Subseasonal predictability from atmospheric, land, and ocean initial states

Jadwiga (Yaga) Richter, Anne (Sasha) Glanville, Teagan King, Steve Yeager, Sanjiv Kumar, Nick Davis, Paul Dirmeyer, & Gokhan Danabasoglu

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Introduction & Goal

Goal: To quantify how much subseasonal predictability comes from the initial state of atmosphere, land, and ocean/sea-ice.

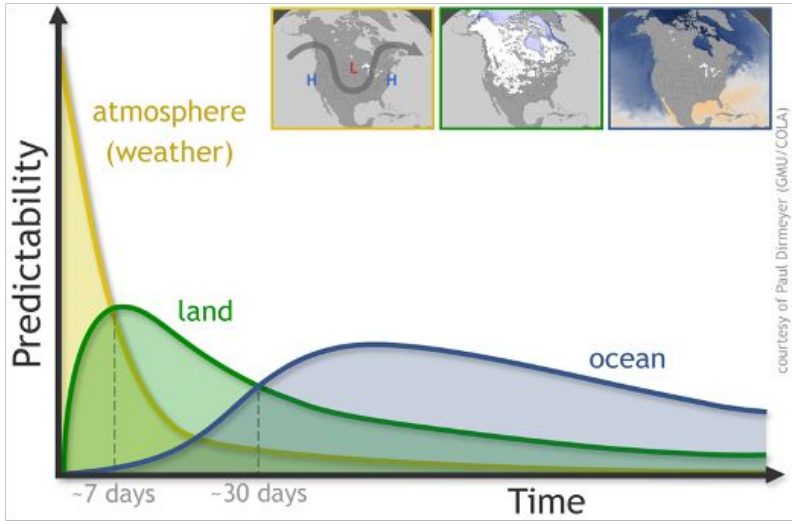


Fig by P. Dirmeyer: representative of predictability of mid-latitude surface temperature over land

Methodology:

- **Compare skill** (Anomaly Correlation Coefficient, ACC)
- **Standard reforecast set** (Realistic ATM, LND, OCN initialization)

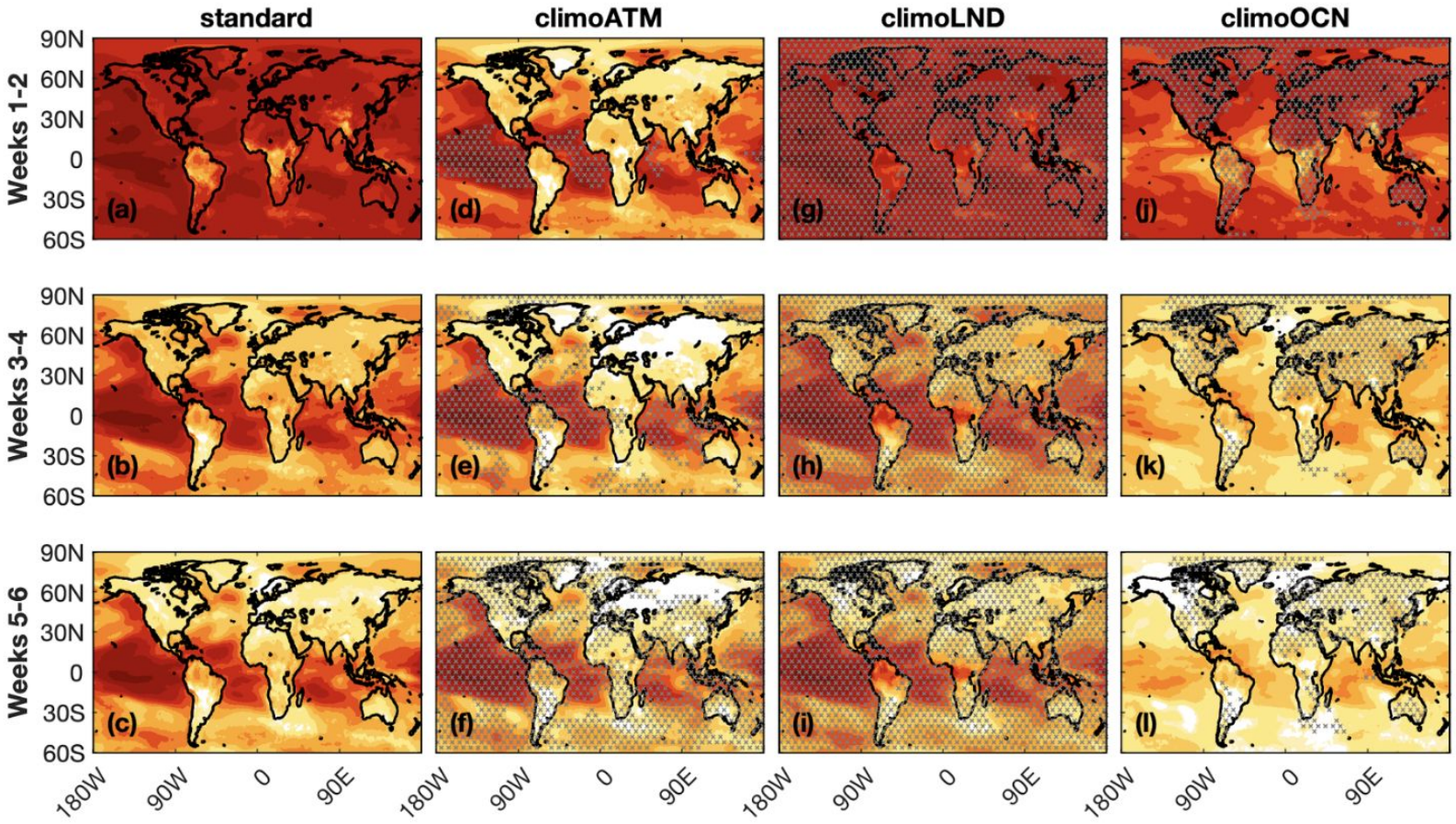
  1999 - 2020; weekly initializations; 11 member ensemble

