

# Interannual to Decadal Earth System Prediction at NCAR

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NCAR/CGD

Thanks to: Jerry Meehl, Steve Yeager, Yaga Richter,  
Alicia Karspeck, Gokhan Danabasoglu et al.



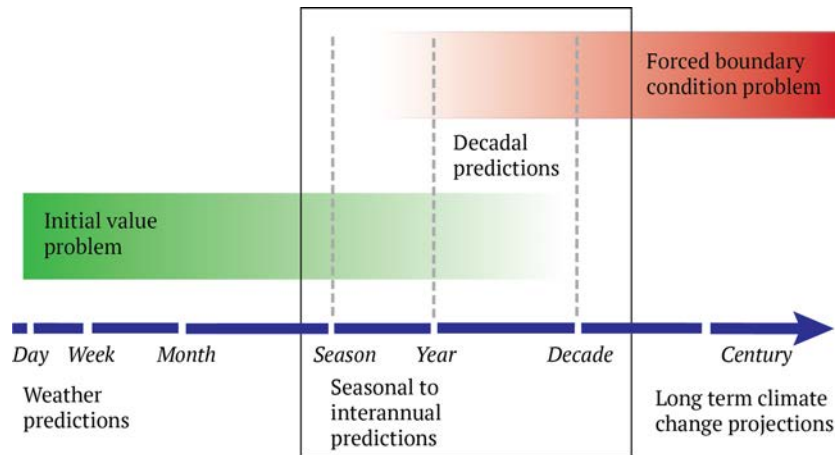
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# Decadal Predictions



**WCRP grand challenge**  
**WCRP scientific objective #2**  
**CMIP6 science question**

## CMIP5

Taylor et al. 2009

- 10 yr and 30 yr hindcasts/predictions
- Initialized every 5 yrs 1960-2005
- Ocean initialization
- ~16 model groups
- Input to Chapter 11 IPCC AR5
- Led to quasi-operational decadal prediction

## CMIP6 (DCPP MIP)

Boer et al. 2016

- Initialized every year 1960-present
- 5-10 yr hindcasts/predictions, 10 members
- Mechanism, predictability and case studies (targeted idealized experiments)
- WGSIP, WCGM, CLIVAR

