Evaluating the climate of coupling SHOC with ZM (+ P3)

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E3SM Energy Exascale Earth System Model

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Context:
Convection development for v3

Guang Zhang (UCSD), Vince Larson (UWM),
Joao Teixeira (JPL), Yaga Richter (NCAR),
Wuyin Lin (BNL), Jiwen Fan (PNNL)


Bierstadt 1880 "Storm Clouds"

Improved features for CLUBB+ZM

A new convective trigger (dCAPE&ULL, Xie et al. 2019) to improve diurnal cycle precipitation and precip distribution

A stochastic convection scheme coupling with ZM to improve precipitation distribution (Wang et al. 2020)

The Multiscale Coherent Structures Parameterization (MCSP, Moncrieff 2019) for mesoscale effect on convection

Cloud microphysics for convective clouds following Song and Zhang (2011)

Improved scale-awareness

New schemes

CLUBB-SILHS to unify all types of clouds. (Vince Larson)

EDMF: A stochastic multi-plume Eddy-Diffusivity/Mass-Flux (EDMF) parameterization for a unified treatment of PBL+ShCu+DeepCu (Joao Teixeira)

Predicted Particle Properties (P3) scheme (Morrison and Milbrandt, 2015) for improving the treatment of ice particles (SCREAM-P3) (Jiwen Fan)

SHOC+ZM (SCREAM - low rez) for v3 Water Cycle

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SHOC+ZM (SCREAM - low rez) for v3 Water Cycle

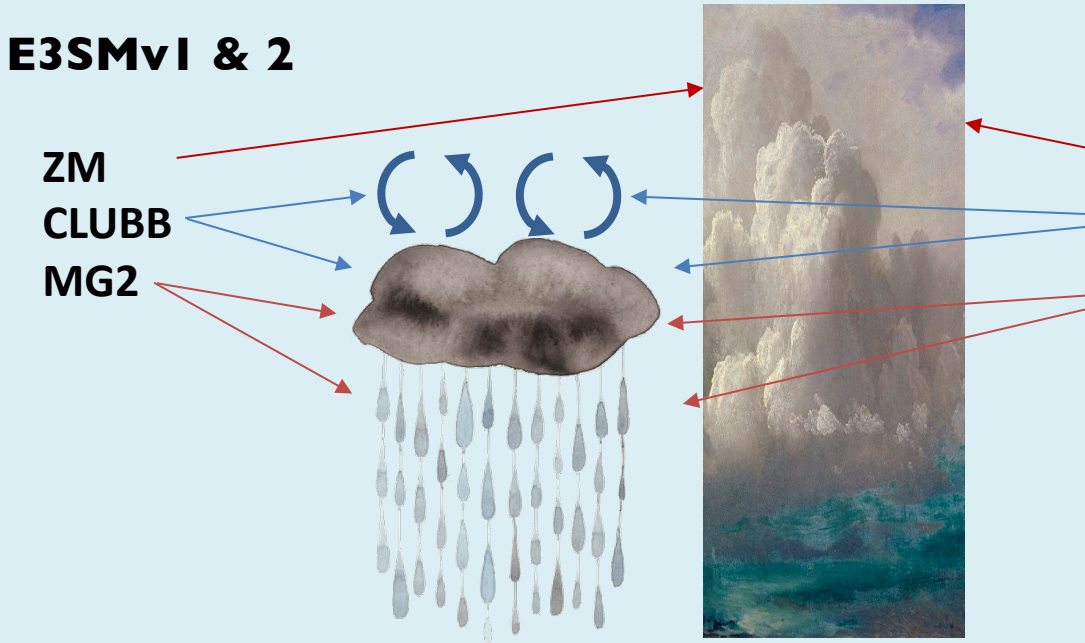
What are the v3 Water Cycle questions?
What is this configuration?

E3SM v3 Water Cycle questions

1 What are the moisture sources for precipitation over land?

2 Do models converge with increasing resolution, and what controls this behavior?

3 How will the moisture sources and precipitation over land change in a warmer climate?



Bierstadt 1880 "Storm Clouds"

[1] deep convection scheme Zhang-MacFarlane (ZM)
[2] turbulence/shallow convection scheme Simplified Higher-Order Closure (SHOC)
[3] microphysics scheme Predicted Particle Properties (P3)
[4] radiation scheme RRTM for General circulation model applications – Parallel (RRTMGP)

Preliminary simulations and evaluation focus

Configurations:

Physics: SHOC+ZM+MG2+RRTMG (un-tuned) – most of this talk

Physics: SHOC+ZM+P3+RRTMGP (un-tuned) for select diagnostics

Chemistry: -chem set to none and run with prescribed aerosols

Resolution: ne30 (1deg x 1deg)

Simulation type: F2010 (atmosphere only simulation using year 2010 forcings)

Simulation: 6-year simulation with one-year spin-up (analyze five years of simulation)

Evaluation of

Mean state:

Water cycle, cloud features

Variability:

Monsoon, Precipitation PDF, Diurnal cycle

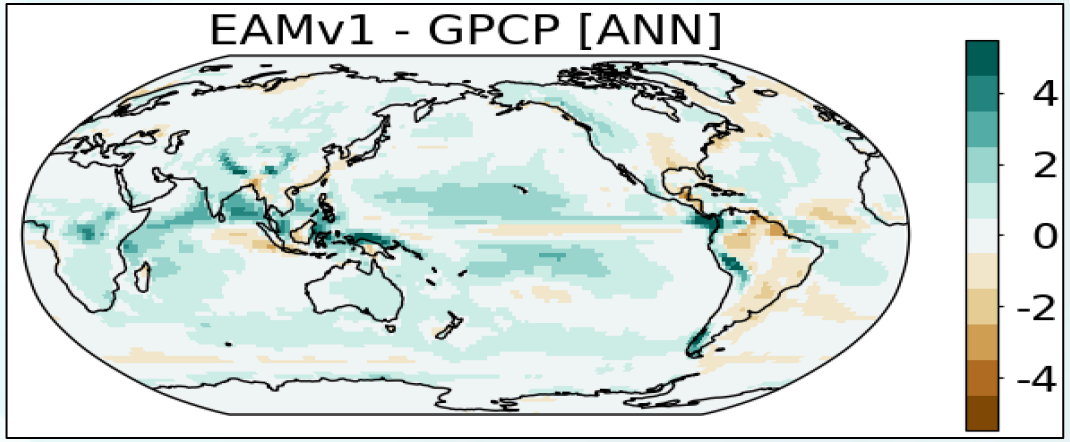
Driving questions:

What is the impact of changing schemes?

How does the overall climate look?

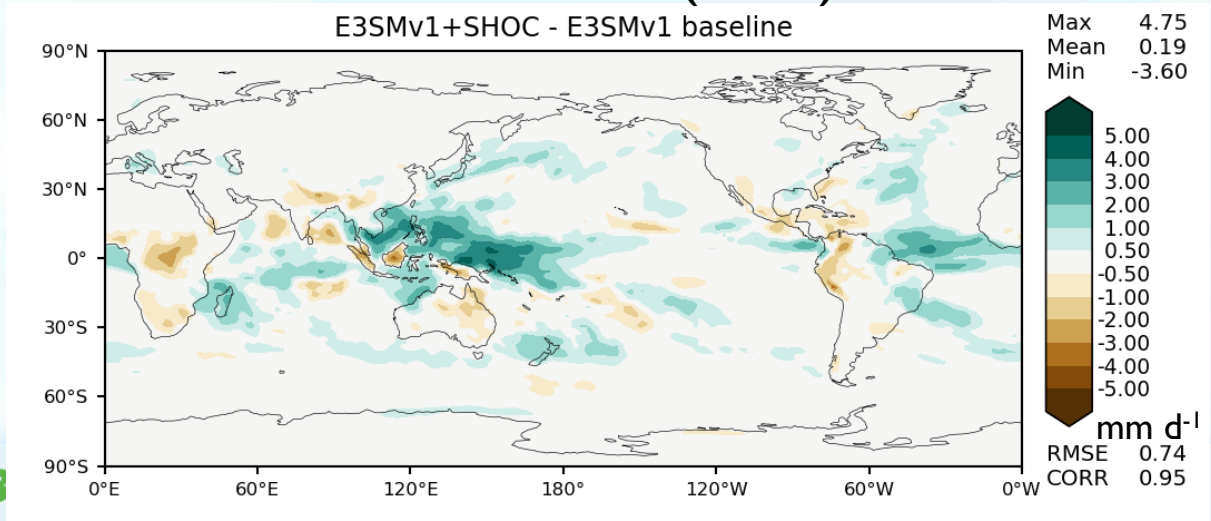
Mean state: Water Cycle

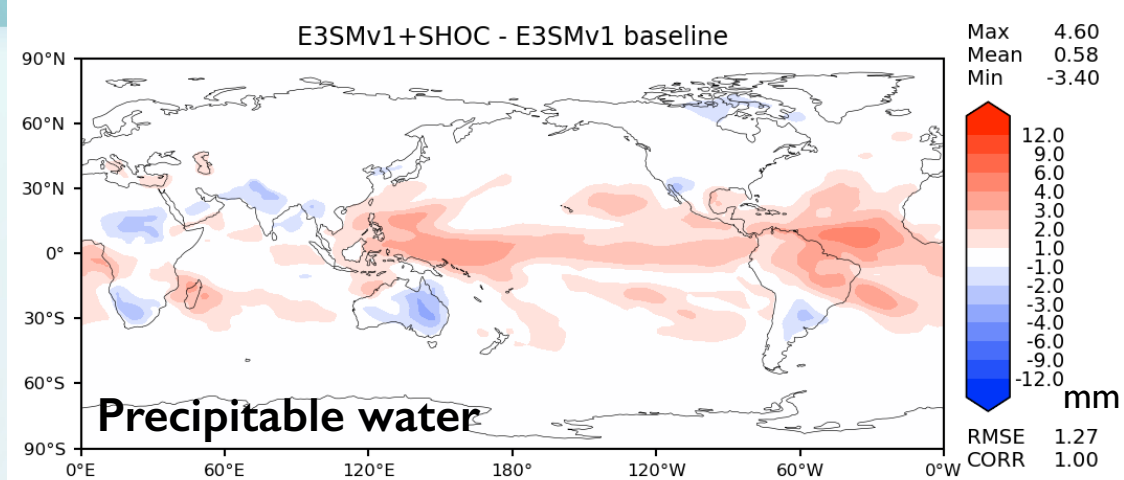
EAMv1 precipitation rate bias (mm/d)