- **Additional reforecast sets with one or two initial states set to climatology**

  1) climoATM (OCN & LND var)
  2) climoLND (ATM & OCN var)
  3) climoOCN (ATM & LND var)
  4) climoALL
  5) climoLNDclimoOCN (ATM var)
  6) climoATMclimoOCN (LND var)
  7) climoATMclimoLND (OCN var)

Results:

ACC if one component is turned into climatology:



ATM IC most important in Weeks 1 - 2 for 2m T skill over all land areas

ATM IC most important in Weeks 3 -4 for 2m T skill over majority but not all land areas

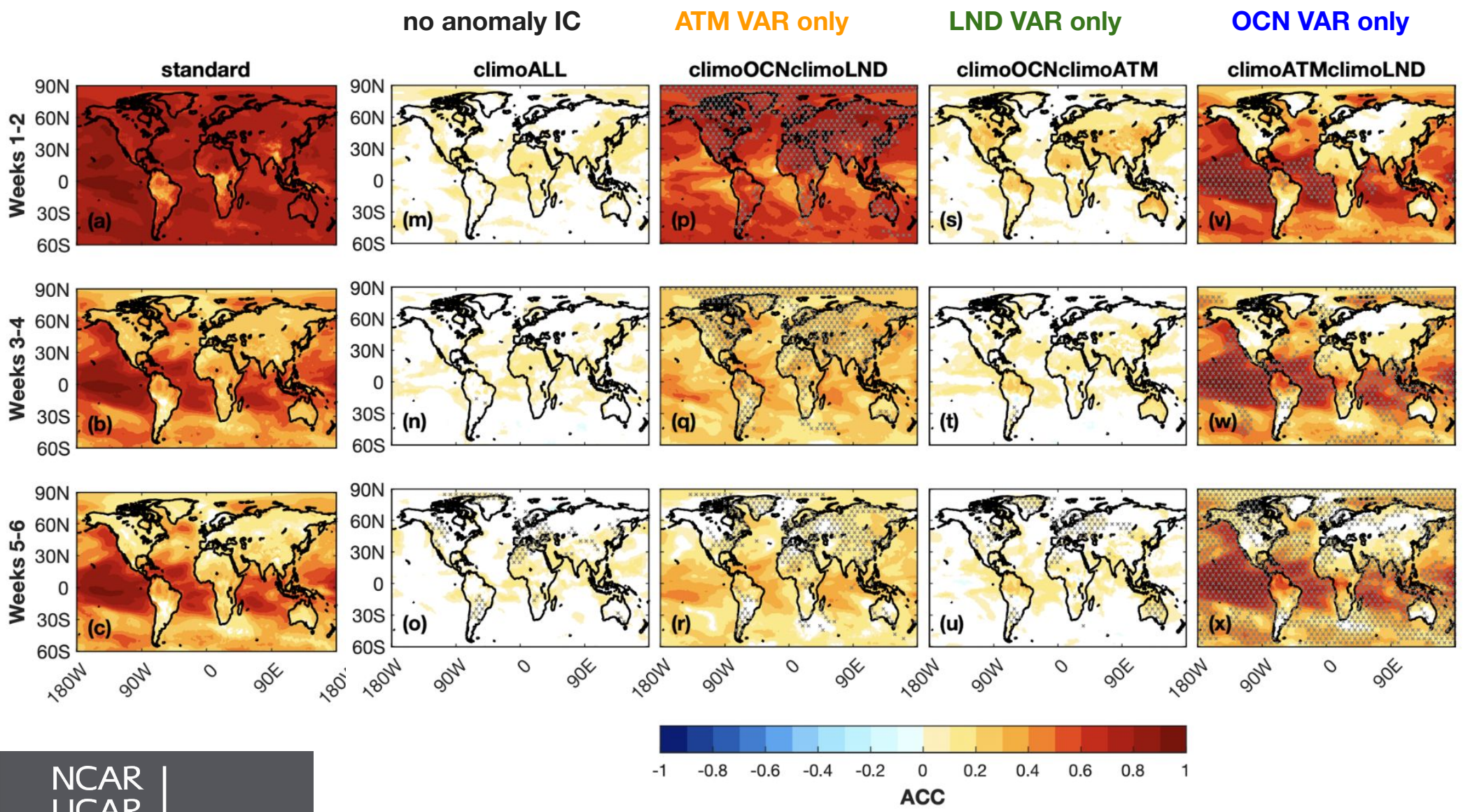
Realistic LND IC does not improve upon climatology over most land regions

Little loss of skill from not initializing the OCN at weeks 1 -6

Areas of ACC in the experimental reforecasts suite that are not statistically different from standard reforecasts are stippled

Quantifying Subseasonal Sources of Predictability

ACC if only 1 component is variable:

