The New Long-term, Global, 3-hourly, high-resolution ISCCP-FH Atmospheric Radiative Transfer Flux Profile Product

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OUTLINE

I. ISCCP-FH atmospheric flux profile product

A. Primary features

B. Feature comparison with other main global flux products

II. Important changes of ISCCP-FH over its precursor, ISCCP-FD

A. Model change: RadH over RadD

B. Improved Vertical Cloud Layer Configuration (VCLC) model

C. Temperature/Humidity profile change: TOVS → nnHIRS

D. Input aerosol data change: NASA GISS Clim → MACv1

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH

A. Comparison with CERES

B. Comparison with BSRN

C. Preliminary error estimates

IV. Conclusions

V. Acknowledgement

I. ISCCP-FH atmospheric flux profile product

A. Primary Features:

►ISCCP-FH is a SuRFace (SRF)-to-TOA, 5-level, flux profile product

- FH stands for: **F**lux profile data calculated (mainly) using ISCCP-**H** series
  to replace its precursor = ISCCP-**FD** (2003, final coverage: 8307-0912)
- Spectral coverage: 0.2 – 200 µm (SW: 0.2 – 5.0 and LW: 5.0 – 200)
- Spatial resolution: horizontal: 110km equal-area (1.0° on equator)
  vertical: 5 levels (SRF-680mb-440mb-100mb-TOA)
- Temporal resolution: 3-houly (UTC = 0, 3, … 21)
- Spatial coverage: fully global (92% based on 5-yr, β-version ISCCP-H filling)
- Temproal coverage: July 1983 → December 2012 (and onwards)

► **C**ompiled into five sub-products using RadH-PRD production code:

(1) FH-**TOA** Top-Of-Atmosphere radiative fluxes (23 var's)
(2) FH-**SRF** SuRFace Radiative Fluxes (34 var's)
(3) FH-**PRF** 5-level PRoFile Radiative Fluxes (including TOA and SRF, 91 var's))
(4) FH-**MPF** Monthly mean of FH-PRF (same 91 var's)
(5) FH-**INP** Complete INPut dataset (up to a maximum of 335 var's)

-- All are available in Binary, and in addition, (1)-(4) are also available in NetCDF

I… A. Primary Features (continued)
Summary of Radiation Model: RadH

(1) History of the ISCCP flux products and their core radiation code

Year	Product / Rad Code	Base GCM Model	Reference
1995	ISCCP-FC / RadC	GISS Model II	Hansen et al., 1983
2003	ISCCP-FD / RadD	GISS Model SI2000	Hansen et al., 2002
2017	ISCCP-FH / RadH	GISS Model E	Schmidt et al., 2006

(2) Important RadH model Characteristics

- **Based on** Newly improved 2006 RadE of GISS GCM ModelE
- **Spectral resolution** improved/updated K in Correlated K-distribution method:
  16 k's for SW (0.2 - 5.0 μm) and 33 k's for LW (5.0 -200.0 μm)
- **Accuracy**: 1 W/m^2 and 1% of cooling rates for LW and SW at TOA/Surface
- **New advances**:

SW: reformulation of line absorption for H2O, O2, CO2, CH4, N2O etc. using latest HITRAN2012 atlas (Rothman et al., 2013)

LW: improved for H2O continua, CFC absorption cross-sections, SO2 line absorption, CH4 and N2O overlap treatment with also HITRAN2012 atlas and base atmospheric profile for better flux accuracy for polar region and else where.

I… A. Primary Features(continued)
Summary of Input Dataset for ISCCP-FH Production

(1) Atmospheric Gases: Climatology from NASA GISS radiation code of ModelE

(2) Atmospheric temperature/humidity Profile: ISCCP-HGG (nnHIRS)

(3) Atmospheric aerosol climatology: MACv1 (Stefan Kinne, MPI-Meteorology)

(5) Clouds: ISCCP-HGG (18 types)

(6) Particle size of liquid/ice clouds based on Han et al. (1994) climatology

(7) Surface air temperature: from ISCCP-HGG (of nnHIRS); in addition, RadH makes cloud-caused, diurnal adjustment on it for land areas (> 1/3 fraction) using climatology from NCEP and WWW Surface Weather station reports

(8) Surface skin temperature: from SCCP-HGG; RadH also makes additional cloud-caused, diurnal-adjustment (for land)

(9) Surface albedo: MACv1-aerosol-corrected reflectance from non-aerosol-corrected (processed based on ISCCP-HXG) for 0.55 µm, modulated using VIS/NIR of revised RadE to have broadband albedo (six wavebands)

(10) O3, Snow/Ice, vegetation and other surface characteristic (type, topography, land ice, etc.) data: from ISCCP-H Ancillary data

(11) TSI: self-consistent daily time series (for 1983 -- 2013 now) based on SORCE V-15, Davos WRC composite and RMIB (from Dr. Shashi Gupta)

I… A. Primary Features (continued)
Summary of Output Variables in ISCCP-FH Production:

(1) Radiative Flux Profile:

Full-sky SW↑, SW↓, LW↑, LW↓ (and direct/diffuse downward at SRF)

Clear-sky SW↑, SW↓, LW↑, LW↓ (and direct/diffuse downward at SRF)

100% overcast SW↑, SW↓, LW↑, LW↓ (and direct/diffuse downward at SRF)

at 5 levels:

TOA —— (~ 100 km high)

100 mb ——

440 mb ——

680 mb ——

Surface —— (Ground ≤ 1100 mb)

} **Flux Profile**

(2) Input data Variables:

- Summary input variables for **TOA, SRF, PRF** and **MPF** sub-products
- ~Complete inputs for **INP** sub-product that may be used to reproduce FH

I…

B. Feature comparison of main long-term, global flux products

Feature	CERES (Level 3) (SYN1deg Edition3A)	GEWEX-SRB (v3.1LW/3.0SW)	ISCCP-FH (v 0.00)
Cover Period	2000 – current	1983 – ISCCP-D/H current	1983 – ISCCP-H current
Spatial Reso	1° x 1°	1° x 1°	1° x 1° (110 km EQ)
Temporal Reso	3-hourly	3-hourly	3-hourly
TOA flux	yes (observed + calculated)	yes (calculated)	yes (calculated)
SRF flux	yes (calculated)	yes (calculated)	yes (calculated)
In-Atmosphere Flux (Profile)	Yes, 3 levels: 70, 200 and 500 mb	No	Yes, 3 levels: 100. 440 and 680 mb
SW: algorithm based on	Various (http://ceres.larc.nasa.gov/atbd.php)	Pinker and Laszlo (1992)	Correlated K-distribution (Schmidt et al., 2006)
LW: algorithm based on		Fu et al. (1997)	
PAR/UV index	Yes	PAR (?)	No

II. Important Changes in 2017-FH over 2003-FD

A. Model changes: 1. Overall

- **Based on** RadH, improved+revised from 2006 RadE of GISS GCM ModelE
  vs. RadD, revised from 2002 NASA GISS Model SI2000
- **Spectral resolution** in k's (for Correlated K-distribution method): Improved
  reformulated/updated 16 k's for SW (0.2 - 5.0 μm) [vs. 15 k's in FD]
  reformulated/updated 33 k's LW (5.0 -200.0 μm) [same 33 k's in FD]
- **Spatial resolution**: 110 km [vs. 280 km in FD]
- **Accuracy**: 1 W/m^2 and 1% cooling rates at TOA and SRF for LW and SW, respectively with significant reformulation and updates, especially atmospheric gas absorption and elaboration of LW calculation
- **Reformulation of Atmospheric Gases for SW calculation**:
  Added weak line absorption for H2O, O2 and CO2, and updated line absorption for CH4, N2O, etc., using latest HITRAN2012 atlas.
- **Reformulation/Refining for LW calculation**:

RadH has several improvements for LW flux calculation over RadD, including additional Ma2008 option and MT-CKD H2O continua options (vs. RadD's sole Ma2000 scheme), CFC absorption cross-section, SO2 line absorption and better treatment of CH4 and N2O overlap with major absorbers with HITRAN2012 atlas, if possible.

In addition, RadH increases the base atmospheric vertical resolution using a 43-layer standard atmosphere (vs old 24 layers), and now takes into account of amount of water vapor above and below a given layer as well as the water vapor gradient.

II… A. Model changes (continued):
2. RadD's low-bias atmospheric SW absorption's in CIRC

The Continual Intercomparison of Radiation Codes (CIRC) Phase I

- RT model intercomparison aspiring to become the standard for documenting the performance of RT codes used in Large-Scale Models
- **Purpose:** examining GCM RT code performance in realistic, but not too complex, atmospheric conditions, against CIRC
- **Phase 1** was launched on June 4, 2008; Phase 1a, January 19, 2010, …
- **Ref**: *Oreopoulos and Mlawer, BAMS, 2010 and Oreopoulos et al., JGR, 2012*

How CIRC differs from previous intercomparisons:

- **7 CIRC Phase I baseline cases**: 5 cloud free and 2 with overcast liquid clouds from an ARM product named BBHRP.
- Carefully selected/designed, additional idealized "subcases" are also employed to facilitate interpretation of model errors, e.g., 2 X CO2, …
- **Observation-and-LBL-based** radiative benchmarks are built/used for CIRC
- Flexible structure and longer lifespan than previous intercomparisons
- Benchmark results are publicly available

II… A. Model changes:
2. RadD's low-bias (continued) … CIRC Phase I Baseline cases

Case	SZA	PWV (cm)	τ_{aer}	LWP (gm^{-2})	LW_{SFC}	LW_{TOA}	SW_{SFC}	SW_{TOA}
(1) SGP 9/25/00	47.9°	1.23	0.04		0.5	-0.9	0.5	-3.1
(2) SGP 7/19/00	64.6°	4.85	0.18		0.6	-1.4	-1.1	8.4
(3) SGP 5/4/00	40.6°	2.31	0.09		1.0	-1.2	-0.1	-8.7
(4, 5) NSA 5/3/04 2xCO_2)	55.1°	0.29	0.13		1.2	-0.6	-0.8	0.7
(6) SGP 3/17/00	45.5°	1.90	0.24	263.4	1.1	-3.0	4.9	-0.9
(7) PYE 7/6/05	41.2°	2.42		39.1	0.2	0.6	-0.4	-0.1

spectrally resolved (1 cm^{-1}) surface albedo; Yellow boxes for obs – LBL (%)

