Decadal predictions (2010-2040) using pattern scaled SSTs and sea-ice concentrations

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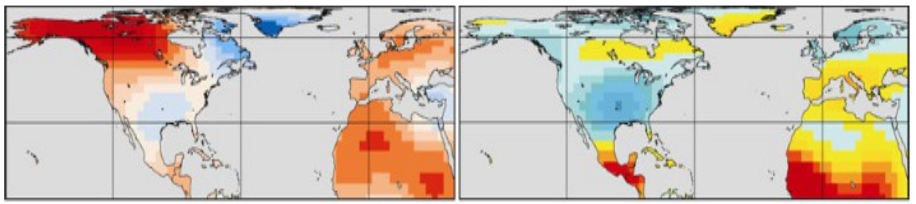
Motivation

- AGCMs fit observed trends better than coupled AOGCMs

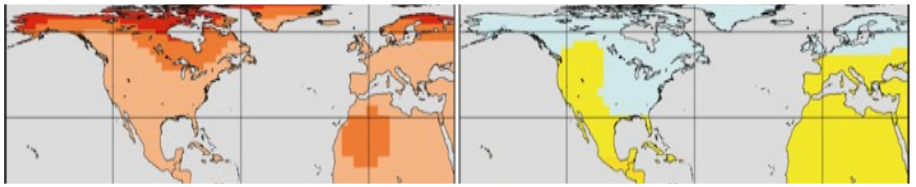
Trends (1951-1999)

Surface temperature **Precipitation**

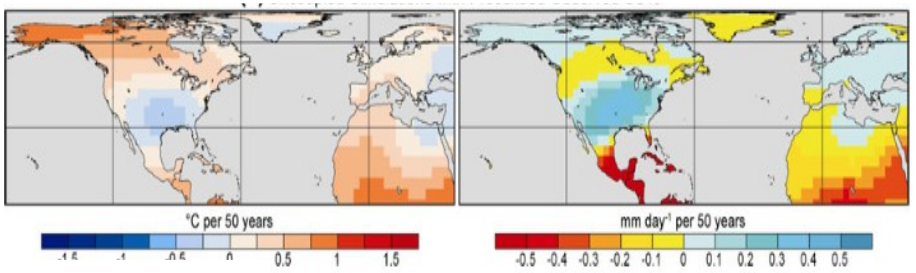
Observations



Coupled AOGCMs



AGCMs forced with observed SSTs and sea ice



AGCM: Atmospheric GCM
AOGCM: Coupled Atmosphere-Ocean GCM

Shin and Sardeshmukh 2011

Motivation

- AGCMs fit observed trends better than coupled AOGCMs

  → Partly because AOGCMs struggle to reproduce observed SSTs, not just internal variability (Shin and Sardeshmukh 2011)

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- **<u>Goal:</u>**

  1. Derive future (global greenhouse gas warming component only (S_{GW})) SST and sea ice patterns from observations

  2. Use it to force AGCM

  => Gain insights into near-term prediction?

  (Hoerling et al. 2011, Bichet et al. 2015 and *in prep.*)

AGCM: Atmospheric GCM
AOGCM: Coupled Atmosphere-Ocean GCM

Method: Estimate S_{GW} using pattern scaling

- Assume separability

$$S_{Obs} = S_{GW} + S_{non\text{-}GW\ (internal\ +\ short\ term\ anth.)}$$

S_{GW}= Global greenhouse gas warming component of SSTs and sea ice concentrations

Method: Estimate S_{GW} using pattern scaling

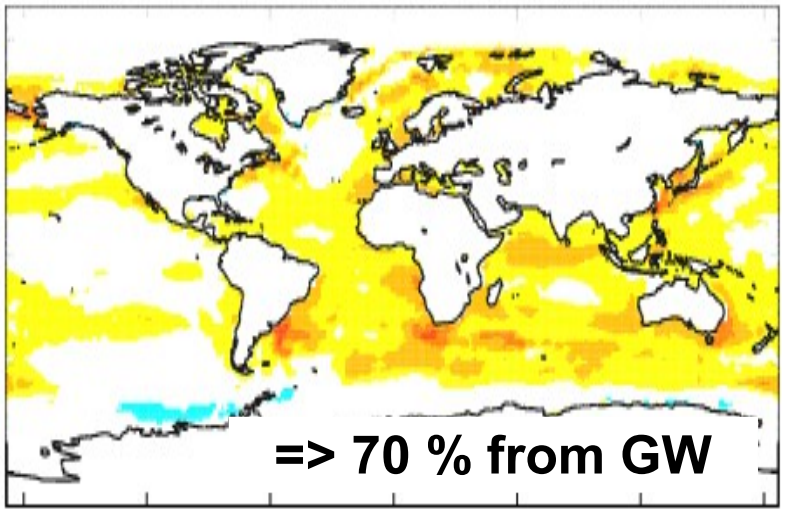
- Assume separability

$$S_{Obs} = S_{GW} + S_{\text{non-GW (internal + short term anth.)}}$$

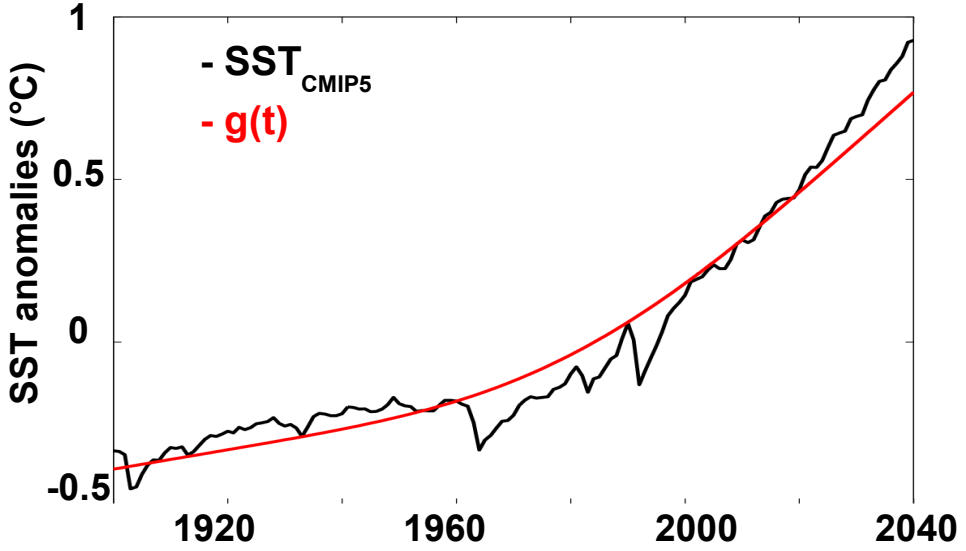
- Assume spatio-temporal decomposition

$$S_{GW} = h(x) \,.\, g(t)$$

From observations (HadISST SST and sea ice (Hurrell et al. 2008)



