Barcelona Supercomputing Center
Centro Nacional de Supercomputación

The Challenge of the Anthropogenic CO_2 emissions verification in the coming years

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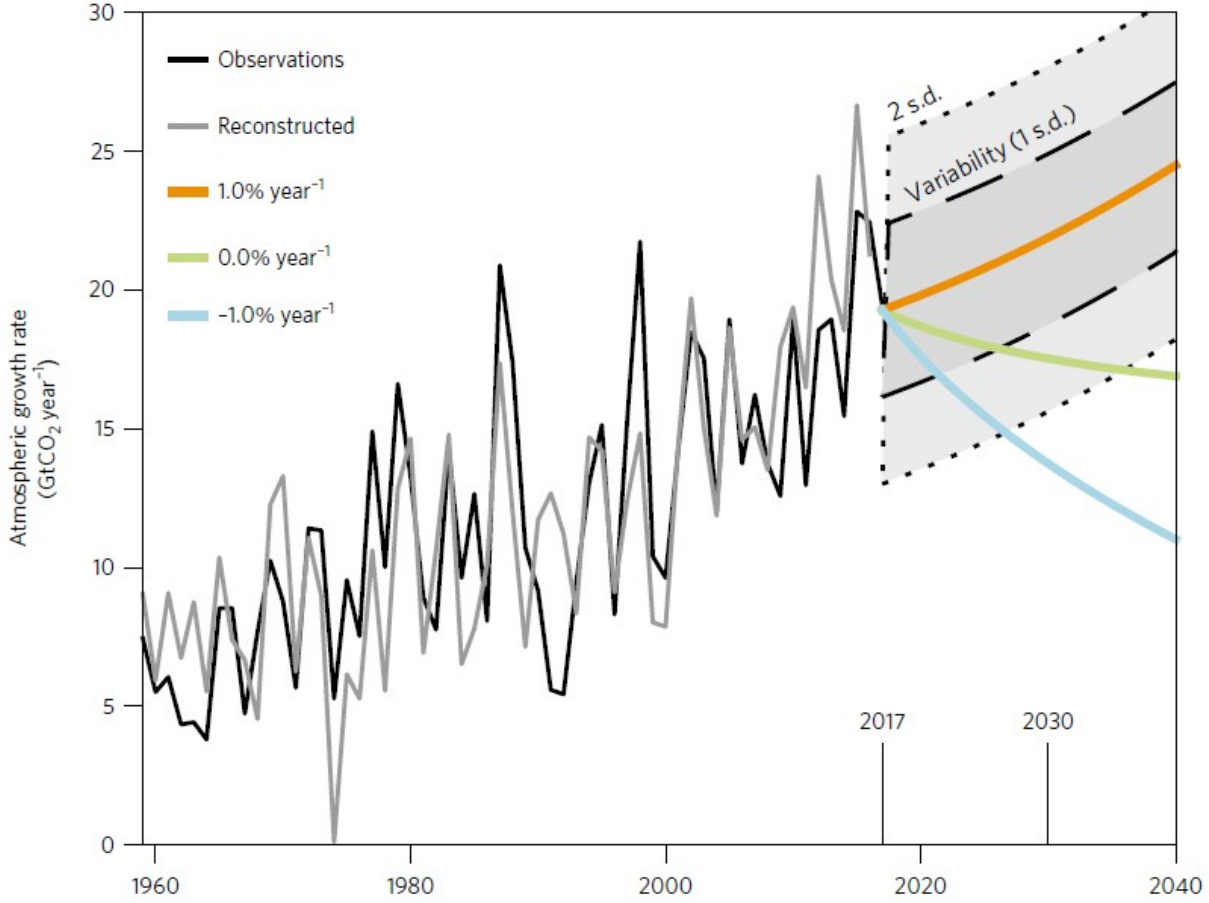
ReSPonSe
Junior leader la Caixa fellowship
LCF/BQ/PR21/11840016

4C Climate-Carbon Interactions in the Current Century

CLIVAR, Feb 2023

Introduction



Atmospheric growth rate (Peters et al., 2017)

- Atmospheric growth rate CO_2
  - Positive trend
  - Large inter-annual variability
    - Natural processes in the Earth System (main reason)
    - Changes in the anthropogenic CO_2 emissions (small)

- Mismatch between reconstruction and observations
  → Related to natural processes that changes CO_2 in atm
  → std(observations – reconstruction) → uncertainty interval.

- Ability to verify global CO_2 emissions: number of years required to detect a change in the trend of the atm CO2 concentration

- Paris Agreement on climate (2015):

Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

- Improve ability verifying global CO_2 emissions → reduce the uncertainty interval by improving the understanding of the:
  - Internal variability of the the atm CO_2 concentration
  - Origin of the uncertainties

Objectives

- Analyse the internal variability of the atmospheric CO_2 concentration understanding:

  → the relative role of the CO_2 fluxes over the land and ocean on the atmospheric CO_2 concentration.
  Which one of these two is the most important triggering natural changes in the atmospheric CO_2 concentration?