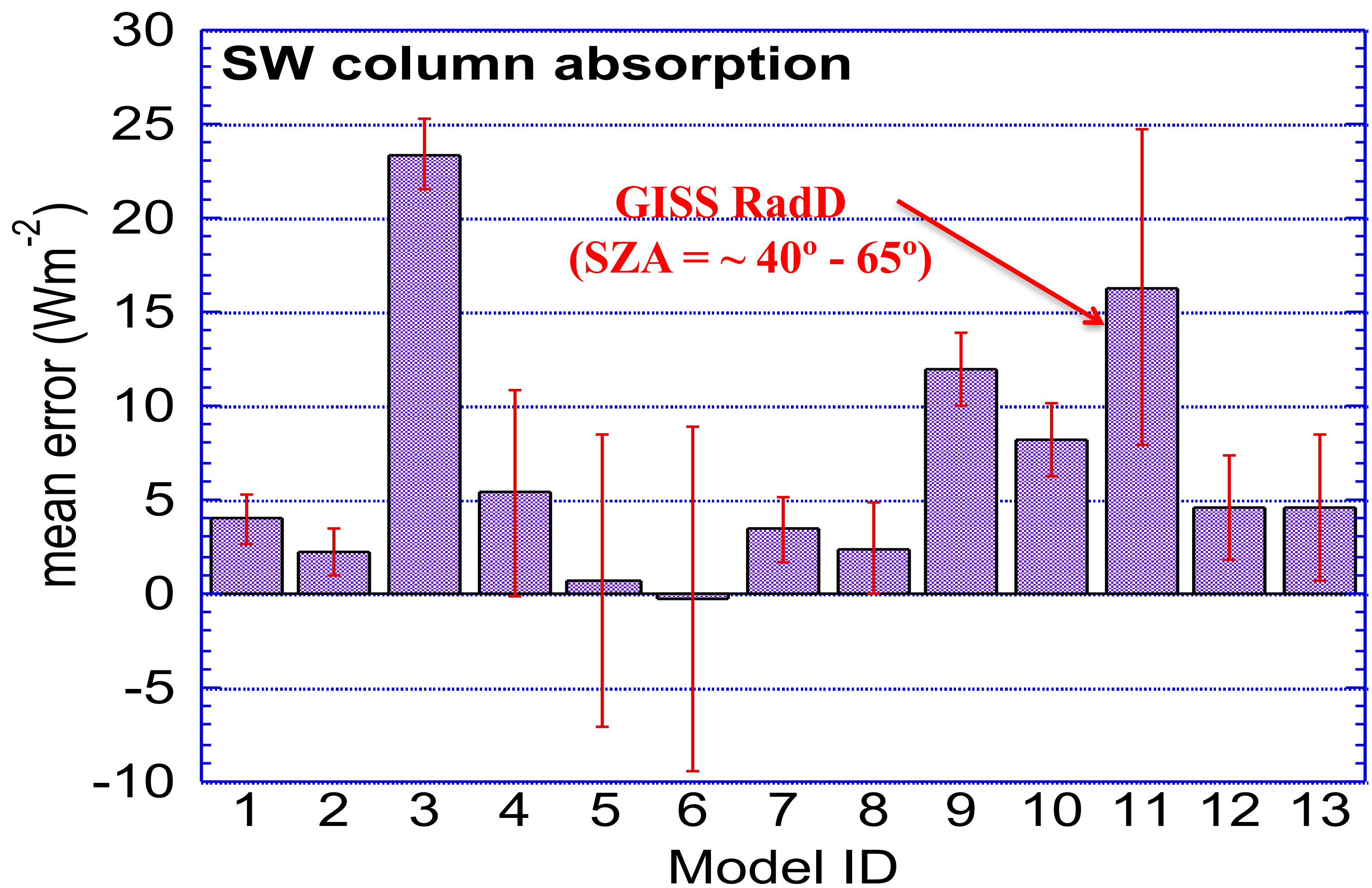
II… A. Model changes:

2. RadD's low-bias … (continued): CIRC I SW participants

Model Index	Brief Model Description	In LSM?	Experiment variants	Submitted By	Reference(s)
0	CHARTS v.4.04/LBLRTM v.11.1/ HITRAN2004, line-by-line	No	None	Delamere, Mlawer	Moncet and Clough (1997); Clough et al. (2005)
1	RRTM-SW, 0.2-12.2 µm, CKD, 14 bands, 224 g-points	No	None	Iacono, Mlawer	Clough et al. (2005)
2	RRTMG-SW, 0.2-12.2 µm , CKD, 14 bands, 112 g-points	Yes	None	Iacono, Mlawer	Iacono et al. (2008)
3	CLIRAD-SW, 0.175-10 µm, 11 bands, pseudo-monochromatic/k-distribution hybrid, 38 k-points	Yes	Two R_{sfc} averaging methods	Oreopoulos	Chou et al. (1998); Chou and Suarez (2002)
4	CCC, 0.2-9.1 µm, CKD, 4 bands, 40 g-points	Yes	Three R_{sfc} averaging methods	Cole, Li	Li and Barker (2005); Li et al. (2005)
5	FLBLM/ HITRAN 11v, 0.2-10 µm, line-by-line	No	None	Fomin	Fomin and Mazin (1998)
6	FKDM, 0.2-10 µm, CKD, 15 g-points	No	Two treatments of cloud optical properties	Fomin	Fomin and Correa (2005)
7	CAM 3.1, 0.2-5.0 µm, 19 spectral and pseudo-spectral intervals,	Yes	Two R_{sfc} averaging methods	Oreopoulos	Briegleb (1992); Collins (2001); Collins et al. (2004)
8	FLCKKR (SW), 0.17-4.0 µm, CKD, 18 bands, 69 g-points	No	Two R_{sfc} averaging methods	Rose, Kratz, Kato, Charlock	Fu and Liou (1992)
9	FMI, 0.185-4 µm, 6 bands, Padé approximants to fit transmission functions	Yes	Two R_{sfc} averaging methods	Räisänen	Fouquart and Bonnel (1980); Cagnazzo et al. (2007)
10	Edwards-Slingo 0.2-10 µm, 6 bands, ESF of band transmissions	Yes	Two R_{sfc} averaging methods	Manners	Edwards and Slingo (1996)
11	NASA-GISS v. D, 0.2-5.0 µm, CKD, 15 g-points	Yes	Three R_{sfc} averaging methods	Zhang, Rossow, Lacis	Zhang et al. (2004)
12	COART, 0.25-4.0 µm, 26 bands, k-distribution	No	None	Jin, Charlock	Jin et al. (2006)
13	CLIRAD-SW modified, 0.2 -10 µm, 8 bands, k-distribution 15 k-points	No	Two R_{sfc} averaging methods	Oreopoulos	Tarasova and Fomin (2007)

II… A. Model changes

2. RadD's low-bias … (continued): RT comparison evidence

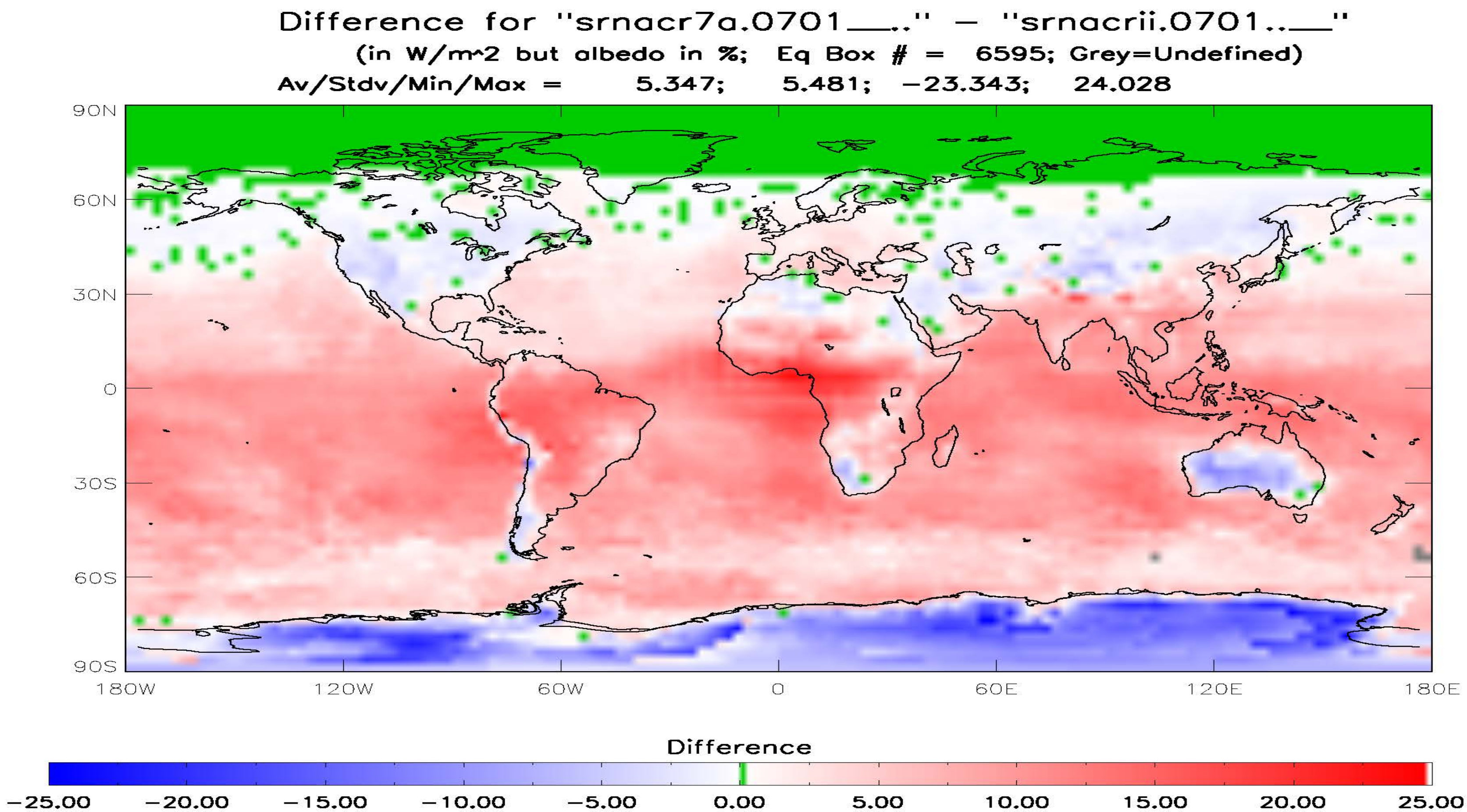


Positive = underestimate

II… A. Model changes

2. RadD's low-bias … (continued): Improvement: FH vs. FD

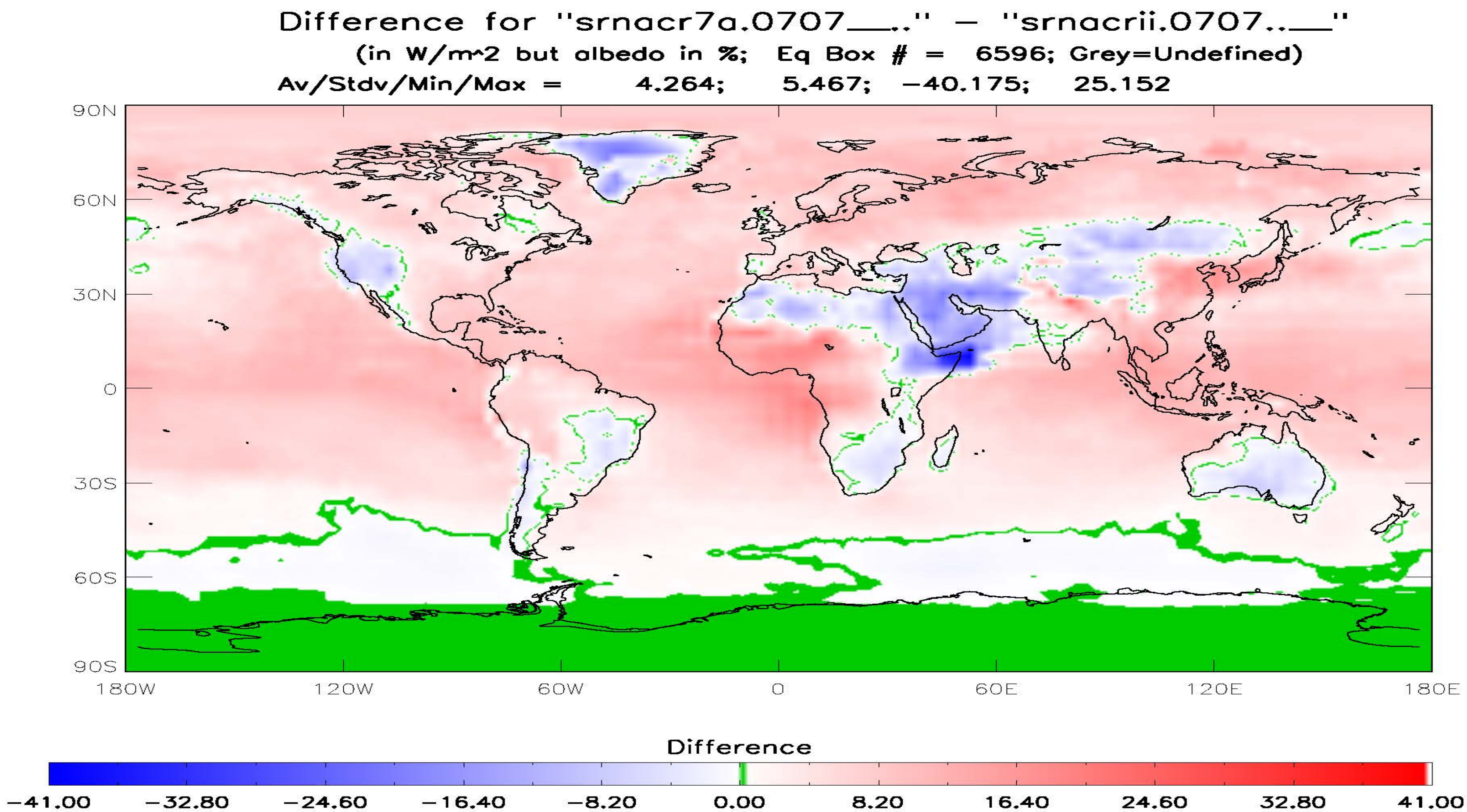
► 12-month-average of global, monthly mean for atmospheric SW absorption: Increased by 5.3 W/m^2, for clear sky, e.g., **5.3** W/m^2 for FH – FD for **0701**



