CRS, the CERES Footprint-scale
Surface and Atmosphere Radiation Budget (SARB)

CERES Science Team Meeting (Fort Collins, 3-5 November 2009)

T. P. Charlock (NASA LaRC)
Fred G. Rose (SSAI)
David A. Rutan (SSAI) - Part II of this presentation
Surface validation with CAVE
Zhonghai Jin (SSAI) - Ocean and Cryosphere Radiative Transfer (COART)
Seiji Kato (LaRC) - SARB with Calipso/CloudSAT (CCCM)
David Fillmore (Tech X, Boulder) - MATCH aerosol assimilation
Thomas E. Caldwell (SSAI) - Data Management
Wenying Su (SSAI) - UV, PAR, comparison with GCMs

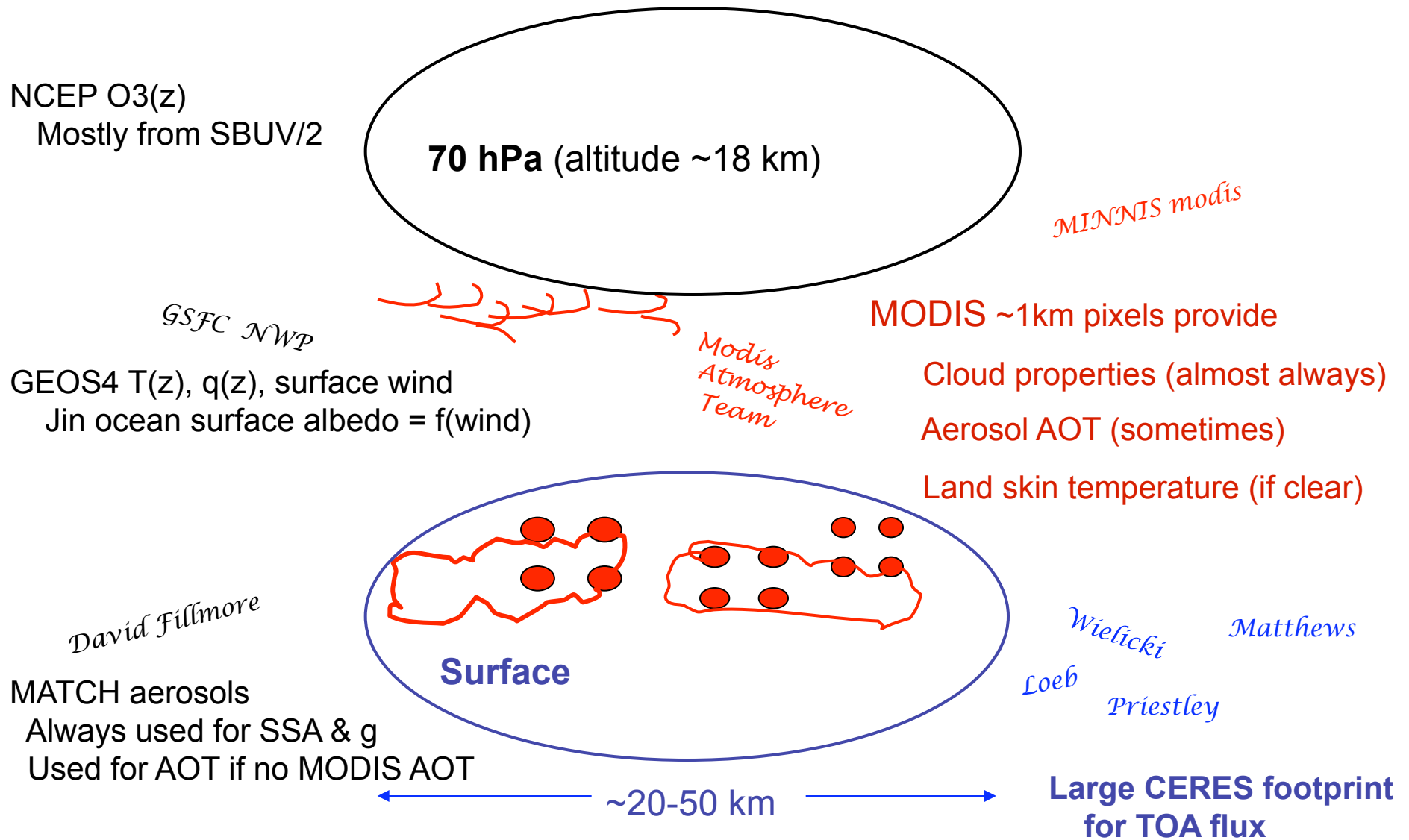**SARB/SOFA Working Group Tuesday Morning:**

