Progress in Longwave ADMs for Cloudy Skies

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Background on LW flux retrieval

- Flux retrievals are related to the anisotropic factors R_j for each scene type j by $F = \frac{\pi I_{obs}}{R_j(\theta)}$ where I_{obs} is the observed radiance and θ is the viewing zenith angle.
- R_j is related to the average LW radiance $\bar{I}_j$ and modeled LW flux F_j by

$$R_j(\theta) = \frac{\pi \bar{I}_j(\theta)}{F_j} = \frac{\pi \bar{I}_j(\theta)}{2\pi \sum_k \bar{I}_j(\theta_k)\cos(\theta_k)\sin(\theta_k)\Delta\theta_k}$$

Pseudoradiance

- Currently, an empirical relationship between ψ (pseudoradiance) and radiance is determined for each VZA, PW, T_{sfc}, ΔT_{sc} ,and f bin (Loeb et al. 2005). ψ is given by

$$\psi = (1-f)\varepsilon_s B(T_s) + \sum_{j=1}^{2}[\varepsilon_s B(T_s)(1-\varepsilon_{c_j}) + \varepsilon_{c_j} B(T_{c_j})]f_j$$

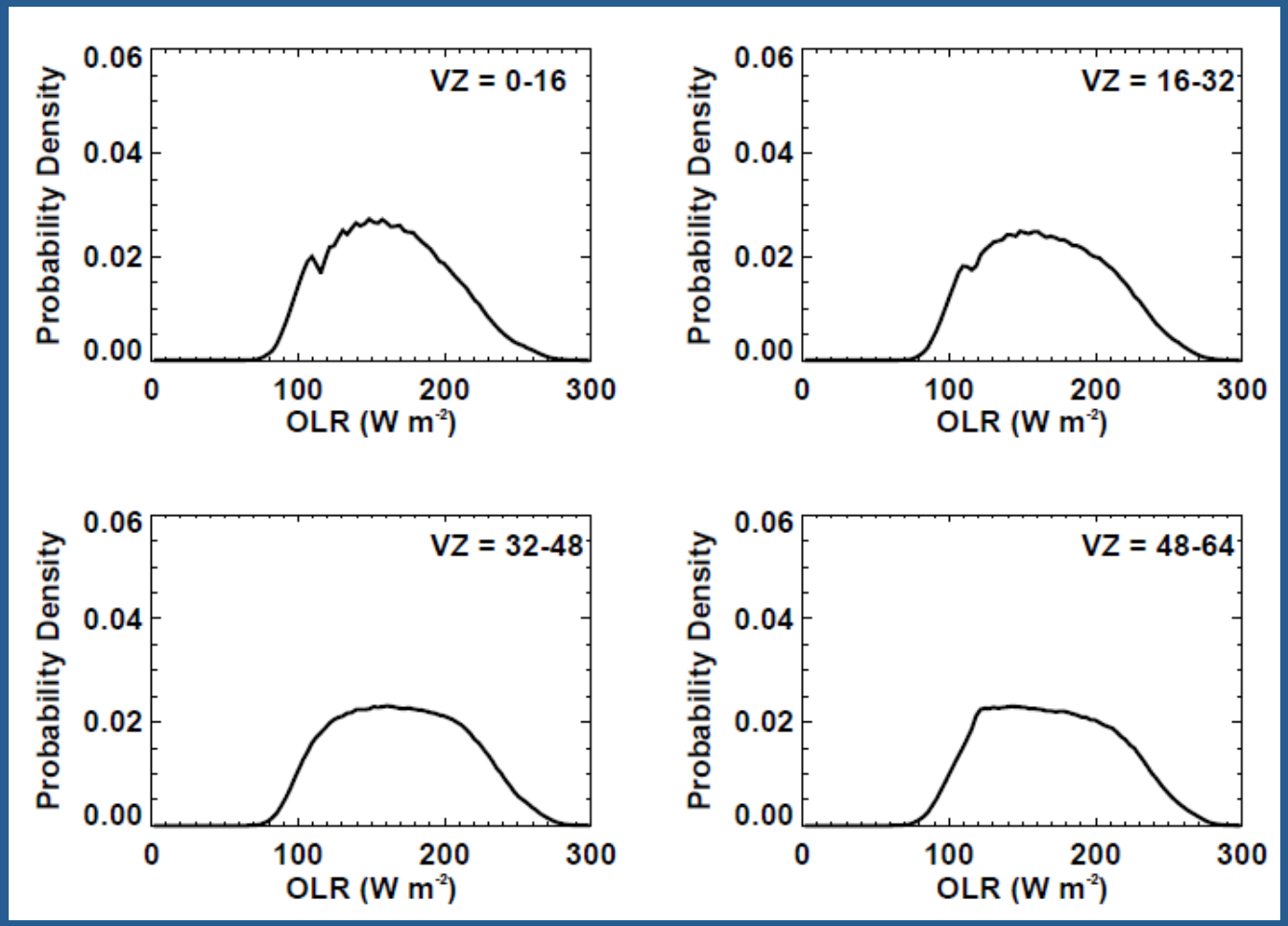
Normalized RMS, relative bias calculated for each 1x1 grid cell

Note: results are not necessarily applicable to fluxes!

$$RMS = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{I_i^m}{\bar{I}^m} - \frac{I_i^o}{\bar{I}^o}\right)^2}$$

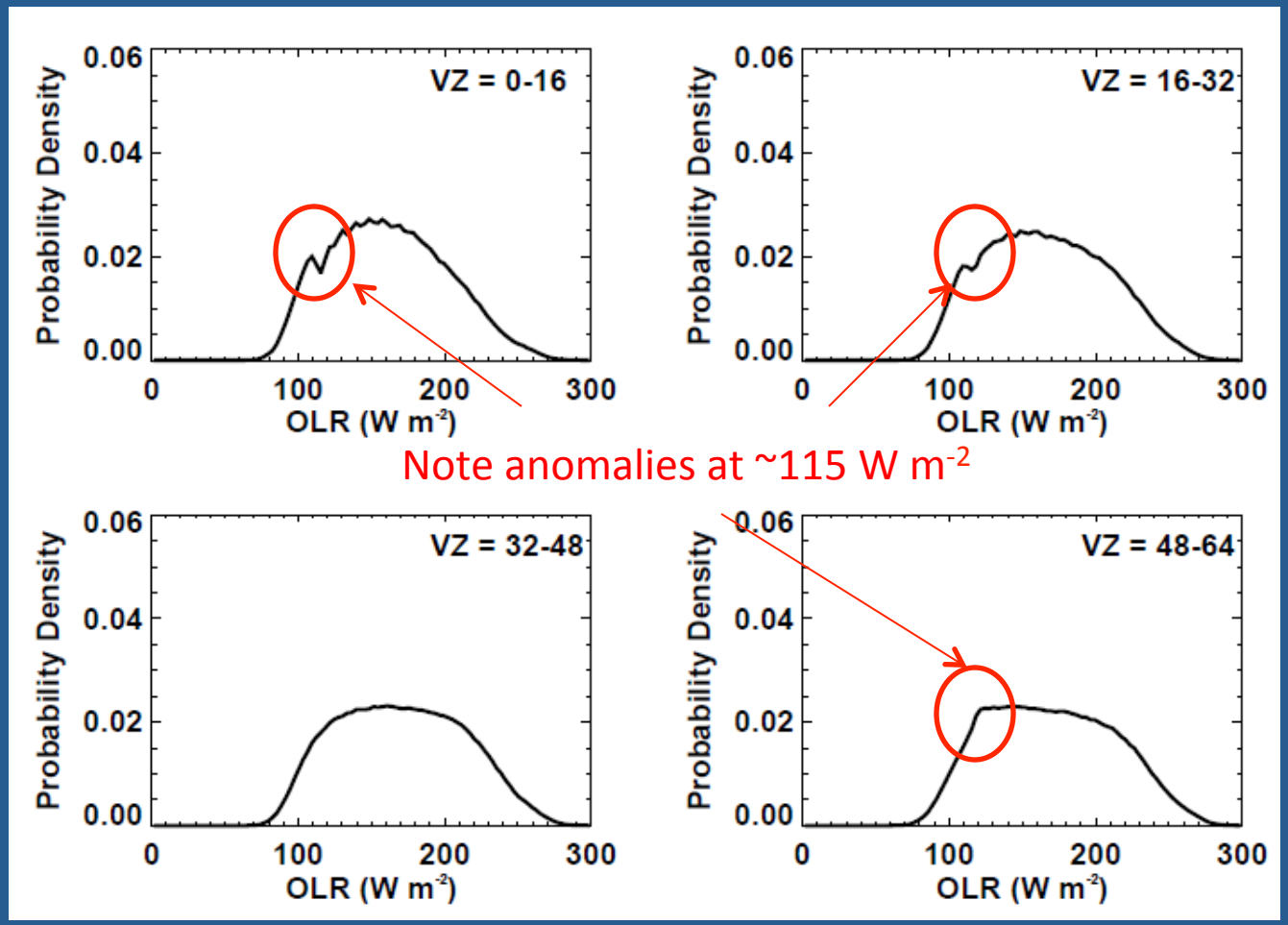
$$B_{rel} = \frac{\bar{I}_m - \bar{I}_o}{\bar{I}_o}$$

