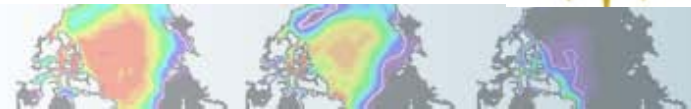


CESM1-CAM5 Coupled Experiments

Rich Neale + AWMG Development Team

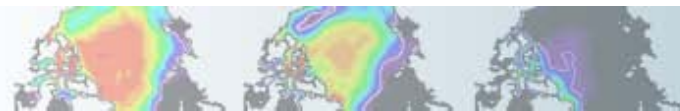
NCAR is sponsored by the National Science Foundation



CAM Evolution



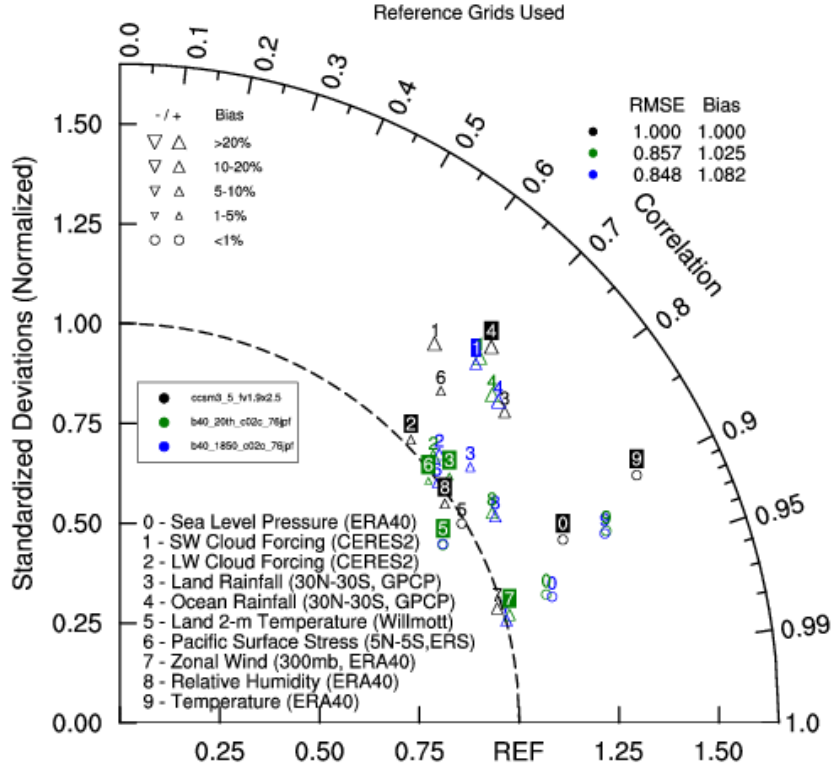
Model	CCSM3 (2004)	CCSM3.5 (2007)	CCSM4 (Apr 2010)	CESM1 (Jun 2010)
Atmosphere	CAM3 (L26)	CAM3.5 (L26)	CAM4 (L26)	CAM5 (L30)
Boundary Layer	Holtslag and Boville (93)	Holtslag and Boville	Holtslag and Boville	UW <i>Diagnostic TKE</i> Park et al. (09)
Shallow Convection	Hack (94)	Hack	Hack	UW <i>TKE/CIN</i> Park et al. (09)
Deep Convection	Zhang and McFarlane (95)	Zhang and McFarlane Neale et al.(08), Richter and Rasch (08) mods.	Zhang and McFarlane Neale et al., Richter and Rasch mods.	Zhang and McFarlane Neale et al., Richter and Rasch mods.
Stratiform Cloud	Rasch and Kristjansson (98) <i>Single Moment</i>	Rasch and K. <i>Single Moment</i>	Rasch and K. <i>Single Moment</i>	Morrison and Gettelman (08) <i>Double Moment</i> Park Macrophysics Park et al. (10)
Radiation	CAMRT (01)	CAMRT	CAMRT	RRTMG Iacono et al. (2008)
Aerosols	Bulk Aerosol Model (BAM)	BAM	BAM	Modal Aerosol Model (MAM) Ghan et al. (2010)
Dynamics	Spectral	Finite Volume (96,04)	Finite Volume HOMME	Finite Volume HOMME
Ocean	POP2 (L40)	POP2.1 (L60)	POP2.2	POP2.2
Land	CLM3	CLM3.5	CLM4 – CN	CLM4
Sea Ice	CSIM4	CSIM4	CICE	CICE