II… A. Model changes

2. RadD's low-bias … (continued): Improvement: FH vs. FD

► 12-month-average of global, monthly mean for atmospheric SW absorption: Increased by 5.3 W/m^2, for clear sky, e.g., **4.3** W/m^2 for FH – FD for **0707**



II. Important Changes (continued)

B. VCLC (Vertical Cloud Layer Configuration)

VCLC consists of CVS and CLTC (next slide)

1. CVS (Cloud Vertical Structure): Model B (of 3 Models) for FH (18 cloud types)

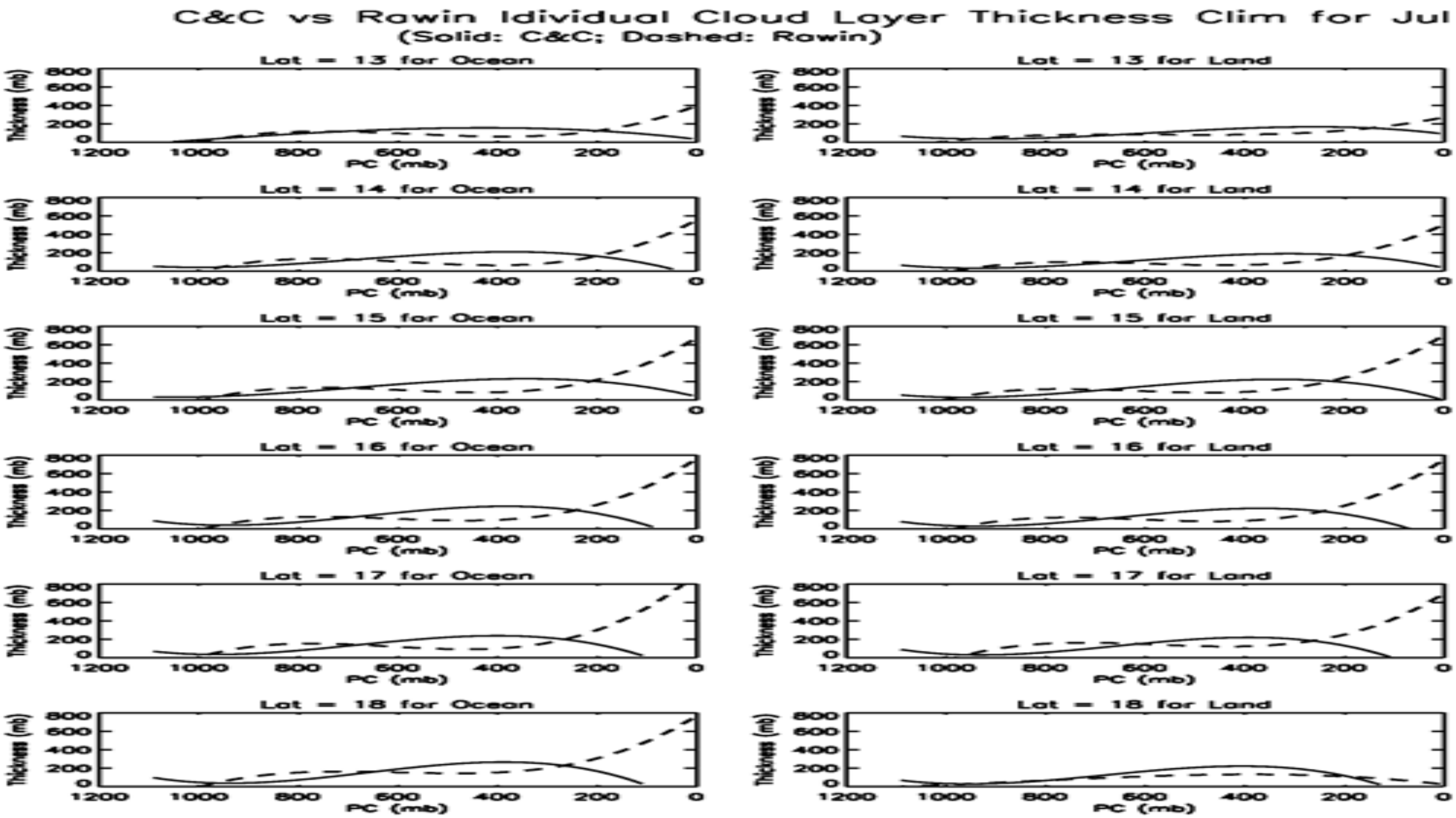
Level	ISCCP Cloud Type	Sub-type	Vertical structure	How to construct
HC	Ci		1H	= single layer cloud
	Cs	Thin	HM*	Radiatively reconstructed
		Thick	HML	ISCCP Clim reconstructed
	Cb		1 H-M-L	ISCCP Clim reconstructed
MC	Ac	Thin	1M	= single layer cloud
		Thick	HL*	Radiatively reconstructed
	As	Thin		
		thick	ML	ISCCP Clim reconstructed
	Ns			
LC	Cu		1L	= single layer cloud
	Sc			
	St			

II… Important Changes
B. VCLC (continued)

2. CLTC (Cloud Layer Thickness Configuration):

-- Function of Cloud-Tau, Longitude, Latitude & Ocean/Land

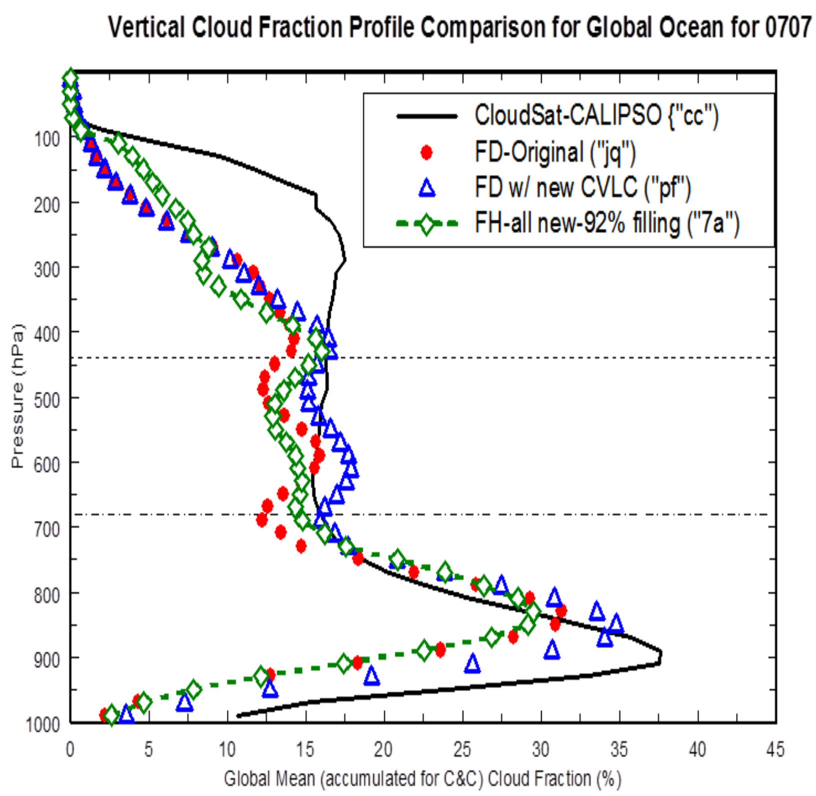
Based on 20-yr Rawinsonde and 5-yr CloudSat-CALIPSO climatology, e.g.,