From CMIP5 (SSTs global, annual, multi model mean)



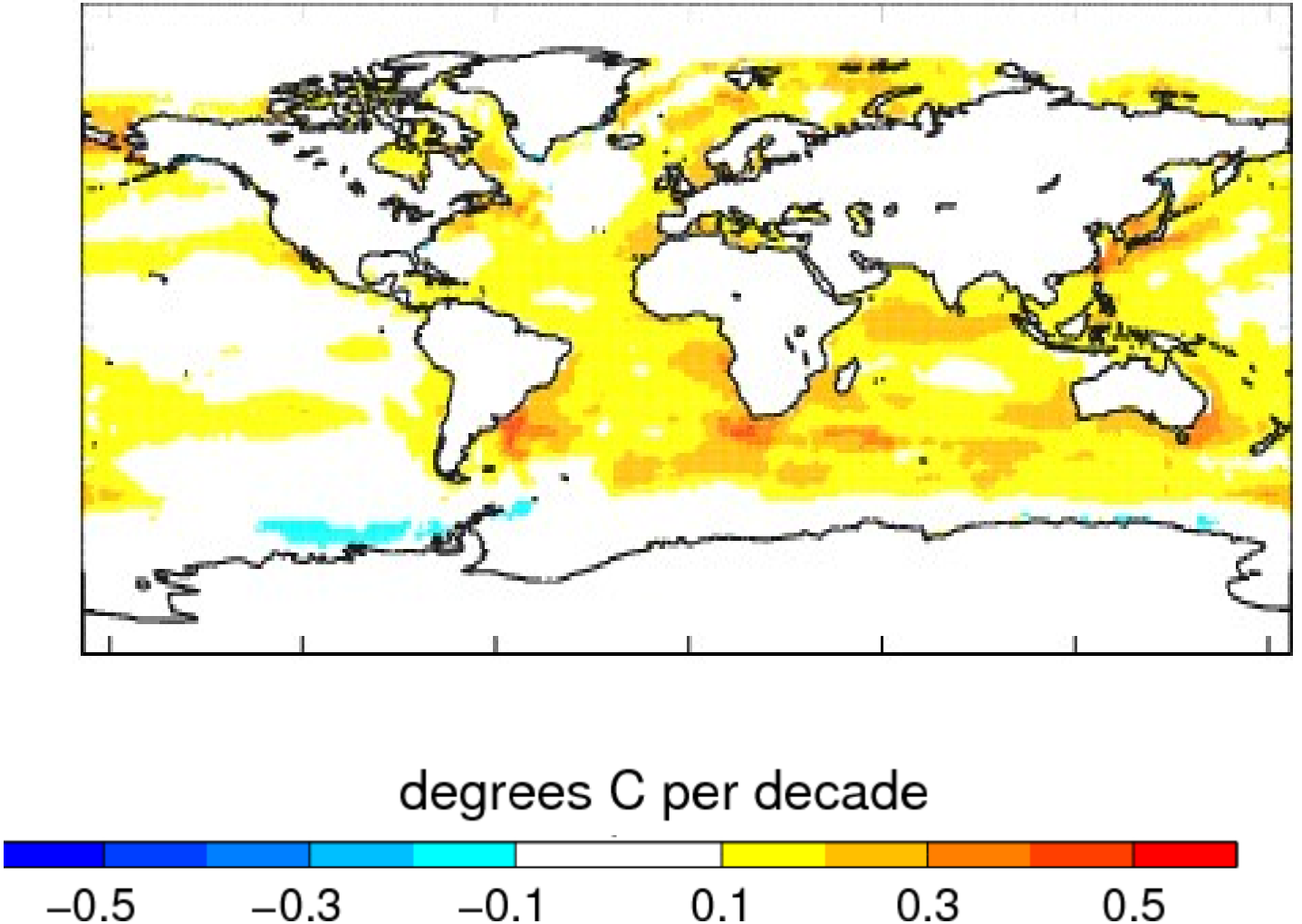
Data

- **3 Ensembles of time-varying simulations**

	Number of members	Model	SST and sea-ice	Time period	Atm. forcing
GW	10	**AGCM** CAM5, 2 deg	S_{GW}	2010-2040	RCP8.5
CESM1 (Kay et al. 2015)	30	**AOGCM** CAM5 + POP, 1deg	/		
CMIP5	26	**AOGCMs** CMIP5 multi model	/		

Annual SST trends (2010-2040)

GW (pattern scaled)



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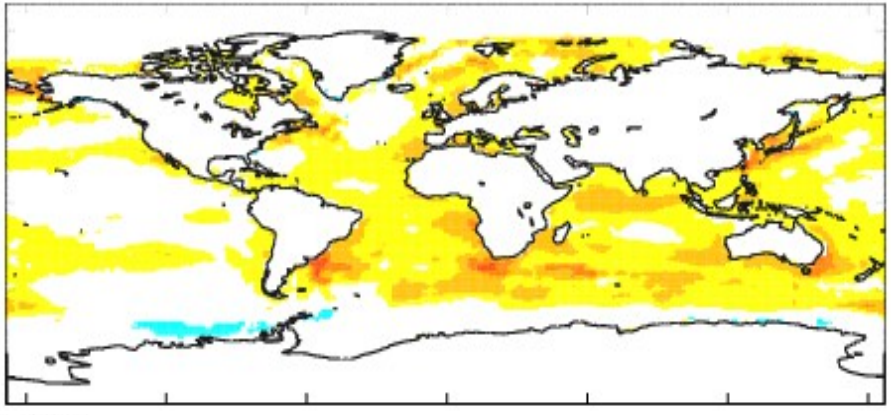
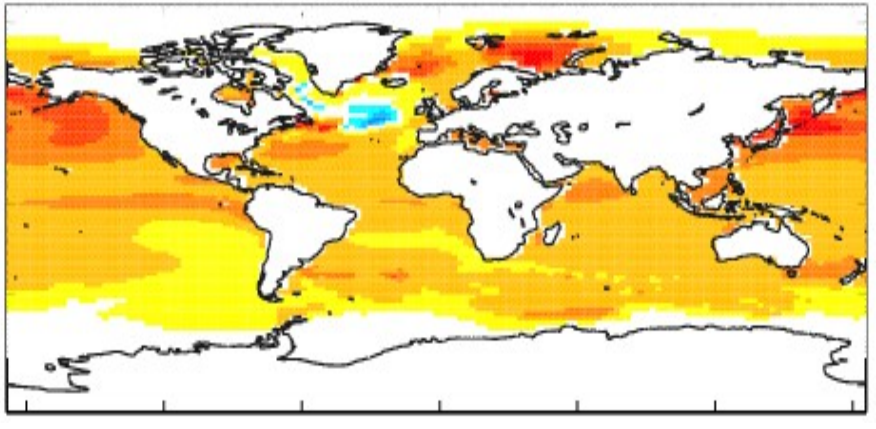
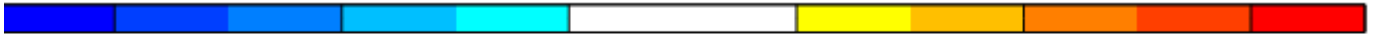