# NCAR Contributions

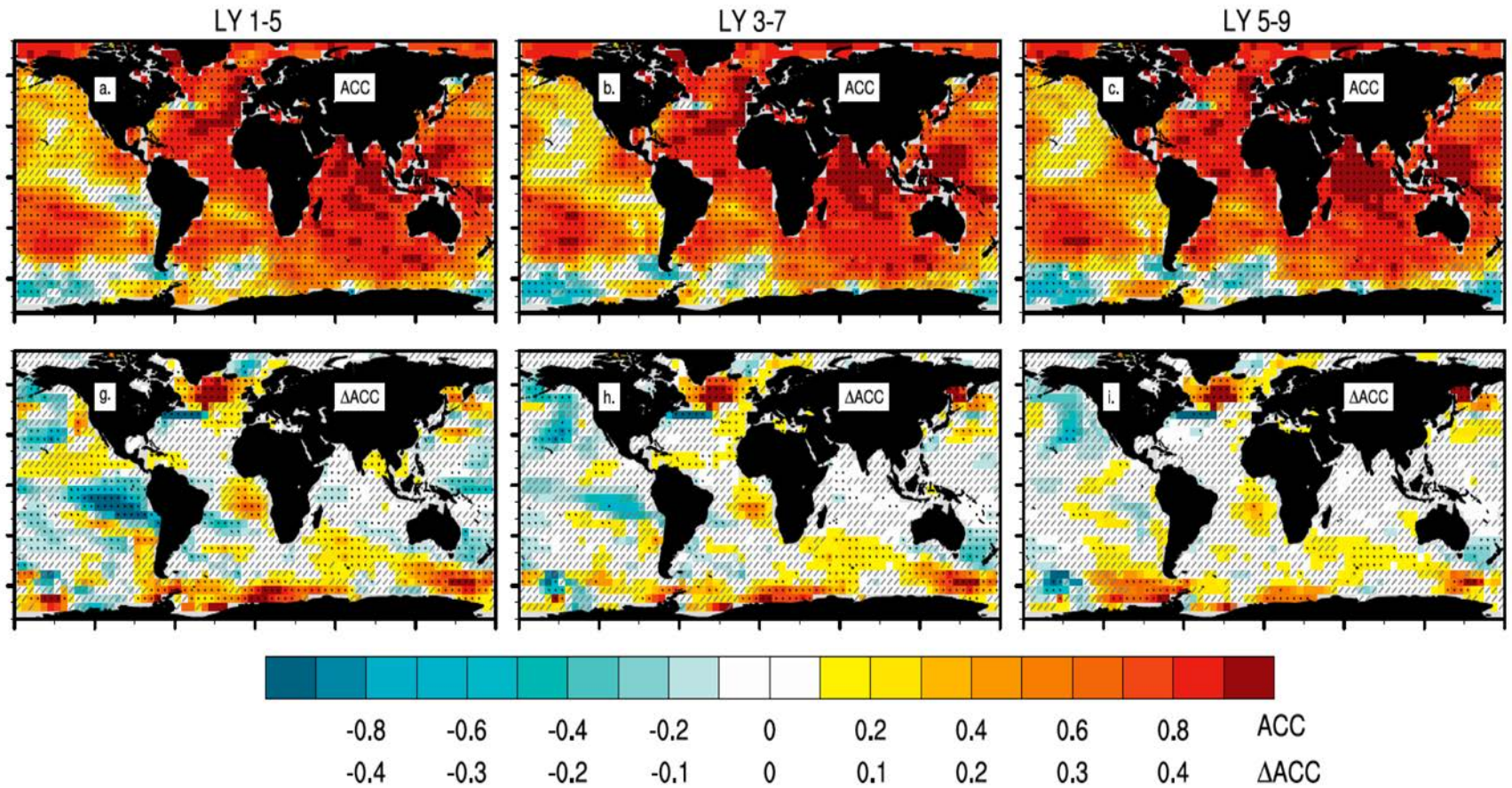
## CMIP5

- CCSM4 DP (~ 1deg)
- ocn hindcast initialization/DART initialization
- 16(the gaps were filled in later)/12 start years
- 10 members

## CMIP6

- CESM1 DPLE (~ 1deg)
- ocn hindcast initialization
- 60+ start years
- 40 members
- ocn BGC

