Update on Longwave Angular Distribution Models

Zachary Eitzen[1] and

THE ADM-TEAM

Wenying Su[2], Joseph Corbett[1],

Lusheng Liang[1]

1- SSAI; 2 – NASA LaRC

Thanks to Norman Loeb, Seiji Kato

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

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

Normalized RMS calculated for each 1x1 grid cell

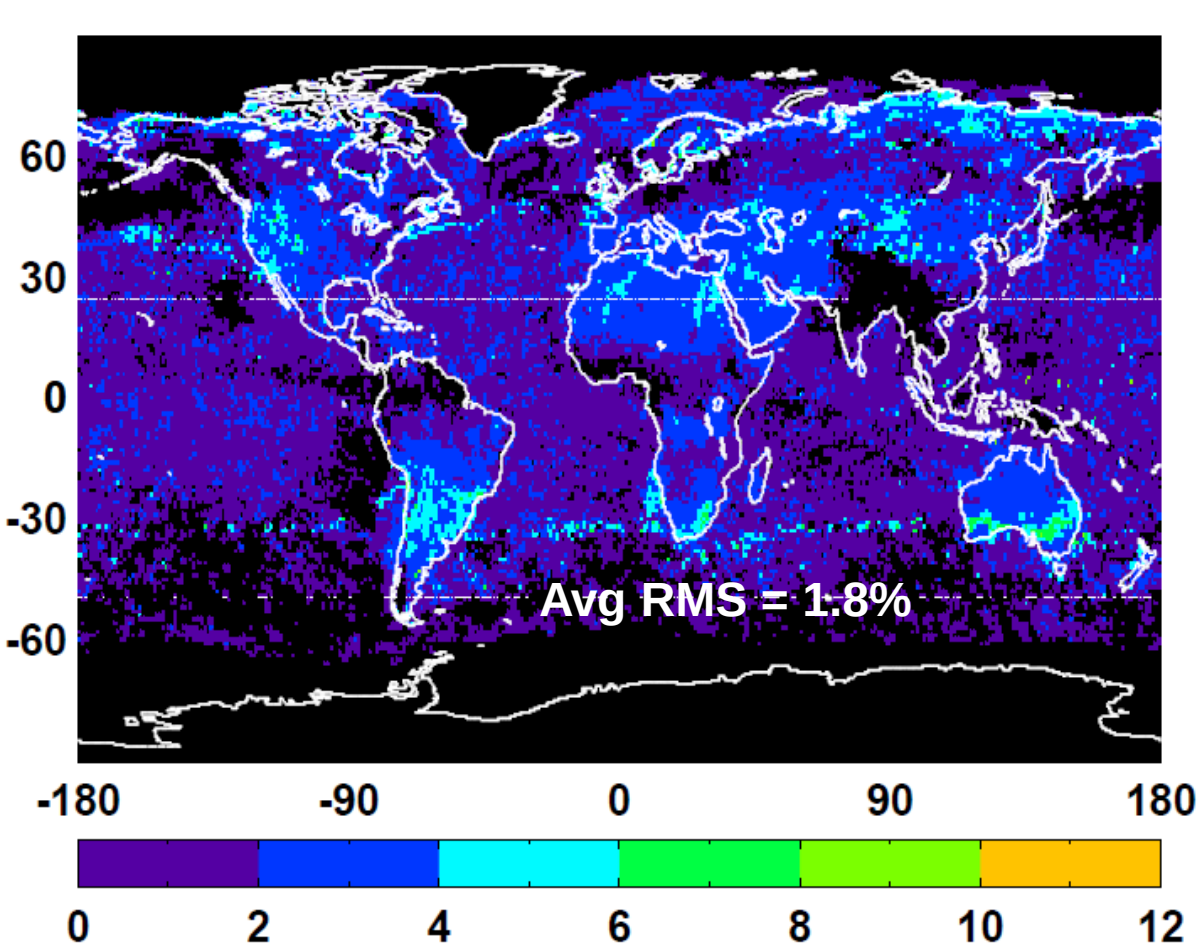
Note: results are not necessarily applicable to fluxes!

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

Edition 2 Setup for Clear-sky LW ADMs

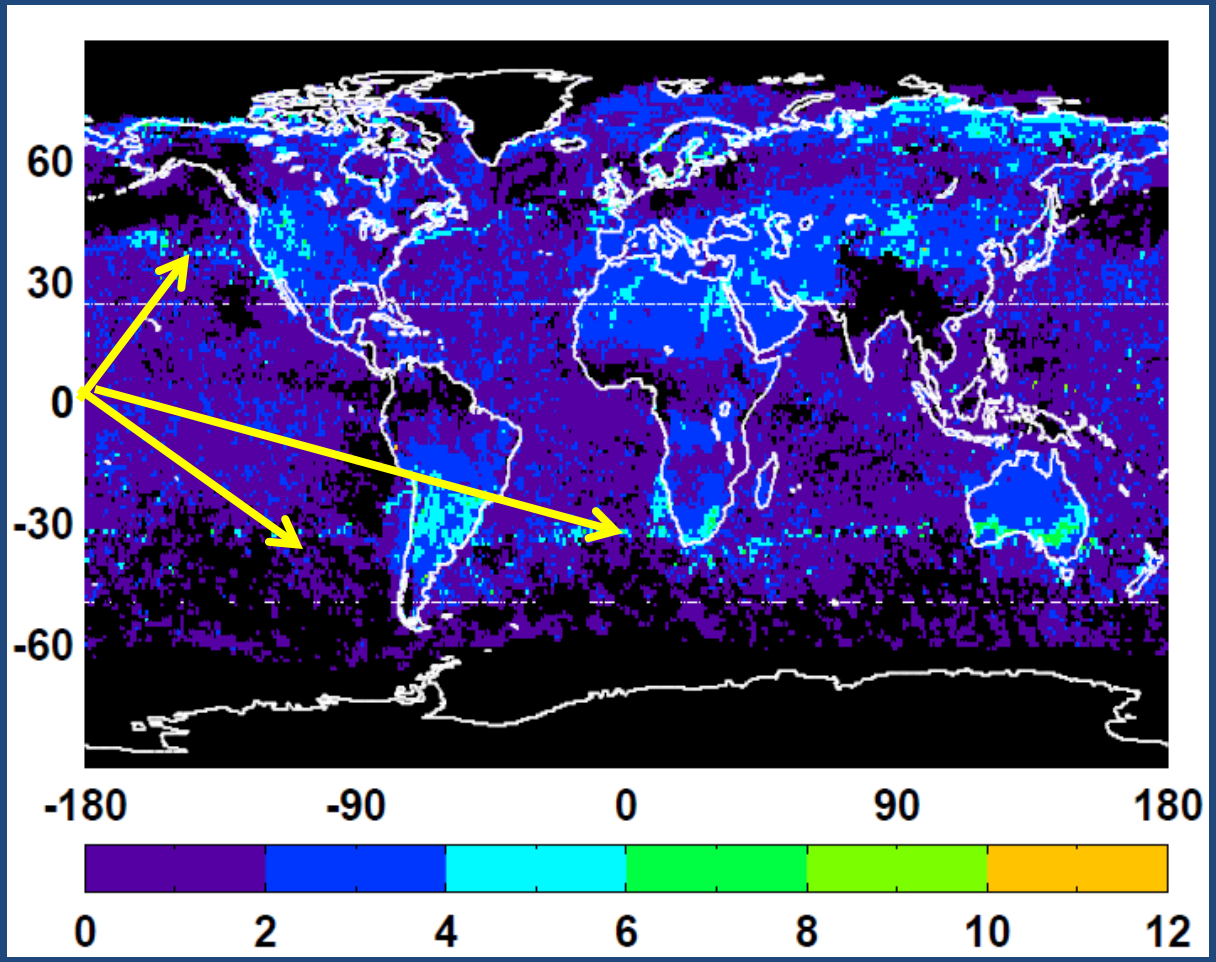
- 4 precipitable water categories (< 1 cm, 1-3 cm, 3-5 cm, 5+ cm).
- 5 surface temperature categories (< 270 K, 270-290 K, 290-310 K, 310-330 K, 330+ K).
- 4 lapse rate categories (< 15 K, 15-30 K, 30-45 K, 45+ K over the lowest 300 hPa).
- 6 surface types (ocean, forests, savannas, grasslands, dark desert, bright desert).
- Separate ADMs for day/night.

Edition 2 Jul 2000 Daytime Normalized RMS (%)



Edition 2 Jul 2000 Daytime Normalized RMS (%)

