

SP-CAM5 with CLUBB: progress and remaining issues

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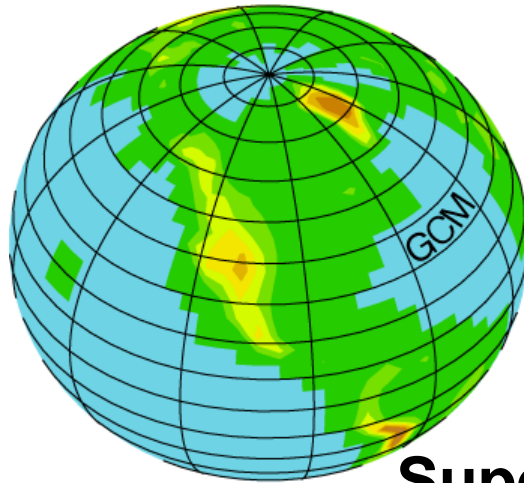
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Andrew Gettelman, Cheryl Craig, Jim Edwards, Brian Eaton – NCAR
Mark Branson, Dave Randall - CSU



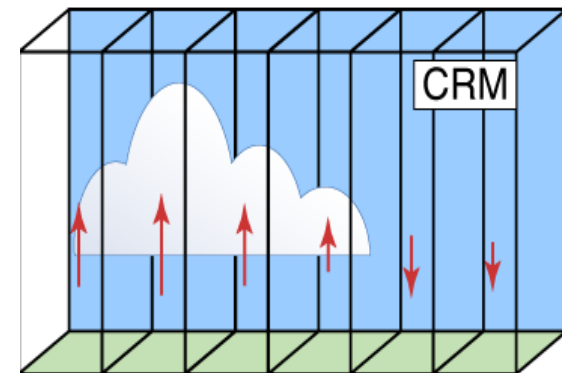


The Multi-scale Modeling Framework (MMF)

GCM



CRM



MMF



Super-Parameterization (SP)

(Grabowski, 2001; Khairoutdinov and Randall, 2001)

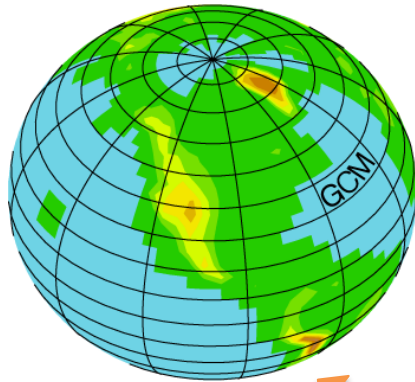
- ▶ Conventional cloud parameterizations are replaced by CRMs
- ▶ MMFs are much faster than GCRMs



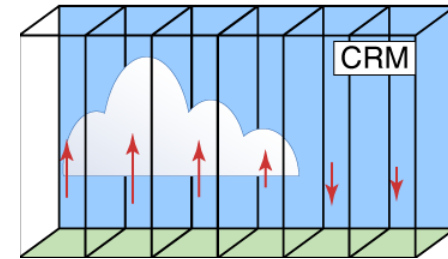
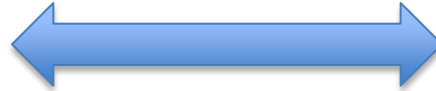
The MMF with aerosol-cloud interactions (PNNL-MMF)

CAM5 with modal aerosols

Two-moment microphysics



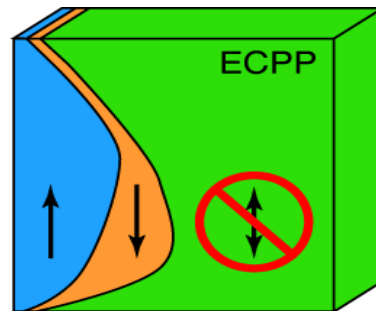
MMF



*CLUBB: a high-order
turbulence/sub-grid
cloud scheme*
(Golaz et al. 2002; Larson
et al., 2012)

