Which cloud types contribute most to the ECMWF's shortwave radiation bias at ARM SGP?

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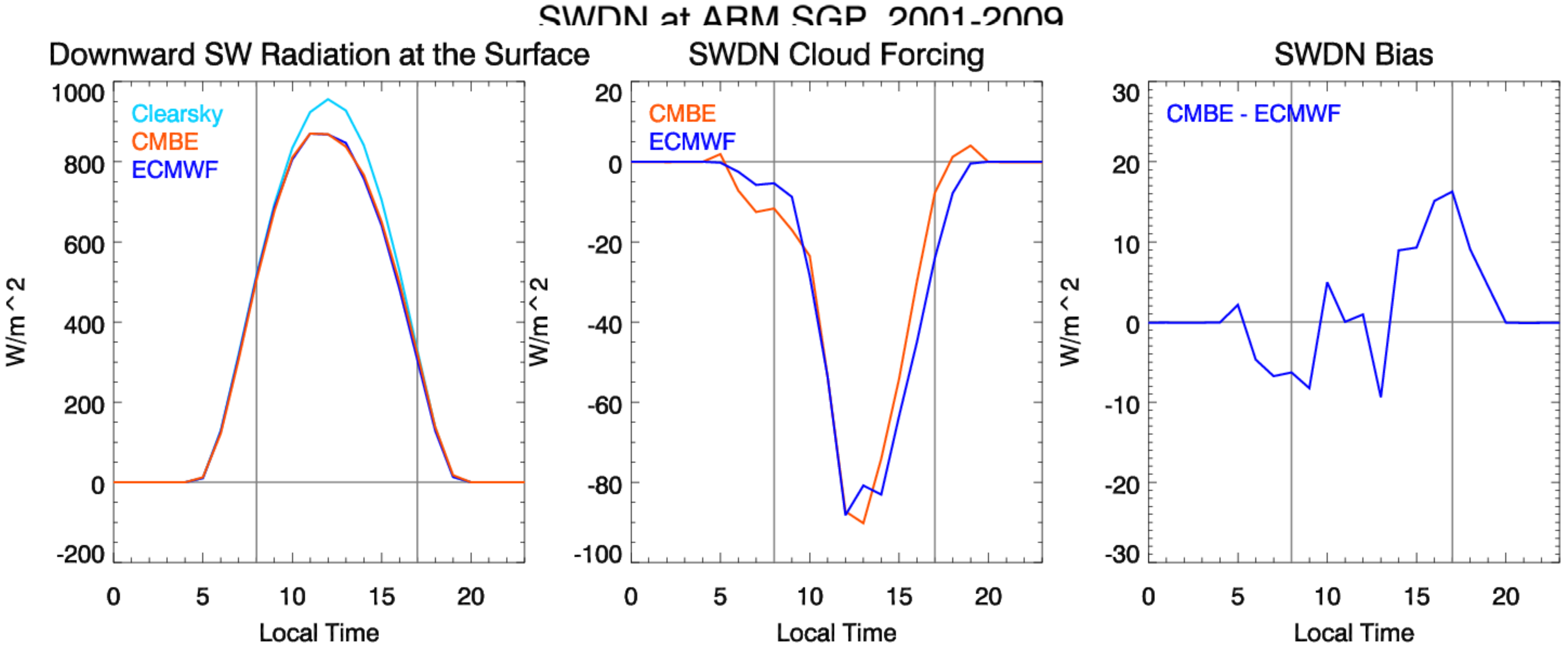
ECMWF

Previously…

- Long-term SW radiation bias at SGP in the ECMWF model
- Fair weather cumulus regime does not contribute significantly, though this is due to compensating errors



Can we identify which (if any) cloud type contributes systematically to mode bias?

- Instead of a priori guess, classify clouds and use SW bias to see if any cloud type stands out
- Obs used: CMBE/ARSCL hourly cloud fraction profile, CBME/QCRAD surface radiation, 2004-2009
- Model data: operational model output at nearest grid point

Simple classification by cloud base height and thickness

- low — base below 2.5km
- congestus
- deep
- thin mid-level — base between 2.5 and 8km
- thick mid-level
- high — base above 8km

