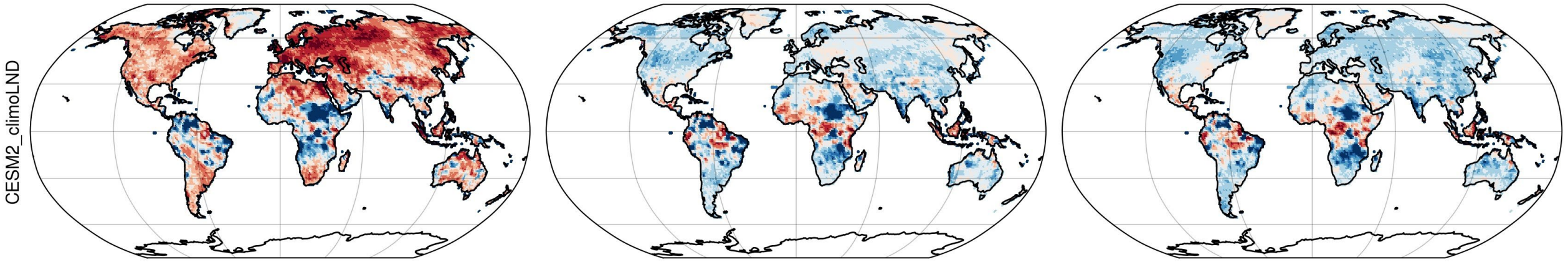

Quantifying Sources of Subseasonal Prediction Skill in CESM2 Within a Perfect Modeling Framework

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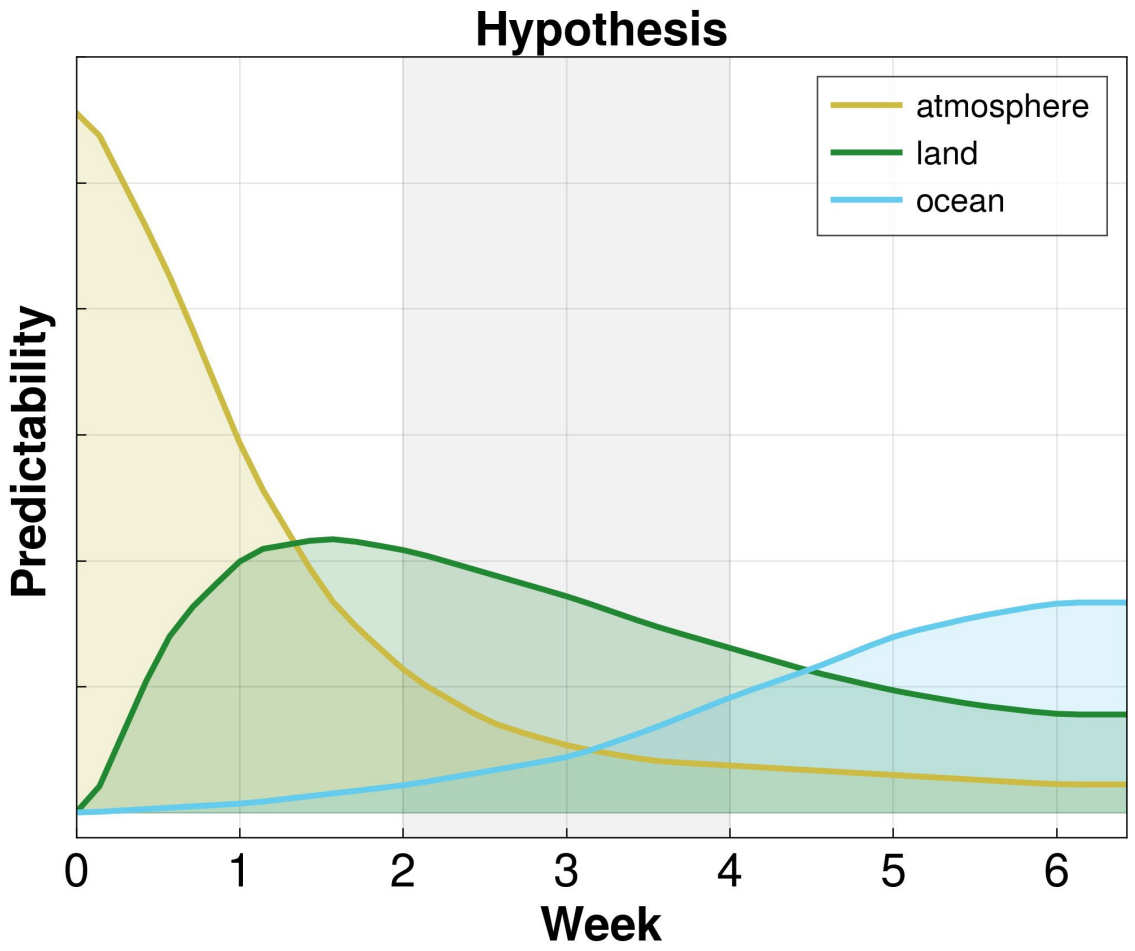
Motivation

- Richter, et al. 2024 investigated the sources of Subseasonal to Seasonal (S2S) (3-6 weeks) predictability from initializing the ocean, atmosphere and land components. When verifying against reanalysis:
  - Initializing the ocean adds limited predictability on the S2S timescale
  - Initializing the land deteriorates the skill on the S2S timescale
- These results point to possible problems with initialization drift (spin-up) and coupled model drift.
- Here, we repeat the analysis, but in the perfect model context.
  - This will eliminate model error, but not initialization drift.