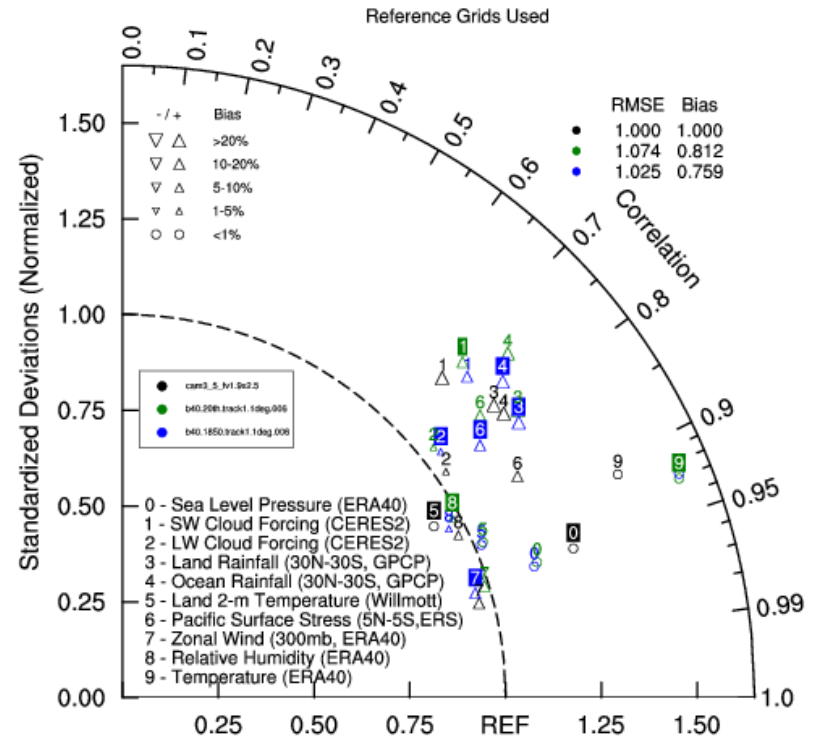
Climate Performance Summary

Relative to CCSM3.5 (2 deg)

CESM1-CAM5 (1 deg, L30)

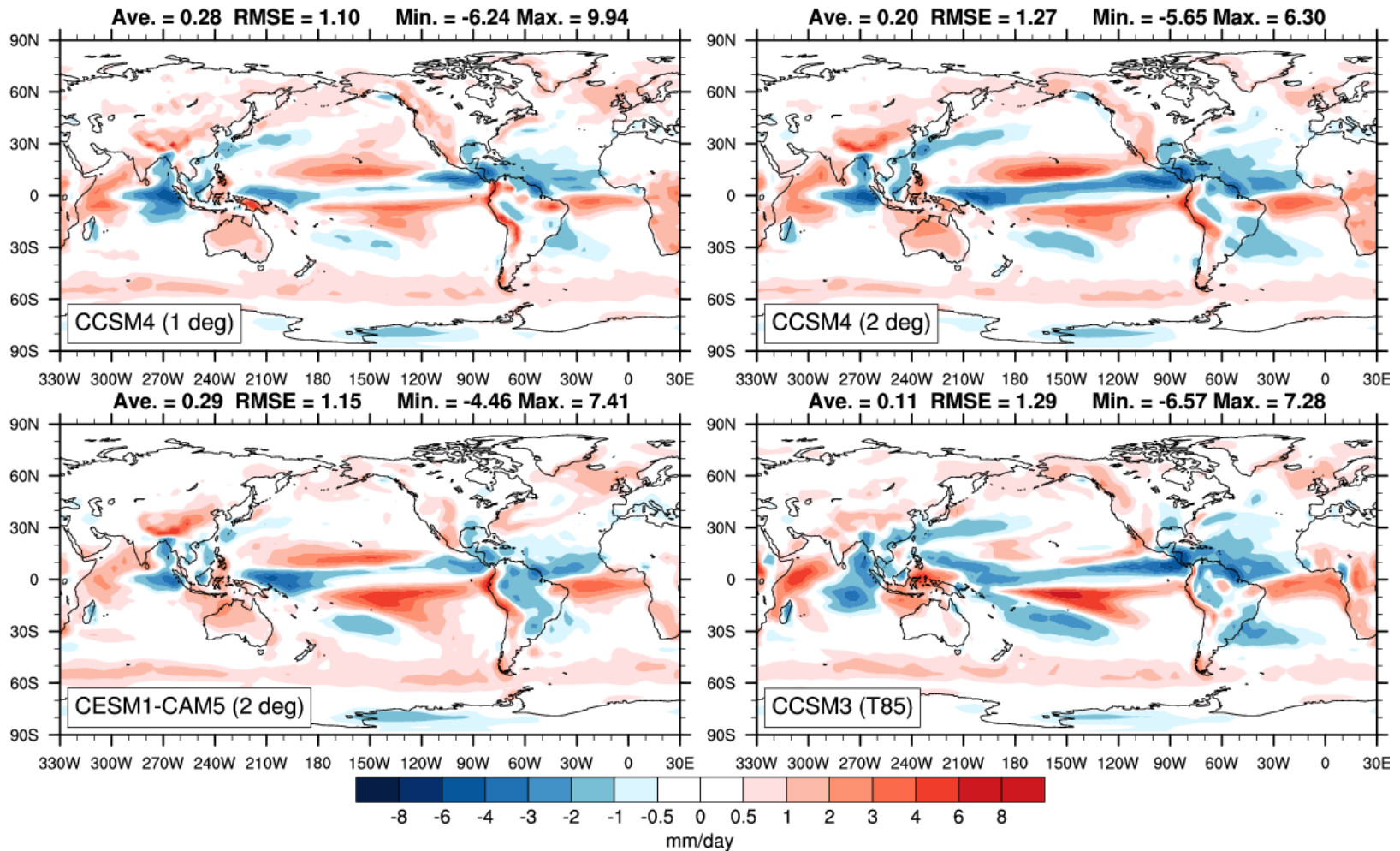


CCSM4-CAM4 (2 deg, L26)

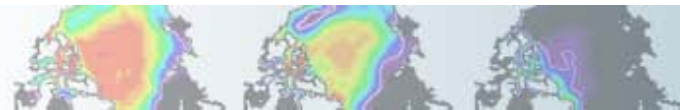


Metric	CESM1-CAM5 1850	CESM1-CAM5 Late 20th	CCSM4-CAM4 1850	CCSM4-CAM4 Late 20th
Bias	1.082	1.025	0.759	0.812
RMSE	0.848	0.857	1.025	1.074