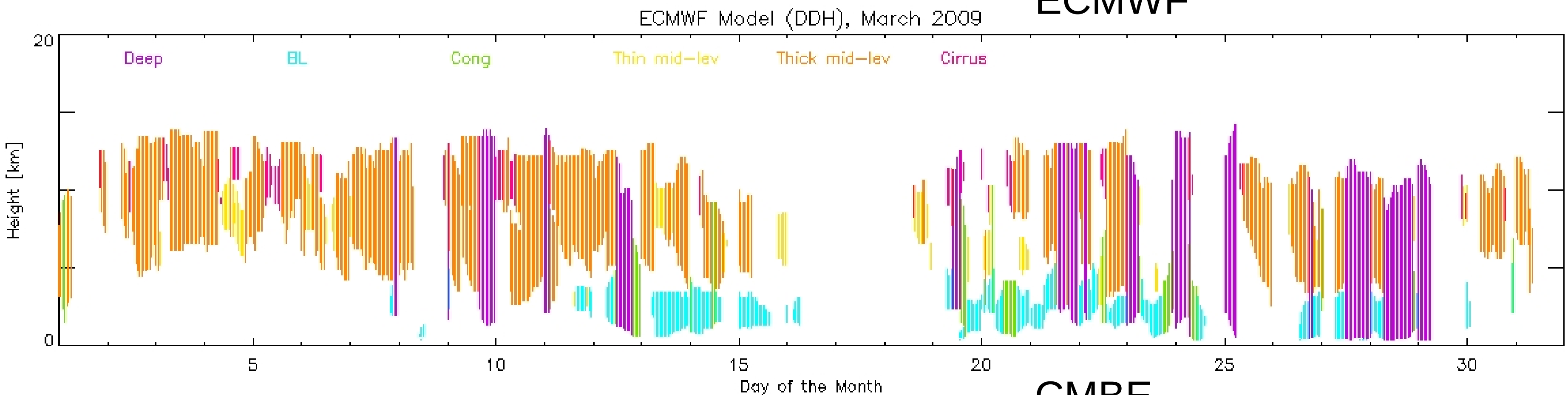
Vertical extent: more or less than 3km

Model: get cloud overlap (100 subcolumns, generalized overlap), then approximate precipitation fraction based on precip flux for a combined hydrometeor cloud fraction