Experiment Setup

- Coupled Global Climate Model (CESM2)
- 1 degree horizontal resolution in atmosphere and ocean
- Weekly initializations 1999-2022, initialized each Monday
- S2S runs follow SubX protocol
  - 11 ensemble members initialized from CFSv2 using an anomaly initialization
- The lead-time dependent bias is removed prior to verification
- Model error arises from shortcomings in the parameterization schemes and in the interactions between the model components (atmosphere, ocean, and land)

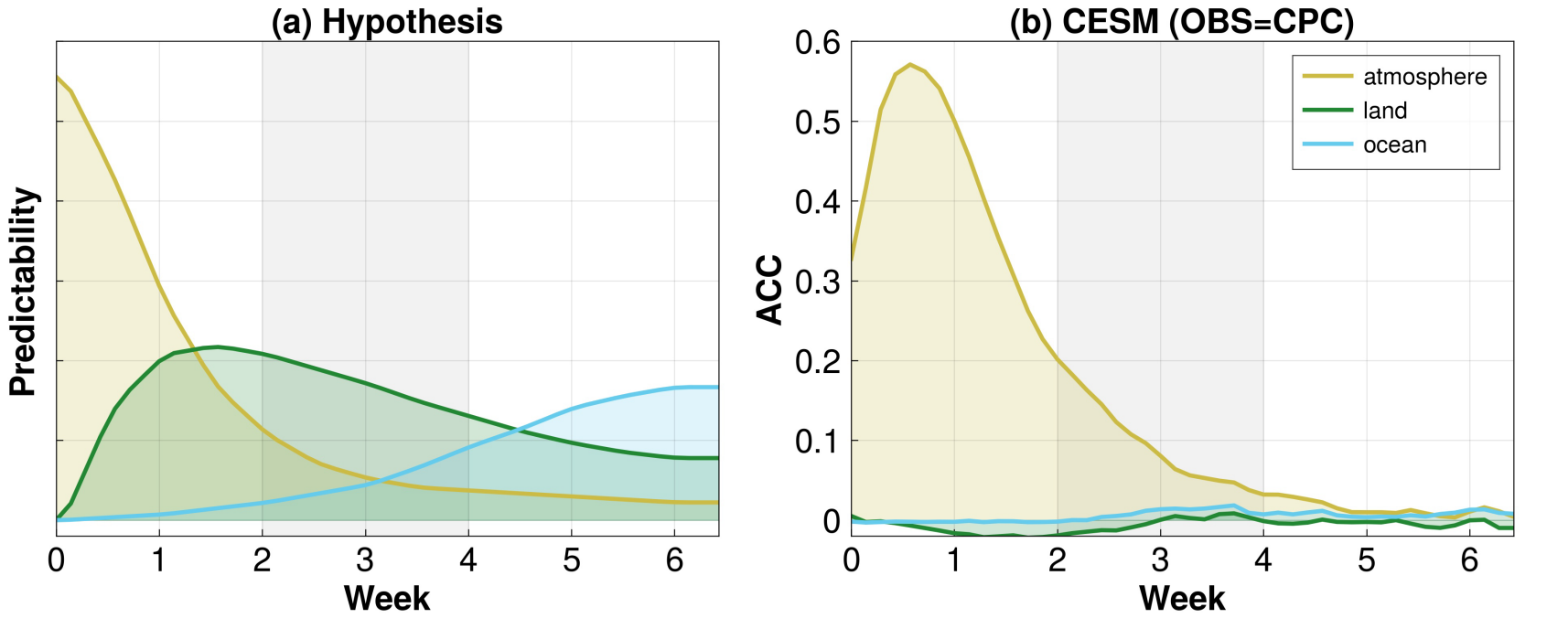
Sources of predictability: Role of initializations



Adapted from Dirmeyer et al 2018

- We quantify the value of land/ocean/atmosphere initializations by rerunning the S2S suite, but replacing the land/ ocean/atmosphere initializations with their climatological counterparts and verifying against the fully initialized simulations

Annual T2 ACC over NH midlats (30N-60N)