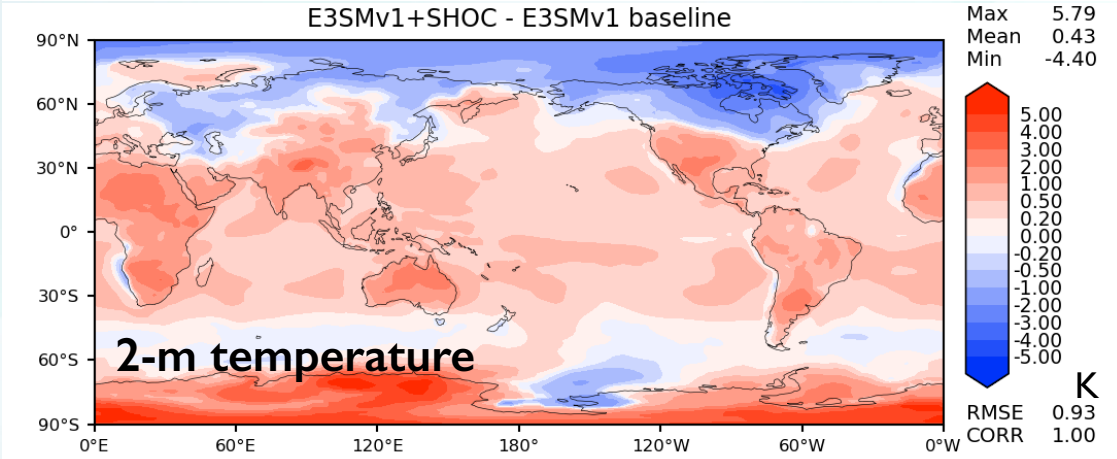


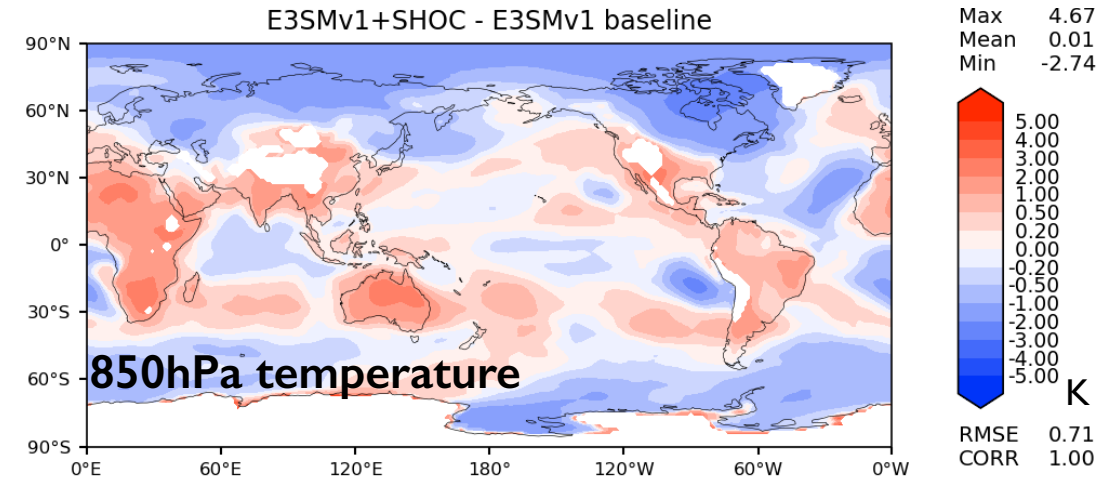
Rasch et al. 2019 mm d^{-1}

SHOC+ZM - EAMv1 (mm/d)

