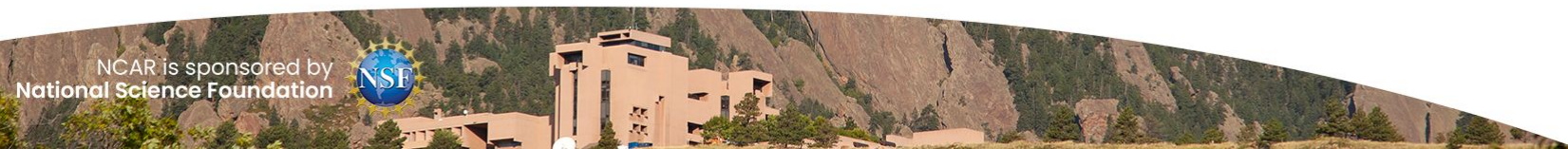


Assembling tropospheric physics in a pre-industrial coupled setup

Adam R. Herrington
Project Scientist II, NCAR
SIMA co-lead for CGD

Special thanks to NCAR software engineers



Towards CAM7

• Coupled Evaluation 1

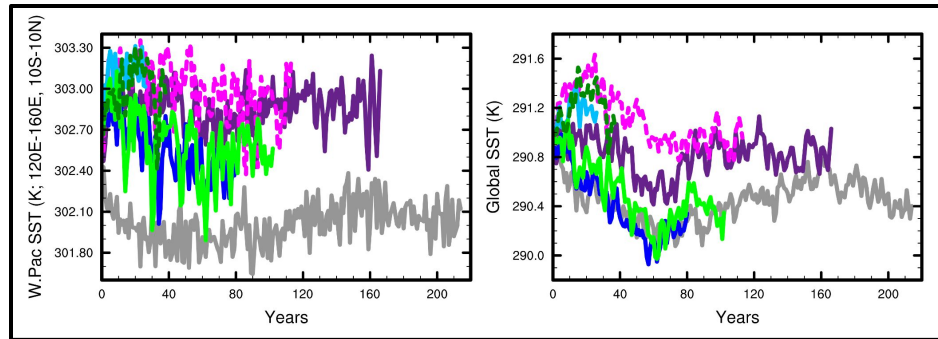
- L58, ZM2, physics reordering & re-align surface stresses in macmic loop
- Coupled run #26g (MOM6, CICE5/6). (Toniazzo, Zarzycki, Santos)

• Coupled Evaluation 2

- Update PUMAS, update CLUBB, update MAM, HB above diff.
- Coupled run #54

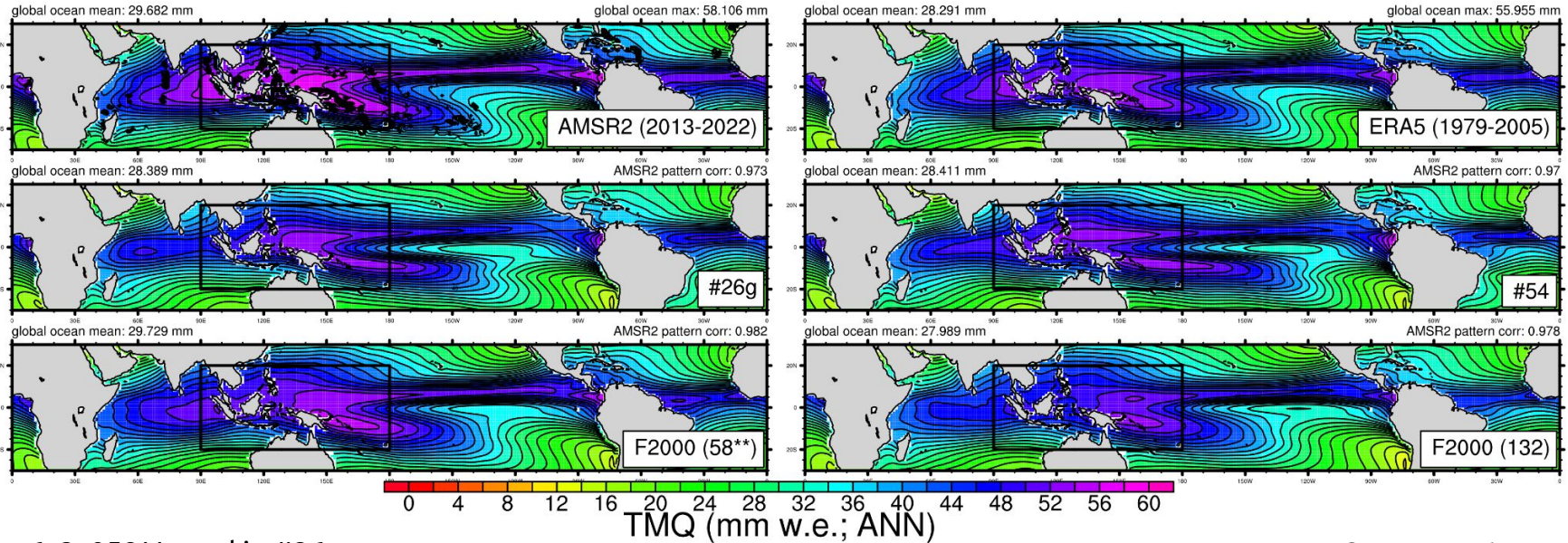
problematic biases → (green)
revisit physics update