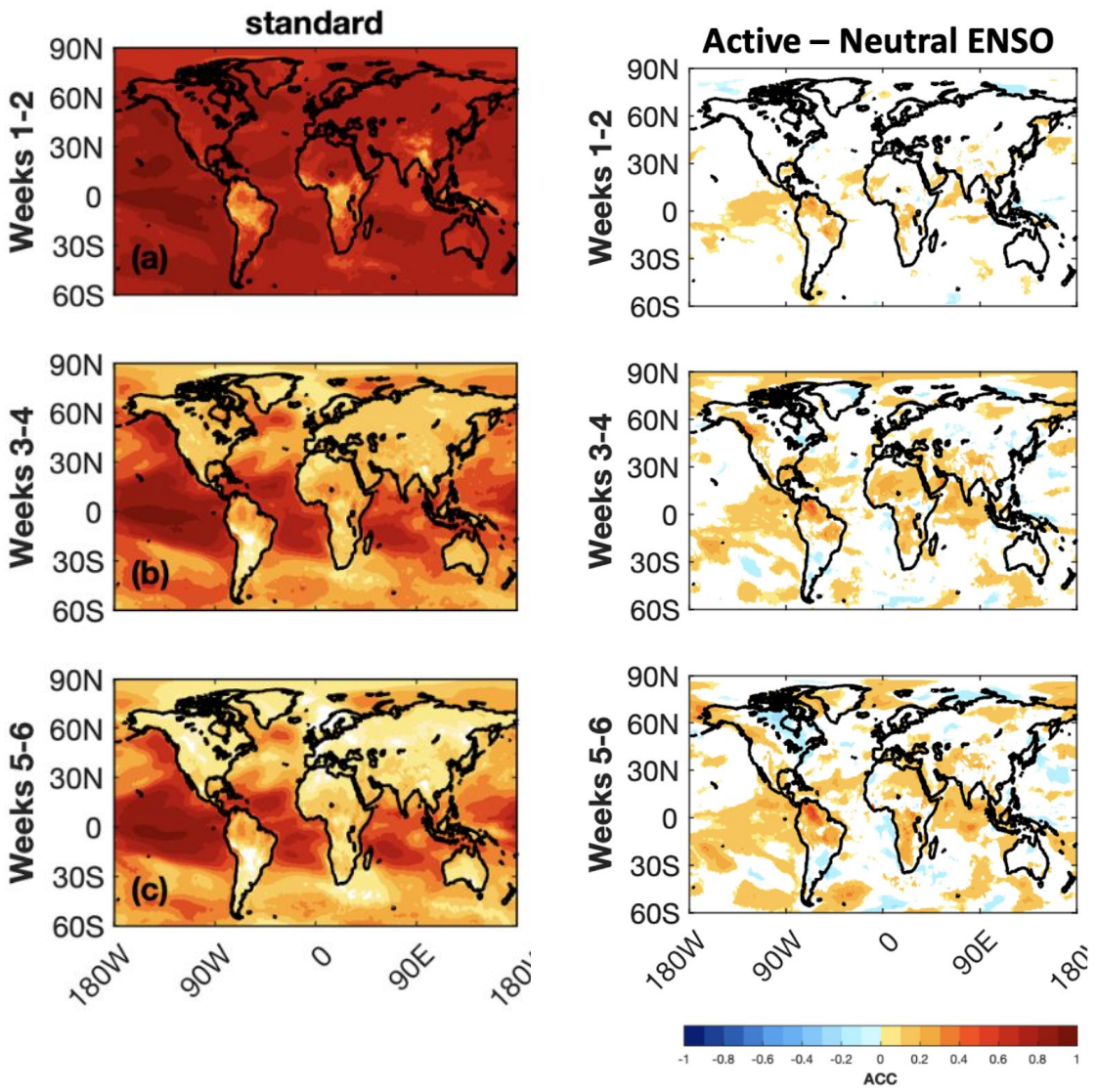


At weeks 1 - 4 ATM IC most important over land

If only LND IC is realistic, skill is low

OCN IC mostly important over ocean, except for S. America

Role of ENSO



Increased skill due to ENSO, mainly over S. America and Africa

Seasonal differences very small

Sources of Predictability

Reforecast Set	Initial Conditions	Predictability Sources
standard	standard ATM, standard LND, standard OCN	CLIM, VATM, VLND, VOCN, CAL, CAO, CLO
climoATM	climatological ATM, standard LND, standard OCN	CLIM, VLND, VOCN, CAL, CAO, CLO
climoLND	Standard ATM, climatological LND, standard OCN	CLIM, VATM, VOCN, CAL, CAO, CLO
climoOCN	Standard ATM, standard land, climatological OCN	CLIM, VATM, VLND, CAL, CAO, CLO
climoOCNclimoLND*	Standard ATM, climatological LND, climatological OCN	CLIM, VATM, CAL, CAO
climoATMclimoOCN	Climatological ATM, standard LND, climatological OCN	CLIM, VLND, CAL, CLO
climoATMclimoLND	Climatological ATM, climatological LND, standard OCN	CLIM, VOCN, CAO, CLO
climoALL	Climatological ATM, LND, OCN	CLIM

CLIM = Climatology (atmos, land, ocean)

VATM = Atmos Variability
VLND = Land Variability
VOCN = Ocean Variability

CAL = Coupling atmosphere-land
CAO = Coupling atmosphere-ocean
CLO = Coupling land-ocean

Sources of Subseasonal Predictability

(1) $\mathbf{ACC_{standard}}$ = ACC(CLIM +VATM+VLND+VOCN+CAL+CAO+CLO)

