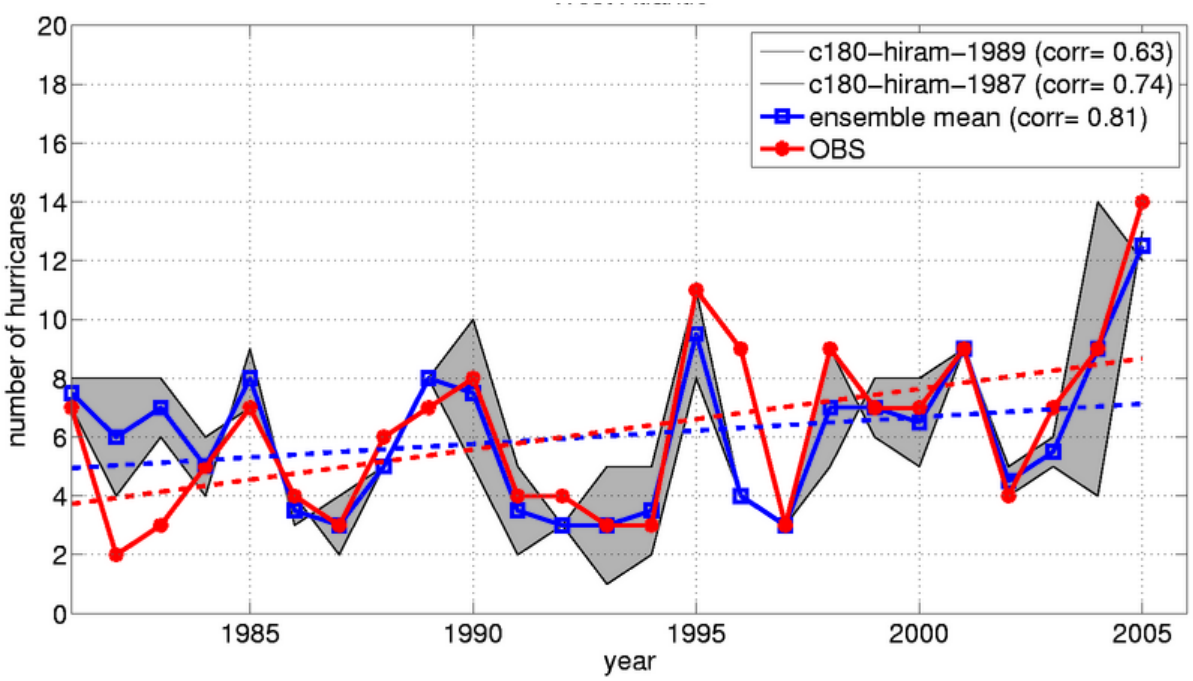
Prediction and Attribution of Regional Climate Change

Isaac Held/GFDL

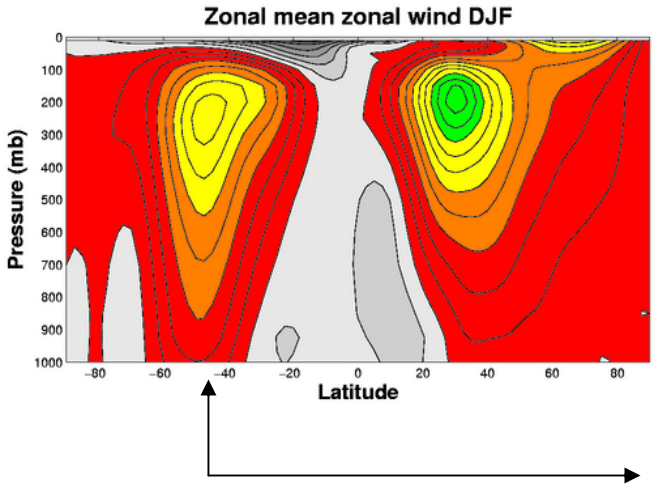
Attribution is as important as prediction