#26g
(grey)



From #26g to #54

Tropical total precipitable water is low #54



cam6_3_058** used in #26g
cam6_3_132 used in #54

AMSR2 courtesy of Brian Medeiros



Physics Updates (for Coupled Eval2)

- **PUMASv1** (Gettelman et al. 2023)
 - New process rate - vapor deposition on snow (new limiter just added)
 - Refactor ice limiter, reduce aerosol (dust and bc) seen by ice nucl.
 - Numerical dt - impl. sedimentation, tighten autoconv/accr., fall speed corr.
- **Update CLUBB** (V. Larson, UWM externals)
 - Prognostic momentum fluxes
 - **Turn-off** downgradient diffusion on Θ_l/Q_t^*
 - Allow CLUBB to operate in layers above the tropopause**
- **Turn-on Hack-Boville diffusion above CLUBB**
 - Downgradient Ri diffusion (counter-gradient term is OFF)
 - Active in layers above where CLUBB is active (up to the top of the model)
- **MAM5** (See Simone's talk)

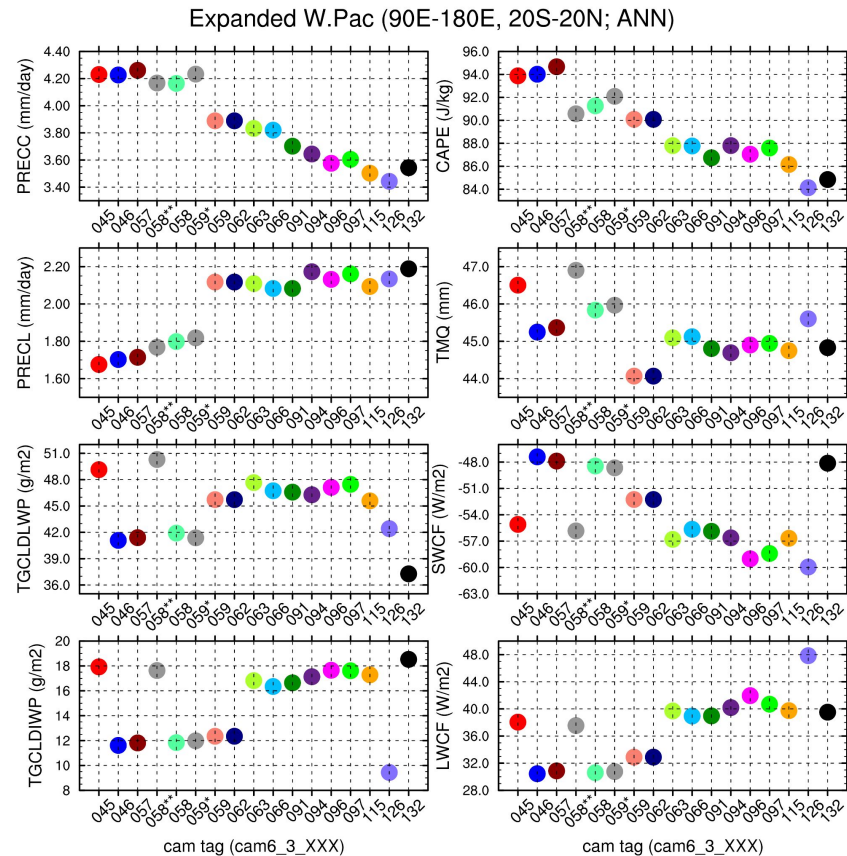
* Diffusion not applied when $LTS > 10$ K

** We do not call CLUBB above 1 hPa

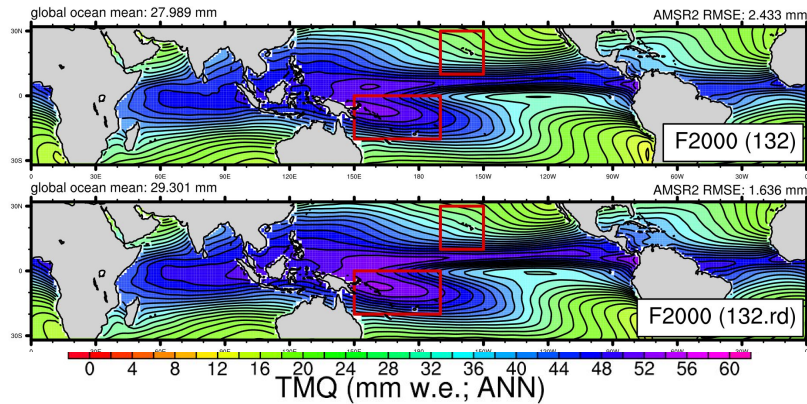
Tag Audit - cam6_3_XXX

10 year L58 F2000dev runs, bracketing all major science changing tags:

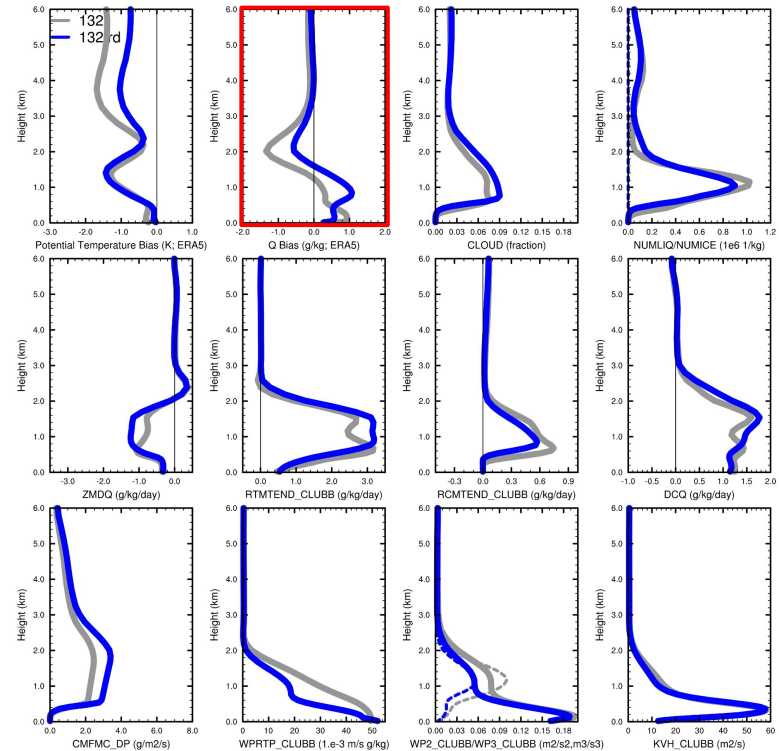
- 046,063,097 : PUMAS updates
- 058** : CoupledEval1 tag
- 059,091,094 : CLUBB updates
- 059* : Revert CLUBB diffusion
- 132 : CoupledEval2 tuning



Revert CLUBB diffusion back on (132.rd)



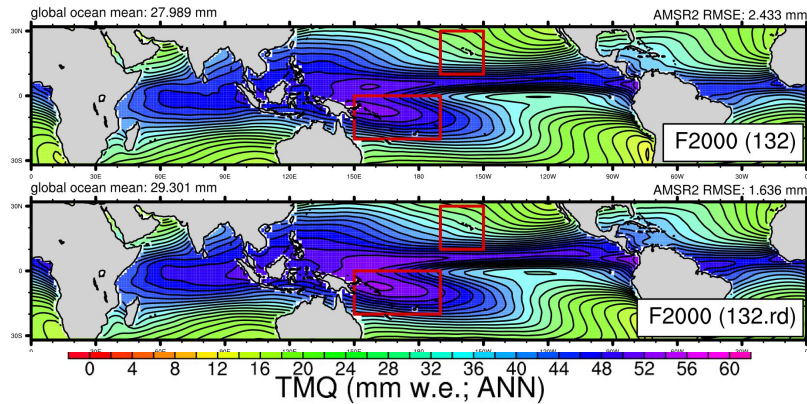
Average over Hawaii Sector (190E-210E, 10N-30N; JJA)



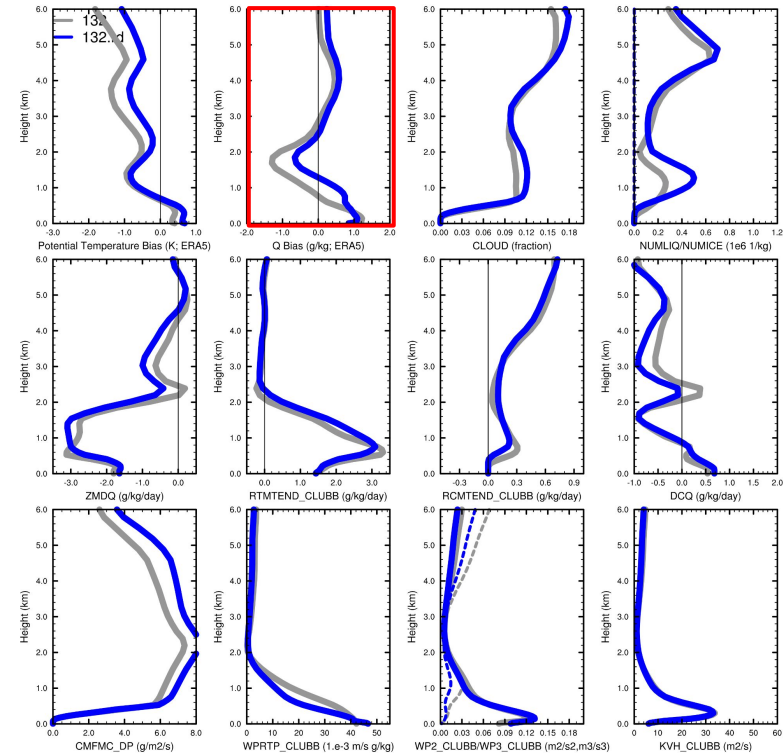
TKE-based downgradient diffusion of $\Theta_{l/Qt}$:

- ❑ Moistens the PBL and shallow layers
- ❑ Resulting in larger values of CAPE
- ❑ Increasing ZM mass fluxes

Revert CLUBB diffusion back on (132.rd)