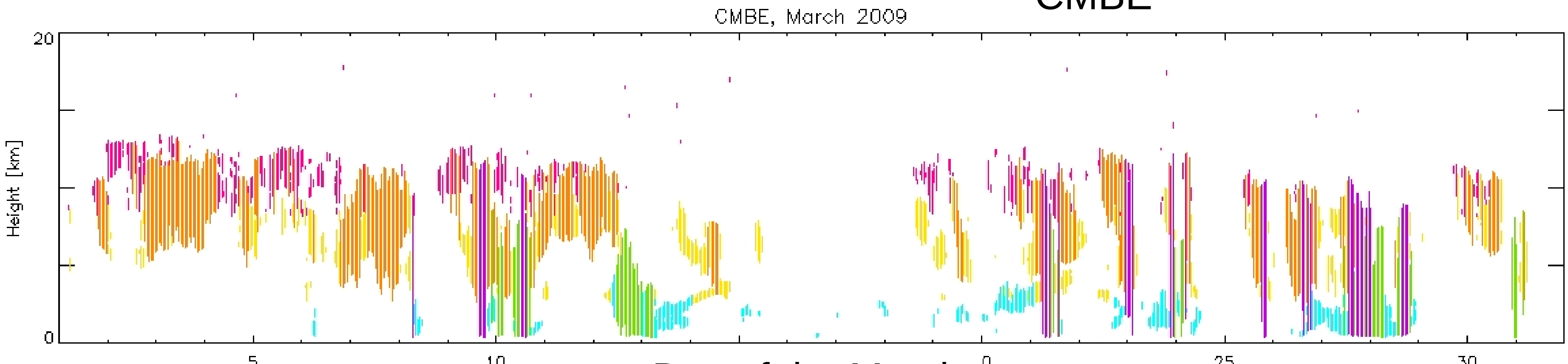
Example: one month of classified clouds

Deep Low Cong Thin mid-lev Thick mid-lev High

ECMWF



CMBE



Day of the Month

Use surface shortwave bias to rank samples

paired sample

Observed cloud type (combination)
e.g. low+cirrus

Modeled cloud type (combination)
e.g. low+ thick mid-lev

SW bias

large sample number

large bias

rank by: cumulative bias

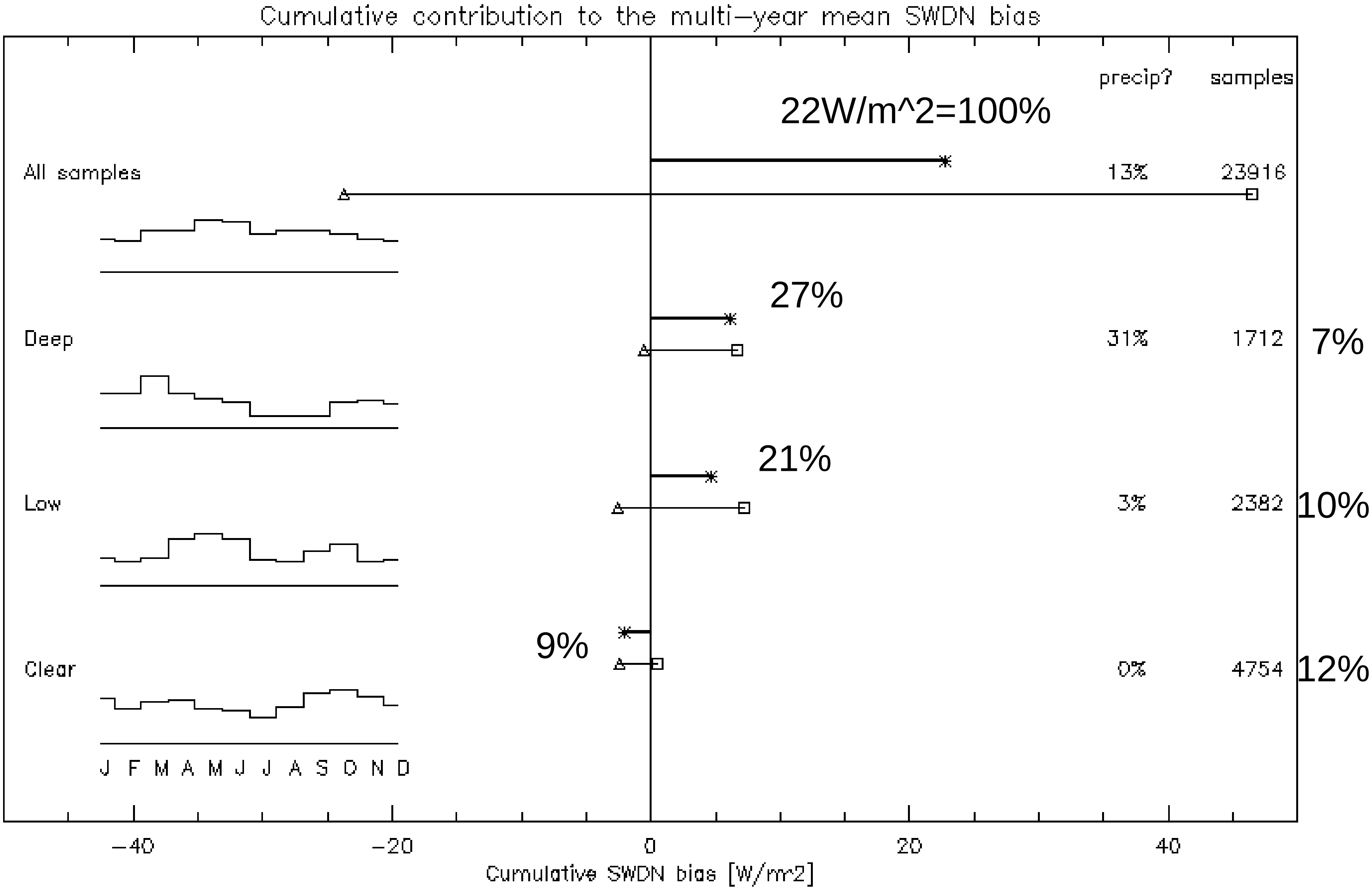
Identify cloud type pairs that systematically contribute to multi-year mean SW bias!