Mean Precipitation Biases



20th Century Coupled Experiments (average 1970-1999)
 Observed (CMAP, average 1979-1998)



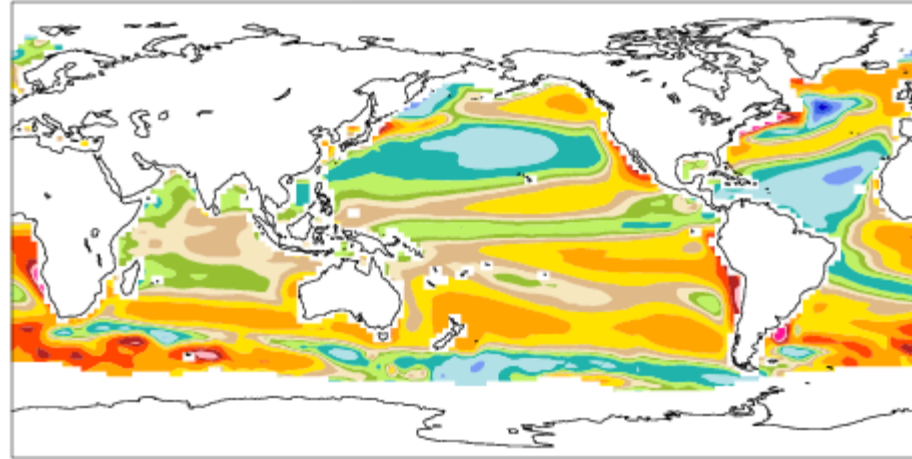
Mean SST Biases

CESM1-CAM5 (2 deg)

mean = 0.32

rmse = 1.07

C

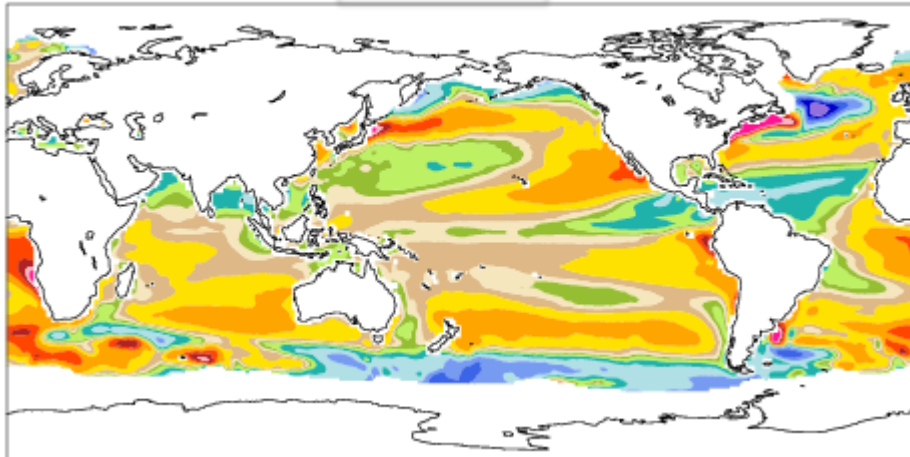


SST error
(1970-1999)
Compared to
HadISST

CCSM4 (1 deg)

mean = 0.31

rmse = 1.06

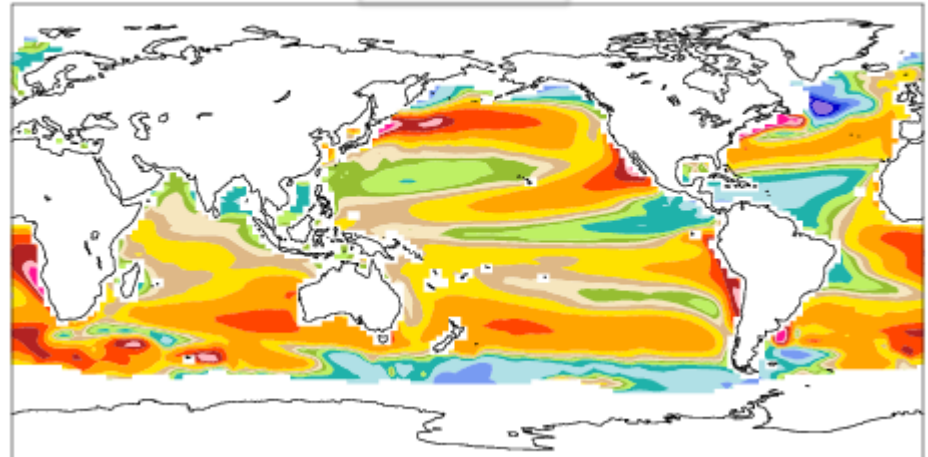


CCSM4 (2 deg)

C mean = 0.58

rmse = 1.34

C

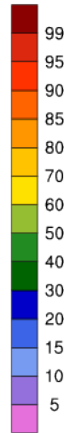
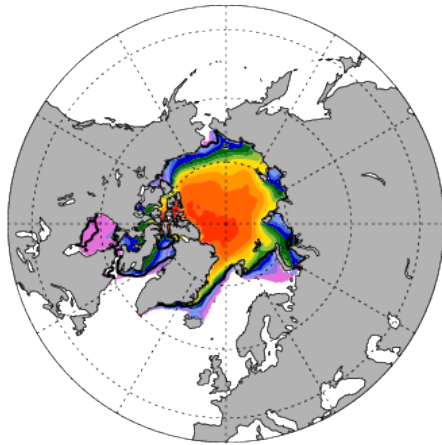


