Validation of CERES/TRMM SSF Edition 2 Angular Distribution Models

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Outline

- TOA Flux/ADM Production Schedule

- Recent Changes to SSF

- CERES ADM Types and Web Page

- SW Flux Validation

- LW and WN Flux Validation

TOA Flux Production Schedule

1. August 2001

- Delivery of SSF Edition 2 SW, LW & WN ADMs. ✓
- Prepare SSF Edition 2 validation results. ✓

2. September 2001

- Begin production of CERES/TRMM Edition 2 SSFs. ✓
- Complete SSF Edition 2 Quality Summary. ✗
- Archive SSF Edition 2 pending Science Team Approval. ✗

3. October 2001 – March 2002

- Preparation of 2-3 manuscripts for publication summarizing TRMM ADMs and validation results. ✗
- Begin developing CERES/Terra ADMs. ✗

Recent Changes to SSF (to appear in SSF Edition 2)

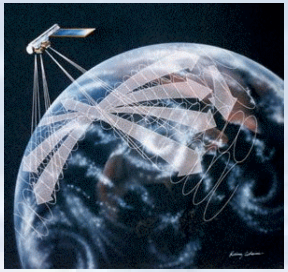
- Include all CERES footprints that have at least 1 VIRS pixel coverage (independent of whether imager data is bad).
  =>User's should carefully check SSF parameters: "percent imager coverage (SSF-54)" and "cloud property extrapolation over cloudy area (SSF-63)".

- Retain clear scenes over "hot" desert and land with saturated VIRS channel 4 radiances.
  - Use CERES WN brightness temperature threshold to identify clear scenes over very hot surfaces.

- Changed units of window (WN) unfiltered radiance and TOA flux from W m^{-2} μm^{-1} to W m^{-2}.
  - WN unfiltered radiance & flux is defined over 8.1 - 11.8 μm wavelength interval.

http://asd-www.larc.nasa.gov/Inversion/

CERES Inversion Group Home Page



Overview

Angular Distribution Models

ADM Version Summary

Validation Results

Publications

Conferences

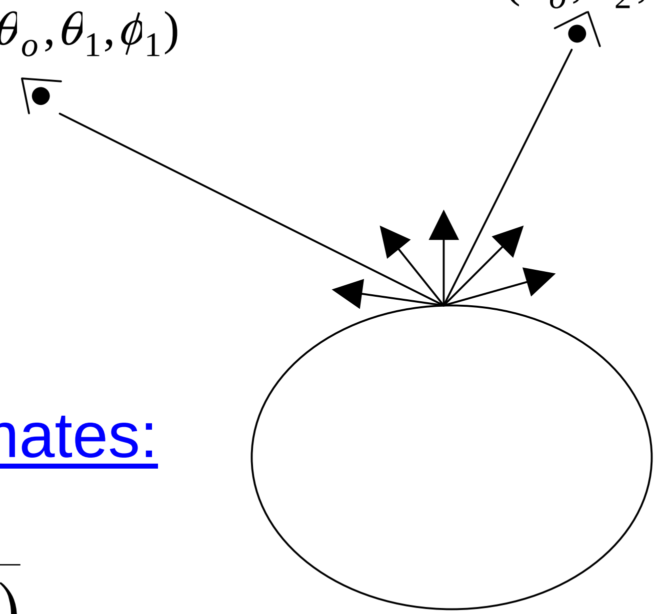
Inversion Production Code

Current Research

Relevant Links

Responsible NASA Official: Dr. Bruce A. Wielicki
Web Curator: Dr. K. Loukachine K.Loukachine@larc.nasa.gov

SW Flux & Albedo Estimation from ADMs



Reflectance (isotropic albedo):

$$r(\theta_o, \theta, \phi) = \frac{\pi I(\theta_o, \theta, \phi)}{\cos\theta_o \, S_o}$$

$(I(\theta_o, \theta, \phi) =$ measured radiance)

Instantaneous Flux & Albedo Estimates:

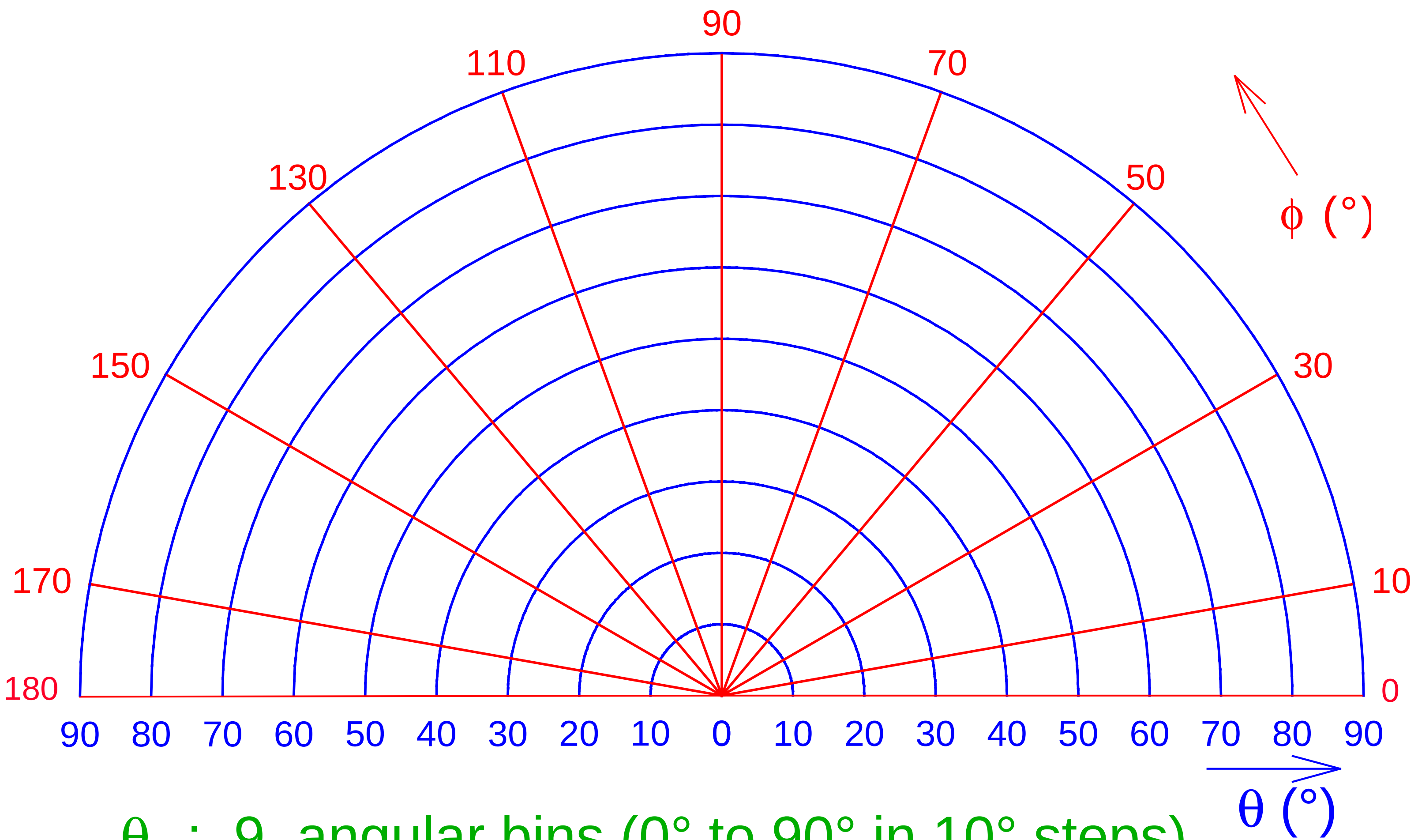
$$\hat{F} = \frac{\pi I(\theta_o, \theta, \phi)}{R_j(\theta_o, \theta, \phi)} \qquad \hat{A} = \frac{r(\theta_o, \theta, \phi)}{R_j(\theta_o, \theta, \phi)}$$

where,

$R_j(\theta_o, \theta, \phi)$ = SW Anisotropic Factor

$$R_j(\theta_o, \theta, \phi) = \frac{\bar{r}_j(\theta_o, \theta, \phi)}{\bar{A}_j(\theta_o)} = \frac{\bar{r}_j(\theta_o, \theta, \phi)}{\pi^{-1} \int_0^{2\pi} \int_0^{\frac{\pi}{2}} \bar{r}_j(\theta_o, \theta, \phi) \cos\theta \, d\theta \, d\phi}$$

CERES SW ADM Angular Bin Definitions



θ_o : 9 angular bins (0° to 90° in 10° steps)

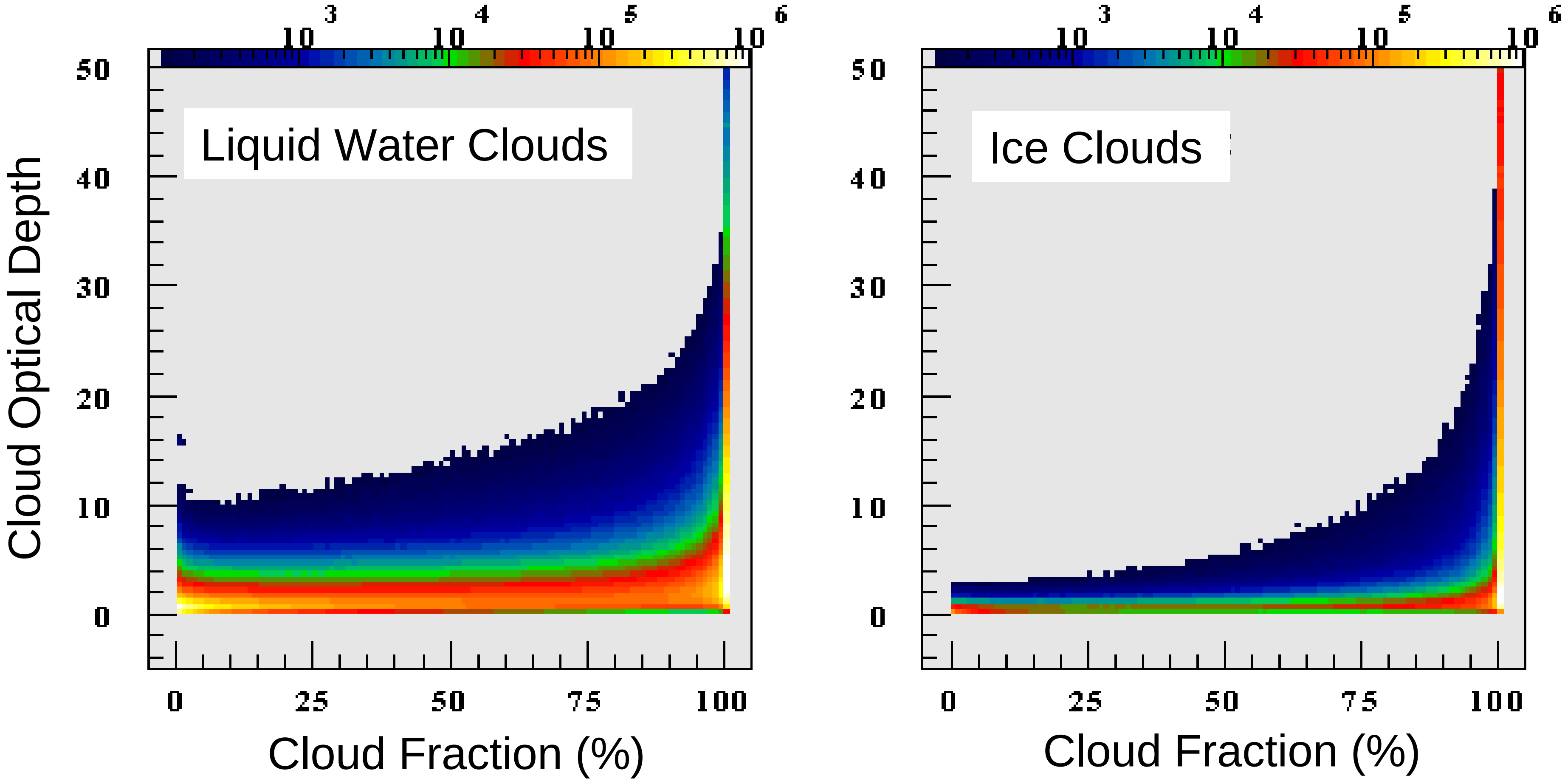
θ : 9 angular bins (0° to 90° in 10° steps)

ϕ : 10 angular bins (0° to 180° in 10° or 20° steps)

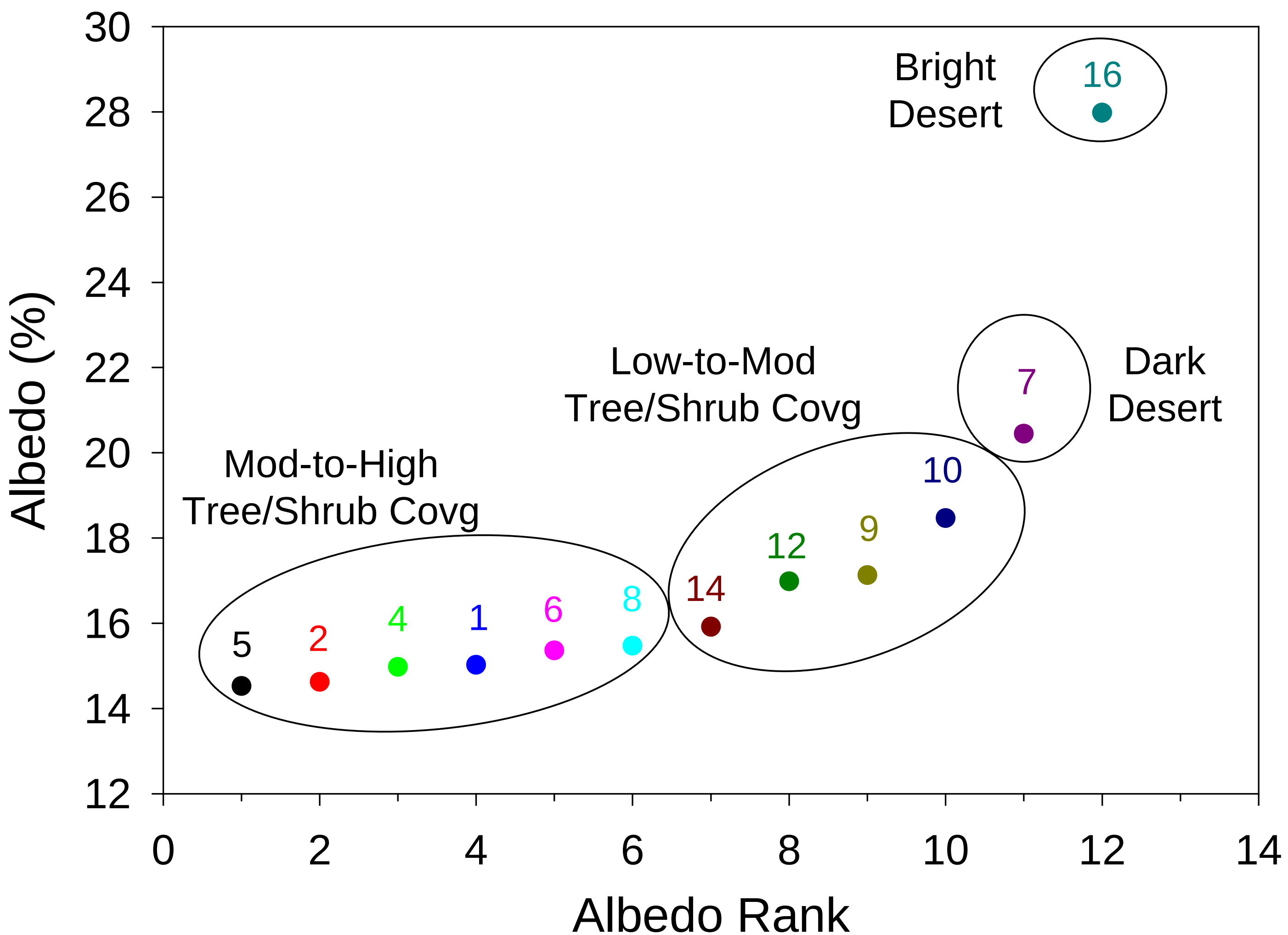
Scene Types for CERES/TRMM SW ADMs

ADM Category		Scene Type Stratification	Actual Total
Clear	Ocean	- 4 Wind Speed Intervals	4
	Land	- 2 IGBP Type Groupings	2
	Desert	- Bright and Dark	2
	Snow	- Theoretical	1
Cloud	Ocean	- Liquid and Ice - 12 Cloud Fraction Intervals - 14 Optical Depth Intervals	62 (L) 53 (I)
	Land	- 2 IGBP Type Groupings - Liquid and Ice - 5 Cloud Fraction Intervals - 6 Optical Depth Intervals	45
	Desert	- Bright and Dark Deserts - Liquid and Ice - 5 Cloud Fraction Intervals - 6 Optical Depth Intervals	33
	Snow	- Theoretical	1
Total			203

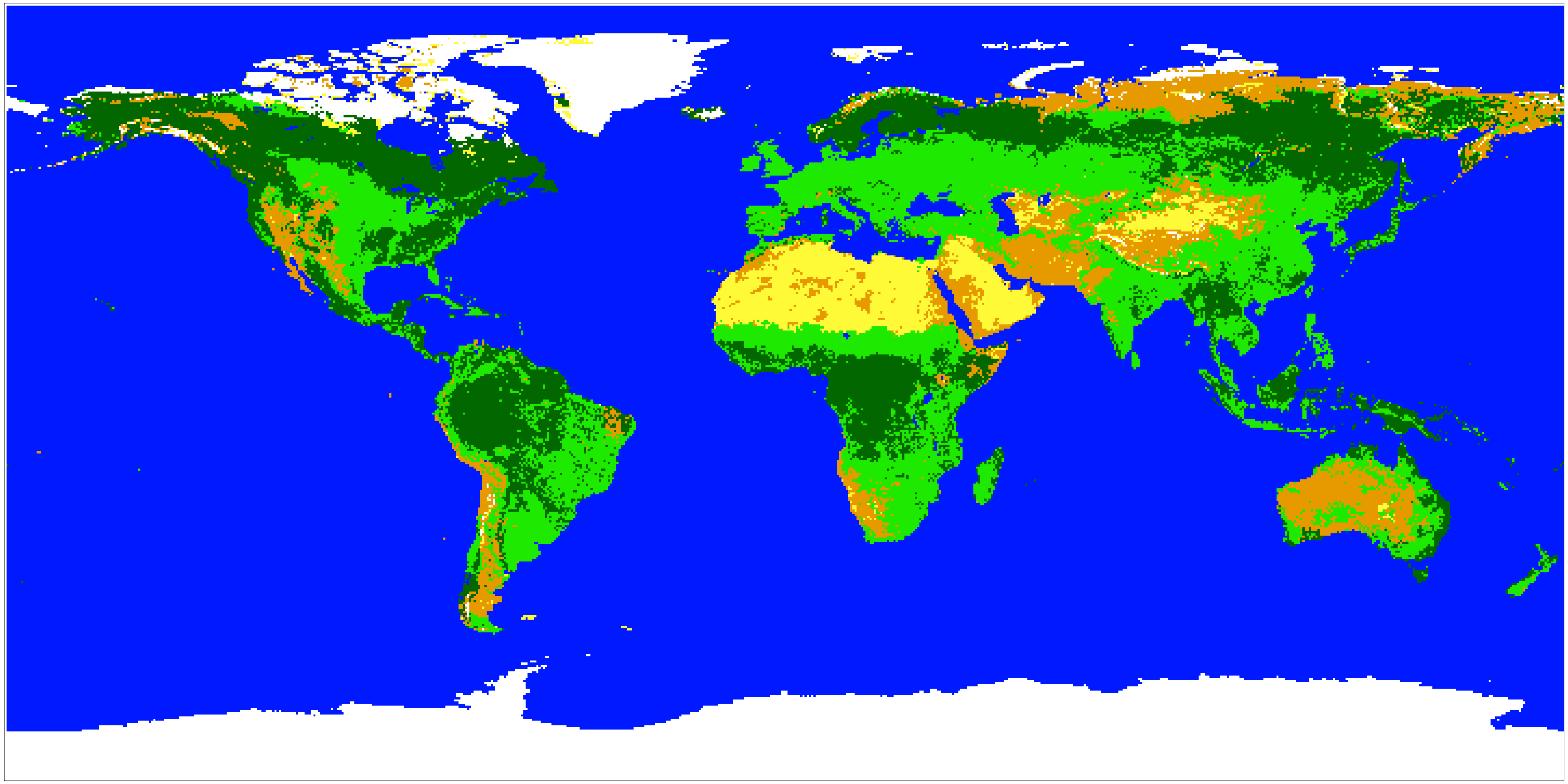
SW ADM Frequency of Occurrence by Cloud Fraction & Cloud Optical Depth (Ocean)

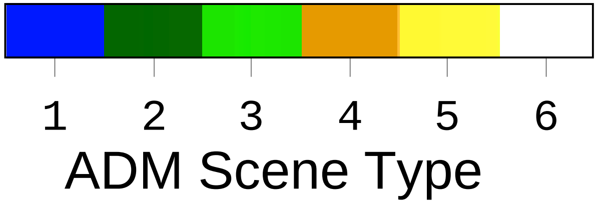


Land and Desert IGBP Type Groupings

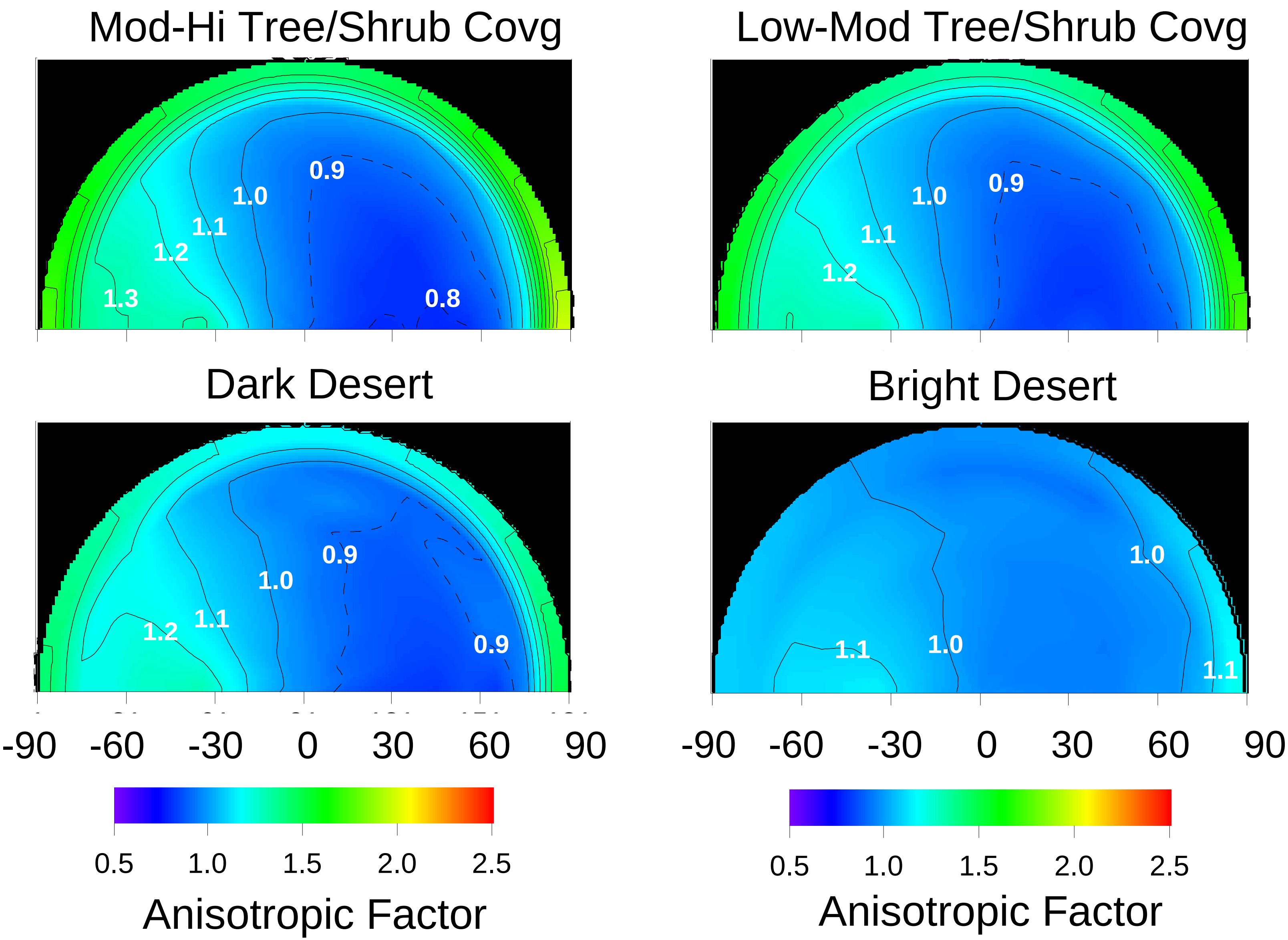


ADM Scene Surface Types

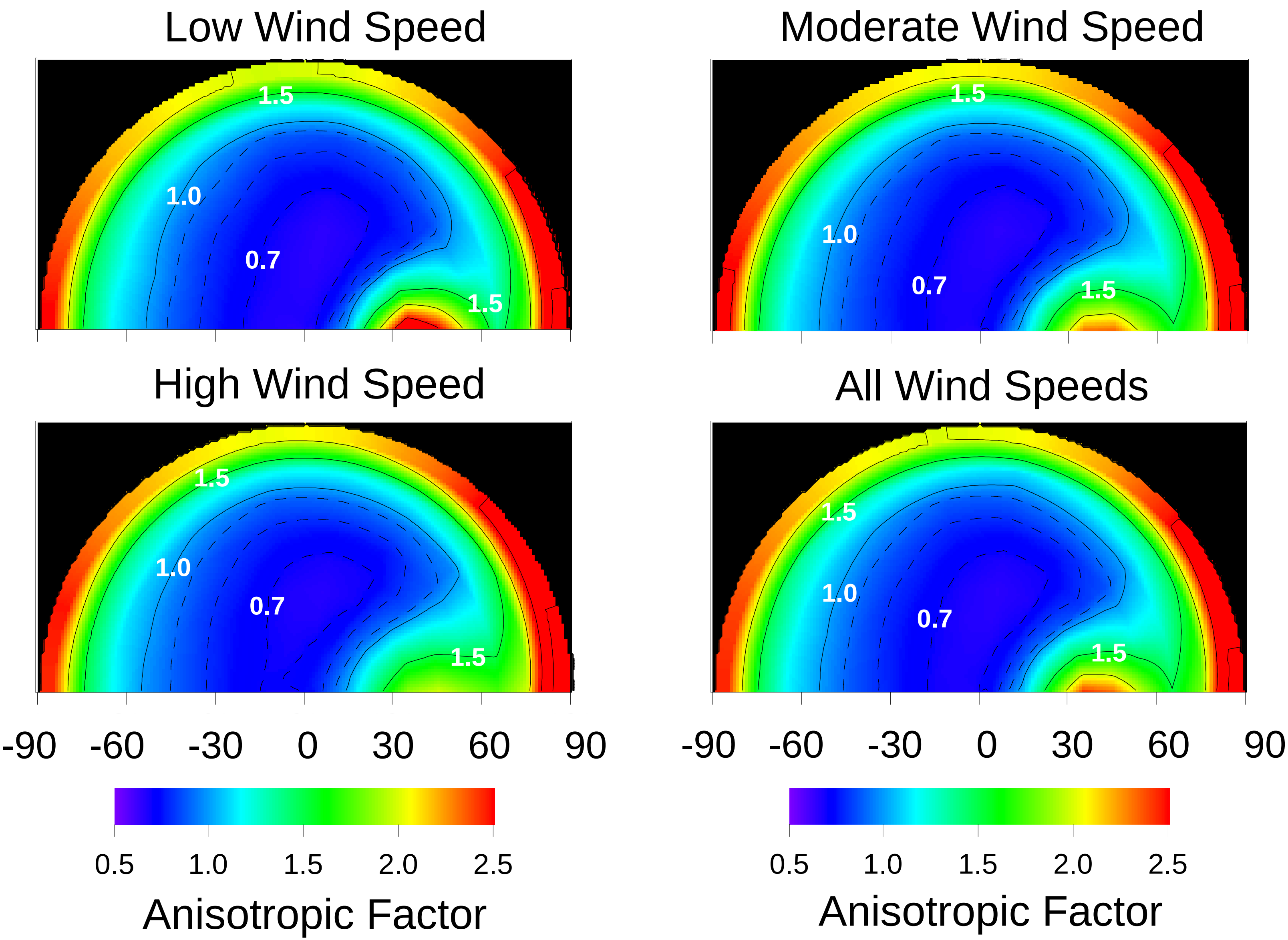




Clear Land and Desert ADMs: $\theta_o=30°-40°$



Clear Ocean ADMs: θ_o=30°-40°



Clear Ocean TOA Flux From CERES

- Define ADMs for 4 discrete wind speed intervals (m s^{-1}):
  < 3.5; 3.5 - 5.5; 5.5 - 7.5; > 7.5

- Estimate instantaneous flux/albedo using ADM:

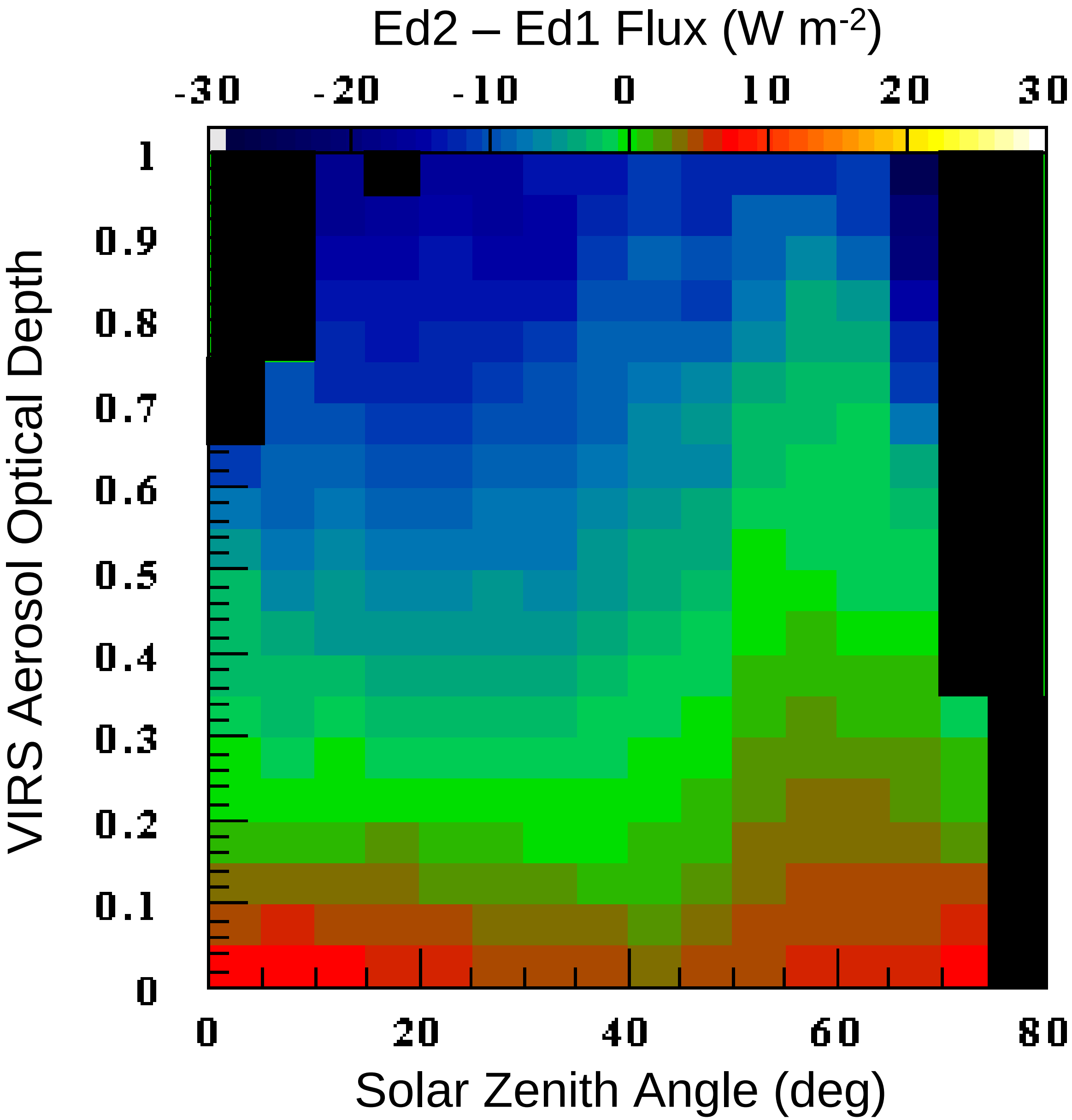
$$\hat{A} = \frac{r(\theta_o, \theta, \phi)}{R_j(w_k, \theta_o, \theta, \phi)}$$

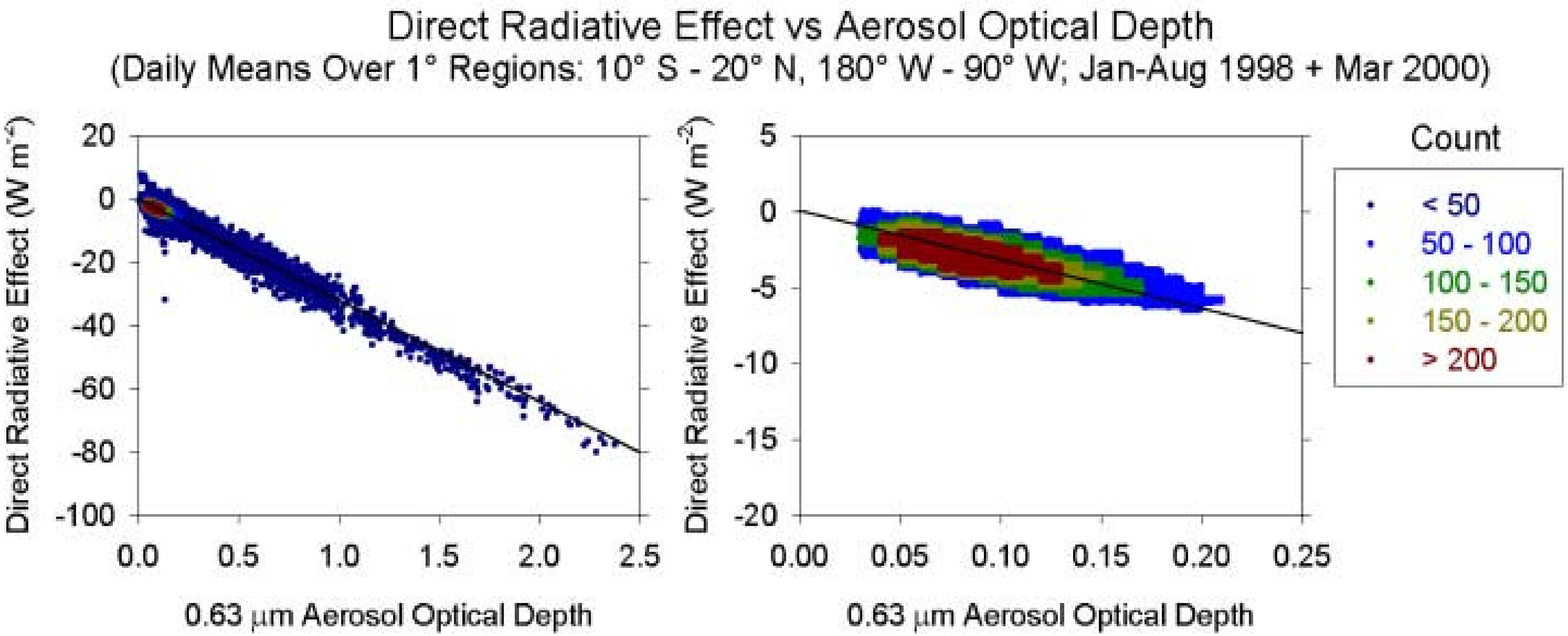
- Account for aerosol optical depth variations theoretically

$$\hat{A}' = \hat{A}\left(\frac{R^{th}(w_k, I^{avg})}{R^{th}(w_k, I^{obs})}\right)$$

where $R^{th}(w_k, I^{obs})$ is a theoretical anisotropic factor inferred from an instantaneous observation and $R^{th}(w_k, I^{avg})$ is determined from the average radiance used to construct the ADM class.

