

# Towards an improved estimate of "time of emergence" of anthropogenic warming

Flavio Lehner<sup>1</sup>

*NOAA Postdoc Applying Climate Expertise (PACE)*

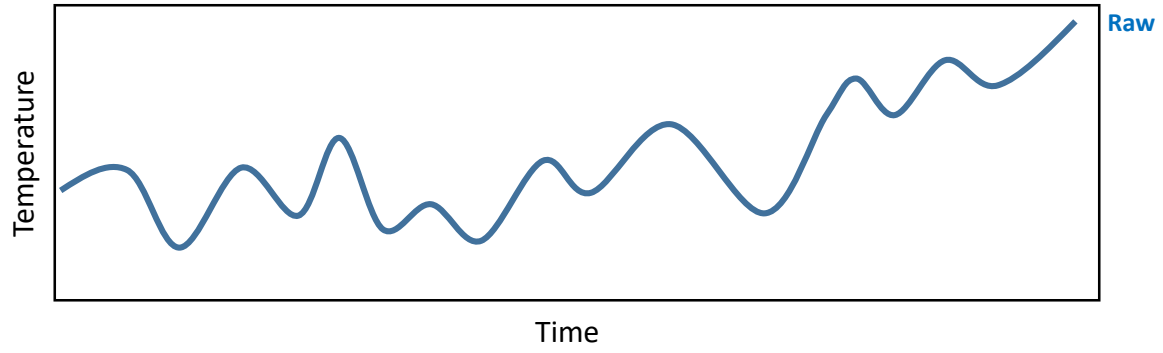
<sup>1</sup>Hydrometeorological Applications Program, RAL, NCAR

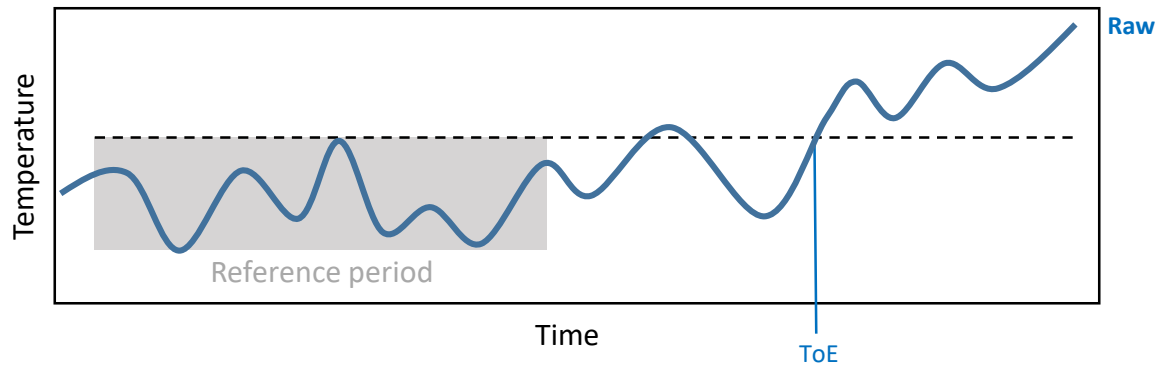
Clara Deser<sup>2</sup>, Laurent Terray<sup>3</sup>

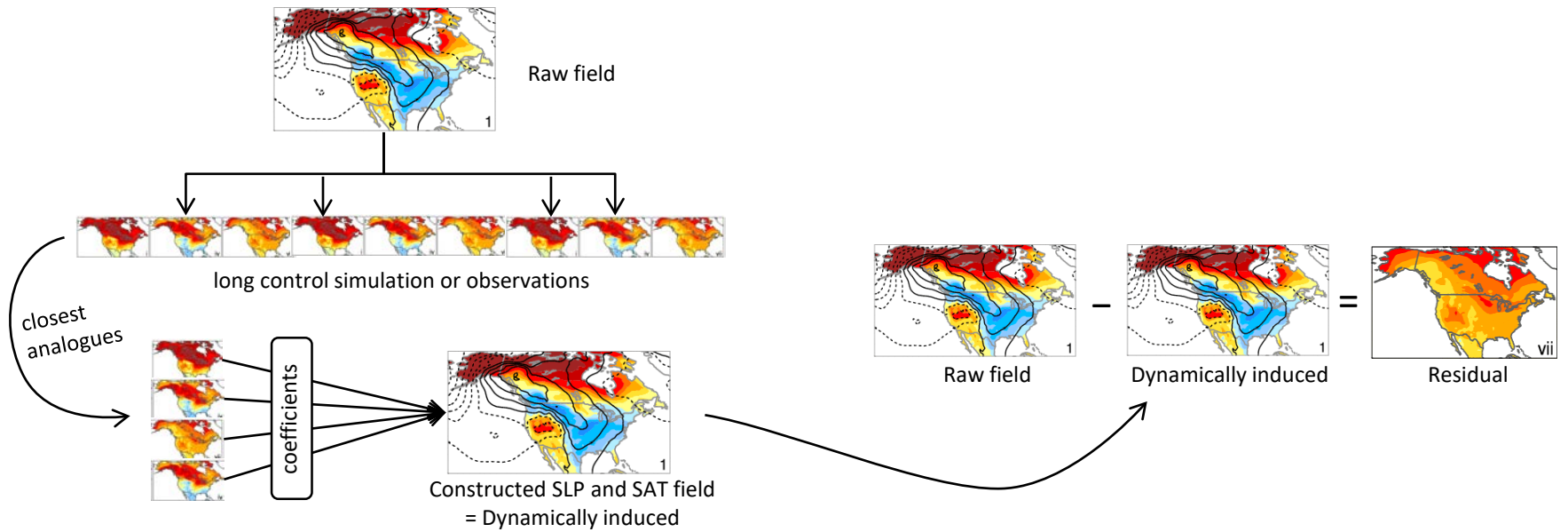
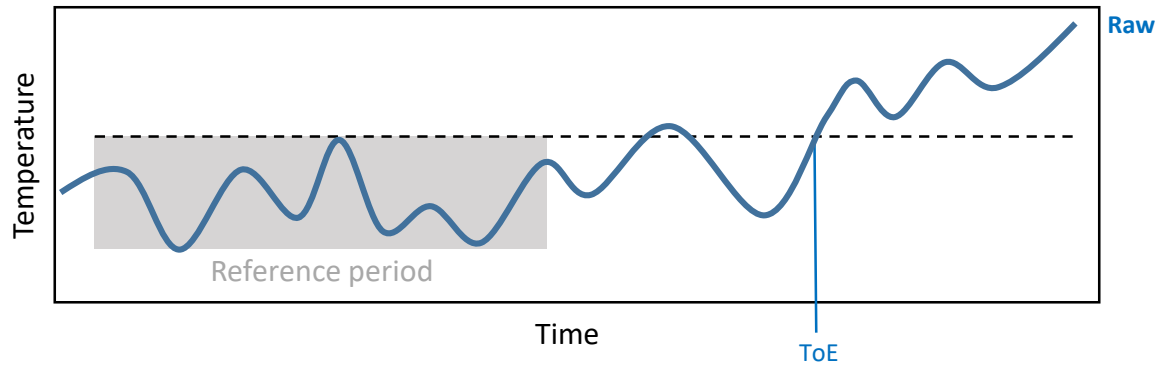
<sup>2</sup>Climate Analysis Section, CGD, NCAR