Polar Sea Ice

JAS Mean Years 1985-2004

ice area (aggregate)

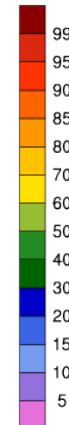
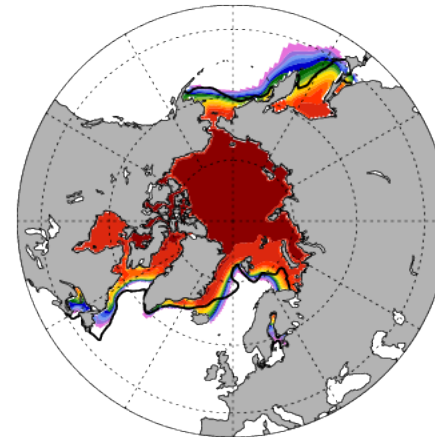
%



JFM Mean Years 1985-2004

ice area (aggregate)

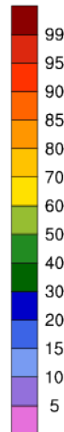
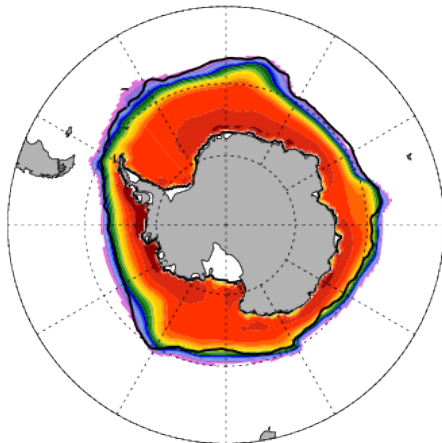
%



Turbulent Mountain Stress

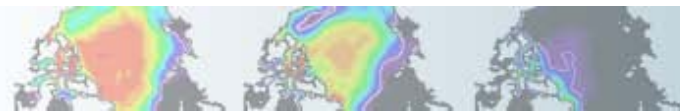
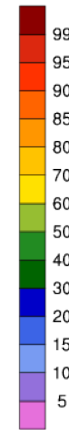
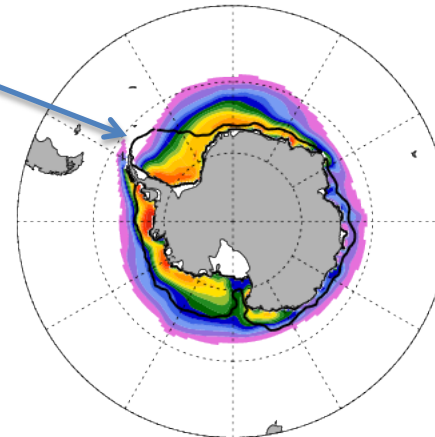
ice area (aggregate)

%

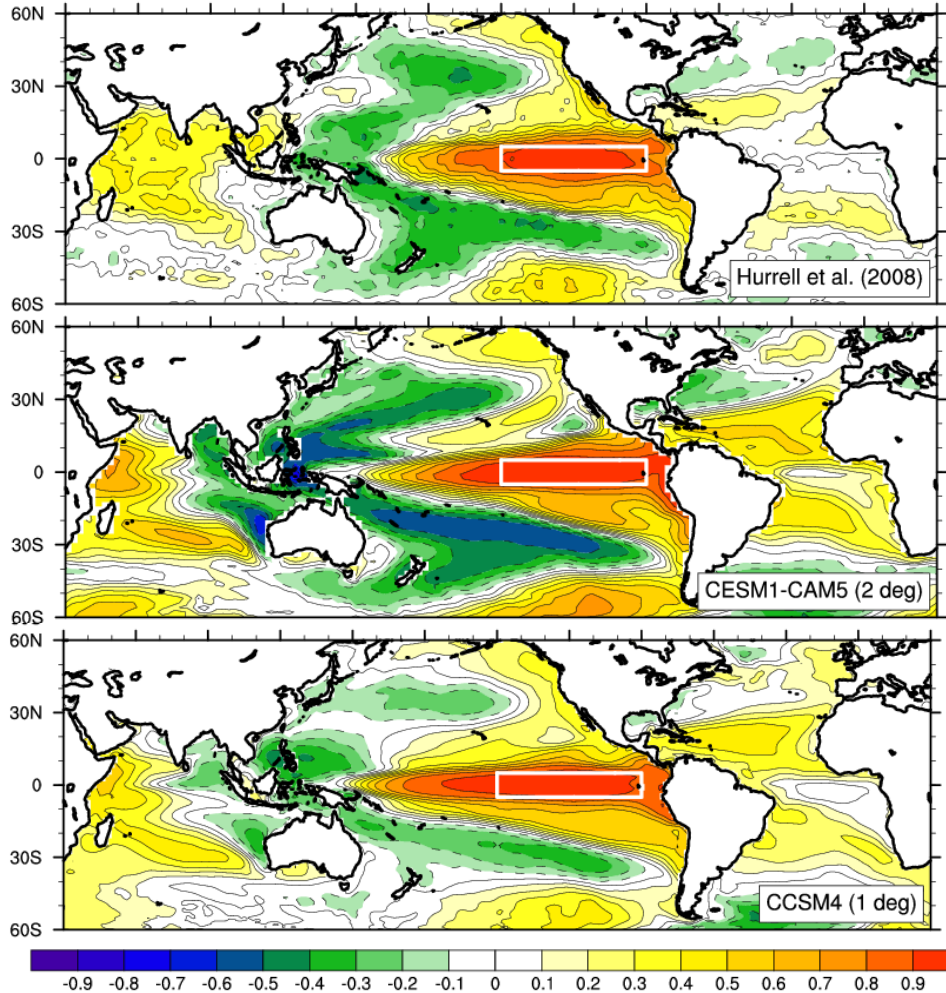


ice area (aggregate)