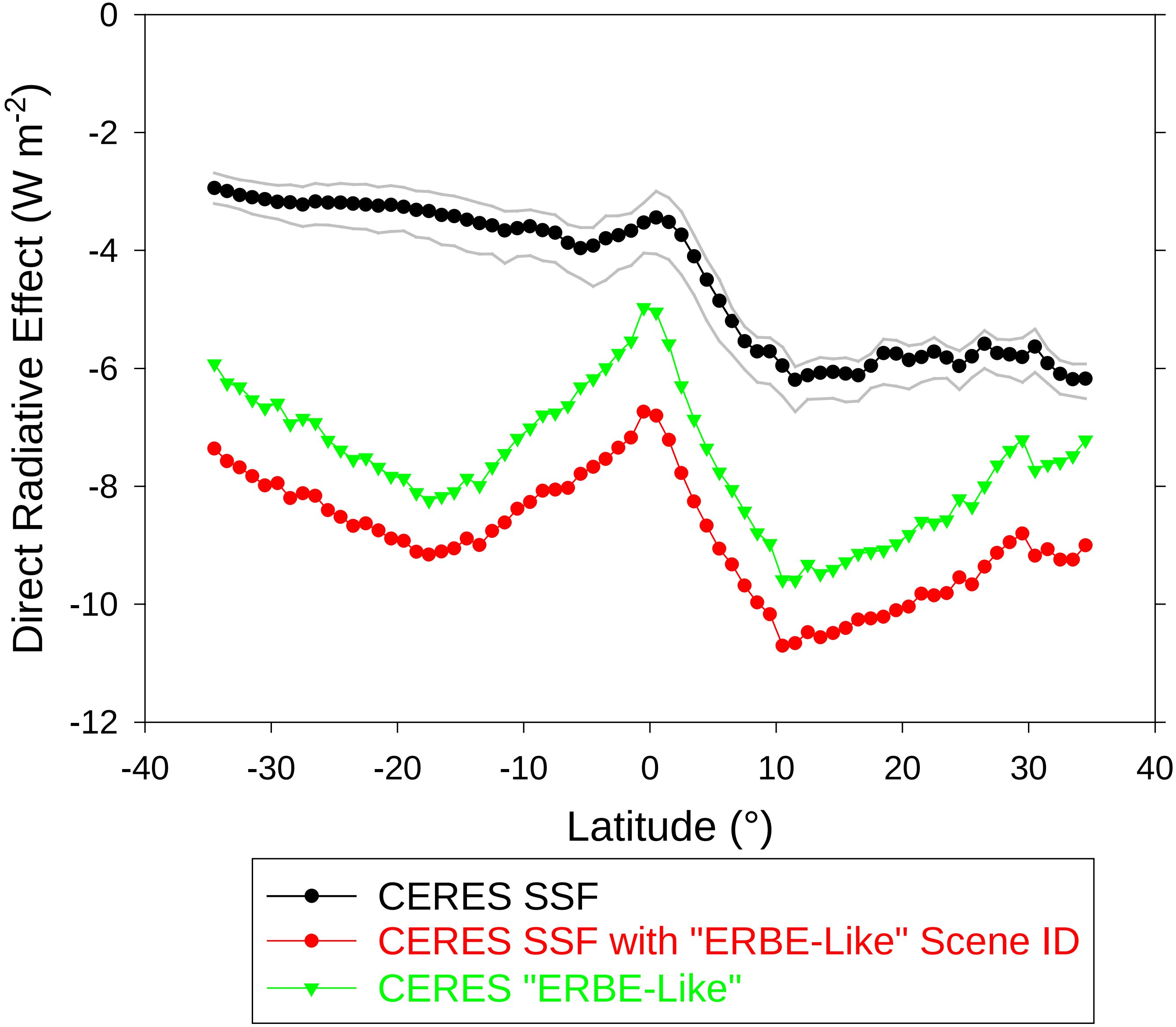
Clear Ocean Fluxes: Edition 2 vs Edition 1 Flux





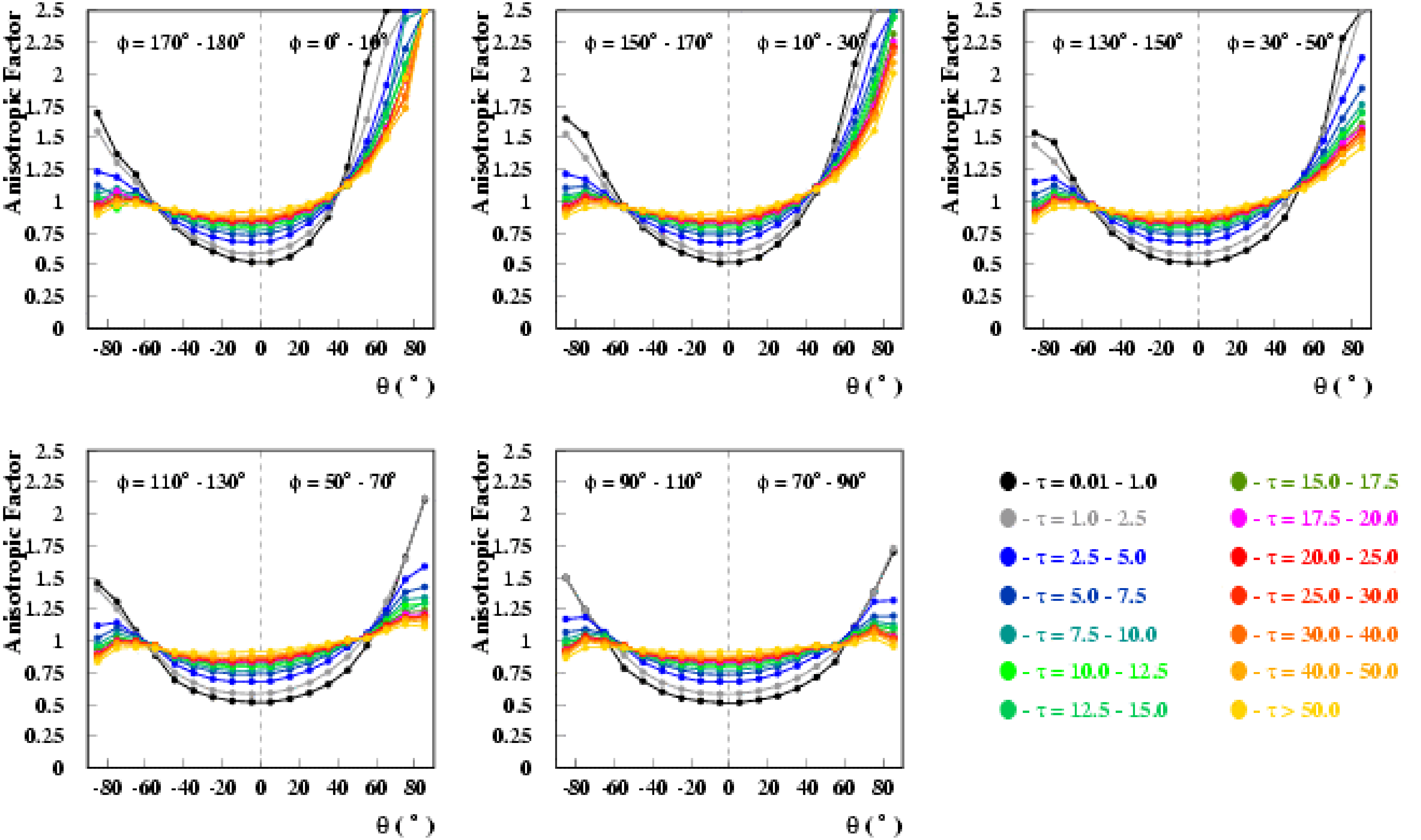
Loeb and Kato, 2001 (*J. Climate*, Submitted)

Direct Radiative Effect of Aerosols vs Latitude
(9 Months CERES/TRMM)



Loeb and Kato, 2001 (*J. Climate*, submitted)

Ocean Cloud ADMs, f = 99.9 - 100, Ice, θ_o = 60 - 70 °

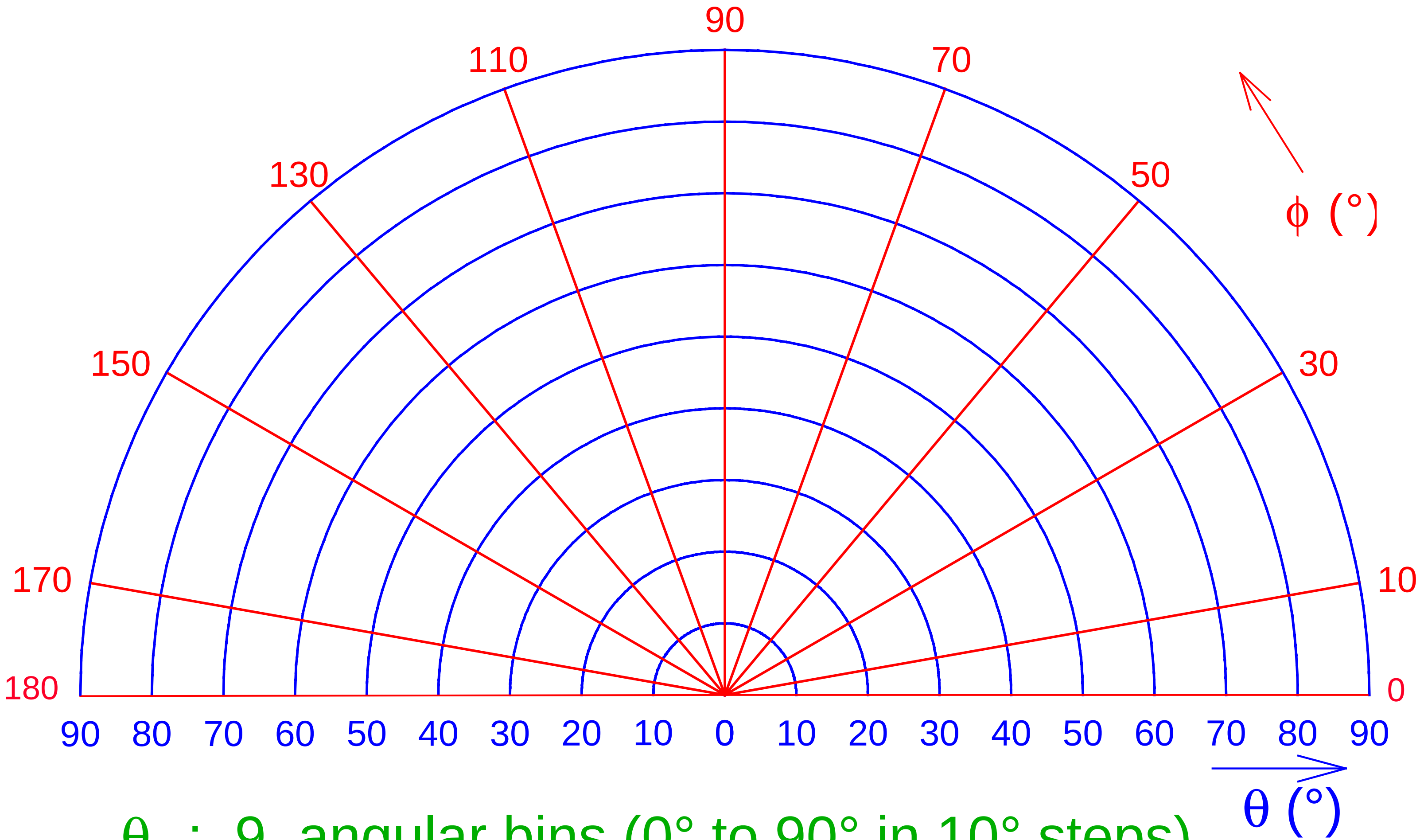


SW TOA Flux Validation

- Does mean all-sky flux depend on viewing geometry?
- Comparisons with Direct Integration Fluxes:
    - Solar zenith angle dependence (SW)
    - Latitudinal dependence
    - Regional fluxes

- Instantaneous Flux Uncertainties
    - Use alongtrack data to examine consistency of incident fluxes from the same scene

CERES SW ADM Angular Bin Definitions

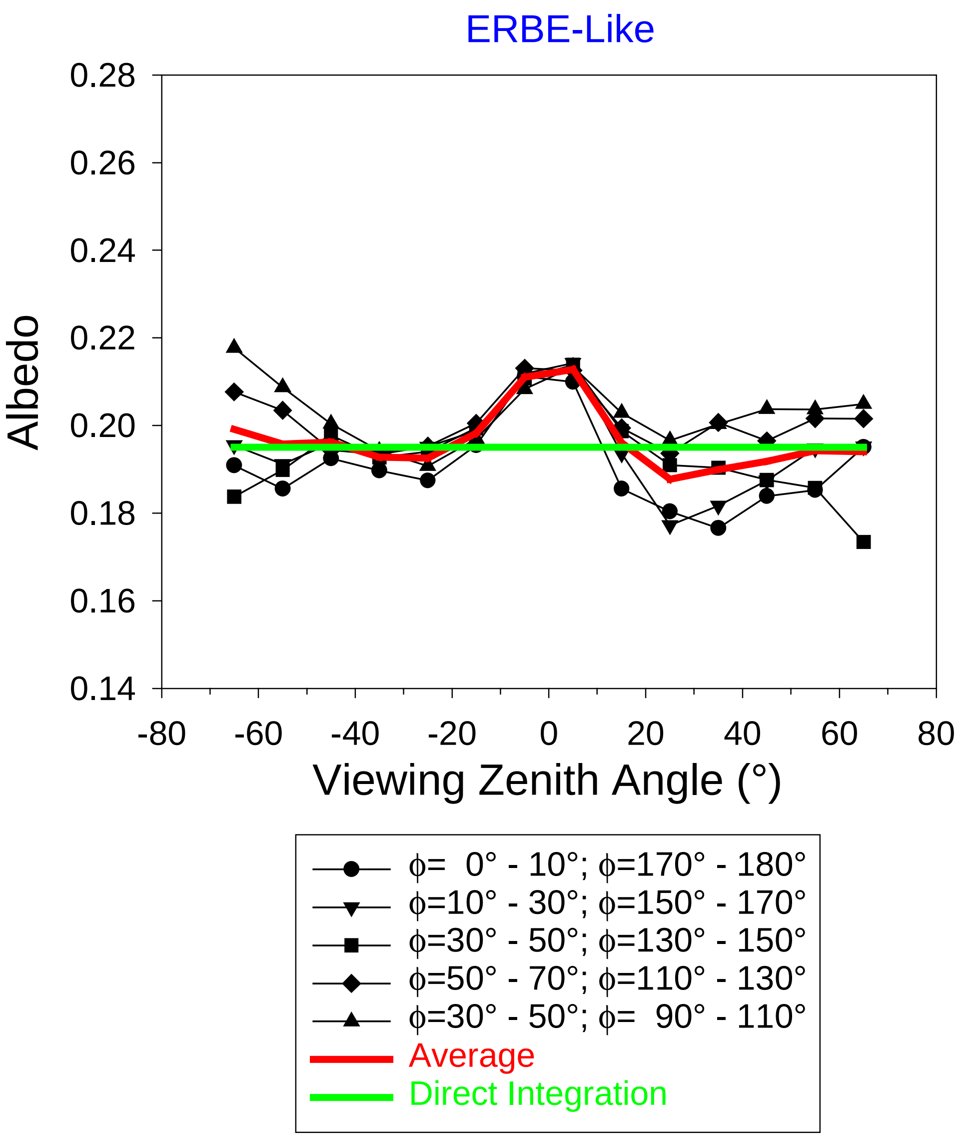


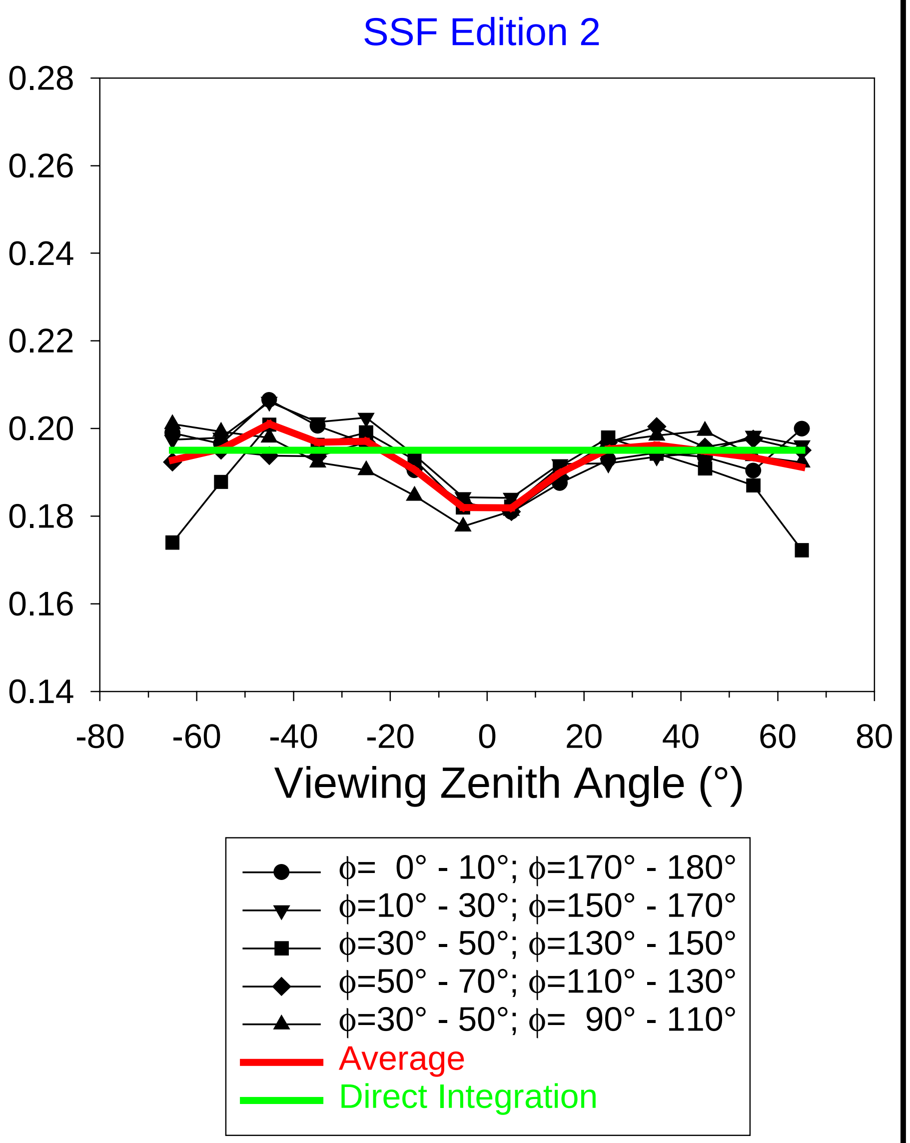
θ_o : 9 angular bins (0° to 90° in 10° steps)

θ : 9 angular bins (0° to 90° in 10° steps)

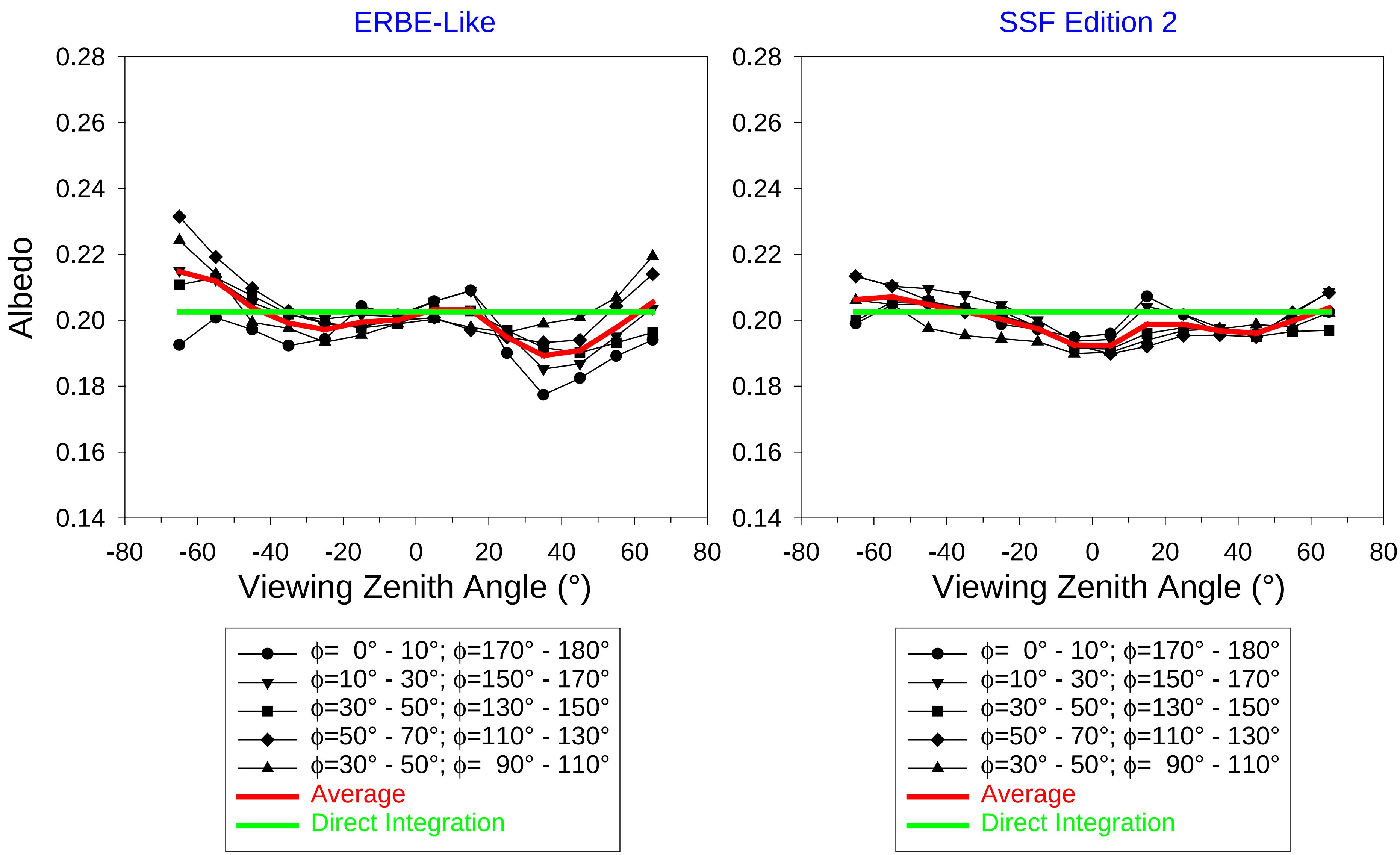
ϕ : 10 angular bins (0° to 180° in 10° or 20° steps)

