Edition 4 Longwave Angular Distribution Models

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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

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

Normalized RMS calculated for each 1x1 grid cell

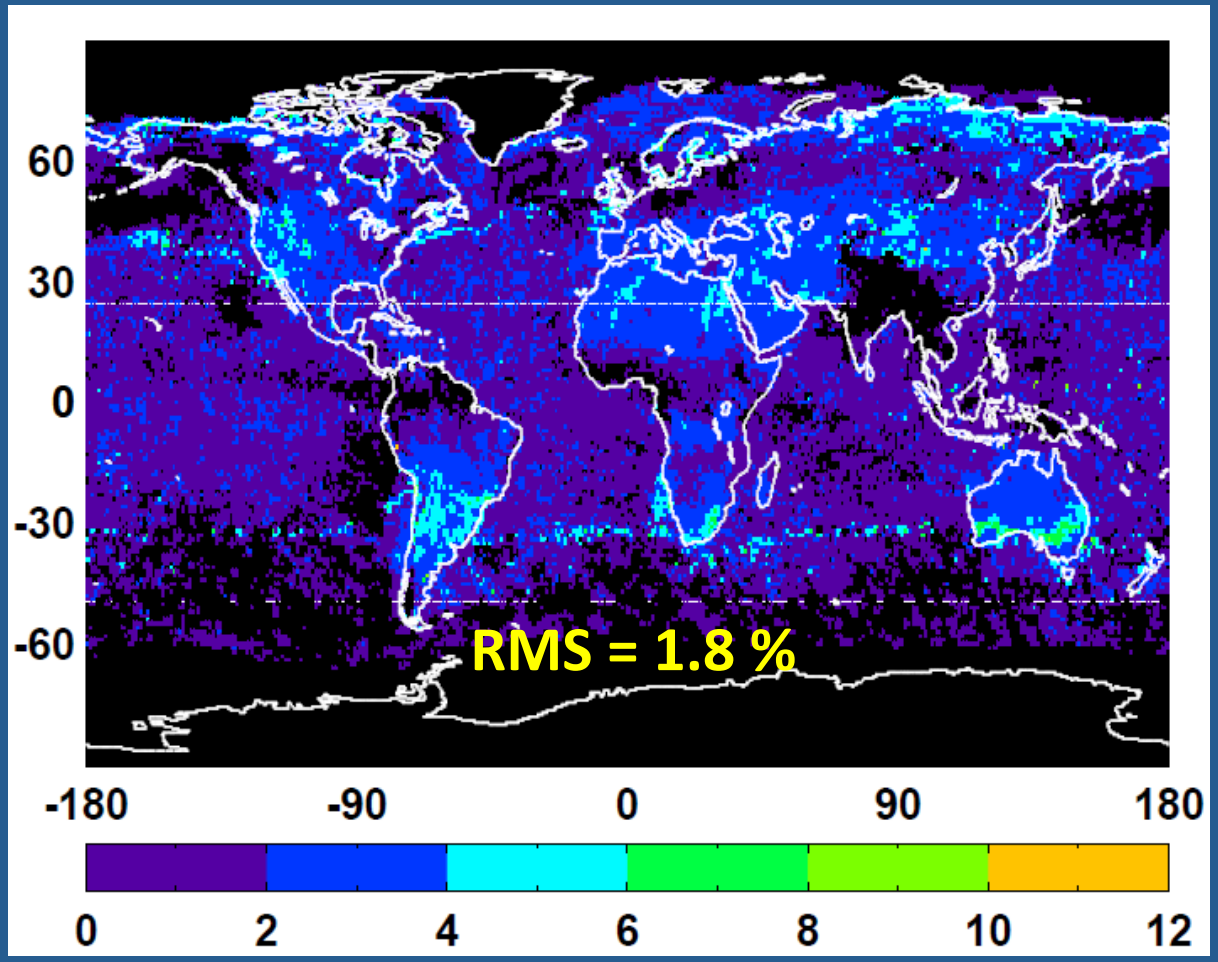
Note: results are not necessarily applicable to fluxes!

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

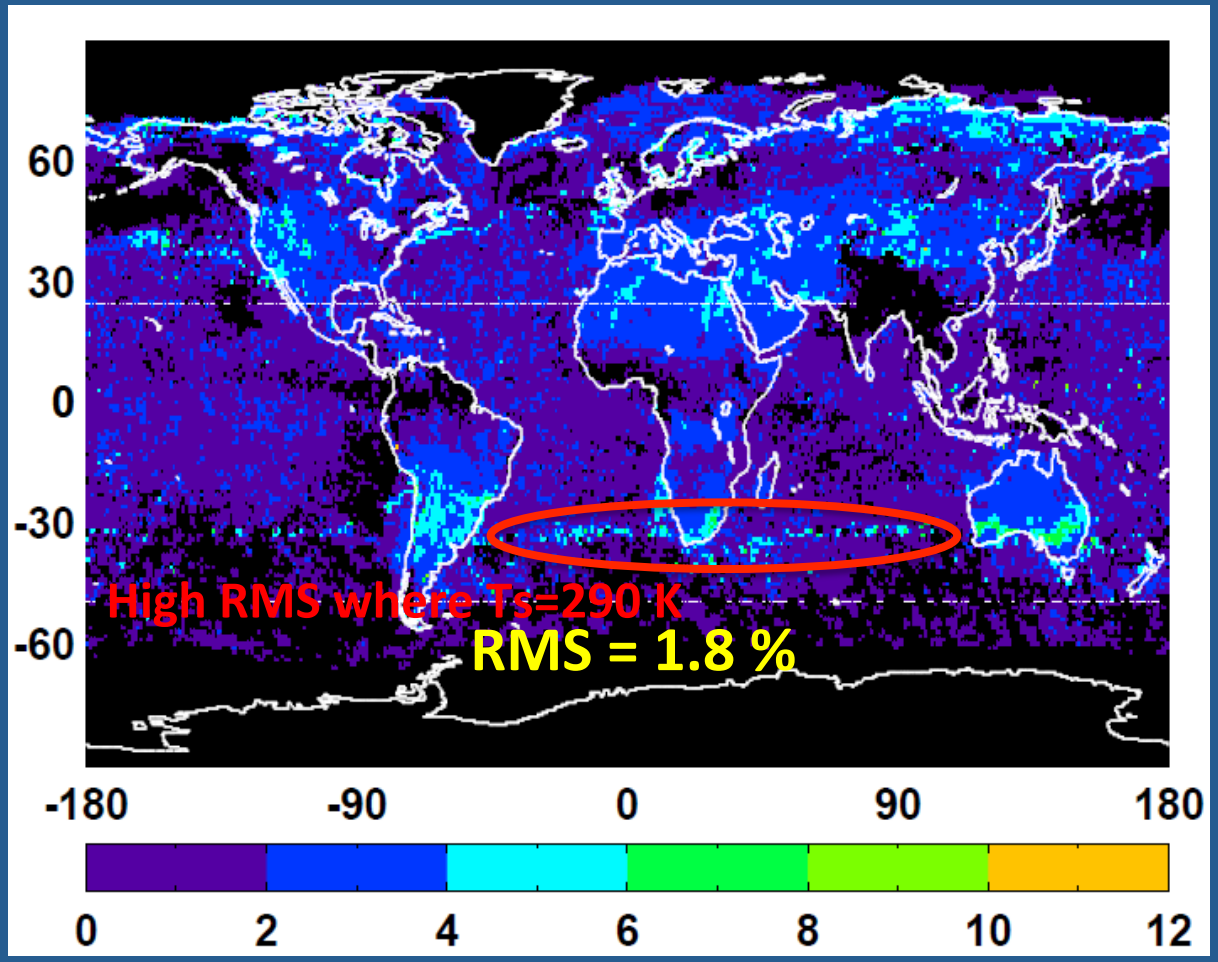
Clear Land, Ocean, Desert Scenes

- In Edition 2, average anisotropic factor is calculated for a given precipitable water (< 1 cm, 1-3 cm, 3-5 cm, 5+ cm), surface temperature (< 270 K, 270-290 K, 290-310 K, 310-330 K, 330+ K), lapse rate (< 15 K, 15-30 K, 30-45 K, 45+ K over the lowest 300 hPa) and surface type (ocean, forests, savannas, grasslands, dark desert, bright desert).
- Edition 4 uses 10 surface temperature categories and interpolates between surface temperature bins when possible.

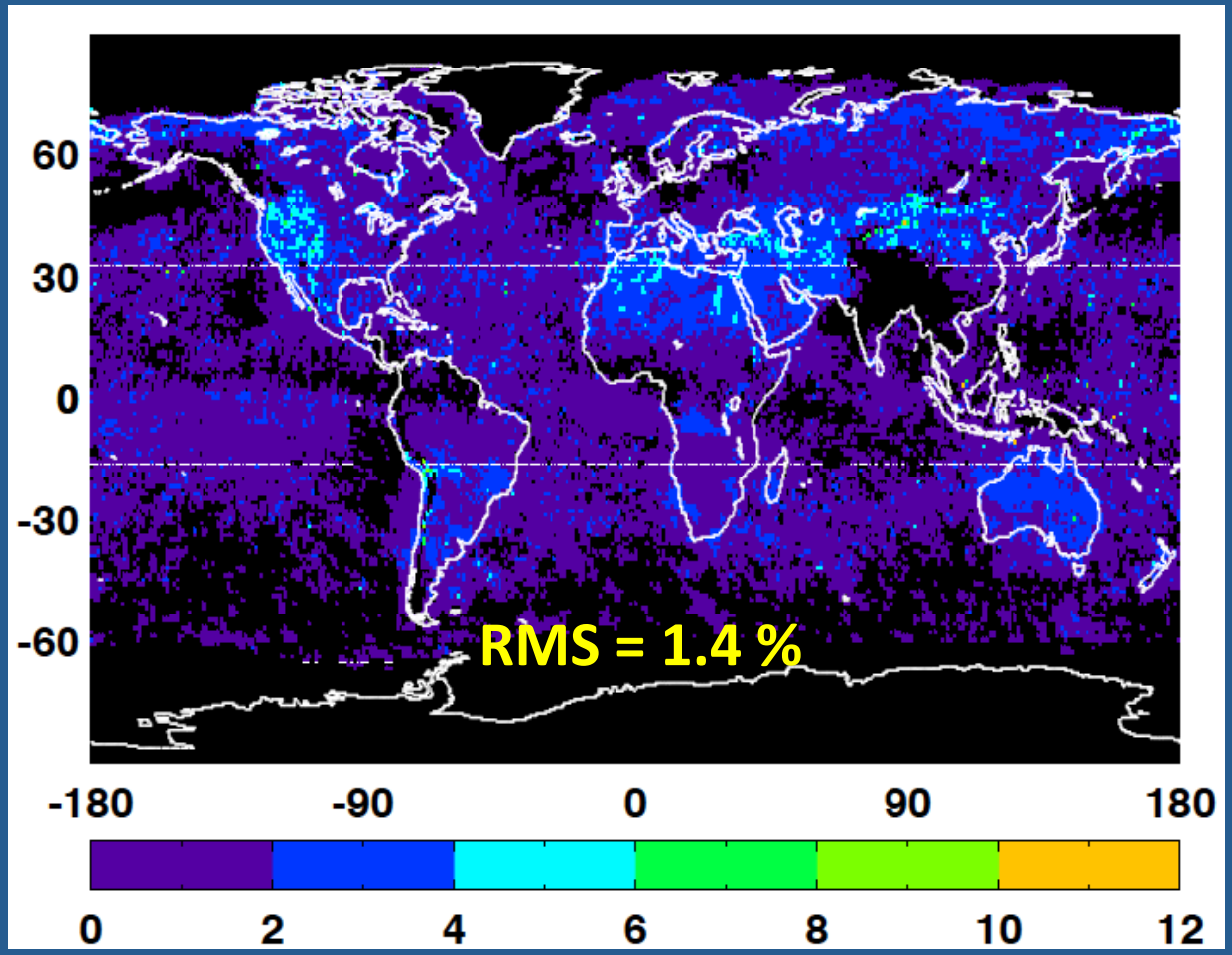
Edition 2 Jul 2000 Daytime Normalized RMS (%) for Clear-Sky Scenes