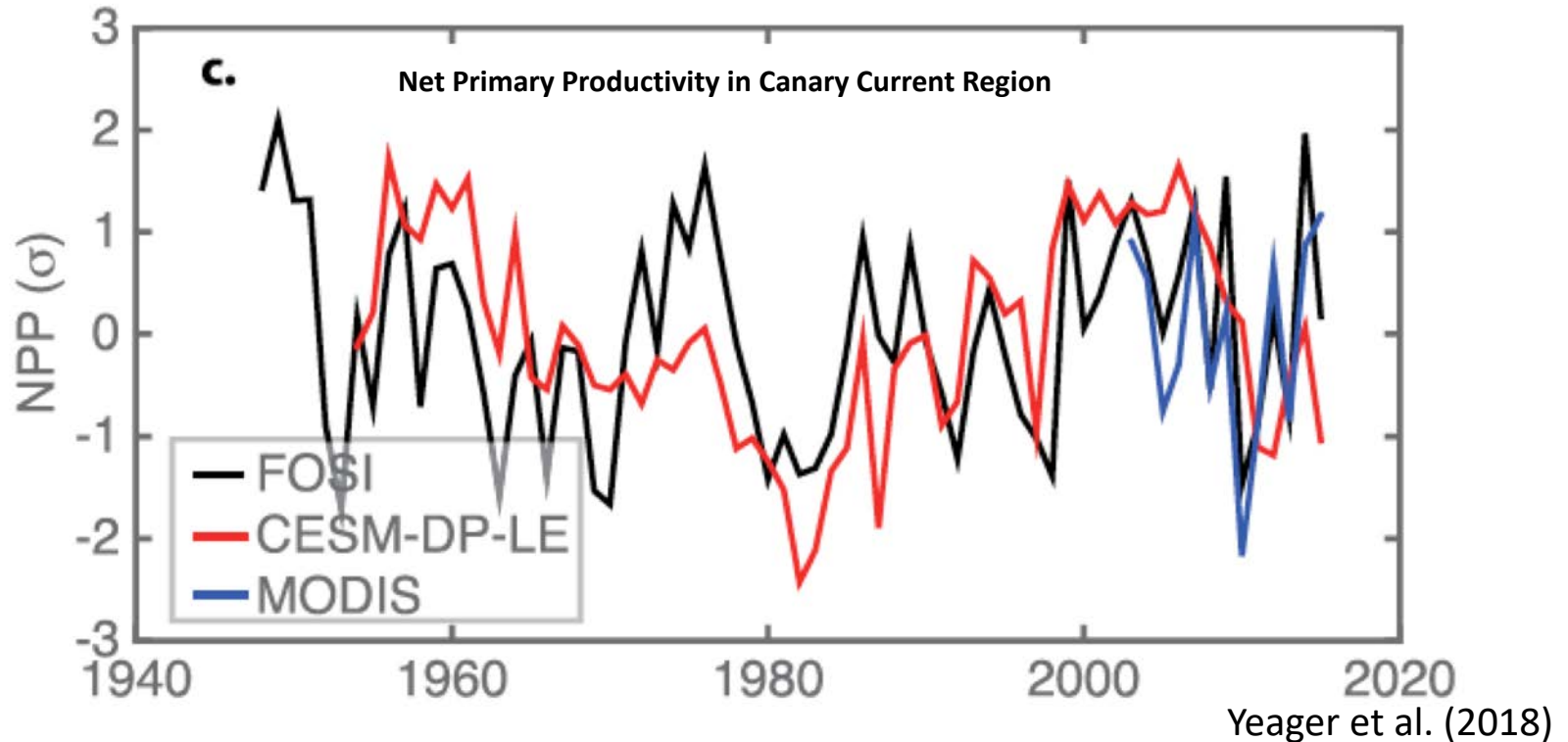
# CESM1 DPLE Highlights



Yeager et al. (2018, BAMS)

# CESM1 DPLE Highlights

## Predicting Ocean Biogeochemistry



- Multi-year skill in predicting air-sea  $\text{CO}_2$  flux & NPP
- Ongoing work to explore predictability of other components of Earth's carbon cycle & other ocean BGC fields



