HighResMIP: Questions and possible lessons from CAM 25km

Contributions from

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HighResMIP model configurations (1)

- Parallel standard and high resolution integrations
  - STD likely to be default CMIP5/CMIP6-DECK resolution (~100km atmosphere resolution)
  - Hence DECK is benchmark for STD, HI is sensitivity test
  - HI being ~25km atmosphere resolution
- Strongly encourage absolutely minimal differences between STD and HI configurations
  - Vital part of HighResMIP is to look for systematic differences with model resolution across multi-model ensemble
  - If extra tuning is made between different resolutions, it will make it extremely hard to pick apart the causes of differences
  - NOT a beauty contest to have the perfect HI model, we are most interested in the delta between resolutions
- Similarly vertical resolution should be the same in STD and HI

Questions for WGNE on HighResMIP protocol

- Prescribed SST and sea-ice (AMIP-style) integrations
  - Best methods to produce a continuous 1950-2050 forcing set?
  - Seamlessly matching the observed record (to 2014) with anomalies from CMIP5 (from 2015)
  - Can partly use Mizuta et al methodology, but are there techniques to match up decadal variability across observed/projected time boundary
  - Understand that some groups prefer to use slab-ocean rather than fixed SST, but we need a standard protocol for all to follow.
- Prescribed aerosol concentrations
  - Would like all participating models to use similar aerosol concentrations (rather than emissions) to be more comparable, to be produced by RFMIP
  - Is this likely to be possible – different models have very different aerosol schemes and climatologies, different tuning needed conpared to standard model
- Coupled models
  - Ocean spinup techniques that do not involve 100's years of integration
  - Suggestions so far include:
    - interpolation from lower resolution model to reduce cost,
    - use shorter spinup as used in decadal forecasting (fixed atmosphere forcing for period of interest, e.g. 1950 here) until TOA within some bounds.
    - Coupled model will be run as pair of fixed CTL forcing (1950) and transient forcing, hence any residual drift can be subtracted
    - Use EN4 ocean analysis for 1950 start point
- Any other advice on experimental design and protocol to answer questions about impact of model resolution on representation of climate processes

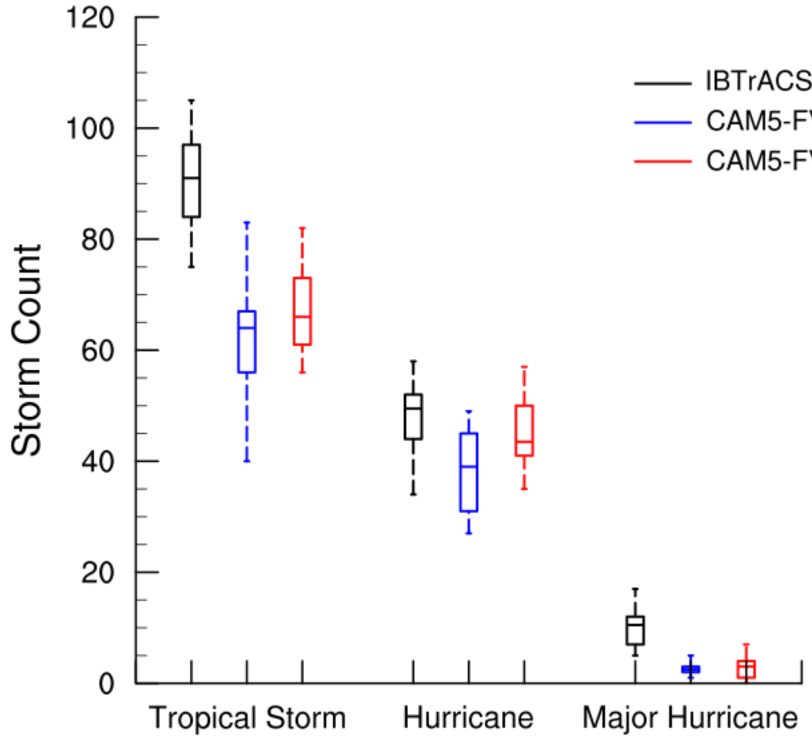
Questions/replies to HighResMIP

- Is continuous 1950-2050 run an optimal use of resources vs. present-day + future "timeslices" (~25 years each, e.g. 1980-2005 and 2075-2100)?
  - More ensemble members to capture internal variability *(Zhao et al. 2009, Deser et al. 2014).* Variability of extremes not yet well understood.
  - "seamlessness" across PD and future not an issue
  - Bigger signal possible, i.e. PD vs 2075-2100 vs 2050
- Demanding use of same prescribed aerosols may not be a good idea.
  - Possible significant impact *(not sure whether this argues "for" or "against")*
  - Shouldn't aerosols be the same or close for the STD and HI configurations of each model? What about models with prognostic aerosols and/or interactive microphysics?
- Do details in air/sea coupling need to be considered?
- Should high-res atmos/low-res ocean be included?
- We have a technique we believe can be used to generate seamless SSTs 1950-2050

Possibly useful CAM experience

- Aerosols appear to matter to TCs. Not clear why.
- Seamless bias-corrected SSTs for present-2100
- Even in AMIP runs atmos/SST coupling details matter