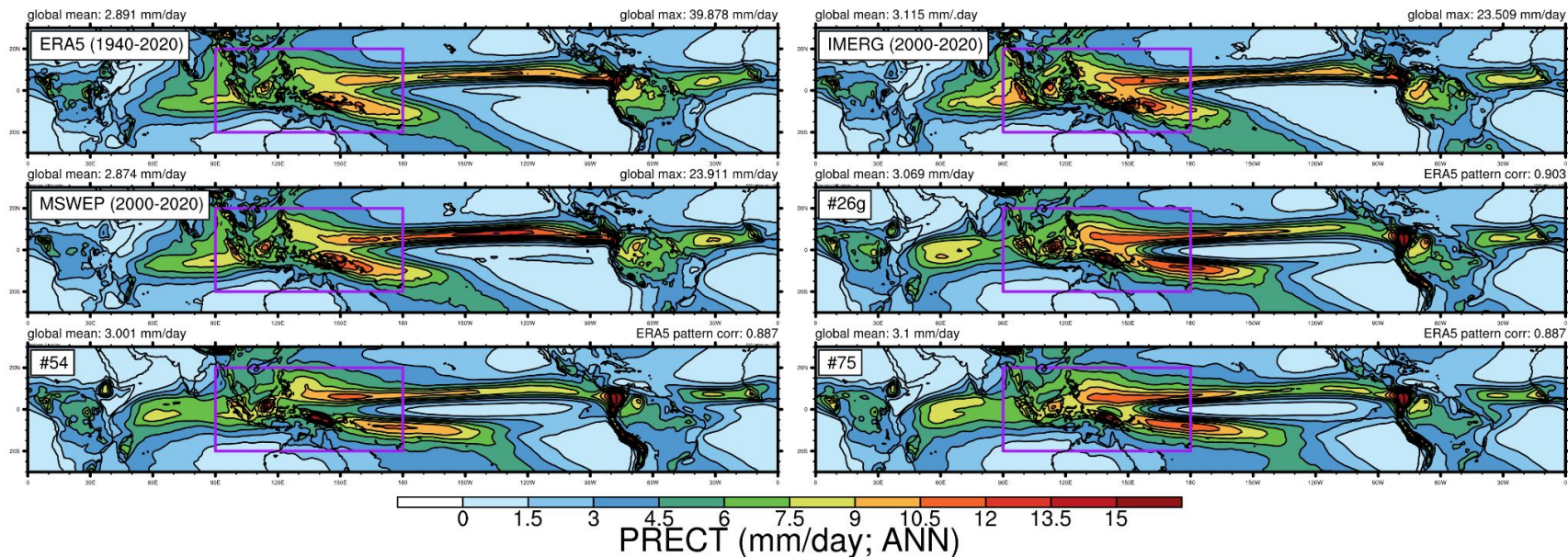
Average over SW.Pac (150E-190E, 20S-0N; DJF)



TKE-based downgradient diffusion of $\Theta_{l/Qt}$:

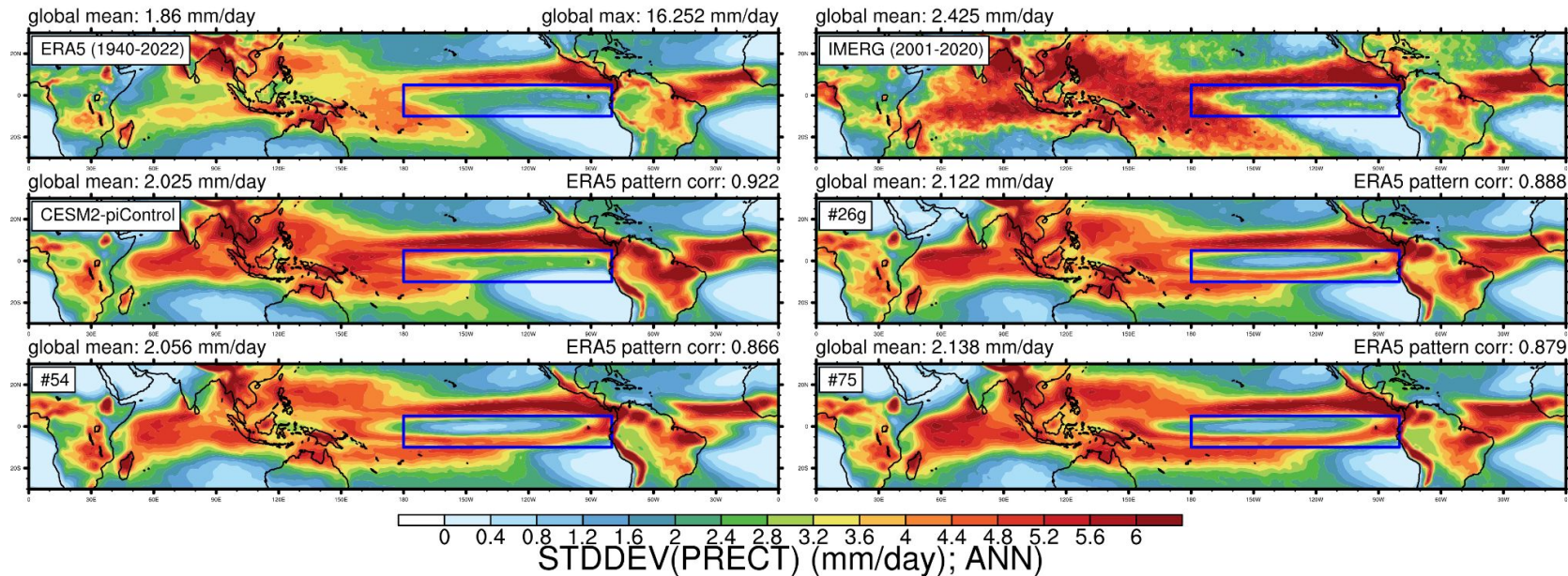
- ❑ Moistens the PBL and shallow layers
- ❑ Resulting in larger values of CAPE
- ❑ Increasing ZM mass fluxes

Coupled run #75



Double-ITCZ in the W.Pac is mostly alleviated in #75.