Example: Atlantic hurricane frequency



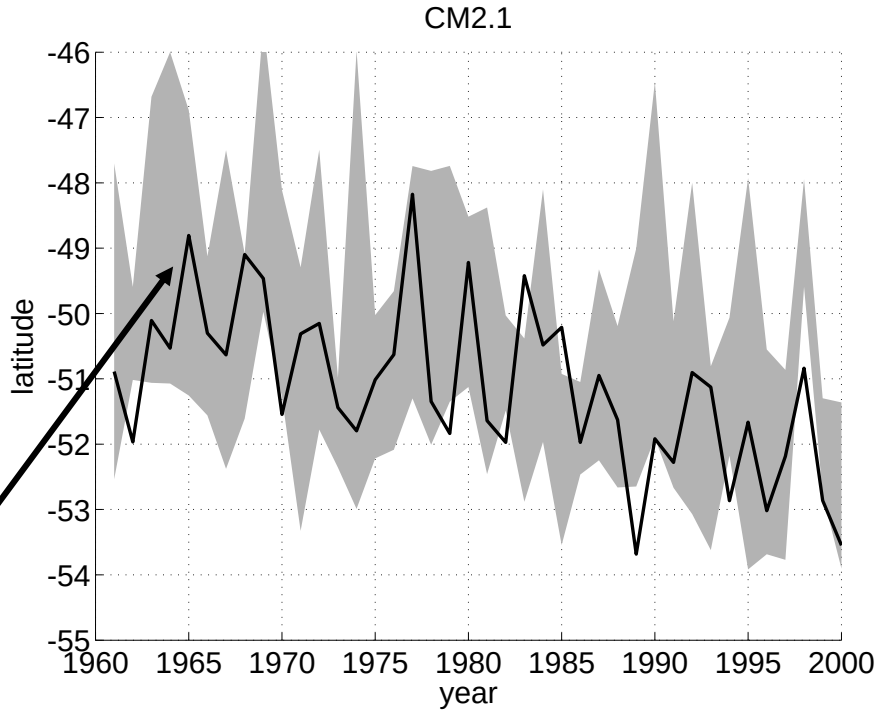
50km global model (modified version of GFDL/AM2.1) with prescribed SSTs

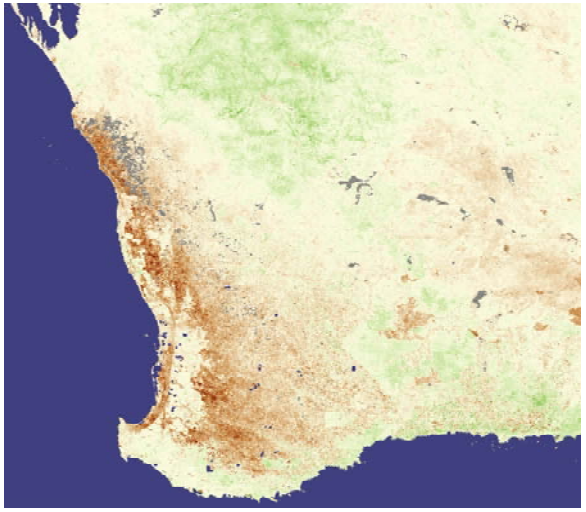
poleward movement of Southern Hemisphere surface westerlies