Potential aerosol impacts on TCs

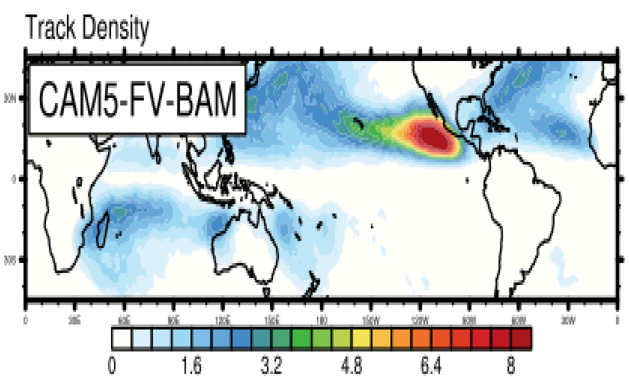


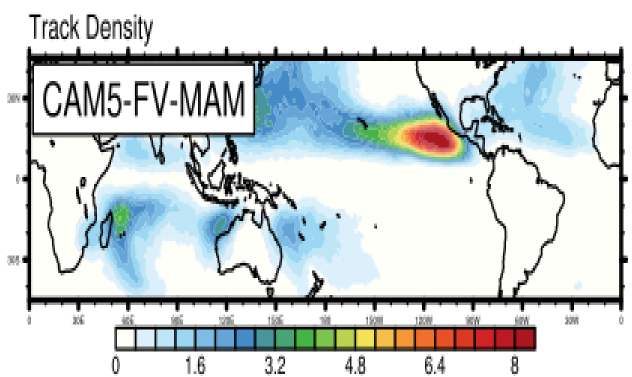
BAM = **B**ulk **A**erosol **M**odel *(prescribed)*
MAM=**M**ulti-modal **A**erosol **M**odel *(interactive)*

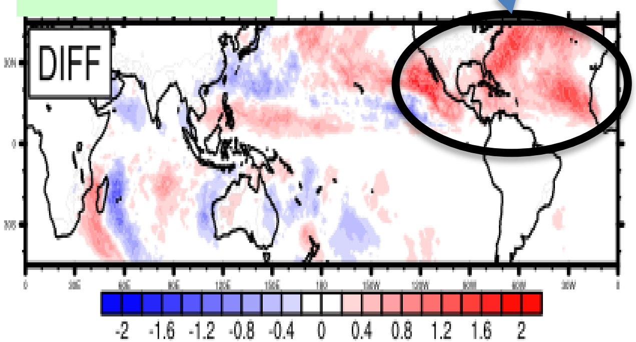
Note: *prescribing aerosols in CAM requires specifying number as well as mass*

MAM *may* reduce N. Atlantic activity by up to 50%

BAM-MAM







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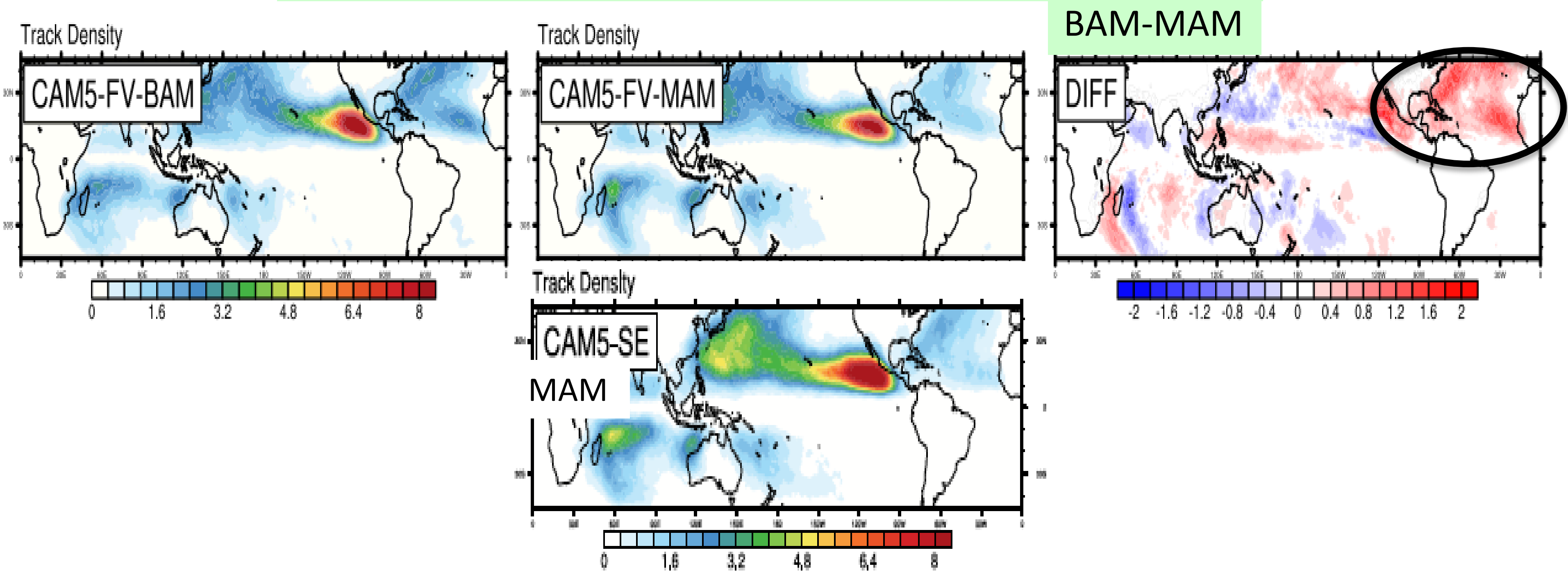

What we don't know

- Role of direct (mean thermodynamics) effect versus indirect (microphysical) effect
- Role of internal variability. Plots compare 30 year climatologies from 30-year AMIP runs.
    - *N Atlantic looks very similar in FV-MAM and SE-MAM but Pacific and Indian Oceans are much more active in SE-MAM*
    - In a position to assess role of variability in the next few weeks

