# Attributing TWS trends from satellite gravimetry to long-term wetting and drying conditions with global climate models

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## Global coupled climate models

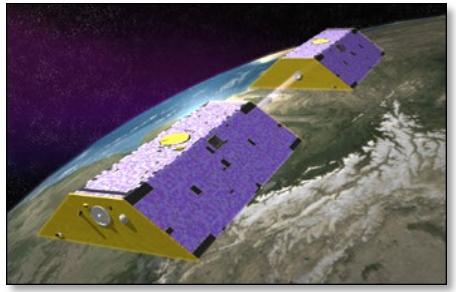
CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Coupled Model Intercomparison Project

## Satellite gravimetry

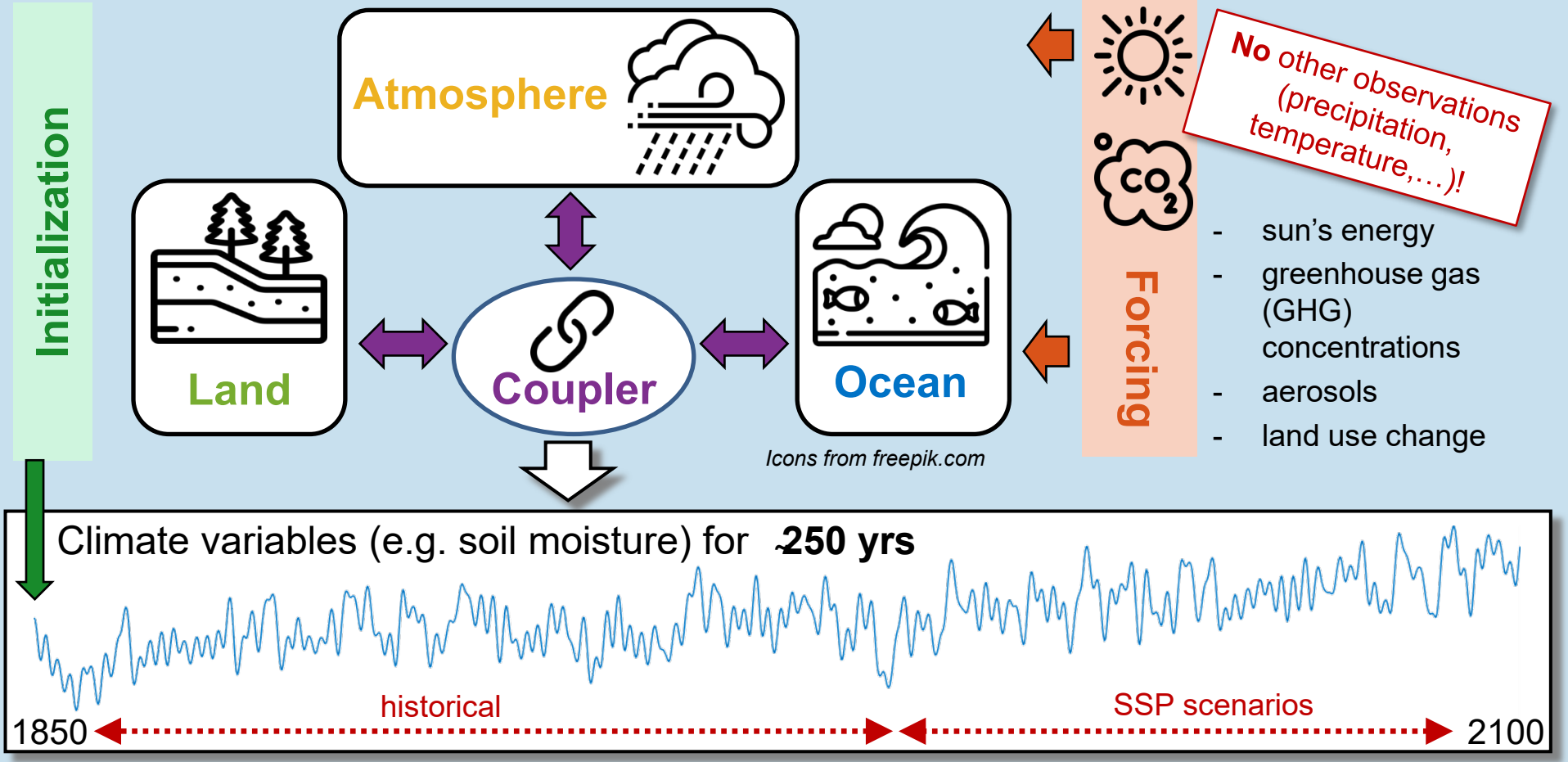


GRACE
GRACE-FO
MAGIC
…

(How) can we use satellite gravimetry to evaluate climate models*?

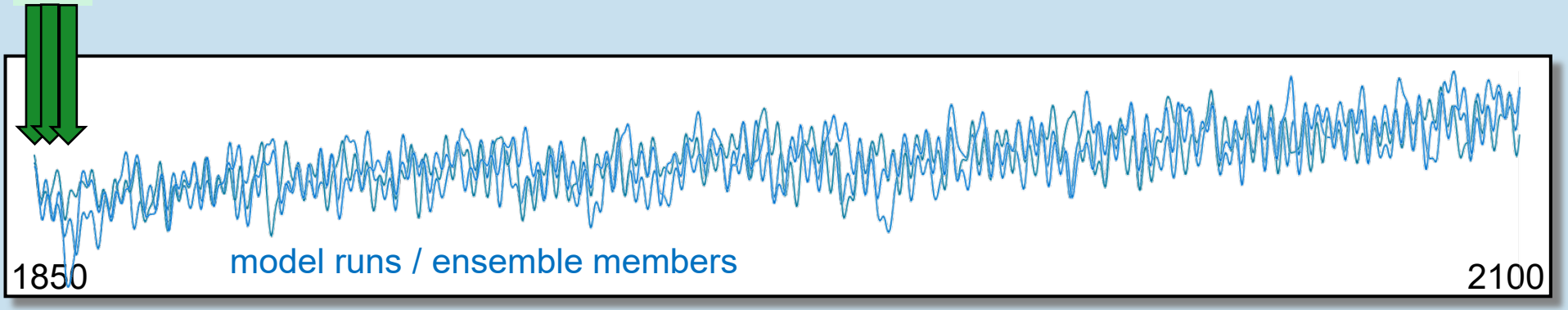
* regarding **land water-storage** related variables

# Coupled climate models



Initialization

Inter-annual (natural) variations are stochastic...



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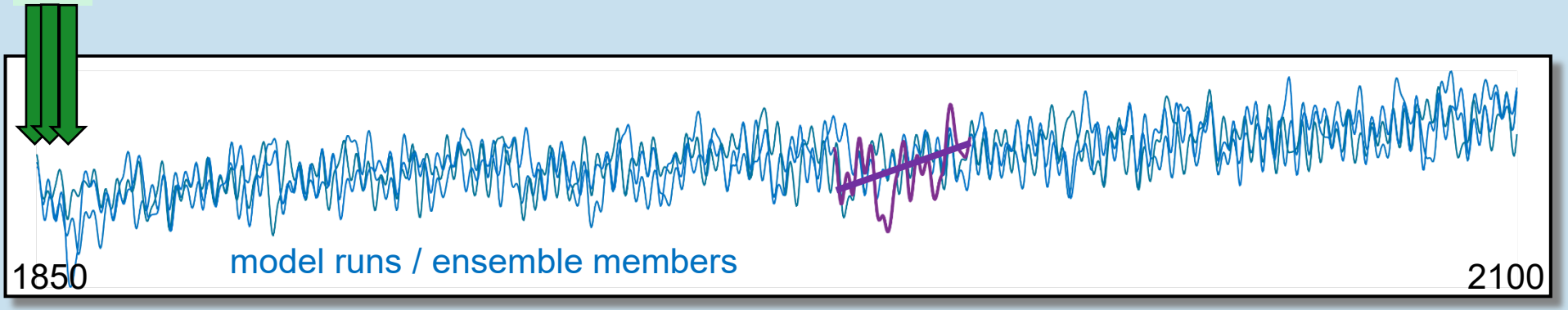