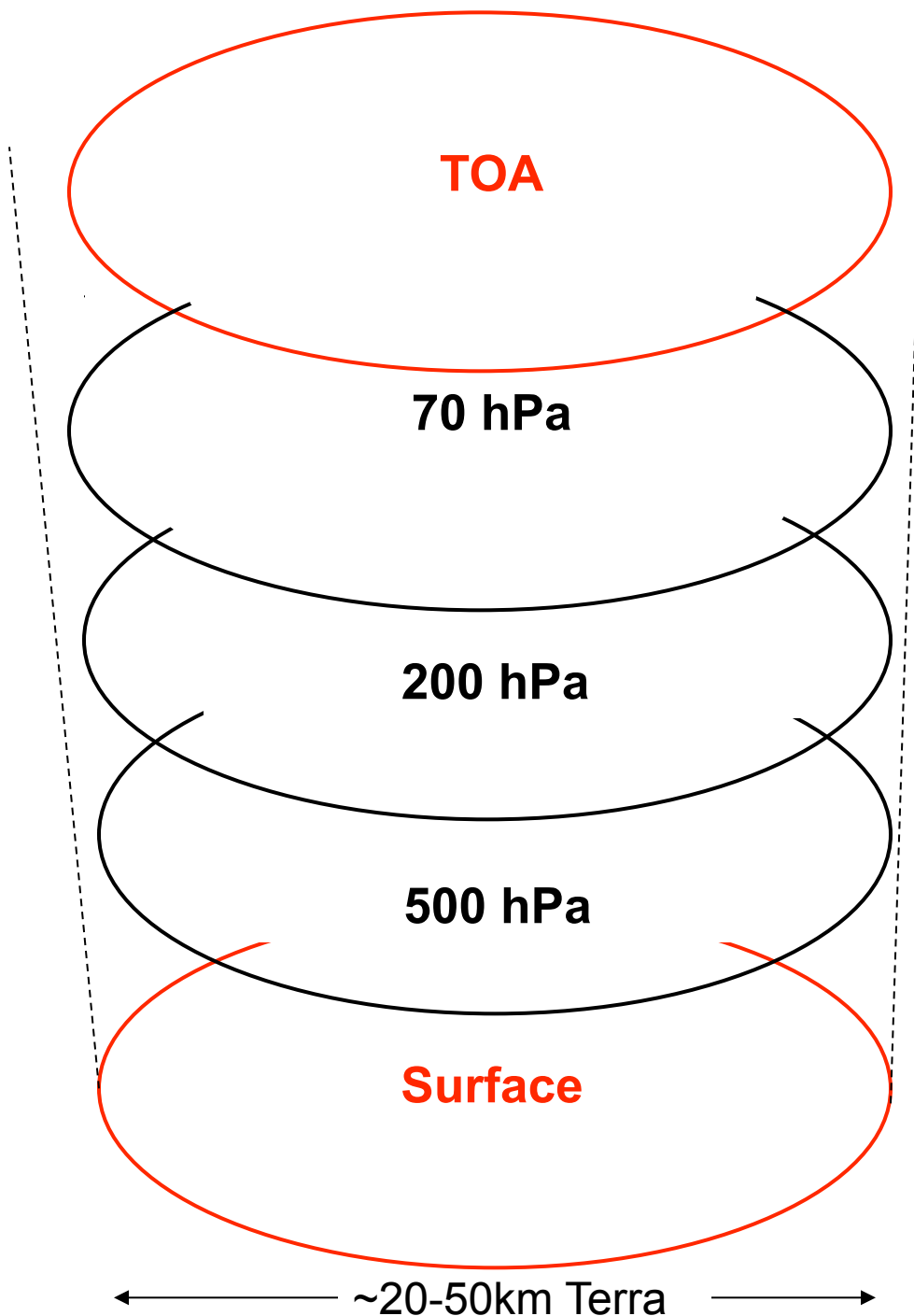**Fillmore** on MATCH developments
Rose on Ice clouds in broadband code
Rutan on CRS-SYN validation