ERA-40

Ensemble of climate model runs GFDL/CM2.1

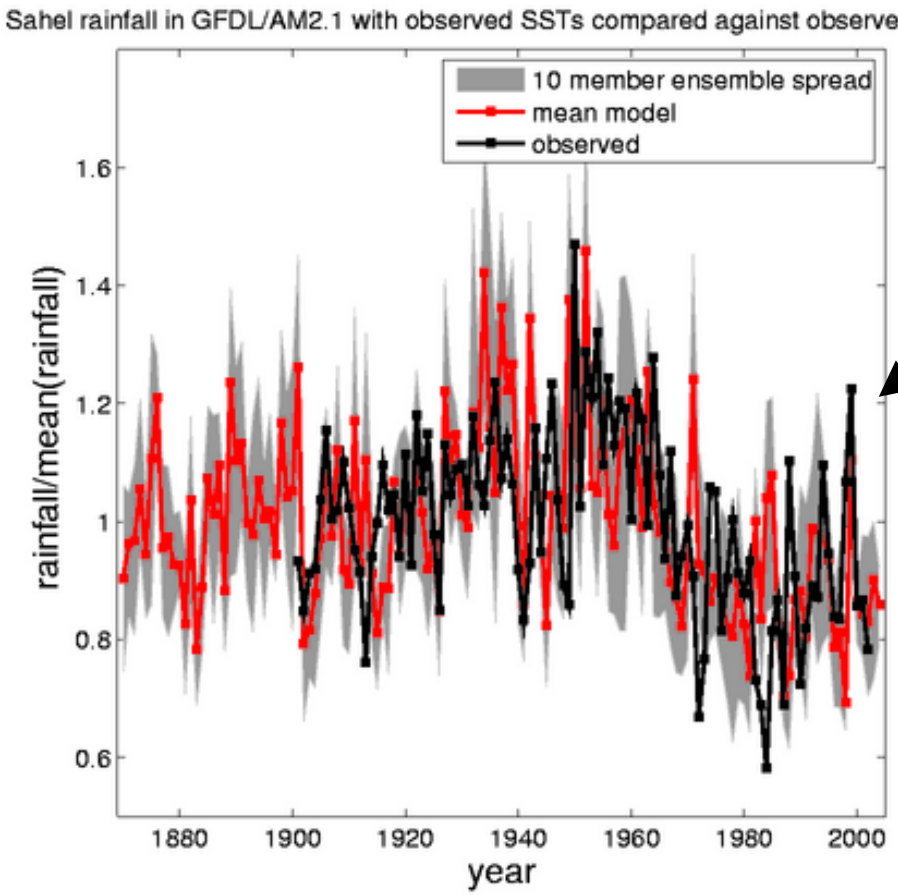




NDVI vegetation index anomaly in June 2006

Sahel drought

known to be related to interhemispheric SST gradients
(Folland, Palmer, Parker 1986)



models can simulate the observed
long term variations in *Sahel* rainfall
if given the observed
ocean surface temperatures

Dynamical downscaling

-- technical issues are not fundamental

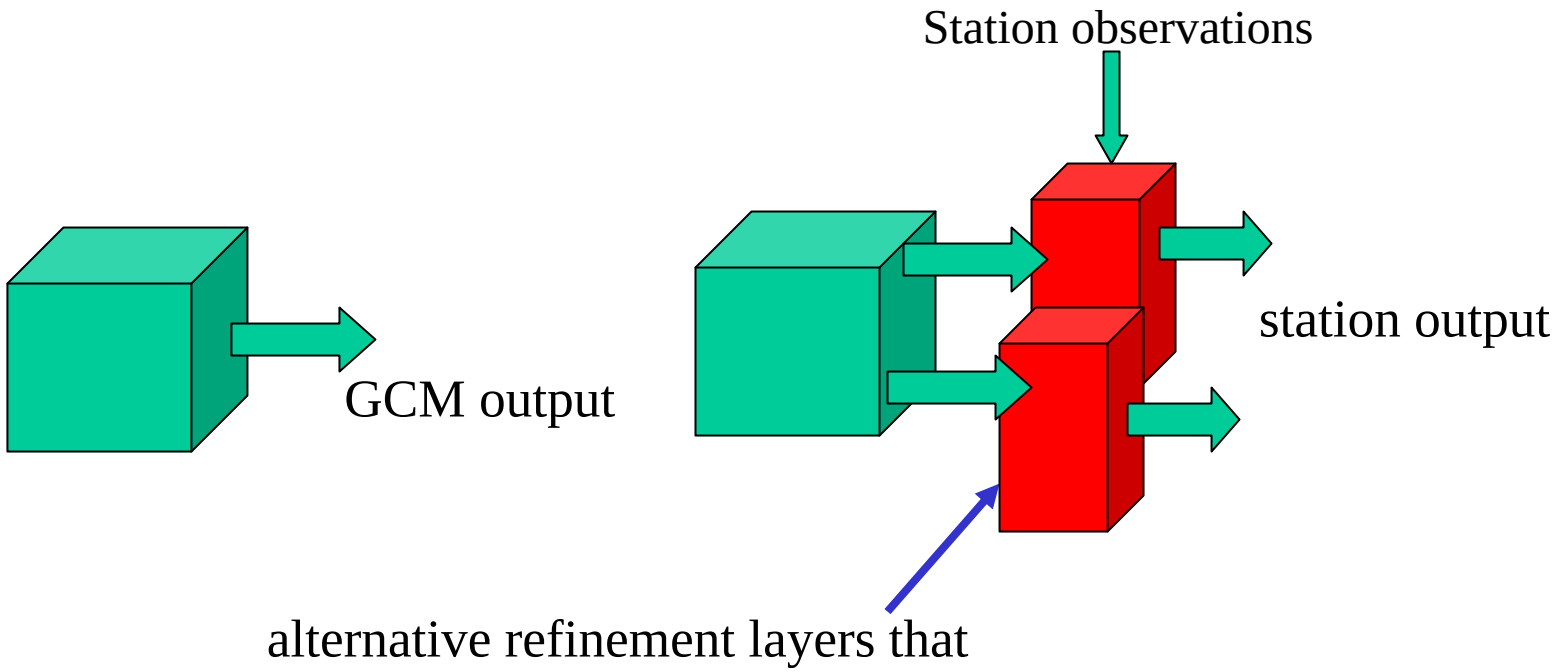
-- value of regional climate change modeling is primarily limited by quality of input from global models