Stop for discussion

- Extra slides show:
  - CAM technique for generating “seamless” PD-future SSTs
  - CAM’s misguided coupling of 1^o observed SSTs to 25km atmosphere on 1^o grid
    - Led to 2x to 3x increase in frequency of CAT3-5 storms

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Extra Slides

Bias corrected SSTs for "Time-Slice" runs

Mean CESM SST bias for month = m at point (x,y) calculated from a present day coupled simulation (years_k=1982-2001)

$$\delta T_{SST}(x,y,\bar{m}) = \frac{1}{N_{years}} \sum_{k=1,N_{years}} T_{CESM}(x,y,m_k) - T_{obs}(x,y,m_k)$$

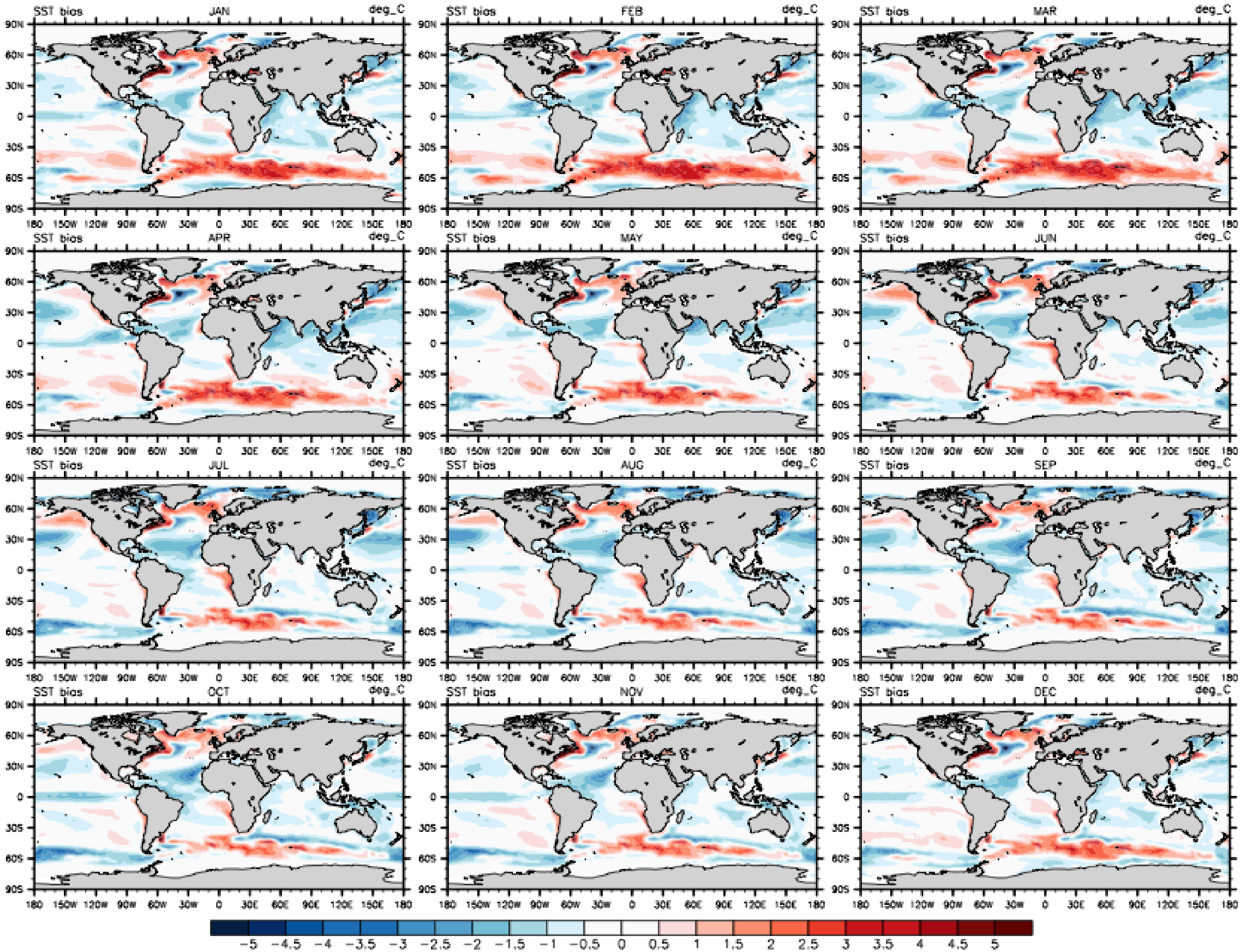
Unbiased SST's for month m_i in any future year_i now estimated by

$$T_{Slice}(x,y,m_i) = T_{CESM}(x,y,m_i) - \delta T_{SST}(x,y,\bar{m})$$

Where T_{CESM} is SST from a coupled 1x1 RCP scenario run.