PNNL-MMF
(Aerosol-MMF)

(Wang et al., 2011a, *GMD*;
2011b, *ACP*; 2012, *GRL*)



CRM cloud/precipitation statistics used for
cloud processing of aerosols



CLUBB in MMF

- ▶ Low clouds have been underestimated in MMF simulations (4km grid-spacing)
- ▶ Improved turbulence/sub-grid cloud treatment is expected to improve the simulation of deep clouds and the transition from shallow to deep clouds as well
- ▶ CLUBB in MMF serves as an early test of CLUBB's scale-aware capability
- ▶ CLUBB: assumed, dynamical PDF approach

$$P = P(w, q_t, \theta_l)$$

w , vertical velocity; q_t , total water mixing ratio;
 θ_l , liquid water potential temperature

Porting the MMF (both aerosol and non-aerosol versions) into CAM5 trunk (SP-CAM5)

- ▶ This is supported by the NSF/DOE through two EaSM projects, and led by Cheryl Craig and Andrew Gettelman at NCAR
- ▶ The PNNL-MMF (based on the tag cam3_6_26) has been merged into a most recent CAM5 tag (cam5_2_09)
- ▶ SPCAM has been merged with CESM1.1.1, and the SPCAM branch of CESM1.1.1 will be released in weeks
- ▶ It includes two compsets:
 - F_2000_SPCAM_sam1om1 (single-moment, non-aerosol)
 - F_2000_SPCAM_m2005 (double-moment, aerosol)



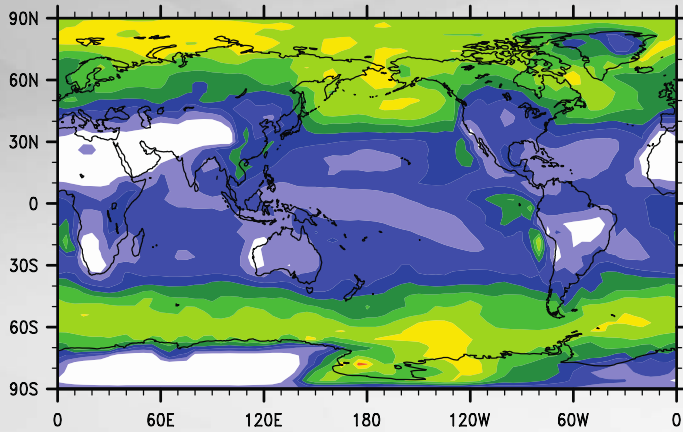
Single-moment (sam1mom) vs. double-moment microphysics (m2005) (No CLUBB, at 1.9x2.5 degree)

	Sam1mom (MMF)	M2005 (MMF)	CAM5	Obs
LWP (g/m ²)	87	55	48	50-87
IWP (g/m ²)	47	11	16	10-65
SWCF (W/m ²)	-52	-50	-50	-46 to -53
LWCF (W/m ²)	28	27	22	27-31
PRECT (mm/day)	2.85	2.82	2.95	2.61
CLDTOT (%)	52.1	51.2	62.7	65-75

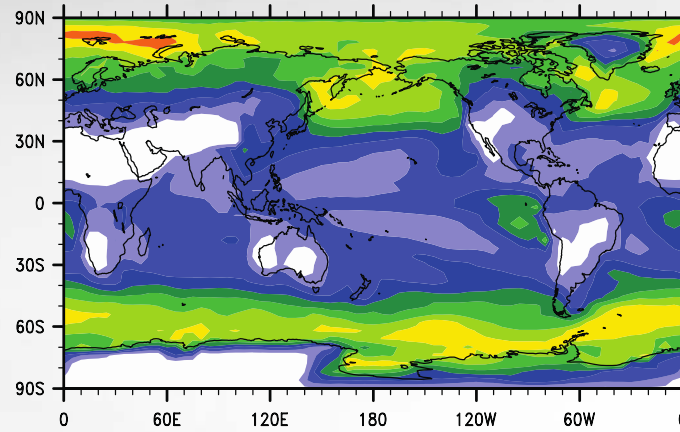


Improved low cloud simulations with CLUBB (at 4x5 degree)