  → the main drivers for this internal variability

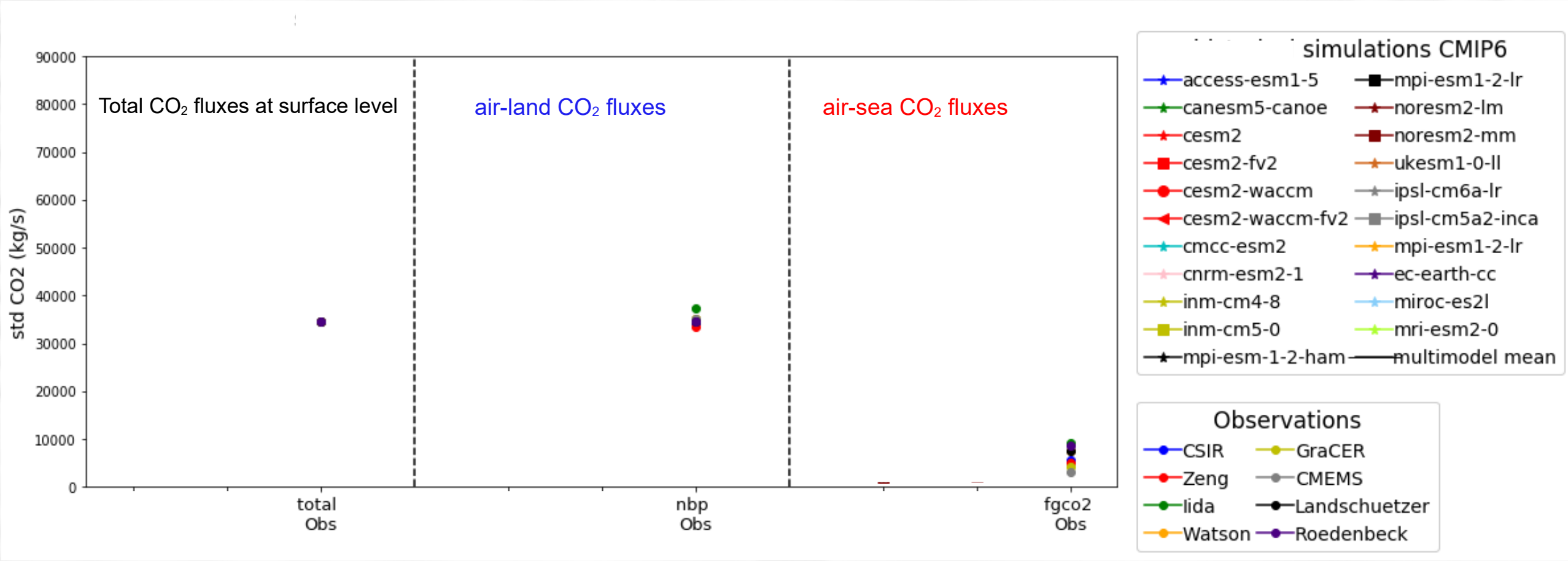
  → the origin of the uncertainties of the CO_2 fluxes in CMIP6 models

Data

- We consider:
  - **From observations:**
    - Monthly mole fraction of carbon dioxide in the air (Meinshausen et al., 2016)
    - Monthly air-sea CO_2 flux data from the Global Carbon Budget 2021 Data Products (Friedlingstein et al., 2021)
  - **From models**:
    - piControl simulations CMIP6-ESMs (20 models)
    - Land-hist LUMIP simulations

Results

Variability of the CO_2 fluxes in observations and piControl simulations



Data from observations have the externally forced signal removed

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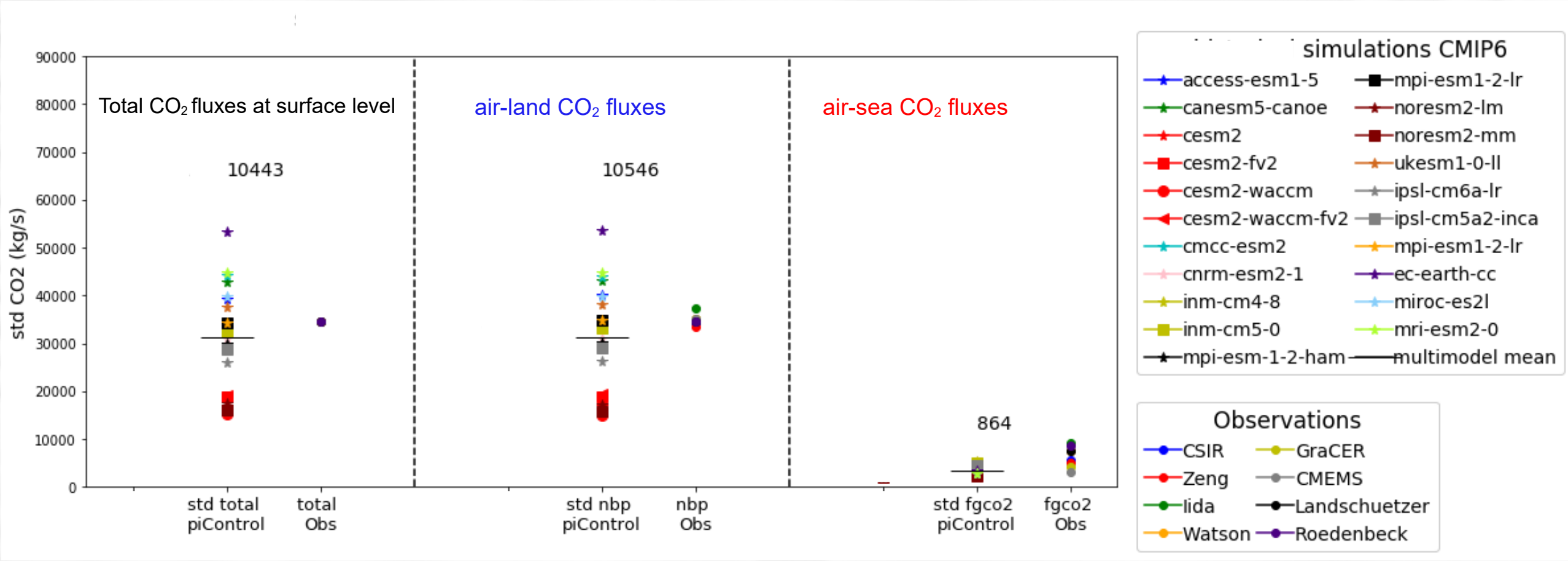