Ungridded SARB vertical profile at ~2,000,000 CRS footprints/day

Langley Fu-Liou radiative transfer: Kato 2005 SW upgrade, Kratz-Rose LW window

70 hPa (altitude ~18 km)

NCEP O3(z)
  Mostly from SBUV/2

GSFC NWP

GEOS4 T(z), q(z), surface wind
  Jin ocean surface albedo = f(wind)

MINNIS modis

Modis Atmosphere Team

MODIS ~1km pixels provide

Cloud properties (almost always)

Aerosol AOT (sometimes)

Land skin temperature (if clear)

David Fillmore

MATCH aerosols
  Always used for SSA & g
  Used for AOT if no MODIS AOT

Surface

Wielicki   *Matthews*

Loeb

Priestley

~20-50 km

**Large CERES footprint
for TOA flux**

CERES CRS: Surface and Atmosphere Radiation Budget (SARB) Product

Tuned fluxes at all 5 levels
  All-sky & Clear-sky, Up & Down,
    SW and LW

Surface & TOA also have Untuned fluxes
  Fluxes with aerosols
  Pristine fluxes (no aerosols)

Aerosol forcing for all-sky & clear-sky

Tuning does NOT yield a perfect
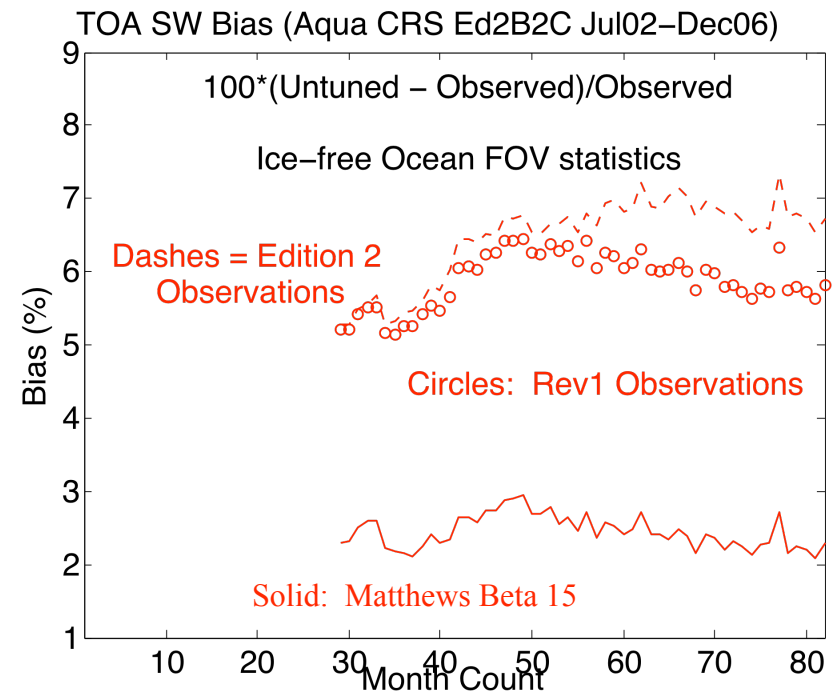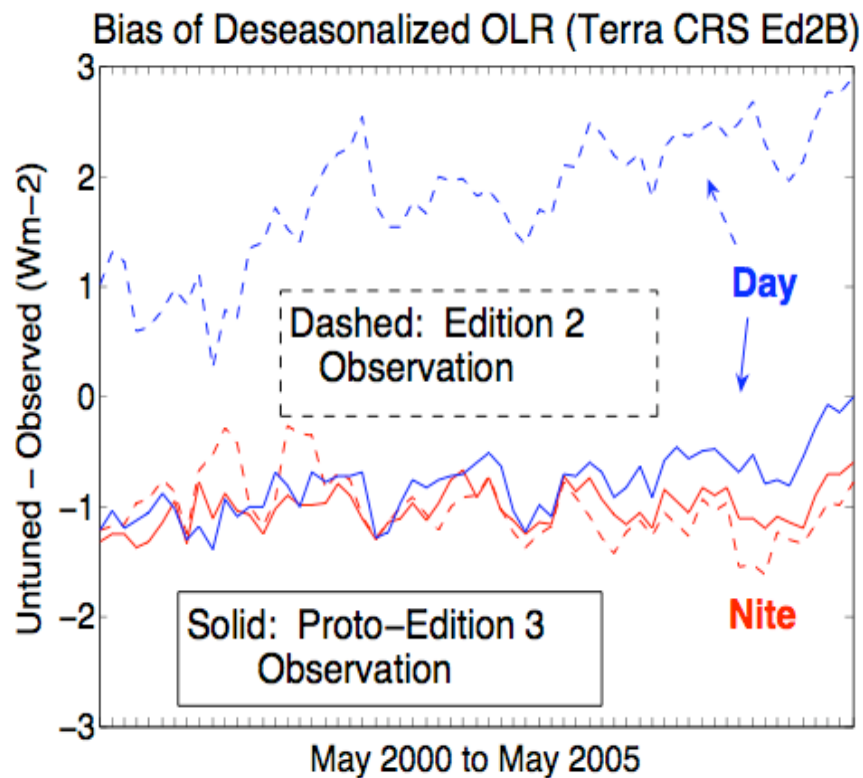 match to TOA observations.