CESM1



degrees C per decade



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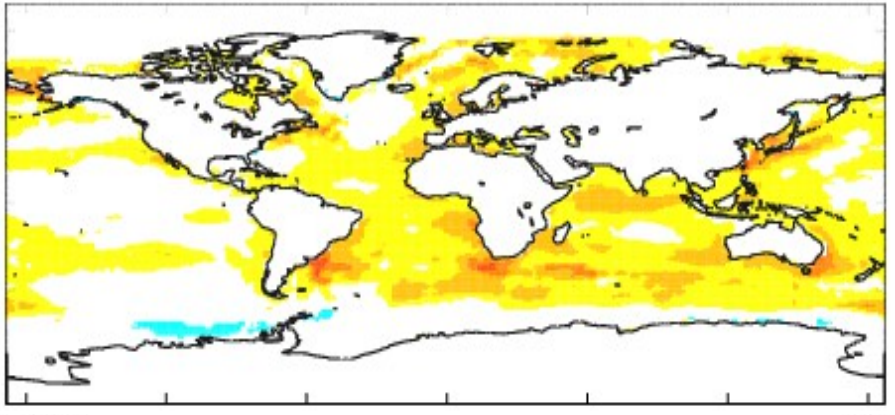

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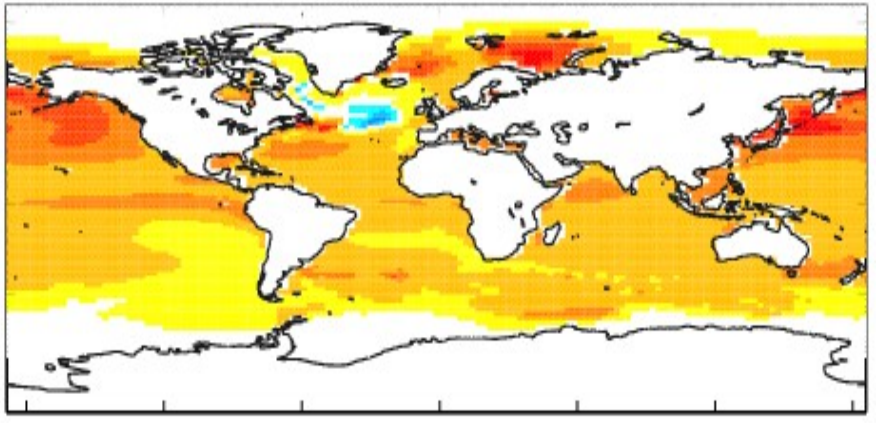
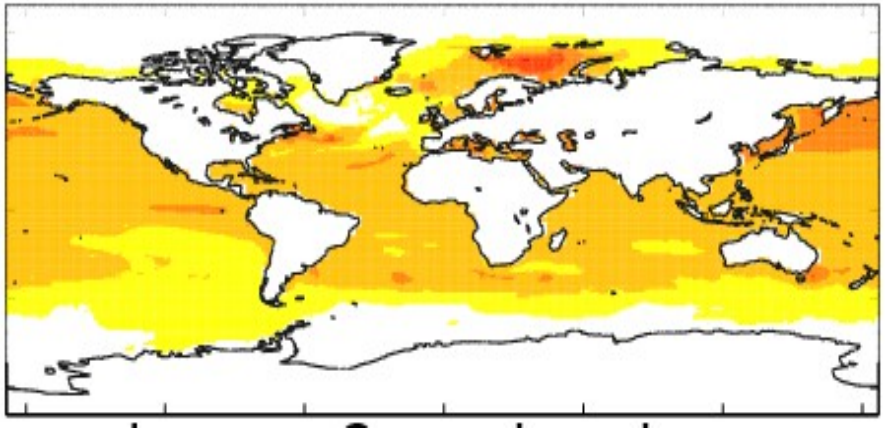
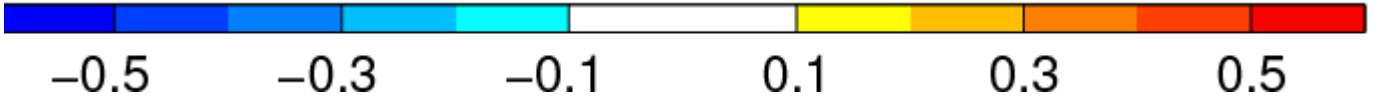