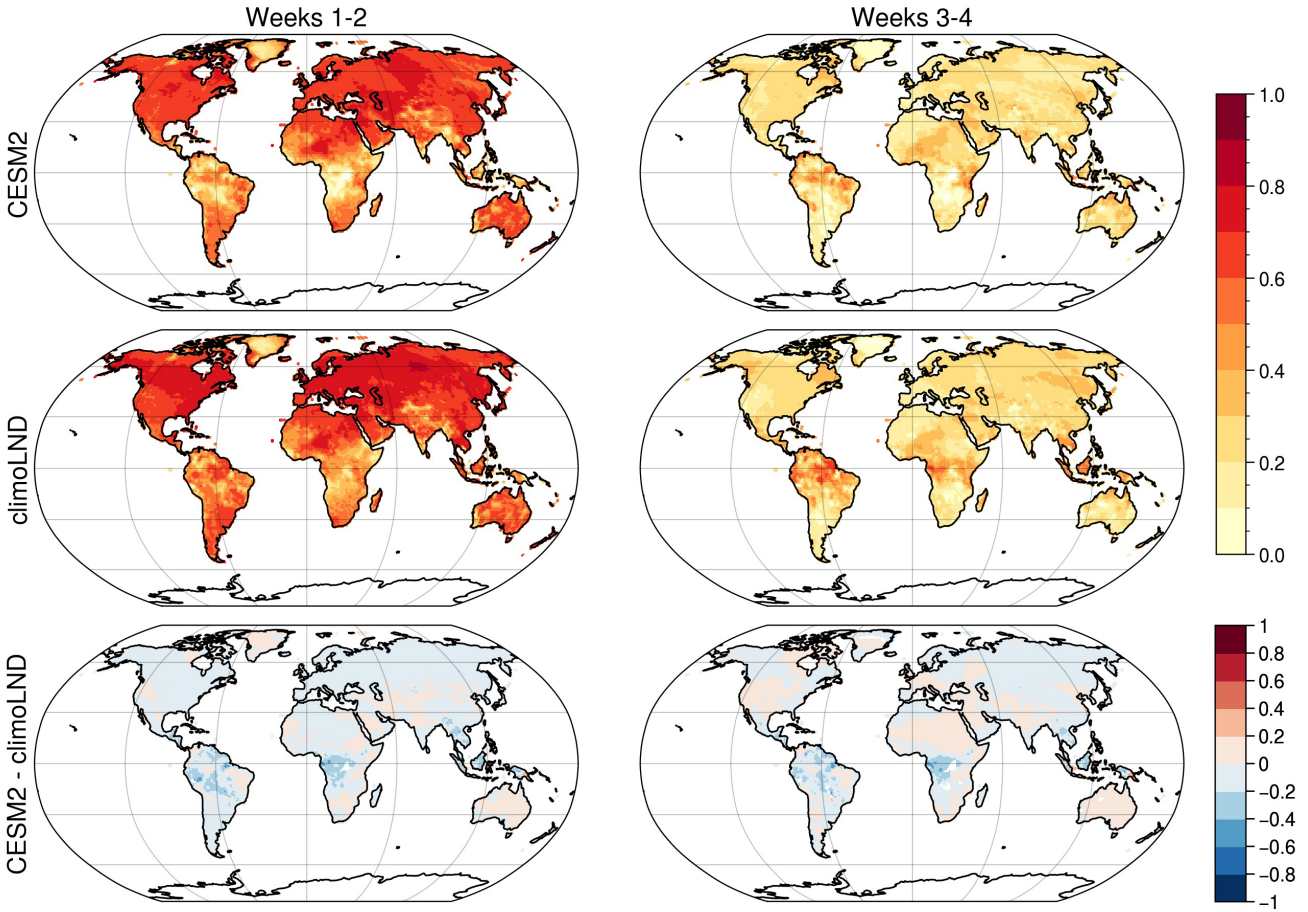


After Richter et al 2024

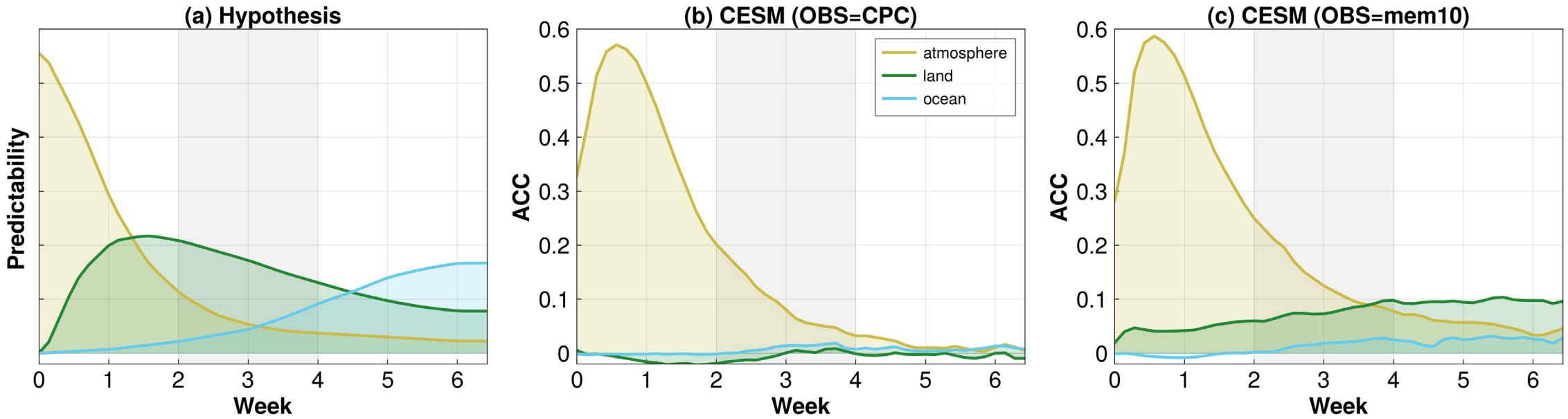
- Both land and ocean initializations add very limited or no skill
- Increase of skill from day 1-4 is the result of initialization drift (model spin-up, initialization shock)

Sources of Predictability: Role of land initializations

- When verifying against observations, the skill of the forecasts with climatological land (climoLND) is higher than the fully initialized forecasts.
  - Initializing the land is detrimental!
- To address this, we repeat the verification in a perfect model framework, i.e. where we verify against one ensemble member rather than observations
  - This eliminates model error

