NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Recent Decadal Prediction Efforts at NCAR

Steve Yeager

Gokhan Danabasoglu, Nan Rosenbloom, Gary Strand, Alicia Karspeck, Keith Lindsay, Matt Long, Susan Bates, Jerry Meehl, Haiyan Teng

Yeager et al. 2017: Predicting near-term changes in the Earth System: A large ensemble of initialized decadal prediction simulations using the Community Earth System Model, *BAMS*, submitted.

The CESM Decadal Prediction Large Ensemble

Experiment Name	CCSM4-DP	CESM-DP-LE
<u>Model</u> -atm -ocn -ice -lnd	CCSM4 CAM4 (FV 1°, 26lvl) POP2 (1°, 60lvl) CICE4 (1°) CLM4	**CESM1.1** **CAM5** (FV 1°, **30lvl**) POP2 (1°, 60lvl) **w/ BGC** CICE4 (1°) CLM4
Uninitialized Ensemble (UI)	6-member CCSM4 20th century ensemble (Meehl et al., 2012)	**40-member CESM 20th century Large Ensemble** (Kay et al., 2015)
Forcing	-2005: CMIP5 historical 2006-: CMIP5 RCP 4.5	-2005: CMIP5 historical 2006-: CMIP5 **RCP 8.5**
<u>Initialization</u> -method -atm -ocn -ice -lnd	 full field UI CORE-forced FOSI CORE-forced FOSI UI	 full field UI **CORE*-forced FOSI** **CORE*-forced FOSI** UI
<u>Ensembles</u> -ensemble size -start dates -ensemble generation -simulation length	 10 annual; Jan. 1st 1955-2014 (N=60) Variable January start days + round-off perturbation of atm initial conditions 120 months	 **40** annual; **Nov. 1st 1954-2015** (**N=62**) round-off perturbation of atm initial conditions 122 months

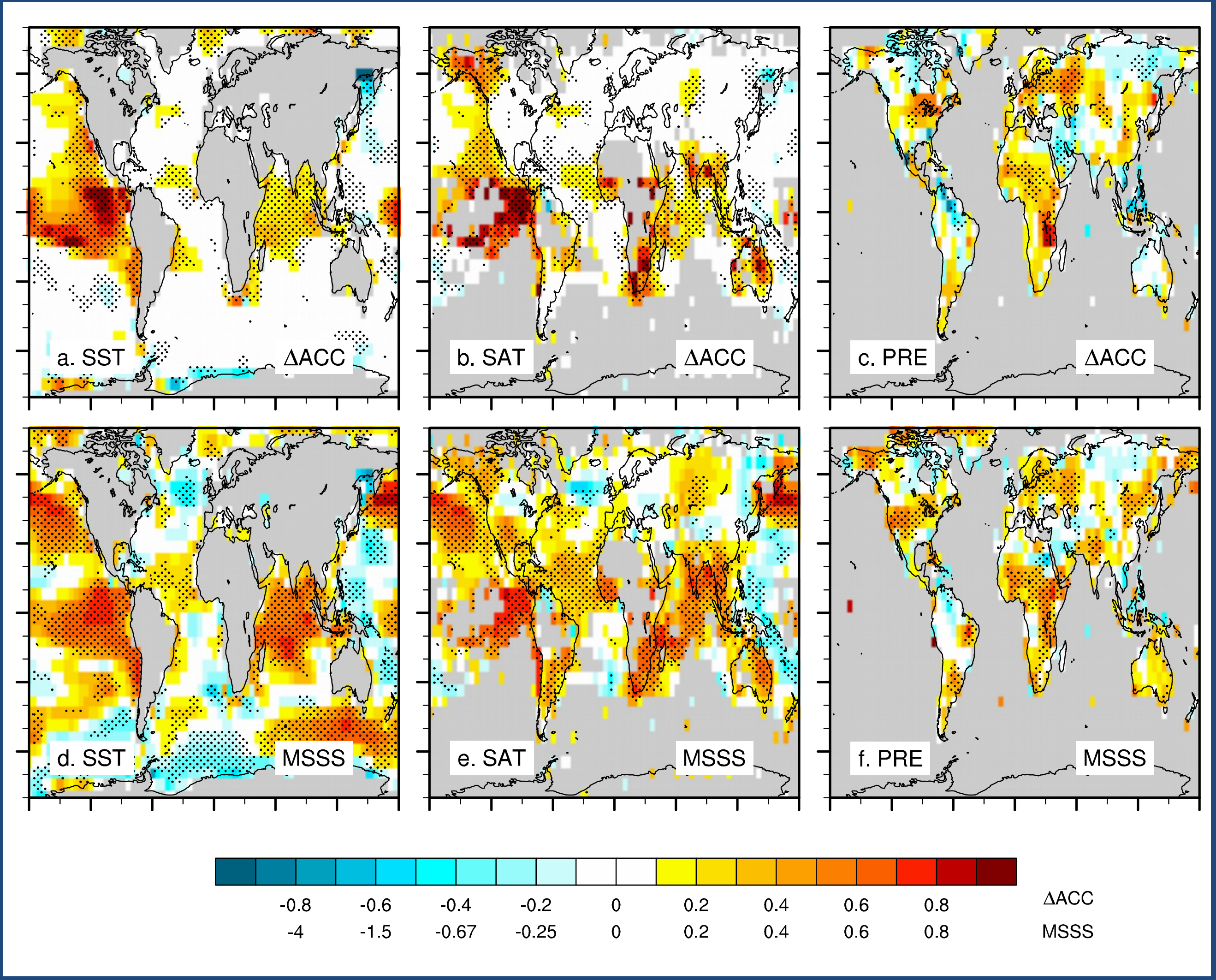
25000 simulation years

CMIP5-era (2011) CMIP6-era (2017)

Improvements over CCSM4-DP

- ACC improvement over CCSM4-DP
- MSSS relative to CCSM4-DP

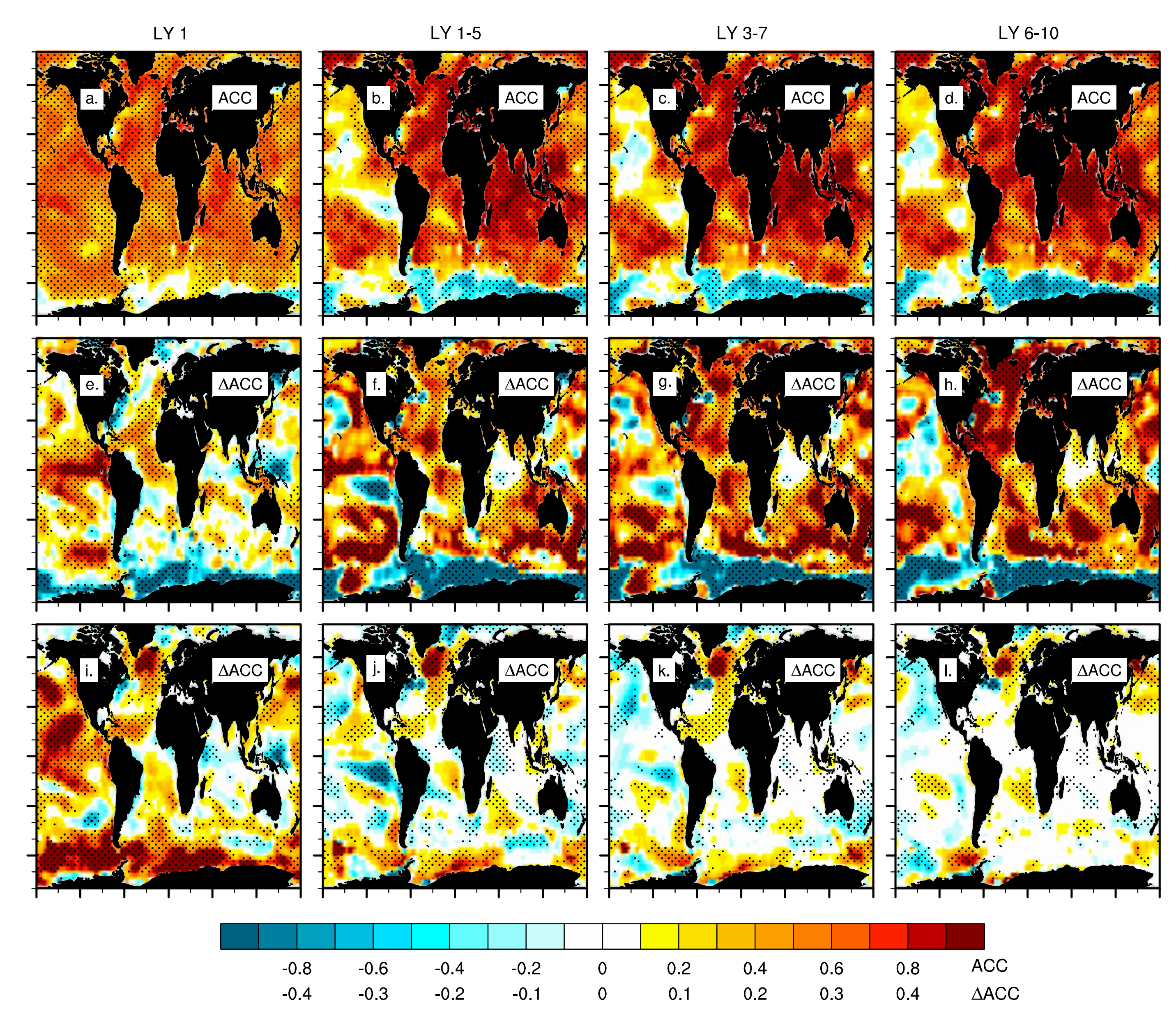
Annual mean (LY1-5):



Annual Sea Surface Temperature

(OBS = Hurrell)