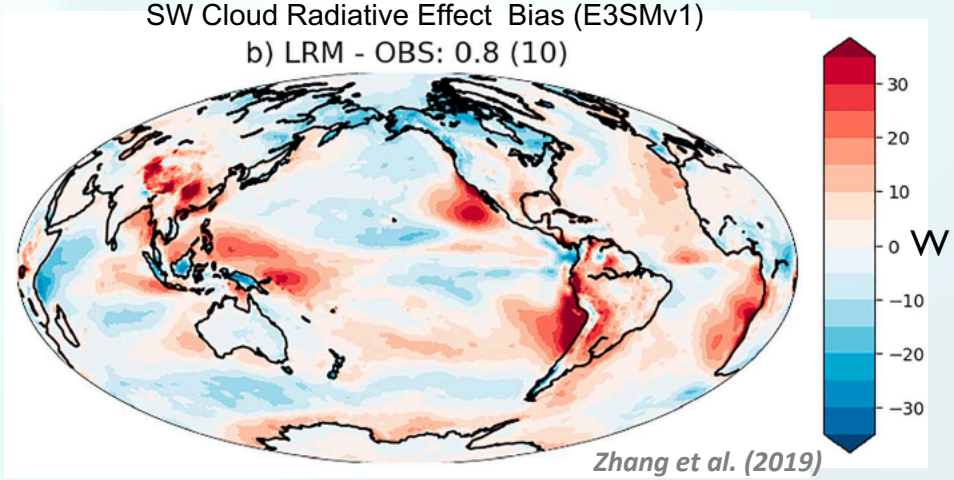


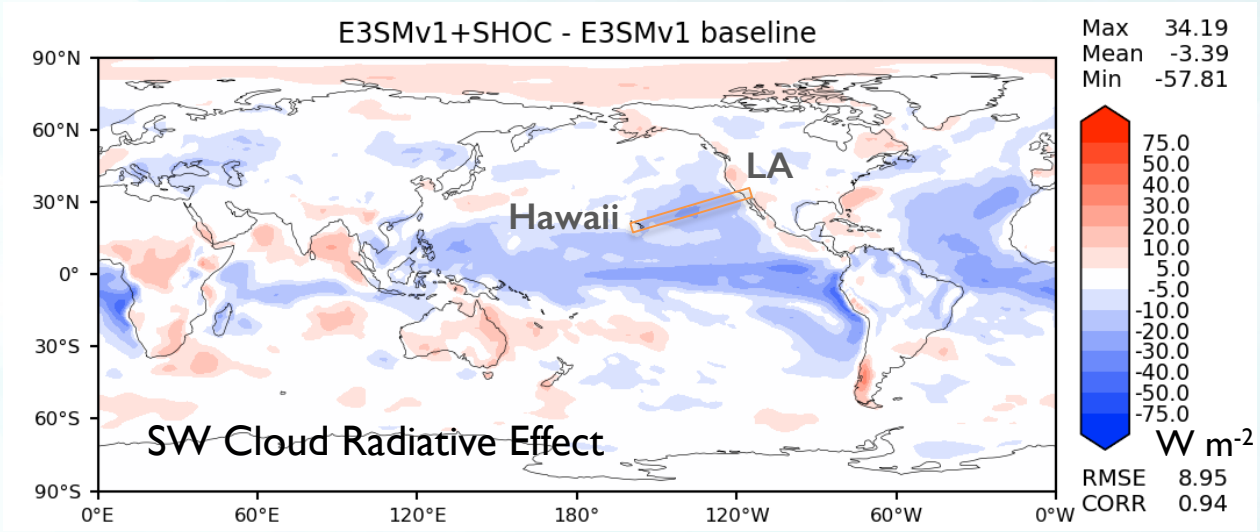






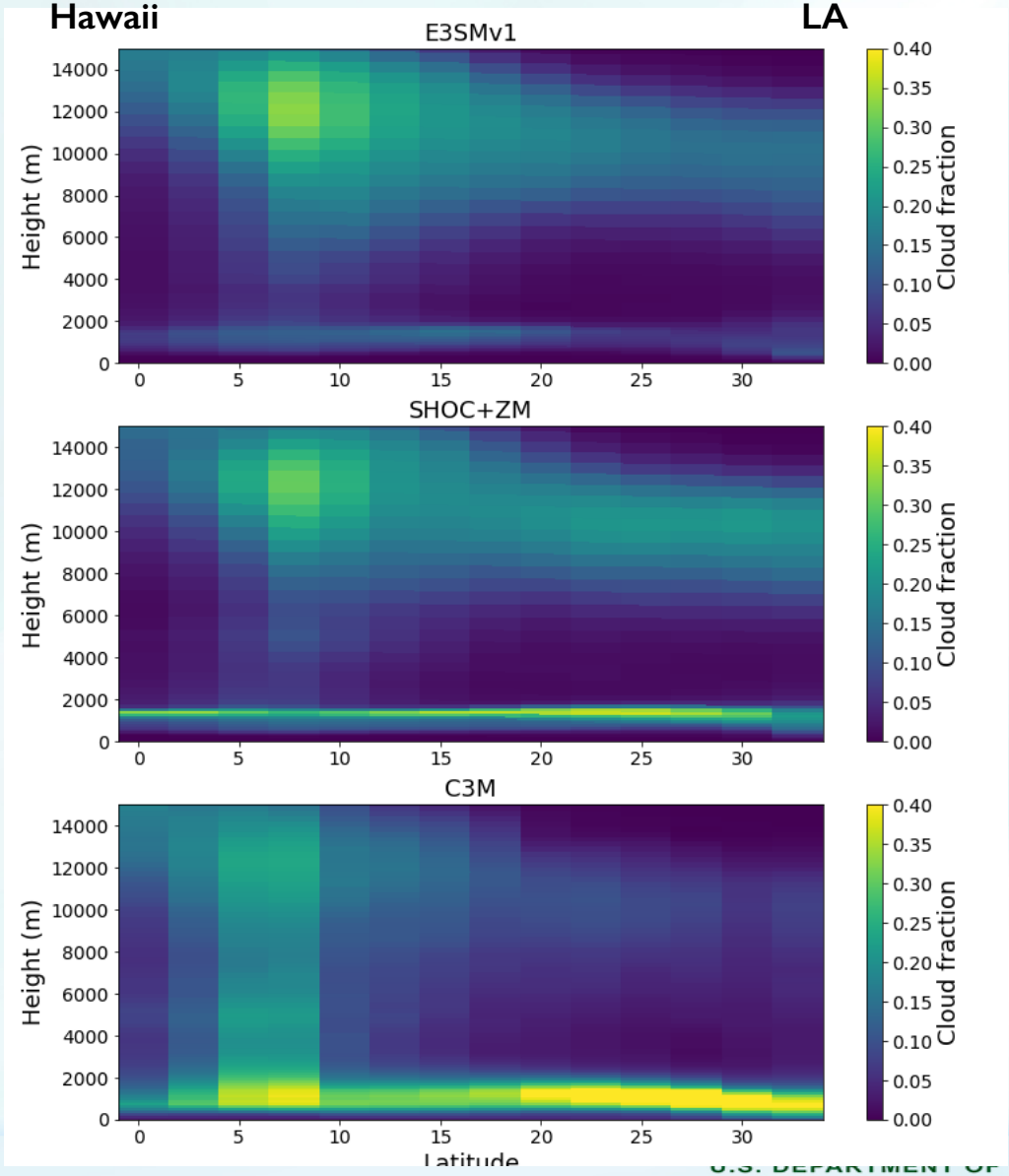
Mean state: Clouds





Blue = More cloud reflection over tropics