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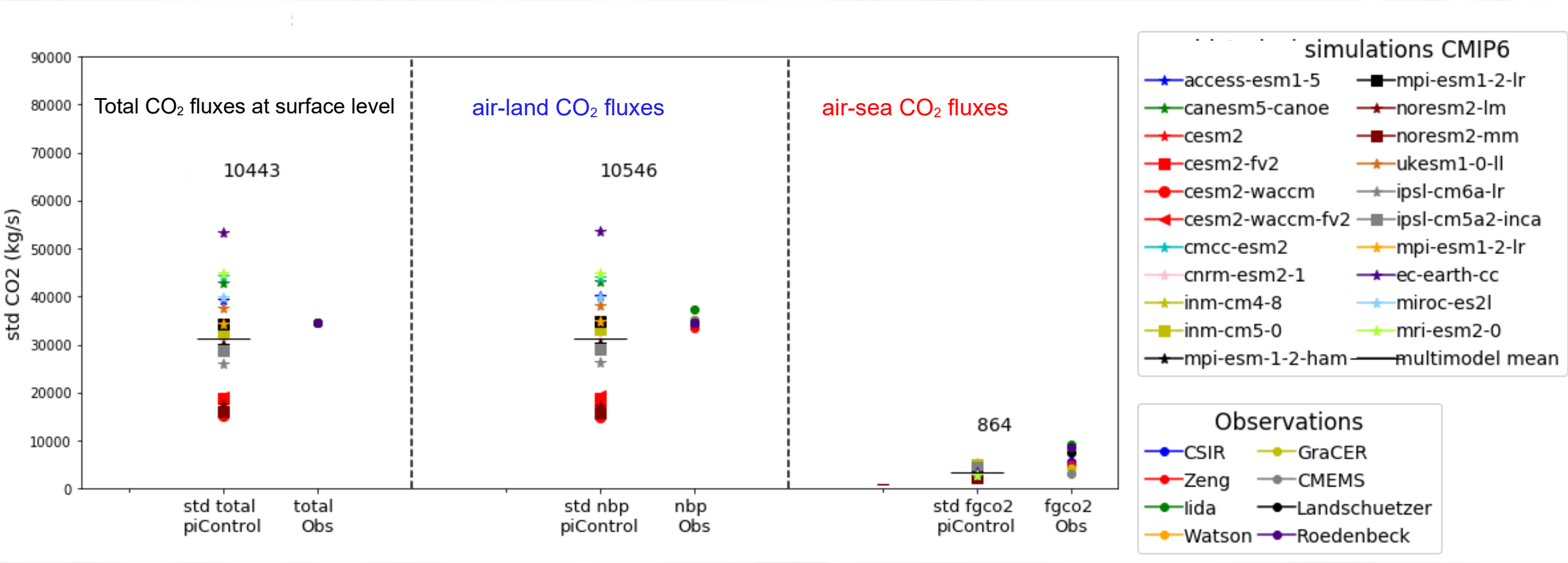
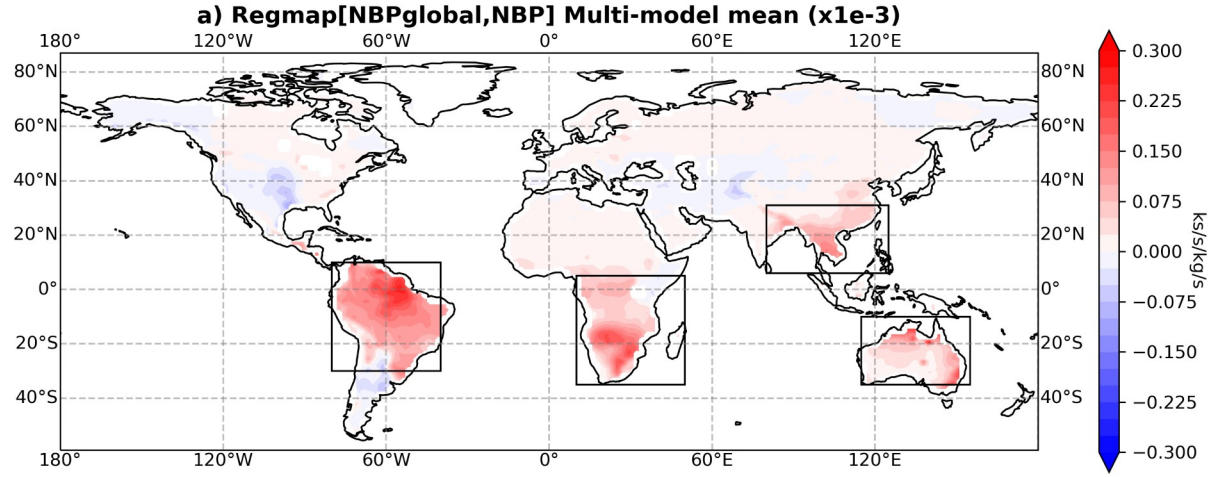
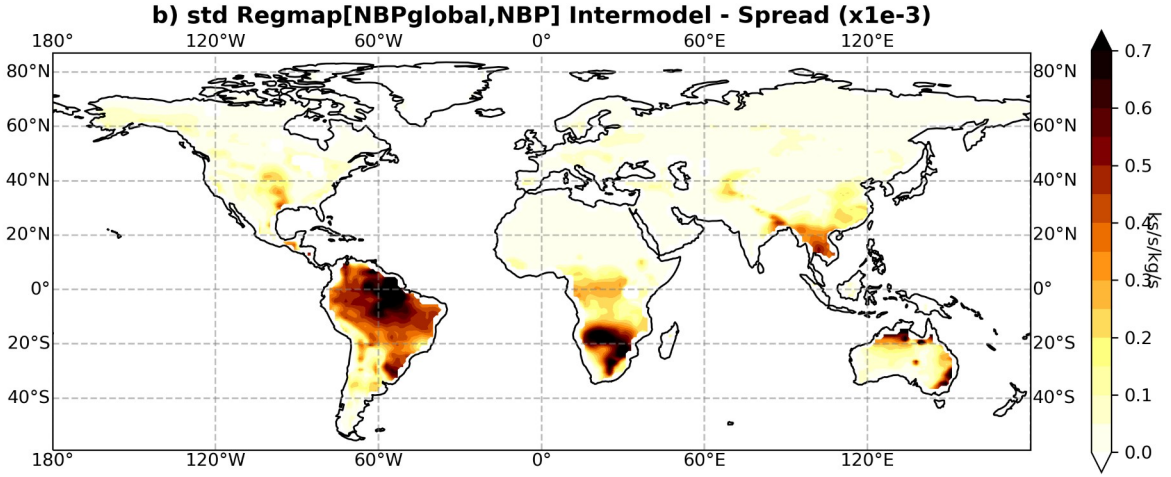


