Errors in Ignoring 3D Radiative Transfer in SW Flux Computations

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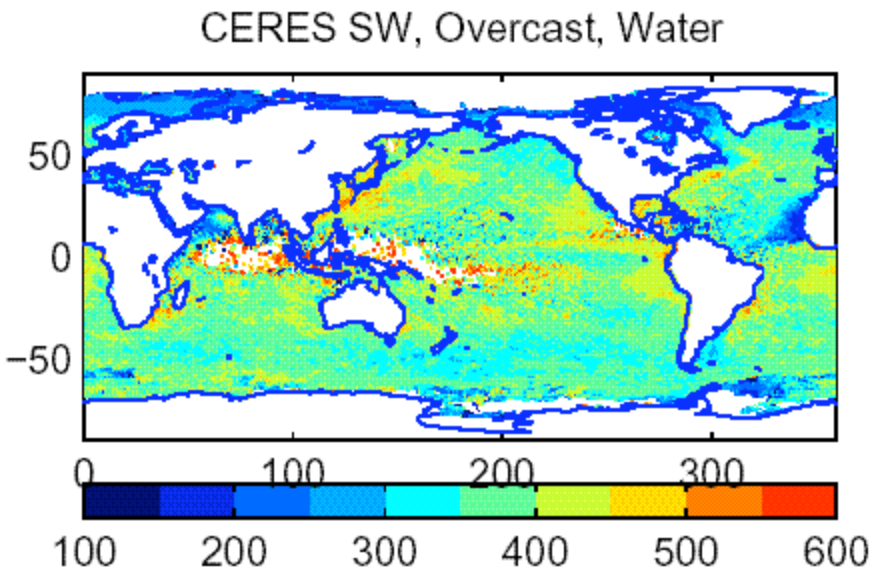
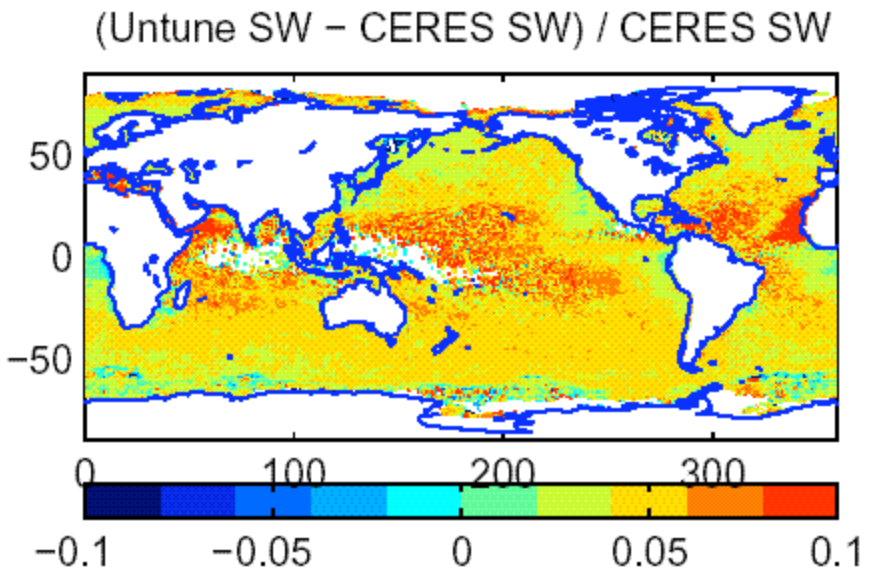
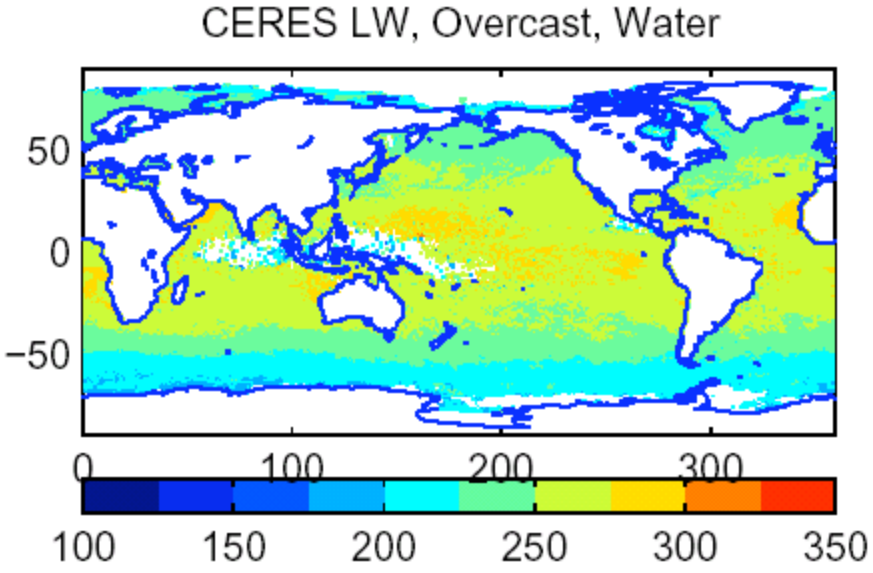
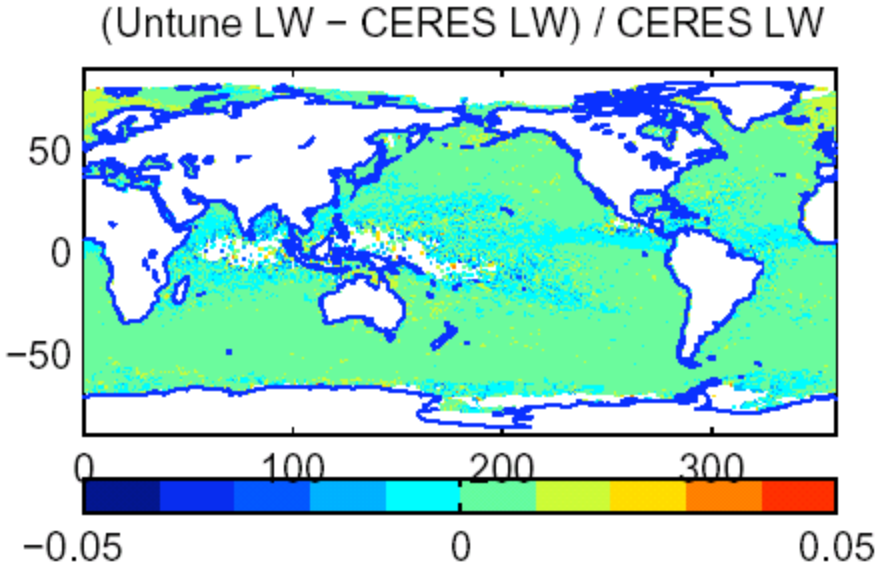
CERES-untuned Flux comparison, overcast water clouds