All-Sky Albedo: Solar Zenith Angle = 0° - 10°

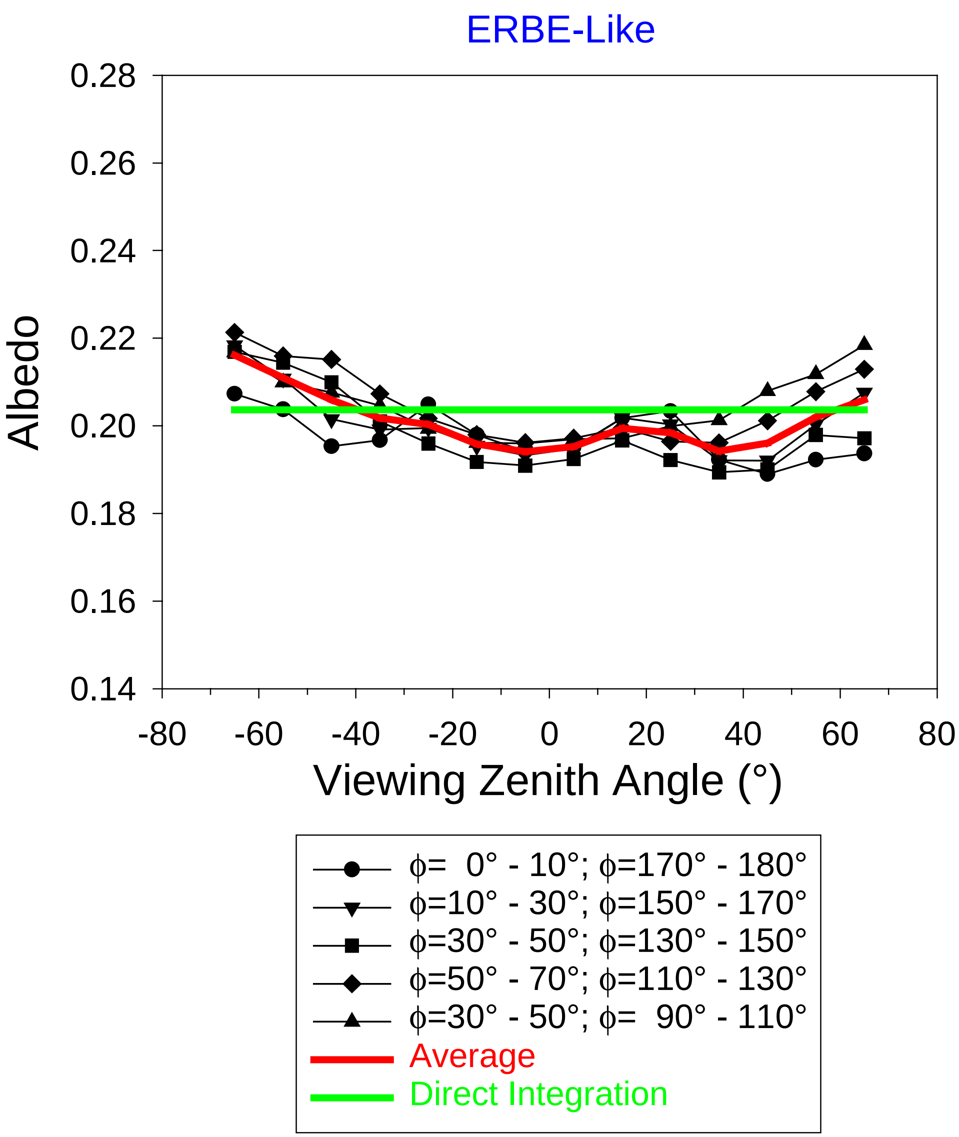


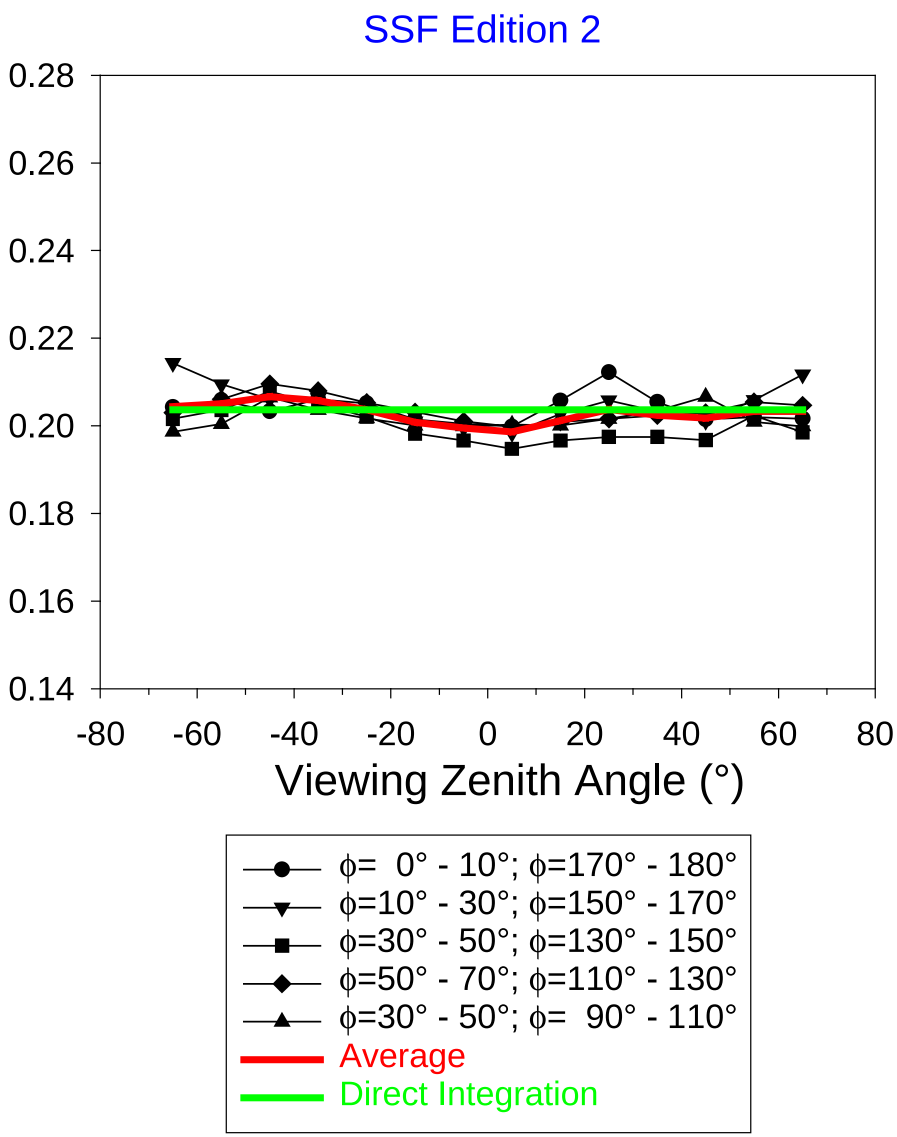


All-Sky Albedo: Solar Zenith Angle = 10° - 20°

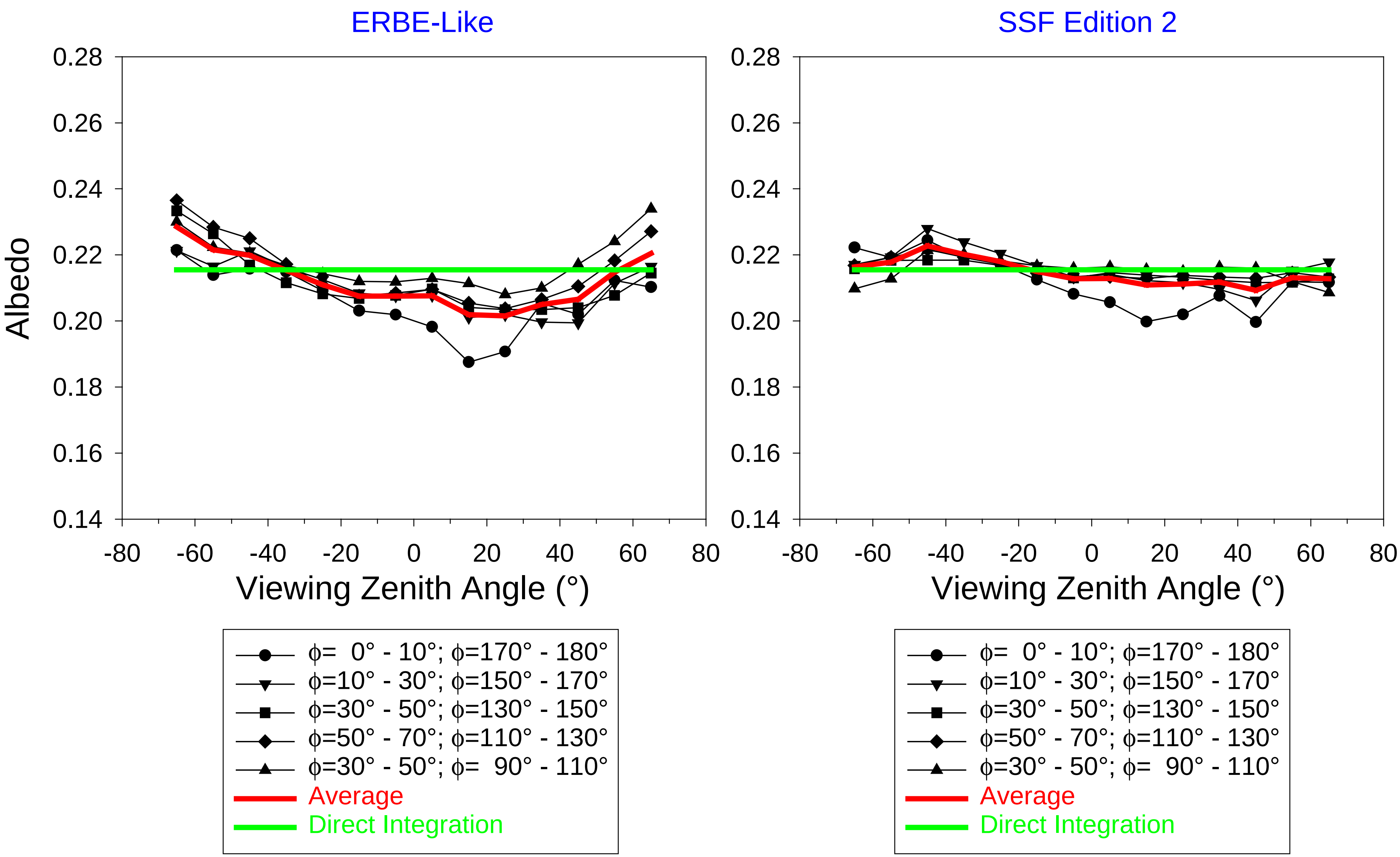


All-Sky Albedo: Solar Zenith Angle = 20° - 30°

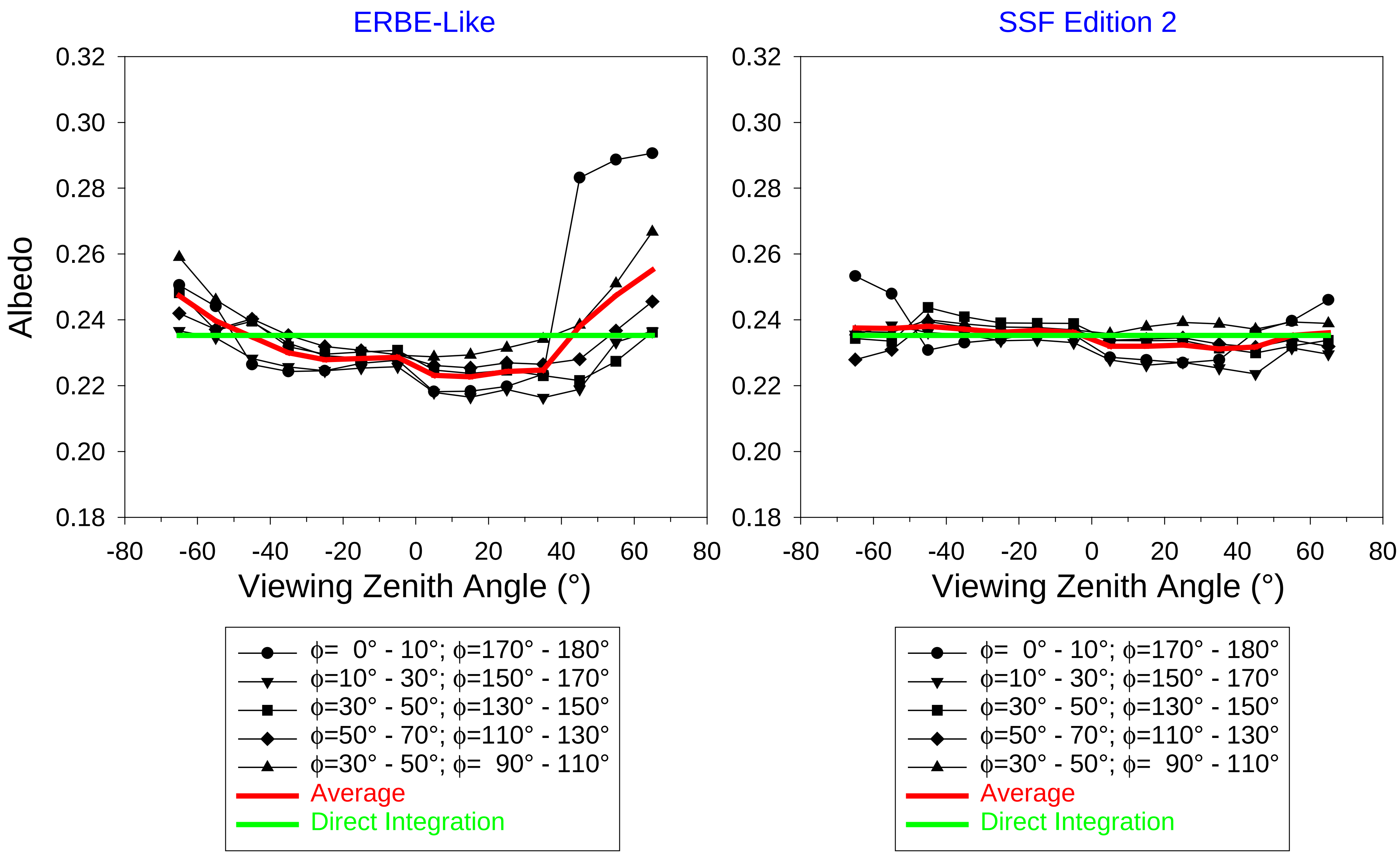




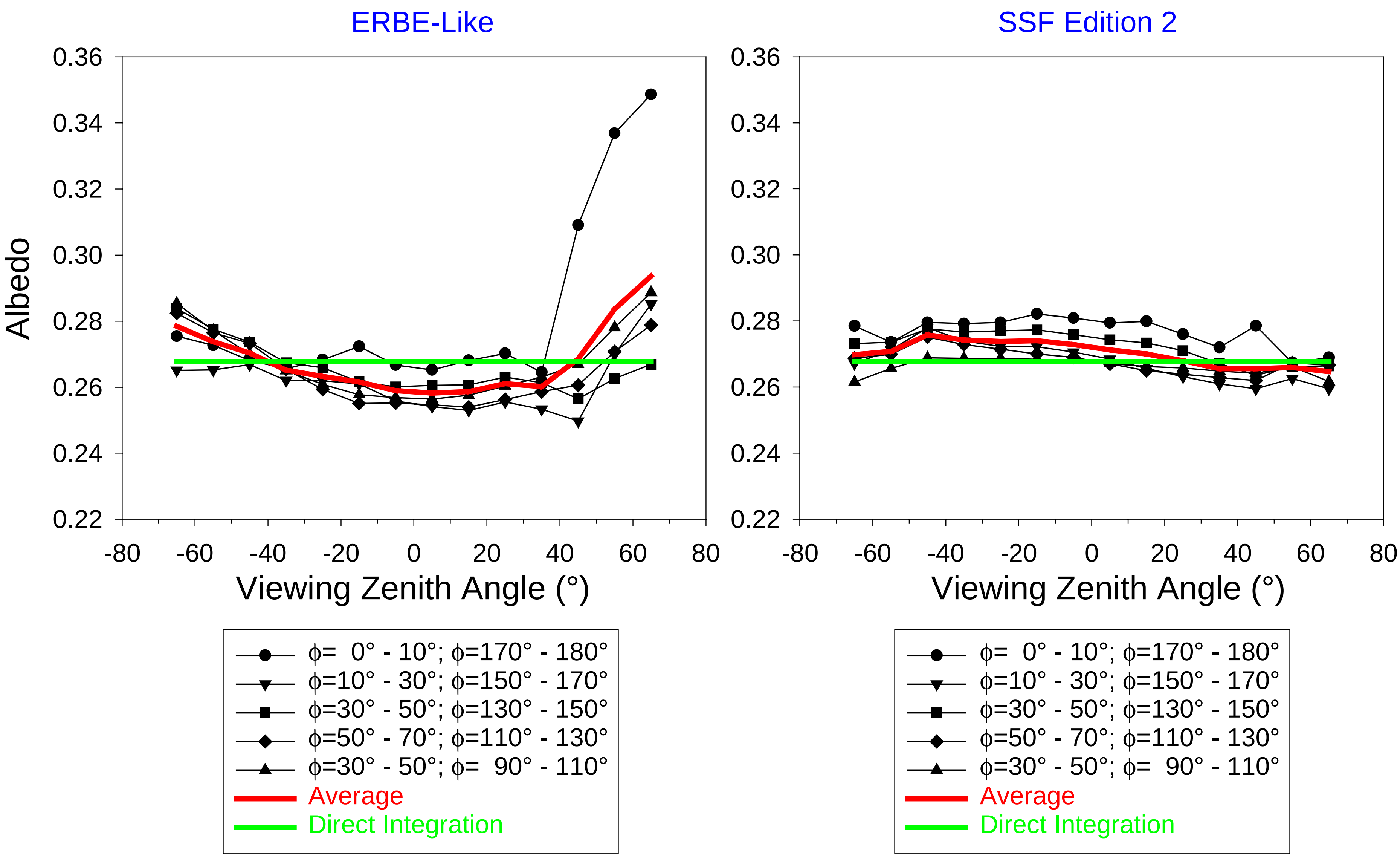
All-Sky Albedo: Solar Zenith Angle = 30° - 40°



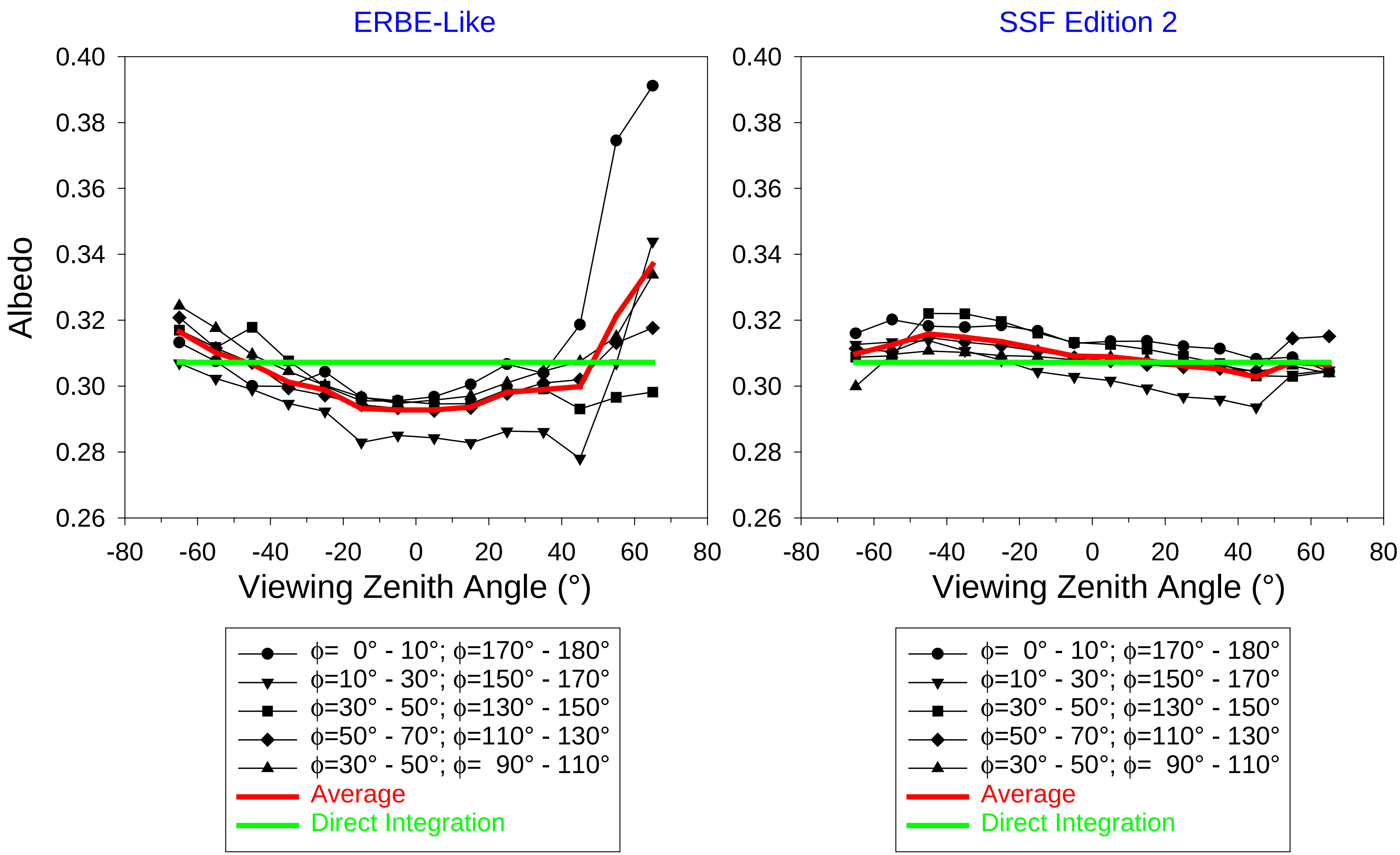
All-Sky Albedo: Solar Zenith Angle = 40° - 50°



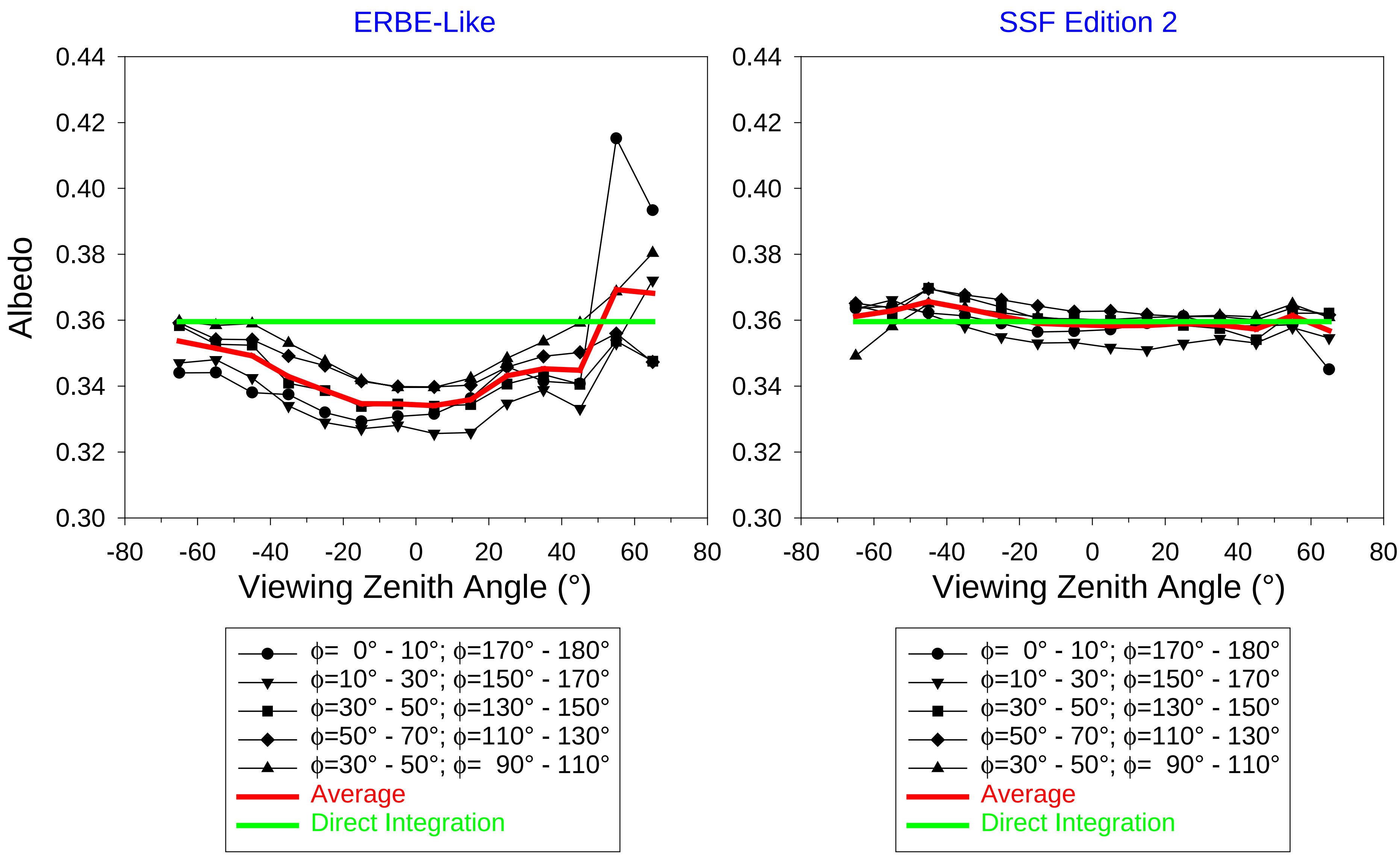
All-Sky Albedo: Solar Zenith Angle = 50° - 60°



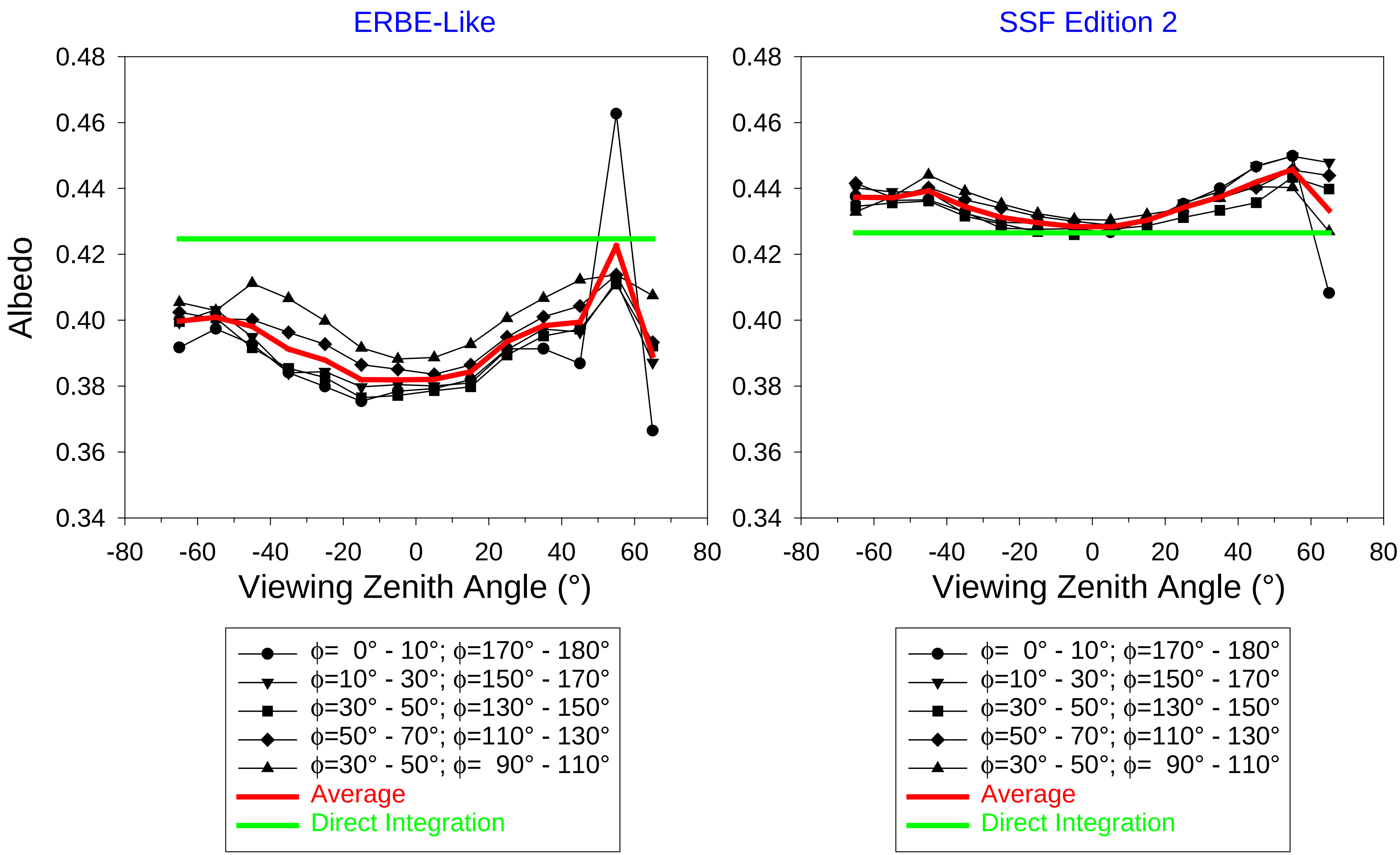
All-Sky Albedo: Solar Zenith Angle = 60° - 70°



All-Sky Albedo: Solar Zenith Angle = 70° - 80°



All-Sky Albedo: Solar Zenith Angle = 80° - 90°



Flux Bias Definitions

- ADM mean flux bias in angular bin $(\theta_o, \theta_j, \phi_k)$:

$$\Delta(\theta_o,\theta_j,\phi_k) = \overline{F}_{ADM}(\theta_o,\theta_j,\phi_k) - F_{DI}(\theta_o)$$

- Footprint-weighted ADM mean flux bias:

$$\Delta_\Omega(\theta_o) = \frac{1}{n_k}\frac{1}{n_j}\sum_{k=1}^{n_k}\sum_{j=1}^{n_j}\Delta(\theta_o,\theta_j,\phi_k)w_j$$

where w_j is a weighting factor accounting for the relative effect of different viewing zenith angles on gridded time-averaged fluxes.

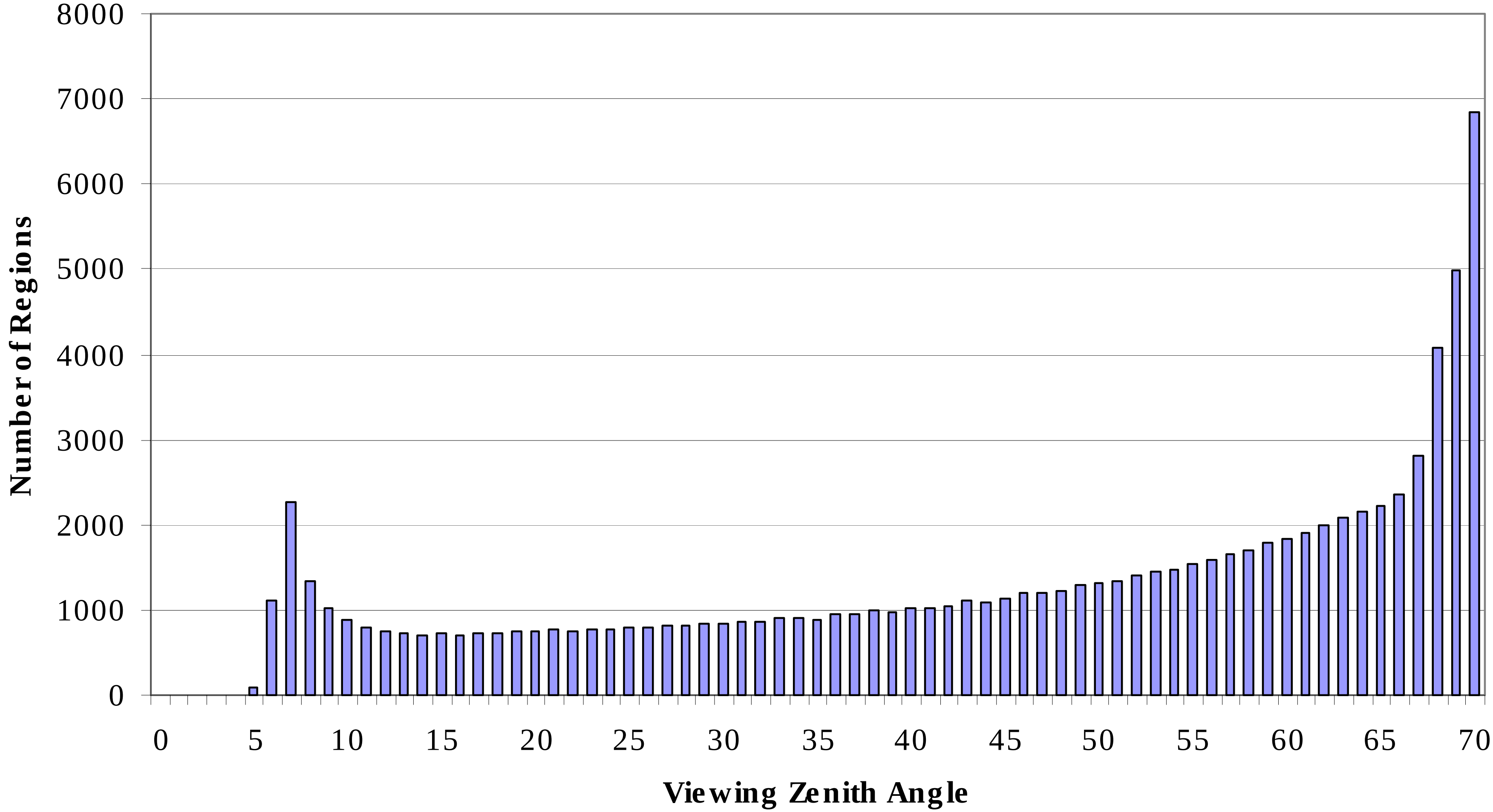
n_k and n_j are the number of relative azimuth and viewing zenith angle bins.

- Standard deviation in footprint-weighted ADM flux bias:

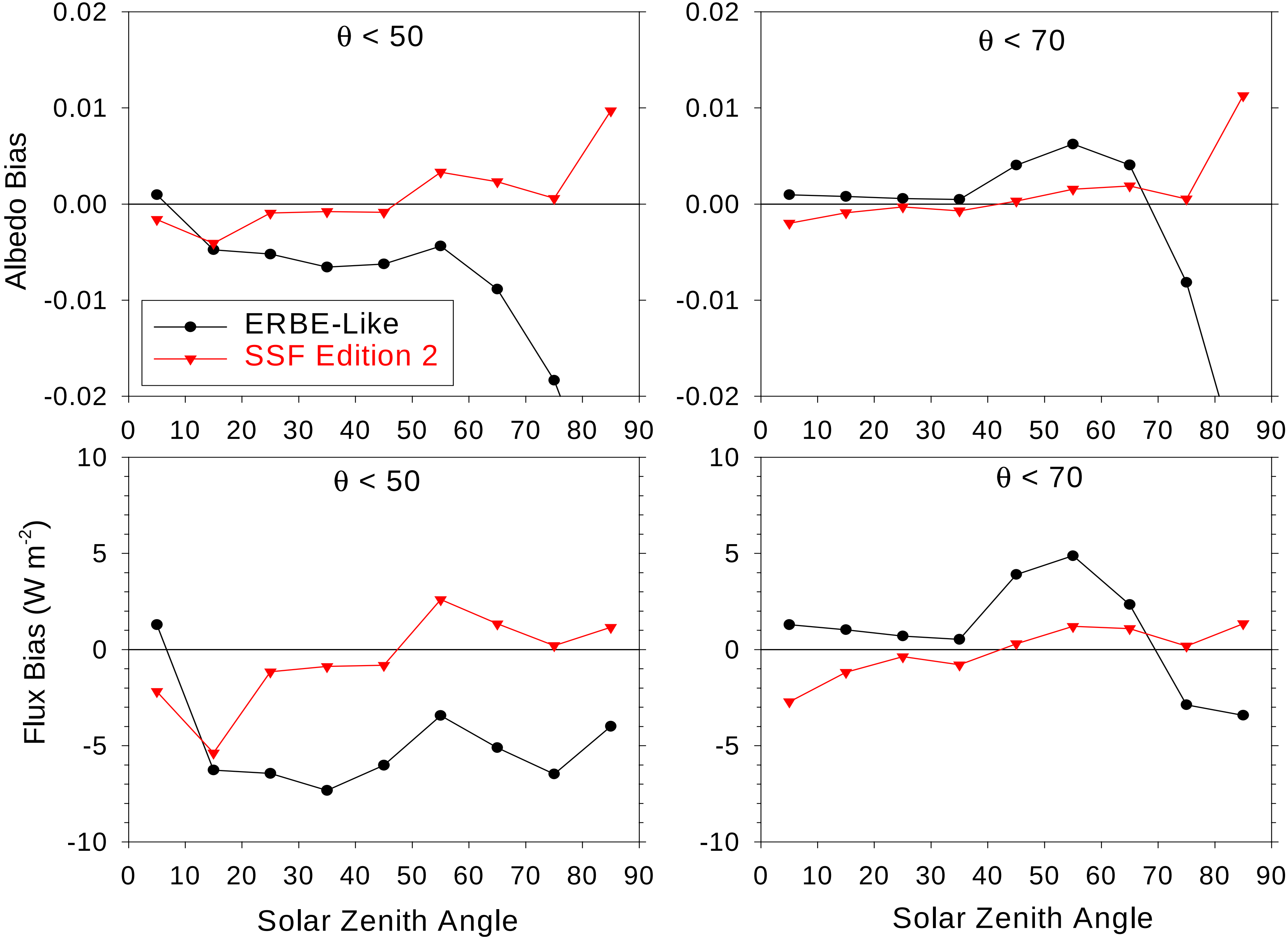
$$\sigma_\Omega(\theta_o) = \sum_{k=1}^{n_k}\sum_{j=1}^{n_j}\frac{[\Delta(\theta_o,\theta_j,\phi_k) - \overline{\Delta}(\theta_o)]^2}{(n_k n_j - 1)} w_j$$

$\Rightarrow$ measure of consistency in ADM mean flux estimate from individual viewing directions.