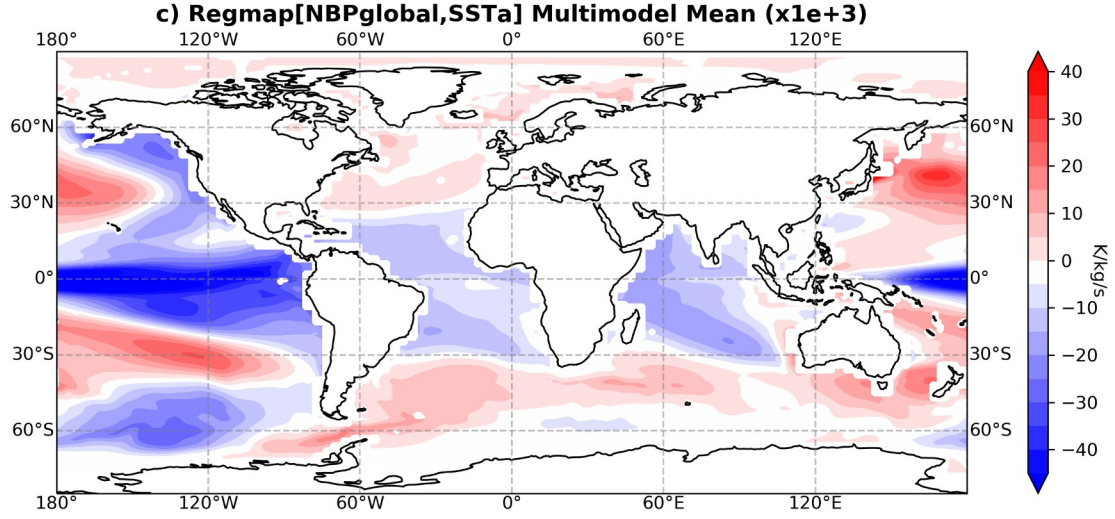
1) Which are the main land areas contributing the most to this natural changes in the atm CO_2?
2) Is there any driver for this inter-annual variability?
3) where the uncertainties are coming from?

Results

Land areas contributing the most to the global land CO_2 fluxes and main oceanic drivers