$\Rightarrow$ Regional models will become more valuable as input from global models improves

statistical downscaling

Statistical downscaling is part of the refinement that should *routinely* accompany climate model output.

Can we agree on more systematic procedures?



downscale the world

atmospheric “time-slices”

Tempting -- but uncoupling can cause problems:

Bretherton+ Battisti, 2000; fixed SSTs artifically enhances thermal damping

Douville, 2006: cannot duplicate coupled model Monsoon response to warming

Copsey, Sutton, Knight 2006; Indian ocean slp not simulated by fixed SST atmosphere

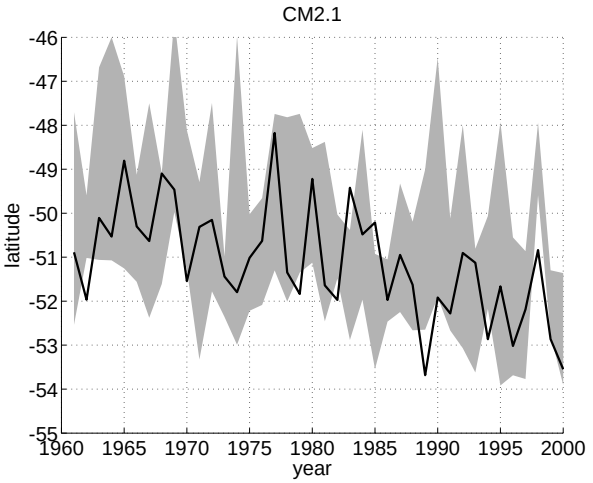
Hendon 2000, Watterson 2002: MJO sensitive to coupling

Despite potential issues we should encourage systematic comparison of high resolution time slice simulations of climate change

“Earth System Models”

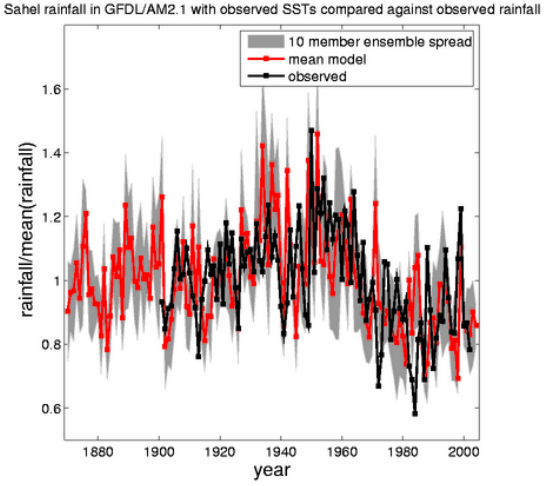
Most regional problems of interest have an “earth system” component even on the 30 year time scale !