<sup>3</sup>Sciences de L'Univers au CERFACS, CERFACS/CNRS, Toulouse, France

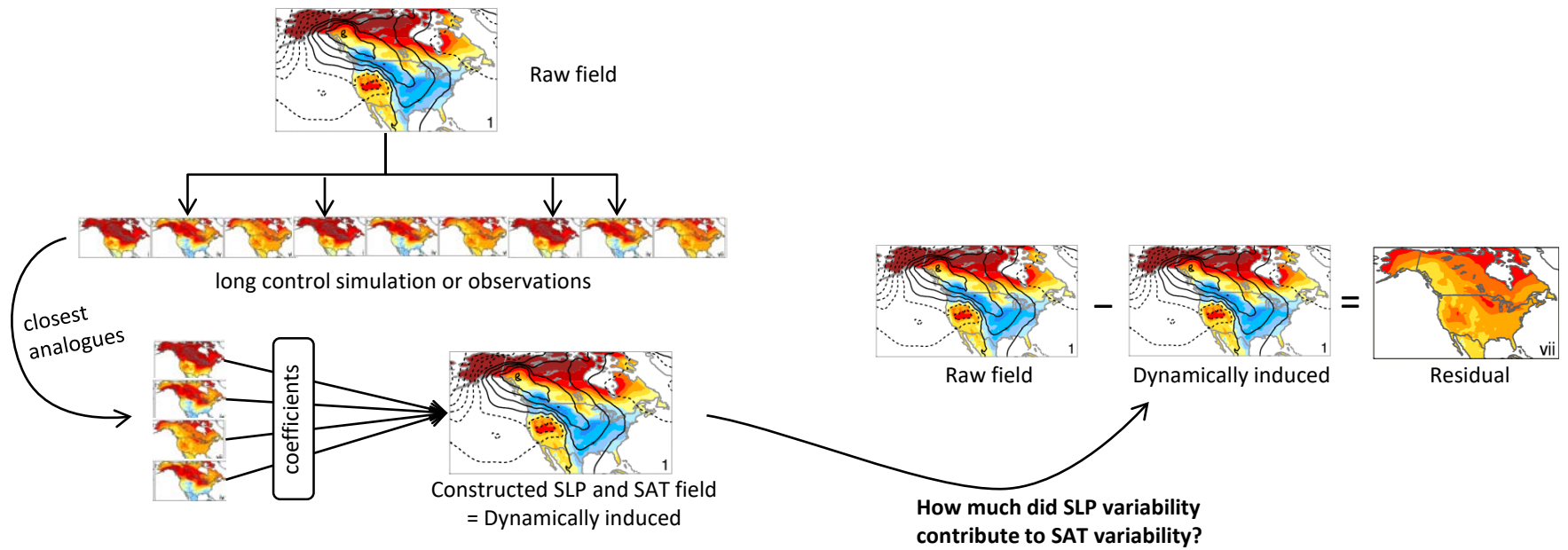
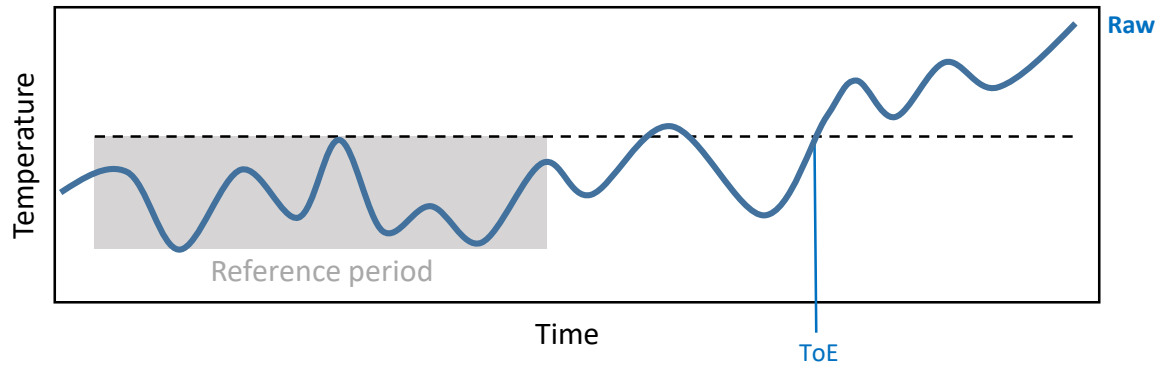