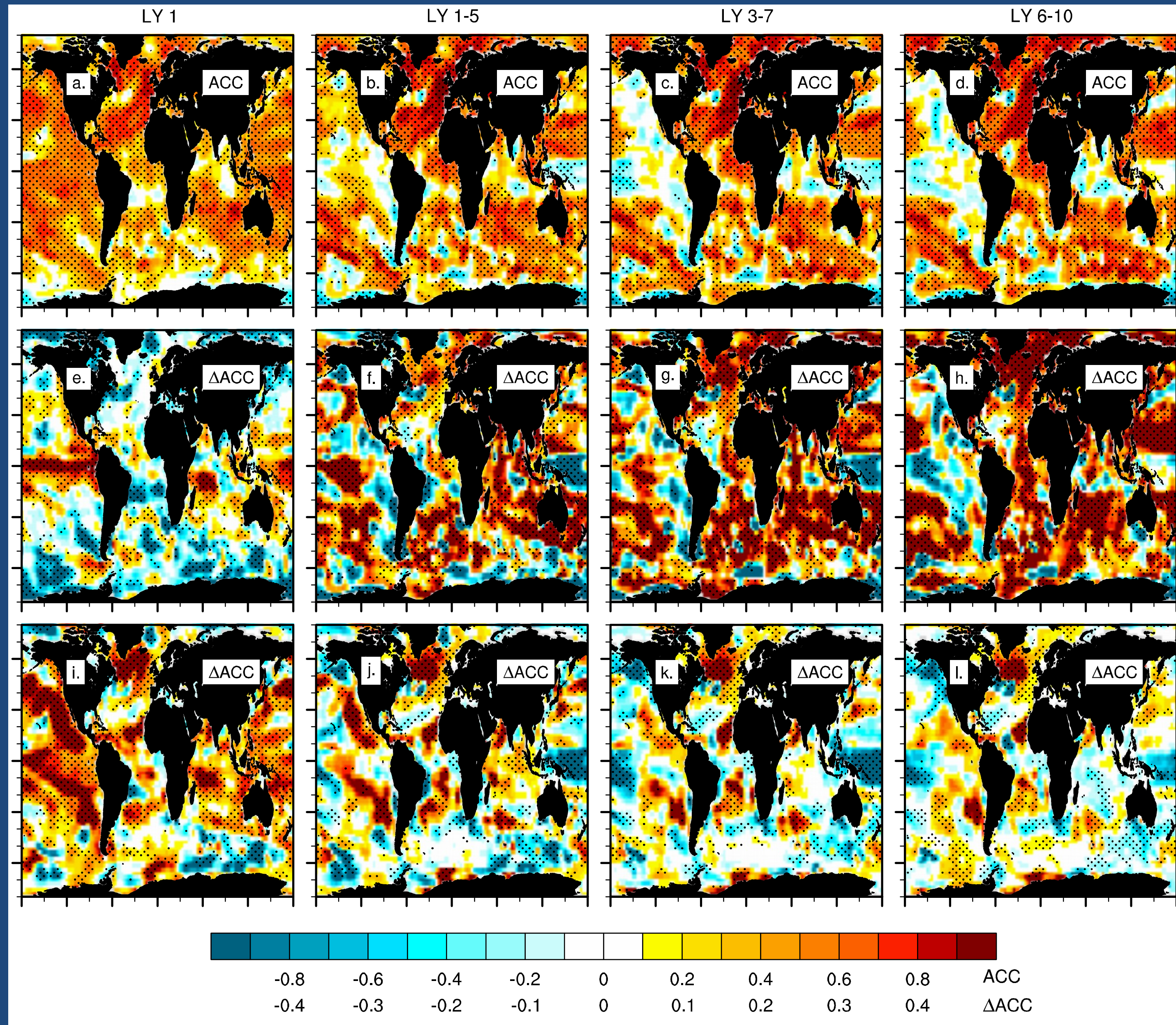
- Anomaly correlation coefficient (ACC)
- Skill improvement over persistence
- Skill improvement over UI



Annual Ocean Heat Content (295m)

(OBS = EN4)

- Anomaly correlation coefficient (ACC)
- Skill improvement over persistence
- Skill improvement over UI

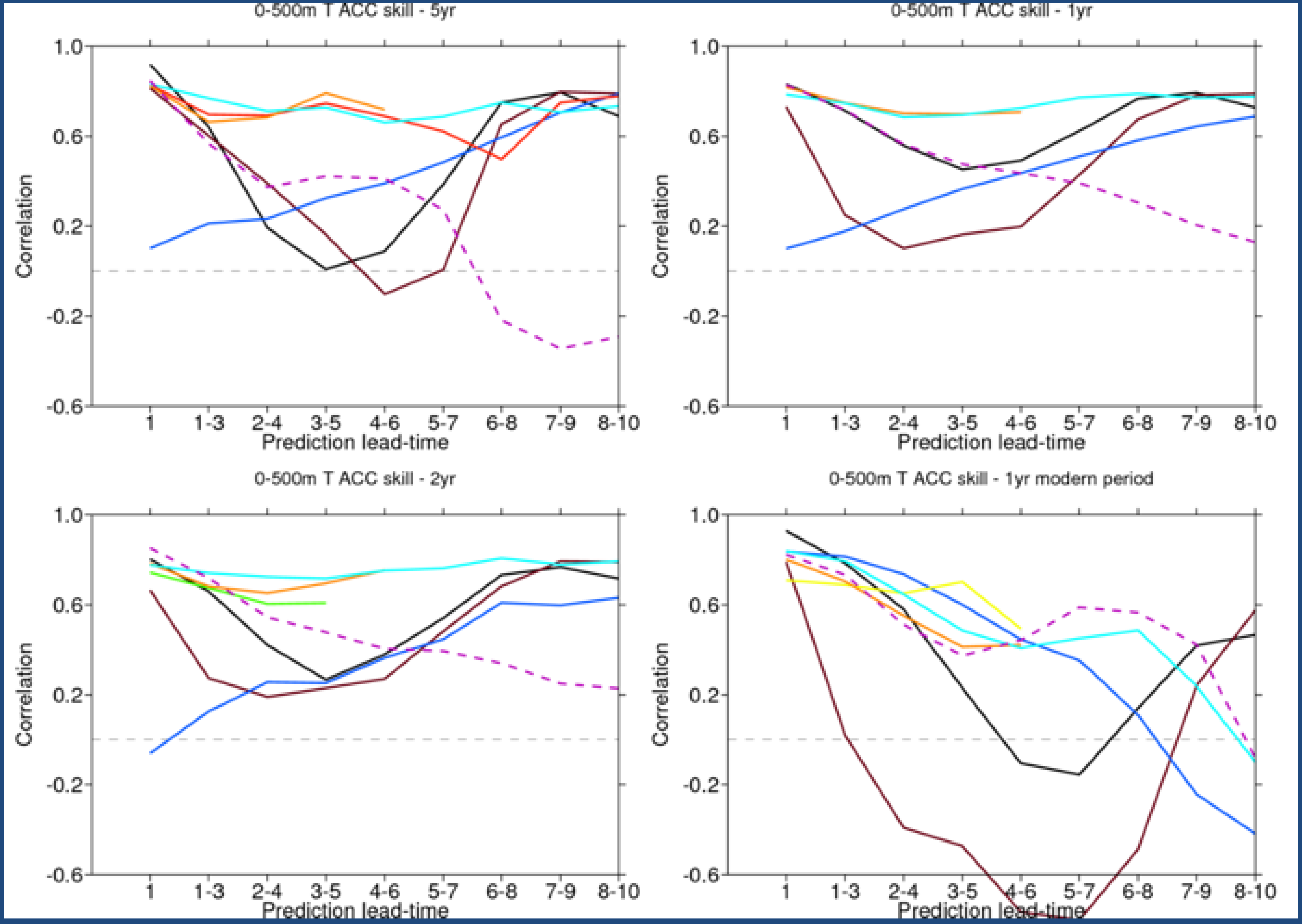


Annual Ocean Heat Content (500m)

(OBS = EN4)

CESM1-DP
HadCM3
HiGEM
MPI
Persistence
EC-Earth (full field, low-res)
EC-Earth (anomaly, low-res)
EC-Earth (high-res)
IPSL

Hindcast skill for subpolar North Atlantic heat content:



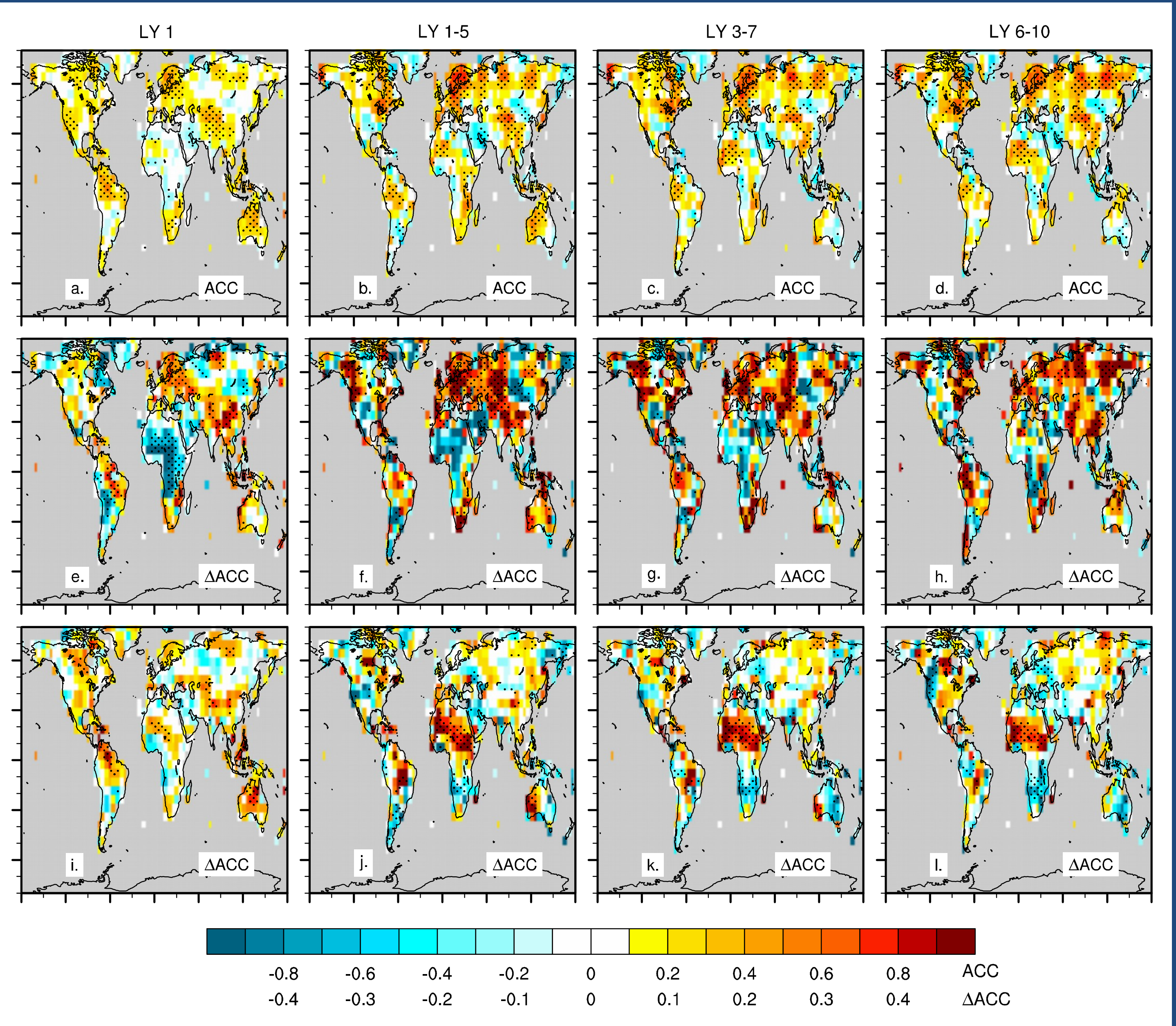
(Figure courtesy Jon Robson)