CMIP5

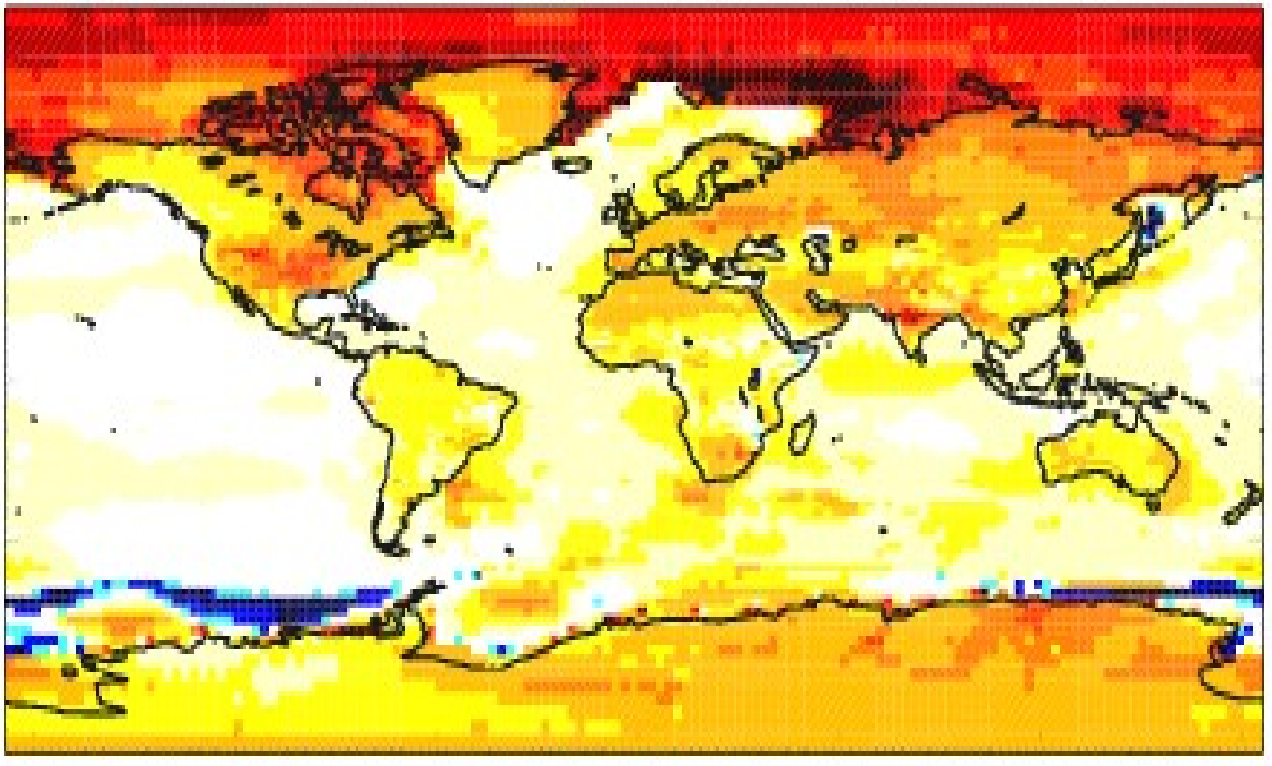


degrees C per decade



Annual surface temperature trends (2010-2040)

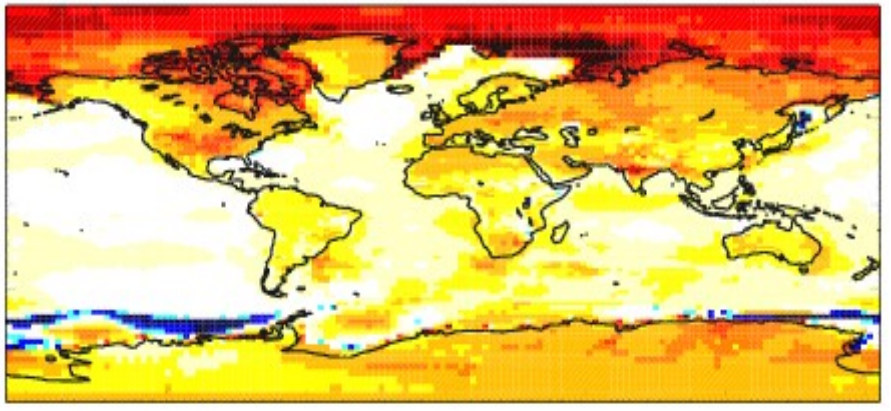
GW (simulated)



degrees C per decade

Annual surface temperature trends (2010-2040)

GW



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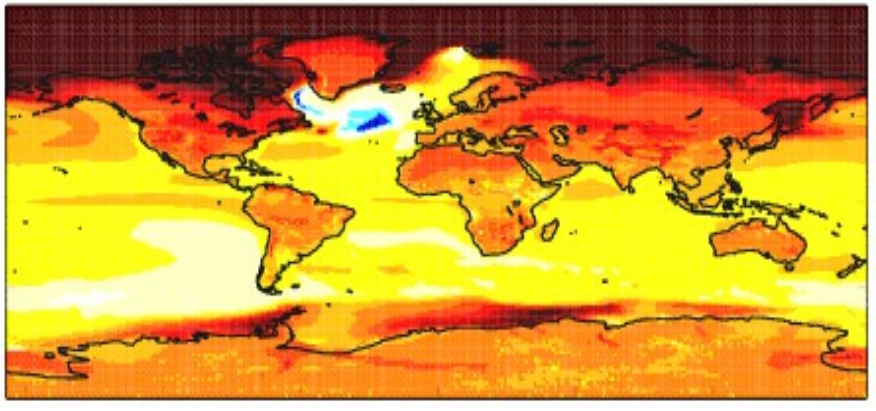