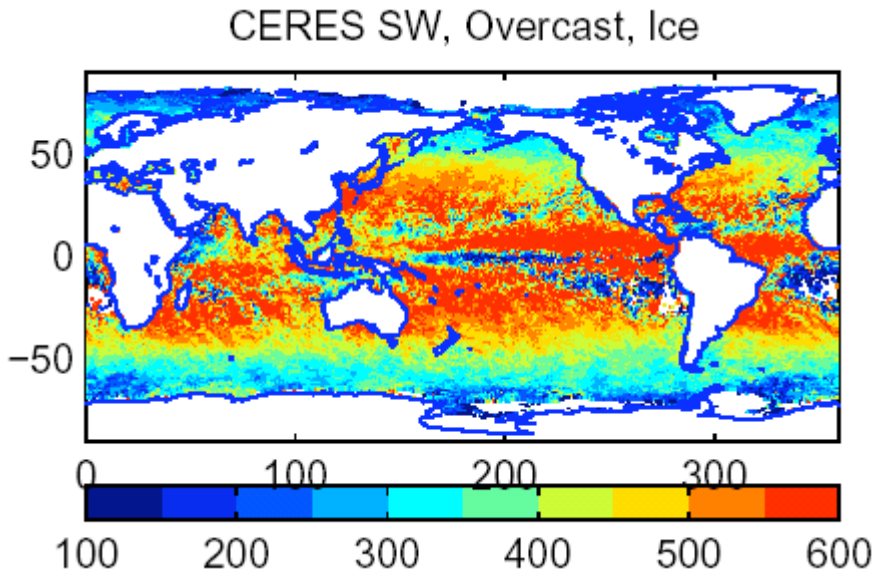


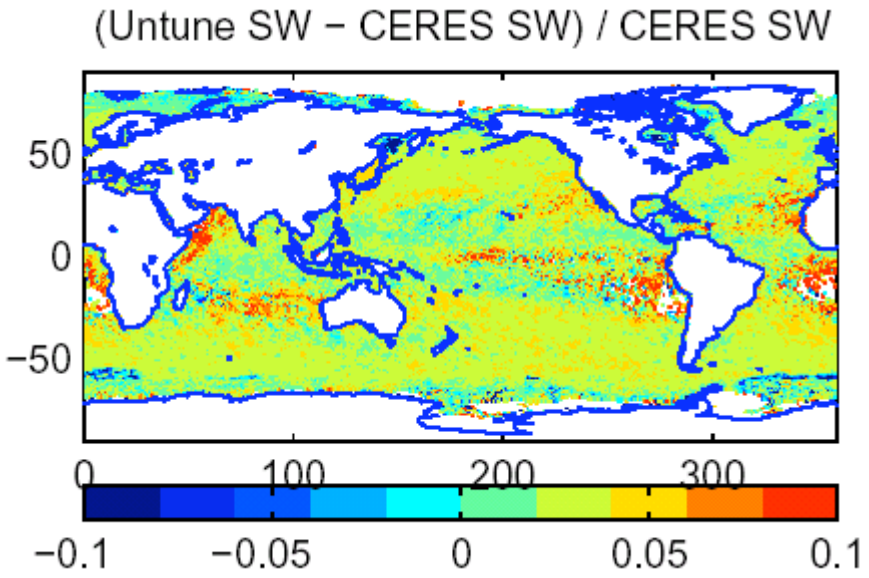


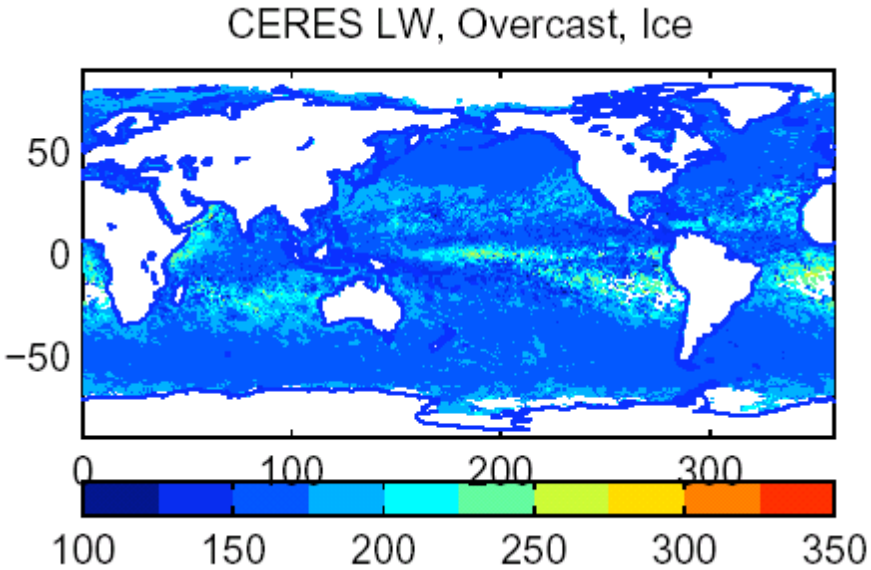


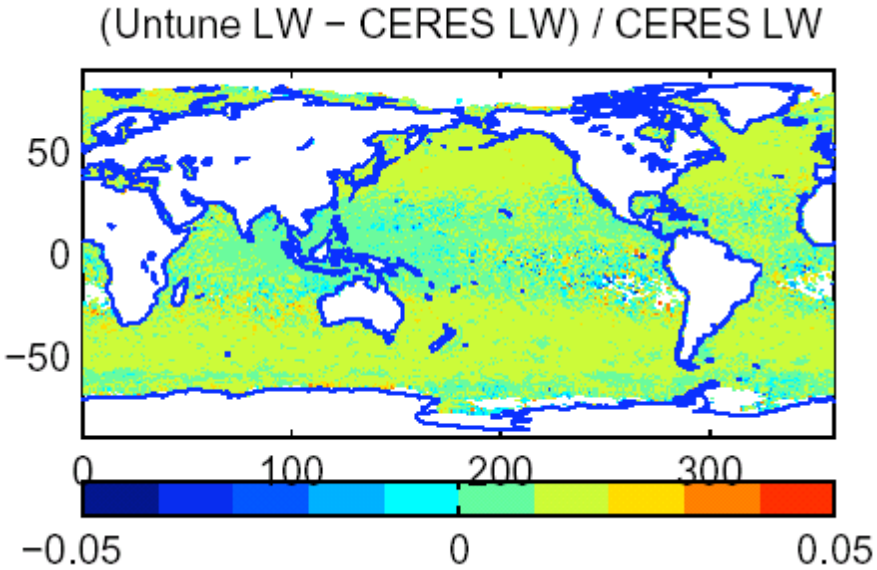
Single layer, LW and WN radiance error<= 3%

