Status of the Edition 4β Surface-Only Flux Algorithms

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Nineteenth CERES-II Science Team Meeting

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Background (Page 1)

CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in conjunction with the detailed model used by SARB. These algorithms include:

LPSA/LPLA:
Langley Parameterized SW/LW Algorithm

		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

References:

SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.
SW B: Darnell et al. (1992): *J Geophys. Res.*, **97**, 15741-15760.
Gupta et al. (2001): *NASA/TP-2001-211272*, 31 pp.
LW A: Inamdar and Ramanathan (1997): *Tellus,* **49B**, 216-230.
LW B: Gupta et al. (1992): *J. Appl. Meteor.,* **31**, 1361-1367.
LW C: Zhou et al. (2007): *J. Geophys. Res.*, **112**, D15102.
SOFA: Kratz et al. (2010): *J. Appl. Meteor. Climatol.*, **49**, 164-180.
SOFA: Gupta et al. (2010): *J. Appl. Meteor. Climatol.,* **49**, 1579-1589.

Background (Page 2)

- The SOFA LW & SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive surface fluxes.
- LW Models A & B as well as SW Model A were incorporated at the start of the CERES project.
- SW Model B was adapted for use in the CERES processing shortly before the launch of TRMM.
- The Edition 2B LW & SW surface flux results underwent extensive validation (See: Kratz et al. 2010).
- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).
- LW Model C has been introduced in Edition 4 processing to maintain two independent LW algorithms after the CERES Window Channel is replaced in future versions of the CERES instrument.

Recent Improvements to the Surface-Only Flux Algorithms

SW Model Improvements: 1) Replacing the ERBE albedo maps with Terra maps greatly improved the SW retrievals, most notably for polar regions. 2) Replacing the original WCP-55 aerosols properties with monthly MATCH/OPAC datasets while also replacing the original Rayleigh molecular scattering formulation with the Bodhaine et al. (1999) model significantly improved SW surface fluxes for clear conditions. 3) To account for the short term aerosol variability we have incorporated daily MATCH aerosol data into Edition 4. 4) Using a revised empirical coefficient in the cloud transmission formula has improved the SW surface fluxes for partly cloudy conditions. 5) Work continues on the improvement of the cloud transmission method for the new Edition 4 clouds.

LW Model Improvements: 1) Constraining the lapse rate to 10K/100hPa (roughly the dry adiabatic lapse rate) improved the derivation of surface fluxes for conditions involving surface temperatures that greatly exceeded the overlying air temperatures, see Gupta et al. (2010). 2) Limiting the inversion strength to -10K/100hPa for the downward flux retrievals provided the best results for cases involving surface temperatures that were much below the overlying air temperatures (strong inversions).

SW and LW Model Improvements: 1) The availability of ocean buoy measurements is expected to allow for improved surface flux retrievals by providing validation over ocean regions.

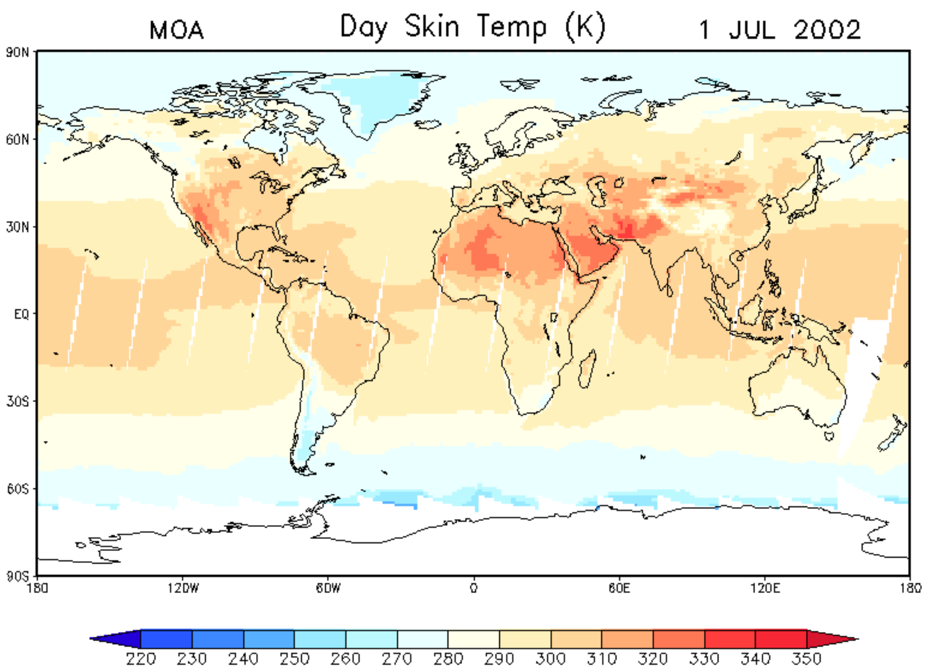
Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

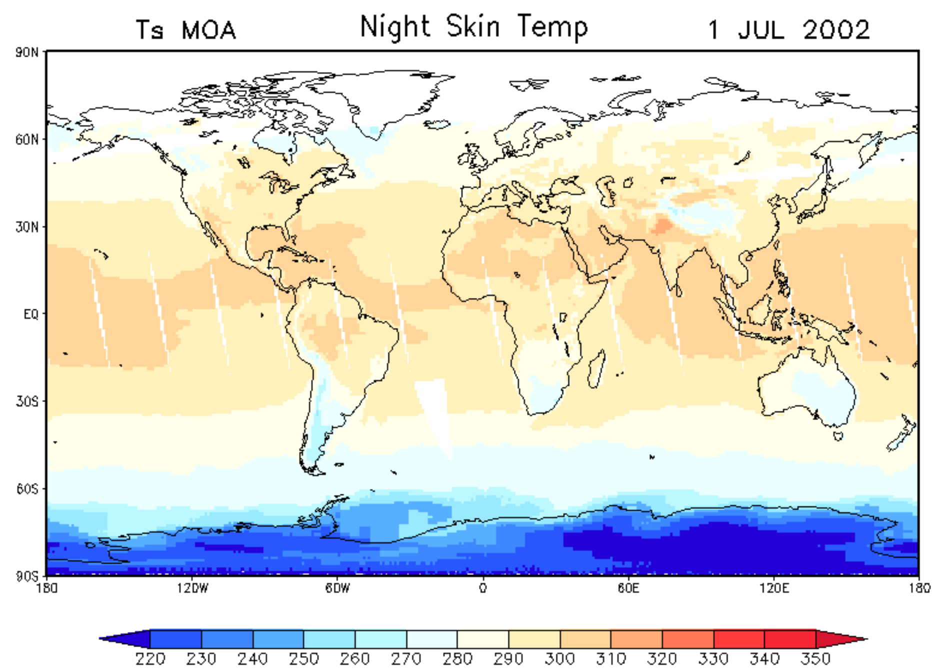
Dataset	CERES 2B	CERES 4A
Clear-Sky TOA albedo Terra	48 month ERBE	70 month Terra
Clearr-Sky TOA albedo Aqua	46 month Terra	70 month Terra
Clear-Sky Surf. albedo	46 month Terra	70 month Terra
TOA to Surface albedo transfer	Instantaneous	Monthly average
Spec. Corr. Coef.	CERES 2B	CERES 3A
Cos (sza) dependence of Surface Flux	LPSA	Briegleb-type
Cloud Algorithm Terra	Terra Ed2	Terra/Aqua Ed4
Cloud Algorithm Aqua	Aqua Ed2	Terra/Aqua Ed4
SW aerosol dataset	WCP-55	MATCH/OPAC
Rayleigh Treatment	Original LPSA	Bodhaine et al (1999), JAOT.
Ozone Range Check	0 to 500 DU	0 to 800 DU
Twilight cutoff		New
Cloud transmission empirical coefficient	0.80	0.75
LW high temperature surface correction	No	Maximum Lapse Rate 10K/100hPa
LW Inversion correction	No	Maximum Inversion Strength -10K/100hPa

Status of Edition 4β LW Models A, B and C

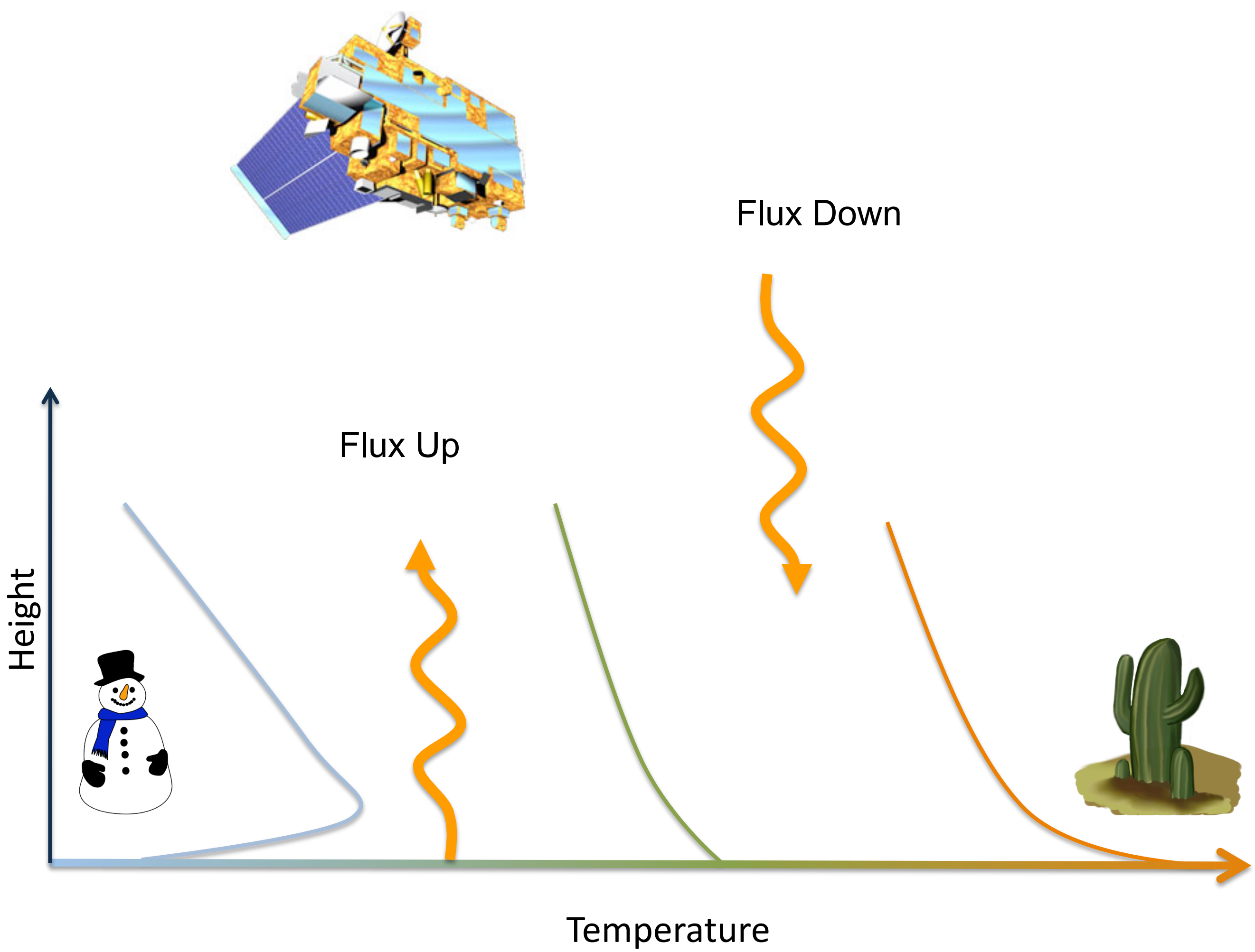
Effect of Temperature Constraints on the calculation of downward LW fluxes for cases involving super-adiabatic lapse rates and extreme temperature inversions.

