

# Influence of GIA uncertainty on climate applications from satellite gravimetry

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Thank you:



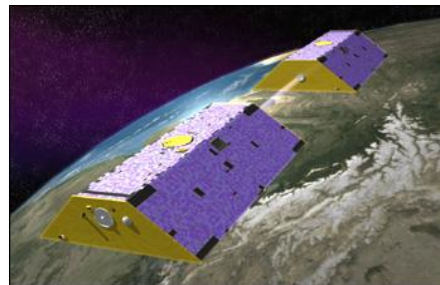
(RFP/3-17121/21/I-DT-Ir)

## Global couple climate models



Coupled Model Intercomparison Project

## Satellite gravimetry



GRACE  
GRACE-FO

...

=> Use satellite gravimetry to evaluate climate models\*

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

Initialization

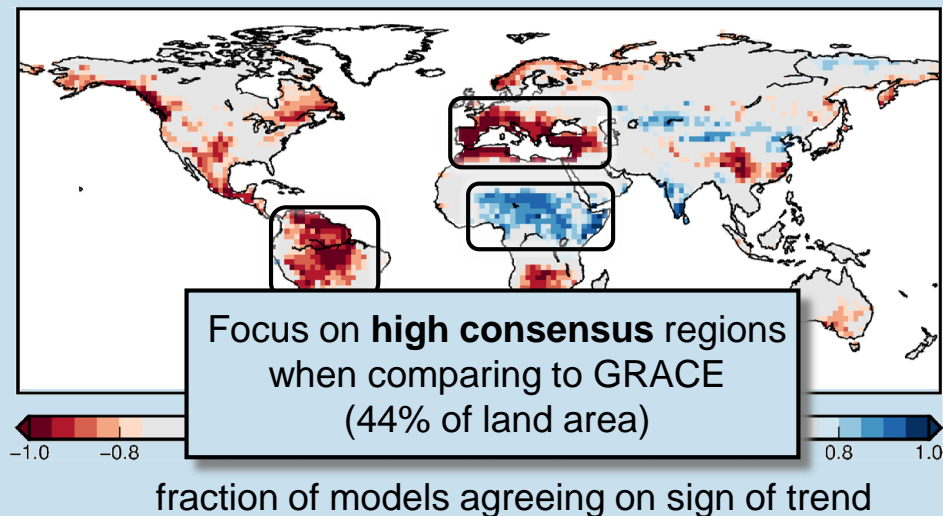
## Challenges:

- Large uncertainty among models

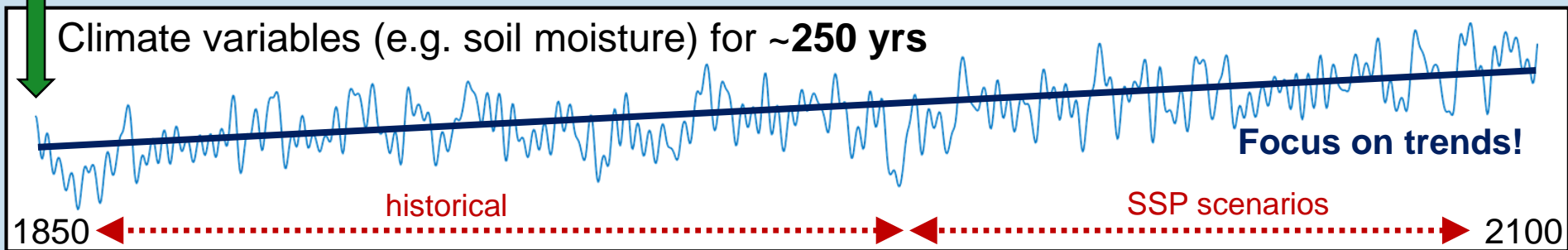
Where do models agree on the (sign of) the trend?

=> „model consensus“

## CMIP6 (17 models)



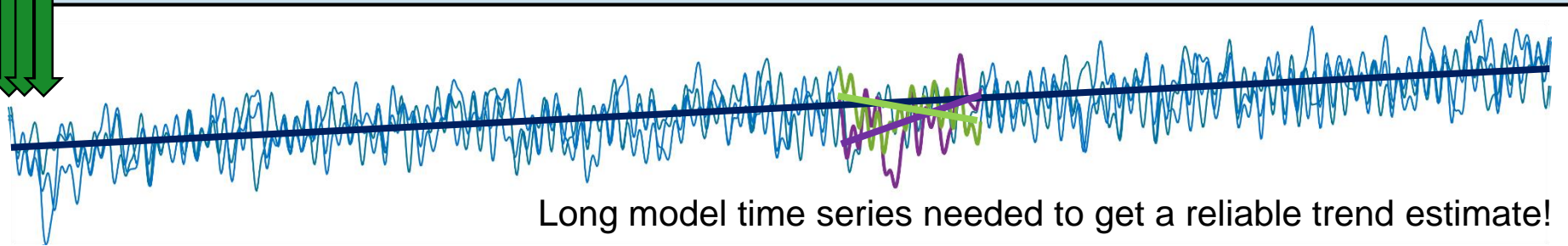
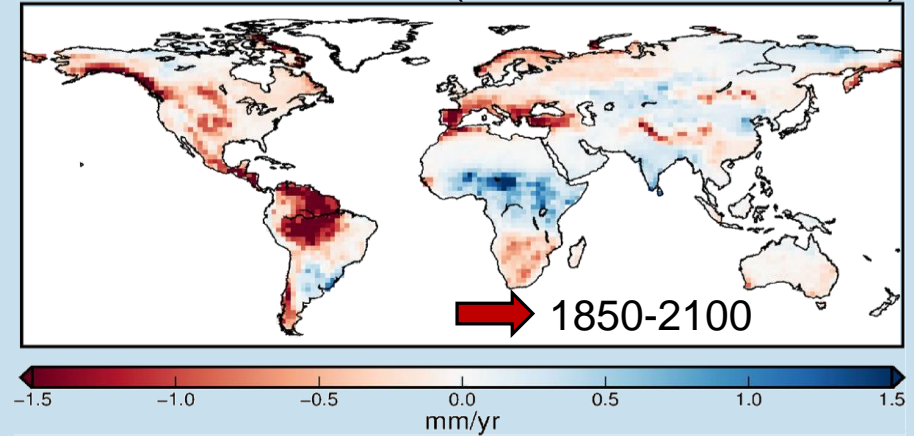
Climate variables (e.g. soil moisture) for ~250 yrs



