SHOC

IMPLEMENTATION STATUS

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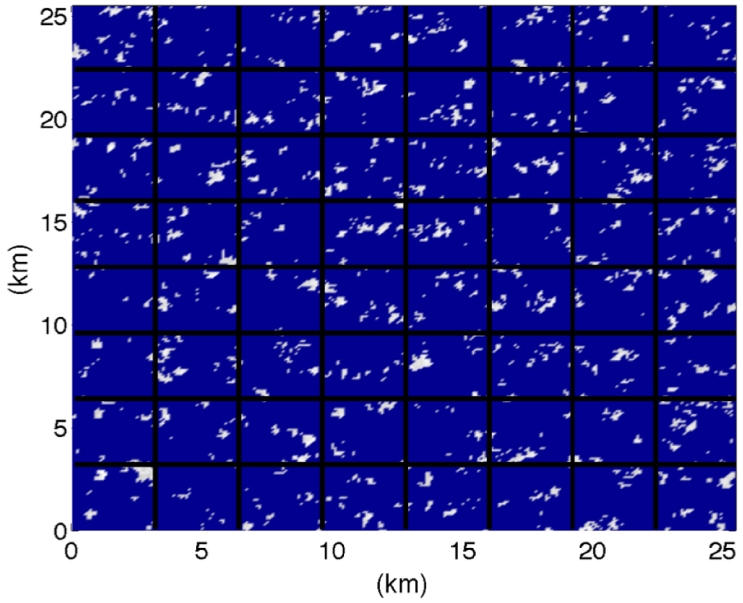
What is SHOC?

- SHOC = Simplified Higher Order Closure
- Reference: Bogenschutz and Krueger (2013)
- The goal of the closure is to represent **subgrid clouds and turbulence** in **cloud resolving models** but at a reduced computational cost compared to similar methods
- PDF-based tri-variate double Gaussian closure
- Similar methods = CLUBB (Vince Larson)

SCREAM is “cloud resolving”!
Why do we need cloud parameterization?!?!

- Technically, we are ”cloud permitting”
- Small clouds and turbulence still need to be parameterized at 1 – 4 km (Cheng et al. 2010)
- These clouds are very important to the climate system
- Neglecting to include adequate SGS parameterization at ~1-4 km will result in unrealistic representation of “small clouds” (Bogenschutz and Krueger 2013)



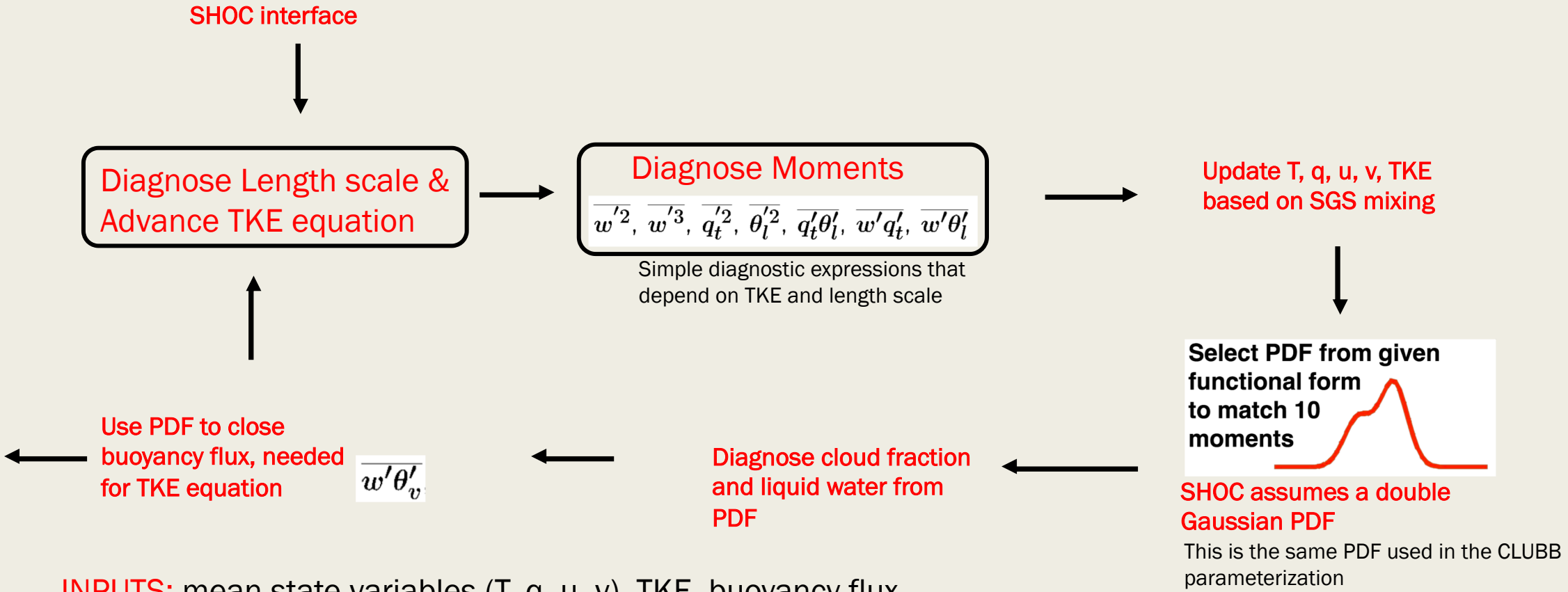
Black lines denote boundaries of CRM type grid spacing (~ 4 km)

