Subseasonal prediction skill from atmosphere, land, and ocean initial conditions

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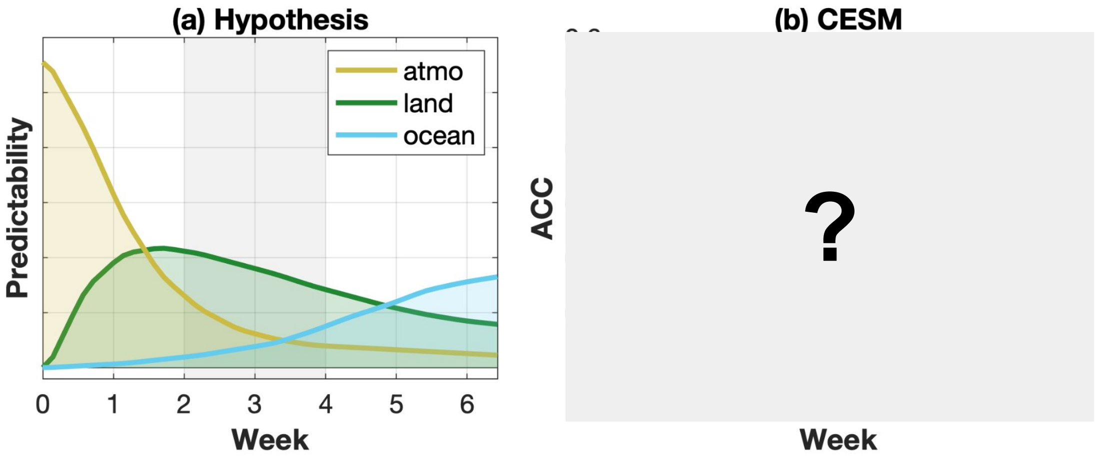
Goal