CERES-untuned flux comparison, overcast ice clouds



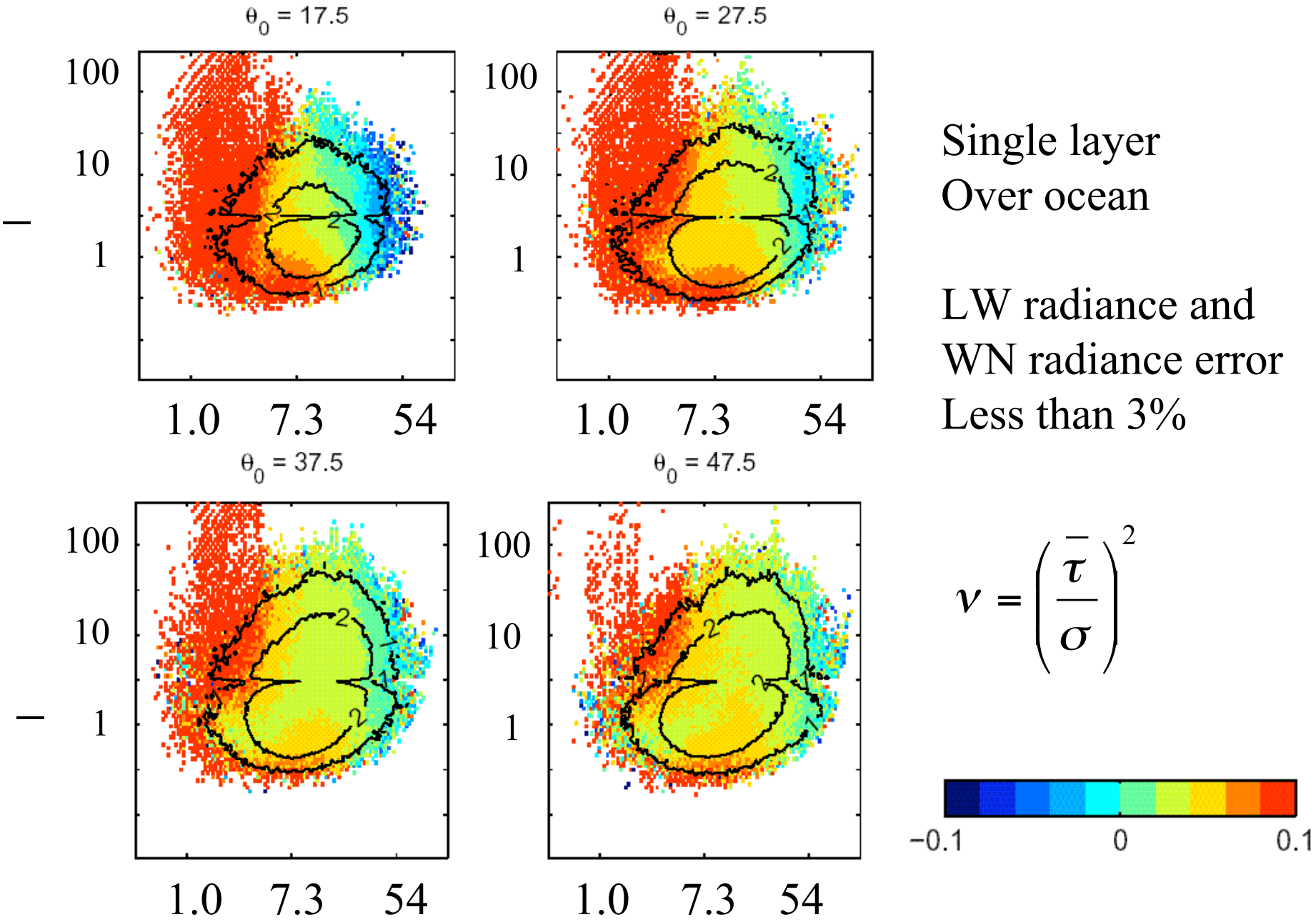




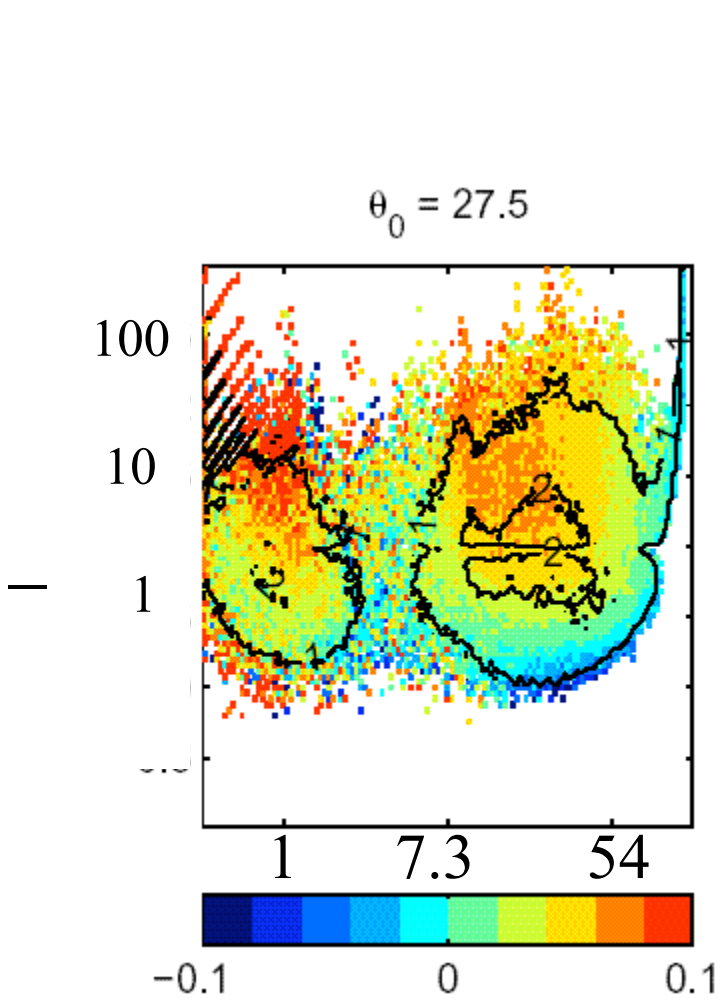


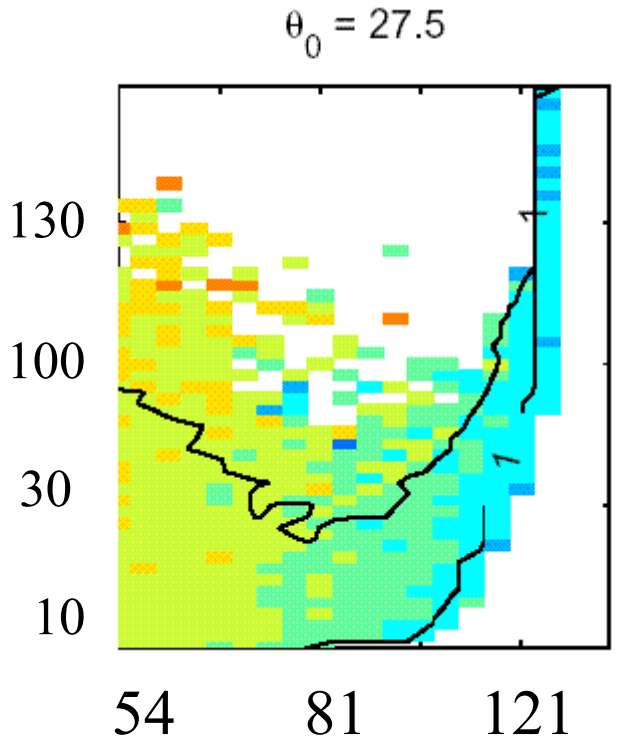
Single layer, LW and WN radiance error<= 3%

Flux Relative Error by Cloud type (Overcast Water)



Flux Relative Error by Cloud type (Overcast Ice)





Deep Convective Clouds

Distinct features of untune - CERES flux difference

- 3% to 5% difference (untuned – CERES) when clouds are uniform
- The difference is solar zenith angle dependent for thick water clouds.

