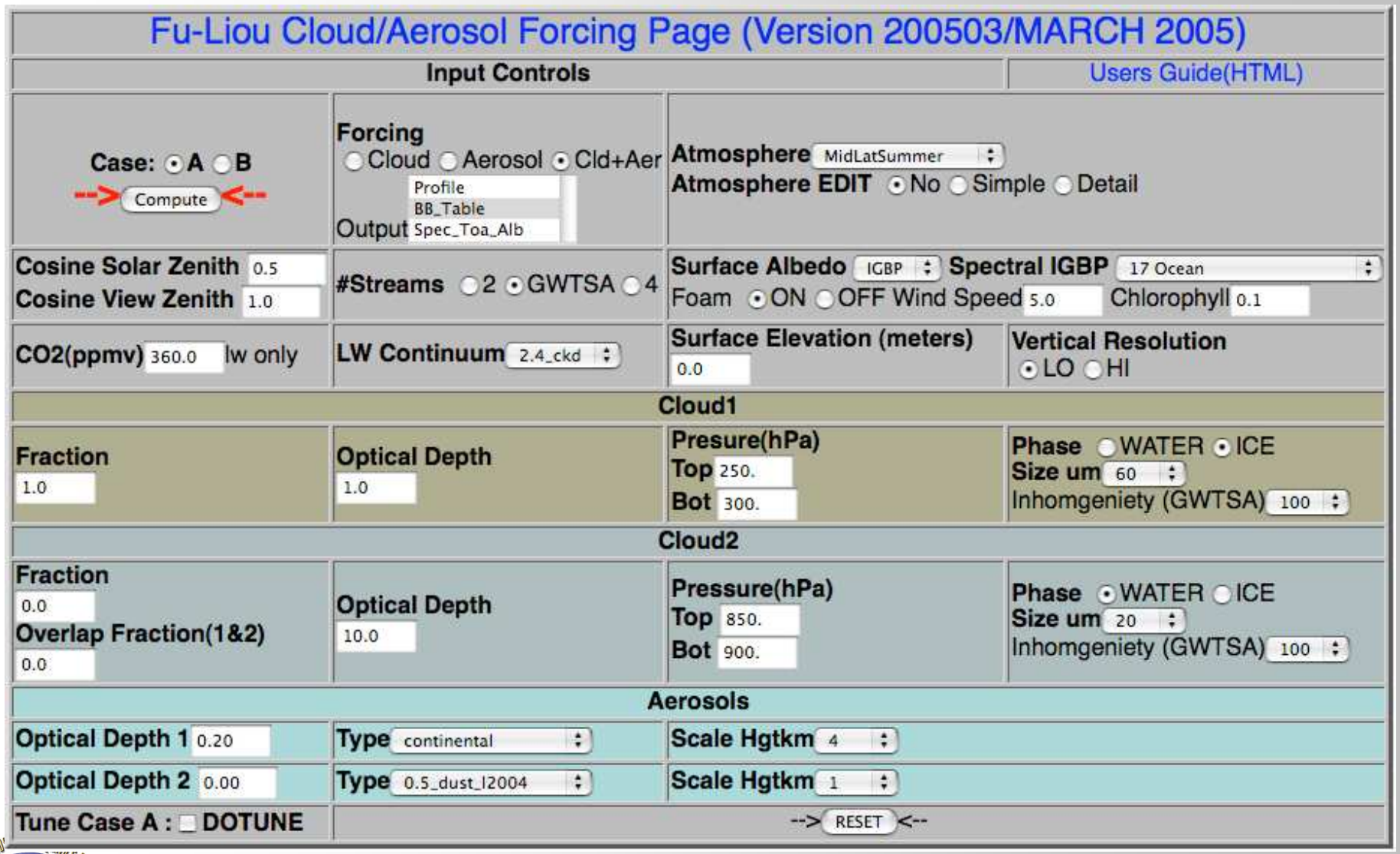
Delta 2-stream
- Correlated K with 15SW &12 LW bands
- Up to 36 levels, 2 near surface levels
- Floating cloud boundaries (no overlap, maximum of 2 levels)

Inputs
- Atmosphere: GEOS4(GMAO)Reanalysis(1Deg)
- Ozone: NCEP (SBUV/2)
- Aerosols: MODIS & MATCH (AOT) MATCH (type, height)
  - OPAC & Lacis (SSA, g)