# Ongoing CESM1 DPLE Analysis

## I2D papers planned, submitted, or published

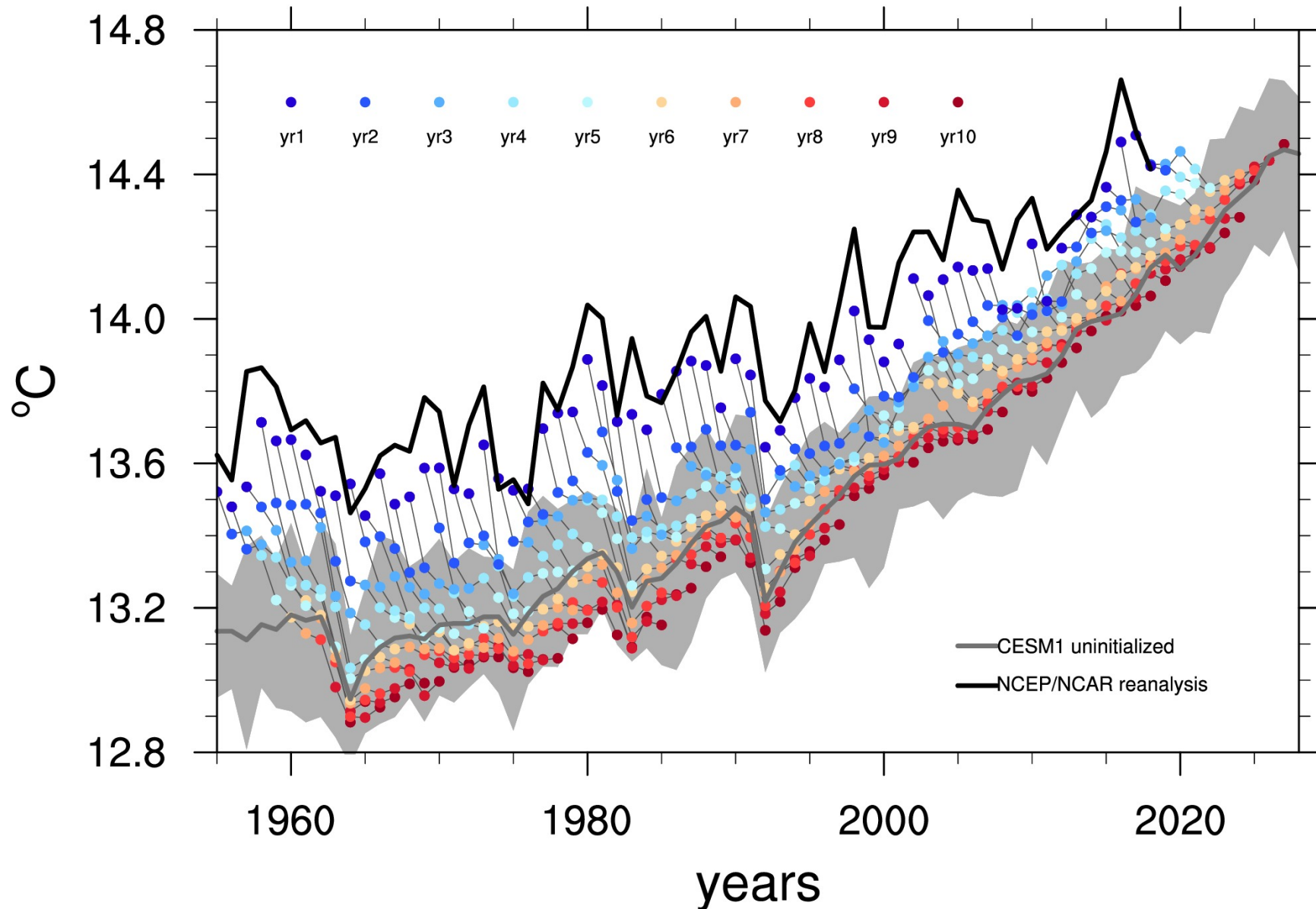
Name(s)	Paper title/description	Status
Simpson et al.	Decadal predictability of late winter precipitation in western Europe through an ocean-jet stream connection	published 2019 (doi:10.1038/s41561-019-0391-x)
Lovenduski et al.	Predicting near-term variability in ocean carbon uptake	published 2019 (doi:10.5194/esd-10-45-2019)
Athanasiadis et al.	Decadal predictability of North Atlantic blocking and the NAO	submission pending
Christensen et al.	The value of initialisation on decadal timescales: state dependent predictability in the CESM Decadal Prediction Large Ensemble	submission pending
Lovenduski et al.	High predictability of terrestrial carbon fluxes from an initialized decadal prediction system	submission pending
Maroon et al.	Was the 2015 subpolar North Atlantic cold blob predictable?	in prep
Brady et al.	Skillful 1 System	submission pending
Krumhardt et al.	Decadal and drive	in prep
Yeager	Mechani -predic -predic -the ro	in prep
Long et al.	Decadal	in prep
Athanasiadis et al.	Decadal	being explored
Robson et al.	Multi-mo	planned
Smith et al.	A global	planned
Smith et al.	Robust s	published 2019
Smith et al.	Likelihood of 1.5 warming	published 2018
Tarun et al.,	Predictability of Arctic freshwater content	in prep