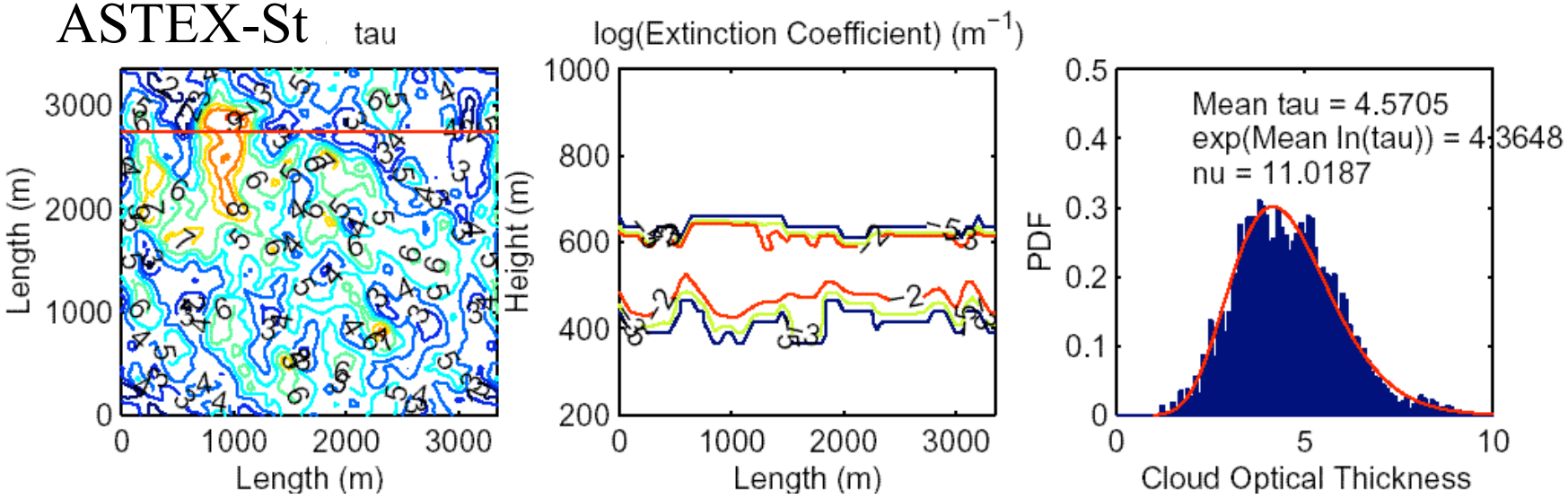
Objective and Method

- Does neglecting horizontal radiative flux in the cloud property retrieval and flux computation cause the difference?

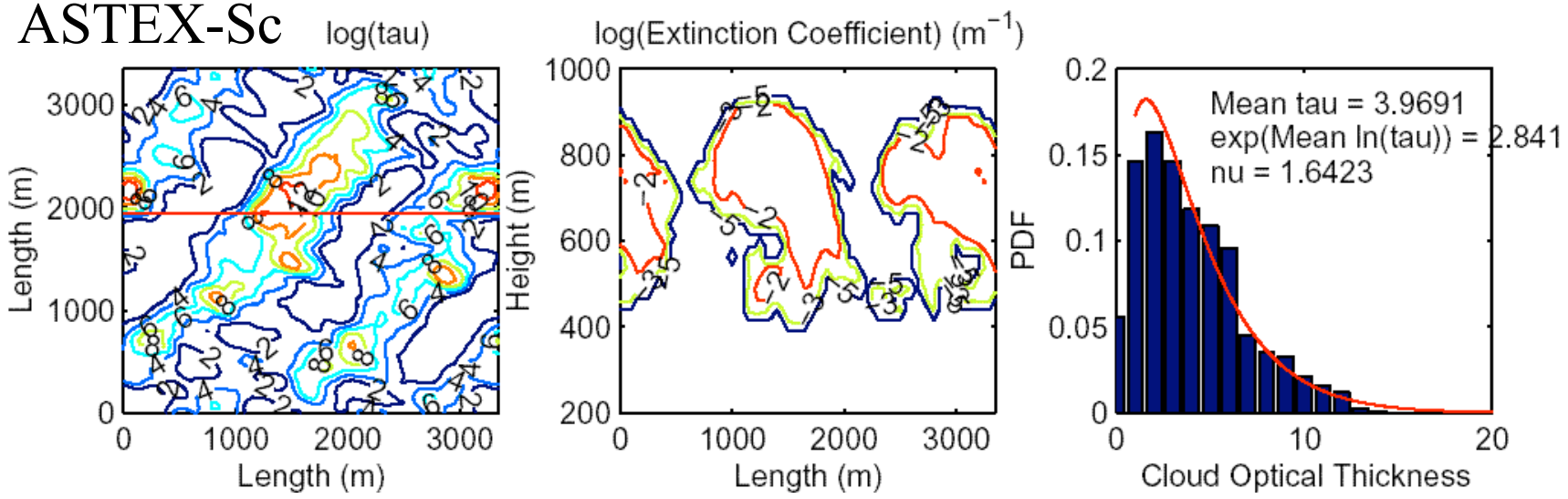
- Use cloud fields generated by LES models and a 3D radative transfer model (SHDOM, Evans 1998) to simulate cloud retrieval processes and flux computations.