Assumes bias is constant in time. Interannual variability is contributed by CESM run

Monthly SST biases 1982-2001



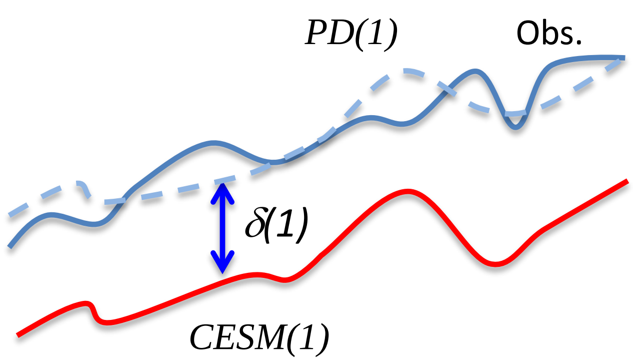
Bias corrected SSTs for “Time-Slice” runs

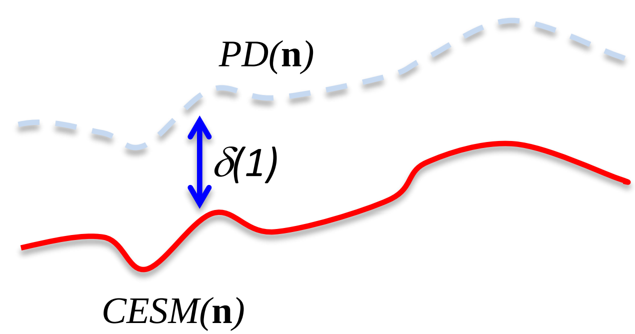
Method is tested by creating “alternate realities” i.e. alternate present day SSTs $T_{PD(n)}$ constructed from present day CESM simulation+bias correction

$$T_{PD(1)}(x,y,m_i) = T_{CESM(1)}(x,y,m_i) - \delta T_{SST(1)}(x,y,\bar{m})$$

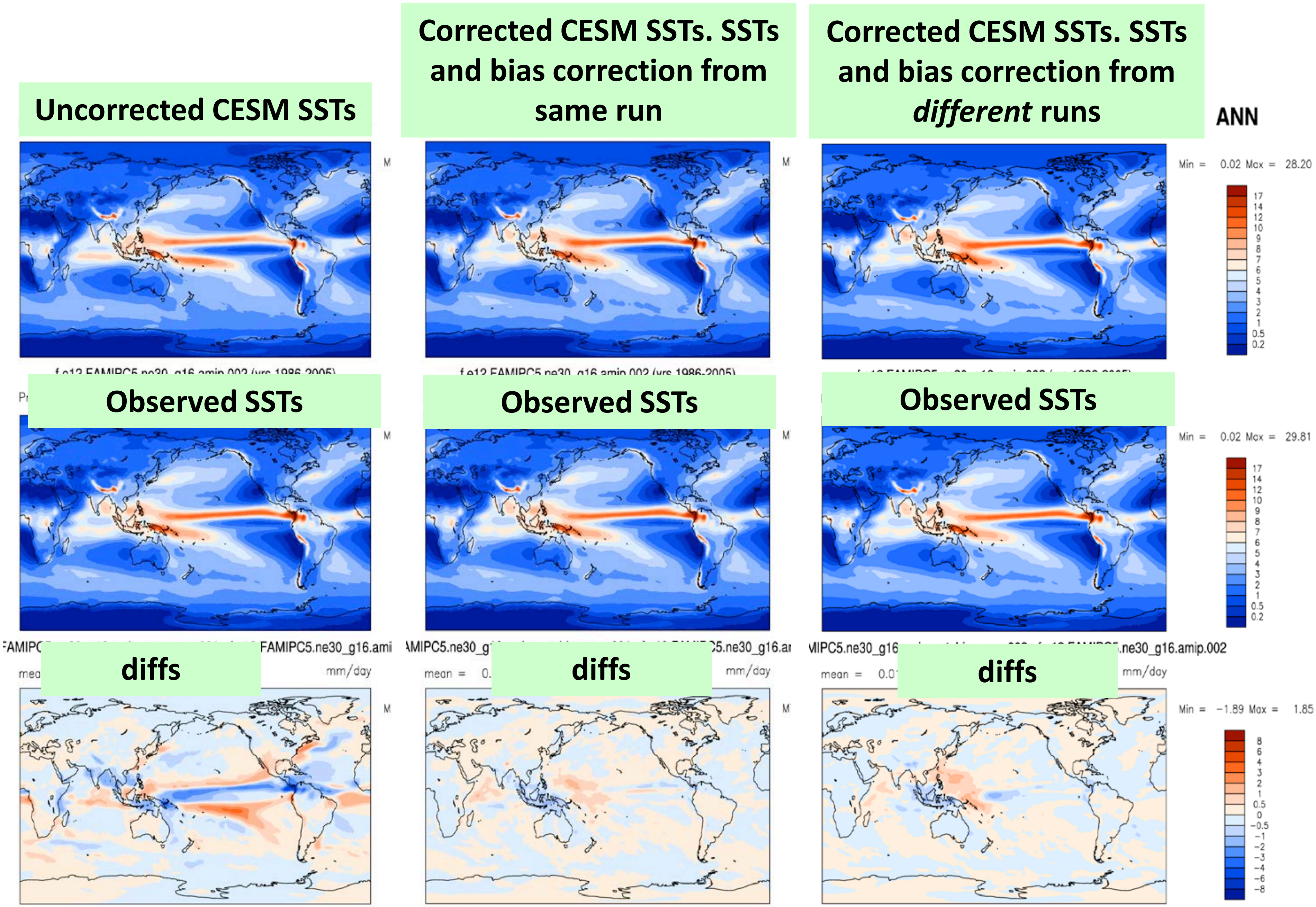
Further test by mixing CESM realizations with bias corrections based on different runs;

$$T_{PD(\mathbf{n})}(x,y,m_i) = T_{CESM(\mathbf{n})}(x,y,m_i) - \delta T_{SST(1)}(x,y,\bar{m})$$