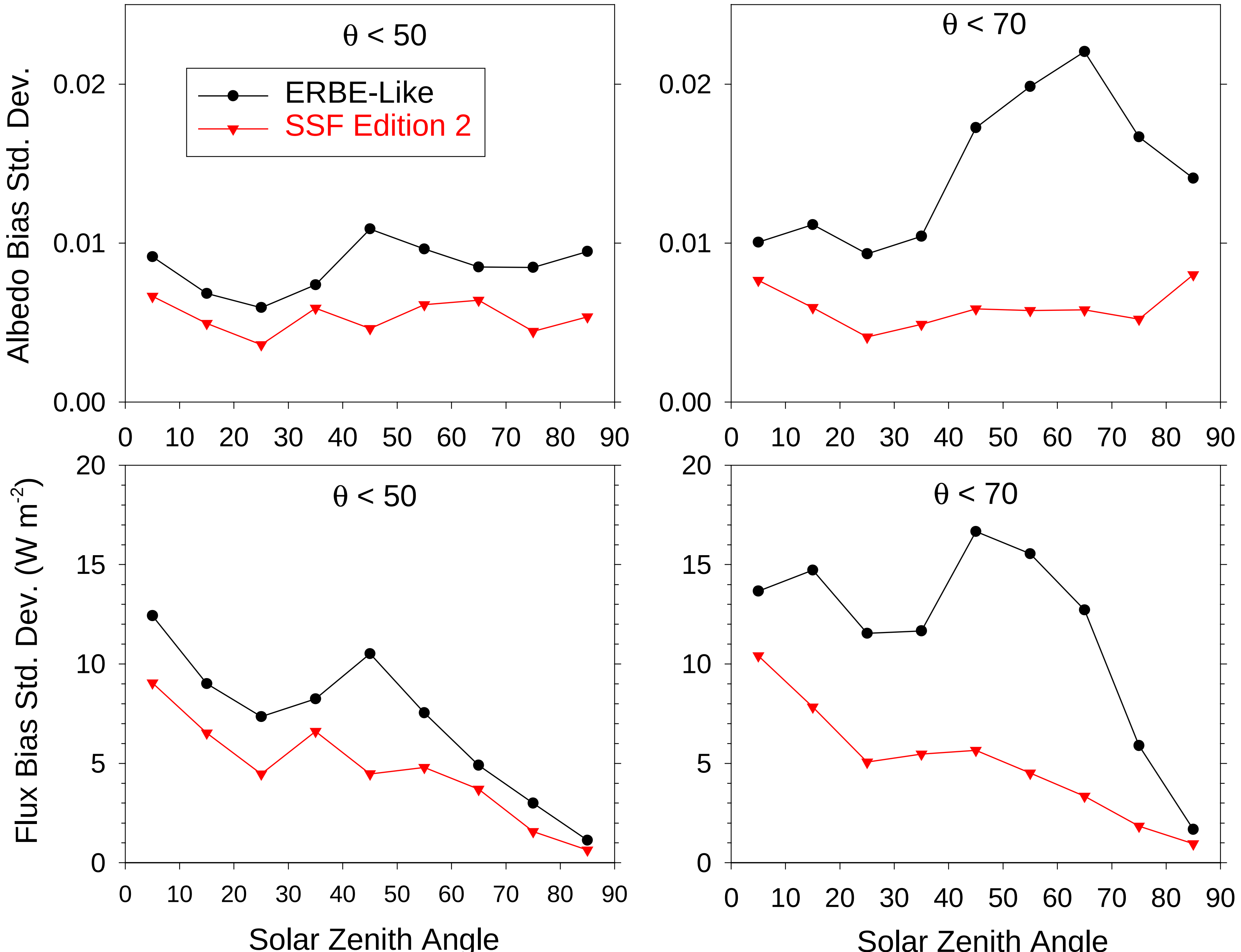
Crosstrack Incidence of Regional Mean VZAs
One Month of CERES Data



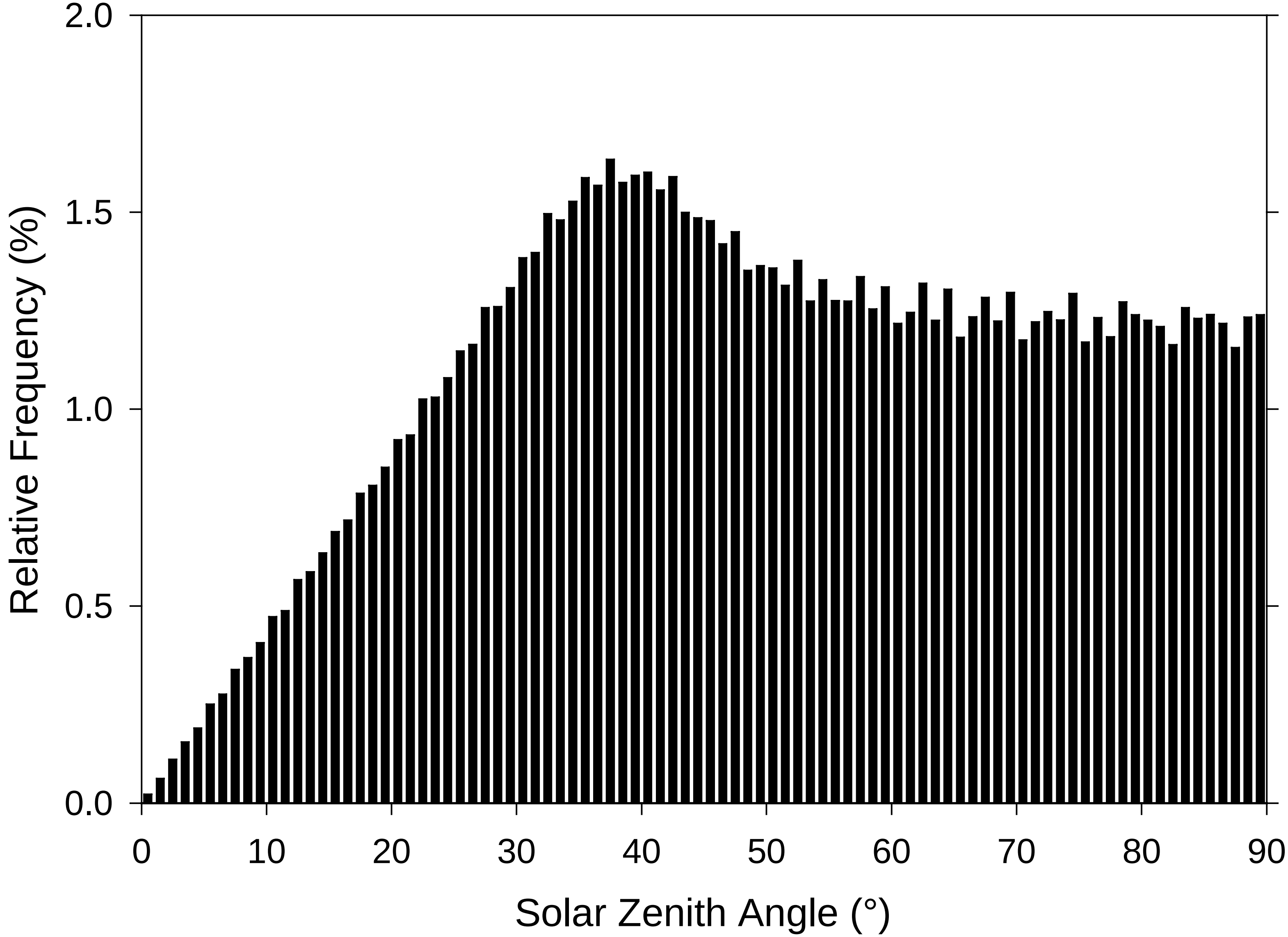
Footprint-Weighted All-Sky Mean Albedo and Flux Bias vs θ_o



Std. Dev. in Footprint-Wtd All-Sky Albedo and Flux Bias vs θ_o



Solar Zenith Angle Relative Frequency
(40°S - 40°N; March 1998)

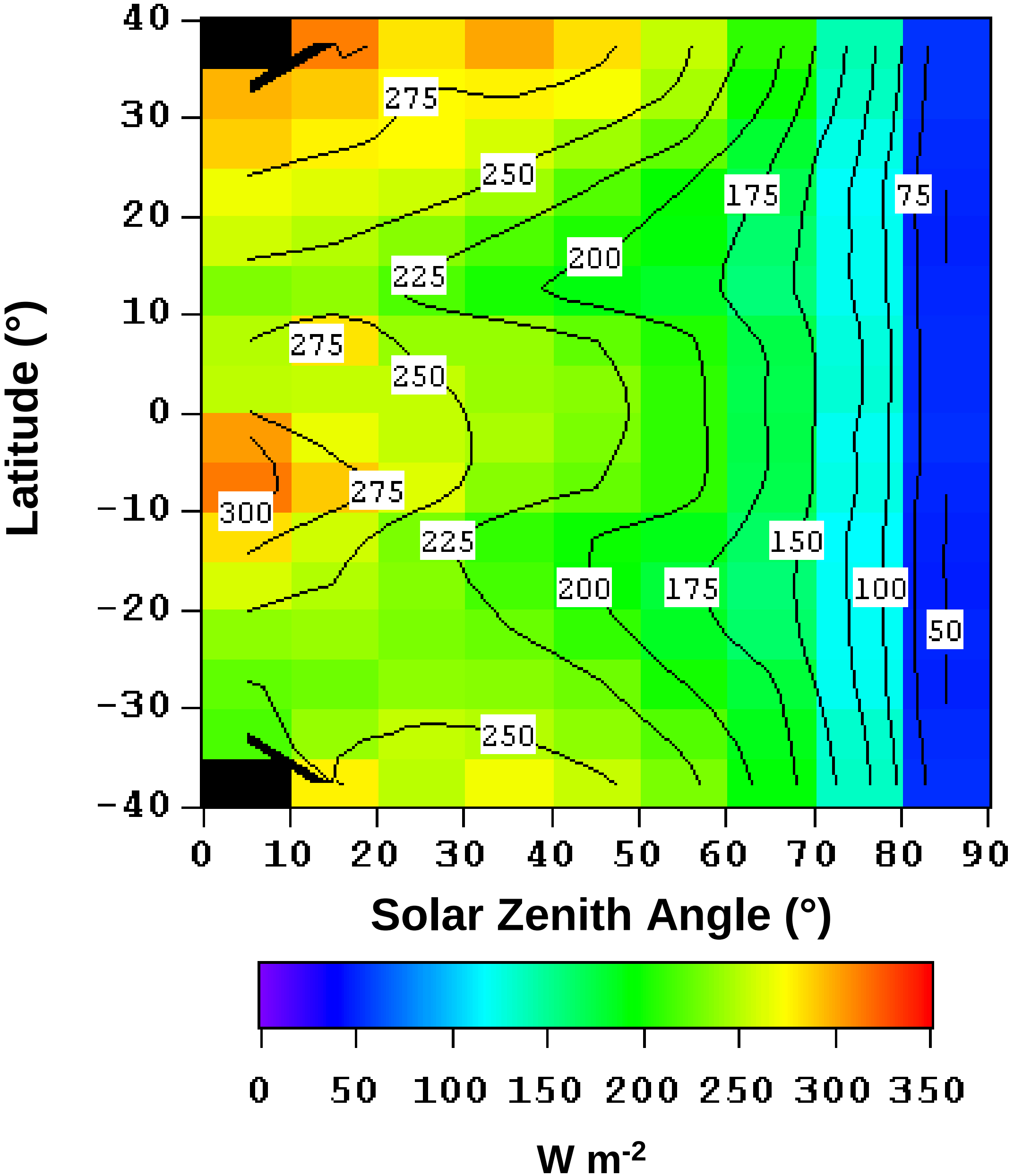


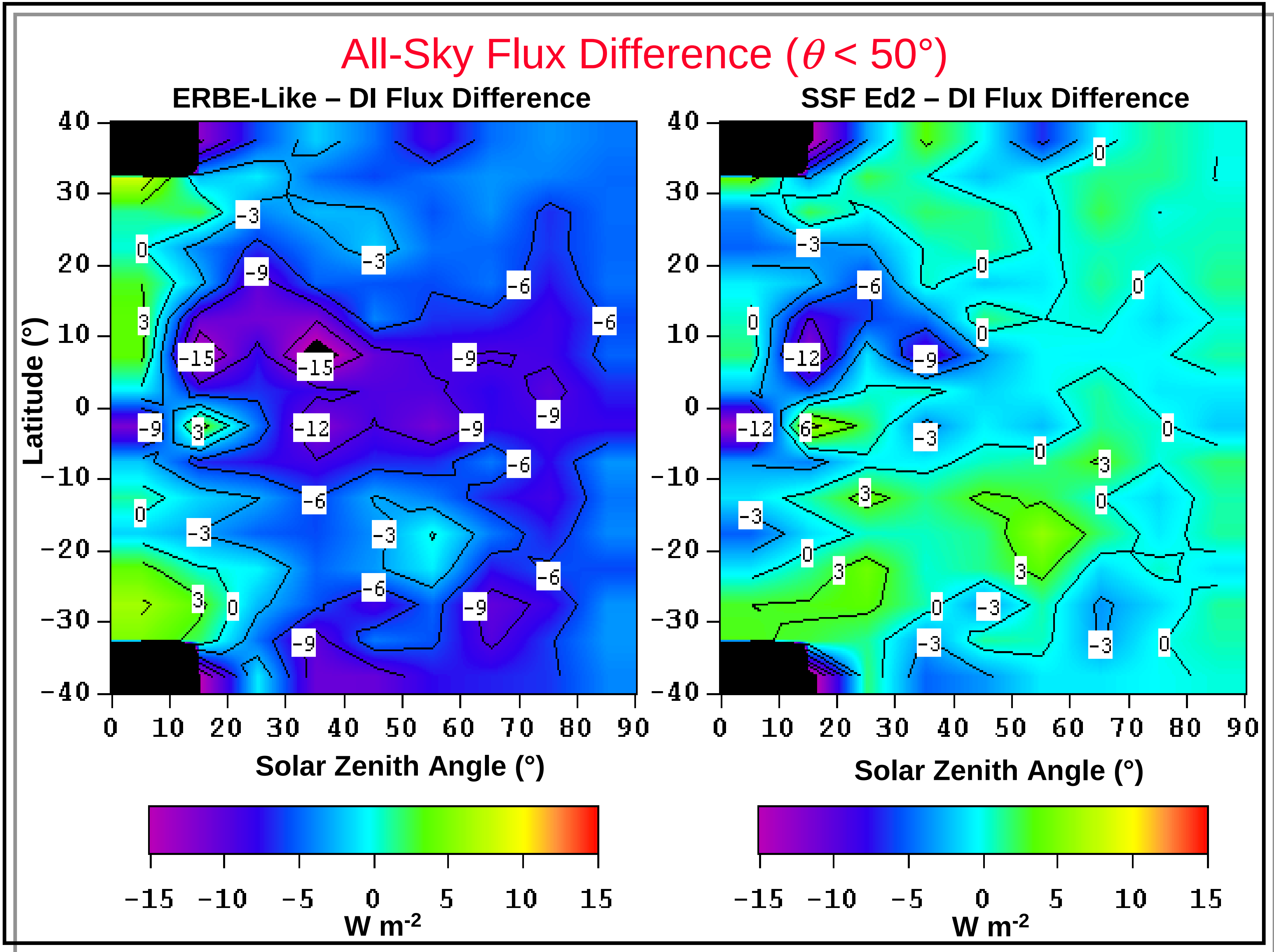
Tropical ADM Mean Flux Bias

(Footprint-Weighted; March 1998 Solar Zenith Angle Sampling)

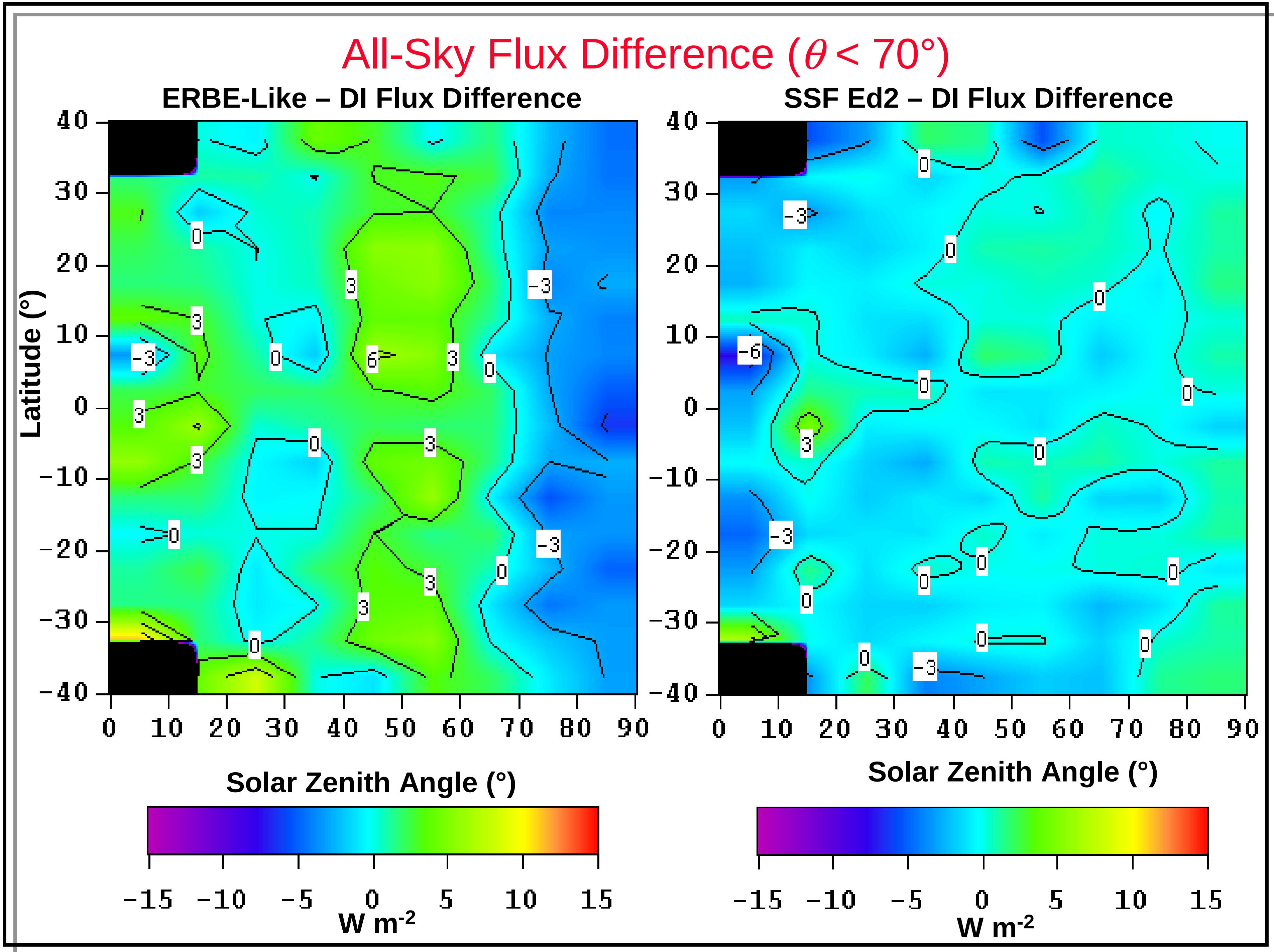
($W\ m^{-2}$)	ERBE-Like		SSF Edition 2	
θ-Range	Mean (Δ_Ω)	Std (σ_Ω)	Mean (Δ_Ω)	Std (σ_Ω)
$\theta < 50°$	-2.7	3.3	-0.05	2.1
$\theta < 70°$	0.50	5.6	0.11	2.2

All-Sky Direct Integration Flux by Latitude & Solar Zenith Angle



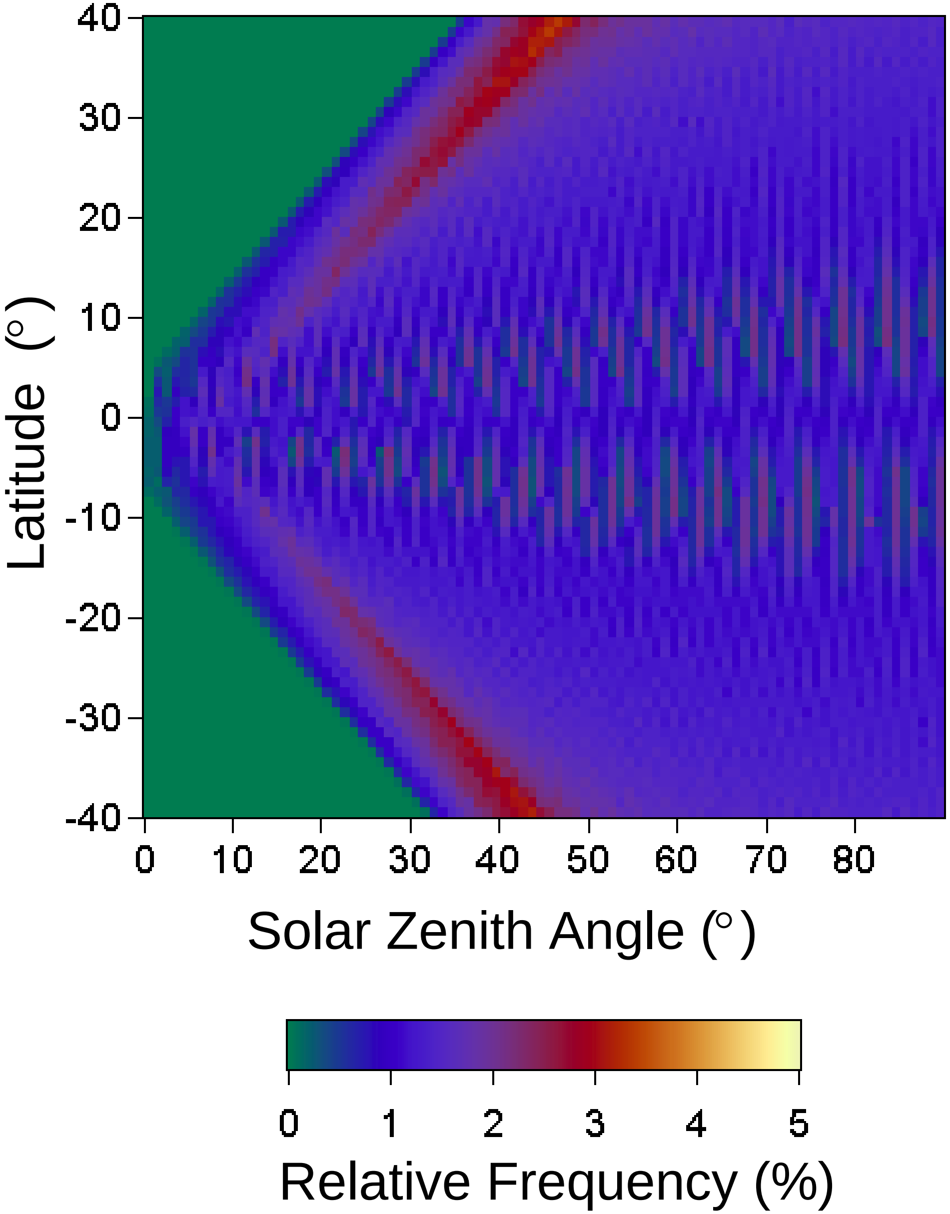


All-Sky Flux Difference (θ < 50°)
ERBE-Like – DI Flux Difference
SSF Ed2 – DI Flux Difference
Latitude (°)
Solar Zenith Angle (°)
Solar Zenith Angle (°)
W m-2
W m-2



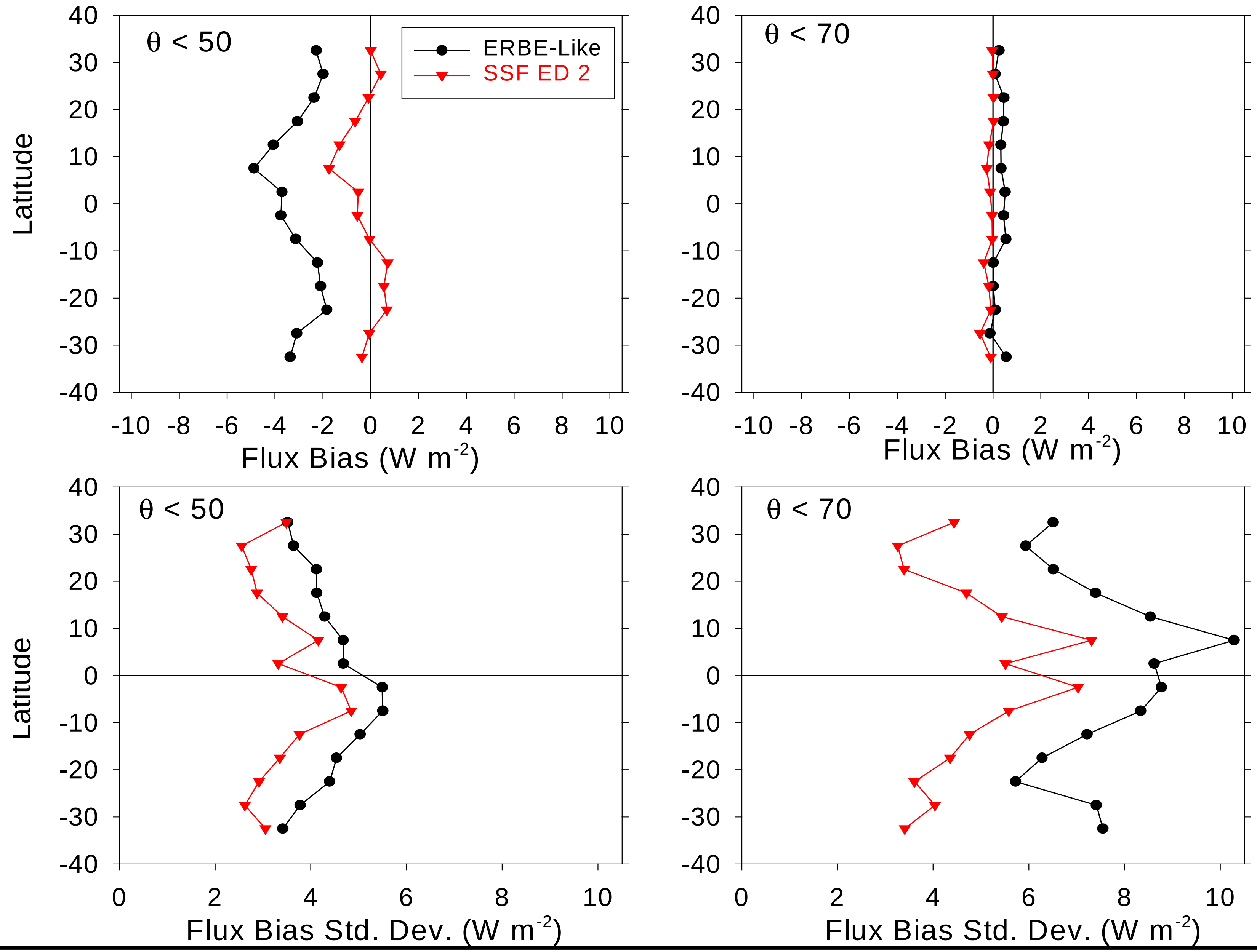
All-Sky Flux Difference (θ < 70°)
ERBE-Like – DI Flux Difference
SSF Ed2 – DI Flux Difference
Latitude (°)
Solar Zenith Angle (°)
Solar Zenith Angle (°)
W m^{-2}
W m^{-2}

Solar Zenith Angle Distribution by Latitude (March 1998)



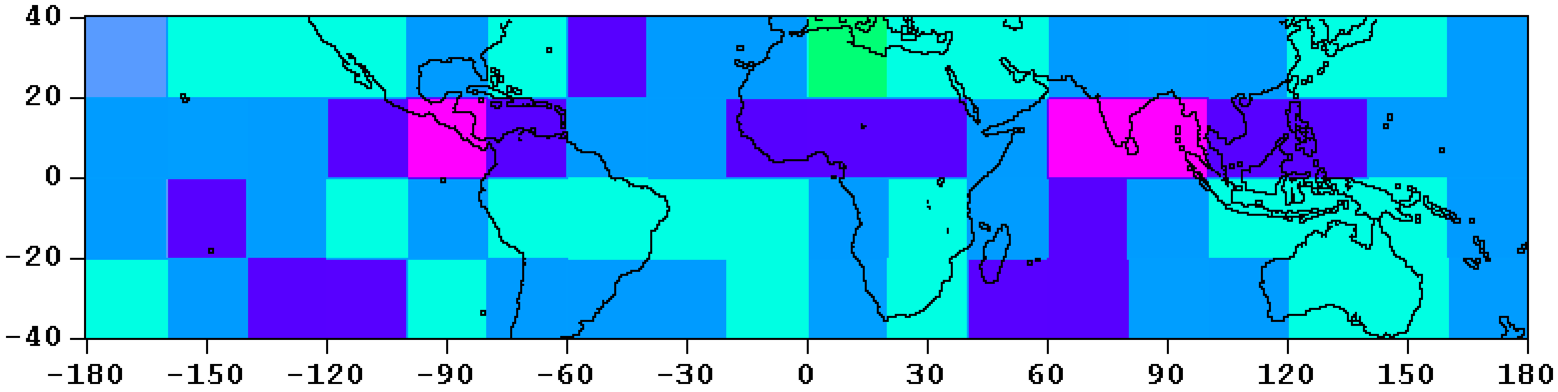
Latitudinal ADM Mean Flux Bias

(March 1998 Solar Zenith Angle Sampling)

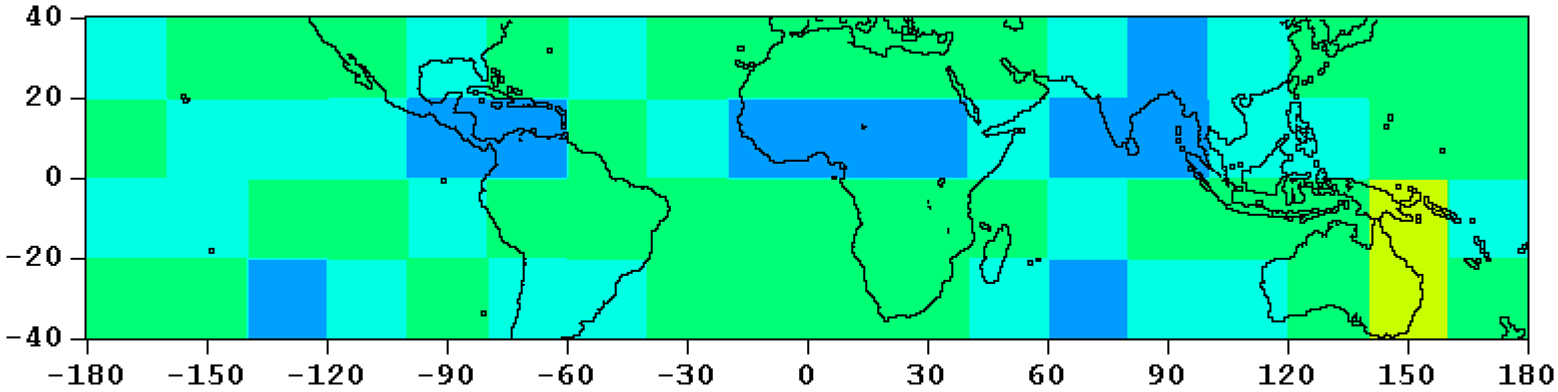


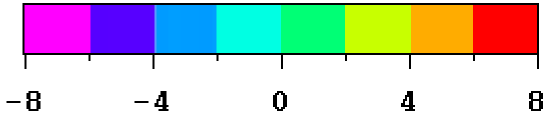
ADM Mean Regional Flux Biases ($\theta < 50°$)

ERBE-Like – DI Flux Difference



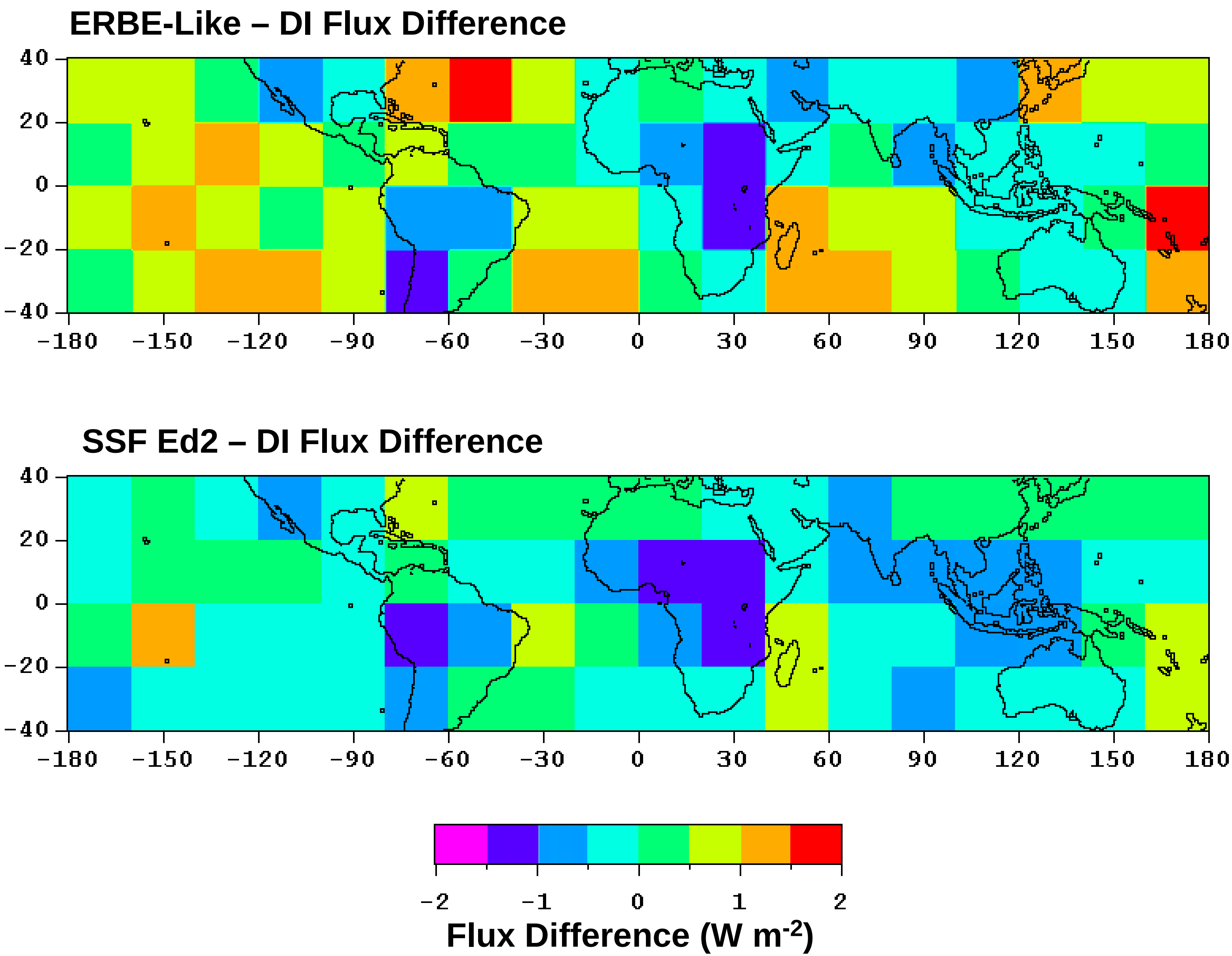
SSF Ed2 – DI Flux Difference





Flux Difference (W m^{-2})