OLR retrievals

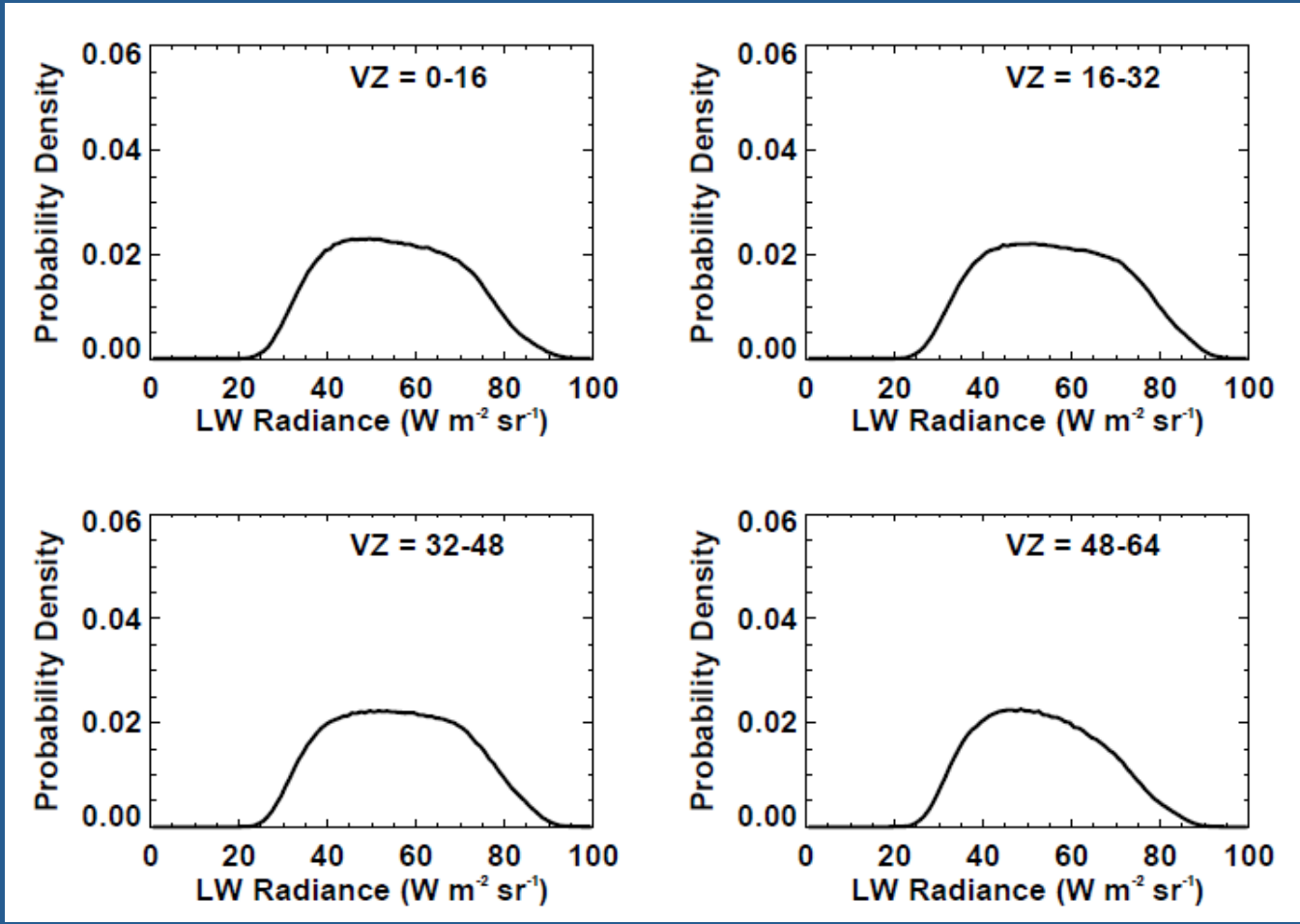


Overcast clouds over ocean with Ts=300-305 K, PW > 5 cm

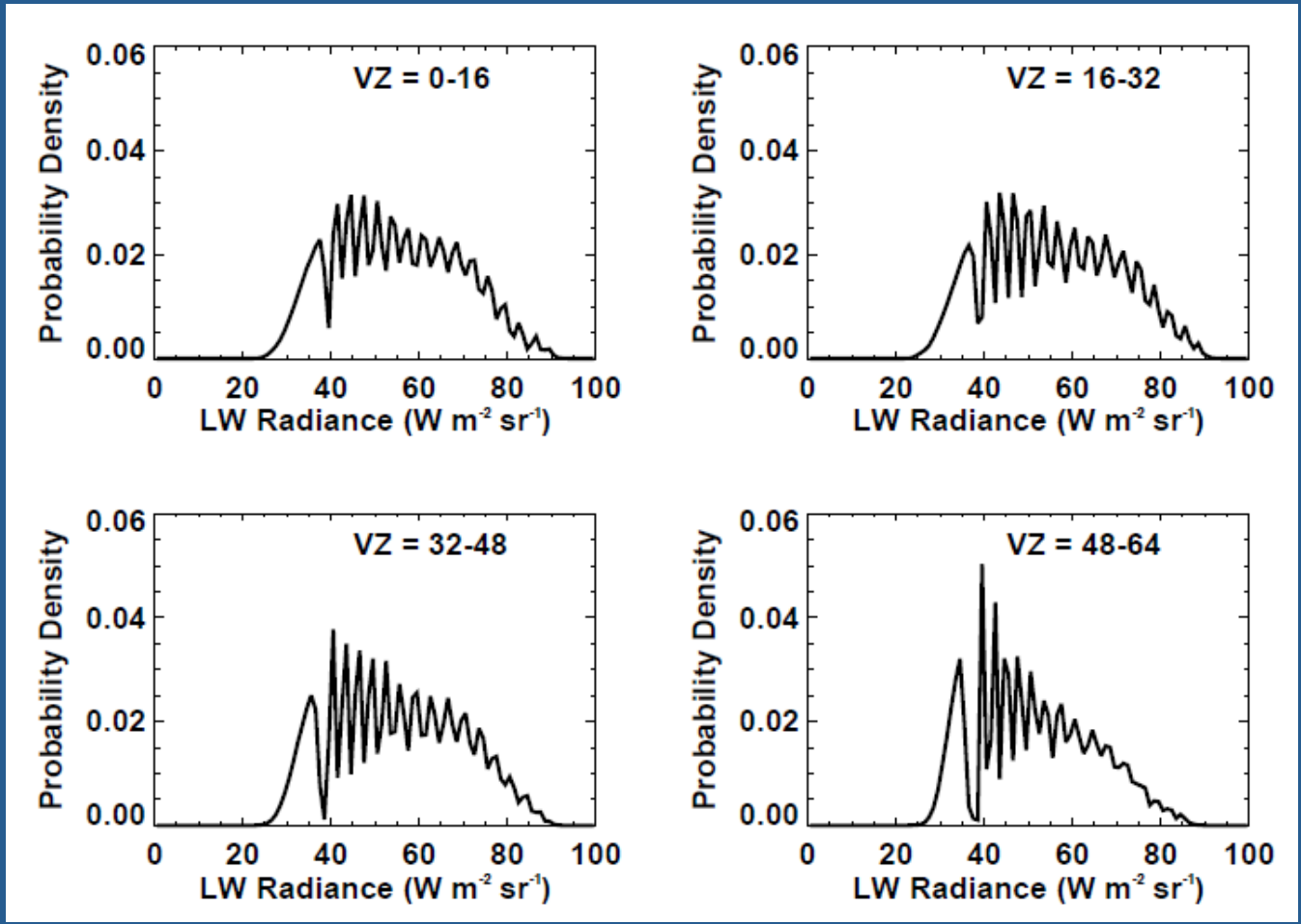
OLR retrievals



No sign of anomalies in observed radiances

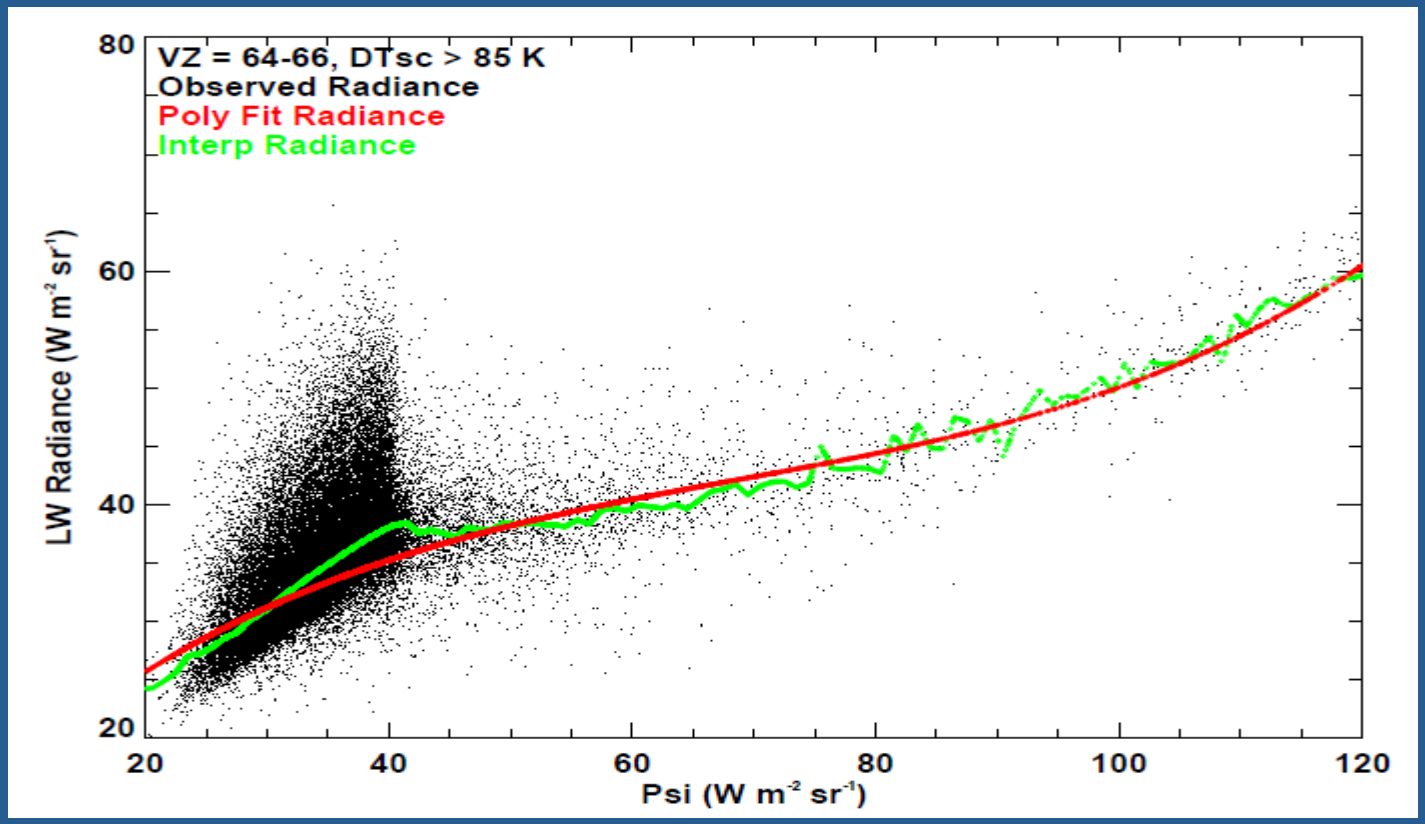


Big spikes in distributions of fitted radiances

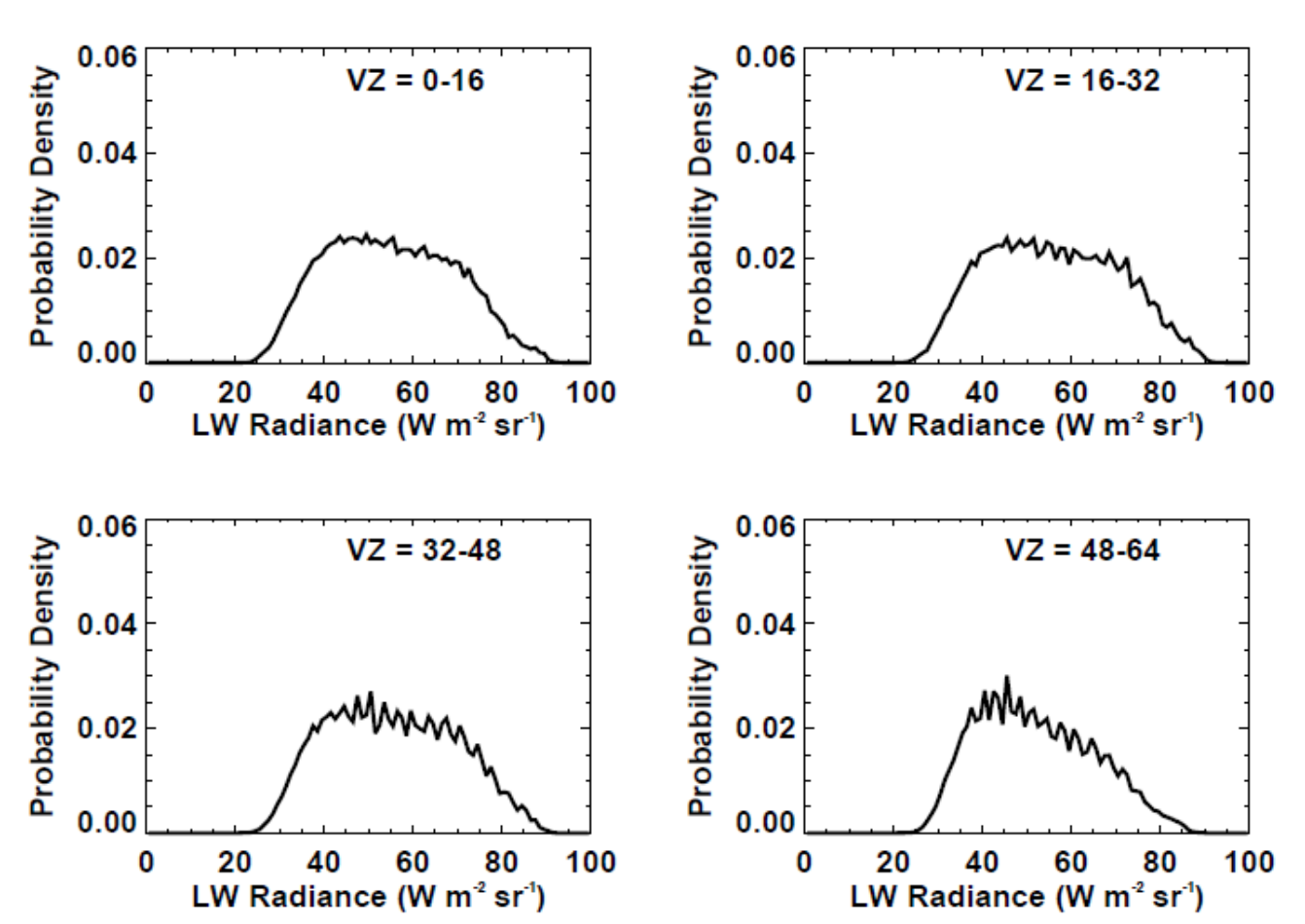


Polynomial fit vs. Mean value method

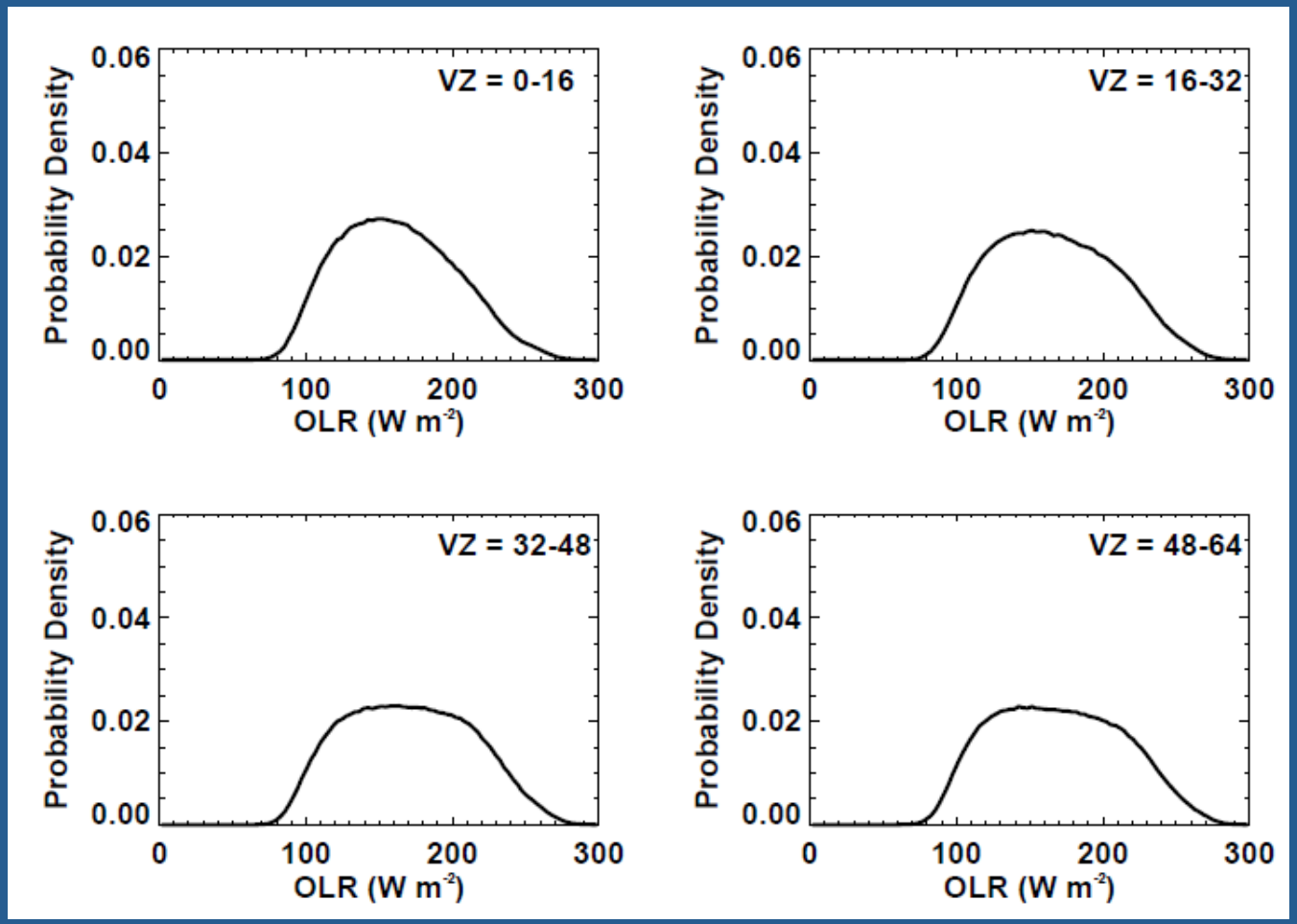
- As an alternative, we simply use the mean radiance (if it exists) for each 1 W m^{-2} sr^{-1} interval of ψ, and using a linear interpolation between bin centers. When the mean radiance does not exist, the polynomial fit is used as a backup. Currently 22 ΔT bins (-15K, -10K, … >85K).



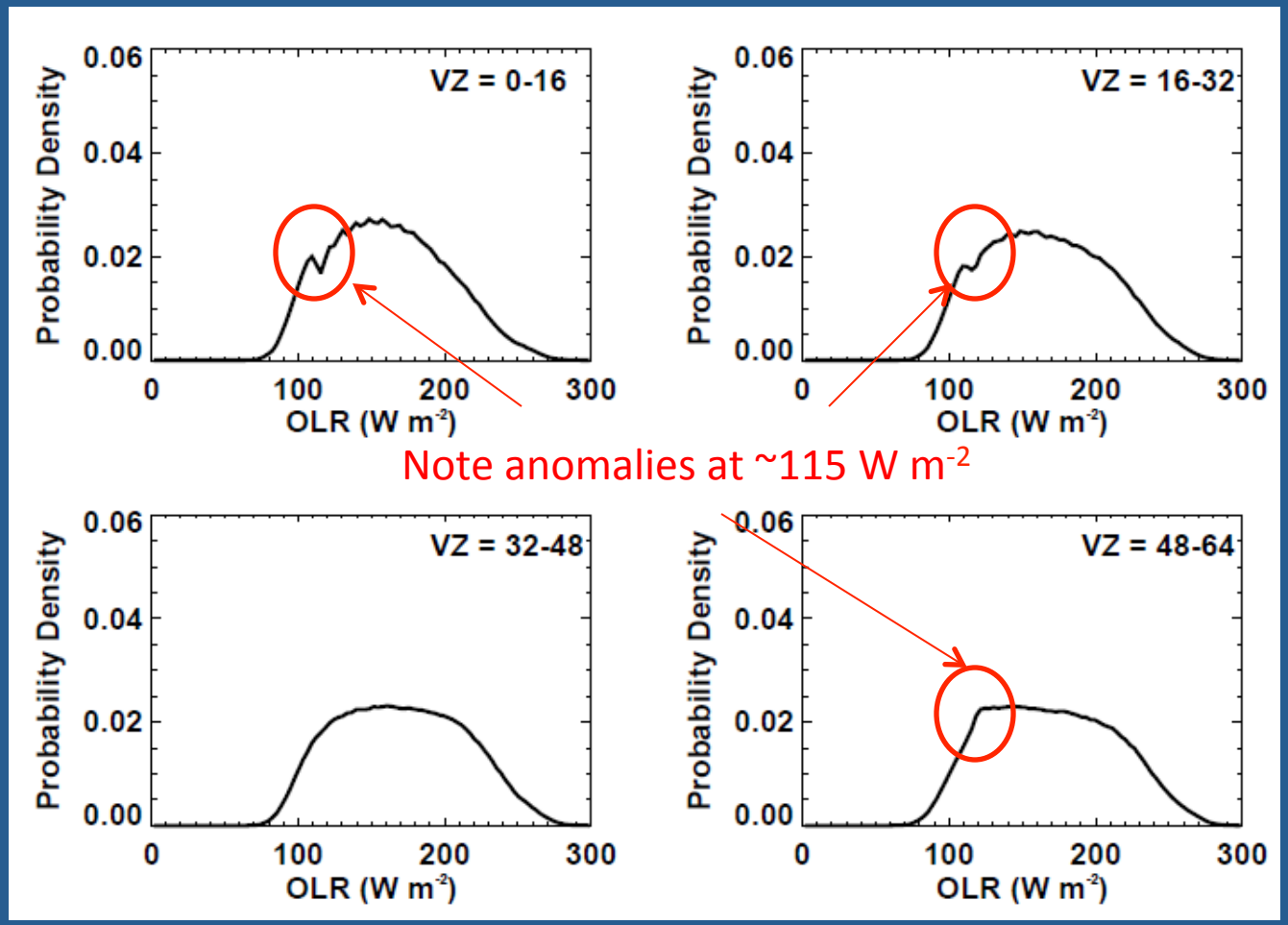
With interpolation, modeled radiances have much smoother distributions.