Daytime and Nighttime Surface Temperatures
[MOA (SSF-59)] Terra Edition 4β 7/1/2002

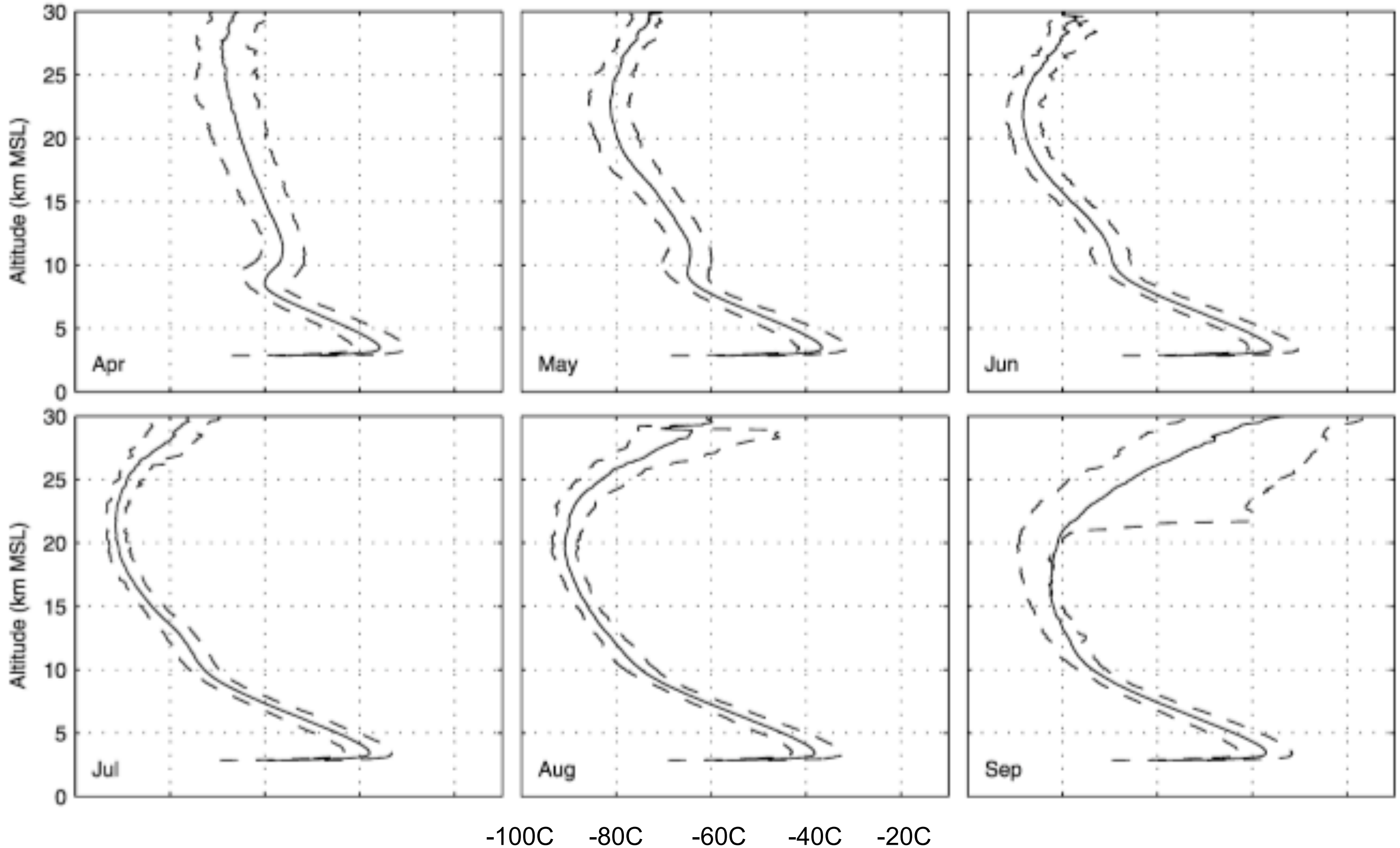




Temperature Profiles for Various Conditions



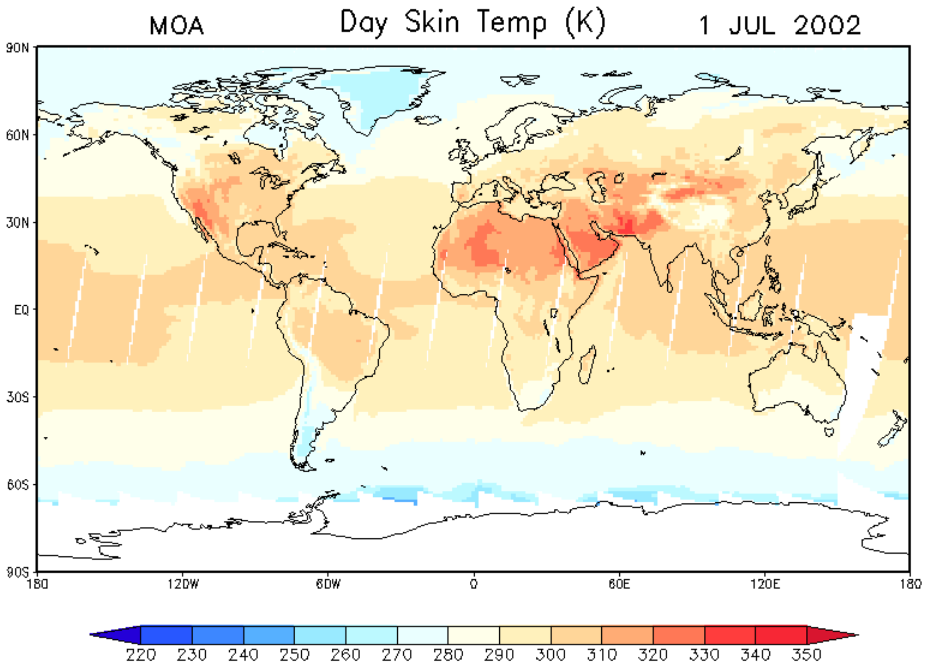
Monthly mean (solid line) atmospheric temperature profiles from 2 m above surface to 30 km above MSL over the South Pole (The dashed lines show the 10th and 90th percentiles of temperature at each height). Figure adopted from Hudson and Brandt (2005), *J. Climate*, **18**, 1673-1696.

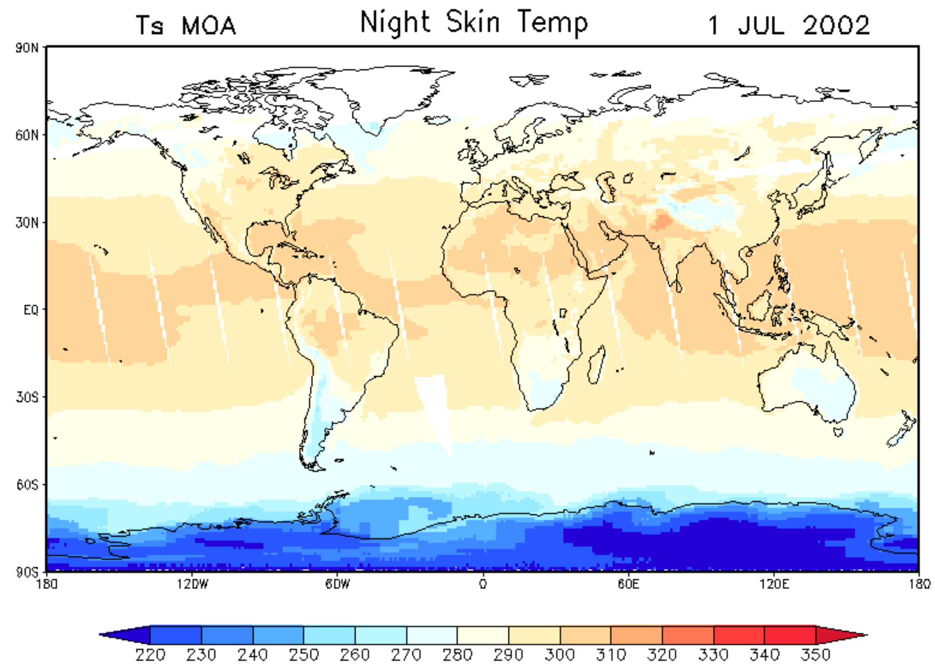


Comparison of input temperatures in SOFA LW Models for calculating downward LW fluxes to the surface

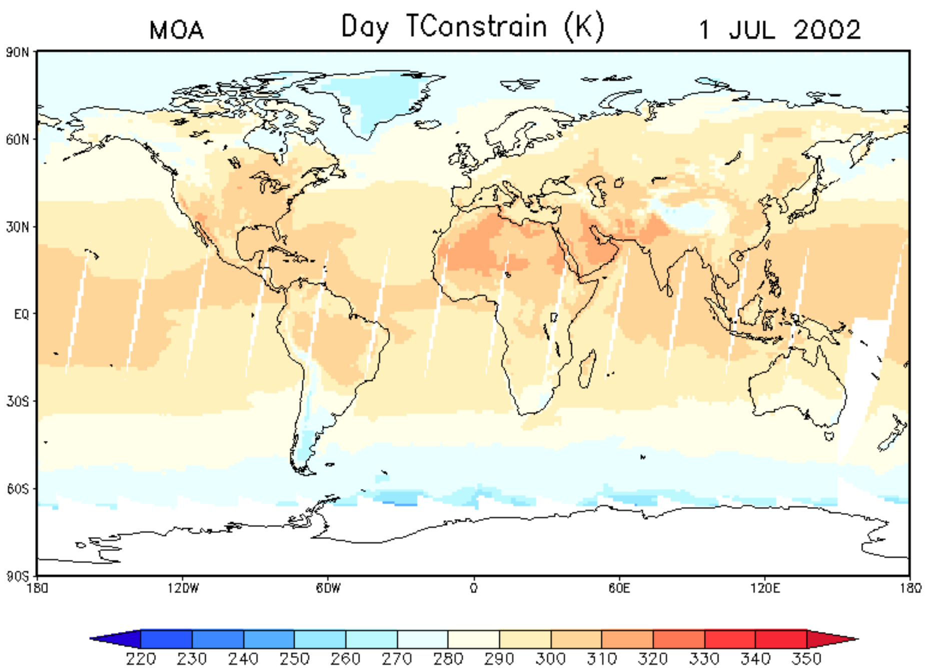
- T_s (MOA SSF-59) versus T_s (Constrained MOA SSF-59b)
- T_s (MOA (SSF-59) versus T_s (CWG SSF-79)
- T_s (Constrained MOA SSF-59b) versus
  T_s (Constrained CWG No SSF#)

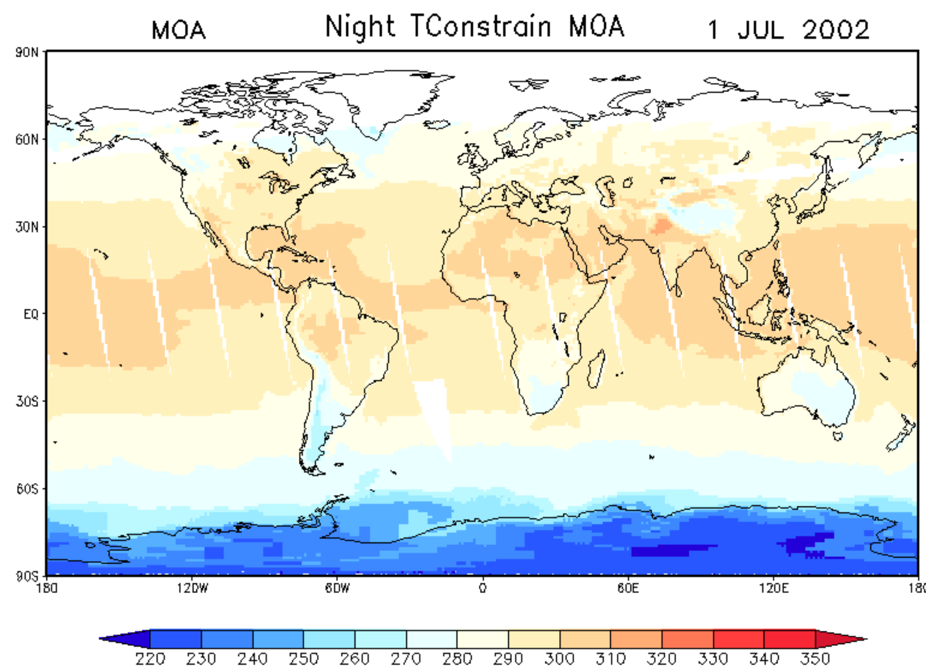
Daytime and Nighttime Surface Temperatures
[MOA (SSF-59)] Terra Edition 4β 7/1/2002