ADM Mean Regional Flux Biases ($\theta < 70°$)



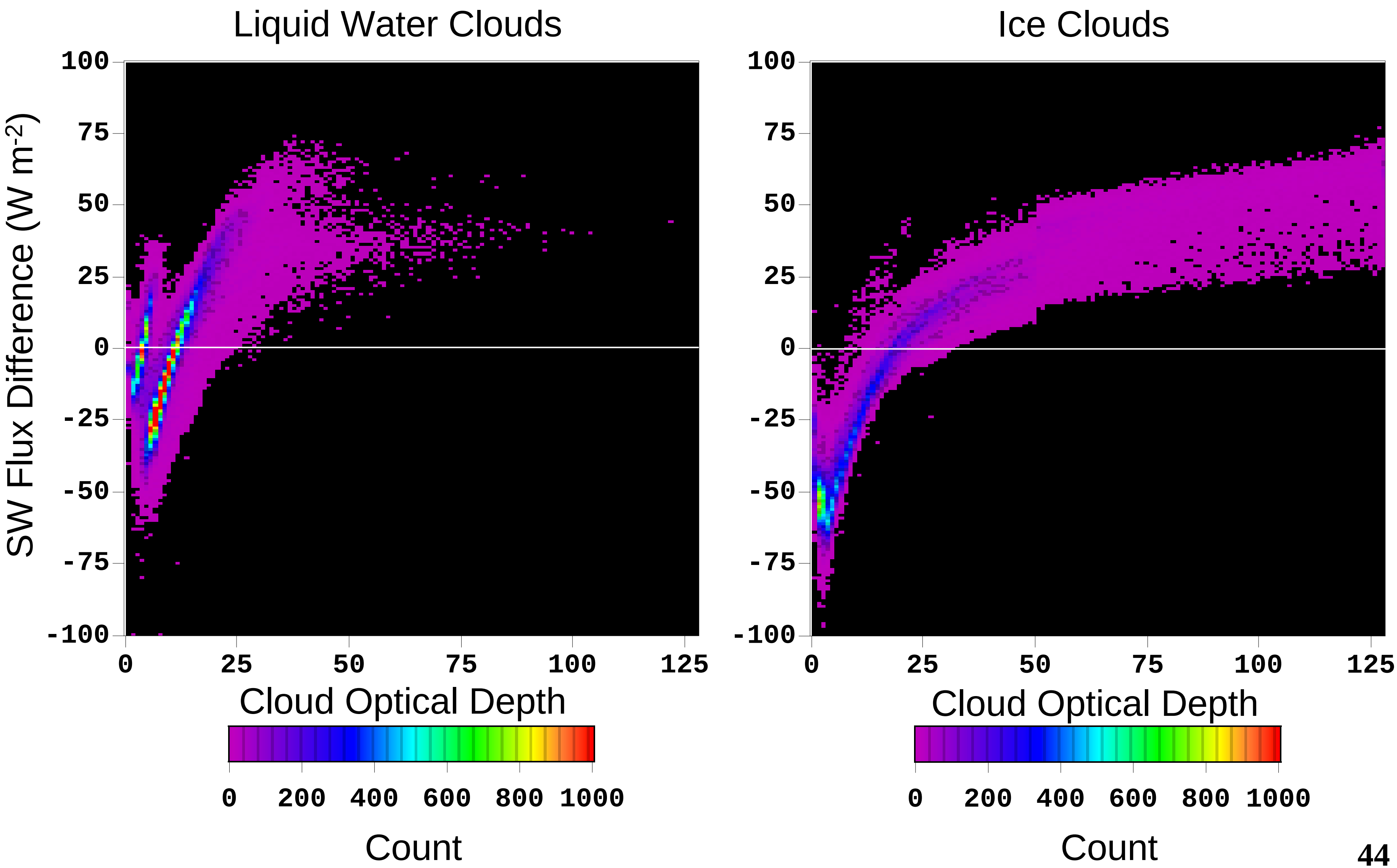
ADM Mean Flux Biases over 20°×20° Regions

(March 1998 Solar Zenith Angle Sampling)

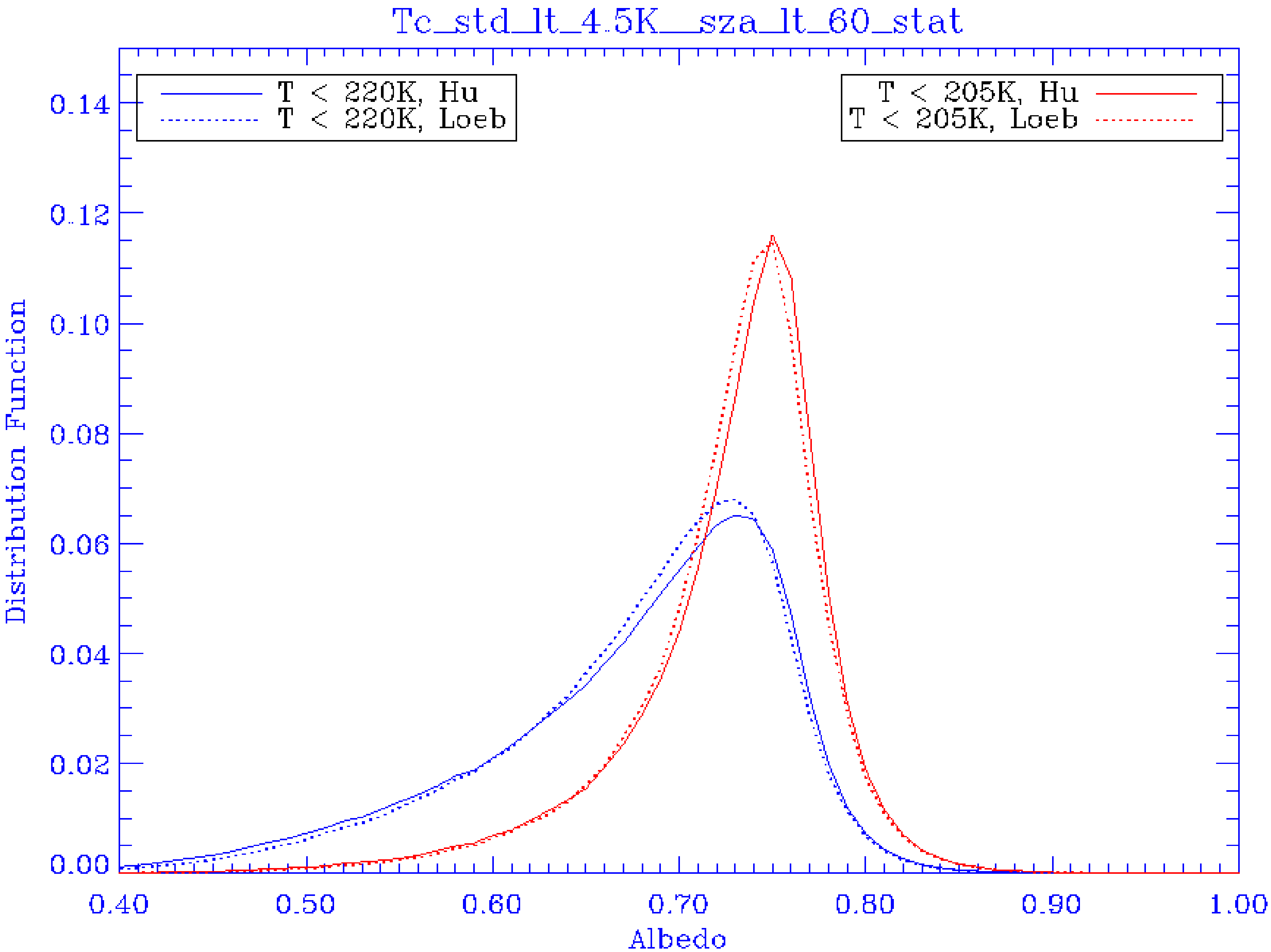
(W m^{-2})

	ERBE-Like		SSF Edition 2	
θ-Range	Δ	σ_Δ	Δ	σ_Δ
$\theta < 50°$	-2.8	1.5	-0.07	1.4
$\theta < 70°$	0.35	0.74	-0.15	0.52
CERES GOAL	0	1	0	1

ERBE-Like – SSF Ed2 SW Flux Difference vs Cloud Optical Depth (Ocean Ocean; θ_o=42° - 44°; θ < 25°)



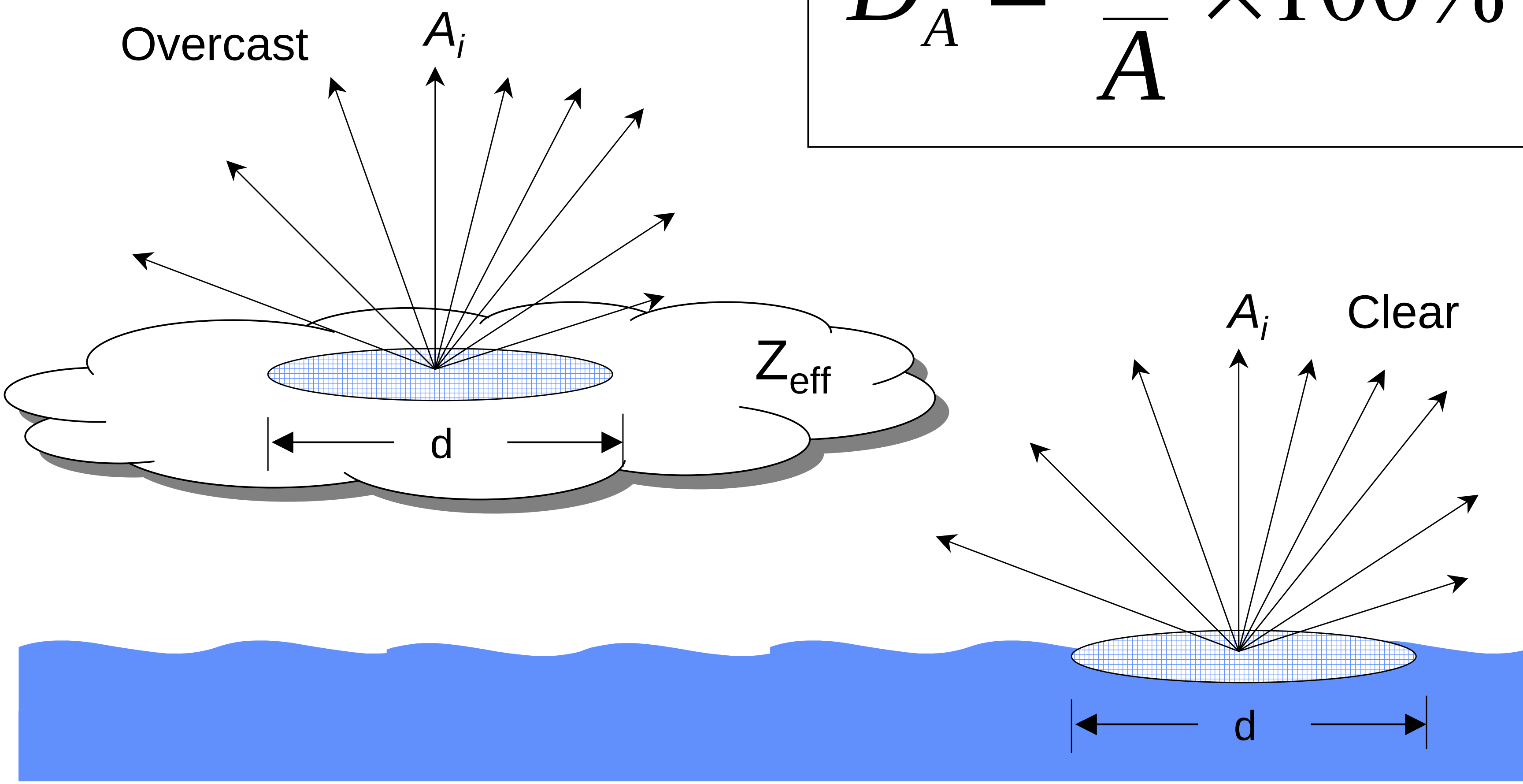
Albedos For Deep Convective Clouds: New ADMs vs Hu



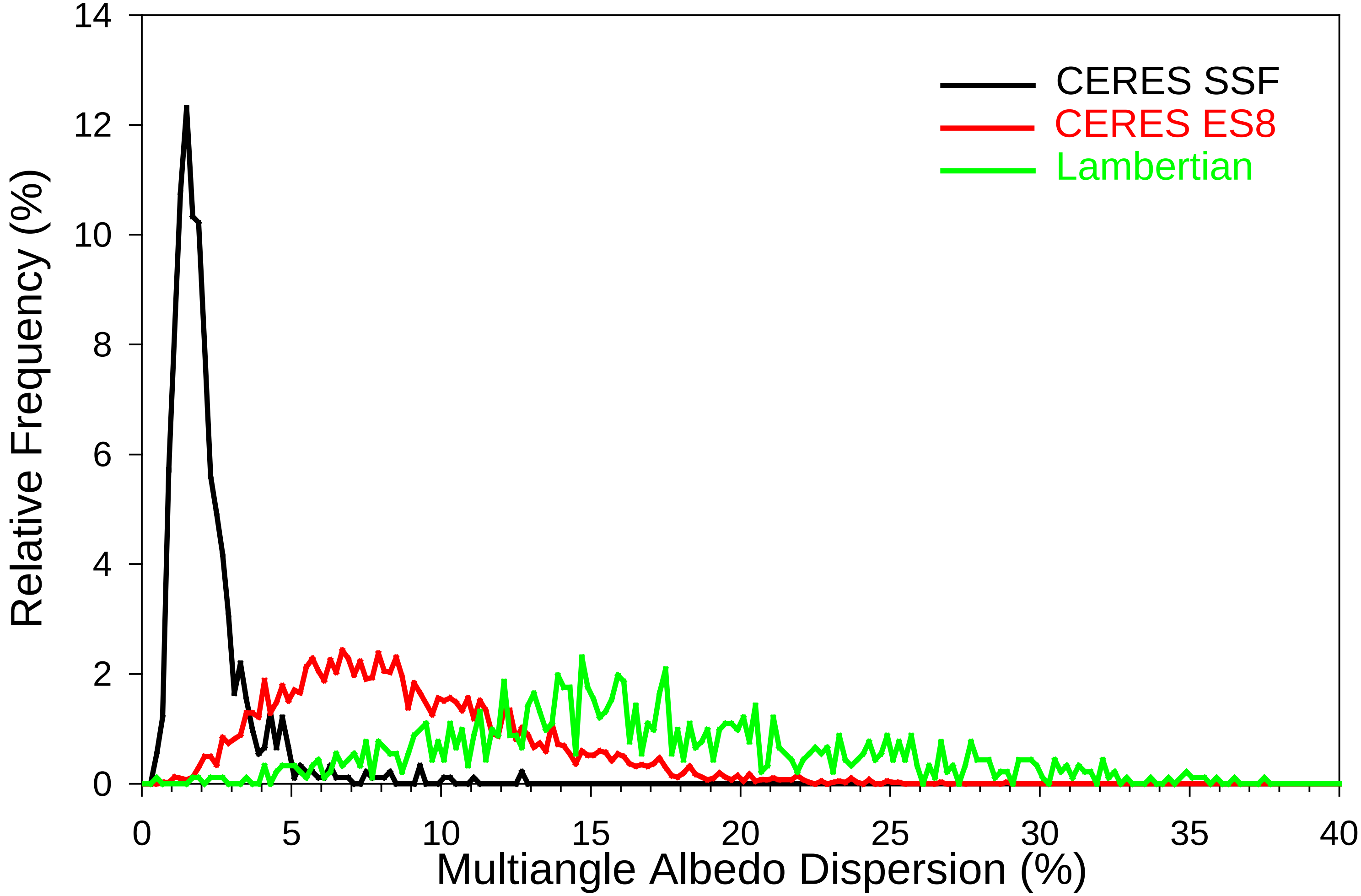
Instantaneous Albedo Errors from CERES Alongtrack Data

Albedo Dispersion Parameter:

$$D_A = \frac{c_A}{\overline{A}} \times 100\%$$



Clear Ocean Alongtrack Albedo Consistency Check

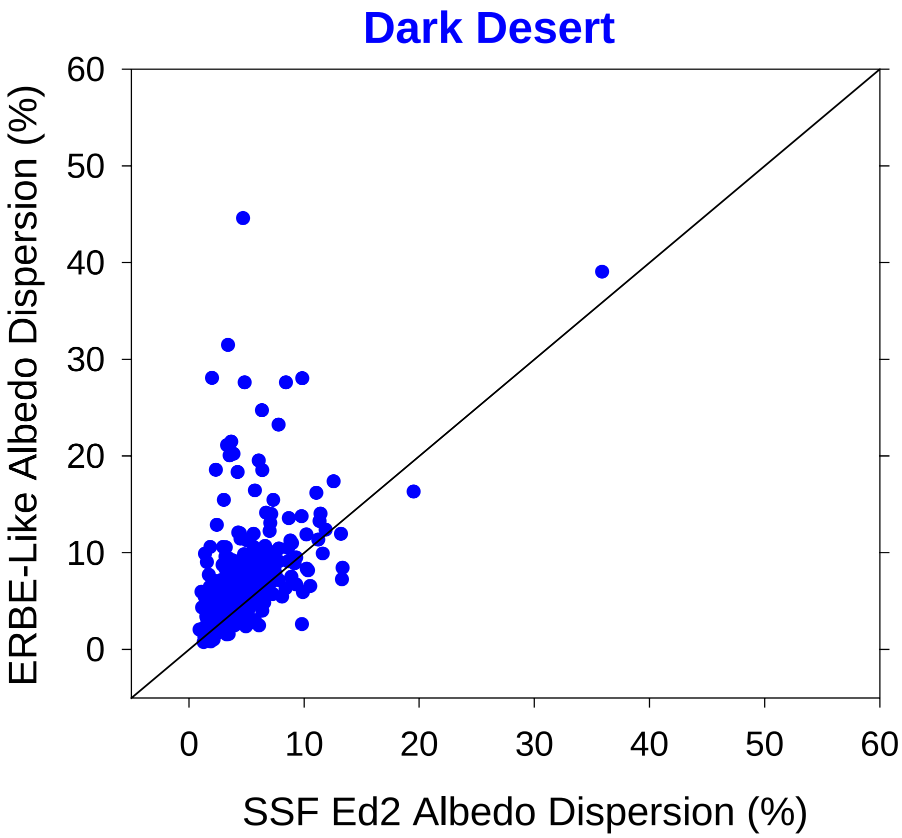


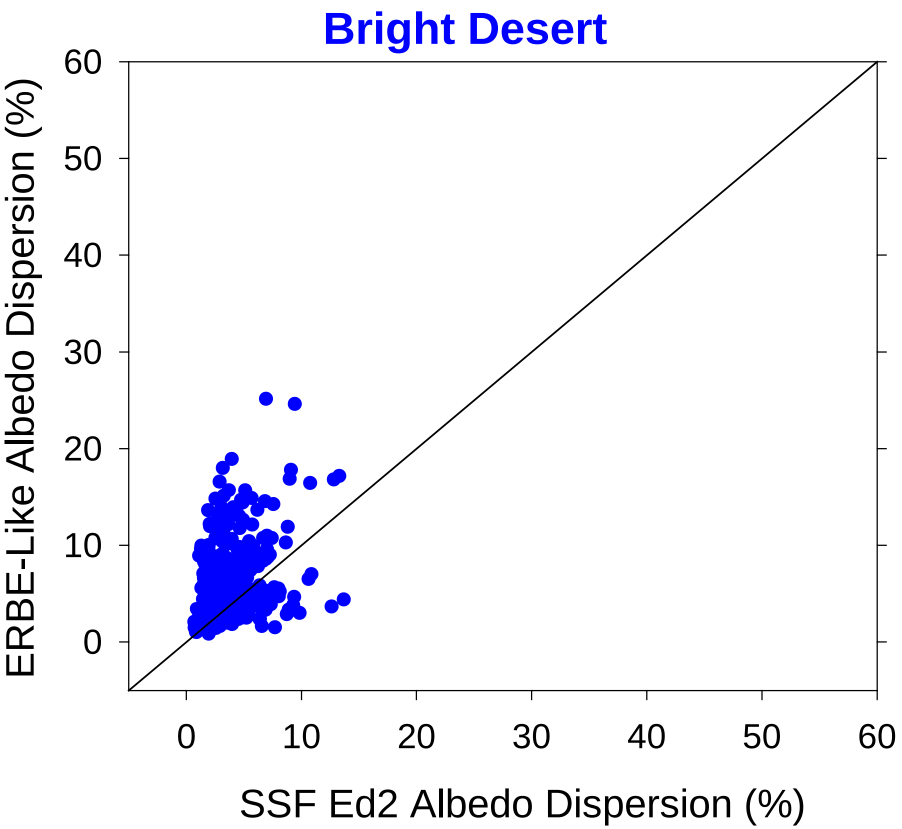
Average Dispersion (%)

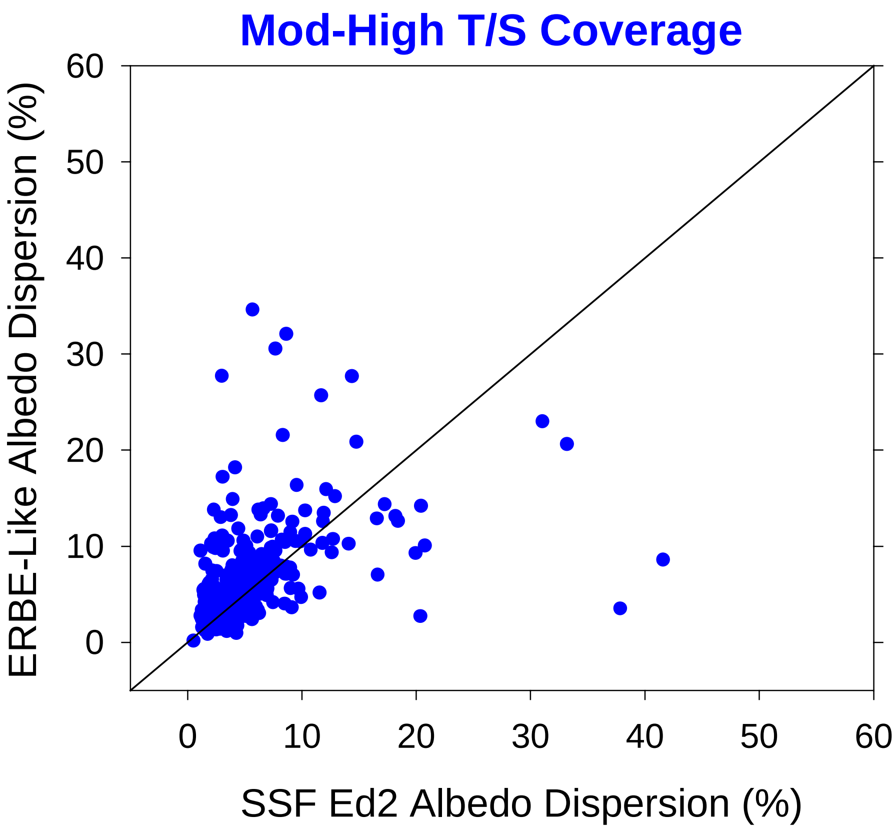
CERES SSF= 2.2

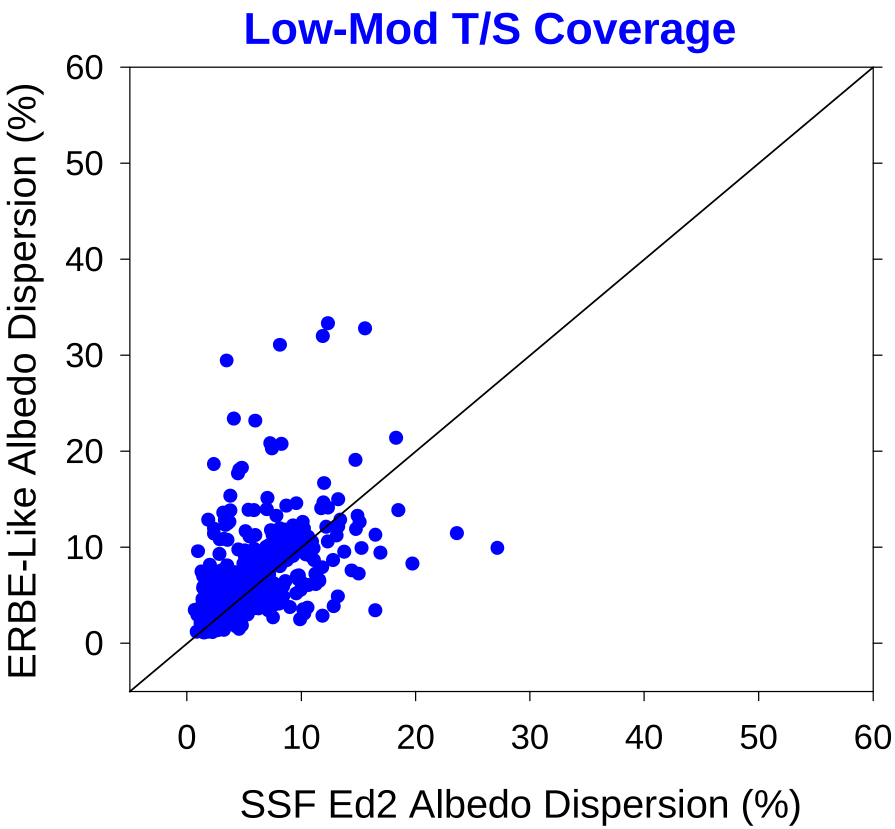
CERES ES8= 8.8

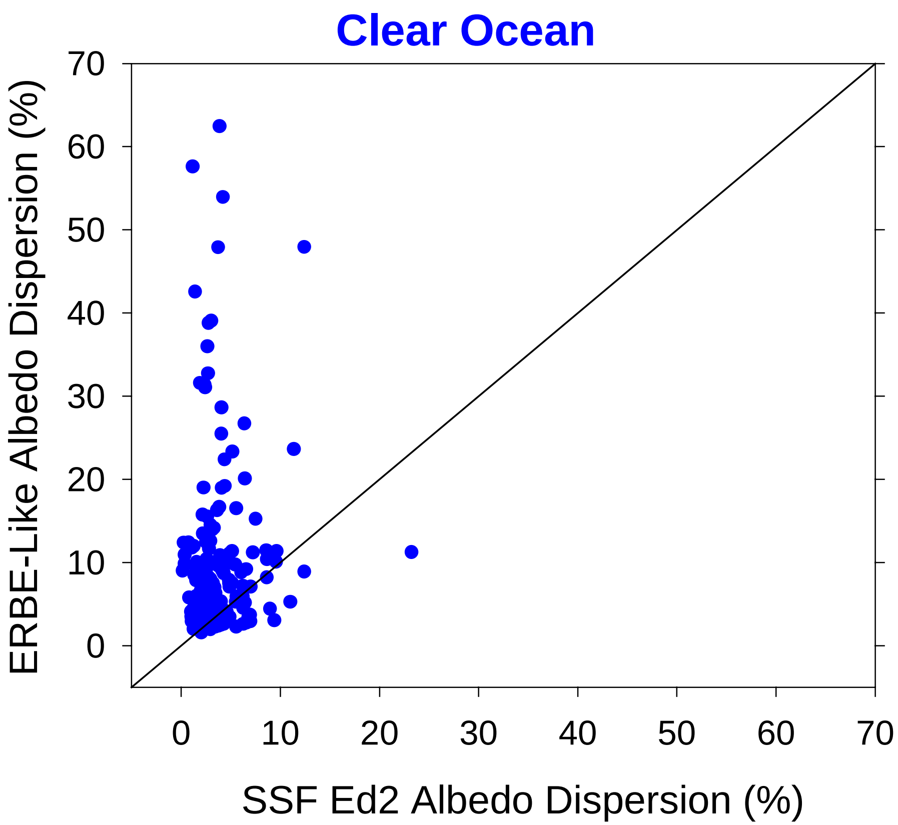
Lambertian = 16.9

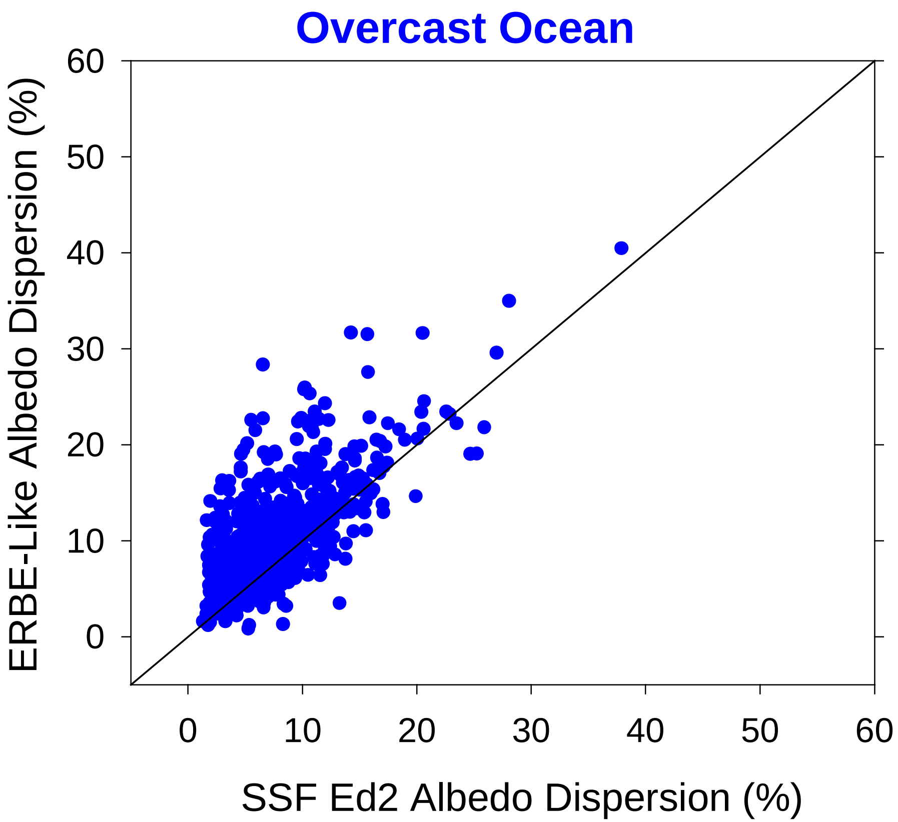

Dark Desert
60
50
40
30
20
10
0
0
10
20
30
40
50
60
ERBE-Like Albedo Dispersion (%)
SSF Ed2 Albedo Dispersion (%)

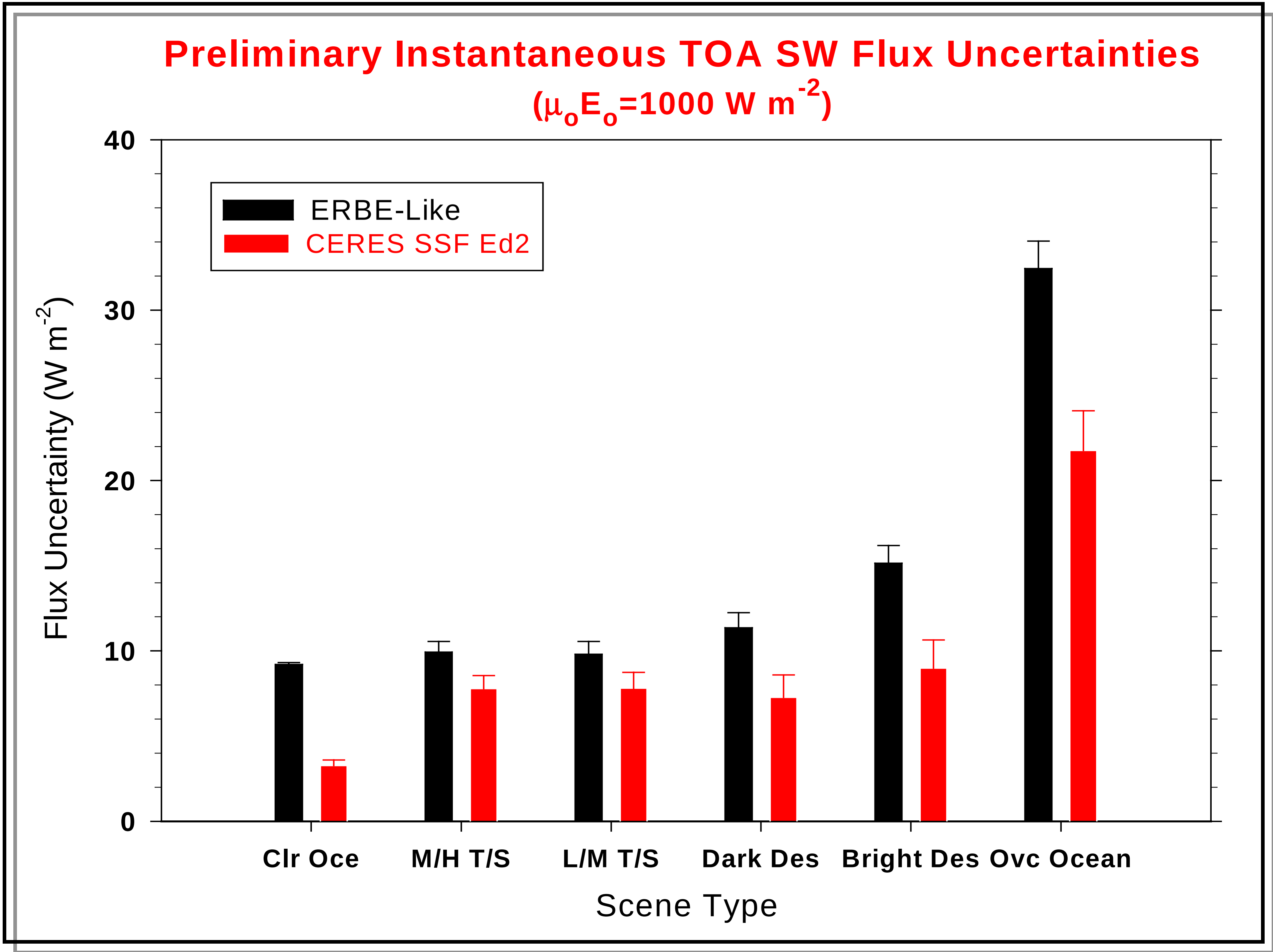

Bright Desert
60
50
40
30
20
10
0
0
10
20
30
40
50
60
ERBE-Like Albedo Dispersion (%)
SSF Ed2 Albedo Dispersion (%)


Mod-High T/S Coverage
ERBE-Like Albedo Dispersion (%)
SSF Ed2 Albedo Dispersion (%)
0
10
20
30
40
50
60


Low-Mod T/S Coverage
ERBE-Like Albedo Dispersion (%)
SSF Ed2 Albedo Dispersion (%)
0
10
20
30
40
50
60


Clear Ocean
ERBE-Like Albedo Dispersion (%)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
SSF Ed2 Albedo Dispersion (%)

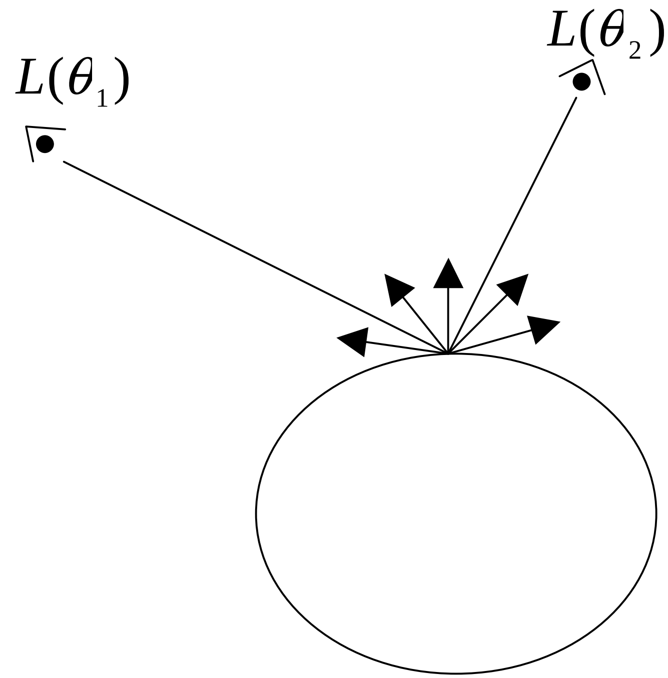

Overcast Ocean
ERBE-Like Albedo Dispersion (%)
60
50
40
30
20
10
0
0
10
20
30
40
50
60
SSF Ed2 Albedo Dispersion (%)


Preliminary Instantaneous TOA SW Flux Uncertainties
($\mu_o E_o$=1000 W m^{-2})
Flux Uncertainty (W m^{-2})
40
30
20
10
0
ERBE-Like
CERES SSF Ed2
Clr Oce
M/H T/S
L/M T/S
Dark Des
Bright Des
Ovc Ocean
Scene Type

LW and WN TOA Flux Validation

- Does mean all-sky flux depend on viewing geometry?
- Comparisons with Direct Integration Fluxes:
    - Regional fluxes
    - Latitudinal flux dependence
- Flux consistency as a function of cloud and clear-sky parameters.