OLR retrievals using interpolation

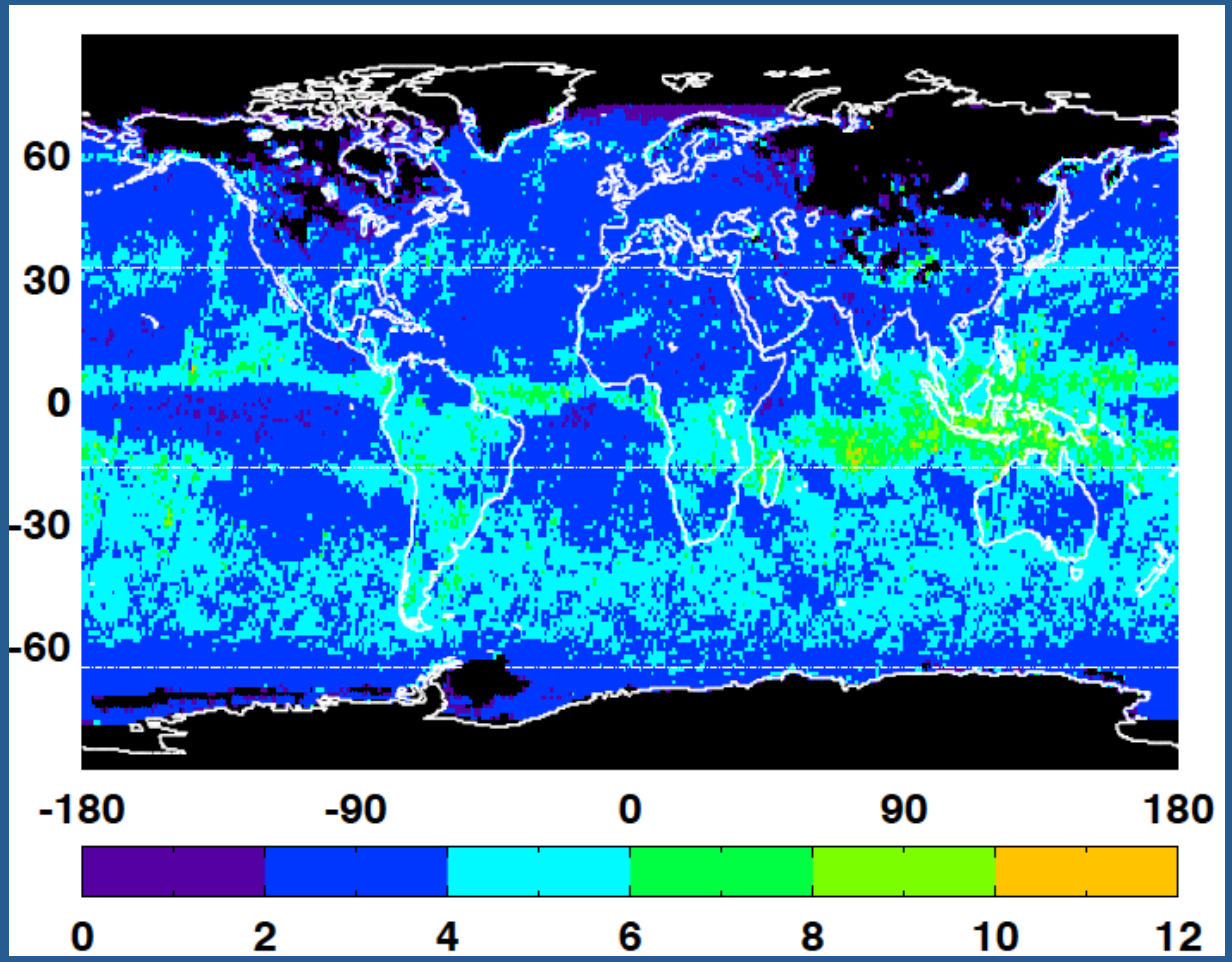


OLR retrievals using polynomial fit



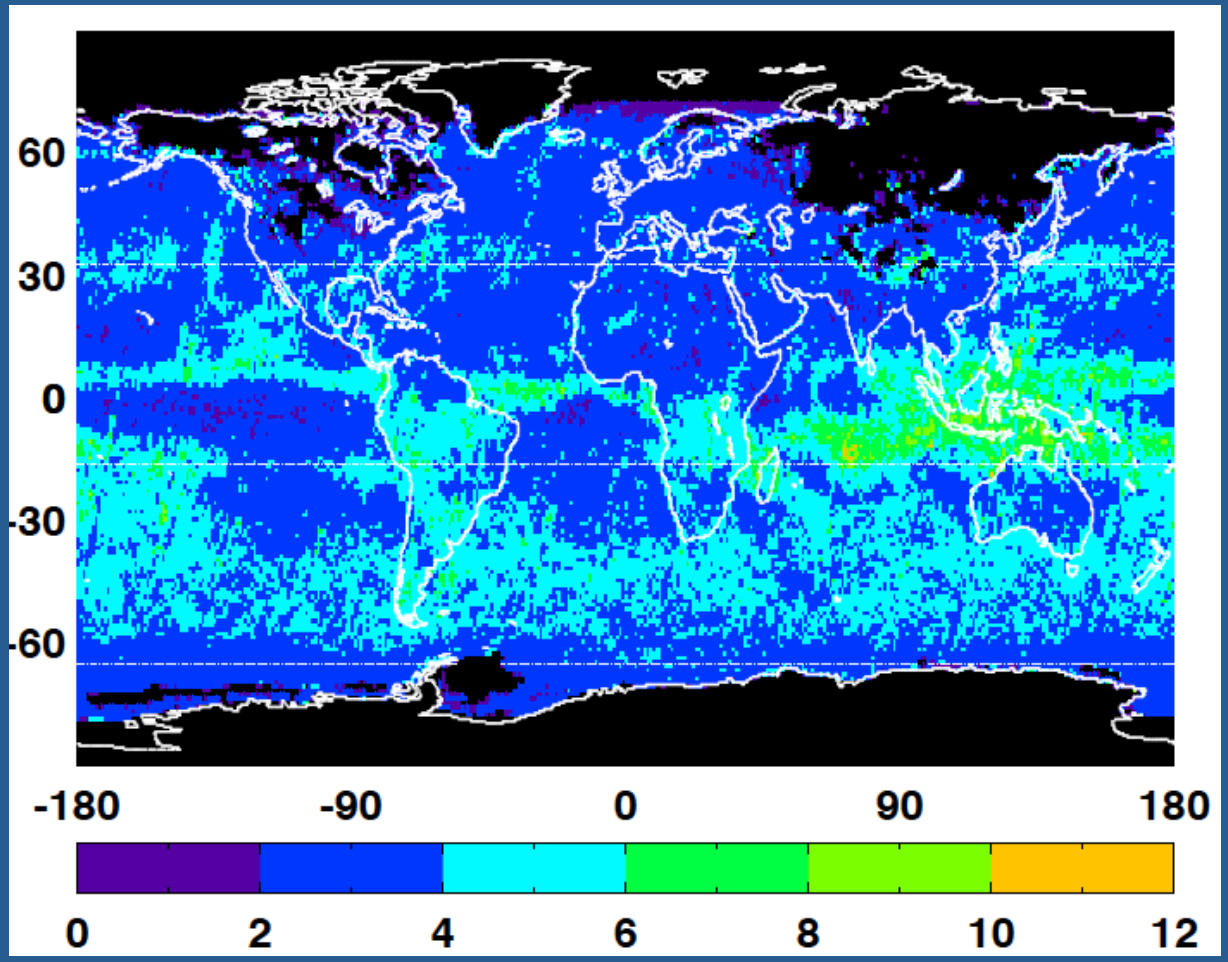
Results: Modeled Radiances

Edition 4 SSFs with Updated Edition 2 ADMs
Jan 2001 Daytime Normalized RMS (%)



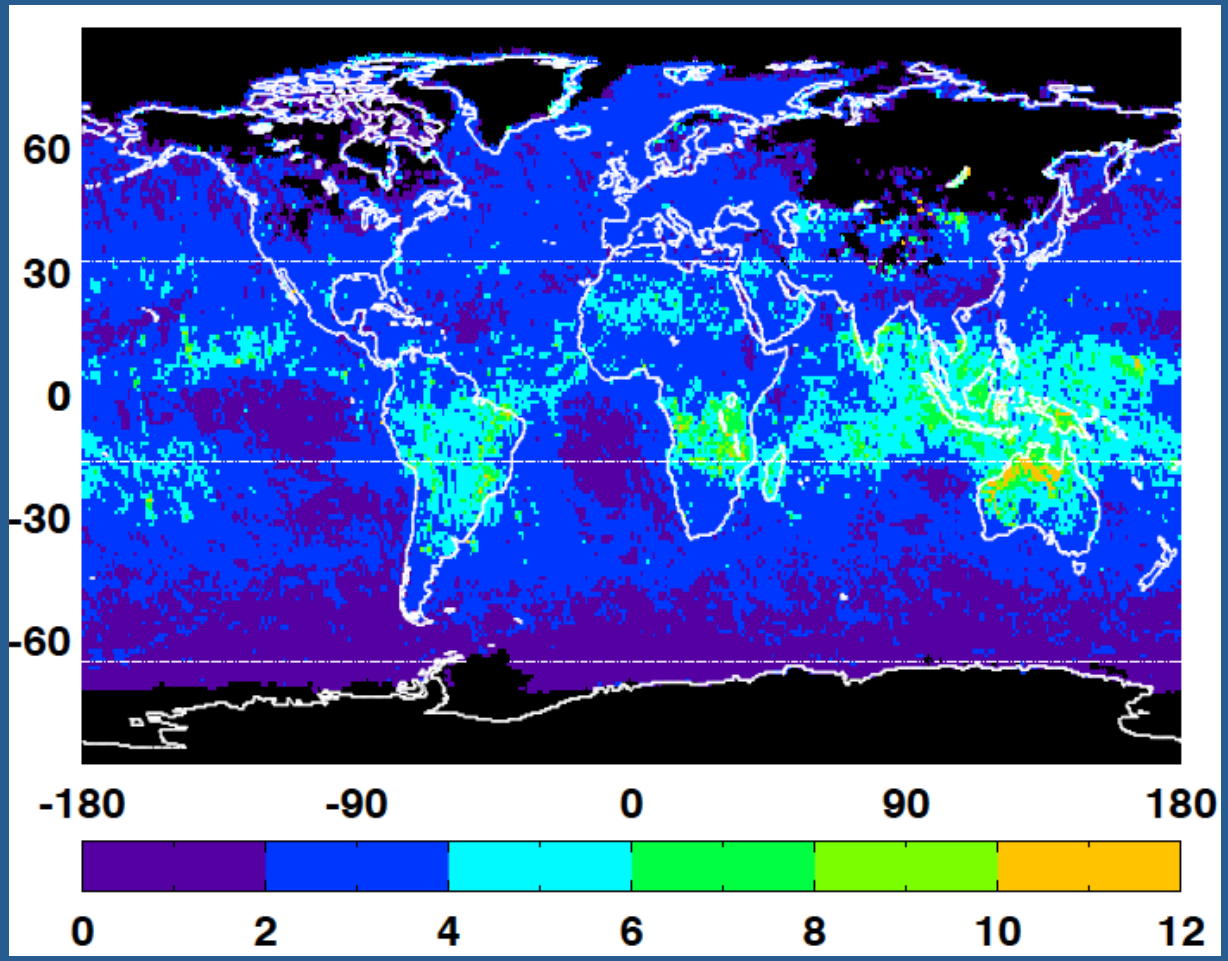
Avg RMS = 3.8%

Edition 4 SSFs with Edition 4 ADMs
Jan 2001 Daytime Normalized RMS (%)



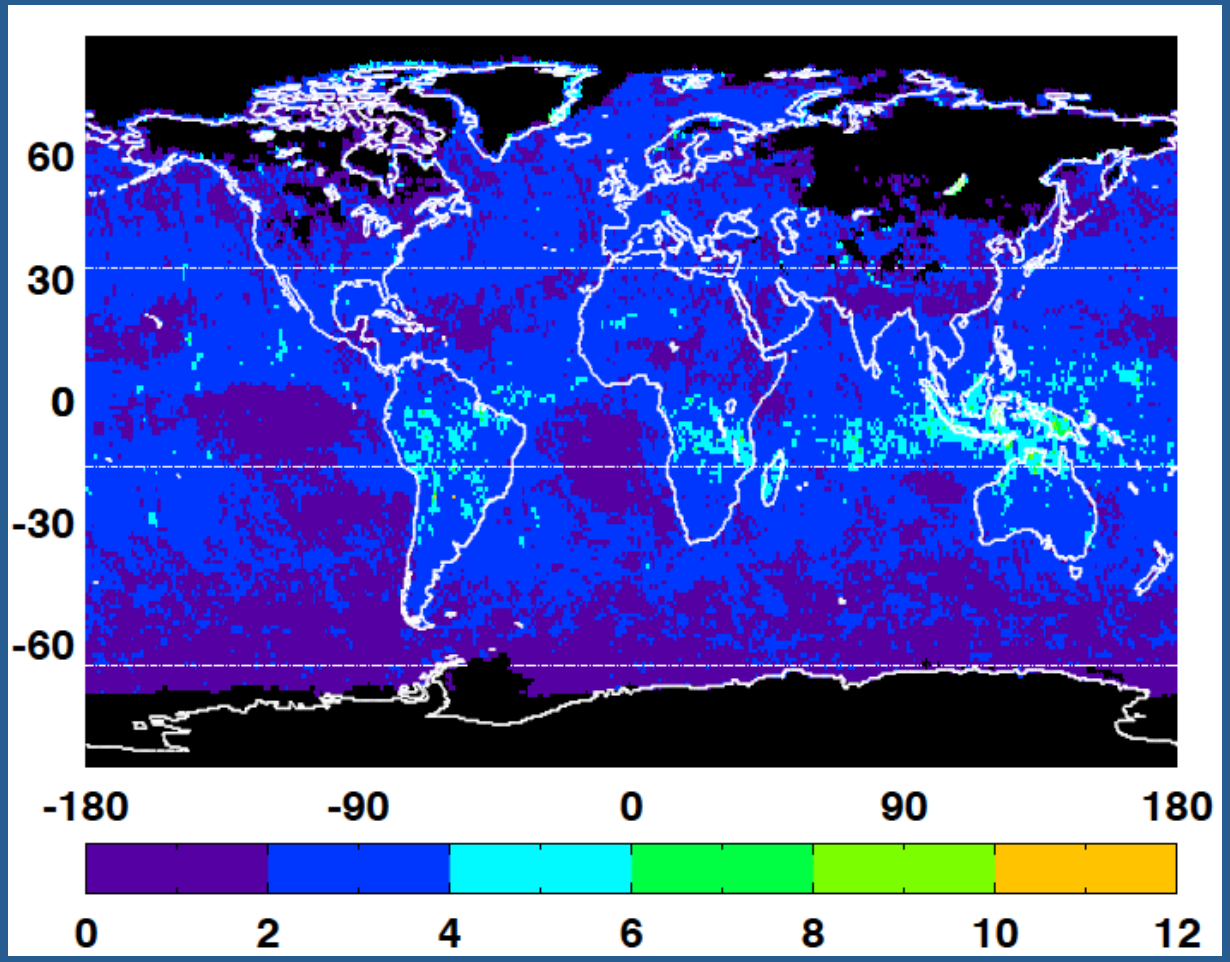
Avg RMS = 3.8%

Edition 4 SSFs with Updated Edition 2 ADMs
Jan 2001 Nighttime Normalized RMS (%)



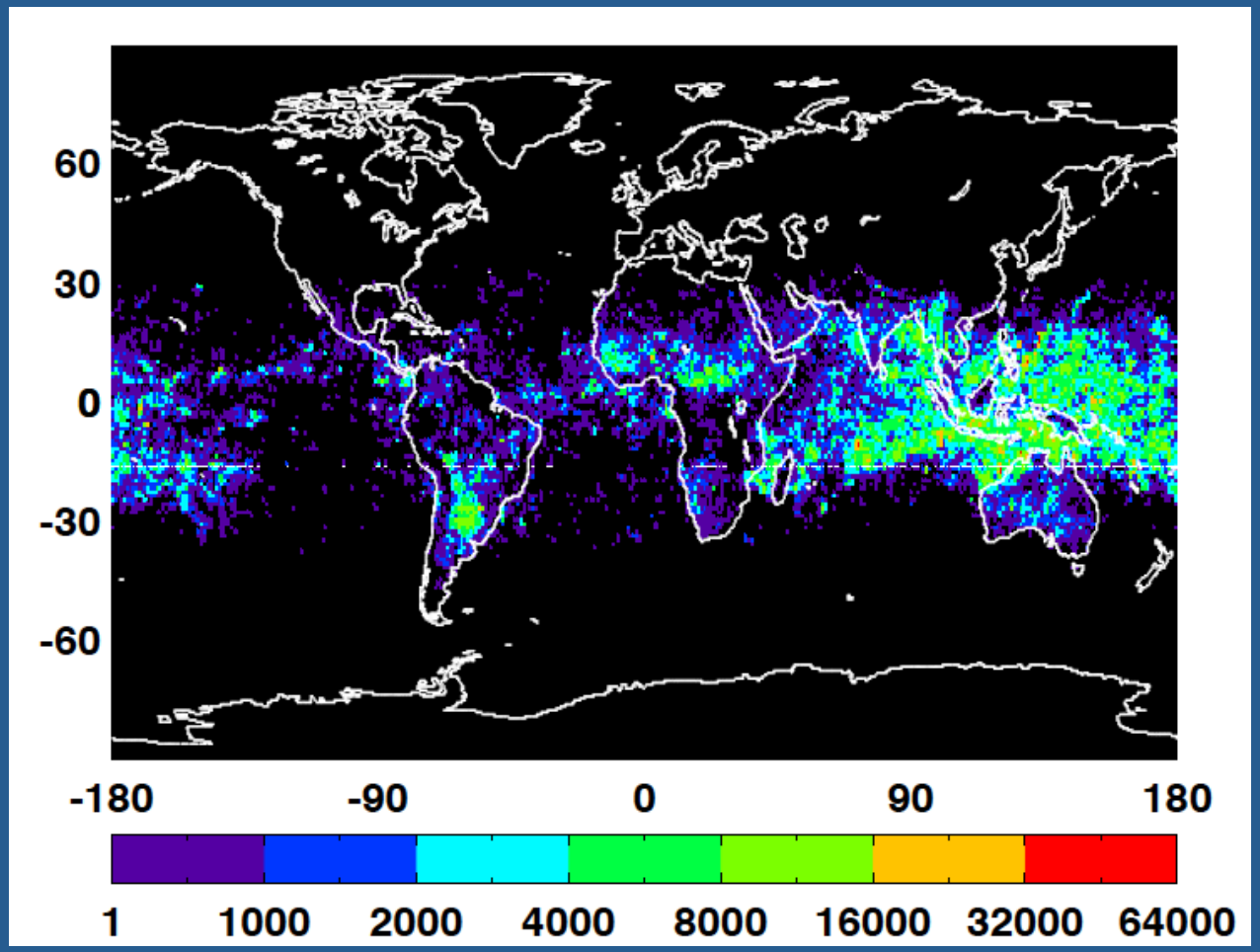
Avg RMS = 2.8%

Edition 4 SSFs with Edition 4 ADMs
Jan 2001 Nighttime Normalized RMS (%)

