CERES GEO LW Narrowband to Broadband Radiance Algorithm and CERES simulator

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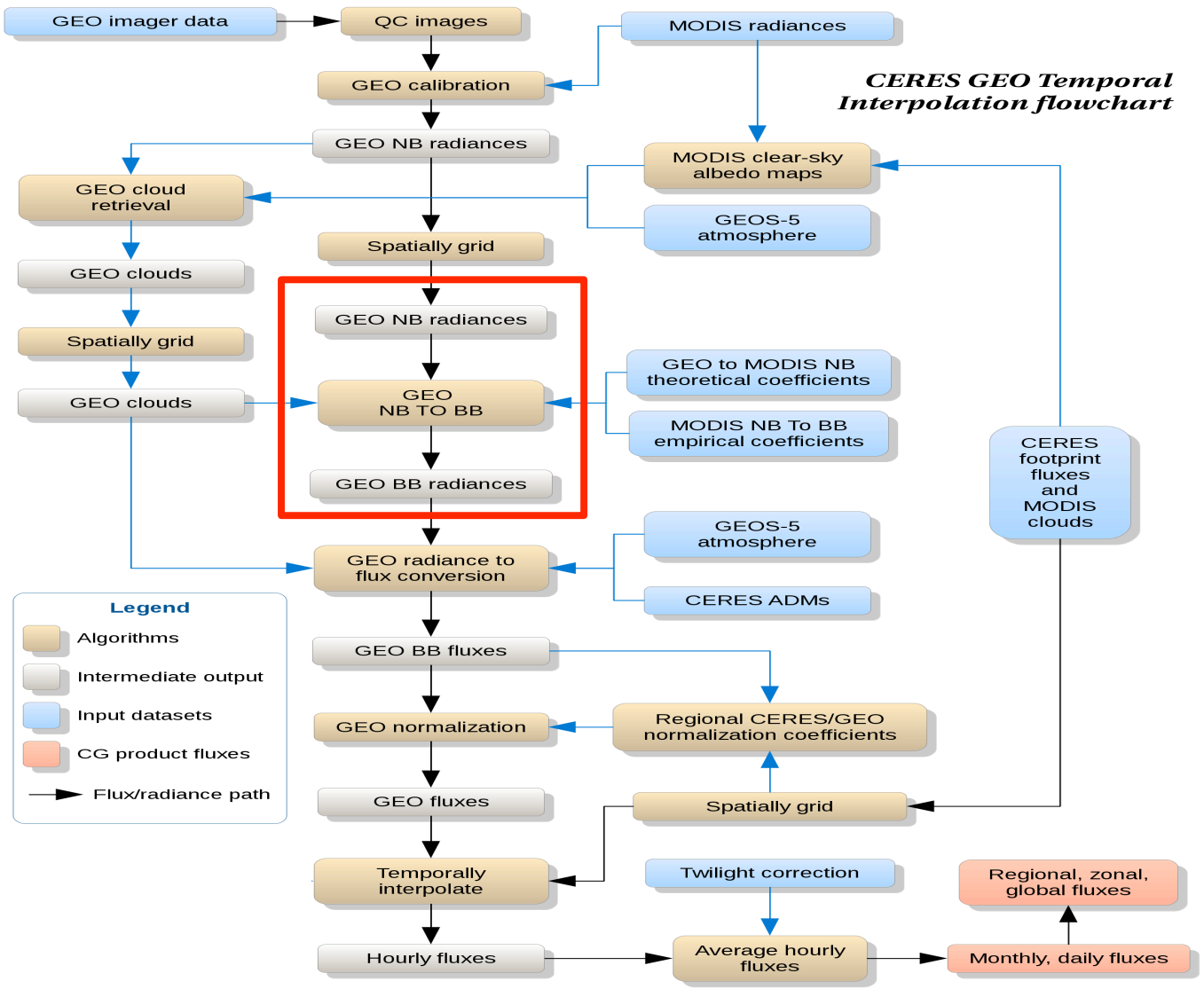
Outline