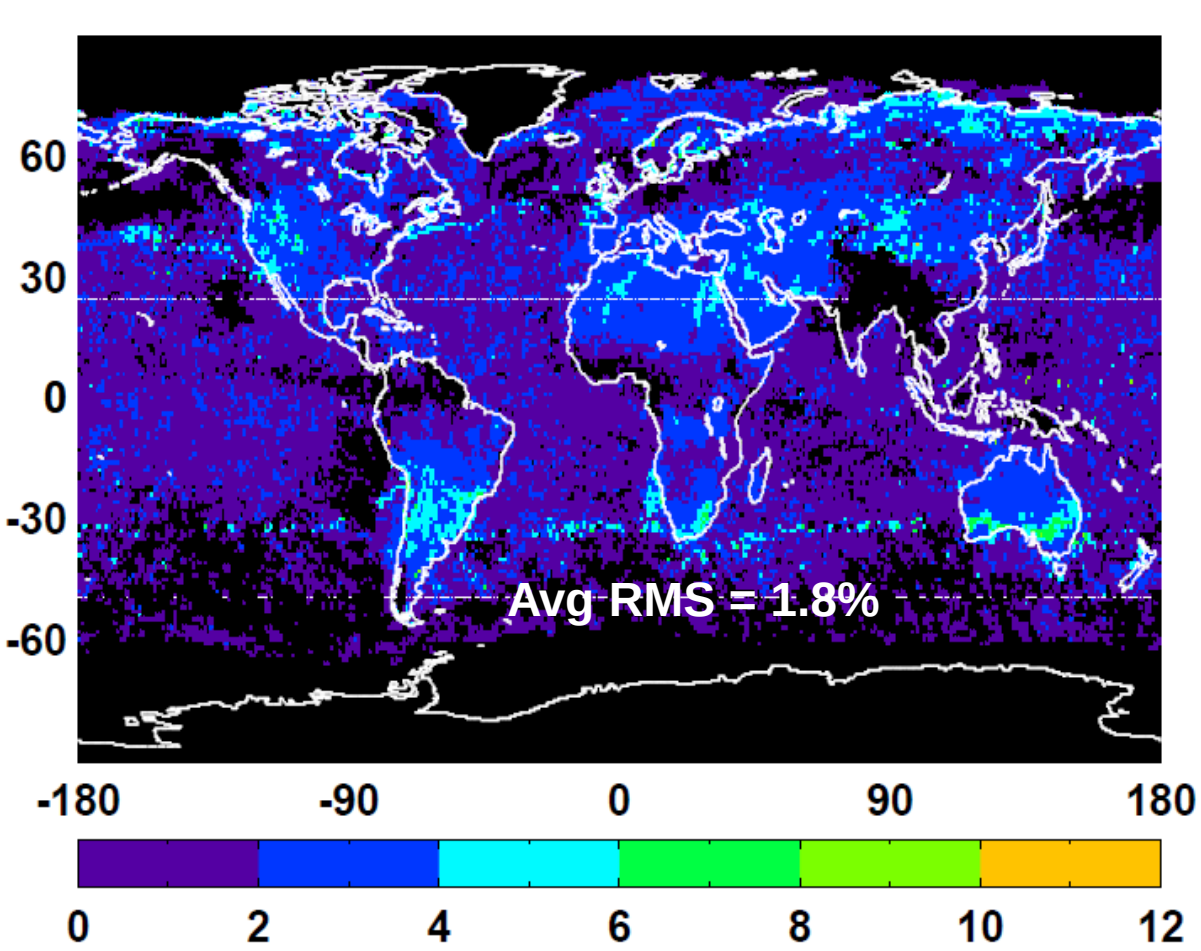
High errors over oceans near 290 K SSTs



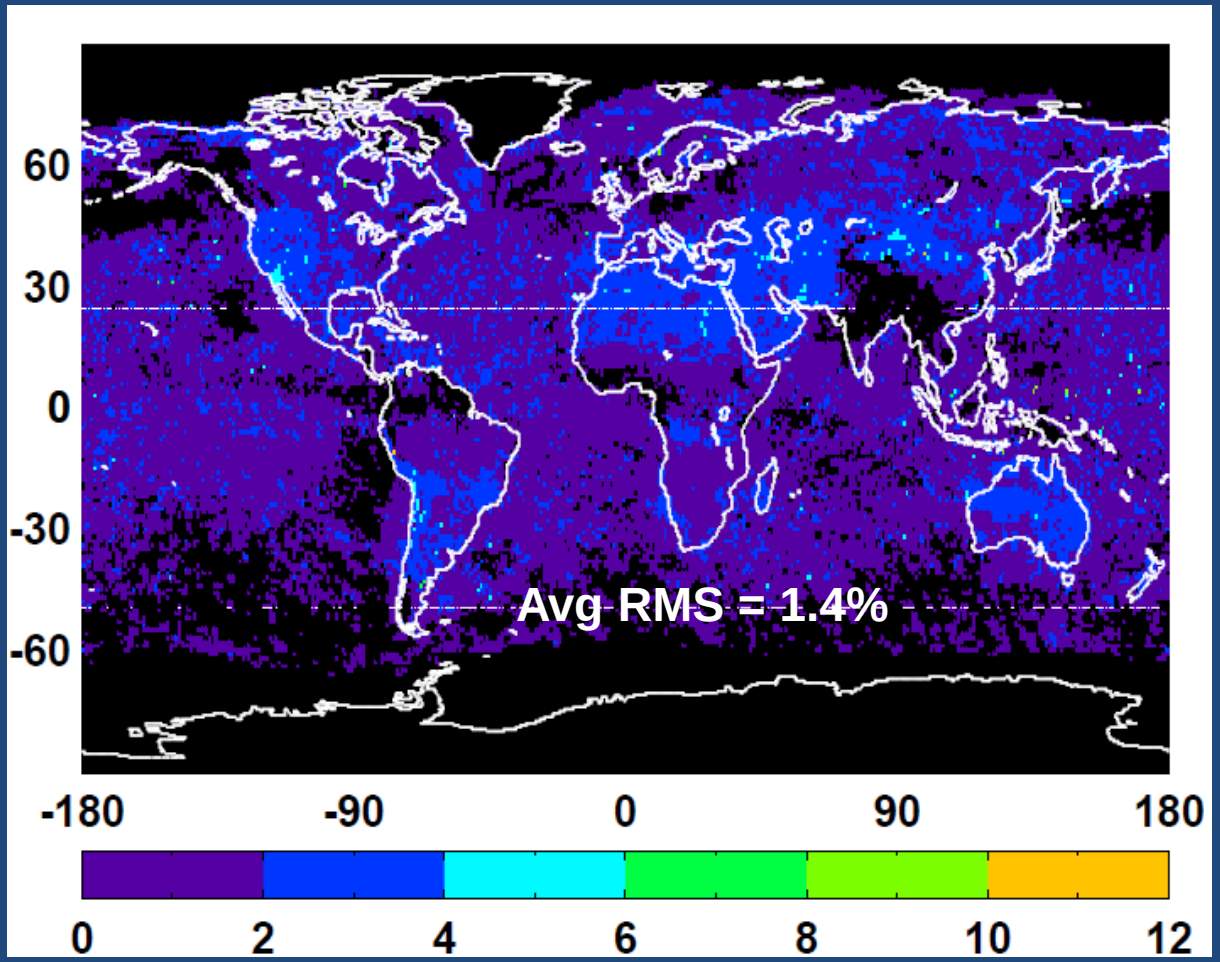
Proposed Edition 4 Setup for Clear-sky LW ADMs

- 10 surface temperature categories (< 260 K, 260-270 K, 270-280 K, …, 340+ K).
- Interpolation between surface temperature bins when possible.

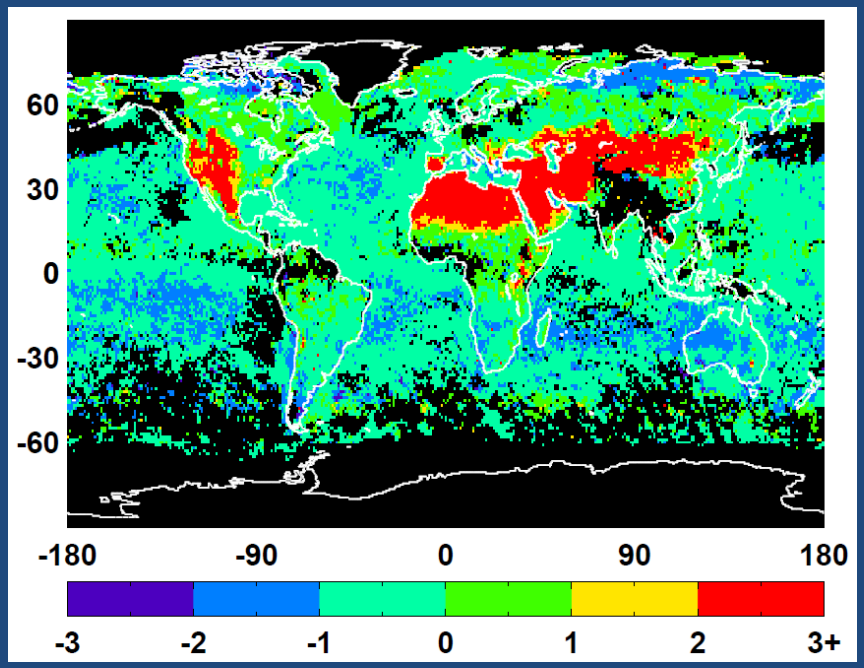
Edition 2 Jul 2000 Daytime Normalized RMS (%)

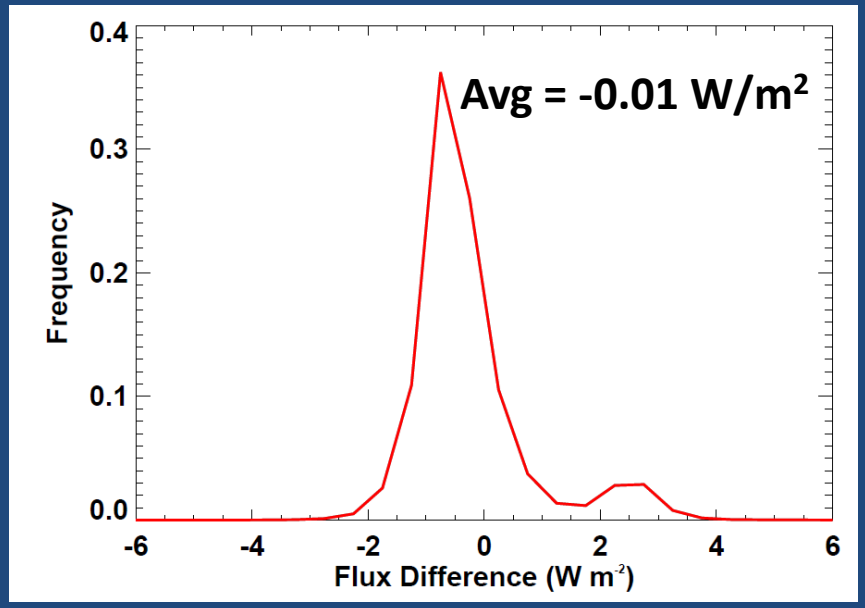


Proposed Edition 4 (10 T_s bins and interpolation) Reduces Jul 2000 Daytime Normalized RMS (%)



Ed 4 ADM – Ed 2 July 2000 Daytime Clear-sky ΔF (W/m²)





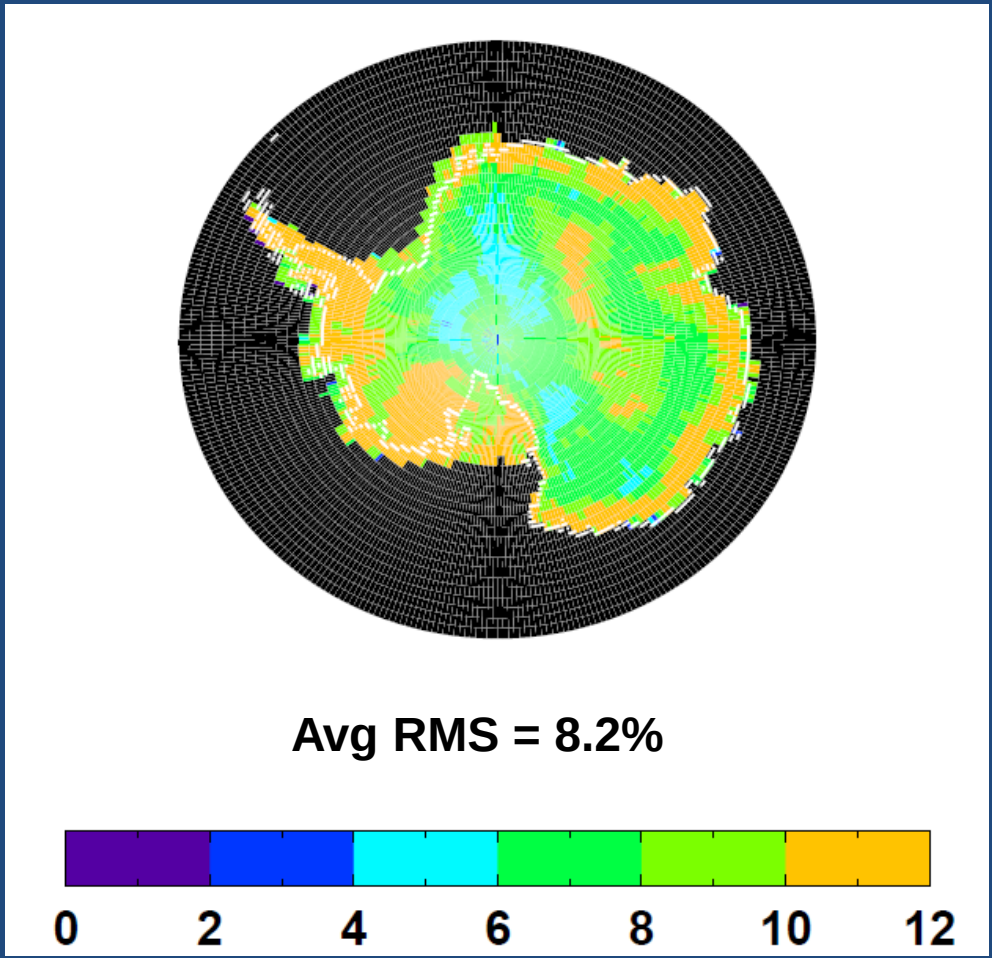
Edition 2 Setup for Snow and Ice LW ADMs

- 3 surface types (permanent snow, sea ice, fresh snow).
- 2 surface temperature categories (< 250 K, > 250 K for all types except permanent snow at night).
- 6 cloud fraction categories (clear, 0.1-25%, 25-50%, 50-75%, 75-99.9%, overcast).
- 2 cloud-surface temperature difference bins (< 20K, > 20 K)
- Separate ADMs for day/night.