CLUBB-L branch - coupled run #75



Double-ITCZ in the Central / East Pacific has been problematic since CoupledEval1.

Towards CAM7

• Coupled Evaluation 1

- L58, ZM2, CLUBB reordering, adjust surface stress in macro loop.
- Coupled run #26g (MOM6, CICE5/6).

• Coupled Evaluation 2

- Update PUMAS, update CLUBB, update MAM, HB above diff.
- Coupled run #54 ← **problematic biases, revisit physics**
- **CLUBB-L*** - default L-scale calc, turn on CLUBB diffusion (coupled run #75)
- **CLUBB-taus*** - turn on CLUBB tau's code (Ben's talk, #77)

*Gust param. on
(see Meg's talk)

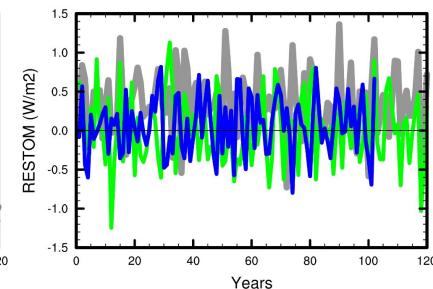
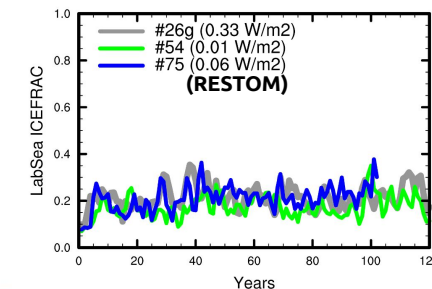
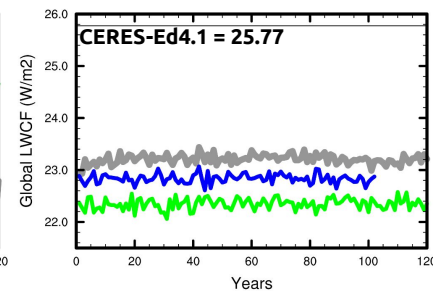
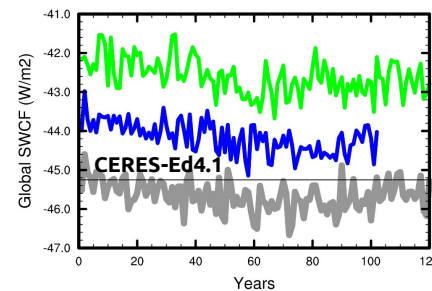
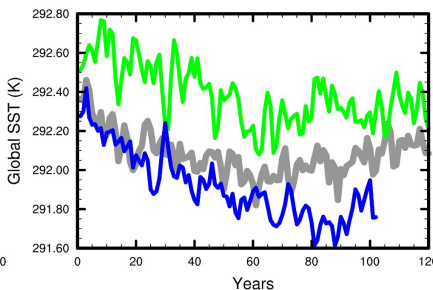
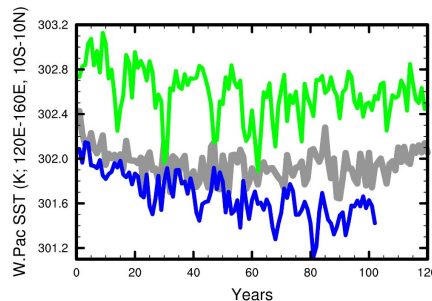
• Coupled Evaluation 3

- RRTMGP
- New enthalpy flux formulation (?) / "moving mountains" gravity source (?)
(see Julio's talk)

Coupled run #75

CLUBB-L Parameter Changes:

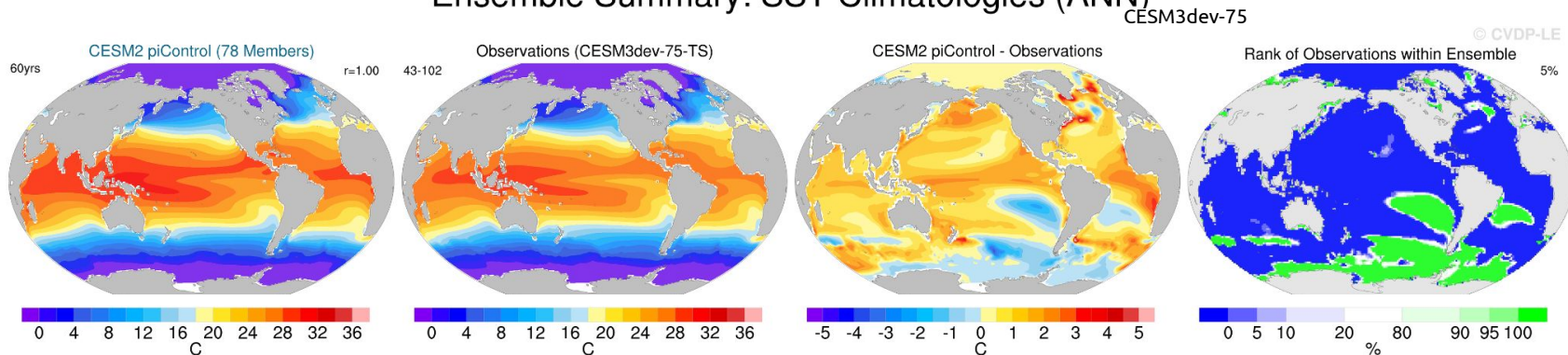
- ❑ `clubb_gamma_coef` = 0.27 → 0.30
- ❑ `clubb_gamma_coefb` = 0.32 → 0.30
- ❑ `clubb_c8` = 4.2 → 4.25
- ❑ `clubb_c7` = 0.5 → 0.1
- ❑ `clubb_c5_uu_shr` = 0.3 → 0.1
- ❑ `clubb_detice_rad` = 25.E-6 → 61.E-6
- ❑ `dust_emis_fact` = 0.7 → 1.3



Coupled run #75

SSTs in #75 are colder than CESM2

Ensemble Summary: SST Climatologies (ANN)



(Figure courtesy of Adam Phillips)

Note: OMWG has not decided on whether to use the 'hycom1' hybrid vertical coordinate, which impacts the SST field.



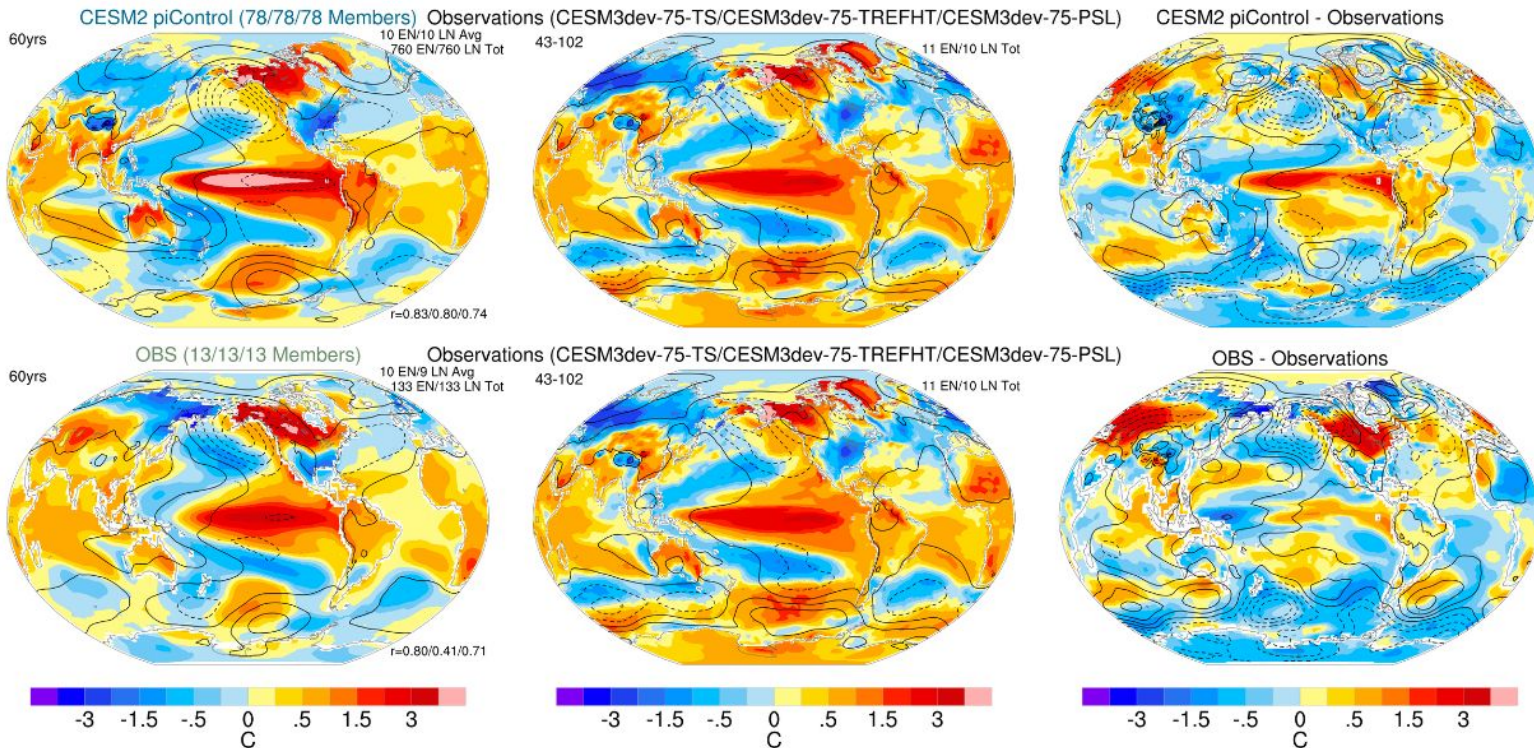
Slide courtesy of Adam Phillips

CVDP-LE Analysis of #75



Ensemble Summary: El Niño - La Niña Spatial Composite SST,TAS,PSL (DJF⁺¹)

© CVDP-LE



Definite improvements seen from CESM2, teleconnections look good despite reduction in Tropical Pacific SST strength

Questions / Comments?