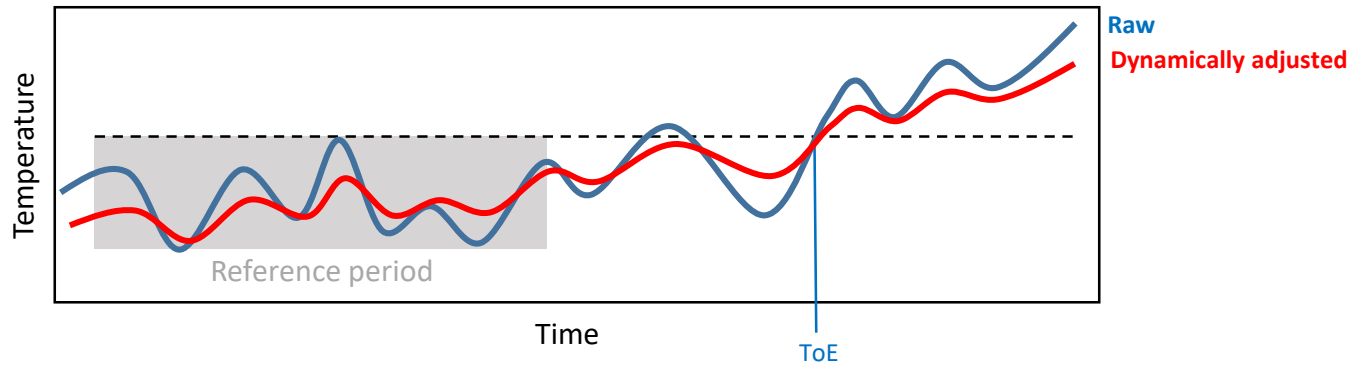


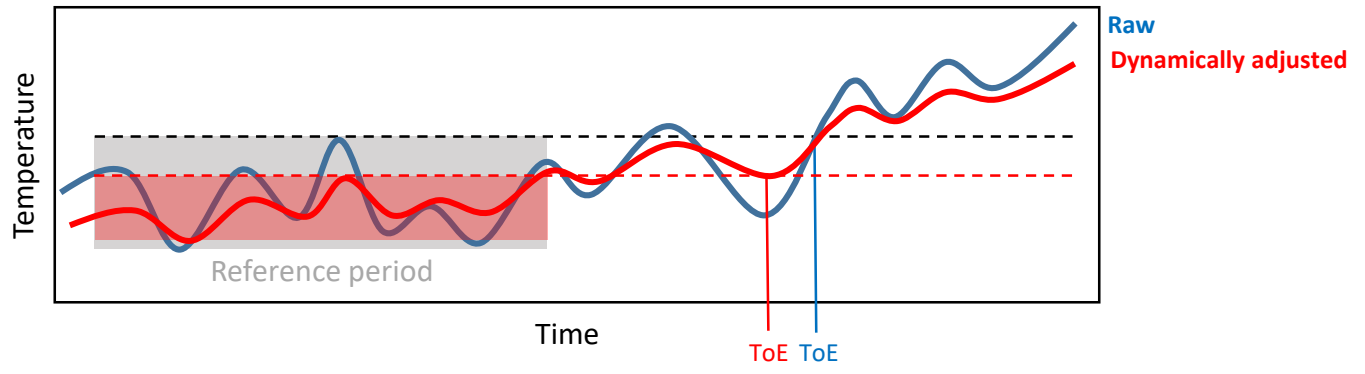


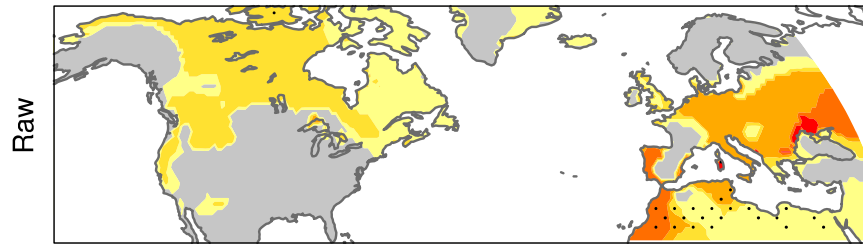






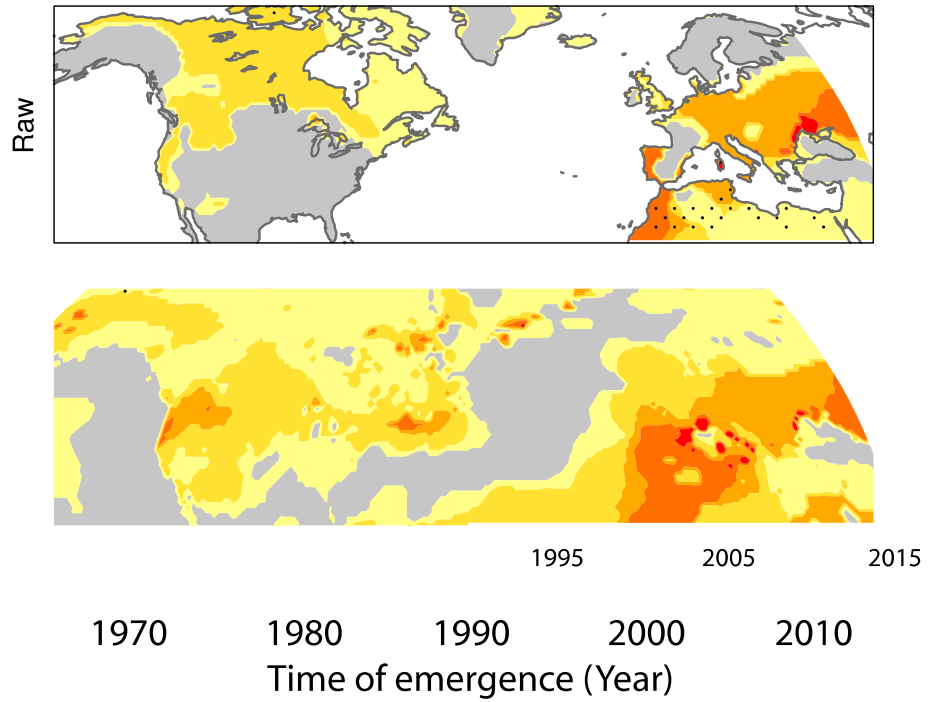


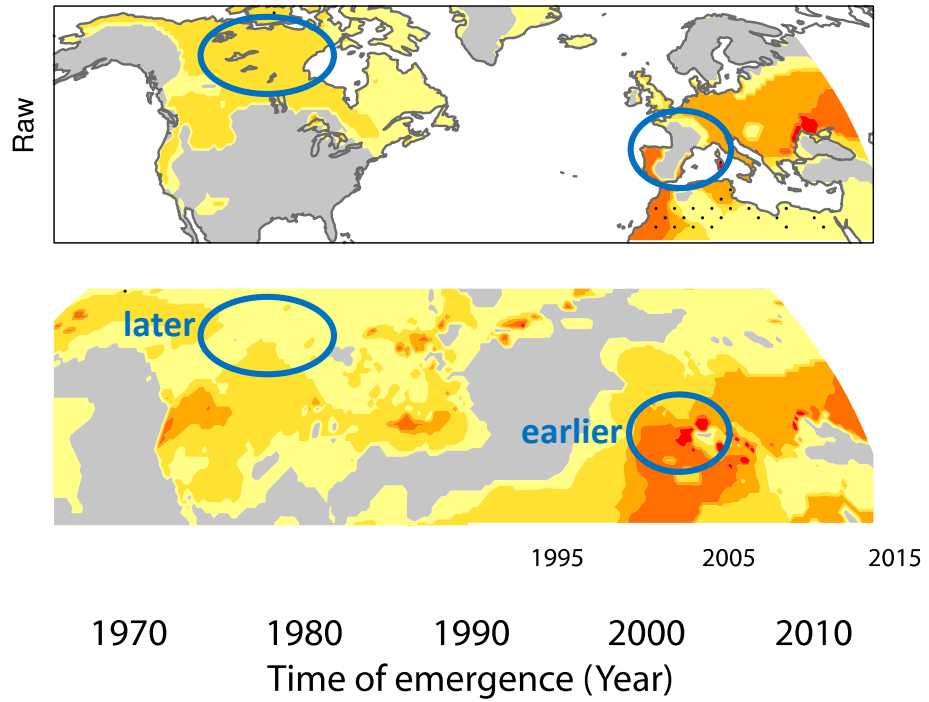


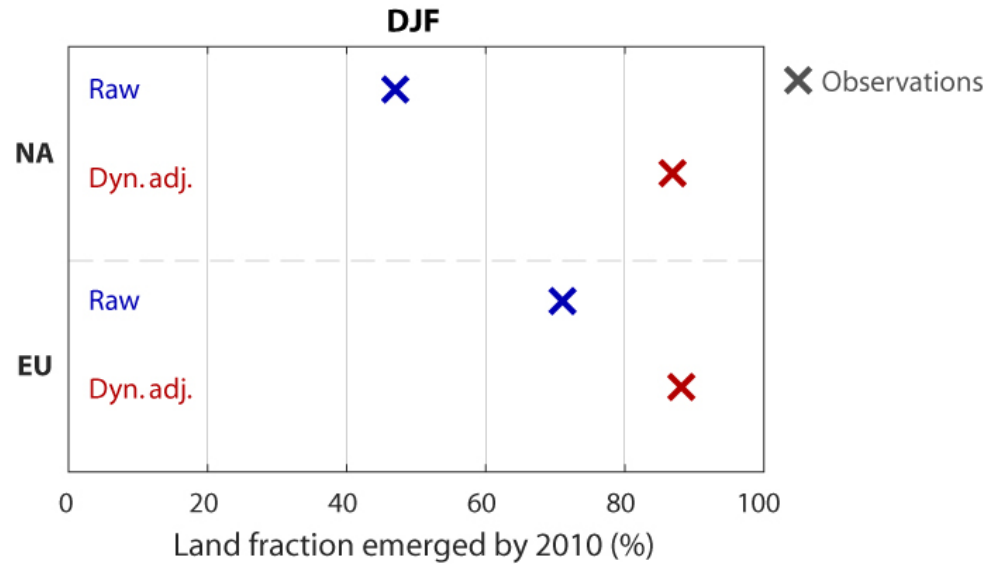
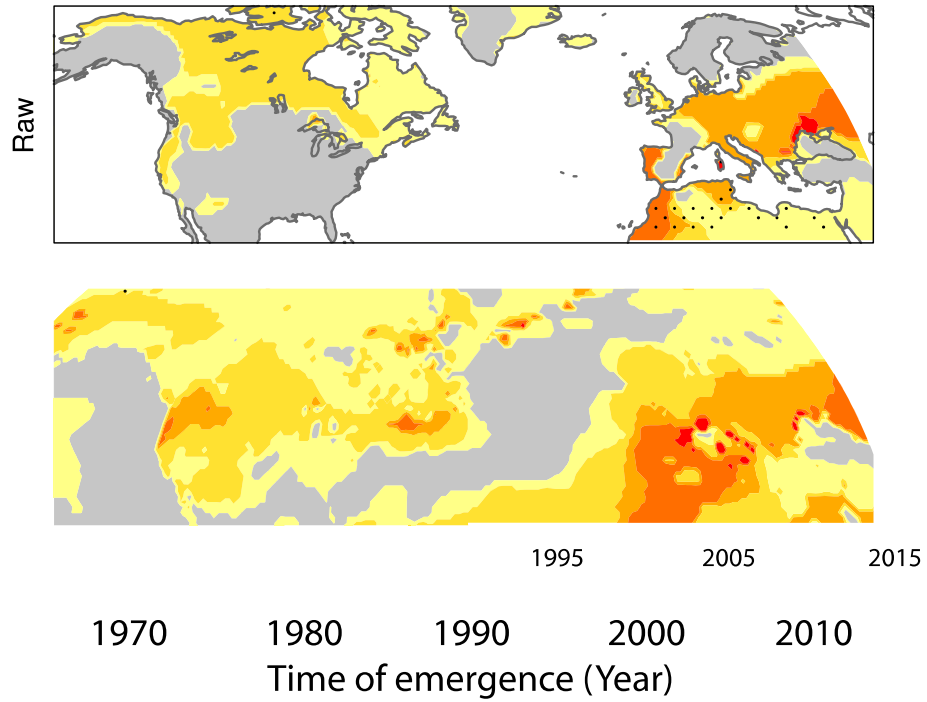


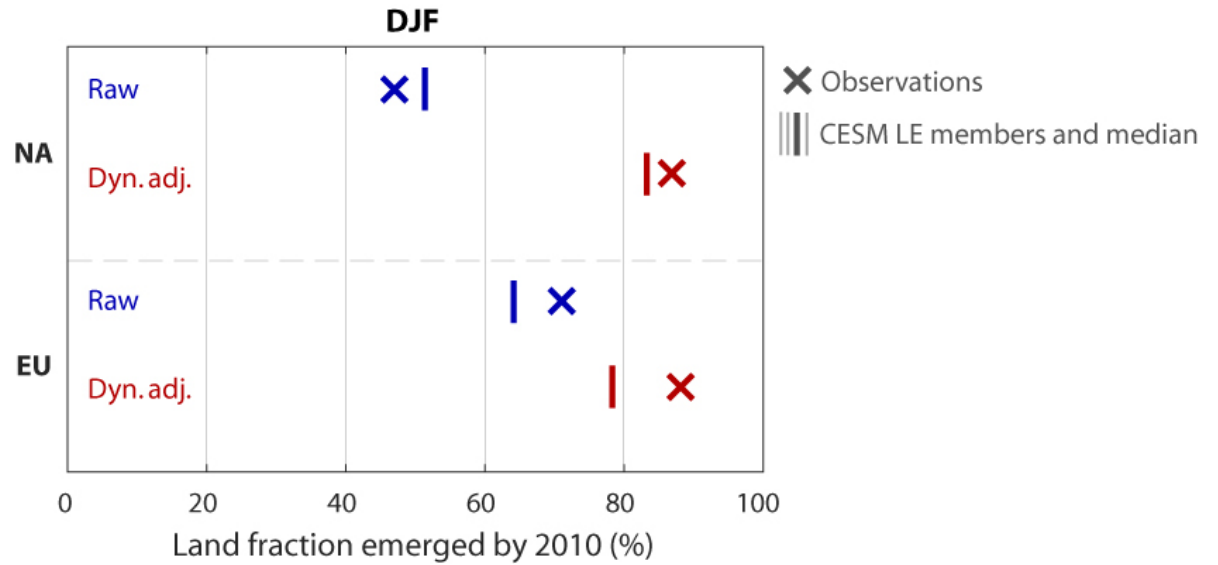
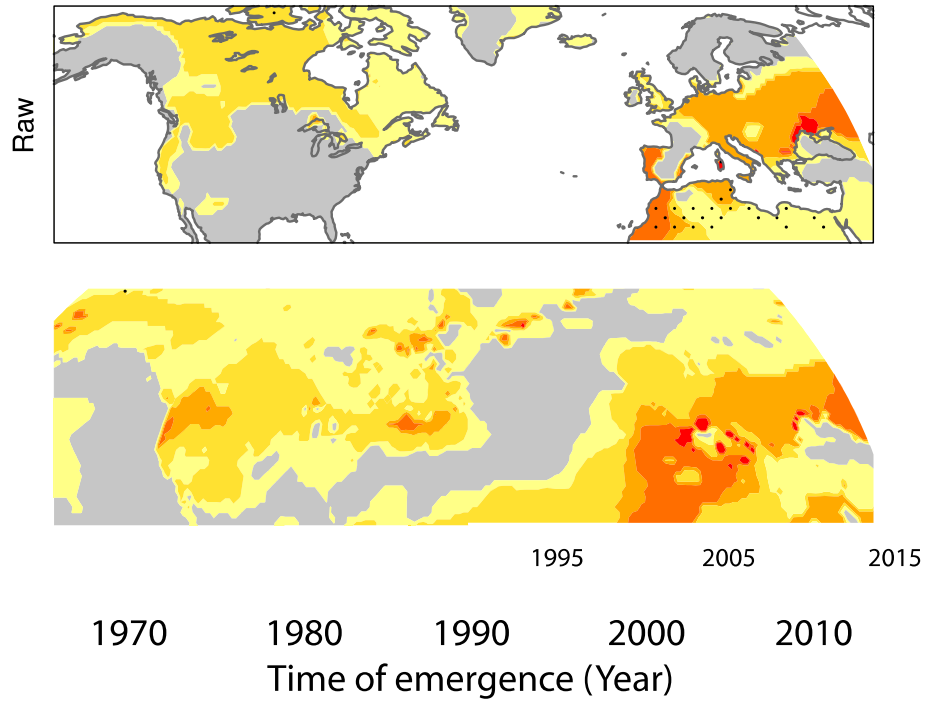
1970      1980      1990      1995      2000      2005      2010      2015