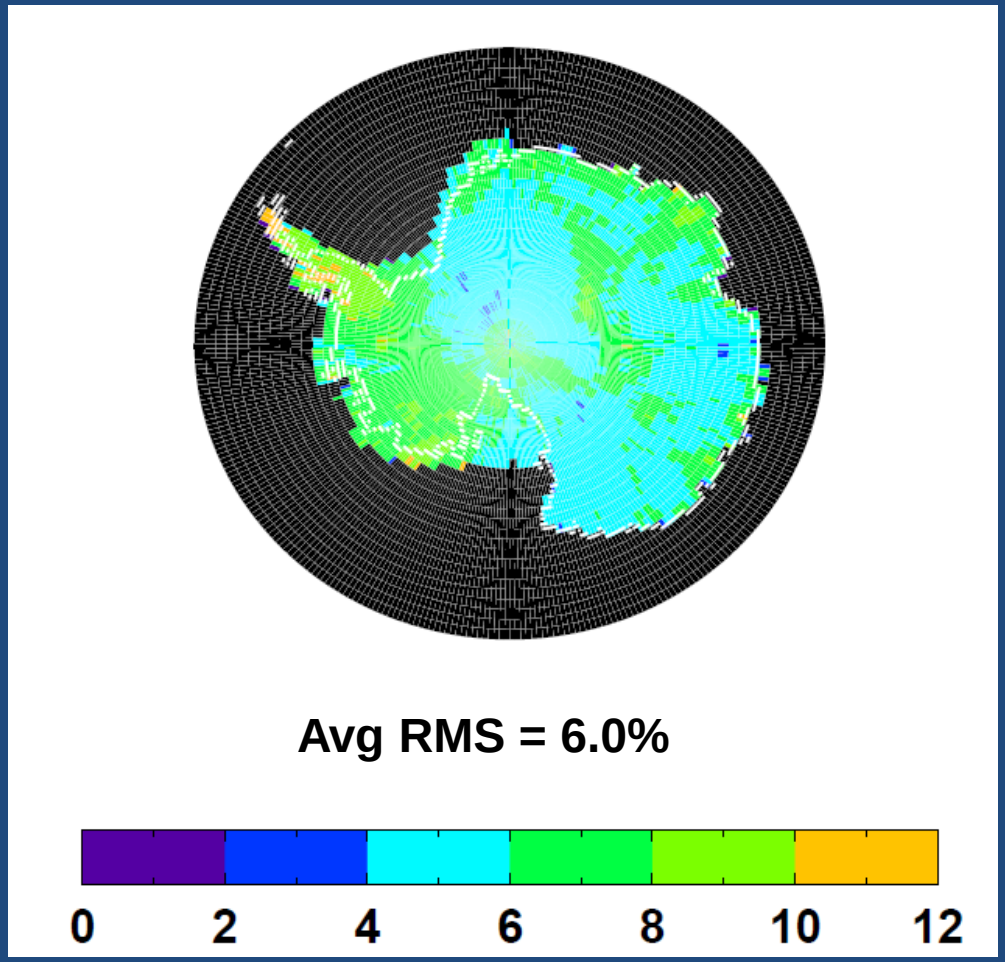
Summary of Changes to Snow/Ice ADMs

- Increased the number of skin temperature bins from 2 (e.g., <250 K, >250 K) to 8 for permanent snow (<210 K, 210-220 K, etc.), 5 for fresh snow and daytime sea ice, and 6 for nighttime sea ice.
- Cloud-surface temperature difference bins increased from 2 (<20 K, >20 K) to 3 (<10 K, 10-20 K, > 20K) for all scene types.
- When possible, model radiances are interpolated in skin temperature.

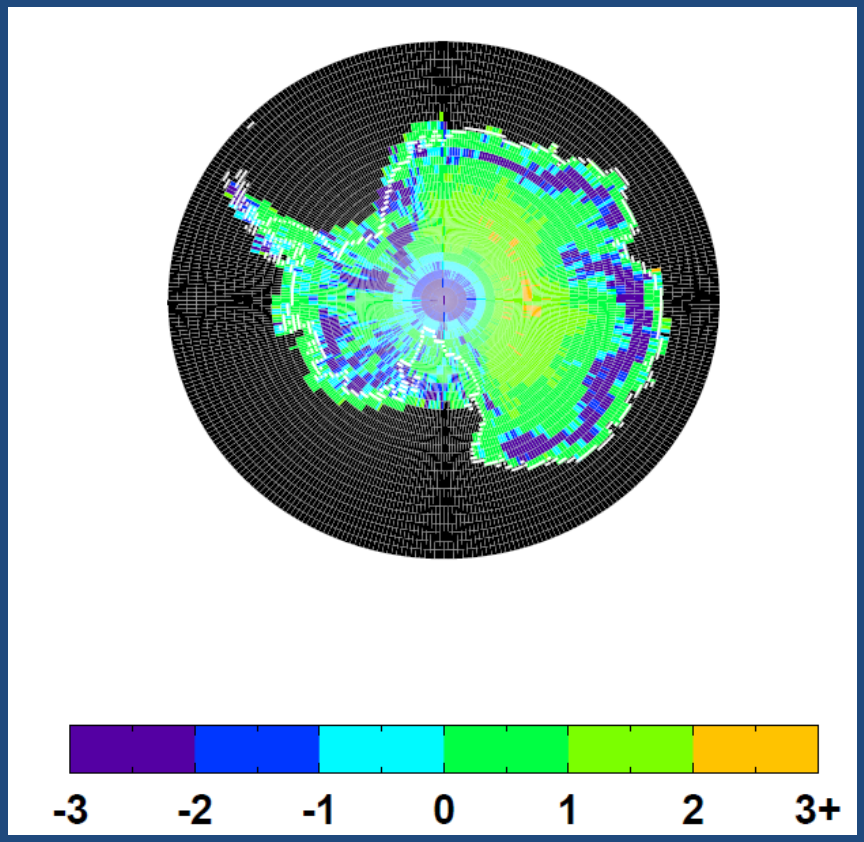
Ed 2 July 2003 Nighttime Antarctic Permanent Snow RMS (%)

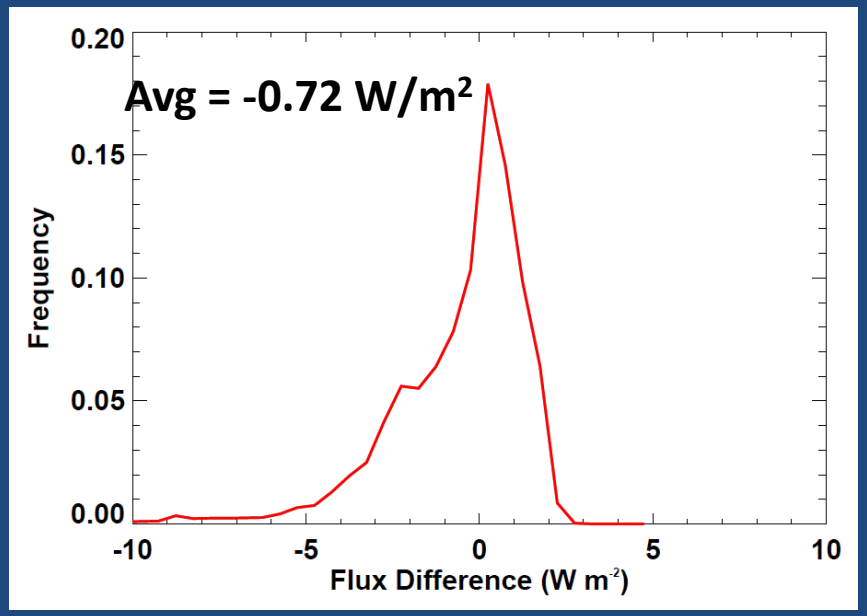


Ed 4 ADM July 2003 Nighttime Antarctic Permanent Snow RMS (%)

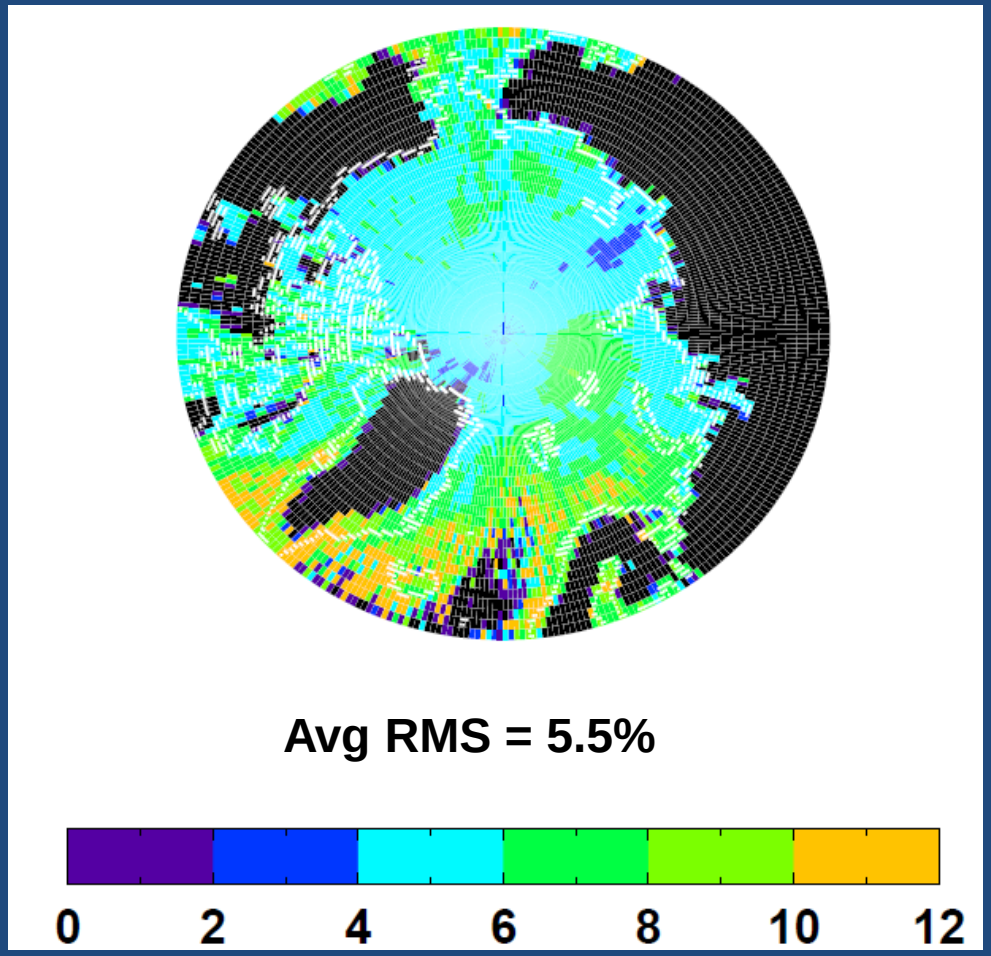


Ed 4 ADM – Ed 2 July 2003 Nighttime Antarctic Permanent Snow ΔF (W/m^2)

