Radiance/Flux comparisons for CERES Aqua/Suomi-NPP and CERES Terra/ScaRaB

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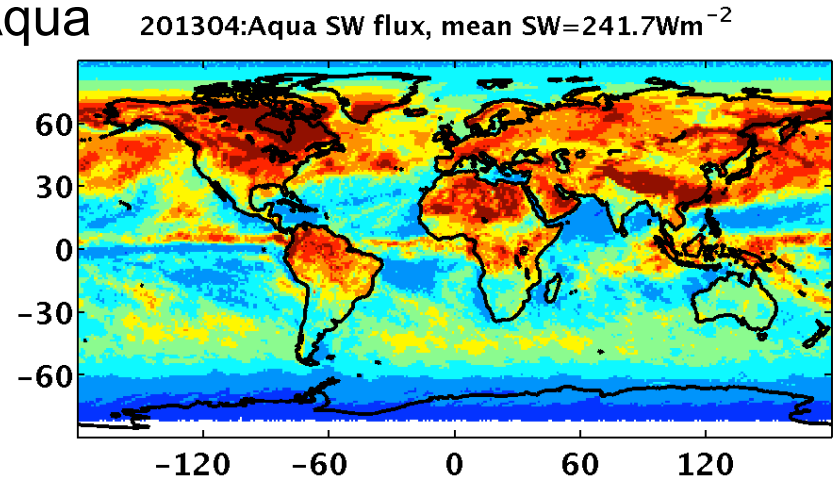
Suomi-NPP

- Suomi-NPP was launched in Oct. 2011 into a sun-synchronous orbit 824 km above the Earth.
- It has a similar orbit as Aqua.

	Aqua	S-NPP
Launch date	May 4, 2002	Oct. 28, 2011
Altitude	705 km	824 km
Inclination	98.14°	98.75°
Period	98.4 min	101.4 min

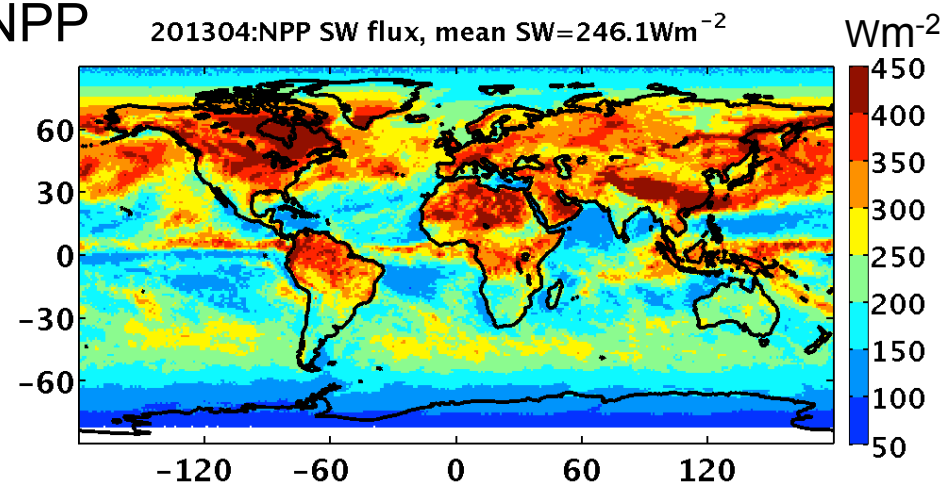
SW flux comparison between Aqua and S-NPP: April 2013

