Near-term Hydroclimate outlooks based on the Community Earth System Model (CESM) Decadal Prediction Large Ensemble (DPLE)

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# The CESM Decadal Prediction Large Ensemble

<table>
<thead>
<tr>
<th>Experiment Name</th>
<th>CCSM4-DP</th>
<th>CESM-DP-LE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
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<tr>
<td>-atm</td>
<td>CCSM4</td>
<td>CESM1.1</td>
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<tr>
<td>-ocn</td>
<td>CAM4 (FV 1°, 26lvl)</td>
<td>CAM5 (FV 1°, 30lvl)</td>
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<tr>
<td>-ice</td>
<td>POP2 (1°, 60lvl)</td>
<td>POP2 (1°, 60lvl) w/ BGC</td>
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<tr>
<td>-Ind</td>
<td>CICE4 (1°)</td>
<td>CICE4 (1°)</td>
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<td></td>
<td>CLM4</td>
<td>CLM4</td>
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<tr>
<td><strong>Uninitialized Ensemble (UI)</strong></td>
<td>6-member CCSM4 20th century ensemble (Meehl et al., 2012)</td>
<td>40-member CESM 20th century Large Ensemble (Kay et al., 2015)</td>
</tr>
<tr>
<td><strong>Forcing</strong></td>
<td>-2005: CMIP5 historical</td>
<td>-2005: CMIP5 historical</td>
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<tr>
<td></td>
<td>2006--: CMIP5 RCP 4.5</td>
<td>2006--: CMIP5 RCP 8.5</td>
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<tr>
<td><strong>Initialization</strong></td>
<td></td>
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<tr>
<td>-method</td>
<td>full field</td>
<td>full field</td>
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<tr>
<td>-atm</td>
<td>UI</td>
<td>UI</td>
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<tr>
<td>-ocn</td>
<td>CORE-forced FOSI</td>
<td>CORE*+forced FOSI</td>
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<td>UI</td>
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<tr>
<td><strong>Ensembles</strong></td>
<td>10 annual; Jan. 1st 1955-2014 (N=60) Variable January start days + round-off perturbation of atm initial conditions 120 months</td>
<td>40 annual; Nov. 1st 1954-2015 (N=62) round-off perturbation of atm initial conditions 122 months</td>
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<tr>
<td><strong>CMIP5-era (2011)</strong></td>
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<td><strong>CMIP6-era (2017)</strong></td>
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- Active ocean biogeochemistry
- More robust assessment of the skill derived from external forcing
- Improved ocean initial conditions (reduced shock)
- Large ensemble size
- Now extended to 2017
OUTLINE

• Global overview of skill at predicting seasonal precipitation over land
  • Impact of initialization

• Focused examination of some select regions/seasons:
  • African Sahel (JAS)
  • Northern Europe (JAS)
  • Pacific Northwest (JAS)
  • Scandinavia (JFM)
  • Pacific NW (JAS)

• Towards an improved understanding of regional precipitation skill:
  • Skill (skill improvement) dependence on ensemble size
  • Skill dependence on lead time
  • What can be learned from skill spread?

Yeager et al., 2018: Predicting near-term changes in the Earth System: A large ensemble of initialized decadal prediction simulations using the Community Earth System Model, Bull Amer Meteorol Soc, in press, doi: 10.1175/BAMS-D-17-0098.1
CESM-DPLE: Boreal Summer (JAS) Precip

- 40-member-, pentadal-means
- Land-only data
- 5°×5° grid with 9-pt spatial smoother (each grid point represents 15°×15°)

- OBS = CRU-TS4.0 (Harris et al. 2014, Int J Climatol)
- Top row: ACC(DPLE,OBS)
- Middle row: ΔACC relative to persistence
- Bottom row: ΔACC relative to 40-member LE

ACC, Precipitation, OBS=CRU-TS4.0, Season=JAS, 9-pt-smoothed, (LY 1-5: 1957.6-2013.6)

LY 1-5

LY 3-7

LY 5-9

Yeager et al. (2018)
• Local p values determined using block bootstrap resampling across time/member (Goddard et al. 2013)

• \( p > 0.1 \) (not significant) indicated by “/”

• Global field significance \( (p << 0.1) \) using False Discovery Rate method (Wilks 2016) indicated by “•”

ACC, Precipitation, OBS=CRU-TS4.0, Season=JAS, 9-pt-smoothed, (LY 1-5: 1957.6-2013.6)

LY 1-5

LY 3-7

LY 5-9

d. \( \Delta \text{ACC} \)

e. \( \Delta \text{ACC} \)
f. \( \Delta \text{ACC} \)
g. \( \Delta \text{ACC} \)
h. \( \Delta \text{ACC} \)
i. \( \Delta \text{ACC} \)
**CESM-DPLE: Boreal Summer (JAS) Precip**

- Complex picture requiring region-by-region scrutiny
- Overall, positive impact of initialization
- Increasing skill with lead time in many regions

ACC, Precipitation, OBS=CRU-TS4.0, Season=JAS, 9-pt-smoothed, (LY 1-5: 1957.6-2013.6)

**LY 1-5**

- a. ACC
- d. ΔACC
- g. ΔACC

**LY 3-7**

- b. ACC
- e. ΔACC
- h. ΔACC

**LY 5-9**

- c. ACC
- f. ΔACC
- i. ΔACC

Color bar:
- ACC: -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8
- ΔACC: -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4

Yeager et al. (2018)
• Skill (and skill difference from UI) largely resilient to detrending ➔ not simply an artifact of trend bias correction

• Increased skill in Africa, Saudi Arabia, South Asia, Brazil

ACC, Precipitation, OBS=CRU-TS4.0, Season=JAS, 9-pt-smoothed, (LY 1-5: 1957.6-2013.6), detrended

Yeager et al. (2018)
CESM-DPLE: Boreal Winter (JFM) Precip

- Mixed impact of initialization
- Some increase of skill with lead time: East Asia, Western US
- Noteworthy skill/skill enhancement: N Europe & Eurasia, E Africa, W Australia
CESM-DPLE:  Boreal Winter (JFM) Precip (detrended)

- Skill (and skill difference from UI) largely resilient to detrending
- Increased skill in central Africa

ACC, Precipitation, OBS=CRU-TS4.0, Season=JFM, 9-pt-smoothed, (LY 1-5: 1957.1-2013.1), detrended