Surface properties
- $\alpha(\nu)$ – scene, α Broadband (clear – CERES, cloudy – History)
- Skin T (clear – MODIS, cloudy – GEOS4)

http://www-cave.larc.nasa.gov/cgi-bin/rose/flp200503/flp200503.cgi

FLCKKR On-Line



FLCKKR On-Line Output

CASE {A:Untuned} --> [PRISTINE] <-Vs-> [Cloud+Aerosol]						
Controll : [PRISTINE]	SHORTWAVE Flux Wm-2					
Perturbed :[Cloud+Aerosol]	TOA			SURFACE		
Cloud& Aerosol	[PRISTINE]	[Cloud+Aerosol]	Forced	[PRISTINE]	[Cloud+Aerosol]	Forced
Up	76.6	174.0	97.3	35.3	29.0	-6.3
Down	682.5	682.5	0.0	485.8	381.0	-104.8
NET	605.9	508.6	-97.3	450.5	351.9	-98.5
ALBEDO	0.112	0.255	0.143	0.073	0.076	0.003
Direct				439.6	158.4	-281.2
Diffuse				46.2	222.6	176.3
Direct FuIceCor				439.6	45.5	-394.1
Diffuse FuIceCor				46.2	335.5	289.2
	LONGWAVE Flux Wm-2					
Up	279.7	214.0	-65.6	422.4	422.5	0.1
Down	0.0	0.0	0.0	350.5	360.5	10.0
NET	-279.7	-214.0	65.6	-71.8	-62.0	9.8

CASE {A:Untuned} --> TOA Spectral Albedo (0-100)																
Sw Band um	.17:.22	.22:.24	.24:.28	.28:.29	.29:.32	.32:.35	.35:.43	.43:.49	.49:59	.59:.70	.70:1.3	1.3:1.9	1.90:2.5	2.5:3.5	3.5:4.0	BB
[PRISTINE]	1.39	0.34	0.17	0.42	6.76	40.56	32.05	22.81	14.46	10.24	5.81	2.55	2.61	0.26	5.74	11.23
[Cloud+Aerosol]	1.39	0.34	0.17	0.42	7.24	47.21	43.33	37.10	29.91	27.08	23.51	14.31	11.16	2.01	5.10	25.49
Forcing	0.00	0.00	0.00	0.00	0.48	6.65	11.28	14.29	15.44	16.83	17.70	11.76	8.54	1.75	-0.65	14.26

Coupled Ocean Atmosphere Radiation Transfer (COART)

Developed from Coupled DIScrete Ordinate Radiative Transfer (CDISORT Jin & Stamnes 1994)

Modified to include ocean surface roughness (Jin 2006)

Ocean treated as additional "atmospheric layers" but with significantly different optical properties

http://www-cave.larc.nasa.gov/jin/rtset.html

COART On-Line Input

Coupled Ocean and Atmosphere Radiative Transfer (COART)

This is a tool for you to calculate radiance and irradiance (flux) at any levels in the atmosphere and ocean (0.2-100um). Specify the inputs simply by **clicking** the buttons and **changing** the default numbers in the table. Setting Ocean_depth=**0** reduces it to conventional atmospheric radiative transfer model. More information here.

Flux or Radiance, spectral range, angular information

- (•) **Spectral fluxes (irradiances)** (up and down) (**W/m^2/um**) at a single wavelength 0.55 (um)
- ( ) **Spectral fluxes(w/m^2/um)** at multiple wavelengths from 0.5 um to 16.0 um **at** every 1.00 um.
- ( ) **Integrated fluxes** (**W/m^2**) from 0.4 to 0.7 um in **Spectral resolution** of 0.01 um.
- ( ) **Broadband shortwave** (0.20-4.0um) **fluxes** (**W/m^2**). (Takes about 30 seconds)
- ( ) **Radiances** (**W/m^2/um/Sr**) at wavelength 0.55 (um).
- ( ) **Radiances** (**W/m^2/um/Sr**) at multiple wavelengths from 0.40 um to 0.50 um **at** every 0.05 um.
- ( ) **Radiance(w/m^2/um/Sr)** (•) in band: 0.58 to 0.68 um in **Spectral Resolution** of 0.025 **um**;
  OR ( ) in satellite channel: AVHRR1 NOAA10 (Need few minutes)