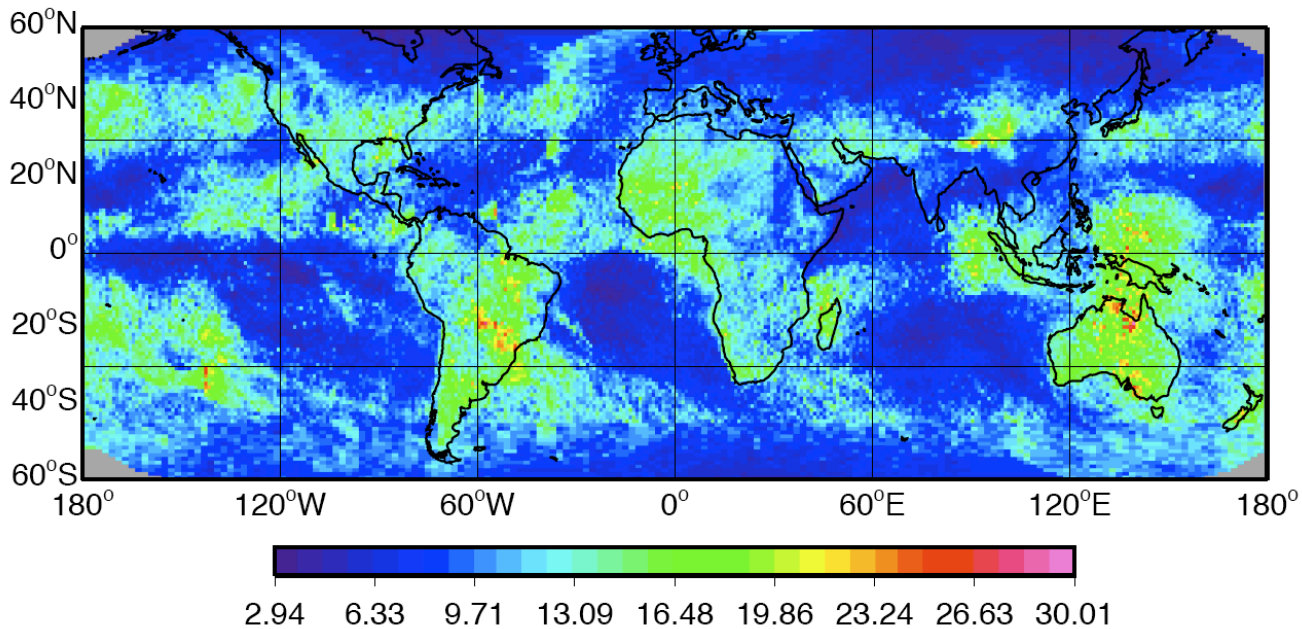
- Current GEO LW flux Status
- Ed4 2-channel NB-BB flux algorithm
- Ed4 NB-BB Radiance algorithm development
- Summary
- Future work

CERES GEO LW Processing



Doelling

Current GEO NB-BB Flux
Matched GEO vs. Terra, January 2006



Global Mean RMS: 8.39

GEO LW and Terra LW Matched within 1.5 hours

Current GEO LW NB->BB Flux Algorithm

- **WN => Nadir NB flux**

WN Rad VZA

$$F_{NB} = 1.97\pi L_{WN}(\theta)/\gamma(\theta)$$

$$\gamma(\theta) = \begin{cases} 1 & \theta \le 11.7 \\ 1.000665 + 0.0324721\ln(\cos\theta) & \theta > 11.7 \end{cases}$$

Limb darkening function

- **NB flux => BB flux (OLR)**

Column Relative Humidity

$$OLR_{BB} = a_0 + a_1 F_{NB} + a_2 F_{NB}^2 + a_3 \ln(RH)$$

NB flux

a_0, a_1, a_2, a_3 Coefficients for ocean and land separately

Current GEO NB->BB Flux Algorithm

- The algorithm is based on Minnis et al. 1991 and not updated since then.
- Doelling et al. (1998 and 2003) validate the algorithm over ocean and land area and investigate the effects of different channels and relative humidity on RMS.
- LW RMS (~3-5%).

Areas for Improvement

- Use Ed4 GEO multiple channels vs. Ed2/Ed3 WN only
- Use WV channel to replace GEOS Relative Humidity
- Use ADM-like scene types vs. global land/ocean formula

Ed4 NB->BB Radiance Development

- Data: SSF-Ed4 (MODIS radiance and CERES flux)
- Test multiple channels:

  3.79µm (Night only), 6.72µm, 11.03µm, 12.02µm

- Create scene types:
  - **Ocean/land (6):** Ocean, Forests, Savannas, Grass-Crop, Dark and Bright Deserts.
  - **Day/Night (2)**
  - **Clear/cloud (2)**
  - **Precipitable Water (4):** 0-1, 1-3, 3-5, 5-10 cm
  - **Viewing Zenith Angle (7):** 0°-70°, every 10°
  - **Total: 672 scene types**

Ed4 NB->BB Radiance Development

- For each scene type:

Linear regress: CERES LW_{BB} *vs.* MODIS (Rad_{nb1} , Rad_{nb2} , Rad_{nb3})

$$LW_{est} = a_0 + a_1 Rad_{11\mu m} + a_2 Rad_{6.7\mu m} + a_3 Rad_{12\mu m}$$

- Evaluation of the algorithm:

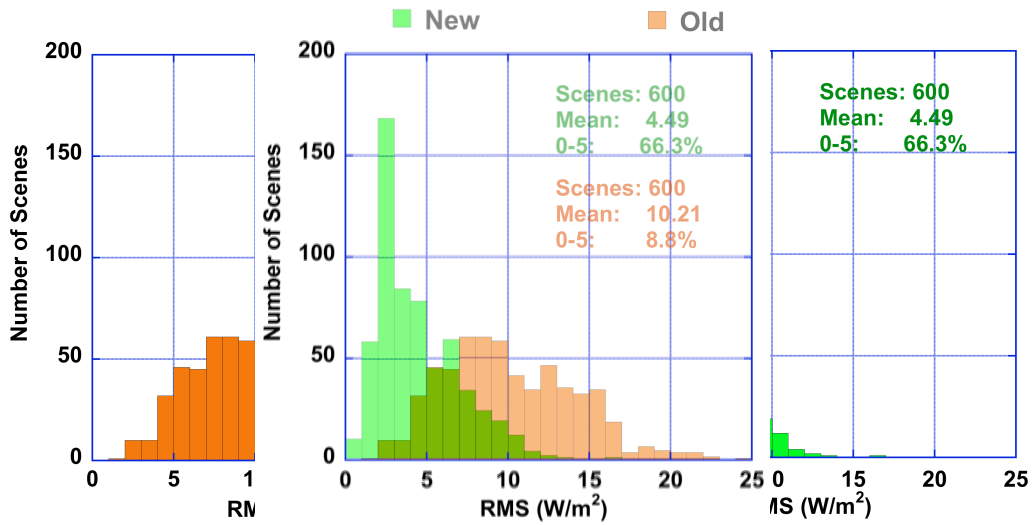
$$RMS = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(LW_i^{est} - LW_i^{BB})^2}$$

NB Rad -> BB Flux Algorithm

Method

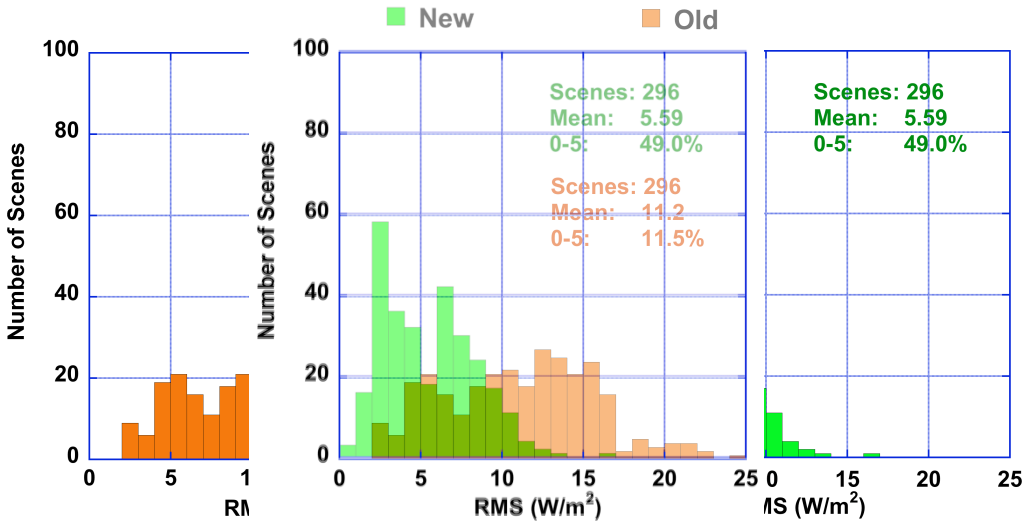
1. Calculate NB-BB flux directly using 11.03µm and 6.72µm for all scenes.
2. Calculate NB-BB flux using current 11.03µm global formula and then sort the data according to the same scene types as in 1.

NB Rad -> BB Flux
2-ch vs. WN-only (All scenes)



