Radiative forcing efficiency

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The concept of radiative forcing efficiency (RFE) has been introduced to decouple uncertainties on aerosol burden/OD from uncertainties in other inputs and RT and to allow intercomparaison.

Clear-sky RFE of a particular aerosol type depends on:
- aerosol single scattering albedo & aerosol upscattering
- surface albedo
- diurnal and seasonal distribution of SZA at a particular location / region
- histogram of AOD (for a given average AOD).

+ small uncertainty on RT scheme (assuming RT is done properly!)

All-sky RFE depends additionnally on:
- vertical distribution of aerosol and cloud
- cloud fraction.

+ it may be more sensitive to the RT scheme used.

Moreover RFE will depend critically on
- RH growth factor if reported by unit of dry mass (sulfate, OM, sea-salt)
- radius cut size if reported by unit of mass for sea-salt and dust

Clear-sky and all-sky TOA SW RFE from our GCM calculations:

	clear-sky	all-sky
sulfate	RFE = -235 and	-145 W (g sulfate)$^{-1}$

per mass of sulfate, but also includes ammonium & water
fairly constant since B&A [1995], on the low side?
fairly constant for different SRES sulfate distributions

BC RFE = +1200 and +1400 W (g BC)$^{-1}$
BC single scattering albedo = 0.2
BC density is low (1 g cm^{-3})

OM RFE = -132 and -87 W (g OM)$^{-1}$
slightly absorbing, less hygroscopic than sulfate

Needs to be intercompared in AEROCOM B & PRE
Weighted by the sophistication of the RT procedure.

Global RF and RFE from MODIS/AERONET aerosol properties and RT calculations

Mineral dust	TOA (Wm^{-2})	Surface (Wm^{-2})	Abs. (Wm^{-2})	τ (550 nm)	E (Wm^{-2} / unit τ)
Global	-0.48	-0.57	0.09	0.009	~~-56~~
Ocean	-0.71	-0.85	0.14	0.013	-56
Marine aerosol					
Global	-3.61	-4.25	0.64	0.076	~~-47~~
Ocean	-5.35	-6.31	0.95	0.113	-47
bb + poll					
Global	-2.39	-5.43	3.04	0.093	-26
Ocean	-0.52	-1.18	0.66	0.014	-37
Land	-6.18	-14.06	7.88	0.255	-24

Bellouin, Boucher & Haywood

Clear-sky TOA SW RFE (@550 nm) from the GCM calculations:

			"MODIS"
dust ocean	RFE = -21 W m^{-2} tau^{-1}	vs	-56 W m^{-2} tau^{-1}
sea-salt ocean	RFE = -25 W m^{-2} tau^{-1}	vs	-47 W m^{-2} tau^{-1}
anthropogenic ocean	RFE = -12 W m^{-2} tau^{-1}	vs	-37 W m^{-2} tau^{-1}
anthropogenic land	RFE = -10 W m^{-2} tau^{-1}	vs	-24 W m^{-2} tau^{-1}
anthropogenic globe	RFE = -11 W m^{-2} tau^{-1}	vs	-26 W m^{-2} tau^{-1}