If linearity would hold:

(2) $\mathbf{ACC_{standard}}$ = ACC_{SUM}, where

(3) ACC_{SUM} = $\mathbf{ACC_C}$+ACC_{VATM}+ACC_{VLND}+ACC_{VOCN}+ACC_{CAL}+ACC_{CAO}+ACC_{CLO}

Sources of Subseasonal Predictability

We can derive individual contributions from the experimental reforecast sets:

(5) $ACC_{VATM} = \mathbf{ACC_{standard}} - \mathbf{ACC_{climoATM}}$

(6) $ACC_{VLND} = \mathbf{ACC_{standard}} - \mathbf{ACC_{climoLND}}$

(7) $ACC_{VOCN} = \mathbf{ACC_{standard}} - \mathbf{ACC_{climoOCN}}$

Assume CLO (land-ocean coupling) = 0

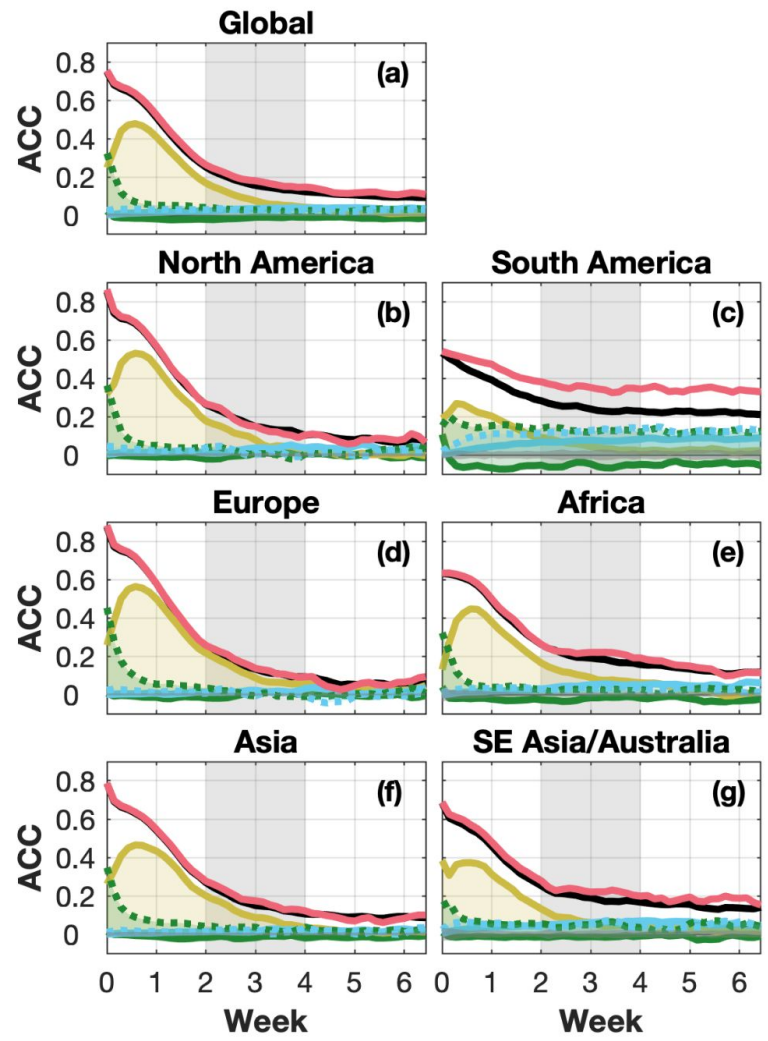
(8) $ACC_{CAL} = (\mathbf{ACC_{climoATMclimoOCN}} - \mathbf{ACC_{climoALL}}) - ACC_{VLND} =$

$= (\mathbf{ACC_{climoATMclimoOCN}} - \mathbf{ACC_{climoALL}}) - (\mathbf{ACC_{standard}} - \mathbf{ACC_{climoLND}})$

(9) $ACC_{CAO} = (\mathbf{ACC_{climoATMclimoLND}} - \mathbf{ACC_{climoALL}}) - ACC_{VOCN} =$