# Outstanding Challenges

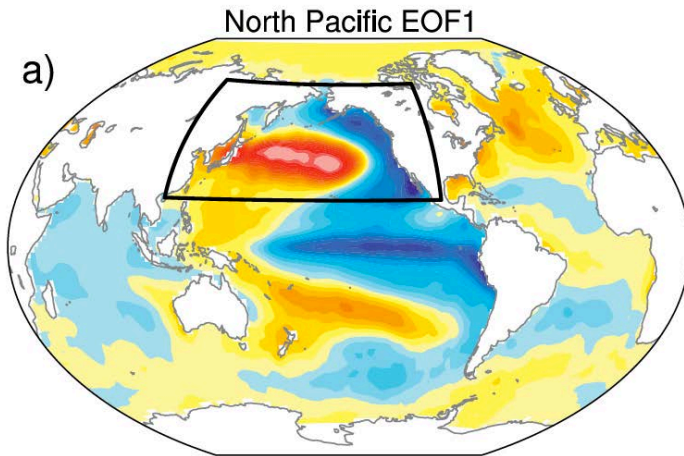
- **Insufficient understanding of CESM1 DPLE behavior & underlying predictability mechanisms**
- **Model bias & drift & initialization shock**
- Initialization
- Ensemble generation
- Big Data issues
- Signal-to-noise “paradox”
- **Funding**