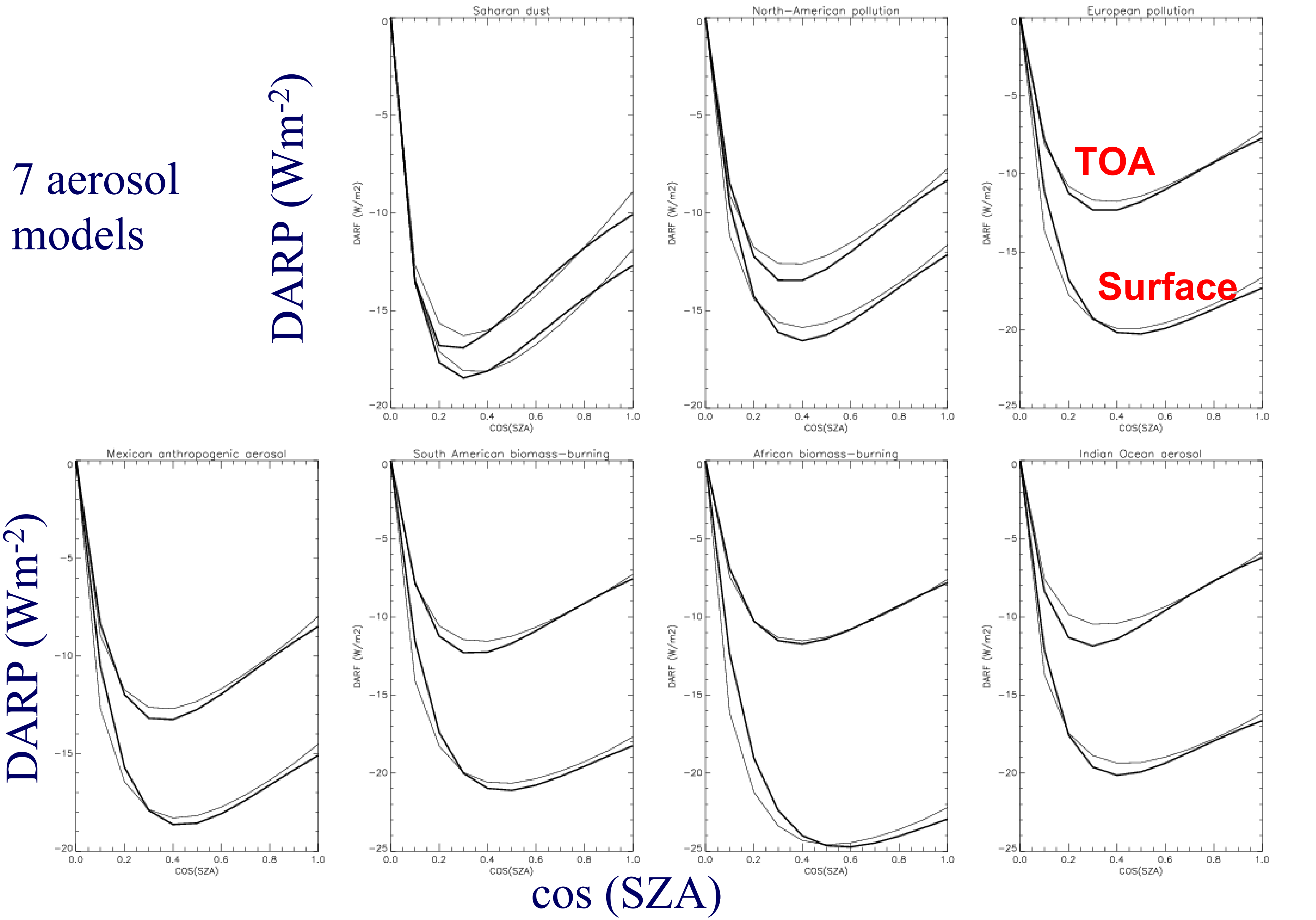
BUT GCM clear-sky <> MODIS clear-sky (sampling issue) !
==> sample MODIS clear-sky in model nudged 2002 run

==> intercompare in AEROCOM B&PRE to see if LMDZ is an outlier
* RT scheme ?
* aerosol SSA ?
* surface albedo ?
* our GCM dust and sea-salt calculations are done in the presence of other (absorbing) aerosols, which shifts RFs to less negative values.