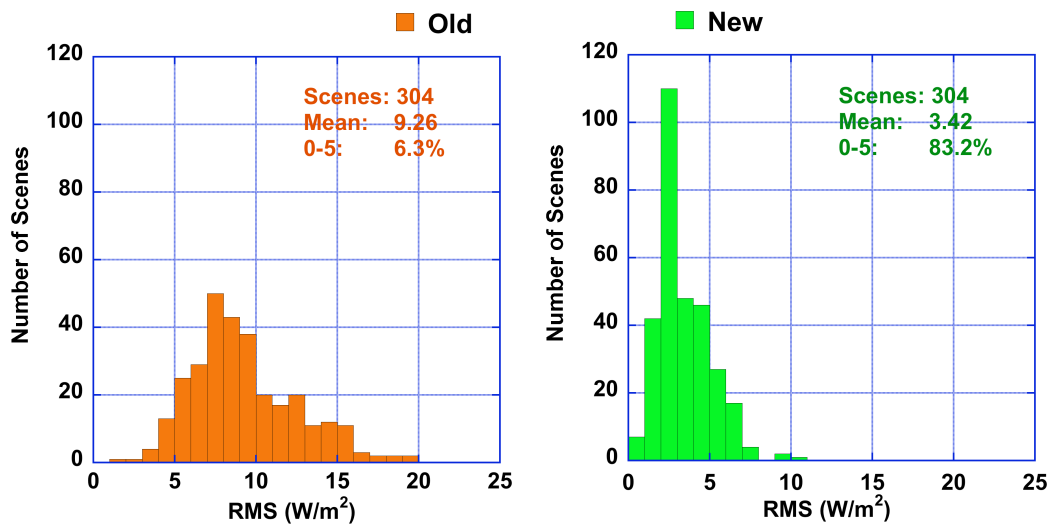
Based on SSF-Ed4 April, 2000

NB Rad -> BB Flux
Daytime



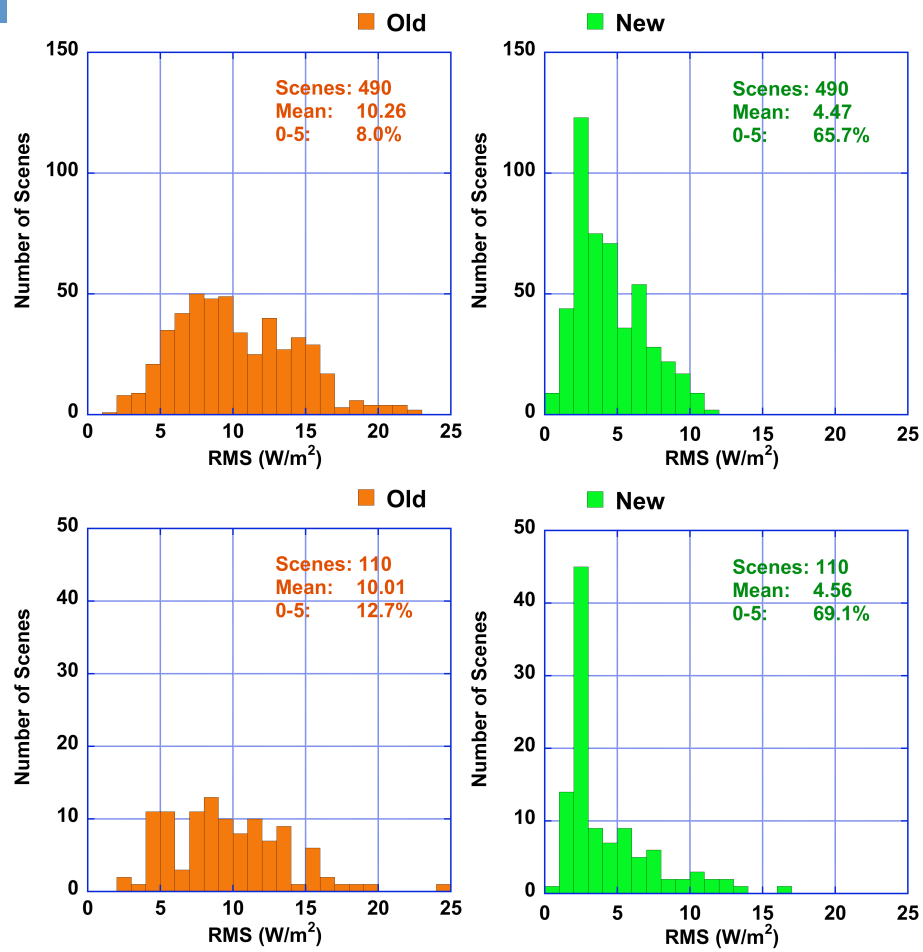
Based on SSF-Ed4 April, 2000

NB Rad -> BB Flux
Night time



Based on SSF-Ed4 April, 2000

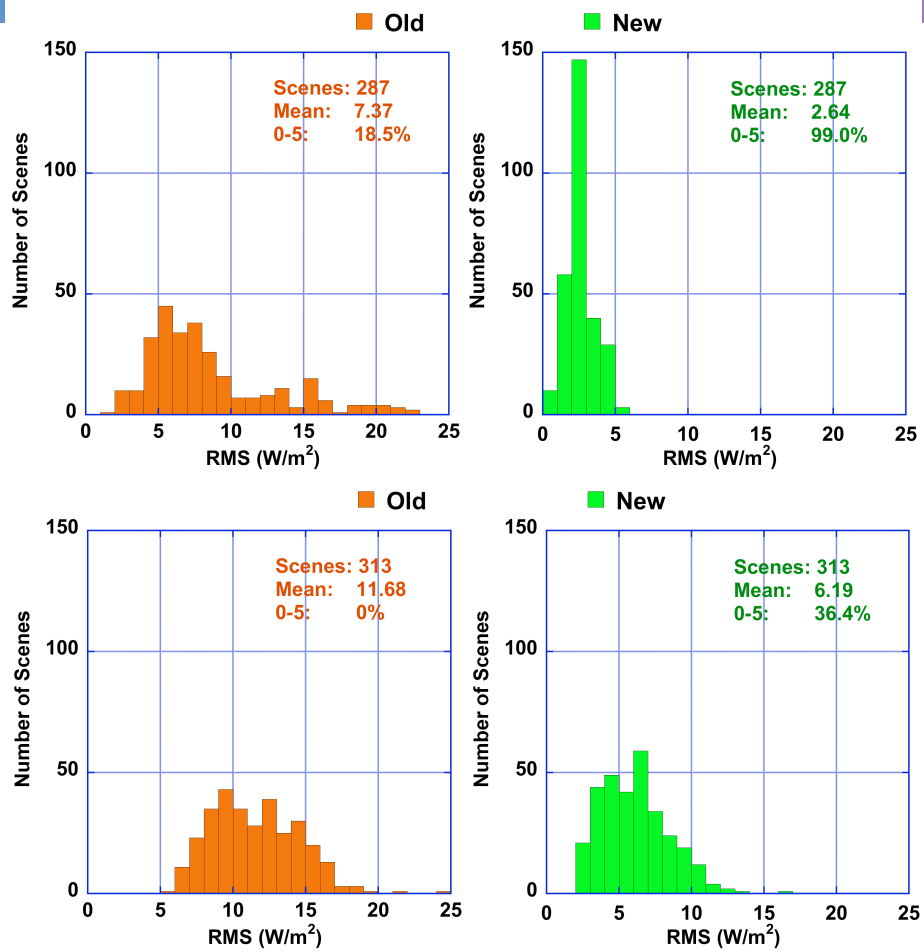
NB Rad - BB Flux
Land and Ocean



Land Scenes

Ocean Scenes

NB Rad -> BB Flux
Clear and Cloud



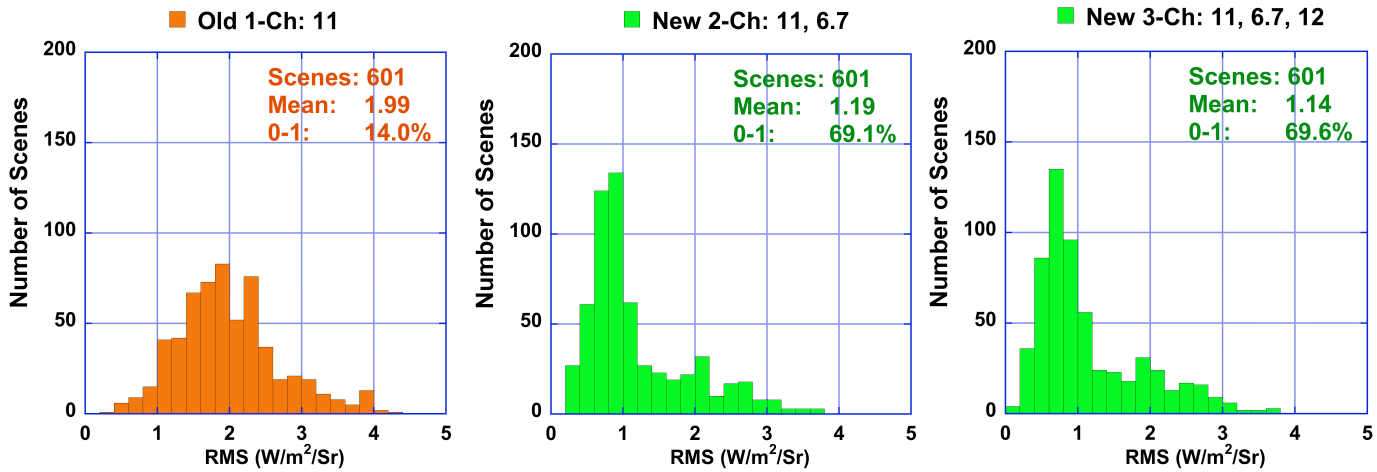
Clear Scenes

Cloud Scenes

NB Rad -> BB Flux Table

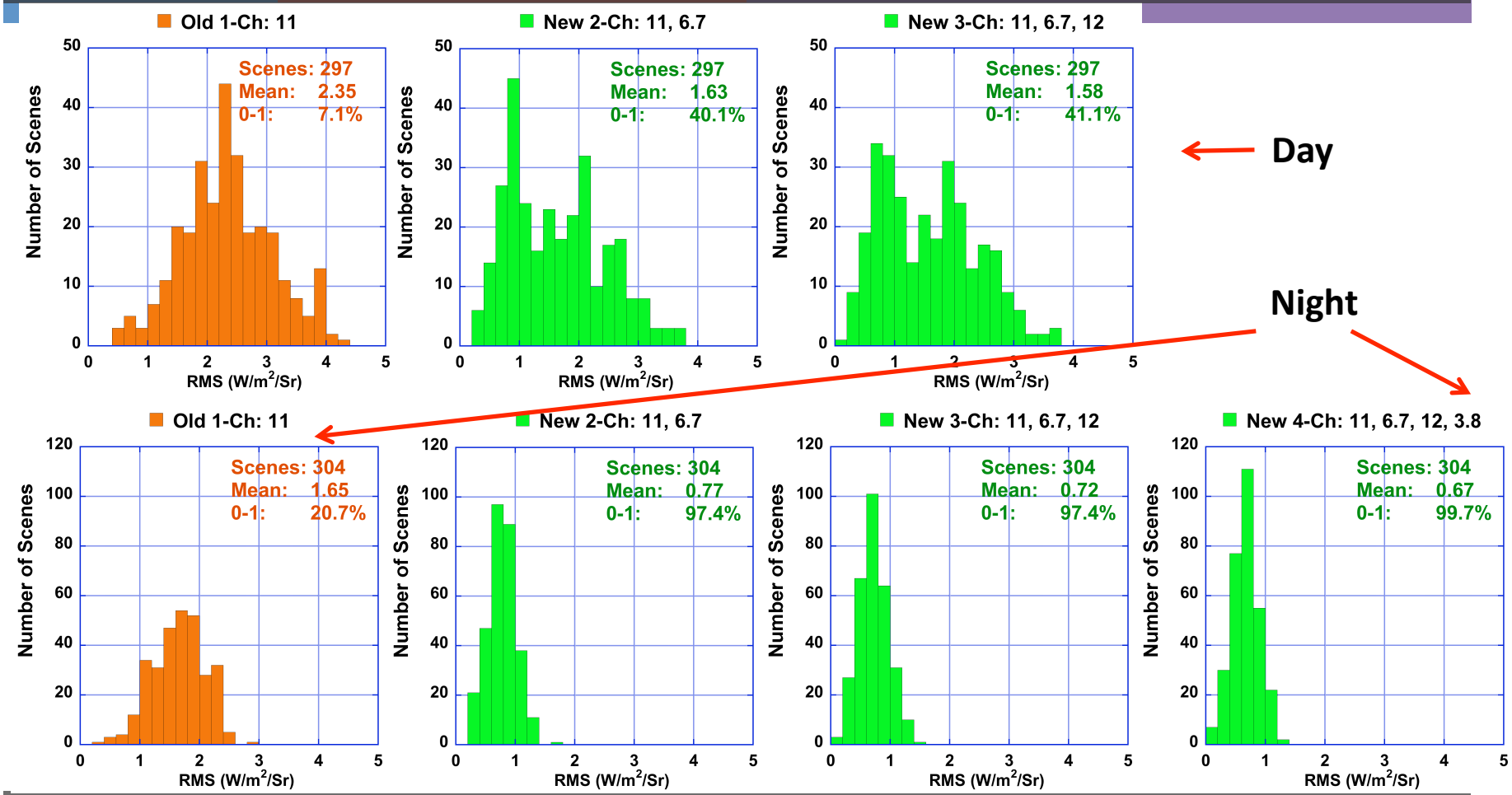