Aqua



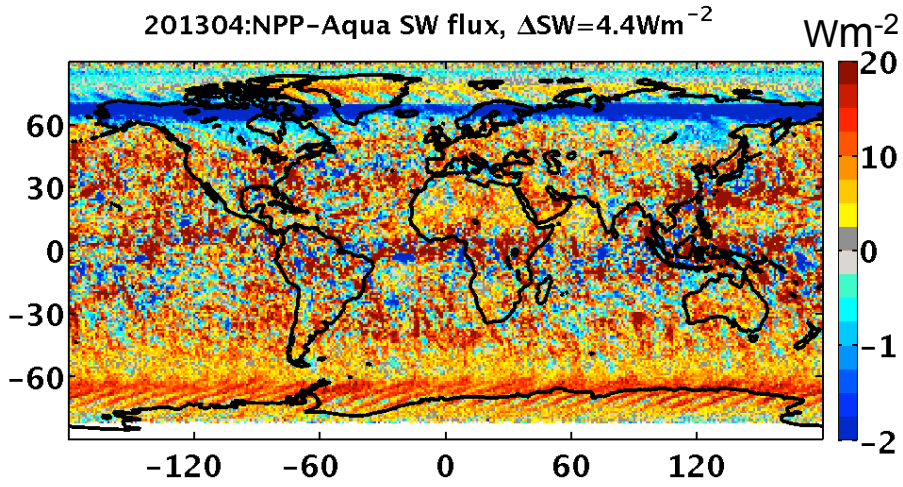
Ed4Cld/ADM&Ed3Cal

NPP

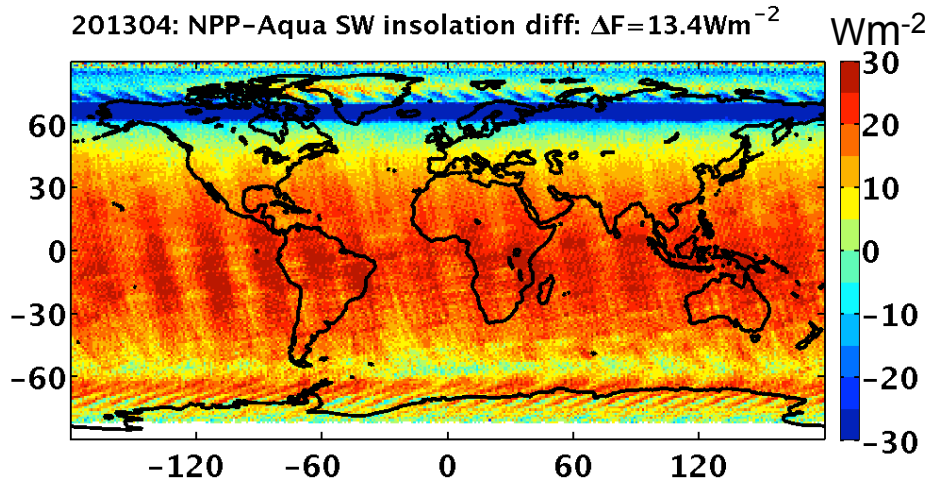


Ed1

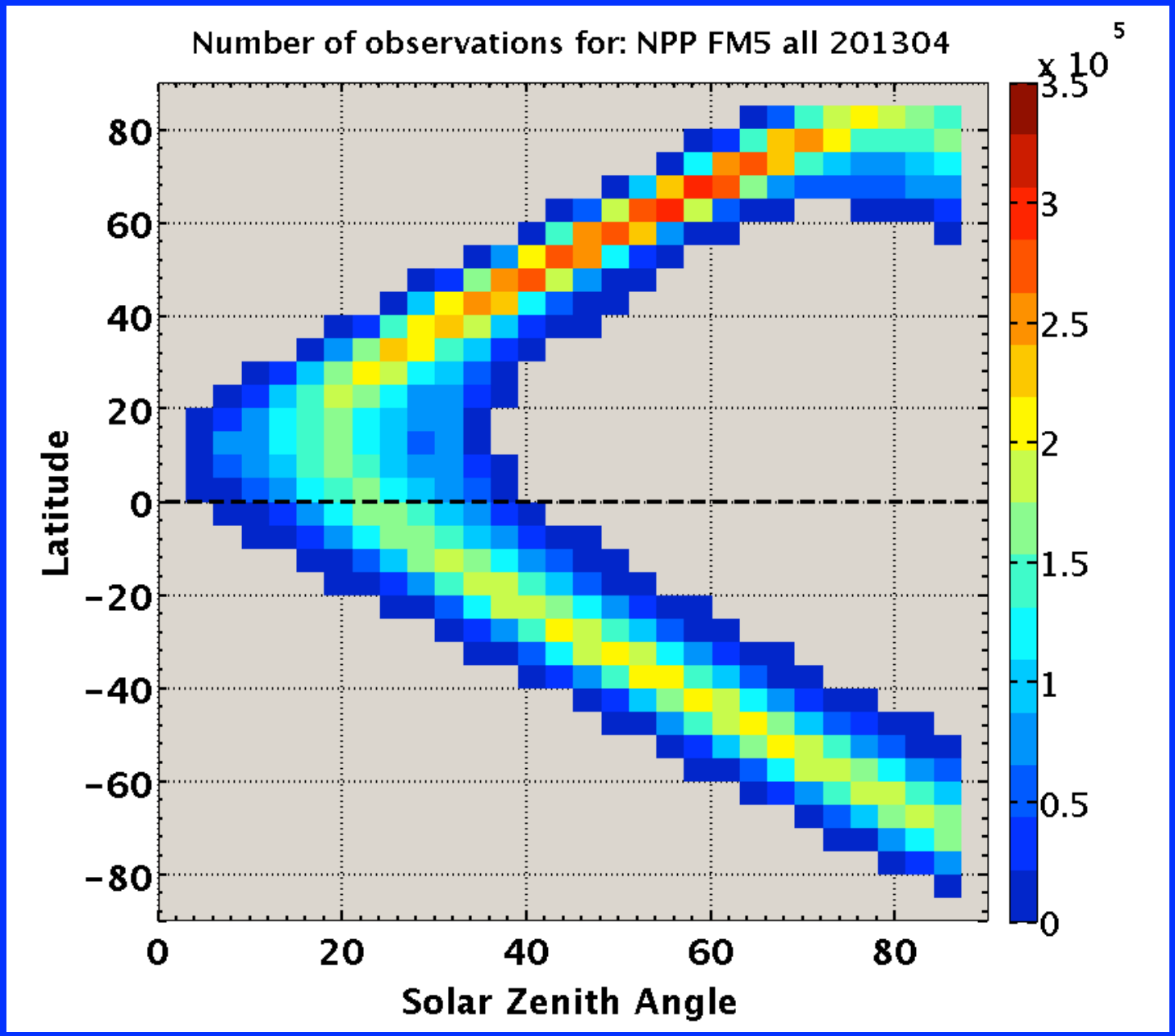
NPP-Aqua: TOA upwelling SW flux



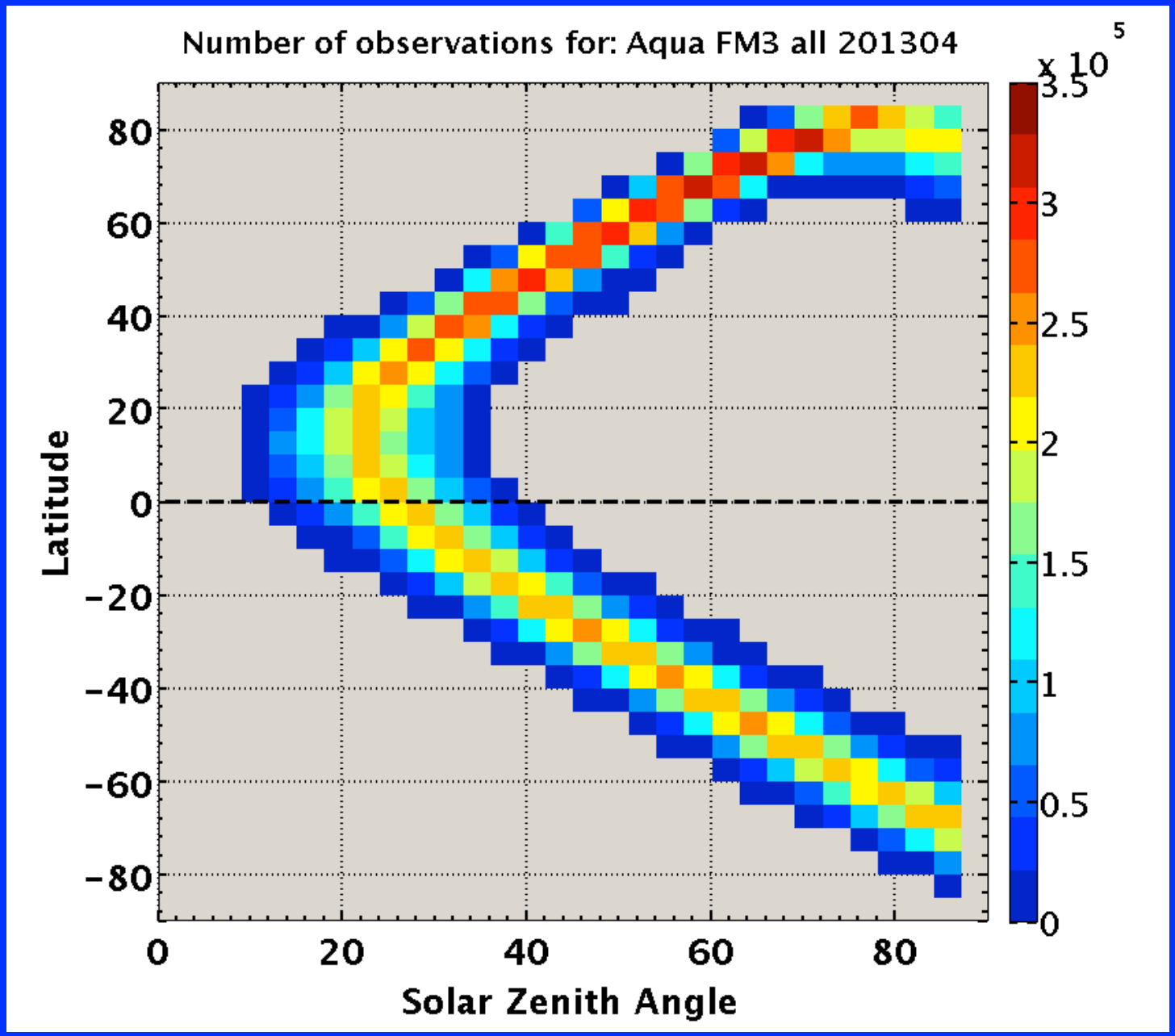
NPP-Aqua:TOA solar insolation



Solar zenith angles sampled by S-NPP as a function of latitude

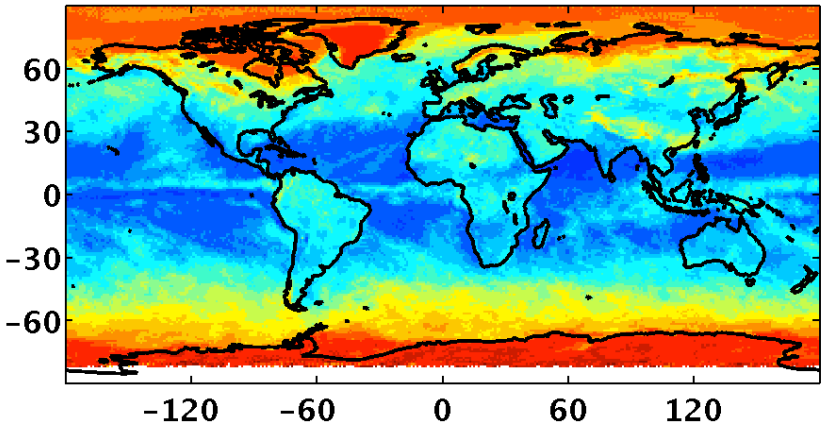


Solar zenith angles sampled by Aqua as a function of latitude



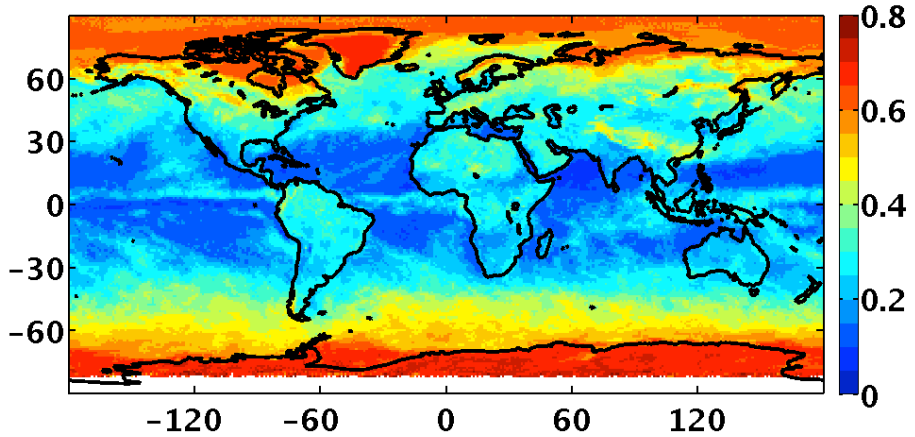
Monthly mean albedo from Aqua and NPP: 201304