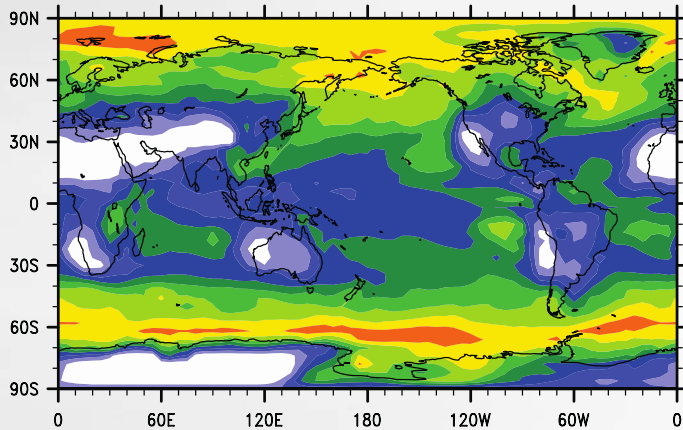
sam1mom **33.2%**



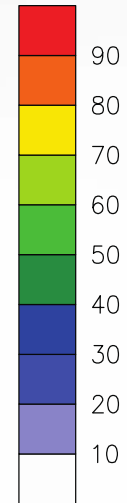
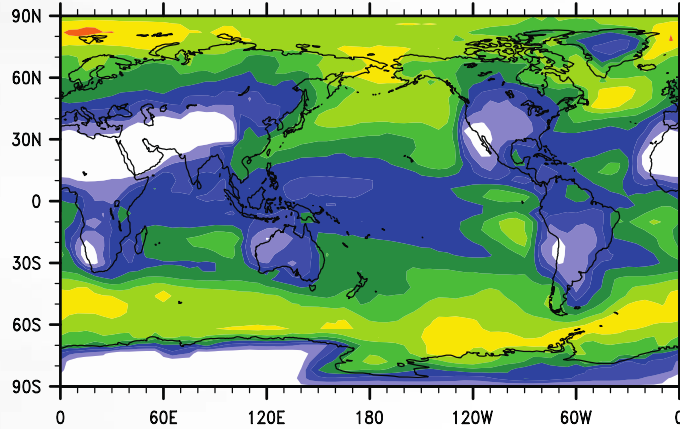
m2005 **31.9%**