GPCI transect



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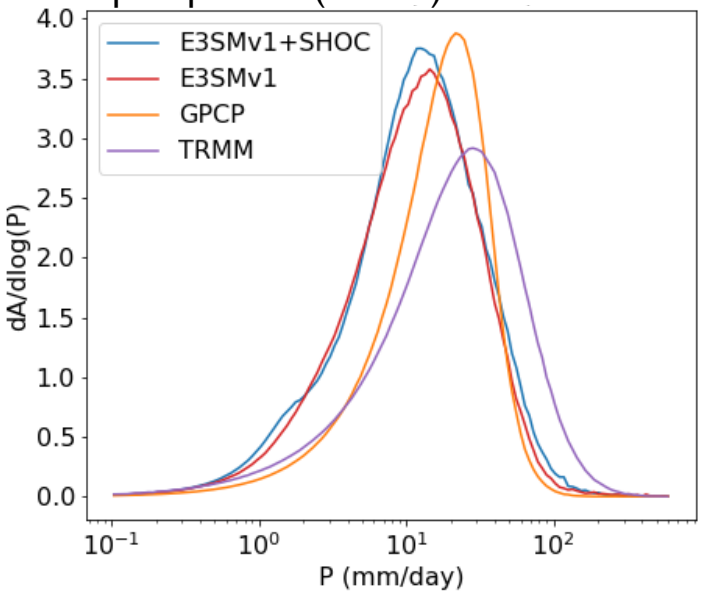
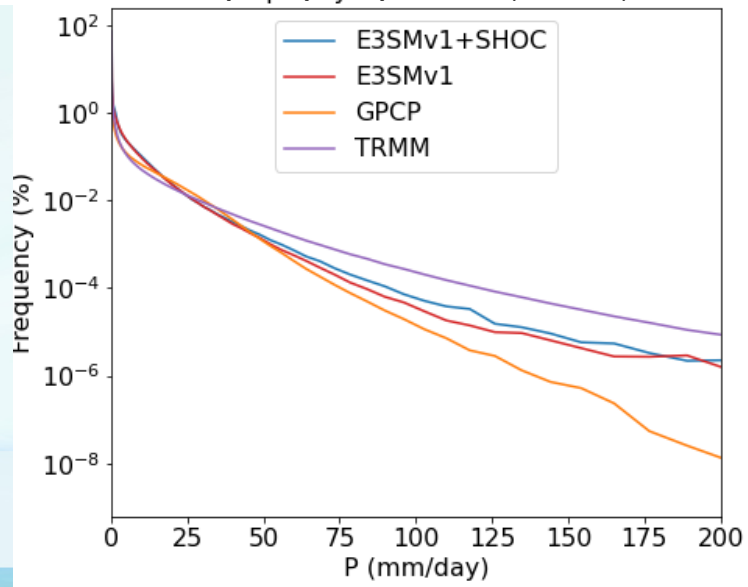
Mean state: Variability