# CESM1 Initialized vs. Uninitialized Global ANN TAS

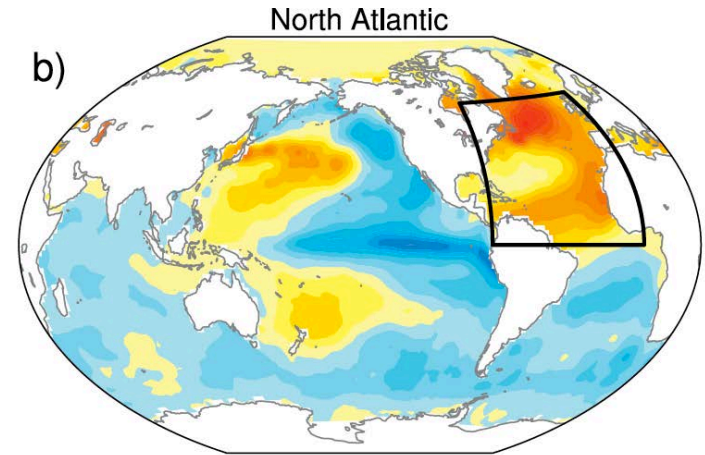




# Processes & Predictability



- mechanisms for IPO transition
- predictability



- role of abyssal flow
- impacts over land
- AMV & NAO

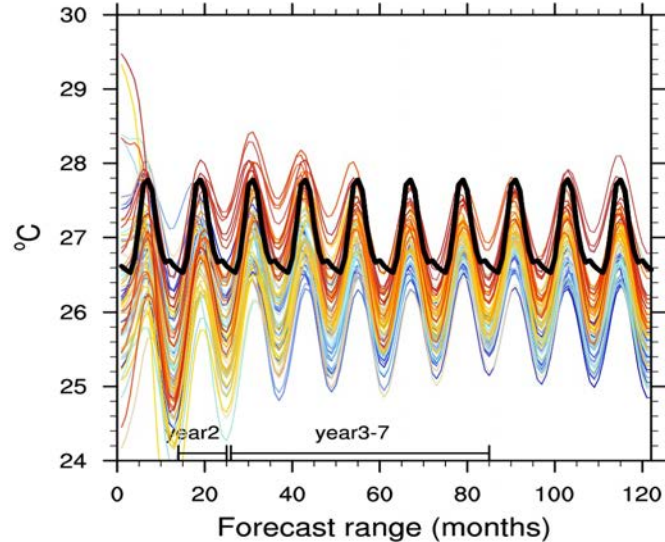
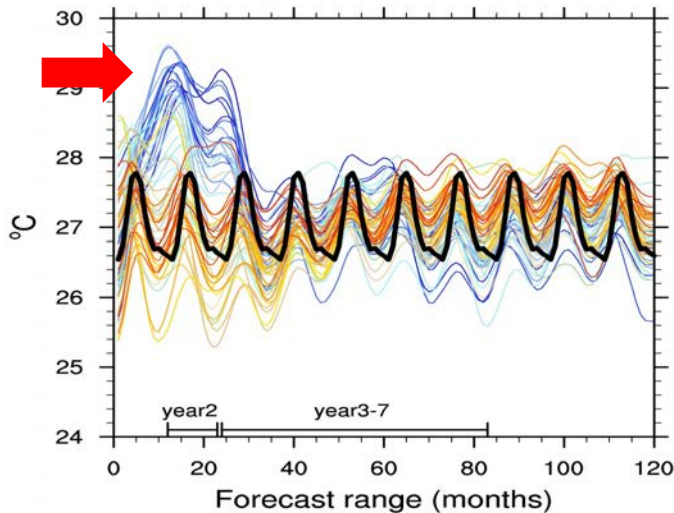


# Model drift/initialization shock

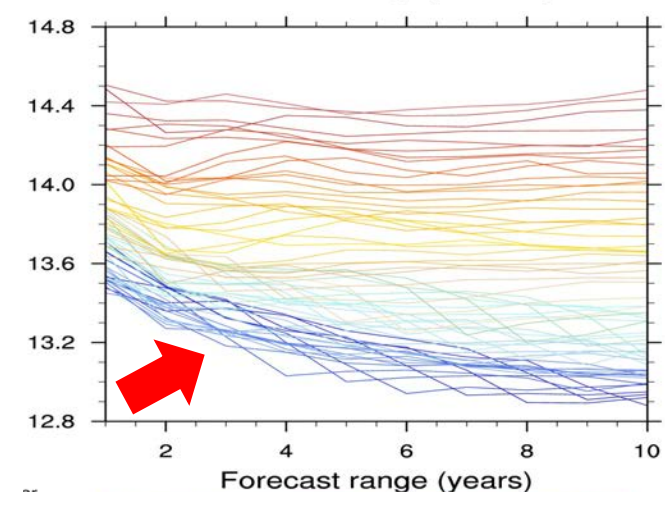
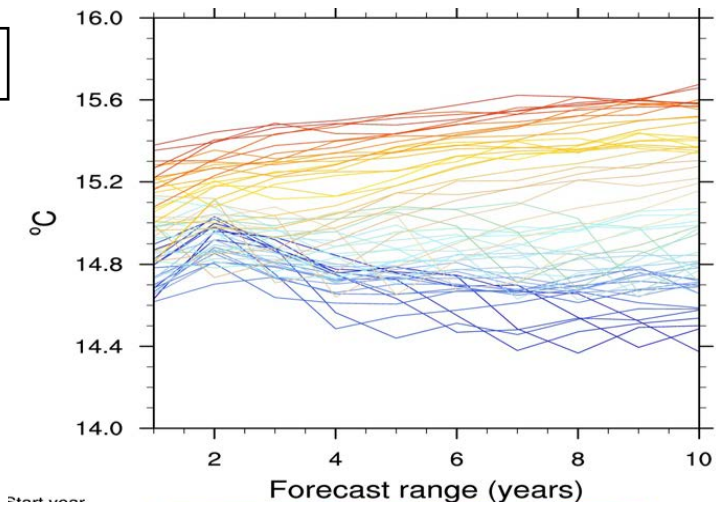
## CCSM4 DP