Aqua



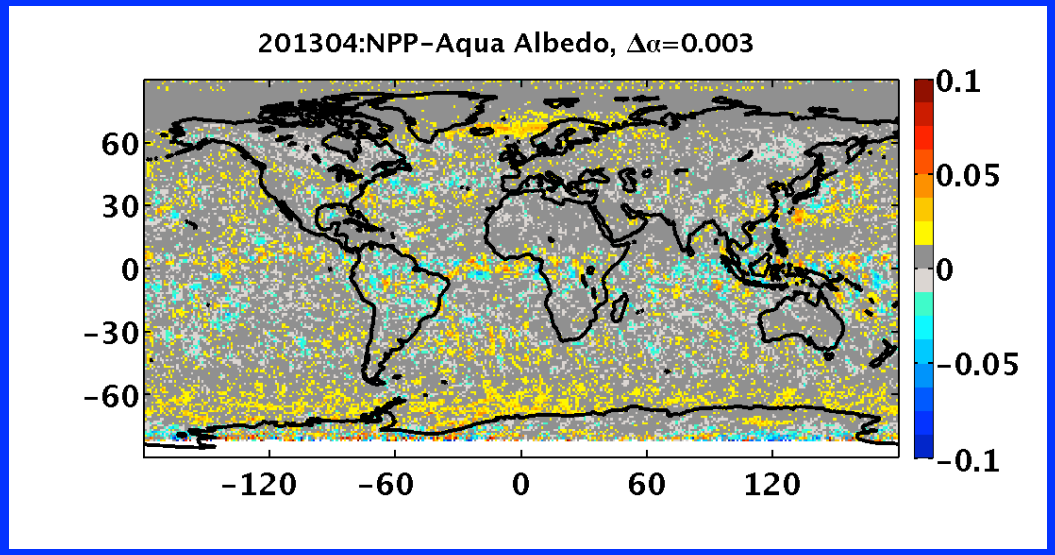
Ed4Cld/ADM&Ed3Cal

NPP

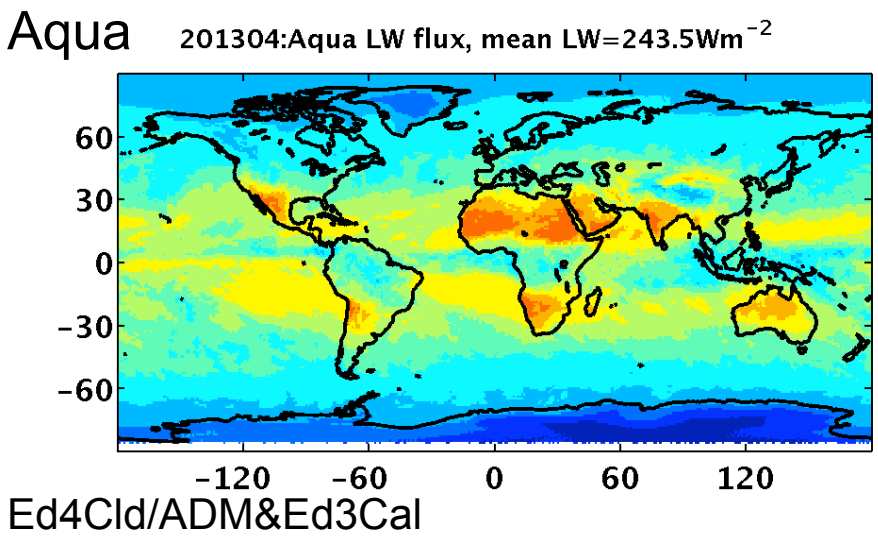


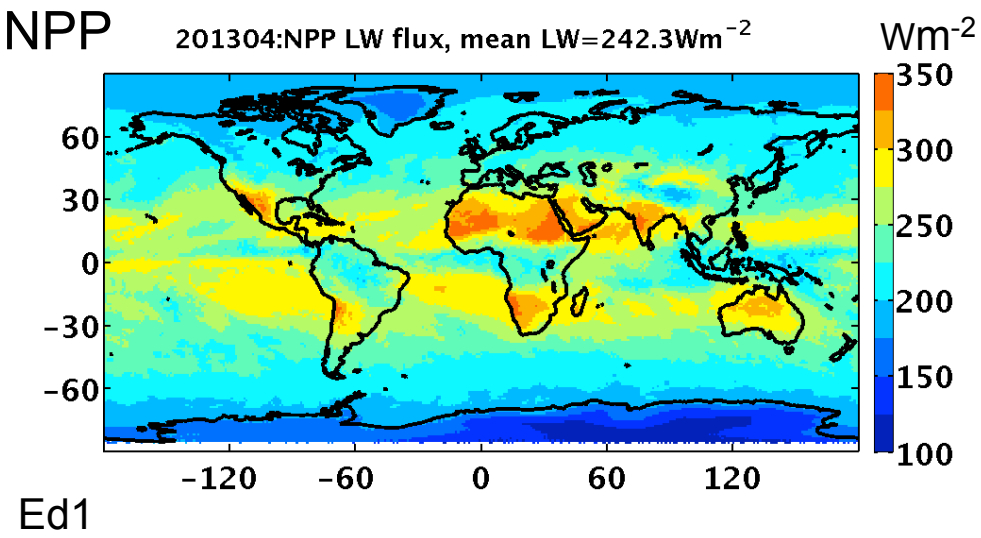
Ed1

NPP-Aqua: TOA albedo

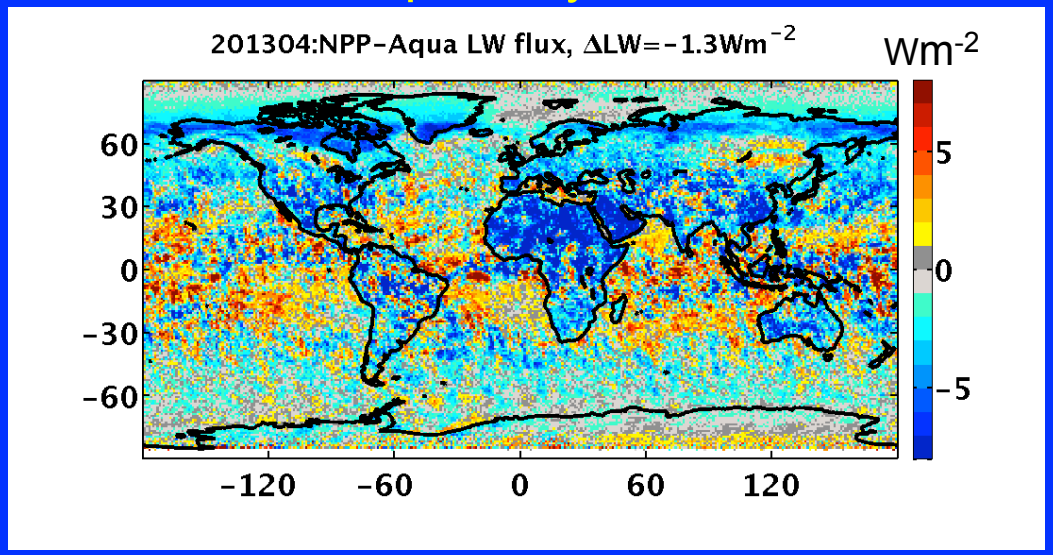


Monthly mean daytime LW from Aqua and NPP: 201304

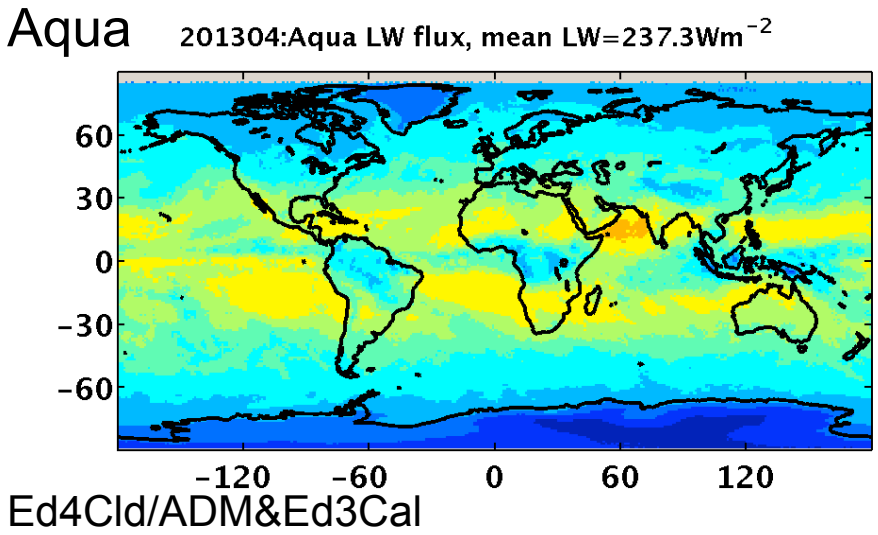


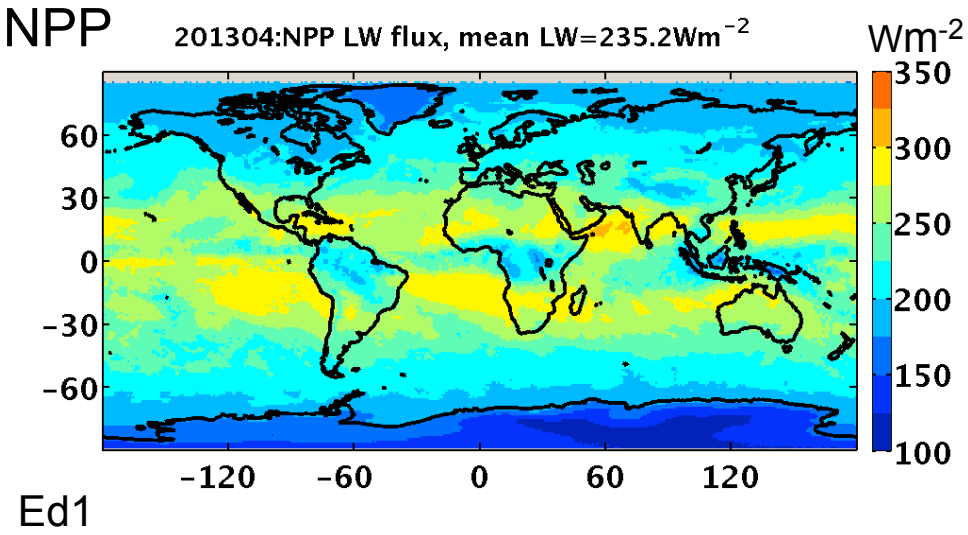


NPP-Aqua: daytime LW

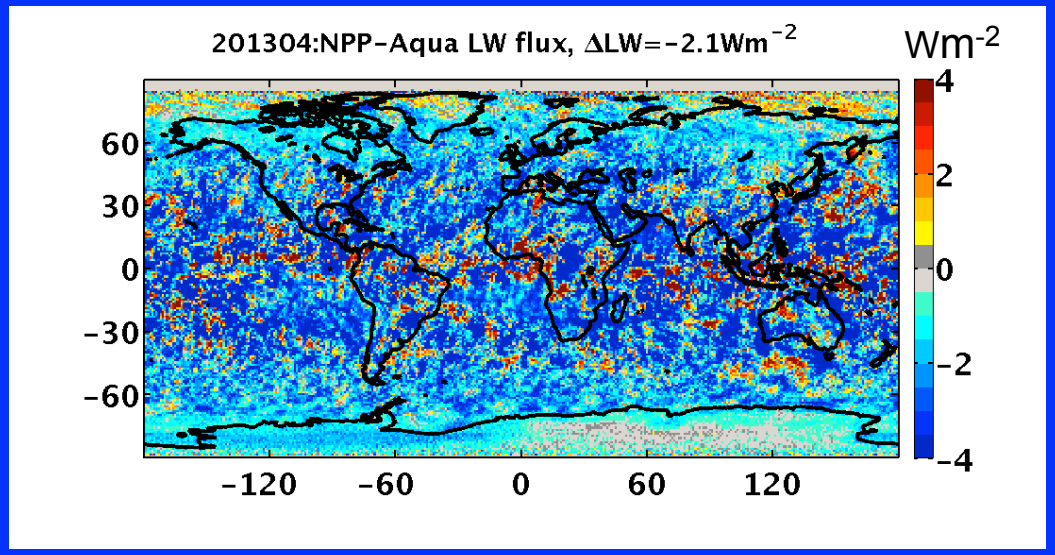


Monthly mean nighttime LW from Aqua and NPP: 201304



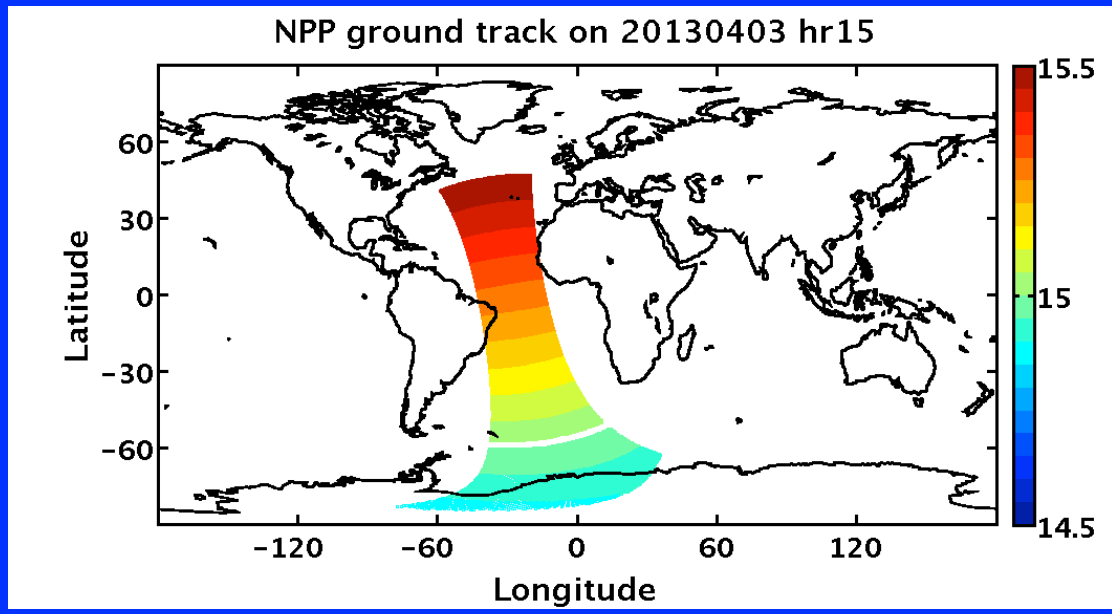


NPP-Aqua: nighttime LW

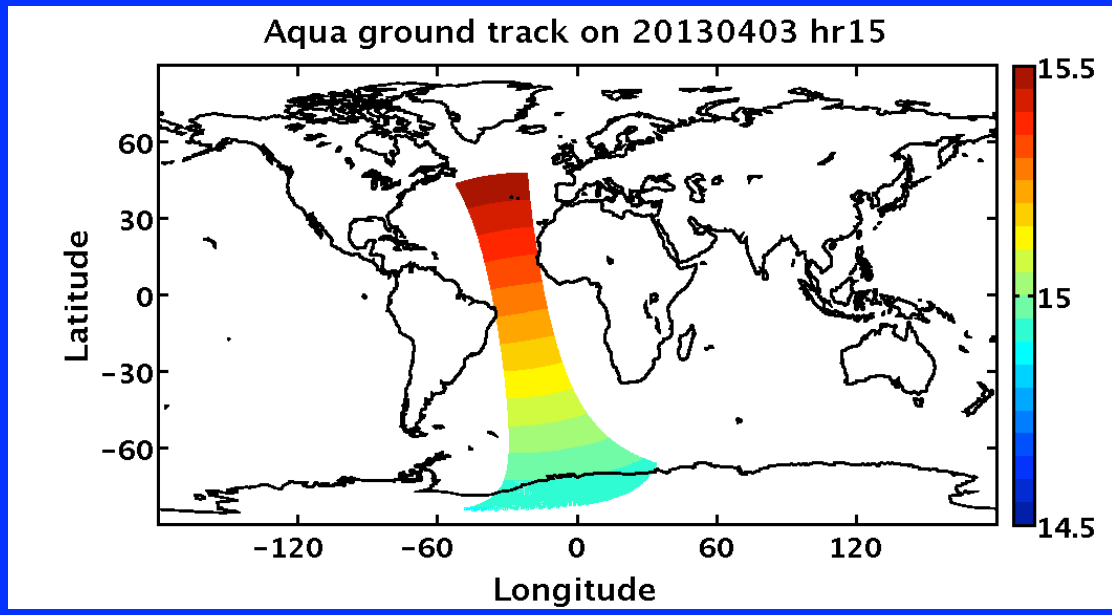


Radiance comparison between matched Aqua and S-NPP footprints

- For SW, match the Aqua and S-NPP footprints:
  - Latitude/longitude within 0.05
  - SZA within 2°
  - VZA/RAA within 5°



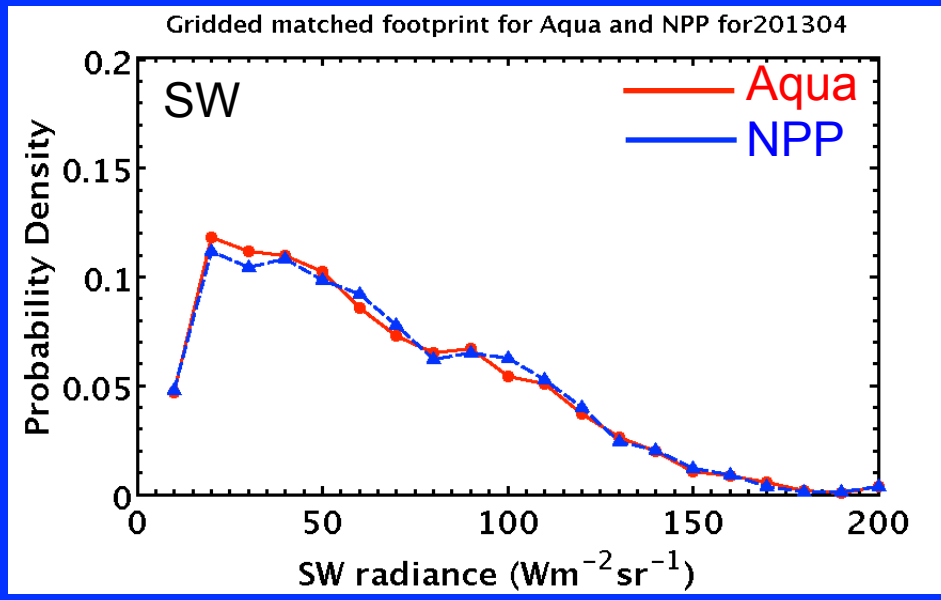
- For LW, match the Aqua and S-NPP footprints:
  - Latitude/longitude within 0.05
  - VZA within 2°