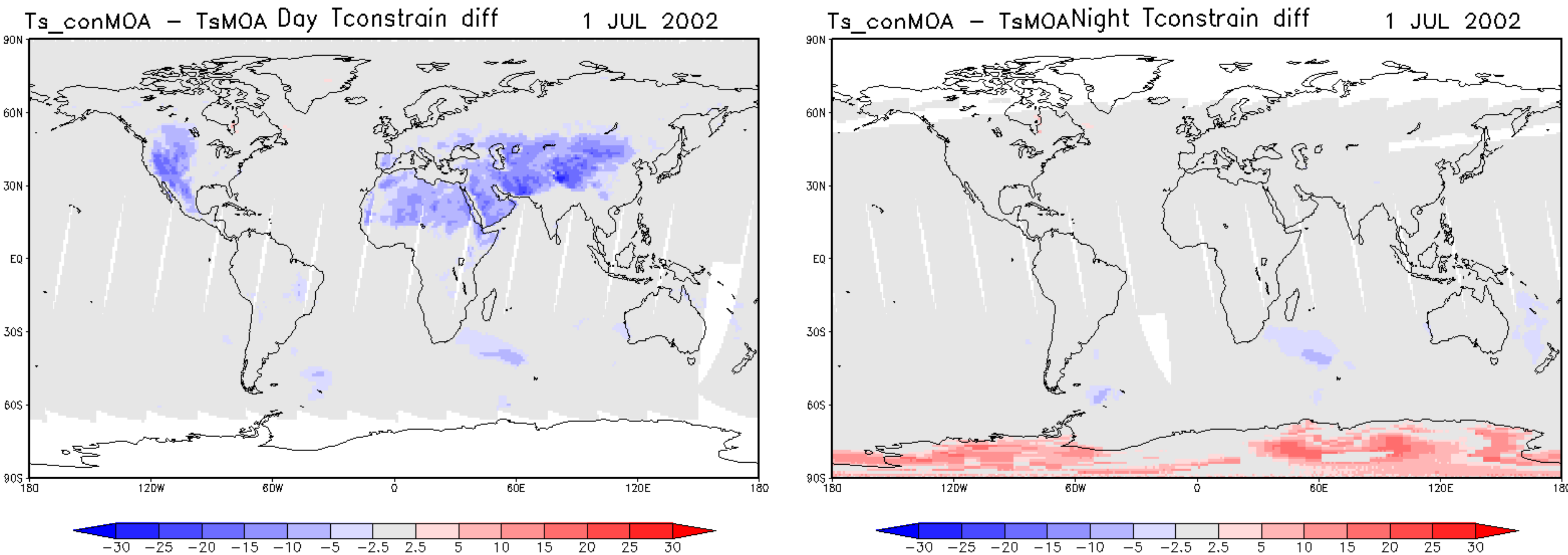


Daytime and Nighttime Surface Temperatures [Constrained MOA (SSF-59b)] Terra Edition 4β 7/1/2002



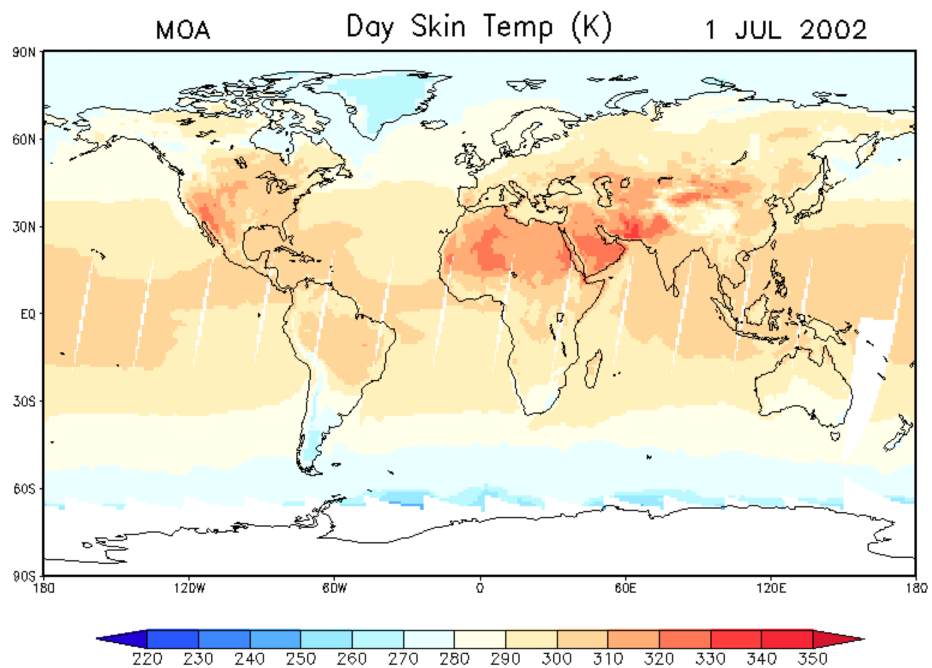


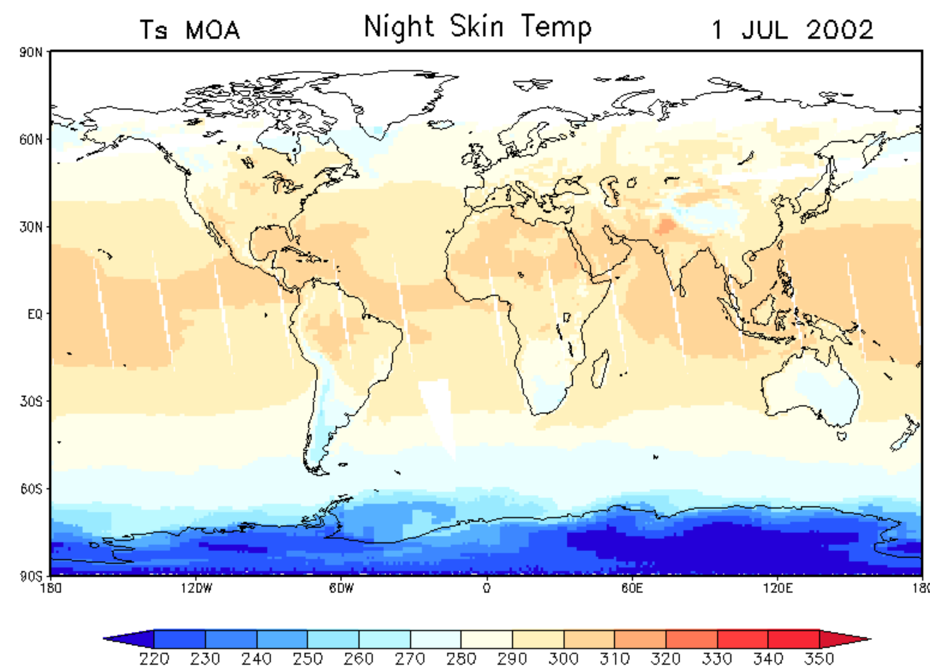
Difference in Daytime and Nighttime Surface Temperatures [Constrained MOA (SSF-59b) minus MOA(SSF-59)] Terra Edition 4β 7/1/2002



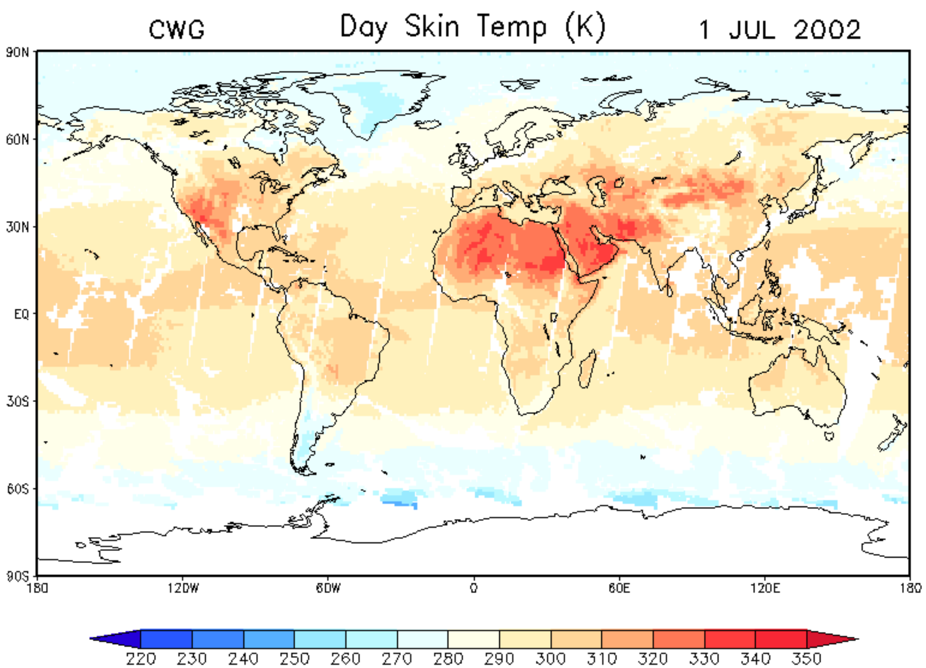
Differences off the eastern coasts of S.A. & Africa are associated with Ocean Currents

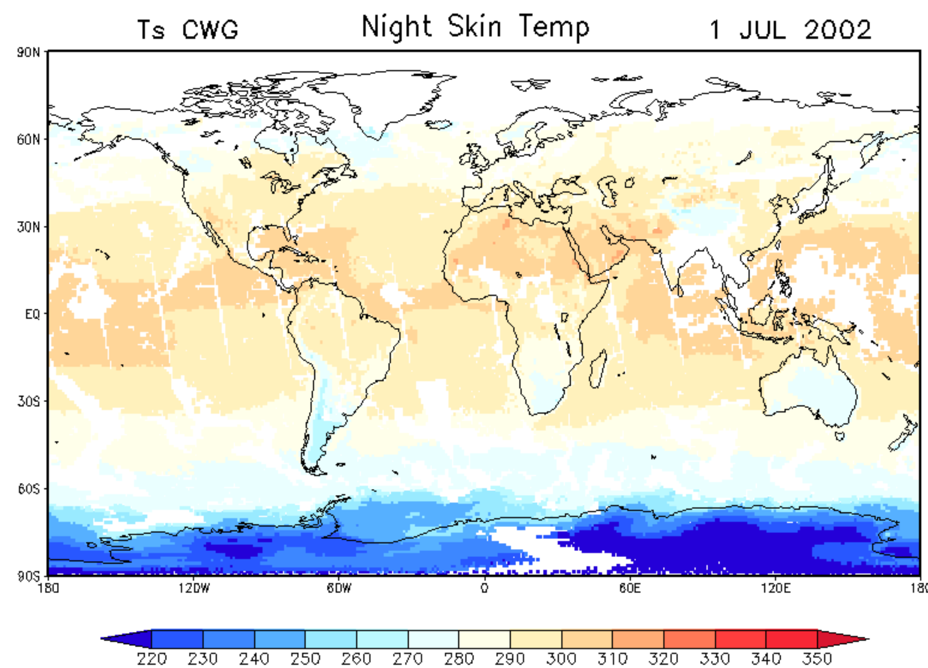
Daytime and Nighttime Surface Temperatures [MOA (SSF-59)] Terra Edition 4β 7/1/2002