Snapshot cloud condensate mixing ratio of trade-wind cumulus from LES (z = 600 m)

A Brief History of SHOC

- Implemented into the System for Atmospheric Modeling (SAM) cloud resolving model
  - *Thoroughly tested for wide range of cloud regimes for grid sizes ranging from 100 m to 25.6 km*
  - *When SHOC is used in the CRM, the simulation of boundary layer clouds is improved compared to baseline CRM*
  - *SHOC is scale aware. As grid box sizes approach LES scales, SHOC will naturally ”shut off”*
- SAM-SHOC was implemented into CAM (super-parameterization)
  - *Improved representation of boundary layer clouds with 10-20% increased computational cost*

SHOC Schematic



INPUTS: mean state variables (T, q, u, v), TKE, buoyancy flux
OUTPUTS: cloud fraction, liquid water, updated T, q, u, v, TKE from SGS mixing

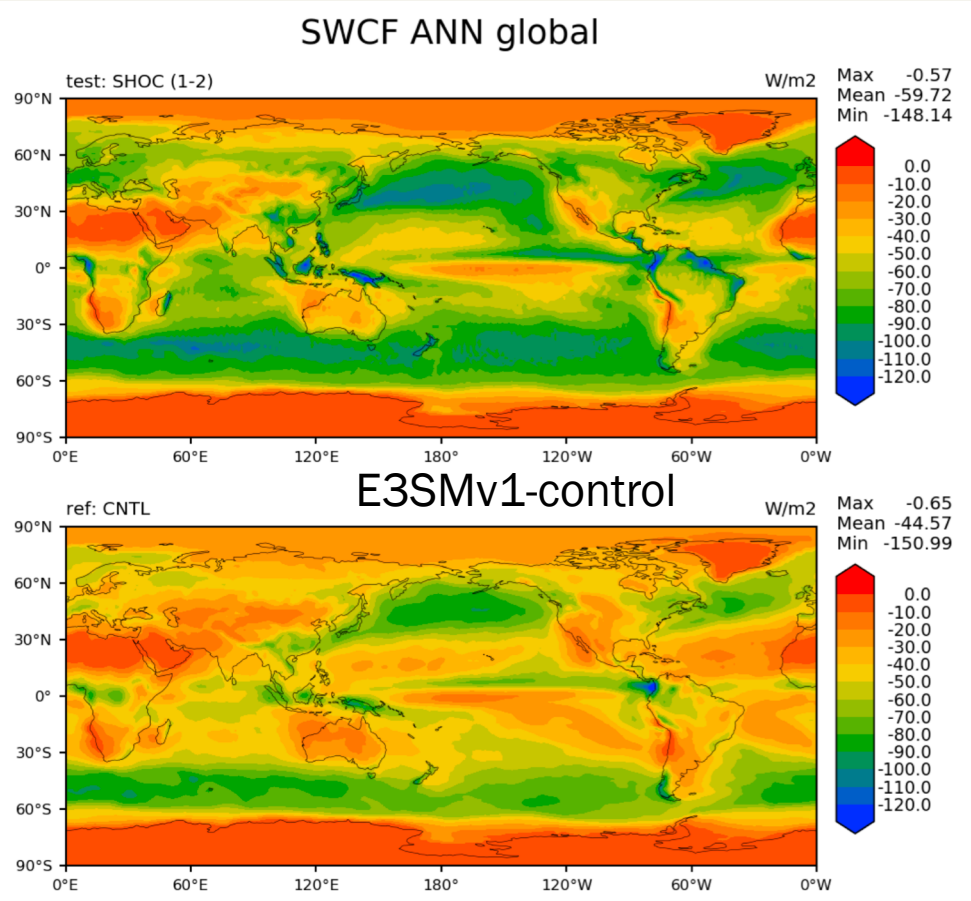
TKE is the only prognostic variable that needs to be saved and advected
Buoyancy flux needs to be saved from timestep to timestep (but not advected)

