A Sensitivity Analysis of Cloud Properties to CLUBB Parameters in SCAM5 and CAM5

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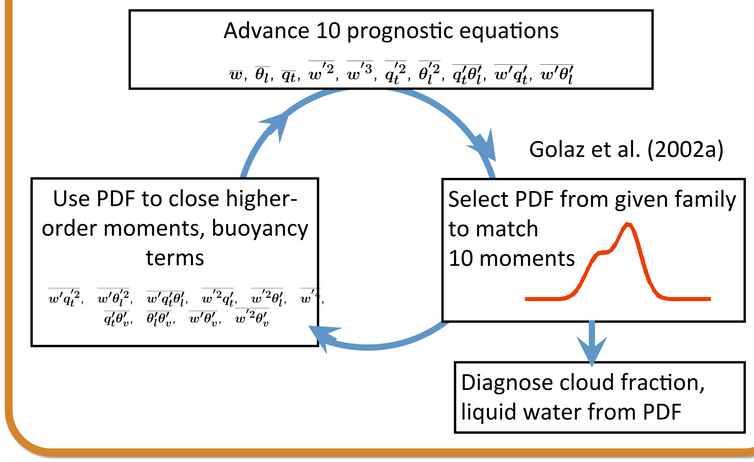
1. Motivations and approaches

- The Cloud Layers Unified By Binormals (CLUBB), an assumed, dynamical PDF method for coupling subgrid turbulence and cloud process, provides a unified treatment of stratocumulus and shallow cumulus
- CLUBB, like many other parameterizations, includes multiple tunable parameters. How sensitive CLUBB simulations to its tunable parameters has not been systematically examined
- Sensitivity Analysis (SA) offers a way to systematically and efficiently examine this
- Cases examined for Single-column CAM5 (CAM5): two for shallow cumulus (BOMEX and RICO); and one for stratocumous (DYCOMS-II RF01)

2. Sensitivity Analysis (SA) approach

- 16 CLUBB tunable parameter are chosen, based on a set of experiments with 35 tunable parameters
- The Quasi-Monte Carlo (QMC) sampling approach provides an efficient and reliable way for sampling high-dimensional parameter space, and is selected in this study
- A generalized line model (GLM) is adopted to analyze the responses of simulated cloud properties to CLUBB tunable parameters
- A cost function based on the spatial standard deviation and spatial correlation is used as a metric to evaluate model results against observations or benchmark simulations