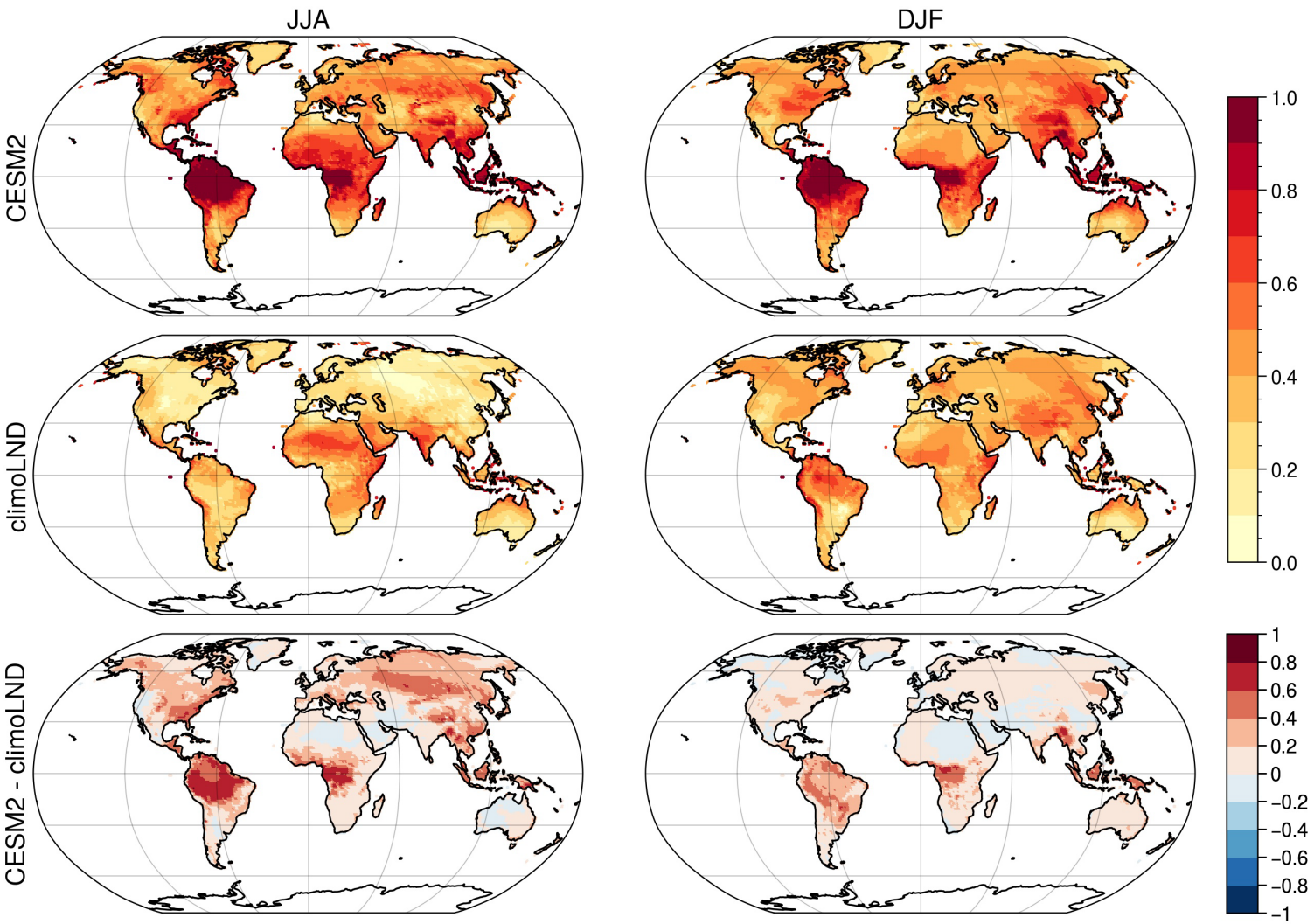


Perfect Model ACC T2M Skill



- Initializing the land/ocean increases the skill significantly and the benefits grow throughout the S2S range
- As expected, the benefits from initializing the land are markedly