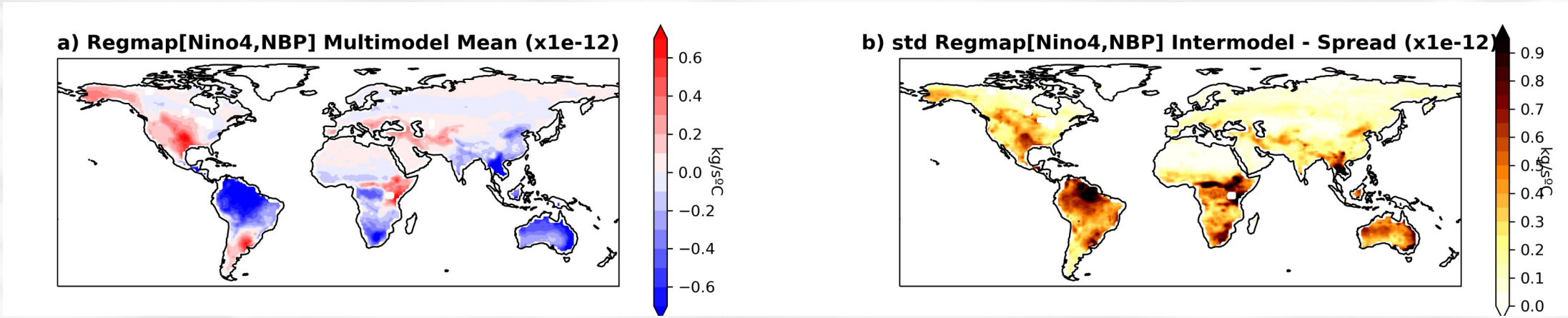






Results

Influence of ENSO in the land CO_2 fluxes



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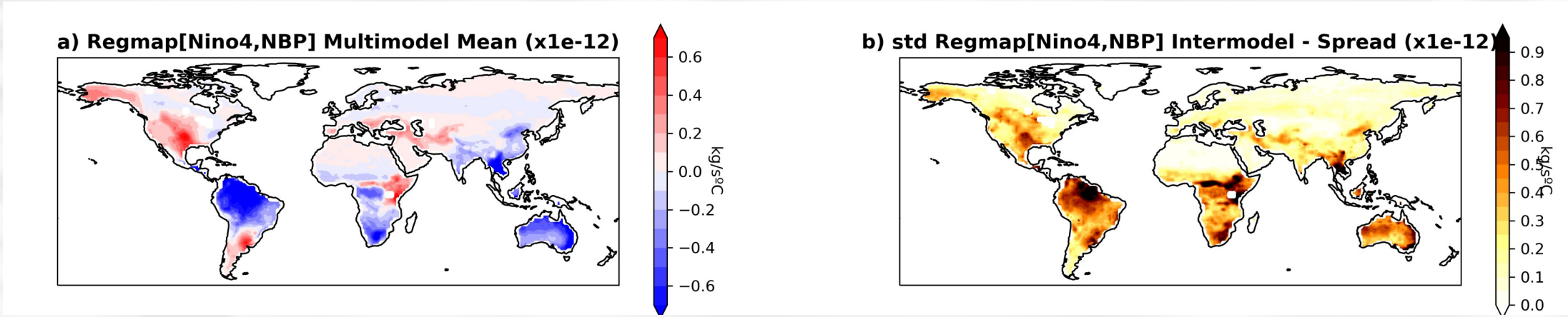

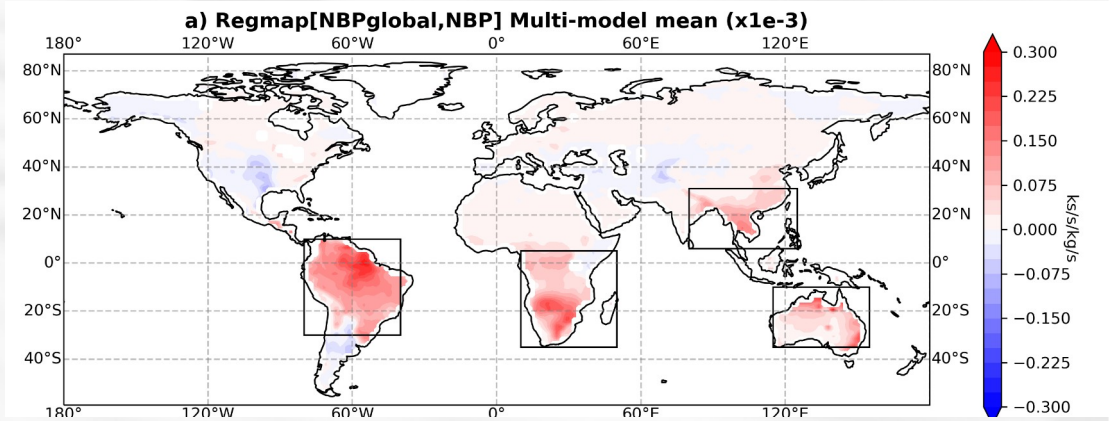

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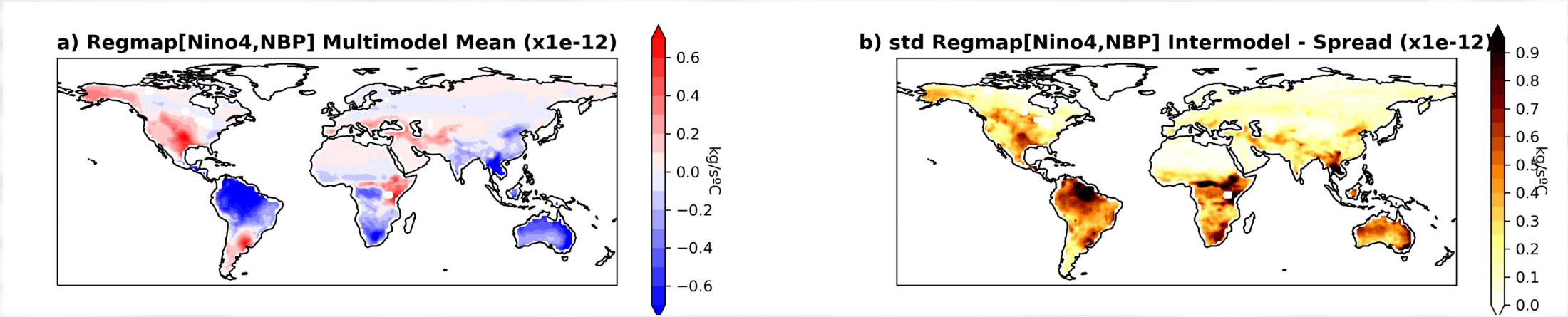