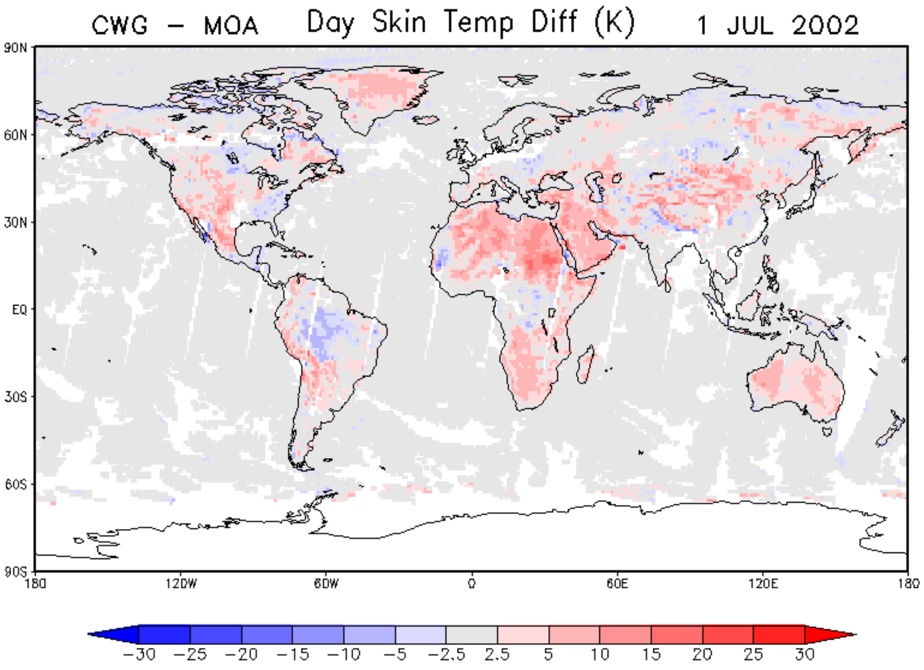


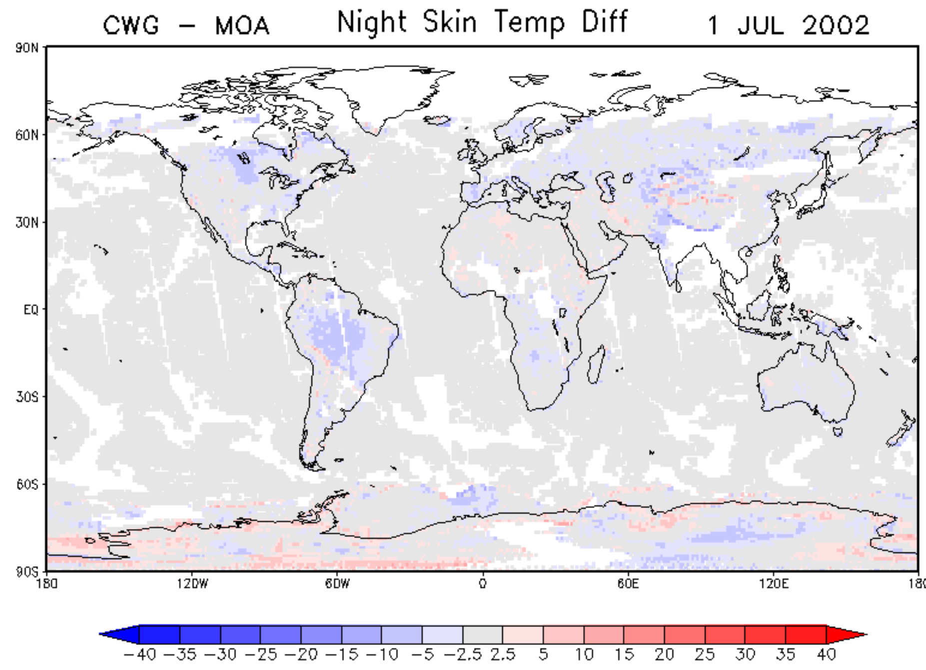
Daytime and Nighttime Surface Temperatures
[CWG (SSF-79)] Terra Edition 4β 7/1/2002



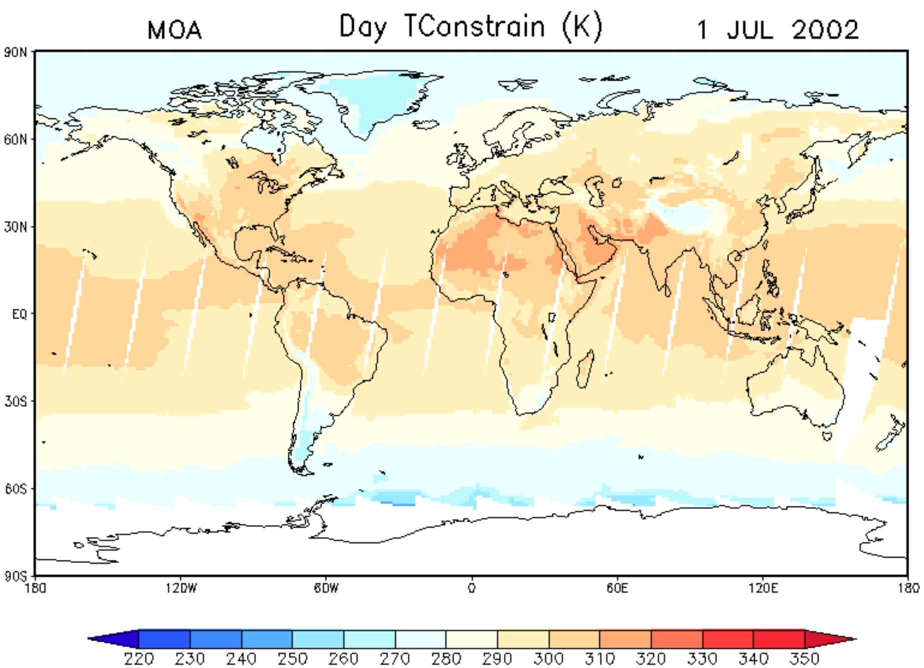


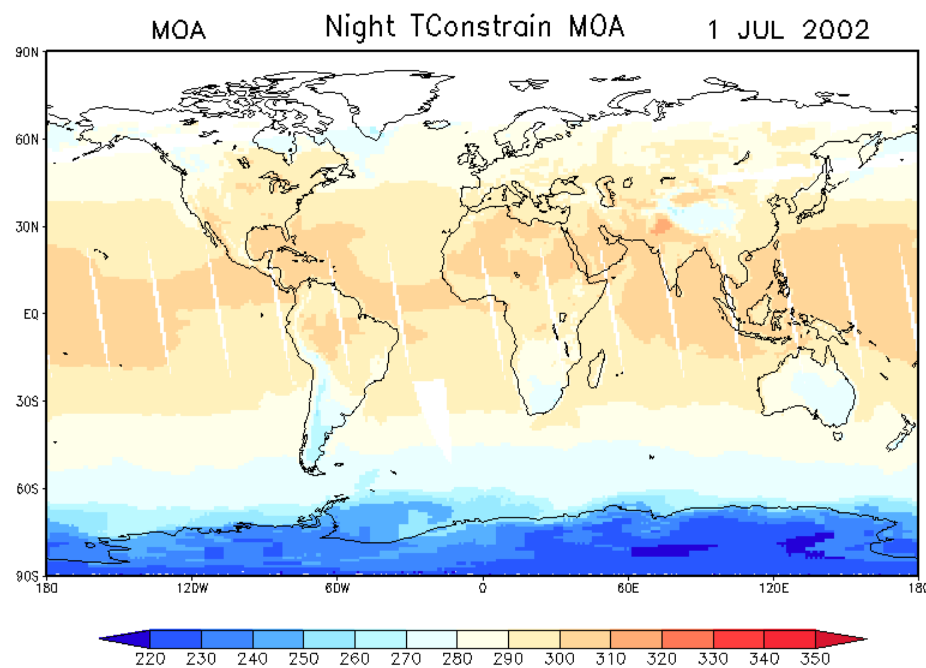
Difference in Daytime and Nighttime Surface Temperatures
[CWG (SSF-79) minus MOA(SSF-59)]
Terra Edition 4β 7/1/2002



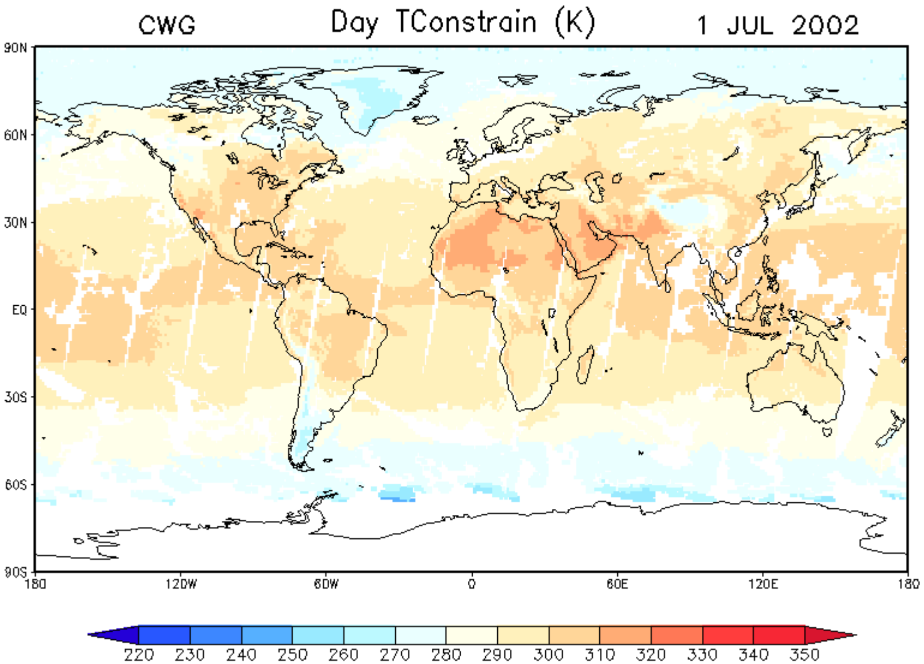


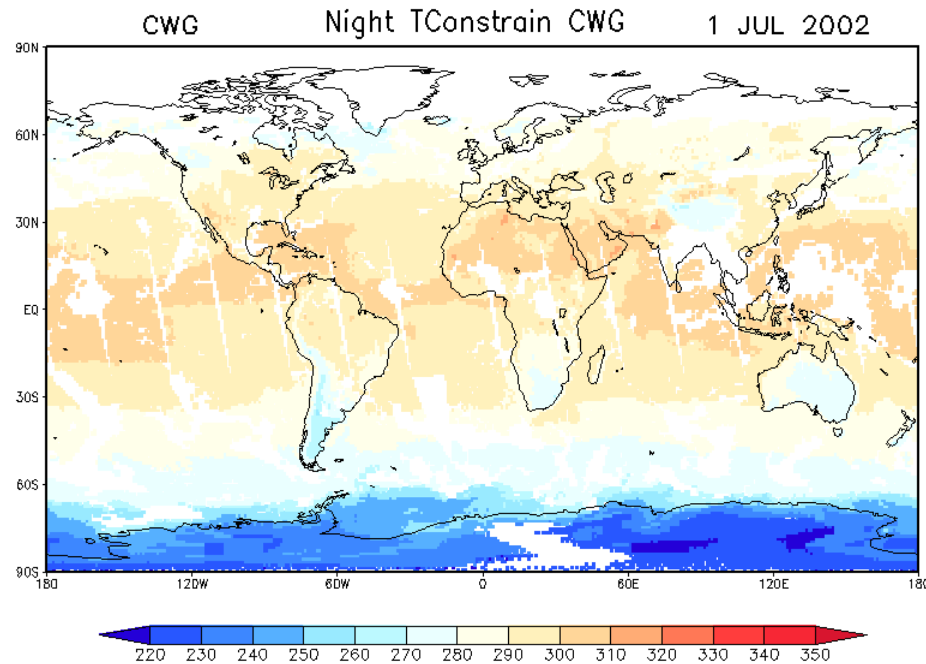
Daytime and Nighttime Surface Temperatures
[Constrained MOA (SSF-59b)] Terra Edition 4β 7/1/2002