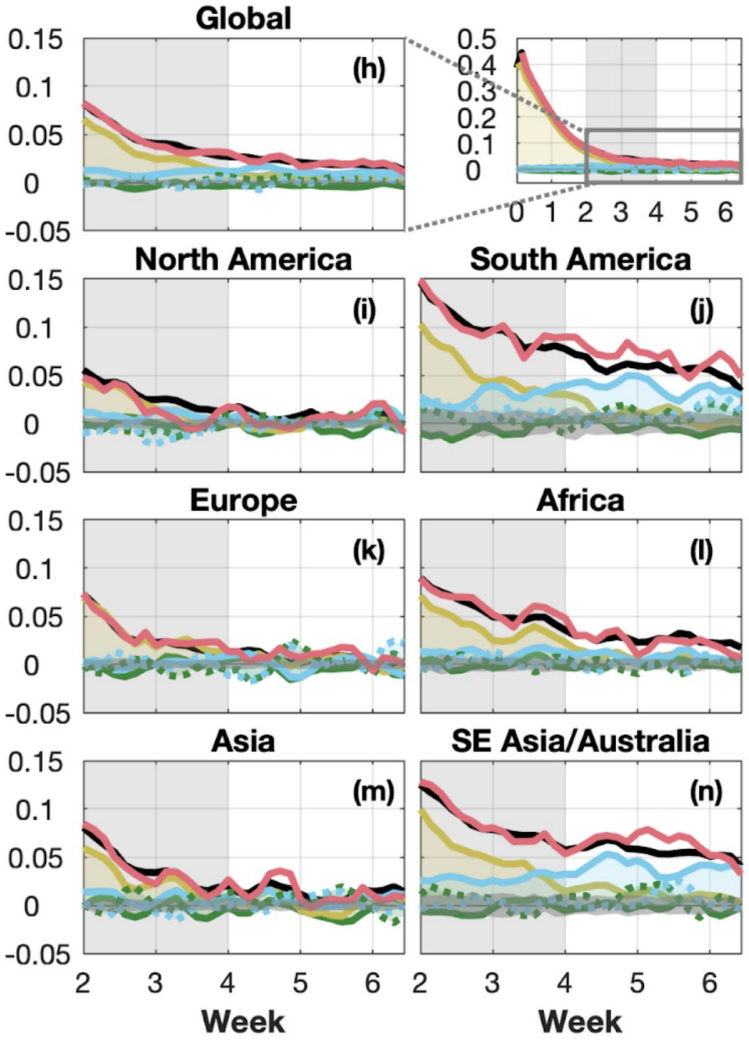
$= (\mathbf{ACC_{climoATMclimoLND}} - \mathbf{ACC_{climoALL}}) - (\mathbf{ACC_{standard}} - \mathbf{ACC_{climoOCN}})$

Sources of Predictability



Linearity assumptions holds everywhere except for South America

Sources of Predictability: Precipitation



- **Precipitation skill very low (in general)**
- **Atmospheric variability main driver except for South America and SE Asia/Australia**
- **Linearity assumption holds very well everywhere**

Discussion

- Results suggest that **atmospheric initial state is the dominant source of 2-m air temperature predictability through weeks 3 - 4** for the majority of land areas
- **Land IC plays a small role in the CESM2(CAM6) subseasonal system** and higher subseasonal skill for surface temperature can be obtained with climatological land initialization: possible that land-coupling not strong enough in CESM2
- Predictability from the **ocean initial state** exceeds that from the atmosphere only after 4 weeks; Slightly increased skill during active ENSO years
- Atmospheric initial state is the main driver of subseasonal precipitation skill, except for South America and SE Asia/Australia
- Prediction skill seems to be fairly linear

DATA

- Available online:
  https://www.earthsystemgrid.org/dataset/ucar.cgd.cesm2.s2s_hindcasts.cesm2.climo.html

- On Casper:
  /glade/campaign/cesm/development/cross-wg/S2S/CESM2/

- DOI: https://doi.org/10.5065/0s63-m767