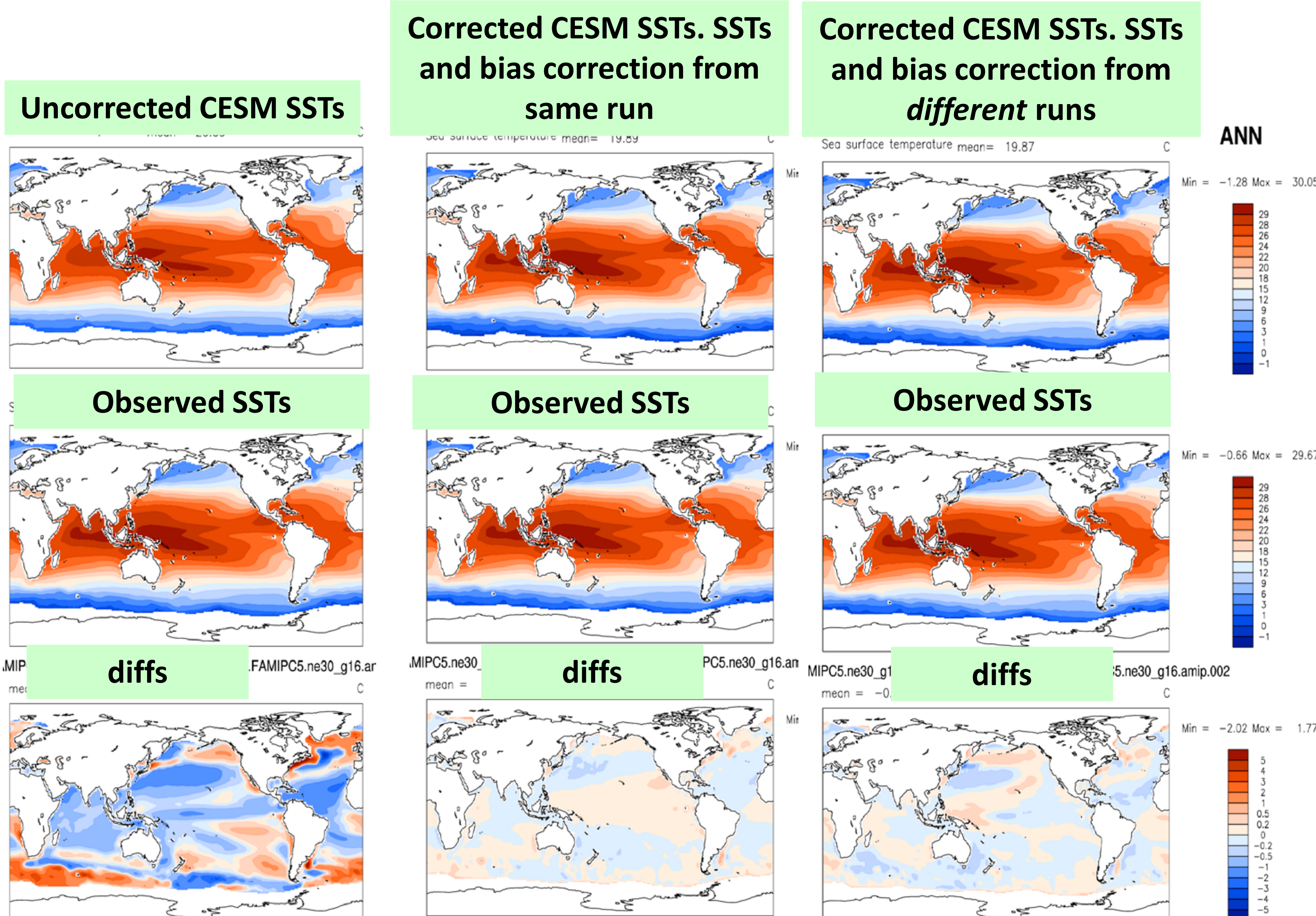




Mean JJA 1986-2005 precipitation (prescribed alternate SSTs) vs AMIP w/obs SSTs



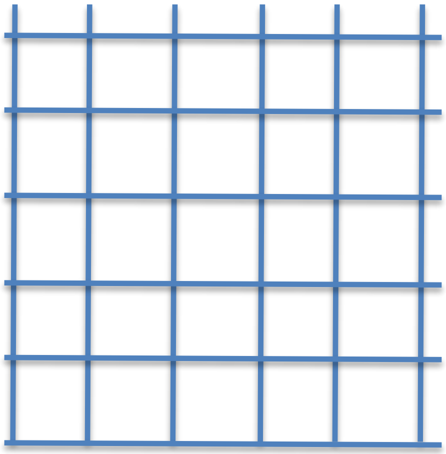
Mean annual 1986-2005 alternate SSTs vs obs SSTs



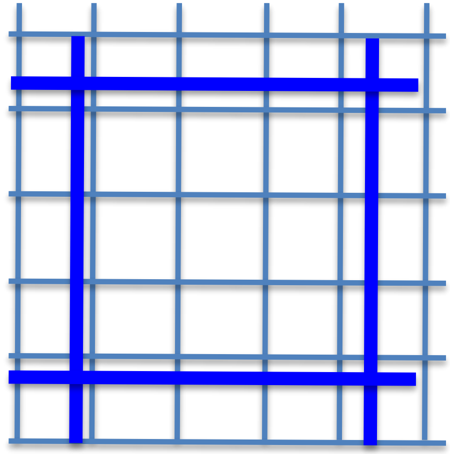
Coupling details may matter

- Current CESM coupler works on ocean grid
- Two approaches have been used
  – First set of ne120 AMIP runs used monthly 1^{o} SST data interpolated on to gx1v6 grid (nominal 1 degree ocean) - “ne120_g16” grid
  – Second set used 1^{o} monthly SST data interpolated onto ne120 SE grid – “ne120_ne120” grid