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

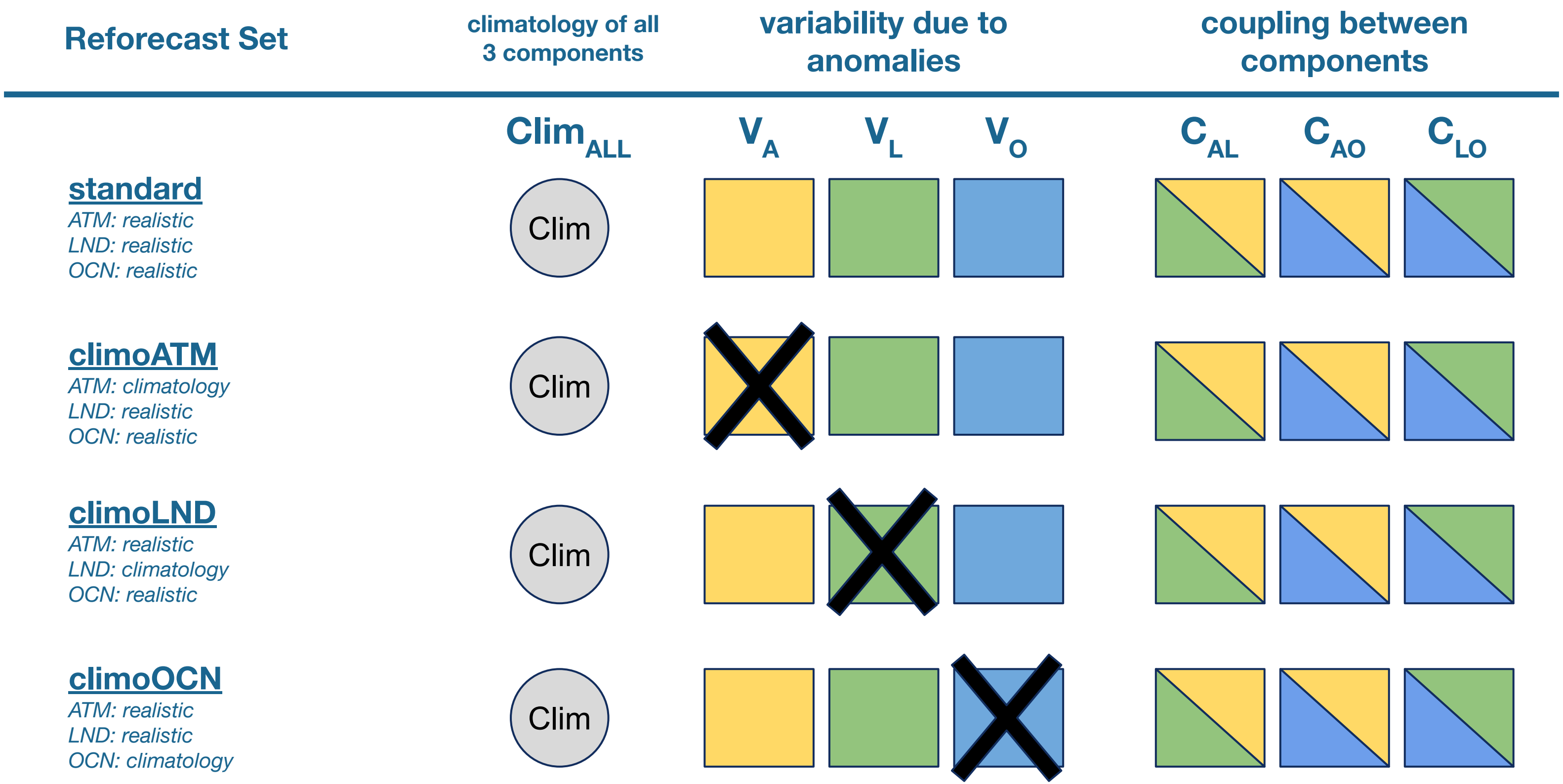


Recreated figure by Paul Dirmeyer: representative of predictability of mid-latitude surface temperature over land