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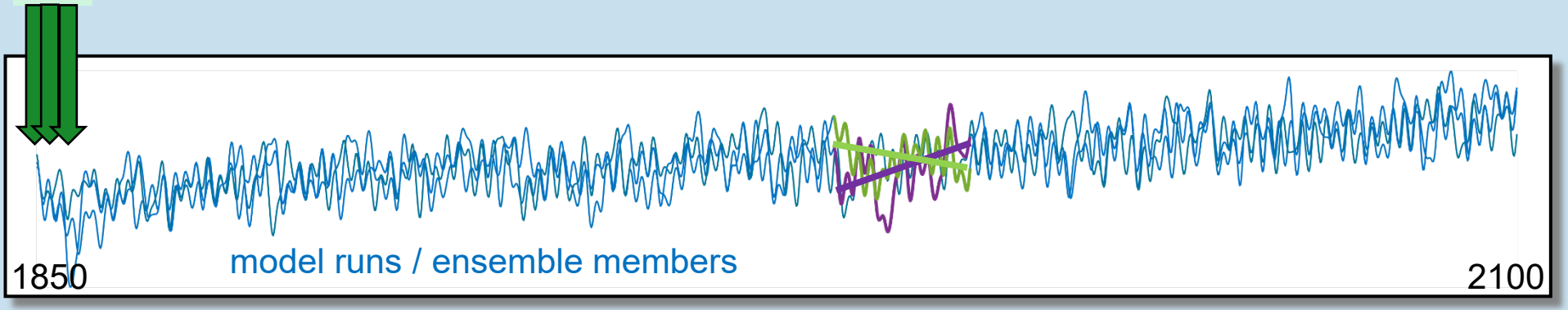
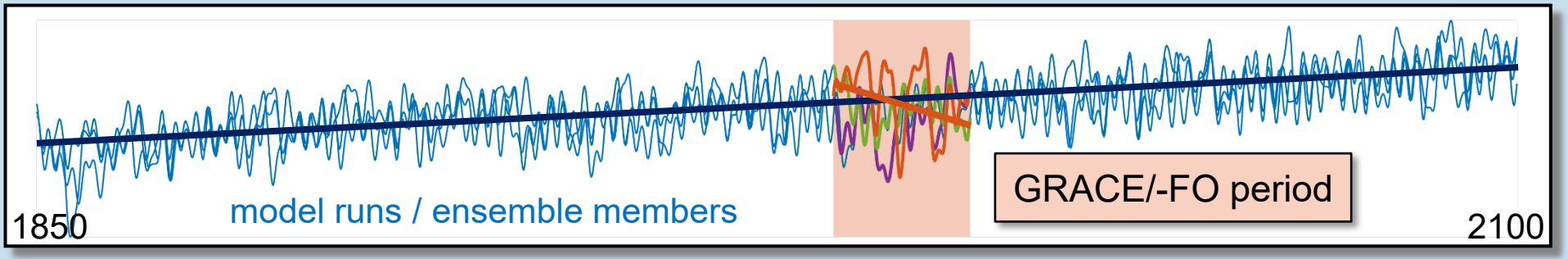


# Challenges

Inter-annual (natural) variations are stochastic...

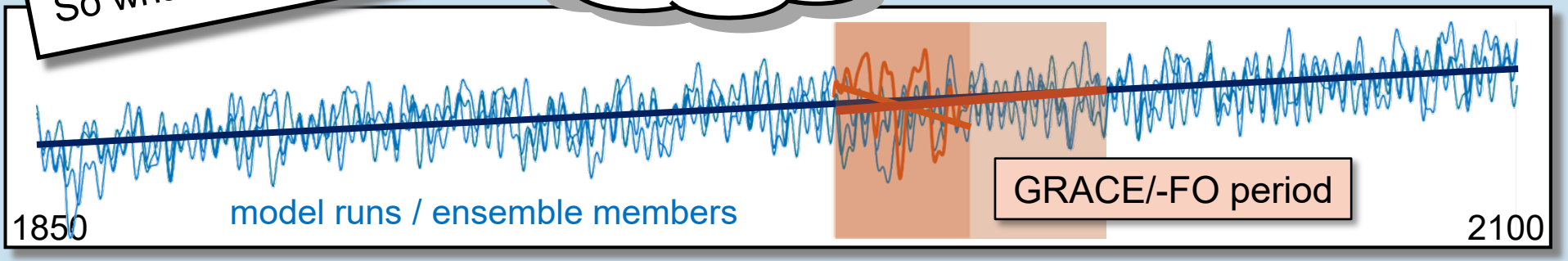
... and might mask long-term (climate trends).



Try to identify **hot spot regions** where GRACE/-FO already sees climate related wetting or drying trends.

So what can we do?

Observe longer…

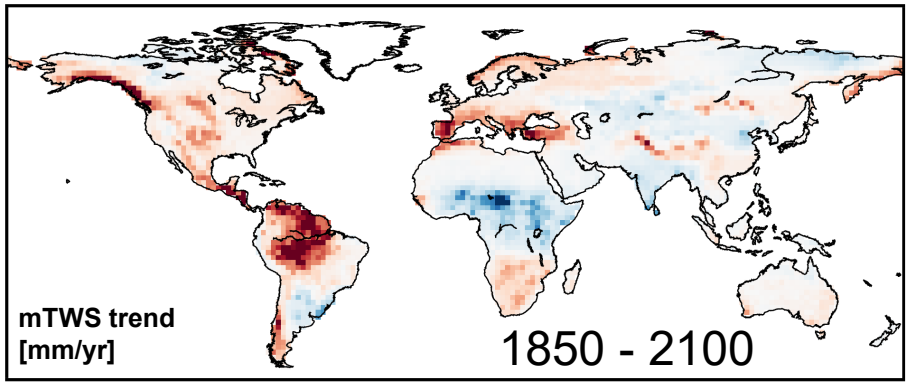


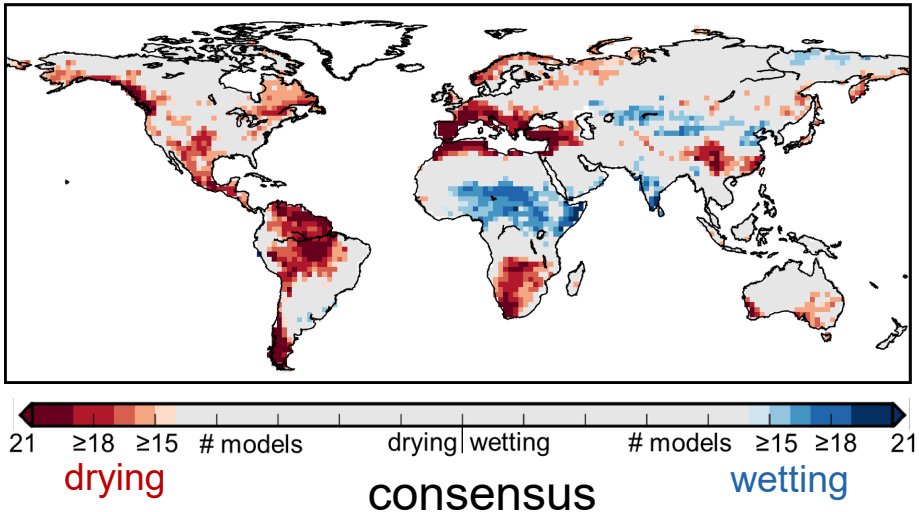
# Long-term linear trends

## Drying or wetting?

Jensen, L., Eicker, A., Dobslaw, H., Stacke, T., & Humphrey, V. (2019). Long-term wetting and drying trends in land water storage derived from GRACE and CMIP5 models. *Journal of Geophysical Research: Atmospheres*, *124*(17-18), 9808-9823.