Time of emergence (Year)

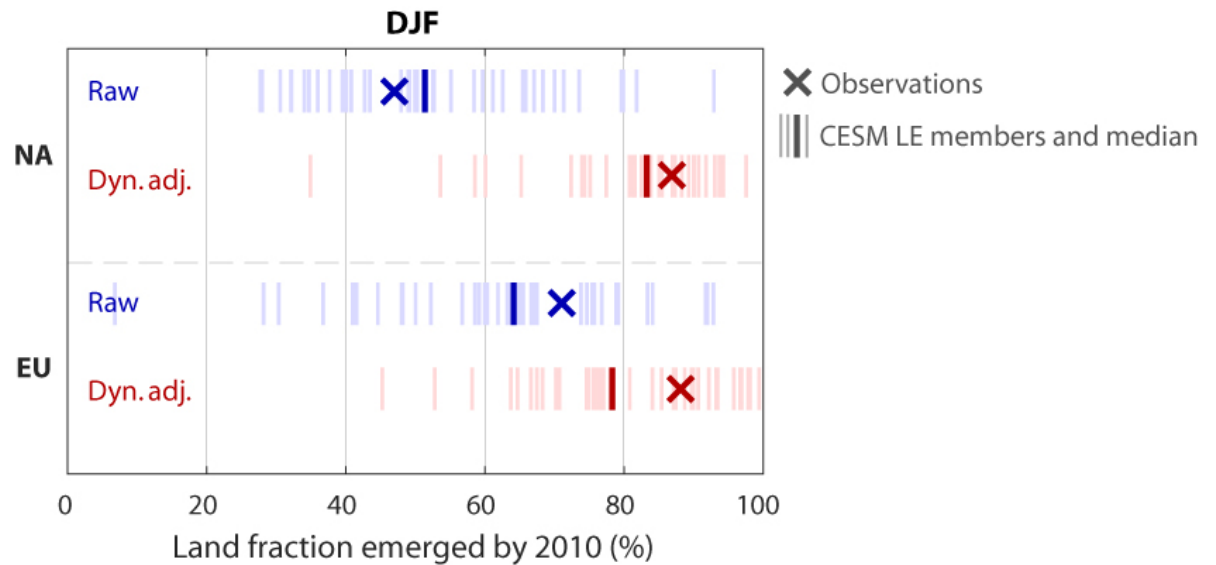
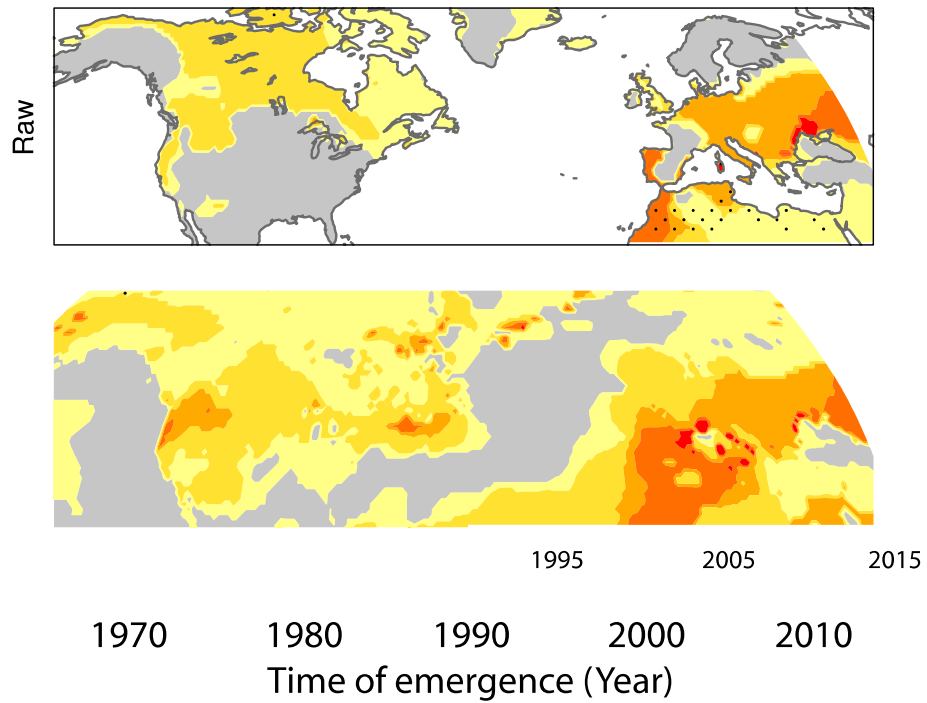