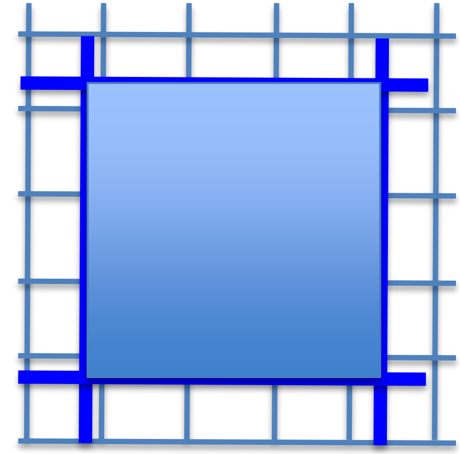
“ne120_g16”



ne120 (~25km) atmos grid

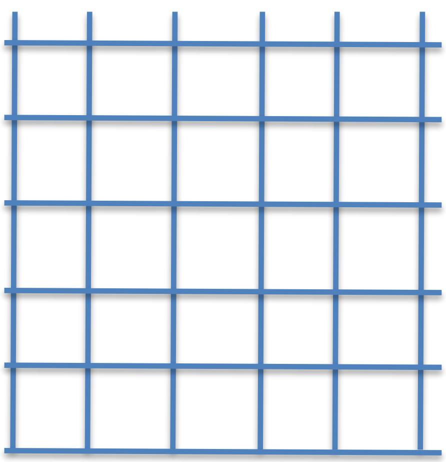


gx1v6 (~100km) ocean grid*

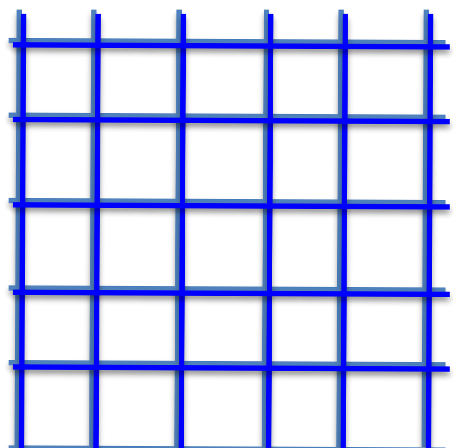


1) Atm fields regridded to ocn. 2) atm/ocn fluxes calculated on gx1v6 ocean grid. 3) Fluxes regridded back to atm

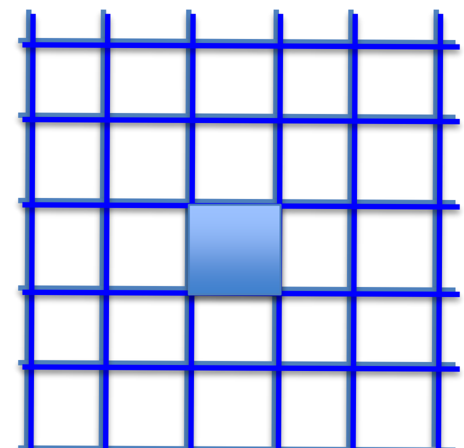
“ne120_ne120”



ne120 (~25km) atmos grid



ne120 (~25km) ocean grid*

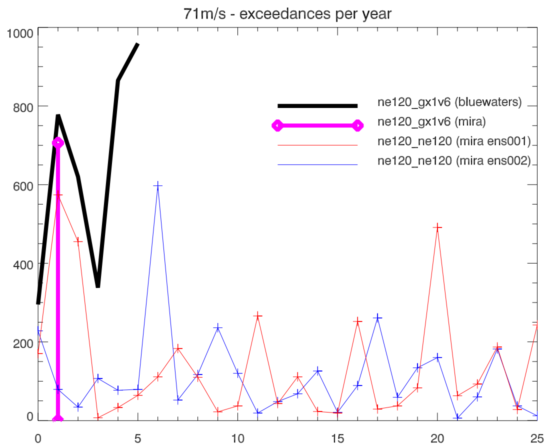


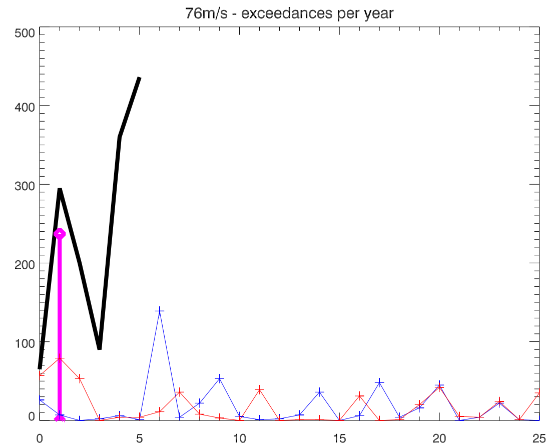
No regridding for flux calculation needed since atm/ocn grids are the same

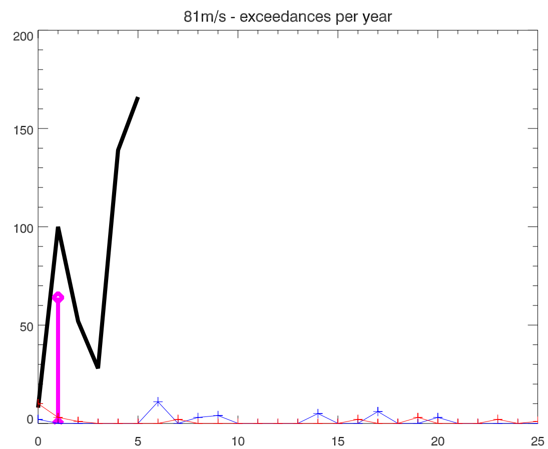
**Note: In both cases, ocean SSTs are interpolated from same 1^{o} dataset*