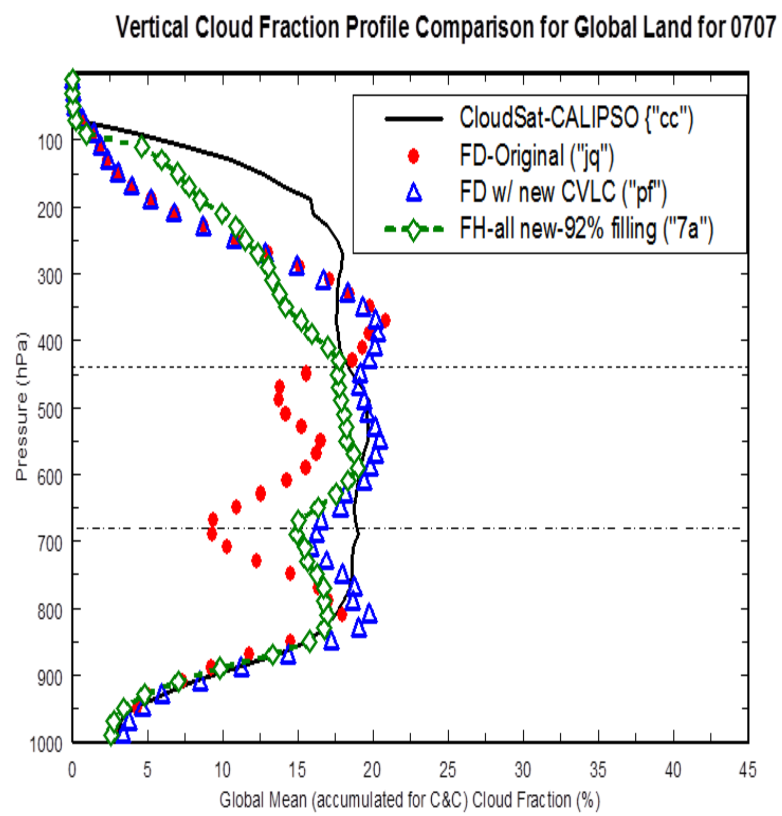


II… Important Changes

B. VCLC (continued): Example

Vertical Cloud Fraction Profile for VCLC Comparison: 0707 Ocean & Land

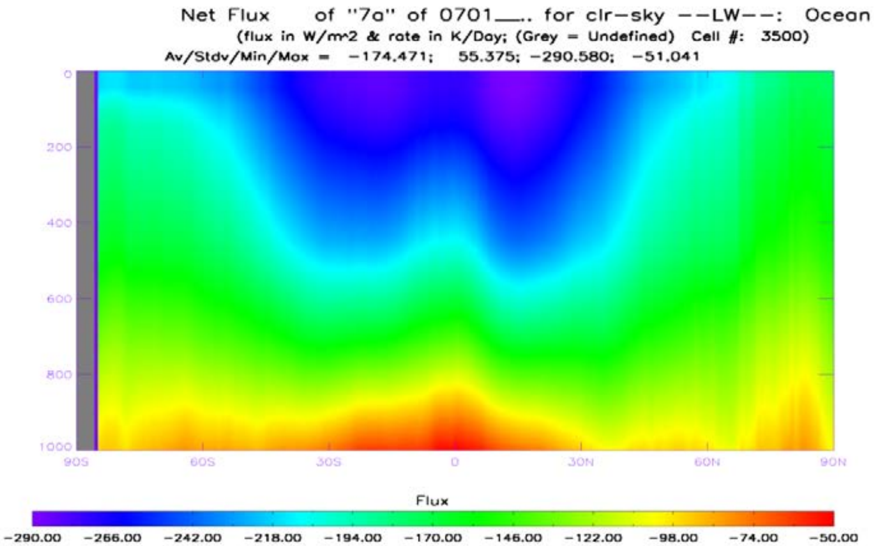


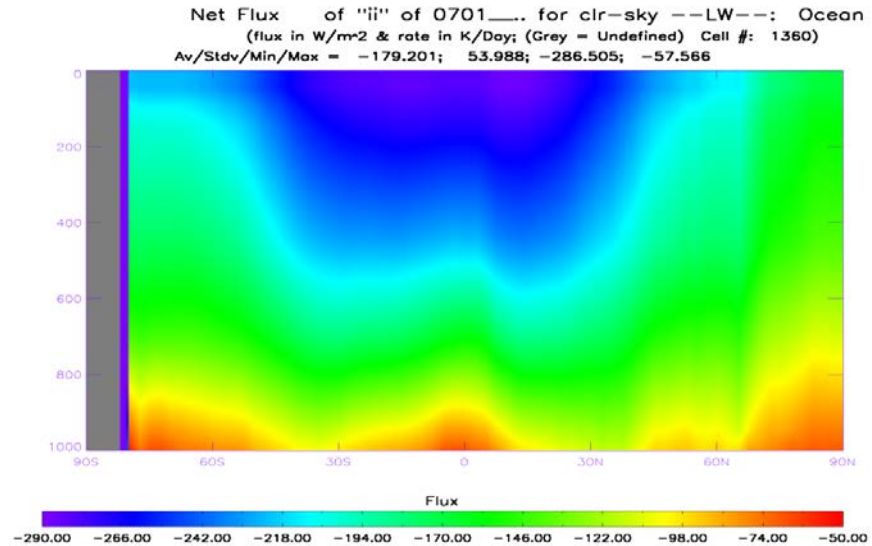


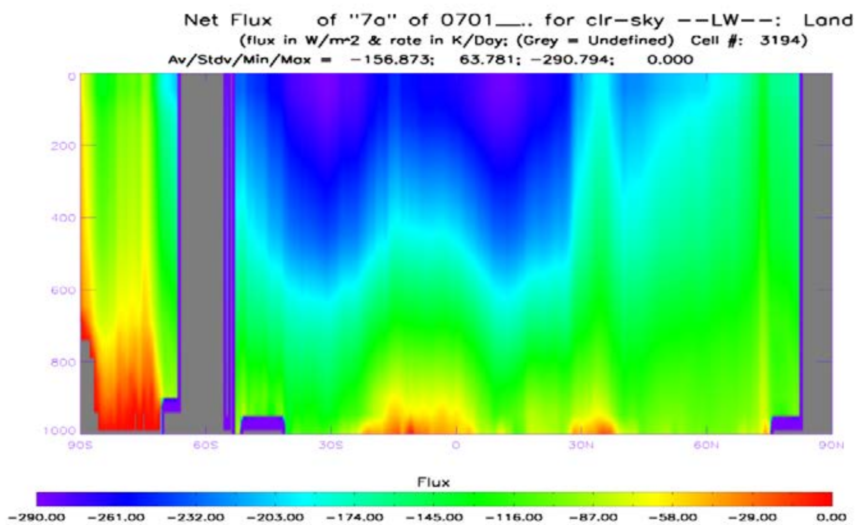
II… Important Changes(continued)

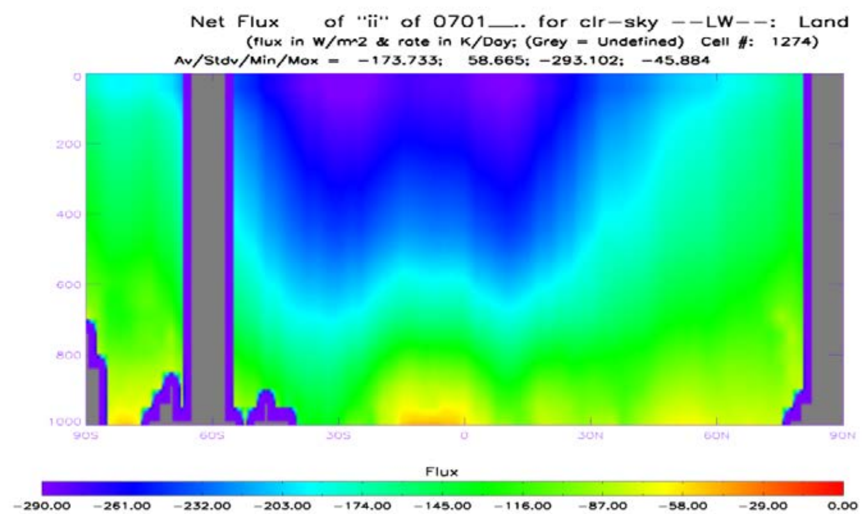
C. Temperature/Humidity (improving temporal inhomogeneity):

TOVS→nnHIRS: <u>0701</u> LW Net Profile (Left: FH O/L; Right: FD O/L)





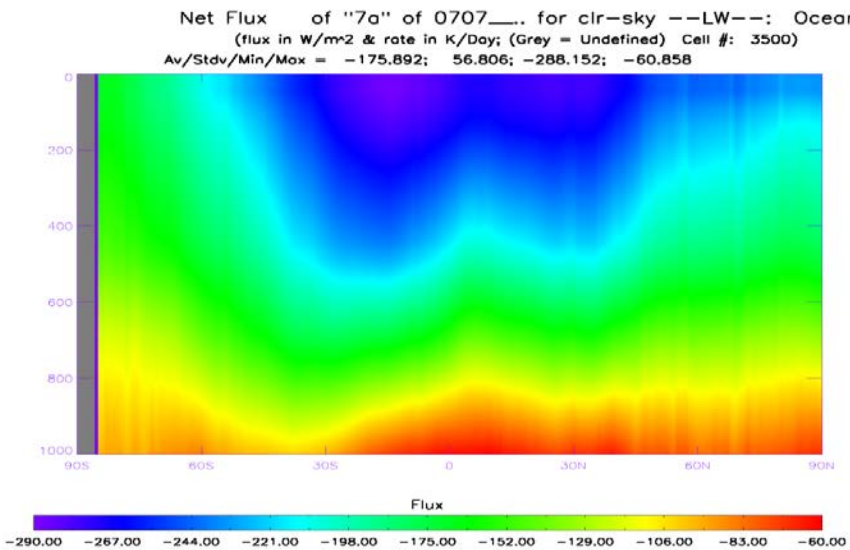


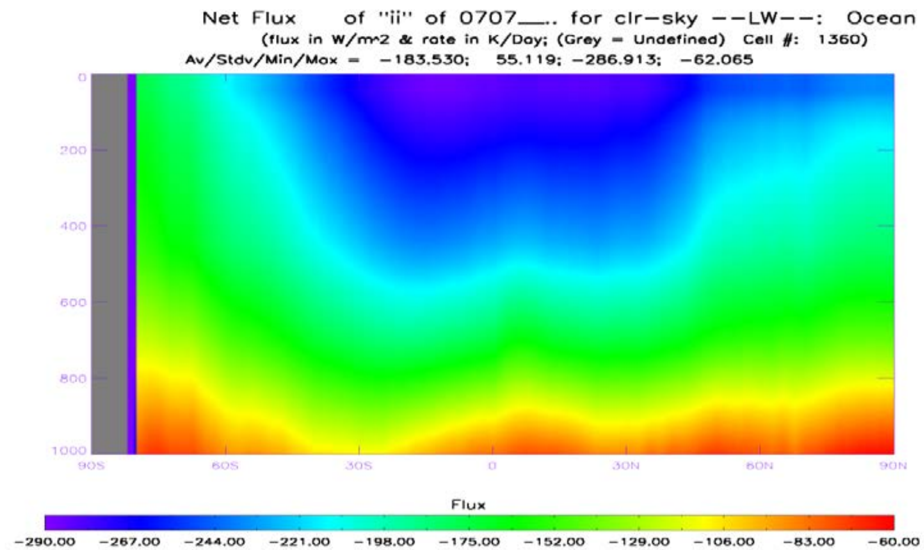


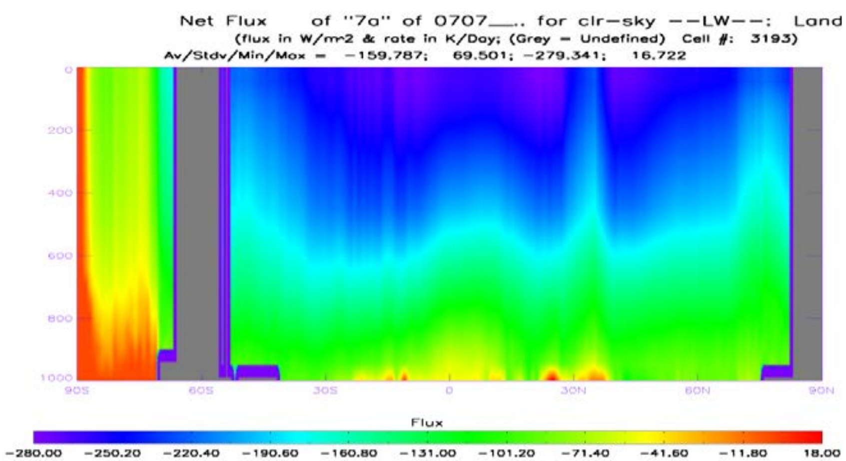
II… Important Changes (continued)

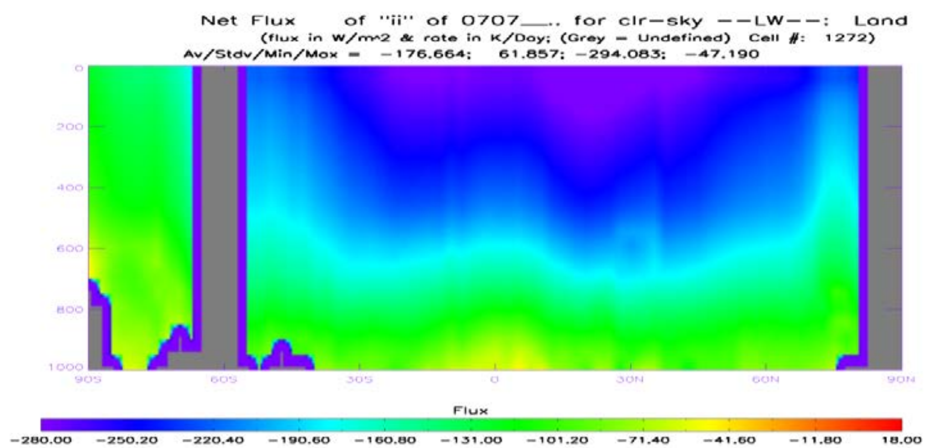
C. Temperature/Humidity: TOVS→nnHIRS:

0707 LW Net Profile (Left: FH O/L; Right: FD O/L)









II… Important Changes (continued)

D. Aerosol Change: NASA GISS RadD (SI2000) Clim → MAC-v1/2

MAC-v1/2 aerosol data (Kinne et al., 2013) supplies ISCCP-FH with:

AOD (0.55 μm), **SSA** and **ASY** for 6 SW bands for column aerosols; MACv1 is currently used.