degrees C per decade

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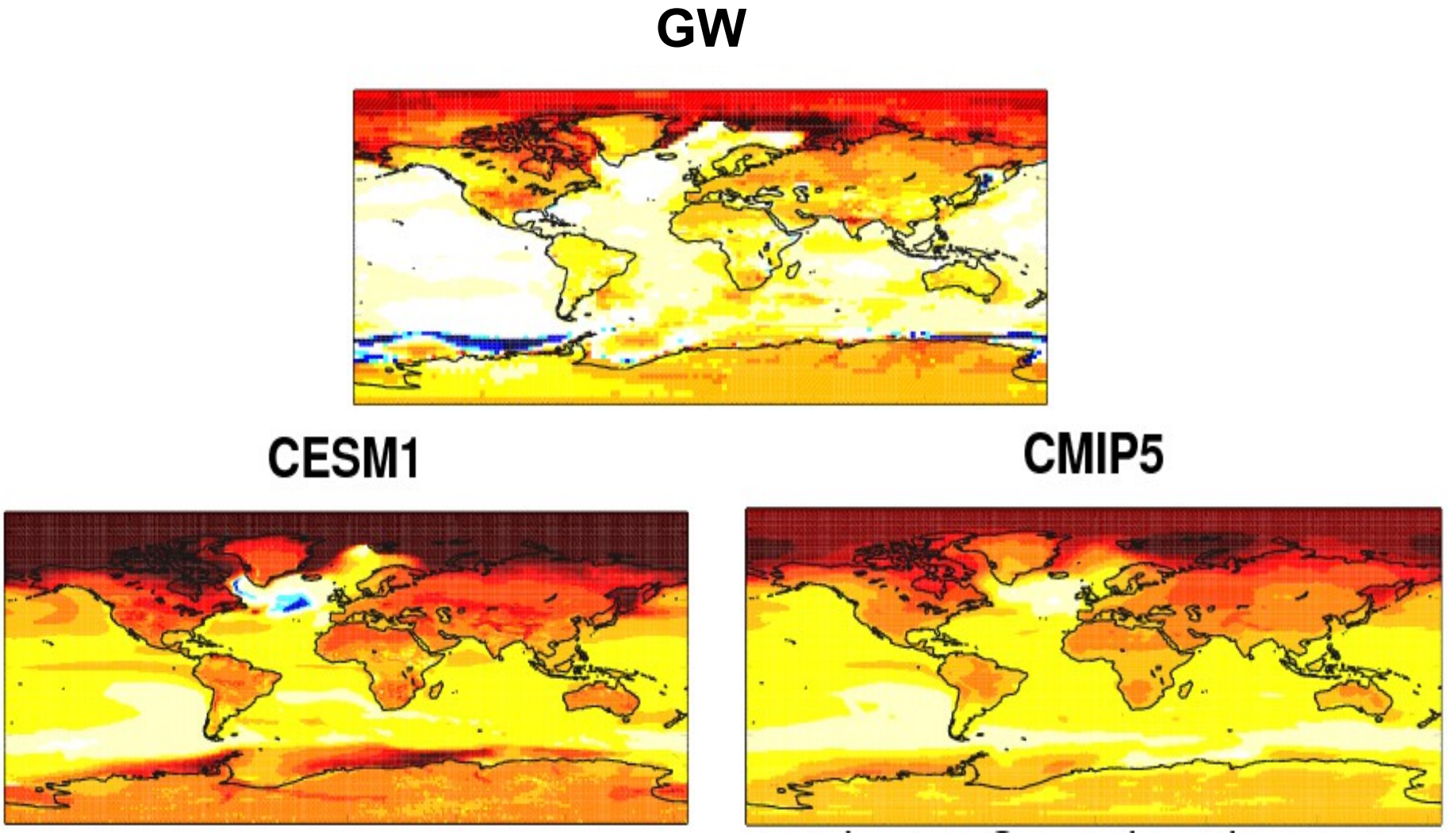
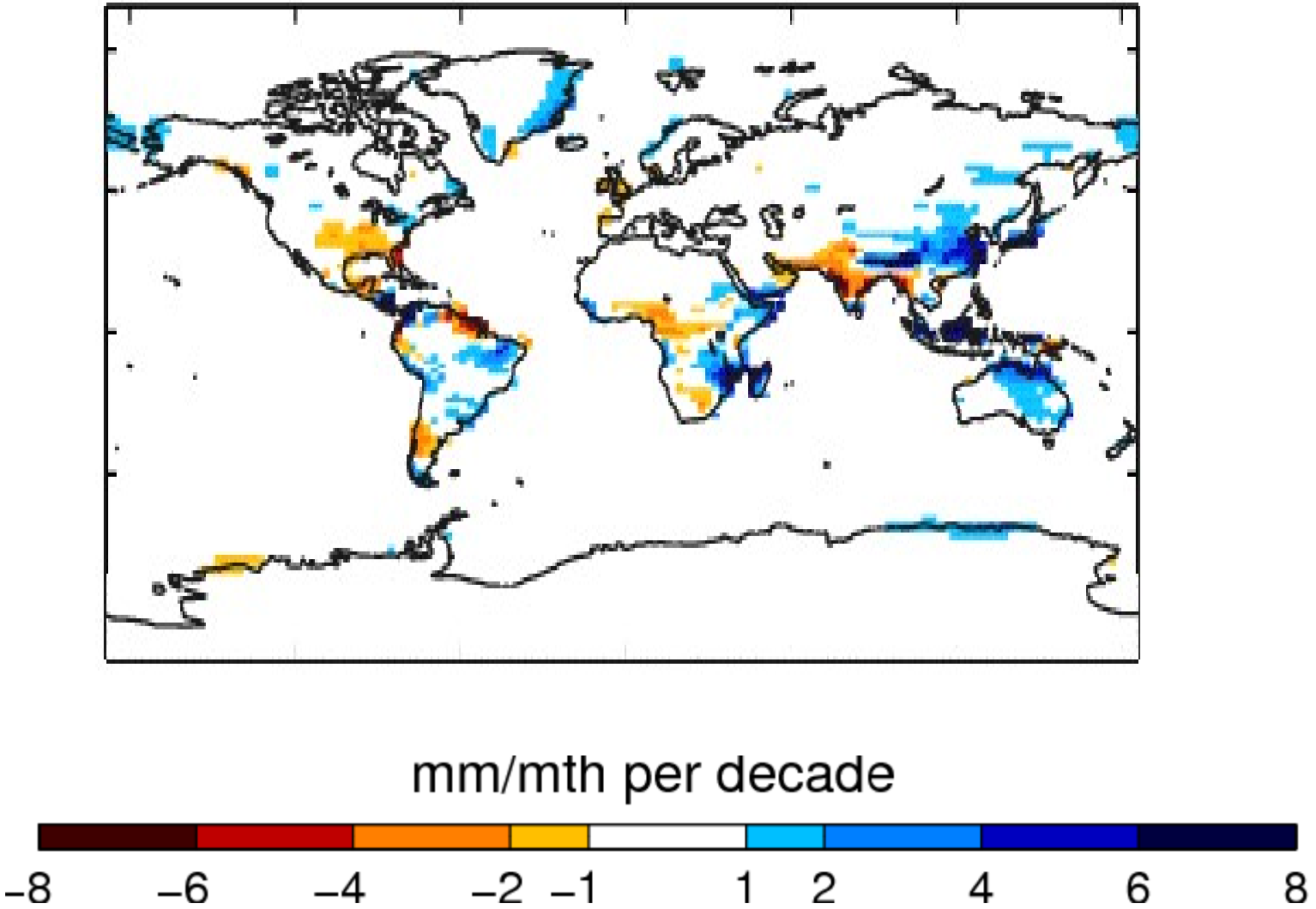