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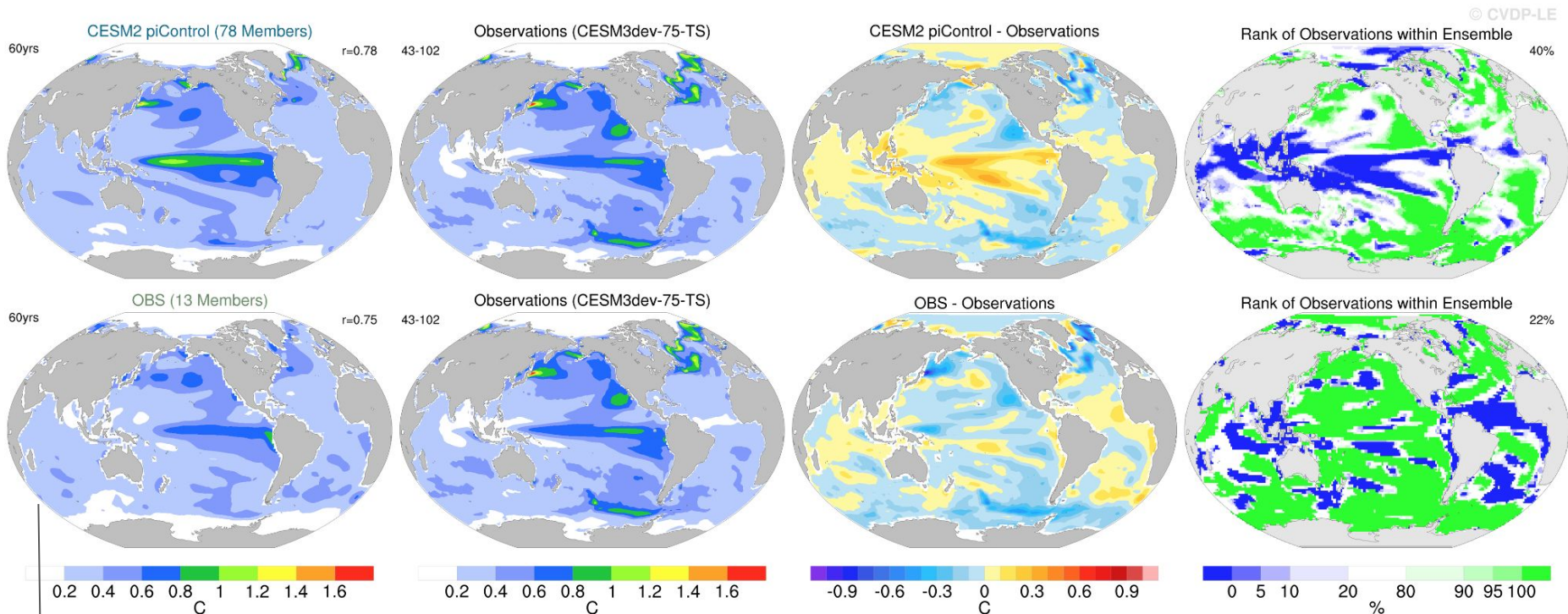


Slide courtesy of Adam Phillips

CVDP-LE Analysis of #75



Ensemble Summary: SST Standard Deviations (ANN)



Average annual SST std dev from 13 60yr slices of observations

Many improvements seen relative to CESM2/observations, but too strong in North Atlantic/Kuroshio regions.