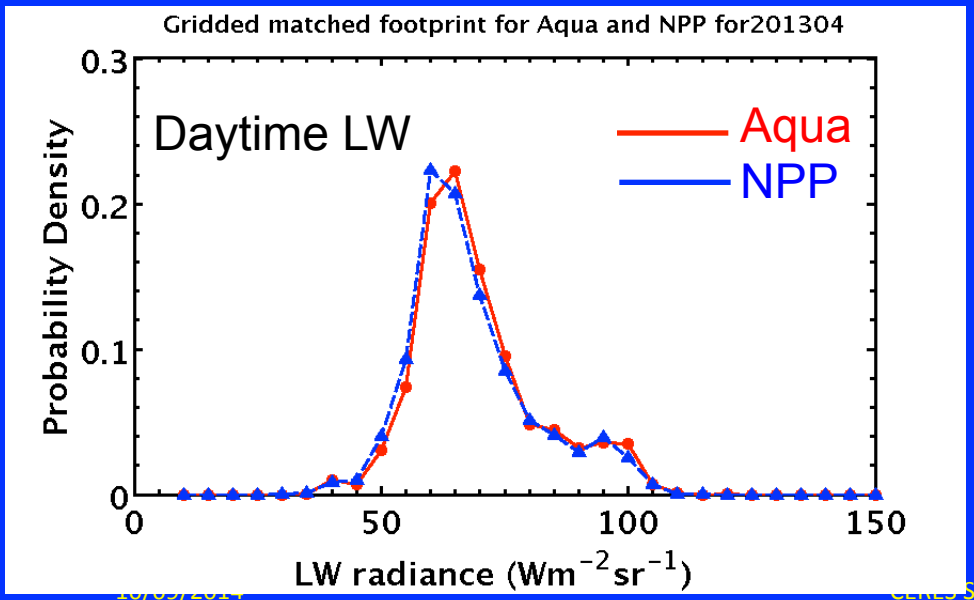


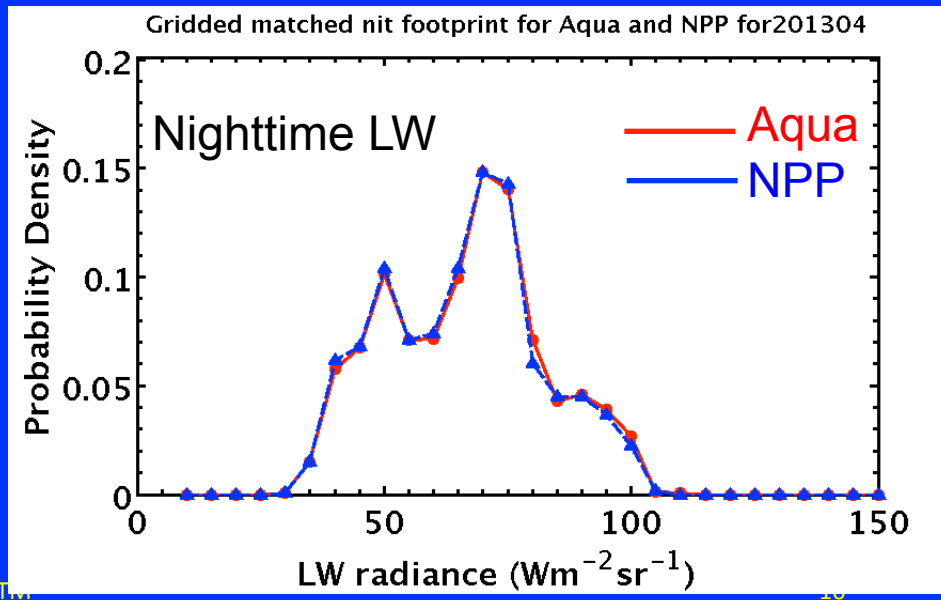
Radiance comparison between matched Aqua and NPP footprints

- Matched footprints are gridded into 1° by 1° grid box;
- Grid mean radiances are used to calculate the relative differences between NPP and Aqua:

$$\frac{\sum_{j=1}^{M}(I_j^N - I_J^A)/I_j^N}{M}$$







SW radiance from NPP is higher than that from Auqa, and LW radiance from NPP is lower than that from Aqua

	SW radiance		LW radiance day (|ΔVZA|<2°)		LW radiance nit (|ΔVZA|<2°)	
	Grid #	Rel diff. (%)	Grid #	Rel. diff. (%)	Grid #	Rel. diff. (%)
January	3726	2.24	1871	-1.96	1843	-0.81
April	3402	1.40	1772	-1.65	1806	-0.81
July	3969	0.57	1850	-1.39	1683	-0.79

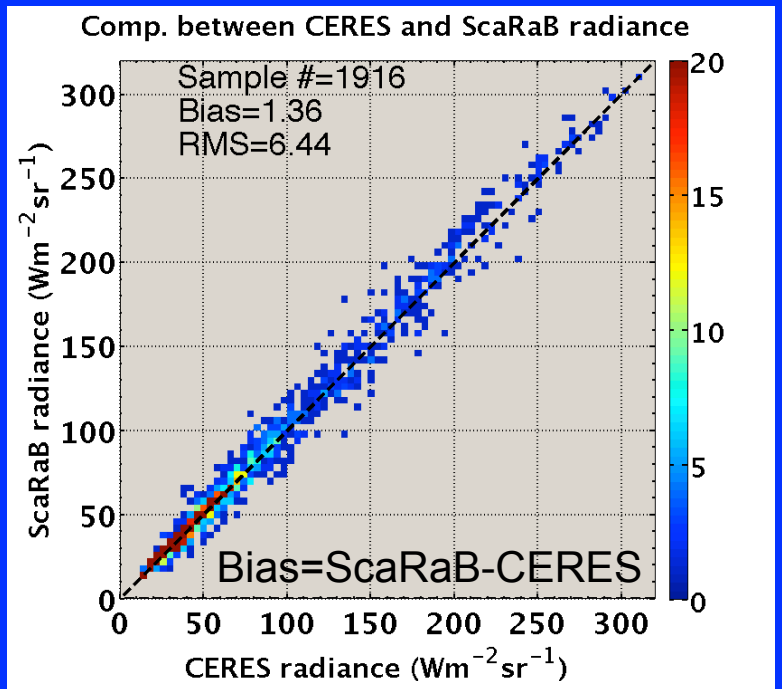
$$\frac{\sum_{j=1}^{M}(I_j^N - I_J^A)/I_j^N}{M}$$

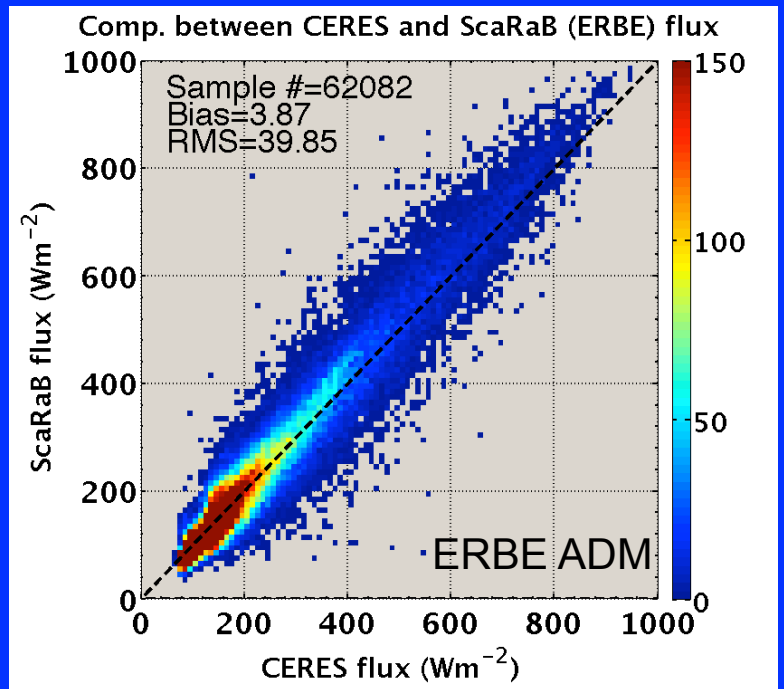
Comparison between ScaRaB and CERES FM2

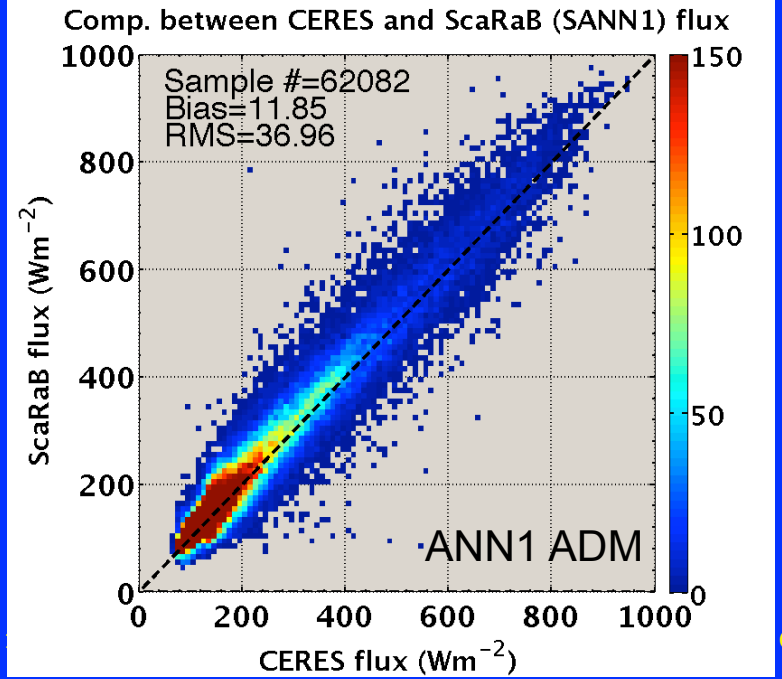
- ScaRaB-3 was launched in Oct. 2011.
- CERES FM2 was placed in programable azimuth plane scan mode between April 17 and June 8 2012 to maximize the collocation of ScaRaB and CERES FM2
- To collocate the ScaRaB and CERES footprints
  - Observation time within 5 min
  - CERES footprints cover at least 80% of ScaRaB footprints
  - Weight CERES radiance/flux with ScaRaB point spread function
  - For SW radiance: cone angle<5°
  - For LW radiance: viewing zenith angle<5°
- Data
  - ScaRaB: L1A2
  - CERES: Ed3A

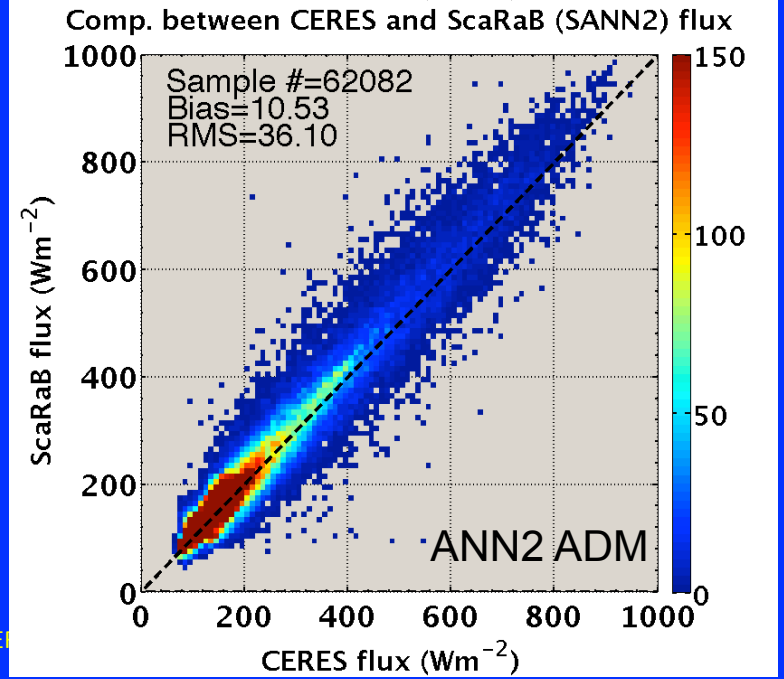
	Terra	ScaRaB
Launch date	Dec. 18, 1999	Oct. 12, 2011
Altitude	713 km	867 km
Inclination	98.20°	19.98°
Period	98.8 min	102.15 min