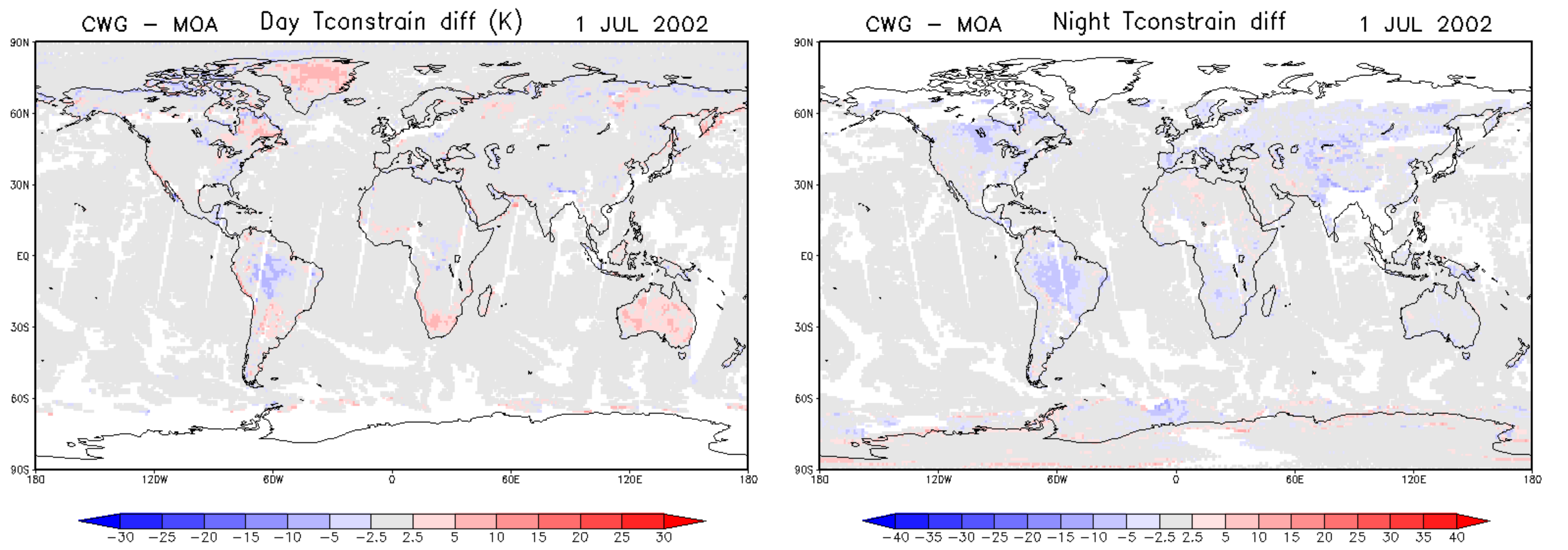


Daytime and Nighttime Surface Temperatures
[Constrained CWG (No SSF #)] Terra Edition 4β 7/1/2002

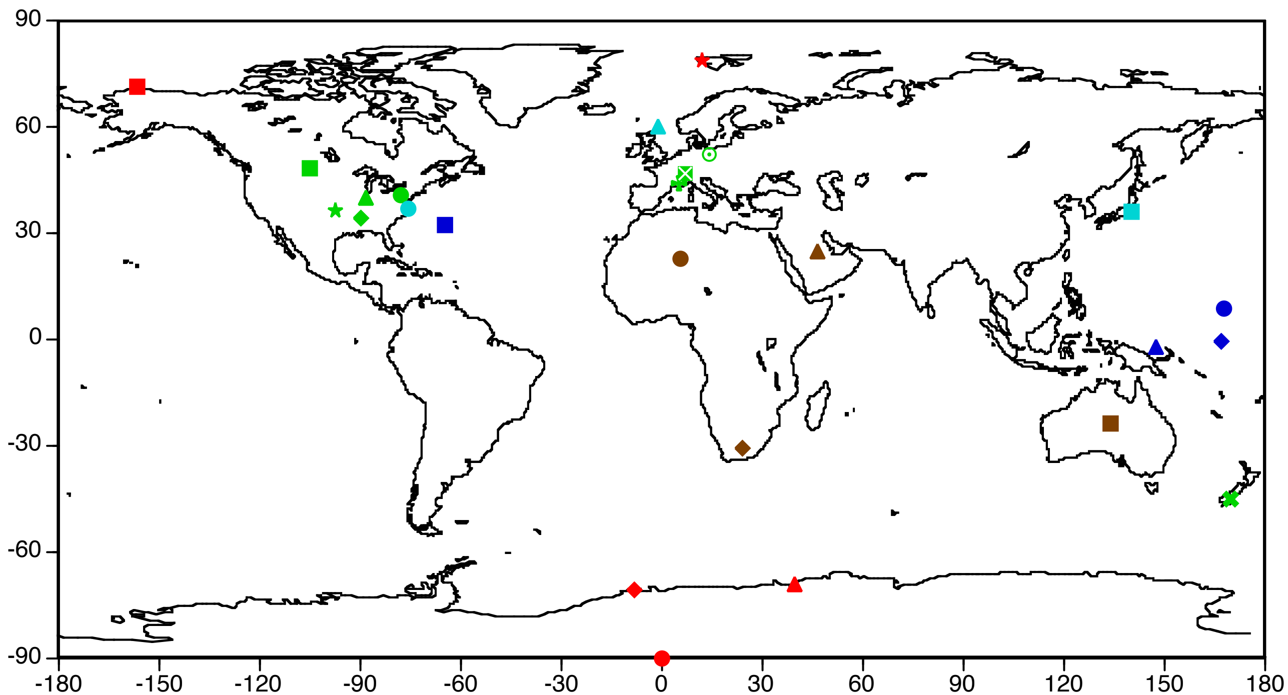


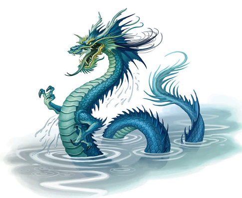


Difference in Daytime and Nighttime Surface Temperatures [Constrained CWG minus Constrained MOA(SSF-59b)] Terra Edition 4β 7/1/2002



Surface Sites Available for Validation of Ed 4β





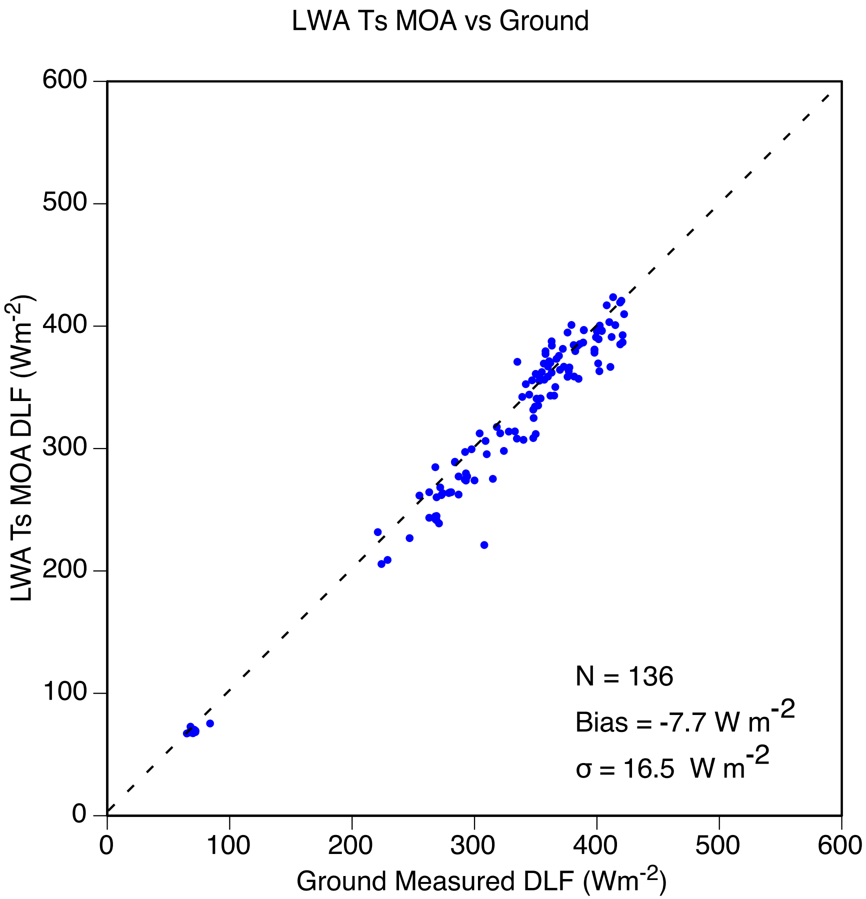
48.31N, 105.10W Fort Peck, MT
40.72N, 77.93W Penn State, PA
40.05N, 88.37W Bondville, IL
34.25N, 89.87W Goodwin Creek, MS
36.60N, 97.48W SGP ARM
45.03S, 169.7E New Zealand
44 N, 5.1E Carpentras, FR

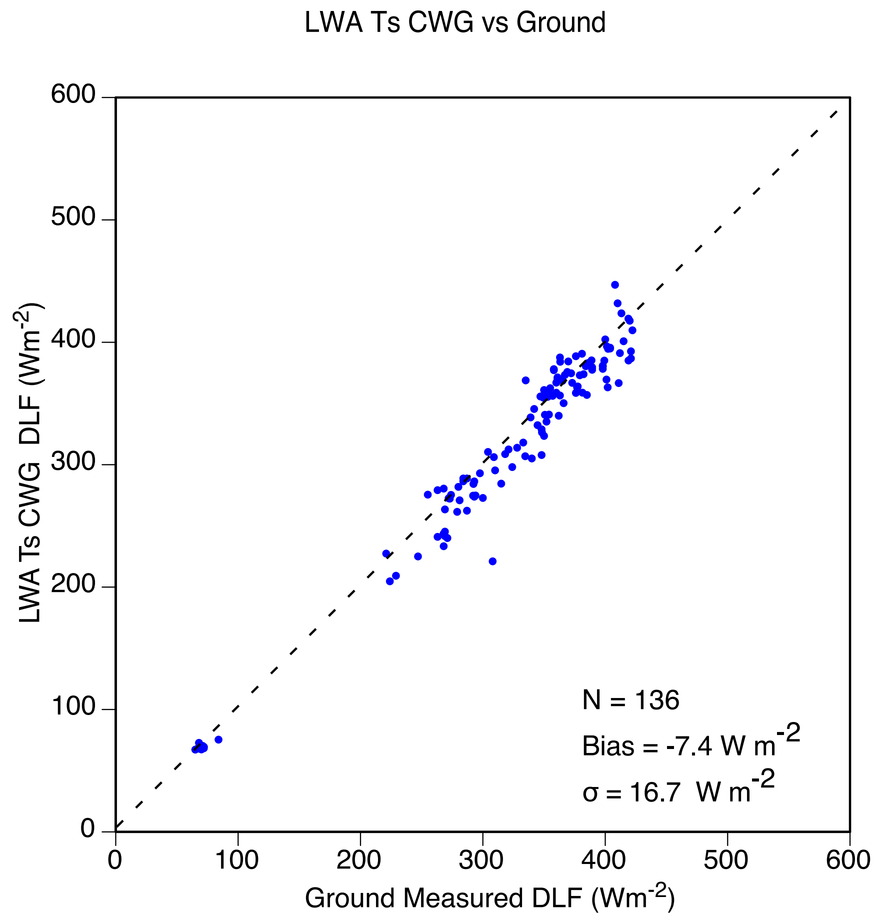
46.82N, 6.9W Payerne, Switzerland
52.22N, 14.1W Lindenberg, Germany
32.30N, 64.77W Bermuda
8.72N, 167.72E Kwajalein
2.06S, 147.42 E Manus
0.52S, 166.9 E, Nauru

36.05N, 140.13E Tatano
36.9N, 75.71W Ches Light
60.13N, 1.2E Lerwick, UK
71.32N, 156.61W Barrow, AK
90.00S, 0.00 South Pole
69.00S, 39.58E Syowa

70.65S, 8.25W Georg von Neumayer
78.9N, 11.95E Ny Alesund
23.70S, 133.87E Alice Springs
22.78N, 5.52E Algeria
24.91N, 46.4E Saudi Solar Village
30.67S, 24.0W, De Aar