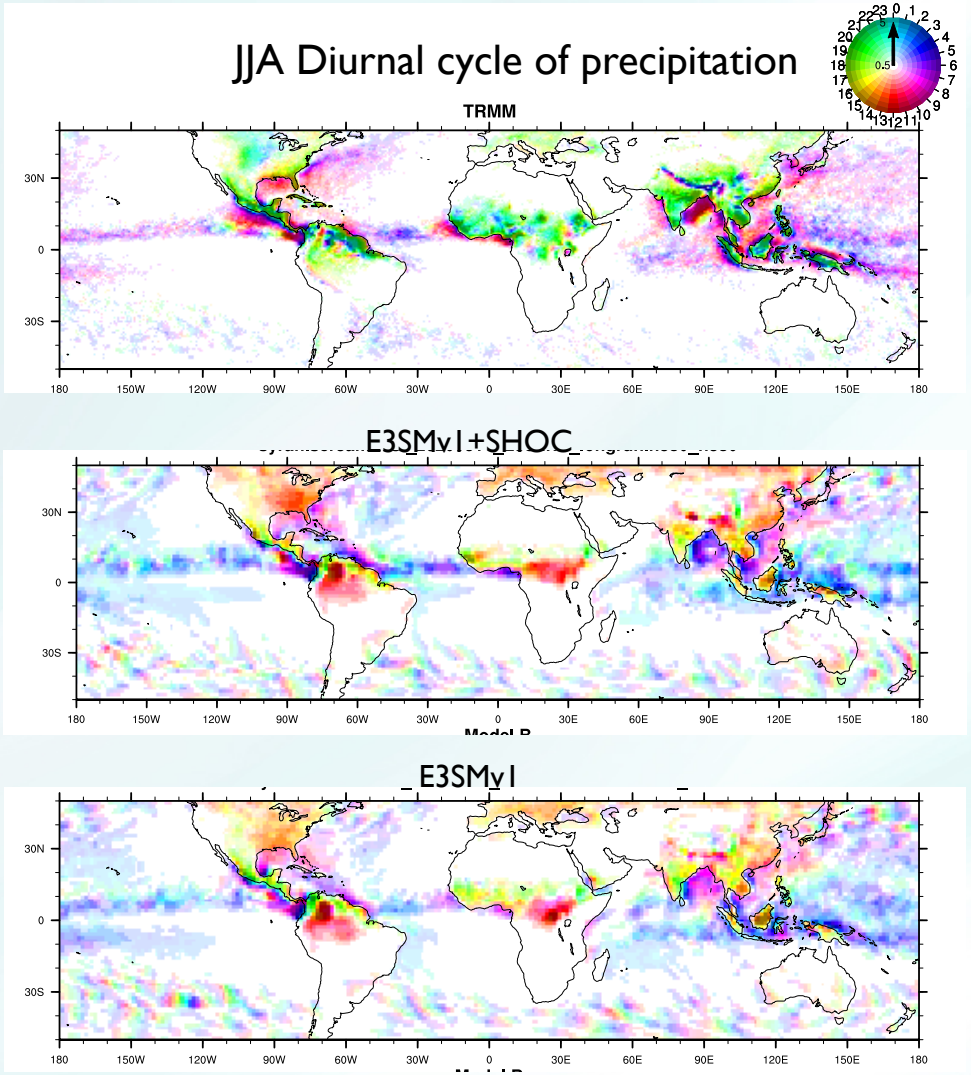
Amount PDF of daily-mean tropical precipitation (1° x 1°)



Frequency of extreme daily-mean tropical precipitation (1° x 1°)