## Challenges:

- Large uncertainty among models
- Inter-annual variations are stochastic

mTWS trend (CMIP6, model median)

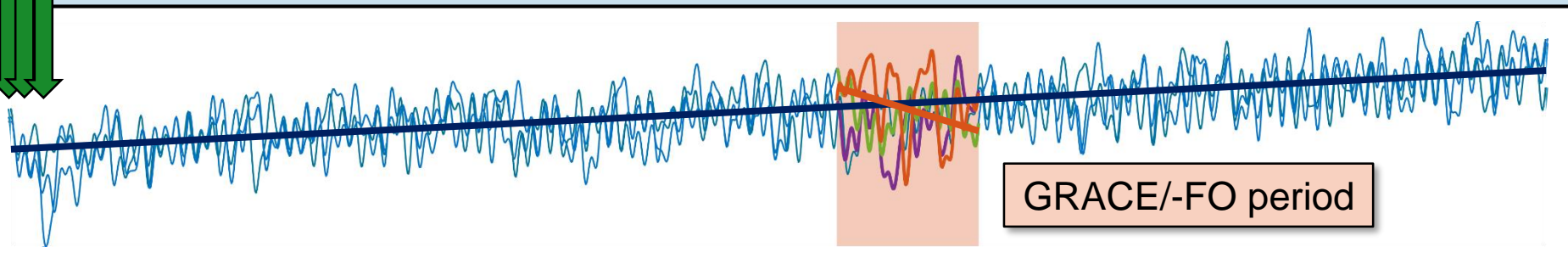
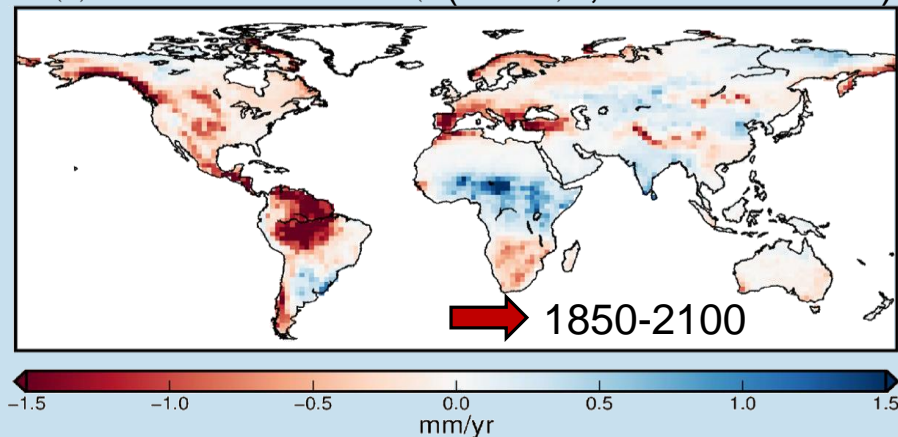


Long model time series needed to get a reliable trend estimate!

## Challenges:

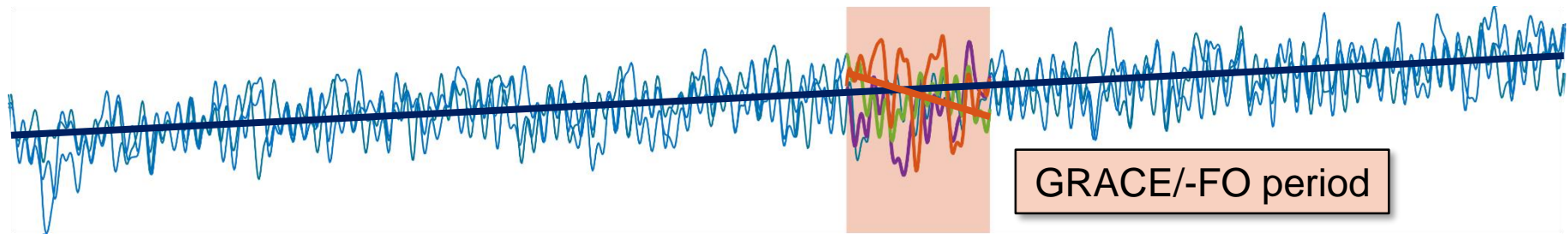
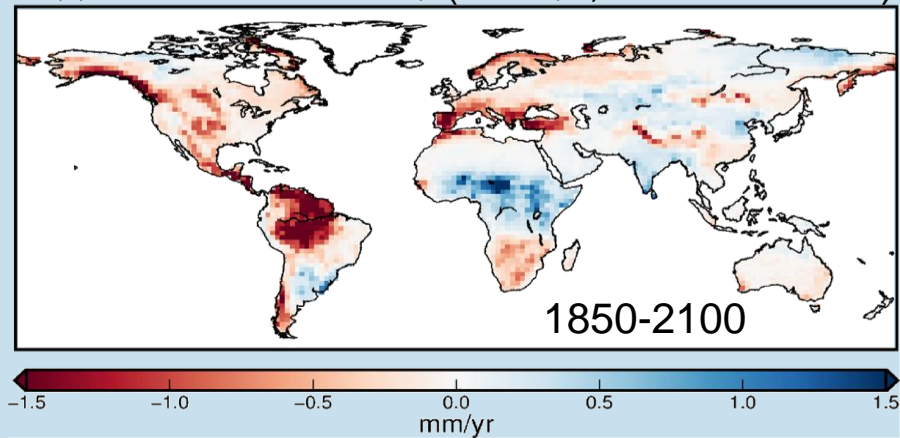
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mTWS trend (CMIP6, model median)