Annual Mean Precipitation (verified against CRU-TS 3.24)

ACC

ΔACC (relative to persistence)

ΔACC (relative to uninitialized)



Annual Mean Precipitation

(verified against CRU-TS 3.24)

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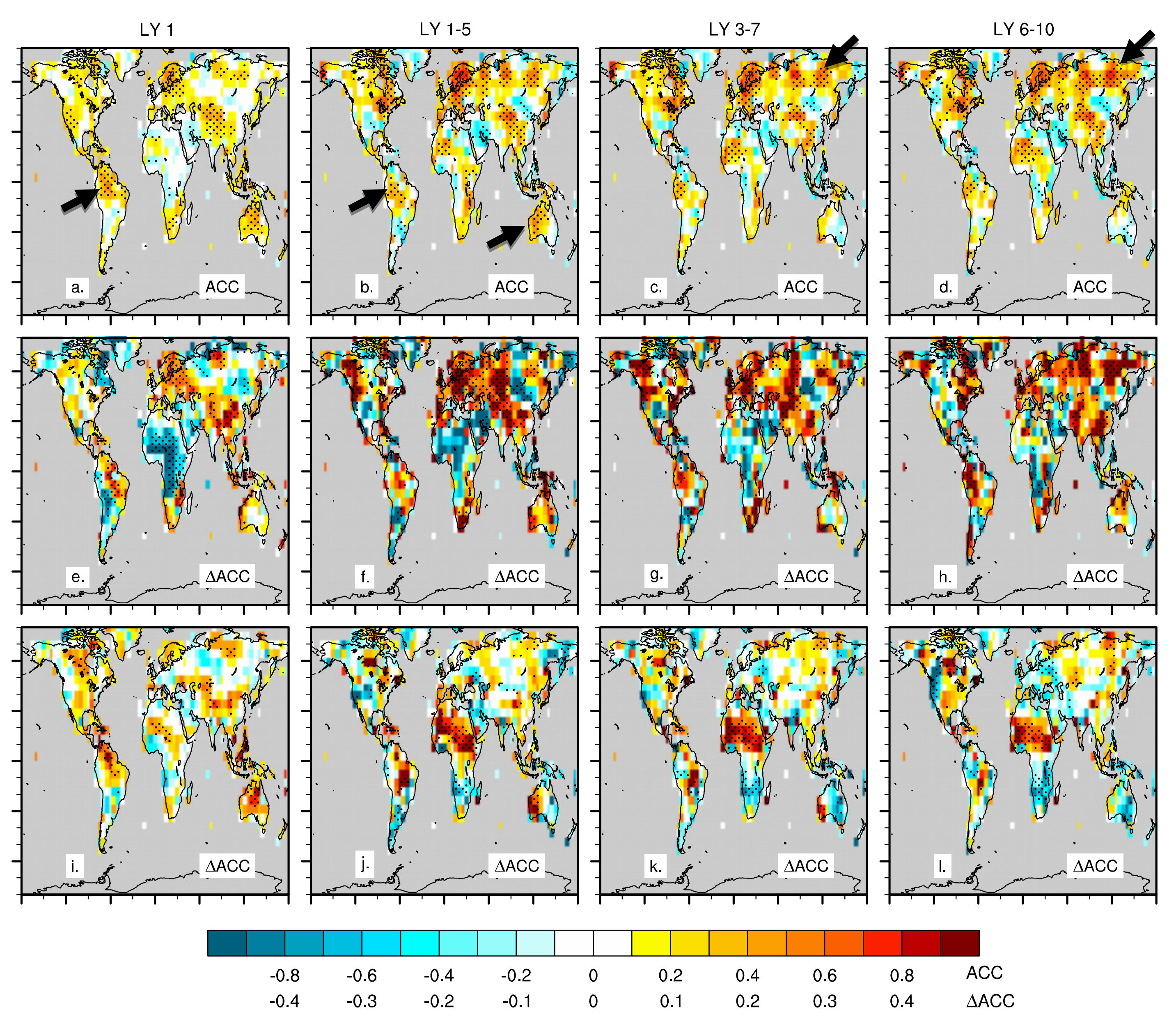


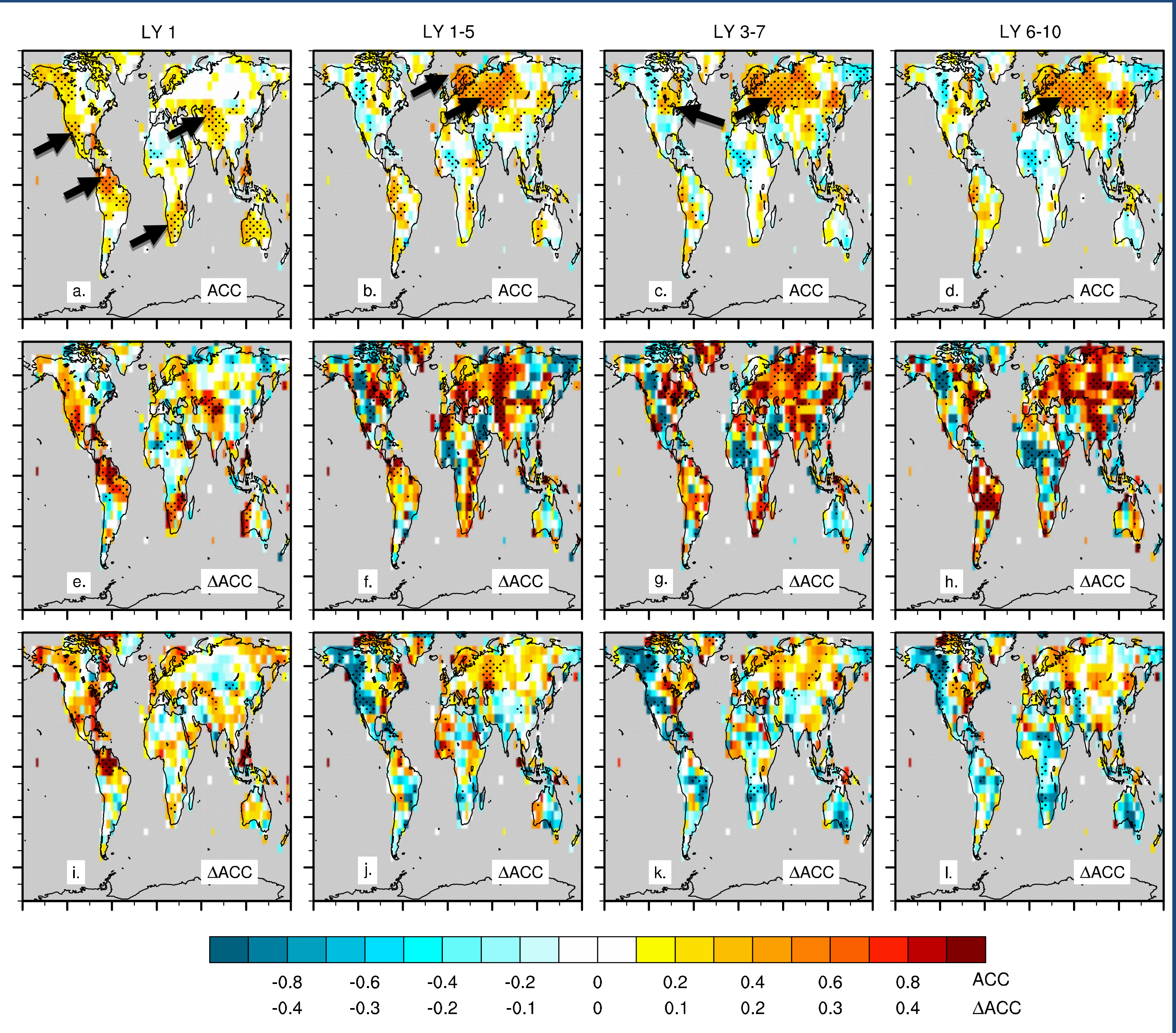
JFM Mean Precipitation

(verified against CRU-TS 3.24)

ACC

ΔACC (relative to persistence)

ΔACC (relative to uninitialized)