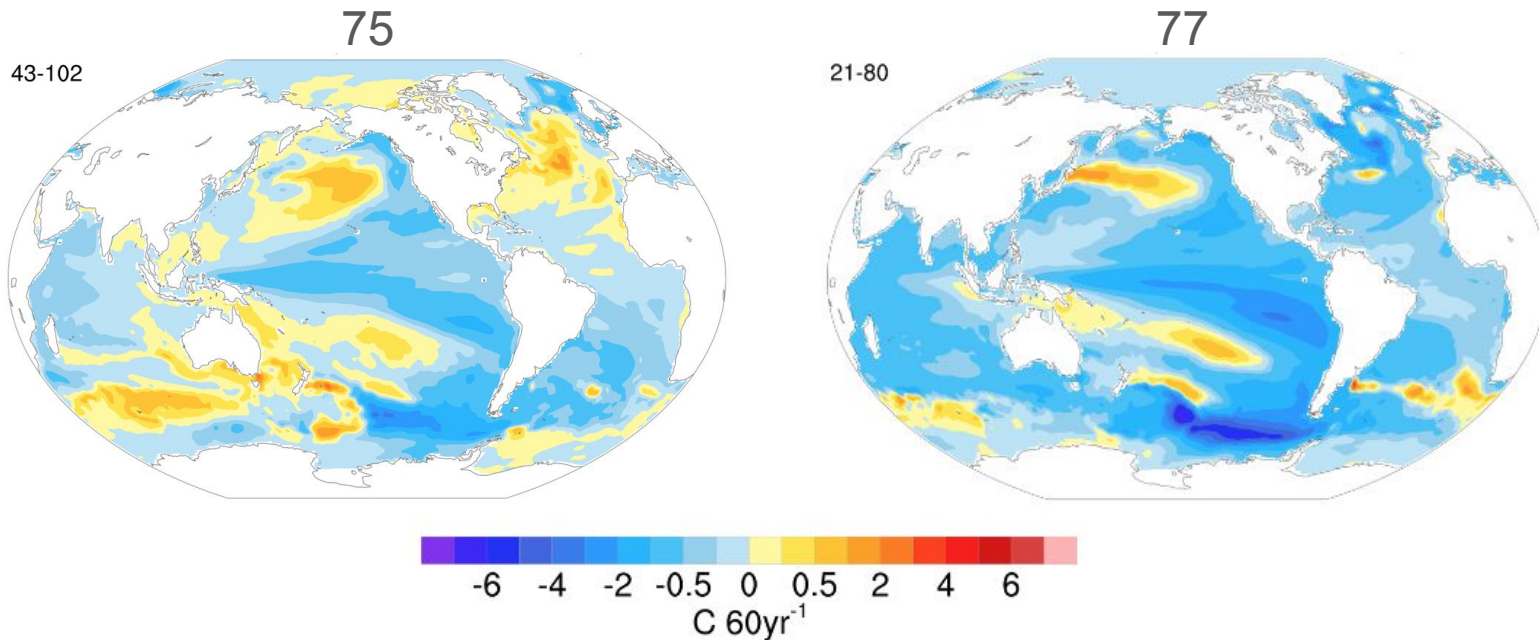


Slide courtesy of Adam Phillips

CVDP-LE Analysis of 75/77



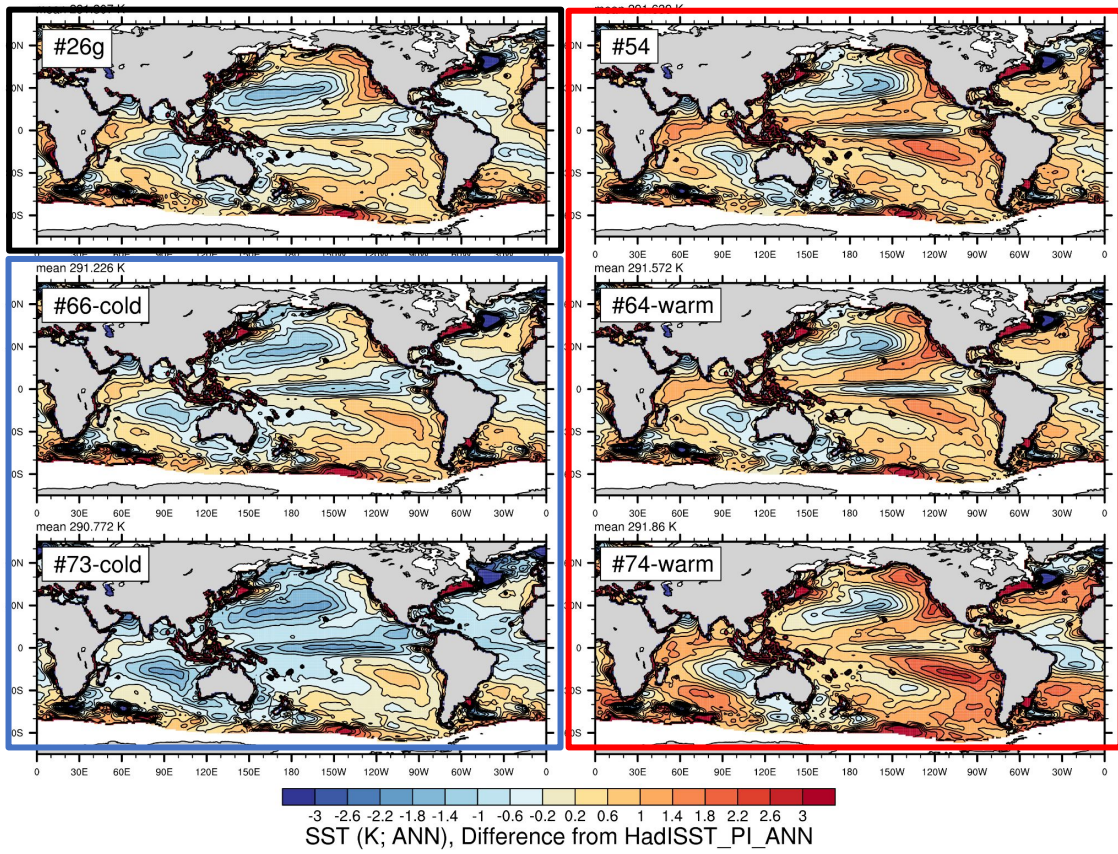
SST Linear Trends (ANN)



Notable SST trends seen in both runs, very strong trends in 77 South Pacific.

The hot and cold configs

+gusts
+ice updates



+gusts



+clubb-taus
+ice updates