Shortwave 24-stream 24-waveband versus 2-stream 2-waveband RT codes

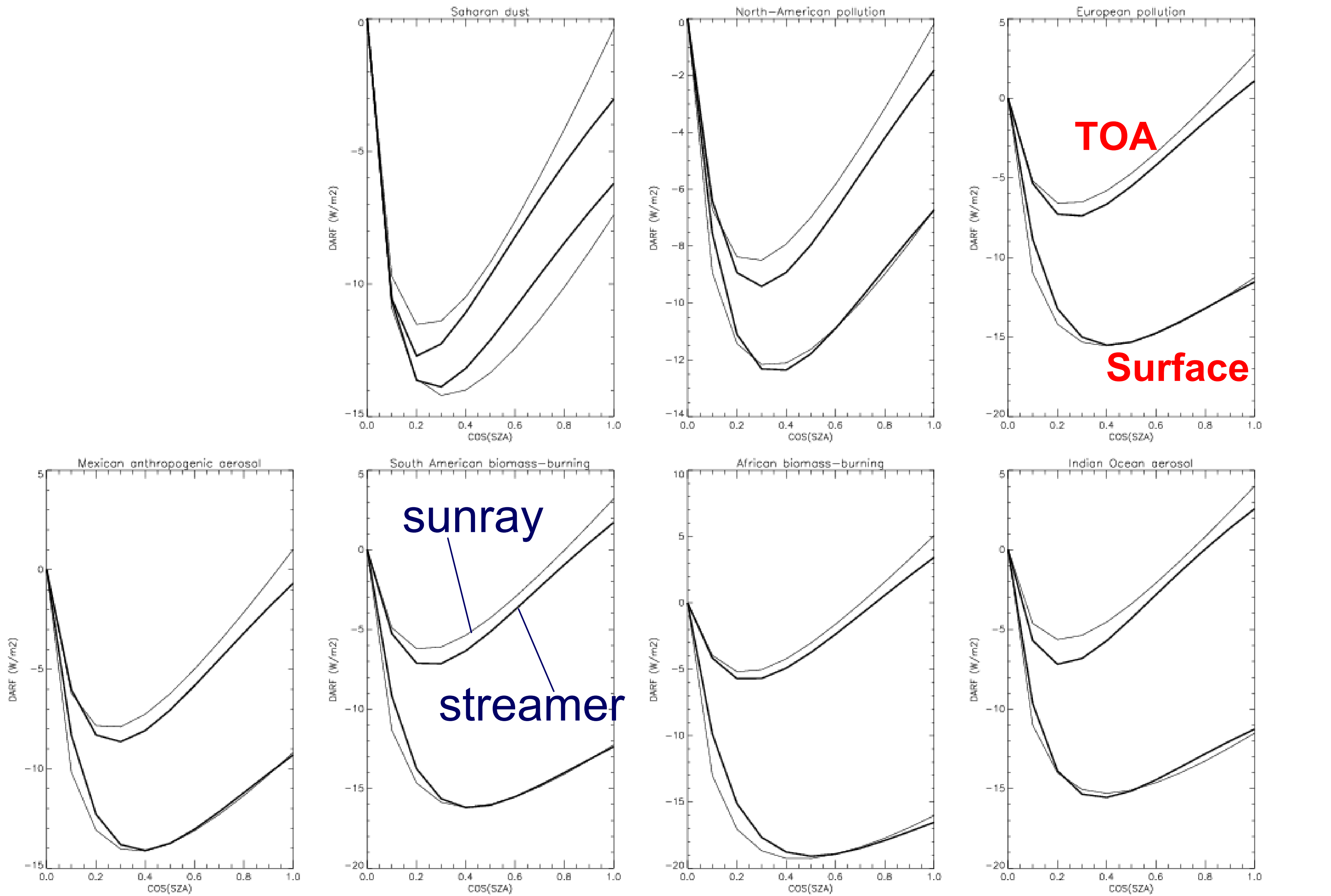
Aerosol optical depth = 0.1   Surface albedo = 0.0