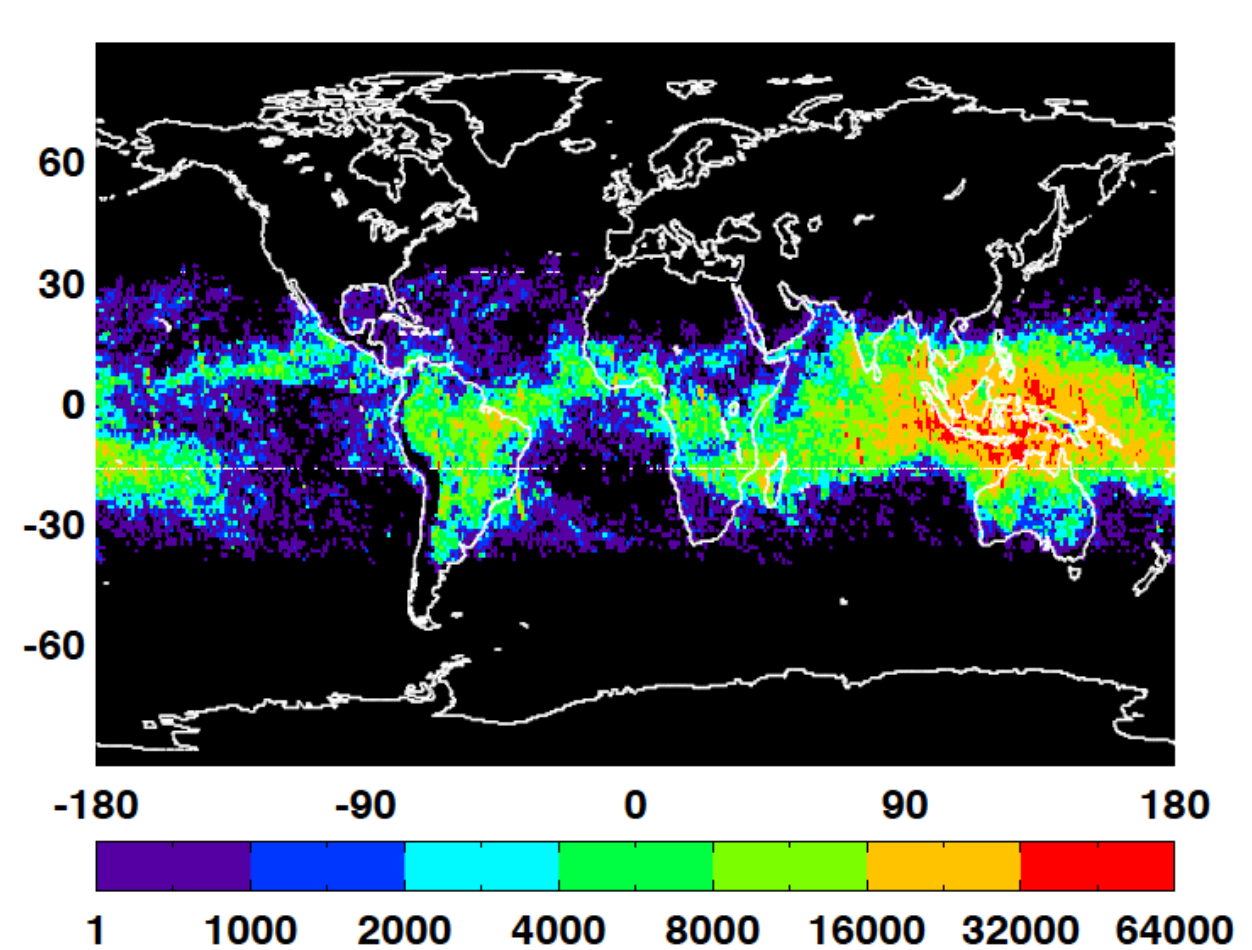


Avg RMS = 2.4%

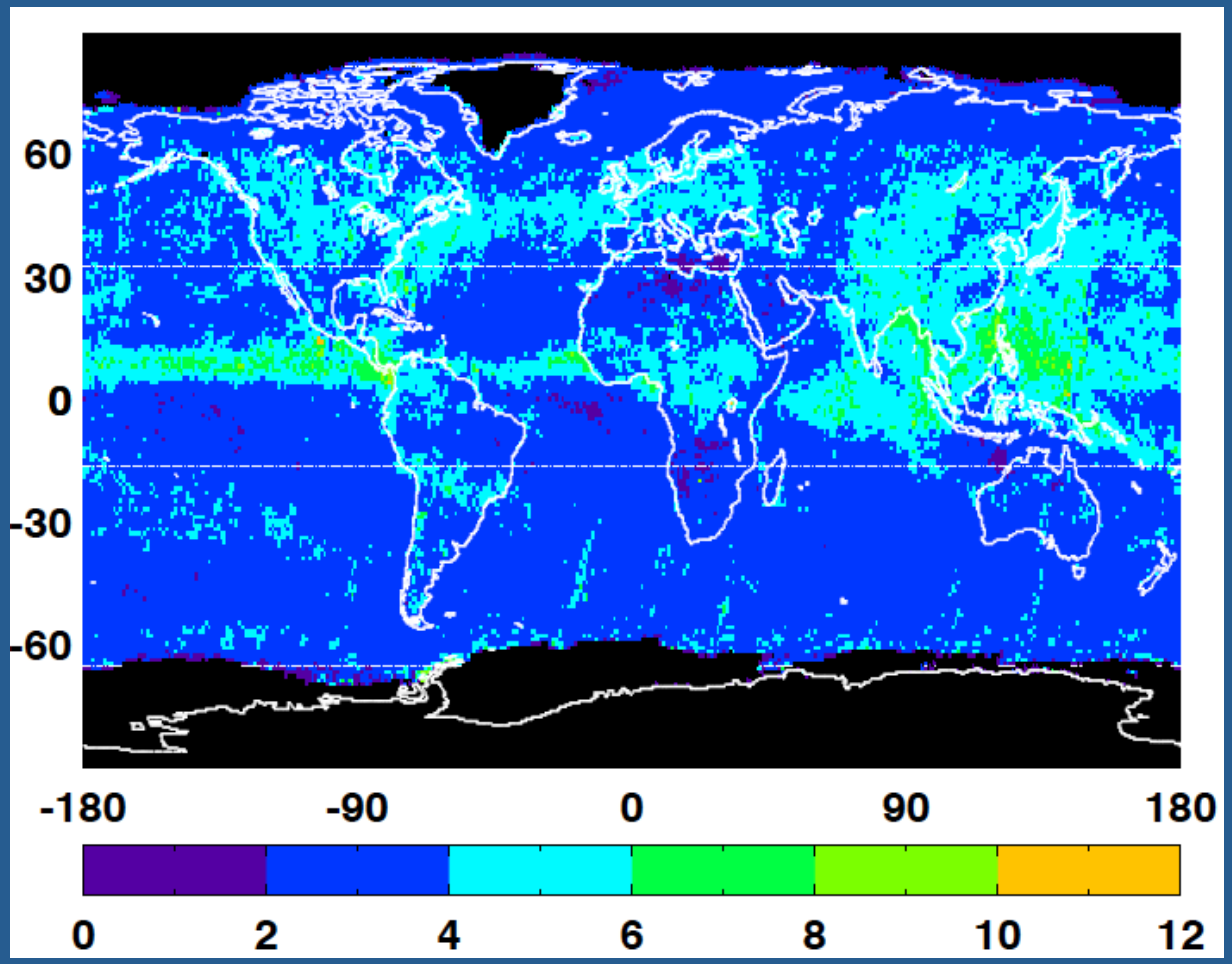
Edition 4 SSFs with Edition 4 ADMs
Jan 2001 Daytime # of samples with ΔT_{sc} > 85K



Edition 4 SSFs with Edition 4 ADMs
Jan 2001 Nighttime # of samples with ΔT_{sc} > 85K

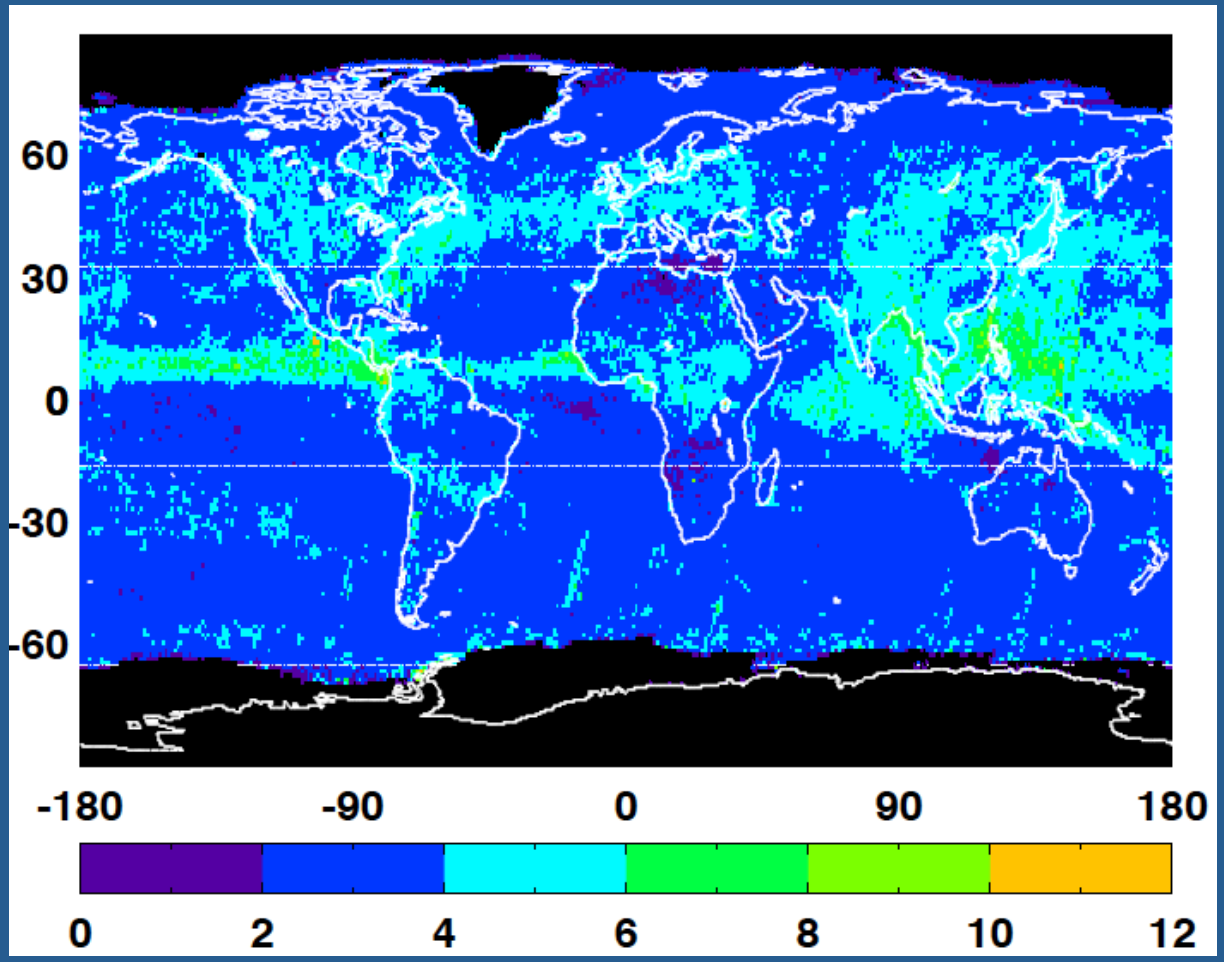


Edition 4 SSFs with Updated Edition 2 ADMs
Jul 2000 Daytime Normalized RMS (%)



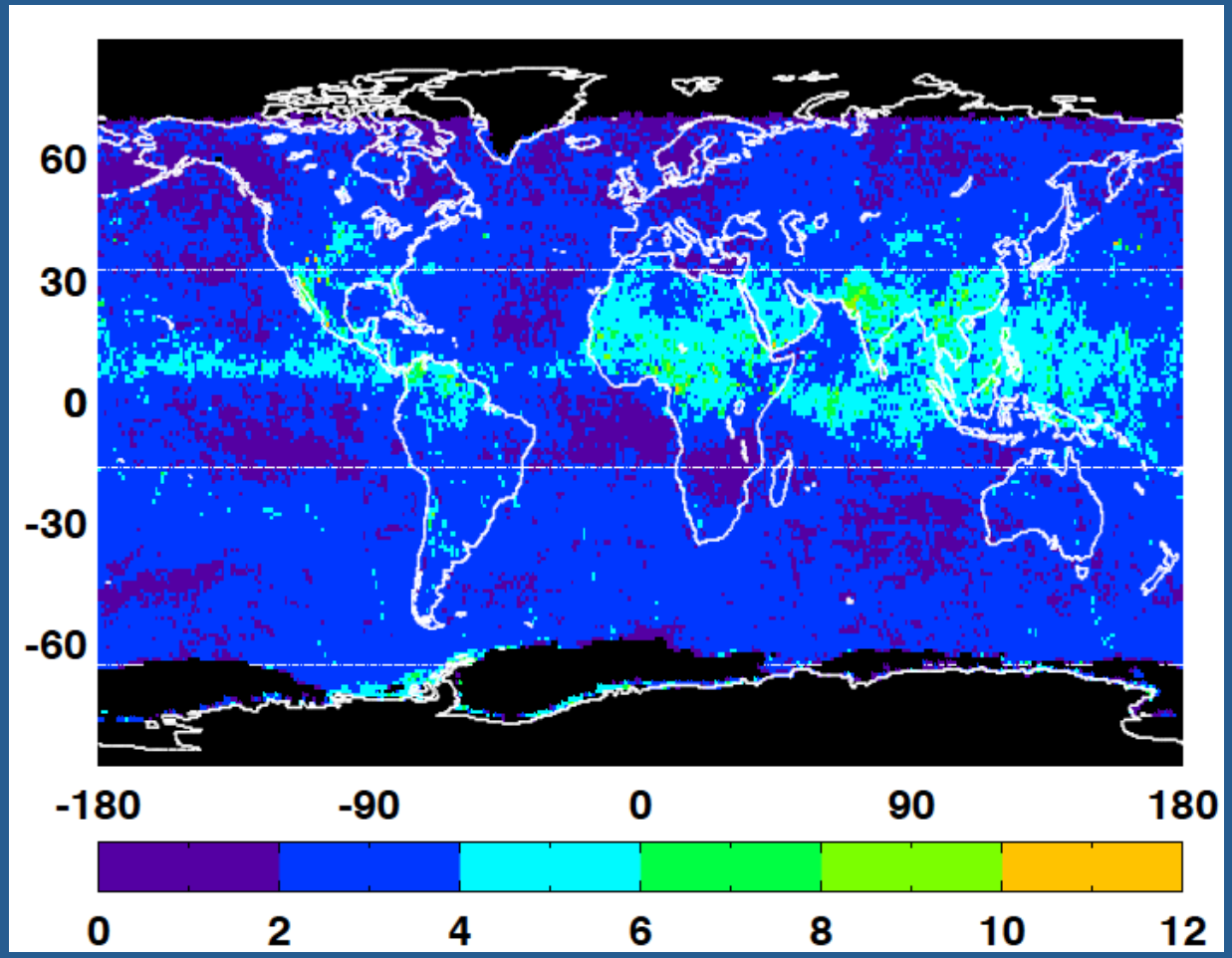
Avg RMS = 3.6%

Edition 4 SSFs with Edition 4 ADMs
Jul 2000 Daytime Normalized RMS (%)



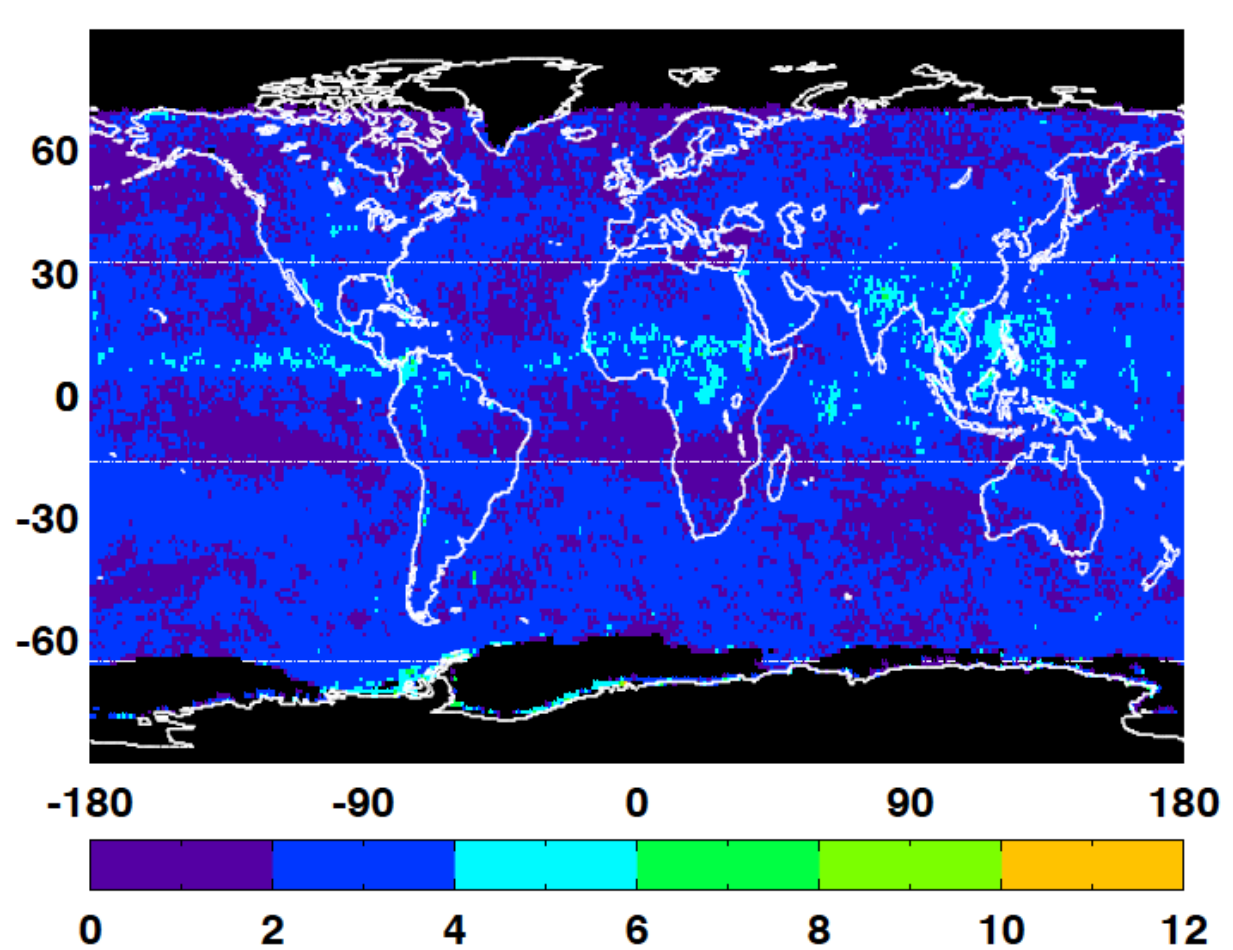
Avg RMS = 3.6%

Edition 4 SSFs with Updated Edition 2 ADMs
Jul 2000 Nighttime Normalized RMS (%)