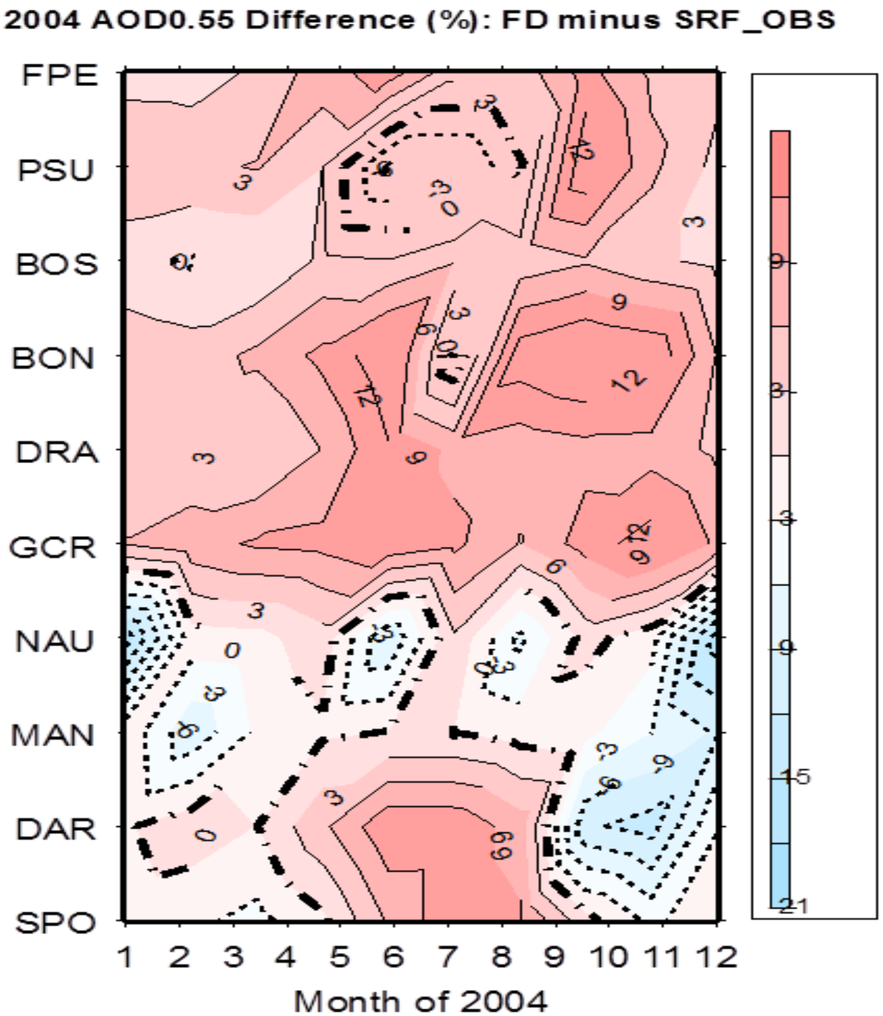
High-quality-controlled 10 Stations (N to S) for 2004 with AOD

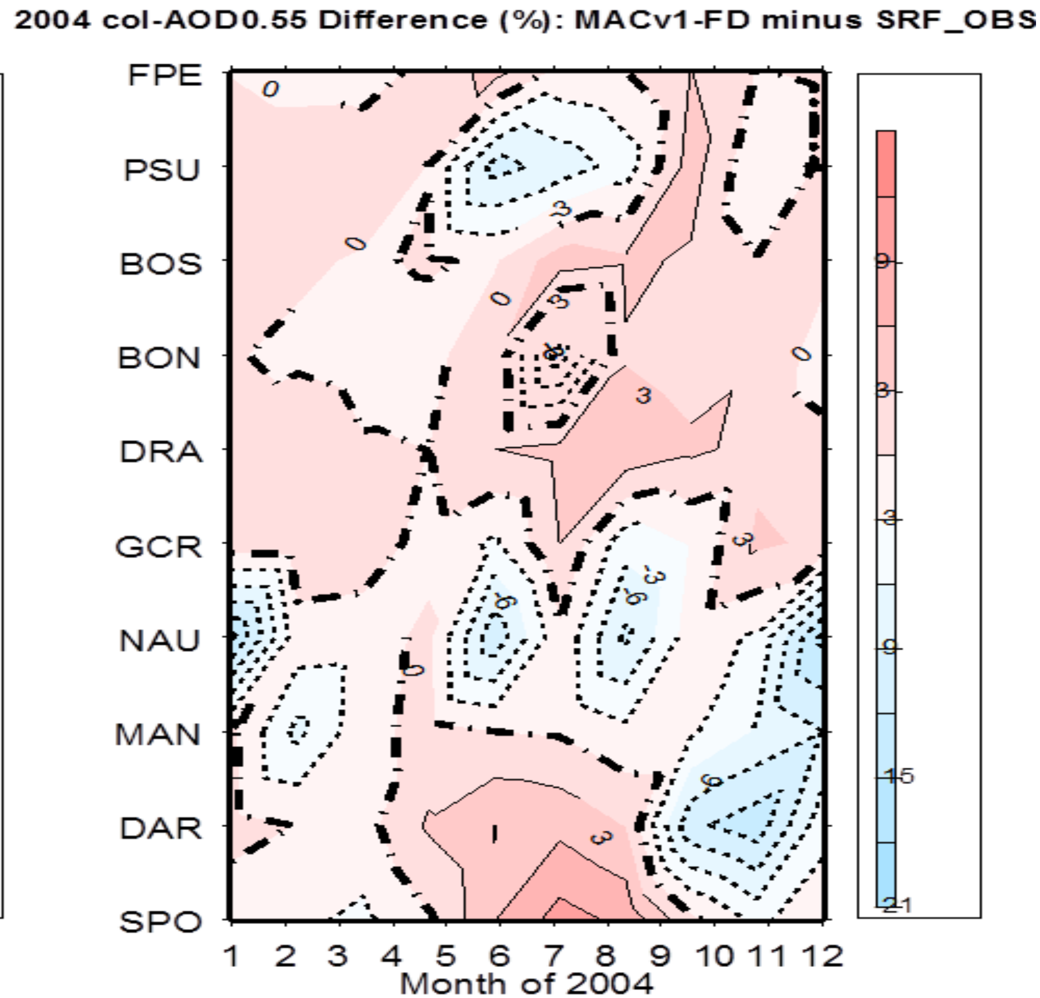
Station Acronym	Station Name [Owner]	Quality Rate-Network	Station Lat/Lon	FD Cell Lat/Lon	AOD
FPE	Fort Peck, MT [USA]	A-SURFRAD	48.5N/254.8E	48.8N/255.8E	AV
PSU	Rock Springs, PA [USA]	A-SURFRAD	40.7N/282.1E	41.2N/281.7E	AV
BOS	Boulder, CO [USA]	A-SURFRAD	40.2N/254.6E	41.2N/255.0E	AV
BON	Bondville, IL [USA]	A-SURFRAD	40.1N/271.4E	41.2N/271.7E	AV
DRA	Desert Rock, NV [USA]	A-SURFRAD	36.6N/243.9E	36.2N/243.6E	AV
GCR	Goodwin Creek, Mississippi [USA]	A-SURFRAD	34.2N/270.1E	33.8N/271.5E	AV
NAU	Nauru Island [USA]	B-ARM	0.5S/166.9E	1.2S/166.2E	AV
MAN	Momote, Manus Is., Papua New Guinea [USA]	B-ARM	2.1S/147.7E	1.2S/148.8E	AV
DAR	Darwin [Australia]	B-ARM	12.5S/130.9E	13.8S/129.9E	AV
SPO	South Pole, Antarctica [USA]	B-BSRN	89.8S/258.0E	88.8S/300.0E	AV

II… Important Changes (continued)

D. Aerosol Change: NASA GISS RadD (SI2000) CLim→ MACv1/2

Clear-sky 0.55 AOD for FD-GISS-Clim (L) and FD-MAC-v1 (R) minus Surface Observation

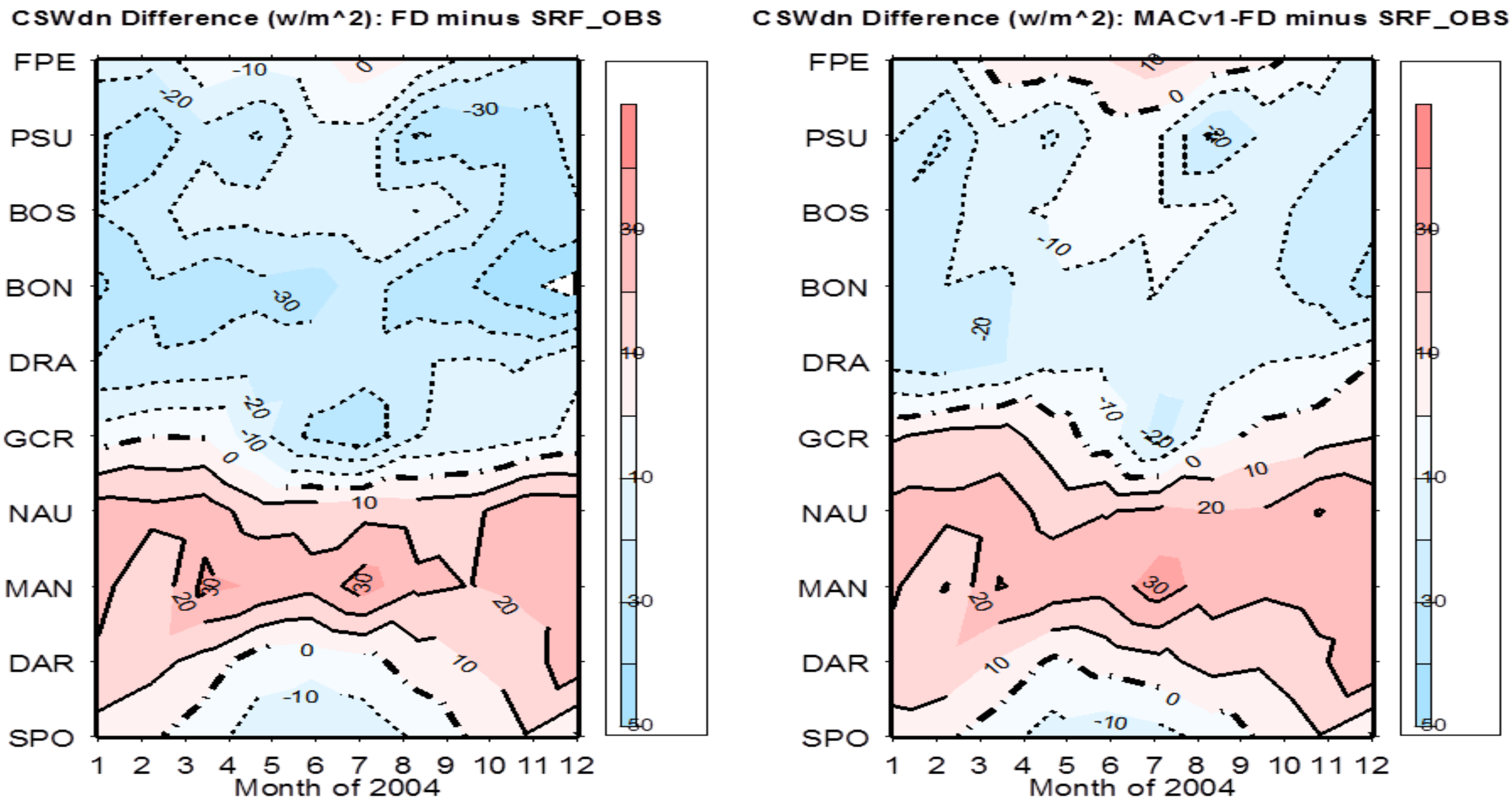




II… Important Changes (continued)