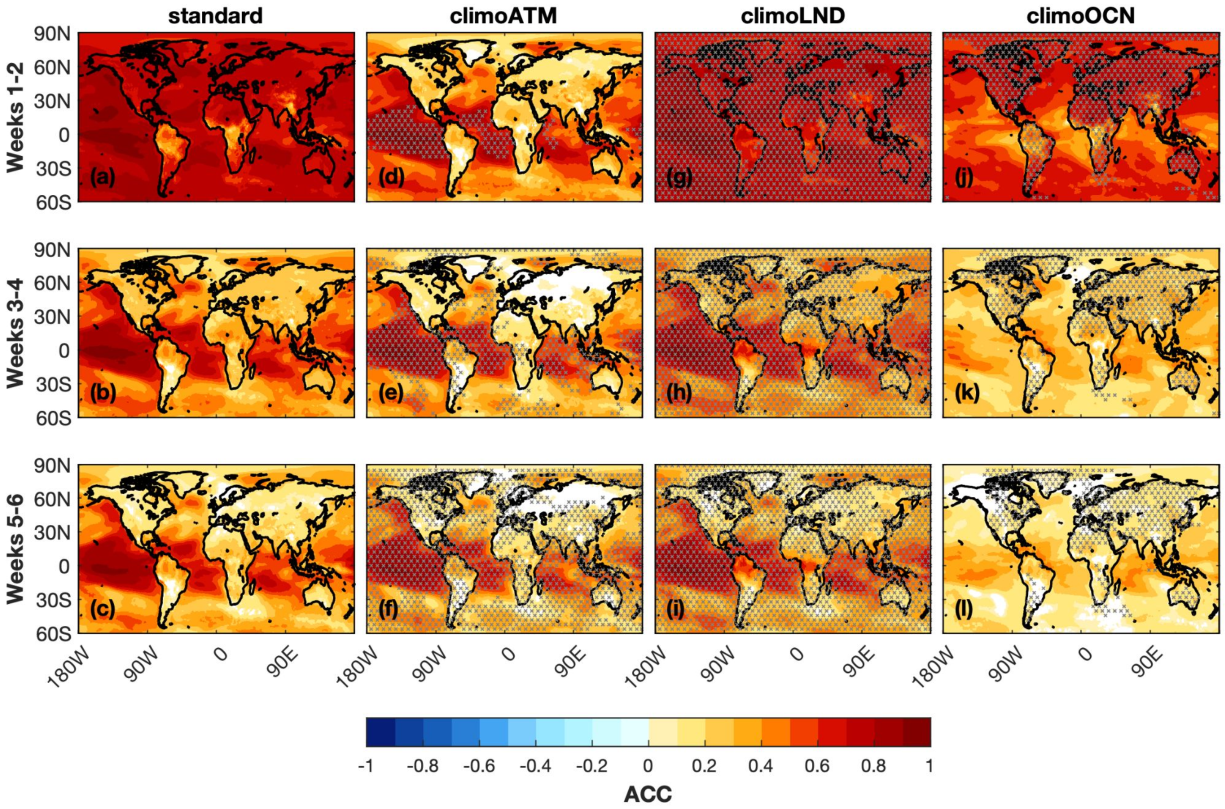
Methods

- **Calculate skill for 2m Temperature and Precipitation**
  - Anomaly Correlation Coefficient (ACC)
  - “Observations” come from ERA5 (2m Temperature) and GPCP (Precipitation) although CPC is comparable
- **Standard reforecast set** (realistic ATM, LND, OCN initialization)
  - 1999 - 2020; weekly initializations; 11 member ensemble
- **Seven additional reforecast sets with various initial states set to climatology**
  - climoATM
  - climoLND
  - climoOCN
  - climoOCNclimoLND
  - climoOCNclimoATM
  - climoATMclimoLND
  - climoALL (all components climo)