SW radiance and flux comparison

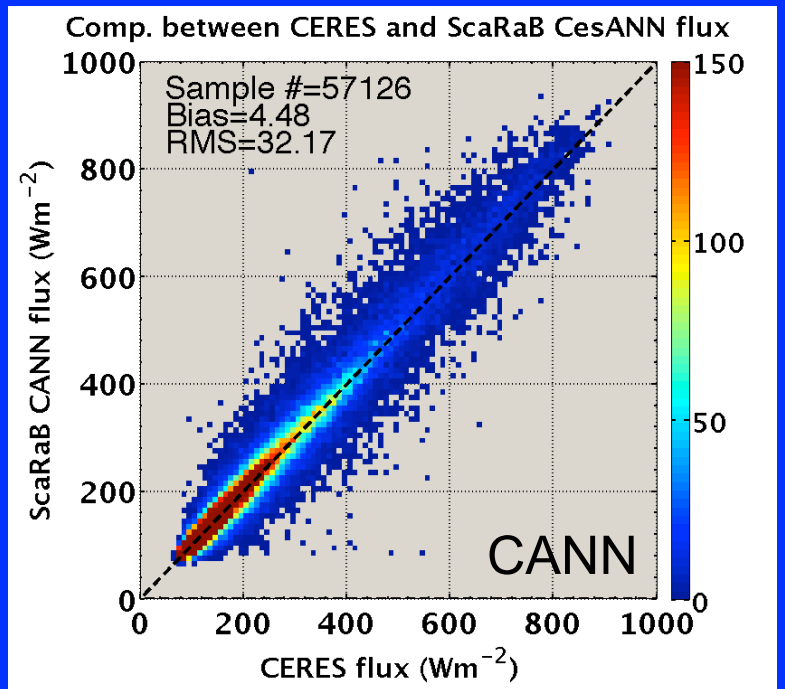


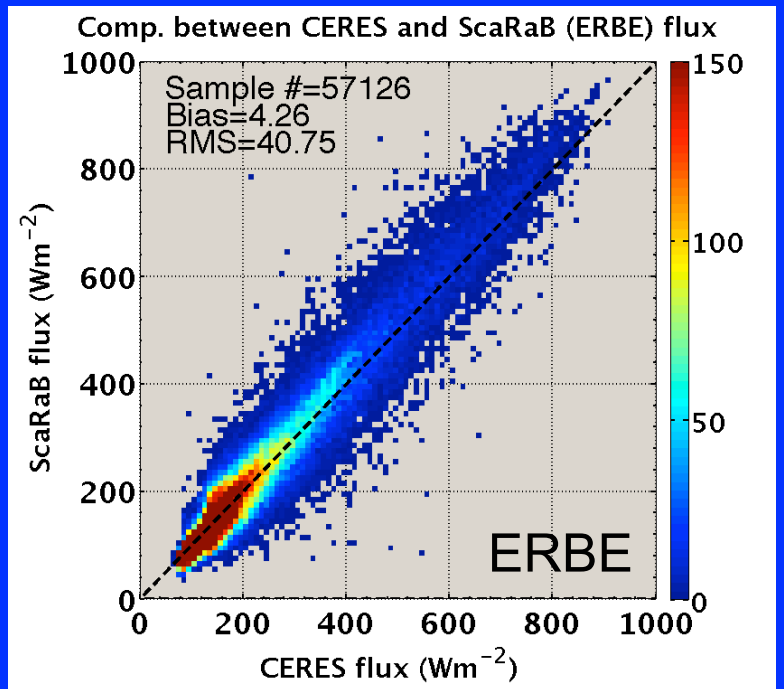


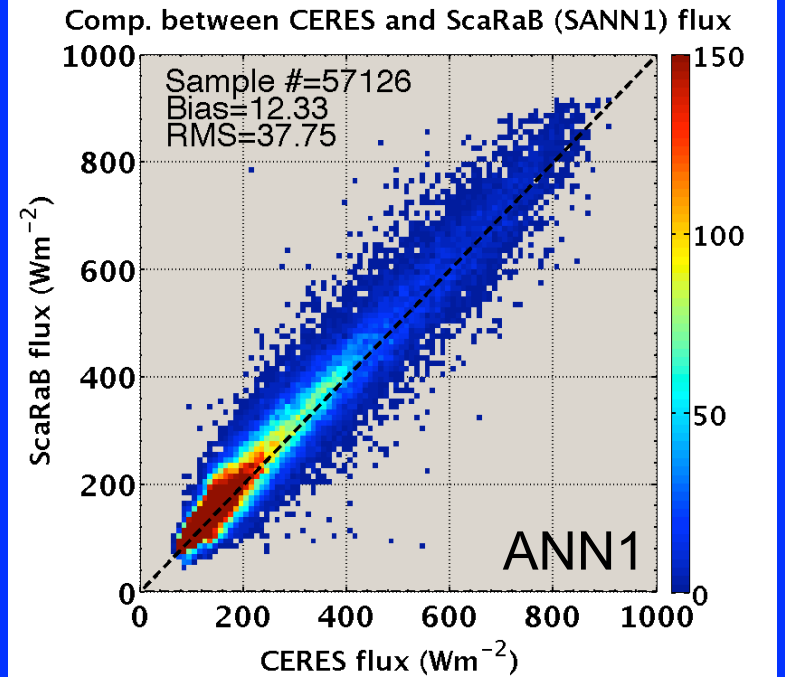


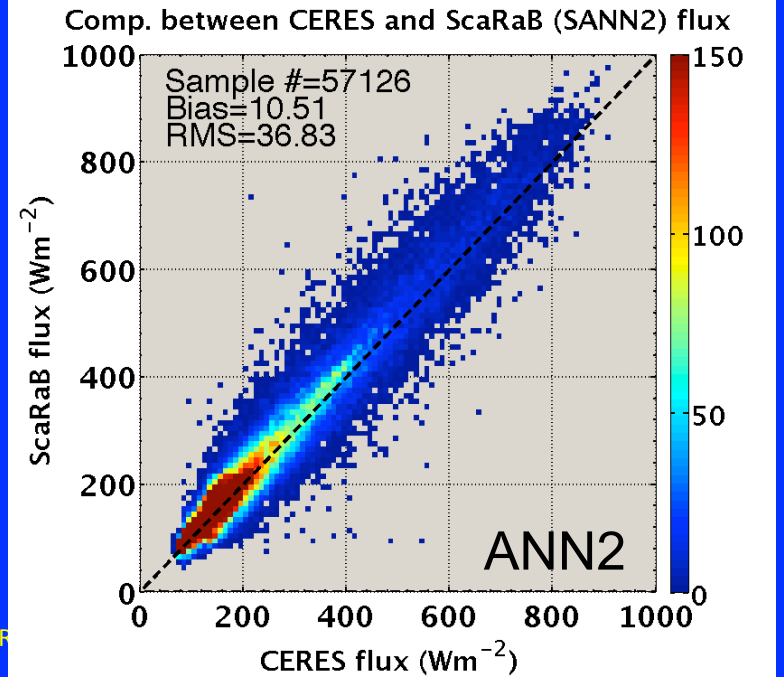


Applying Terra artificial neural network ADMs to ScaRaB improves the agreement

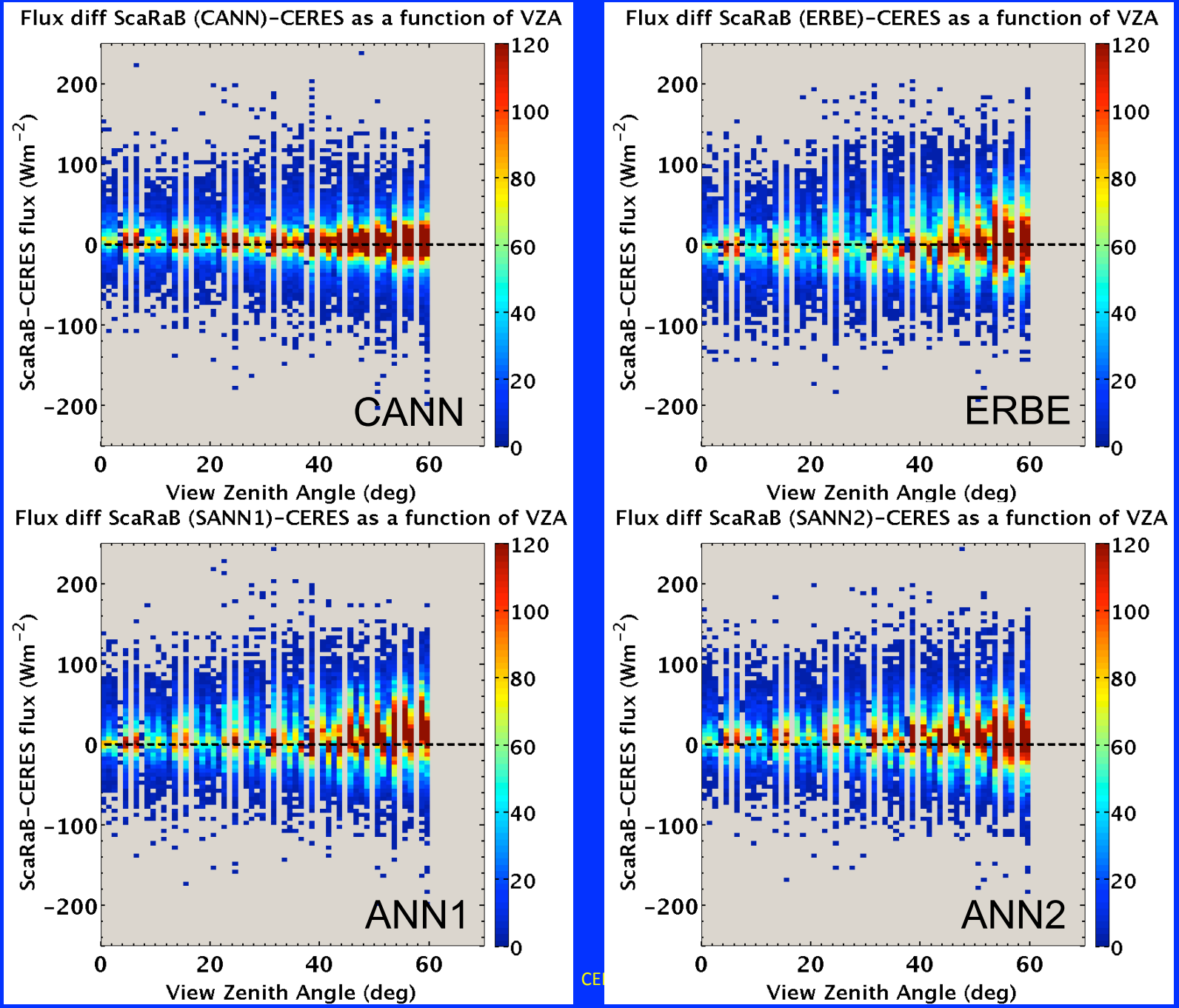








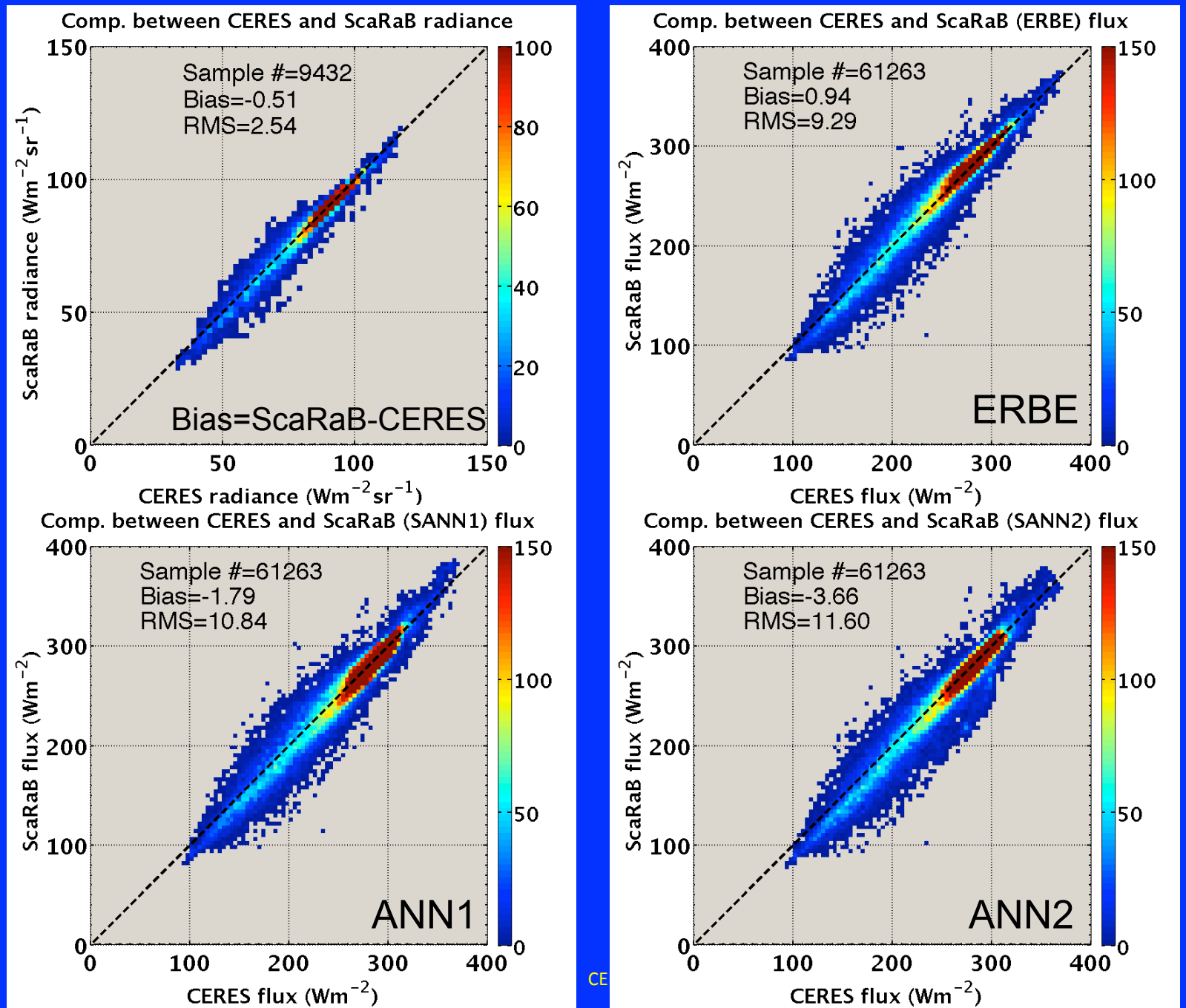
Using Terra ANN ADMs also reduces the VZA dependence of flux difference