Edition 2 Jul 2000 Daytime Normalized RMS (%) for Clear-Sky Scenes



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



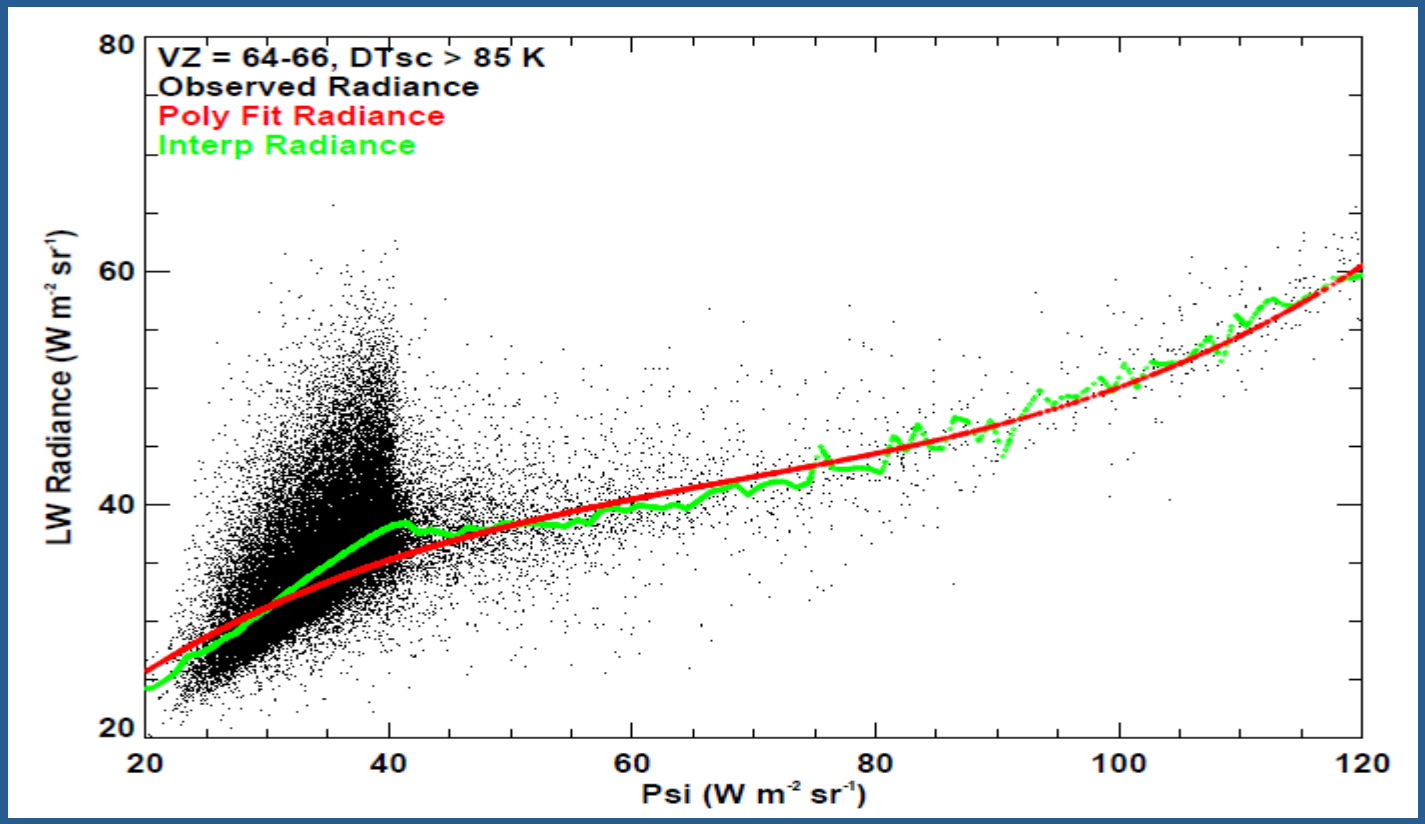
Clouds over Land, Ocean, Desert: Pseudoradiance

- 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

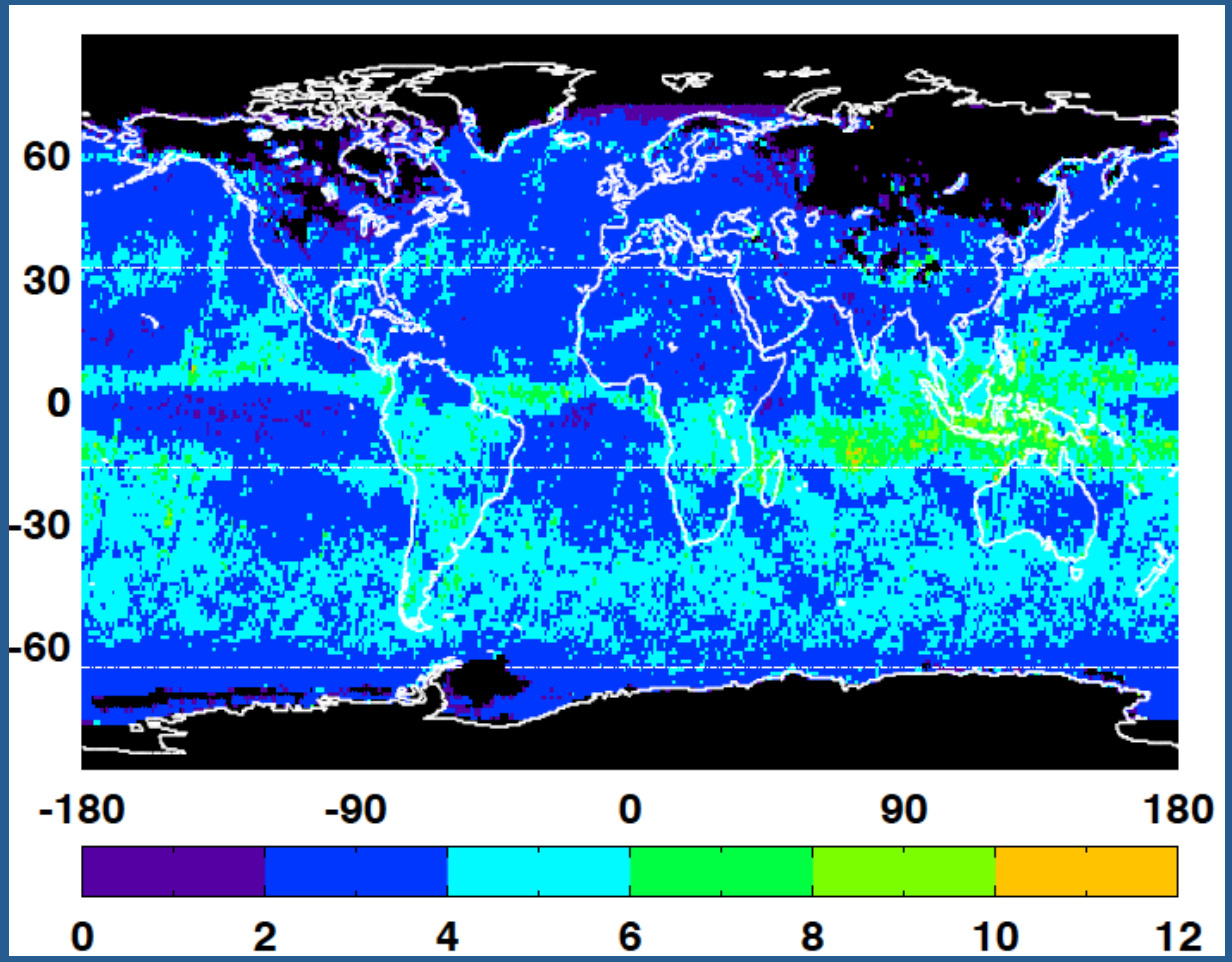
$$\psi = (1-f)\varepsilon_s B(T_s) + \sum_{j=1}^{2}[\varepsilon_s B(T_s)(1-\varepsilon_{c_j}) + \varepsilon_{c_j} B(T_{c_j})]f_j$$

Polynomial fit vs. Interpolation

- As an alternative, we simply use the mean radiance (if there is one) 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.

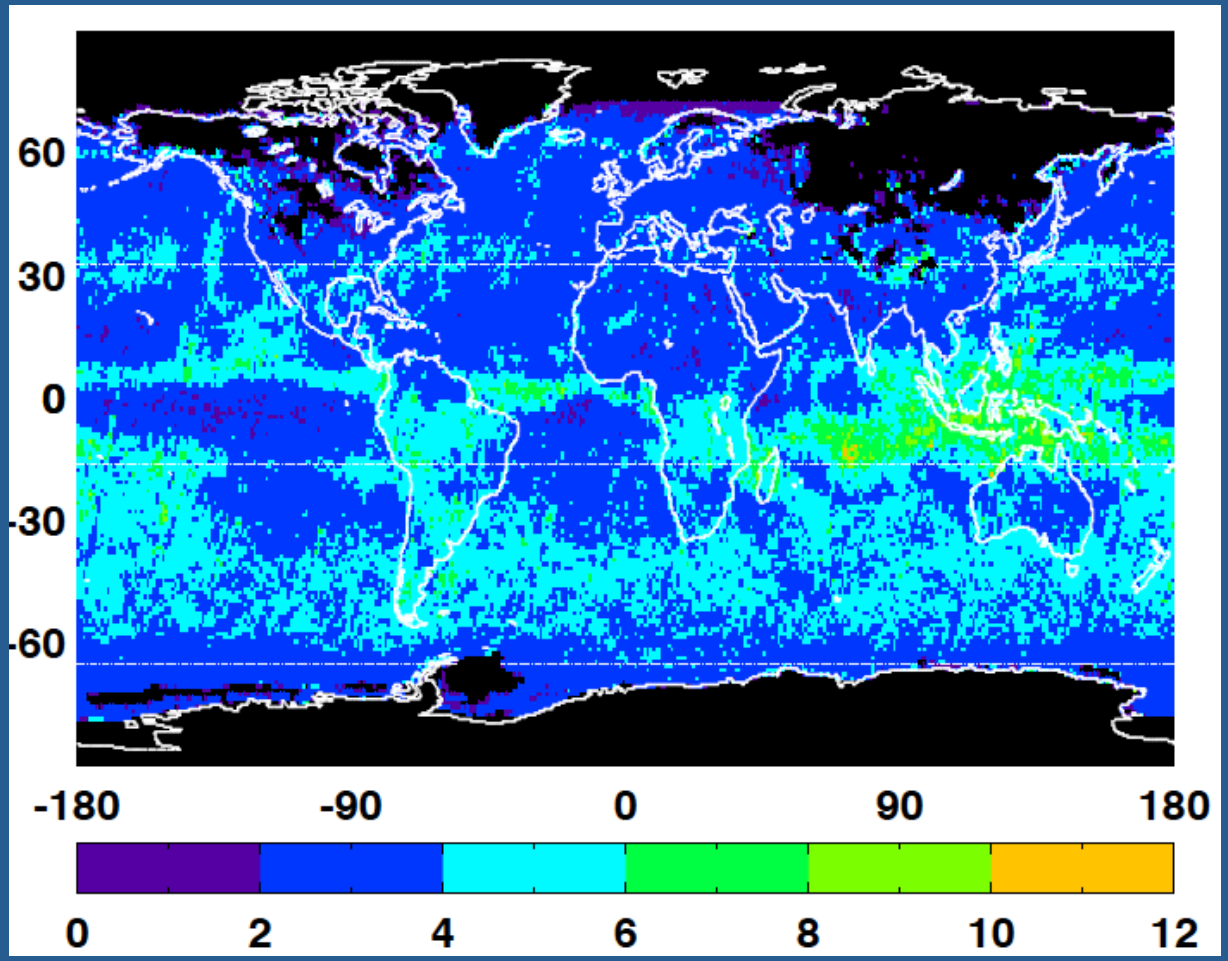


Edition 4 SSFs with Updated Edition 2 ADMs
Jan 2001 Cloudy-sky Daytime Normalized RMS (%)