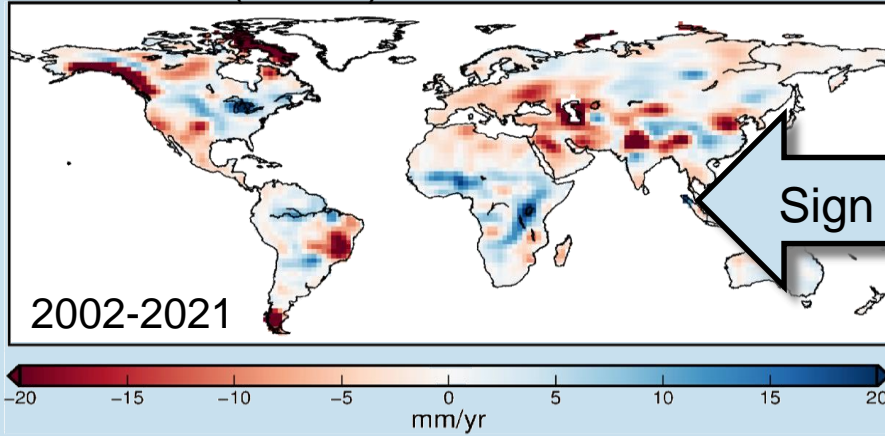


Can long-term trends already be confirmed by 20 years of GRACE/-FO?

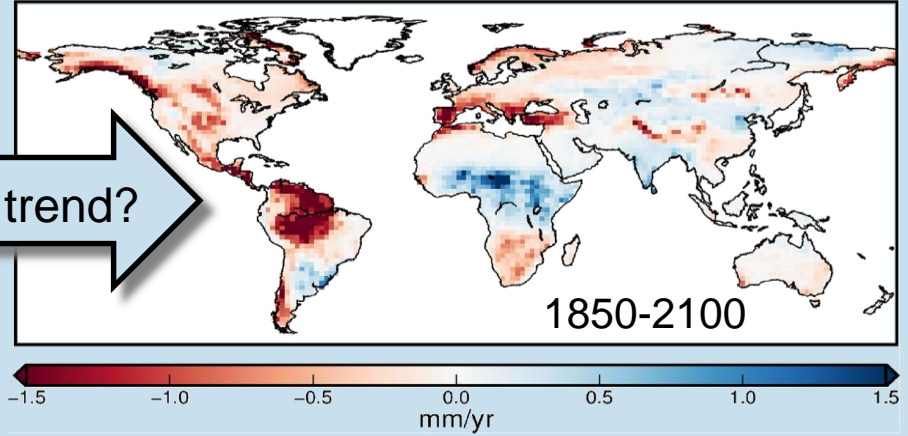
mTWS trend (CMIP6, model median)



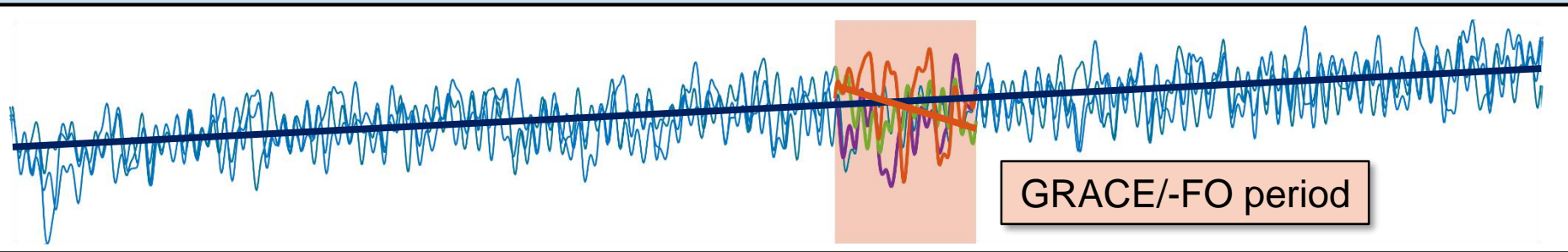
## TWS trend (Gravis)



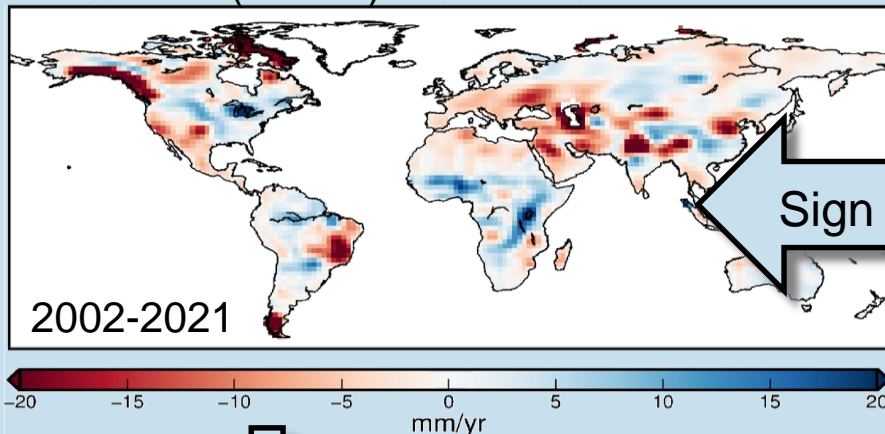
## mTWS trend (CMIP6, model median)