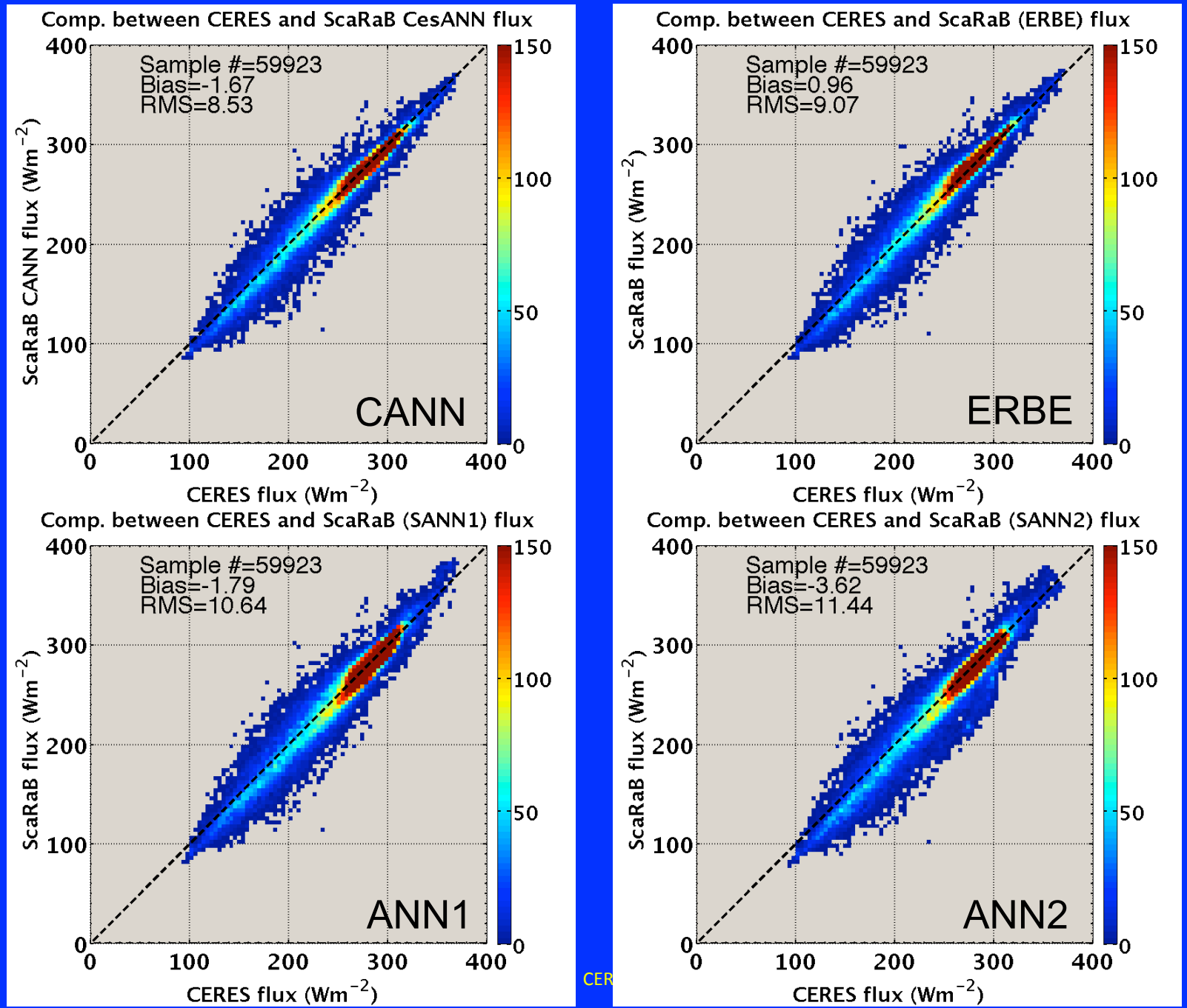
Bias and RMS error for ScaRaB SW flux using different angular distribution models

SW	All (57126)		Ocean (42578)		Land (14548)	
	Bias (%) (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})
SERBE-CERES	4.3	40.8	1.9	39.6	11.2	43.2
SANN1-CERES	12.3	37.8	11.2	36.1	15.7	42.0
SANN2-CERES	10.5	36.8	11.1	36.0	8.7	39.2
SCANN-CERES	4.5	32.2	4.9	32.9	3.3	29.8