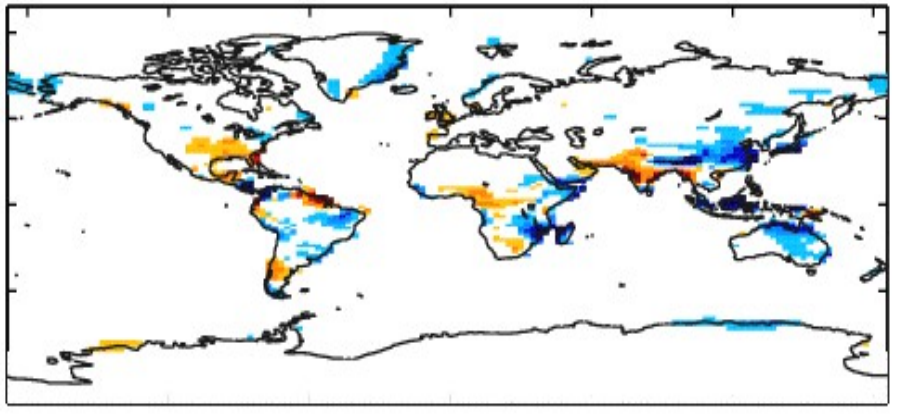
Annual precipitation trends (2010-2040)

GW (simulated)



Annual precipitation trends (2010-2040)

GW



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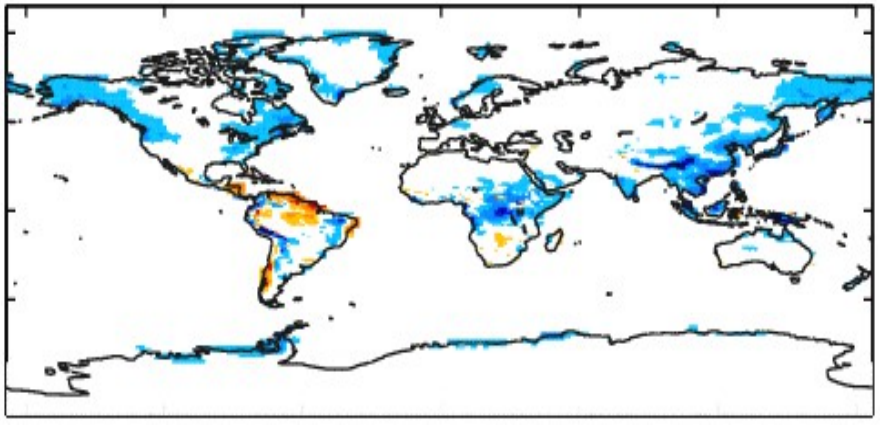
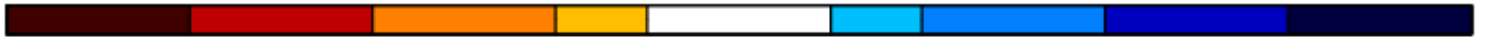
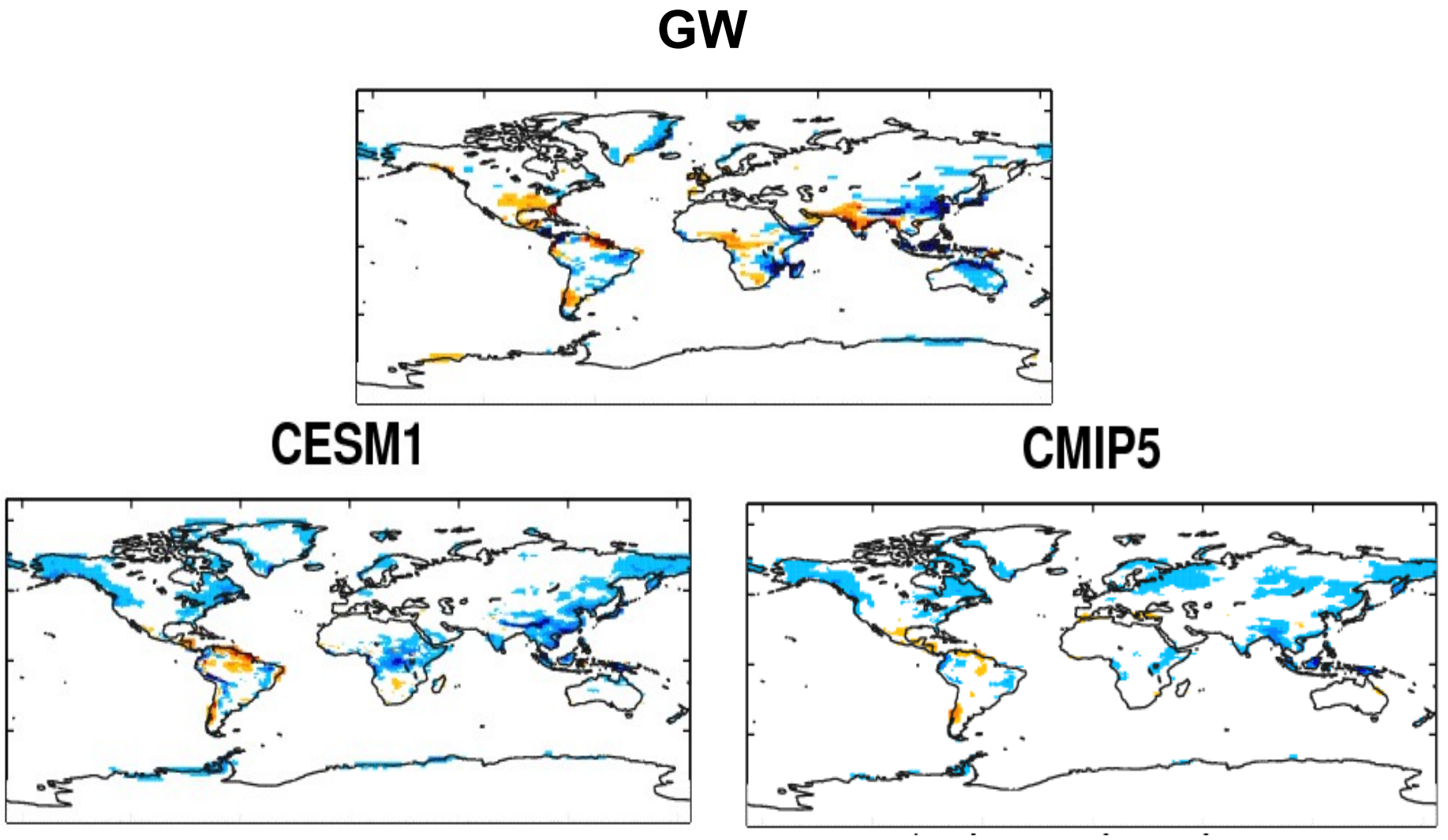