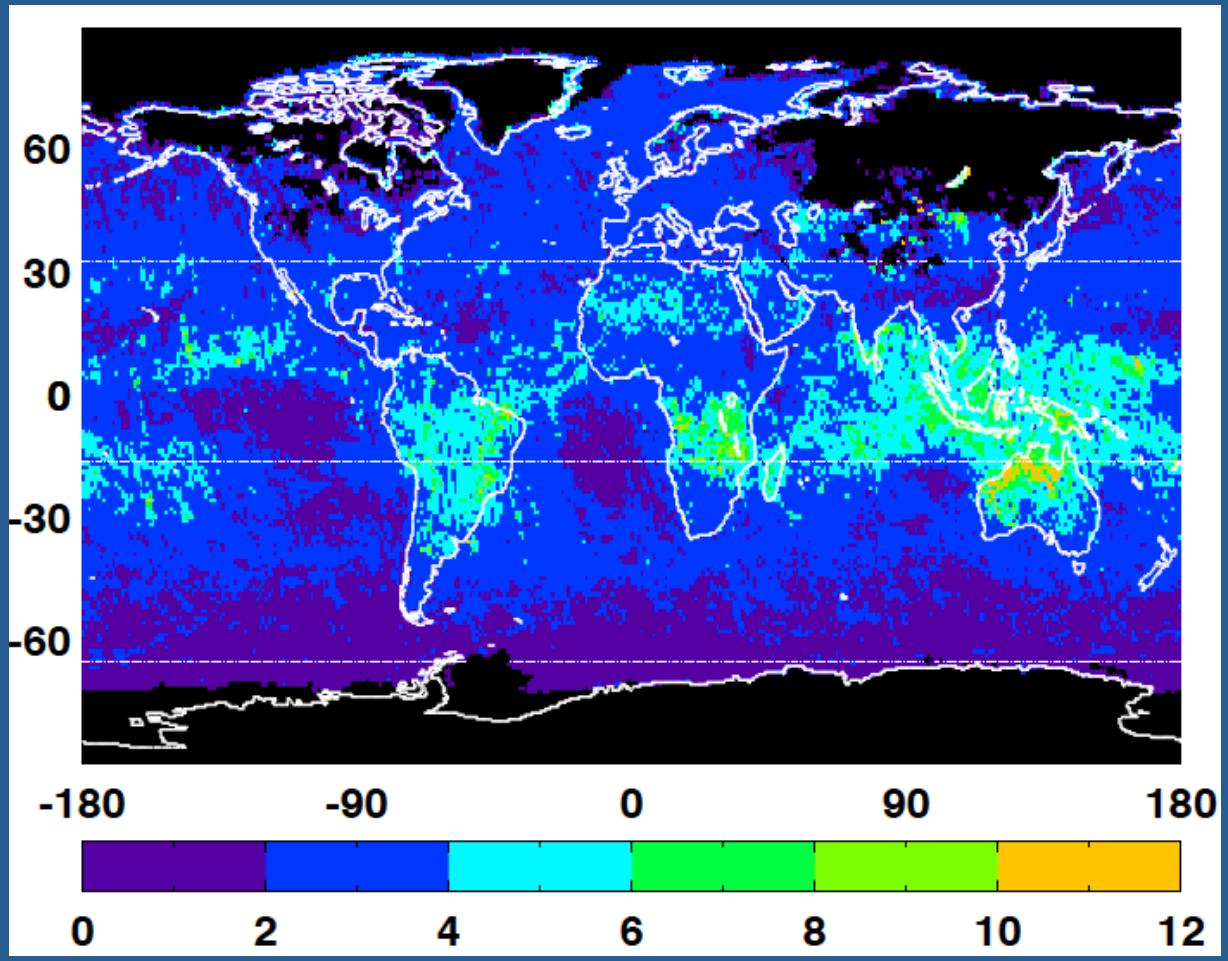
Avg RMS = 3.8%

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



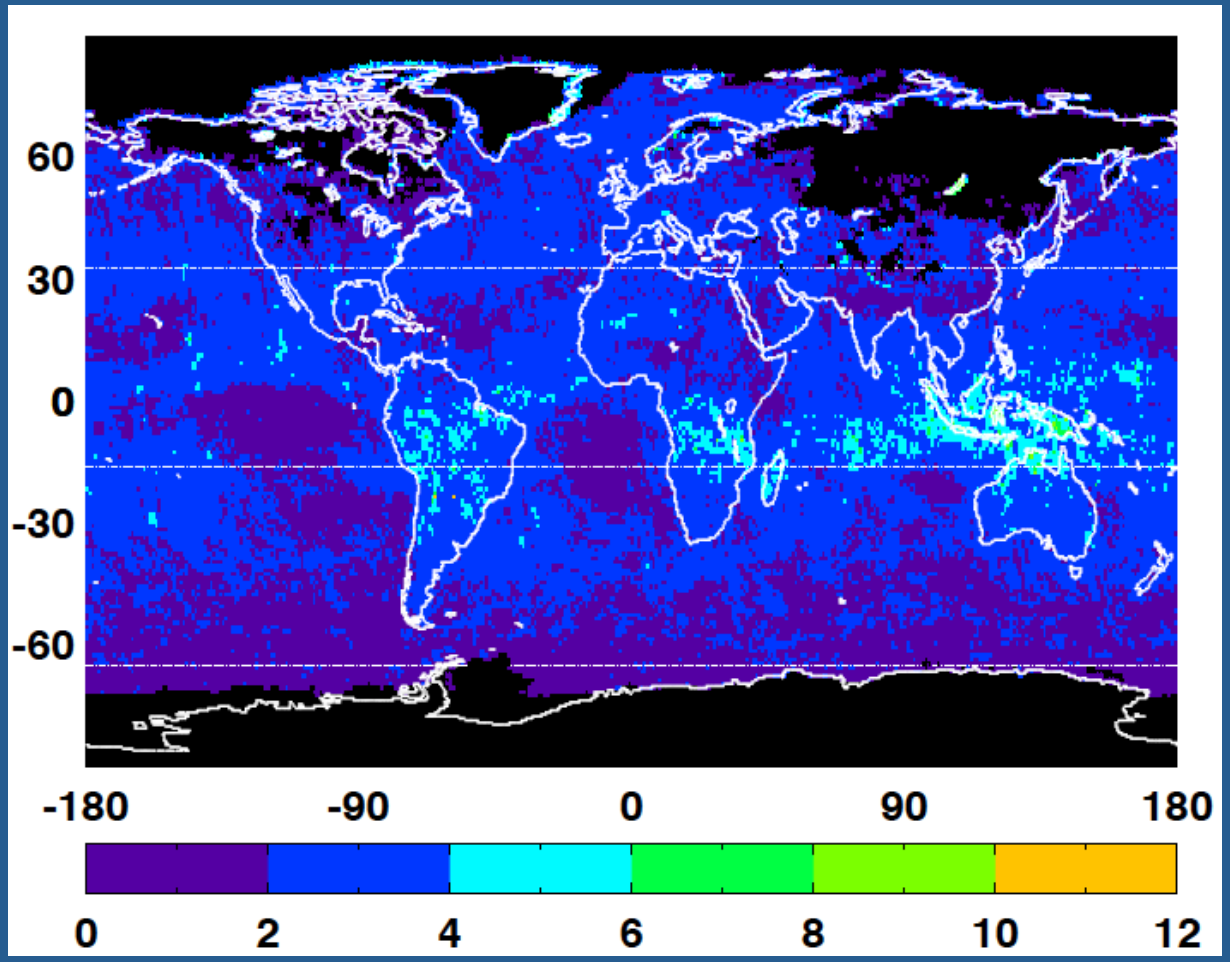
Avg RMS = 3.8%

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



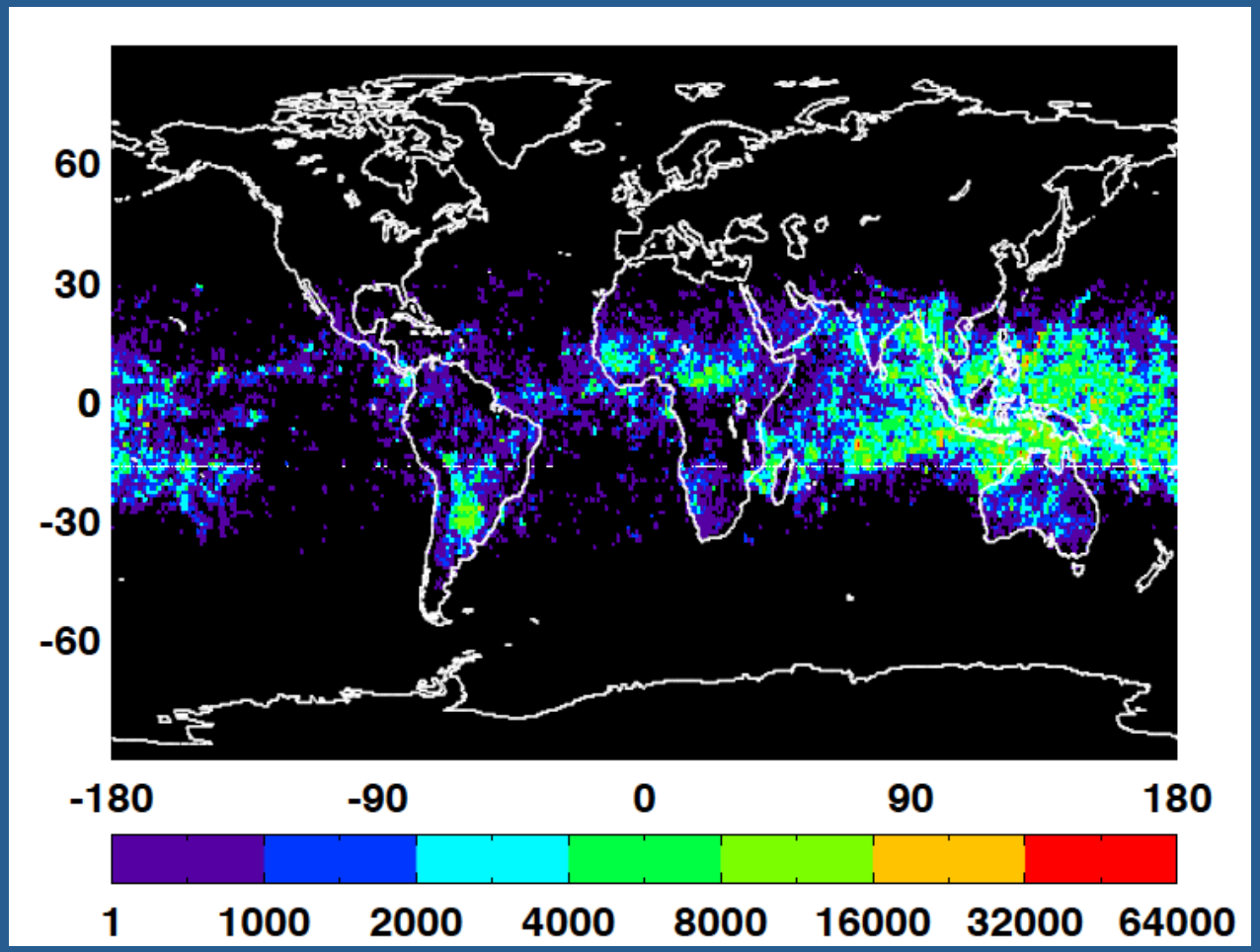
Avg RMS = 2.8%

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

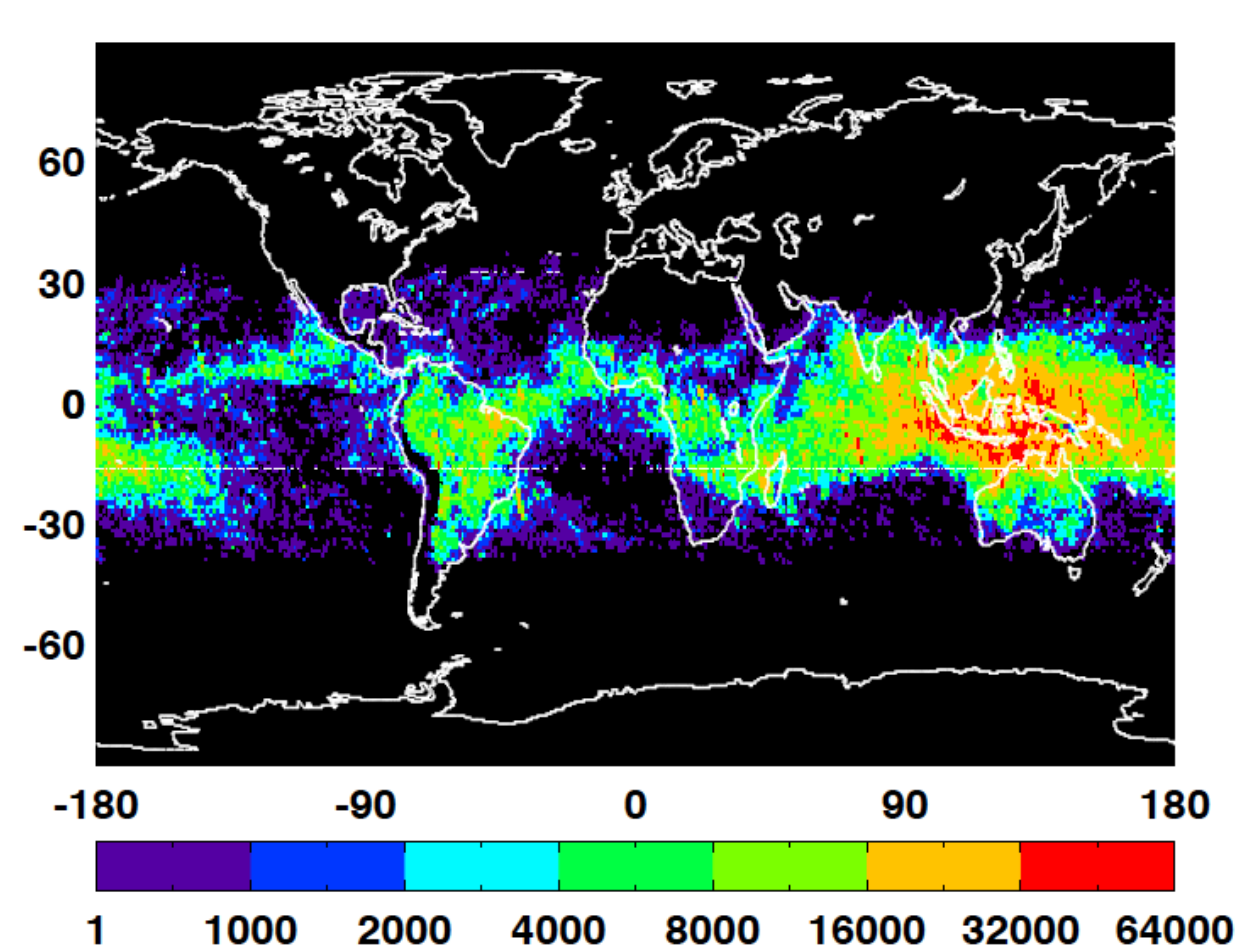


Avg RMS = 2.4%

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



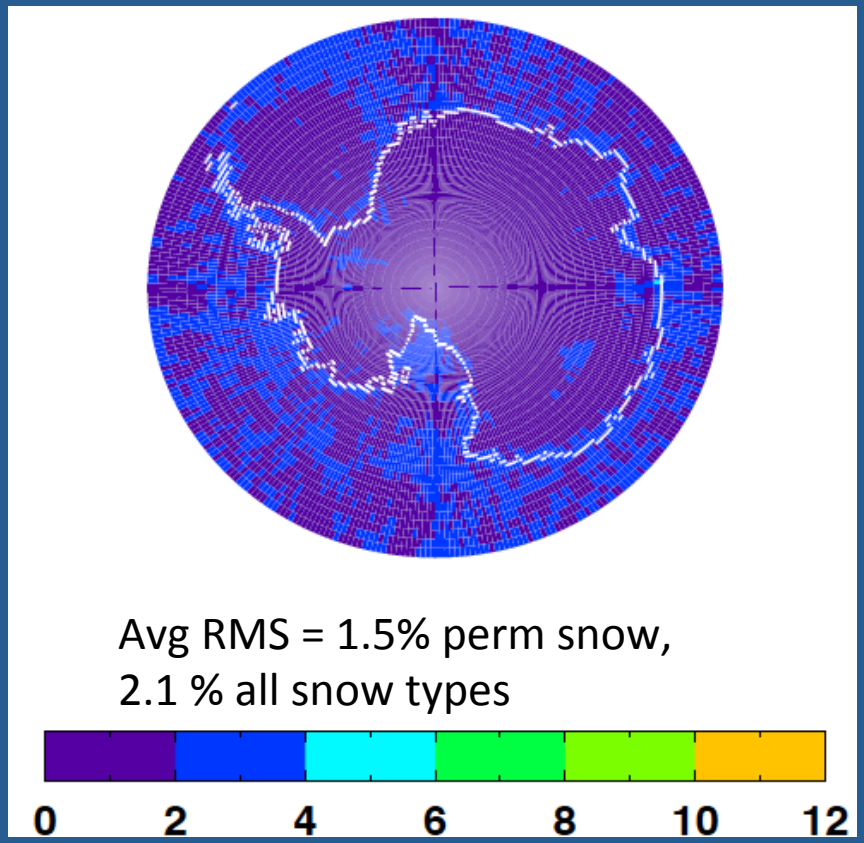
Clouds over snow

- Previously, average radiance was calculated for a given cloud fraction and snowy surface type (permanent snow, sea ice, fresh snow), with two surface temperature categories.
- Now, basic idea is to use Edition 4 pseudoradiance formulation for scenes with snowy surfaces:

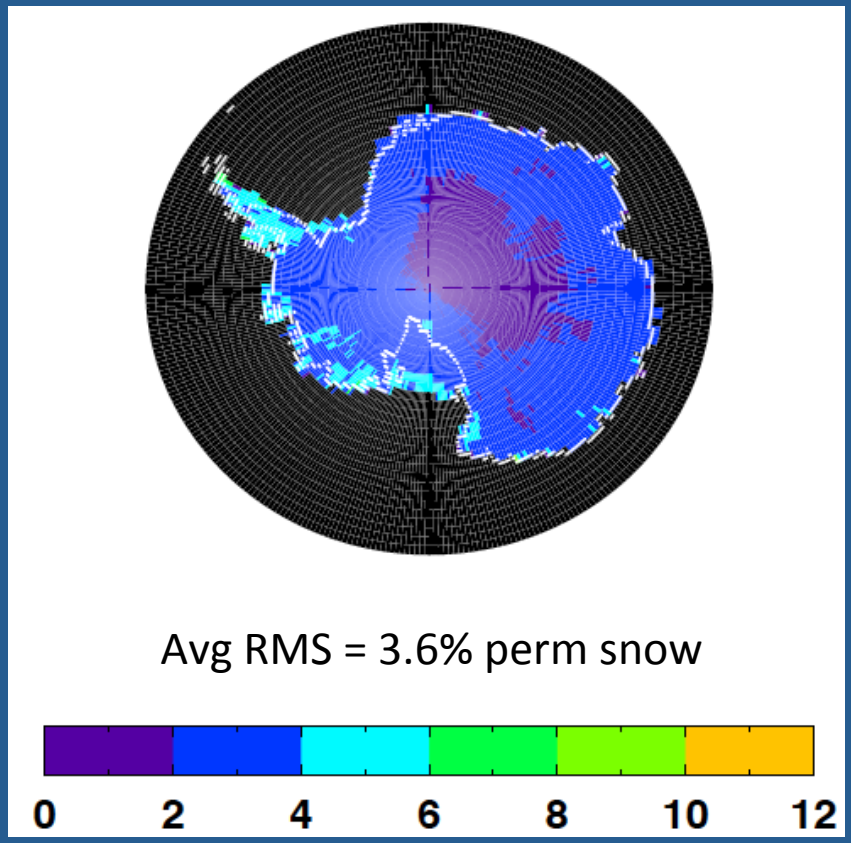
$$\psi = (1-f)\varepsilon_s B(T_s) + \sum_{j=1}^{2}[\varepsilon_s B(T_s)(1-\varepsilon_{c_j}) + \varepsilon_{c_j} B(T_{c_j})]f_j$$

New Results with Ed 4 data

Jan 2003 Aqua daytime – new pseudoradiance method

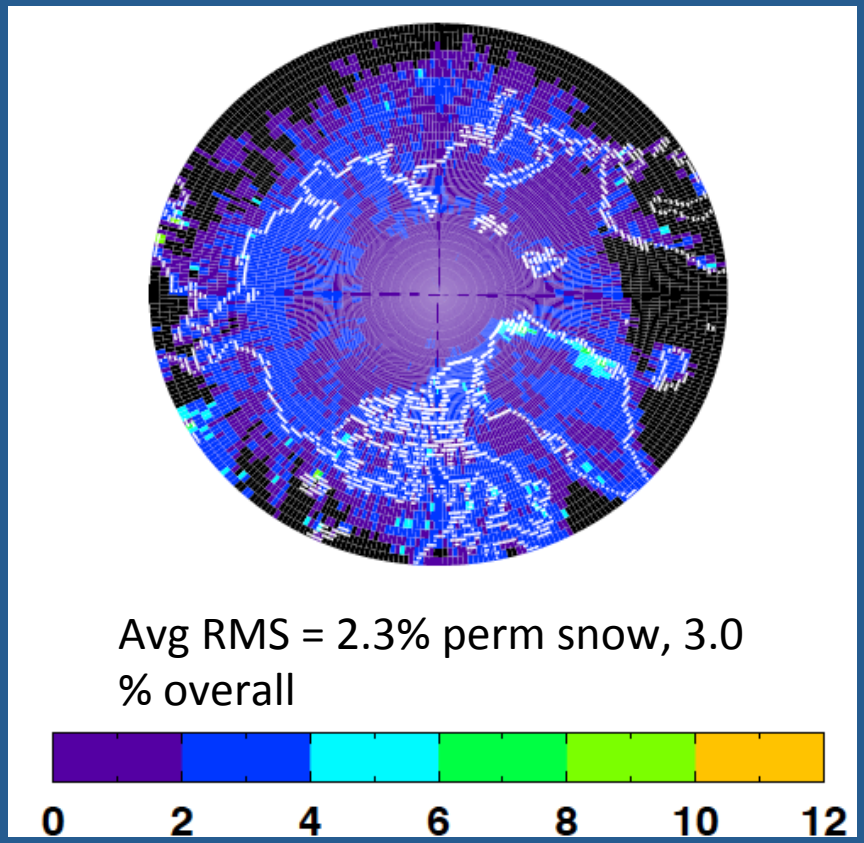


Jan 2003 Aqua daytime – scene type method (Ed2)

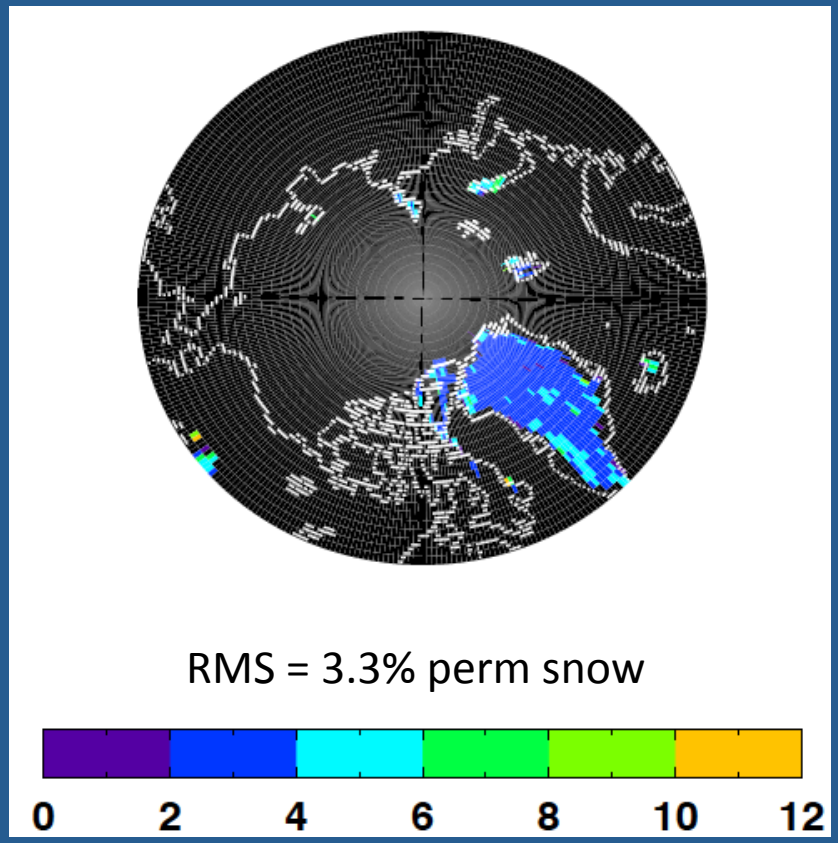


New Results with Ed 4 data

Jul 2003 Aqua daytime – new pseudoradiance method



Jul 2003 Aqua daytime – scene type method (Ed2)



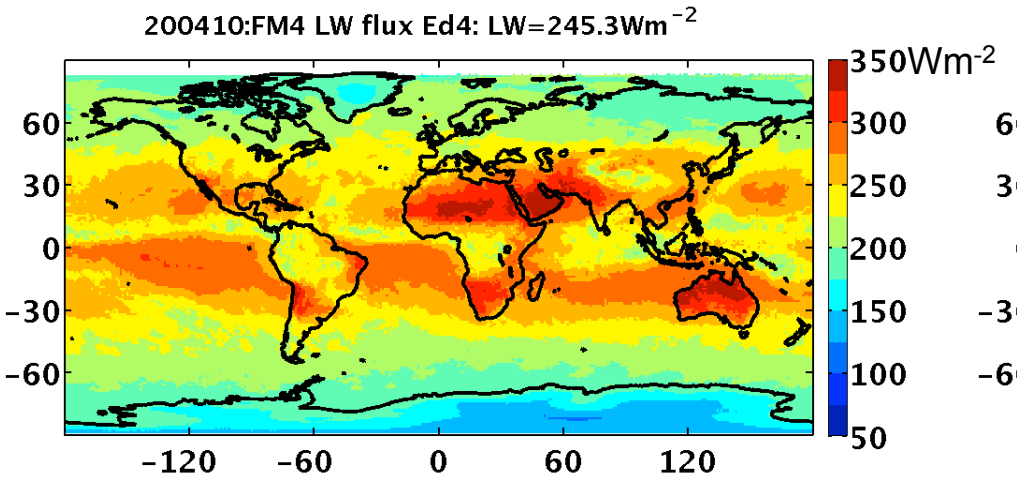
Summary of Changes

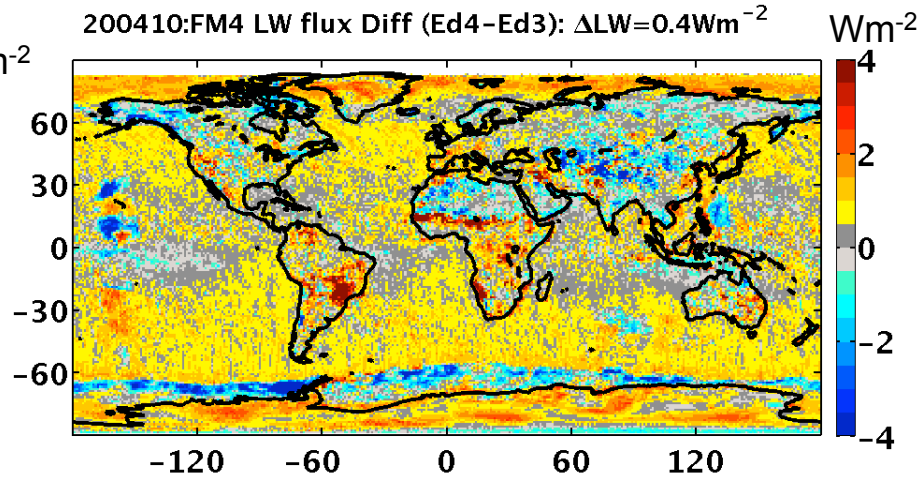
- Clear Sky Land, Desert, Ocean: Edition 4 has additional T_s bins; interpolation is performed between bins.
- Cloudy Sky Land, Desert, Ocean: Instead of a polynomial fit between pseudoradiance Ψ and radiance, the mean radiance for each 1 W m^{-2} sr^{-1} interval of Ψ is used. In addition, there are now 5 cloud fraction bins (0.1-25%, 25-50%, 50-75%, 75-99.9%, overcast).

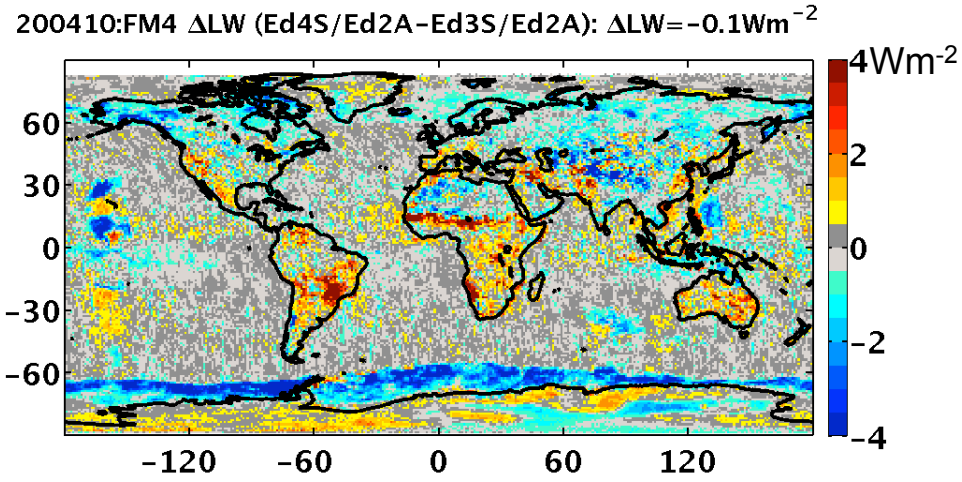
Summary of Changes (2)

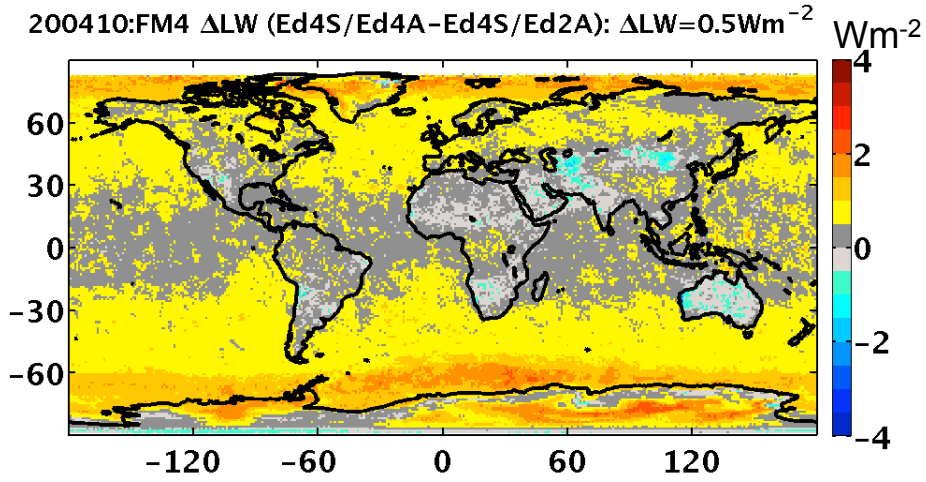
- Clear Sky Permanent Snow, Sea Ice, Fresh Snow: Edition 4 has additional T_s bins; interpolation is performed between bins.
- Cloudy Sky Permanent Snow, Sea Ice, Fresh Snow: Instead of an ADM for a few T_s, ΔT_{sc}, and cloud fraction bins, the Edition 4 pseudoradiance approach is used.