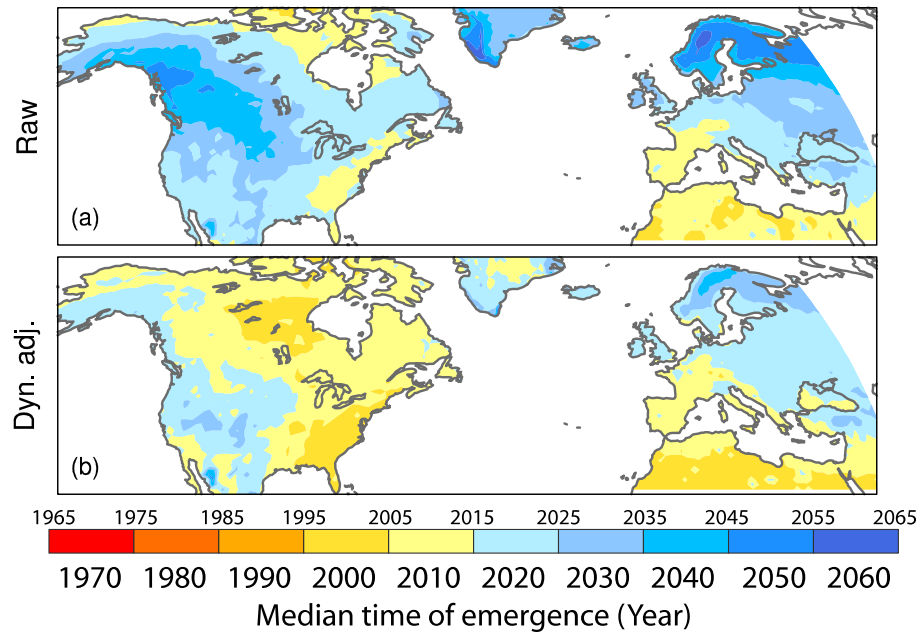






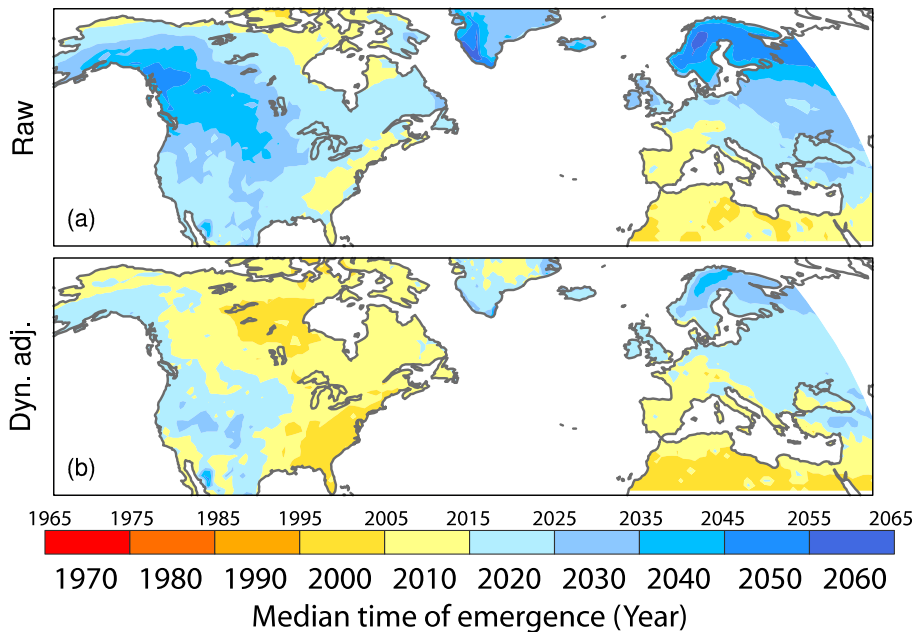
CESM LE

### DJF full ensemble

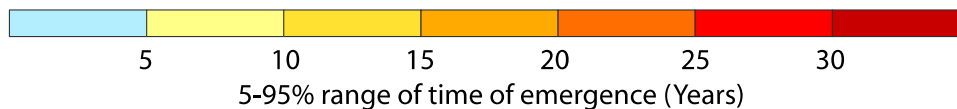
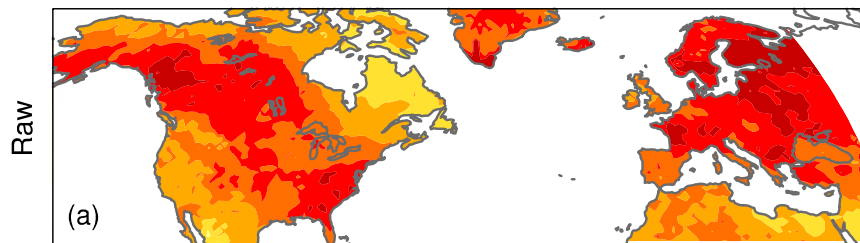


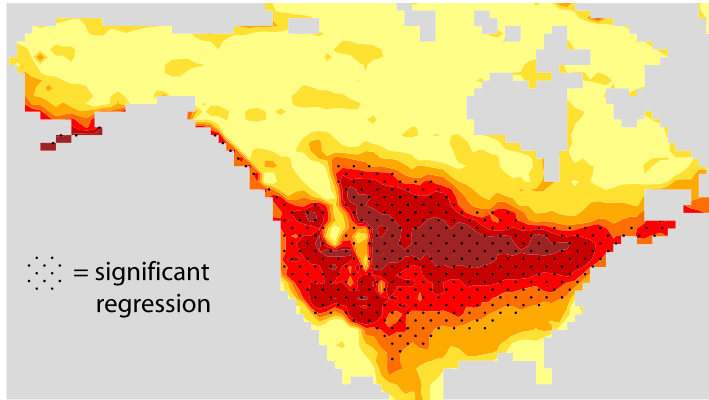
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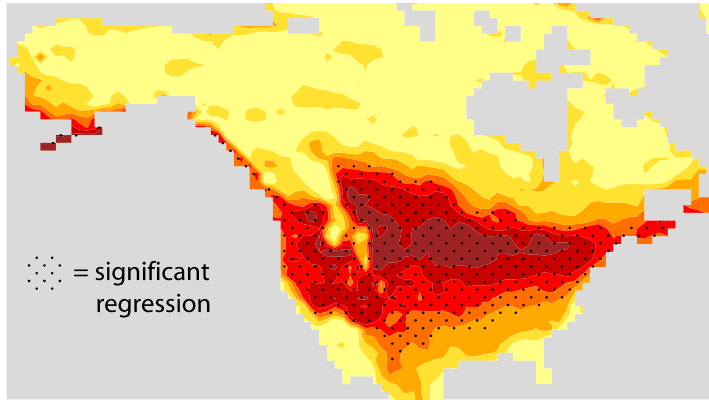
CESM LE



Uncertainty

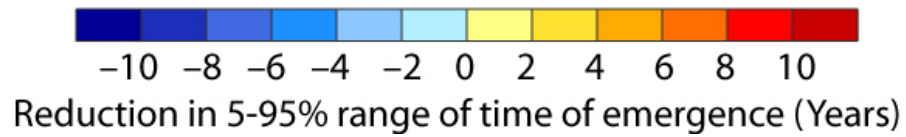
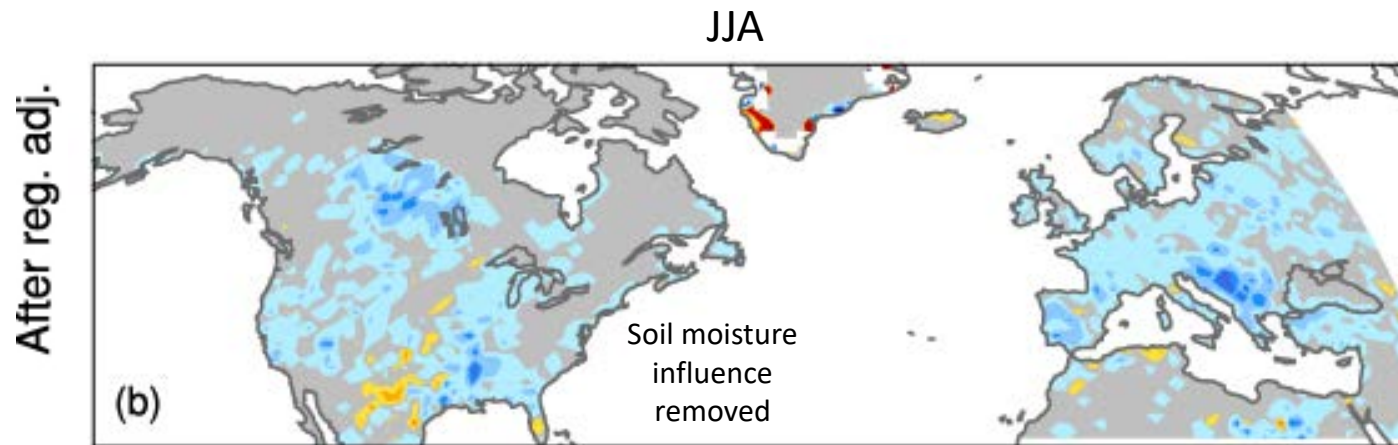
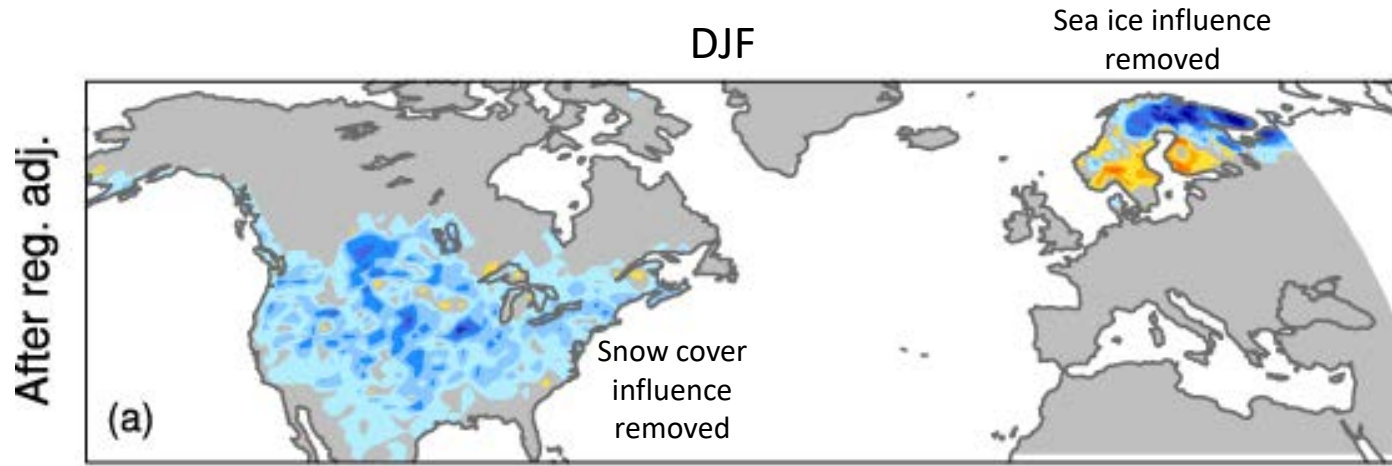