LES model generated cloud fields

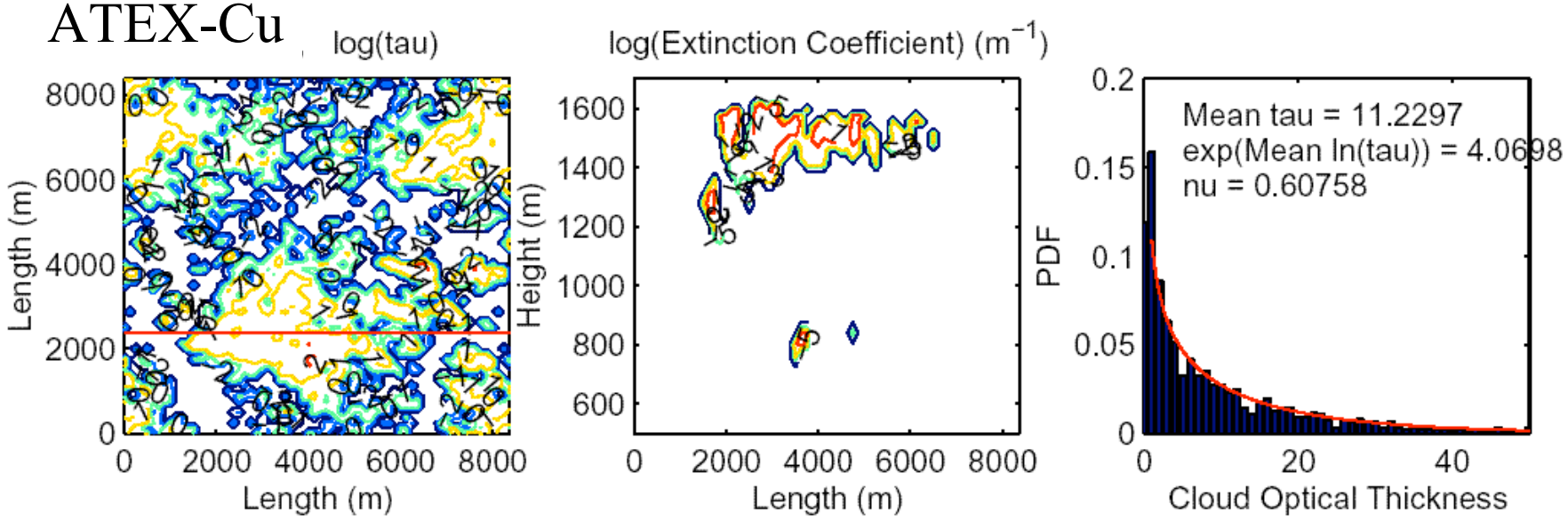
ASTEX-St



ASTEX-Sc

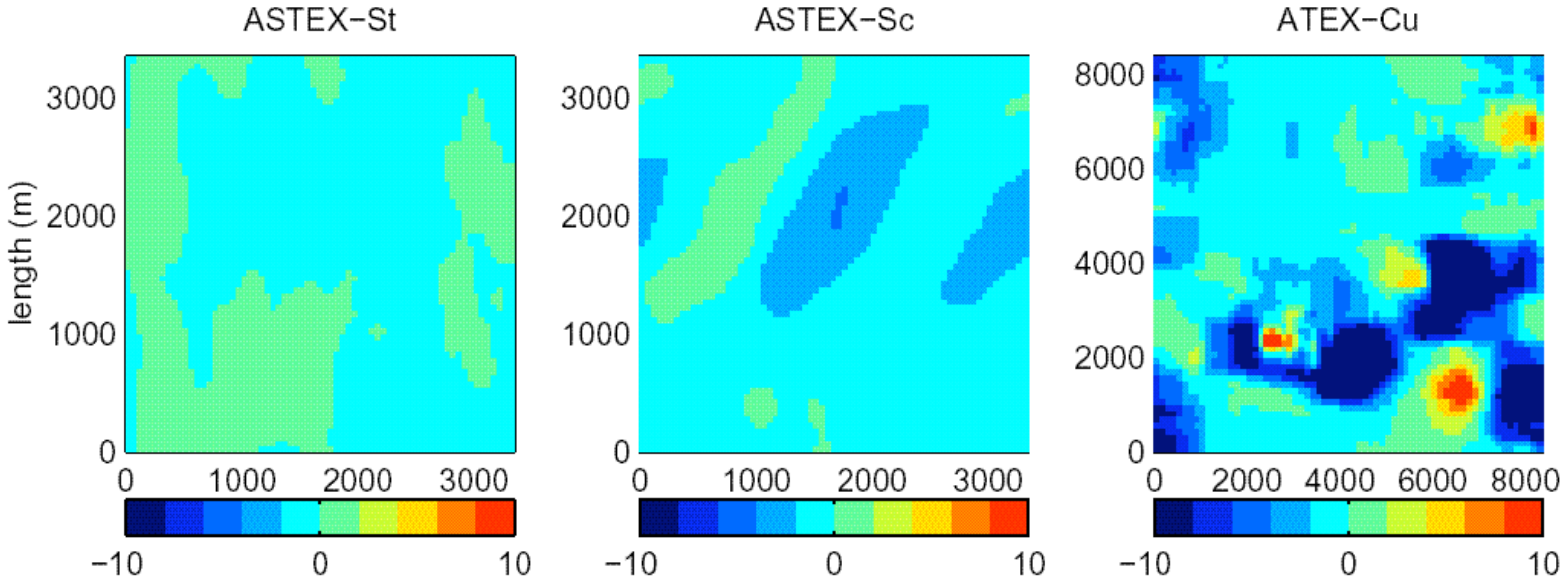


LES model generated cloud fields

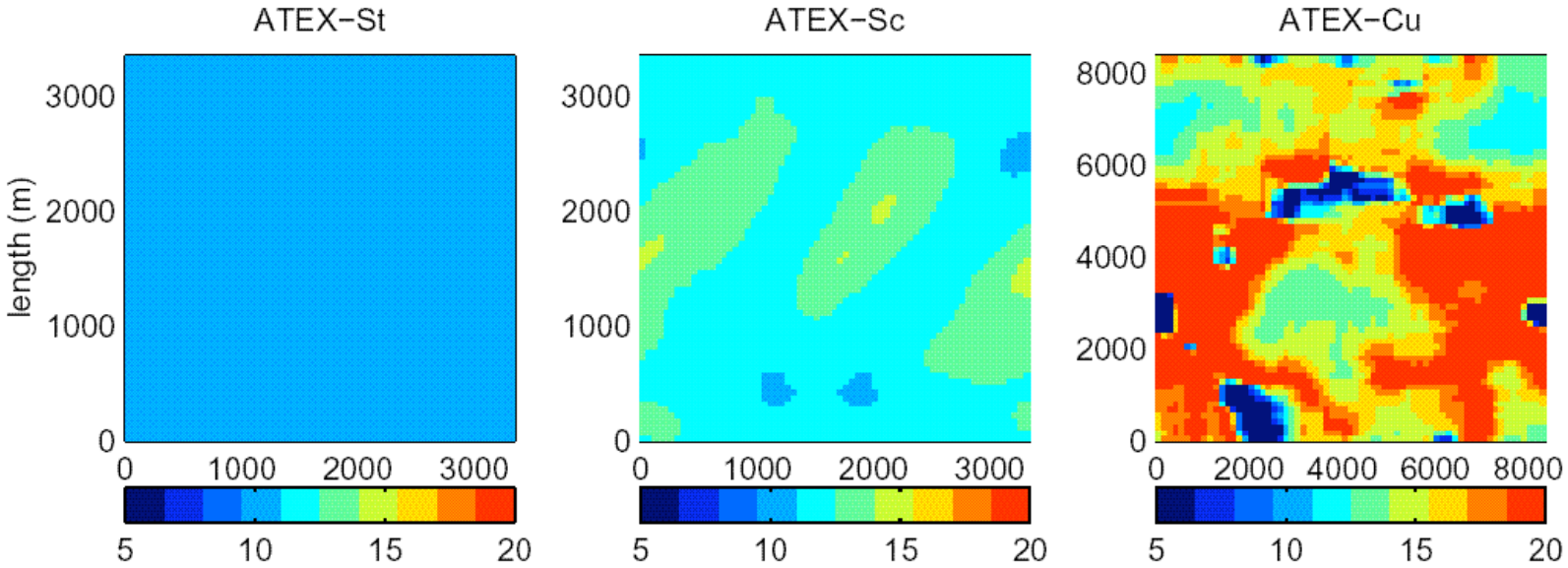


Retrieved Optical Thickness and Mode Radius