higher than the ocean in the S2S range
- This points to coupled model error between the atmosphere and land as an essential problem in our simulations

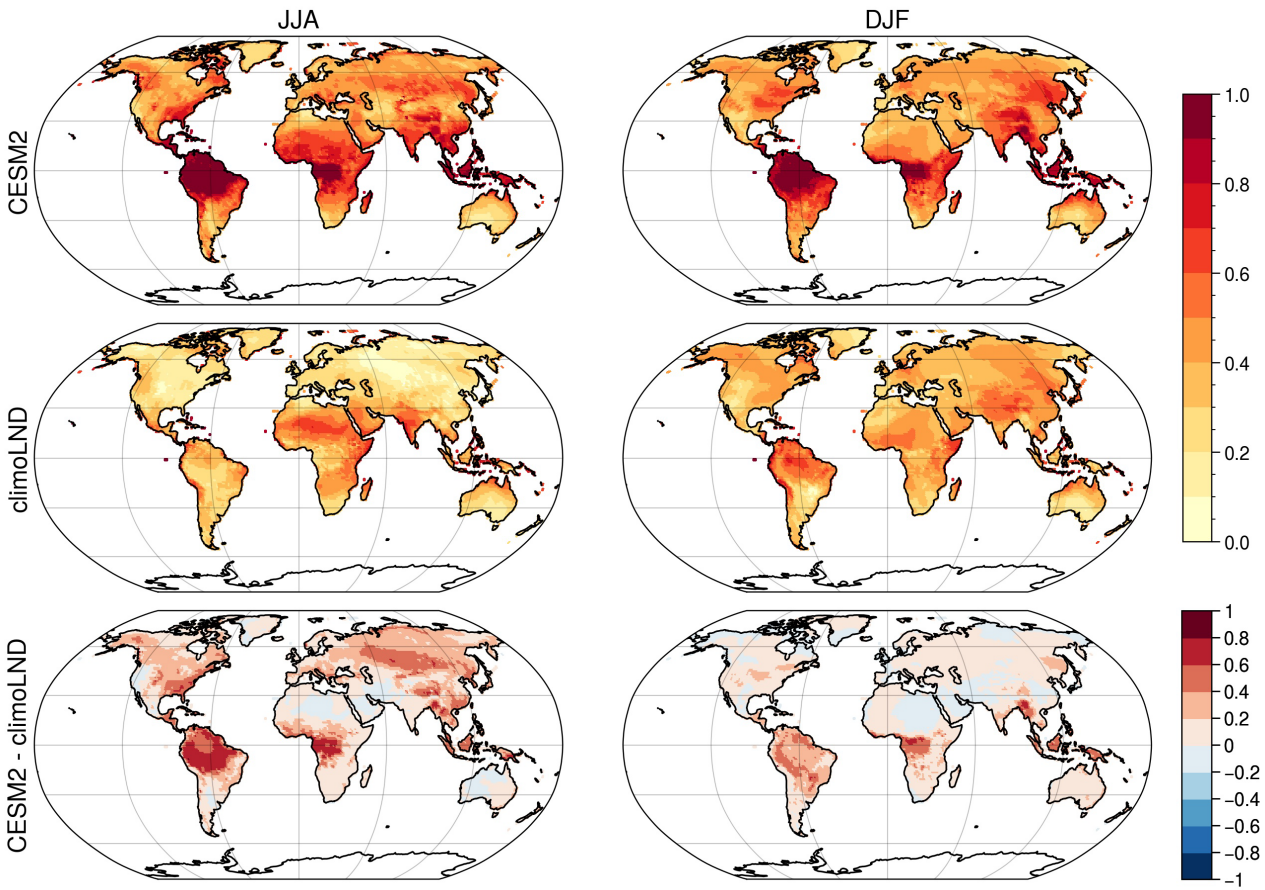
T2 ACC Skill of Perfect Model Week 3-4: Seasonality