poleward movement of SH westerlies caused in part by ozone hole --
Thompson+Solomon, 2002; Gillett+Thompson, 2003



Past and future changes in interhemispheric SSTs gradients plausibly controlled in part by aerosol forcing

e.g., Rotstayn, Lohmann, 2002:



Seamless prediction:

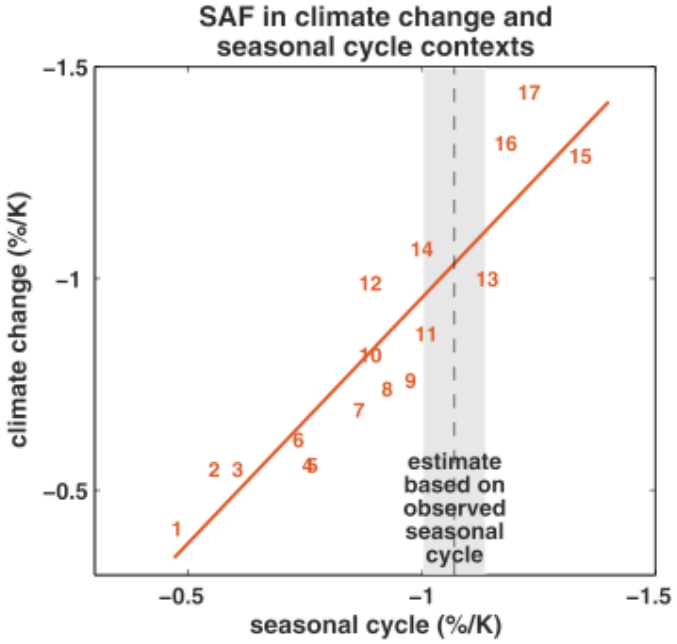
Is relative success at regional seasonal/interannual prediction a good metric for judging the relative quality of models for regional climate change prediction on time scales of decades and longer?

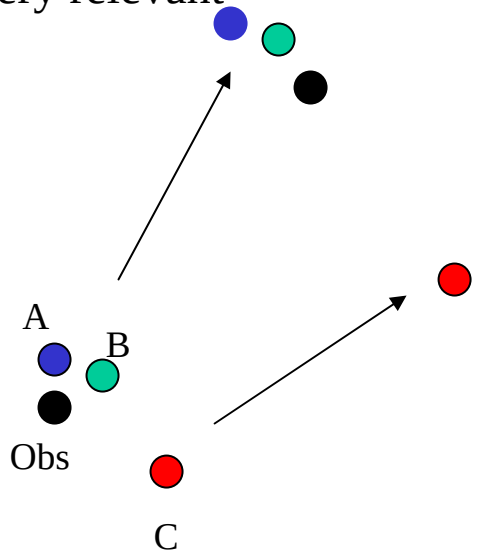
Generalizing: What are the most relevant metrics?

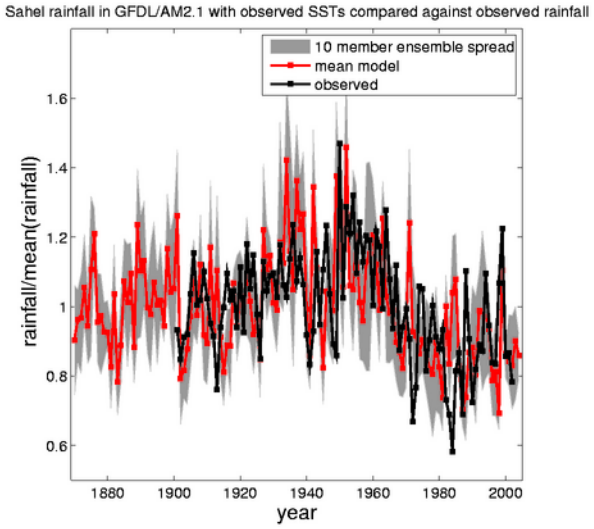
Excellent simple example of useful metric: Hall and Qu (2006), Hall, Qu, Neelin (2008)