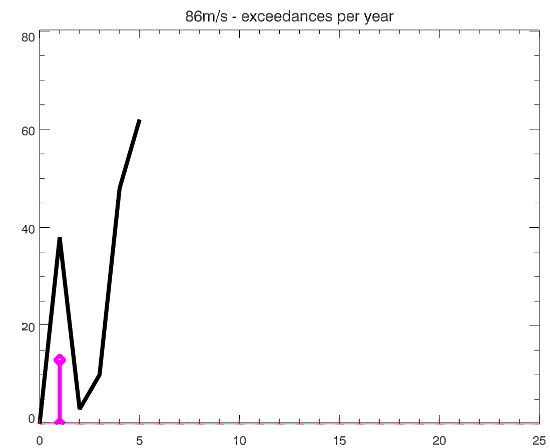
of occurrences of 50m wind speeds > threshold

(per-year, 3hrly instantaneous, 30S-30N)

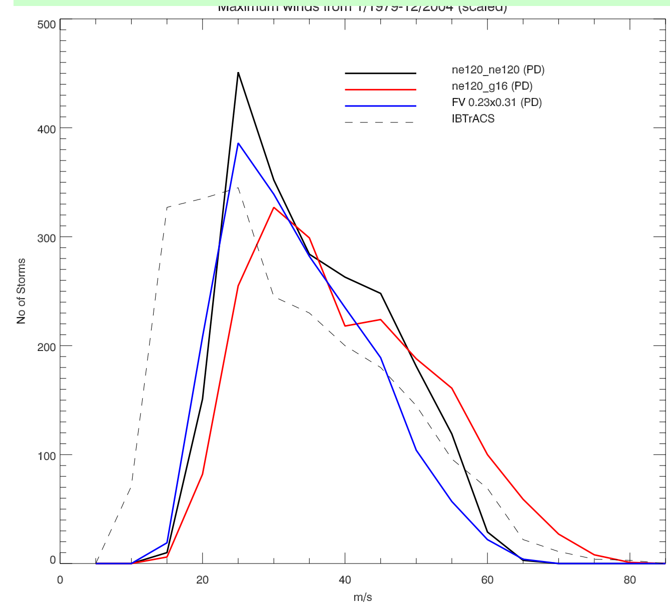








Windspeed PDFs along TC tracks



ne120_g16 coupling produces significant increase in extreme winds, leading to altered TC statistics

AMIP runs and time-slice runs at 25 km

All runs untuned, i.e., 100km physics settings used at 25km

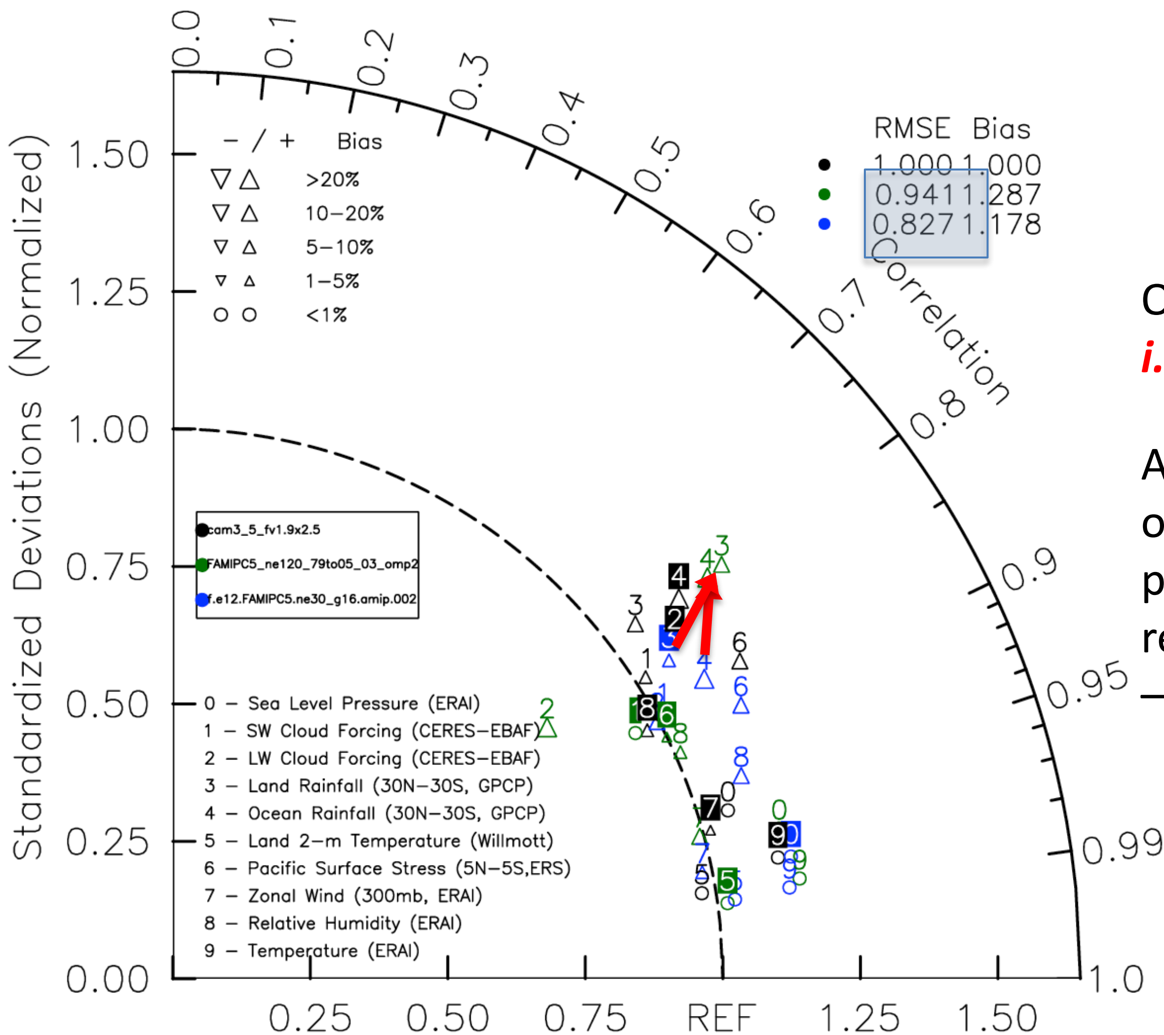
Experiment	period
Present day AMIP runs (ne120_ne120)	
f.e13.FAMIPC5.ne120_ne120.1979_2012.001	1979-2010
f.e13.FAMIPC5.ne120_ne120.1979_2012.002	1979-2010
f.e13.FAMIPC5.ne120_ne120.1979_2012.003	1979-2010
Future Time-slice runs	
f.e13.FAMIPC5.ne120_ne120.RCP85_2070_2099.001	2070-2100
f.e13.FAMIPC5.ne120_ne120.RCP85_2070_2099.002	2070-2100
f.e13.FAMIPC5.ne120_ne120.RCP85_2070_2099.003	2070-2100
Alternate SST runs	
f.e13.FAMIPC5.ne120_ne120.RCP85_2070_2099_sst2.001	2070-2087 (continuing)
f.e13.FAMIPC5.ne120_ne120.RCP85_2070_2099_sst3.001	2070-2100
ne120_g16 runs	
FAMIPC5_ne120_79to05_03_omp2	1979-2010
f.e12.FAMIPC5.ne120_g16.amip.001	1979-1990 (continuing)
f.e12.FAMIPC5.ne120_g16.rcp4.5.001 ***(RCP4.5)***	2070-2100
FAMIPC5_ne120_2070to2100_03_omp2 ***(RCP8.5)***	2070-2100
0.23x0.31 FV runs	
cam5_amip_run1 *(prescribed BAM aerosols)*	1979-2008
f.e13.FAMIPC5.02_02. …. *(fully prognostic MAM3)*	1979-2010