Parameters adjusted when clear:
  Skin temperature, aerosol AOT,
    precipitable water (PW)

Parameters adjusted when cloudy:
  LWP/IWP, cloud top temperature,
  cloud fractional area within footprint

TOA

70 hPa

200 hPa

500 hPa

Surface

~20-50km Terra

For CERES newcomers:

Google "CERES CAVE" seek CAVE home page for data, codes, etc.

This group has looked at global time series previously (i.e., below).

Bias of Deseasonalized OLR (Terra CRS Ed2B)

Dashed: Edition 2 Observation

Solid: Proto-Edition 3 Observation

Day

Nite

May 2000 to May 2005

TOA SW Bias (Aqua CRS Ed2B2C Jul02–Dec06)

100*(Untuned – Observed)/Observed

Ice–free Ocean FOV statistics

Dashes = Edition 2 Observations

Circles: Rev1 Observations

Solid: Matthews Beta 15

Month Count

COMPARISON OF 2 CERES PRODUCTS FOR SURFACE RADIATION

Aqua Edition 2B/2C SSF and CRS (July 2002 - December 2006)

ENSEMBLE statistics: Every site grouped in a single series.

SW down (Wm-2)	Observed	Bias	RMS	Correlation	N	47 sites
SSF Model B	564	16	116	0.92	60564	
CRS untuned	564	9	111	0.92	60564	
SSF Model B	728	-25	35	0.99	9652	Clear sky
CRS untuned	728	5	23	0.99	9652	Clear sky

Transmission	Observed	Bias	RMS	Correlation	N	
SSF Model B	0.5832	0.0151	0.1214	0.8588	60564	
CRS untuned	0.5832	0.0090	0.1139	0.8728	60564	
SSF Model B	0.7642	-0.0277	0.0379	0.6742	9652	Clear sky
CRS untuned	0.7642	0.0056	0.0239	0.7408	9652	Clear sky

COMPARISON OF 2 CERES PRODUCTS FOR SURFACE ALBEDO

Aqua Edition 2B/2C SSF and CRS (July 2002 - December 2006)

ENSEMBLE statistics: Every site grouped in a single series.

Sfc Albedo	Observed	Bias	RMS	Correlation	N	36 sites
SSF Model B	0.2233	-0.0255	0.1137	0.6810	48191	
CRS untuned	0.2233	-0.0526	0.1136	0.7566	48191	
SSF Model B	0.2152	-0.0135	0.0800	0.7335	8095	Clear sky
CRS untuned	0.2152	-0.0380	0.0603	0.9170	8095	Clear sky

SITE-AVERAGED statistics follow: Determine statistics at each of 36 sites, then average.