The shortlist

Mean SWDN (Model-Obs): 22W/m^2

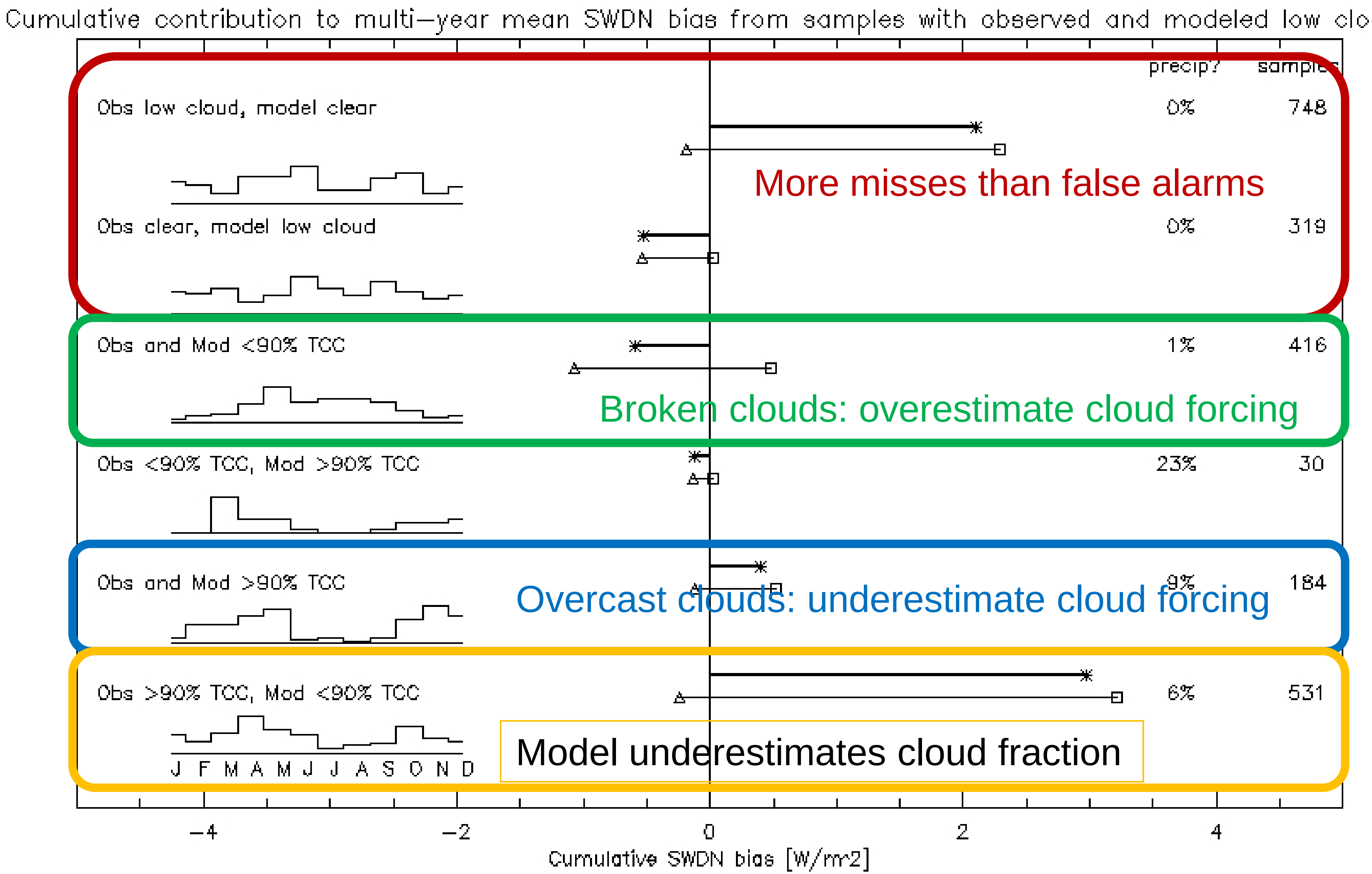
Obs cloud	Mod cloud	net contri-bution %	neg cont. %	pos cont. %	% samples
clear	clear	-8.7	-10.8	2.2	12.0
clear	low	-2.3	-2.4	0.1	1.3
low	clear	9.2	-0.9	10.1	3.1
low	low	11.7	-6.9	18.6	4.9
low	low+high	2.0	-0.9	2.9	0.6
deep	deep	9.6	-1.0	10.6	2.4
thick m-l	thick m-l	5.2	-0.5	5.6	1.7
low+thick	thick m-l	2.0	-0.1	2.2	0.4
low+thick	low+thick	3.3	-0.8	4.1	0.8
thick m-l	high	3.1	-0.2	3.2	0.9
thick m-l	thin m-l	3.7	-0.2	3.9	1.0

