Observational Constraint On Greenhouse Gas And Aerosol Contributions To Global Ocean Heat Content Changes

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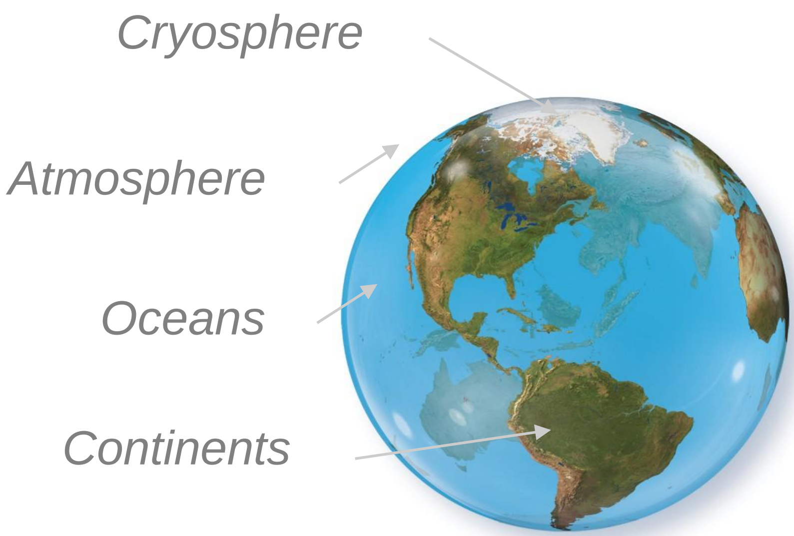
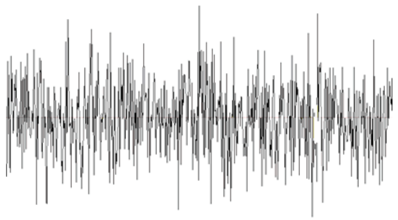
Climate system and its variability

The climate system and sea level respond to internal variability and to a forced variability:



Internal variability (IV)
- *unforced*
- *chaotic*
- *non-predictable*



Forced variability
- *driven by external forcings*
- *predictable*

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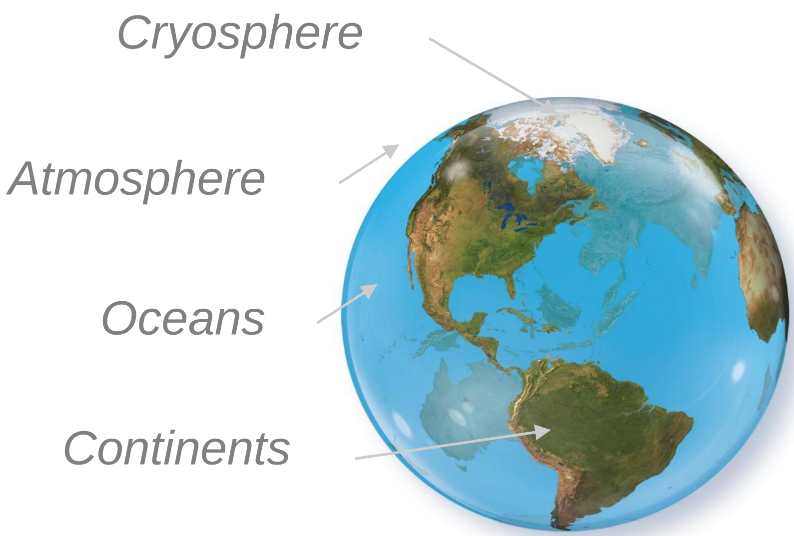

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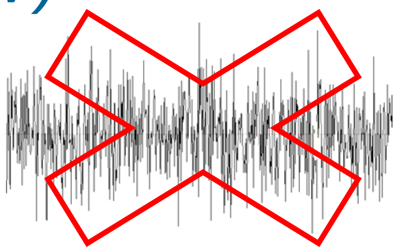