JJA Diurnal cycle of precipitation



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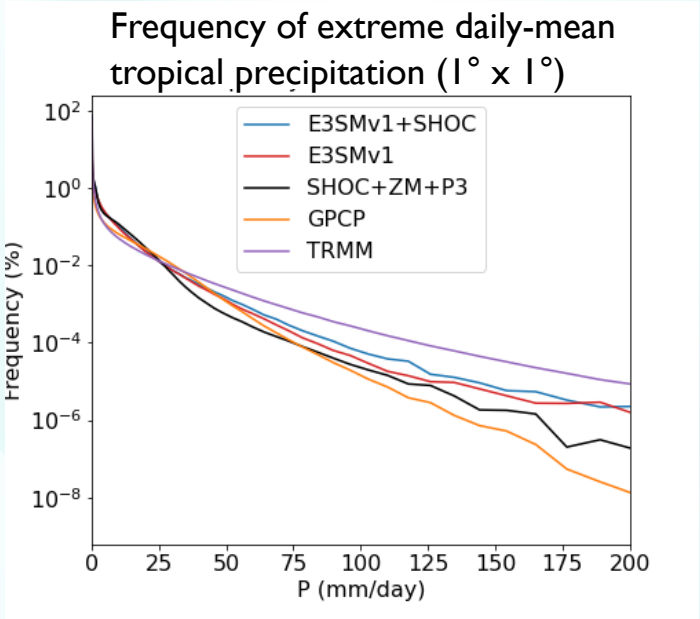
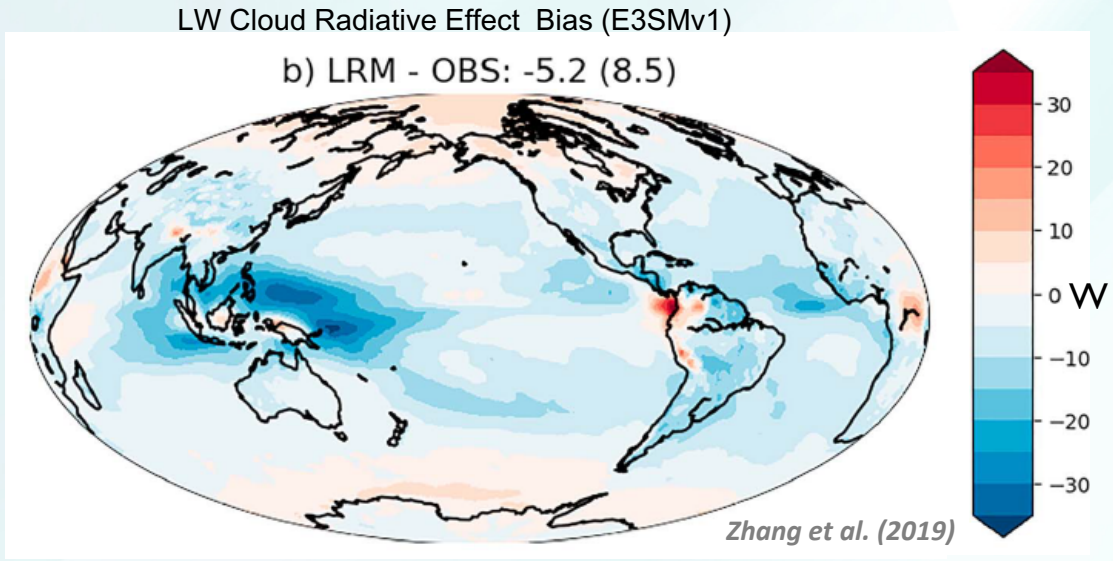
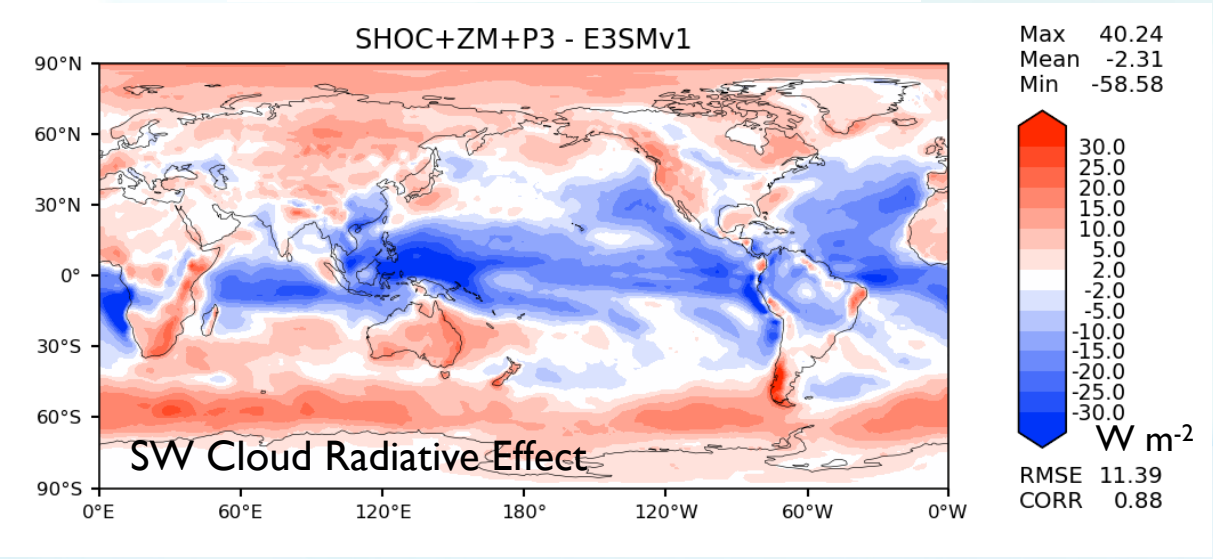
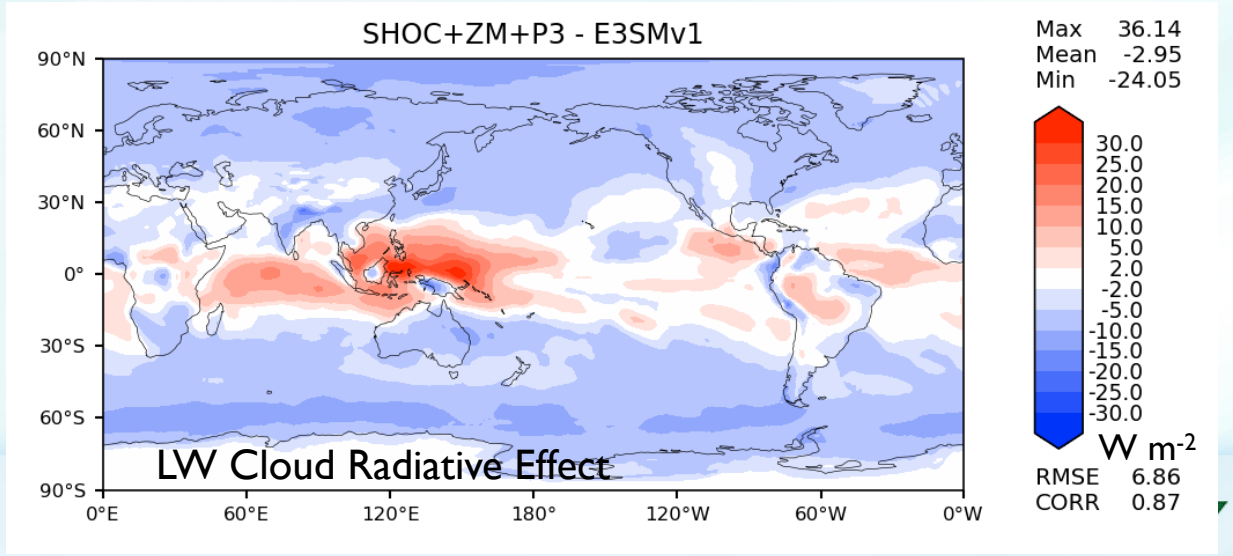
Climate state of FSCREAM-LR (SHOC+ZM+P3)