Seasonal cycle of snow cover good predictor
of snow cover response to greenhouse gas increase
=> comparing control simulation of snowcover to obs is very relevant

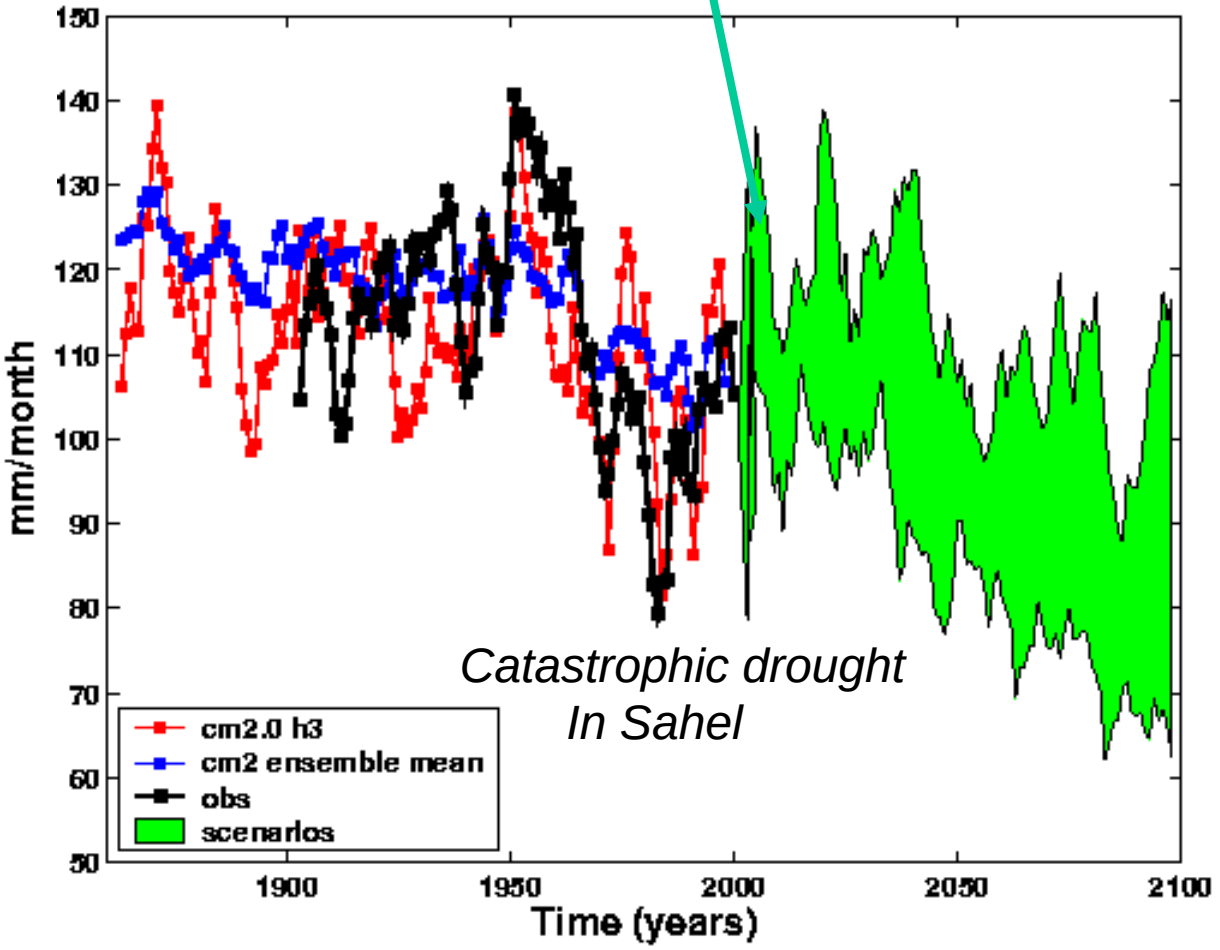
Hall and Qu







Response of GFDL/CM2 to range of SRES scenarios (B1/A1B/A2)