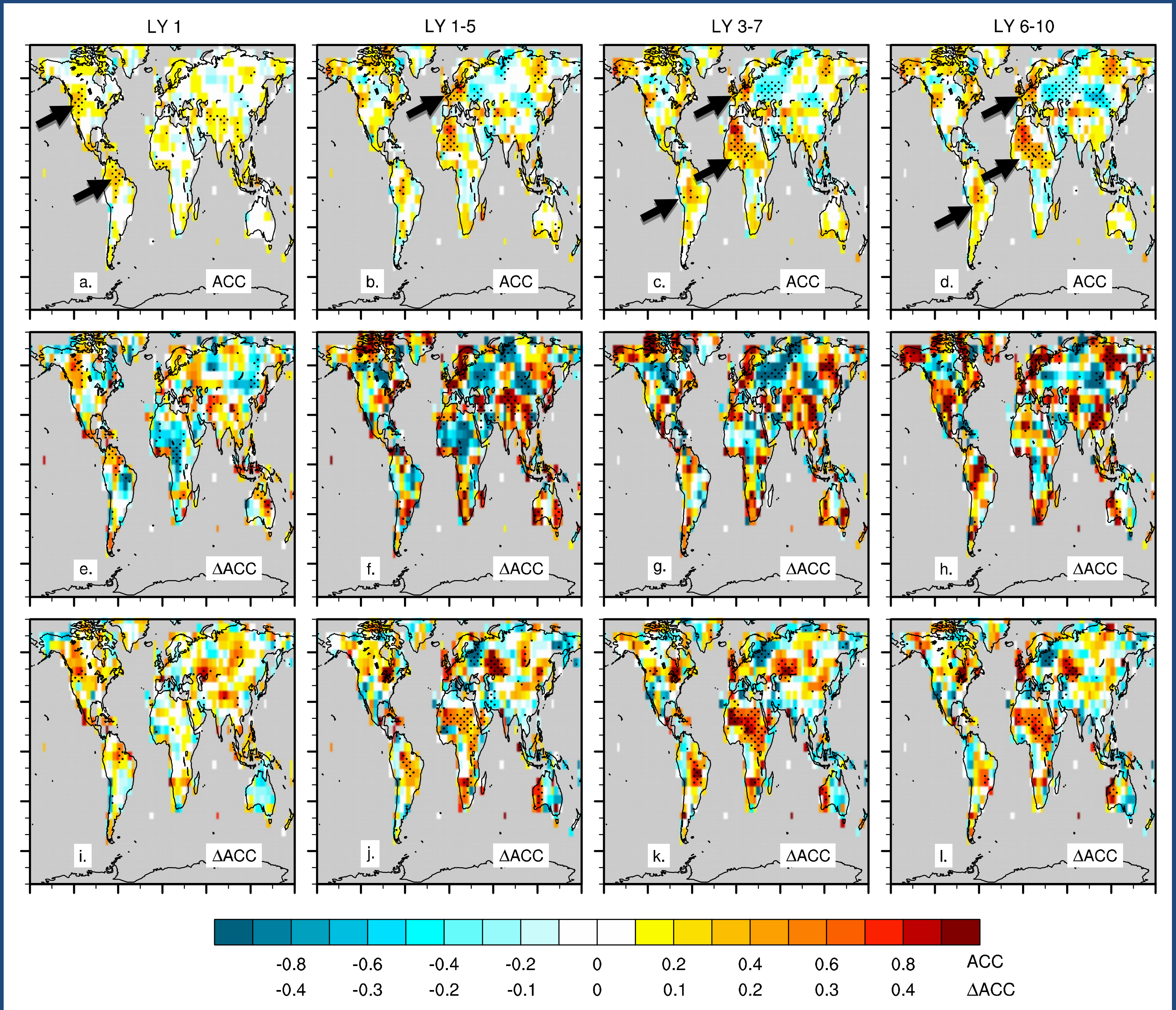
JAS Mean Precipitation

(verified against CRU-TS 3.24)

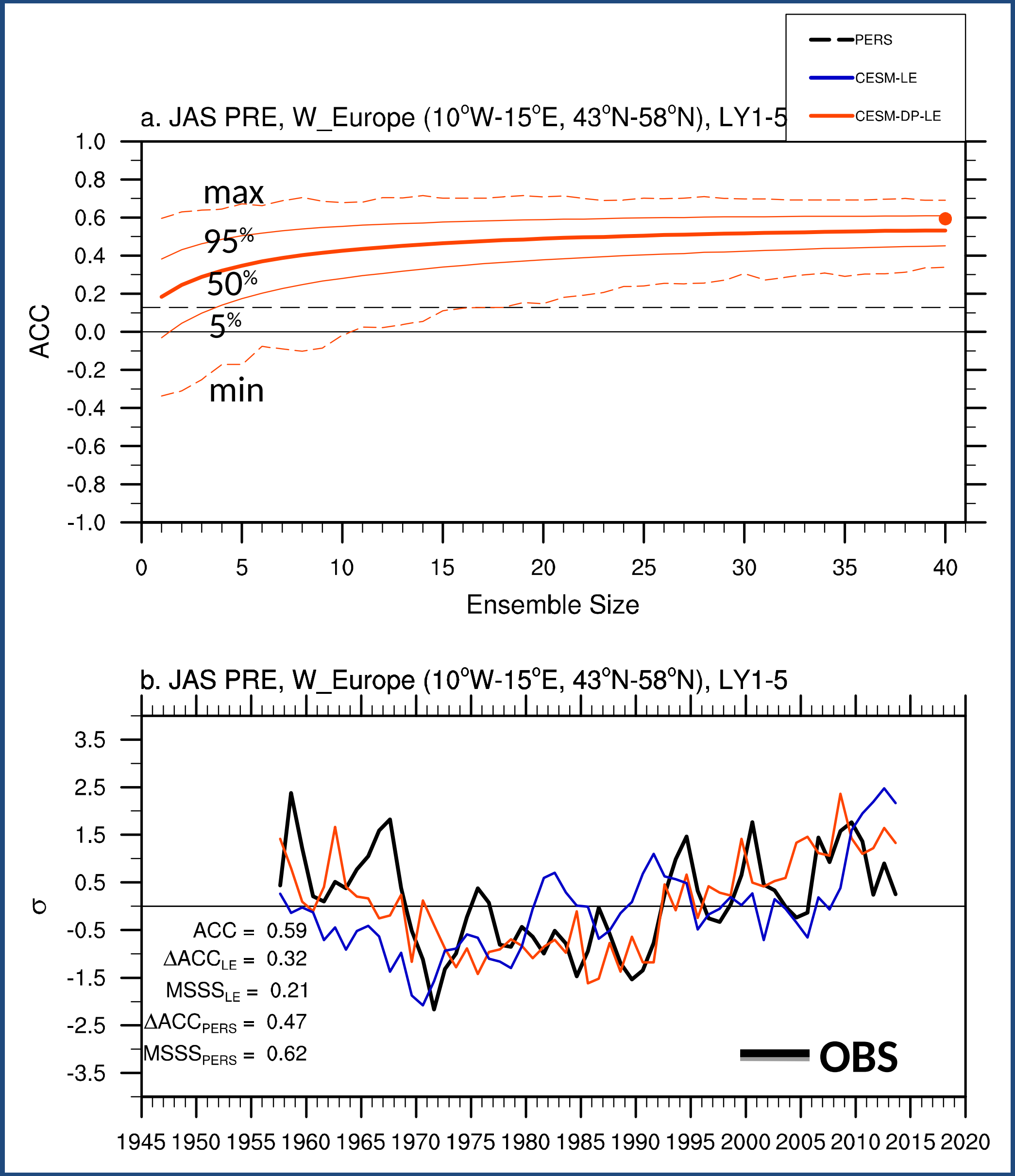
ACC

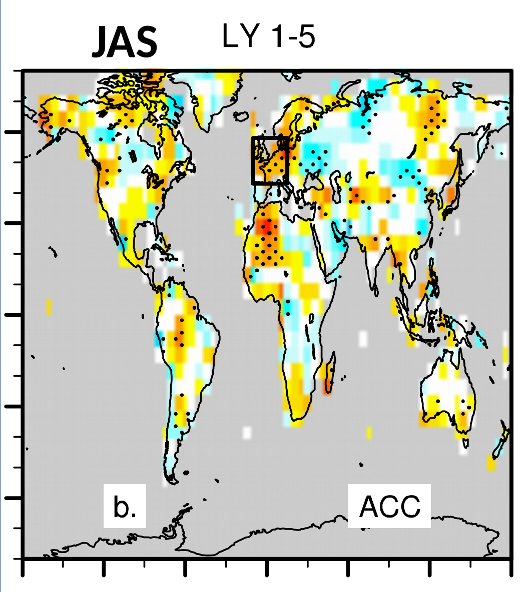
ΔACC (relative to persistence)

ΔACC (relative to uninitialized)