SHOC Implementation in E3SM

- In SAM implementation, SHOC is “tied” to SAM
- First action item was an implementation of SHOC into E3SM by designing a “clean” parameterization that is independent of any model
  - *Following CLUBB / MG etc. parameterizations as an example*
  - *Now it is possible to “easily” interface SHOC to any model*
- Four to five months of intensive code development and debugging (all done exclusively in the E3SM SCM)
- Two months to get SHOC to run stable in E3SM for two years at a five minute SHOC timestep
  - *Required changing the diffusion solver from an explicit one to an implicit method*

SHOC It To Me (very early results)

E3SM-SHOC (untuned)



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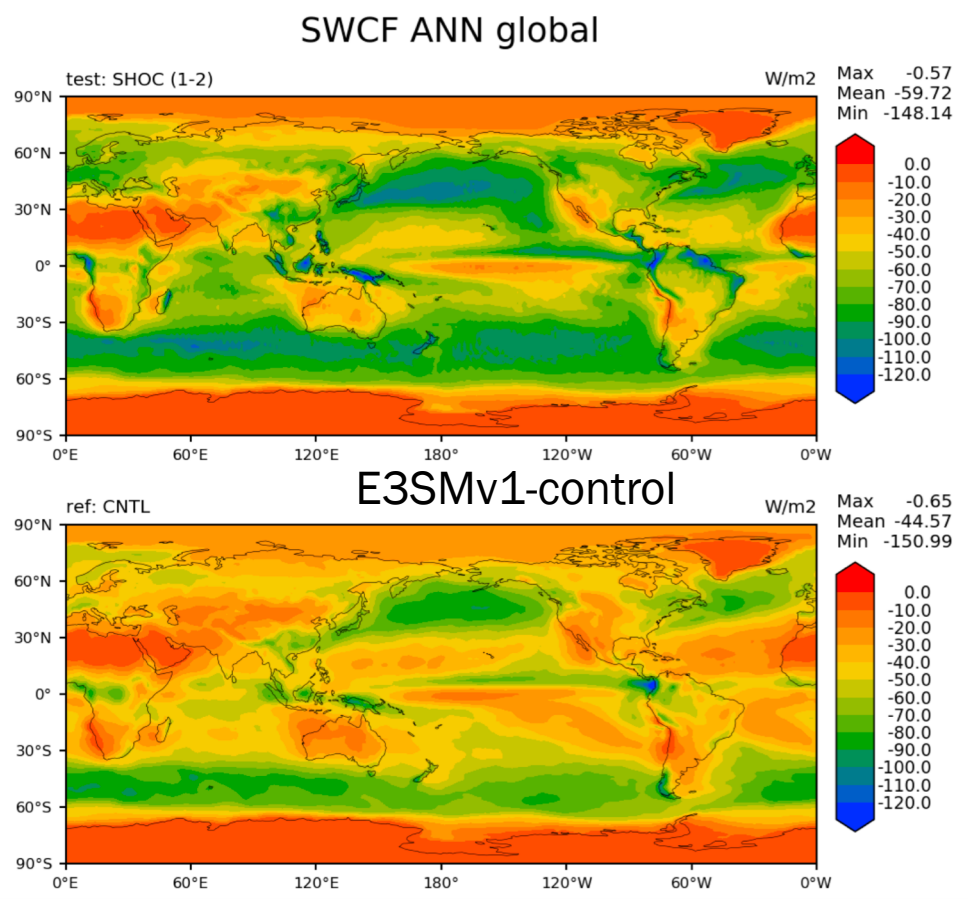
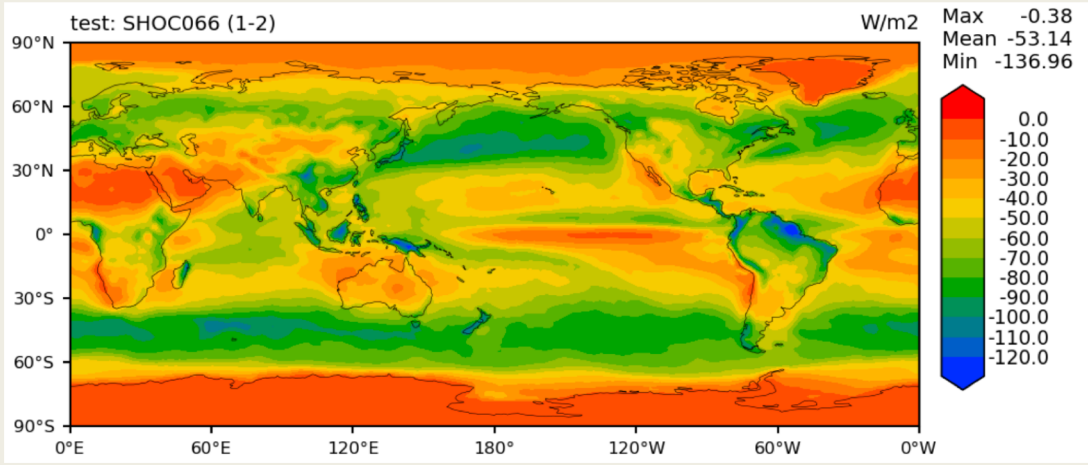