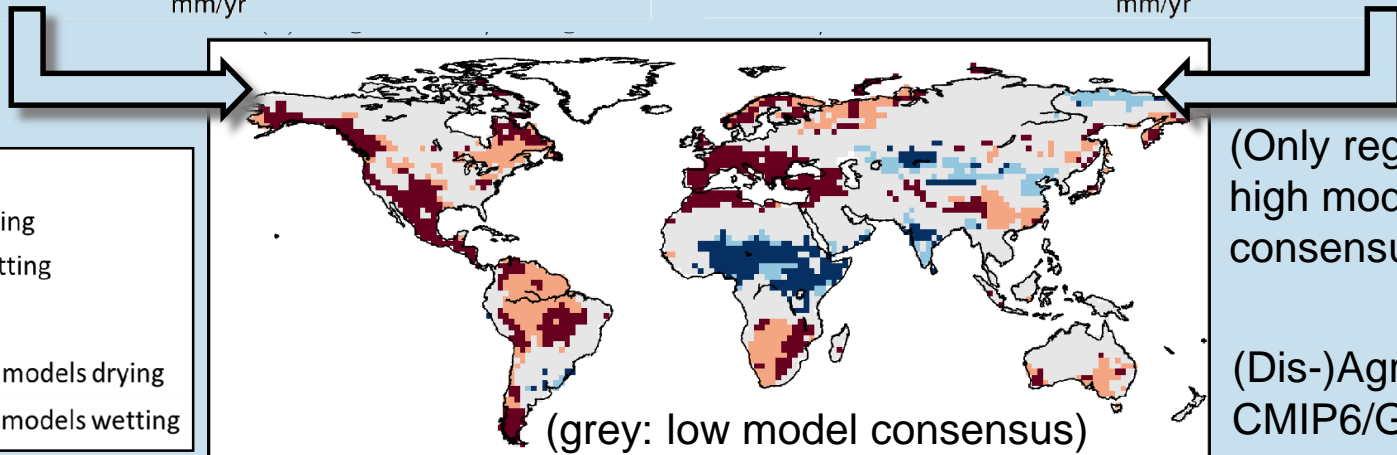
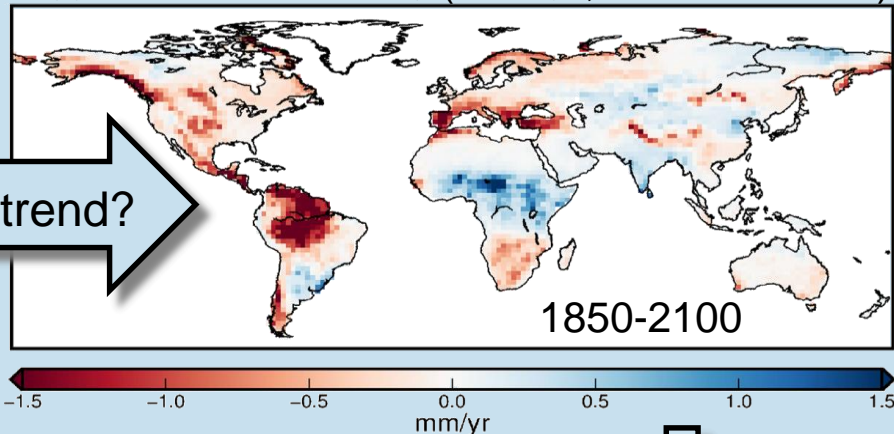
Sign of trend?



TWS trend (Gravis)



mTWS trend (CMIP6, model median)



**agreement:**

- dark red: same direction, drying
- dark blue: same direction, wetting

**disagreement:**

- orange: opposite direction, models drying
- light blue: opposite direction, models wetting

(Only regions of high model consensus!)

(Dis-)Agreement CMIP6/Gravis



# Assessment of trends: CMIP vs GRACE

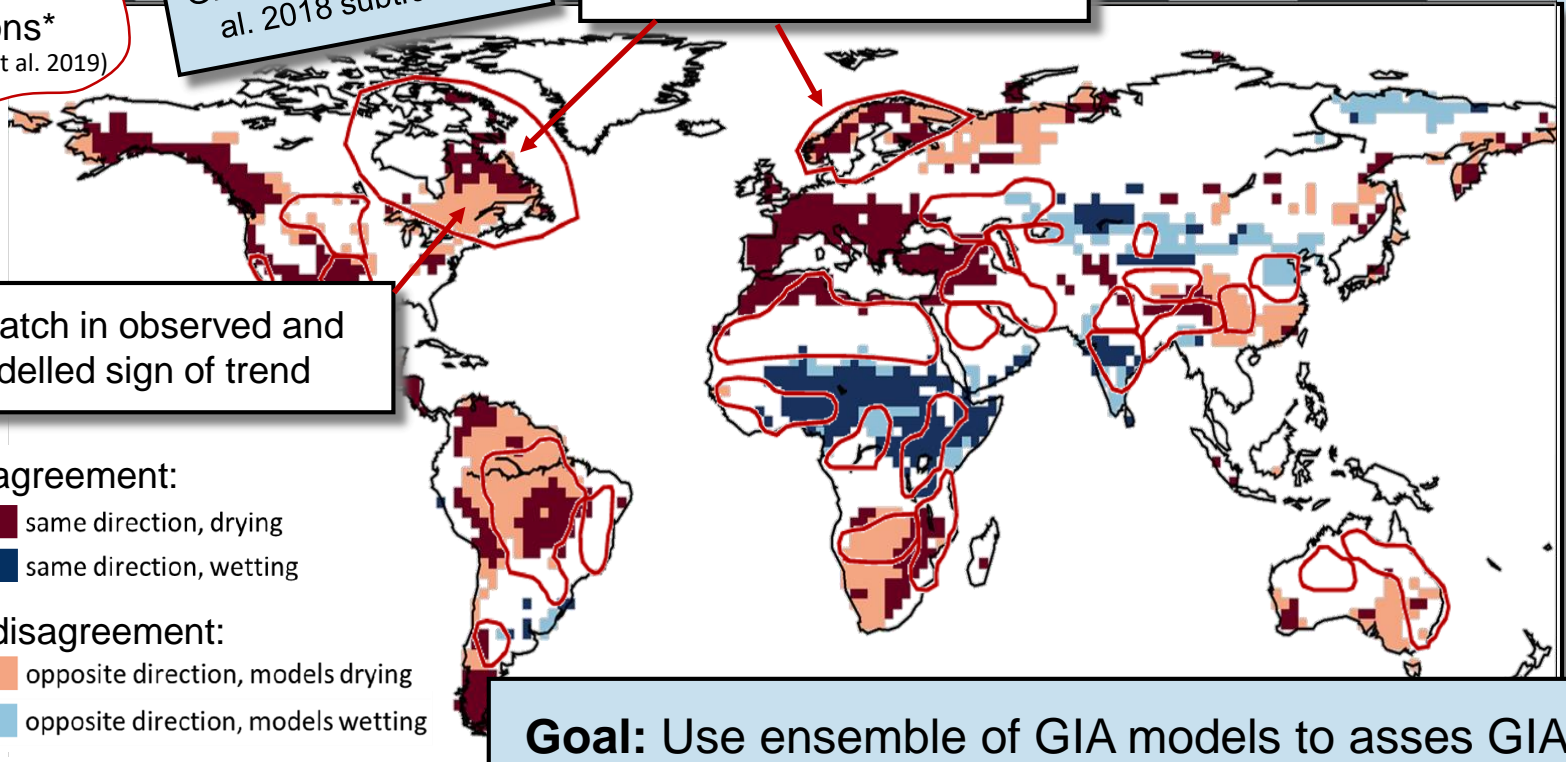
uncertain regions\*  
(Jensen et al. 2019)