D. Aerosol Change: NASA GISS RadD (SI2000)) CLim → MACv1/2

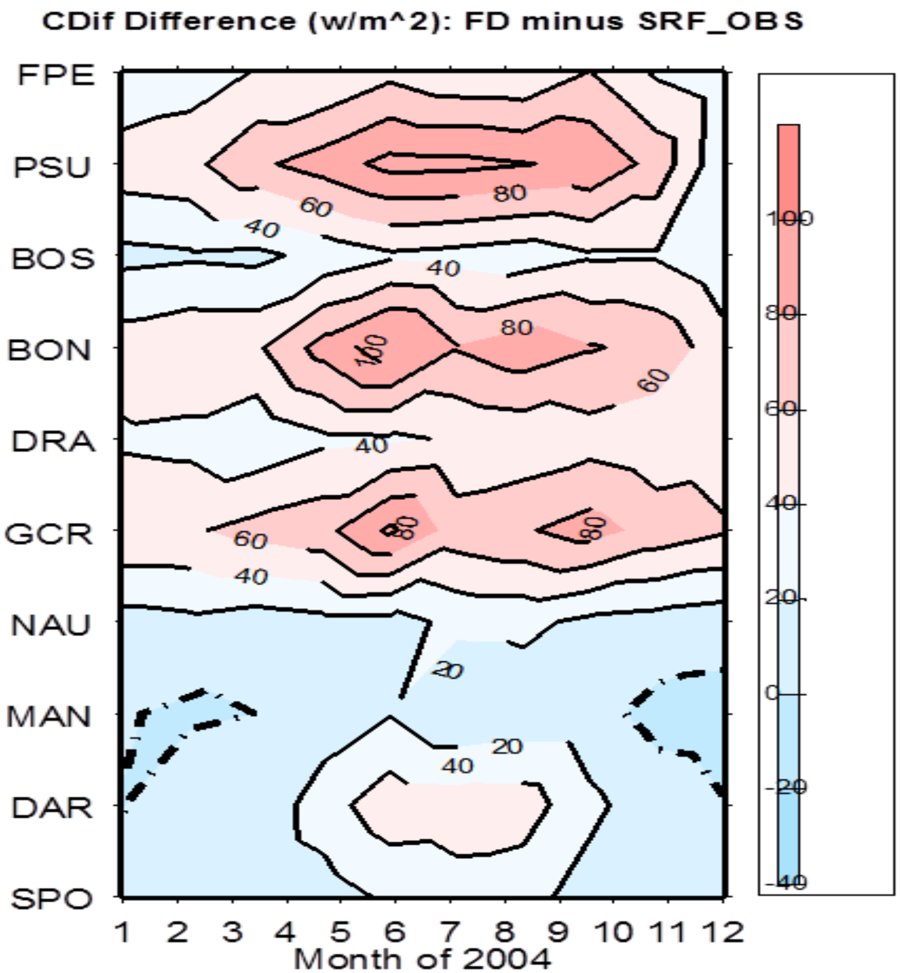
Clear-sky SWdn for FD-GISS-Clim (L) and FD-MAC-v1 (R) minus Surface observation

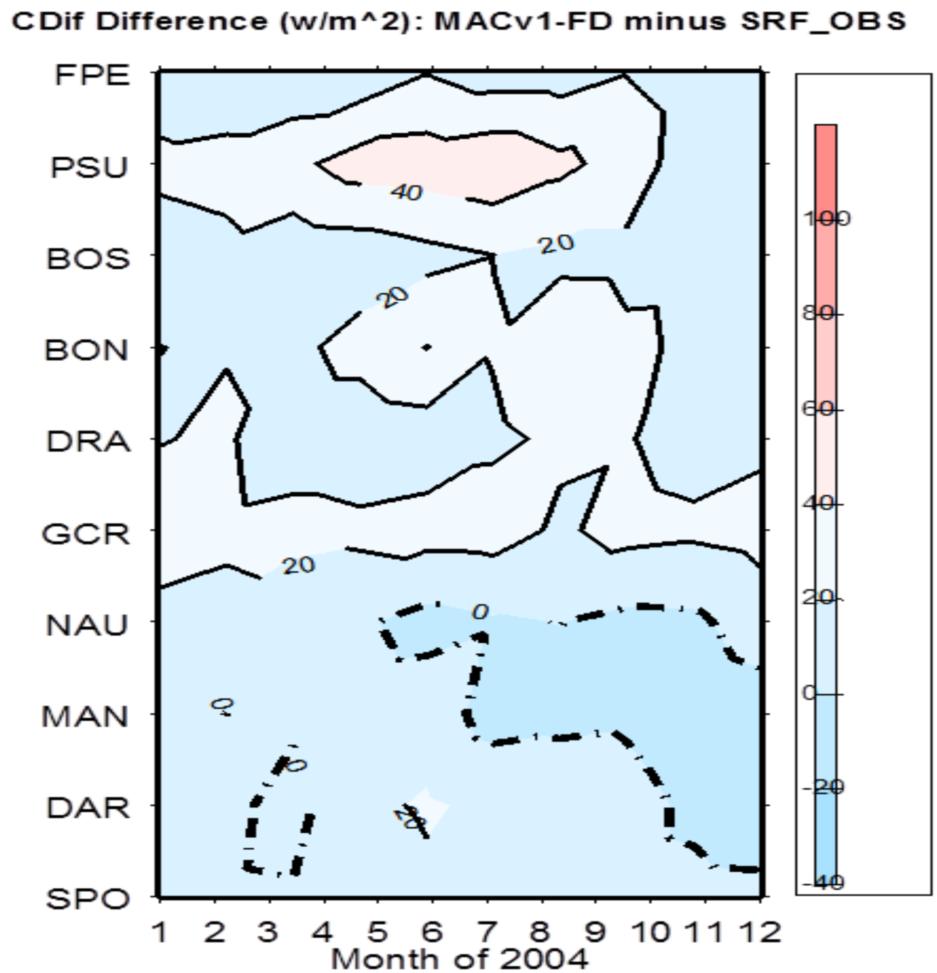


II… Important Changes (continued)

D. Aerosol Change: NASA GISS RadD (SI2000)) CLim → MACv1/2

Clear-sky Diffuse for FD-GISS-Clim (L) and FD-MAC-v1 (R) minus Surface observation

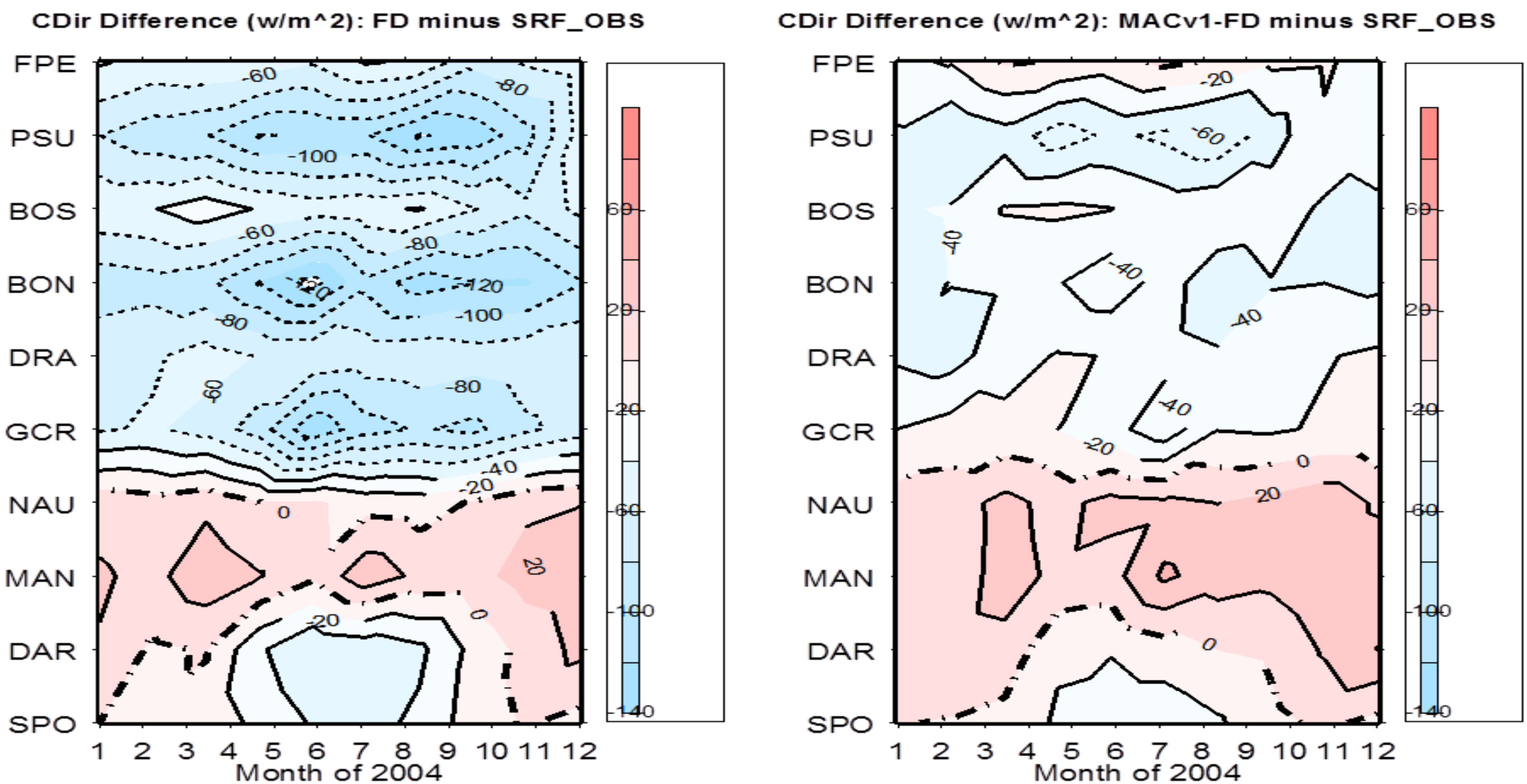




II… Important Changes (continued)