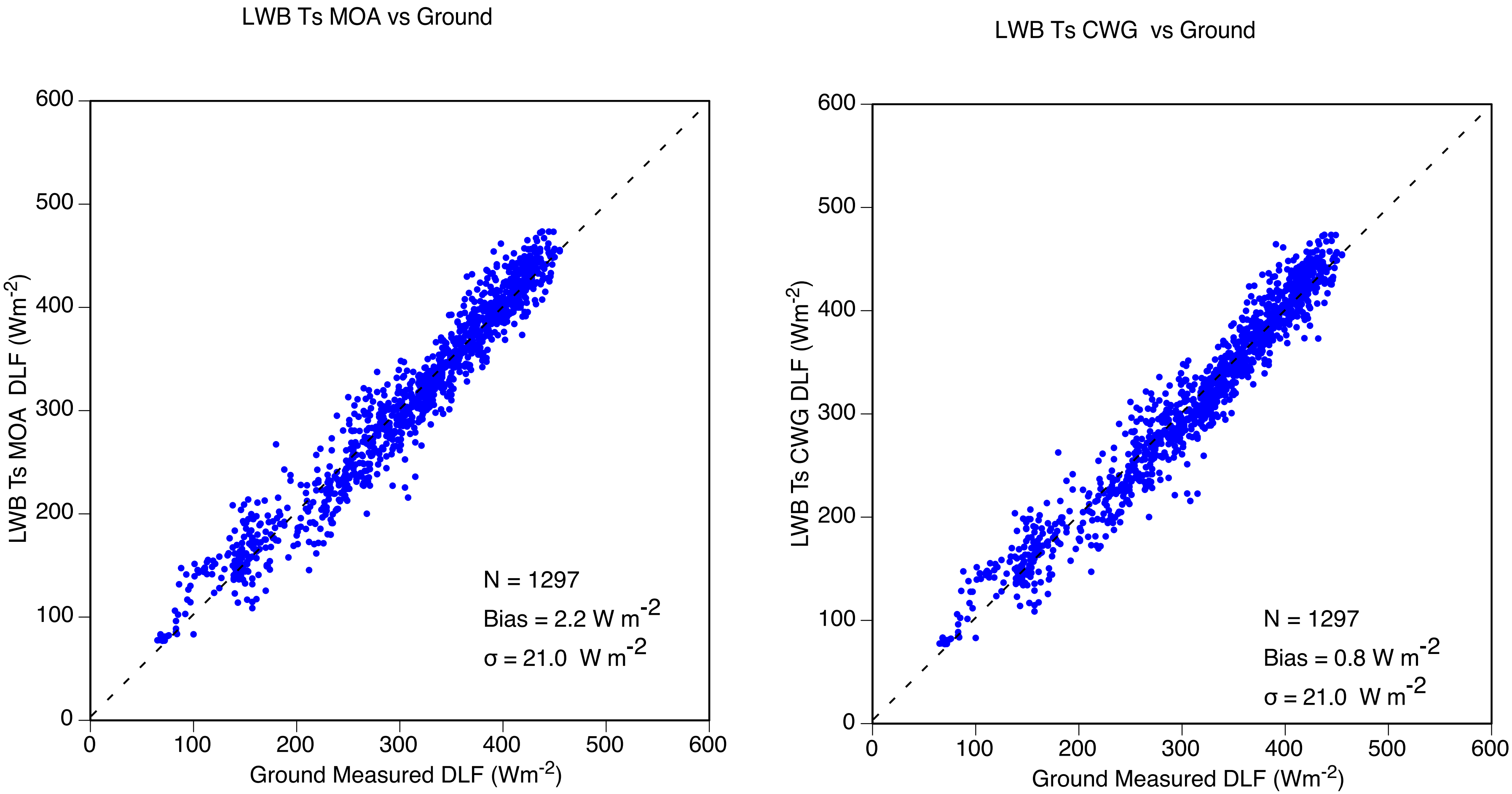
LWA ($T_{s,con}$ MOA) & ($T_{s,con}$ CWG) versus Ground Truth





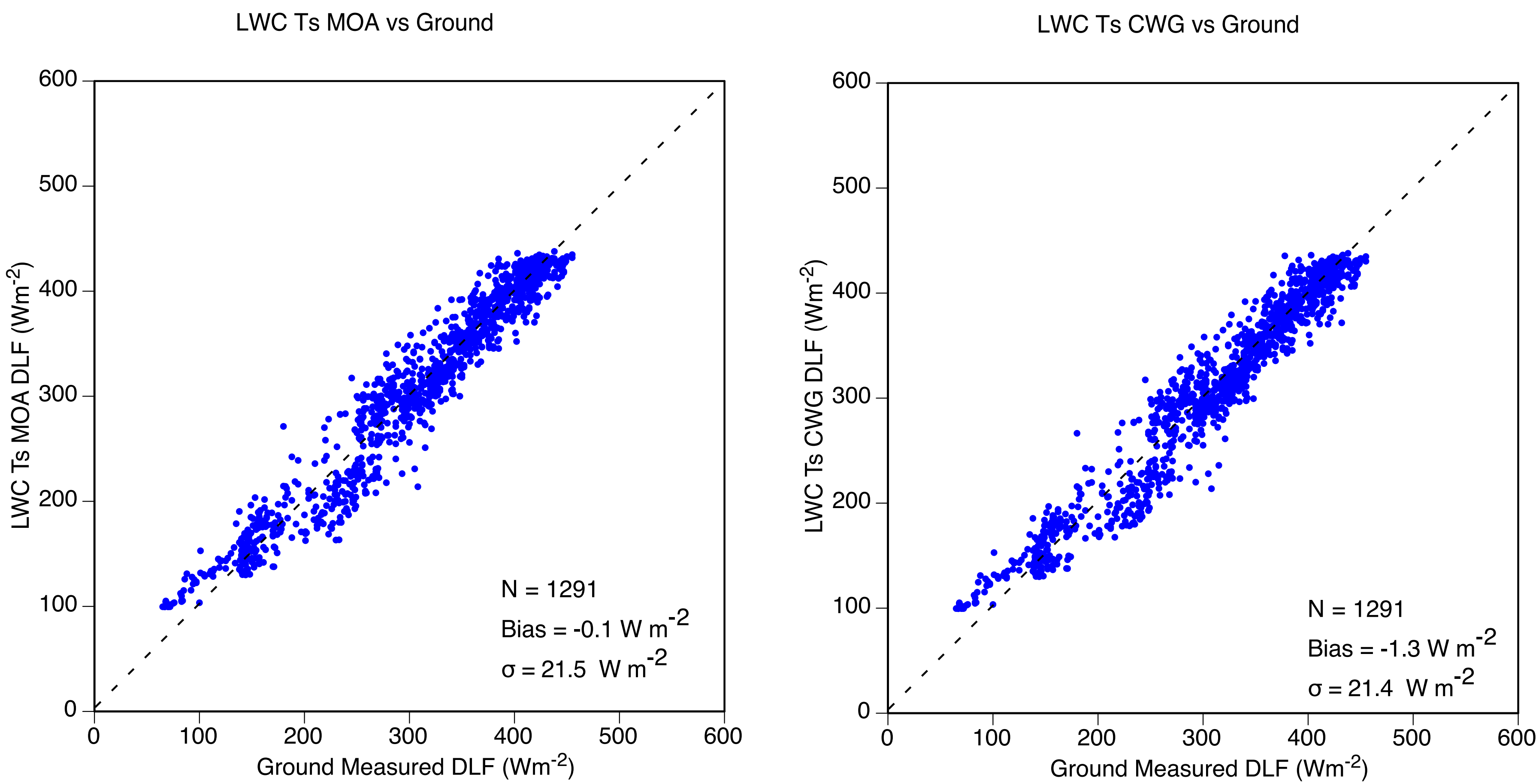
Constrained Near-Surface Air Temperatures

LWB ($T_{s,con}$ MOA) & ($T_{s,con}$ CWG) versus Ground Truth



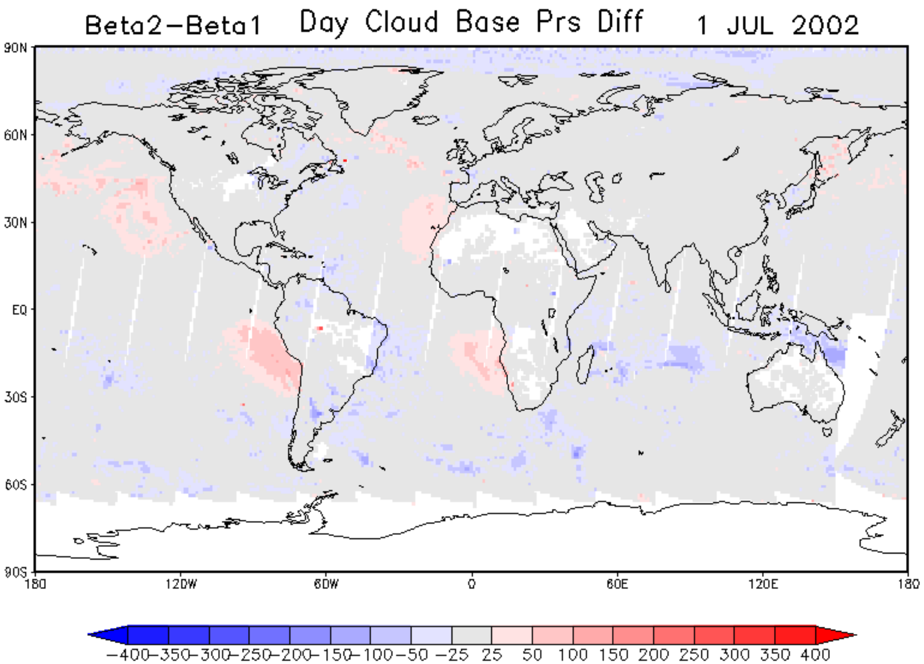
Constrained Near-Surface Air Temperatures

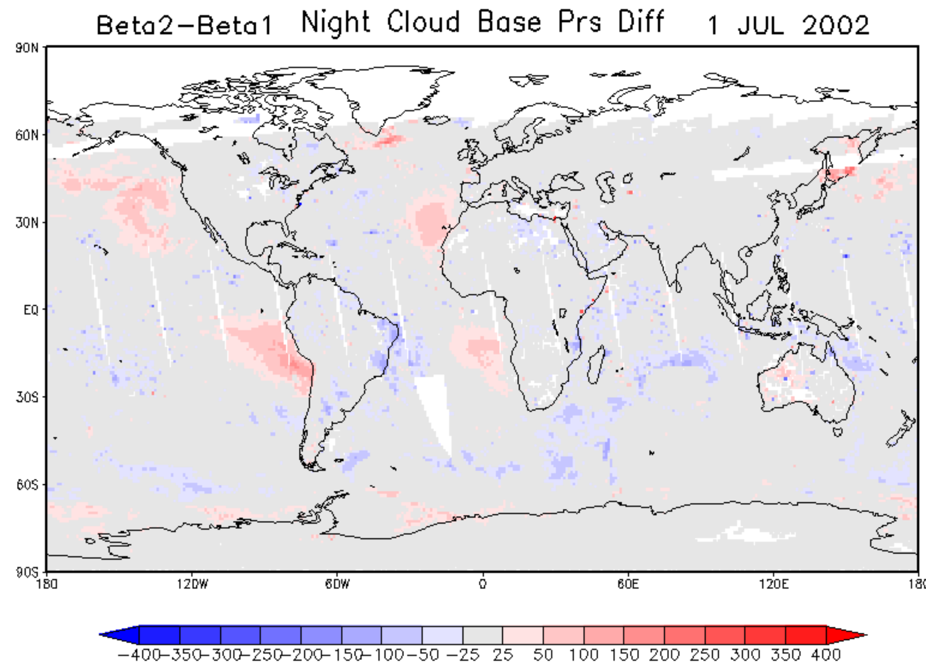
LWC ($T_{s,con}$ MOA) & ($T_{s,con}$ CWG) versus Ground Truth



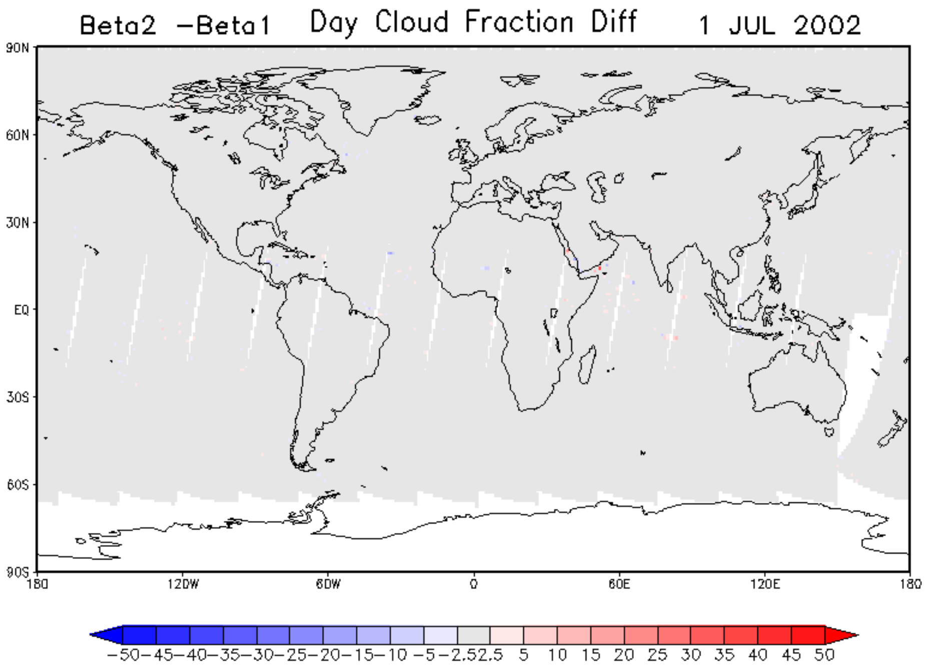
Constrained Near-Surface Air Temperatures