GIA model by Peltier et al. 2018 subtracted

GIA-affected regions classified as "uncertain"

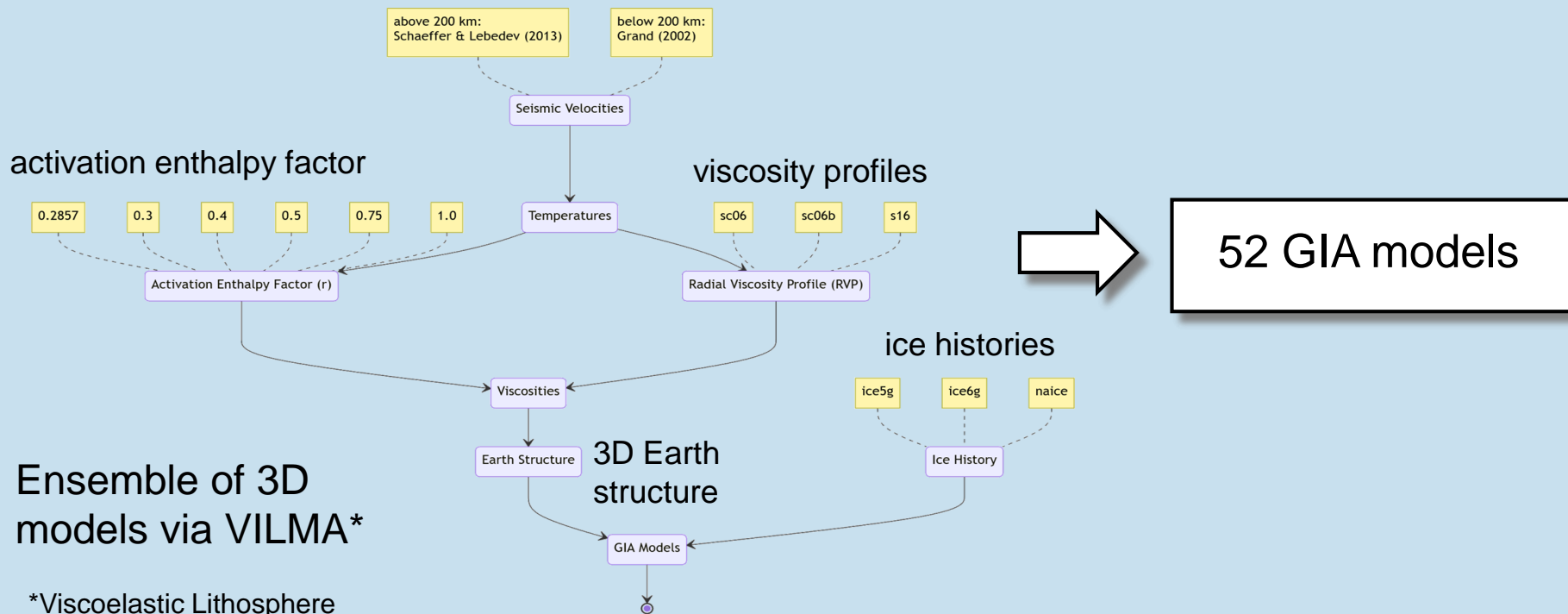
Mismatch in observed and modelled sign of trend

- agreement:
- same direction, drying
  - same direction, wetting
- disagreement:
- opposite direction, models drying
  - opposite direction, models wetting



**Goal:** Use ensemble of GIA models to assess GIA influence on evaluation of climate model trends

\*human activity, known inter-annual variations,... (based on Rodell et al. 2018)