TOA LW & WN Flux Estimation from Satellite



Flux:

$$M = 2\pi \int_0^{\pi/2} L(\theta)\cos\theta \sin\theta \, d\theta$$

$L(\theta) =$ Measured Radiance

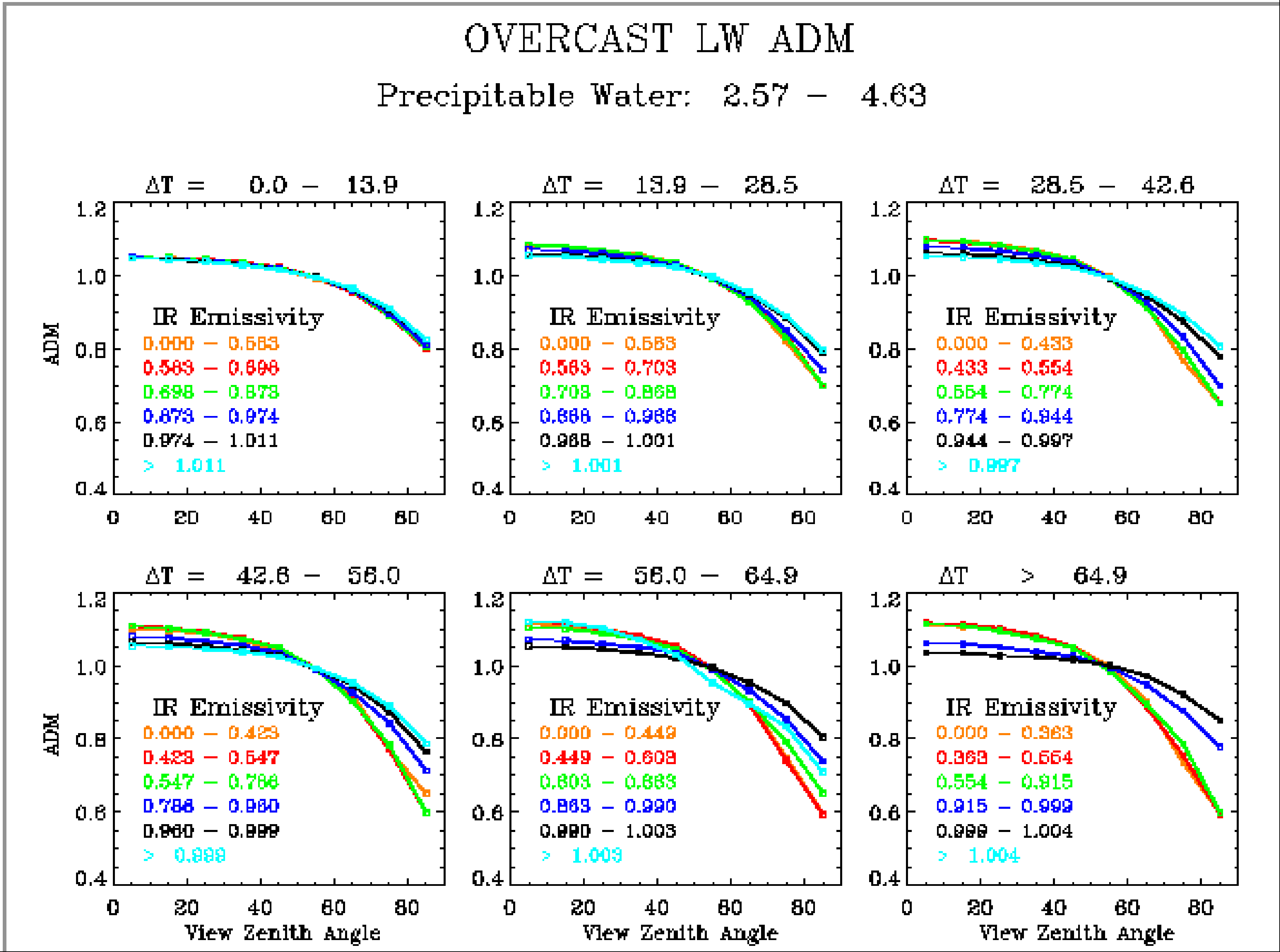
Instantaneous Flux Estimate:

$$\hat{M} = \frac{\pi L(\theta)}{R(\theta)}$$

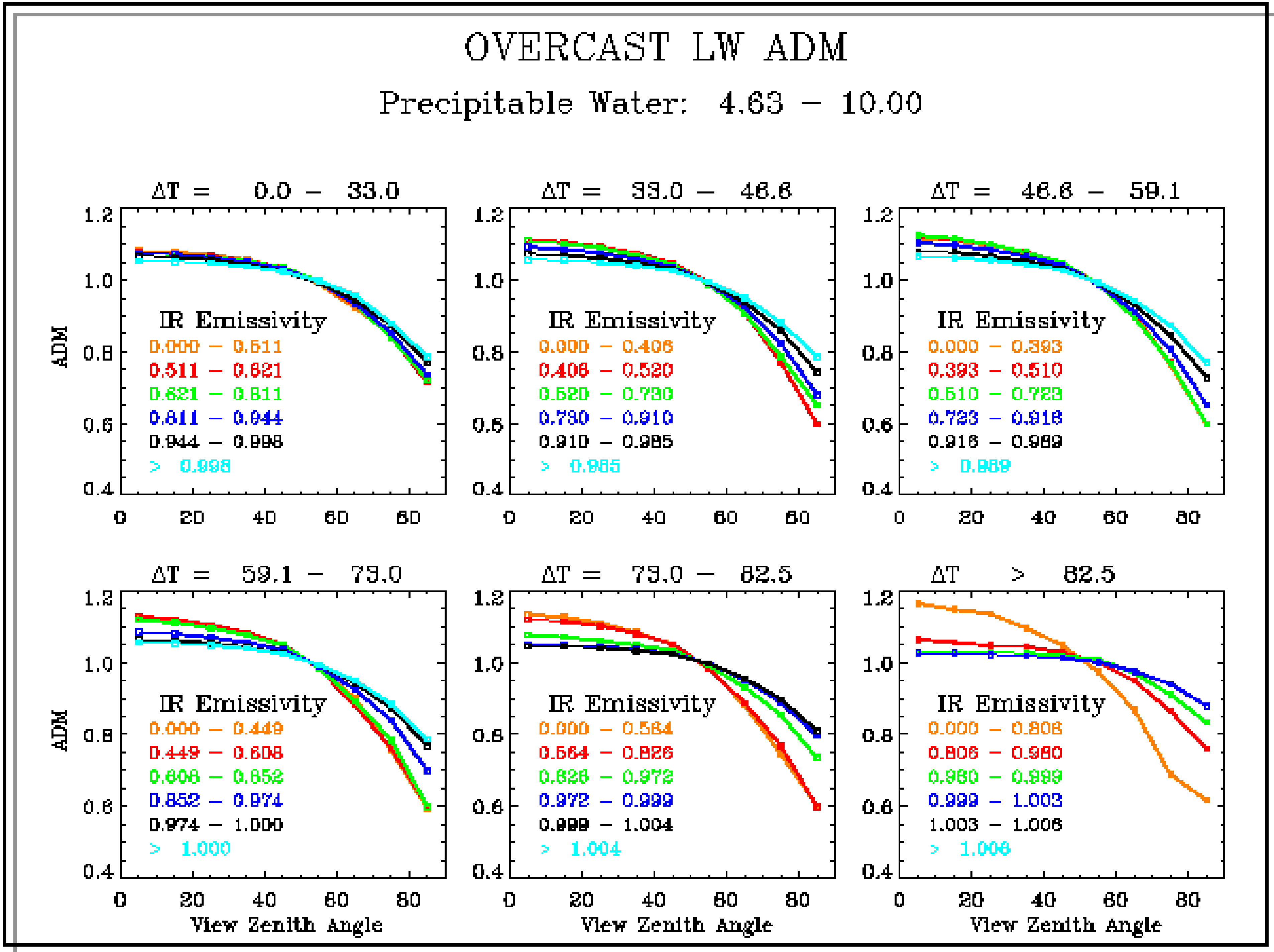
$R(\theta) =$ LW Anisotropic Factor

Scene Types for CERES/TRMM LW and WN ADMs

ADM Category		Parameter Stratification	Total
Clear	Ocean	3 Precipitable Water	12
		4 Vertical Temperature Change	
	Land	3 Precipitable Water	36
		4 Vertical Temperature Change	
		3 Surface Emissivity	
	Desert	3 Precipitable Water	36
		4 Vertical Temperature Change	
		3 Surface Emissivity	
Broken Cloud Field (4 intervals)	Ocean/Land/ Desert	3 Precipitable Water	288 (O) 288 (L) 288 (D)
		6 ΔT (Sfc-Cloud)	
		4 IR Emissivity	
Overcast	Ocean+ Land+Desert	3 Precipitable Water	108
		6 ΔT (Sfc-Cloud)	
		6 IR Emissivity	

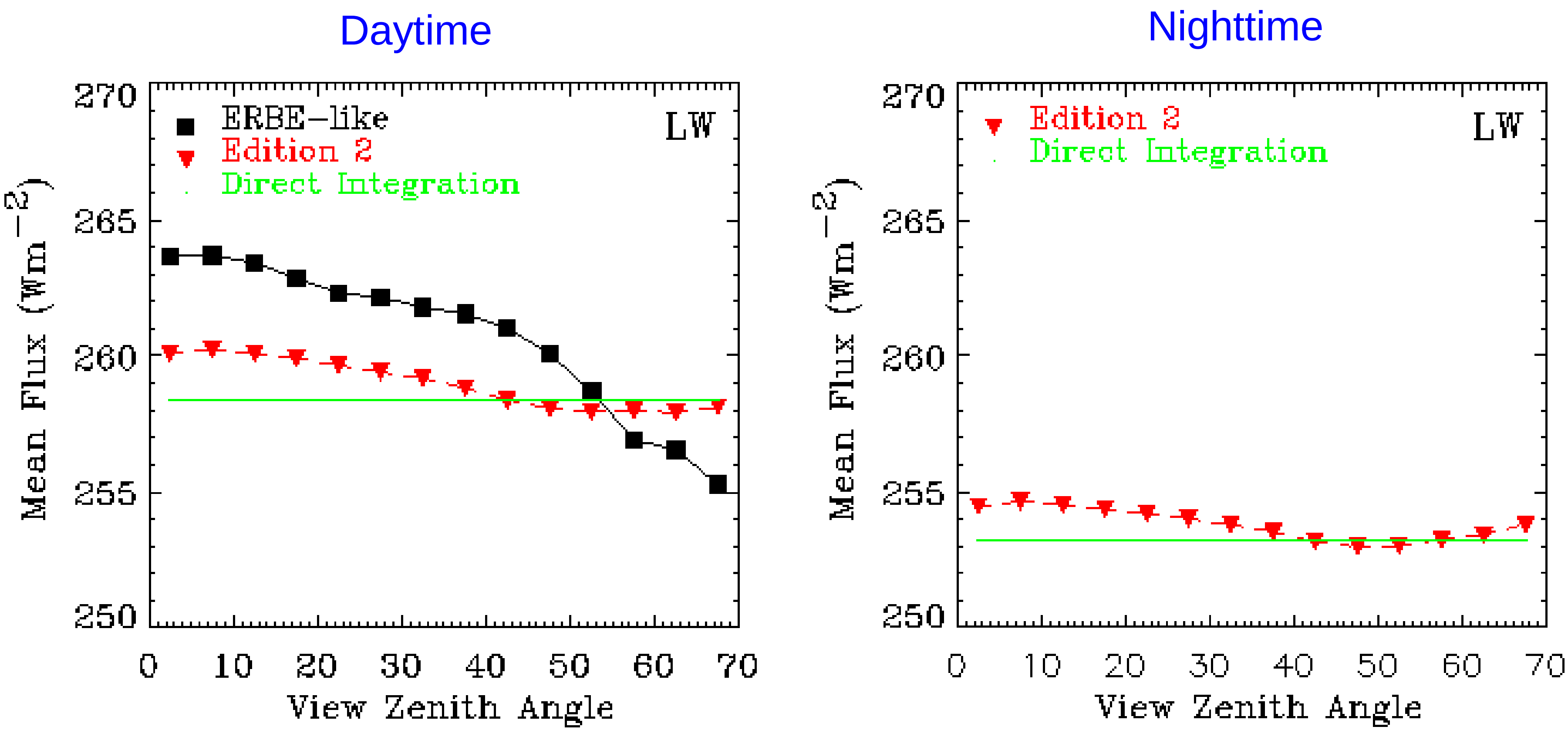


OVERCAST LW ADM
Precipitable Water: 2.57 – 4.63
ΔT = 0.0 – 13.9
ΔT = 13.9 – 28.5
ΔT = 28.5 – 42.6
ΔT = 42.6 – 56.0
ΔT = 56.0 – 64.9
ΔT > 64.9
ADM
View Zenith Angle
IR Emissivity
0.000 – 0.583
0.583 – 0.698
0.698 – 0.873
0.873 – 0.974
0.974 – 1.011
> 1.011
IR Emissivity
0.000 – 0.583
0.583 – 0.703
0.703 – 0.868
0.868 – 0.968
0.968 – 1.001
> 1.001
IR Emissivity
0.000 – 0.433
0.433 – 0.554
0.554 – 0.774
0.774 – 0.944
0.944 – 0.997
> 0.997
IR Emissivity
0.000 – 0.423
0.423 – 0.547
0.547 – 0.786
0.786 – 0.960
0.960 – 0.999
> 0.999
IR Emissivity
0.000 – 0.449
0.449 – 0.603
0.603 – 0.863
0.863 – 0.990
0.990 – 1.003
> 1.003
IR Emissivity
0.000 – 0.363
0.363 – 0.554
0.554 – 0.915
0.915 – 0.999
0.999 – 1.004
> 1.004



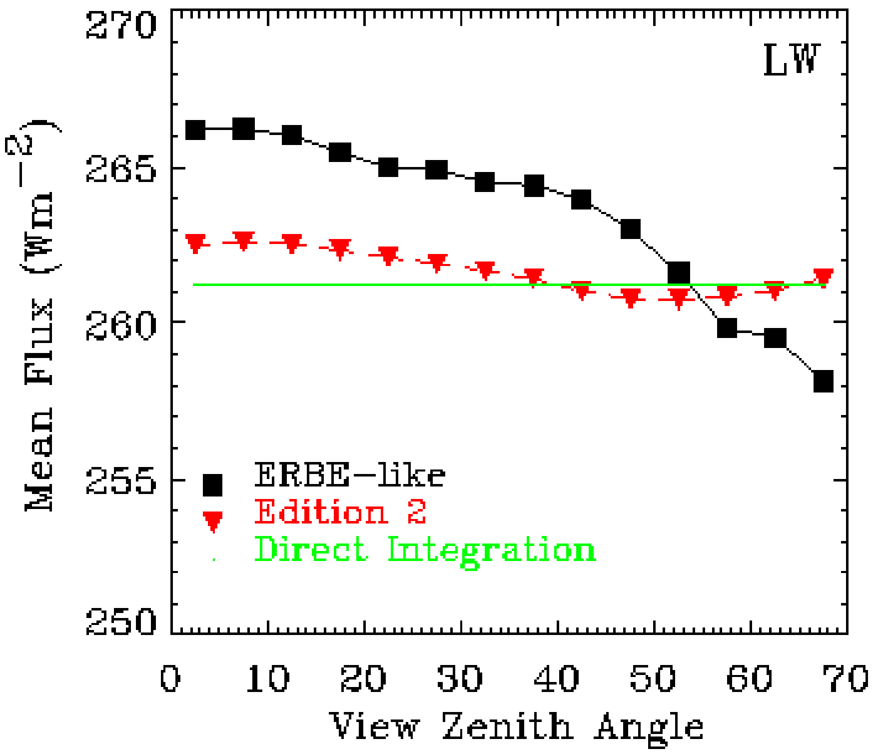
OVERCAST LW ADM
Precipitable Water: 4.63 – 10.00
ΔT = 0.0 – 33.0
ΔT = 33.0 – 46.6
ΔT = 46.6 – 59.1
ΔT = 59.1 – 73.0
ΔT = 73.0 – 82.5
ΔT > 82.5
ADM
View Zenith Angle
IR Emissivity
0.000 – 0.511
0.511 – 0.621
0.621 – 0.811
0.811 – 0.944
0.944 – 0.998
> 0.998
0.000 – 0.406
0.406 – 0.520
0.520 – 0.730
0.730 – 0.910
0.910 – 0.985
> 0.985
0.000 – 0.393
0.393 – 0.510
0.510 – 0.723
0.723 – 0.916
0.916 – 0.989
> 0.989
0.000 – 0.449
0.449 – 0.608
0.608 – 0.852
0.852 – 0.974
0.974 – 1.000
> 1.000
0.000 – 0.564
0.564 – 0.826
0.826 – 0.972
0.972 – 0.999
0.999 – 1.004
> 1.004
0.000 – 0.806
0.806 – 0.960
0.960 – 0.999
0.999 – 1.003
1.003 – 1.006
> 1.006

Mean LW Flux vs Viewing Zenith Angle (Jan-Mar 1998)

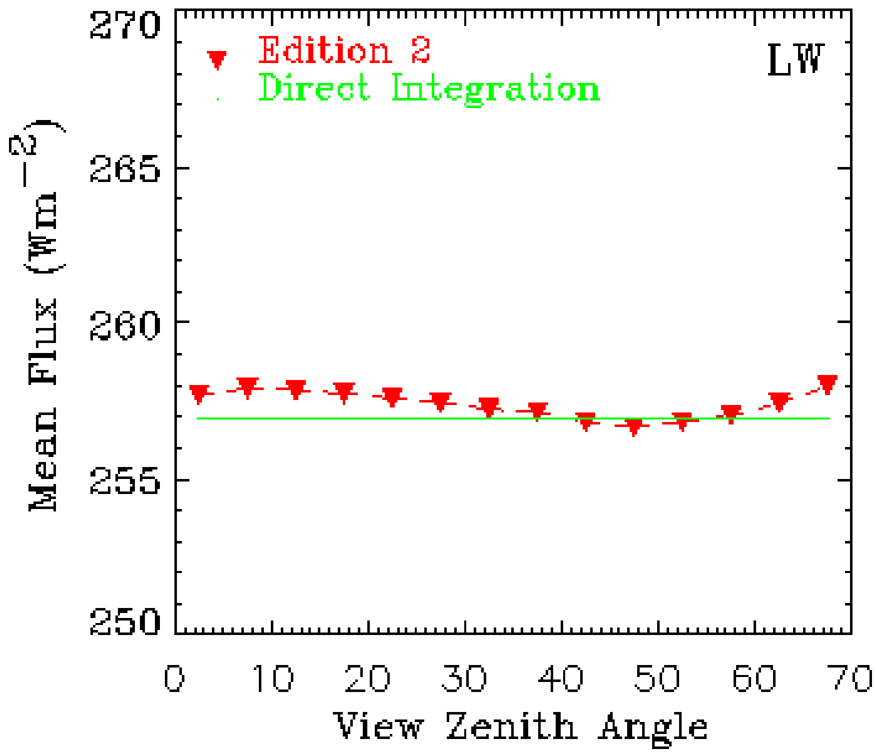


Mean LW Flux vs Viewing Zenith Angle (Jun-Aug 1998)

Daytime

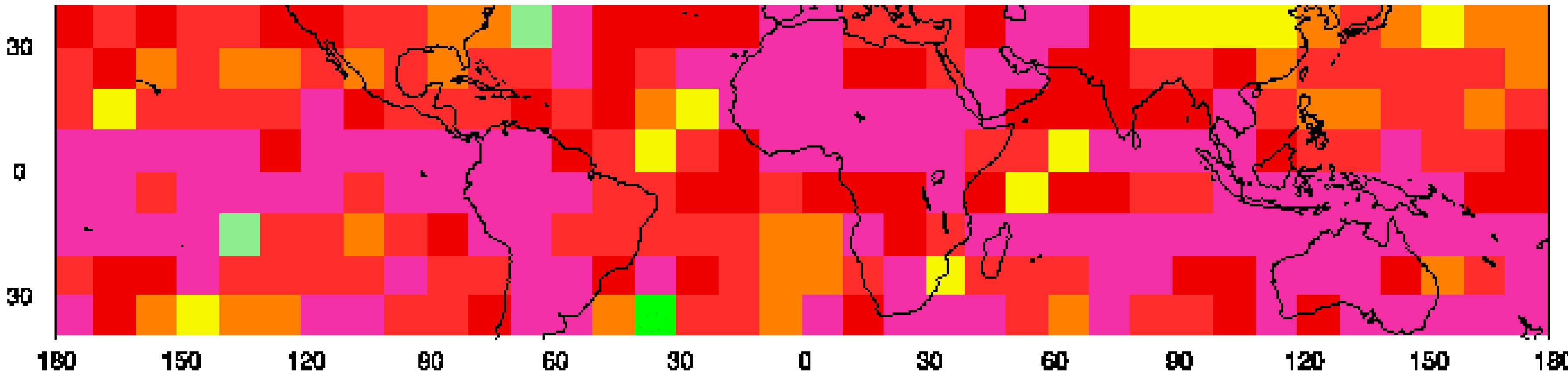


Nighttime

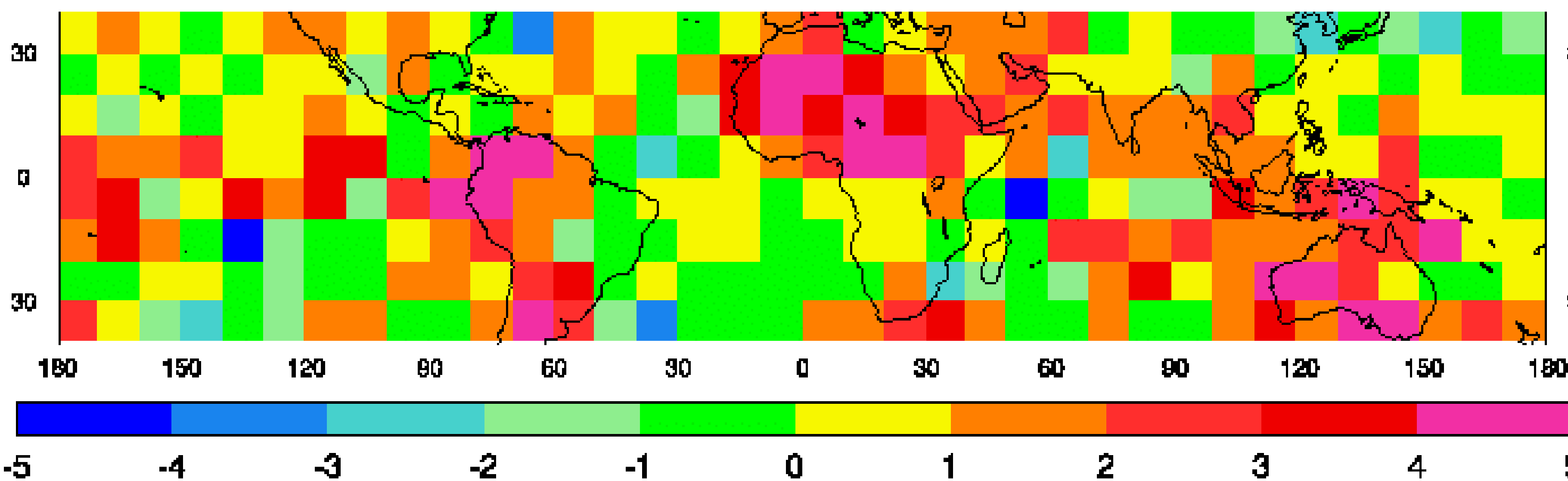


Daytime LW ADM Mean Regional Flux Biases ($\theta < 50°$)
(Jan, Feb, Mar 1998)

ERBE-Like – DI Flux Difference



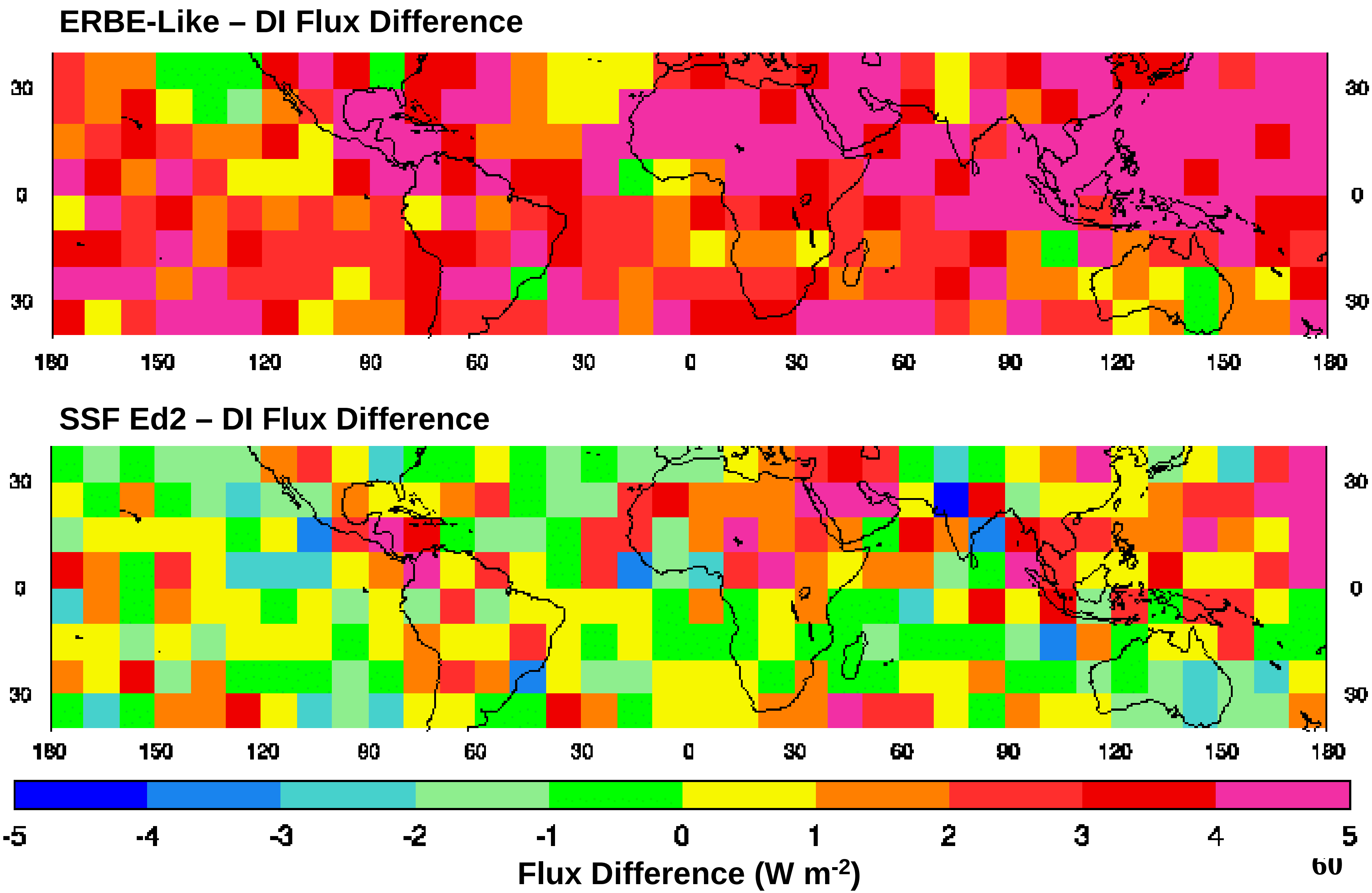
SSF Ed2 – DI Flux Difference



Flux Difference (W m^{-2})