mm/mth per decade

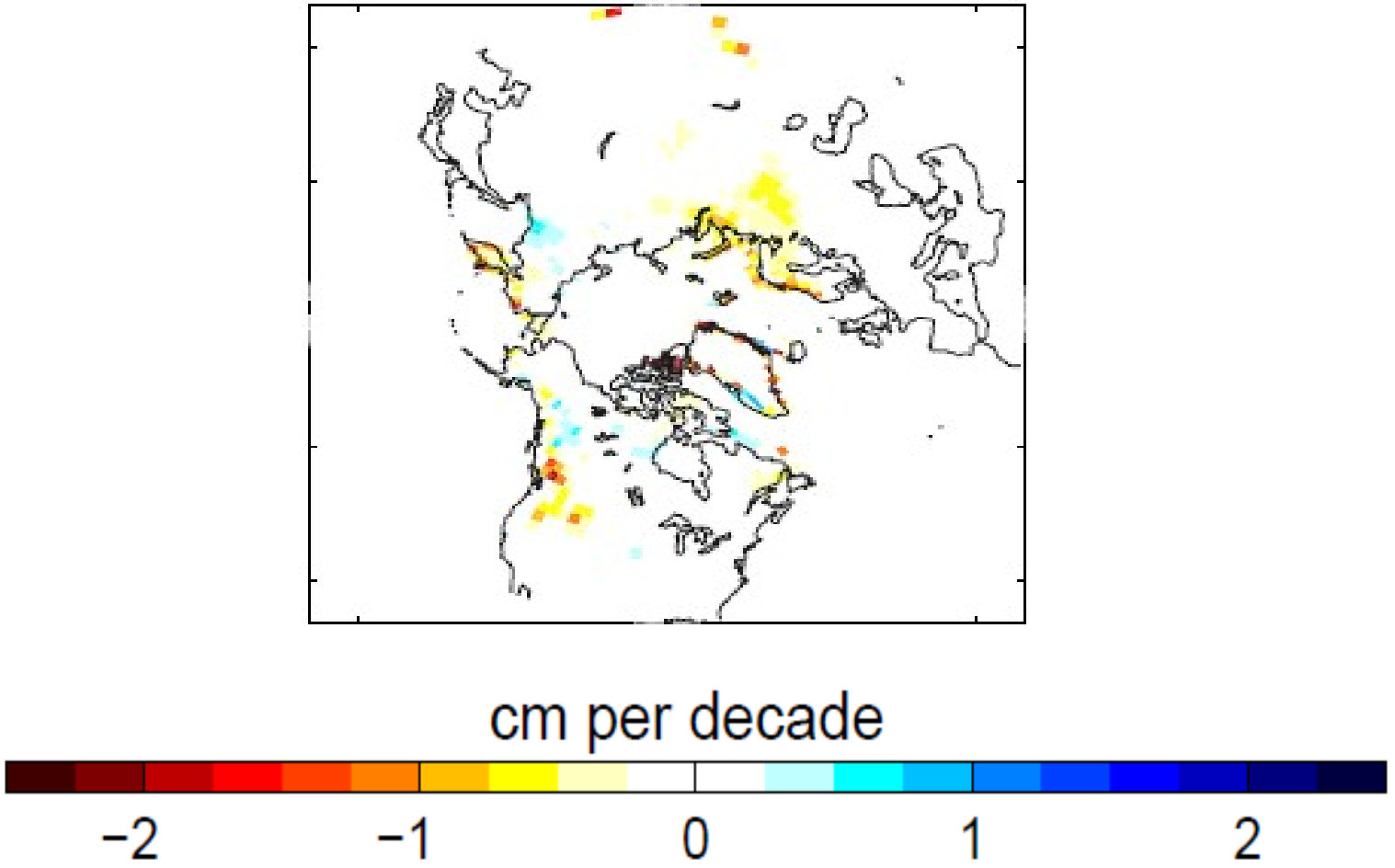


Annual precipitation trends (2010-2040)



April-May-June snow cover trends (2010-2040)

GW (simulated)



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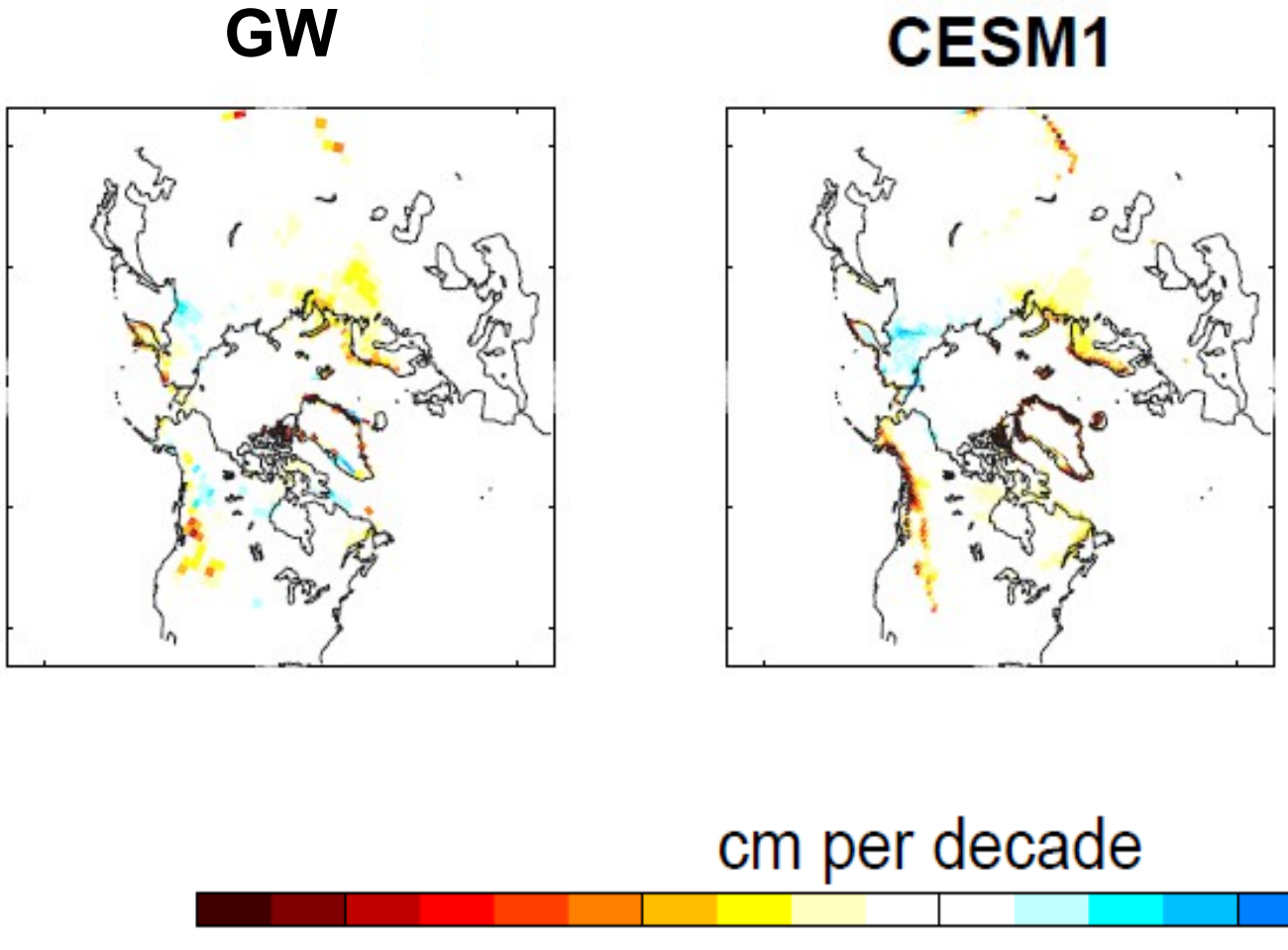