Optical thickness Difference, Retrieved - Truth



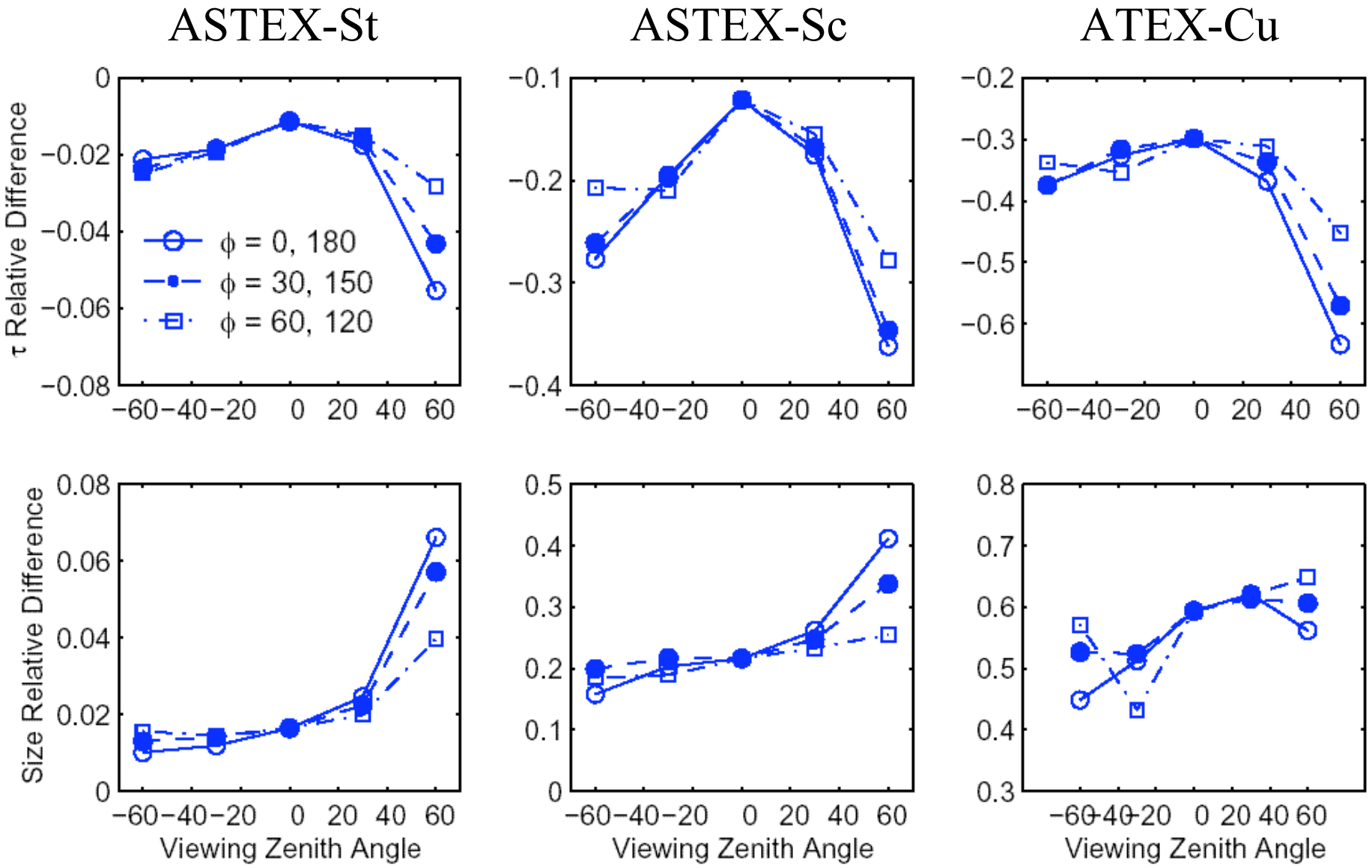
Retrieved Mode radius, Truth = 10 micron



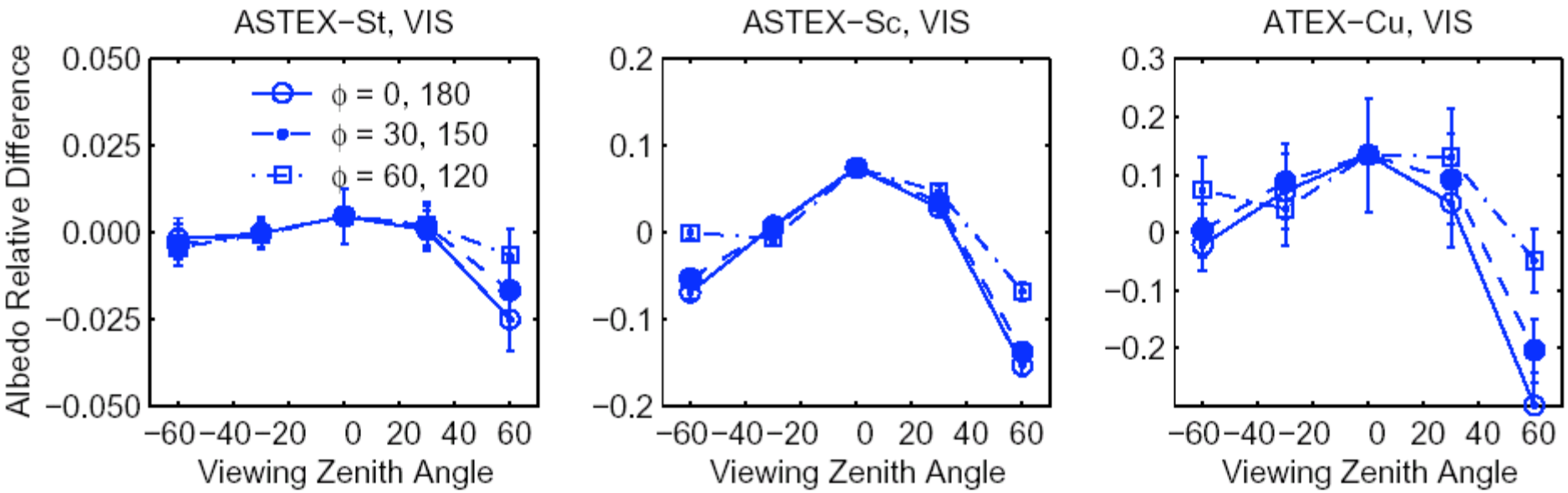
Cloud Properties Retrieved from Nadir View (Solar Zenith Angle = 30/50 degree)