? Want to include the **Water-leaving radiance** output ? ( ) **yes** (•) **no**

Radiance output angles: ( ) at **Zenith**(deg) 0.0 **or** (•) at every 20 (deg) from 0.0 to 180
( ) **Azimuth**(deg) 30.0 **or** (•) at every 45 (deg) from 0.0 to 180

**See how the angles are defined here.

Output at: ☑ TOA, ☑ Surface, ☑ 10.0 **km** above surface, and ☑ 5.0 **(m)** below surface; **OR** ☐ All levels in atmosphere.

Preselected Satellite Channels

METEO
AVHRR1 NOAA8
AVHRR2 NOAA8
AVHRR1 NOAA9
AVHRR2 NOAA9
AVHRR1 NOAA10
AVHRR2 NOAA10
AVHRR1 NOAA11
AVHRR2 NOAA11
AVHRR3
MISR Ch1 Blue
MISR Ch2 Green
MISR Ch3 Red
MISR Ch4 NIR
MODIS Ch1 . . . Ch7
GOES 8 . . . 13 Ch1
MTSAT Ch1
MSG 0.6
MSG 0.8
MSG 1.6

COART On-Line Input

Atmosphere/Aerosol specifics

Select an **atmospheric model** [Mid-Latitude Summer]

☑ If checked, use less atmospheric layers **to save computation time** (not recommended for UV and IR).

☐ If checked, input your **total integrated precipitable water (g/cm^2):** 4.2

☐ If checked, input your **integrated ozone amount (atm-cm):** 0.350 (1 atm-cm=1000 Dobson)

You can also **change these trace gas amounts** by a **factor** (1.0 for no change) of --> **CO_2:** 1.0 **CH_4:** 1.0

Select **Mixed layer aerosol:** [MODTRAN Maritime] & **Stratospheric aerosol:** [No aerosol]

Select a method to specify aerosol loading (To be ignored if "No aerosol" selected above):

○ by **Visibility (km):** 23.0 ⊙ by **AOT** at 0.5um: 0.20 ○ by **AOT** at 0.55um: 0.20

☐ If checked, input aerosol optical properties in the table below (not required to fill all elements, undefined numbers will be fit in by the selected model above):

λ(um):										
AOT:										
SSA:										
g :										

☐ If checked, upload aerosol phase function file: [Browse...]

Select **Cloud:** [No Cloud] **Bottom**(km): 3 **Top**(km): 4 ; size **RE**(um): 10

⊙ **LWP**(g/m^2): 200 **or** ○ **OpticalDepth**(0.6um): 10. (**RE** is effective size for nonspheric)

Ocean specifics

Wind speed(m/s): 0 **Depth (m):** 100 **Bottom albedo:** 0.1 **Chl (mg/m^3):** 0.2 (Chlorophyll)

Particle scattering coefficient (m^{-1}): $b_p(\lambda) = b_0(550/\lambda)^n \times [Chl]^k$; Input b_0: 0.45 , **n:** 0.6 and **k:** 0.62

Particle scattering **phase function** [Petzold Average(bb/b=0.0183)] If use **F-F** func., input **bb/b:**

☐ If checked, input absorption **a**(m^{-1}): (Override the default parameterization)

☐ If checked, input your $a440_{DOM}$(m^{-1}): 0.20 (DOM absorption coefficient at 440nm)