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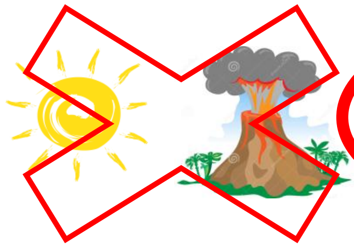
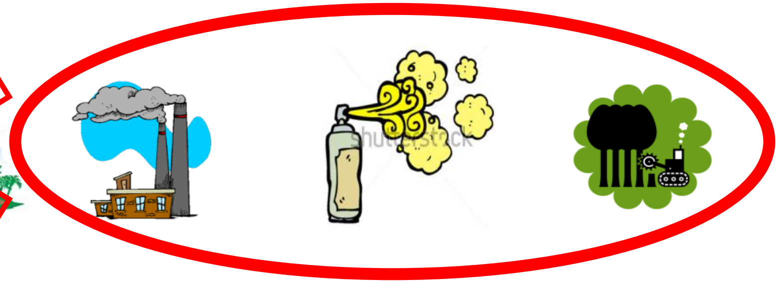


NAT



ANT

Slangen et al. 2014, Marcos and Amores 2014, Gleckler et al. 2012, etc.

Detection & Attribution Approach

Detection & Attribution aims at providing an optimal framework to compare observations and simulations and to separate the forced response from the chaotic IV.

Measurements

- Heterogeneous spatio-temporal coverage
- Instrument errors
- Internal variability, "one run"
- All forcings

Global Climate Models

- Global coverage
- Modelling, forcing errors
- Internal variability, multiple runs
- All forcings, NAT, GHG only

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Reconstructions from Ishii and Kimoto (2009) and Levitus et al. (2012)

Global Climate Models

- Global coverage
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- Internal variability, multiple runs
- All forcings, NAT, GHG only

CMIP5 simulations:

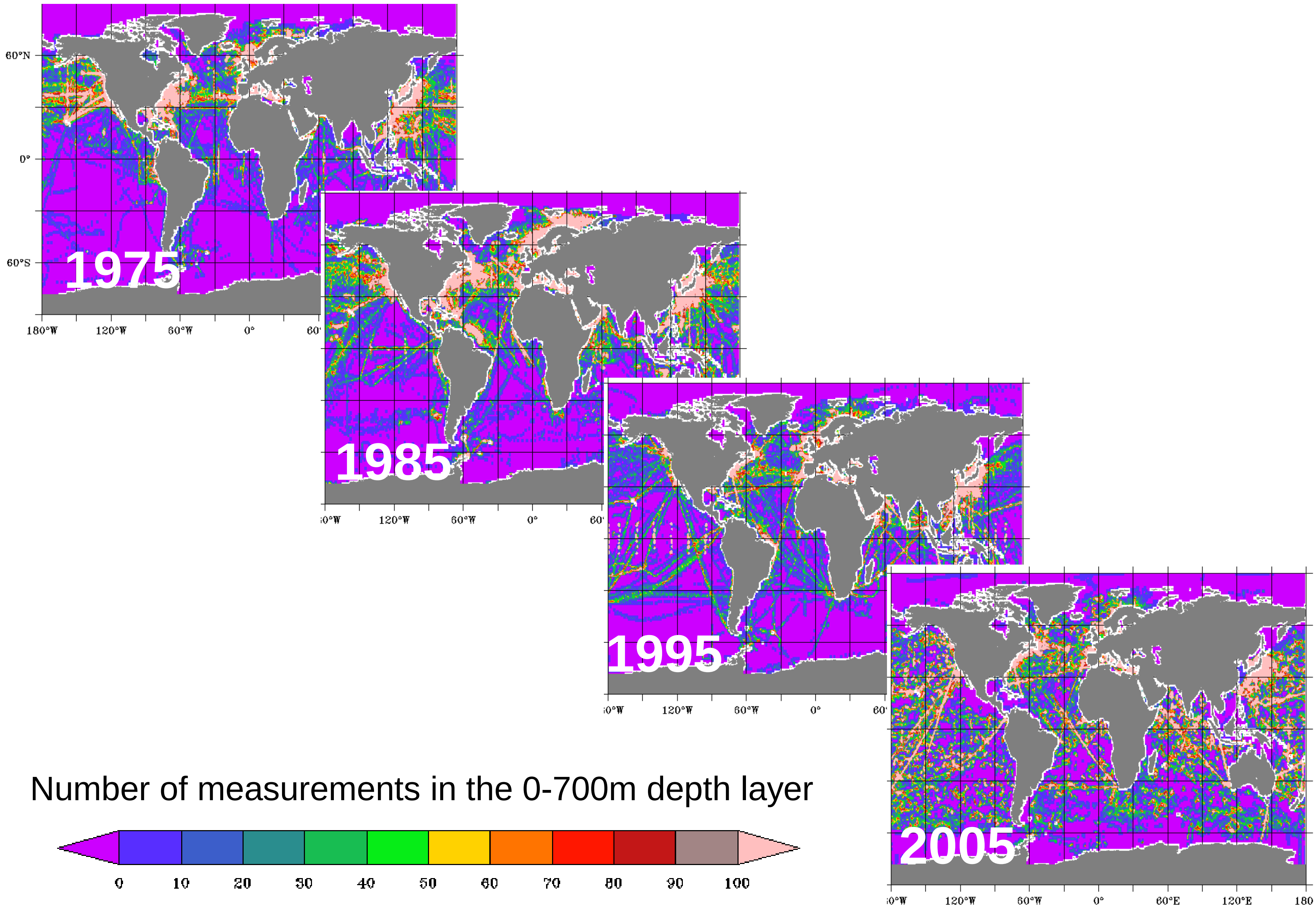
- 39 models for PIC and HIST
- 18 models for NAT and GHG