## CESM1 DPLE

### Nino34 SST



### GANN TAS



Start years



# How to initialize CESM?



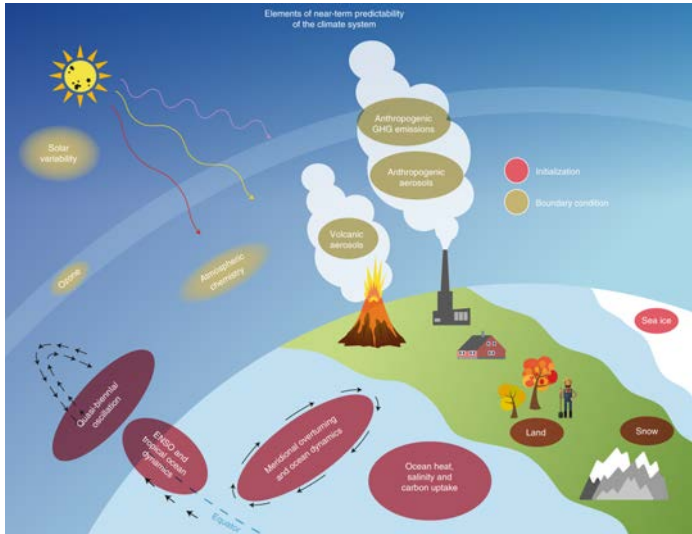
- **Close to nature or to the model trajectory?**

1. full field vs. anomaly vs. modes
2. reanalysis/DA, hindcast products, nudging, analog, etc.

- **Model components/variables**

1. ocn, lnd, atm...
2. ocn surface or abyssal ocn too

Elements of near-term predictability of the climate system (Kushnir et al. 2019)



# Model Resolution: Collaboration with iHESP @TAMU



- High resolution CESM1 (0.1 deg ocean, 0.25 deg atm) initialized decadal prediction following DCPD protocols
- Plan to start in fall 2019, currently waiting for ocean hindcast initialization with JRA55



## Model & Initialization : Collaboration with U of Miami & LANL

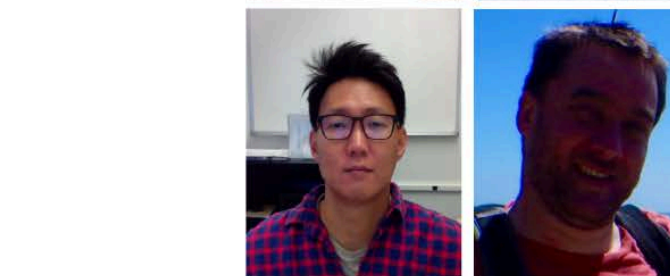
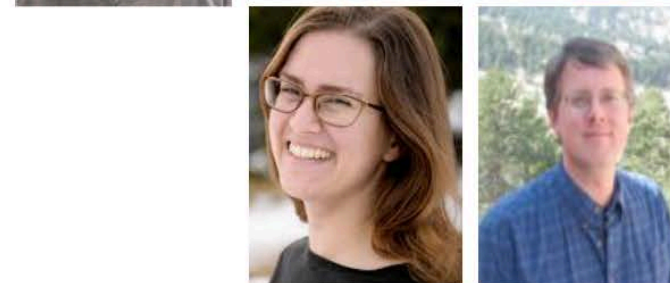
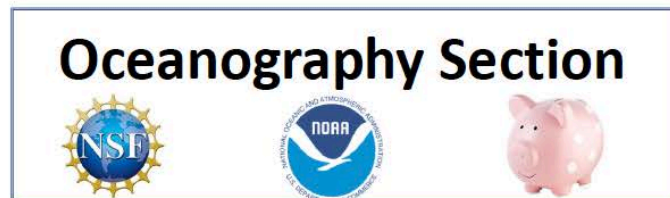
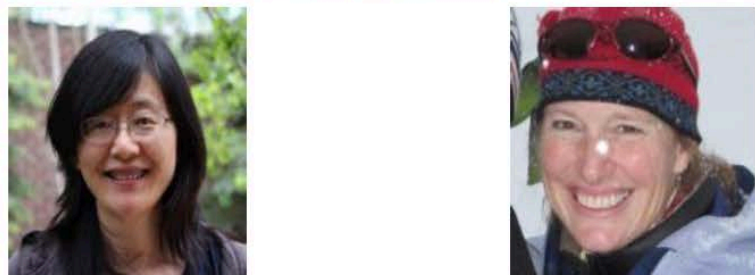
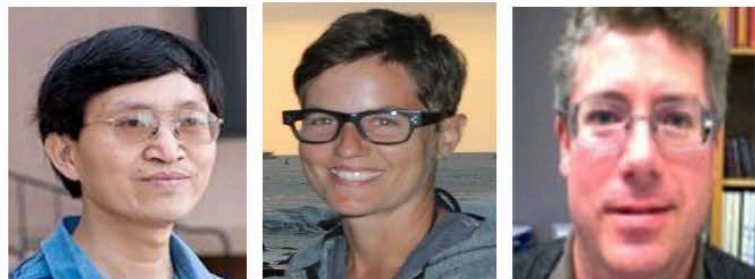
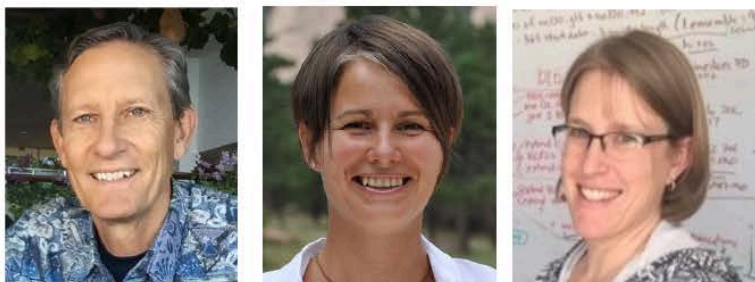