7 aerosol models

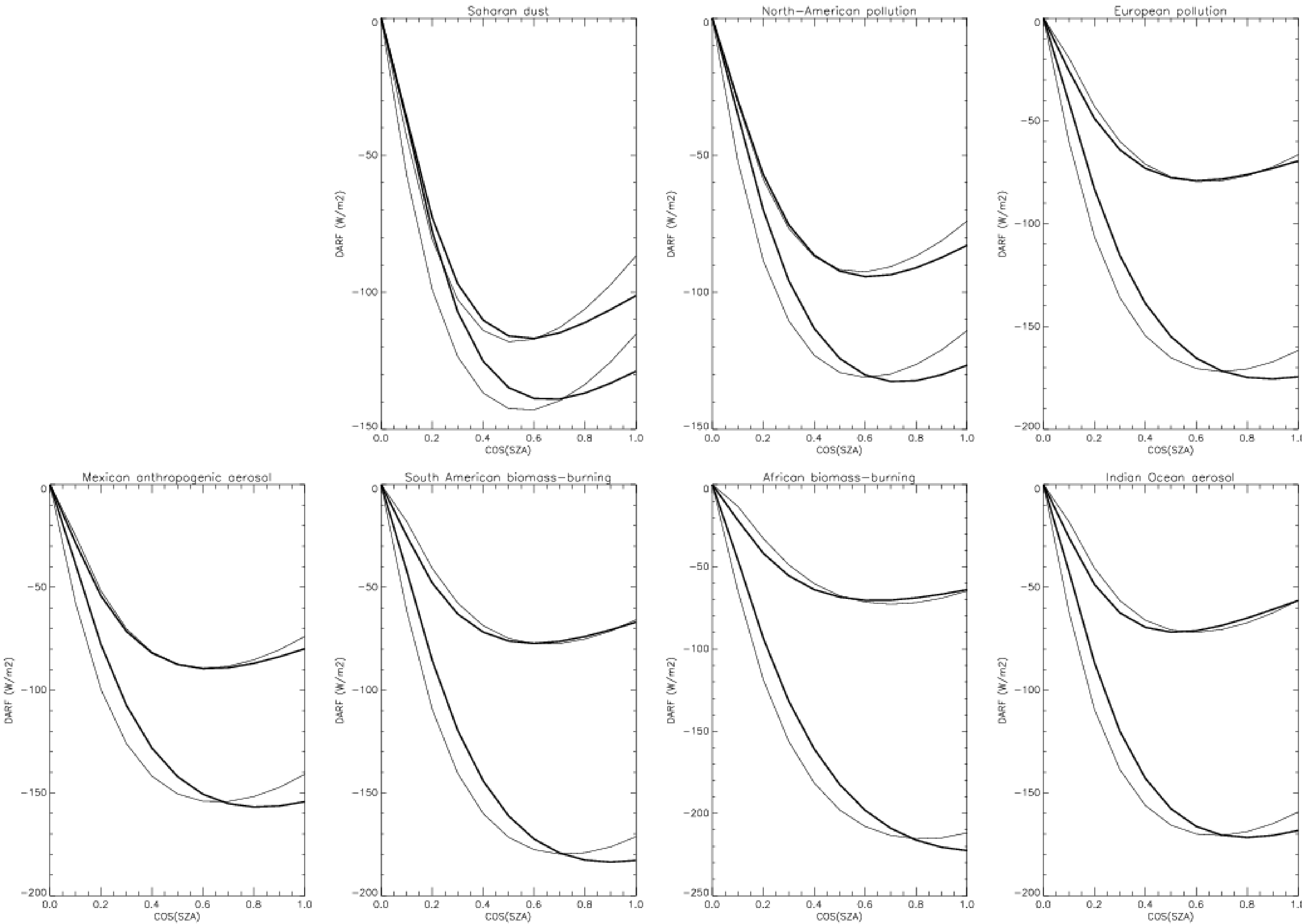


Broadband 24-stream 24-waveband versus 2-stream 2-waveband RT codes

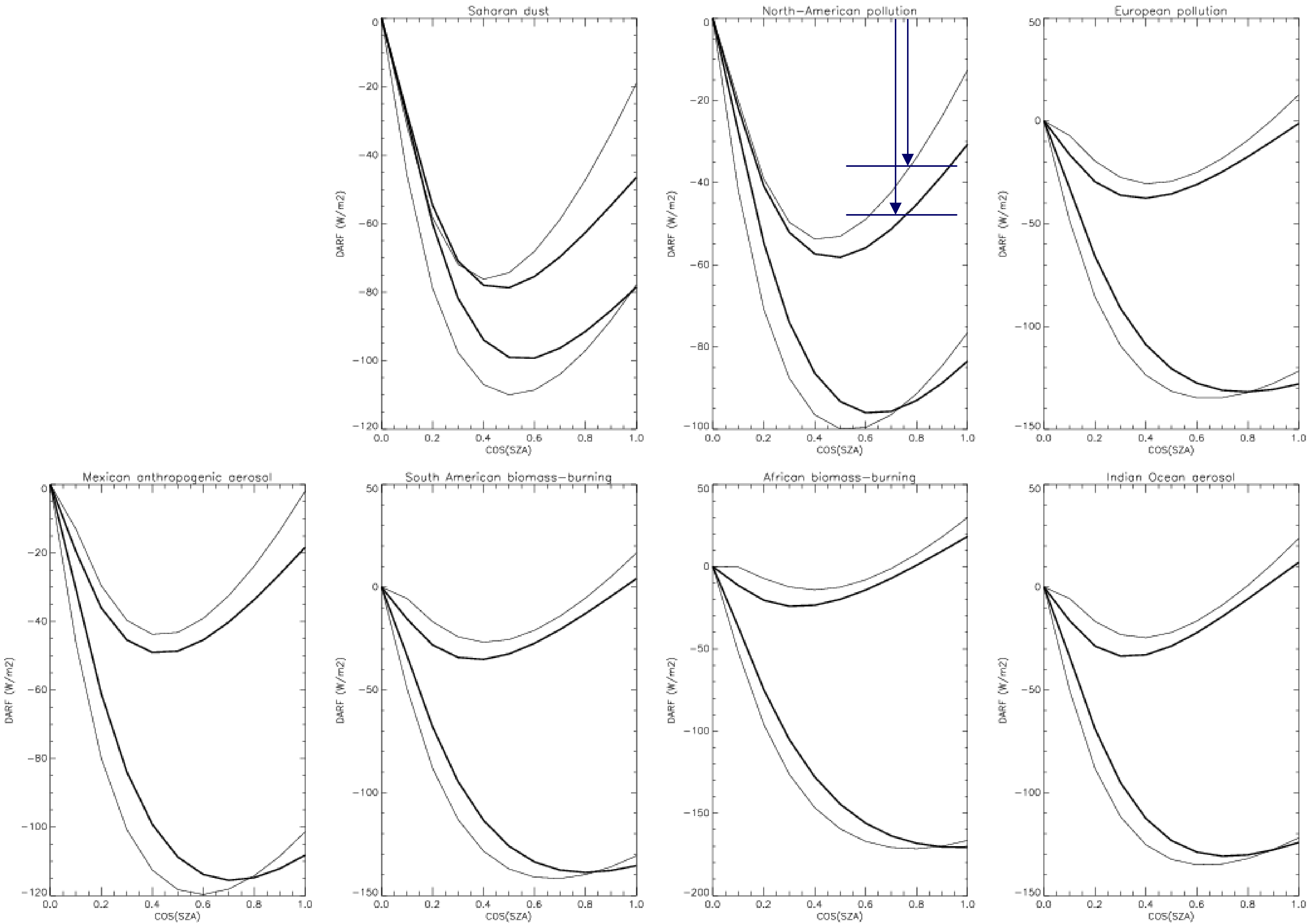
Aerosol optical depth = 0.1   Surface albedo = 0.2



Broadband 24-stream 24-waveband versus 2-stream 2-waveband RT codes
Aerosol optical depth = 1.0   Surface albedo = 0.0



Broadband 24-stream 24-waveband versus 2-stream 2-waveband RT codes
Aerosol optical depth = 1.0   Surface albedo = 0.2



The direct aerosol RF is not as linear as we may think!

$DF_{dust} + DF_{bb} <> DF_{dust+bb}$

Implication is that $F_{dust+bb} - F_{bb} > F_{dust} - F_0$