%

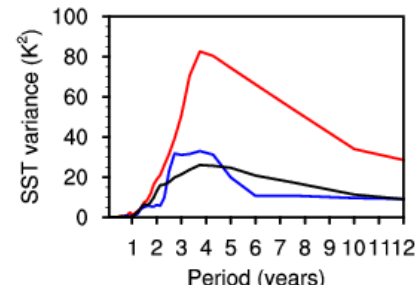


ENSO Variability

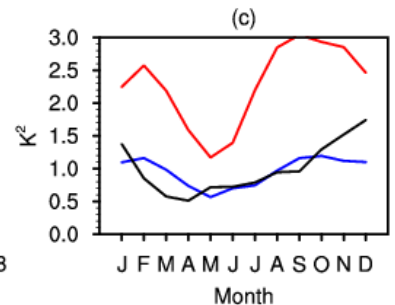
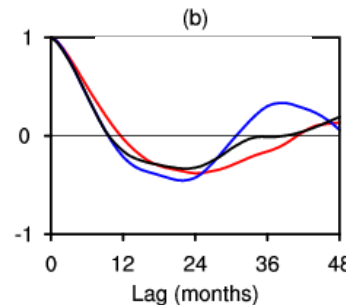


20th Century El Nino

- Lag-zero nino3 SSTA correlation
- nino3 SSTA power spectrum
- ✓Teleconection patterns maintained from CCSM4
- ✓Amplitude is very strong
- ✓Changed low-cloud feedbacks in East Pacific?

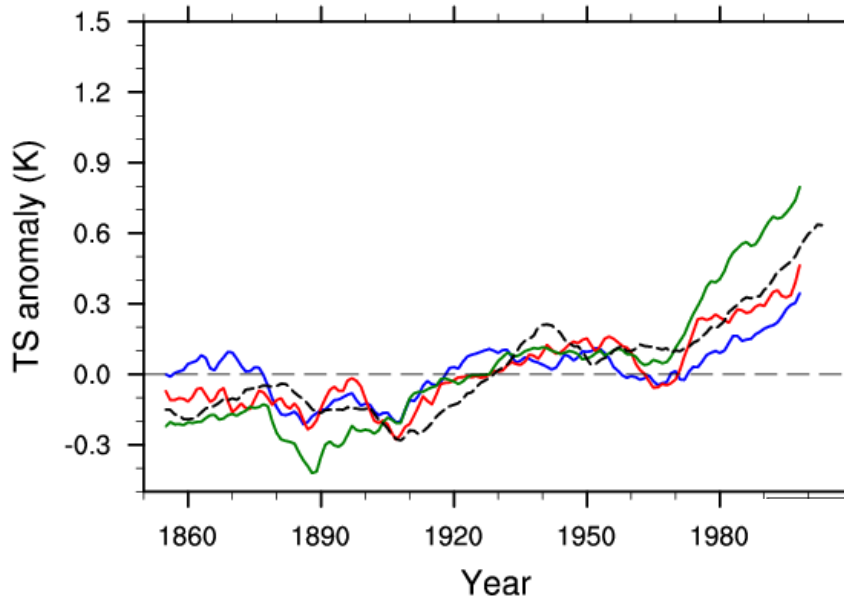


Hurrell et al (2008)
 CCSM4 (1 deg)
 CESM1-CAM5 (2 deg)