Ensemble of 3D models via VILMA\*

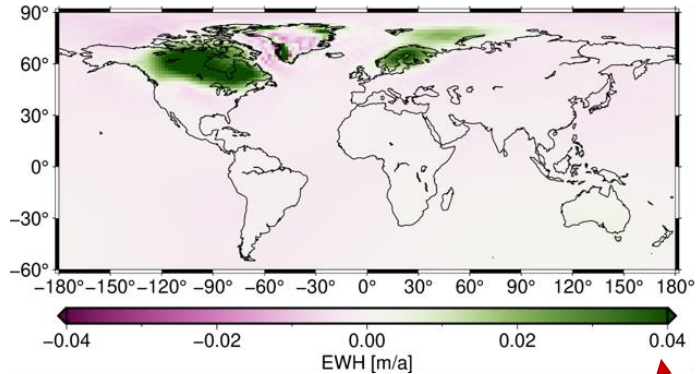
\*Viscoelastic Lithosphere and Mantle model

(Bagge et al 2021)

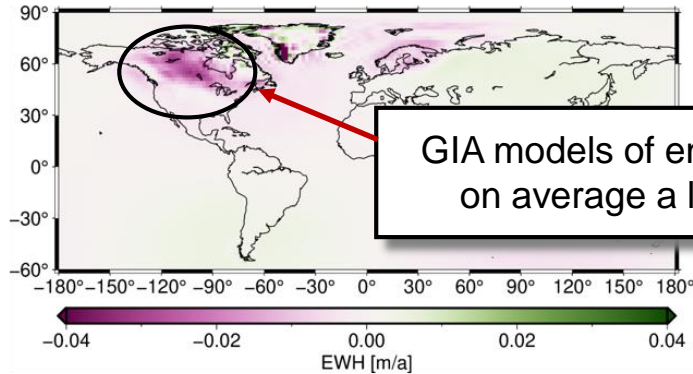
**Goal:** Use ensemble of GIA models to assess GIA influence on evaluation of climate model trends

## Investigation of GIA ensemble in terms of water storage trends

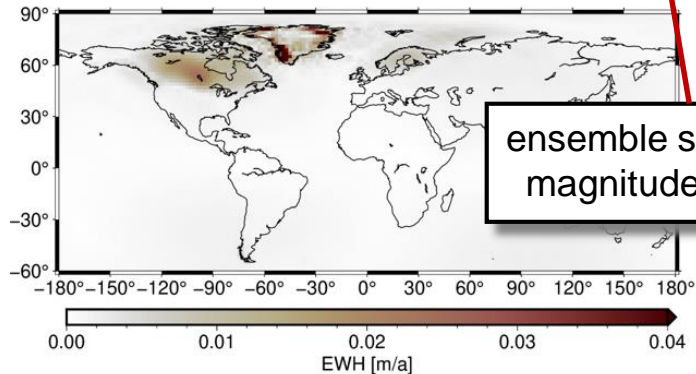
(a) Ensemble mean



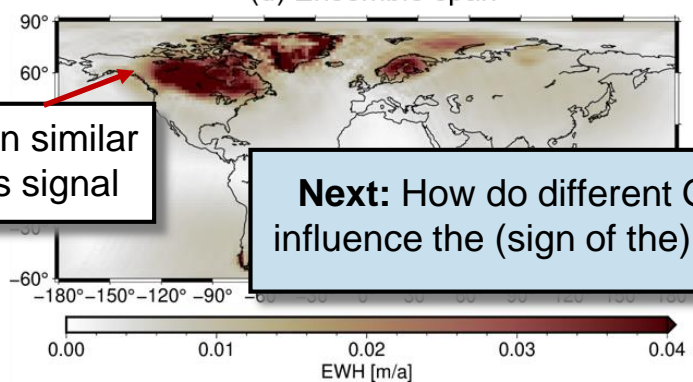
(b) Mean differences to Peltier et al. (2018)