3. Schematic of the Assumed PDF method (CLUBB)

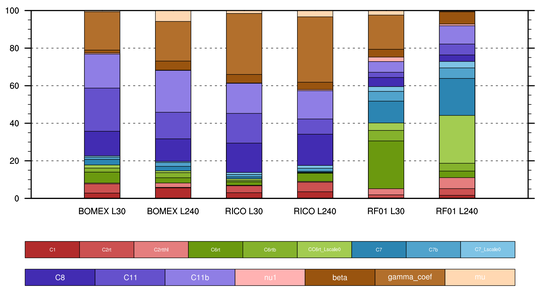


4. Single-CAM5 at two vertical resolutions: 30 layers (L30) and 240 layers (L240)

A. CLUBB parameters in SCAM5 experiments

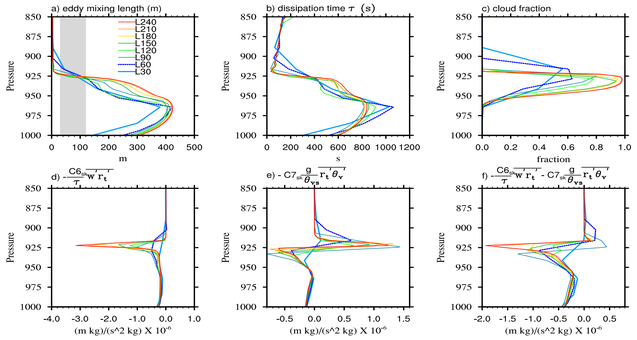
Tuning Parameter	Description	Default Value	Investigated Range
C1	Low Skewness in C1 Skewness Function	2.5	1.25~5
C2rt	Constant associated with $\overline{r_t'^2}$ dissipation term	1.0	0.5~2
C2rtthl	constant associated with $\overline{r_t'\theta_l'}$ dissipation term	1.0	0.5~2
C6rt	Low Skewness in C6rt Skewness Function	4.0	2.0~8.0
C6rtb	High Skewness in C6thl Skewness Function	4.0	2.0~8.0
C7	Low Skewness in C7 Skewness Function	0.5	0.0~1.0
C7b	High Skewness in C7 Skewness Function	0.5	0.0~1.0
C8	Coefficient in C8 Skewness Equation	3.0	1.5~6.0
C11	Low Skewness in C11 Skewness Function	0.8	0.0~1.0
C11b	High Skewness in C11 Skewness Function	0.65	0.0~1.0
C6_Lscale0	Used to damp C6rt as a function of Lscale	14.0	7.0~28.0
C7_Lscale0	Used to damp C7 as a function of Lscale	0.85	0.425~1.7
ν (nu)	Background Coefficient of Eddy Diffusion	20.0	10.0~40.0
β (beta)	Constant related to "plume" variance of $\overline{\theta_l'^2}$ and $\overline{r_t'^2}$	1.75	0.0~3.0
γ (gamma_conf)	Low Skewness in γ coefficient Skewness Function	0.32	0.0~0.83
μ (mu)	Parcel Entrainment Rate (Lscale) [1/m]	1.e-3	0.5~2.0e-3

B. The relative contribution to cloud fraction variance



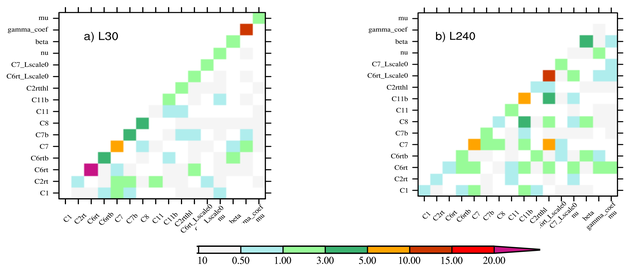
- Most of variance in cloud fraction can be explained by a small number of tunable parameters
- For shallow cumulus, they are related to skewness of vertical velocity, while for stratocumulus, they are related to water and heat flux equations

C. Resolution dependence in statocumulus



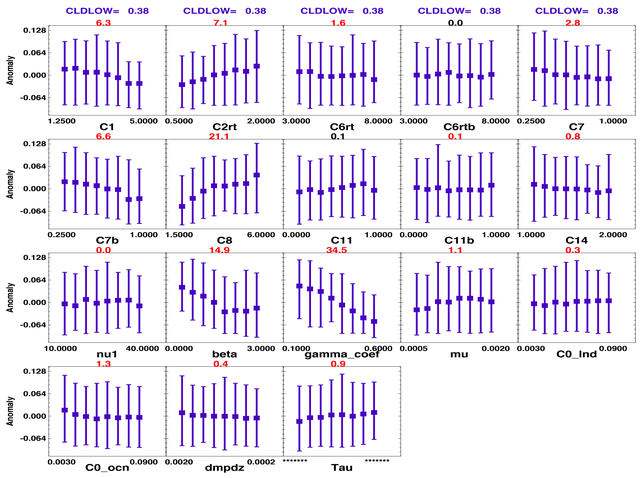
- Resolution dependence of influential parameters in stratocumulus is partly caused by the strong resolution dependence of eddy mixing length

D. Contributions from interaction terms



- Contributions from interaction terms are generally small

5. Global results (based on 512 2-year simulations)



- Some of influential parameters identified in SCAM5 contribute little to variance in low cloud fraction in CAM5 simulations, including C6rt, C6rtb, C11, and C11b

6. Future work

- Understand the discrepancy in influential parameters between SCAM5 and CAM5
- Examine regional sensitive of simulated cloud fields to CLUBB tunable parameters

Zhun et al., 2014, A sensitivity analysis fo cloud properties to CLUBB parameters in SCAM5, under revision, *J. Adv. Model. Earth Syst.*