Summary

Various efforts to improve convection in E3SM

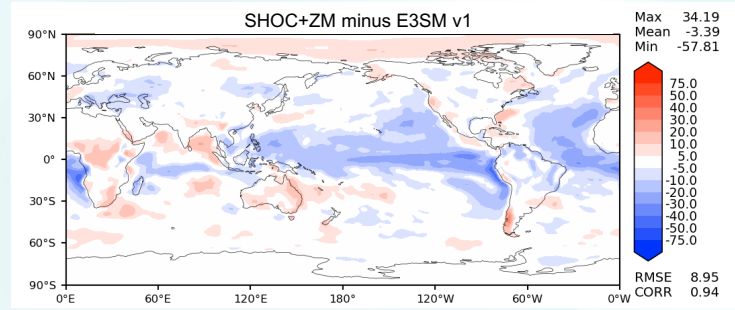
Configuration with SHOC+ZM+P3 examined as candidate for E3SM v3 Water Cycle campaigns

Improvements:
- Increase in stratocumulus clouds
- Reduced outgoing longwave in Tropical West Pacific

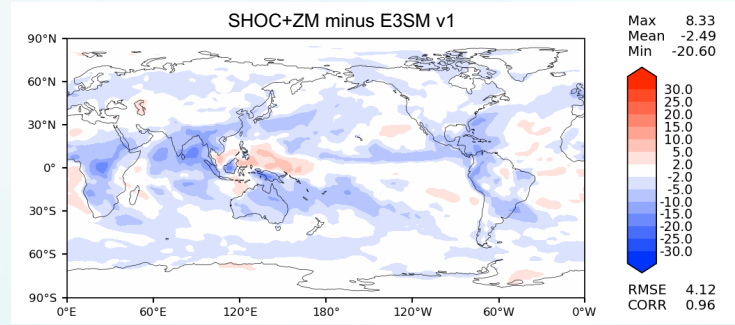
Biases:
- Too strong precipitation over Tropical West Pacific
- Too much reflection over trade wind regions

Tuning can potentially reduce the too many clouds issue

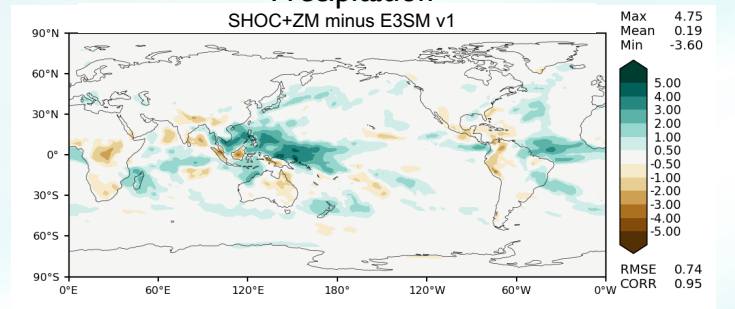
SW Cloud Radiative Effect



LW Cloud Radiative Effect



Precipitation



Next steps: Convection assessment

Convection assessment (Jan – July 2021)
- Each convection configuration run in atmosphere-only (at 1 and ¼ deg)
- Diagnostics examining mean state and variability (*a few of which were used in this presentation)

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Two rounds of assessment

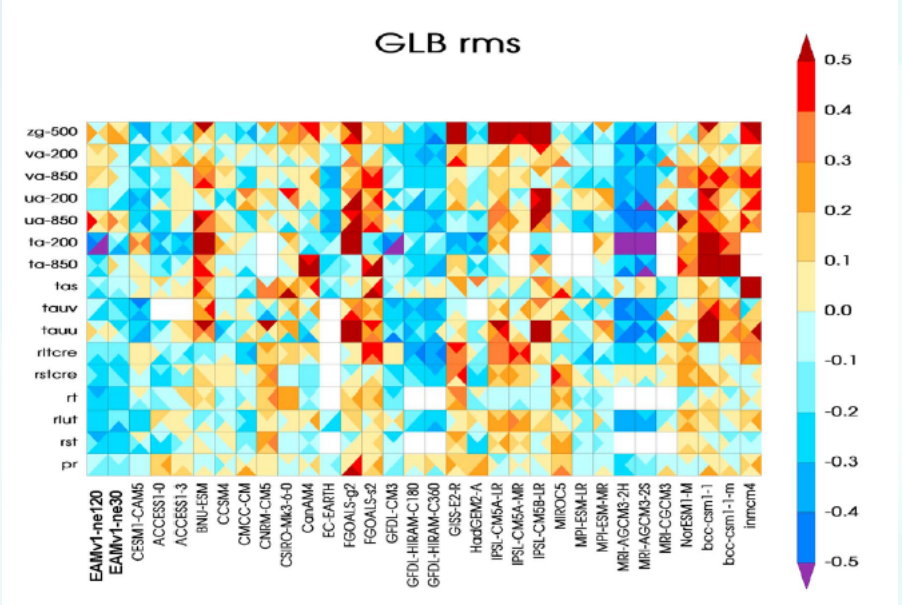
- Physical basis, Performance, Computational cost, Future improvement,
- Potential to work and evolve with next generation

Metrics

- Mean state
- Variability (diurnal cycle, Tropical variability, MCS diagnostics, precip PDF)
- Cloud regime transition (GPCI...)

Existing biases

- Coastal Sc, lack of high clouds over TWP
- Excessive precipitation over tropical IO and warm pool / Lack of precipitation over Amazon and CONUS
- Rain too frequent, too weak
- Double ITCZ
- Wrong diurnal cycle



PCMDI Metrics Package