	Optical Thickness	Shape Factor	Mode Radius	Cloud Fraction
ASTEX-St Truth	4.57	11.0	10.0	1.00
ASTEX-St Retrieved	4.48/4.53	62.4/62.1	10.2/10.2	1.00/1.00
ASTEX-Sc Truth	3.75	1.4	10.0	0.96
ASTEX-Sc Retrieved	3.30/3.29	19.2/20.9	12.4/12.2	1.00/1.00
ATEX-Cu Truth	6.29	0.6	10.0	0.57
ATEX-Cu Retrieved	4.13/4.41	0.7/0.8	16.2/15.9	1.00/1.00

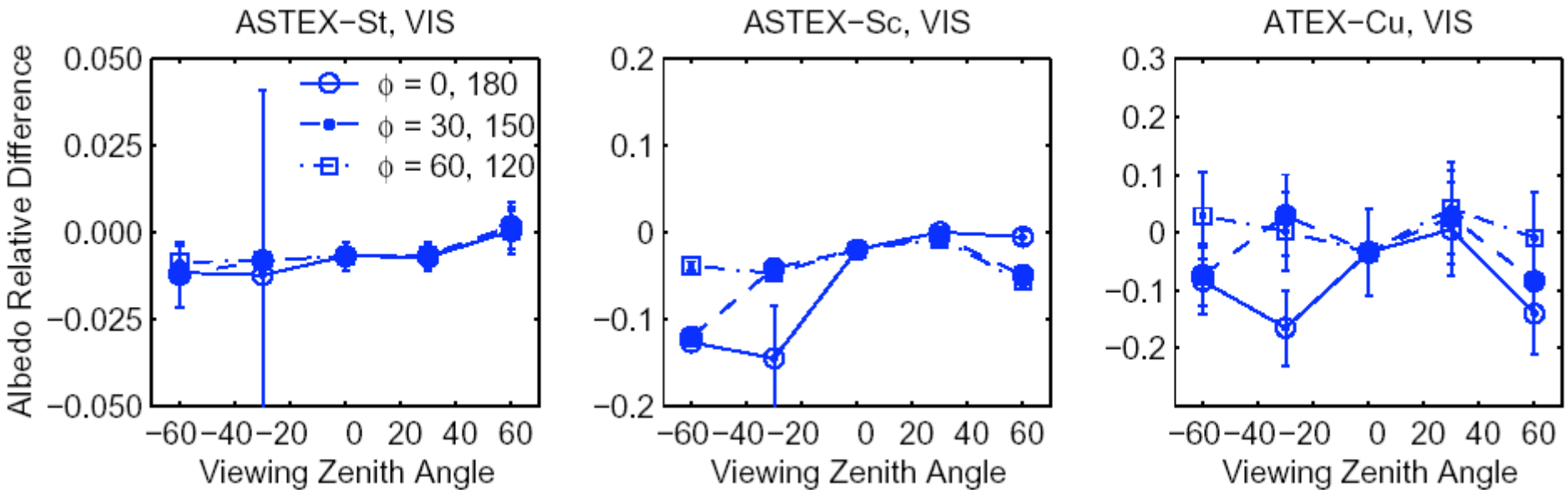
Optical thickness particle size retrieval error