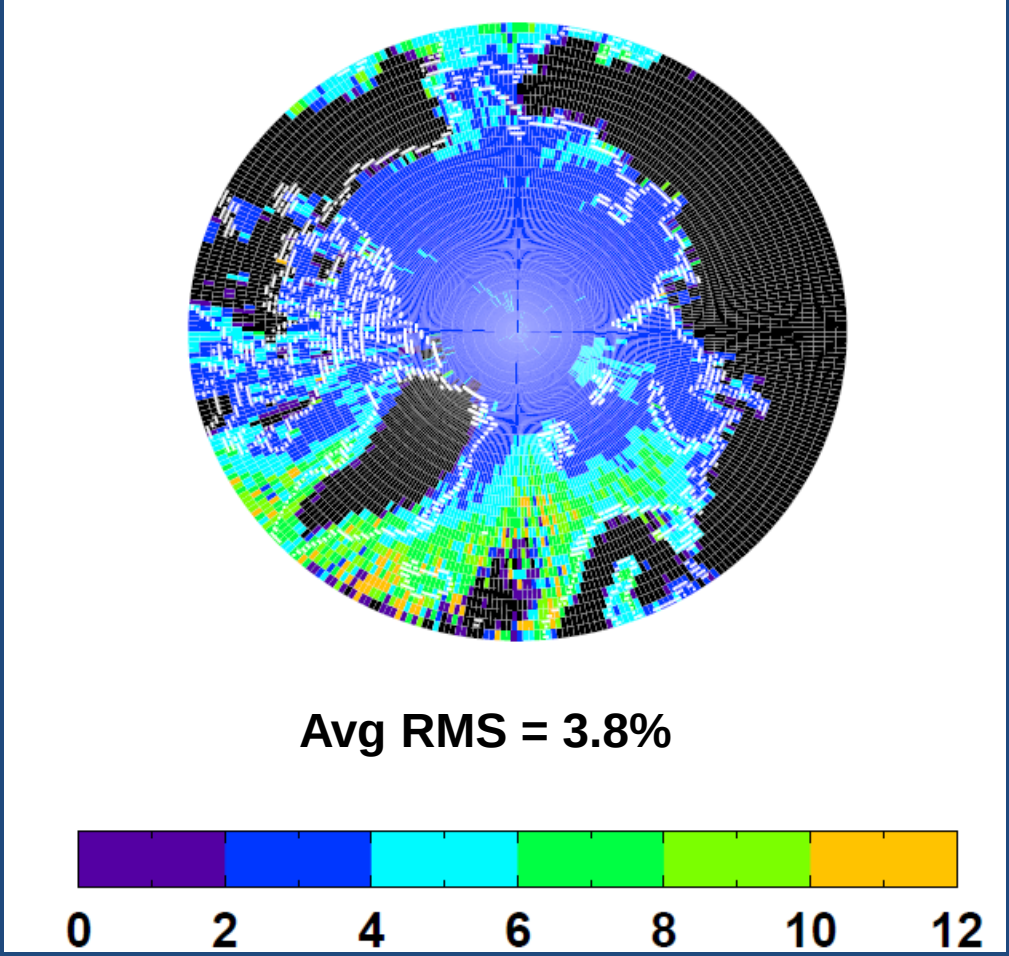




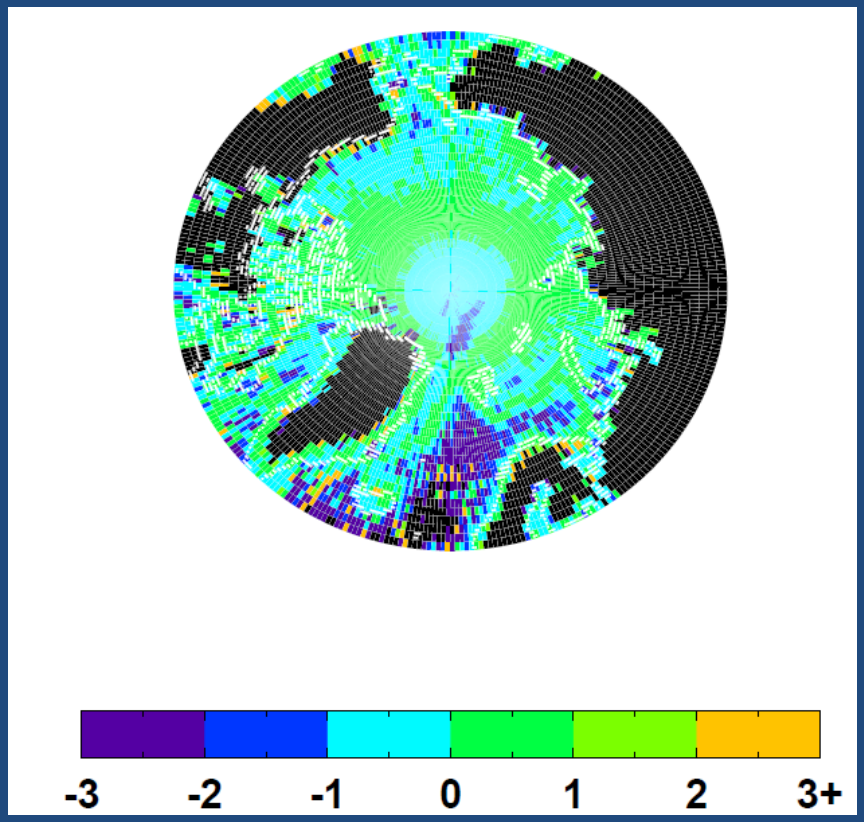
Ed 2 January 2003 Nighttime Sea Ice RMS (%)

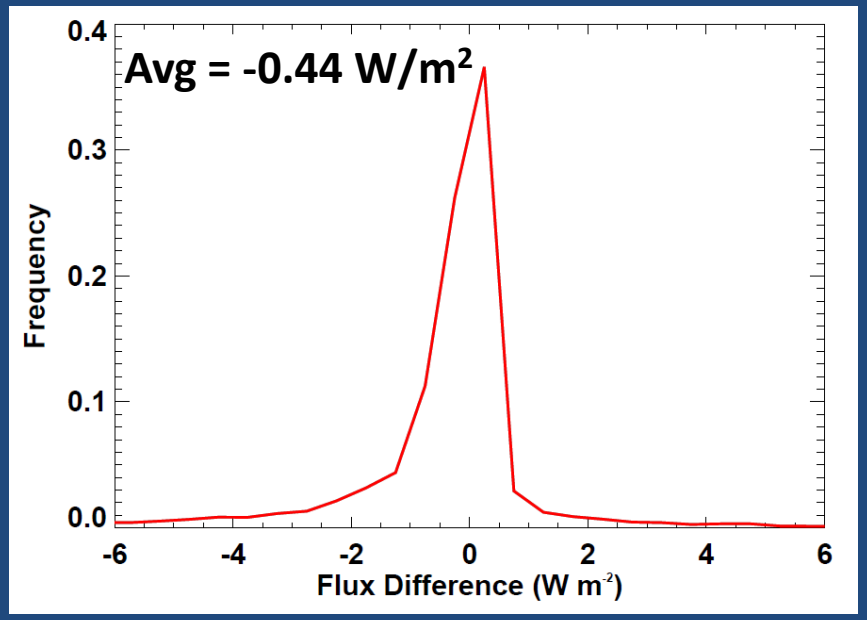


Ed 4 ADM January 2003 Nighttime Sea Ice RMS (%)



Ed 4 ADM – Ed 2 January 2003 Nighttime Sea Ice ΔF (W/m^2)

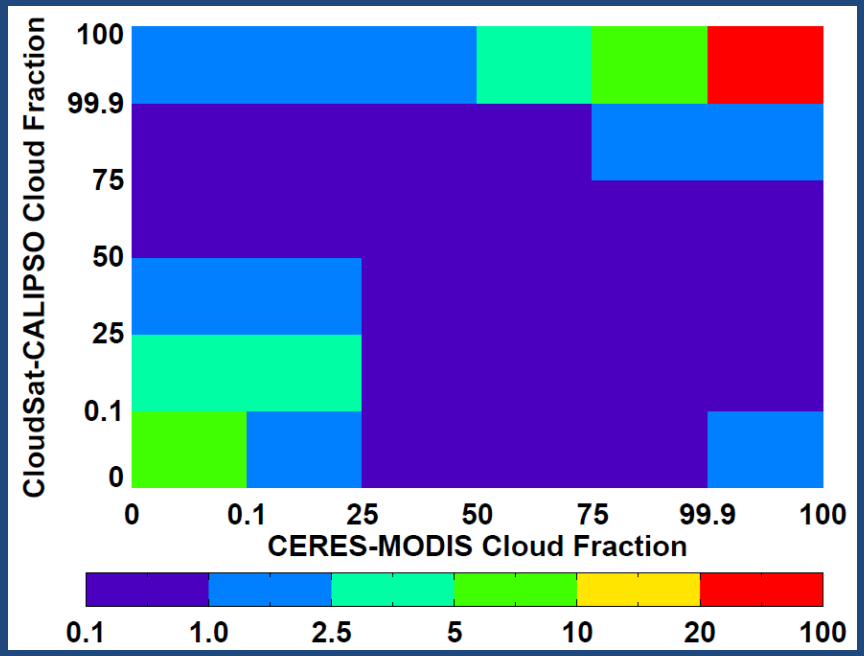


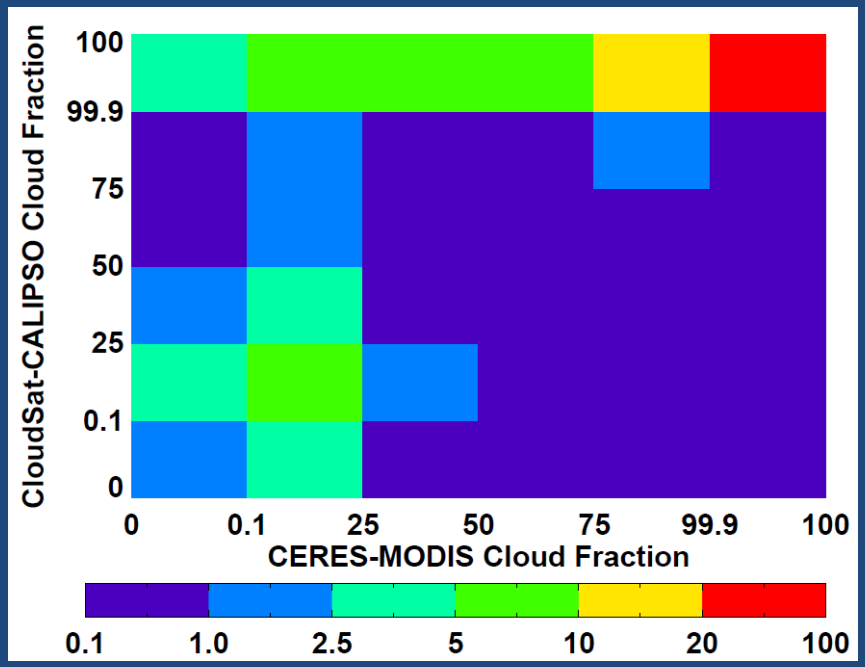


Cloudsat-CALIPSO and Ed 2 CERES-MODIS Cloud Masks for Sea ice scenes for 2007

Daytime: 61.3% CF on target, 27.9% CF too low, 10.8% CF too high

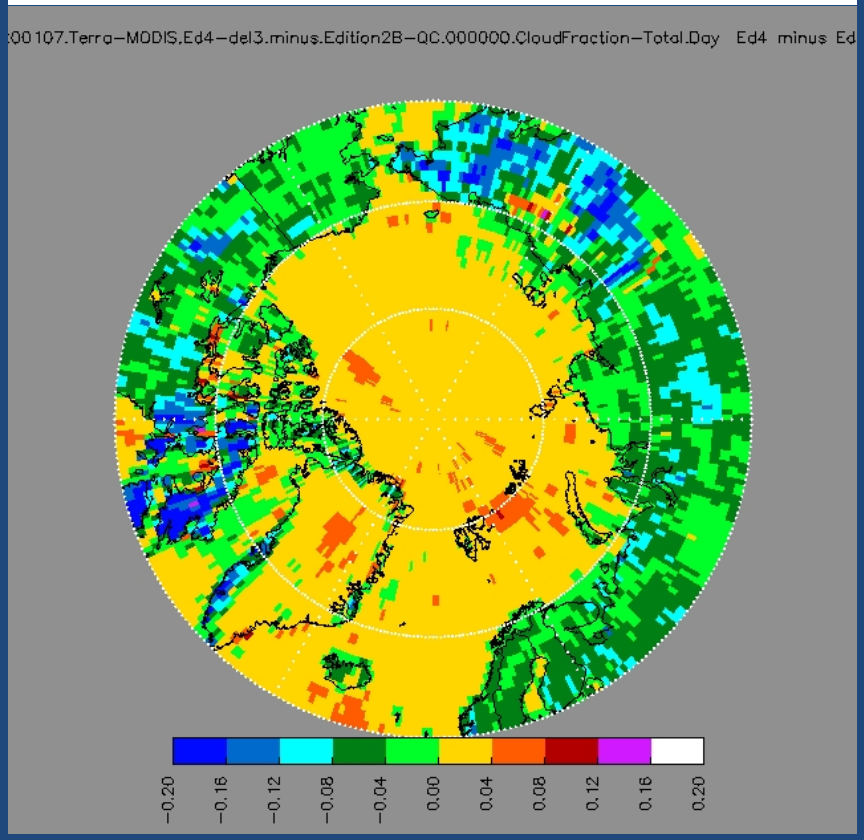
Nighttime: 36.8% on target, 53.3% CF too low, 9.8% CF too high