Sfc Albedo	Observed	Bias	RMS	Correlation	Site Averaged (36 sites)
Model B	0.2501	-0.0345	0.1059	0.1554	
untuned CRS	0.2501	-0.0560	0.1063	0.4070	
Model B	0.2556	-0.0350	0.0864	0.2874	Clear sky
Untuned CRS	0.2556	-0.0538	0.0701	0.6544	Clear sky

COMPARISON OF 2 CERES PRODUCTS FOR SURFACE LW

Aqua Edition 2B/2C SSF and CRS (July 2002 - December 2006)

SITE-AVERAGED statistics follow

Downward LW FLux (DLF)

LW Down	Observed	Bias	RMS	Correlation	Site Averaged (47 sites)
SSF Model B	329.35	-3.17	20.43	0.91	
CRS untuned	329.35	-9.02	19.81	0.92	
SSF Model B	298.76	-7.17	15.81	0.87	Clear sky
CRS untuned	298.76	-8.62	15.52	0.88	Clear sky

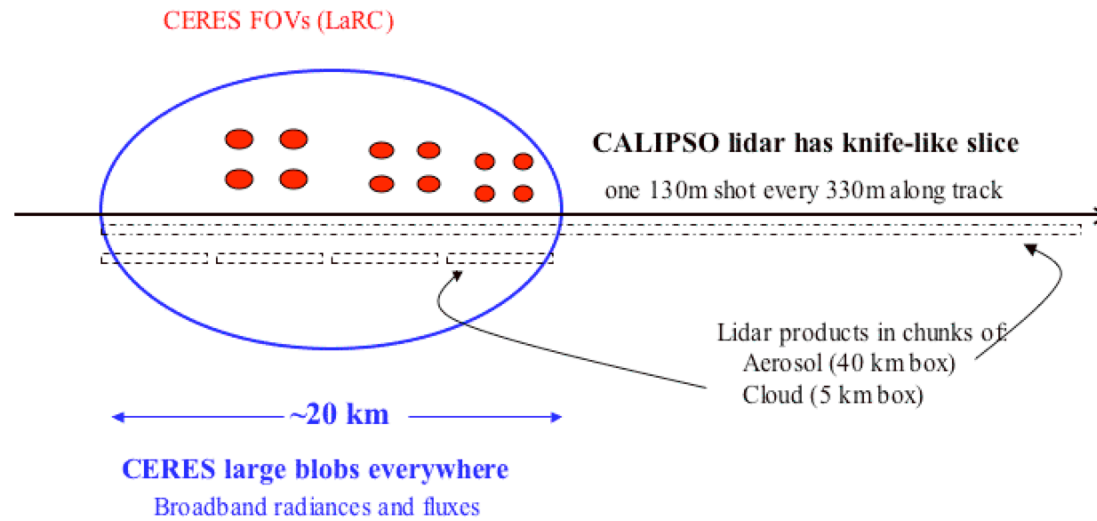| LW UP	Observed	Bias	RMS	Correlation	Site Averaged (36 sites)
SSF Model B	390.60	-6.16	26.85	0.88	
CRS untuned	390.60	-3.29	24.86	0.89	
SSF Model B	376.96	-3.27	27.14	0.89	Clear sky
CRS untuned	376.96	3.29	18.19	0.93	Clear sky

Changes to CRS for Edition 3 include:
    18 band SW code (tests with new SSF coming…)
    Additional layer at 850 hPa
    Surface albedo forcing

CCCM (CERES CloudSat CALIPSO MODIS):
        A resource for testing Edition 3 CRS

CERES FOVs (LaRC)

CALIPSO lidar has knife-like slice

one 130m shot every 330m along track

~20 km

CERES large blobs everywhere
Broadband radiances and fluxes

Lidar products in chunks of
Aerosol (40 km box)
Cloud (5 km box)

Ocean Surface Albedo (Ed2C CRS – CCCM)