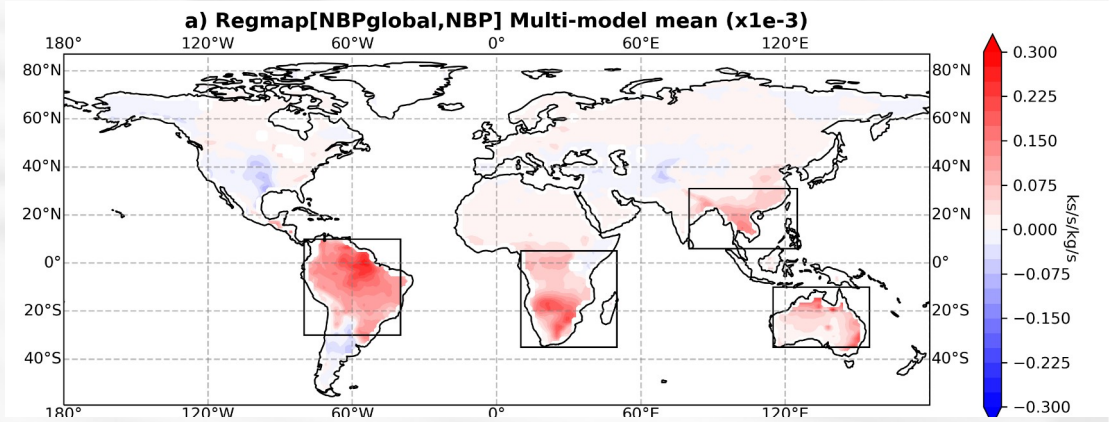

- **Possible origins of the inter-model spread std(CO_2) in models**
  - Different ENSO amplitudes in models
  - Different ENSO teleconnections in models
  - Different Land vegetation models

Results

Different Land Vegetation models

- **Possible origins of the uncertainties**
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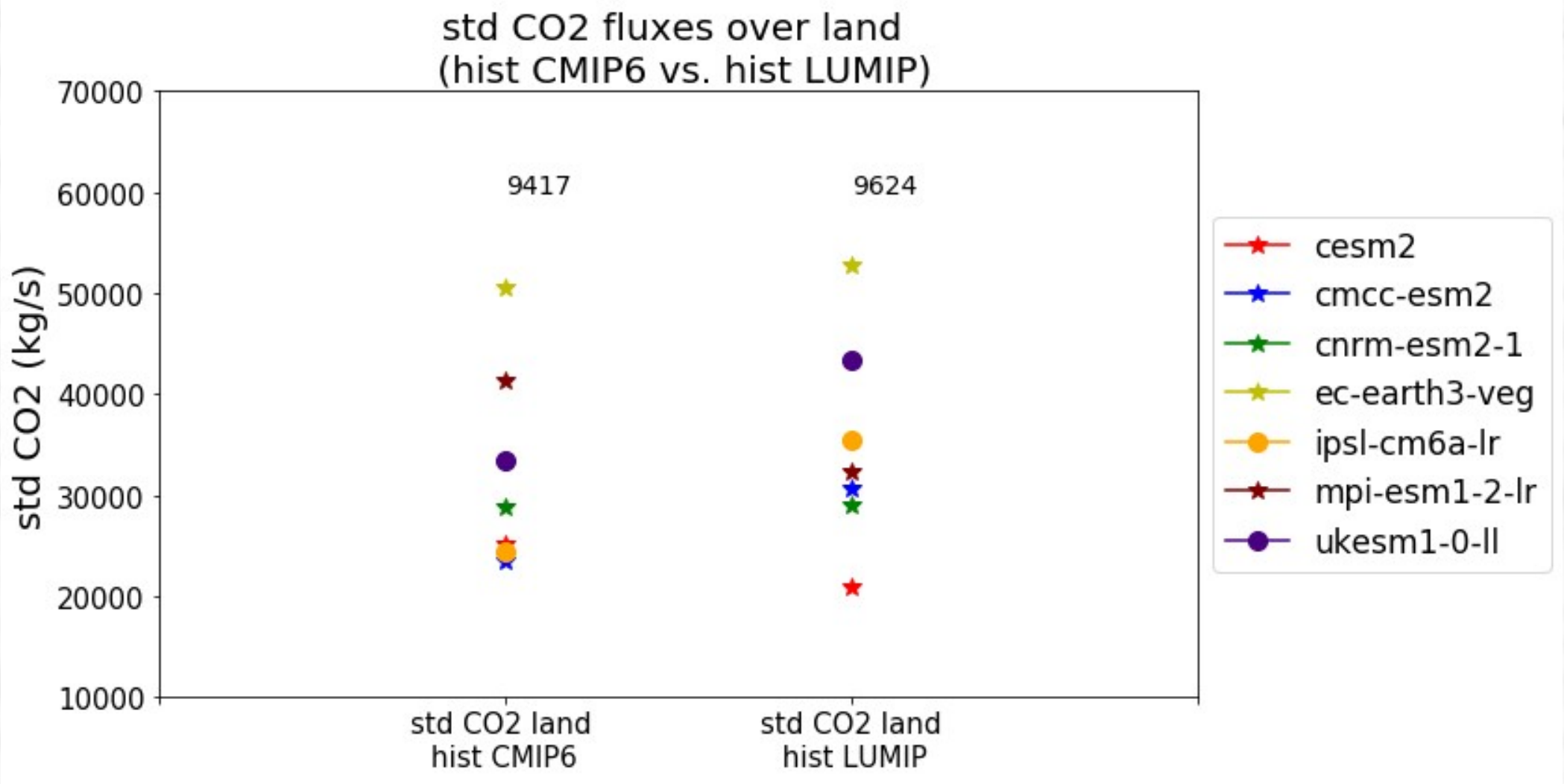

Conclusions

- The main source of internal variability of the atm CO_2 concentration are the air-land CO_2 fluxes
  - In both, models and observations
- For all models ENSO is the main driver of interannual variability of these land CO_2 fluxes
  - La Niña events remove CO_2 from the atmosphere
- There is a large spread in std(CO_2) in models, which is synonymous of uncertainty
- Main source of the large spread in std(CO_2)are the land vegetation models
- We need to improve land vegetation models in order to:
  - Reduce the uncertainty interval (spread among models)
  - Have robust estimation of the natural changes in the atmospheric CO_2 growth rate
  - Be able to attribute the changes in the atmospheric growth rate to mitigation measures or natural processes

Thank you!