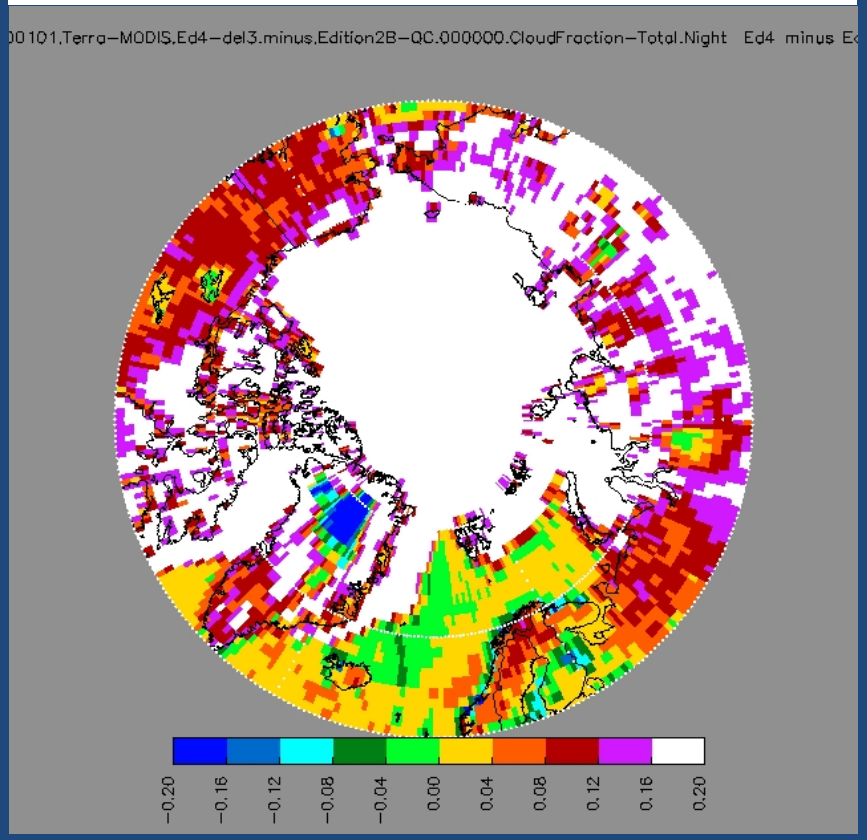


Ed 4 Cloud Mask Will Likely Be Closer to Active Sensor Results

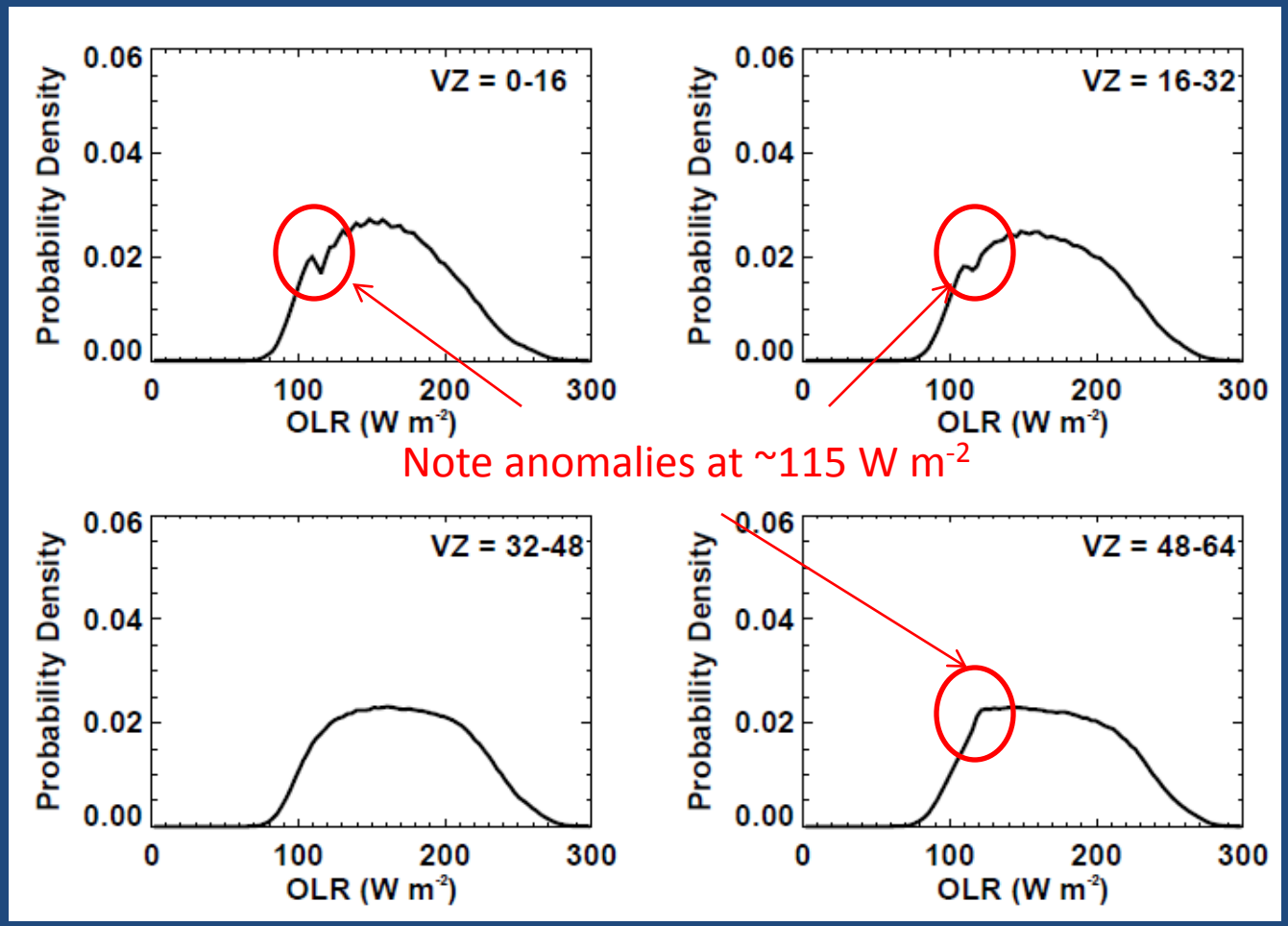
Terra July 2001 Ed4 – Ed2 Day Cloud Fraction



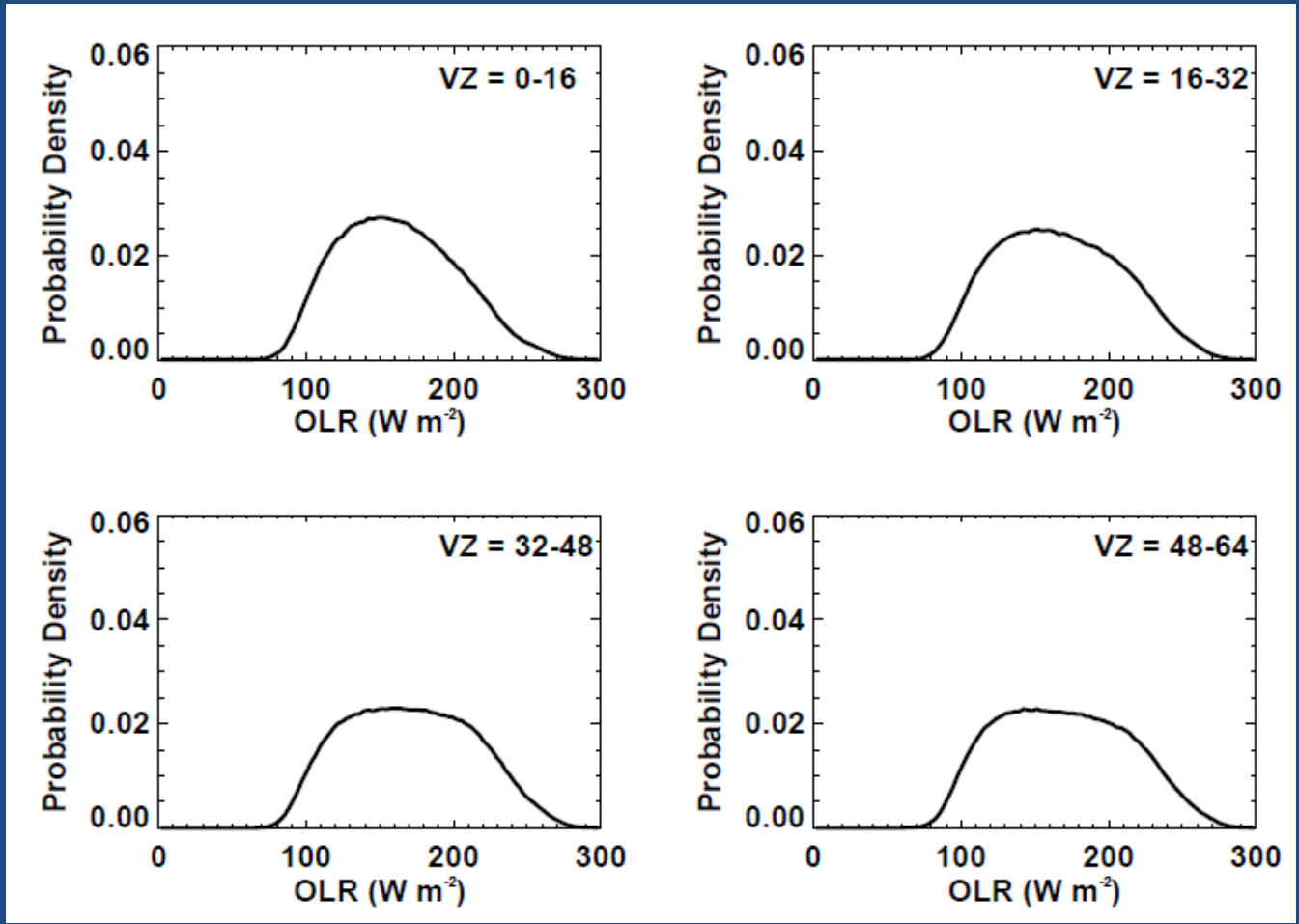
Terra January 2001 Ed4 – Ed2 Night Cloud Fraction