# Comparison of long-term trends



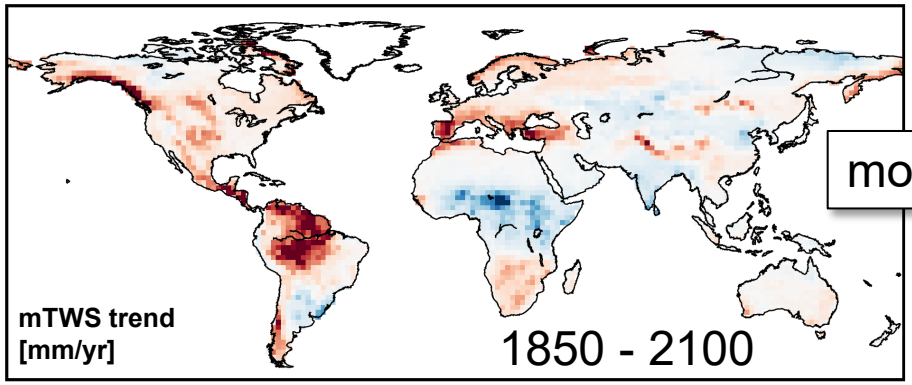




Multi-model median (MMMed)
trend of 17 CMIP6 models

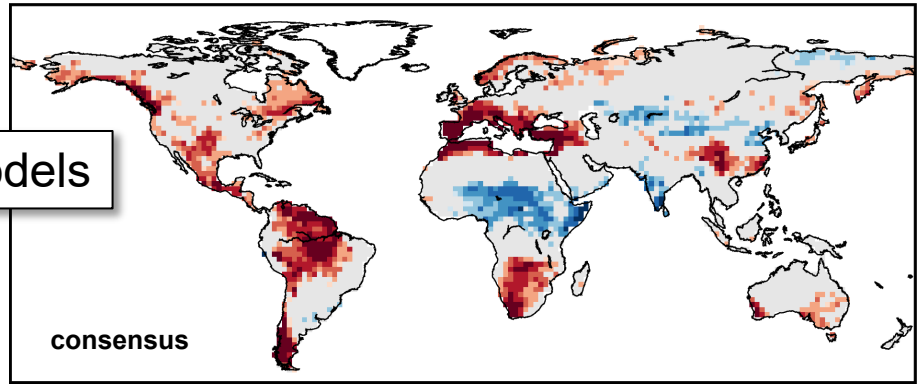
**But: Large inter-model differences!**

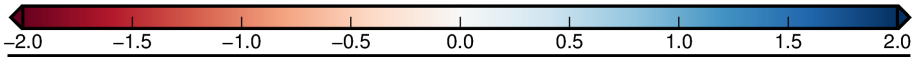
= number of models
agreeing on **sign** of trend