- Perform **E3SM** and **CESM2** 1deg ocean hindcast simulation with JRA55
- Run initialized hindcasts with E3SM and CESM2 from limited start years (2000, 2005, 2010, 2015), and compare with **reanalysis initialization** (CFS, from Ben Kirtman)





# Lack of base funding

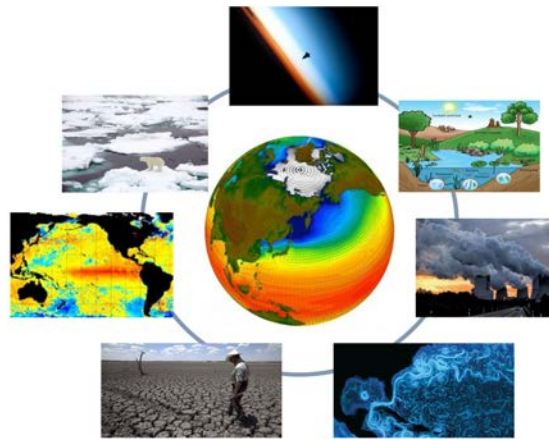




# NCAR CGD Earth System Prediction Project

*Co-leads: Yaga Richter, Haiyan Teng and Steve Yeager*

*Coordinate 15+ currently funded S2D prediction projects across all CGD sections*



- Promote fundamental research on understanding of predictability on the S2D time scales
- Strengthen the bridge btw model development/improvement and coupled prediction
- Foster coordinated efforts across CGD, NCAR and the community
- Contribute to R2O/R2A

## Discussions: How to advance the field?

- Better model (model improvement & coupled prediction)
- **Process/predictability understanding** (IPO/IPV, predictability source beyond ocean, etc.)
- Initialization (full field/anomaly/DA, how to initialize land, BGC, atm)
- Resolution (value of high-res?)
- Ensemble size
- Bias adjustment/verification (advanced methods)
- What should we aim to predict (over land? low-hanging fruits)?
- **Closer collaborations** with other communities (modelers, seasonal prediction, land-atm/land-ocn interaction, ocean/land reanalysis, climate service ...)
- How to use obs data to constrain the I2D hindcast? Changing obs network?
- Who is interested in investing in I2D prediction?