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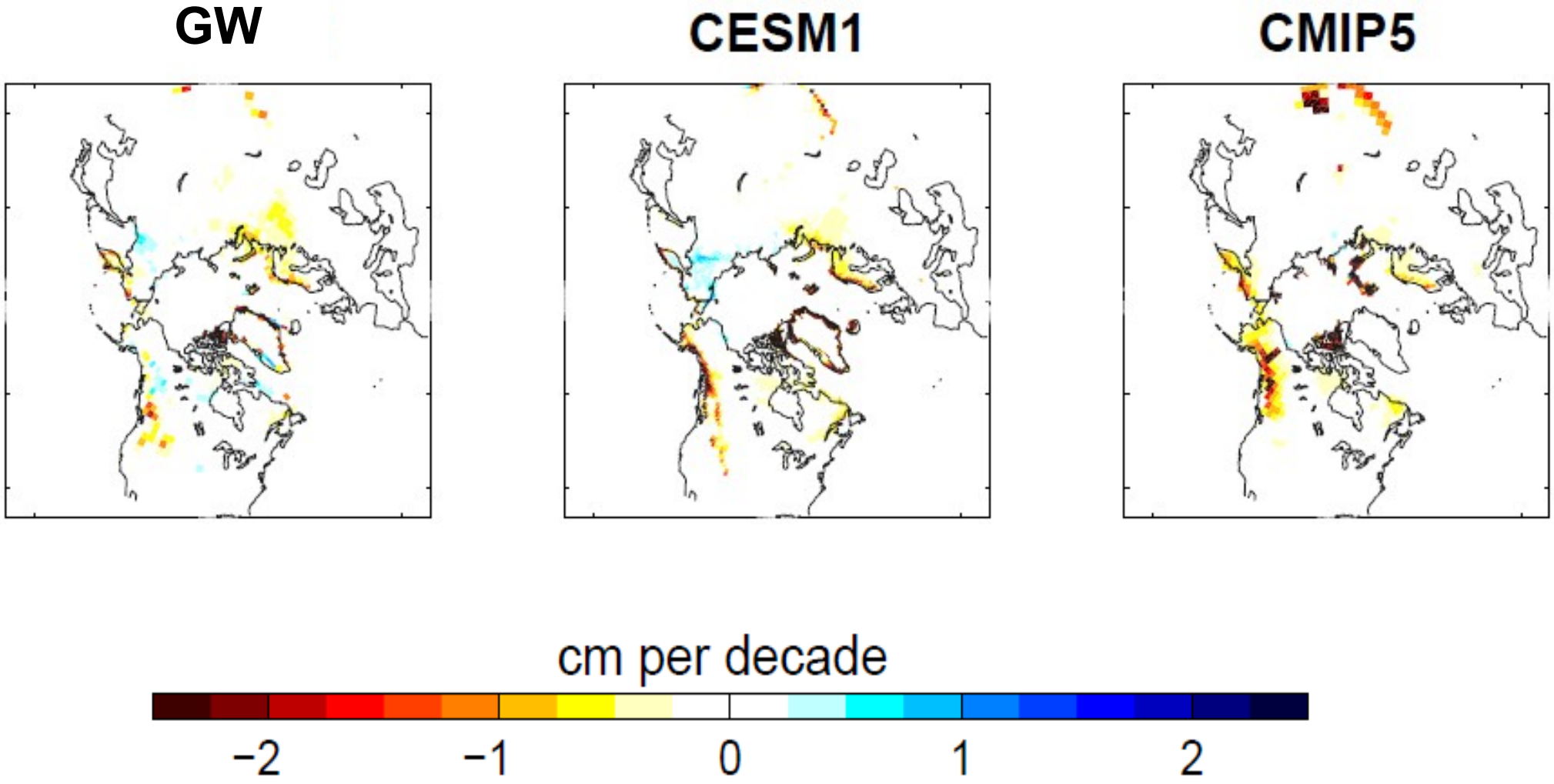

Summary

- Simple method to estimate GW component of future SST and sea ice
- Use it to force AGCM (2010-2040) → Insights into near-term prediction

- SST pattern: some differences between GW and AOGCMs: no Pacific warming, Indian Ocean N/S, stronger N/S gradient in Atlantic Ocean

  → Small differences in land temperature trends (colder, regional pattern)

  → Larger differences in precipitation trends (dryer, opposite trends in US, western tropical Africa, and India)

  → Small differences in high northern latitude spring snow cover trends
- CESM1 and CMIP5 trends are generally similar, but different from GW

Future work

- Can we explain some GW precipitation patterns with GW SST patterns?
- What is the role of direct radiative forcing?
- Insights into near-term prediction (beyond prescribed SST experiment)?
- Linearity of continental response?

- Limits of the approach:

  - Only make sense in regions strongly influenced by ocean

  - S_{GW} (e.g. not the totality of anth. forcing, depends on S_{obs})

  - Model dependent (although CESM1 looks more like CMIP5 than GW)

April-May-June sea ice trends (2010-2040)