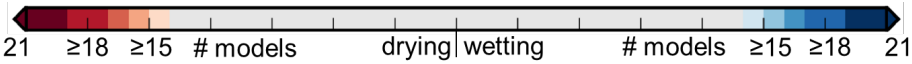
# Comparison of long-term trends

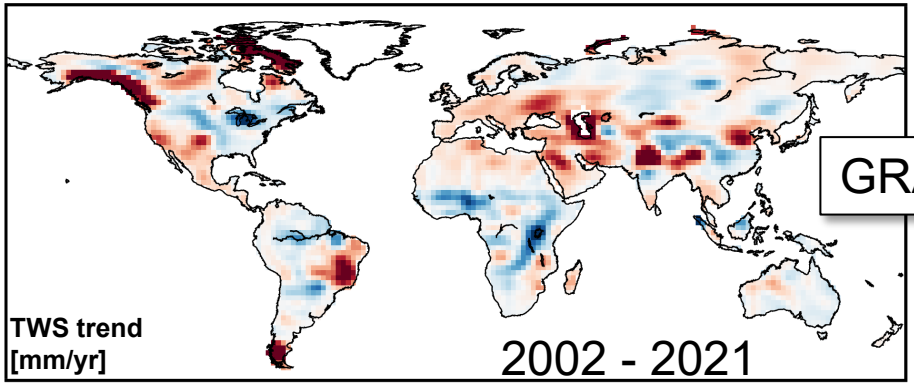



models



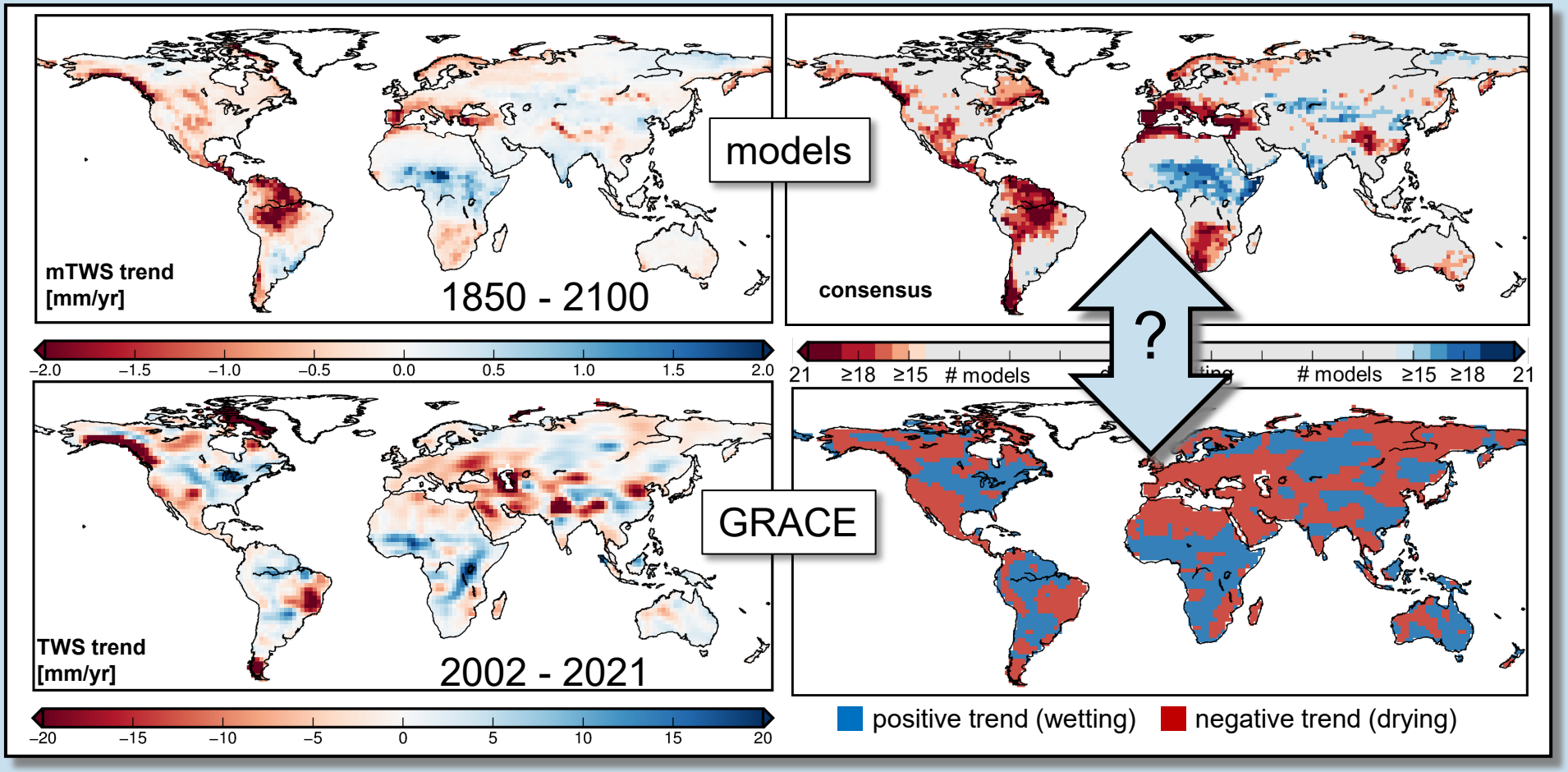




GRACE

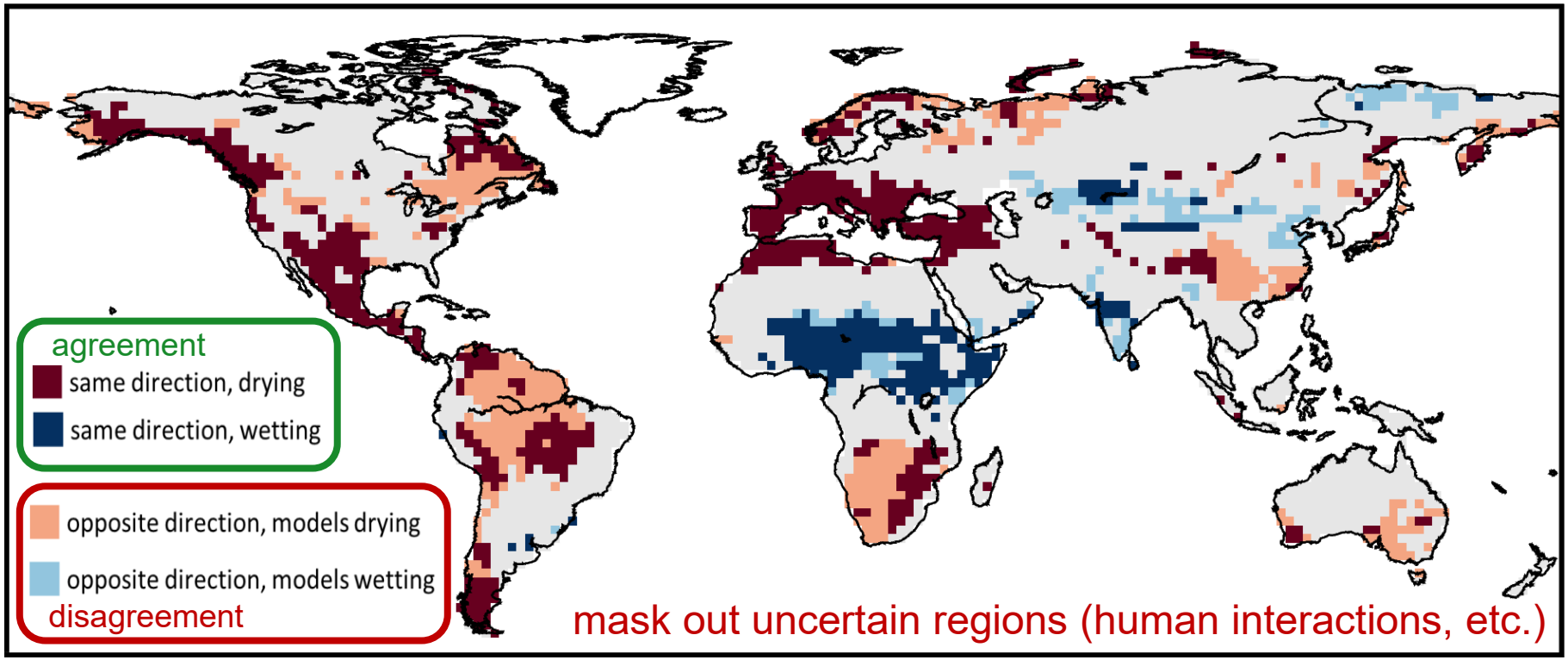

**Agreement on wetting or drying?**

**(sign of the trend)**

# Comparison of long-term trends



# Agreement of GRACE and model trends




agreement/disagreement of trends from **GRAVIS v4** (2002/04 - 2021/11) & **CMIP6** models

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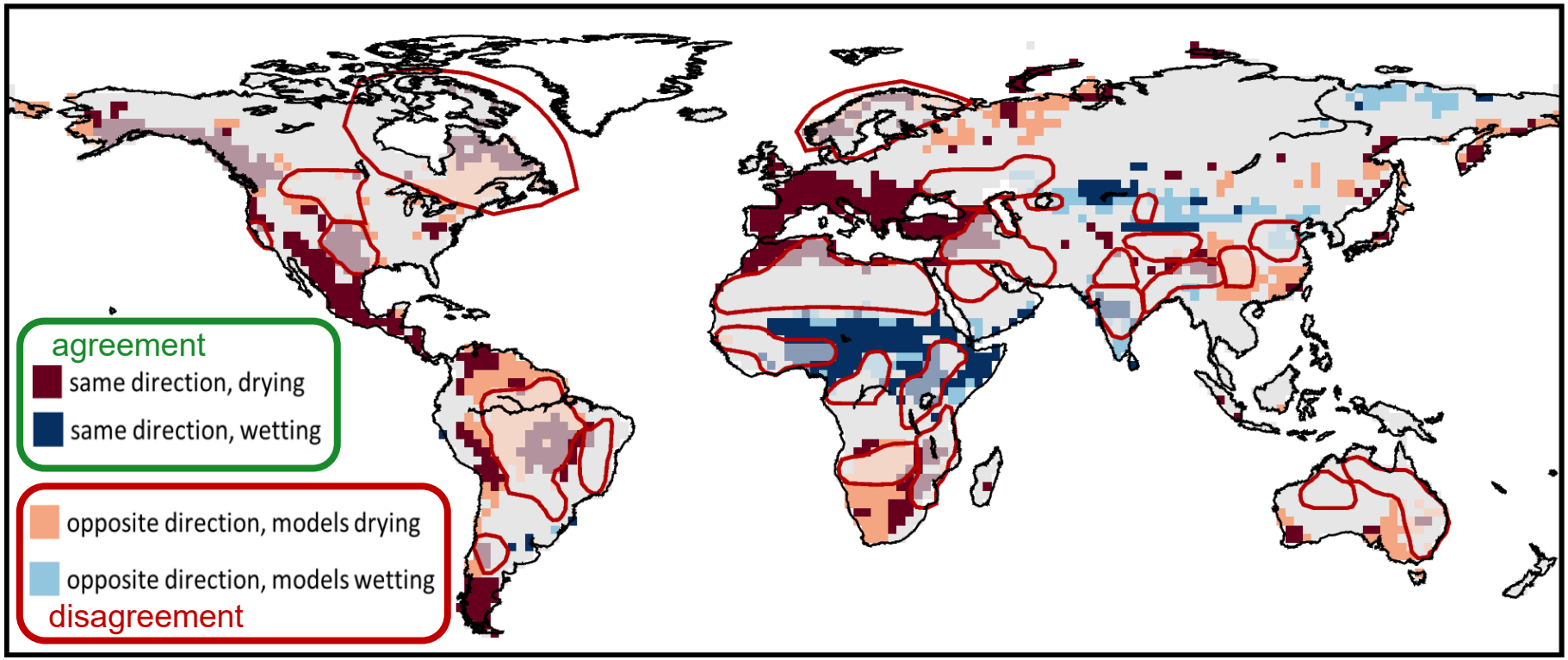