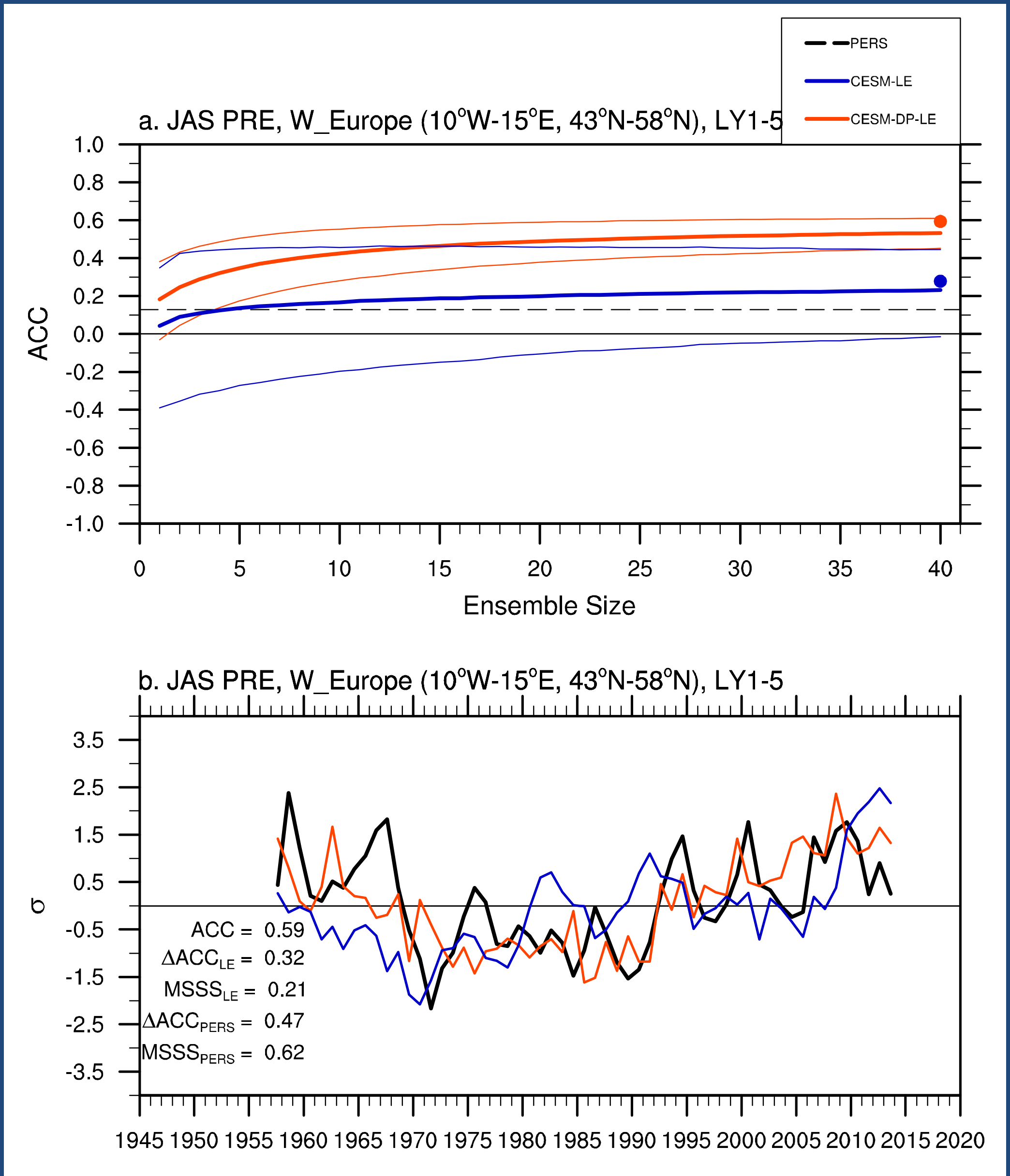


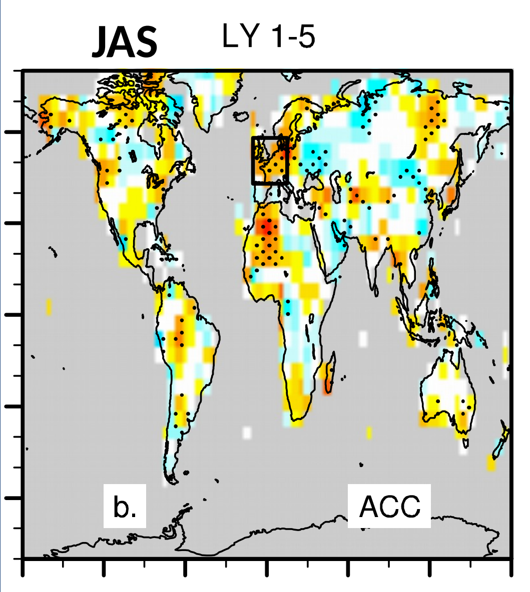
Summer Precipitation Skill



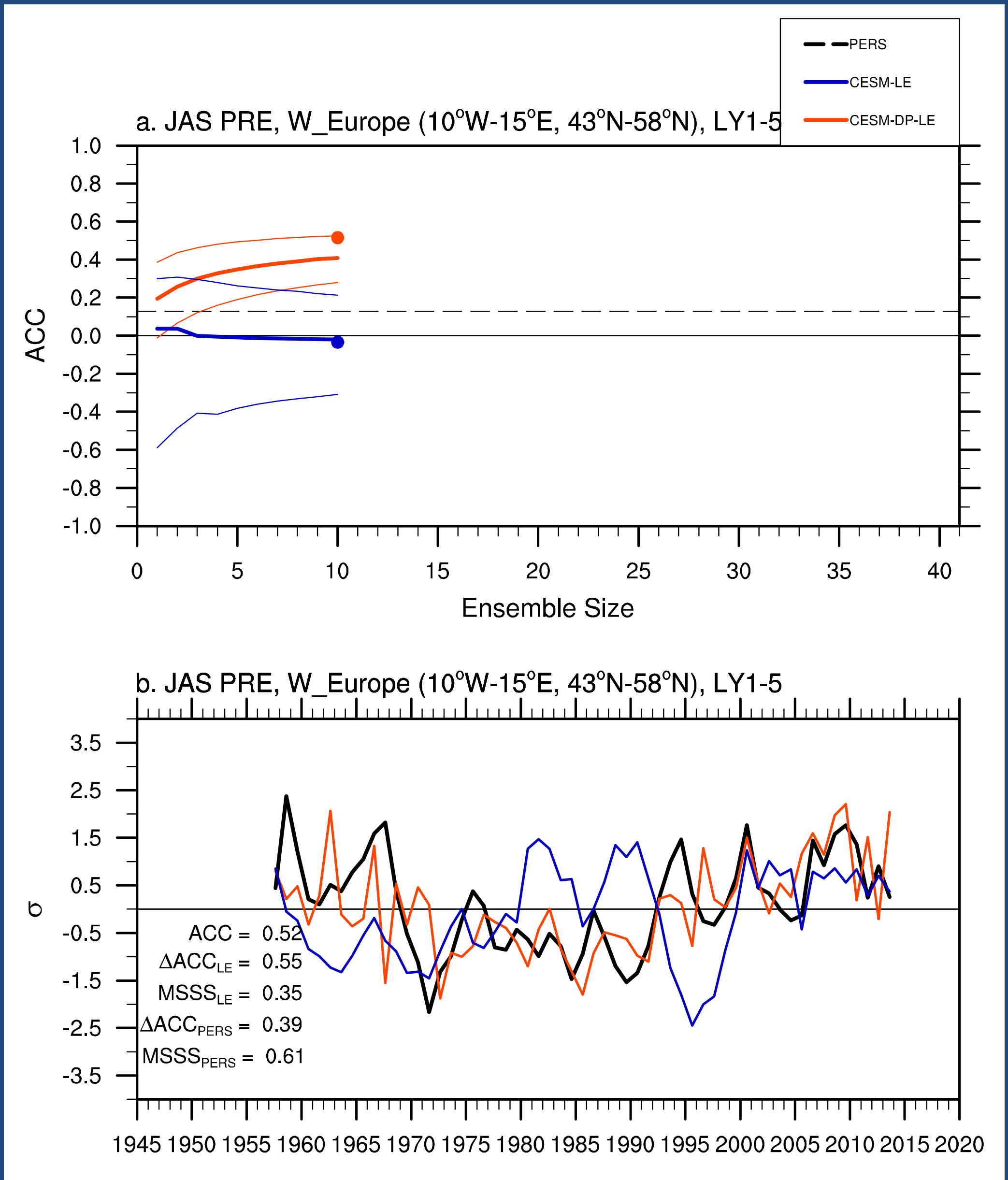


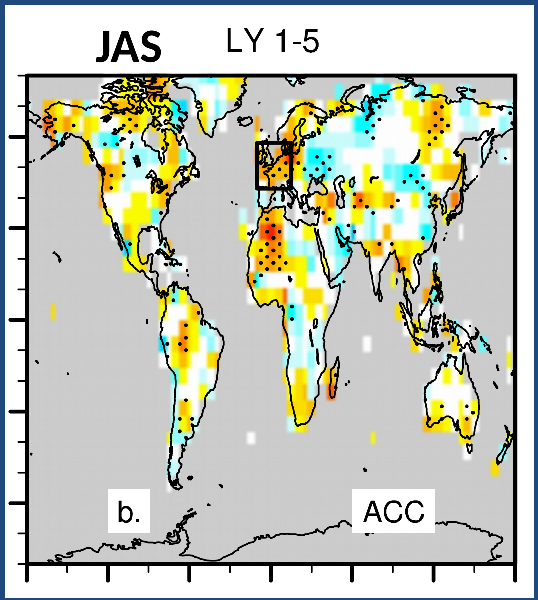
Summer Precipitation Skill





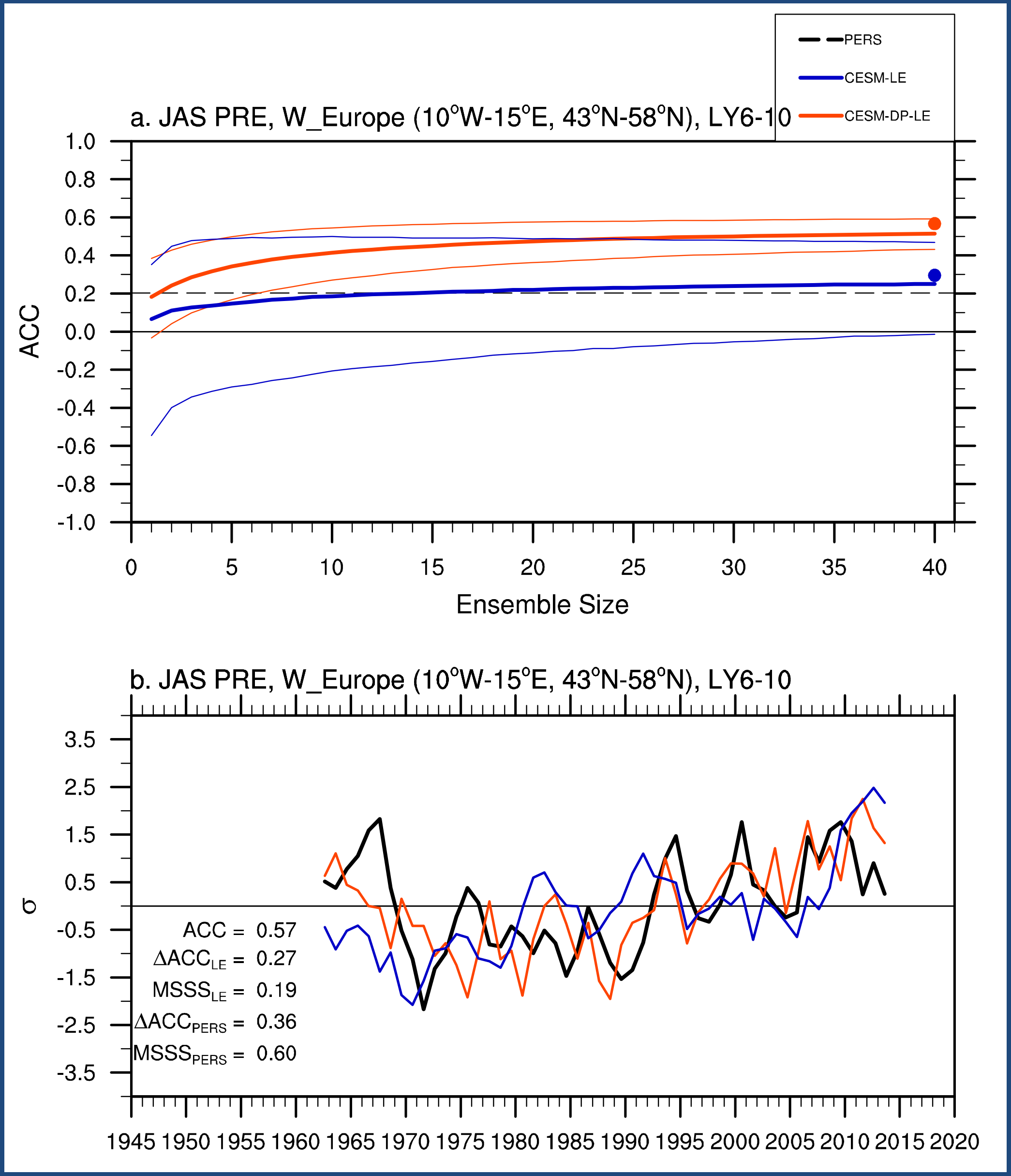
Summer Precipitation Skill





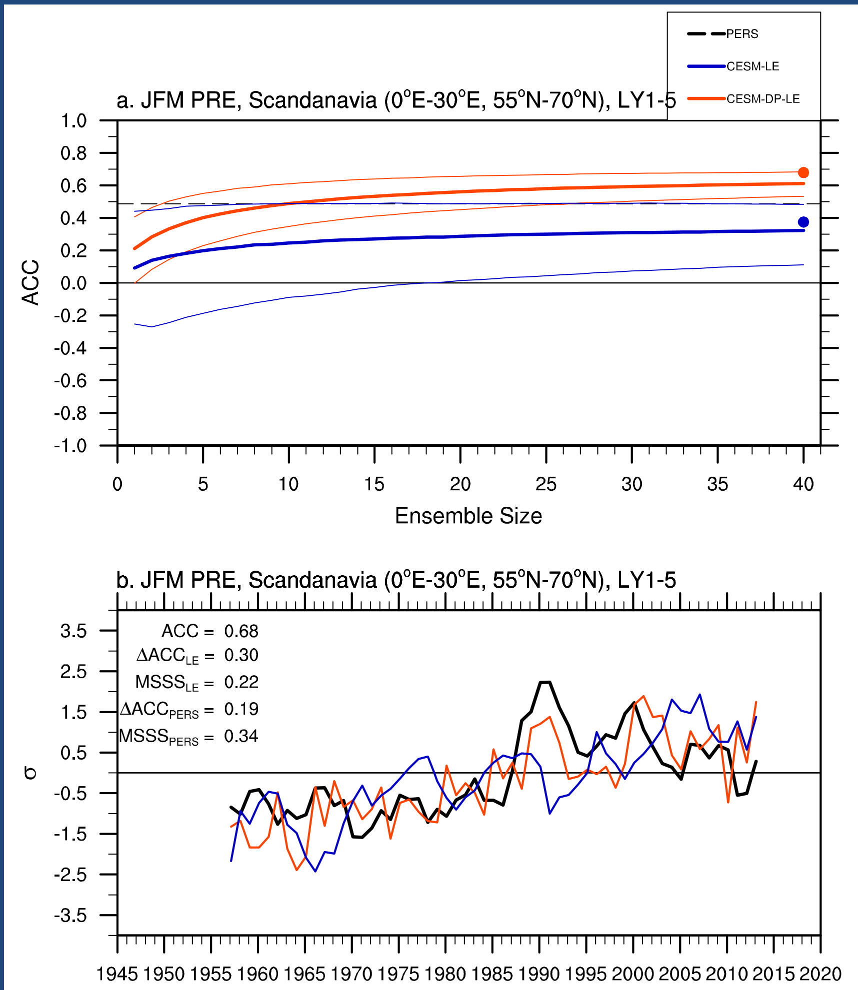
- Standard (10-member or less) ensembles can give misleading impressions regarding skill & skill improvement w.r.t. uninitialized