LW ADMs for cloudy conditions need further evaluation, but a small anomaly has been corrected. OLR retrievals with (Ed2) polynomial fit



OLR retrievals without polynomial fit



Summary

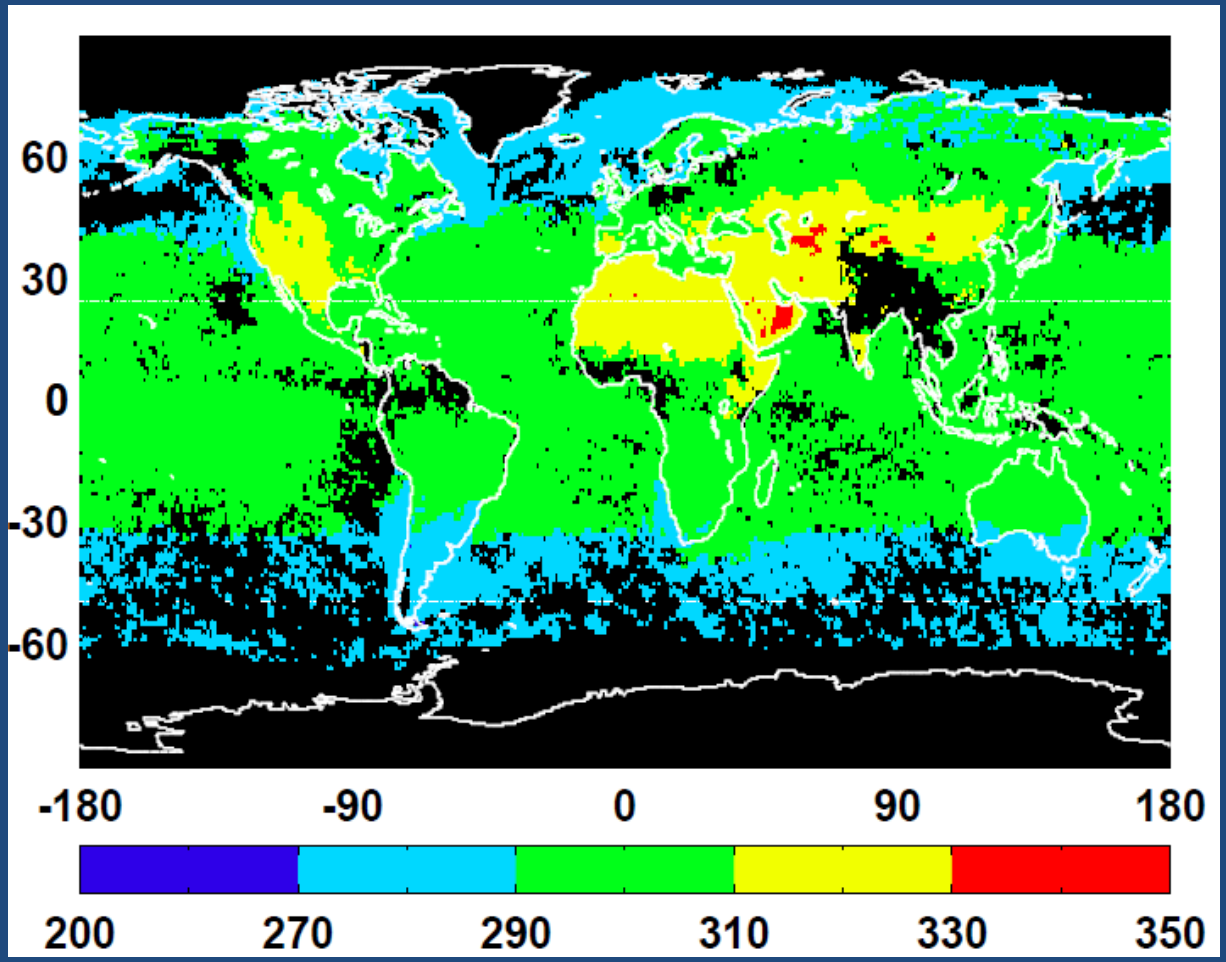
- The addition of surface temperature bins and interpolation between the bins significantly reduced the magnitudes of both the RMS and relative bias for both clear-sky and snow scenes.
- Edition 4 fluxes are generally altered by up to a few watts, with the biggest impacts for bright deserts in the NH summer.

Future Work

- Focus on effects of new Ed 4 cloud retrievals once they become available.
- Cloudy-sky ADMs have been improved some with a focus on high clouds but need to be further evaluated.

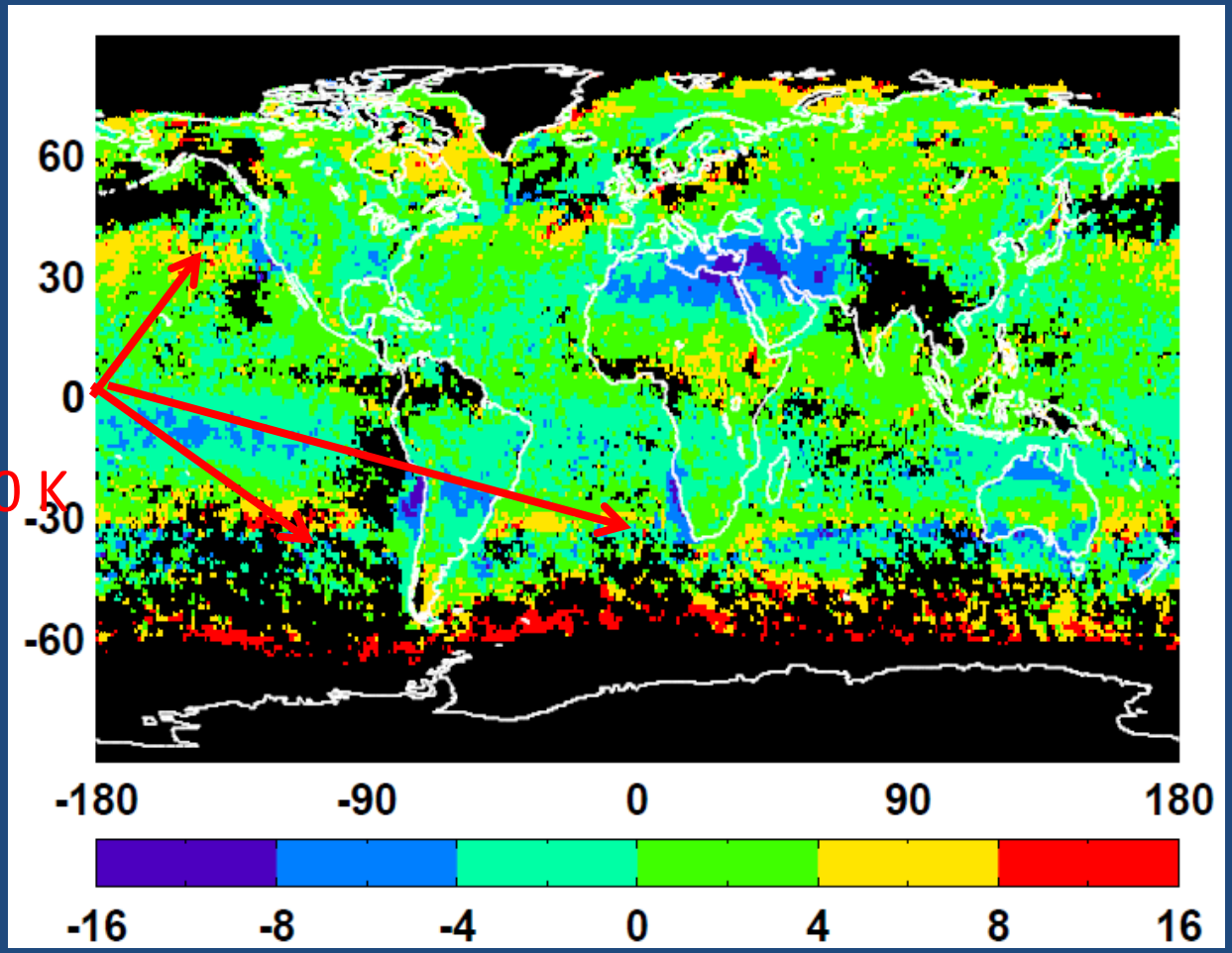
Backup Slides

Jul 2000 Daytime Skin Temperature (K)

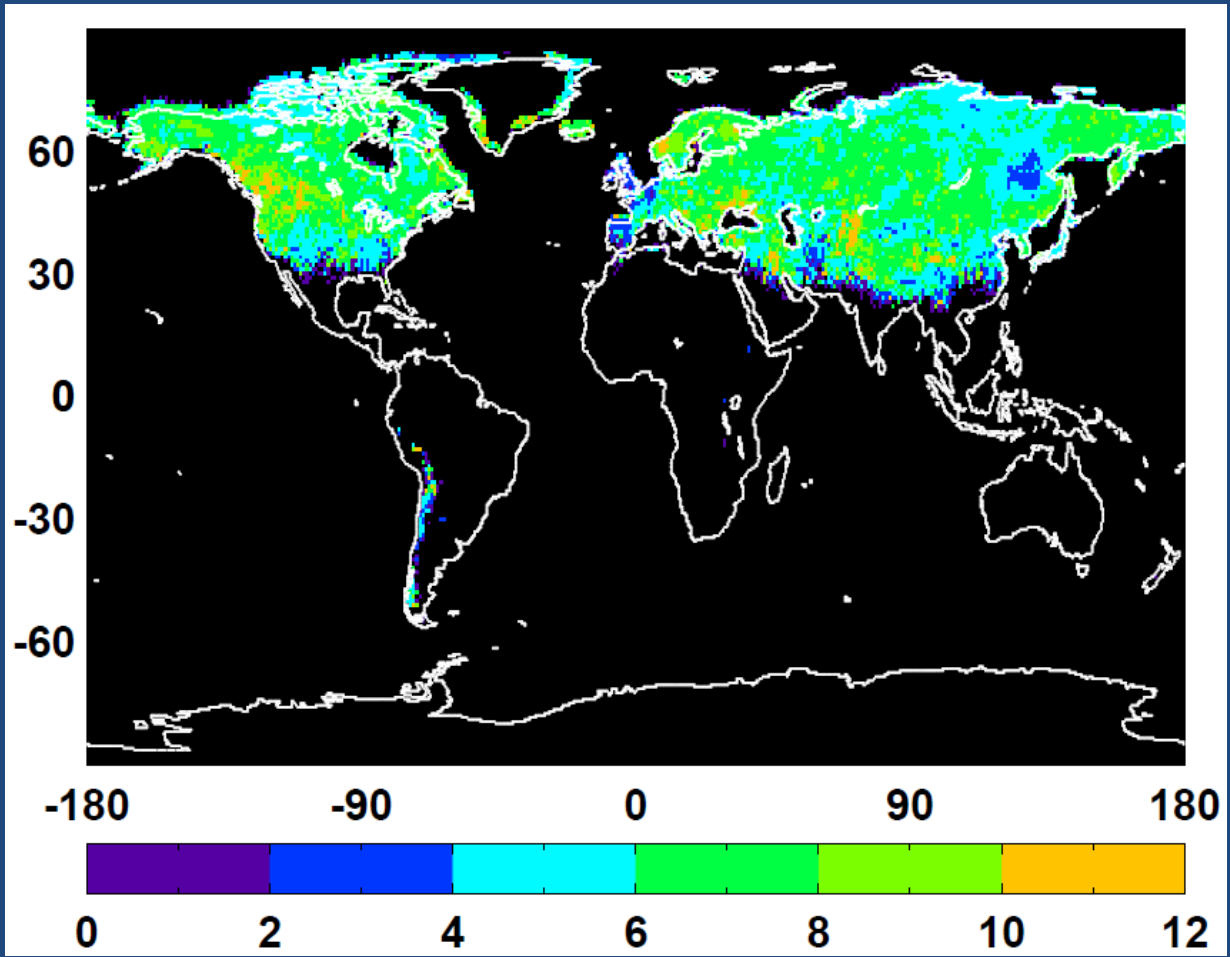


Edition 2 Jul 2000 Daytime Relative Bias (%)