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Climate-Carbon Interactions in the Current Century

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Annex

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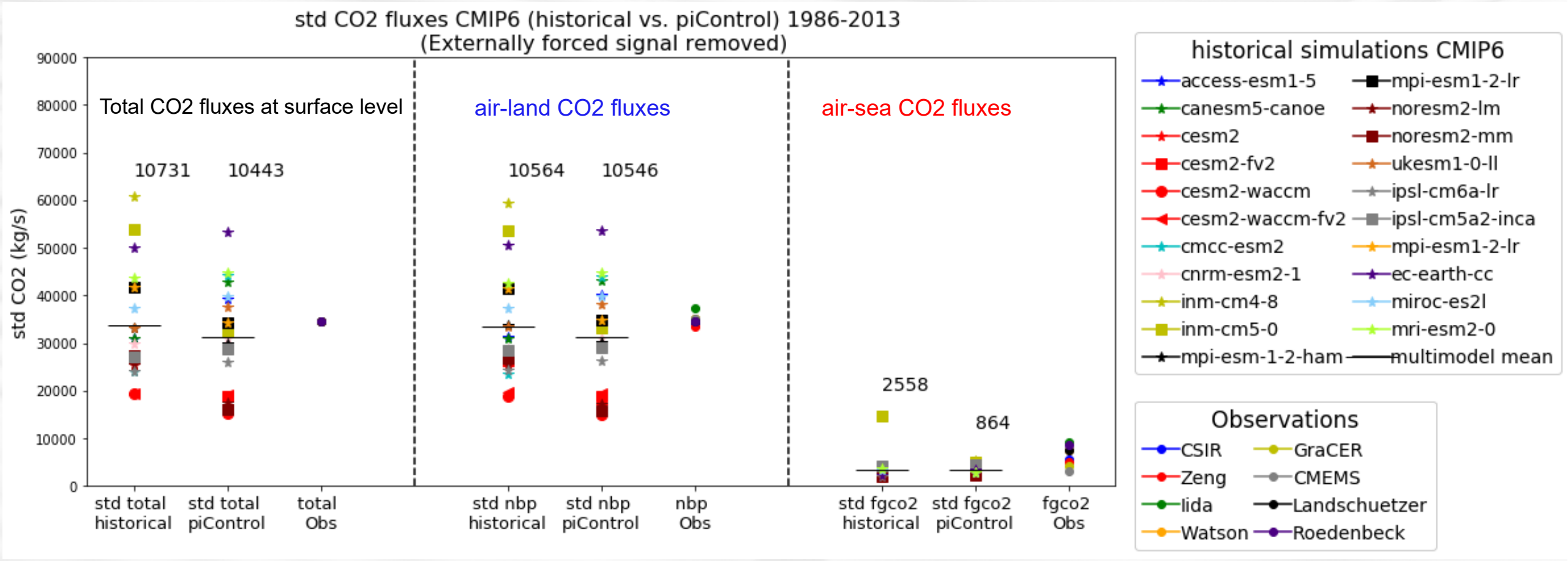
Results

Variability of the CO2 fluxes in observations, historical and piControl simulations



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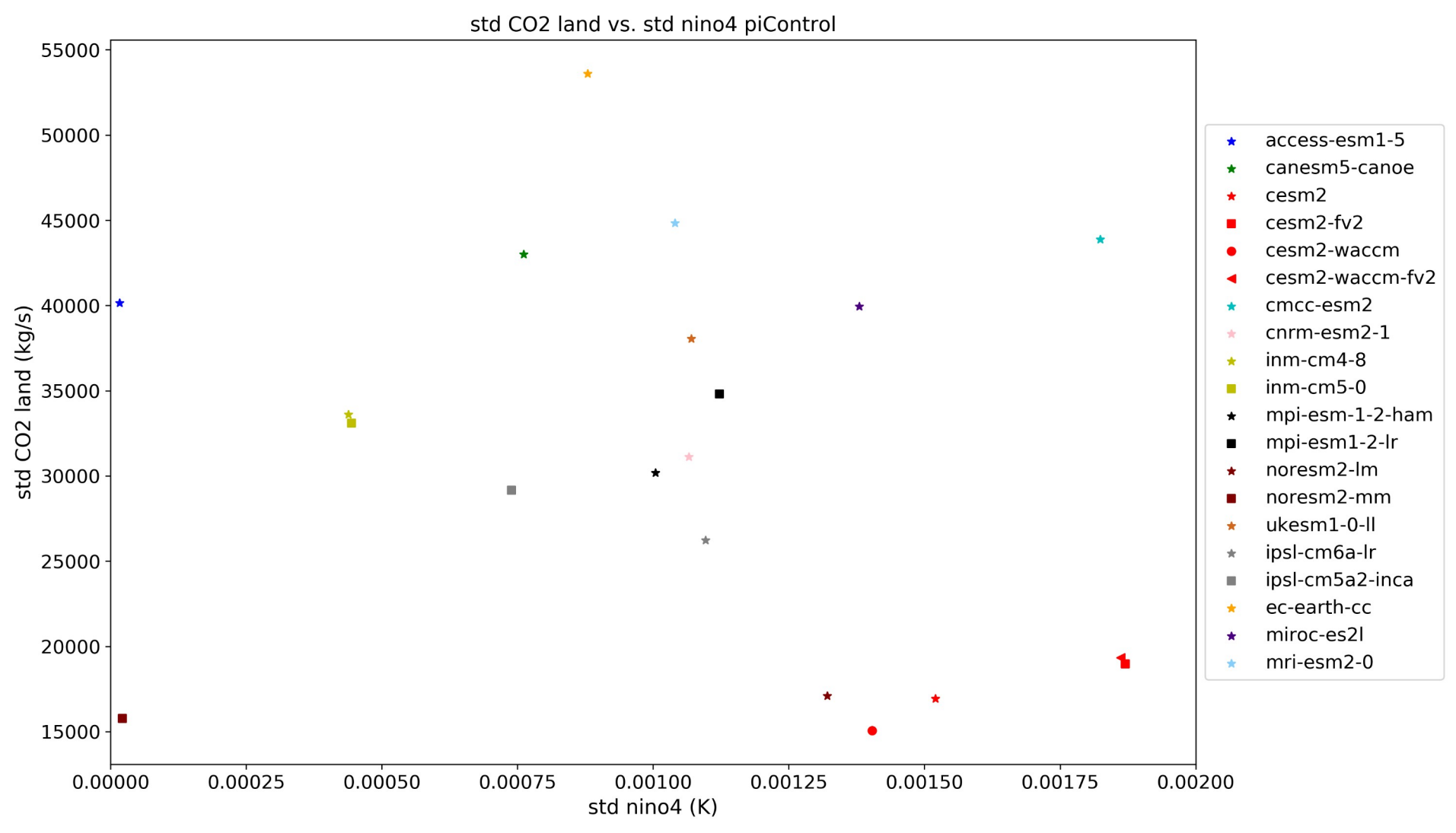