Types	Total Scenes	Ed2/Ed3 WN-only		Ed4 WN + WV		Ed4 vs. Ed2/3 RMS diff (%)
		Mean RMS	(%) RMS < 5	Mean RMS	(%) RMS < 5	
All	600	10.21	8.8	4.49	66.3	**56.02**
land	490	10.26	8.0	4.47	65.7	**56.43**
ocean	110	10.01	12.7	4.56	69.1	**54.45**
day	296	11.18	11.5	5.59	49.0	**50.00**
night	304	9.27	6.3	3.42	83.2	**63.11**
clear	287	8.61	18.5	2.64	99.0	**69.34**
cloud	313	11.68	0.0	6.19	36.4	**47.00**

NB -> BB Radiance
All Scenes



April, 2000

NB Rad -> BB Rad
Day and Night, April 2000



NB Rad -> BB Rad Table

Types	Total Scenes	Ed2/Ed3 WN-only		Ed4 WN + WV		Ed4 vs. Ed2/3 RMS diff (%)	Ed4 WN+WV+12μm	
		Mean RMS	(%) RMS < 1	Mean RMS	(%) RMS < 1		Mean RMS	(%) RMS < 1
All	601	1.99	14.0	1.19	69.1	**40.20**	1.14	69.6
land	490	2.03	13.1	1.22	66.3	**39.90**	1.17	66.9
ocean	111	1.84	18.0	1.08	81.1	**41.30**	1.02	81.1
day	297	2.35	7.1	1.63	40.1	**30.64**	1.58	41.1
night	304	1.65	20.7	0.77	97.4	**53.33**	0.72	97.4
clear	287	1.72	17.1	0.79	89.2	**54.07**	0.74	90.2
cloud	314	2.25	11.1	1.56	50.6	**30.67**	1.52	50.6