D. Aerosol Change: NASA GISS RadD (SI2000)) CLim → MACv1/2

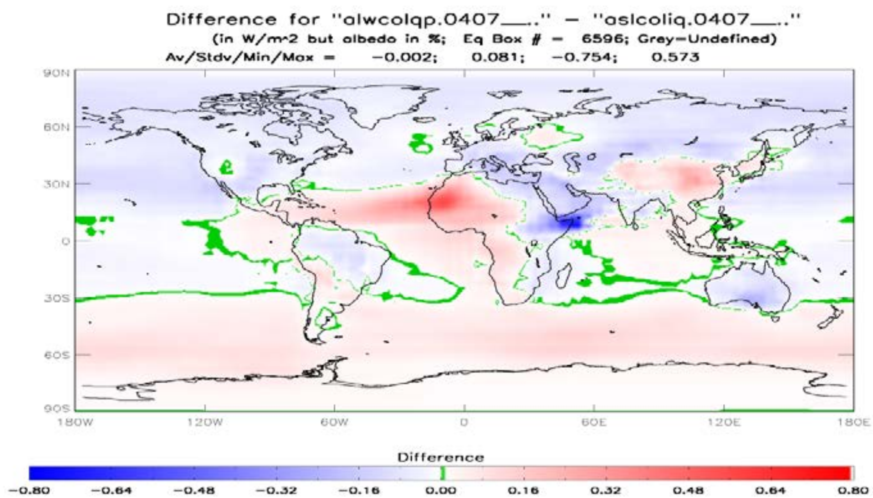
Clear-sky Direct for FD-GISS-Clim (L) and FD-MAC-v1 (R) minus Surface Observation

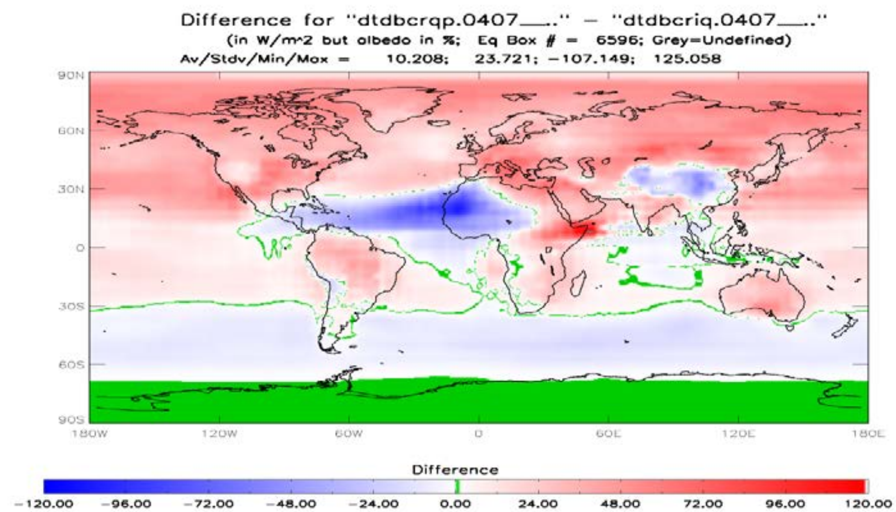


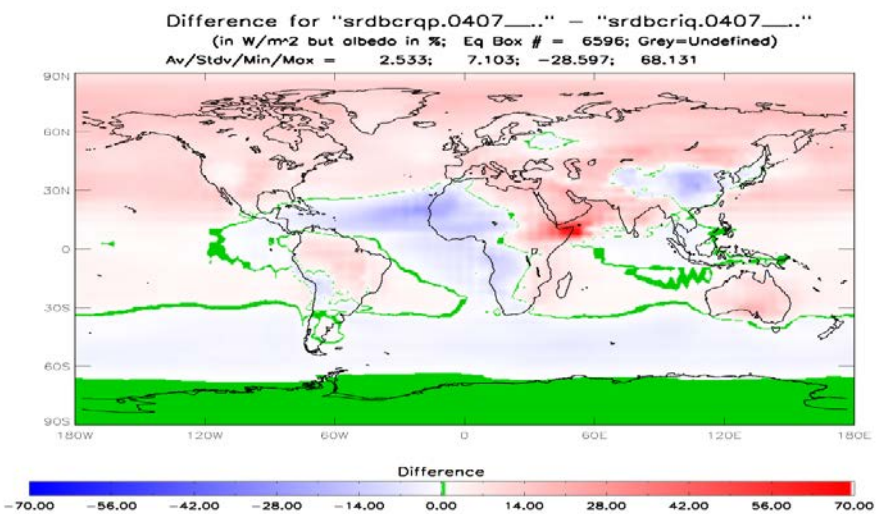
II… Important Changes (continued)

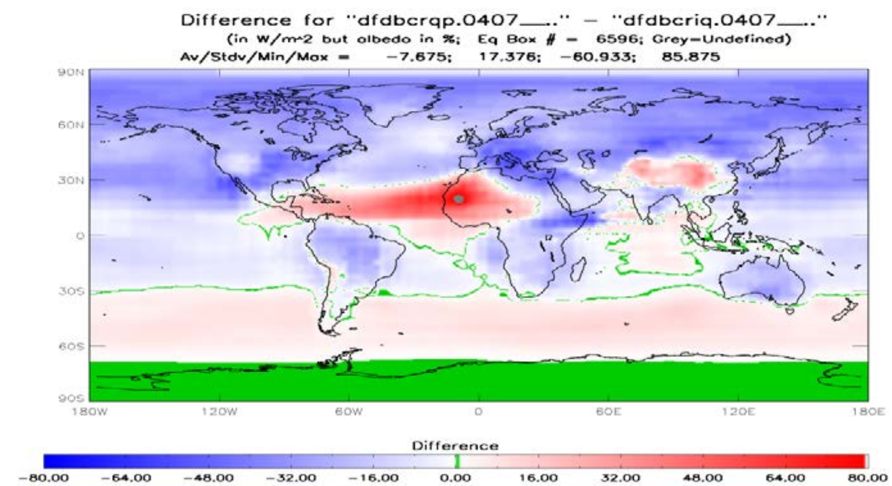
D. Aerosol Change: NASA GISS RadD (SI2000)) CLim → MACv1/2

0407 AOD, Clear-sky SWdn, Direct and Diffuse difference for FD-MAC-v1 minus FD-GISS-Clim









III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH

A. Comparison with CERES for 2017 Monthly means

All-sky FH vs CERES at TOA

Variable	FH mean	CERES mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	34.23	31.24	2.988	3.451	0.9676	0.94	-0.89	2.44	469336
SW_net (W/m^2)	235.16	244.79	-9.630	8.621	0.9968	1.01	8.39	6.07	478330
LW_net (W/m^2)	-230.64	-238.87	**8.223**	5.066	0.9884	1.01	-5.43	3.55	478330
SW_ce (W/m^2)	-52.41	-48.45	-3.960	10.836	0.9517	0.91	-0.62	7.67	478107
LW_ce (W/m^2)	28.48	27.23	1.253	6.423	0.9227	0.97	-0.27	4.60	469722

All-sky FD vs CERES at TOA

Variable	FD mean	CERES mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	34.13	31.64	2.489	3.718	0.9627	1.00	-2.47	2.63	77842
SW_net (W/m^2)	234.57	242.57	-8.000	8.577	0.9969	1.01	5.54	5.98	79152
LW_net (W/m^2)	-236.10	-239.16	***3.061***	4.876	0.9899	1.01	-0.50	3.42	79152
SW_ce (W/m^2)	-52.78	-47.15	-5.631	8.182	0.9763	0.90	0.13	5.40	79152
LW_ce (W/m^2)	26.88	26.94	-0.059	4.884	0.9574	0.93	2.00	3.47	79063

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH
A. Comparison with CERES for 2017 Monthly (continued)

Clear-sky FH vs CERES at TOA

Variable	**FH** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	19.33	17.16	2.170	4.462	0.9495	0.89	-0.06	3.12	483935
SW_net (W/m^2)	284.17	289.82	-5.654	11.109	0.9961	0.99	8.78	7.84	493695
LW_net (W/m^2)	-259.36	-266.35	6.989	6.167	0.9828	1.03	0.33	4.25	485080

Clear-sky FD vs CERES at TOA

Variable	**FD** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	18.56	17.30	1.261	3.620	0.9630	0.98	-0.81	2.58	77752
SW_net (W/m^2)	287.35	289.72	-2.369	8.191	0.9979	0.99	5.15	5.76	79152
LW_net (W/m^2)	-262.97	-266.10	3.126	6.474	0.9802	0.99	-5.58	4.60	79063

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH

A. Comparison with CERES for 2017 Monthly (continued)

All-sky FH vs CERES at Surface

Variable	**FH** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	15.24	13.22	2.018	6.733	0.9386	0.80	1.01	4.36	471542
SW_net (W/m^2)	158.55	165.93	**-7.376**	11.288	0.9900	0.97	11.56	7.95	478330
LW_net (W/m^2)	-53.78	-54.95	1.164	16.936	0.7243	0.62	-21.72	12.08	478330
SW_ce (W/m^2)	-55.15	-50.68	-4.476	9.415	0.9684	0.91	-0.69	6.48	478330
LW_ce (W/m^2)	20.31	26.20	-5.884	10.304	0.7788	0.94	7.04	7.47	478330

All-sky FD vs CERES at Surface

Variable	**FD** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	14.45	13.64	0.805	5.164	0.9618	0.85	1.32	3.36	78039
SW_net (W/m^2)	162.81	164.57	***-1.761***	12.589	0.9889	0.95	10.52	8.55	79152
LW_net (W/m^2)	-51.02	-55.77	4.751	17.068	0.7802	0.61	-24.85	11.34	79152
SW_ce (W/m^2)	-56.10	-49.30	-6.804	8.464	0.9804	0.87	-0.26	5.18	79152
LW_ce (W/m^2)	31.39	26.05	5.332	7.449	0.8951	0.89	-1.96	5.40	79152

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH
A. Comparison with CERES for 2017 Monthly (continued)

Clear-sky FH vs CERES at Surface

Variable	**FH** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	15.54	14.25	1.297	6.683	0.9423	0.81	1.70	4.32	486988
SW_net (W/m^2)	210.80	213.83	-3.030	12.627	0.9919	0.96	10.50	8.73	493925
LW_net (W/m^2)	-74.98	-81.82	**6.840**	17.866	0.7171	0.57	-39.41	12.20	493925

Clear-ky FD vs CERES at Surface

Variable	**FD** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
ALBEDO (%)	14.19	14.24	-0.047	5.045	0.9592	0.88	1.69	3.45	78039
SW_net (W/m^2)	218.91	213.87	5.043	12.459	0.9936	0.94	8.62	7.83	79152
LW_net (W/m^2)	-82.40	-81.82	***-0.581***	18.353	0.6015	0.54	-36.96	13.64	79152

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH

A. Comparison with CERES for 2017 Monthly (continued)

All-sky FH vs CERES in Atmosphere

Variable	**FH** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
SW_net (W/m^2)	76.60	78.86	-2.253	7.977	0.9678	1.03	0.21	5.54	478330
LW_net (W/m^2)	-176.86	-183.92	**7.058**	18.134	0.8852	0.68	-63.98	11.14	478330
SW_ce (W/m^2)	2.76	2.25	0.518	7.595	0.3383	0.73	0.24	6.09	478107
LW_ce (W/m^2)	8.37	1.41	6.964	11.364	0.8835	0.99	-6.87	8.08	469722

All-sky FD vs CERES in Atmosphere

Variable	**FD** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
SW_net (W/m^2)	71.76	78.00	-6.240	10.167	0.9512	1.08	0.34	6.72	79152
LW_net (W/m^2)	-185.08	-183.39	***-1.690***	18.118	0.7889	0.84	-28.06	13.48	79152
SW_ce (W/m^2)	3.32	2.15	1.173	6.406	0.3724	0.61	0.13	5.30	79152
LW_ce (W/m^2)	-4.48	0.95	-5.429	8.455	0.9367	0.94	5.18	6.07	79063