.SAT

-0.6 -0.5 -0.4 -0.3 -0.2 -0.1  
Correlation of soil moisture with dyn. adj. SAT

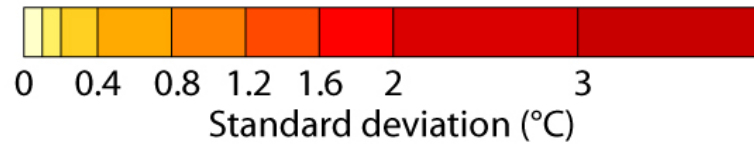
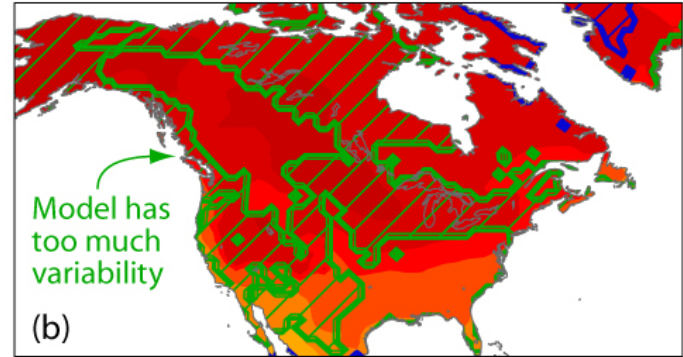
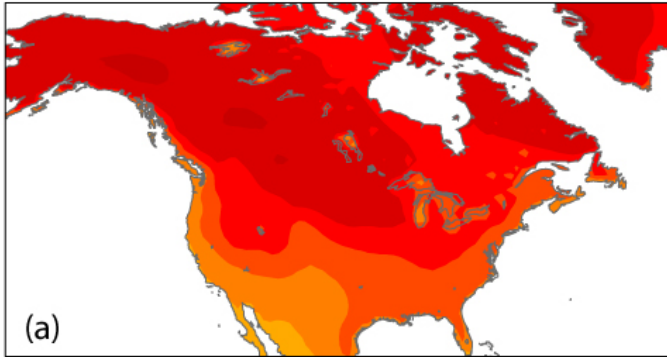


# Dec-Feb surface air temperature

Observations

CESM LE mean

Raw

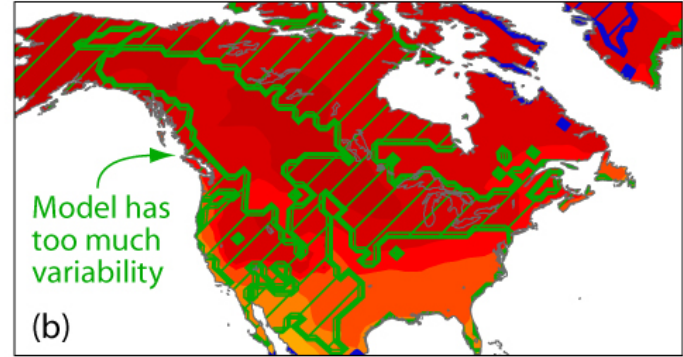
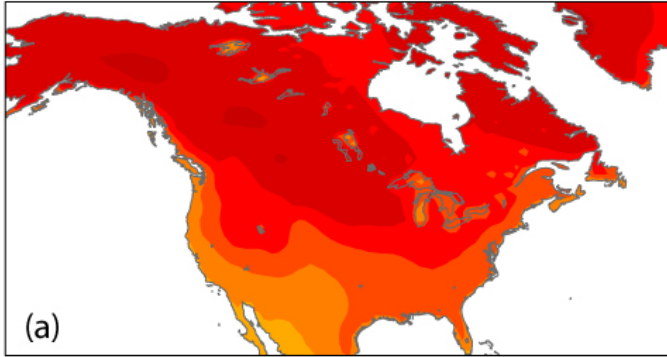


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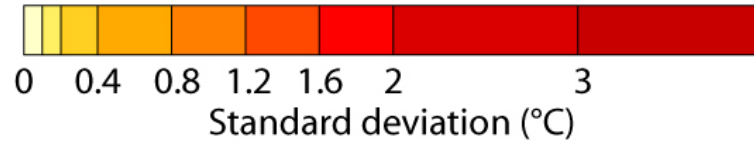
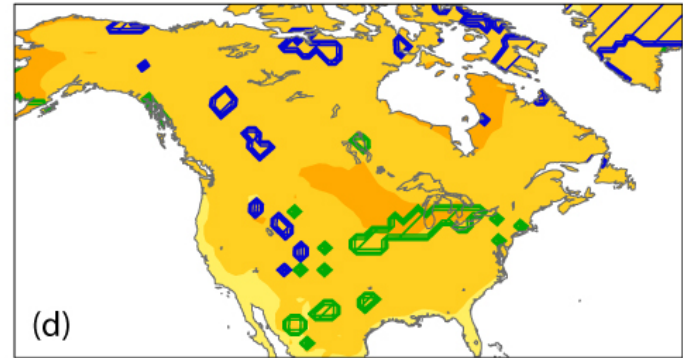
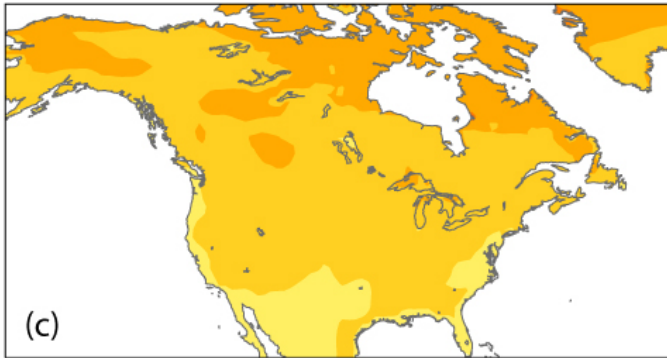
Observations

CESM LE mean

Raw



Dynamically adjusted





## **Dynamical adjustment and the CESM Large Ensemble help to:**

Detect anthropogenic warming earlier, over larger area, and with less uncertainty

10-20 years earlier, 5-30% more land area, 5-10 years uncertainty reduction

Identify drivers of remaining uncertainty

Snow cover, sea ice, soil moisture; up to 8 additional years of uncertainty reduction

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Learn about model biases in variability

Too much variability in DJF, but also JJA --> ToE in reality could be earlier than in model

Account for model biases in variability

After dynamical adjustment, model biases in variability are reduced

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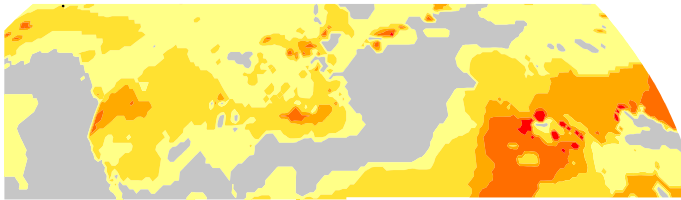
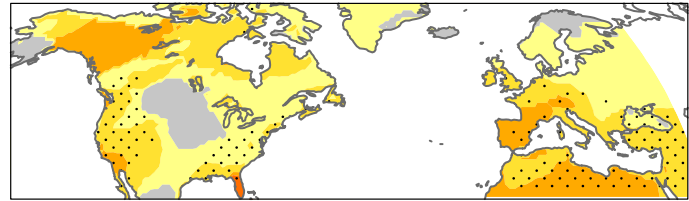
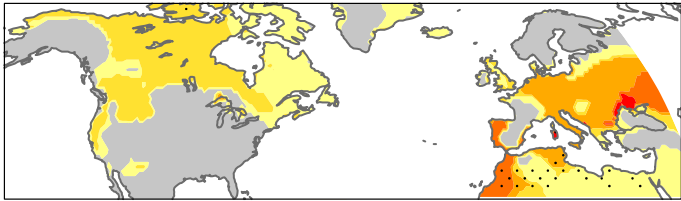
Account for model biases in variability

After dynamical adjustment, model biases in variability are reduced

Lehner, F., C. Deser, L. Terray (submitted): Towards an improved estimate of "time of emergence" of anthropogenic warming over the Northern Hemisphere continents



Raw



1995

2005

2015

1970

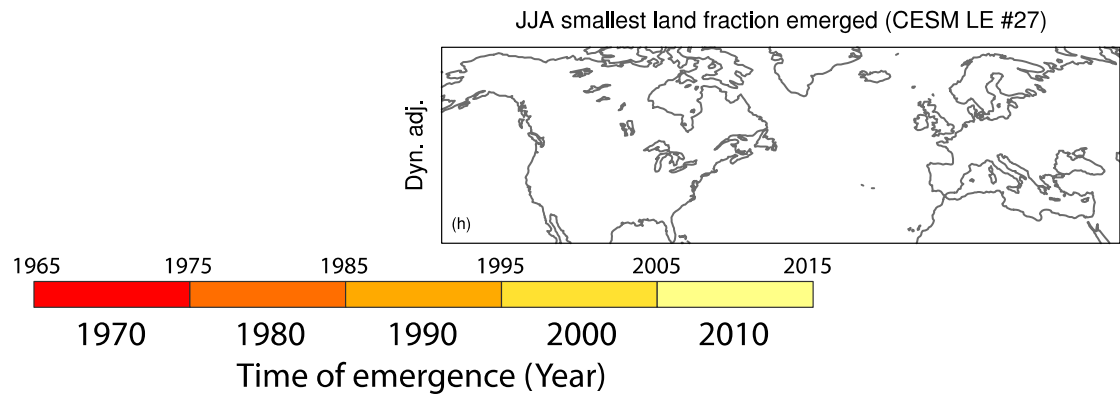
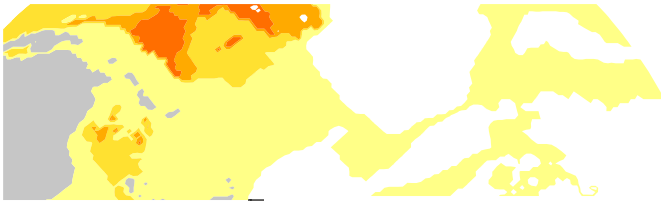
1980