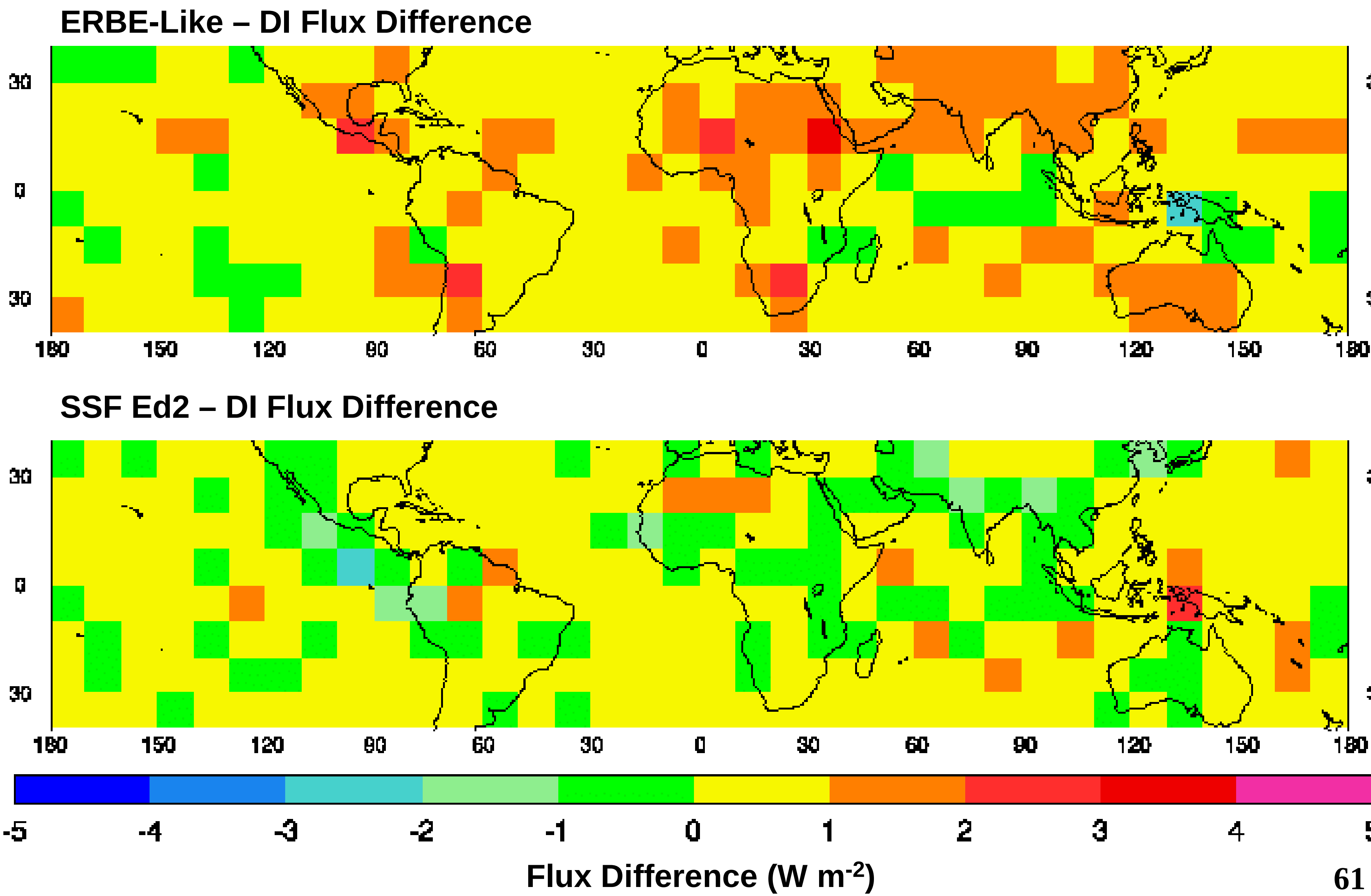
Daytime LW ADM Mean Regional Flux Biases ($\theta < 50°$)

(Jun, Jul, Aug 1998)

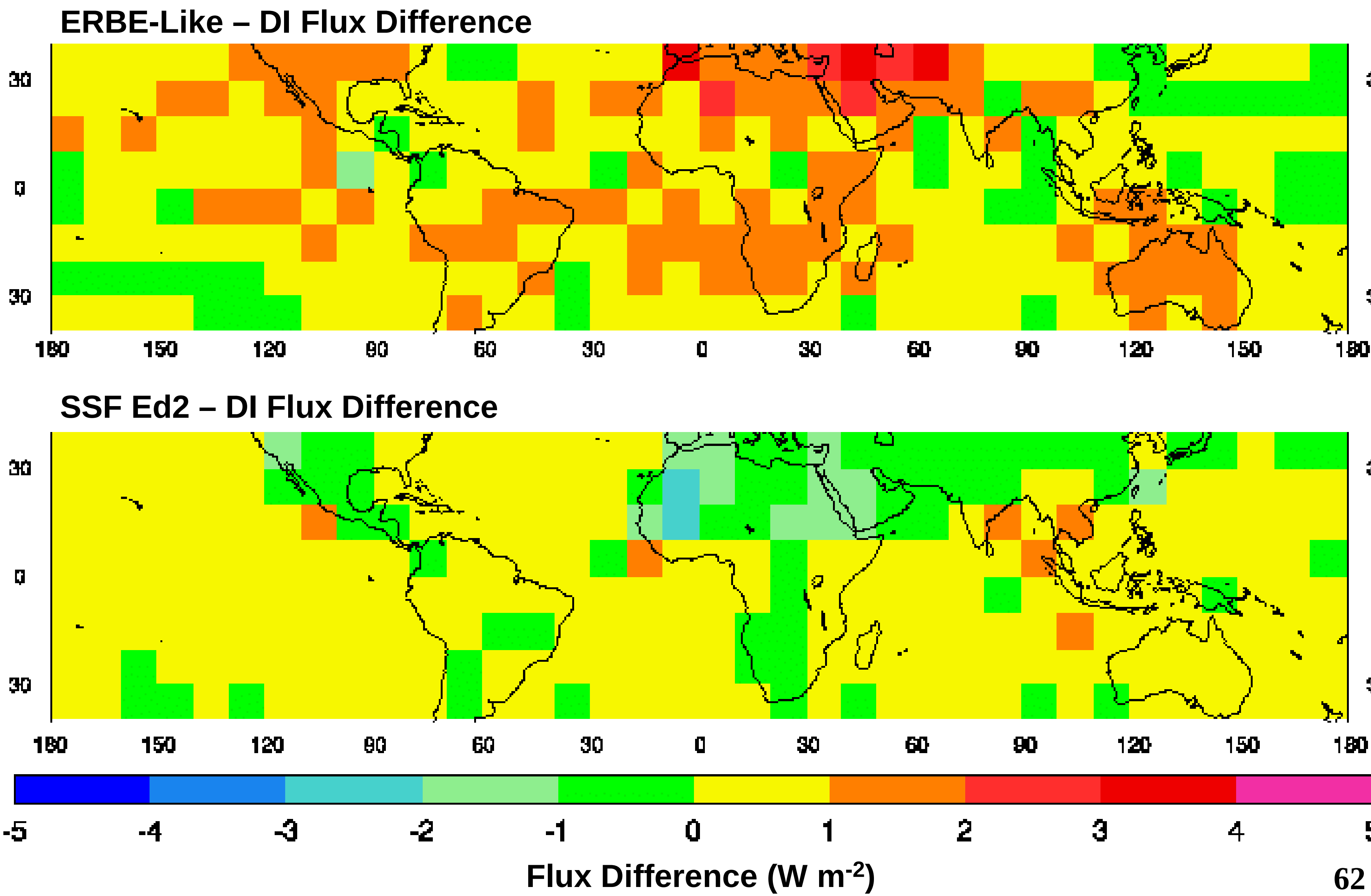


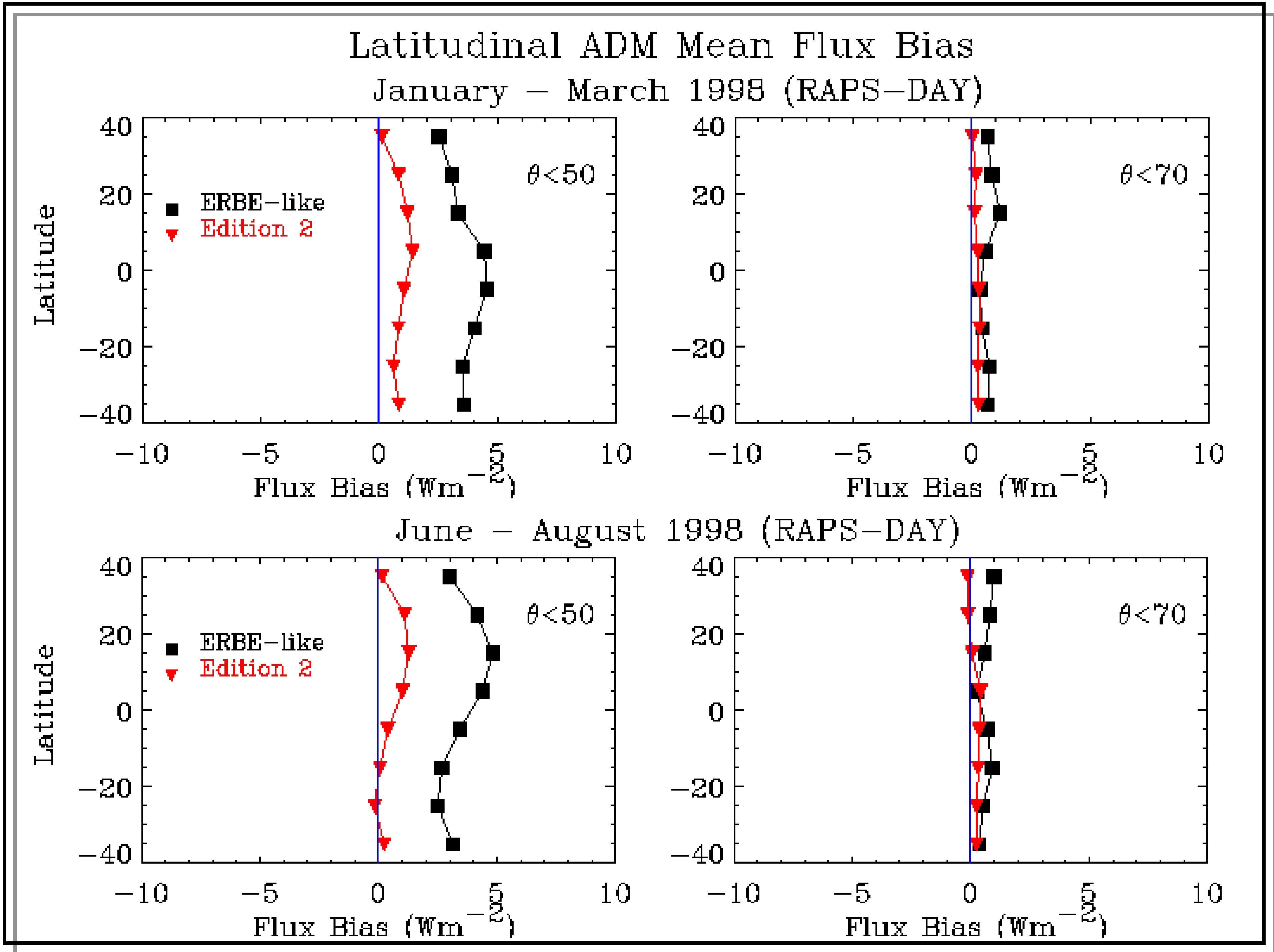
Daytime LW ADM Mean Regional Flux Biases ($\theta < 70°$)

(Jan, Feb, Mar 1998)



Daytime LW ADM Mean Regional Flux Biases (θ < 70°)
(Jun, Jul, Aug 1998)




Latitudinal ADM Mean Flux Bias
January – March 1998 (RAPS–DAY)
June – August 1998 (RAPS–DAY)
Latitude
Flux Bias (Wm^{-2})
ERBE–like
Edition 2
θ<50
θ<70
40
20
0
–20
–40
–10
–5
0
5
10

ADM Regional LW Flux Biases : Daytime

(10°×10° regions; Jan-March 1998)

($W\ m^{-2}$)

	ERBE-Like		SSF Edition 2	
θ-Range	Δ	σ_Δ	Δ	σ_Δ
$\theta < 50°$	3.7	1.9	0.87	1.7
$\theta < 70°$	0.67	0.60	0.21	0.57
CERES GOAL	0	0.5	0	0.5

ADM Regional LW Flux Biases: Daytime

(10°×10° regions; Jun-Aug 1998)

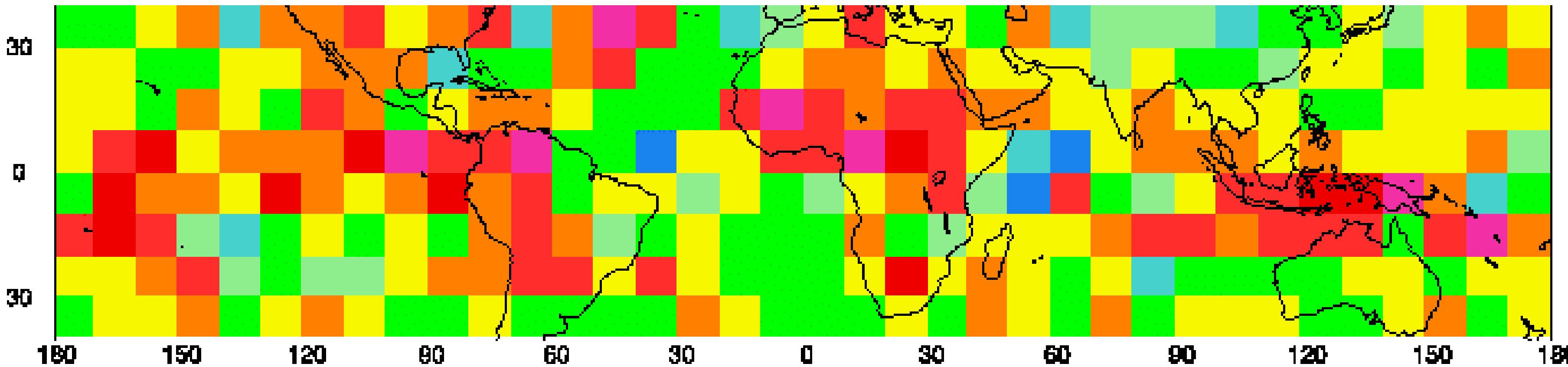
(W m^{-2})

	ERBE-Like		SSF Edition 2	
θ-Range	Δ	σ_Δ	Δ	σ_Δ
$\theta < 50°$	3.5	2.2	0.52	1.9
$\theta < 70°$	0.64	0.68	0.18	0.56
CERES GOAL	0	0.5	0	0.5

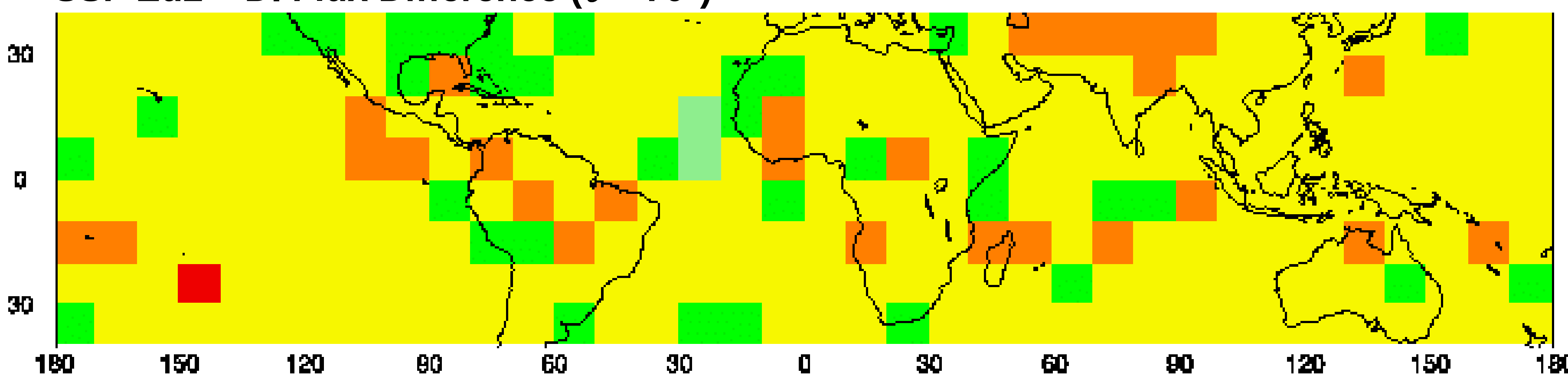
Nighttime LW ADM Mean Regional Flux Biases

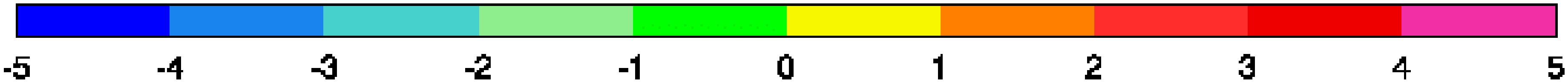
(Jan, Feb, Mar 1998)

SSF Ed2 – DI Flux Difference ($\theta < 50°$)



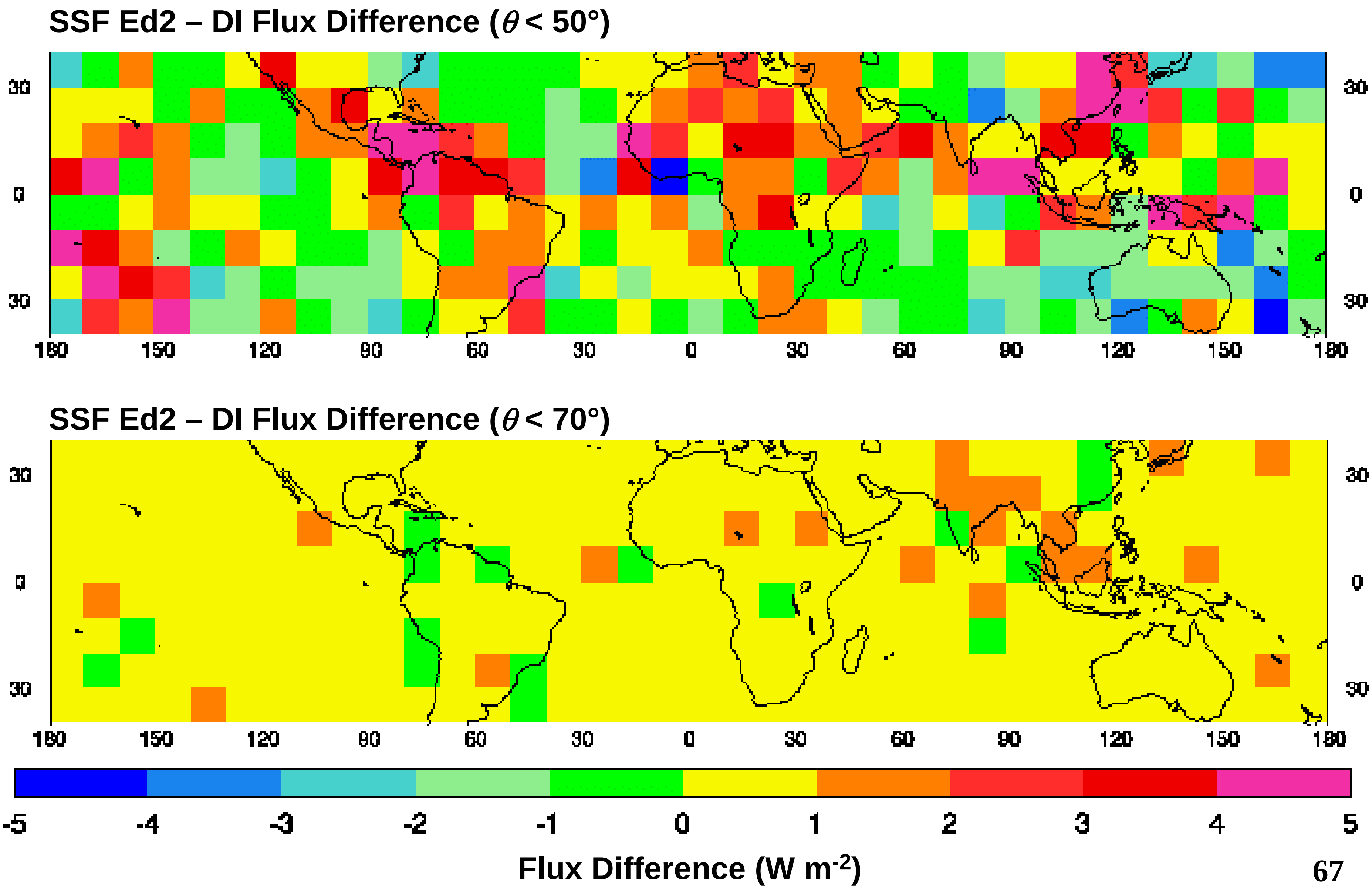
SSF Ed2 – DI Flux Difference ($\theta < 70°$)

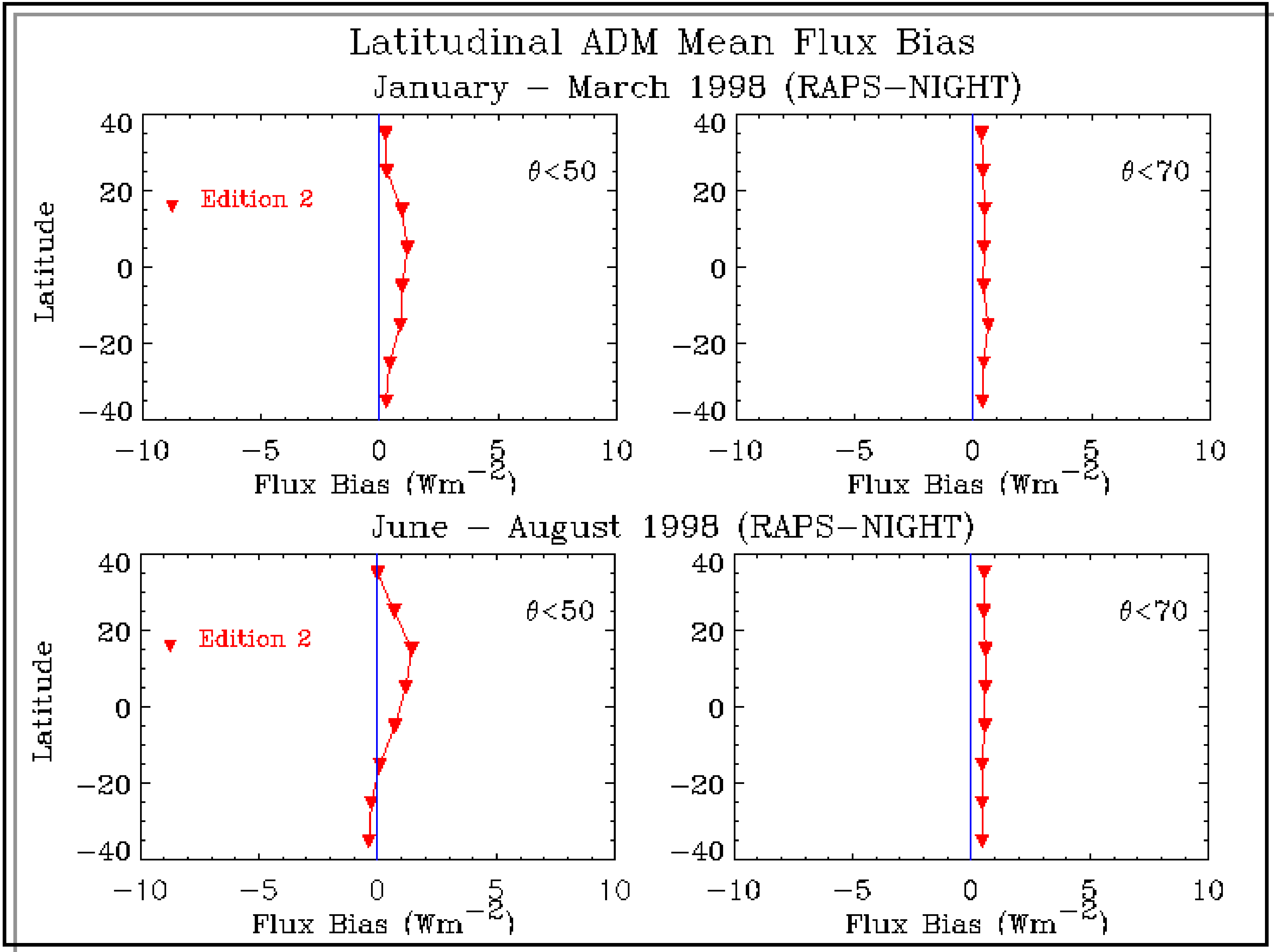




Flux Difference (W m^{-2})

Nighttime LW ADM Mean Regional Flux Biases
(Jun, Jul, Aug 1998)




Latitudinal ADM Mean Flux Bias
January – March 1998 (RAPS–NIGHT)
June – August 1998 (RAPS–NIGHT)
θ<50
θ<70
Edition 2
Latitude
Flux Bias (Wm^{-2})
40
20
0
–20
–40
–10
–5
0
5
10

SSF Edition 2 ADM Regional LW Flux Biases : Nighttime

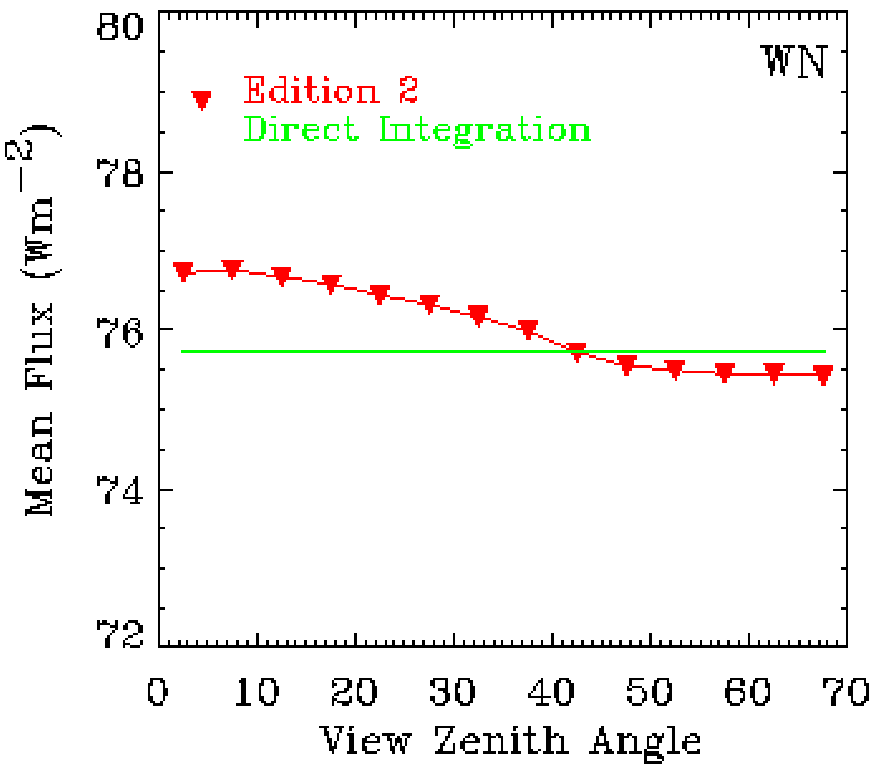
($10° \times 10°$ regions)

($W\ m^{-2}$)

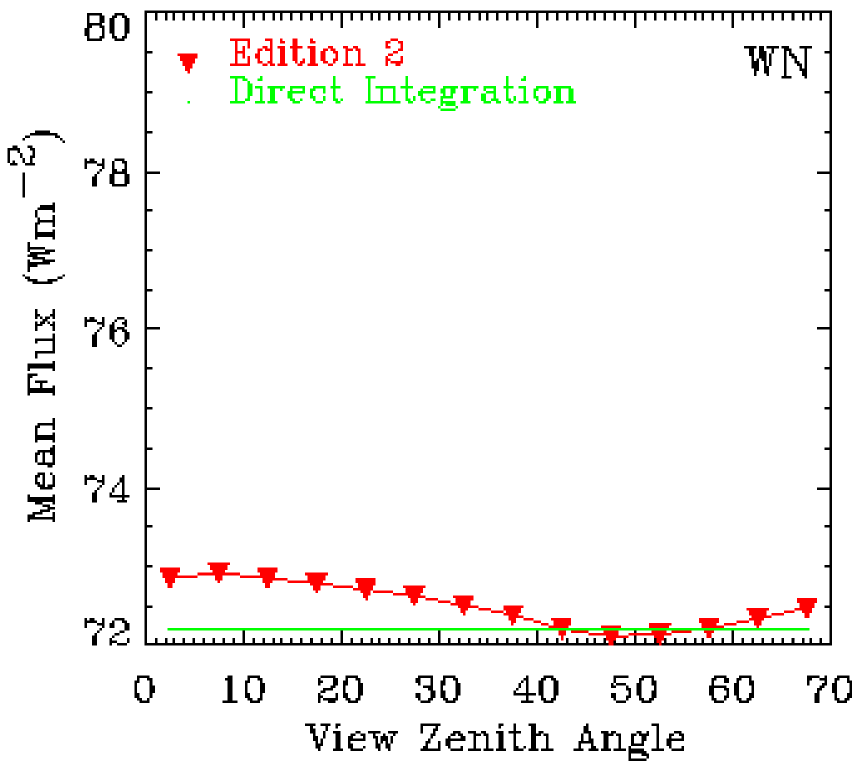
	Jan-Mar		Jun-Aug	
θ-Range	Δ	σ_Δ	Δ	σ_Δ
$\theta < 50°$	0.66	1.5	0.46	2.0
$\theta < 70°$	0.45	0.46	0.52	0.36
CERES GOAL	0	0.5	0	0.5

Mean WN Flux vs Viewing Zenith Angle (Jan-Mar 1998)

Daytime

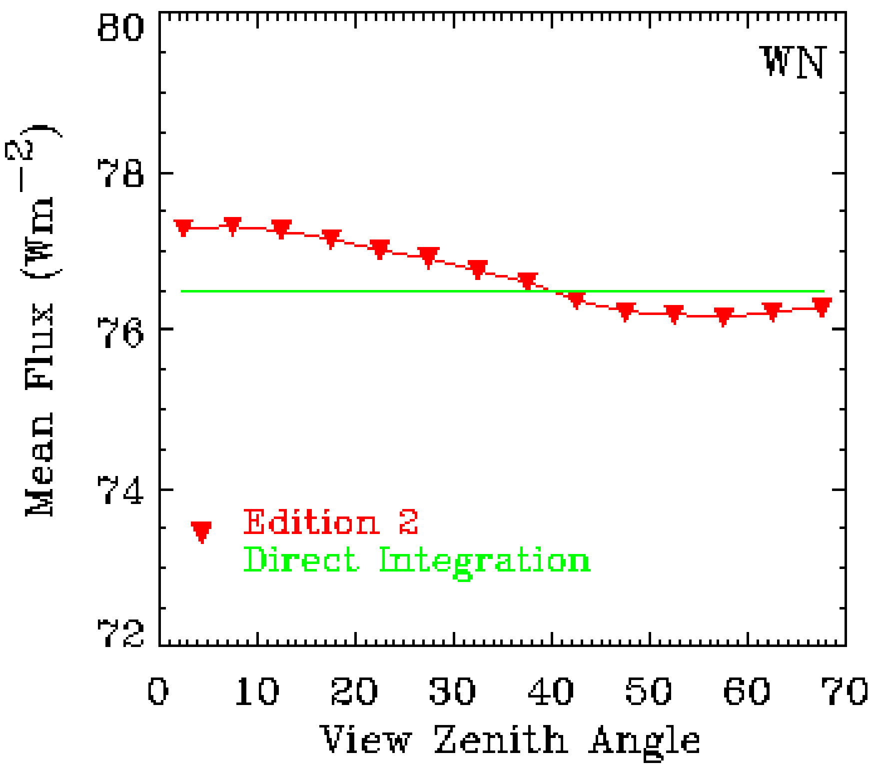


Nighttime

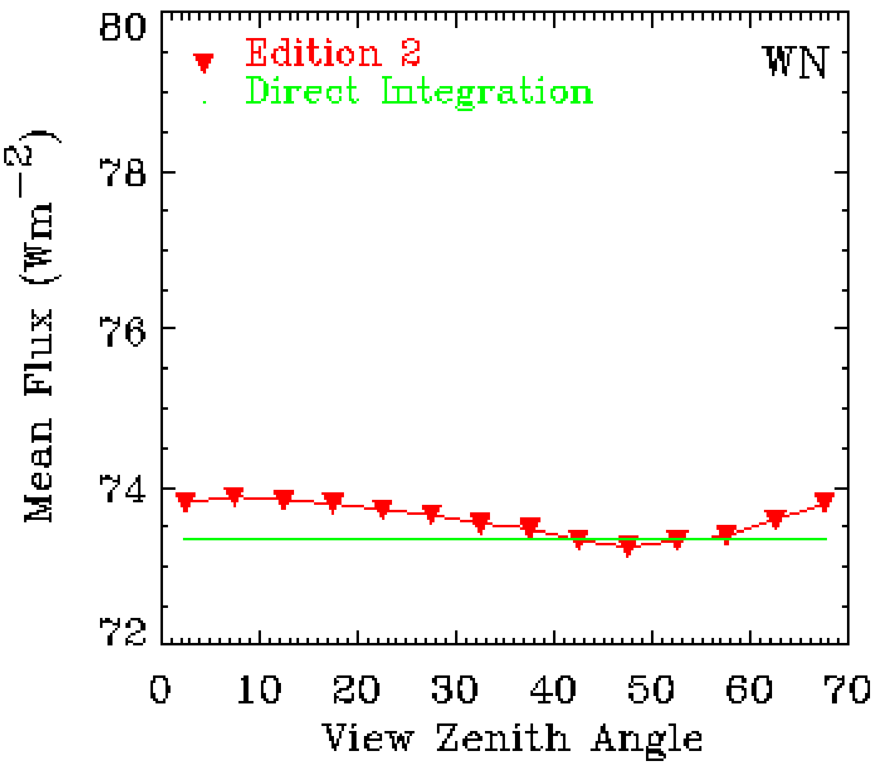


Mean WN Flux vs Viewing Zenith Angle (Jun-Aug 1998)