The shortlist



ECMWF

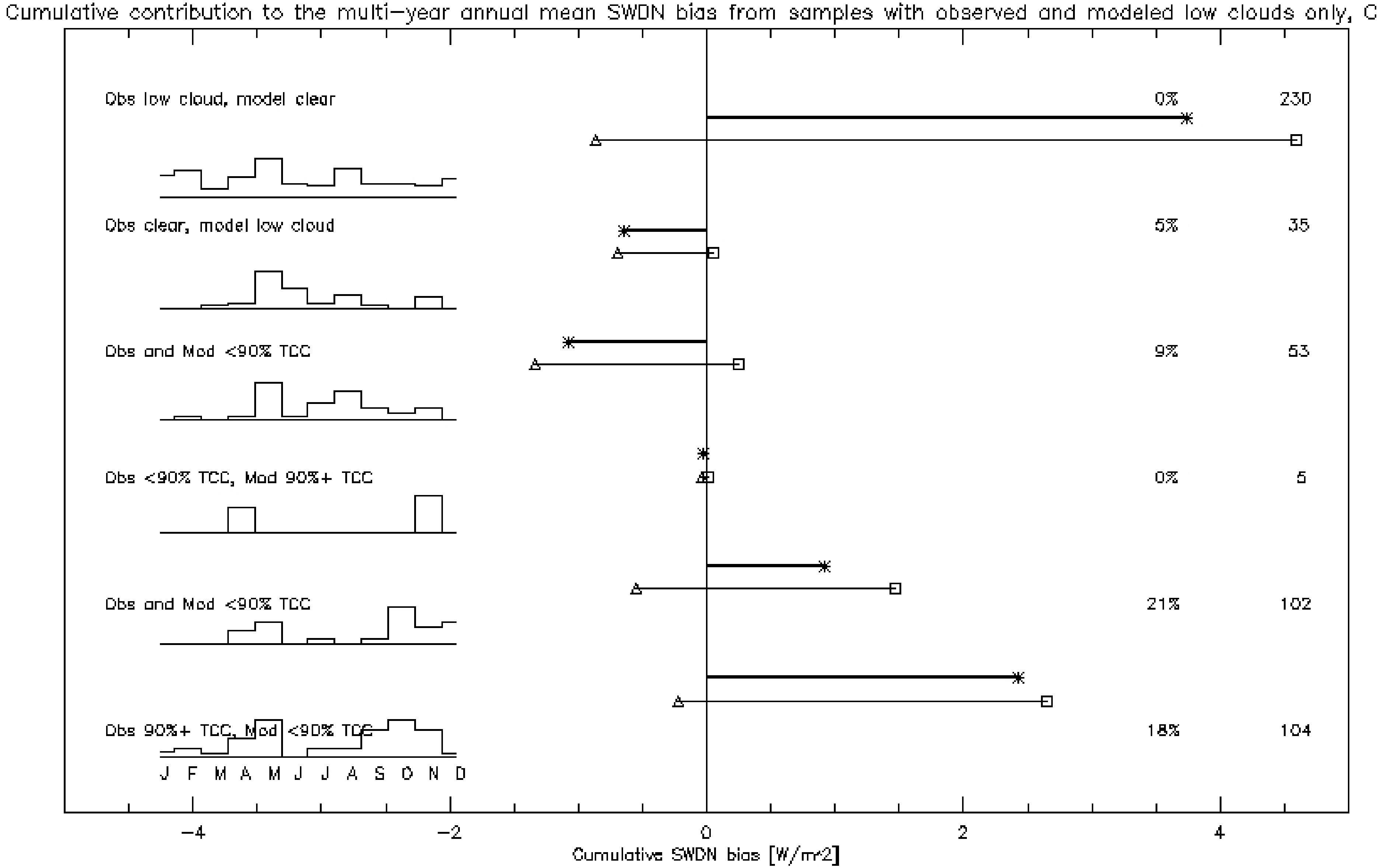
Focus: Low group



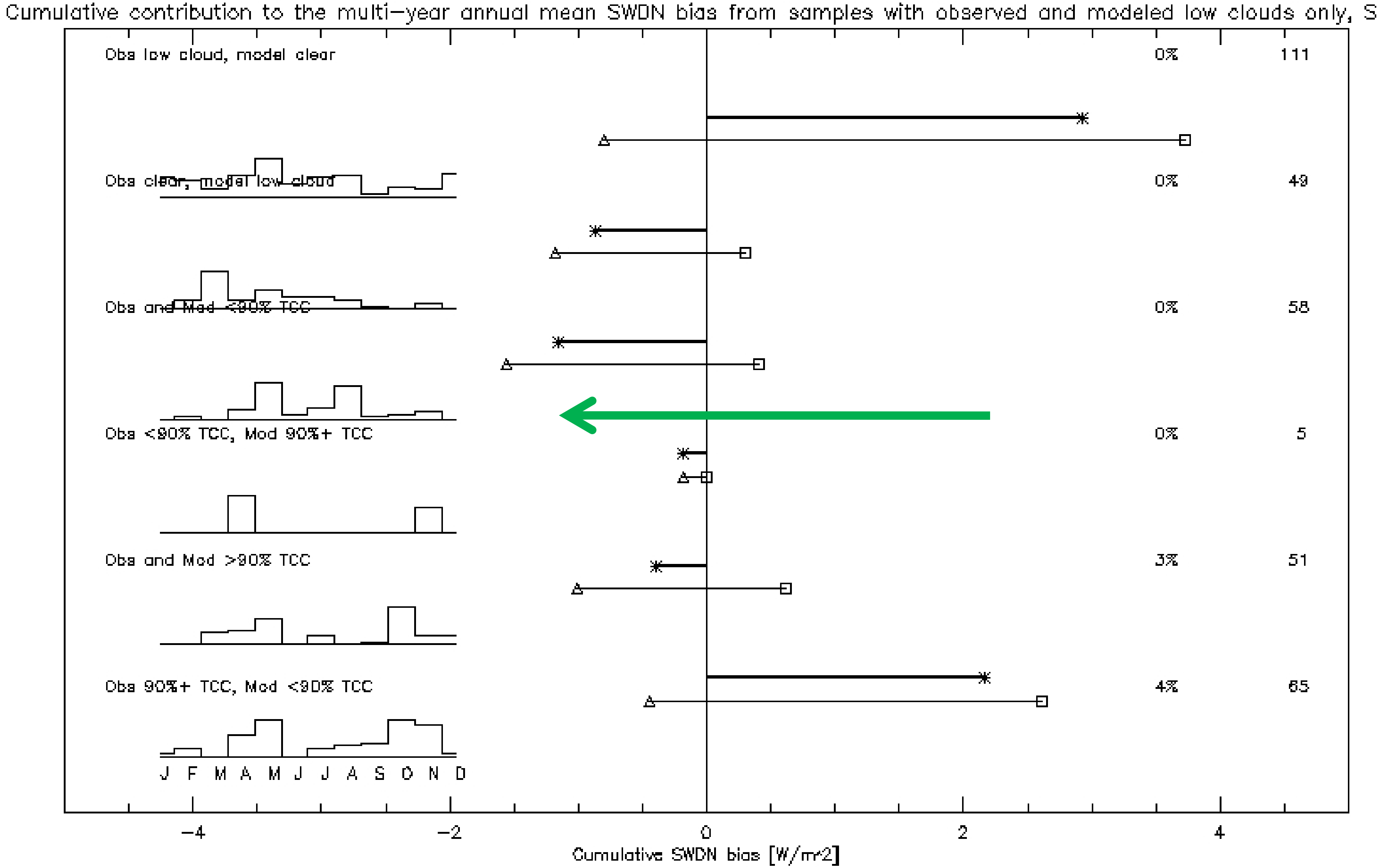
SCM experimentation

- Shallow convection trigger (shallow Cu FOO)