Avg RMS = 2.8%

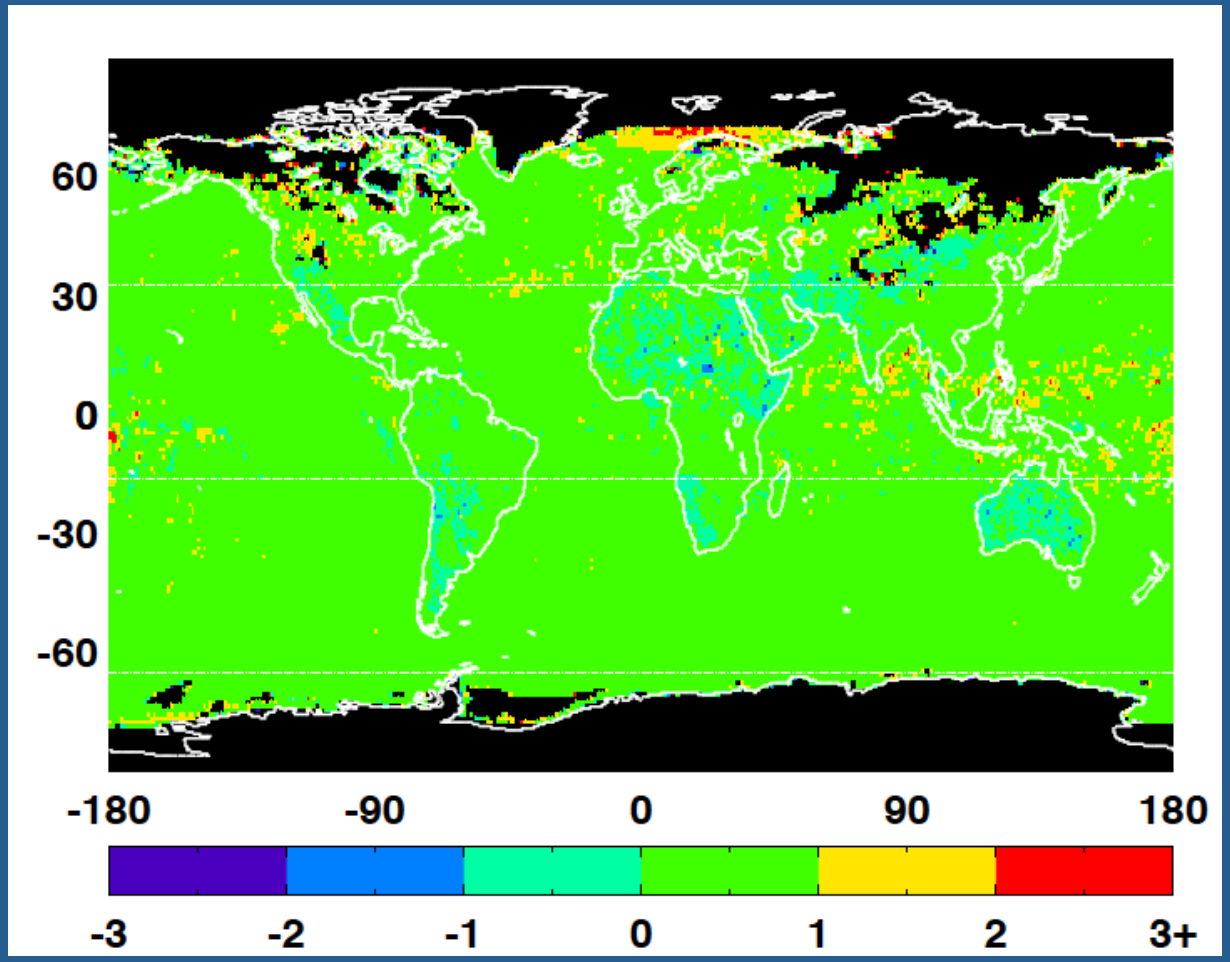
Edition 4 SSFs with Edition 4 ADMs
Jul 2000 Nighttime Normalized RMS (%)



Avg RMS = 2.4%

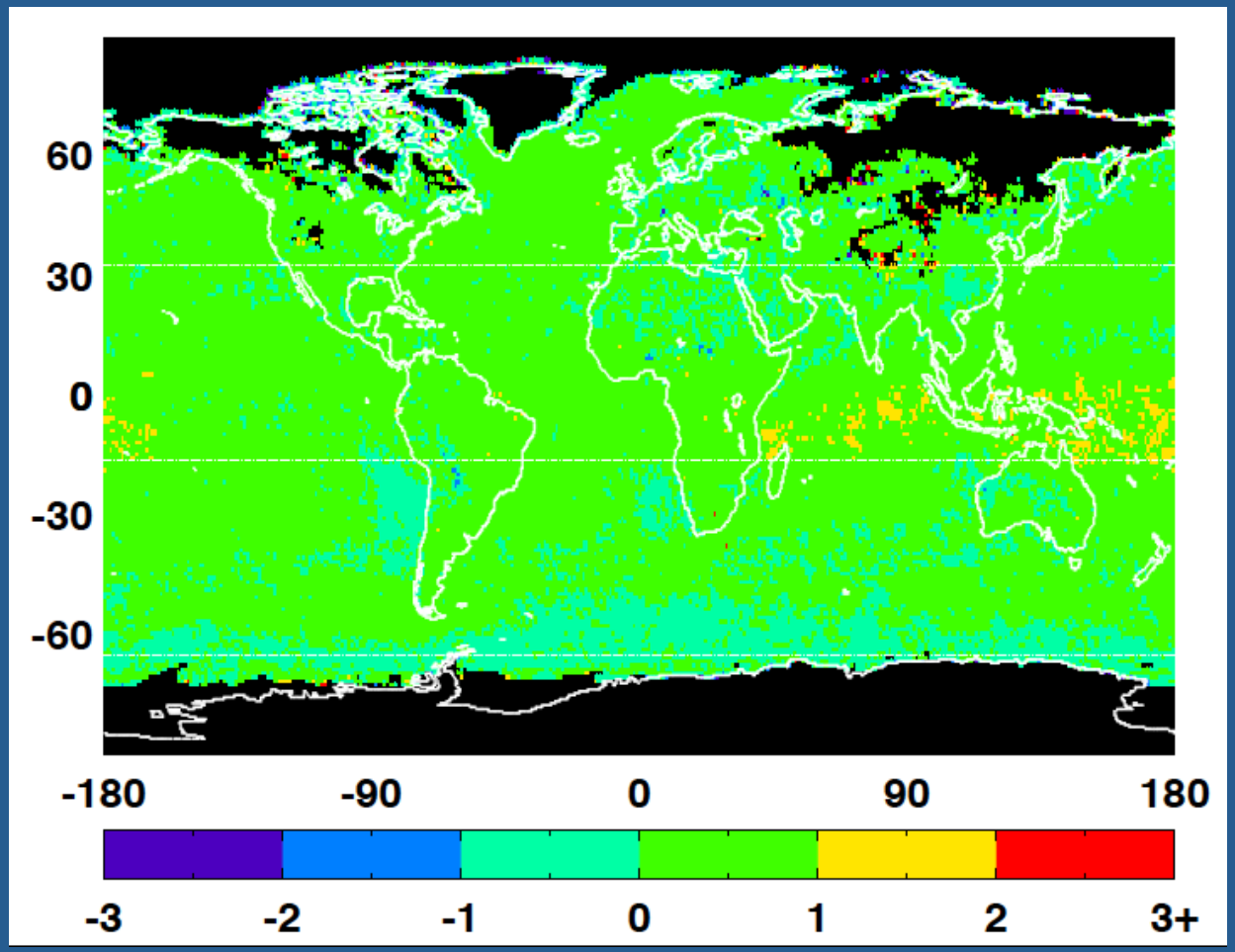
Results: Changes in LW fluxes with new ADM scheme versus Ed4-Beta1 fluxes

Jan 2002 Daytime Cloudy-sky Flux Differences (Ed4 SSFs/Ed4 ADMs – Ed4 SSFs/Ed2 ADMs)



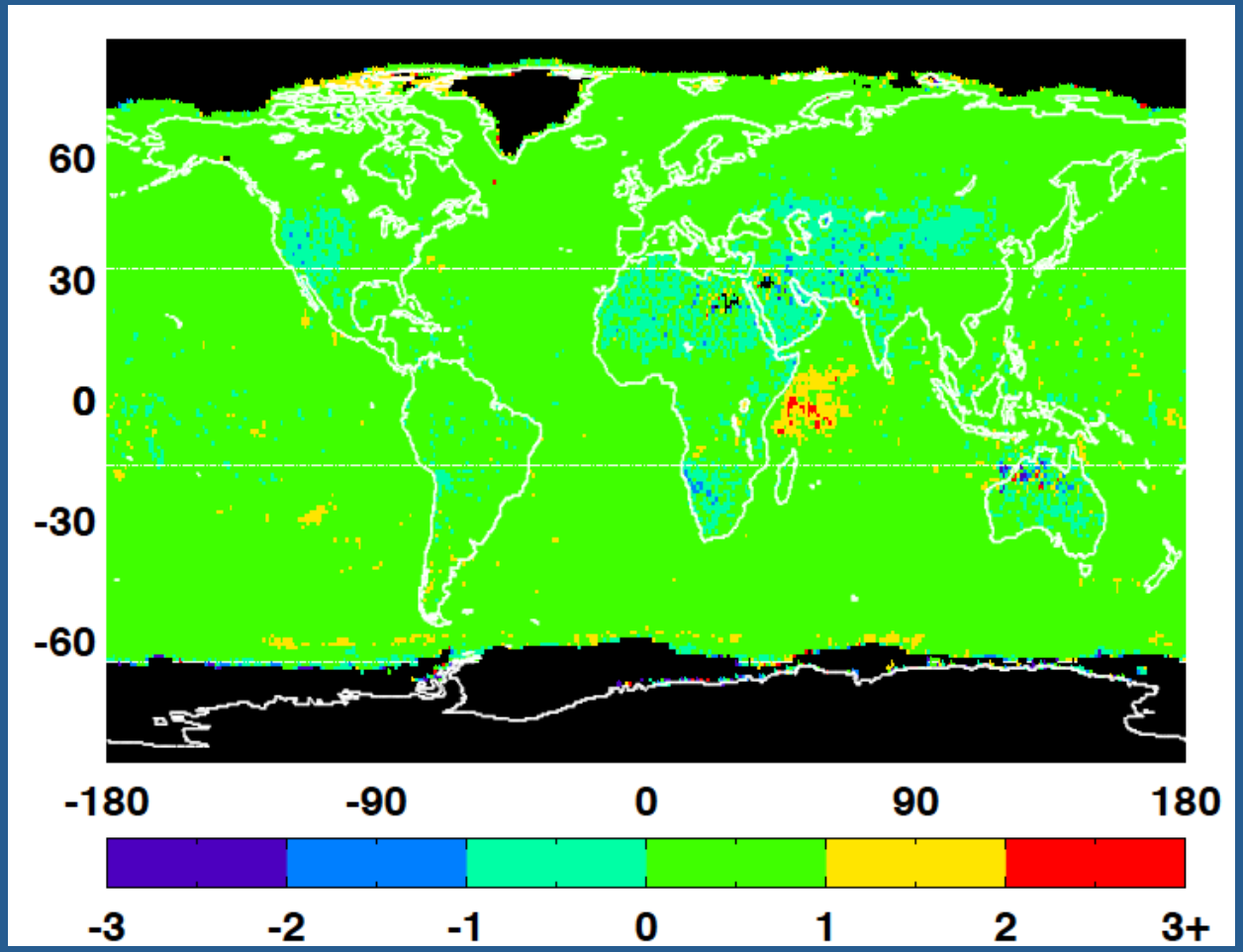
Avg $\Delta F = 0.5\ W\ m^{-2}$

Jan 2002 Nighttime Cloudy-sky Flux Differences (Ed4 SSFs/Ed4 ADMs – Ed4 SSFs/Ed2 ADMs)



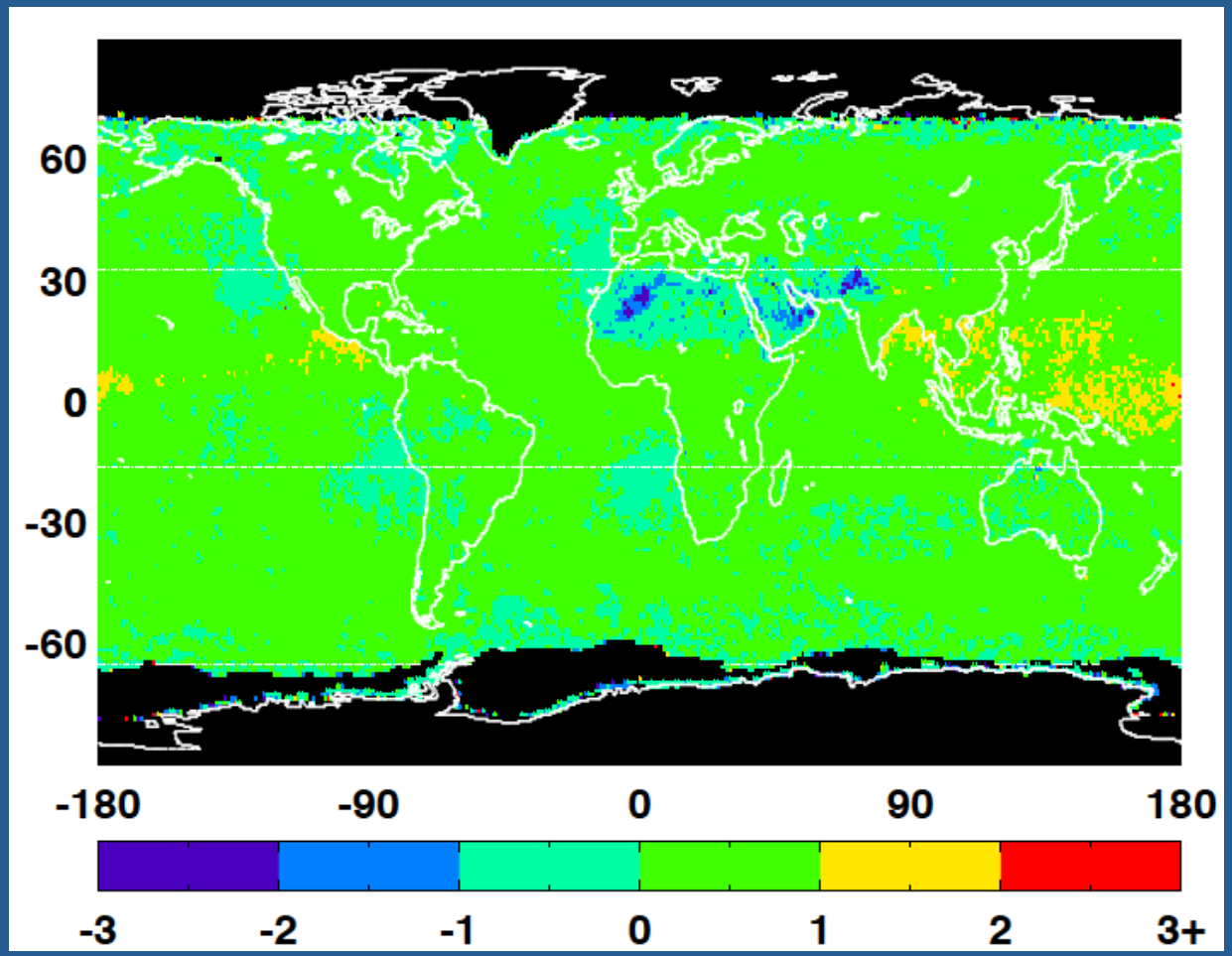
Avg $\Delta F = 0.2$ W m^{-2}

Jul 2002 Daytime Cloudy-sky Flux Differences (Ed4 SSFs/Ed4 ADMs – Ed4 SSFs/Ed2 ADMs)