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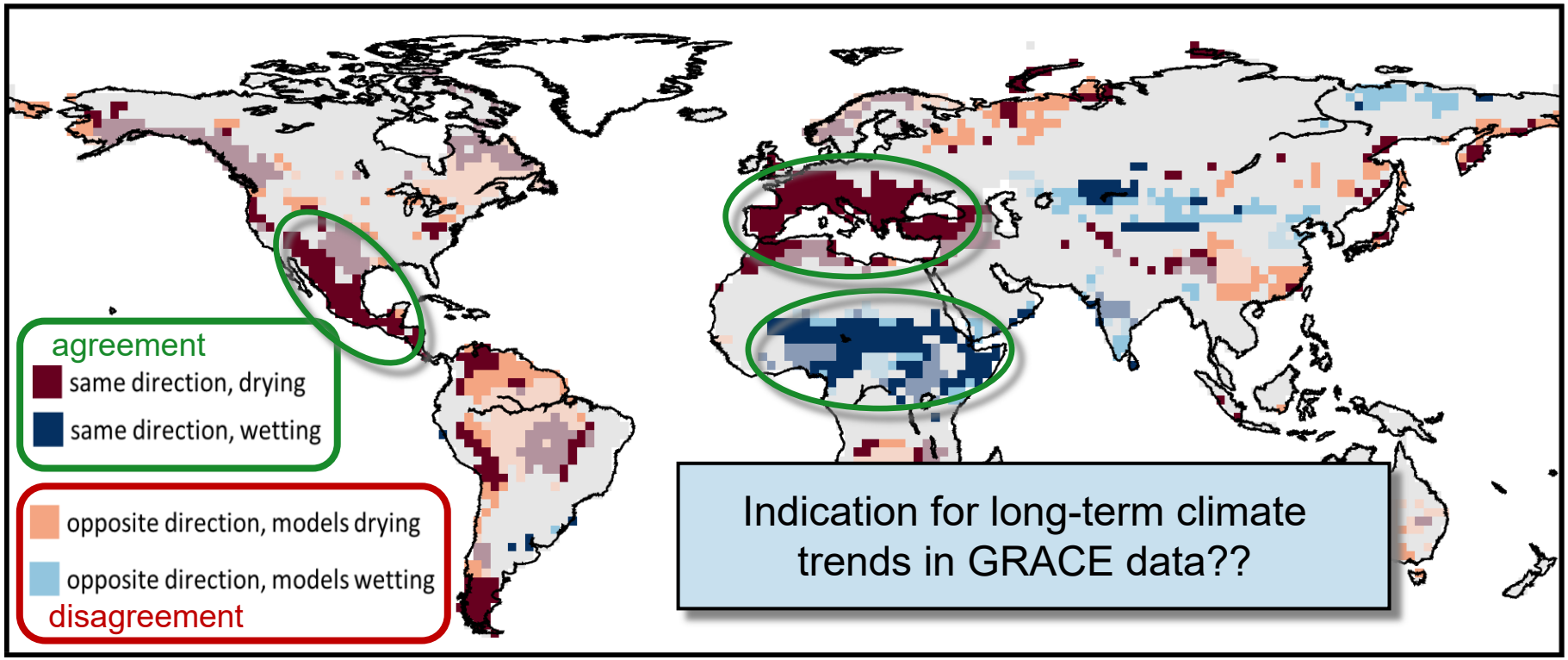
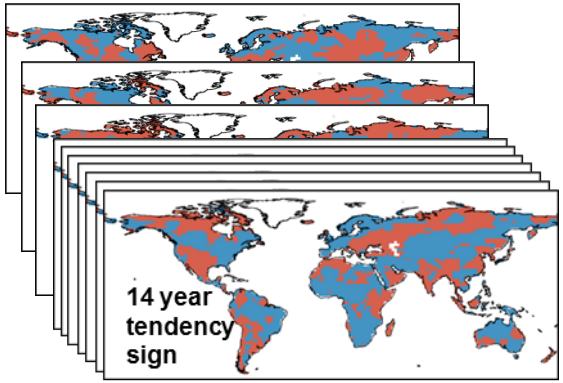
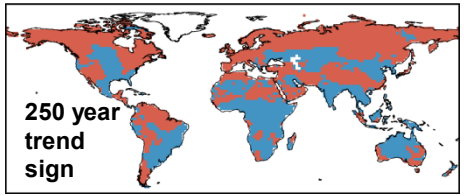



agreement/disagreement of trends from **GRAVIS v4** (2002/04 - 2021/11) & **CMIP6** models