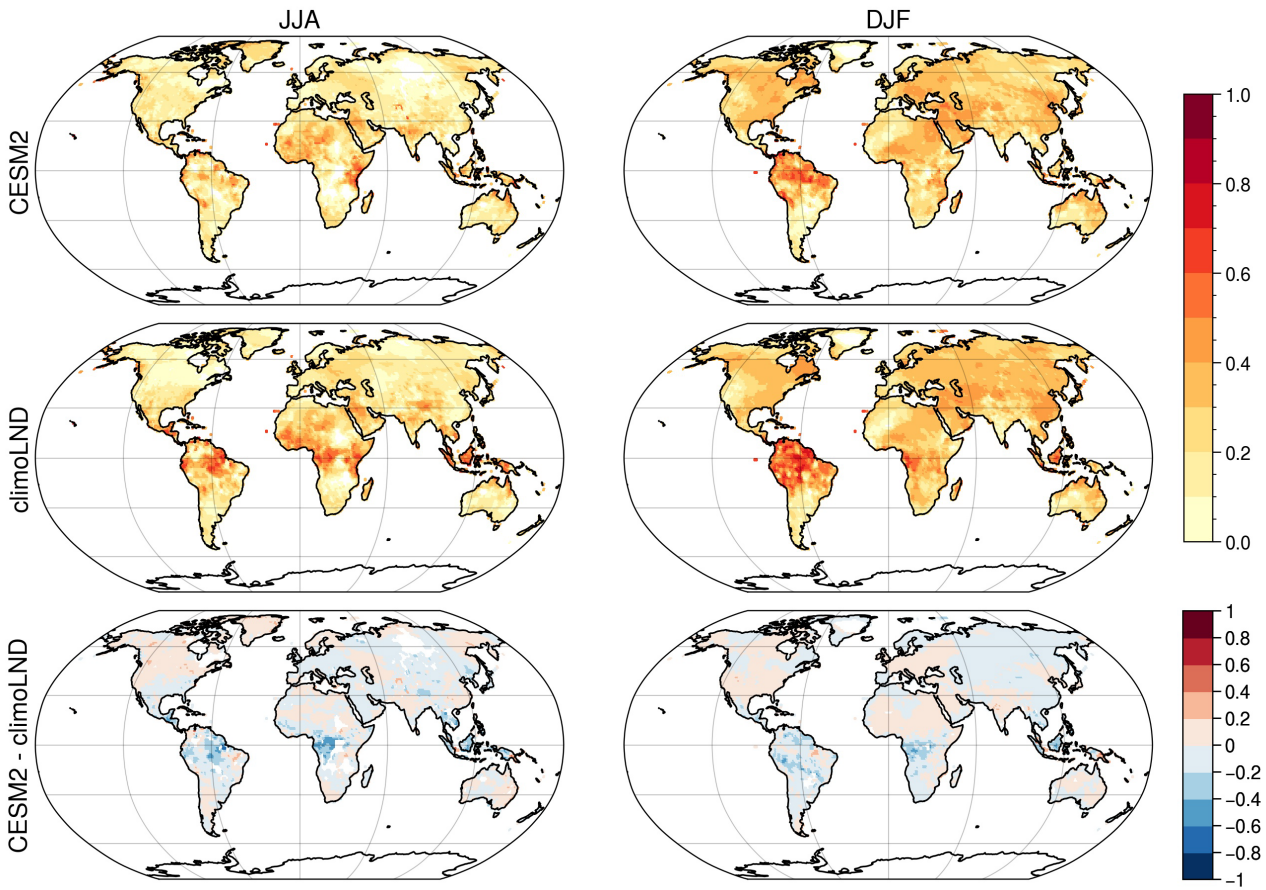
- Looking at the results in a perfect model framework, initializing the land is beneficial
- This adds skill, especially in the tropics in the summer hemisphere (JJA)