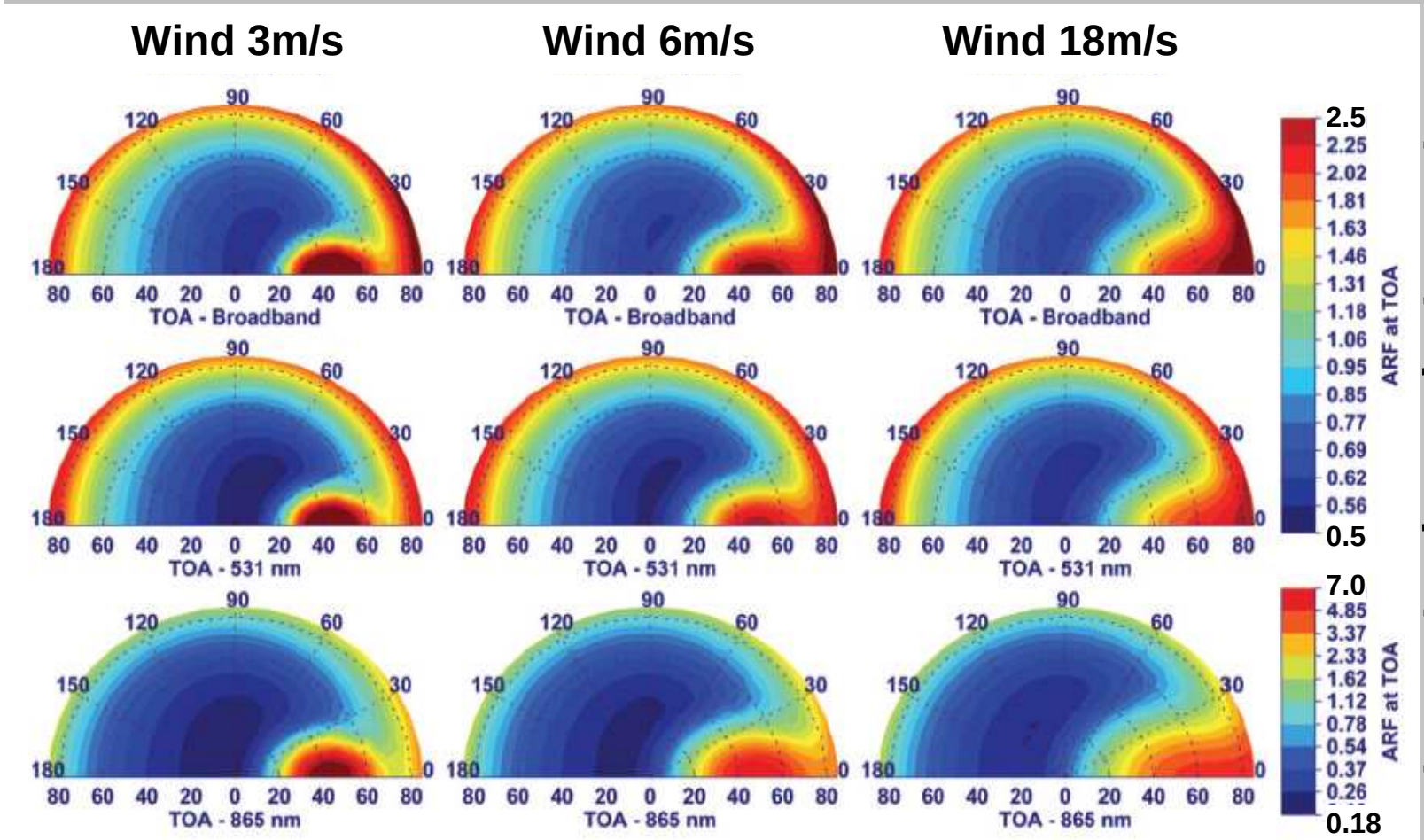
☐ If checked, ignore surface roughness and assume **Flat ocean surface.**

*Note: Input *Depth=0* will ignore the ocean and ocean inputs above (no water, same as atmosphere-land case).