Summary Taylor diagram for 1980-2005 AMIP runs

Black – CAM3 FV 1 Deg

Blue – CAM5 ne30 (100 km)

Green – CAM5 ne120 (25 km)

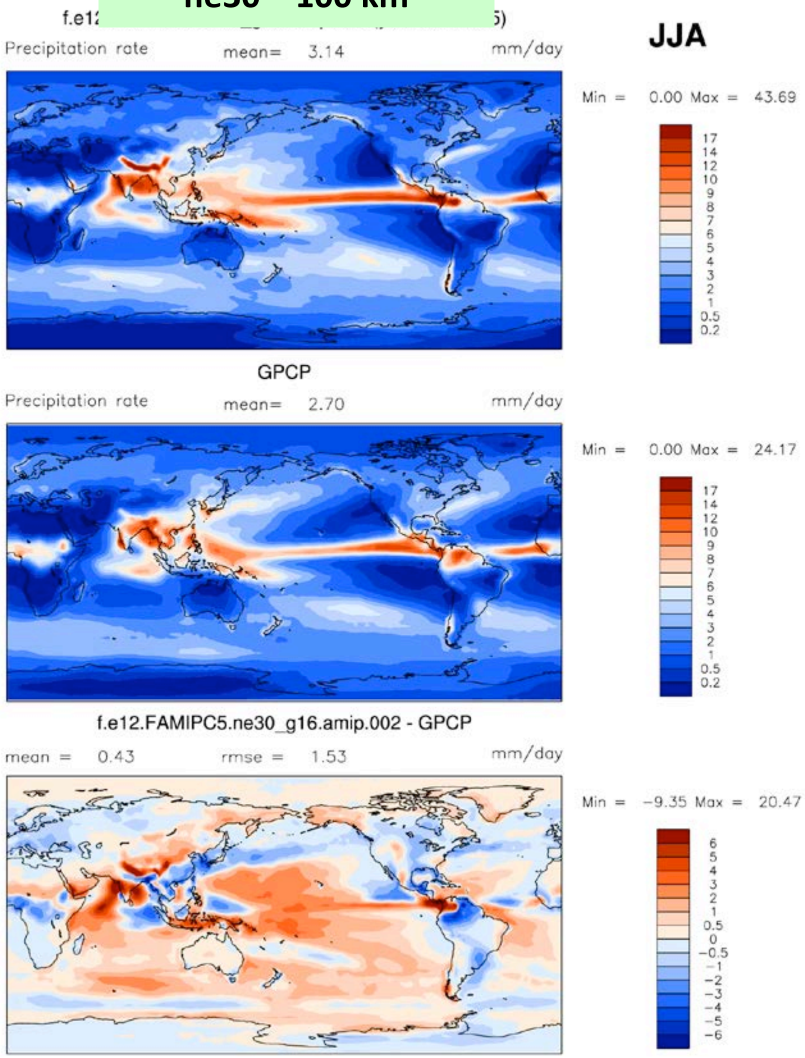


Overall RMSE ***lower, i.e. better, for ne30***

Arrows show change of land and ocean precipitation as resolution increases –***both degrade***

JJA Seasonal-mean precipitation (1980-2005)

ne30 – 100 km



ne120 – 25 km