A PDF-based unified cloud and turbulence scheme (CLUBB) in AM3: Implications for marine stratocumulus

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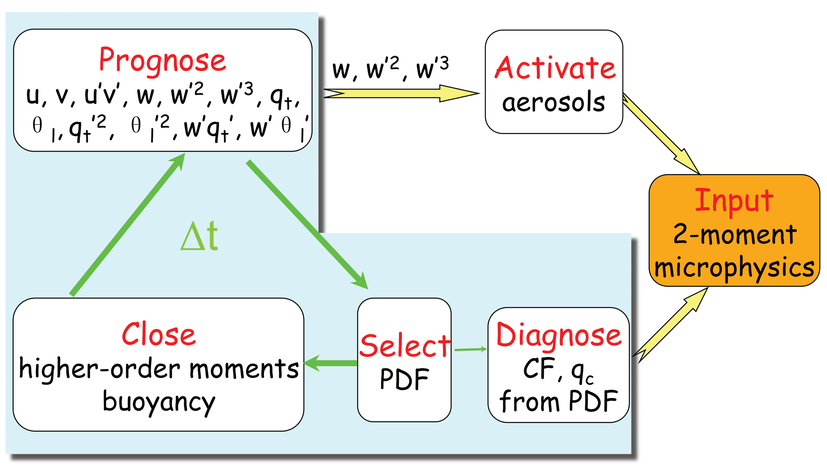
1. Motivation

- Observations show stratocumulus plays a crucial role in radiation balance owing to high albedo and large coverage;
- Models often under-estimate low-level marine stratocumulus;
- Parameterizations are often developed for specific regimes, which poses challenges when combining various components to function together for various cloud regimes in global simulations.

2. CLUBB (1,2,3)

- Cloud Layers Unified By Binormals;
- Unified cloud and turbulence parameterization;
- Assumed double-Gaussian probability density function



3. Configurations (4,5)

CLUBB is incorporated in GFDL AM3: AM3-CLUBB

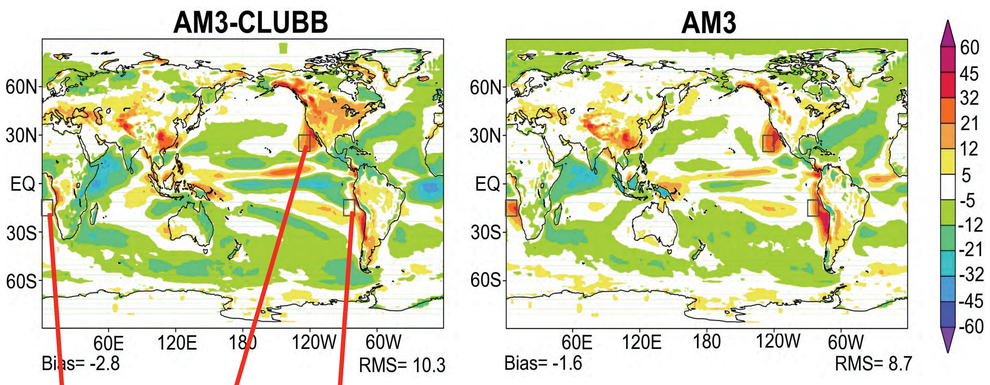
	AM3	AM3-CLUBB
Deep Conv.	Donner	Donner
Shallow Conv.	Univ. Washington	CLUBB
PBL	Lock	CLUBB
Macro-physics	Tiedtke	CLUBB
Micro-physics	one-moment Rotstayn-Klein	two-momentz Morrison-Gettelman

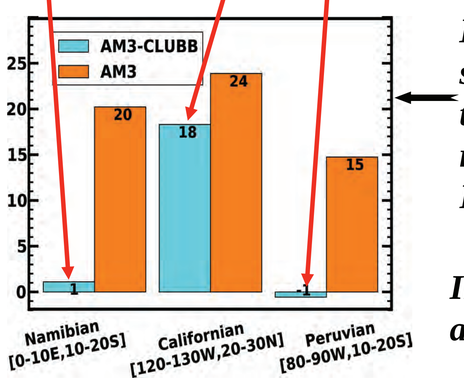
4. Atmospheric Model Intercomparison Project (AMIP) simulations (5)

Improved marine stratocumulus in AM3-CLUBB!

(4a) 1-degree AMIP run (1981-2000)

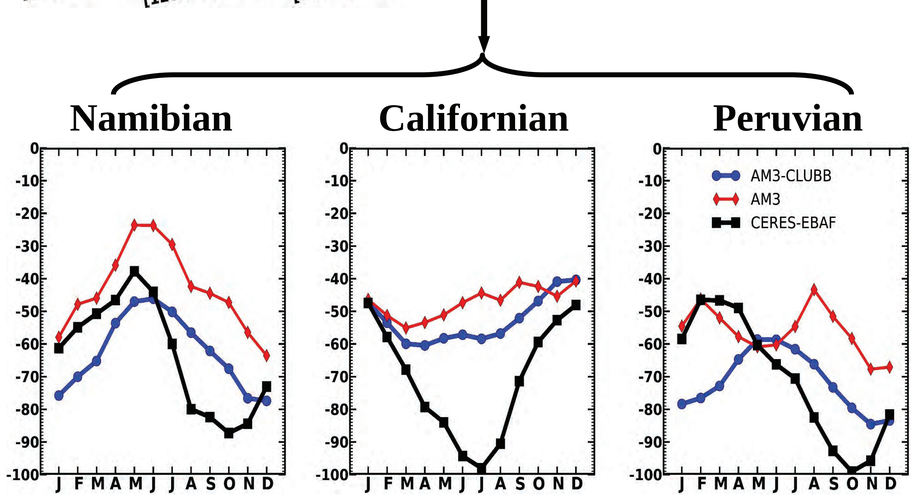
Global annual mean shortwave cloud forcing bias