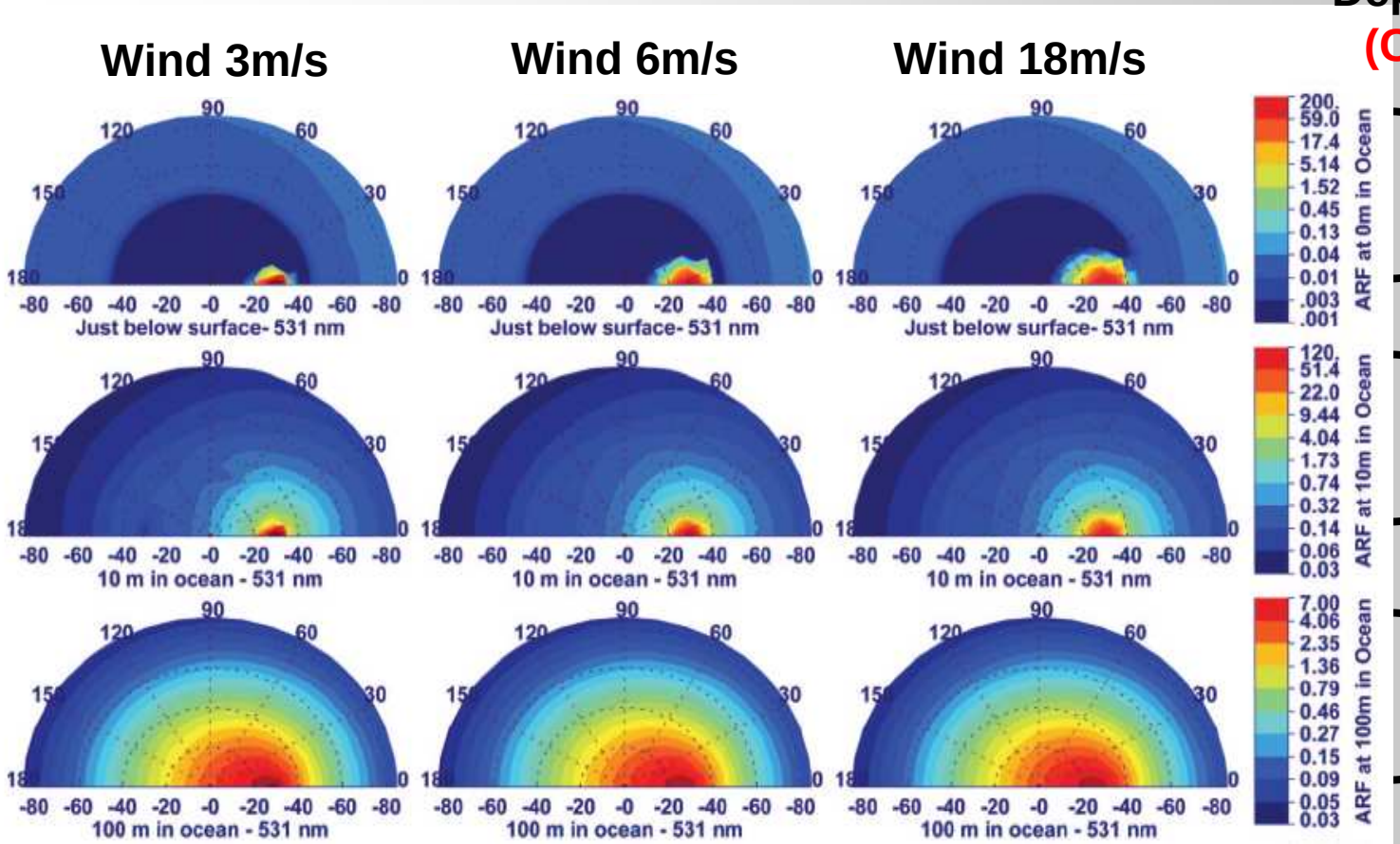
[Submit Form] [Reset Form] . . . . Not clear on some input? Read "The Input" section Here.

TOA+ Anisotropic Reflectance Factor

Broadband, 531nm & 865nm Varying Surface Wind Speed



Ocean Anisotropic Reflectance Factor (all at 531nm)



Depth Below Surface
(Color Bar Range)

1cm
(0.001 – 200.0)

10m
(0.03 – 120.0)