- Massflux transport (in-cloud LWP, shallow Cu cloud forcing)
- Autoconversion threshold/timescale, re-evaporation (in-cloud LWP for overcast low clouds)

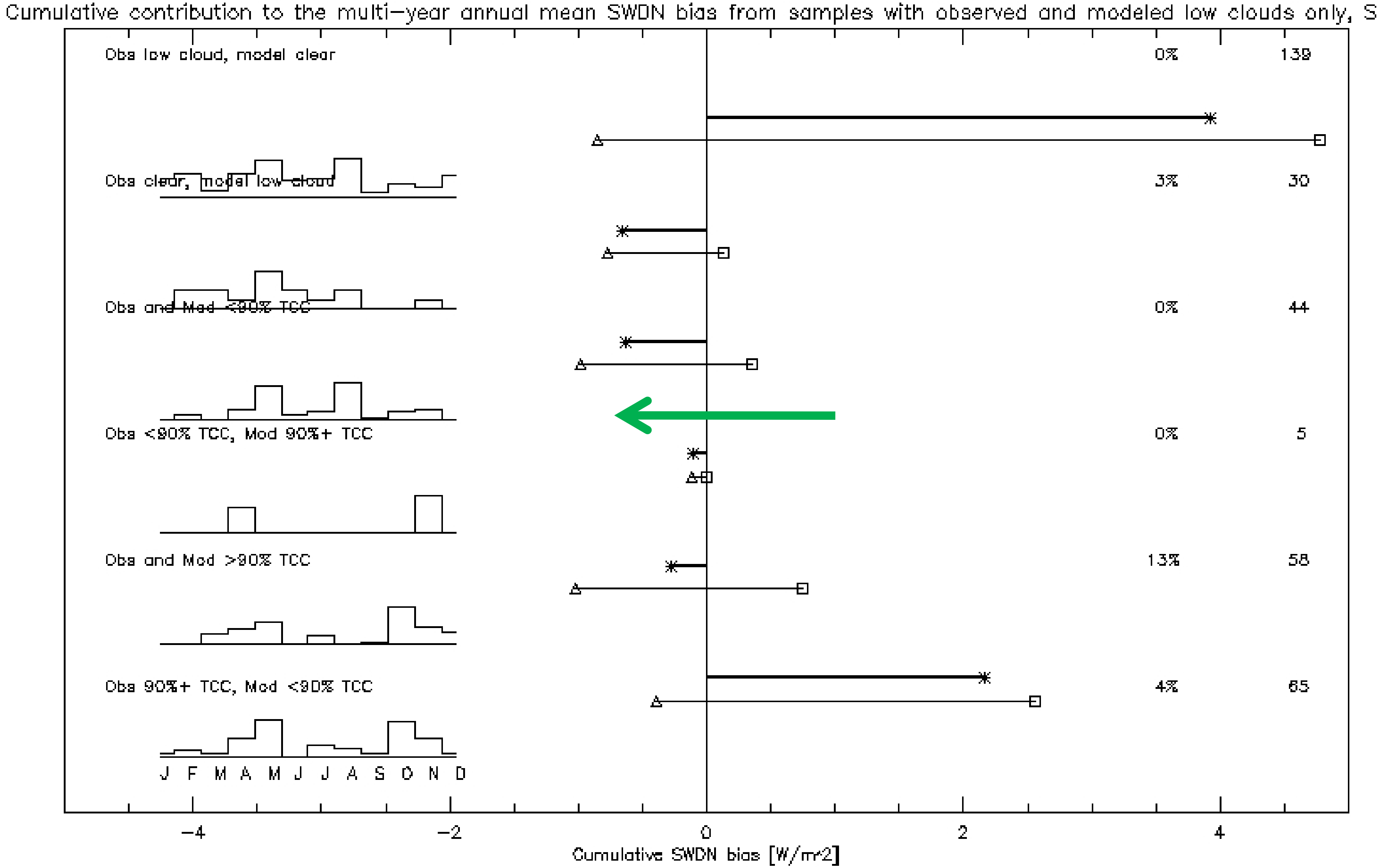
SCM: Control (36R4), one year (2009)