Avg $\Delta F = 0.4$ W m^{-2}

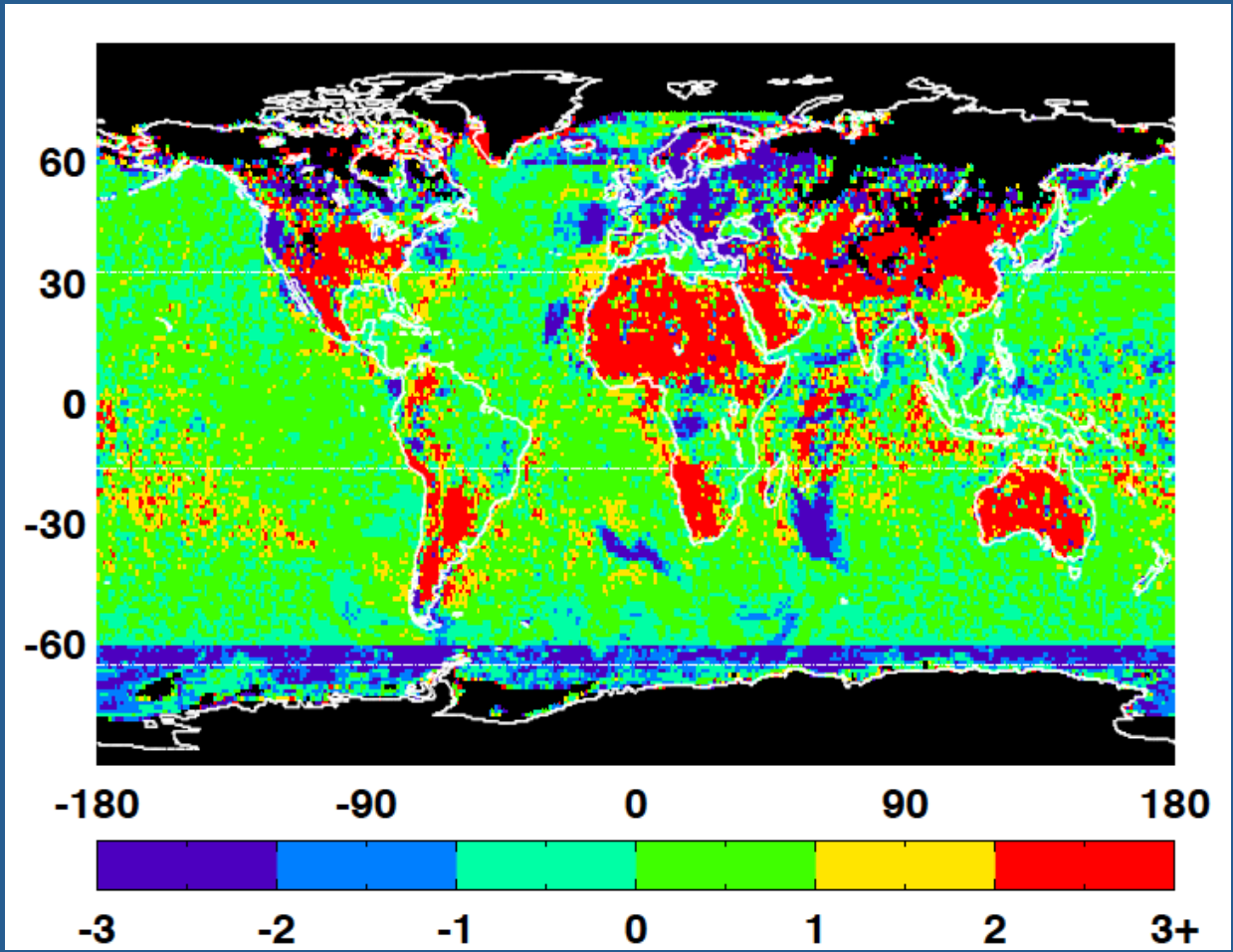
Jul 2002 Nighttime Cloudy-sky Flux Differences (Ed4 SSFs/Ed4 ADMs – Ed4 SSFs/Ed2 ADMs)



Avg $\Delta F = 0.2$ W m^{-2}

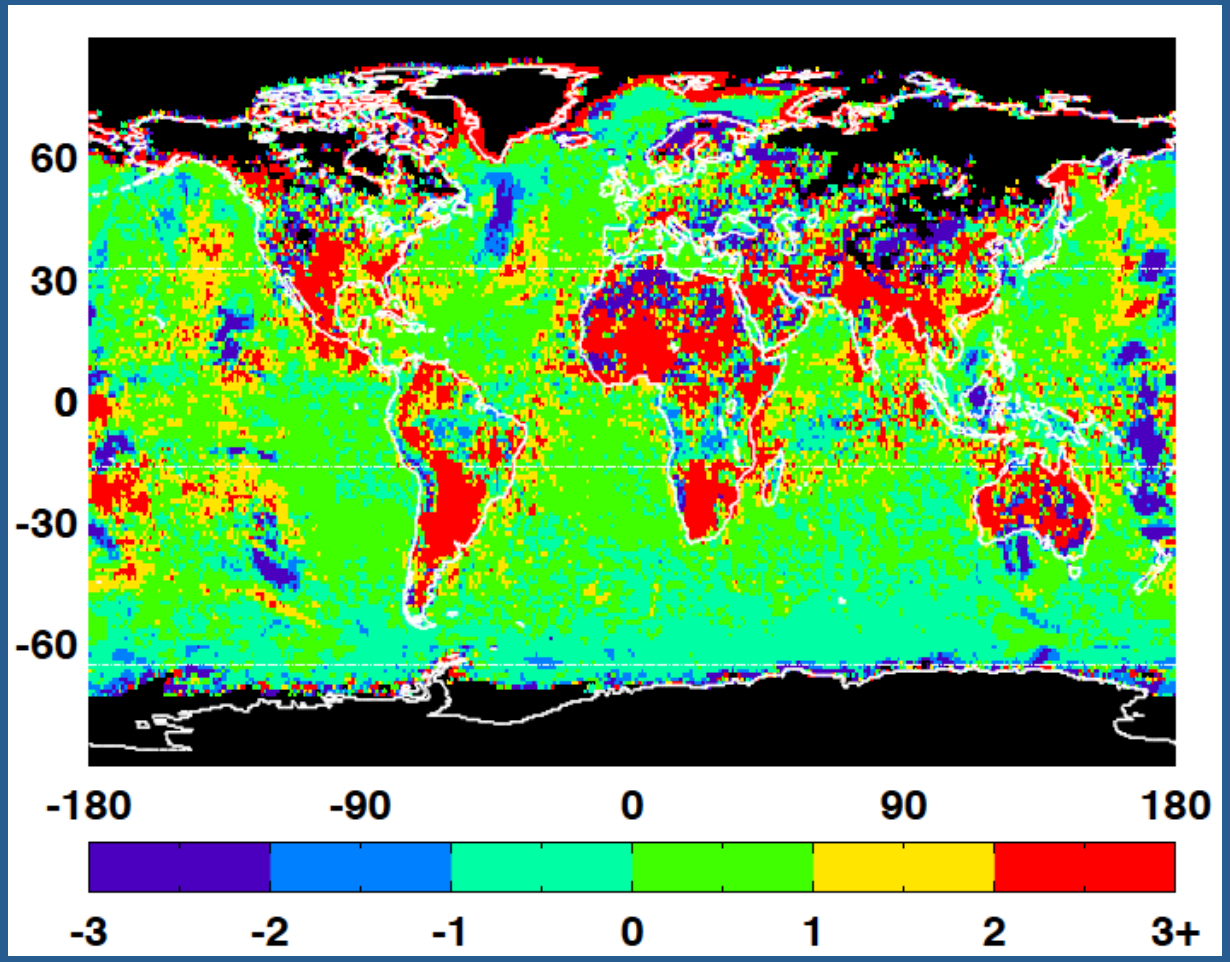
Results: Impact of cloud mask

Jan 2002 Daytime Cloudy-sky Flux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



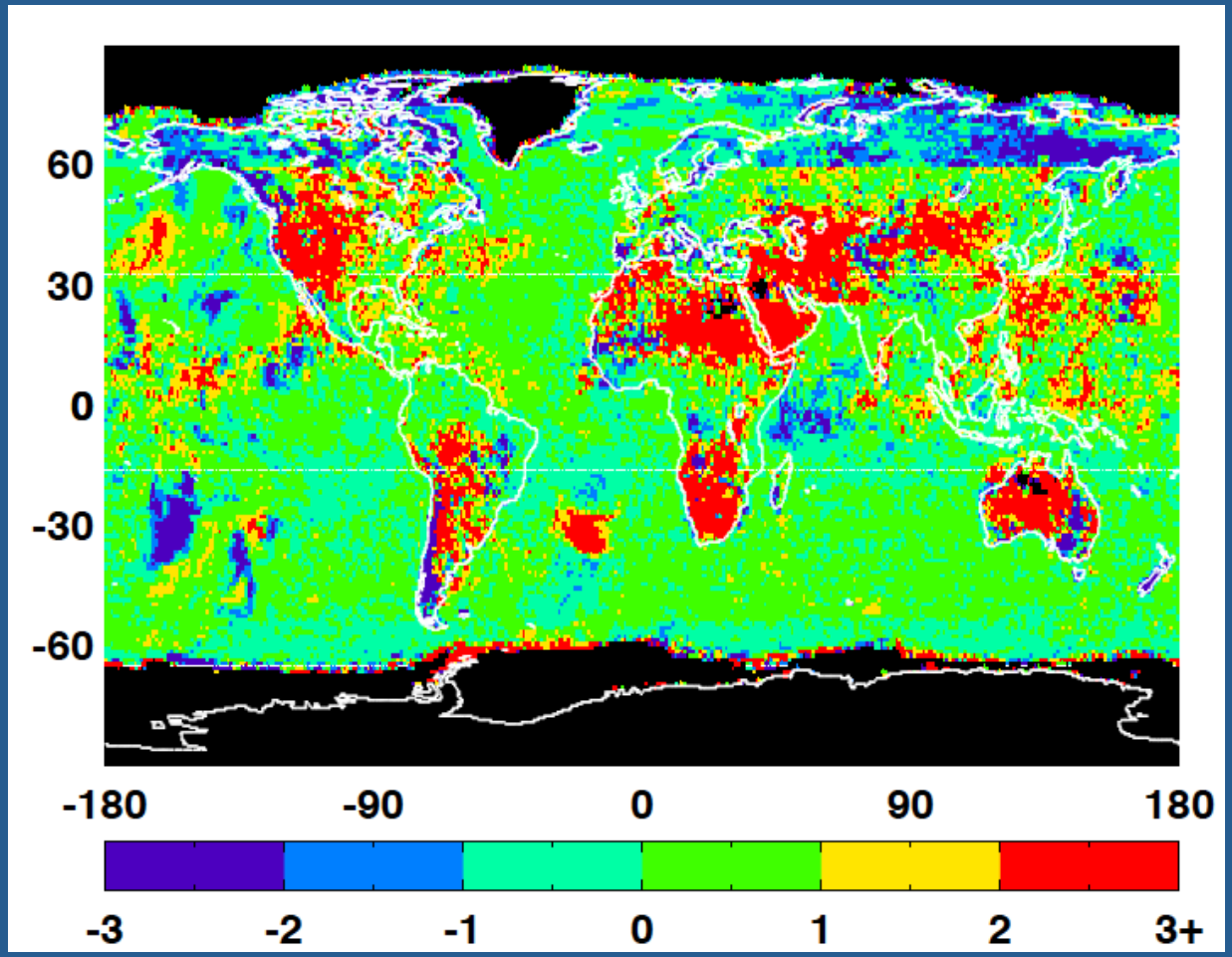
Avg $\Delta F = 0.7\ W\ m^{-2}$

Jan 2002 Nighttime Cloudy-sky Flux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



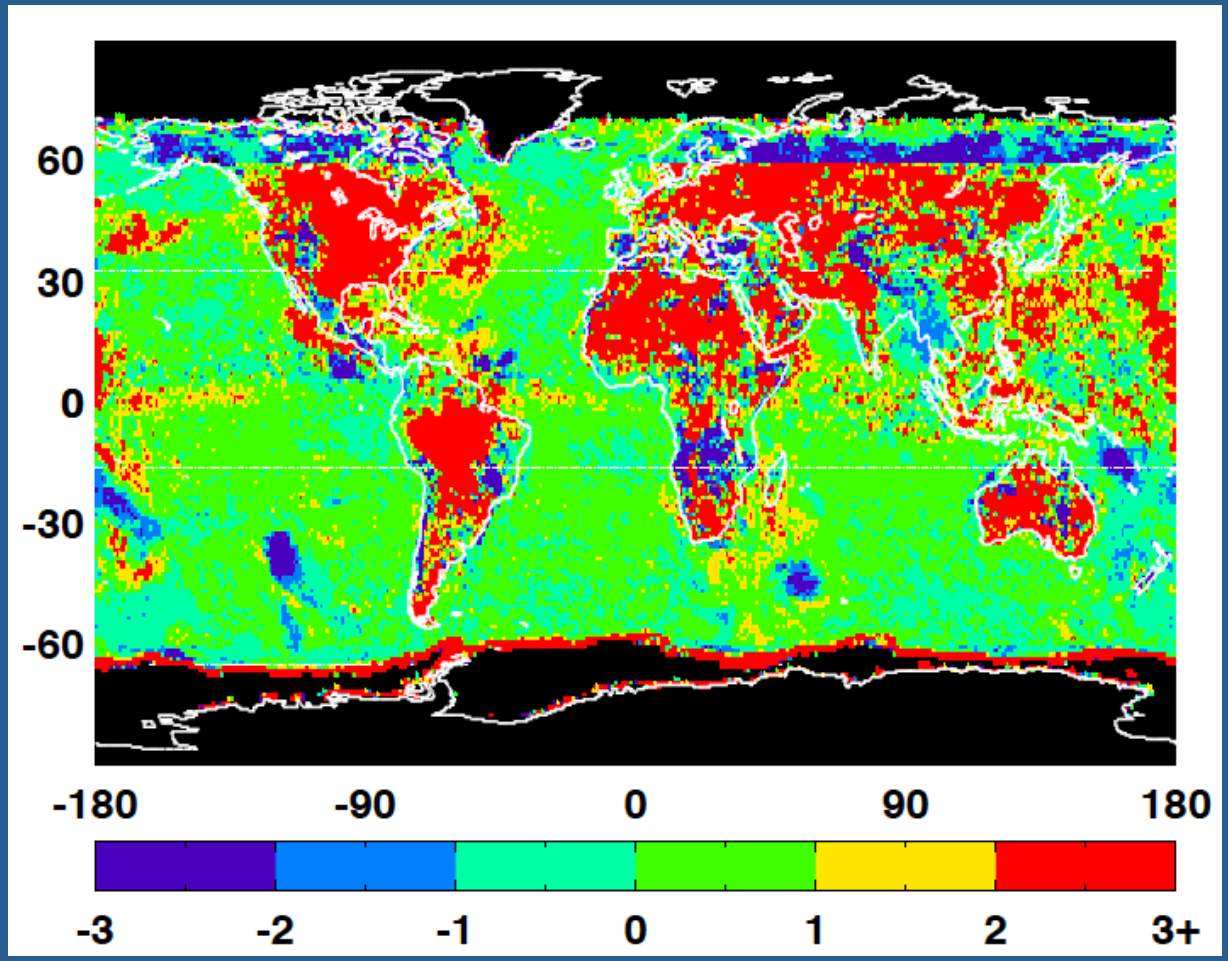
Avg $\Delta F = 0.8$ W m^{-2}

Jul 2002 Daytime Cloudy-sky Flux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



Avg $\Delta F = 0.6$ W m^{-2}

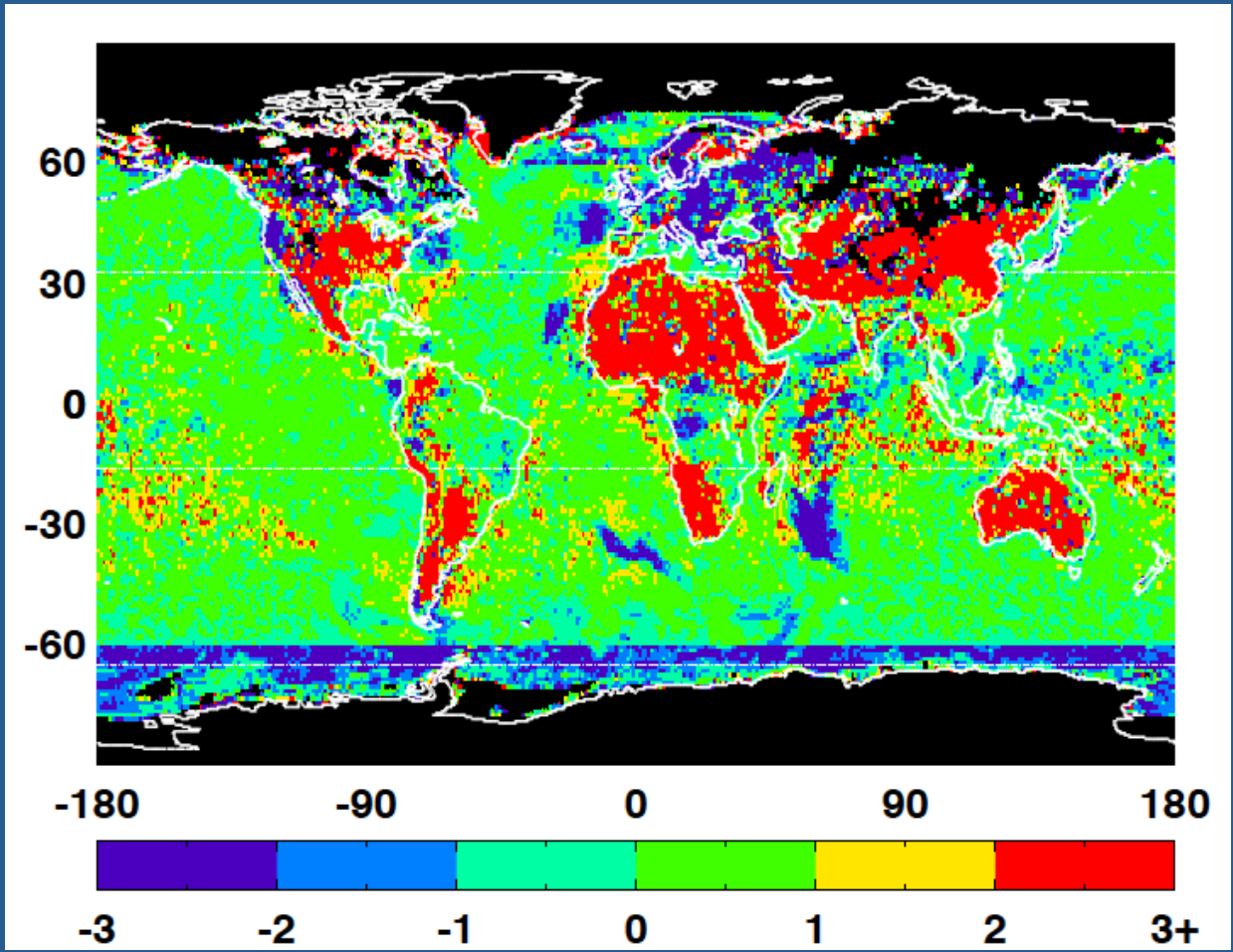
Jul 2002 Nighttime Cloudy-sky Flux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