1990

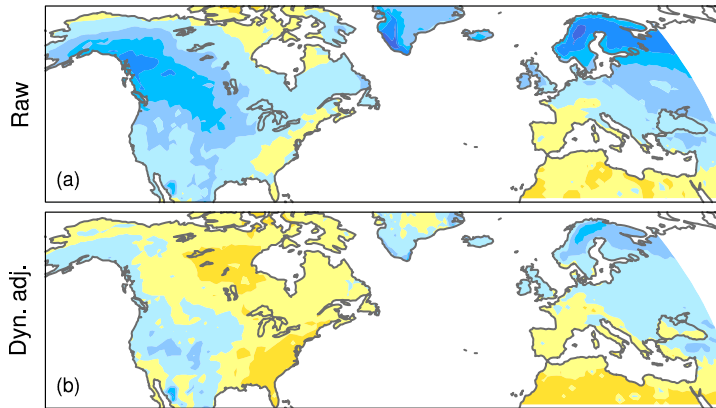
2000

2010

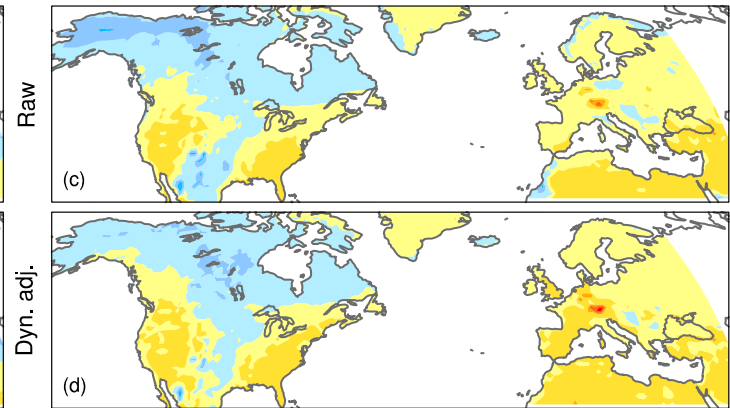
Time of emergence (Year)



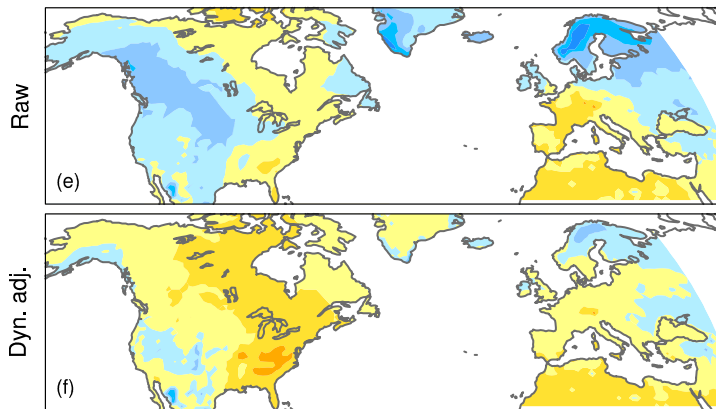
DJF full ensemble



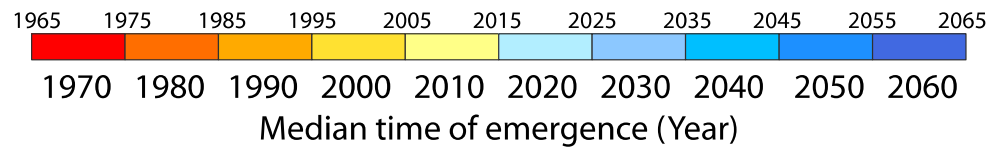
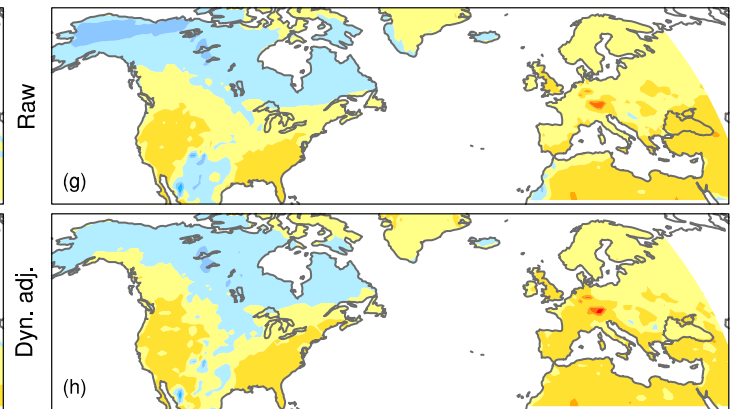
JJA full ensemble

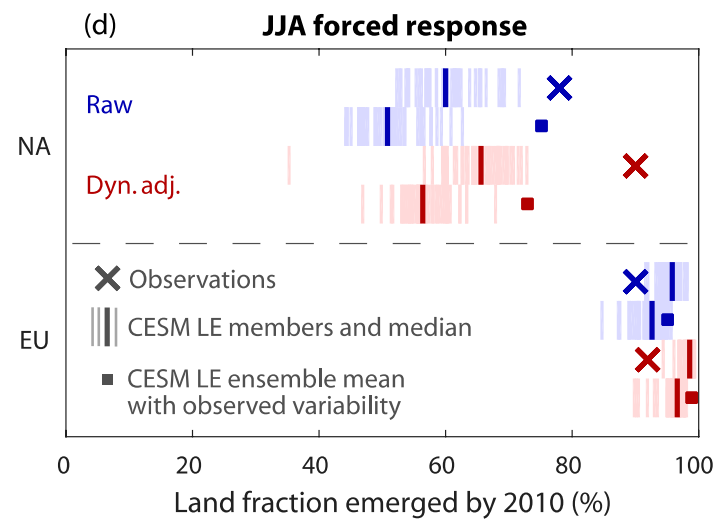
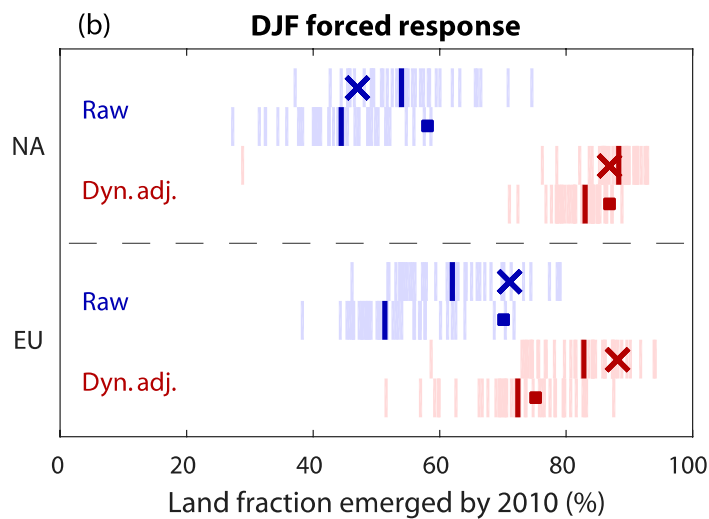
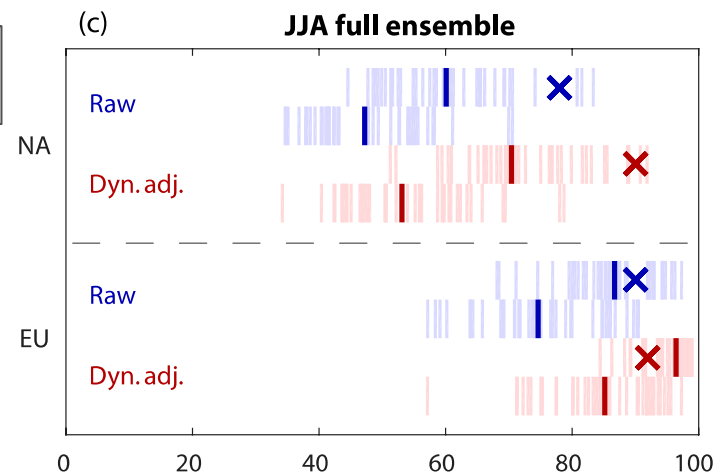
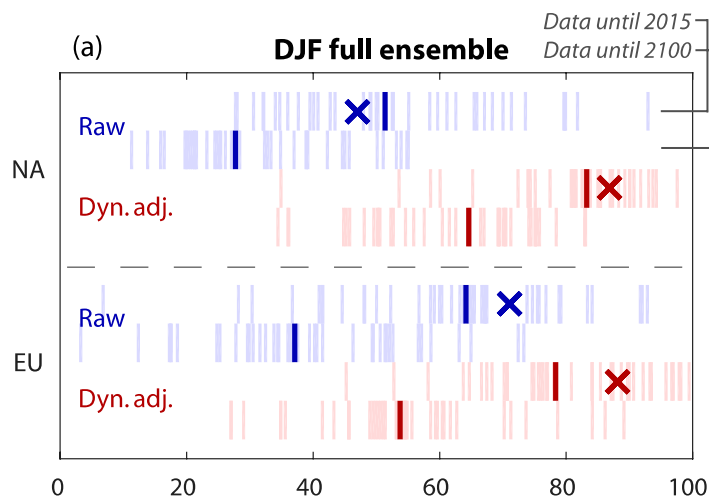