E3SMv1-control

E3SM-SHOC (early tuning attempt)



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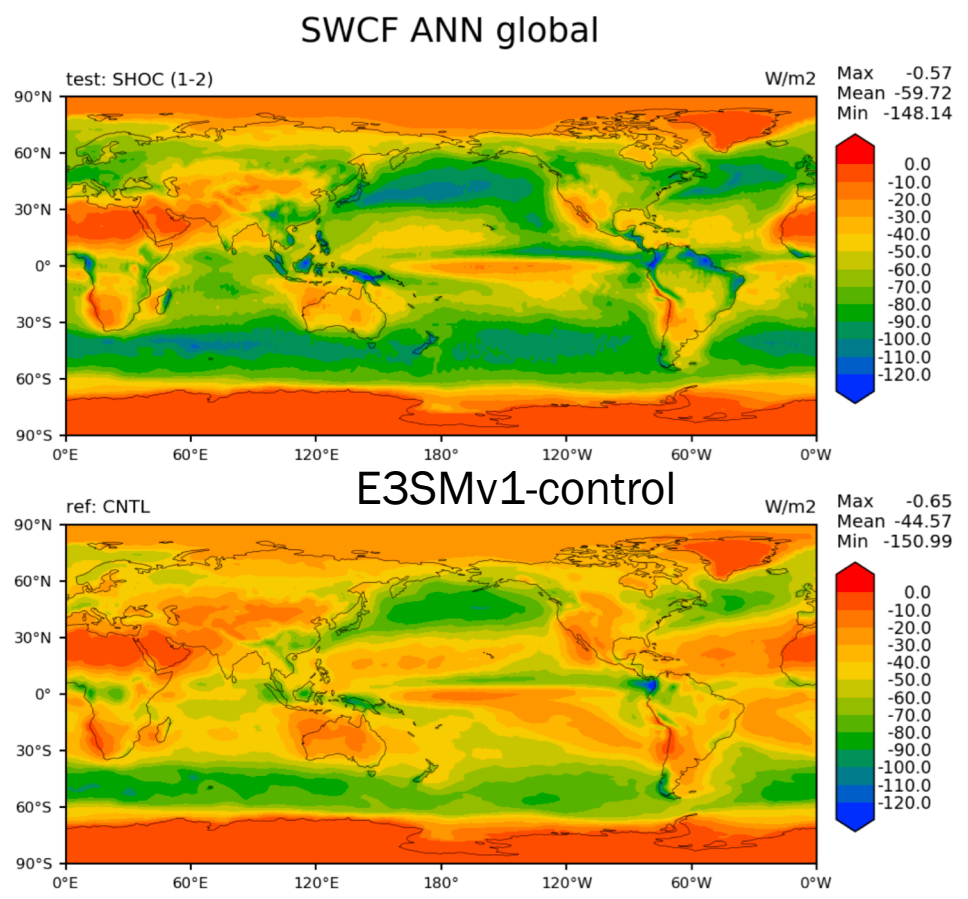