sam1mom+CLUBB **42.3%**



m2005+CLUBB **40.8%**

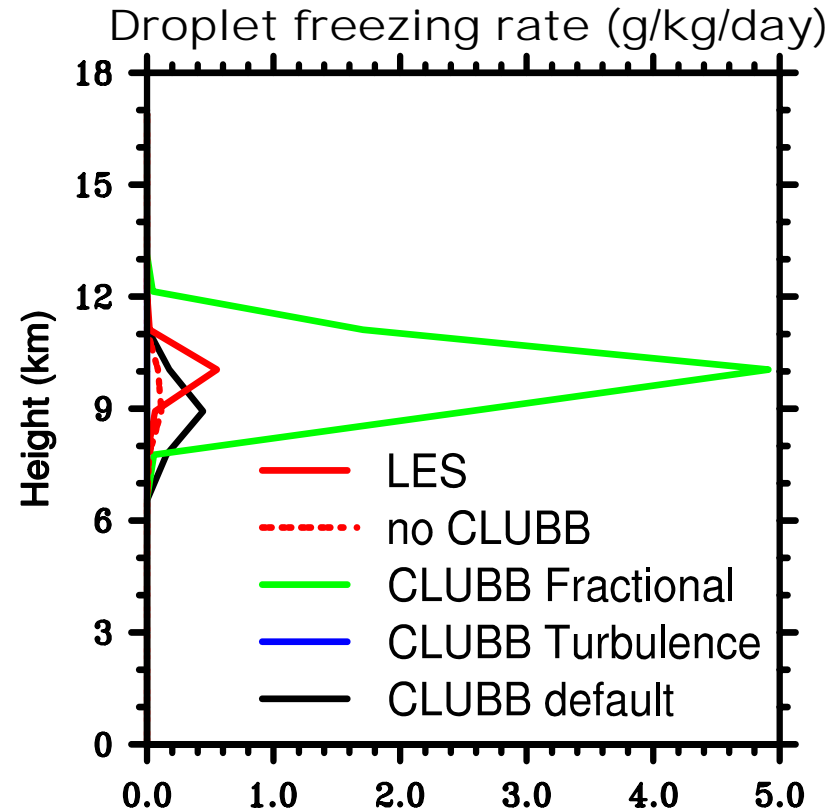
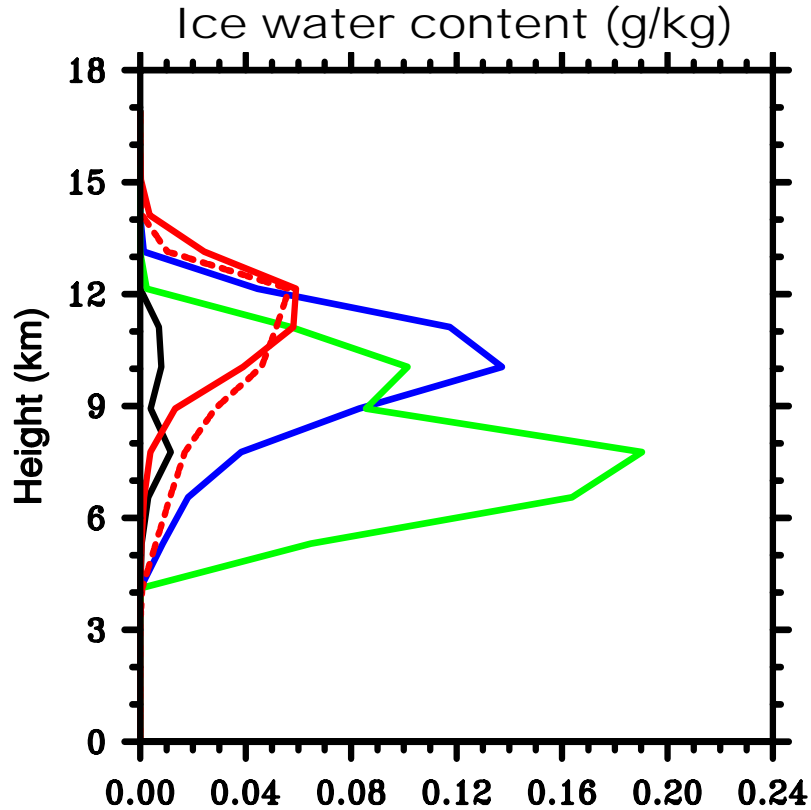