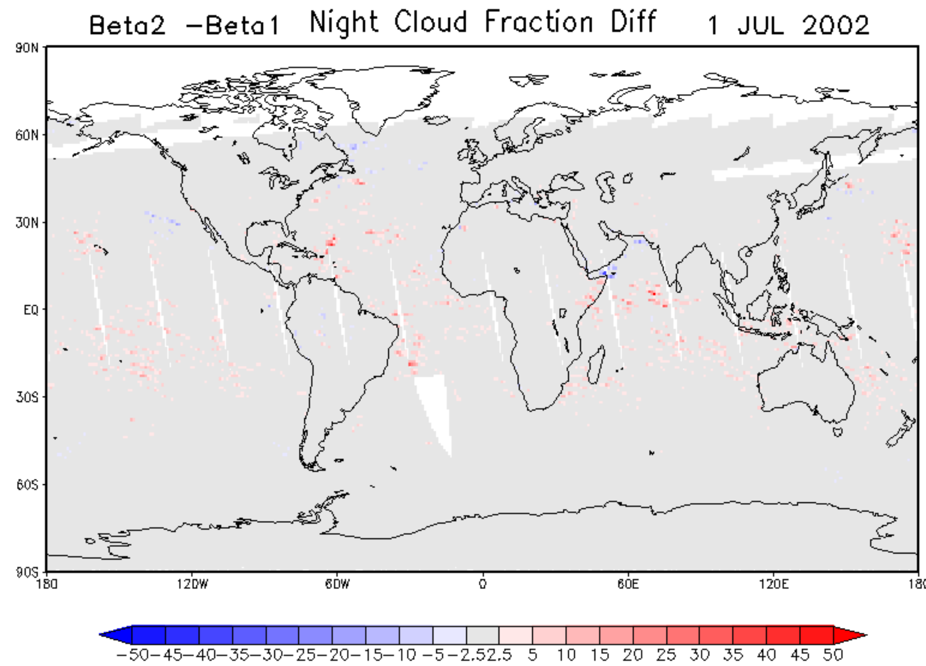
Difference in Daytime and Nighttime Cloud Base Pressure
Terra Edition 4β2 minus Terra Edition 4β1 7/1/2002





Difference in Daytime and Nighttime Cloud Fractions
Terra Edition 4β2 minus Terra Edition 4β1 7/1/2002

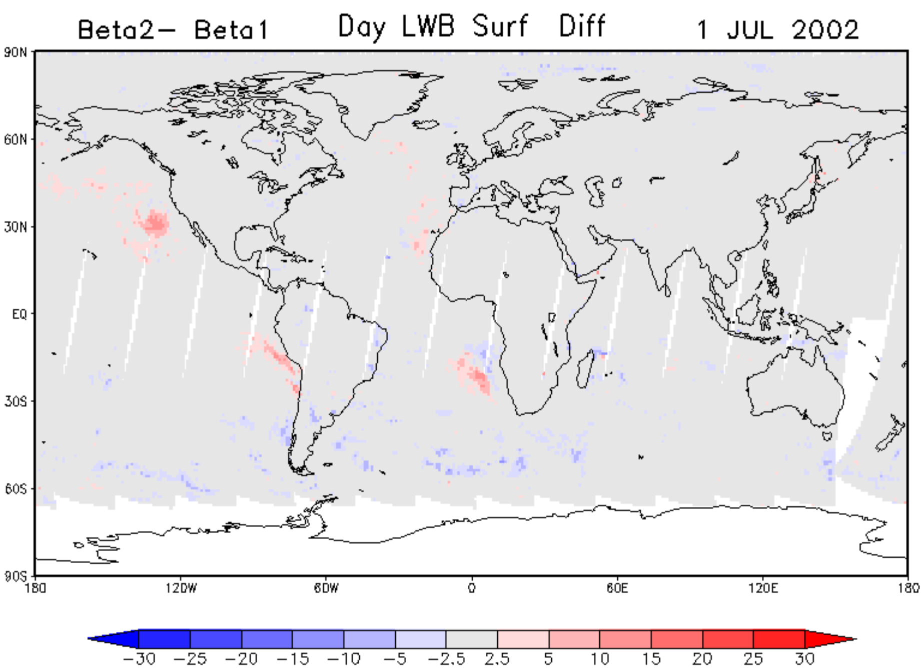


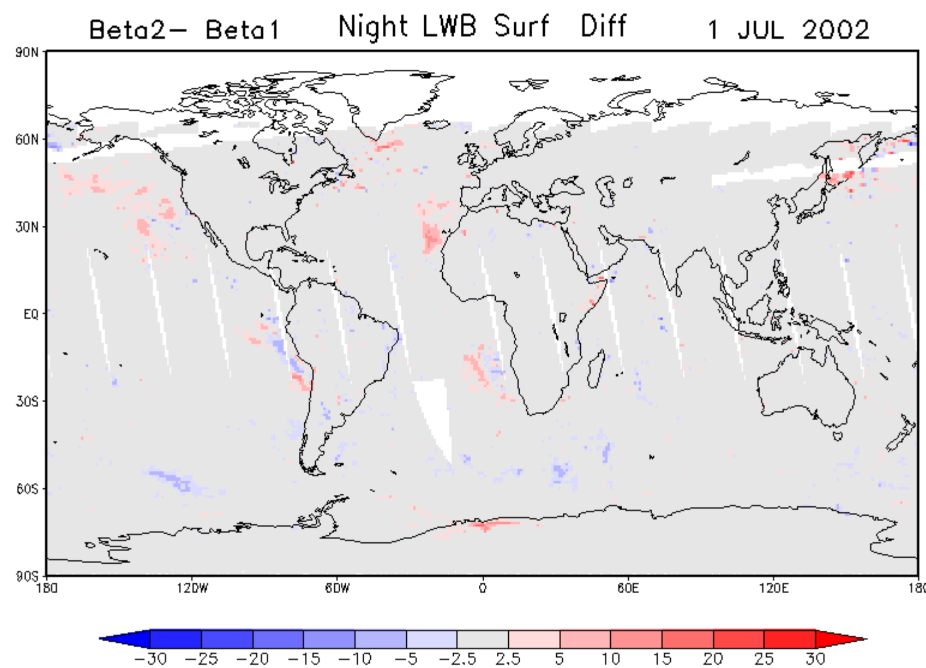


July 1, 2002 MOA Surface Temperatures

Climate Science Branch, NASA Langley Research Center

Difference in Daytime and Nighttime LW Model B
Terra Edition 4β2 minus Terra Edition 4β1 7/1/2002





Results of Recent LW Model Improvements

The CWG skin temperatures have a significantly greater dynamic range than the MOA surface temperatures. The use of the CWG skin temperatures will, therefore, tend to have a wider range of fluxes at the surface. Constraining the CWG and MOA surface temperatures using the SOFA methods, however, tends to yield comparable results.

For the condition involving surface temperatures that greatly exceed the overlying air temperatures, constraining the lapse rate to 10K / 100hPa (roughly the dry adiabatic lapse rate) has significantly improved the results for both MOA and CWG T_s, see Gupta et al. (2010).

For conditions involving surface temperatures that are much below the overlying air temperatures (strong inversions), limiting the inversion to a maximum of 10K / 100hPa for the downward flux calculations provides the best results for all conditions for both MOA and CWG T_s.

Edition 4β inputs into the LW model are providing the expected results.

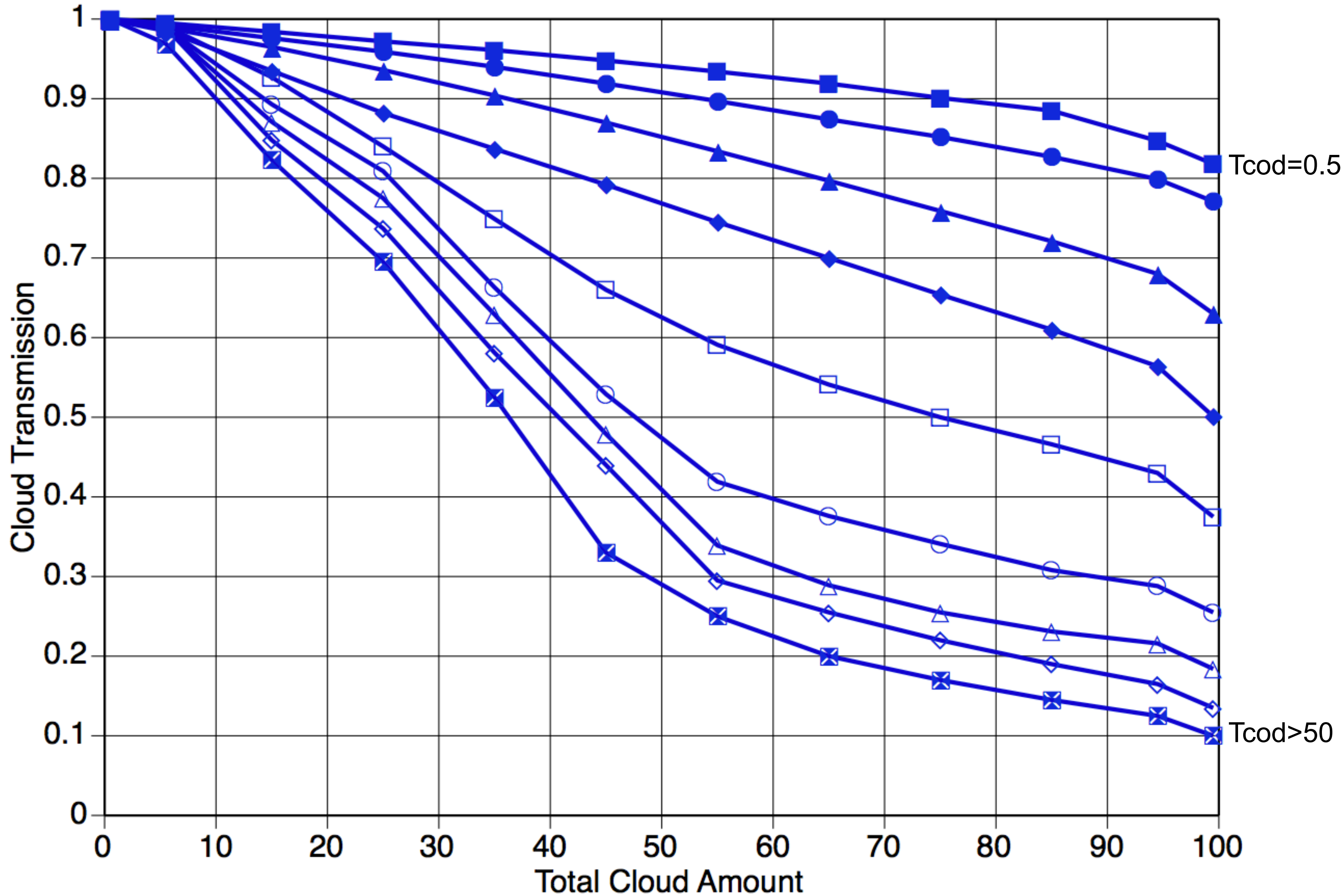
Status of SW Model Improvements from previous CERES Science Team Meeting

Simultaneously replacing the original WCP-55 aerosols with the MATCH aerosols, and the original Rayleigh molecular scattering formulation with an improved Rayleigh molecular scattering formulation has significantly improved the surface SW flux calculations for clear through partly cloudy sky conditions.