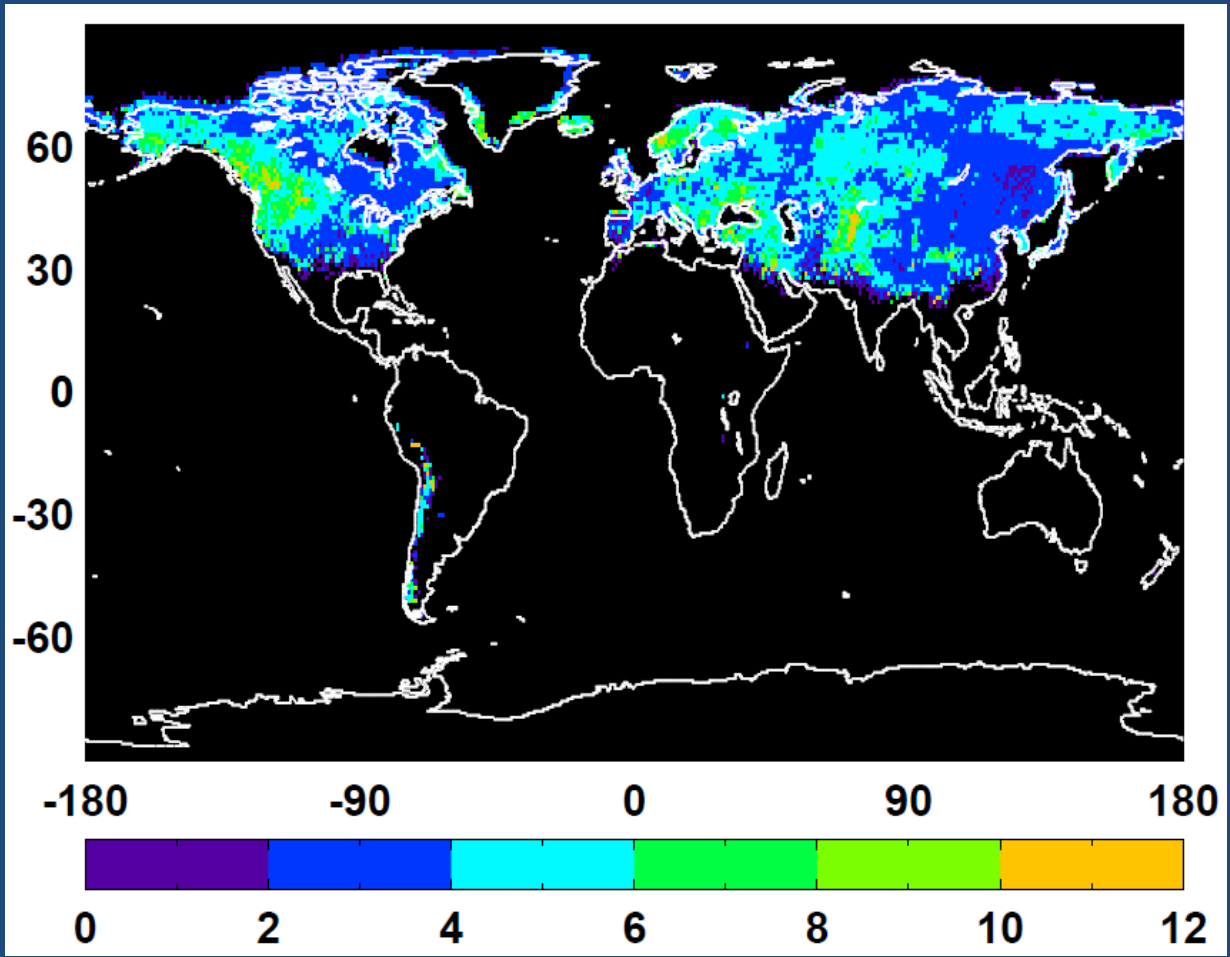
High biases over oceans near Ts = 290 K boundary



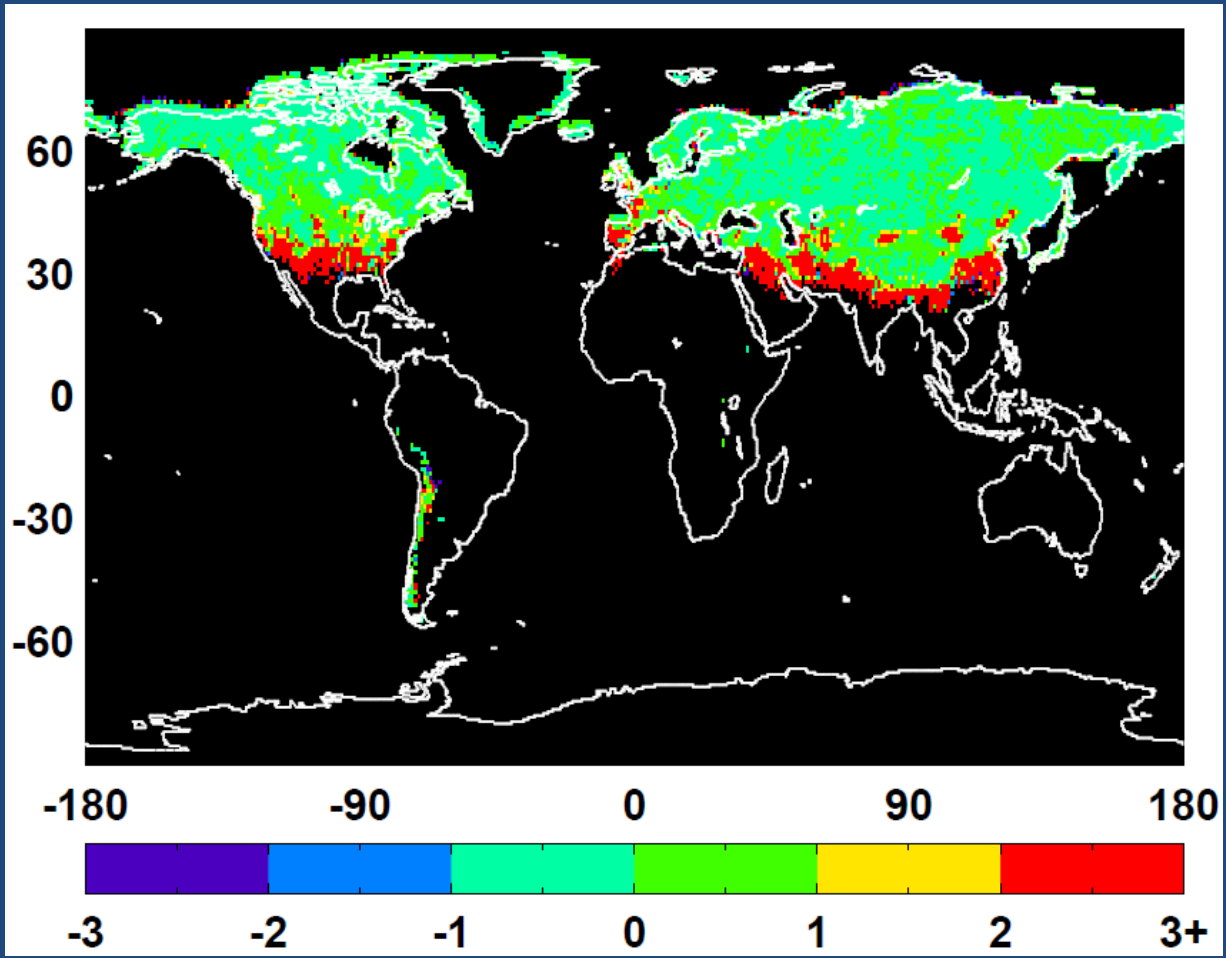
Ed 2 January 2003 Nighttime Fresh Snow RMS (%)



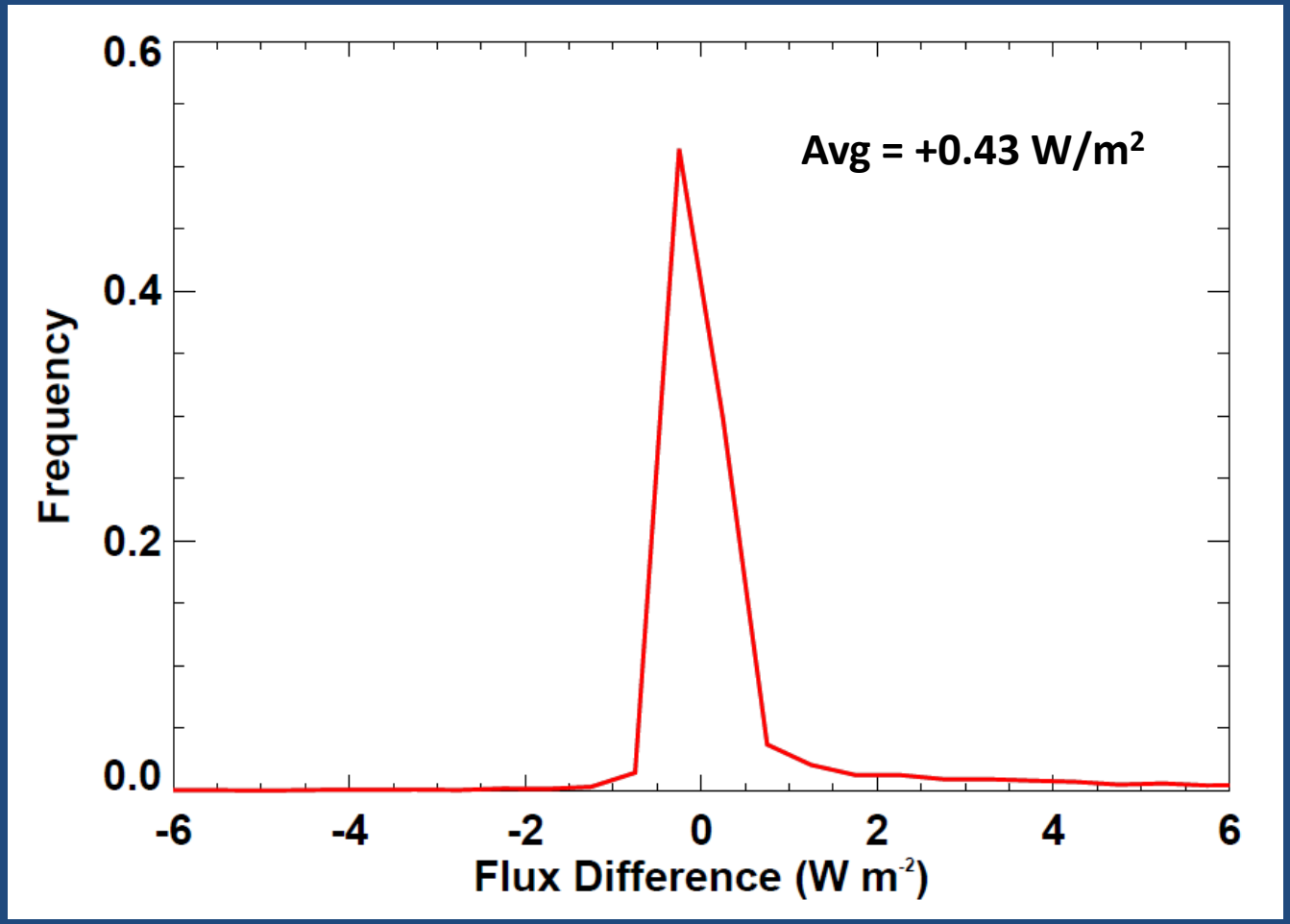
Ed 4 January 2003 Nighttime Fresh Snow RMS (%)



Ed 4 – Ed 2 January 2003 Nighttime Fresh Snow ΔF (W/m^2)



Ed 4 – Ed 2 January 2003 Nighttime Fresh Snow ΔF (W/m^2)



Daytime Mean Normalized RMS values (%) – Magnitudes reduced in Ed 4

Edition 2 Values in **black**, proposed Edition 4 values in **red**.