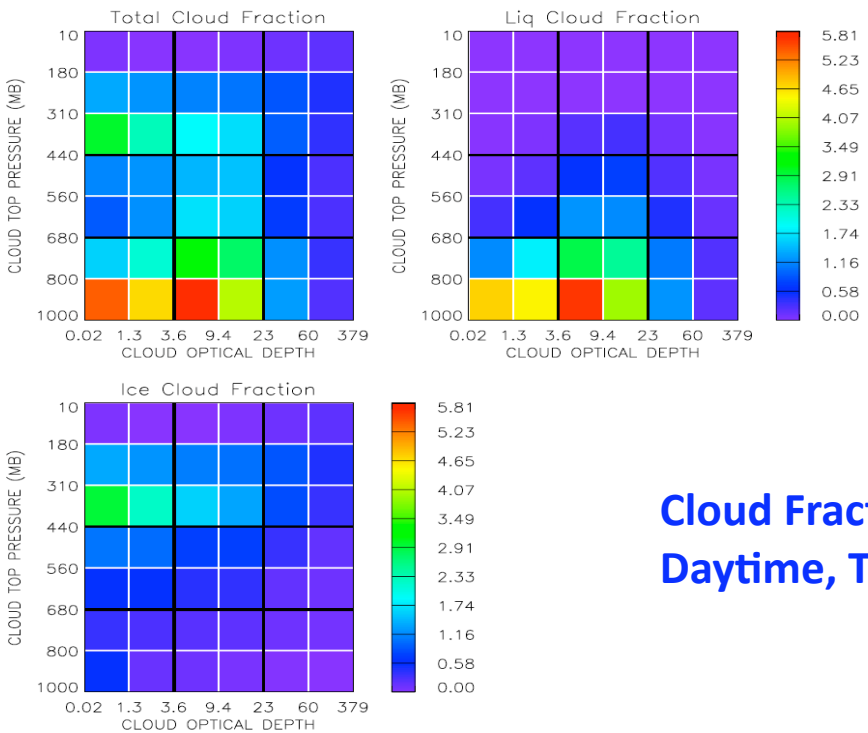
Summary

- ADM-like 2-channel (WN+WV) NB-BB flux algorithm reduce RMS by more than 55% compared with current WN only global land/ocean algorithm based on SSF Ed4 data.
- For NB-BB radiance conversion, 2-channel algorithm reduce RMS by about 40% compared with 1-channel algorithm averaged for all scenes.
- Adding other channels to the 2-channel algorithm improves RMS only slightly.

Future Work

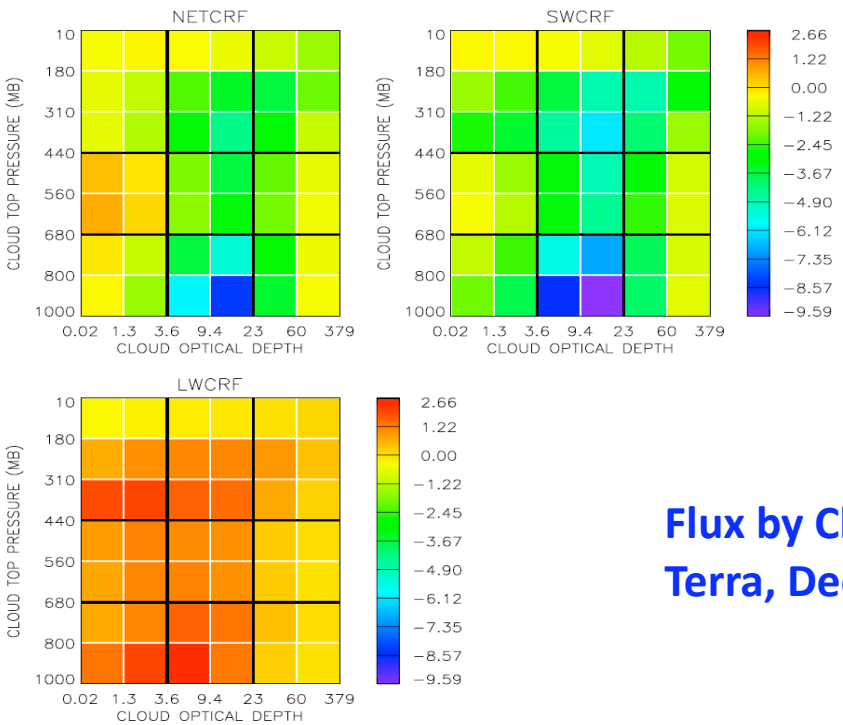
- Adapt the 2-channel NB-BB radiance algorithm to the future ED4 GEO LW algorithm.
- Develop simulator for CERES ISCCP-like cloud

Simulator for CERES Cloud



Cloud Fraction by ISCCP-D1 types, Daytime, Terra, Dec 2002

Simulator for CERES Cloud



Flux by Cloud types, Daytime
Terra, Dec 2002

Simulator for CERES Cloud

- *ISCCP simulator*

  by Klein and Jakob, 1999; Webb et al, 2001

- *MODIS simulator*

  by Pincus et al. 2012

Simulator for CERES Cloud

A MODIS simulator for climate models (i)

Accepts sub-column inputs of $r_{e(l,i)}(z), \tau_{(l,i)}(z)$ or $q_{(l,i)}(z)$

Provides subcolumn estimates of

$$\tau = \int_{\mathrm{TOA}}^{\mathrm{sfc}} \sigma_c(z)dz$$ (no errors, as ISCCP simulator)

$$p_c = 1/2 \int_{\mathrm{TOA}}^{\tau=2} p(z)\sigma_c(z)dz$$ (when > 700 mb, use ISCCP IR)

$$P = \int_{\mathrm{TOA}}^{\tau=1} P(z)\sigma_c(z)dz$$ (can be "undetermined")

$$r_e = F^{-1}(F(r_e(z)))$$ (pseudo-retrieval based on near-IR fluxes)