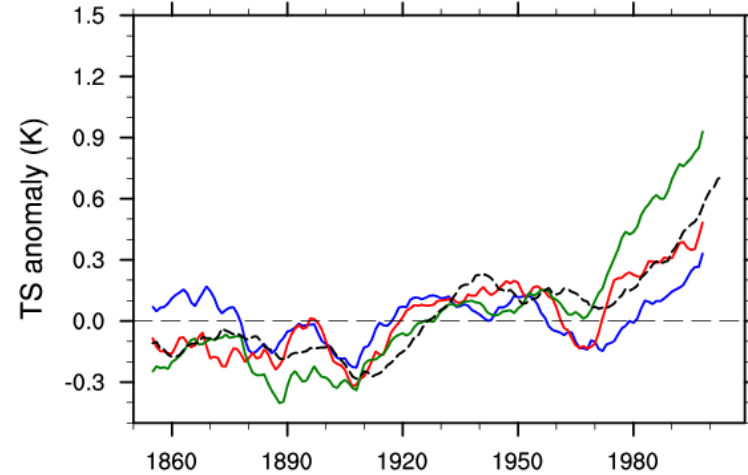


20th Century Climate

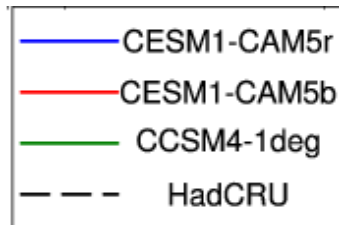
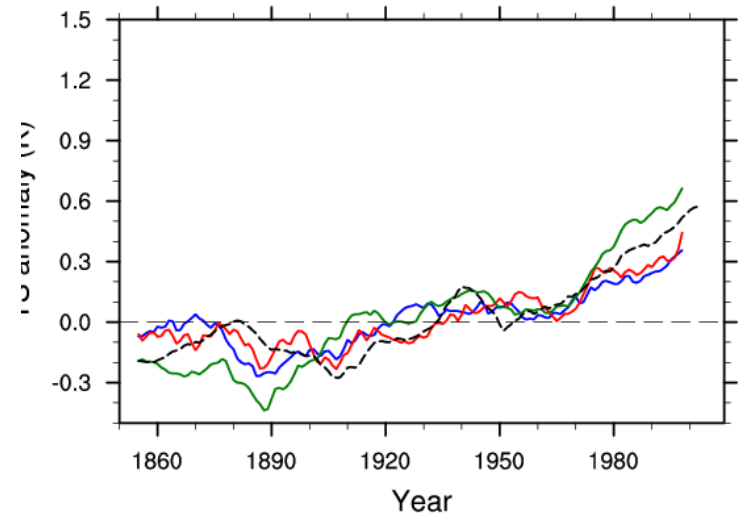
Global



Northern Hemisphere

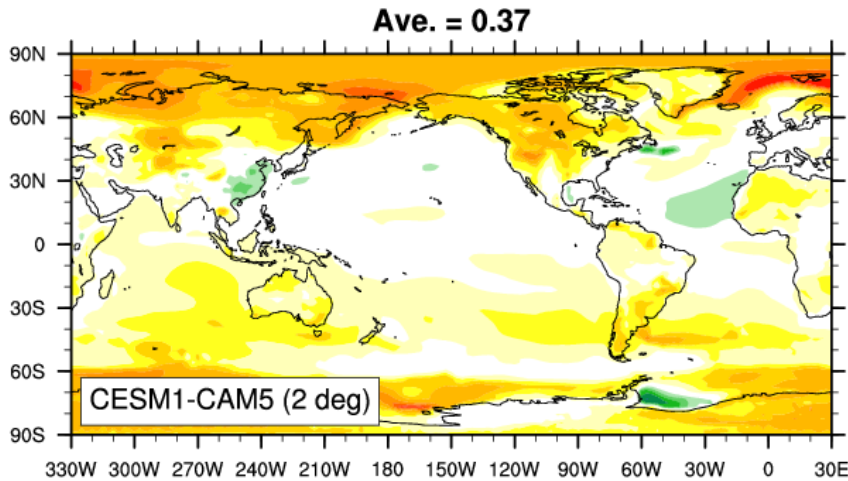


Southern Hemisphere



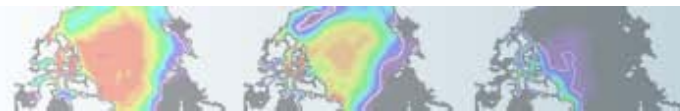
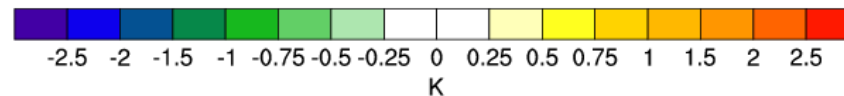
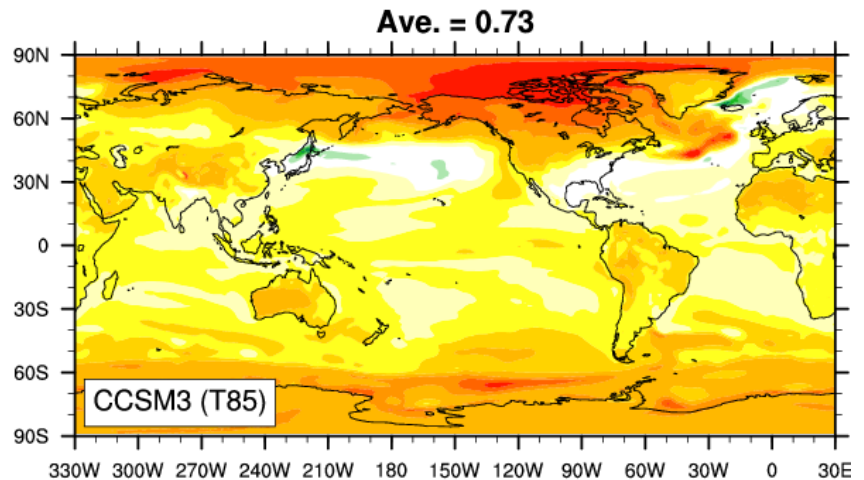
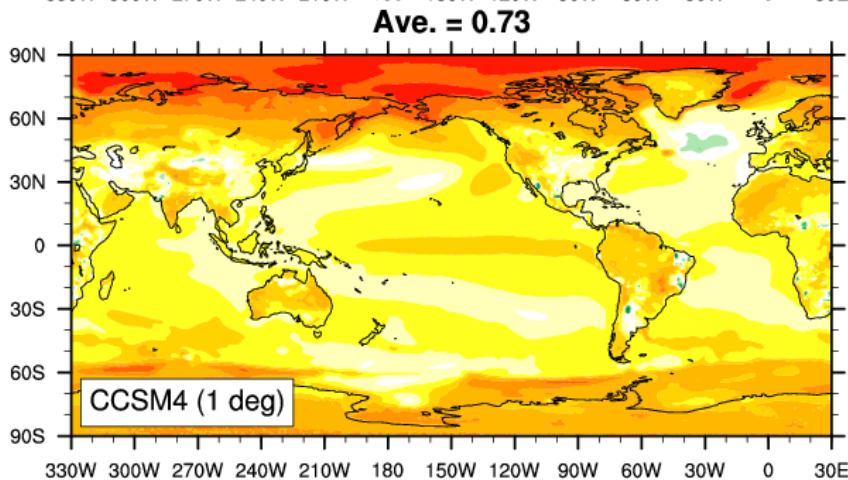
Surface temperature anomalies relative to (1961-1990) – 11-year smoothing