Daytime LW flux change between Ed3 and Ed4

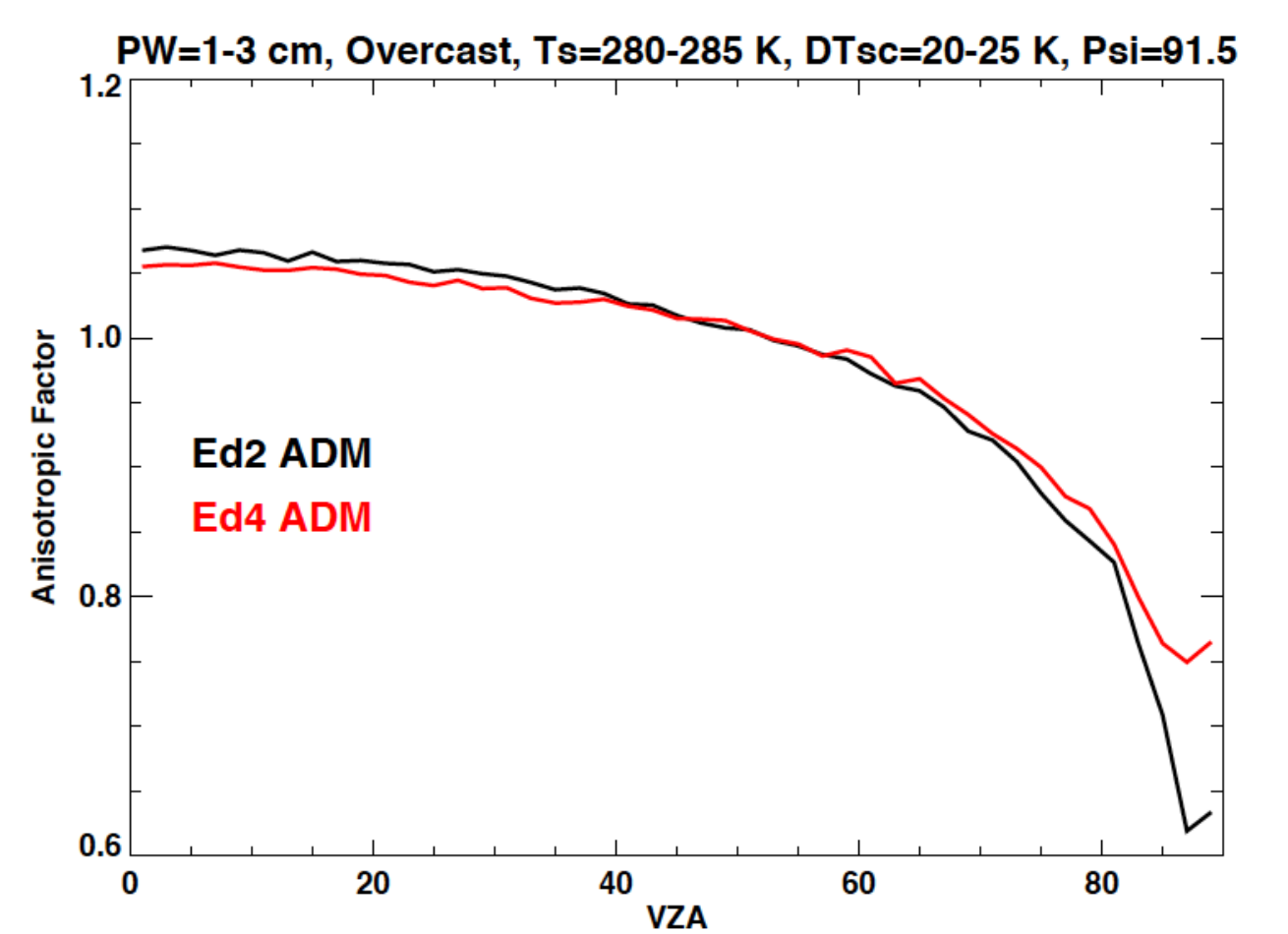




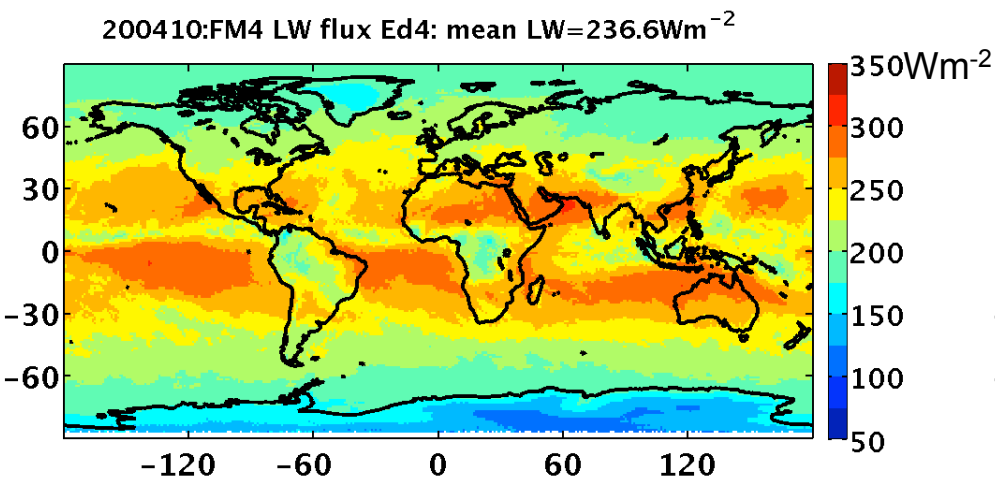


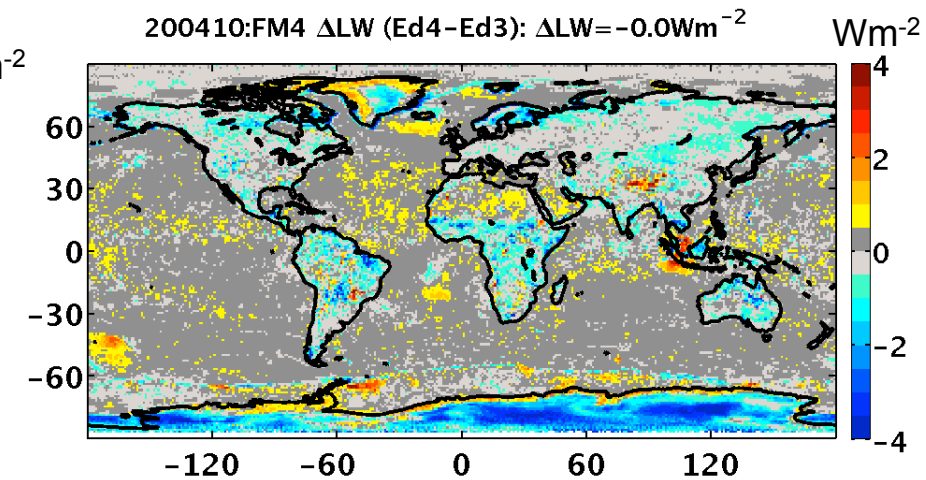


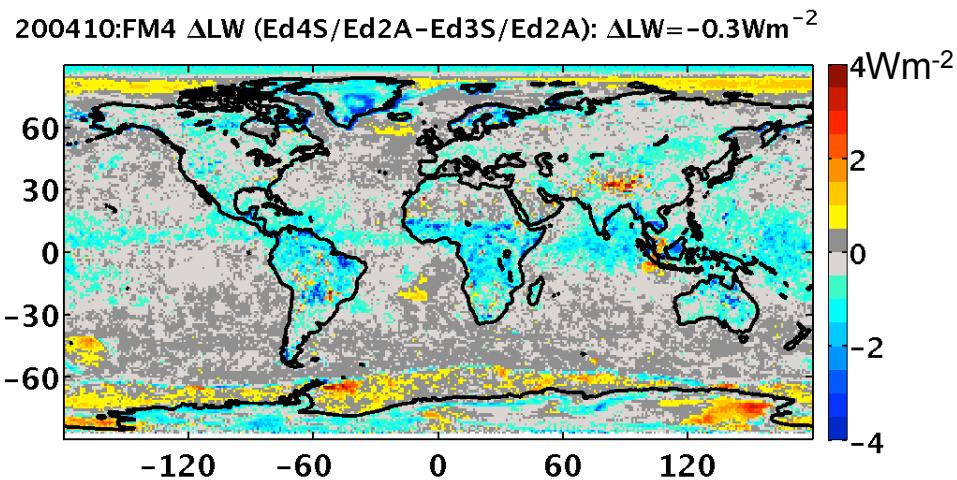
Ed 4 vs Ed2 ADM comparison (Ψ=91.5)