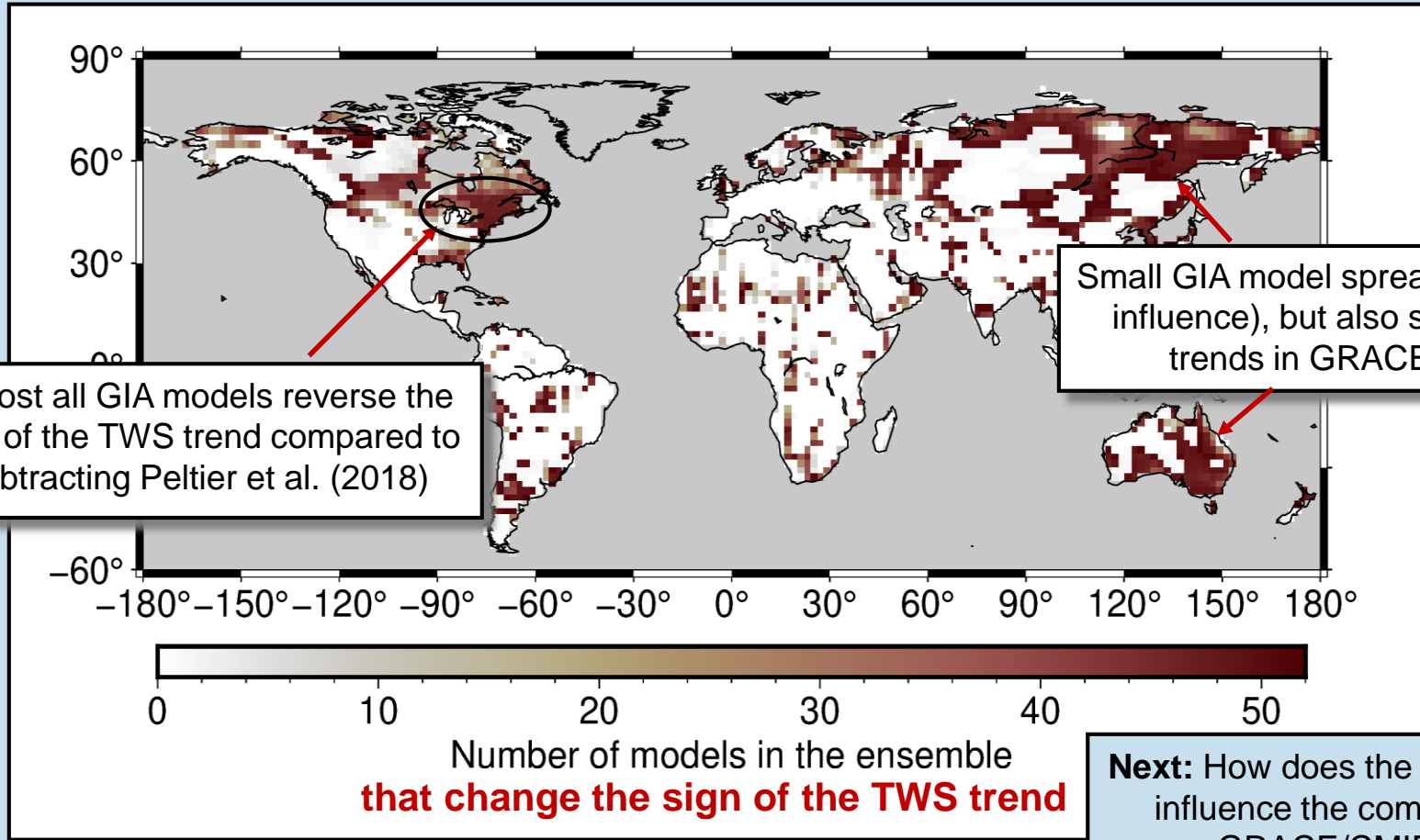


(c) Ensemble standard deviation

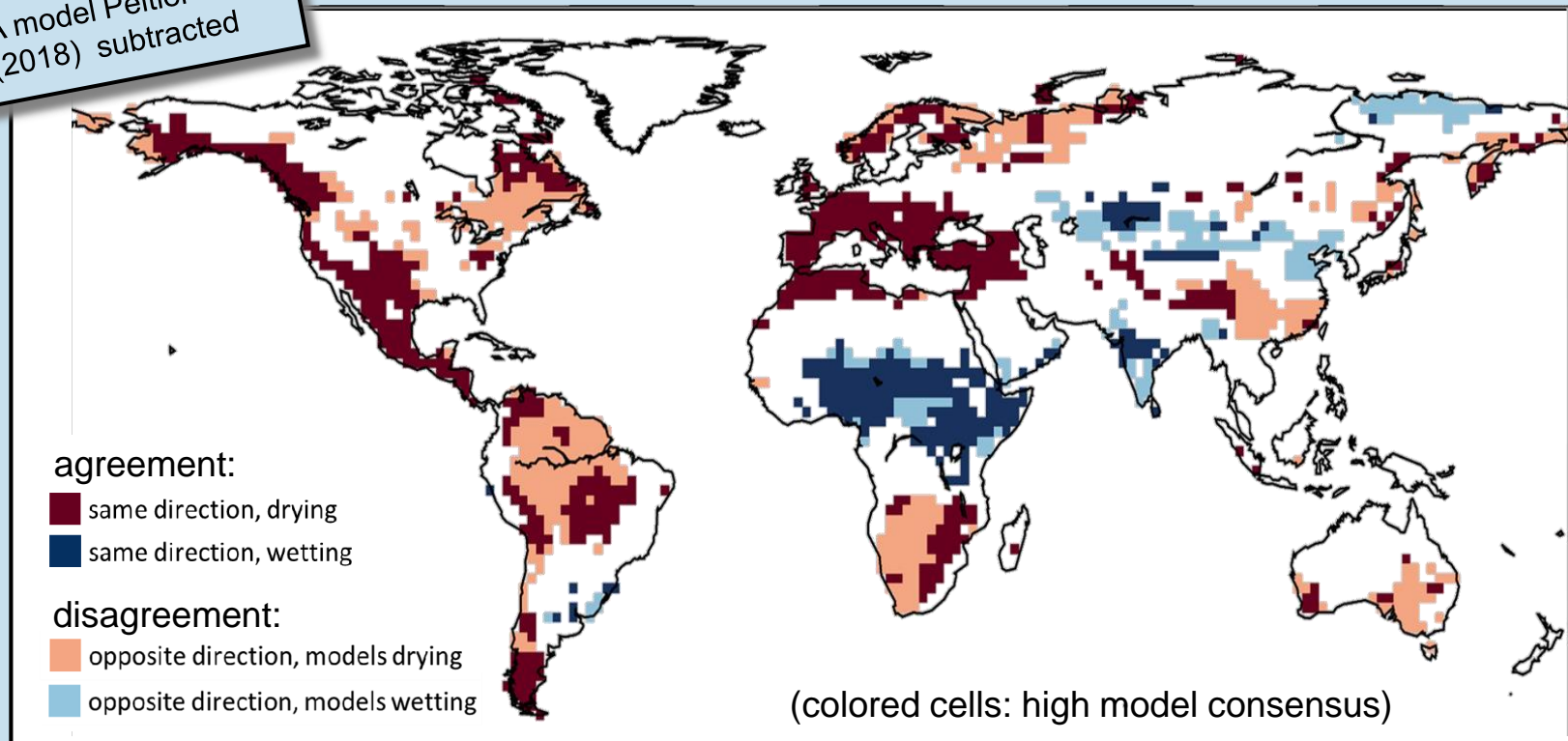


(d) Ensemble span





GIA model Peltier et al.  
(2018) subtracted



# Assessment of trends

Ensemble member  
m\_1.0\_s16\_3d\_ice6g\*  
subtracted

With the alternative GIA  
model the sign in GRACE  
and CMIP6 agree!