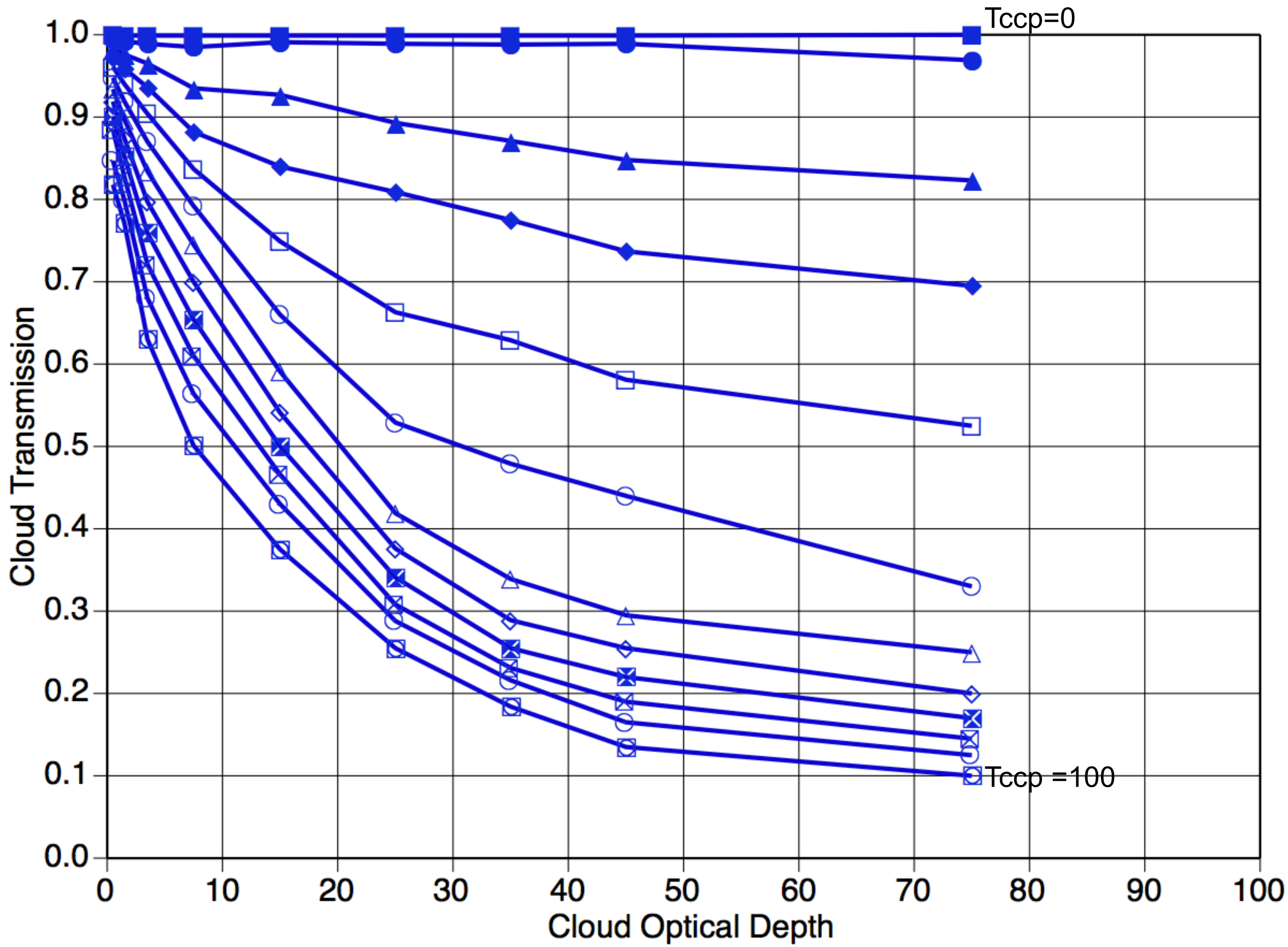
To account for the short term variability of aerosol properties, we have incorporated the daily aerosol properties into SW Model B.

Results for the mostly cloudy to overcast conditions showed some improvement by revising the a_0 coefficient but strongly suggest that further work on the cloud transmittance calculation is necessary. Our attention is currently focused on developing a lookup table method to account for the cloud transmittance.

Cloud Transmission as a Function of Total Cloud Cover Percent (Tccp); range of Total Cloud Optical Depth (Tcod) is 0 to > 50



Cloud Transmission as a Function of Total Cloud Optical Depth (Tcod); range of Total Cloud Cover Percent (Tccp) is 0 to 100



Lookup table to compute the SW Cloud Transmission as a function of total cloud optical depth (Tcod) and total cloud cover percent (Tccp)

Tccp	Tcod									
	0.0	0.5	1.5	3.5	7.5	15.0	25.0	35.0	45.0	>50.0
0.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.5	1.000	1.000	0.999	0.999	0.999	0.999	0.998	0.998	0.998	0.998
5.5	1.000	0.995	0.992	0.989	0.985	0.991	0.989	0.988	0.989	0.969
15.0	1.000	0.984	0.976	0.965	0.935	0.927	0.893	0.871	0.848	0.823
25.0	1.000	0.972	0.959	0.936	0.882	0.840	0.809	0.775	0.737	0.695
35.0	1.000	0.961	0.940	0.904	0.837	0.749	0.663	0.629	0.581	0.525
45.0	1.000	0.948	0.919	0.870	0.792	0.660	0.529	0.479	0.440	0.330
55.0	1.000	0.934	0.897	0.834	0.745	0.591	0.419	0.339	0.295	0.250
65.0	1.000	0.919	0.874	0.797	0.700	0.541	0.376	0.289	0.255	0.200
75.0	1.000	0.901	0.852	0.759	0.654	0.500	0.341	0.255	0.220	0.170
85.0	1.000	0.885	0.827	0.721	0.610	0.466	0.308	0.231	0.190	0.145
94.5	1.000	0.847	0.799	0.680	0.564	0.430	0.288	0.216	0.165	0.125
99.5	1.000	0.818	0.771	0.630	0.501	0.375	0.255	0.184	0.135	0.100

Results of Recent SW Model Development (Course of Action for the Future)

The present look-up table was developed using parameters using daily averaged, SYN 1°x1° gridded data for the year 2004.

These parameters include: 1) All-Sky Surface SW Fluxes, 2) Clear-Sky Surface SW Fluxes, 3) Total Cloud Amounts, and 4) Total Cloud Optical Depths.

An underestimation of the surface fluxes were realized when cloud transmission values derived from this daily-gridded data were applied to the instantaneous footprint level computation.

The reasons of this underestimation are under investigation.

Conclusions for SOFA Ed4β algorithms

Validation studies have shown that revisions to both the LW algorithms and the SW algorithms (for clear to partly cloudy conditions) appear to be working well, though further revisions to the cloud transmission method and/or overcast albedo method are needed for SW Model B.

A preliminary analysis of the LW and SW surface only flux algorithm results using the Edition 4β inputs, especially those from the Clouds Subsystem, indicate improved accuracies for most locations.

CERES Journal Publication Citations

For all publications whether funded by CERES or using CERES data, please include the word “CERES” in the keyword list as this will facilitate listing your publication in the CERES formal publication web-page list (http://ceres.larc.nasa.gov/docs.php).

When any paper, technical report, or book chapter has either been accepted for publication or been published, please notify the CERES group of this publication by contacting Anne Wilber at (anne.c.wilber@nasa.gov).

CERES Journal Publication Citation Values (1/1/2013)

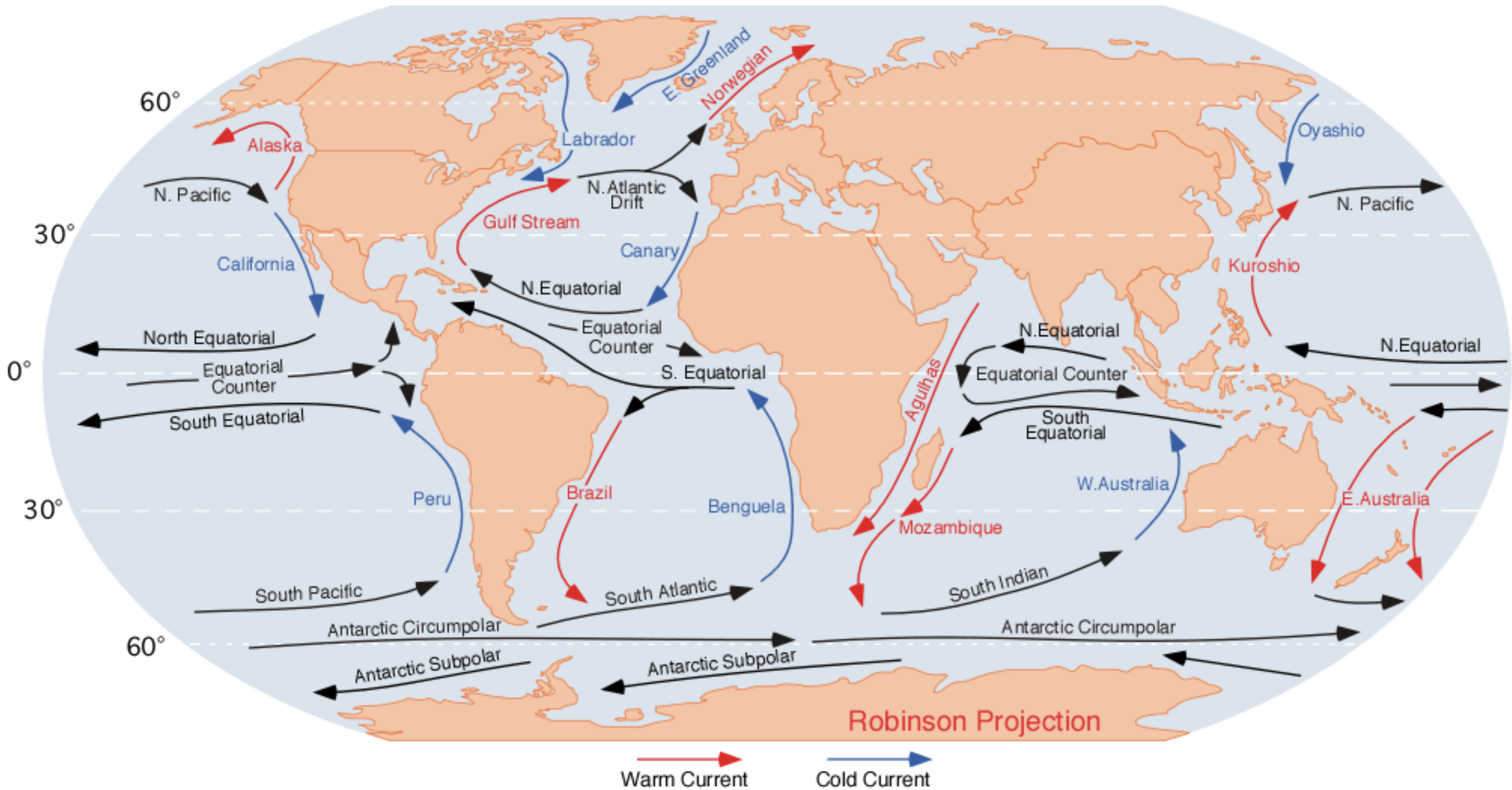
Year	All References[1]	Journal Articles[2]	c1 Citation[3]	c2 Citation[4]	c3 Citation[5]
2012	77	68	55	1294	2837
2011	62	61	284	1421	3115
2010	65	60	428	1208	2648
2009	48	47	785	1034	2267
2008	62	61	817	881	1932
2007	39	31	826	719	1576
2006	44	40	1300	518	1136
2005	49	47	1548	455	998
2004	39	38	1179	348	763
2003	51	48	1593	324	710
2002	78	69	4622	303	666
2001	50	44	1869	179	392
2000	34	32	991	179	392
1999	24	21	688	126	276
1998	20	20	1930	56	123
1997	9	9	282	33	72
1996	5	5	698	17	37
1995	1	1	17	4	9
1994	1	1	3	1	2
1993	6	6	36	0	0
Total	764	709	19951	9100	19951

Citation c1 = # of citations for papers published in that year.

Citation c2 = # of citations in ISI for papers published in all years using a specified set of categories.

Citation c3 = renormalized # of citations for papers published in all years so that the total number of citations in c3 = c1

Backup Slide showing Ocean Currents: Explains surface flux differences observed in slide 12 off the Eastern coasts of South America & Africa.



http://www.physicalgeography.net/fundamentals/8q_1.html