20th Century Temperature Change

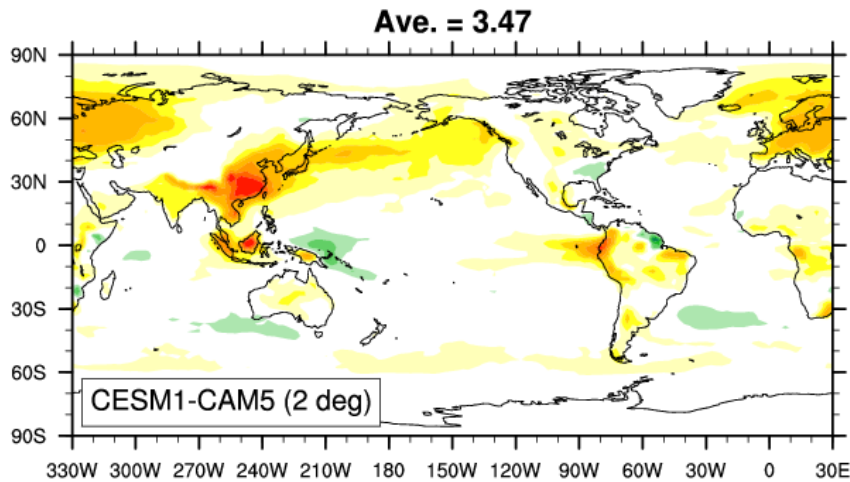


Surface Temperature Change (1970-1999) minus 1850 control

✓ Marginal Nhem ocean and south-east Asia warming consistent with obs.

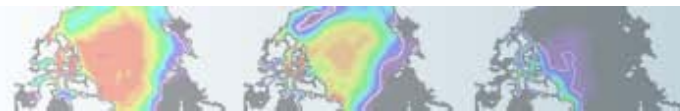
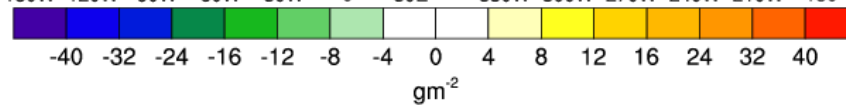
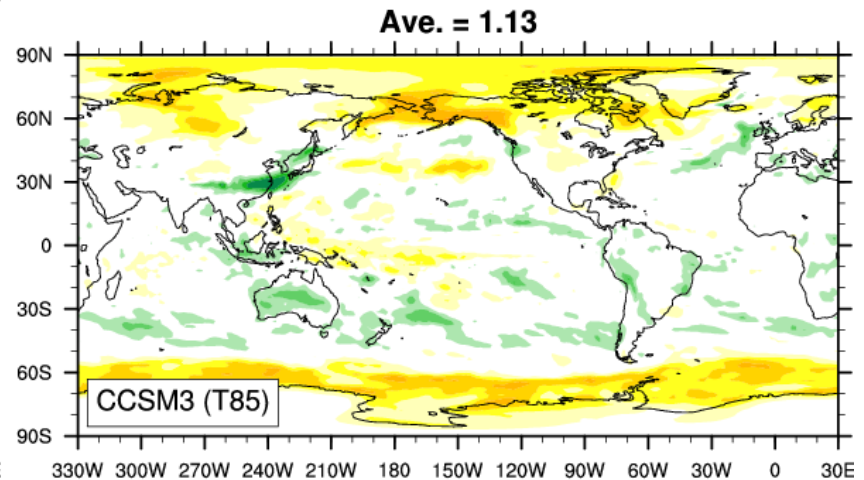
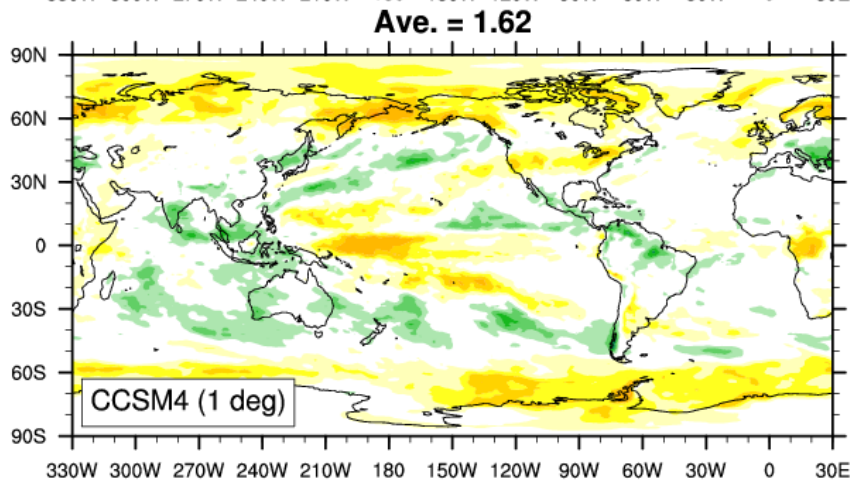