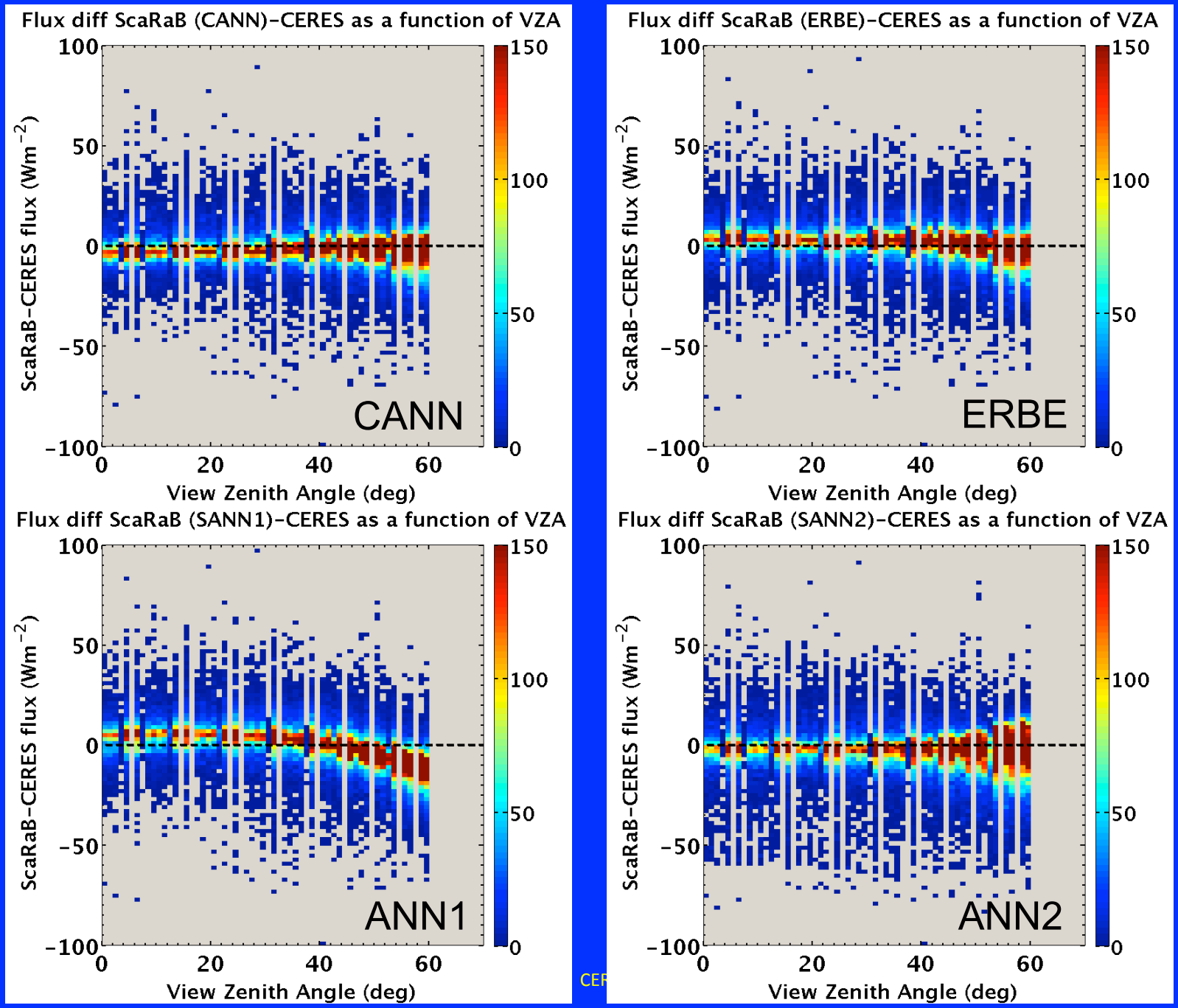
LW day radiance and flux comparison



Applying Terra artificial neural network ADMs to ScaRaB improves the agreement



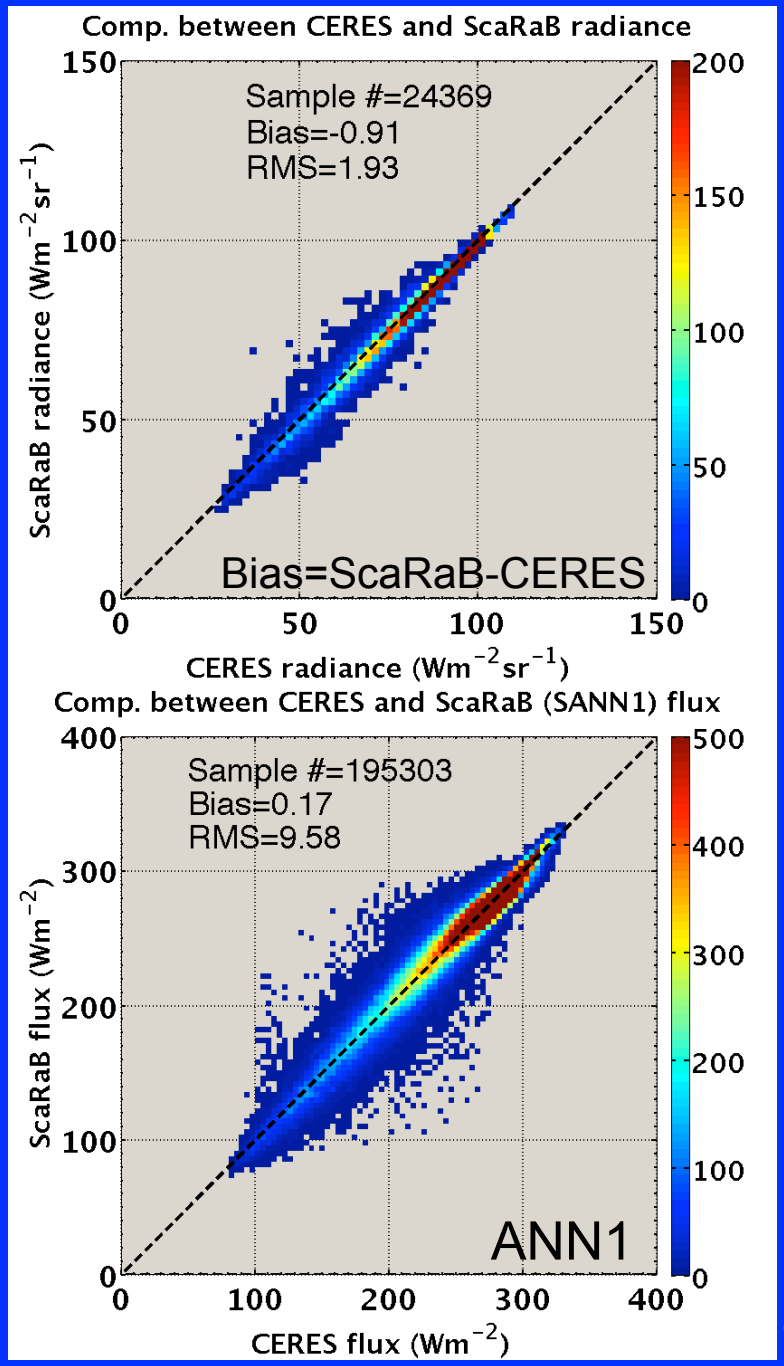
Using Terra ANN ADMs also reduces the VZA dependence of flux difference

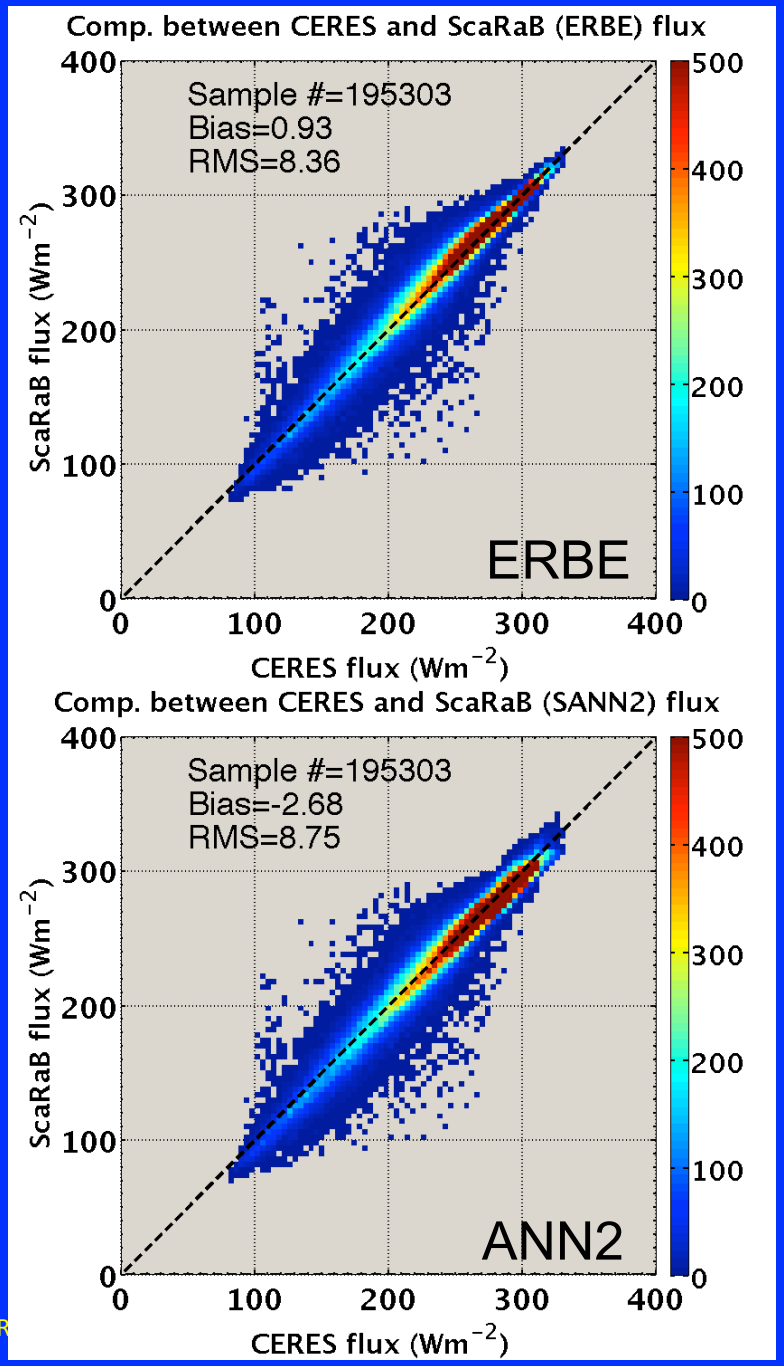


Bias and RMS error for ScaRaB daytime LW flux using different angular distribution models

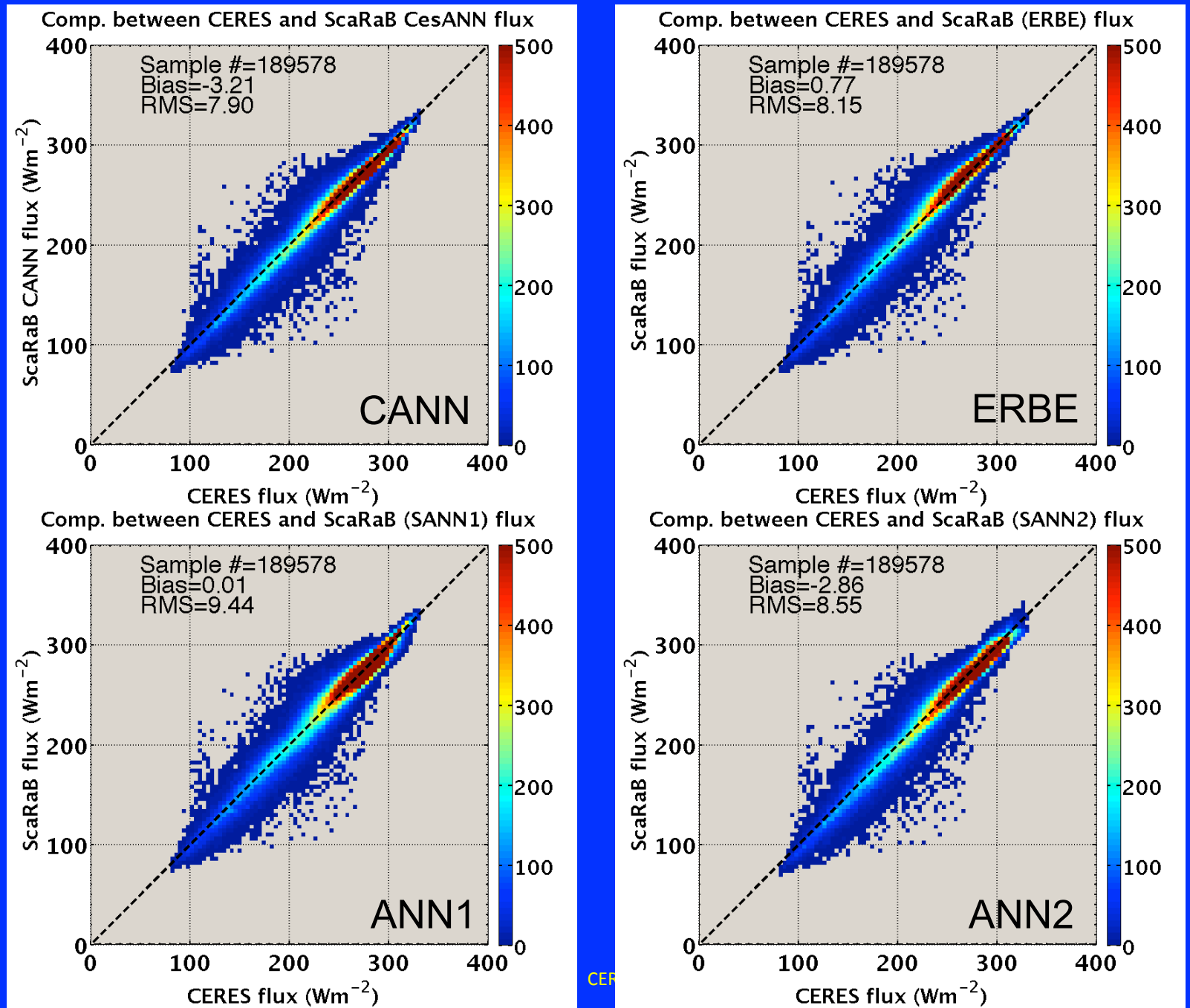
LW day	All (59923)		Ocean (46251)		Land (13672)	
	Bias (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})
SERBE-CERES	1.0	9.1	1.3	8.6	-0.1	10.5
SANN1-CERES	-1.8	10.6	-1.8	10.1	-1.8	12.2
SANN2-CERES	-3.6	11.4	-3.5	11.3	-4.1	12.0
SCANN-CERES	-1.7	8.5	-1.4	8.0	-2.8	10.0