Daytime



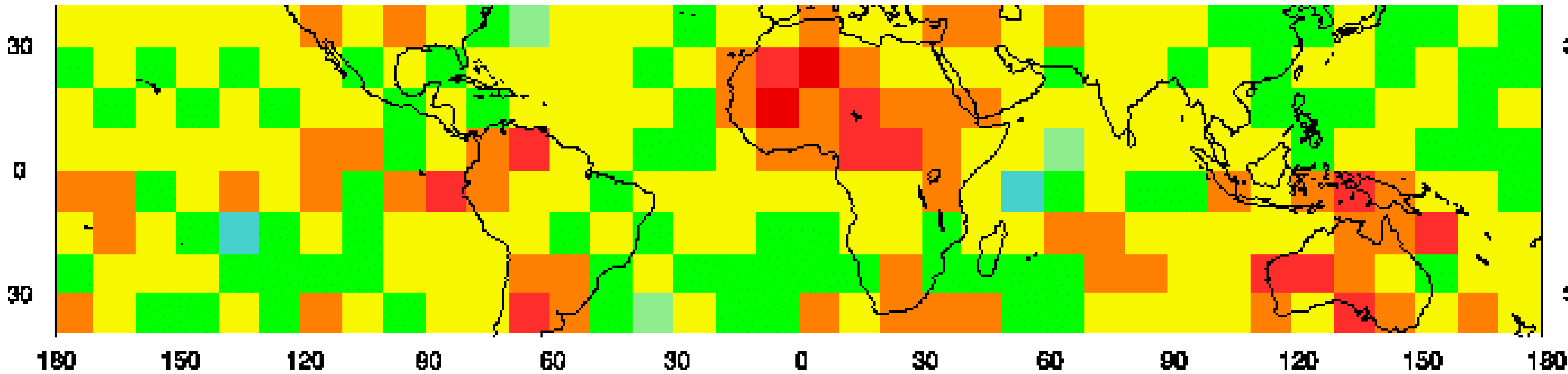
Nighttime



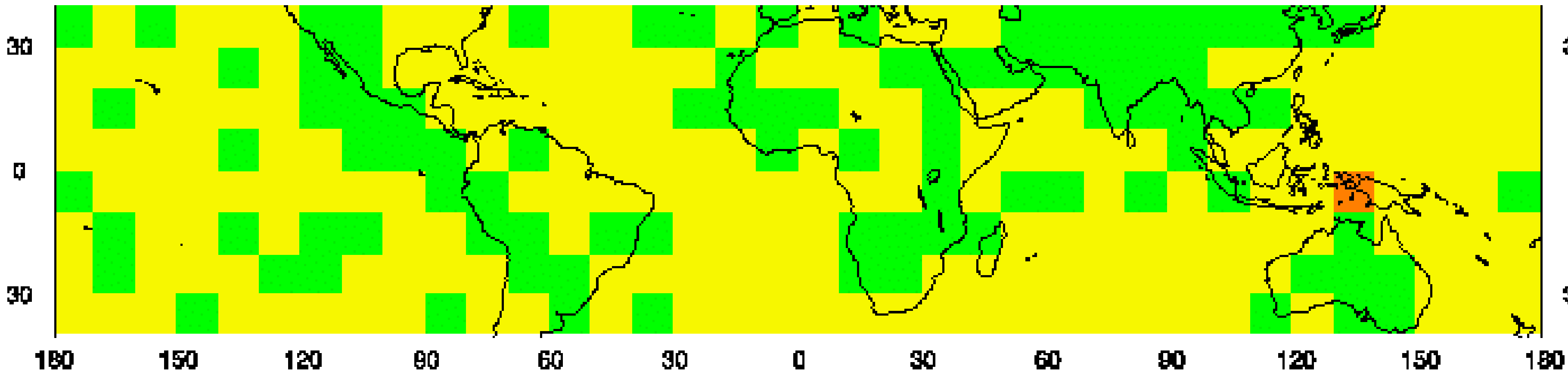
WN ADM Monthly Mean Regional Flux Biases

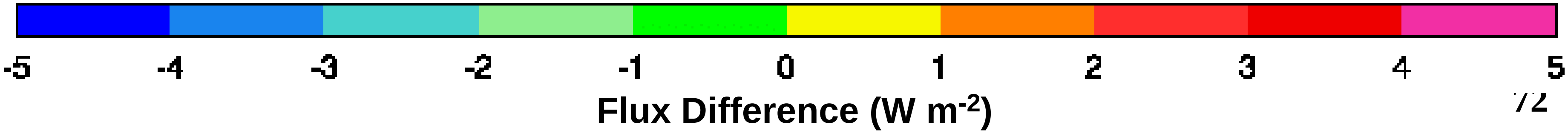
(Jan, Feb, Mar 1998)

SSF Ed2 – DI Flux Difference ($\theta < 50°$)



SSF Ed2 – DI Flux Difference ($\theta < 70°$)

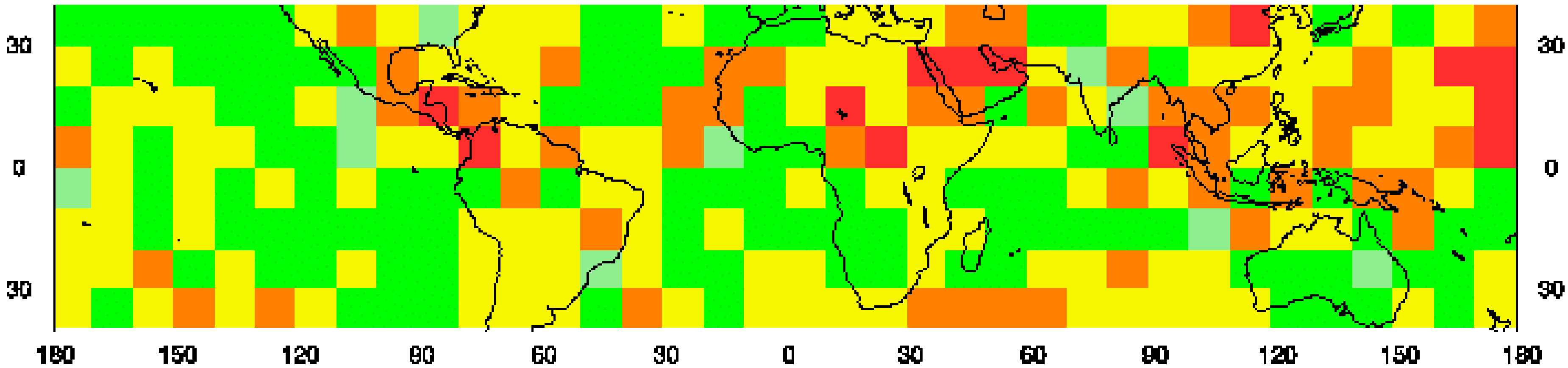




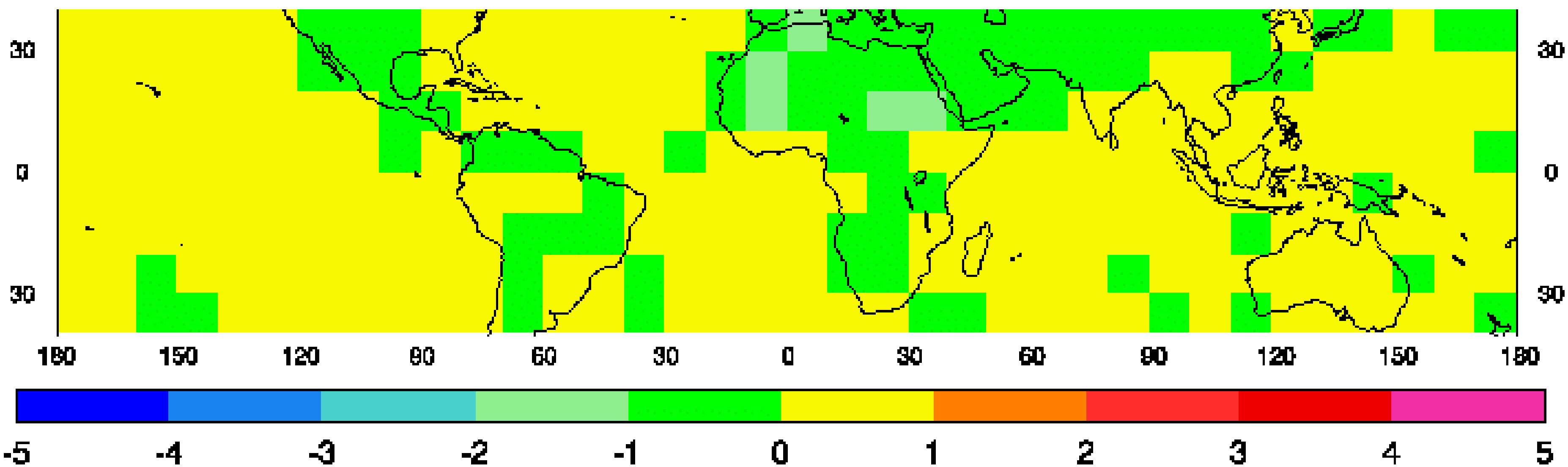
WN ADM Monthly Mean Regional Flux Biases

(Jun, Jul, Aug 1998)

SSF Ed2 – DI Flux Difference ($\theta < 50°$)



SSF Ed2 – DI Flux Difference ($\theta < 70°$)



Flux Difference (W m^{-2})

SSF Edition 2 ADM Regional WN Flux Biases: Daytime

(10°×10° regions)

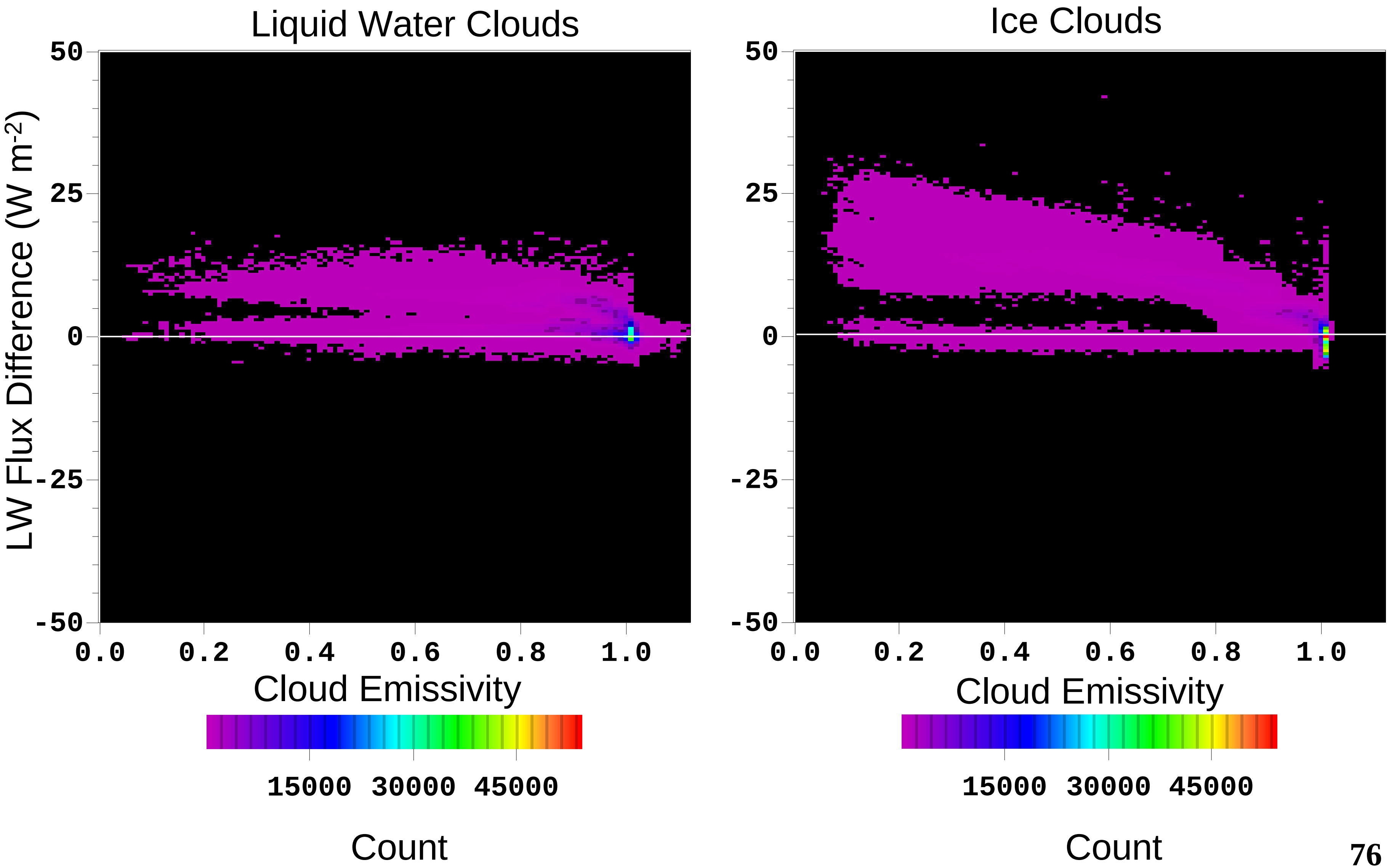
(W m^{-2})

	Jan-Mar		Jun-Aug	
θ-Range	Δ	σ_Δ	Δ	σ_Δ
$\theta < 50°$	0.48	0.79	0.33	0.87
$\theta < 70°$	0.07	0.27	0.03	0.32
CERES GOAL	-	-	-	-

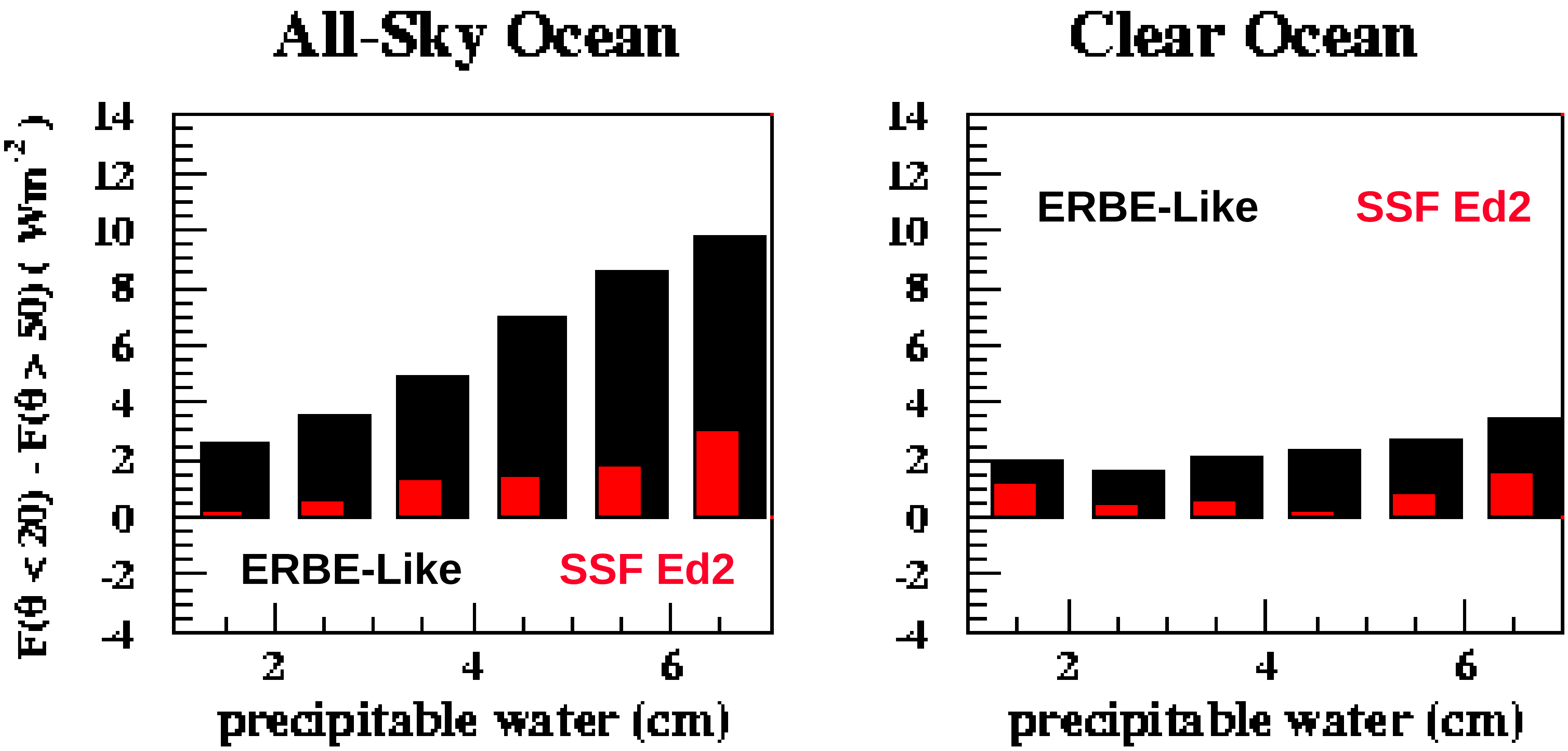
SSF Edition 2 ADM Regional WN Flux Biases: Nighttime
(10°×10° regions)
($W\ m^{-2}$)

	Jan-Mar		Jun-Aug	
θ-Range	Δ	σ_{Δ}	Δ	σ_{Δ}
$\theta < 50°$	0.34	0.66	0.25	0.86
$\theta < 70°$	0.23	0.22	0.25	0.18
CERES GOAL	-	-	-	-

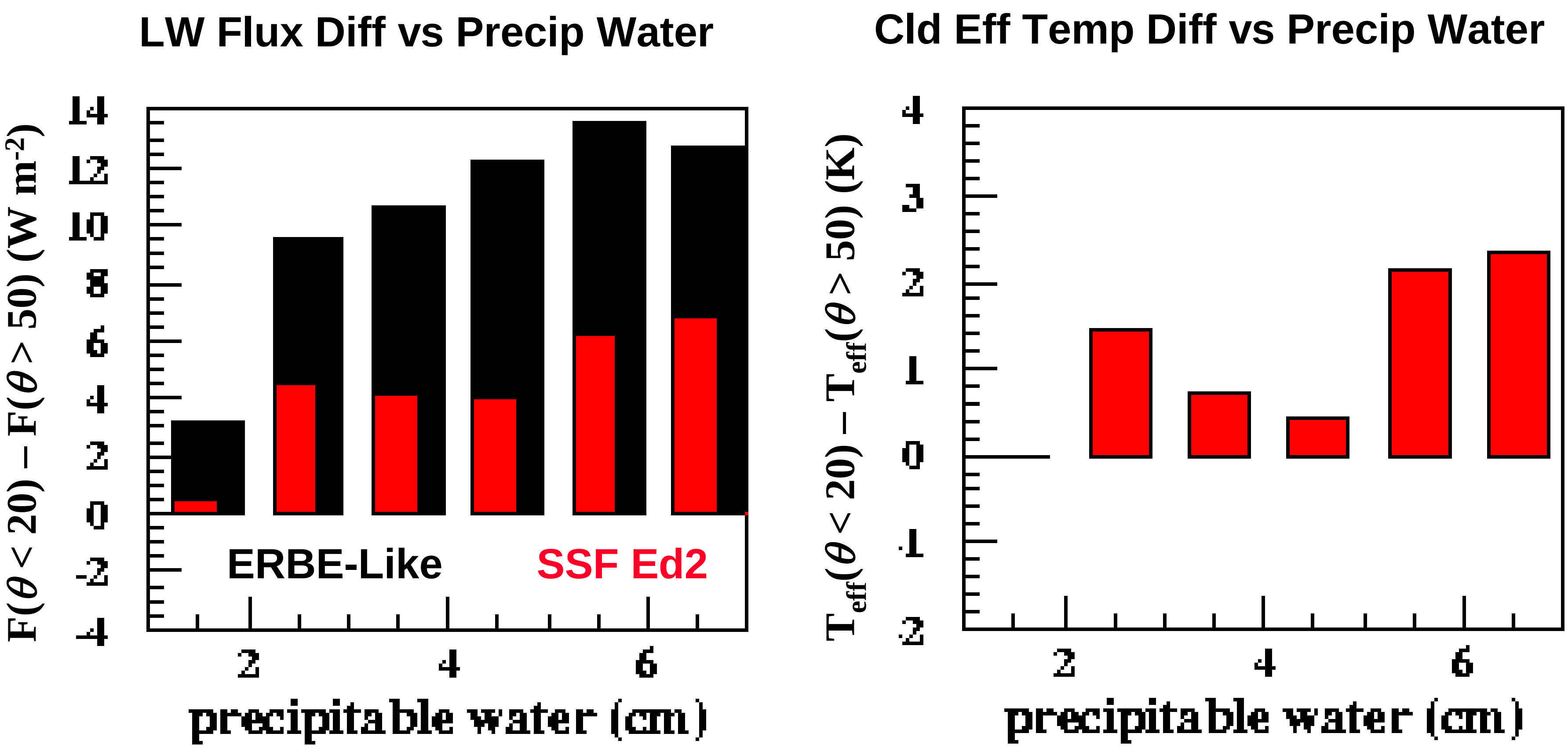
ERBE-Like – SSF Ed2 LW Flux Difference vs Cloud Emissivity
(Overcast; Ocean; θ < 25°; 90 days)



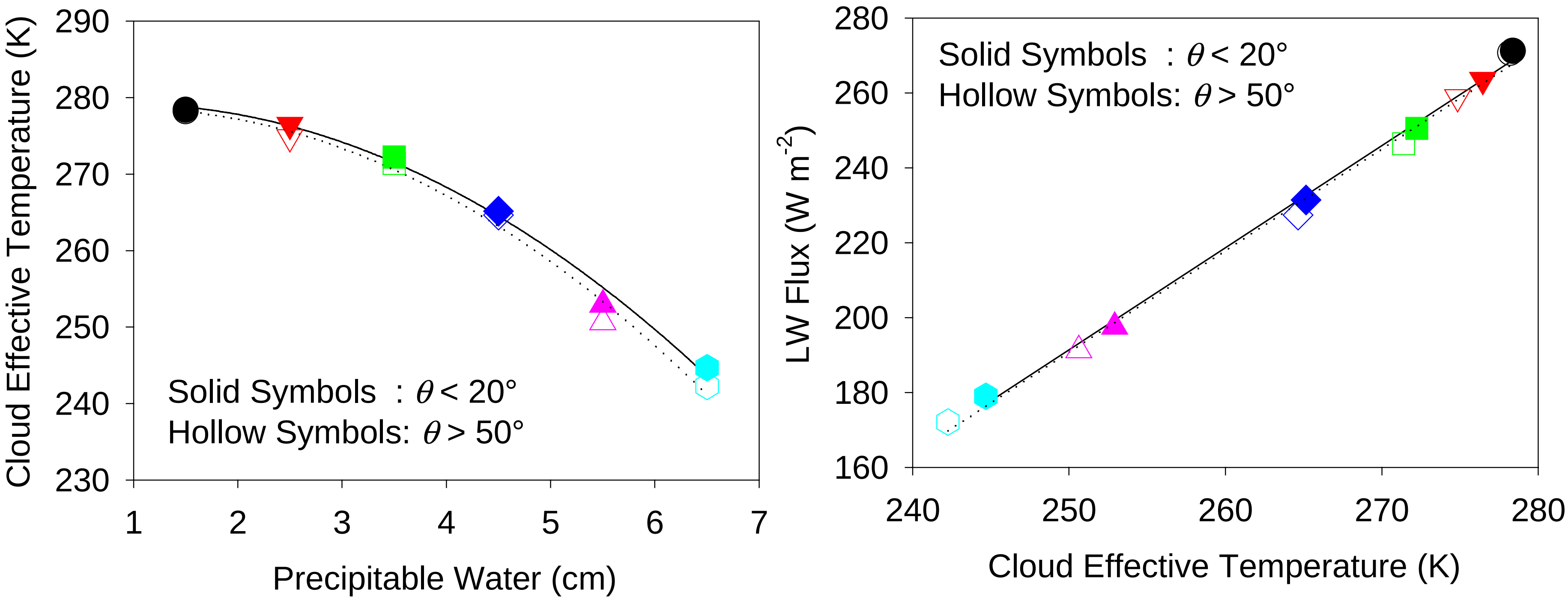
LW Flux Difference [F(θ < 20)-F(θ > 50)] vs Precipitable Water (20°S – 20°N)



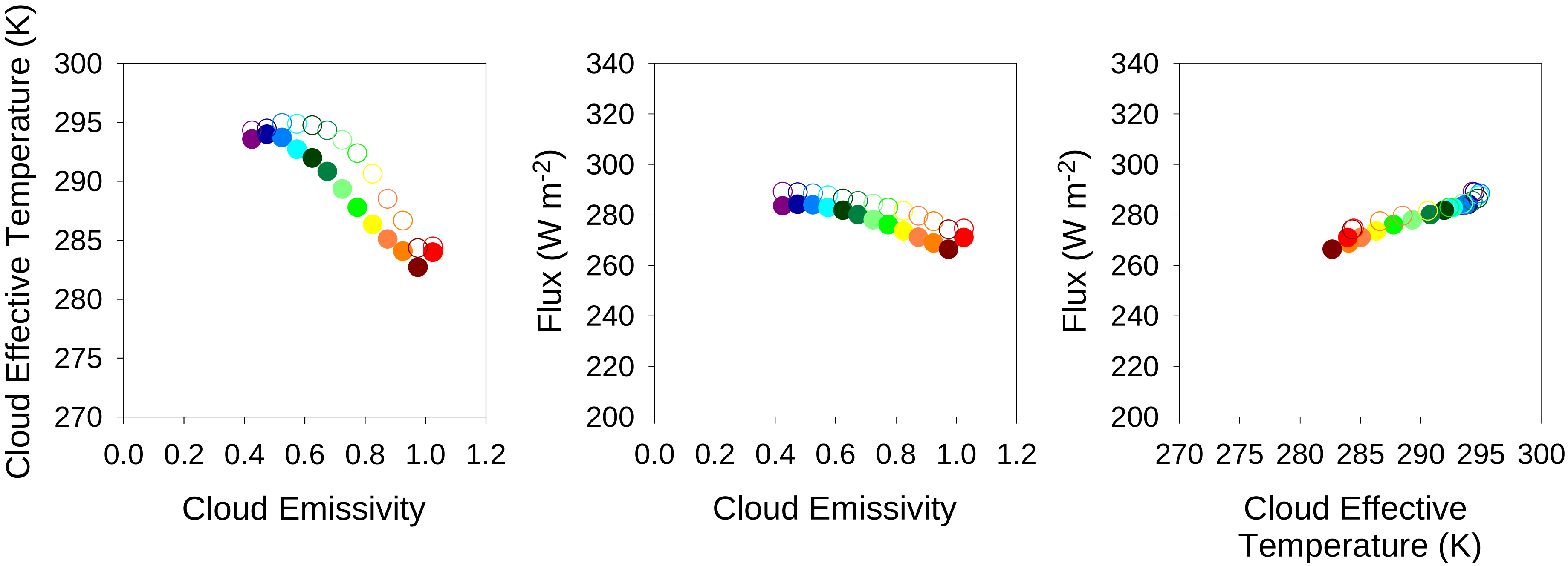
Overcast Ocean (20°S – 20°N)



Overcast Ocean (20S - 20N)

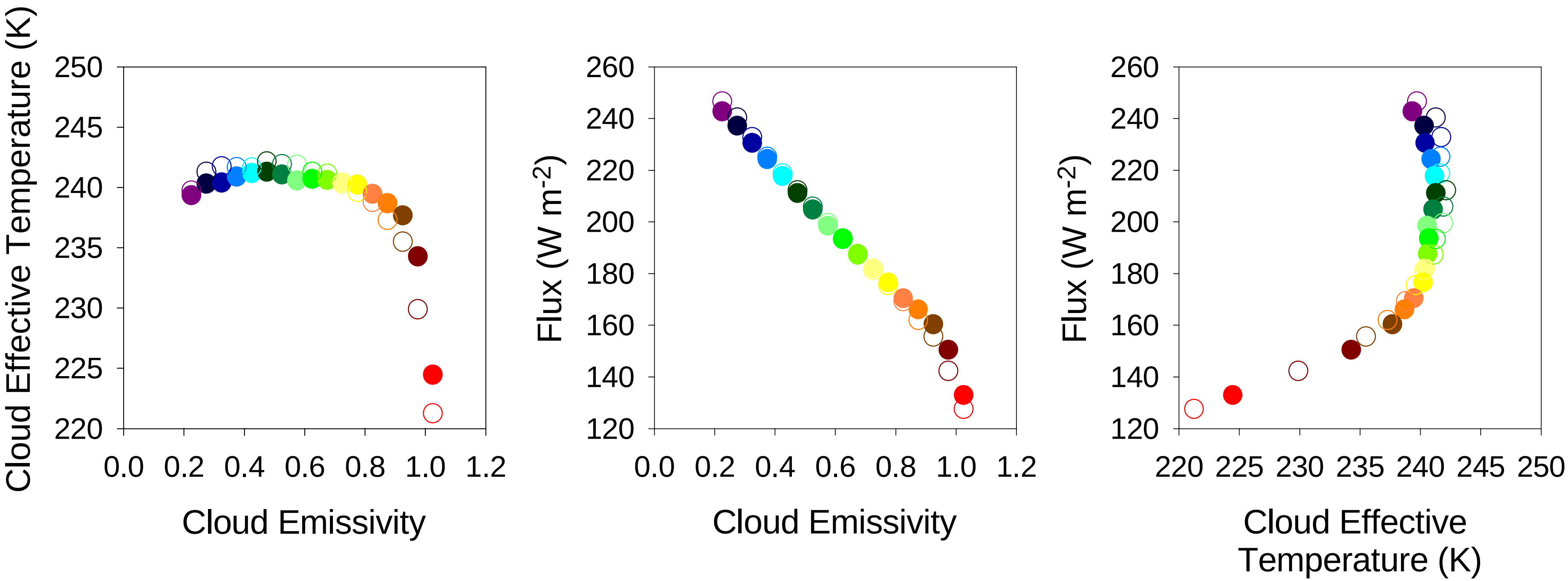


SSF Ed2 LW Flux As Function of Cloud Effective Temperature and Emissivity (Overcast Liquid Water Clouds over Ocean; 20S - 20N)



Solid Symbols : $\theta < 20°$
Hollow Symbols: $\theta > 50°$

SSF Ed2 LW Flux As Function of Cloud Effective Temperature and Emissivity (<u>Overcast Ice Clouds</u> over Ocean; 20S - 20N)



Solid Symbols : $\theta < 20°$

Hollow Symbols: $\theta > 50°$

Summary and Conclusions

- CERES/TRMM SSF Edition 2 Status:

• SW, LW & WN ADMs have been delivered.

• Production of Edition 2 SSFs to begin week of September 24th.

• Archival requires:

(i) Science Team approval and

(ii) Quality Summary

- Recent Changes to SSF:

• Include all CERES footprints with any VIRS coverage.

• Include footprints over hot land and desert for which VIRS IR radiance saturates.

• Change units of window channel unfiltered radiance & TOA flux to W m^{-2}.

- New ADM web page: *http://asd-www.larc.nasa.gov/Inversion*

- SW TOA Flux Validation:

- SSF Ed2 SW fluxes show less dependence on viewing geometry than ERBE-Like ($\approx$ 10% for ES8; $\approx$ 2% SSF).

- CERES goal for regional mean flux accuracy (1σ < 1 W m^{-2}) is attained provided full viewing zenith angle coverage < 70° is used. For θ < 50 °, 1σ error is 1.4 W m^{-2}.

- Near-nadir cloudy-sky SSF Ed2 fluxes larger than ERBE-Like at small optical depths and smaller at large cloud optical depths (differences up to ±75 W m^{-2} for $\theta_o \approx$ 43°).

- First estimates of instantaneous flux uncertainties from alongtrack measurements: < 10 W m^{-2} for clear scenes; ~20 W m^{-2} for overcast.

  => Further study needed with multiple CERES instruments.

- LW and WN TOA Flux Validation:

- SSF Ed2 LW fluxes show less dependence on viewing geometry than ERBE-Like (9 W m^{-2} for ES8; 1.5 W m^{-2} for Ed2).
- CERES goal for regional mean LW flux accuracy ($1\sigma < 0.5$ W m^{-2}) is almost reached. 1σ error is $\approx$ 0.56 W m^{-2} during daytime.
- Nighttime LW flux shows a 0.5 W m^{-2} mean bias with 1σ of $\approx$ 0.4 W m^{-2} .
- WN 1σ flux error is 0.3 W m^{-2} . Nighttime WN flux bias is 0.25 W m^{-2}.
- Near-nadir cloudy-sky SSF Ed2 LW fluxes are smaller than ERBE-Like at small emissivity but comparable for emissivity close to 1.0 (differences at small ε up to 25 W m^{-2}).
- SSF Ed2 LW flux errors as a function of precip water are a factor of 3-4 smaller than ERBE-Like.

Future Work (Terra)

- Increase angular resolution of ADMs.

- Land SW ADMs stratified by vegetation index.

- Empirical SW, LW and WN ADMs over snow.

- Use of multi-CERES instruments for instantaneous flux errors.

- Determine flux errors by cloud type, cloud and clear-sky parameters.

- Improve theoretical tools for ADM development and comparisons between observations and theory.