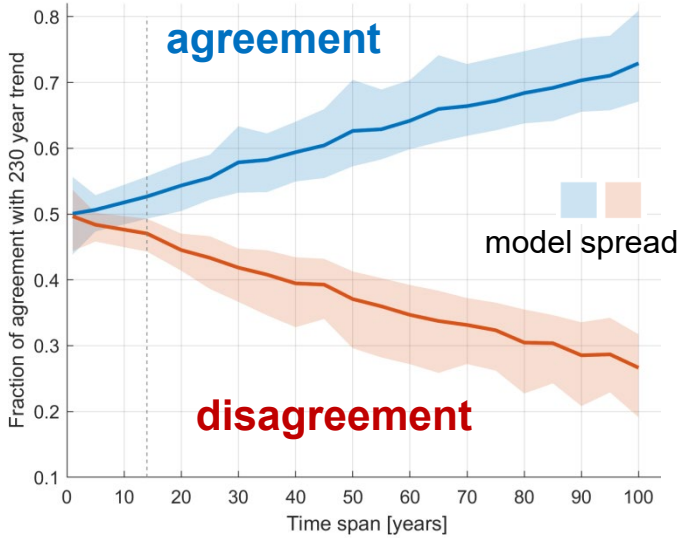
# Influence of interannual variations

# Model study: fit of trend for different time spans

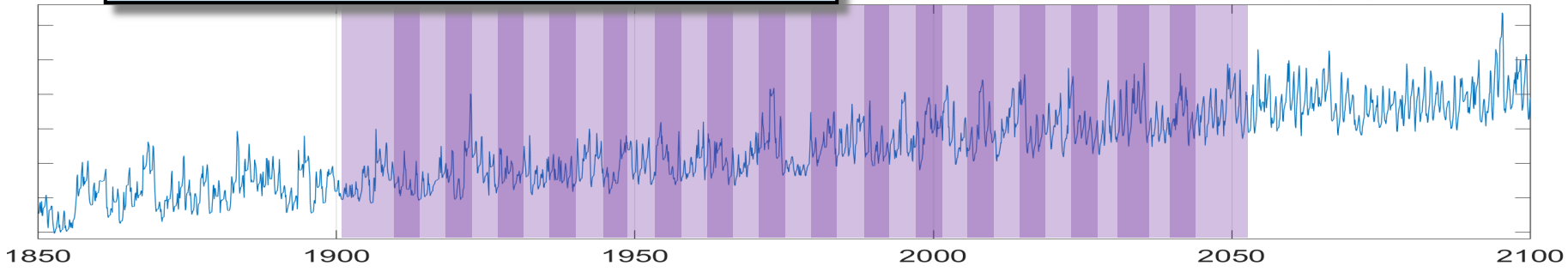



Count number of grid cells where sign of trend agrees with sign of

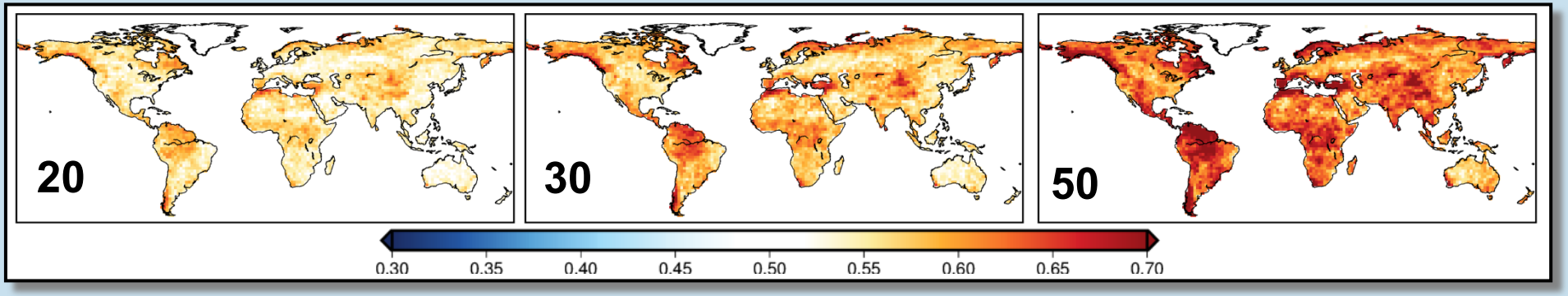



**Are there regions with a good temporal consensus on trends?**

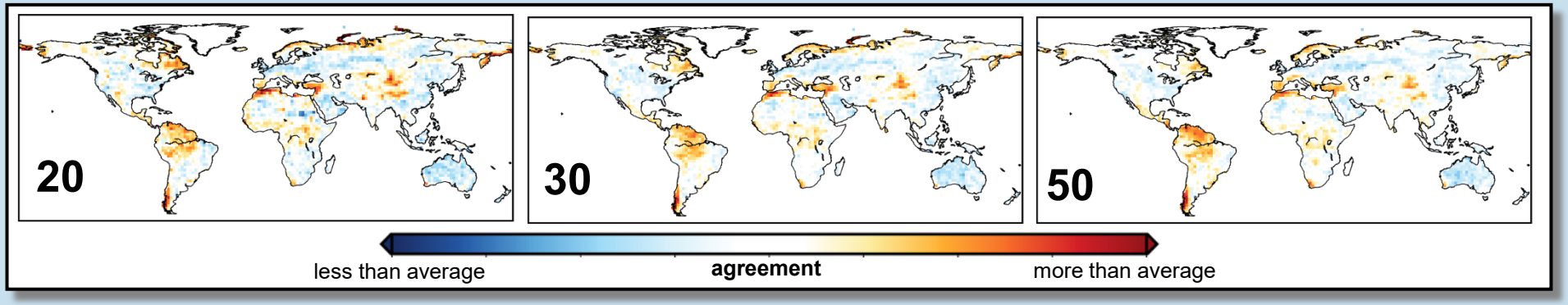


# Regional analysis of temporal consensus for trends

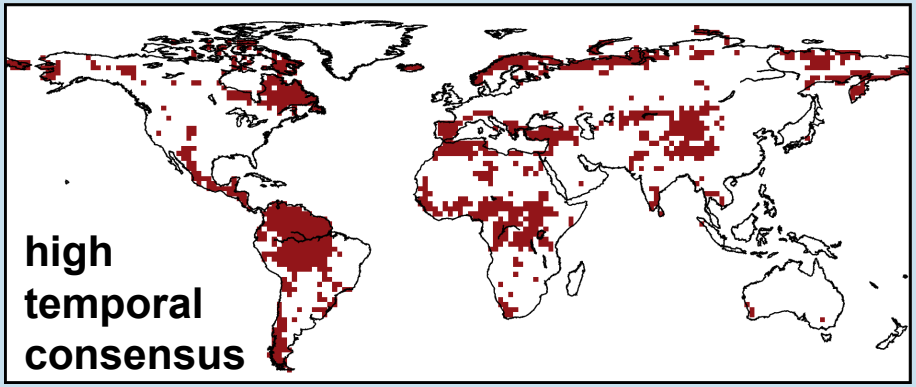
percentage of agreement between x-yr trend and 250-yr trend
(using slices of 5 yrs distance, from 17 models)



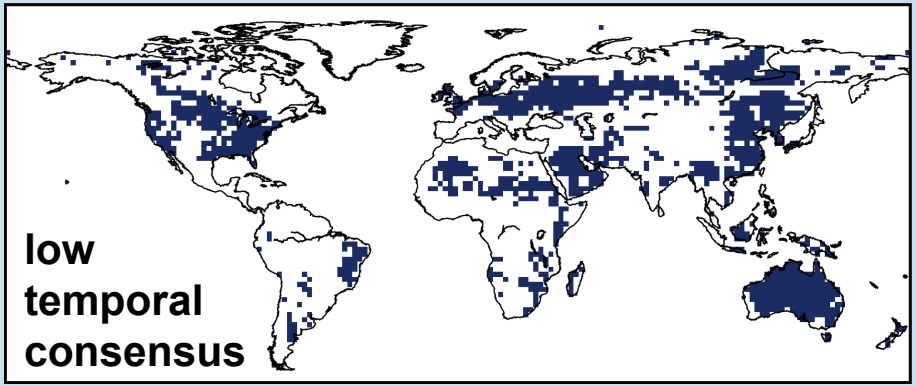

removing the global mean agreement →similar pattern for different time spans

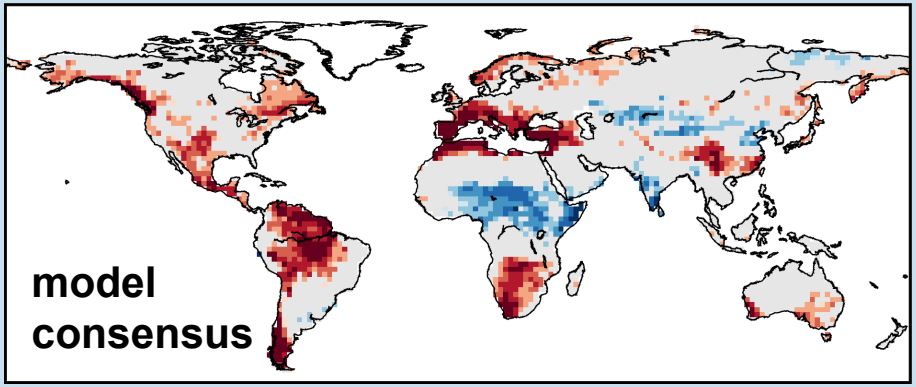


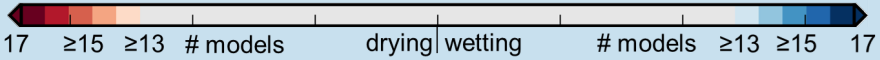
# Temporal and model consensus




20, 25, 30, 35, 40, 45, 50 years



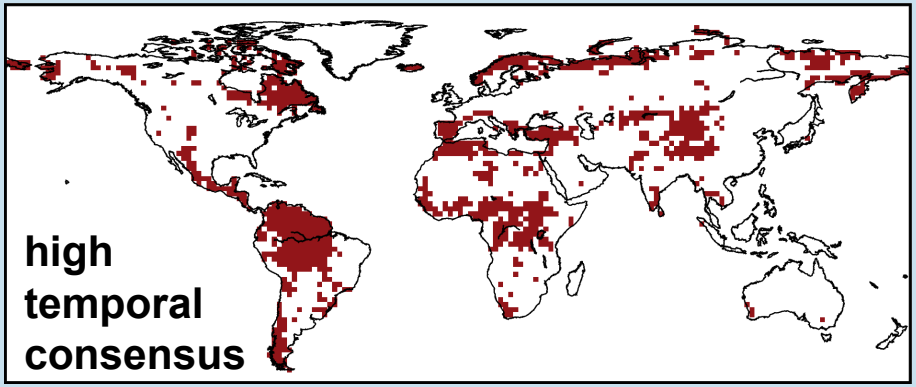



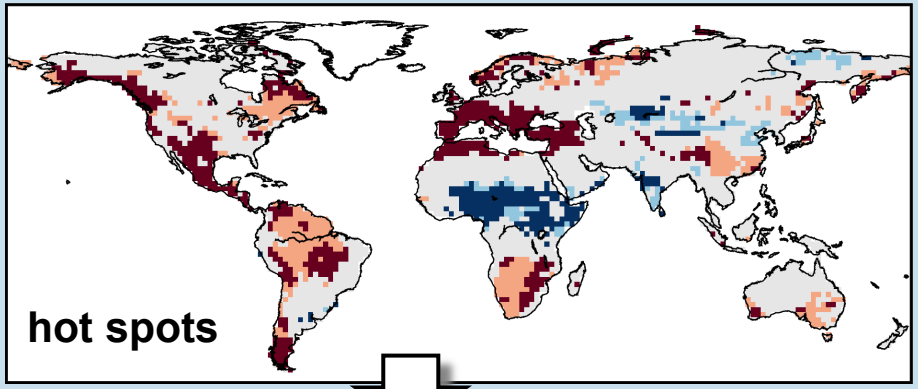

**more than average** trend agreement
for all time spans
= high temporal consensus

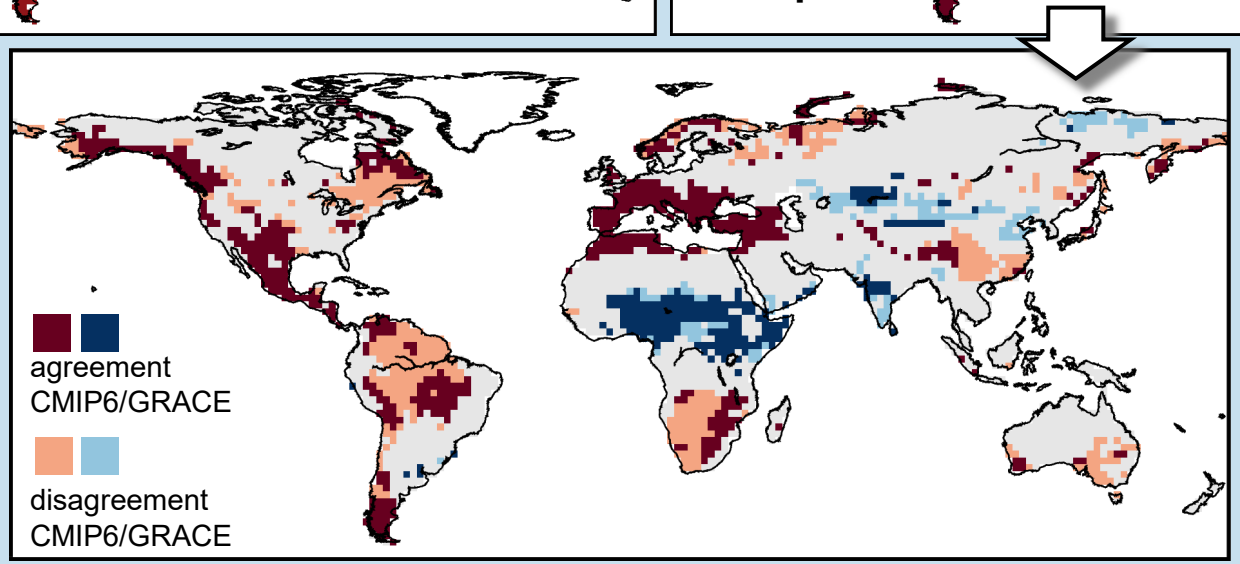
**less than average** trend agreement
for all time spans
= low temporal consensus