Surface Albedo (Ed2C – CCCM)
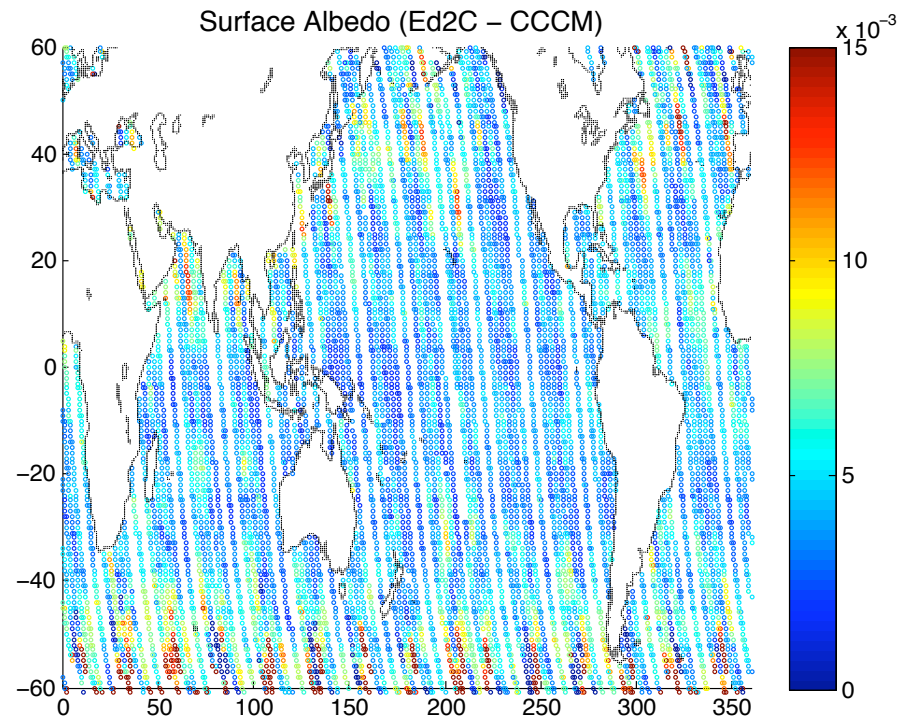
Ed2C has 15 bands

CCCM has 18 bands

Dates for map:

20060701, 20060720,
20061001, 20061029,
20070101, 20070129,
20070401, 20070429

Differences in above color map are typically ~0.01
 (i.e., 0.07 versus 0.06)

Discovery 1: CCCM does not include surface foam.