DJF forced response

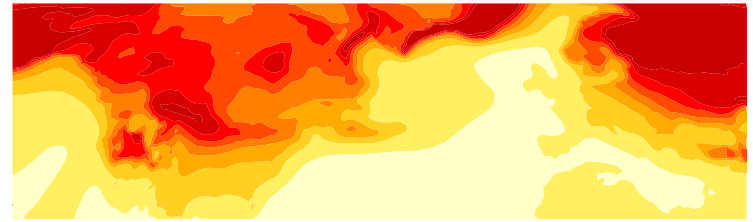
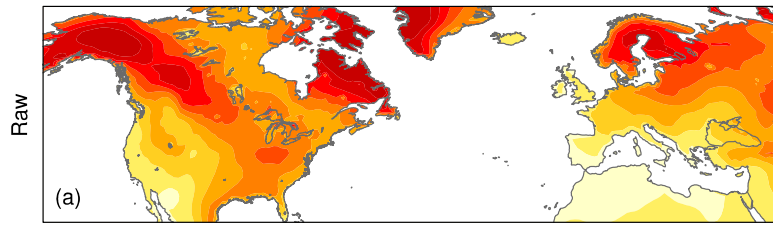


JJA forced response

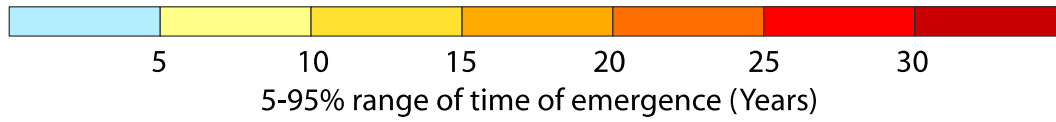
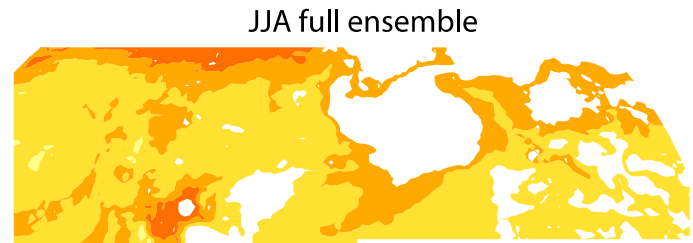
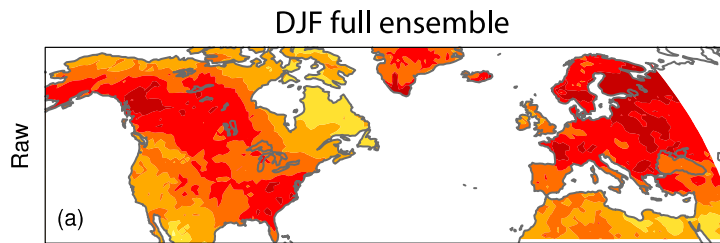


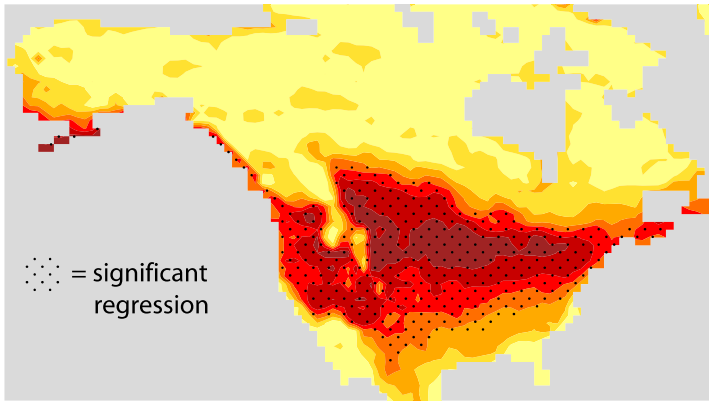






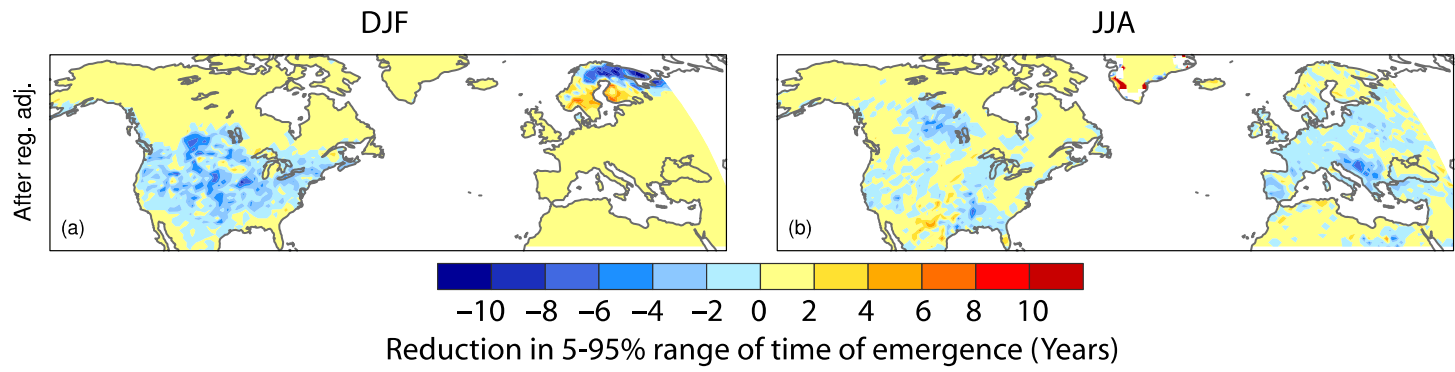
Temperature standard deviation (°C)



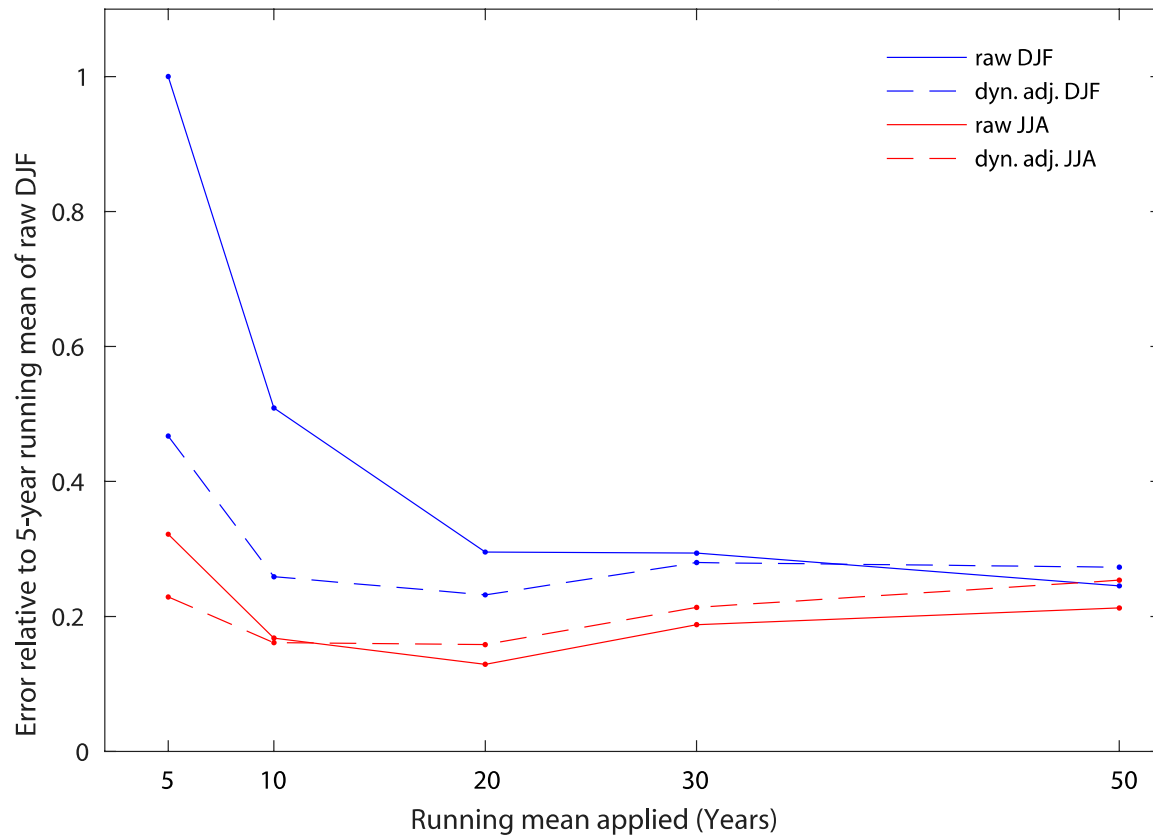


.SAT

-0.6 -0.5 -0.4 -0.3 -0.2 -0.1  
Correlation of soil moisture with dyn. adj. SAT



Error in time of emergence of SAT due to early end of record in 2015



After Mahlstein et al. (2011)