Avg $\Delta F = 1.2\ W\ m^{-2}$

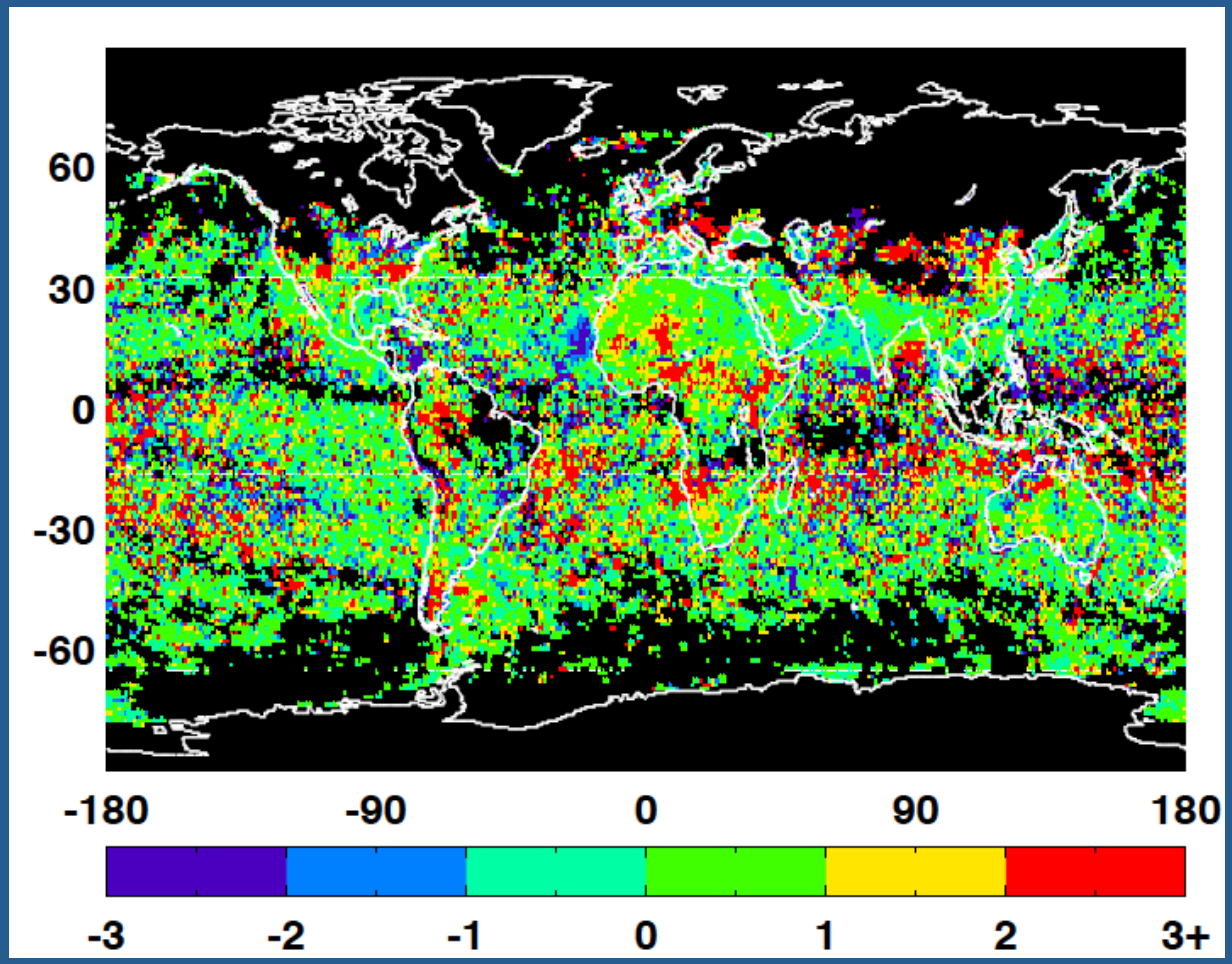
Results: Changes in Cloudy/Clear/Allsky Fluxes

Jan 2002 Daytime Cloudy-sky Flux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



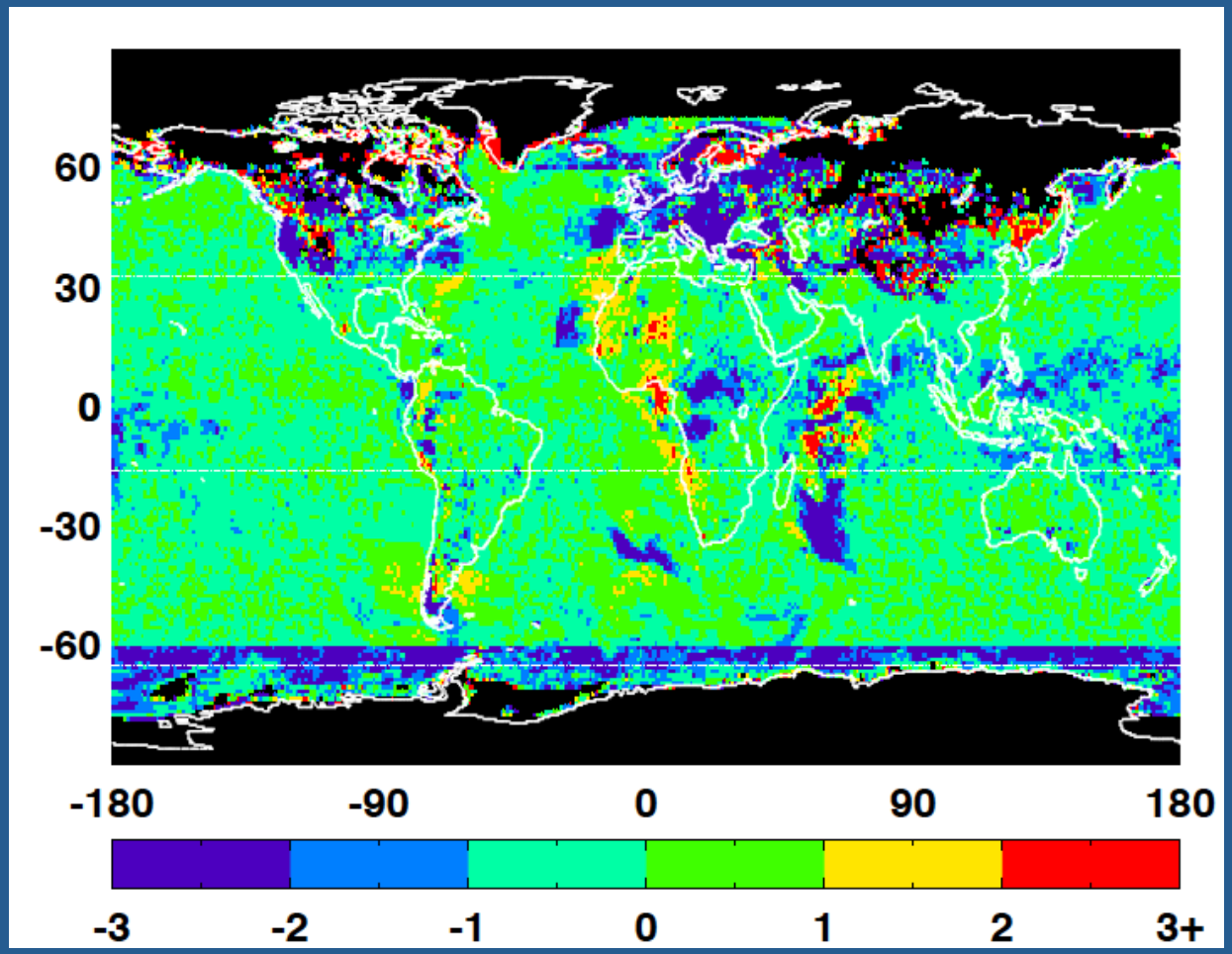
Avg $\Delta F = 0.7\ W\ m^{-2}$

Jan 2002 Daytime Clear-sky Flux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



Avg $\Delta F = 0.5$ W m^{-2}

Jan 2002 Daytime All-sky Flux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



Avg ΔF = -0.4 W m^{-2}

All-sky LW flux decrease is due to decrease in clear-sky footprints

- All-sky flux can be approximated by:

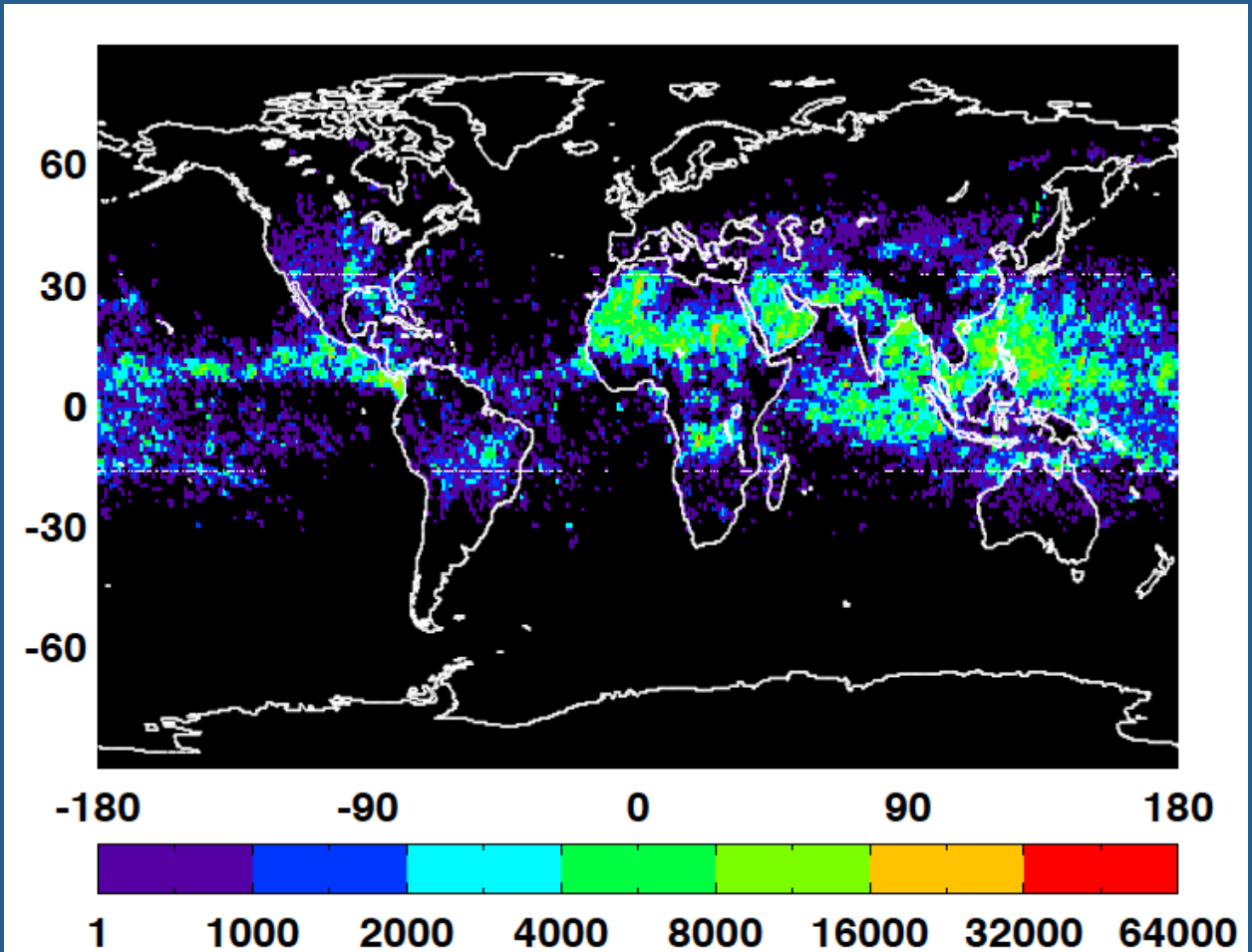
$$f_{clr}F_{clr} + f_{cld}F_{cld}$$

- When Ed3 values of 0.088, 284.4, 0.912, and 240.8 are substituted for f_{clr},F_{clr},f_{cld} and F_{cld} respectively, we get an approximate flux of 244.7 W m^{-2}.
- When Ed4 values of 0.066, 285.0, 0.934, and 241.6 are substituted for f_{clr},F_{clr},f_{cld} and F_{cld} respectively, we get an approximate flux of 244.3 W m^{-2}, or an (Ed4-Ed3) flux difference of -0.4 W m^{-2}.

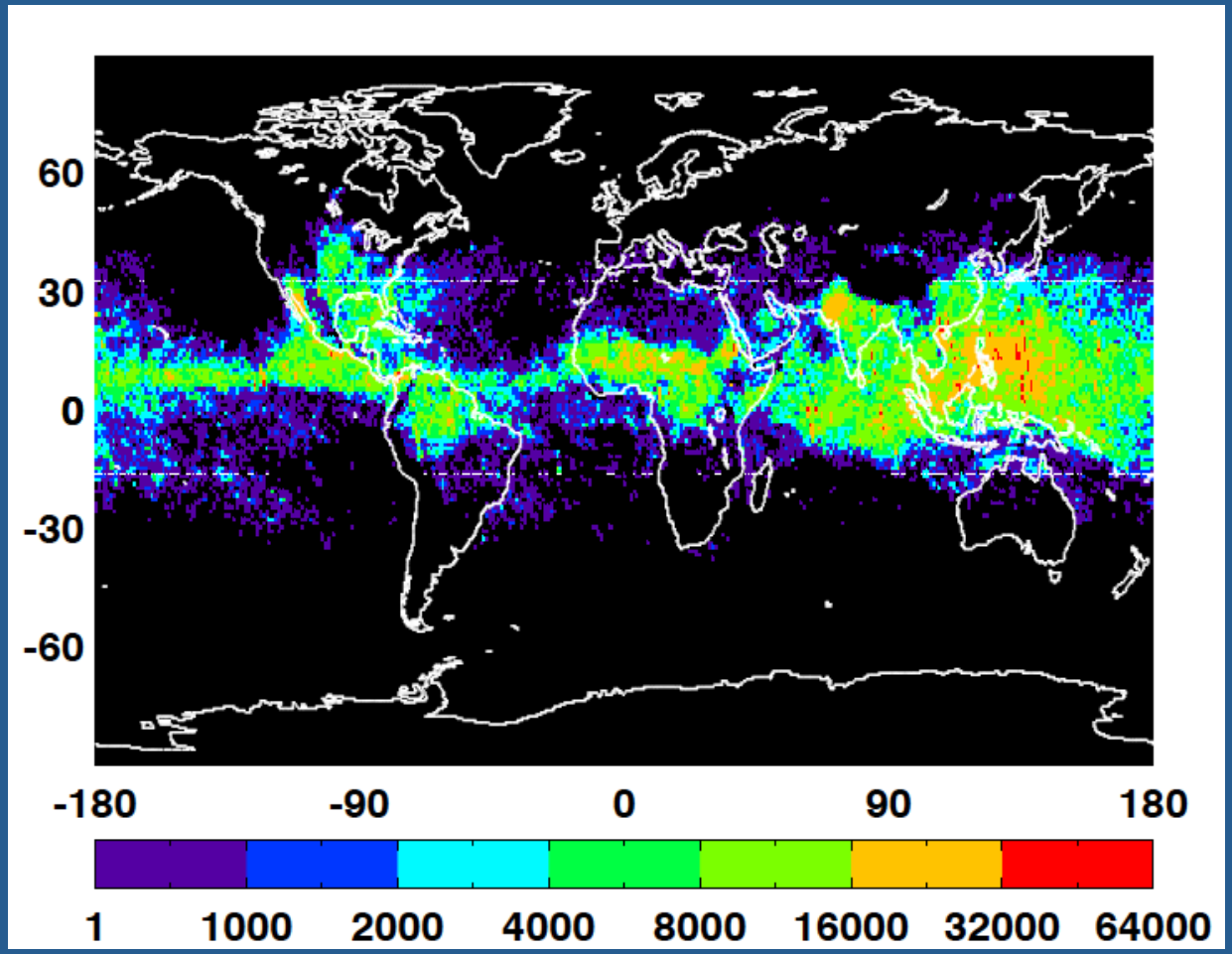
Summary

- A new (Edition 4) LW and WN ADM scheme for cloudy scenes has been developed, using mean values of pseudoradiance rather than polynomial fits.
- Normalized RMS errors in LW and WN radiance are generally similar in Edition 4 as Edition 2, except that errors are reduced at night for the LW channel.
- Edition 4 cloudy-sky LW fluxes tend to be higher (especially over land) than Edition 3 due to inclusion of thin clouds. Clear-sky fluxes also tend to be higher due to the exclusion of these footprints, but overall fluxes are slightly lower.