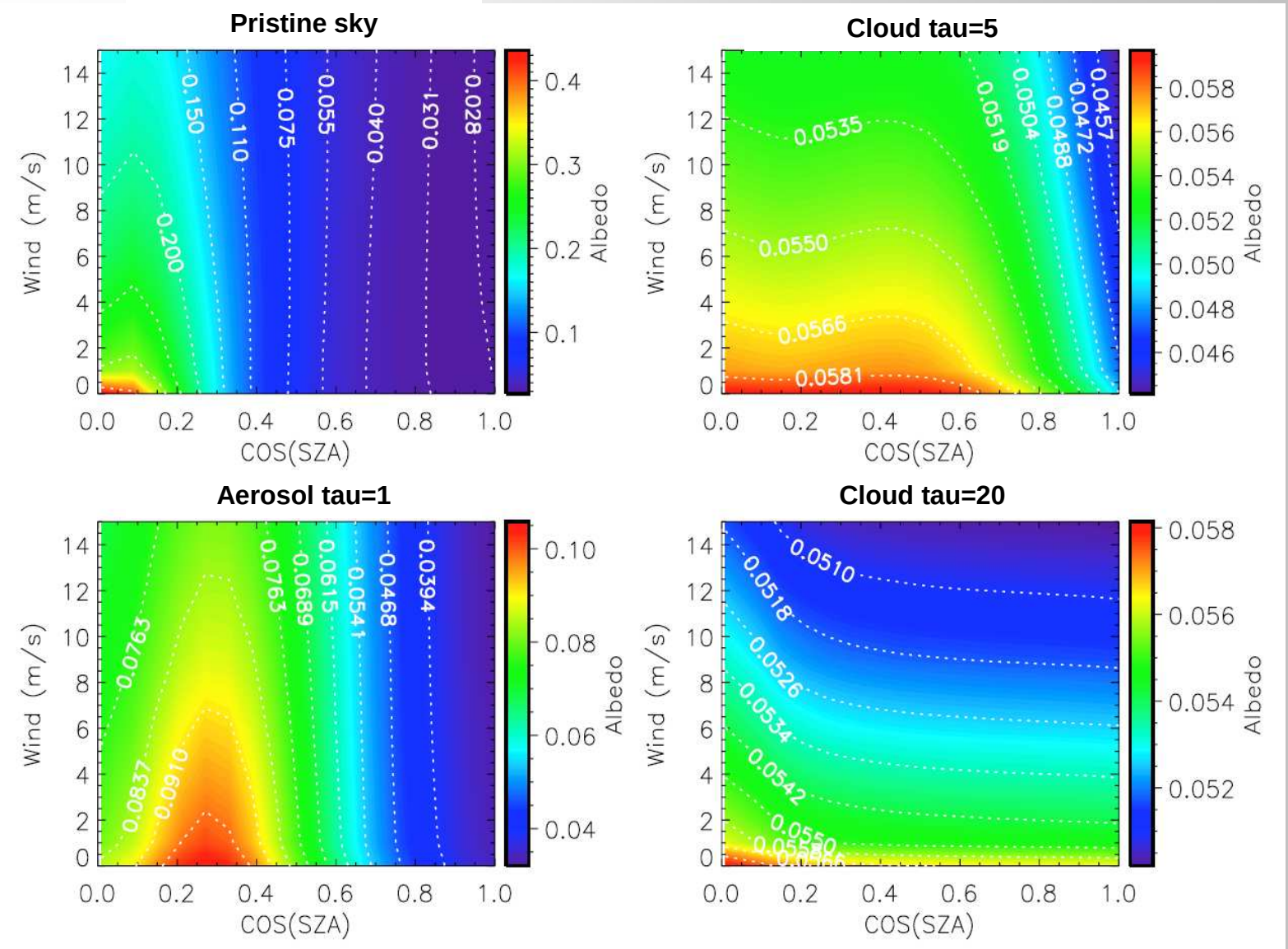
100m
(0.03 – 7.0)

COART Ocean Albedo Parameterization

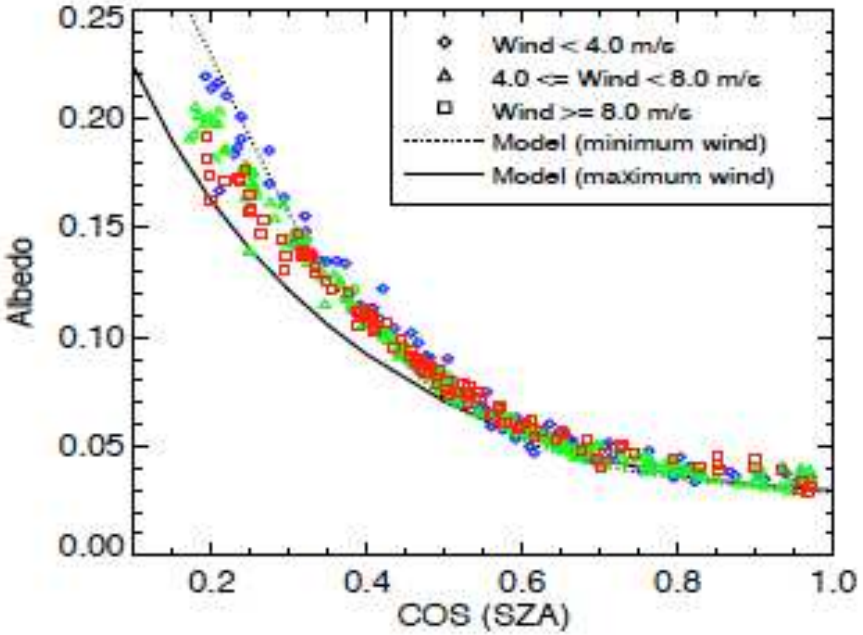
- COART model can only be run on-line
- Can download a parameterized version that produces water spectral albedo.
- Input parameters are:
  - solar zenith angle
  - wind speed
  - aerosol/cloud optical depth
  - ocean chlorophyll concentration