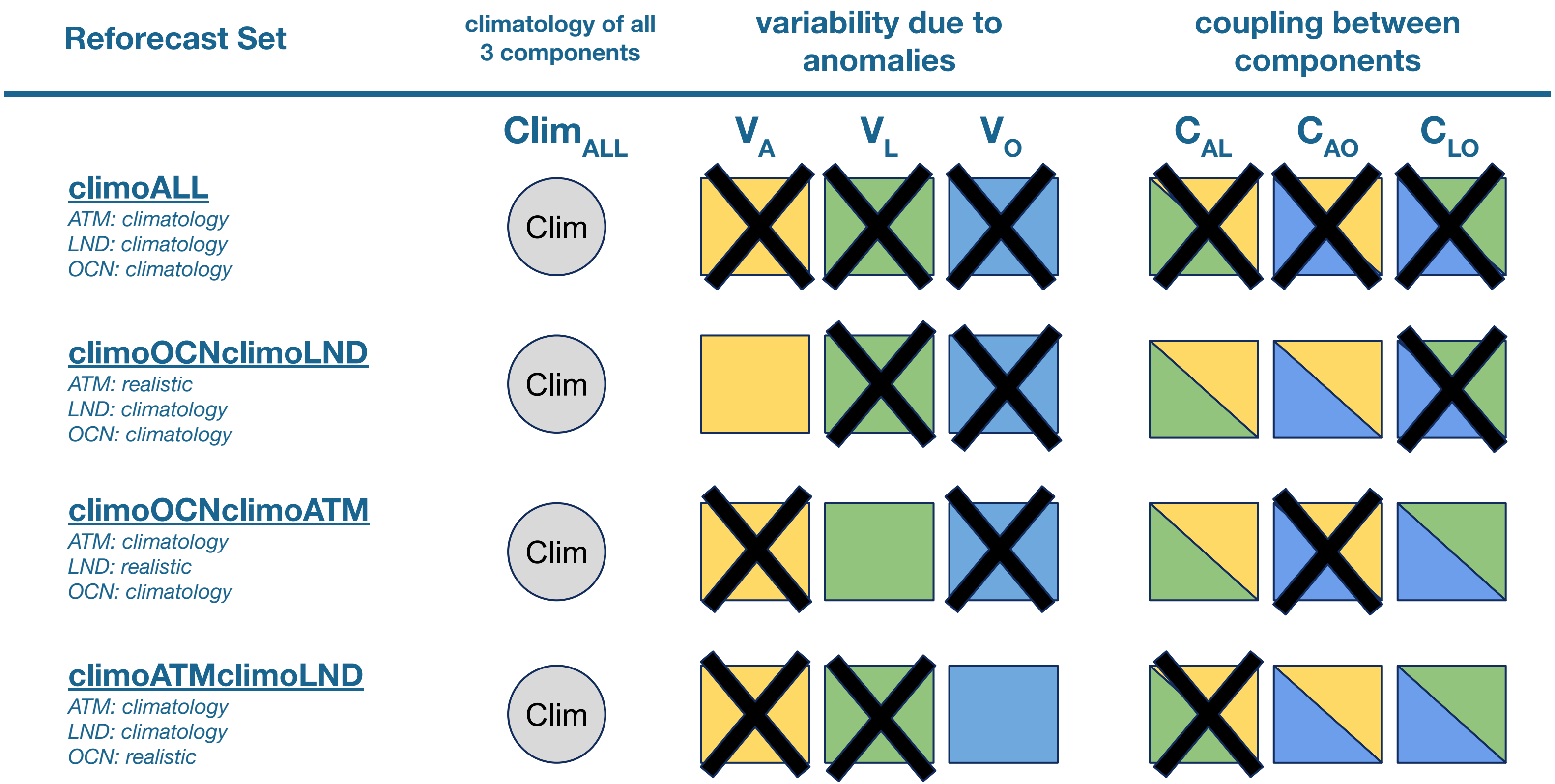
Sources of Predictability



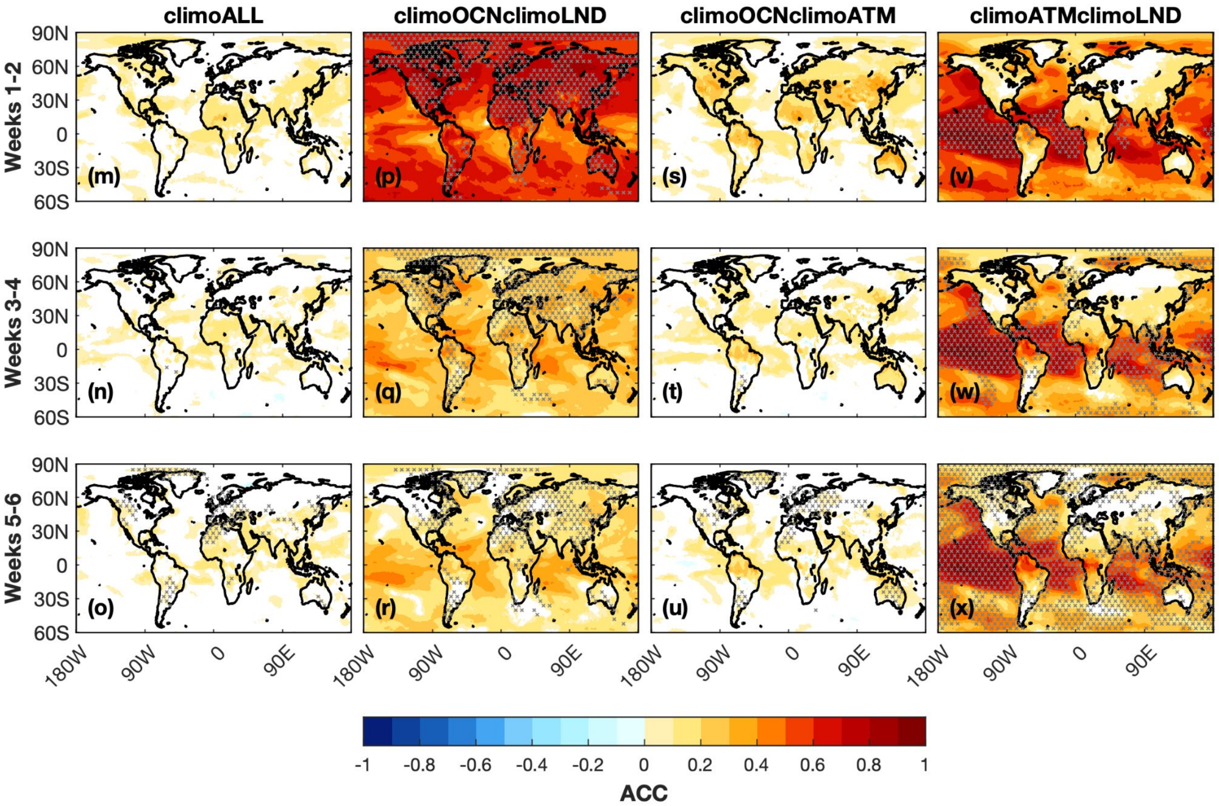
Annual Mean 2m Temperature ACC



Sources of Predictability



Annual Mean 2m Temperature ACC



How do we quantify the sources of predictability?

(1) **standard** = $Clim_{ALL} + \mathbf{V_A + V_L + V_O} + C_{AL} + C_{AO} + C_{LO}$

(2) **climoATM** = $Clim_{ALL} + V_L + V_O + C_{AL} + C_{AO} + C_{LO}$
(3) **climoLND** = $Clim_{ALL} + V_A + V_O + C_{AL} + C_{AO} + C_{LO}$
(4) **climoOCN** = $Clim_{ALL} + V_A + V_L + C_{AL} + C_{AO} + C_{LO}$

When **climatological** initial conditions are **used for a single component**, we can remove that component's variability term. We assume that the average coupling between the components do not change much between the reforecast sets.

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(6) **climoOCNclimoATM** = $Clim_{ALL} + V_L + C_{AL} + C_{LO}$
(7) **climoATMclimoLND** = $Clim_{ALL} + V_O + C_{AO} + C_{LO}$

(8) **climoALL** = $Clim_{ALL}$

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When **climatological** initial conditions are **used for two components**, we assume their two variability terms are negligible, along with their shared coupling term

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(9) sum = $Clim_{ALL} + V_A + V_L + V_O + C_{AL} + C_{AO}$
(10) sum ≈ **standard**