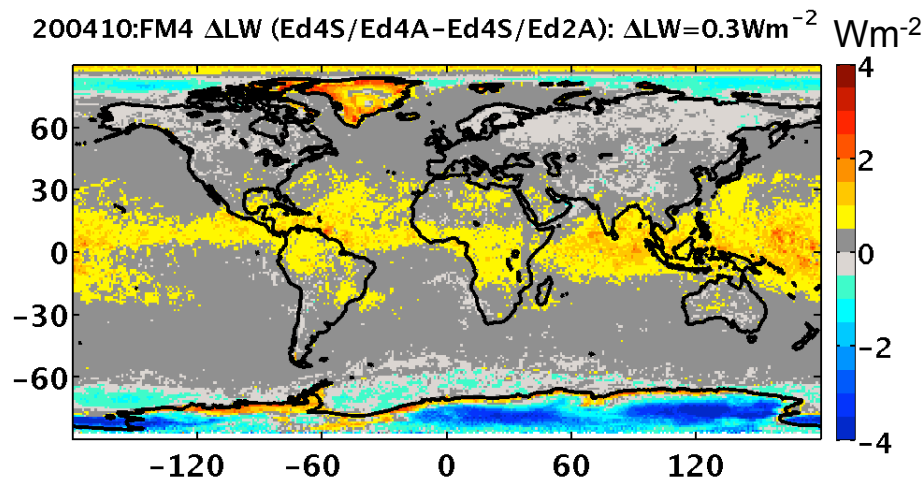


Nighttime LW flux change between Ed3 and Ed4



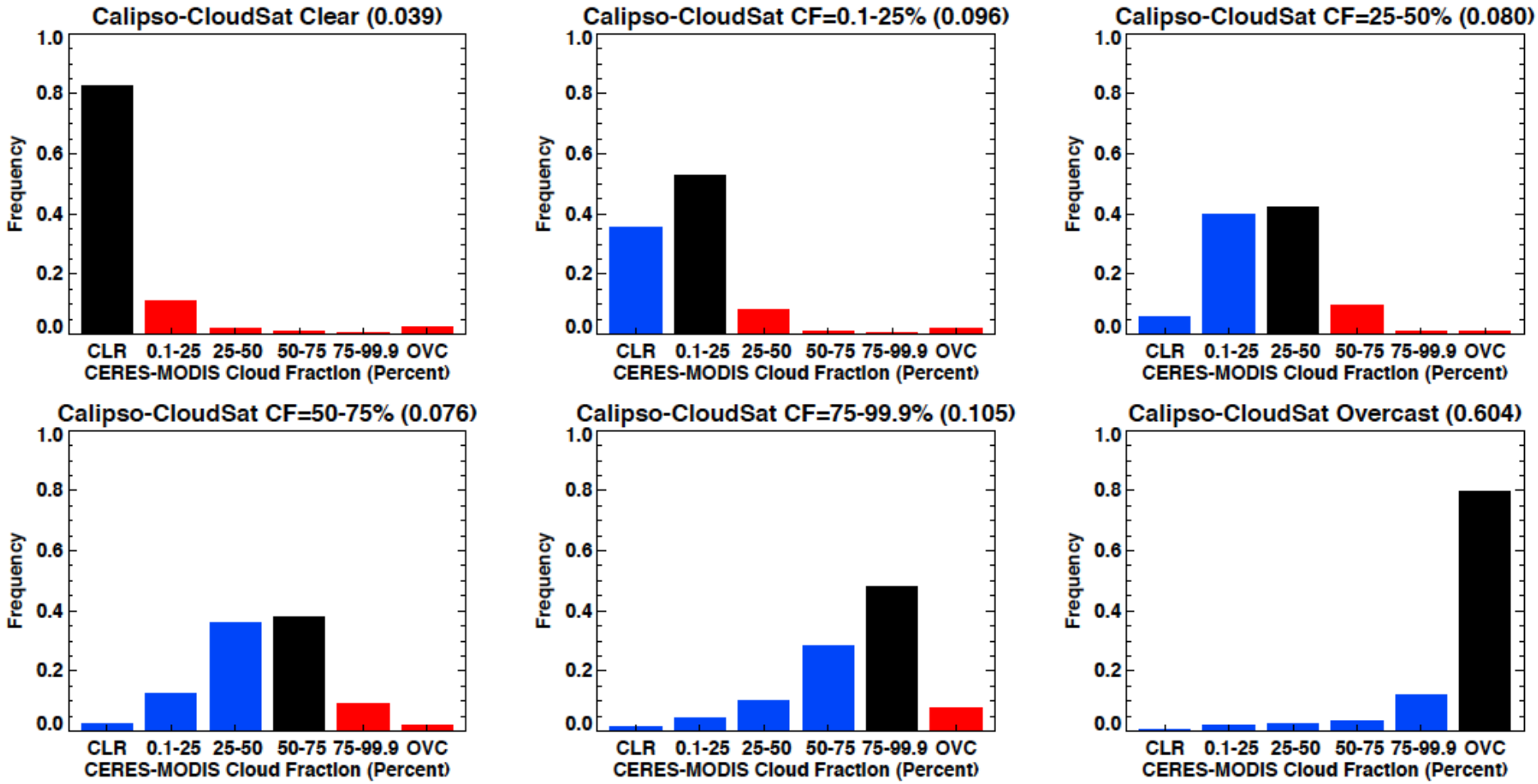




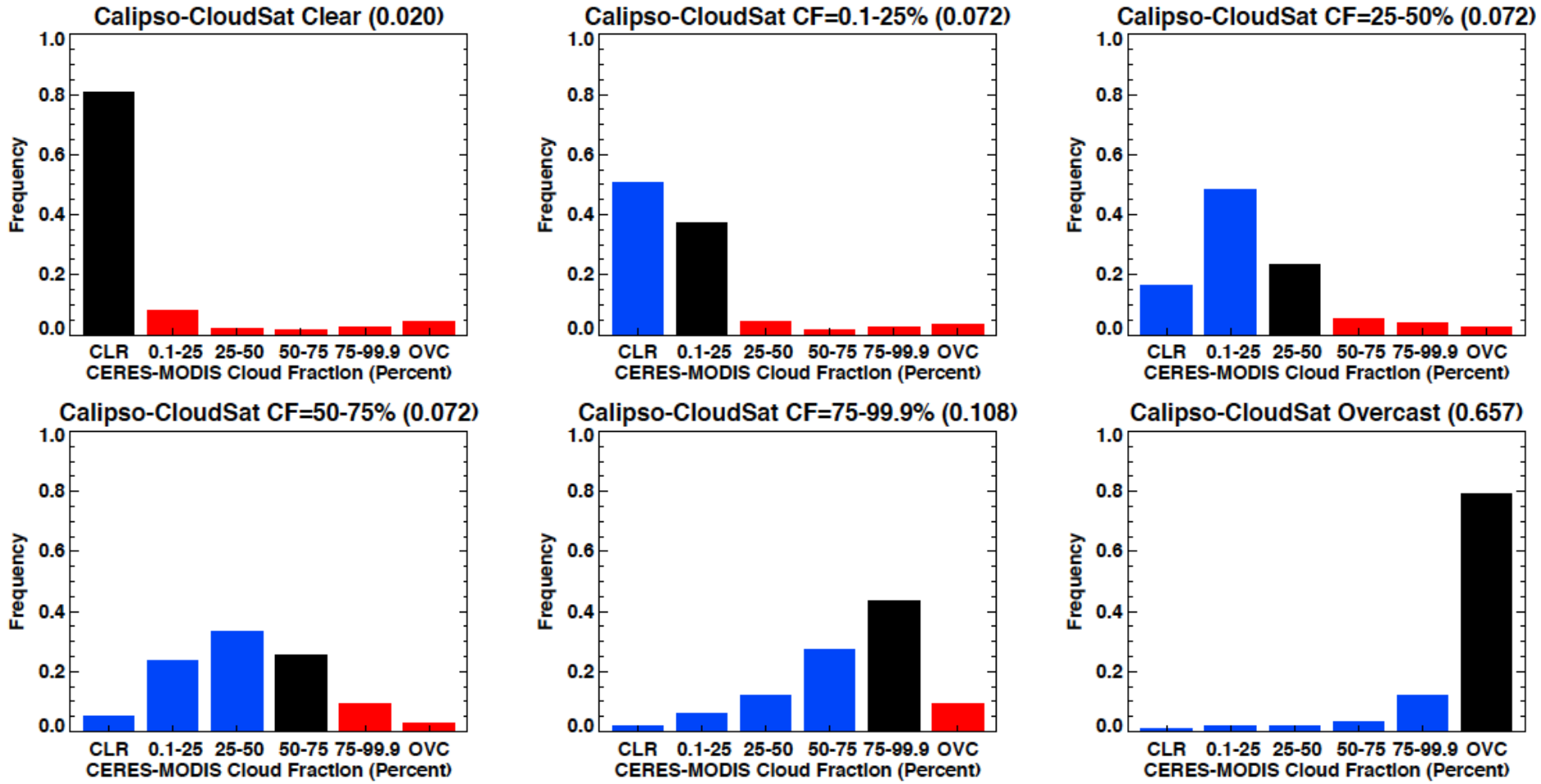


Ocean Daytime – Jan, Apr, Jul, Oct 2010

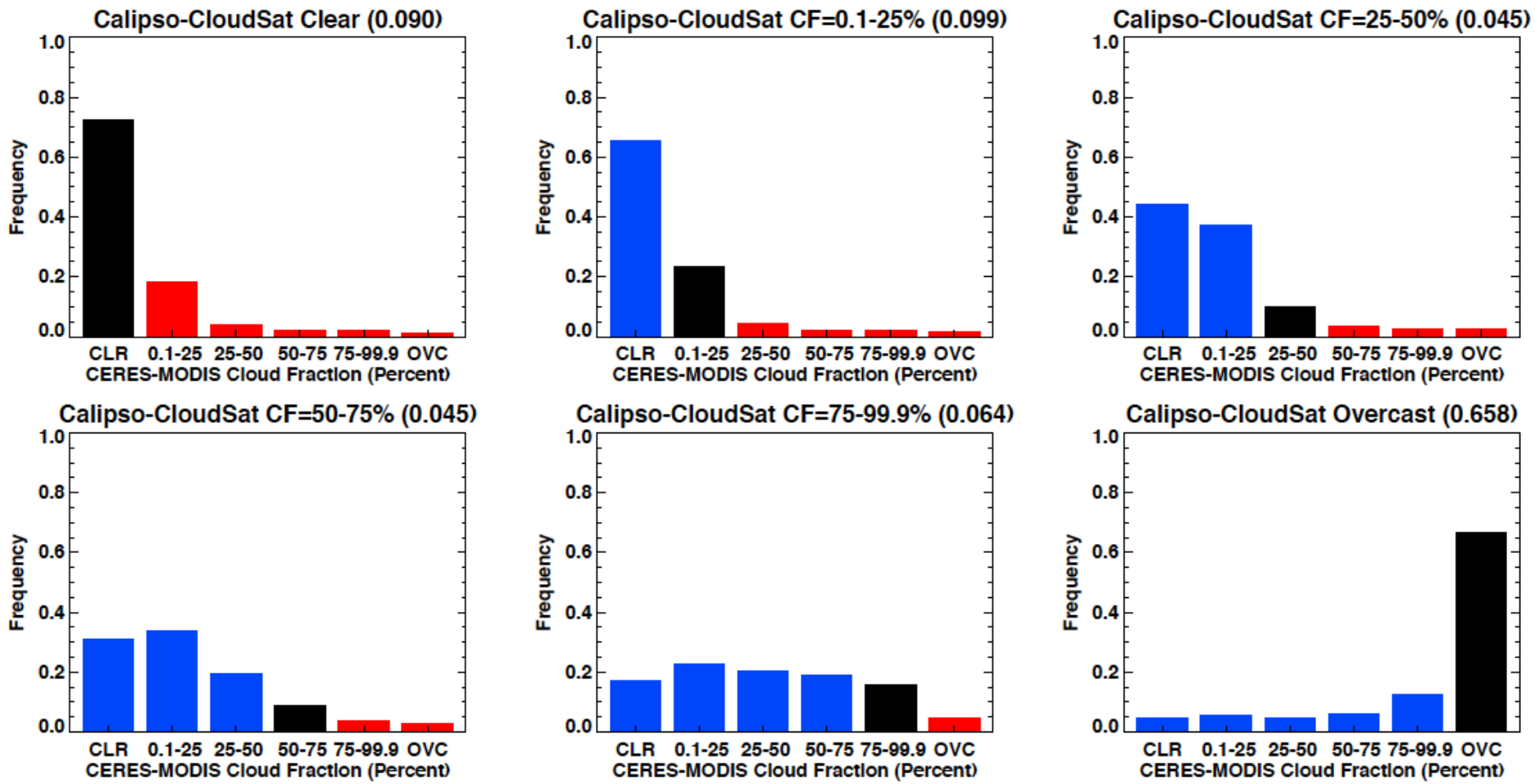
Blue, black, red bars mean CERES-MODIS cloud fraction is in lower, same, or higher category, respectively