http://www-cave.larc.nasa.gov/jin/gtocnlut.html

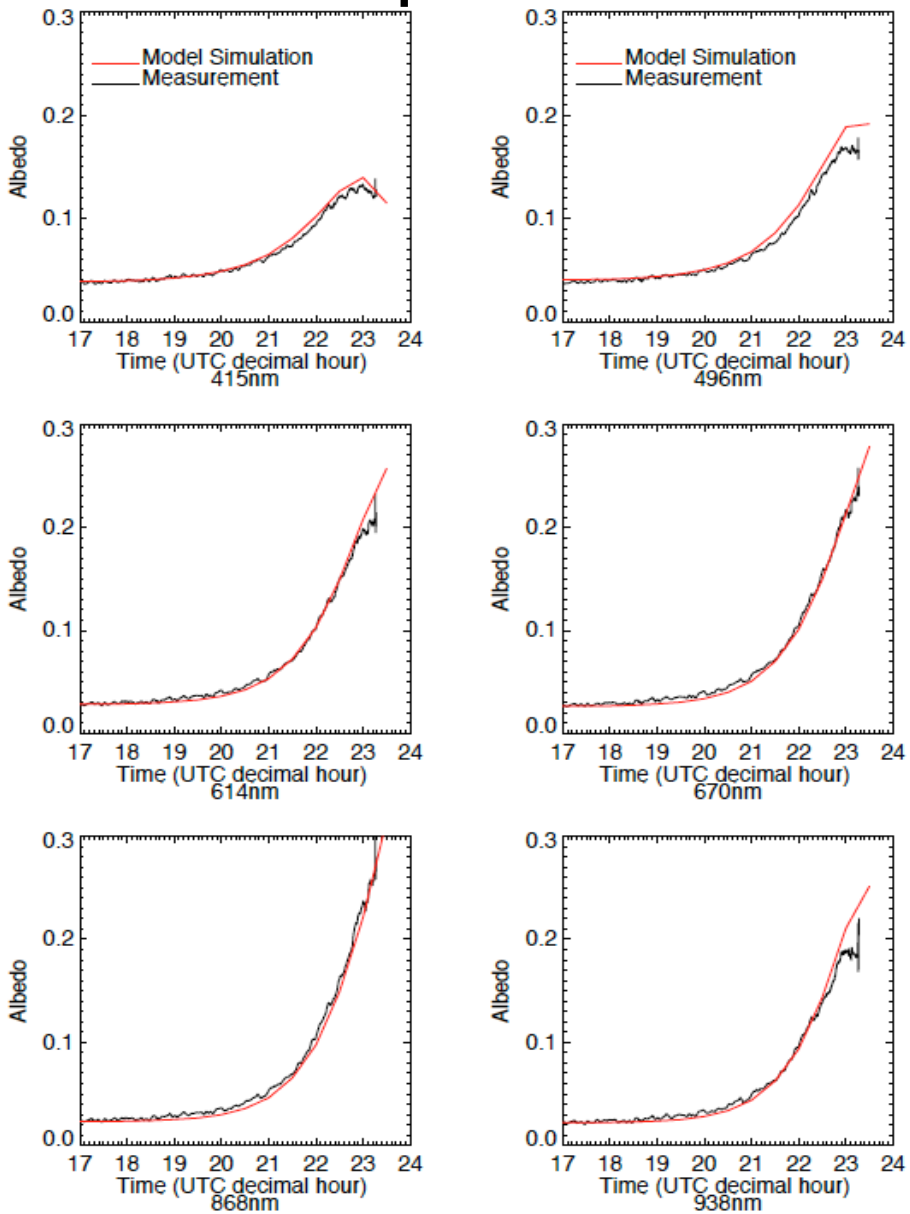
COART Ocean Albedo from LUT Table