This is not a “validation” of GIA  
models, only an indication of  
importance of GIA correction!

agreement:

- same direction, drying
- same direction, wetting

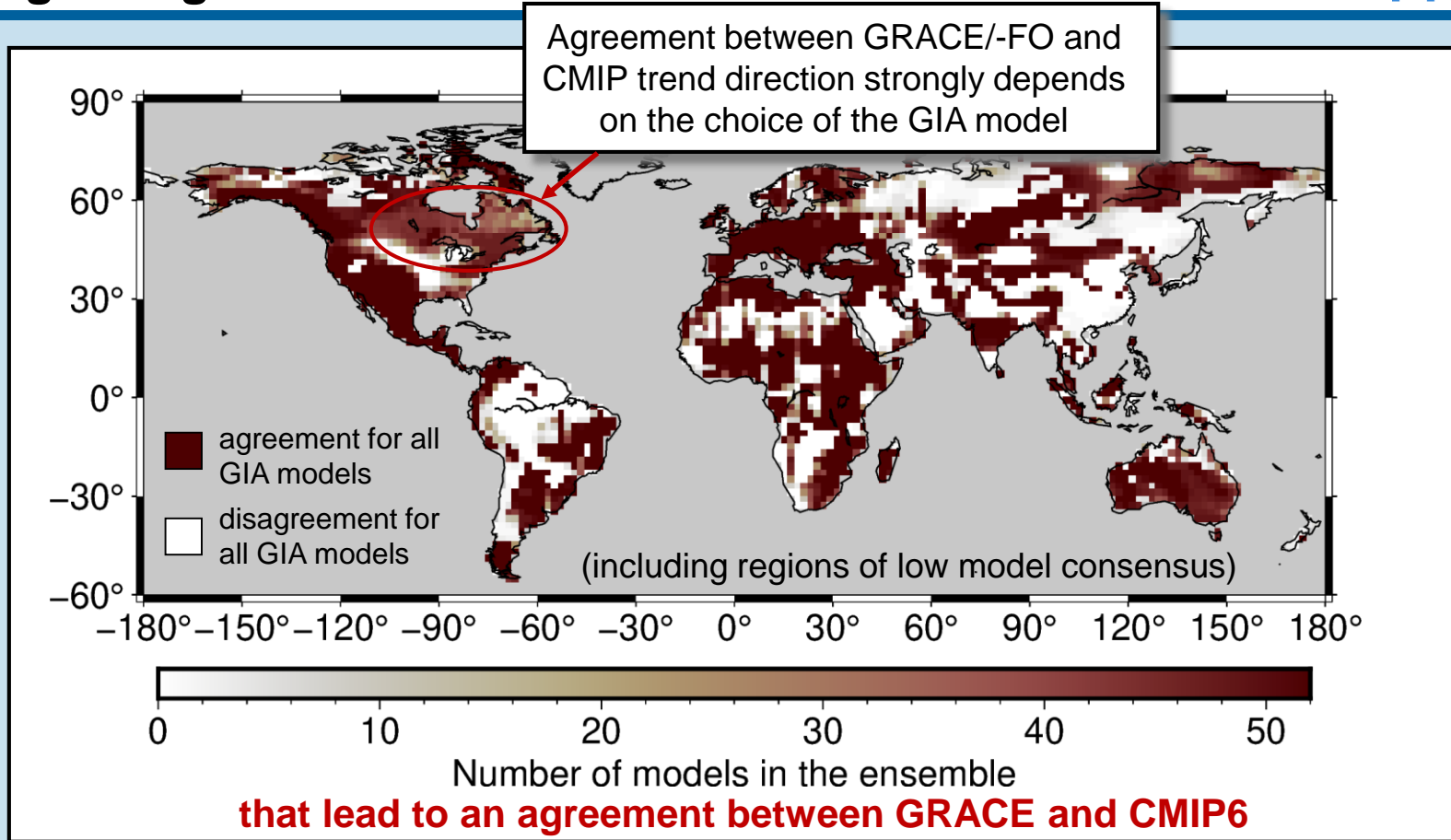
disagreement:

- opposite direction, models drying
- opposite direction, models wetting

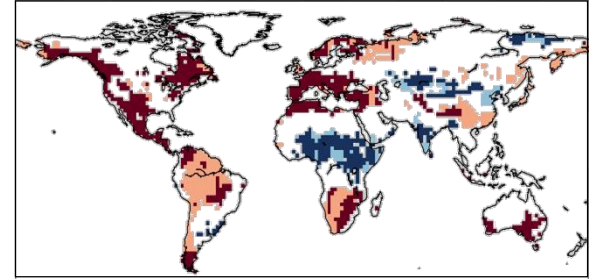
(colored cells: high model consensus)

\* GIA model m\_1.0\_s16\_3d\_ice6g showed very good agreement with observed uplift rates

# Change in agreement GRACE and CMIP6: ensemble

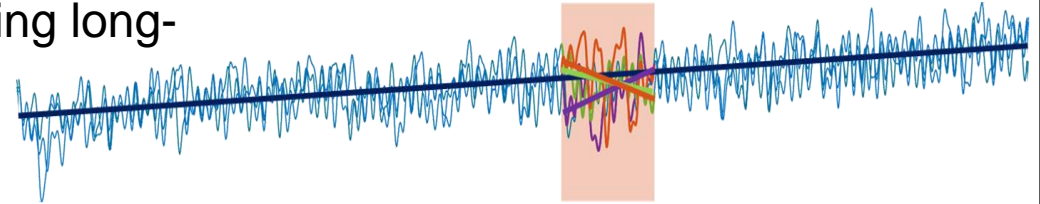


Long-term wetting and drying conditions predicted by global climate models are (often) confirmed by satellite gravimetry



Interannual variations are still masking long-term trends in 20-years time series

=> **We need GRACE-I / MAGIC!!**



GIA uncertainty (and choice of model) needs to be carefully considered when interpreting climate trends