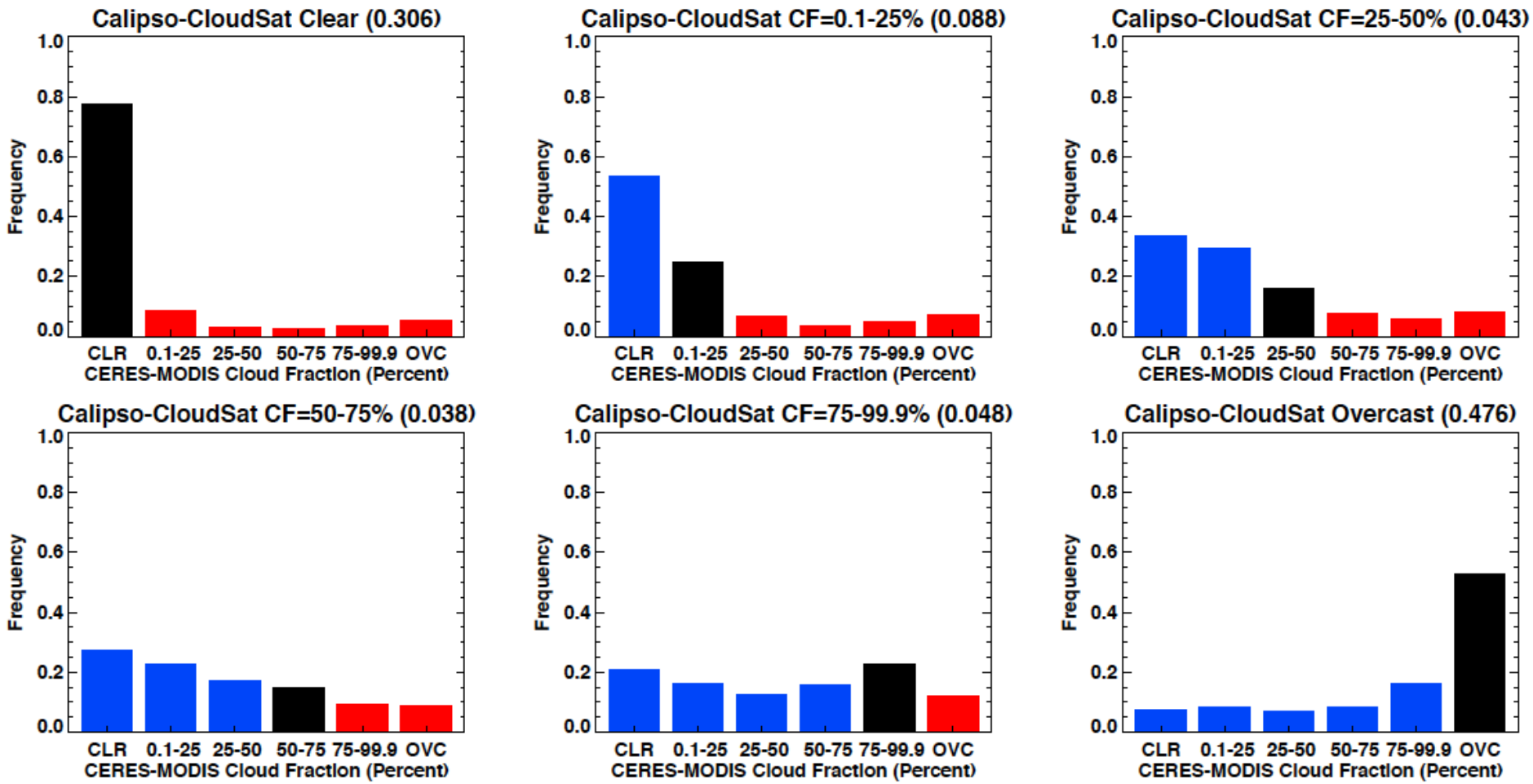
Ocean Nighttime



Land Nighttime

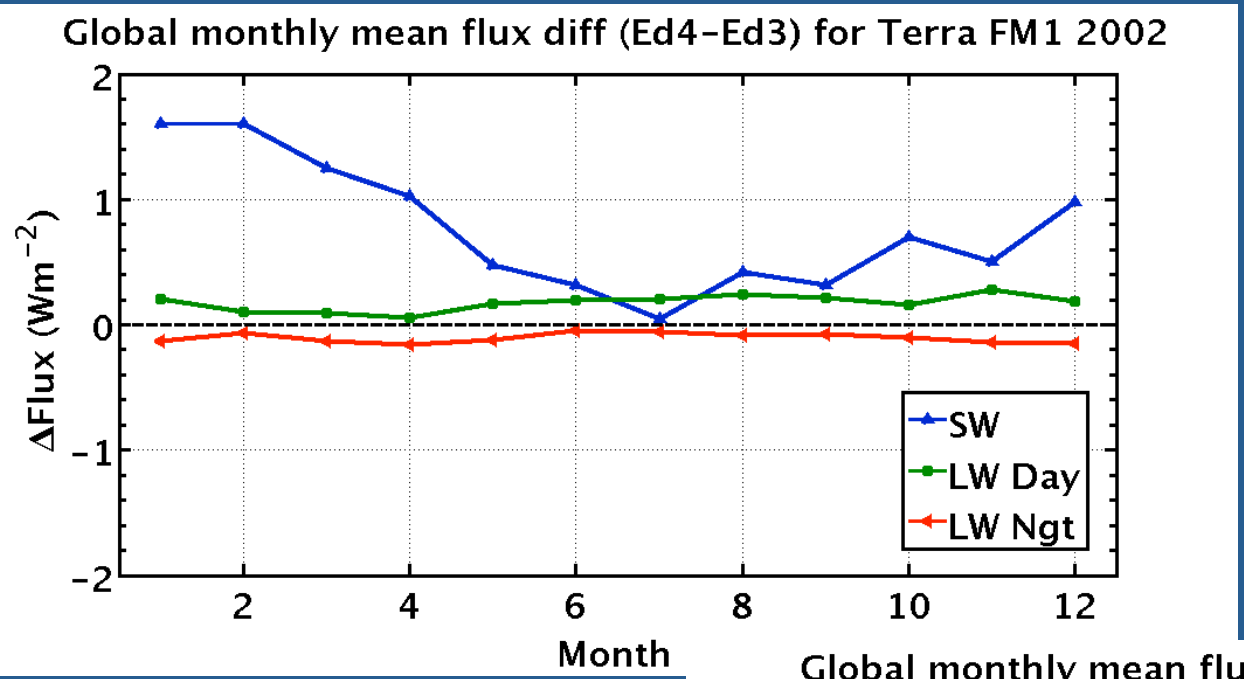


Permanent Snow Daytime

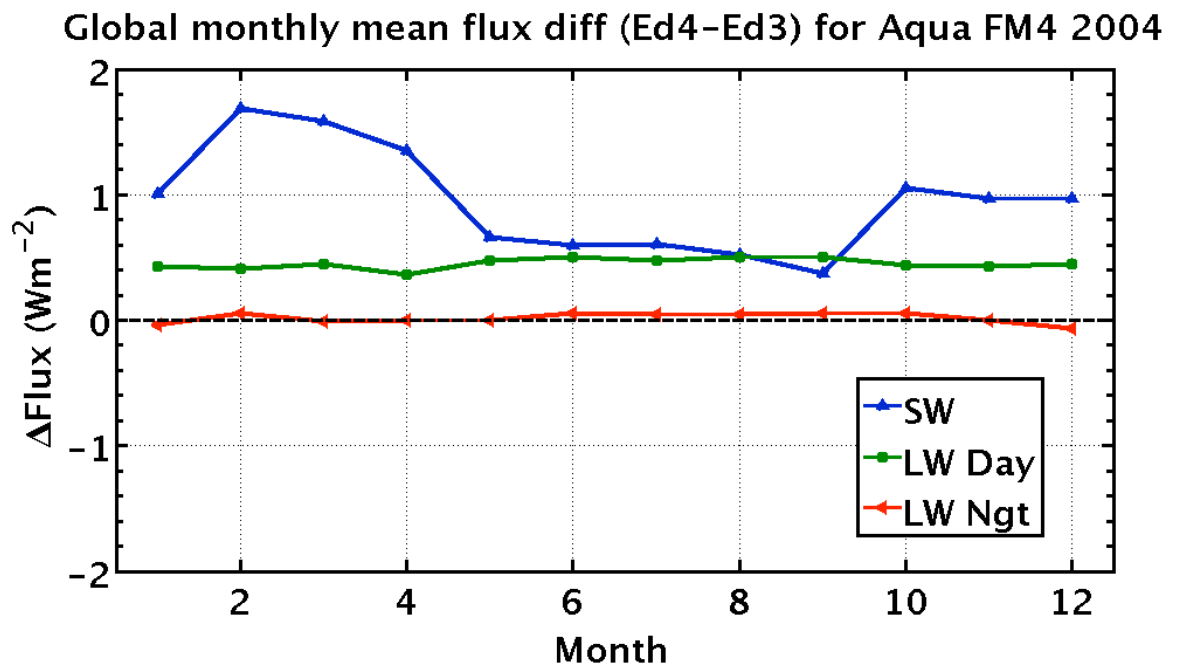


Backup slides

Global monthly mean flux difference between Ed4 and Ed3



- Annual mean SW flux increases 0.8 Wm^{-2}
- Annual mean daytime LW flux increases 0.2 Wm^{-2}
- Annual mean nighttime LW flux decrease 0.1 Wm^{-2}

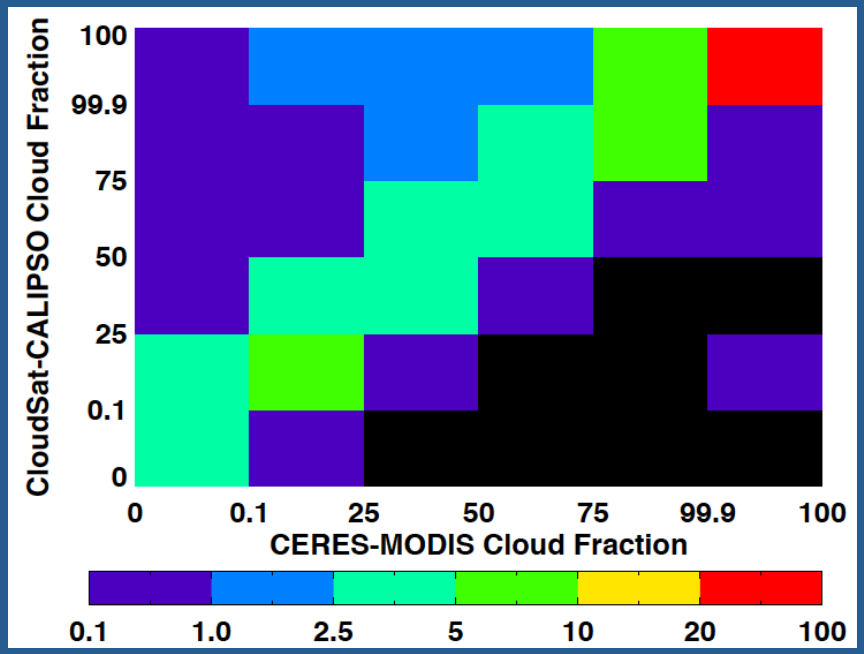


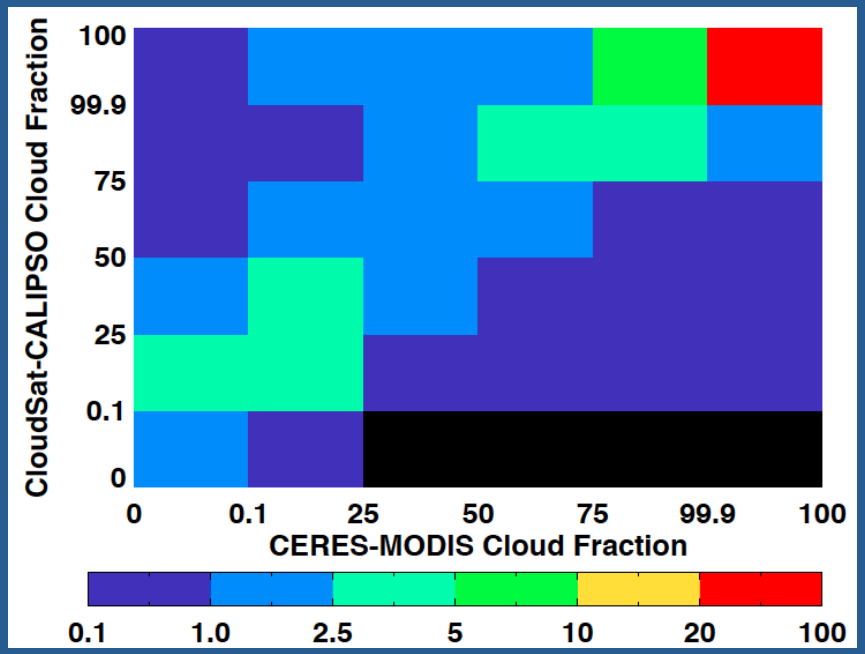
- Annual mean SW flux increases 1 Wm^{-2}
- Annual mean daytime LW flux increases 0.4 Wm^{-2}
- Annual mean nighttime LW flux is essentially unchanged