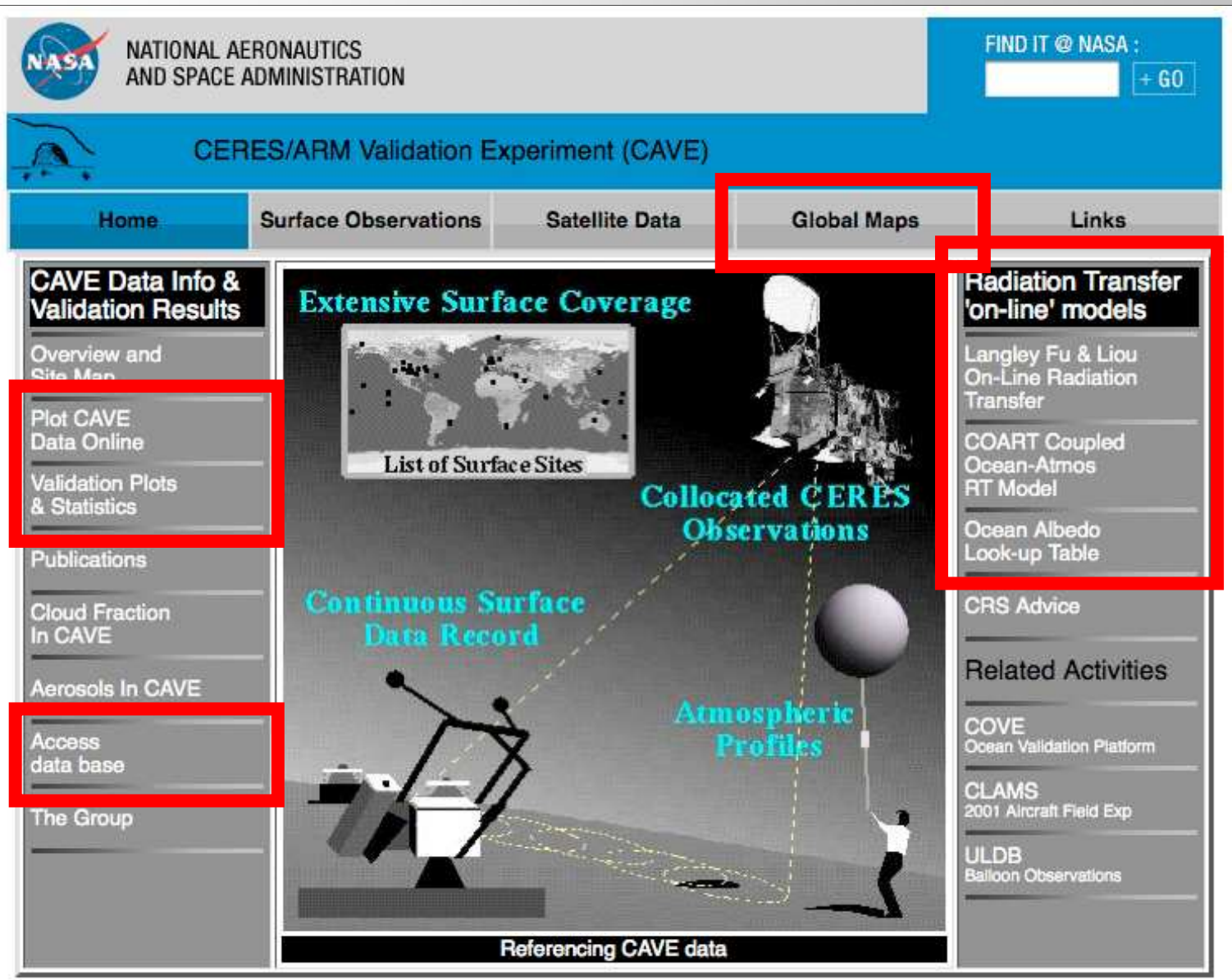


COART Validated at Offshore Platform



Model compared to MFRSR





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