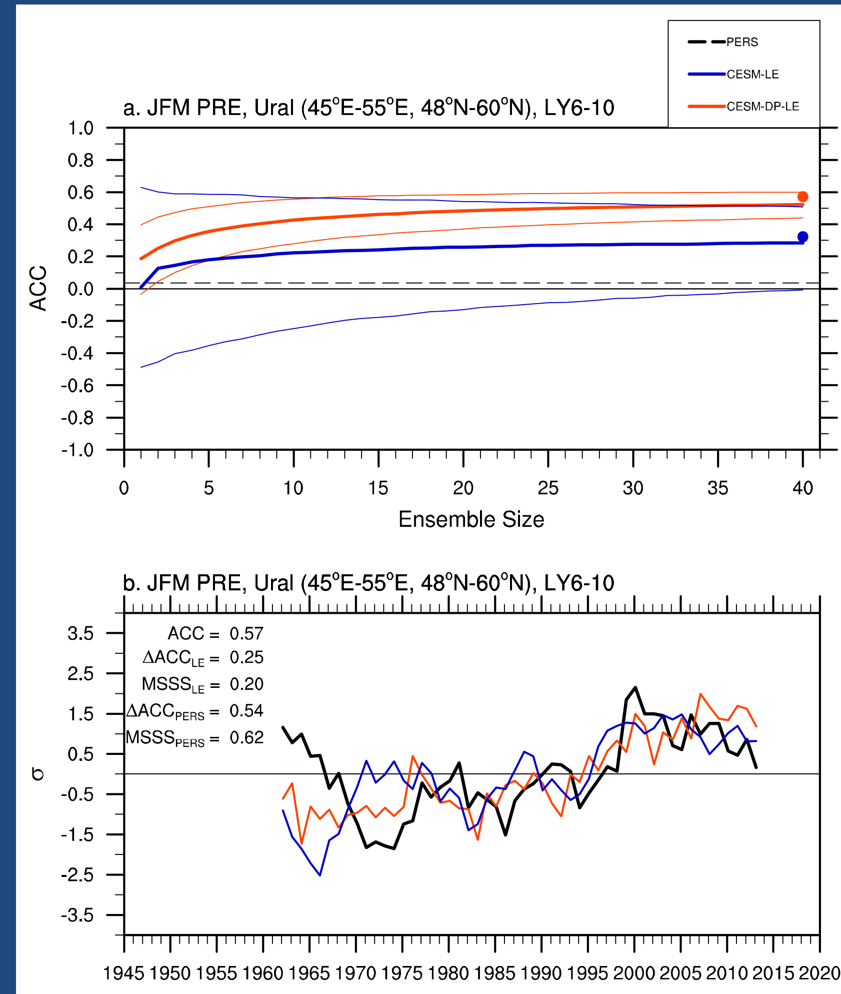
Summer Precipitation Skill

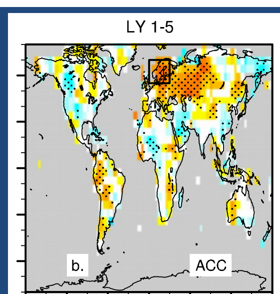


JAS

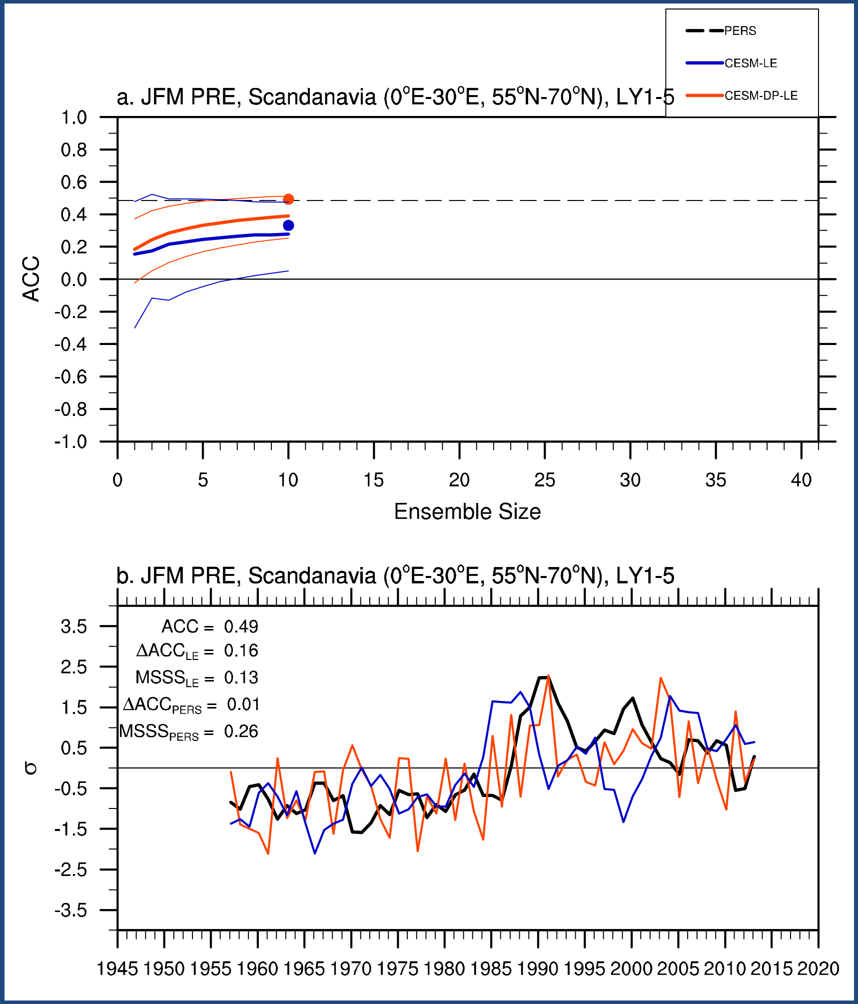
Winter Precipitation Skill

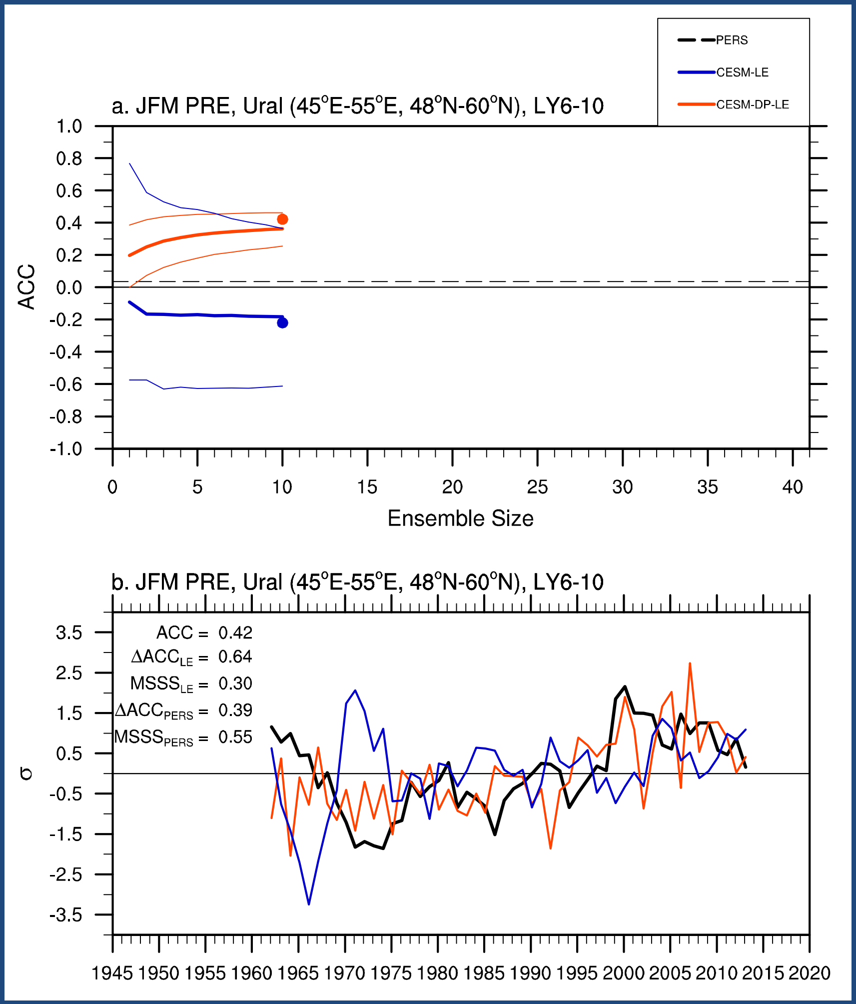


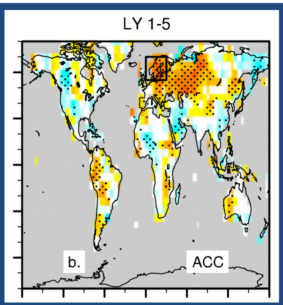




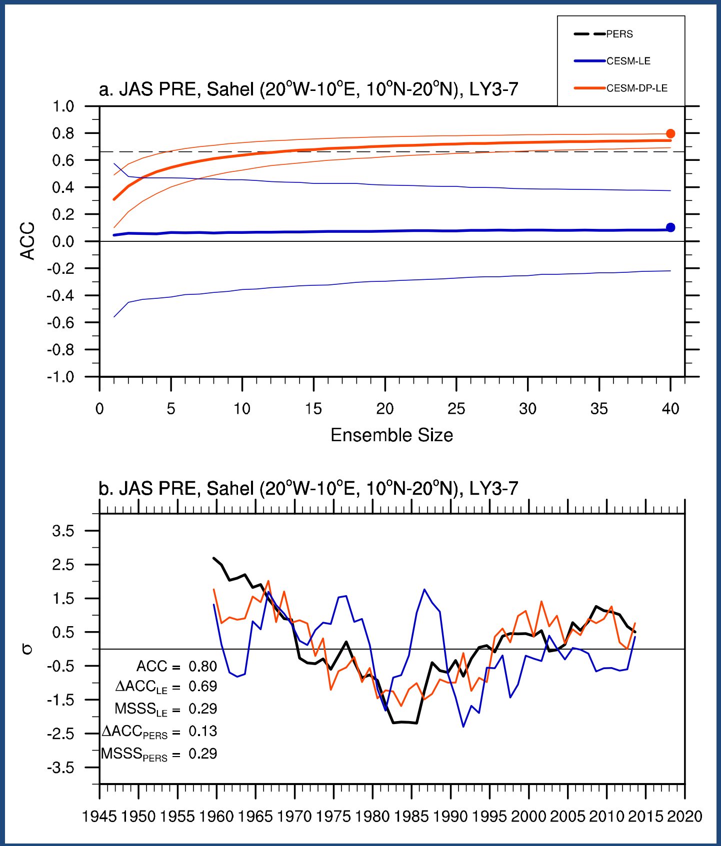
Winter Precipitation Skill

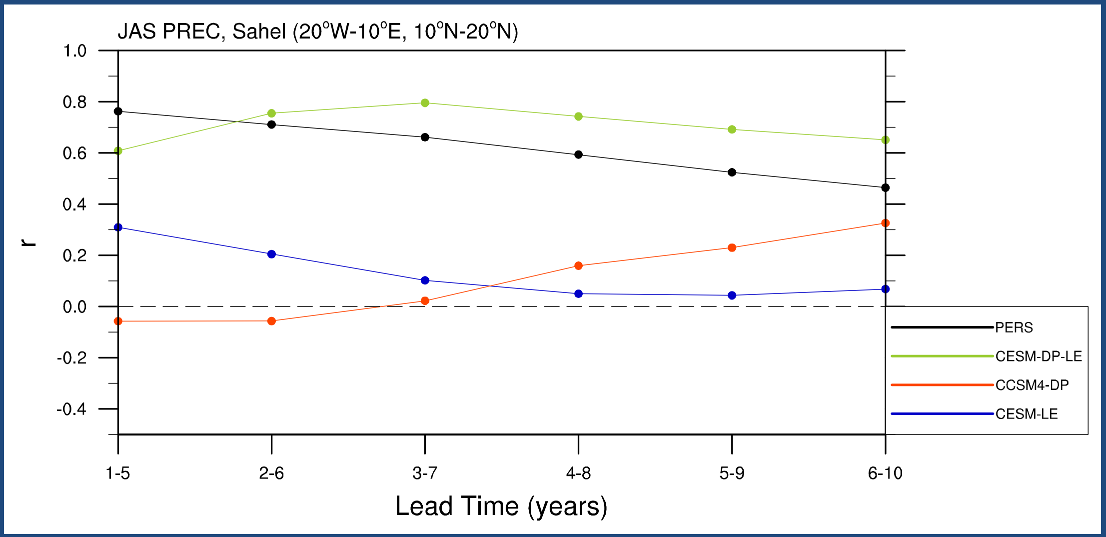


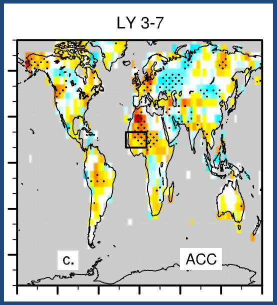




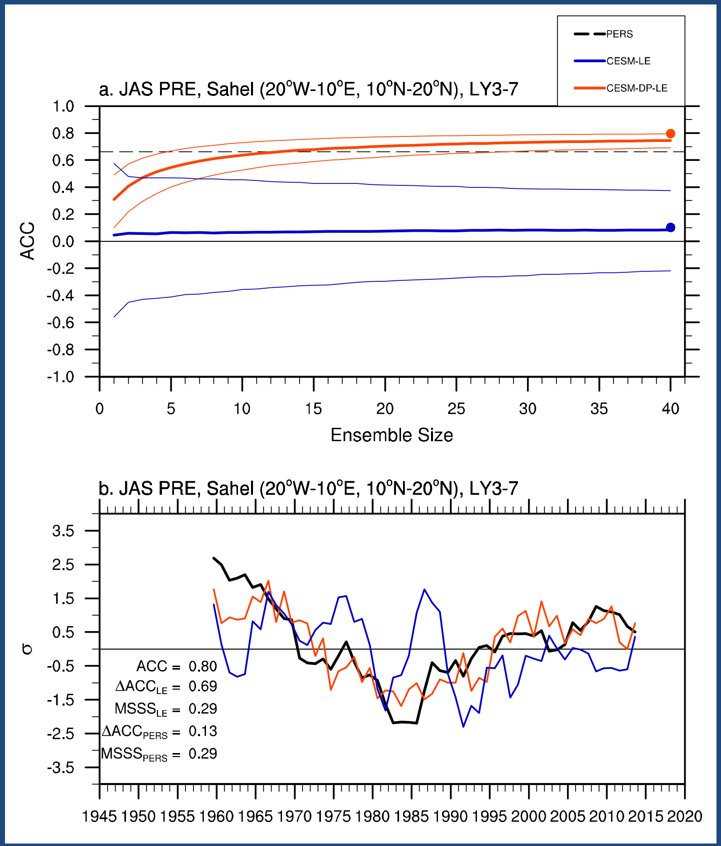
Summer Precipitation in the Sahel

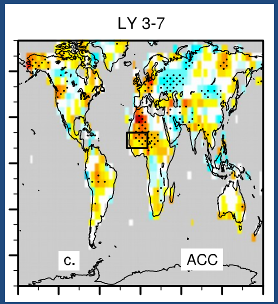


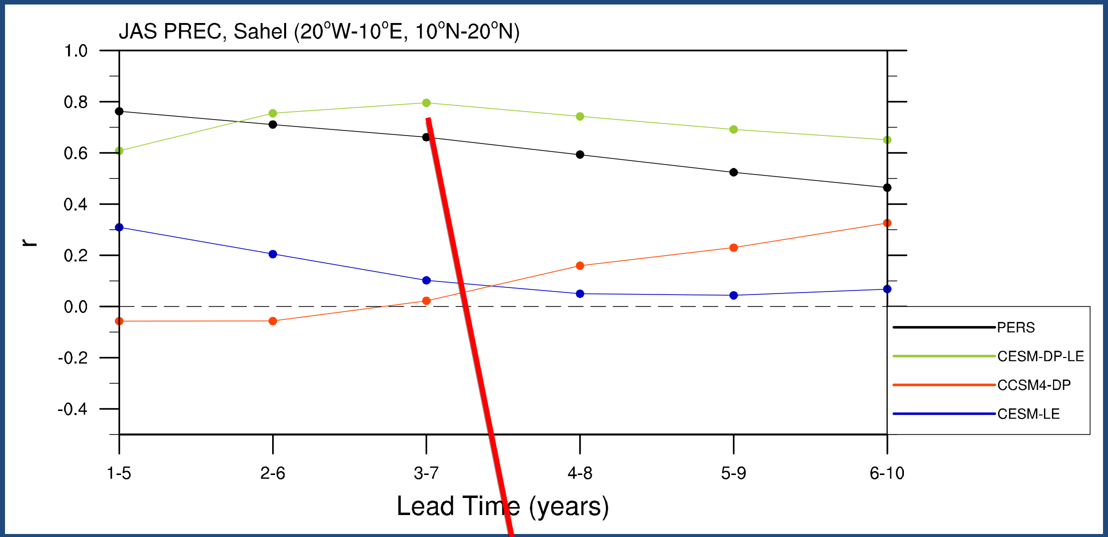


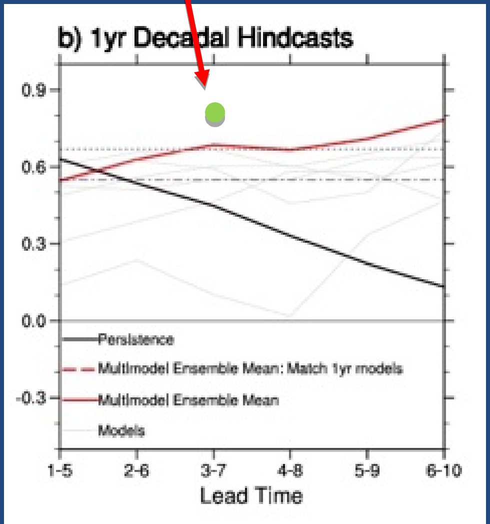


Summer Precipitation in the Sahel







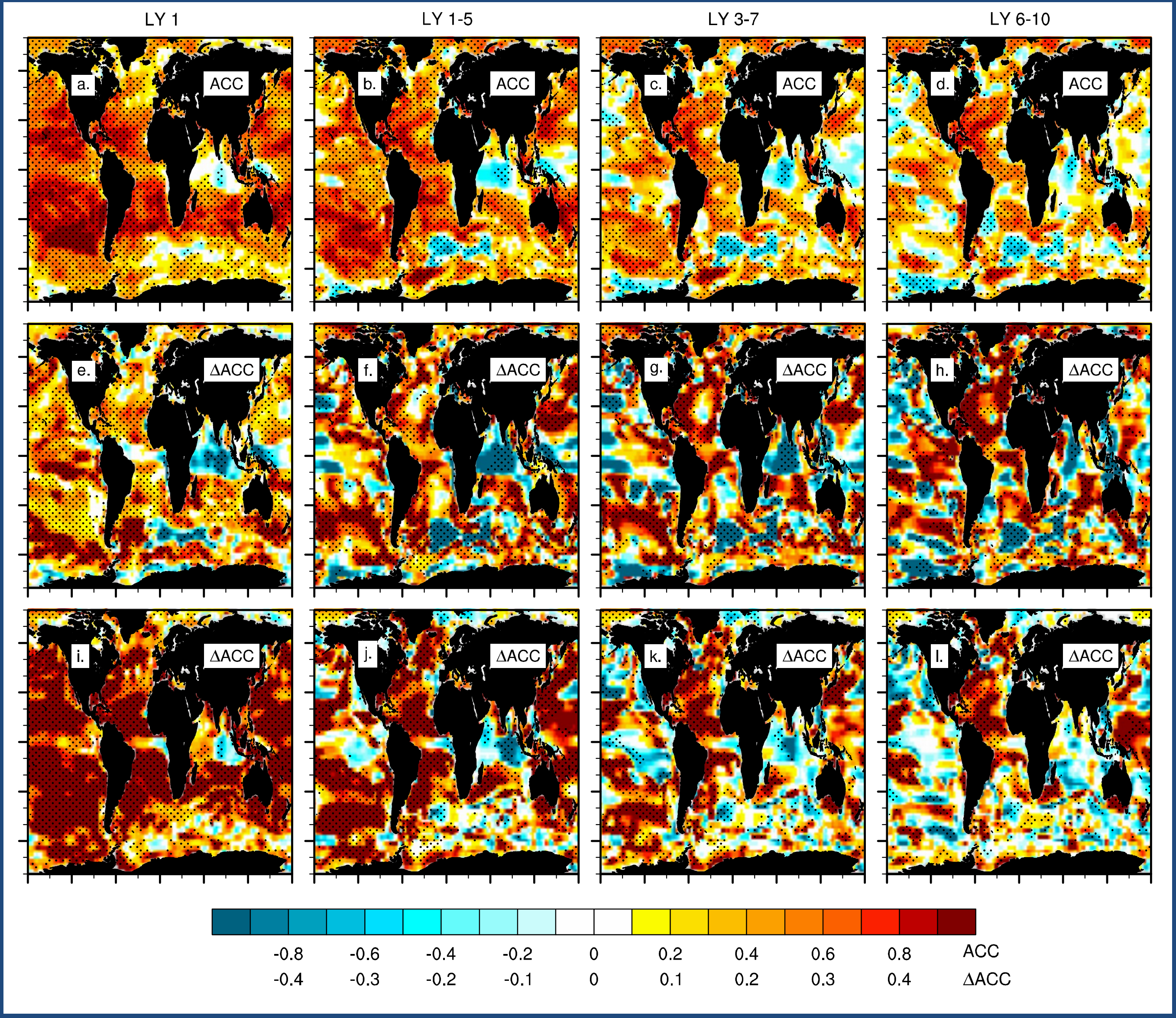


Martin & Thorncroft, *GRL*, 2014, doi: 10.1002/2014GL059338

Net Primary Productivity (NPP)

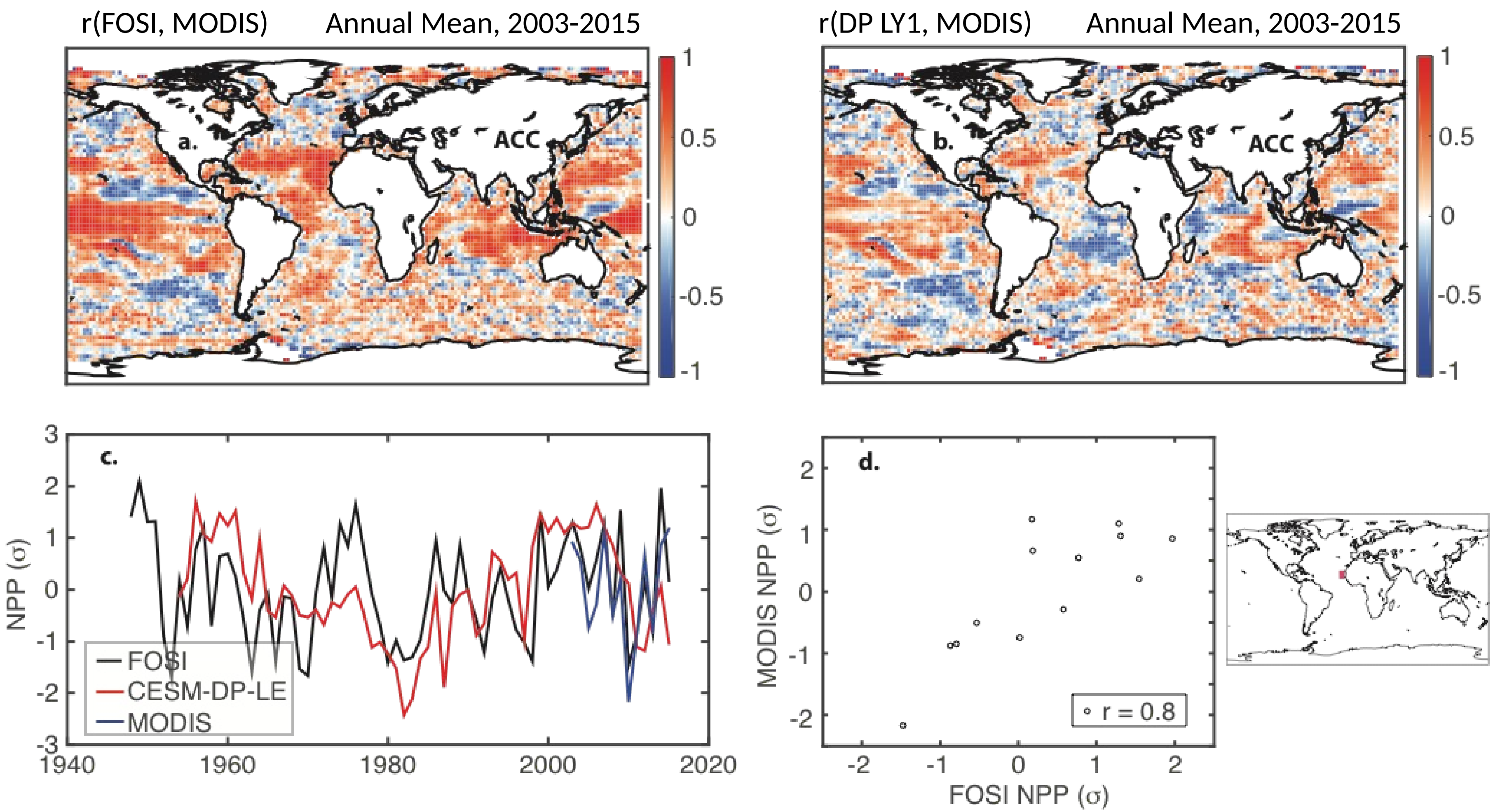