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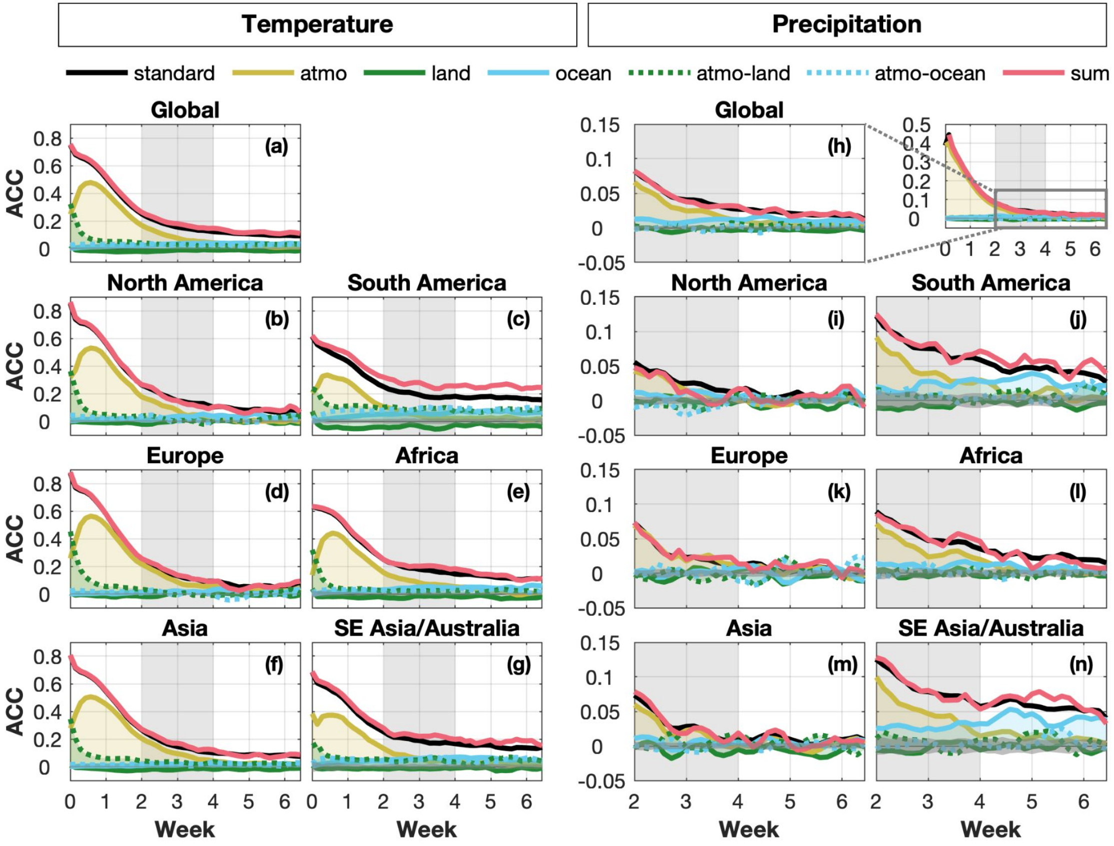
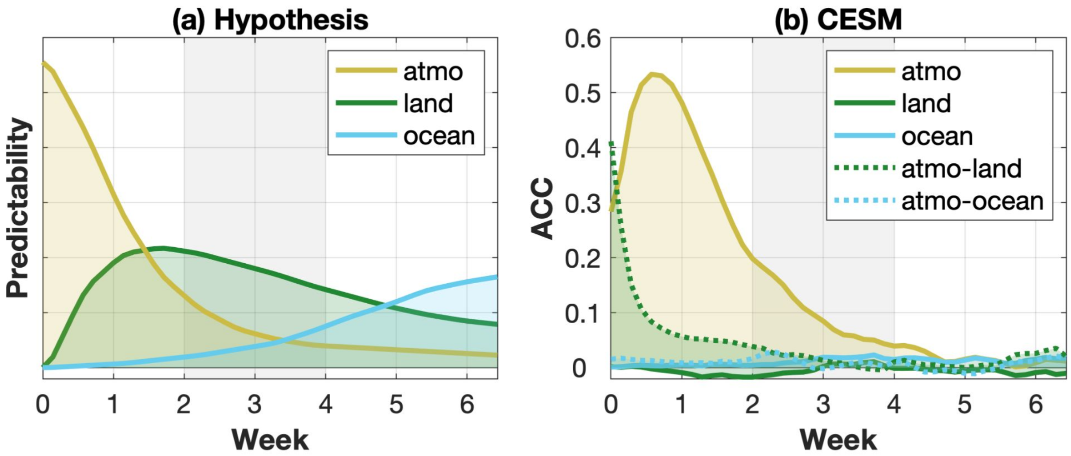
Assuming that the **land-ocean coupling C_{LO} is nearly zero** over land, we can then use the earlier variability results (V_L and V_O) to solve for C_{AL} and C_{AO}. If the linearity assumption holds, we should be able to retrieve the standard ACC by adding the individual components.

Annual Mean 2m Temperature and Precipitation ACC



Mid-Latitude (30N-60N) Annual Mean 2m Temperature ACC



Discussion

- Results suggest that **atmospheric initial state is the dominant source of 2m 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

- 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
- NCAR casper: /glade/campaign/cesm/development/cross-wg/S2S/CESM2/
- DOI: https://doi.org/10.5065/0s63-m767