	Jan 2003	April 2003	July 2003	Oct 2003
Perm Snow	5.2, 2.6	6.4, 3.6	4.3, 3.3	8.1, 5.2
Sea Ice	4.8, 3.8	5.8, 3.7	5.3, 4.1	5.2, 4.1
Fresh Snow	6.5, 4.2	6.3, 4.4	4.7, 3.8	5.5, 3.9

Daytime Mean Relative Biases (%) – Magnitudes reduced in Ed 4

Edition 2 Values in **black**, proposed Edition 4 values in **red**.

	Jan 2003	April 2003	July 2003	Oct 2003
Perm Snow	-4.4, -0.8	12.5, 4.7	-5.0, 0.8	10.0, 2.1
Sea Ice	-0.6, 0.7	1.8, 0.8	-1.2, 1.3	2.7, 1.2
Fresh Snow	0.5, -0.2	-2.0, -0.9	-10.5, -5.8	-2.9, -1.0

Nighttime Mean Normalized RMS values (%) – Magnitudes reduced in Ed4

Edition 2 Values in **black**, proposed Edition 4 values in **red**.

	Jan 2003	April 2003	July 2003	Oct 2003
Perm Snow	6.7, **4.7**	8.0, **5.1**	8.2, **6.0**	7.6, **5.5**
Sea Ice	5.5, **3.8**	5.4, **3.6**	6.4, **4.9**	5.9, **4.2**
Fresh Snow	6.2, **4.1**	5.6, **4.0**	3.0, **2.9**	5.2, **3.7**

Nighttime Mean Relative Biases (%) – Magnitudes reduced in Ed 4

Edition 2 Values in **black**, proposed Edition 4 values in **red**.

	Jan 2003	April 2003	July 2003	Oct 2003
Perm Snow	-8.6, -4.2	-0.7, -0.1	8.0, 3.5	-2.5, -2.5
Sea Ice	-2.9, -1.3	-3.4, -1.5	-0.6, 1.6	-3.2, -1.4
Fresh Snow	-0.9, 0.0	-3.5, -0.7	-14.1, -6.0	-3.4, -0.3

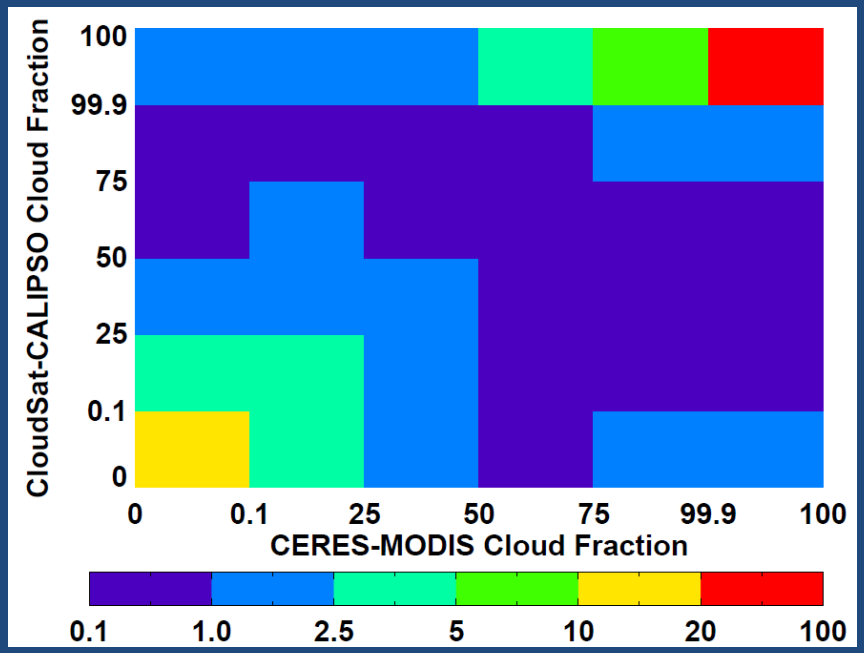
CCCM versus Ed 2 CERES-MODIS cloud fractions

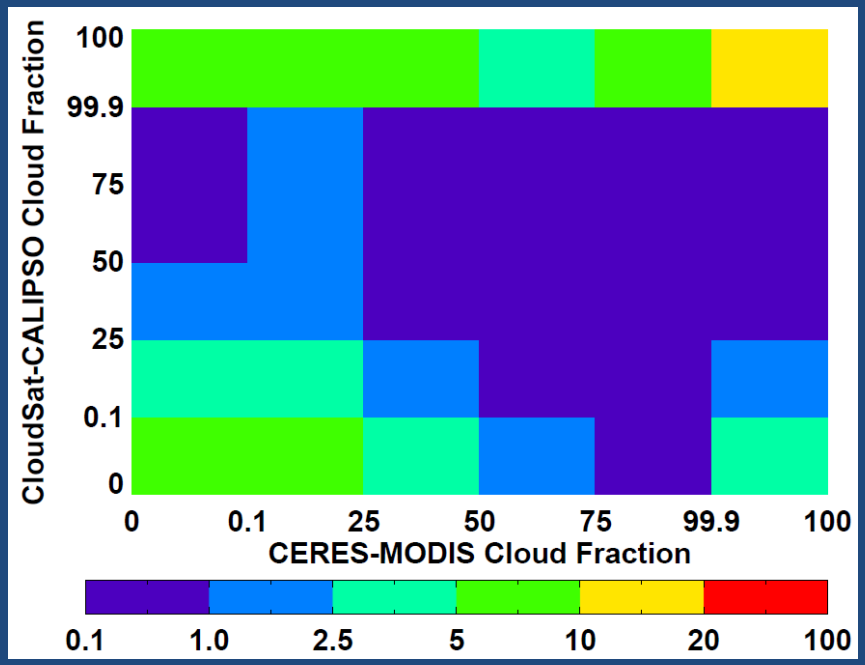
- 12 Months of data from 2007 used
- CERES-MODIS cloud fraction compared to CALIPSO-CloudSat cloud fraction for portions of footprints along the track of the active sensors.
- CALIPSO-CloudSat columns with $\tau<0.3$ considered clear in this analysis to account for sensitivity of MODIS instrument.
- Analysis carried out for 6 different cloud fraction categories for permanent snow, fresh snow and sea ice scene types. If both analyses are in the same category, then the CERES-MODIS mask is said to be "on target", and we also add up the fraction of footprints where the CERES-MODIS cloud fraction category is above or below the CALIPSO-CloudSat category.

For Permanent Snow, more underestimates and overestimates of cloud fraction at night

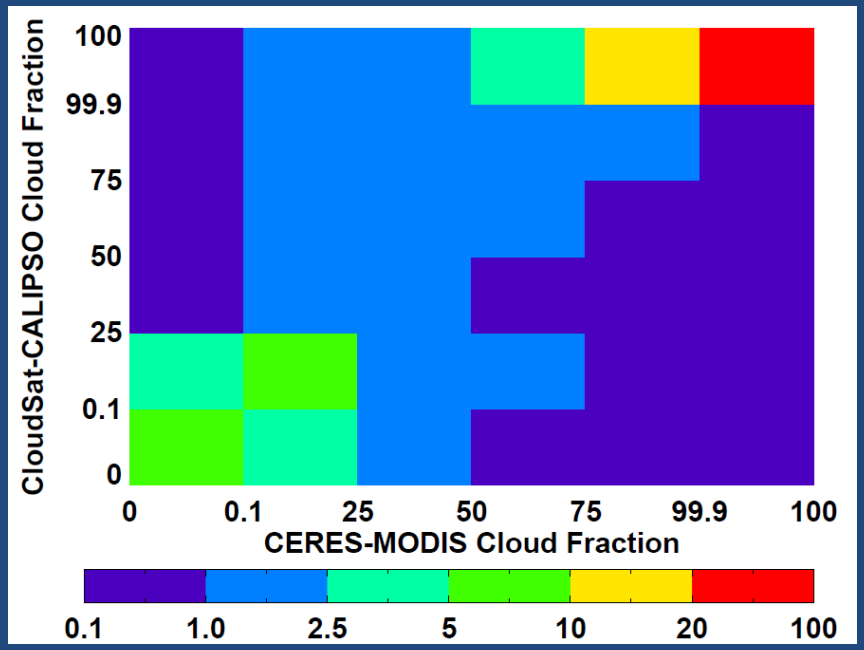
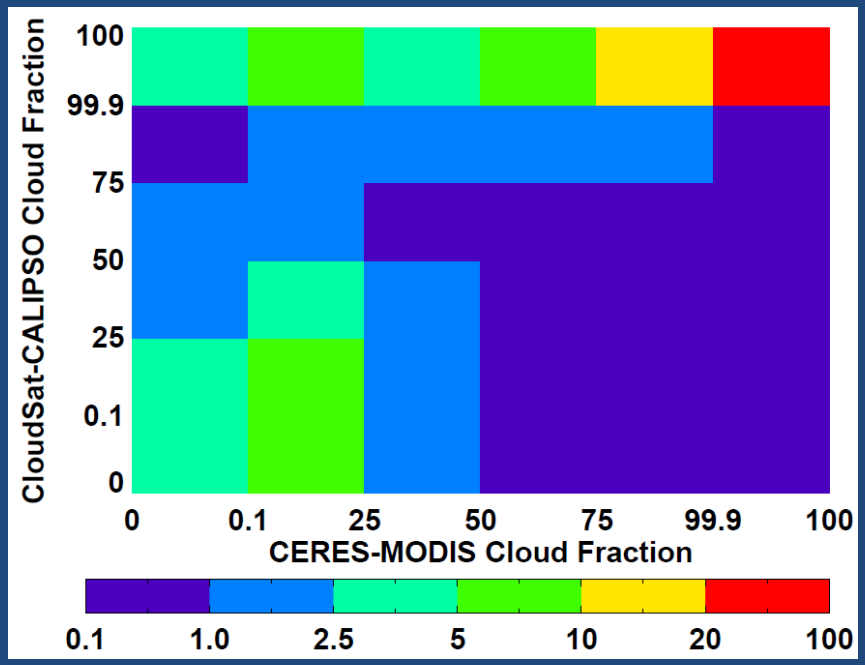
Daytime: 54.2% CF on target, 28.4% CF too low, 17.4% CF too high

Nighttime: 32.5% on target, 47.4% CF too low, 20.0% CF too high





For Fresh Snow, more underestimates of cloud fraction at night.

Daytime: 49.9% CF on target, 35.2% CF too low, 14.9% CF too high

Nighttime: 35.5% on target, 49.6% CF too low, 14.9% CF too high