LW night radiance and flux comparison

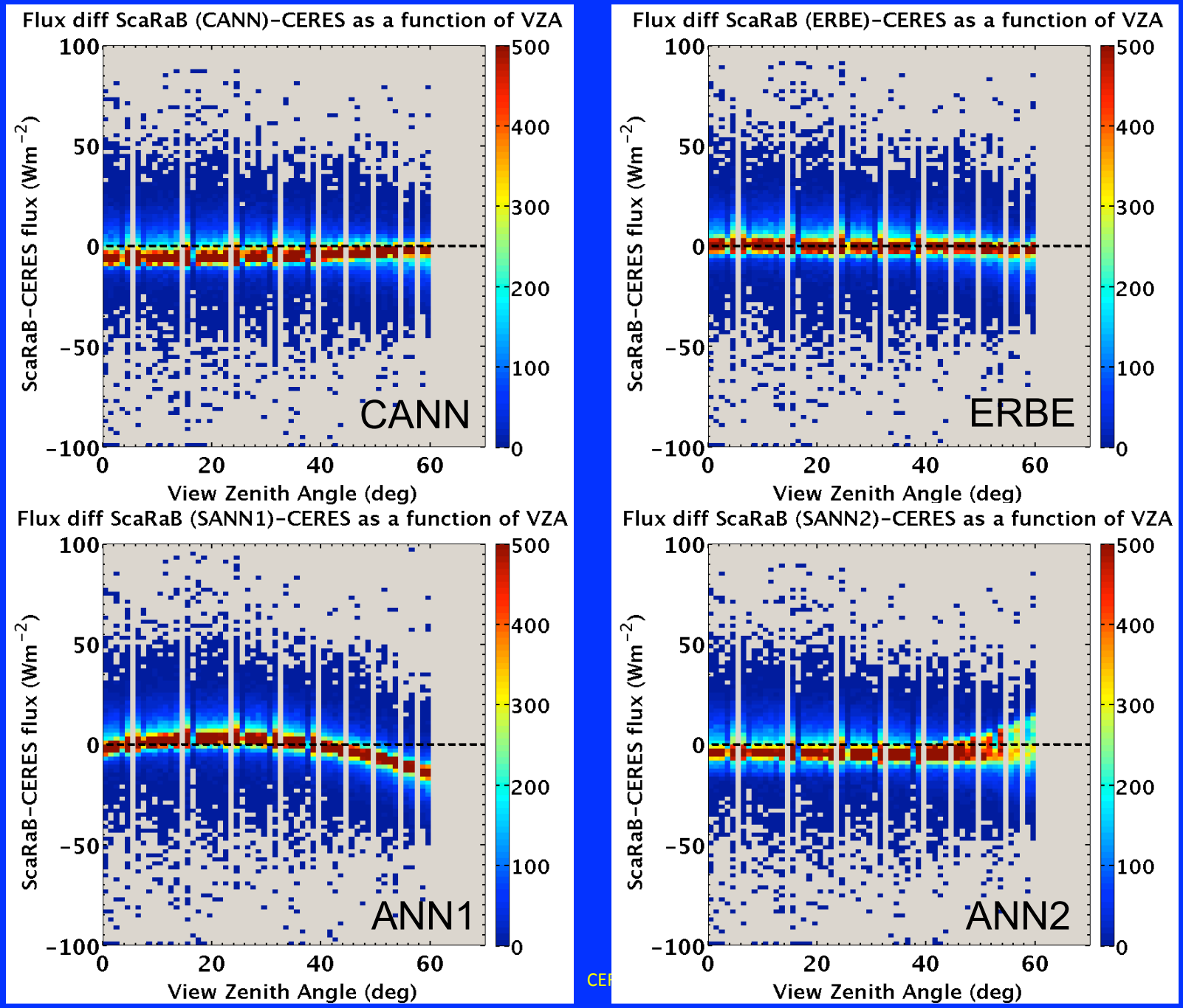




Applying Terra artificial neural network ADMs to ScaRaB



Using Terra ANN ADMs reduces the VZA dependence of flux difference



Bias and RMS error for ScaRaB nighttime LW flux using different angular distribution models

LW night	All (189578)		Ocean (147723)		Land (41855)	
	Bias (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})
SERBE-CERES	0.8	8.2	1.0	7.9	0.1	8.8
SANN1-CERES	0.0	9.4	0.2	9.2	-0.6	10.1
SANN2-CERES	-2.9	8.6	-2.7	8.2	-3.3	9.7
SCANN-CERES	-3.2	7.9	-3.3	7.7	-2.8	8.7

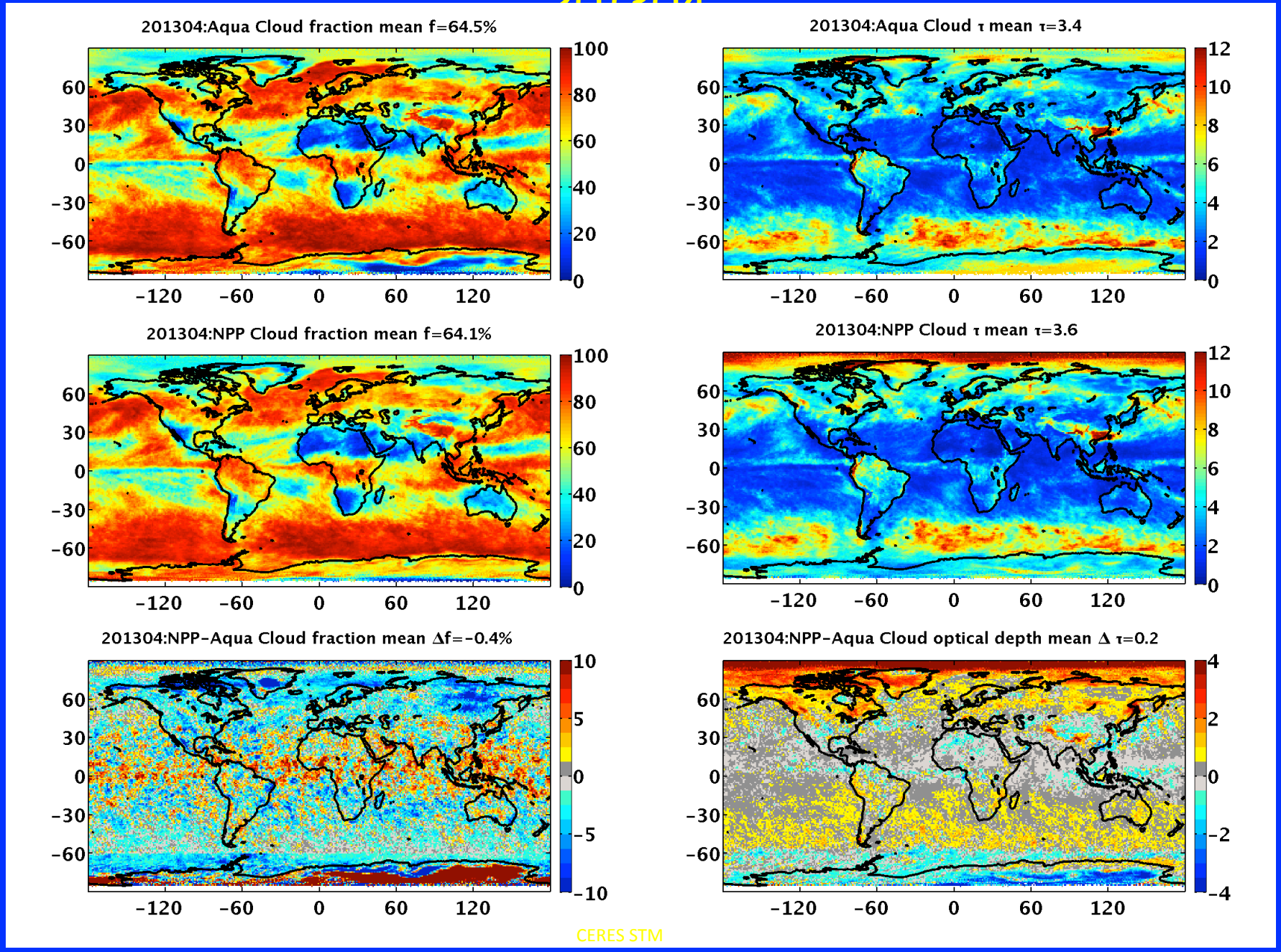
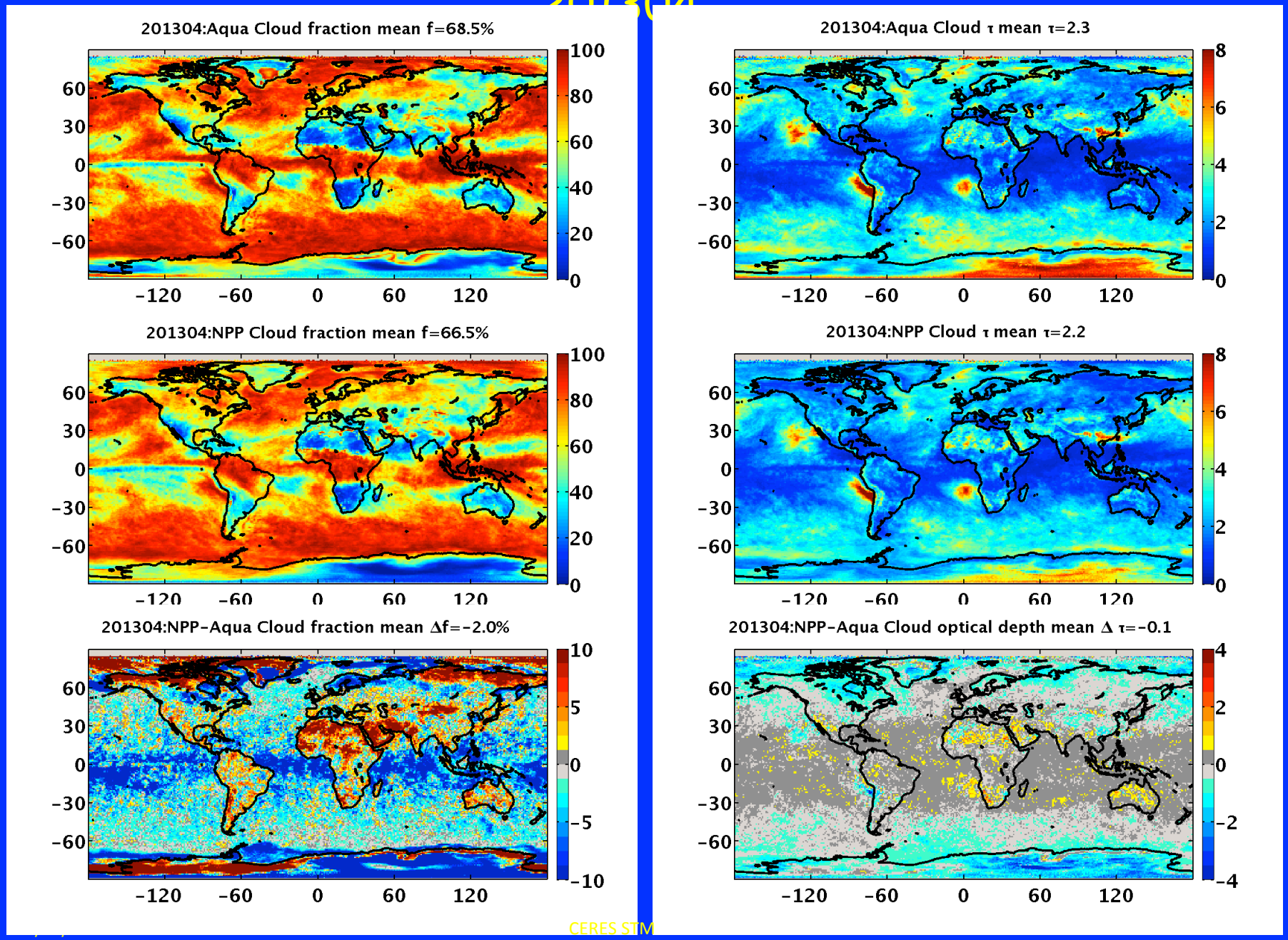
Summary

- Global monthly mean solar insolation for the NPP orbits is larger than that for the Aqua orbits by 13 Wm^{-2}.
- Comparison of simultaneous NPP and Aqua measurements indicates:
  - SW radiance: NPP is higher than Aqua by 0.5 to 2.2%
  - Daytime LW radiance: NPP is lower than Aqua by 1.4 to 2.0%
  - Nighttime LW radiance: NPP is lower than Aqua by 0.8%
- Comparison of collocated ScaRaB and CERES FM2 shows:
  - SW radiance: ScaRaB is higher than FM2 by 2%
  - Daytime LW radiance: ScaRaB is lower than FM2 by 0.6%
  - Nighttime LW radiance: ScaRaB is lower than FM2 by 1%
- ScaRaB fluxes inverted using CERES Ed4 Terra artificial neural network (ANN) angular distribution models (ADMs) agree better with CERES fluxes, and flux bias shows less viewing zenith angle dependence than using the ScaRaB ANN ADMs.

Bias and RMS error for ScaRaB SW flux using different angular distribution models

SW	All (57126)		Ocean (42578)		Land (14548)	
	Bias (%) (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})	Bias (Wm^{-2})	RMS (Wm^{-2})
SERBE-CERES	4.3 (1.9)	40.8 (18.2)	1.9 (0.9)	39.6 (18.8)	11.2 (4.2)	43.2 (16.3)
SANN1-CERES	12.3 (5.5)	37.8 (16.9)	11.2 (5.3)	36.1 (18.6)	15.7 (5.9)	42.0 (15.9)
SANN2-CERES	10.5 (4.7)	36.8 (16.4)	11.1 (5.3)	36.0 (18.5)	8.7 (3.3)	39.2 (18.6)
SCANN-CERES	4.5 (2.0)	32.2 (14.4)	4.9 (2.3)	32.9 (15.6)	3.3 (1.3)	29.8 (11.3)

Monthly mean day cloud f and tau from Aqua and NPP: 201304



Monthly mean night cloud f and tau from Aqua and NPP: 201304