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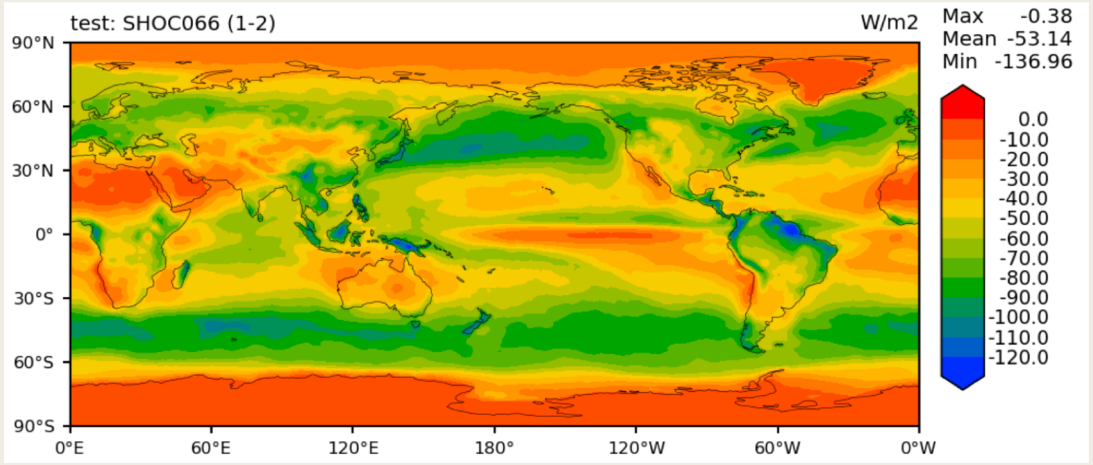
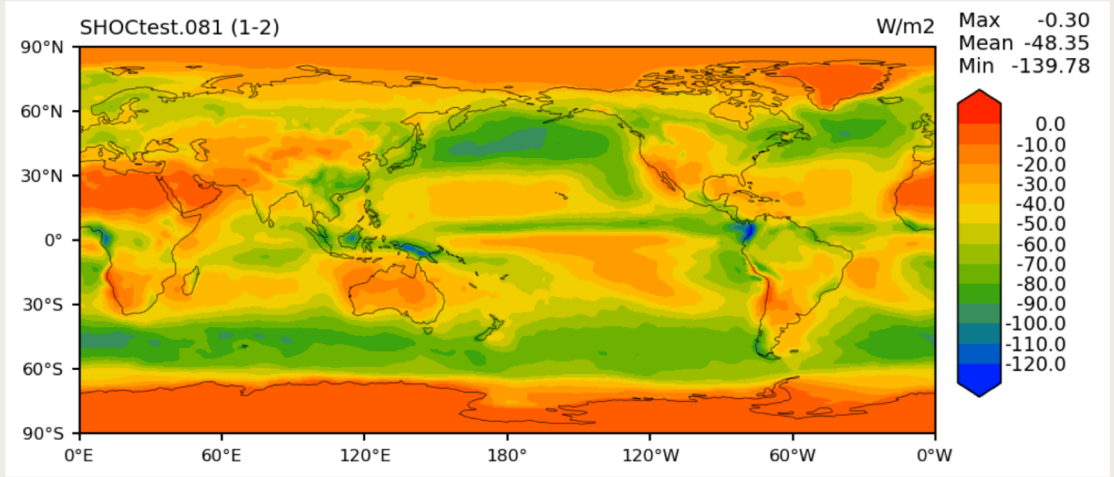


E3SM-SHOC (minor structural change + tuning)



Summary and Roadmap

- Thus far implementation of SHOC into E3SM is reminiscent of experiences of putting CLUBB into CAM
- Currently investigating SHOC sensitivity to minor structural changes
- Getting close to ready to merging SHOC into the SCREAM master (F90)
  - *Will enable tests of SCREAM with P3&SHOC simultaneously*
- Investigate SHOC sensitivity to tuning parameters
  - *Currently there are 7 adjustable parameters*
  - *This number likely to grow or shrink based on sensitivity experiments*