Pincus

Daytime only

Simulator for CERES Cloud

MODIS/ISCCP simulator modified for CERES

1. *P_c > 700mb, Klein/Webb ISCCP simulator*

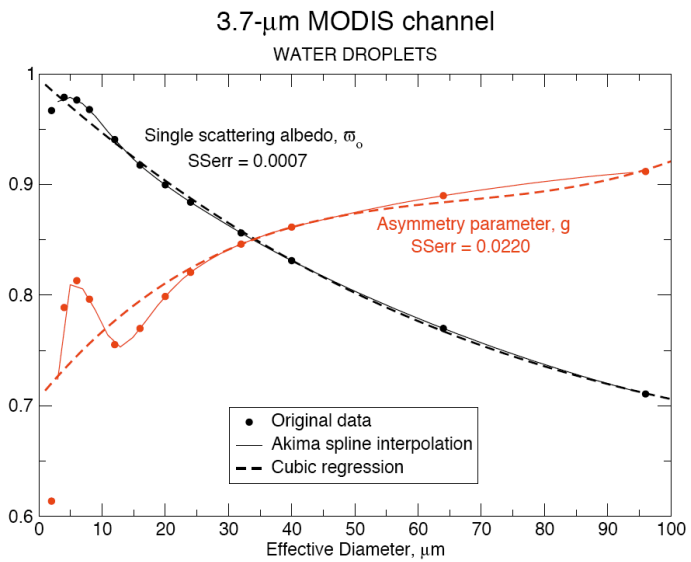
   slightly different IR channels: 11.03µm vs. 10.5µm

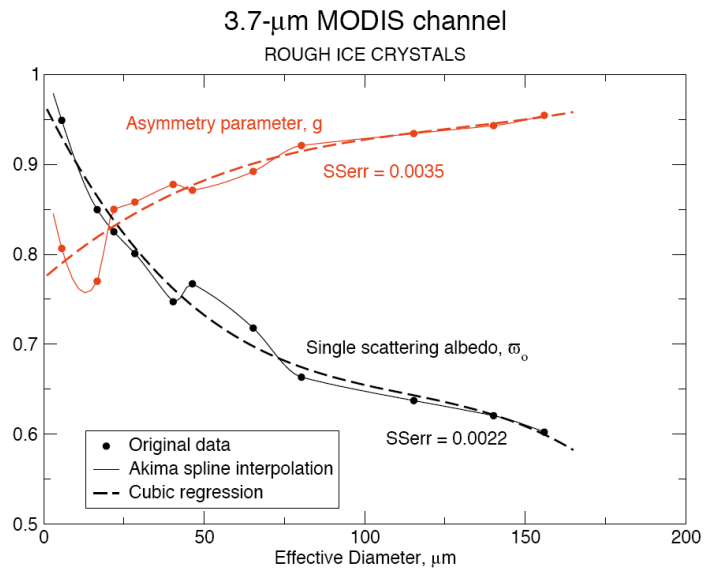
2. *P_c<= 700mb, Pincus MODIS simulator*

   r_e effective particle size

   CERES MODIS uses different lookup table to calculate ω_o(single scattering albedo) and g (asymmetry factor) for R (Reflectance) for r_e pseudo retrieval

Simulator for CERES Cloud



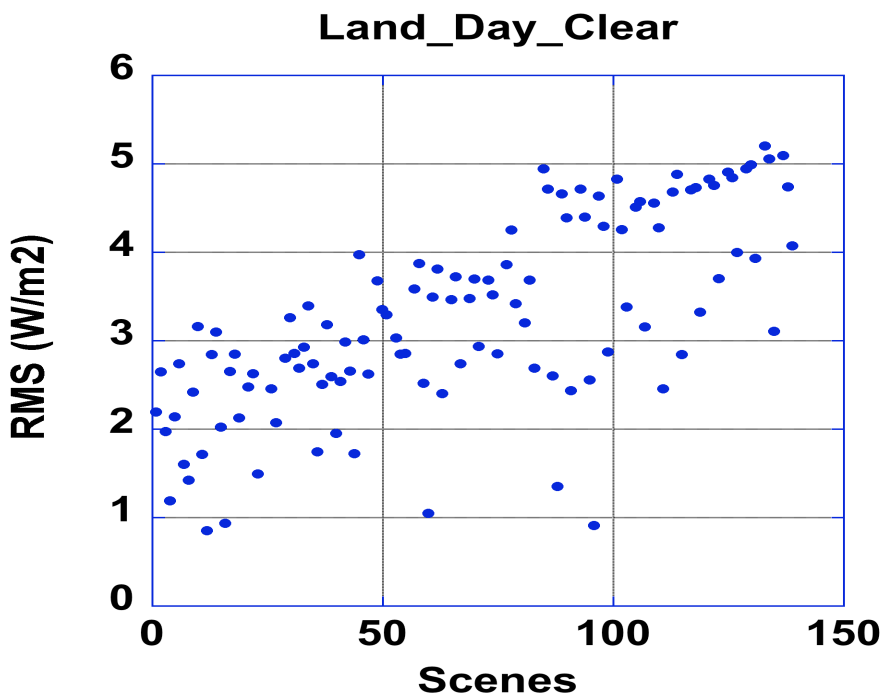


Minnis and Arduini

CERES MODIS $\omega_0(R_e)$ and $g(R_e)$ calculation of Reflectance for pseudo retrieval

Thank You!

Backup



2-channel NB-BB flx
April, 2000