T2 ACC Skill of Perfect Model Week 3-4: Seasonality

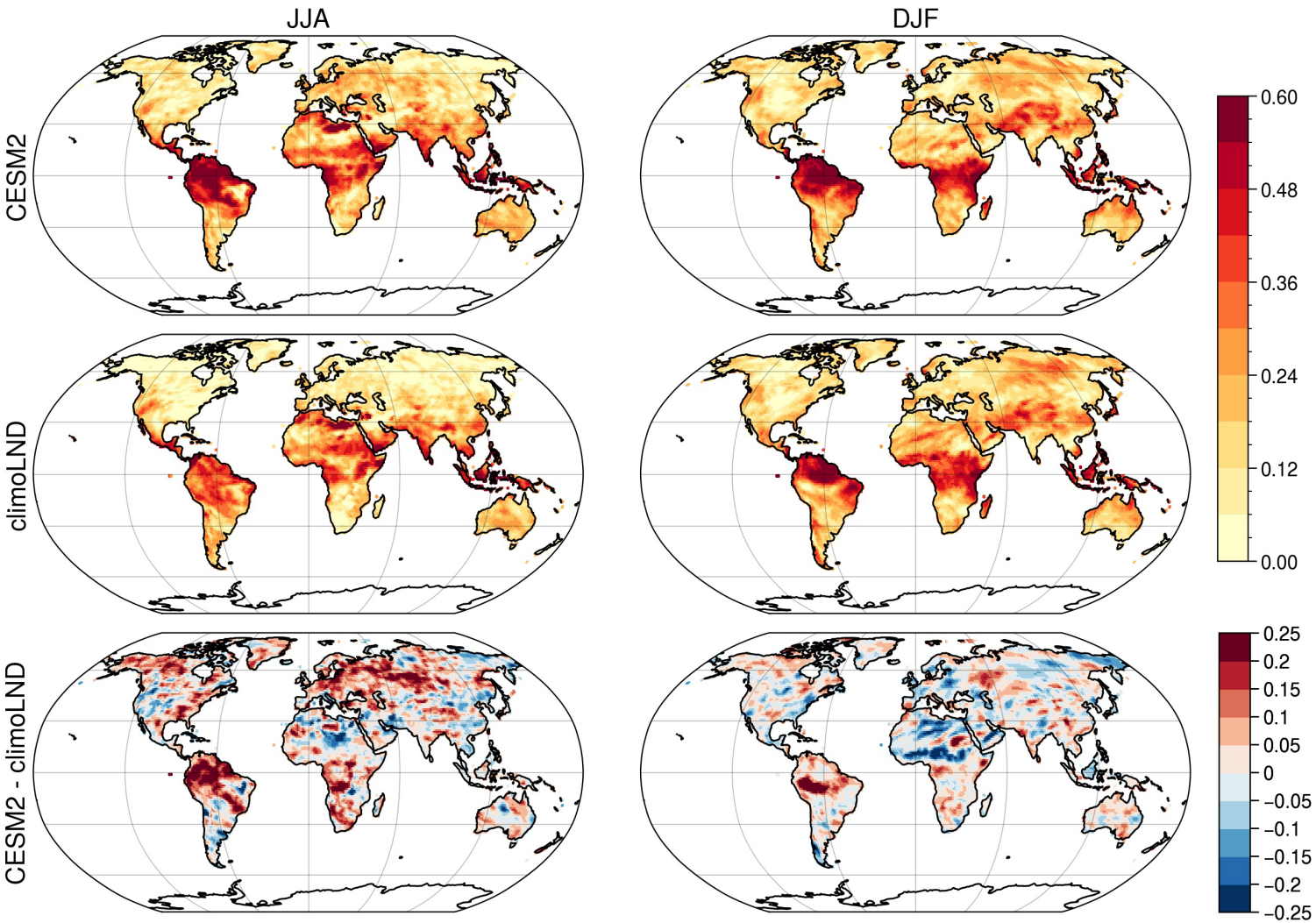
Perfect Model



Verification with Observations



TP ACC Skill of Perfect Model Week 3-4: Seasonality

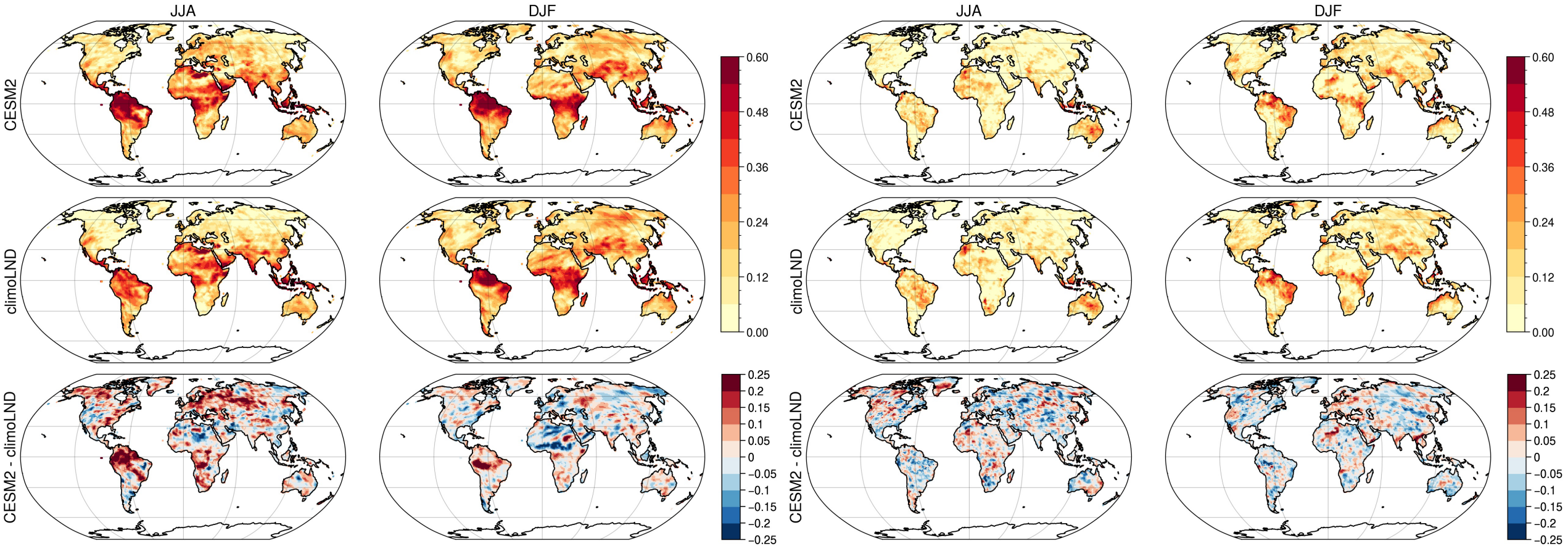


- Initializing the land also helps precipitation, but on a more regional basis.
- Skill increase is best in JJA over tropical S. America and northern Europe.

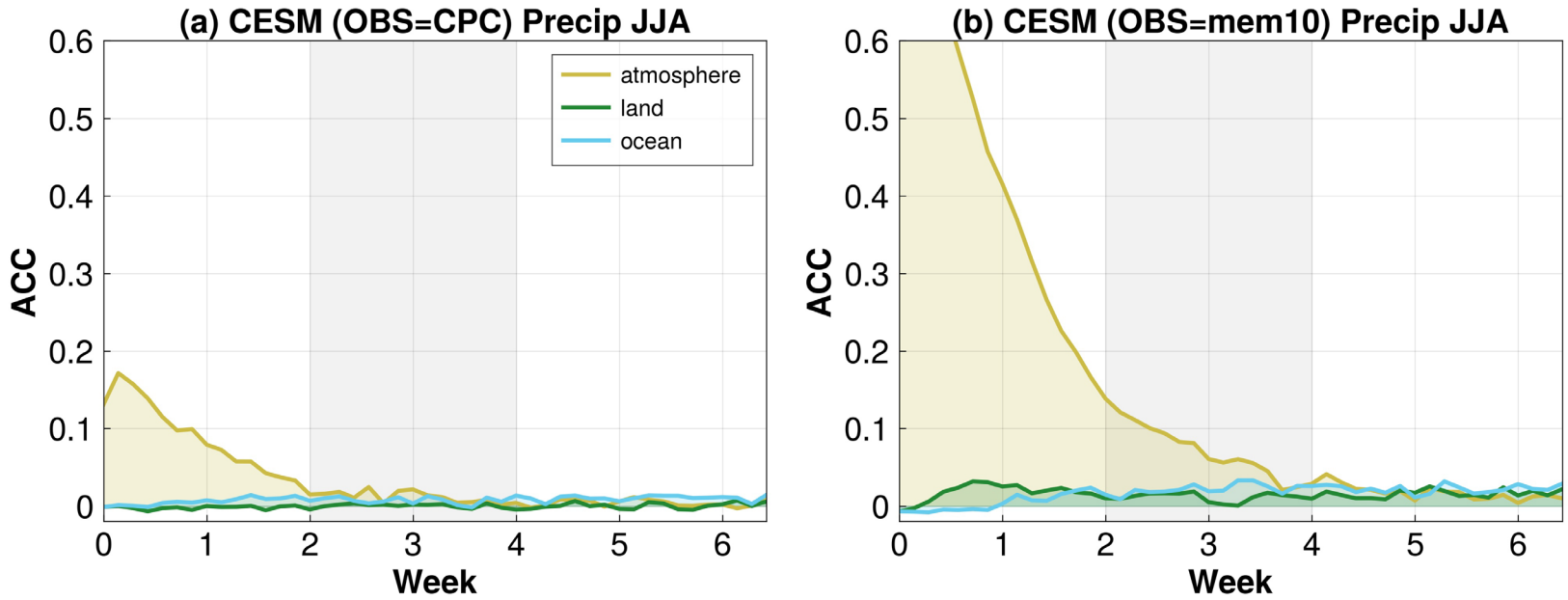
TP ACC Skill of Perfect Model Week 3-4: Seasonality

Perfect Model

Verification with Observations



Perfect Model ACC TP Skill



- Average over from 30S to 30N over the tropics. Land only.
- There is some benefit to initializing the land, mostly over weeks 1-2, but does persist through week
- Not surprisingly the initializing the ocean doesn't help early on, but increases after a few weeks.

Conclusions

- Richter et al 2024 investigated the sources of predictability from initializing the ocean, atmosphere and land components
  - It was found that initializing the ocean and land components is not beneficial when verifying against observations/reanalysis
- The analysis was repeated here, but verified against an ensemble member with a perfect model framework that eliminated the model error
- In the perfect model, initializing the land adds significant skill and the benefits grow throughout the S2S range
- This points to coupled model error between the atmosphere and land as an essential problem in our simulations

Thank you!

Questions??

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