Edition 4 SSFs with Edition 4 ADMs
Jul 2000 Daytime # of samples with ΔTsc > 85K



Edition 4 SSFs with Edition 4 ADMs
Jul 2000 Nighttime # of samples with ΔTsc > 85K



Terra Daytime Mean Cloudy-sky Normalized RMS (%)- Terra ADMs, LW Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	**3.9, 3.9**	**2.7, 2.7**	**3.5, 3.5**	**2.7, 2.7**
Land	**3.5, 3.5**	**2.8, 2.8**	**3.8, 3.8**	**2.6, 2.6**
Deserts	**3.4, 3.3**	**3.2, 3.2**	**3.5, 3.3**	**2.9, 2.8**
All fovs	**3.8, 3.8**	**2.8, 2.7**	**3.6, 3.6**	**2.7, 2.7**

Terra Daytime Mean Cloudy-sky Relative Bias (%)- Terra ADMs, LW Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	-0.4, -0.2	0.2, 0.3	0.2, 0.4	-0.2, 0.0
Land	0.5, 0.5	0.8, 0.9	-0.2, -0.1	0.9, 1.0
Deserts	0.3, 0.4	0.4, 0.5	-1.0, -0.9	0.4, 0.6
All fovs	-0.2, 0.0	0.3, 0.5	0.0, 0.2	0.1, 0.3

Terra Daytime Mean Cloudy-sky Flux Differences ($W\ m^{-2}$), LW Channel

Ed4SSF/Ed2updateADM-Ed4SSF/Ed2ADM in **black**, Ed4SSF/Ed4ADM-Ed4SSF/Ed2ADM in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
All fovs	**0.3, 0.4**	**0.4, 0.4**	**0.3, 0.4**	**0.4, 0.4**

Terra Daytime Mean Cloudy-sky Normalized RMS (%)- Terra ADMs, WN Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	**2.9, 2.9**	**3.0, 2.9**	**3.0, 3.0**	**2.8, 2.8**
Land	**3.7, 3.7**	**3.8, 3.7**	**3.6, 3.5**	**3.4, 3.3**
Deserts	**4.1, 4.1**	**4.6, 4.7**	**4.1, 4.1**	**4.0, 4.1**
All fovs	**3.1, 3.1**	**3.2, 3.2**	**3.2, 3.2**	**3.0, 3.0**

Terra Daytime Mean Cloudy-sky Relative Bias (%)- Terra ADMs, WN Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	**-0.6, -0.6**	**-0.2, -0.2**	**0.2, 0.2**	**-0.5, -0.5**
Land	**0.4, 0.4**	**0.4, 0.4**	**0.1, 0.1**	**0.0, 0.1**
Deserts	**1.0, 1.3**	**0.4, 0.6**	**0.0, 0.1**	**0.3, 0.5**
All fovs	**-0.4, 0.0**	**0.0, 0.0**	**0.1, 0.1**	**-0.3, -0.3**

Terra Daytime Mean Cloudy-sky Flux Differences ($W\ m^{-2}$), WN Channel

Ed4SSF/Ed2updateADM-Ed4SSF/Ed2ADM in **black**, Ed4SSF/Ed4ADM-Ed4SSF/Ed2ADM in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
All fovs	**0.0, 0.1**	**0.0, 0.1**	**0.0, 0.0**	**0.0, 0.1**

Terra Nighttime Mean Cloudy-sky Normalized RMS (%)- Terra ADMs, LW Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	**2.6, 2.3**	**2.6, 2.2**	**2.7, 2.3**	**2.6, 2.3**
Land	**3.3, 2.5**	**3.0, 2.3**	**3.0, 2.5**	**3.0, 2.4**
Deserts	**3.9, 2.5**	**3.6, 2.5**	**3.5, 2.4**	**3.3, 2.3**
All fovs	**2.8, 2.4**	**2.7, 2.3**	**2.8, 2.4**	**2.7, 2.3**

Terra Nighttime Mean Cloudy-sky Relative Bias (%)- Terra ADMs, LW Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	**-0.6, -0.3**	**-0.3, 0.2**	**0.0, 0.5**	**-0.6, -0.1**
Land	**-0.5, 0.1**	**-0.9, -0.1**	**-1.8, -0.4**	**-0.4, 0.3**
Deserts	**-2.5, -0.3**	**-2.0, 0.4**	**-2.9, -1.0**	**-1.6, 0.4**
All fovs	**-0.7, -0.2**	**-0.5, 0.2**	**-0.6, 0.2**	**-0.6, 0.0**

Terra Nighttime Mean Cloudy-sky Flux Differences (W m^{-2}), LW Channel

Ed4SSF/Ed2updateADM-Ed4SSF/Ed2ADM in **black**, Ed4SSF/Ed4ADM-Ed4SSF/Ed2ADM in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
All fovs	**0.1, 0.1**	**0.1, 0.1**	**0.1, 0.1**	**0.1, 0.1**

Terra Nighttime Mean Cloudy-sky Normalized RMS (%)- Terra ADMs, WN Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	**2.7, 2.7**	**2.5, 2.4**	**2.7, 2.6**	**2.5, 2.4**
Land	**3.5, 3.5**	**3.1, 3.1**	**3.4, 3.3**	**3.1, 3.0**
Deserts	**3.4, 3.3**	**3.1, 3.1**	**3.1, 3.0**	**3.0, 2.9**
All fovs	**2.9, 2.9**	**2.6, 2.6**	**2.9, 2.8**	**2.7, 2.6**

Terra Nighttime Mean Cloudy-sky Relative Bias (%)- Terra ADMs, WN Channel

Ed2 scheme in **black**, Ed4 scheme in **green**.

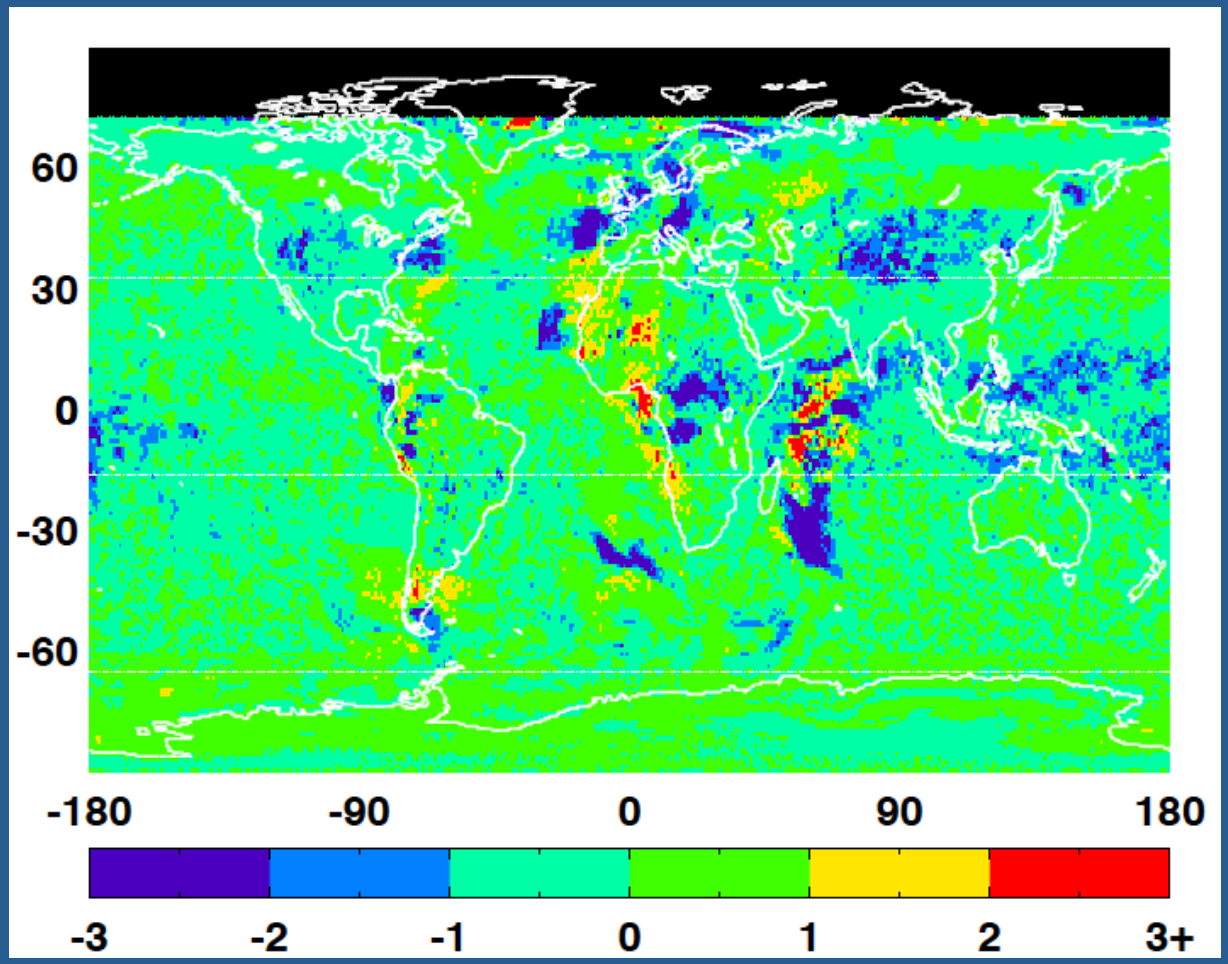
	Jan 2001	April 2000	July 2000	Oct 2000
Oceans	**-0.8, -0.7**	**-0.3, -0.2**	**0.0, 0.1**	**-0.5,**
Land	**0.3, 0.3**	**0.3, 0.3**	**0.3, 0.4**	**0.0,**
Deserts	**0.0, 0.1**	**0.4, 0.5**	**-0.2, -0.2**	**0.1,**
All fovs	**-0.5, -0.5**	**-0.1, -0.1**	**0.0, 0.1**	**-0.3,**

Terra Nighttime Mean Cloudy-sky Flux Differences (W m^{-2}), WN Channel

Ed4SSF/Ed2updateADM-Ed4SSF/Ed2ADM in **black**, Ed4SSF/Ed4ADM-Ed4SSF/Ed2ADM in **green**.

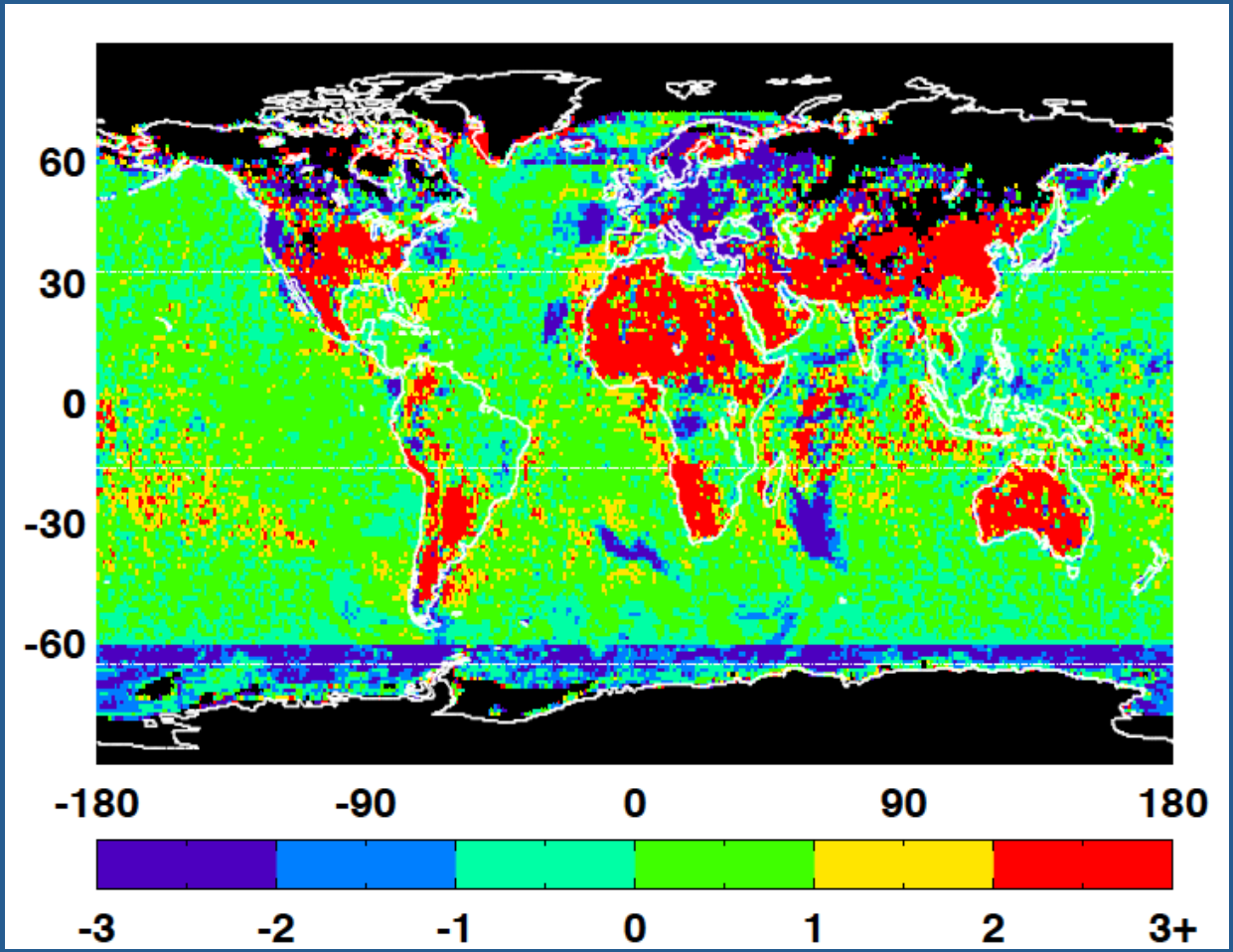
	Jan 2001	April 2000	July 2000	Oct 2000
All fovs	**0.0, 0.1**	**0.0, 0.1**	**0.0, 0.1**	

Jan 2002 Daytime All-sky Fux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



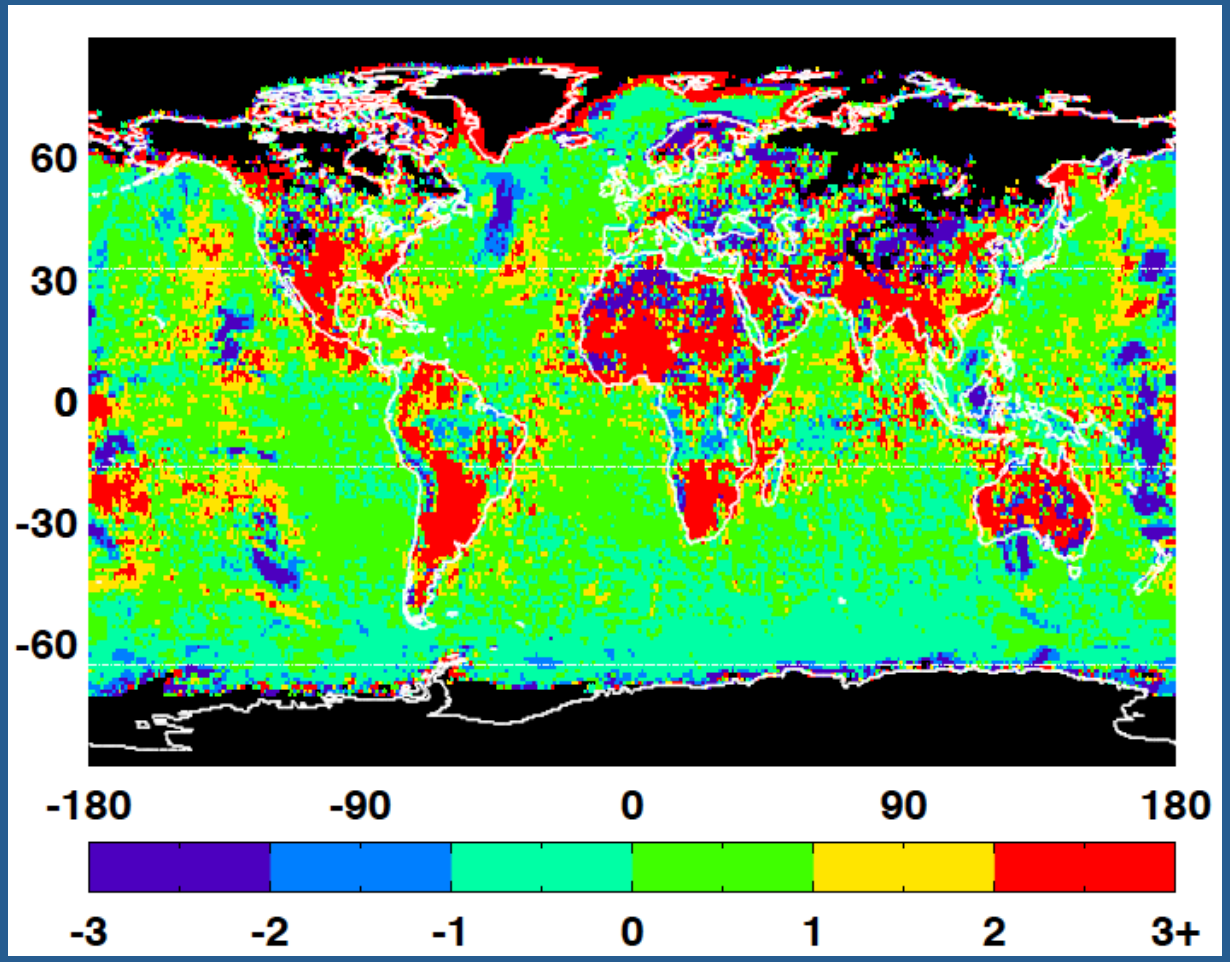
Avg ΔF = -0.1 W m^{-2}

Jan 2002 Daytime Cloudy-sky Fux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



Avg $\Delta F = 0.5\ W\ m^{-2}$

Jan 2002 Nighttime Cloudy-sky Fux Differences (Ed4 SSFs/Ed2 ADMs – Ed3 SSFs/Ed2 ADMs)



Avg $\Delta F = 0.9\ W\ m^{-2}$