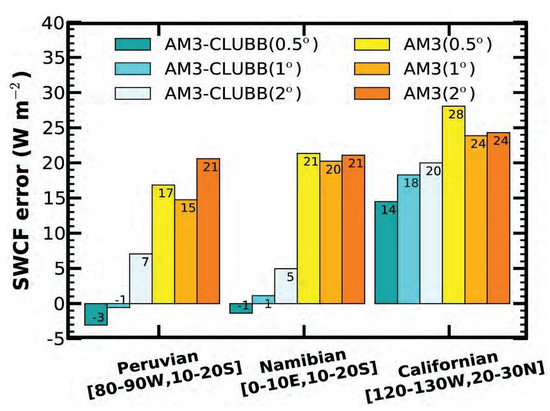


In AM3-CLUBB, smaller shortwave cloud forcing bias in three subtropical stratocumulus regions: Namibian, Californian, Peruvian.

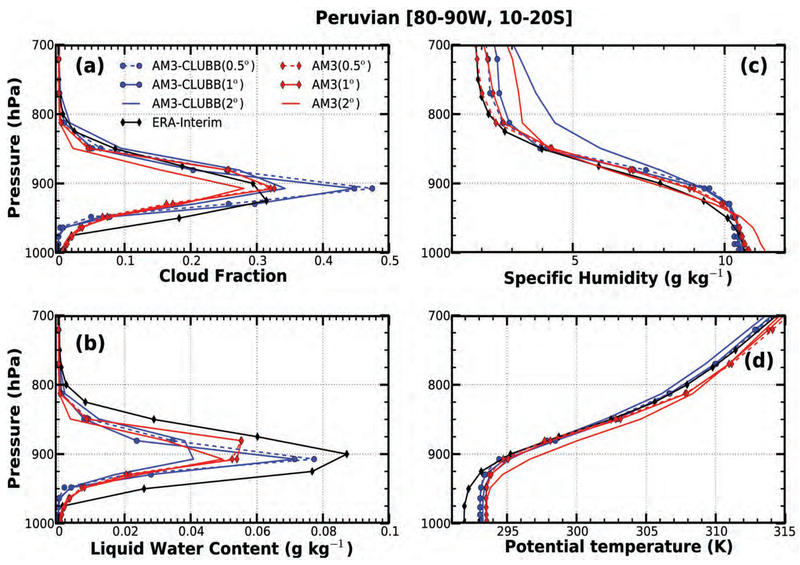
In AM3-CLUBB, seasonal cycles agree better with observations.



(4b) AMIP runs at different resolutions

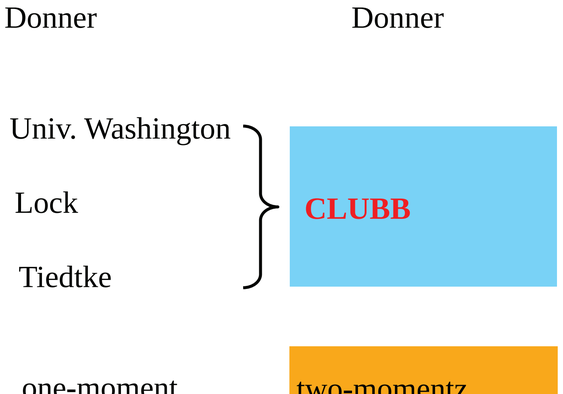


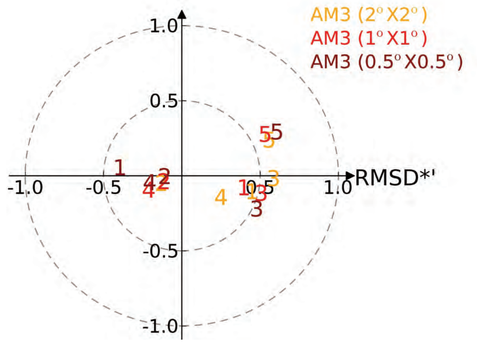
In AM3-CLUBB, annual shortwave cloud forcing bias becomes smaller at higher resolution in subtropical stratocumulus regions; but it does not in AM3.



sharper inversion at higher resolution in AM3-CLUBB

(4c) Summary: target diagram





AM3-CLUBB has weaker sensitivity to resolution.

Future work:

- Aerosol effect estimate;
- Improved ice microphysics;
- Prognostic precipitation treatment;
- …

References

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4) *Guo, H., Golaz, J.-C., Donner, L. J., Larson, V. E., Schanen, D. P., and Griffin, B. M.: Multi-variate probability density functions with dynamics for cloud droplet activation in large-scale models: single column tests, Geosci. Model Dev., 3, 475–486, doi:10.5194/gms d-3-475-2010, 2010.*

5) *Guo, H., Golaz, J.-C., Donner, L. J., Ginoux, P., and Hemler, R. S.: Multivariate Probability Density Functions with Dynamics in the GFDL Atmospheric General Circulation Model: Global Tests, J. Climate 27 (5), 2087-2108, 2014.*

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