Cloudsat-CALIPSO and Ed 4 CERES-MODIS Cloud Masks for Ocean scenes for 2010

Daytime: 67.7% CF on target, 27.9% CF too low, 4.4% CF too high

Nighttime: 64.5% on target, 31.5% CF too low, 4.0% CF too high

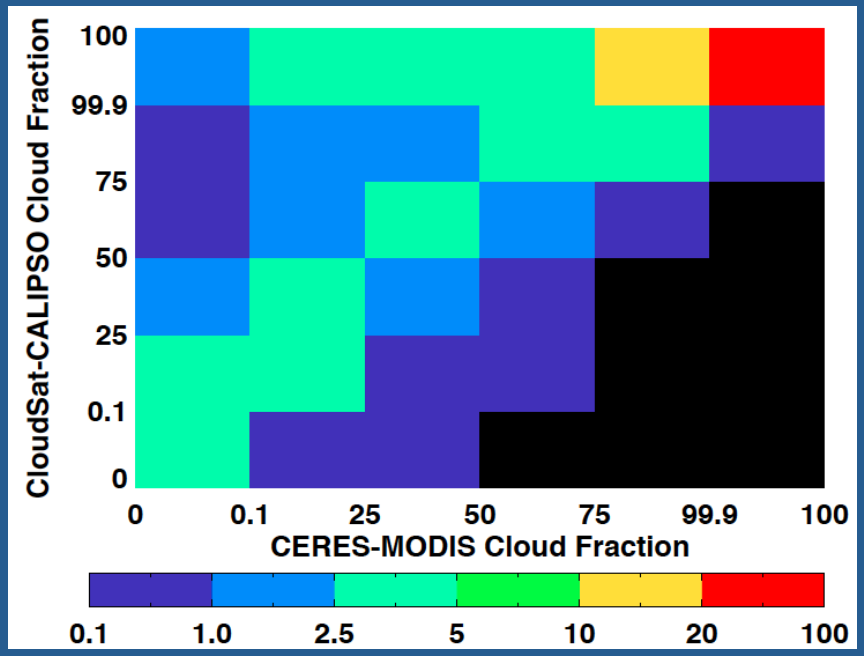


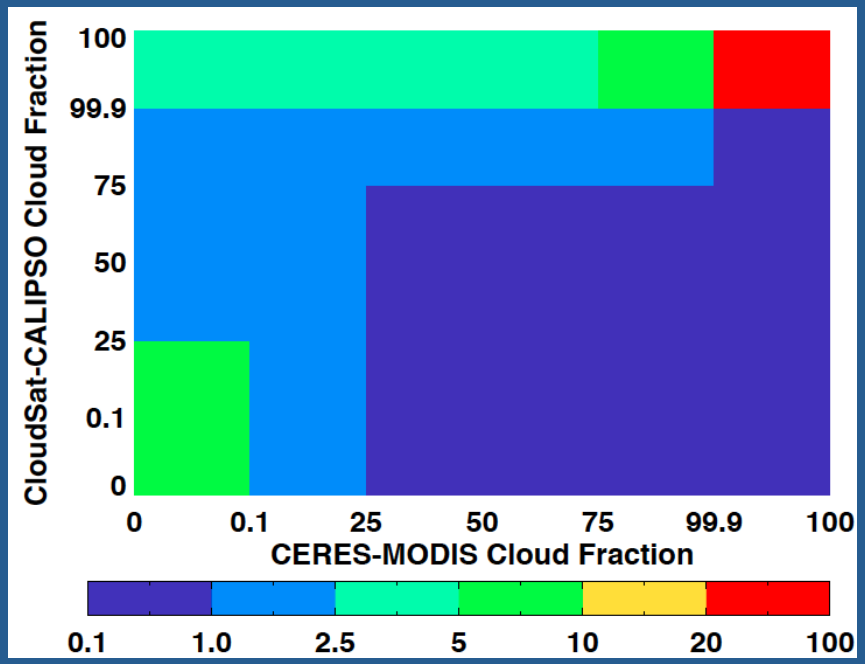


Cloudsat-CALIPSO and Ed 4 CERES-MODIS Cloud Masks for Land scenes for 2010

Daytime: 52.6% CF on target, 44.6% CF too low, 2.8% CF too high

Nighttime: 54.6% on target, 40.9% CF too low, 4.5% CF too high

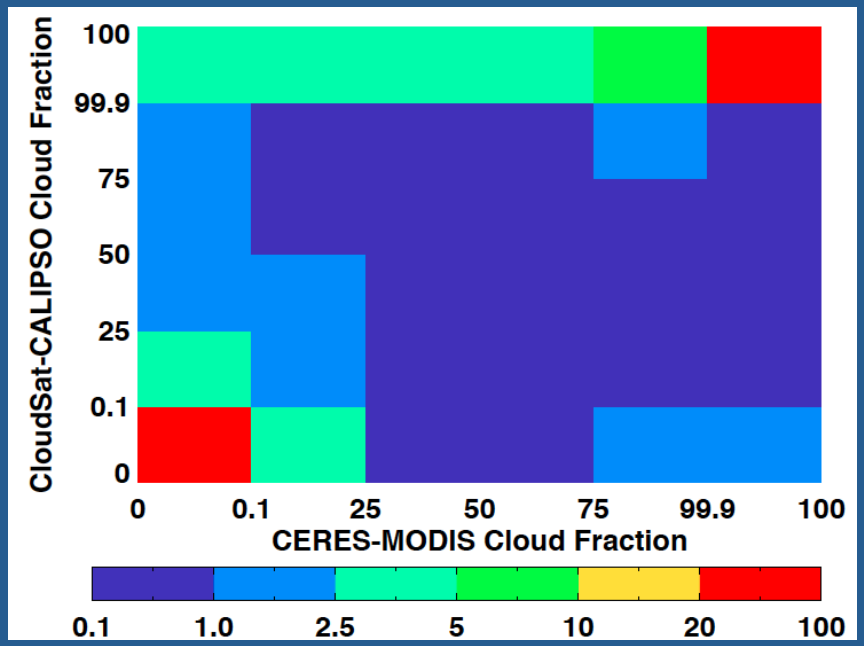


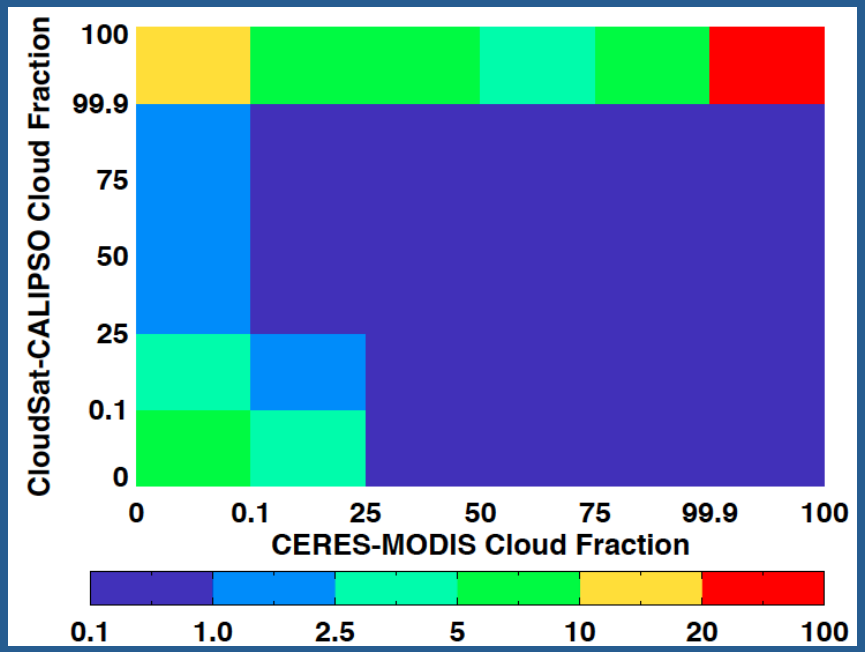


Cloudsat-CALIPSO and Ed 4 CERES-MODIS Cloud Masks for Permanent Snow scenes for 2010

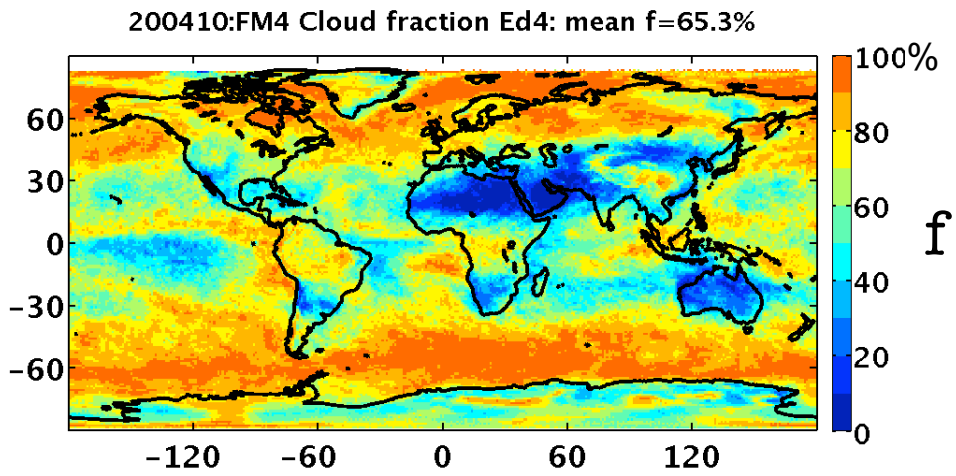
Daytime: 53.3% CF on target, 35.6% CF too low, 11.1% CF too high

Nighttime: 38.2% on target, 51.9% CF too low, 9.9% CF too high





Daytime Cloud property difference between Ed3 and Ed4



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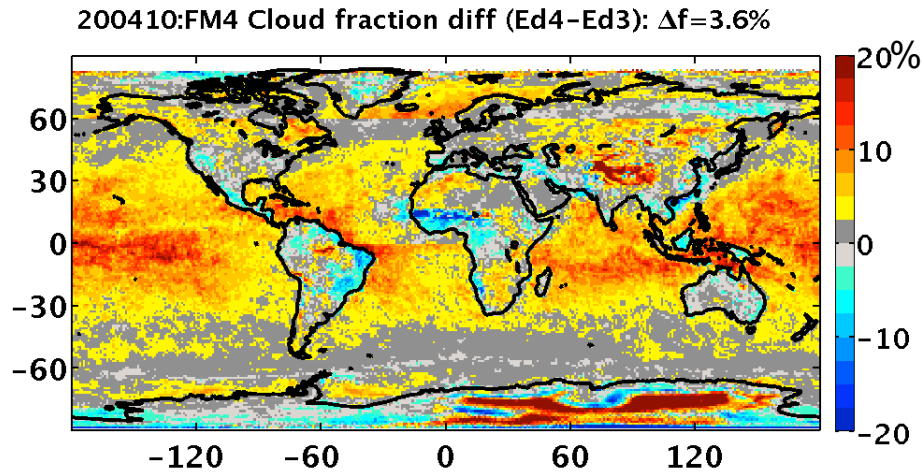

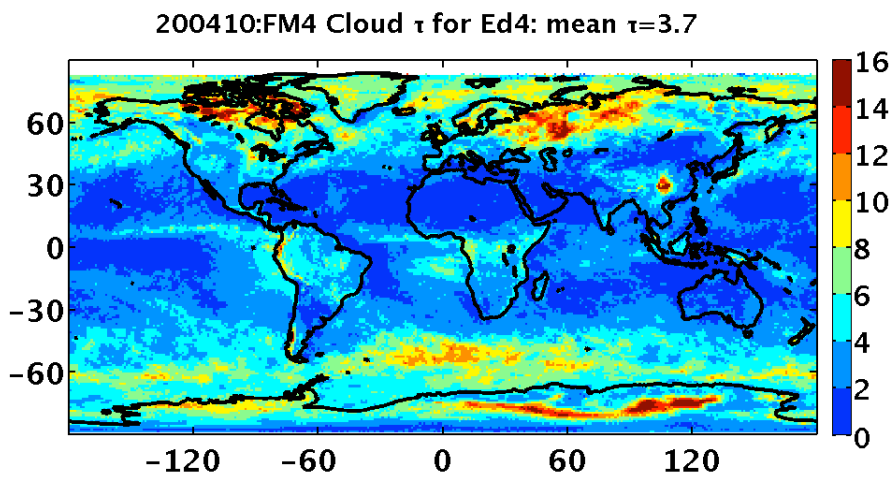

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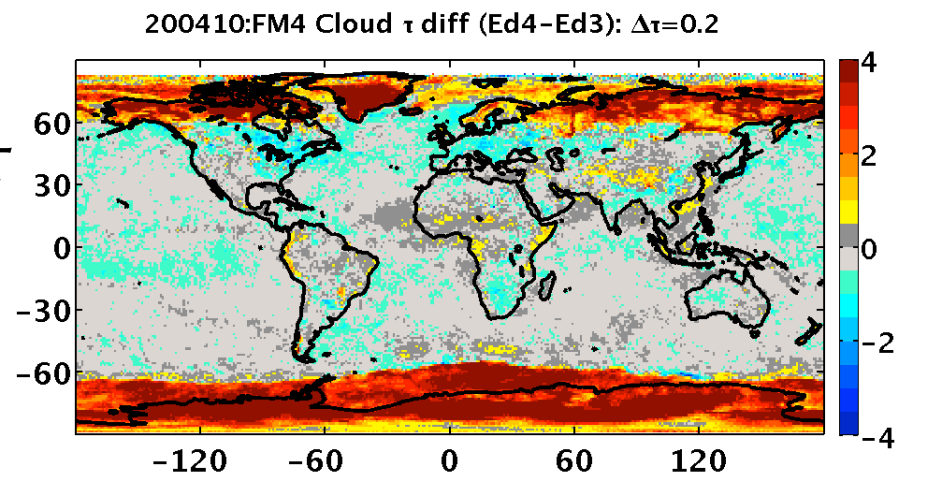
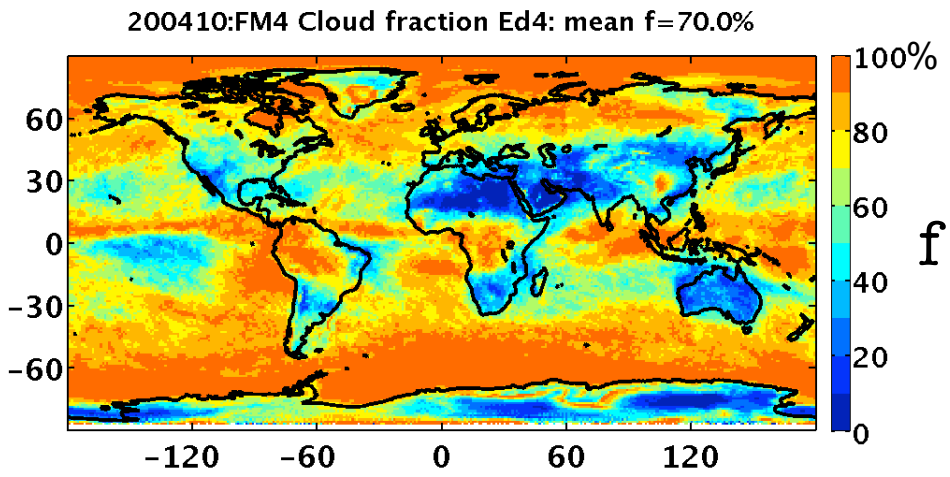


Nighttime Cloud property difference between Ed3 and Ed4



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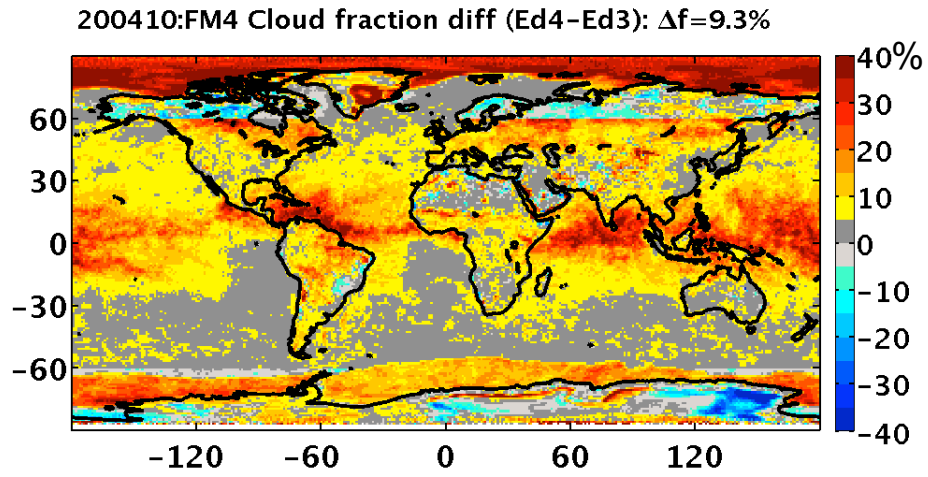

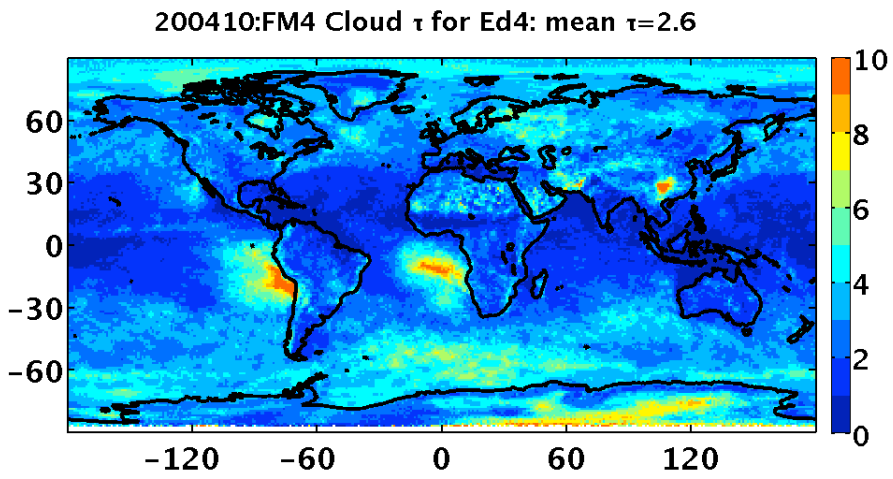

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