(verified against FOSI)

- Anomaly correlation coefficient (ACC)
- Skill improvement over persistence
- Skill improvement over UI



Net Primary Productivity (NPP)

(verified against MODIS)



(Figure courtesy Nicole Lovenduski, University of Colorado)

Summary

- A new large-ensemble CESM decadal prediction ensemble[1] represents the initialized counterpart to an existing large-ensemble of historical simulations[2]. Together, these experiments offer unprecedented statistical power for disentangling the external and internal sources of skill, exploring signal-to-noise characteristics, and studying climate extremes.
- CESM-DP-LE exhibits promising skill for a variety of fields across a range of forecast lead times up to decadal, both in the ocean and over land. Skill for surface climate over land appears to be related, at least in part, to skill at predicting SST forcing of the atmosphere, which is sustained by skillful prediction of ocean heat content. This explains the significantly improved SAT and precipitation skill scores compared to CESM-LE and CCSM4-DP (which share the same external forcing).
- Increasing the DP ensemble size results in further "micro" skill improvements by enhancing the atmospheric response to (presumably SST) forcing through noise reduction (Scaife et al. 2014; Eade et al. 2014).

[1]Yeager et al. 2017: Predicting near-term changes in the Earth System: A large ensemble of initialized decadal prediction simulations using the Community Earth System Model, *BAMS*, submitted.

[2]Kay et al. 2015: The Community Earth System Model (CESM) Large Ensemble Project: A Community Resource for Studying Climate Change in the Presence of Internal Climate Variability, *BAMS*, doi:10.1175/BAMS-D-13-00255.1.