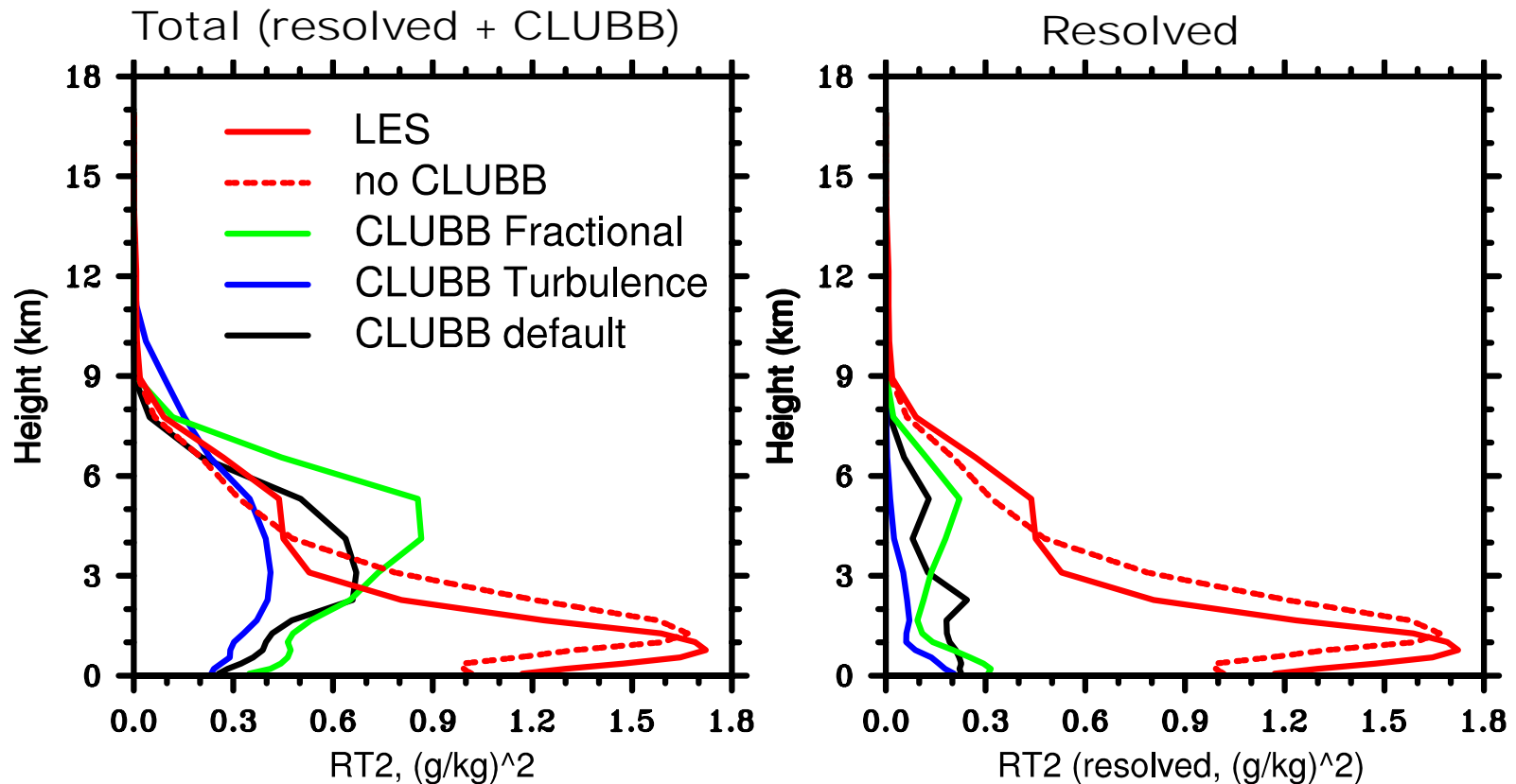
High clouds and deep convection in m2005

	sam1mom CLUBB (no clubb)	M2005 CLUBB (no clubb)
IWP (g/m ²)	52 (47)	7 (11)
CLDHGH (%)	24 (24)	21 (28)
LWCF (W/m ²)	30 (28)	22 (27)
Aerosol optical depth (AOD)		0.06 (0.13)
Black carbon burden (Tg/yr)		0.09 (0.16)
Wet removal from convective clouds (%)		12 (34)

Sensitive to the microphysical coupling for deep clouds in SAM_CLUBB (ARM9707 case over SGP site, 16 4-km CRM columns)



Variance of total water: resolved variance is too weak, while variance from CLUBB is strong



Summary and Future work

- ▶ A next generation MMF model has been built to simulate multi-scale interactions between aerosols, clouds, and precipitation
- ▶ This MMF model has been ported into a most recent tag of CAM5 (cam5_2_09)
- ▶ SPCAM branch of CESM1.1.1 will be released to the public in weeks
- ▶ Further work is needed to improve the SPCAM simulations with CLUBB: time evolution of budget terms; resolution dependence; applying UQ to quantify the parameter dependence of CLUBB