**similarities between temporal and model consensus**

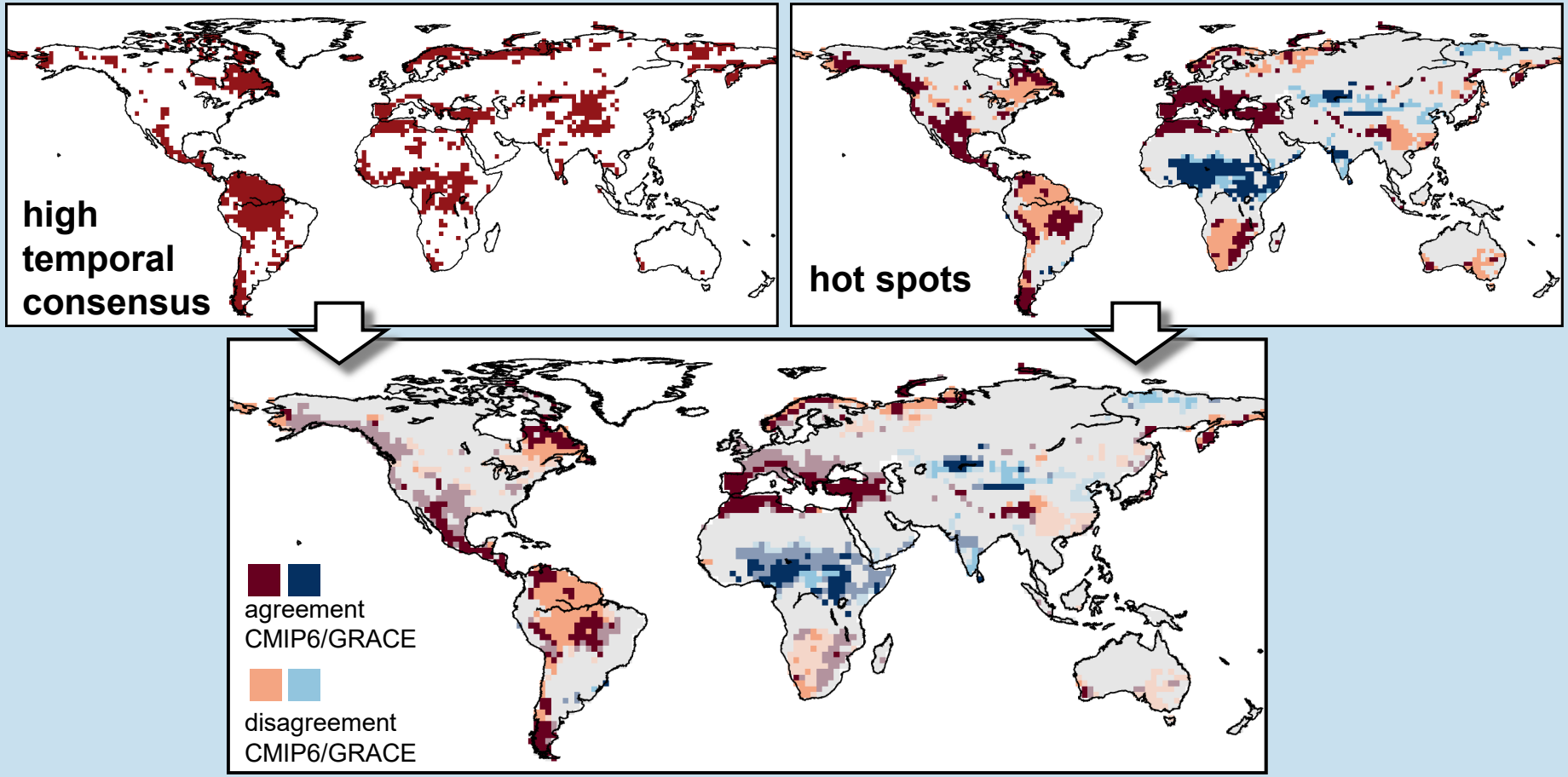
# Temporal and model consensus: fit to GRACE/-FO



# Temporal and model consensus: fit to GRACE/-FO



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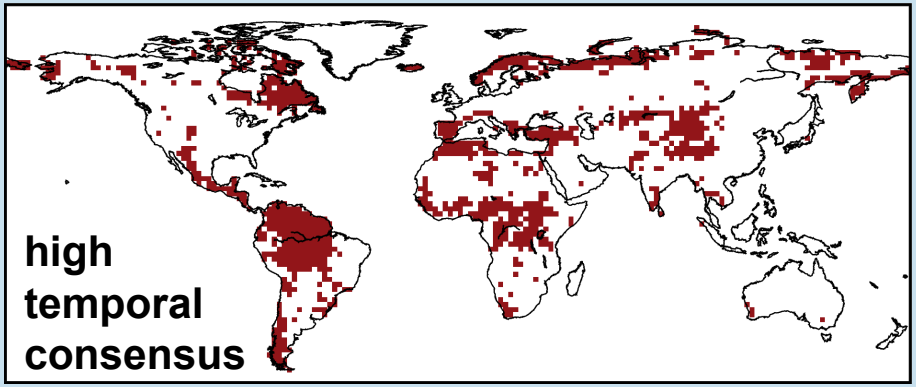
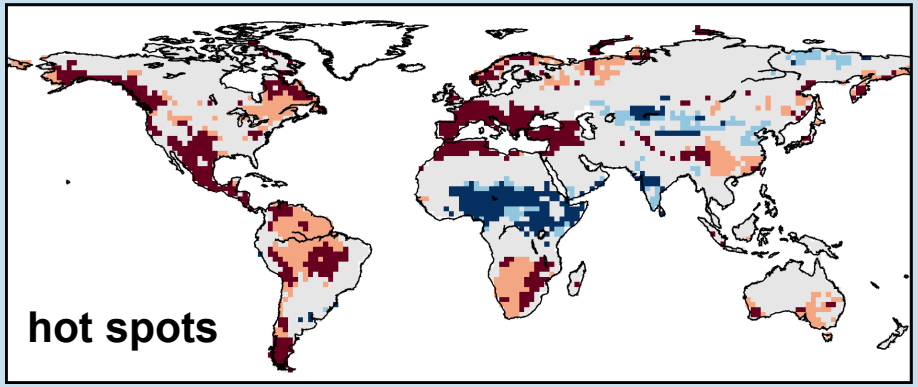
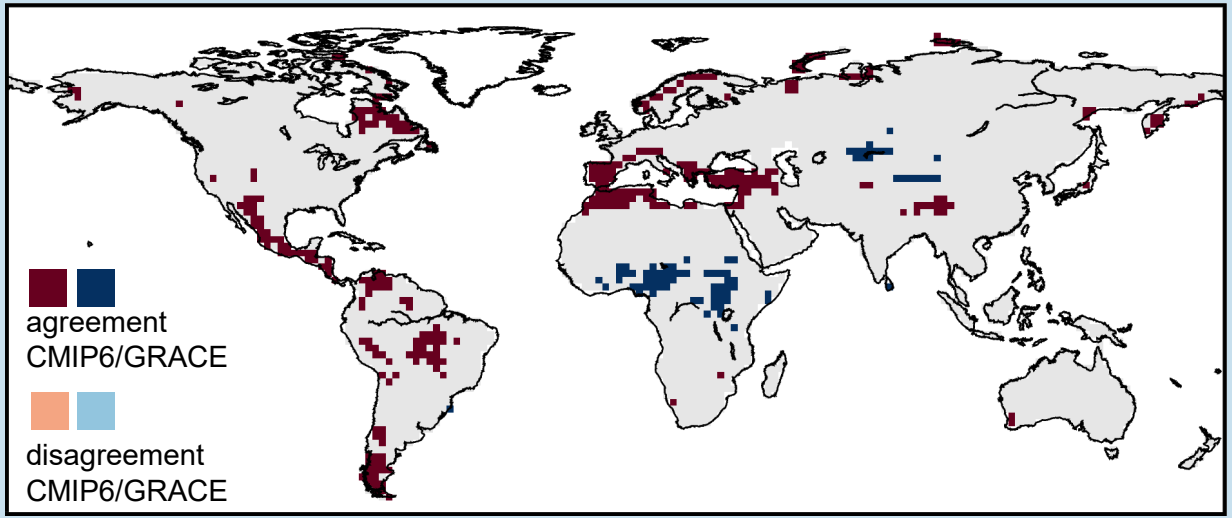
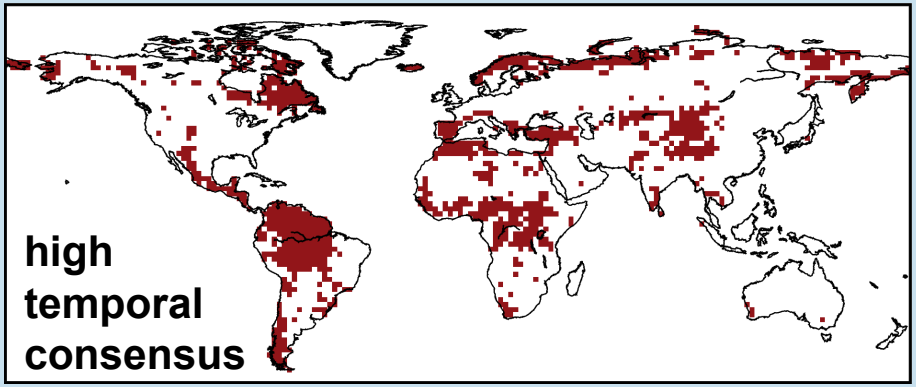