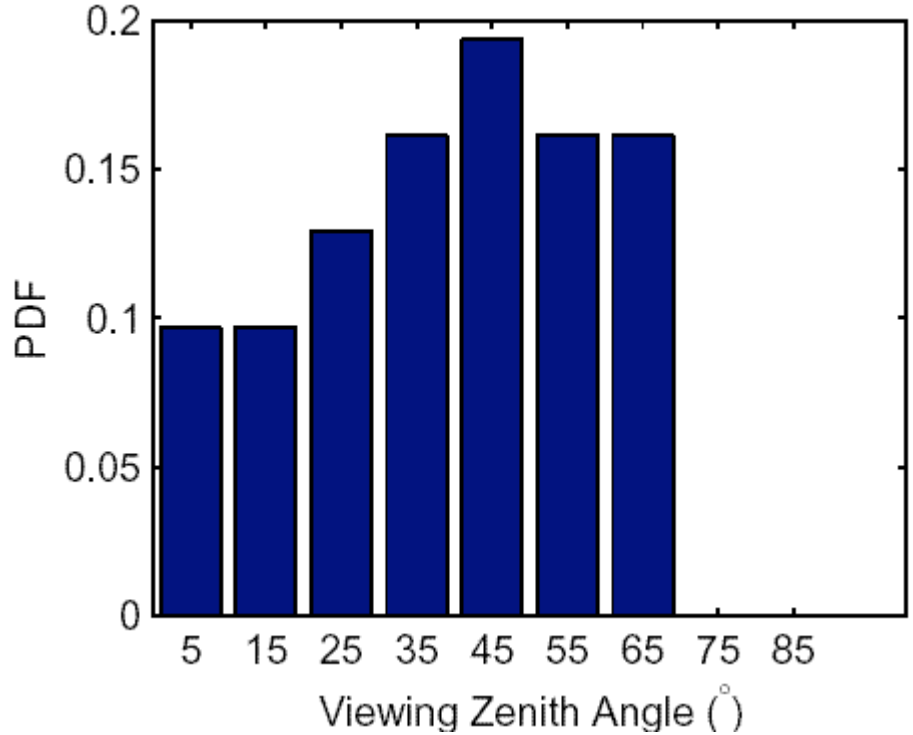
Albedo Error
Solar Zenith Angle = 50°



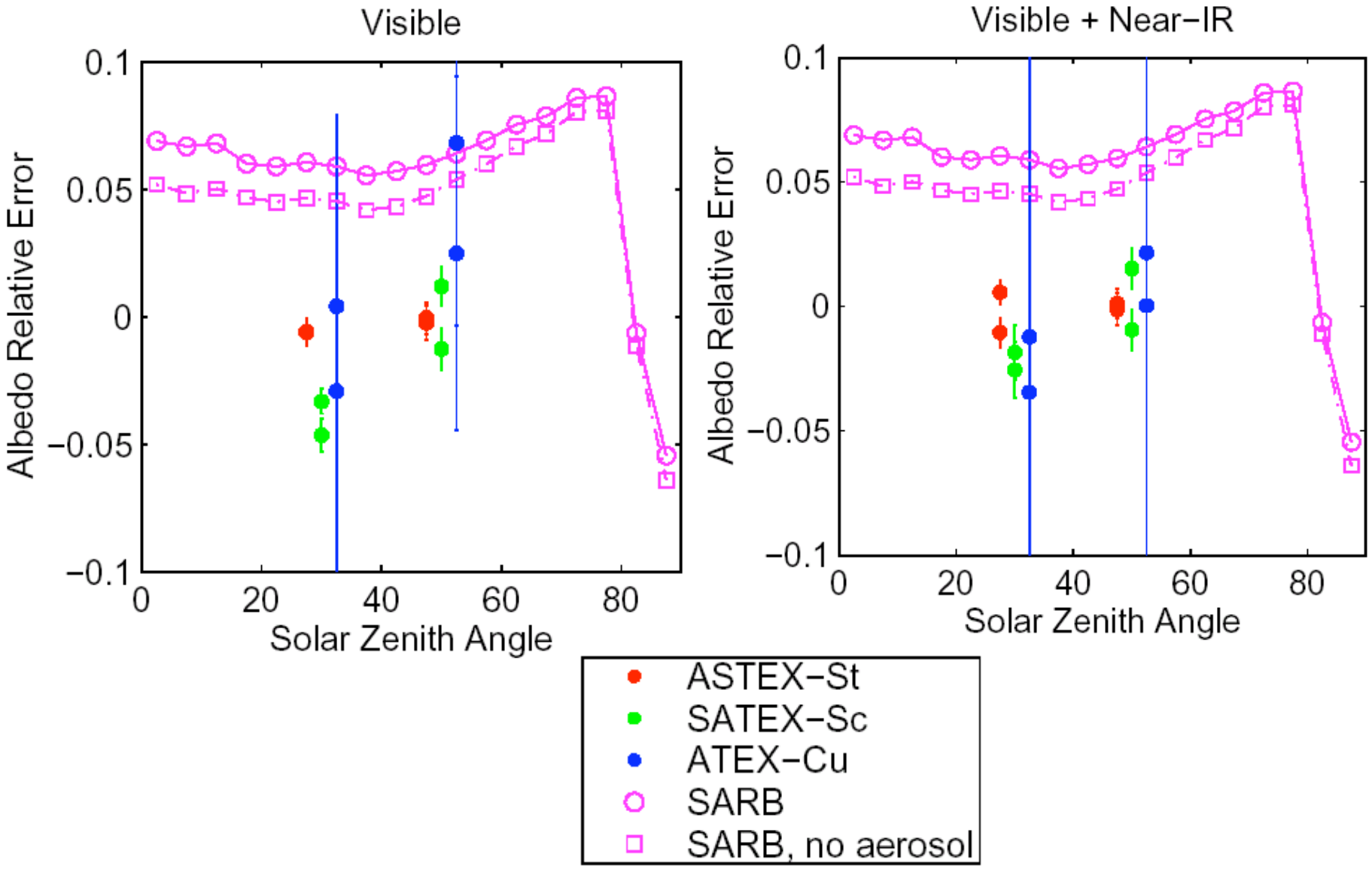
Albedo Error
Solar Zenith Angle = 30°



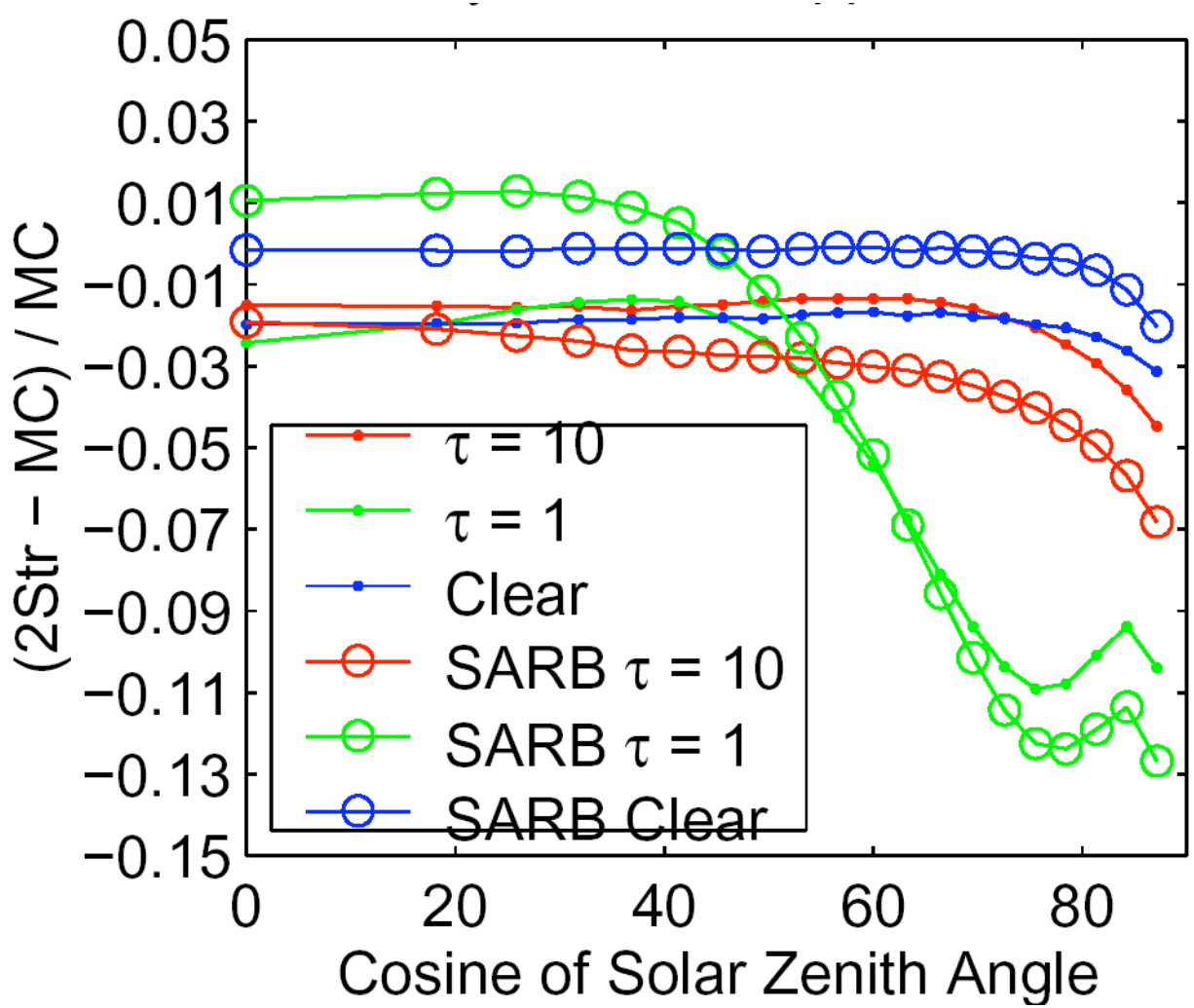
Viewing Zenith Angle PDF



Average Albedo Error



Error by 2-stream approximation



Monte Carlo results provided by E. Clothiaux

Conclusions

- Retrieved optical thickness tends to be smaller than the true value and the error increases with increasing horizontal inhomogeneity.
- Retrieved particle size tends to be larger than the true value and the error increases with increasing horizontal inhomogeneity.
- When the retrieved optical thickness and particle size from various viewing zenith angles are used for flux computations, the average flux tends to be smaller than the true flux.
- +5% flux error is unlikely caused by neglecting 3D effects.

Albedo error averaged over all viewing zenith angles (%)

	ASTEX-St		SATEX-Sc		ATEX-Cu	
Relative Azimuth Angle	30-150	60-120	30-150	60-120	30-150	60-120
Solz=30 Visible	-0.06	-0.06	-4.65	-3.33	-2.93	0.40
Near IR	-0.48	-0.37	-3.98	-2.86	-1.46	1.72
Solz=50 Visible	-0.25	-0.06	-1.27	1.18	2.47	6.82
Near IR	0.01	0.28	0.63	1.85	-2.41	-2.51

Albedo Error (Solar zenith Angle= 30)