SCM: Convection Trigger

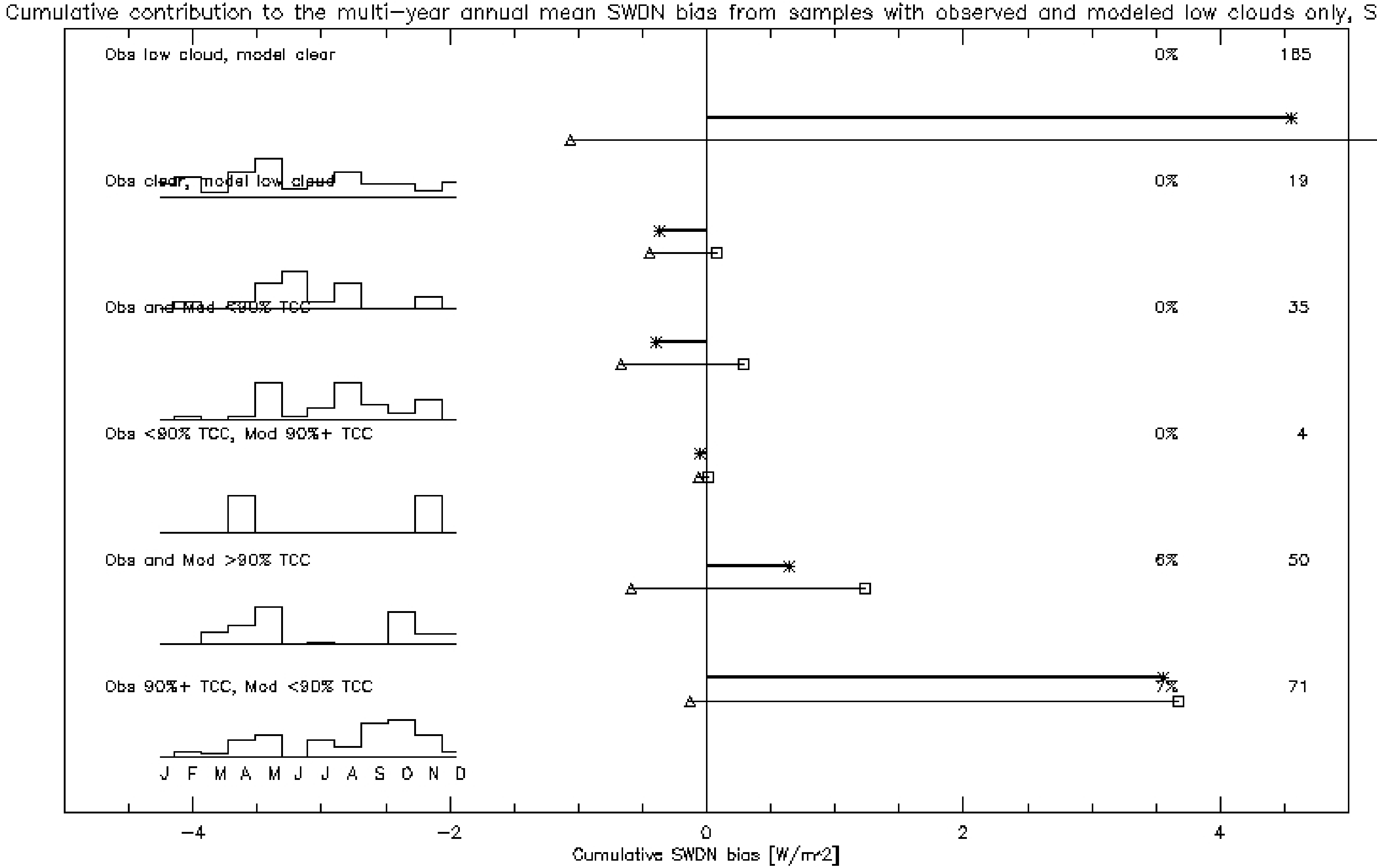


SCM: Effective radius

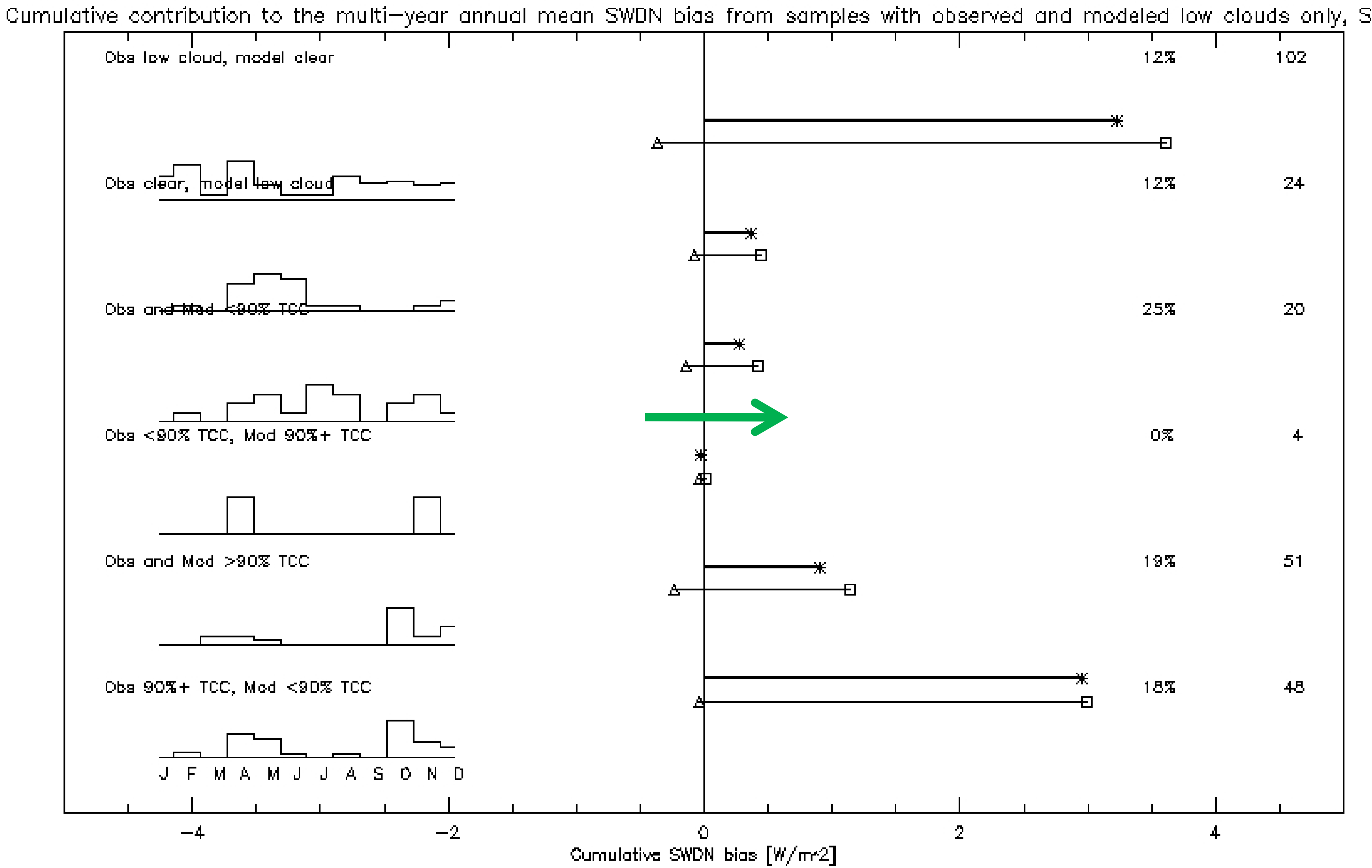


ECMWF

SCM: Control (36R1), one year (2009)



SCM: DualM (36R1)



ECMWF

SCM experimentation

First results:

- DualM does much better job at shallow convection initiation
- Difficult to change LWP and cloud fraction independently
- Not much impact from precip processes – not surprising as most cases non-precipitating

Next?

Graciosa (precipitating cases)

More sophisticated cloud classification?

Mixed-phase clouds