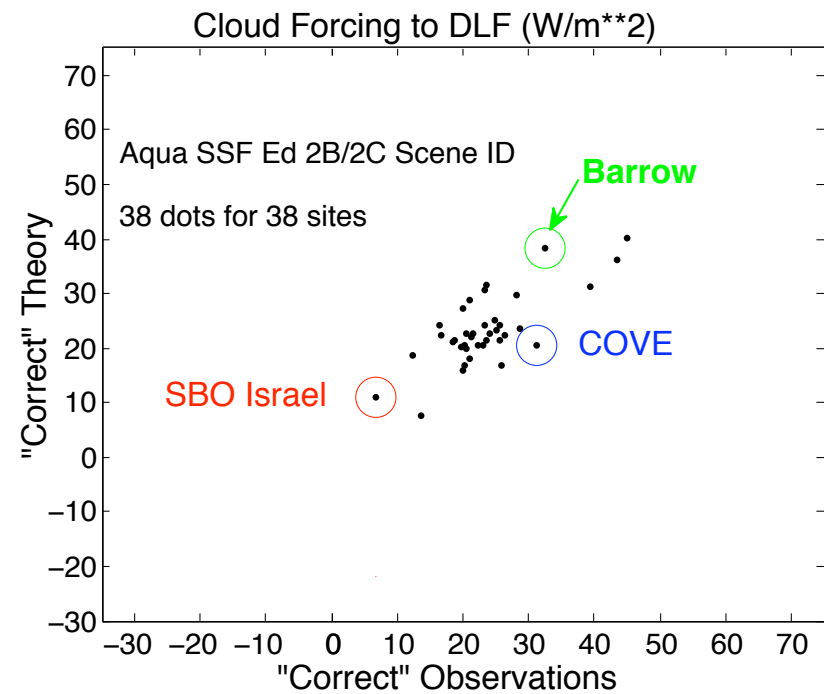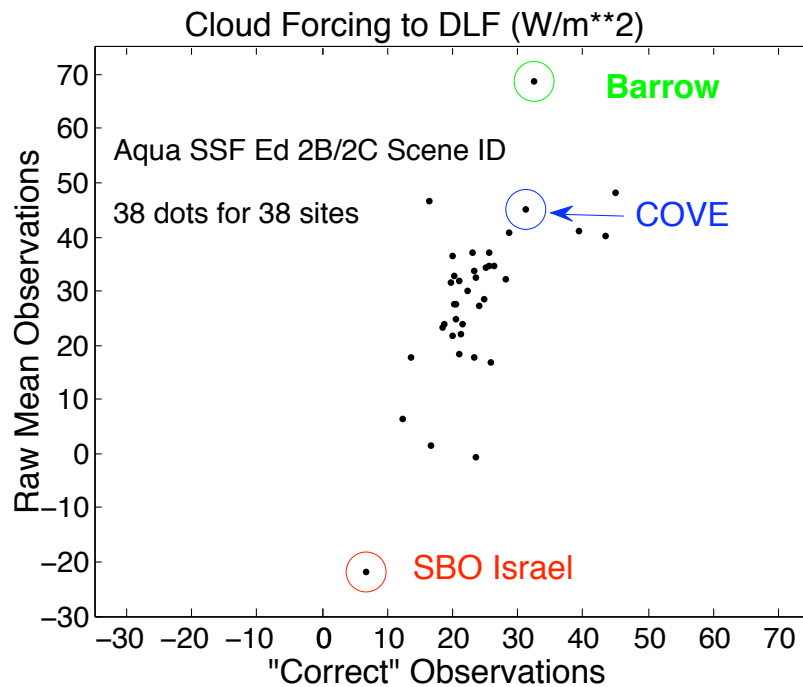*Discovery 2: **CRS forgot to apply Chlorophyll maps!***

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Bias of Aqua CRS Edition 2B/2C with respect to new CCCM calculations
Downward LW Flux (DLF) at Surface
Field of view (FOV) statistics. NOT gridded.

Bias = (CRS untuned) – (CCCM MODIS Enhanced)
    Presentation showed incorrect sign for equation with bias.
    The equation above is a correction.

CCCM flux	CRS Bias	(W/m**2)		
317	-8	All-sky	GLOBE	
280	-1	Clear-sky		
341	-9	All-sky	LAND - no snow	
310	0	Clear-sky		
376	-8	All-sky	OCEAN 55N-55S no sea ice	
343	-1	Clear-sky		

Raw Mean Observation:
    (All-sky mean for whole time series) – (Clear-sky mean for whole time series)

"Correct" Observation and "Correct" Theory:
    Cloud forcing as monthly mean of (all-sky scenes)-(clear-sky scenes)
    Then average those monthly mean cloud forcing values

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                                   Bias of Aqua CRS Edition 2B/2C with respect to new CCCM calculations
                                   Downward LW Flux (DLF) at Surface
                                   Field of view (FOV) statistics.  NOT gridded.


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                                   CCCM    CRS
                                   flux    Bias      (W/m**2)

                                   317     -8        All-sky    GLOBE
                                   280     -1        Clear-sky

                                   341     -9        All-sky    LAND - no snow
                                   310     0         Clear-sky

                                   376     -8        All-sky    OCEAN 55N-55S no sea ice
                                   343     -1        Clear-sky
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Downward LW Flux (DLF)

Biases for Aqua CRS Edition 2B/2C   July 2002 - December 2006

"Correct" site by site from monthly averages with clear-sky data
Cloud forcing = (all sky) - (clear sky)
Clear-sky only when MODIS identifies cloud free.

------Day and Nite--------			...........Day.............			''''''''''Nite''''''''''				
All sky	Clear	Forcing	All sky	Clear	Forcing	All sky	Clear	Forcing		
-8	-9	1	-9	-16	7	-9	-5	-3	CAVE	DLF
-10	-10	0	-11	-19	7	-8	-4	-4	SGP	DLF
9	6	3	14	11	3	3	4	-1	COVE	DLF