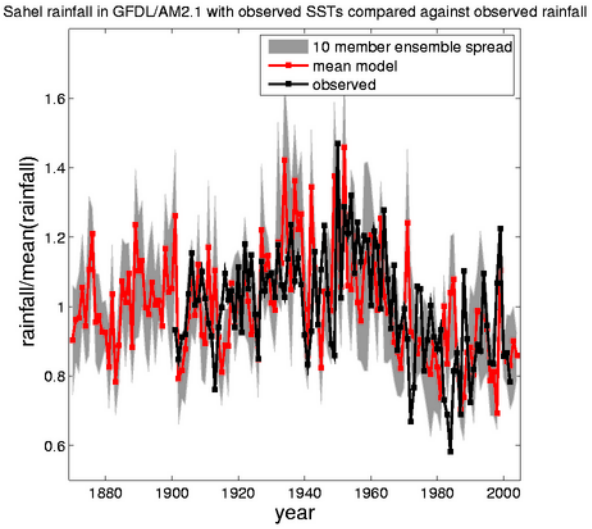
Catastrophic drought In Sahel

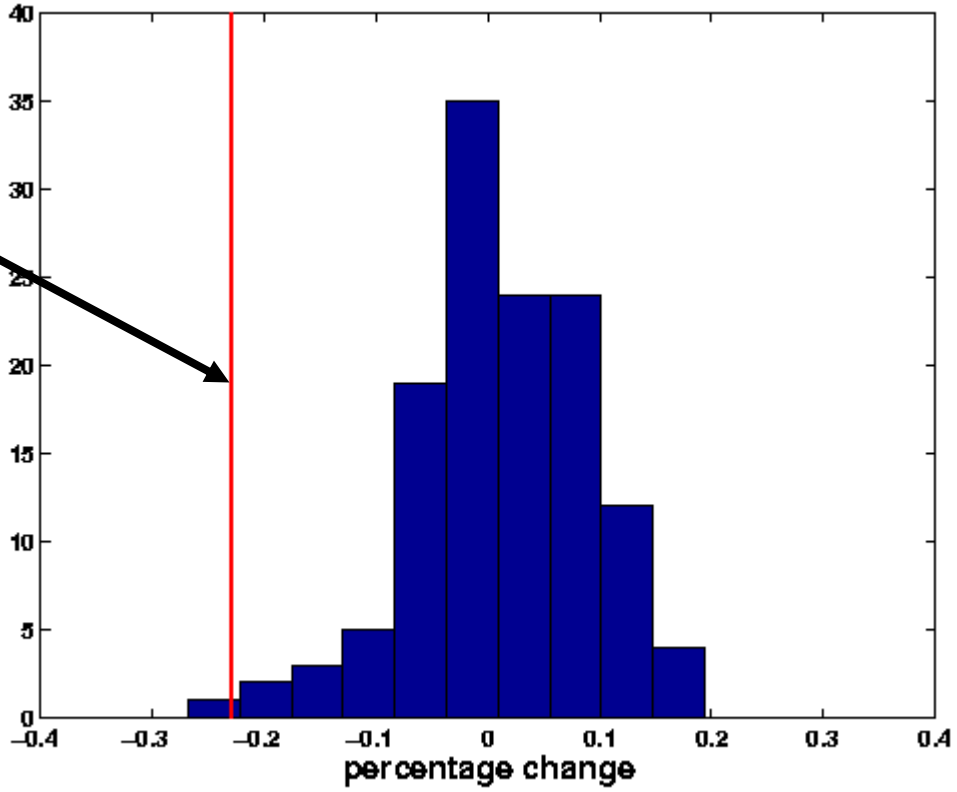
Geophysical Fluid Dynamics Laboratory
GFDL
NOAA

129 different models -- perturbed physics ensemble :
(courtesy of Matthew Collins, Hadley Center)

histogram of % Sahel rainfall response to 2xCO2

GFDL/CM2.1
is an outlier





Currently have no metric that distinguishes models that dry the Sahel in the future from those that get wetter, given control or 20th century simulations
-- Biasutti, et al 2008