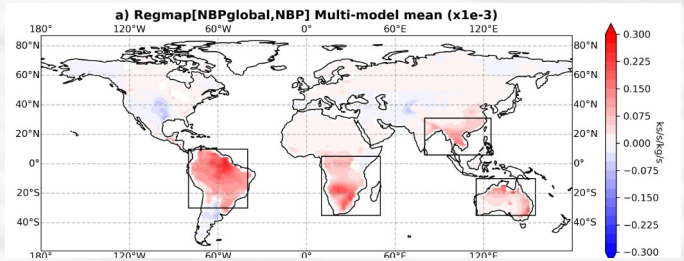

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Different ENSO teleconnections in models

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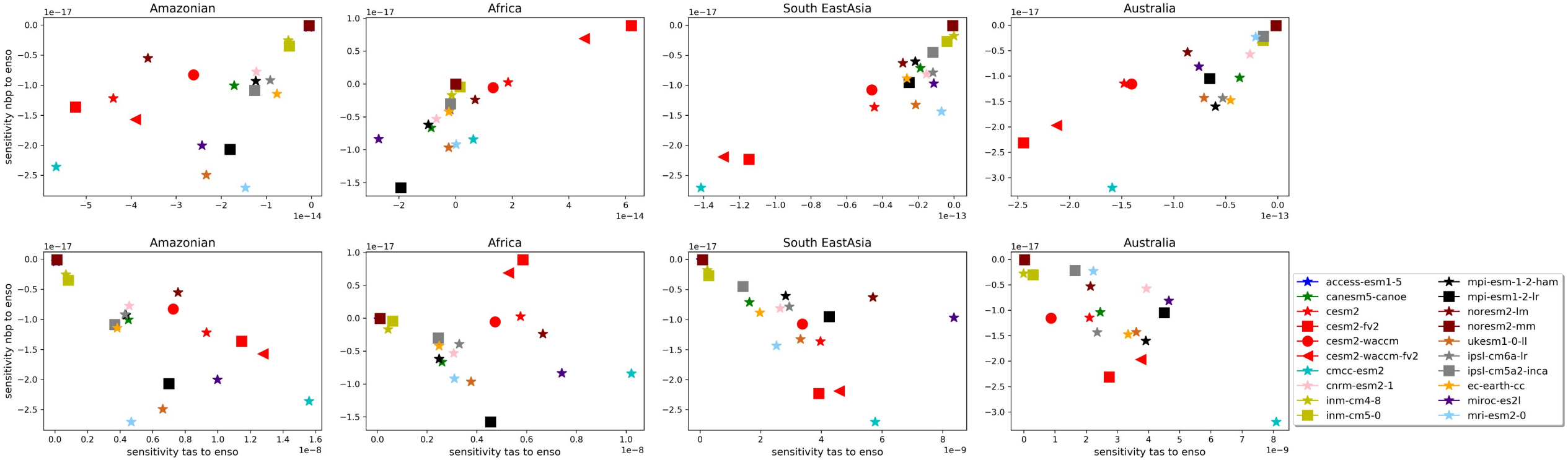

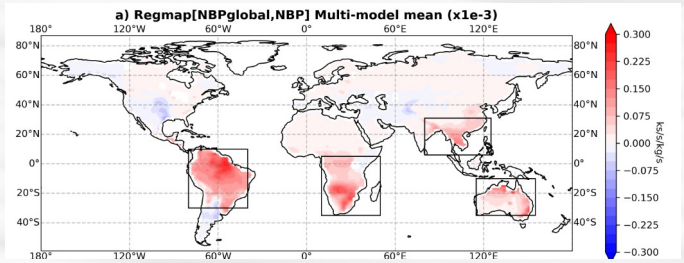

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