20th Century Cloud Forcing



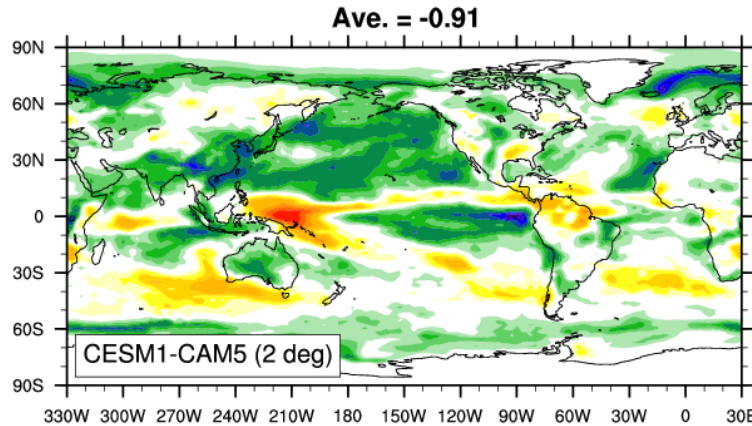
Grid-Mean Liquid Water Path (1970-1999) minus 1850 control

- ✓ Increases in LWP dominate over cloud low-cloud fraction
- ✓ Increased droplet activation/condensation due to aerosols



20th Century Cloud Forcing

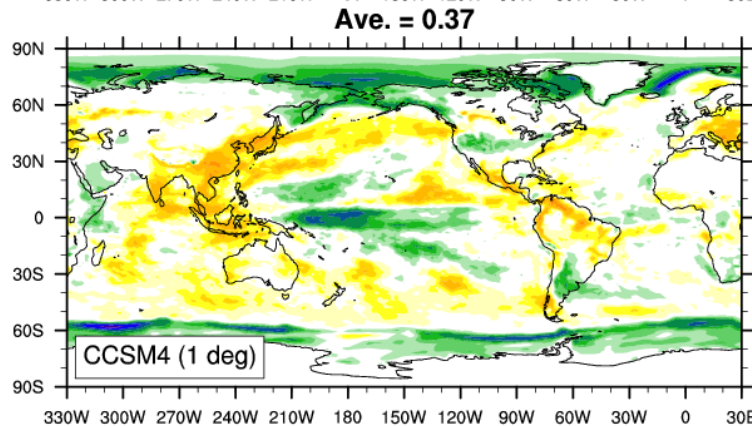
Feedbacks + Forcing



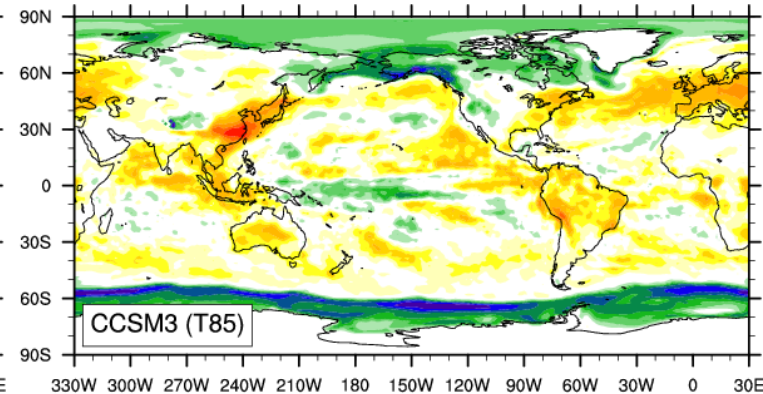
Short wave cloud forcing over the 20th Century (1970-1999 minus 1850)

- ✓CCSM3 and CCSM4: low-cloud feedbacks are **positive (warming)**
- ✓CESM1-CAM5: low-cloud feedbacks+indirect forcing are net **negative (cooling)**

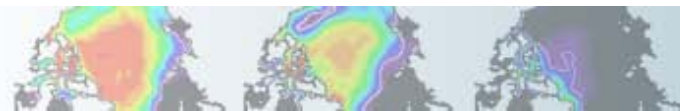
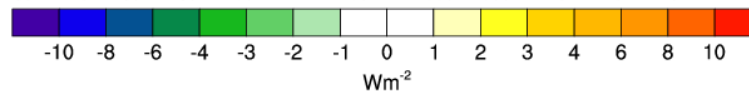
Feedbacks



Ave. = 0.71



Feedbacks



Summary of CESM1-CAM5 runs

- ✓ Mean coupled climate improved over CCSM3 (T85)/CCSM4 (2 deg)
- ✓ Competitive with CCSM4 (1 deg)
- ✓ Maintains many positive features from CCSM4 climate (e.g., ENSO period)
- ✓ 20th Century simulations
 - ✓ Final warming less than CCSM4; less than observed
 - ✓ Regional features better captured (NH ocean/SE Asia cooling)
 - ✓ Consistent with local increases in liquid-water water path
 - ✓ Increased cloud droplet number at PBL top; increased activation
 - ✓ Net low-cloud feedbacks becomes negative CCSM4 positive
- ✓ Final 20th Century runs to be analyzed
- ✓ ENSO amplitude excessive (and very sensitive)
- ✓ Indirect affects a little strong