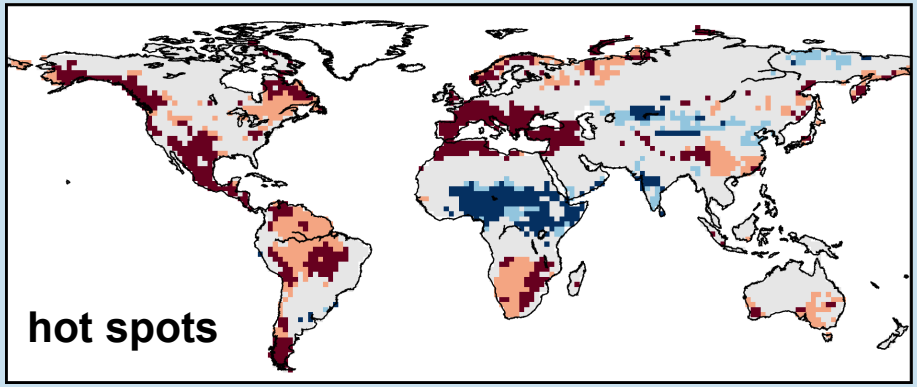



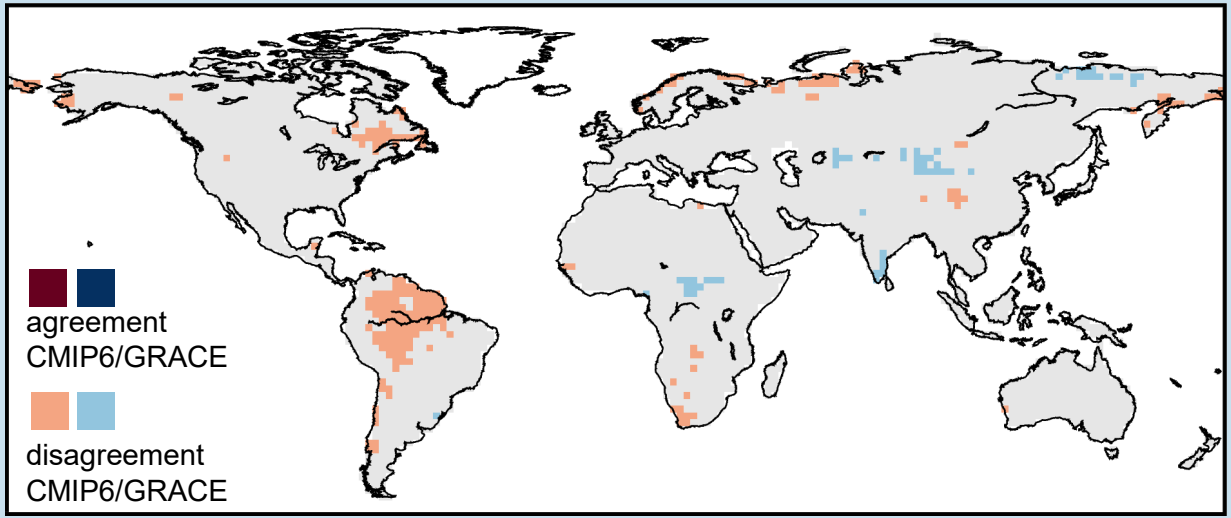




high temporal and model consensus and **agreement** with GRACE/-FO

# Temporal and model consensus: fit to GRACE/-FO

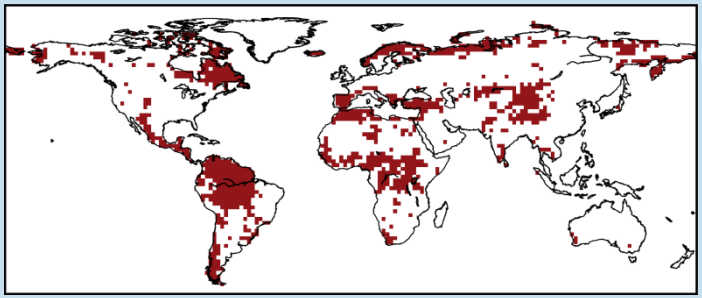



high temporal and model consensus but **disagreement** with GRACE/-FO

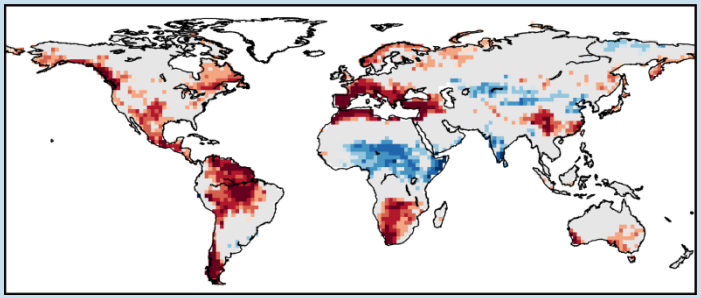
# Summary



high temporal consensus

+

high model consensus



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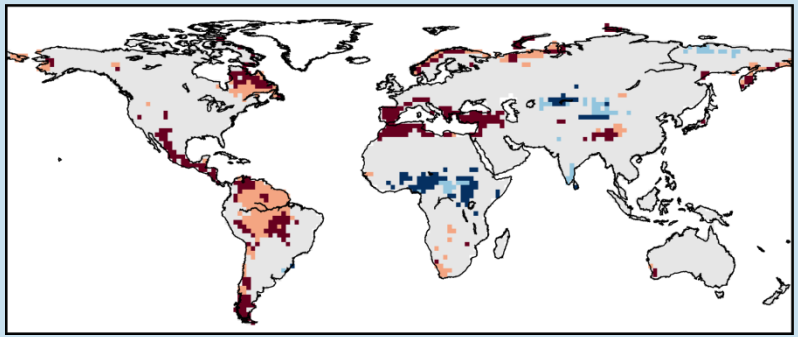
agreement/ disagreement with GRACE/-FO



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**hot spots** of climate related wetting/drying trends supported by observations & indications of **discrepancies** between models and observations

Challenging task but great potential for satellite gravimetry!

Model evaluation would largely benefit from:

**longer observational time series** & **higher spatial resolution**

MAGIC…