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH
A. Comparison with CERES for 2017 Monthly (continued)

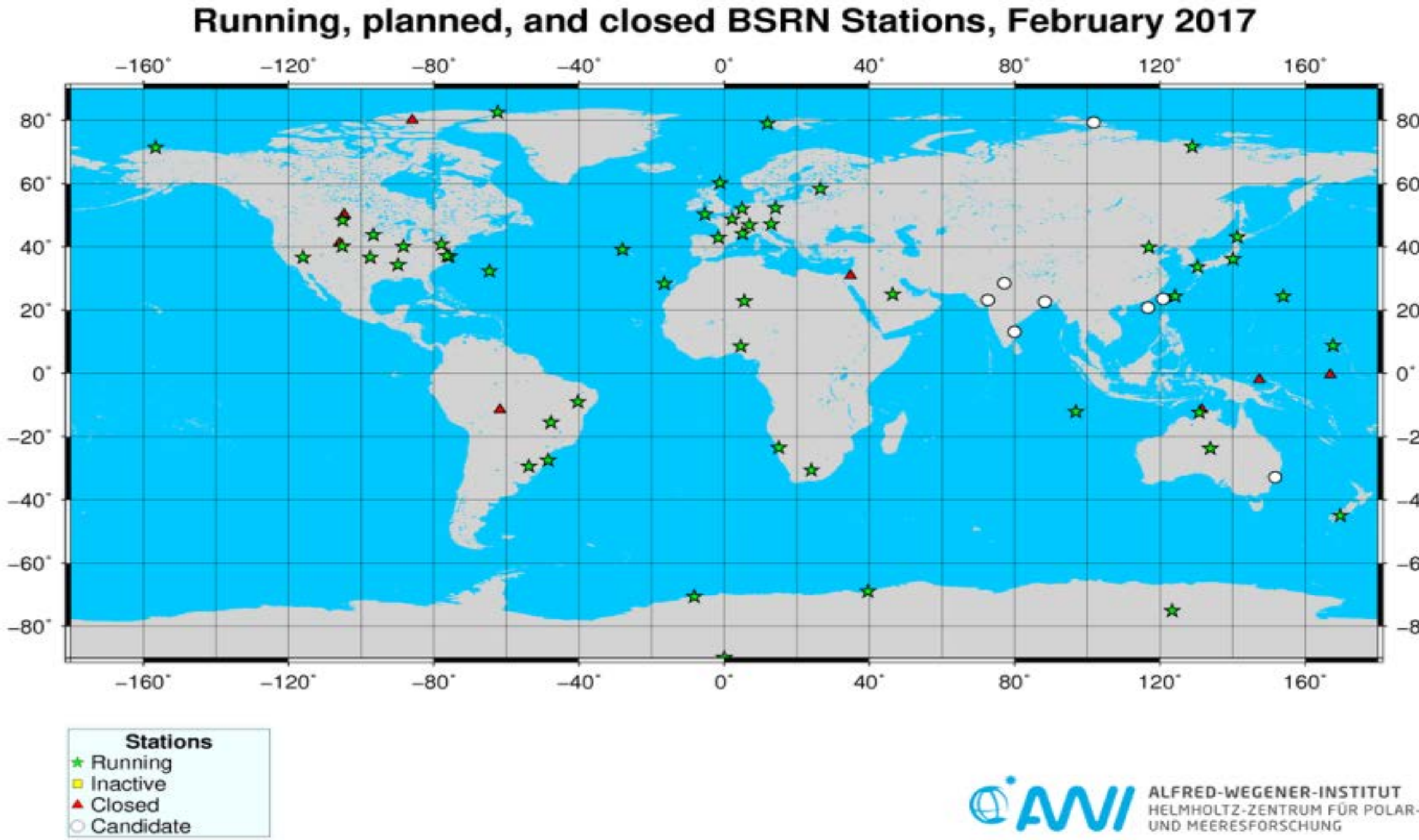
Clear-sky FH vs CERES in Atmosphere

Variable	**FH** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
SW_net (W/m^2)	73.27	75.89	***-2.622***	8.069	0.9668	1.03	0.12	5.57	493695
LW_net (W/m^2)	-184.26	-184.62	0.362	17.057	0.9256	0.78	-41.07	11.06	485080

Clear-ky FD vs CERES in Atmosphere

Variable	**FD** mean	**CERES** mean	Mean diff	Stdv	cor coef	Slope	intrcept	Nrm dev	Eq cell #
SW_net (W/m^2)	68.44	75.85	**-7.412**	9.173	0.9611	1.12	-0.97	5.70	79152
LW_net (W/m^2)	-180.55	-184.30	3.752	18.951	0.8571	0.95	-13.56	13.71	79063

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH
B. Comparison with BSRN: 68 Stations as of March 2017



III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH

B. . BSRN (continued): But only 39 Stations are data-available for 2007

	Station		Lat	Lon
1	ALE	ale	82.49	297.58
2	EUR	eur	79.989	274.060
3	NYA	nya	78.925	11.930
4	LER	ler	60.139	358.815
5	TOR	tor	58.254	26.462
6	LIN	lin	52.210	14.122
7	CAB	cab	51.971	4.927
8	REG	reg	50.205	255.287
9	CAM	cam	50.217	354.683
10	PSU	psu	40.720	282.067
11	PAL	pal	48.713	2.208
12	FPE	fpe	48.317	254.900
13	PAY	pay	46.815	6.944
14	CAR	car	44.083	5.059
15	SXF	sxf	43.730	263.380
16	BOS	bos	40.125	254.763
17	BON	bon	40.067	271.633
18	BOU	bou	40.050	254.993
19	XIA	xia	39.754	116.962
20	CLH	clh	36.905	284.287

	Station		Lat	Lon
21	DRA	dra	36.626	243.982
22	BIL	bil	36.605	262.484
23	E13	e13	36.605	262.515
24	TAT	tat	36.058	140.126
25	GCR	gcr	34.255	270.127
26	BER	ber	32.267	295.333
27	SBO	sbo	30.860	34.779
28	TAM	tam	22.790	5.529
29	KWA	kwa	8.720	167.731
30	NAU	nau	-0.521	166.917
31	MAN	man	-2.058	147.425
32	COC	coc	-12.193	96.835
33	DAR	dar	-12.425	130.891
34	ASP	asp	-23.798	133.888
35	LAU	lau	-45.045	169.689
36	SYO	syo	-69.005	39.589
37	GVN	gvn	-70.650	351.750
38	DOM	dom	-75.100	123.383
39	SPO	spo	-89.983	335.201

III. Preliminary validation for β-ISCCP-H-based, β-ISCCP-FH
B. . BSRN (continued): for 2017 Monthly Mean

FLux	**FH**	**BSRN**	M. diff	Stdv	Cr coef	Slope	intrcept	Nrm dev	Stn #
SWdn (W/m^2)	166.95	171.06	-4.110	20.744	0.9738	0.99	6.24	14.74	434
LWdn (W/m^2)	301.94	310.89	-8.953	17.769	0.9757	0.95	25.15	12.51	453
SWup (W/m^2)	56.43	67.87	***-11.439***	26.352	0.9546	1.09	6.26	17.19	89
LWup (W/m^2)	286.89	289.15	***-2.258***	20.351	0.9757	1.09	-22.98	12.96	96

FLux	**FD**	**BSRN**	M. diff	Stdv	Cr coef	Slope	intrcept	Nrm dev	Stn #
SWdn (W/m^2)	165.79	171.06	-5.273	23.020	0.9676	1.00	5.99	16.31	434
LWdn (W/m^2)	321.41	310.89	10.521	21.035	0.9660	1.08	-35.40	13.82	453
SWup (W/m^2)	44.58	67.87	**-23.296**	32.808	0.9279	1.11	18.36	21.30	89
LWup (W/m^2)	289.62	289.15	***0.467***	19.163	0.9759	1.02	-7.59	13.31	96

FLux	**CERES**	**BSRN**	M. diff	Stdv	Cr coef	Slope	intrcept	Nrm dev	Stn #
SWdn (W/m^2)	175.75	171.06	4.693	15.879	0.9847	1.00	-4.45	11.24	434
LWdn (W/m^2)	305.77	310.89	-5.126	11.165	0.9899	0.99	8.08	7.91	453
SWup (W/m^2)	57.27	67.87	***-10.598***	24.017	0.9598	1.02	9.69	16.82	89
LWup (W/m^2)	282.13	289.15	**-7.017**	11.472	0.9923	1.04	-5.66	7.50	96

III. Preliminary validation for β-ISCCP-H-based β-ISCCP-FH
C. Preliminary Error Estimate

Uncertainties for ISCCP-FH in Regional, Monthly Mean Fluxes (on 110-km equal-area map) based on the above validation studies

(1) At TOA: for *Single flux component* based on Comparisons with CERES:

Bias ≤ ~10 W/m^2 STDV ≤ ~11 W/m^2 Corr coefficient ≥ 0.95

► Uncertainty ~ 5-10 W/m^2

with higher resolution and incomplete filling (92%), FH's slightly worse than FD

(2) At Surface: for *single flux component* based on Comparisons with BSRN:

Bias ≤ 11 W/m^2 STDV ≤ 26 W/m^2 Corr coefficient ≥ 0.93

► Uncertainty ~ 10-25 W/m^2

-- FH is overall better than FD (and CERES),

(3) In Atmosphere: for *Net and CE*, FH, FD and CERES are comparable

Bias ≤ ~7 W/m^2 STDV ≤ ~20 W/m^2 Corr coefficient: 0.33 – 0.97

► Uncertainty ~ 7 - 20 W/m^2

IV Conclusions

1. **RadH represents most recent improvements of NASA GISS ModelE's radiation code, especially in atmospheric gas absorption and polar-region LW calculation, i.e., ISCCP-FH flux profile product, though still in its β-version, is an improvement over its precursor, ISCCP-FD.**
2. **Besides increasing spatial resolution (from 280 km to 110 km), ISCCP-H has many substantial improvements. For temperature and humidity profiles, new nnHIRS may be better than previous ISCCP-D's TOVS in temporal homogeneity as well as others, but we are unable to draw definitive conclusions until more years' formal ISCCP-H product is available.**
3. **MACv1 (and later MACv2) seem an improvement as validated using 2004 high-quality surface observations.**
4. **Our cloud-type-dependent statistical VCLC model may be slightly better than previous one for ISCCP-FD; however, because there is no unique solution even with CloudSat- CALIPSO data, it remains to be further improved.**
5. **The new β-version ISCCP-FH product seems acceptable with overall comparable uncertainties to CERES and FD based on the above validation:**
   uncertainties < ~15 W/m² for TOA and < ~25 W/m² for Surface.
6. **It may imply a LIMIT we encounter now under the current status of input parameters and, secondarily, radiation modeling. The limit is largely caused by the restriction of our knowledge on the accuracy of the atmospheric, cloud and surface properties, i.e., UNLESS we make substantial improvements on some major input datasets that cause leading errors, substantial reduction on flux calculation uncertainties may not be achievable.**

V. Acknowledgement

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- ***Special thank is given to Reto Reudy who helped separate RadE (the radiation code) from NASA GISS GCM ModelE code that makes possible to initiate the project, and Stefan Kinne who provided Aerocom, MACv1 and MACv2 aerosol data.***

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- ***Credit should also be given to CERES, BSRN, CloudSat and CALIPSO teams that make possible to have ISCCP-FH processing and validation.***