This study

Goal: reduce uncertainties and better constrain GHG and aerosols contributions to the 1971-2005 Upper Ocean Heat Content (0-700 m depth) changes

- Account for the heterogeneity of measurements: subsampling of simulations and reconstructions using an observational mask
- Homogeneous processing of simulations and reconstructions outputs, using Temperature and Salinity fields
- New D&A method of Ribes et al. 2015: accounting for modelling uncertainties and adding a regional constraint

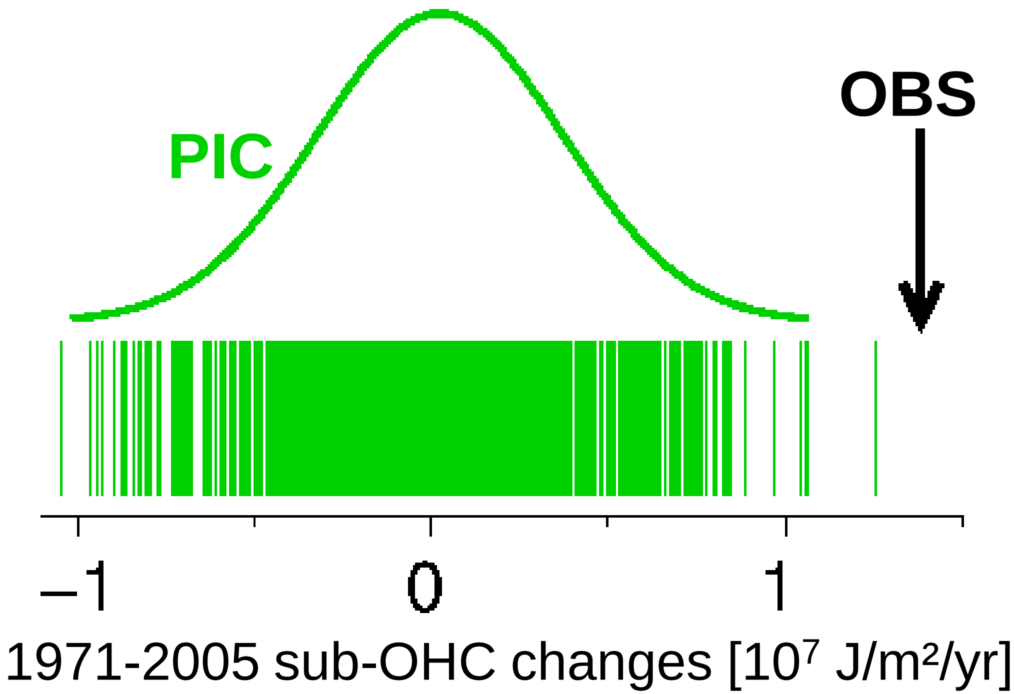
Observational mask and subsampling



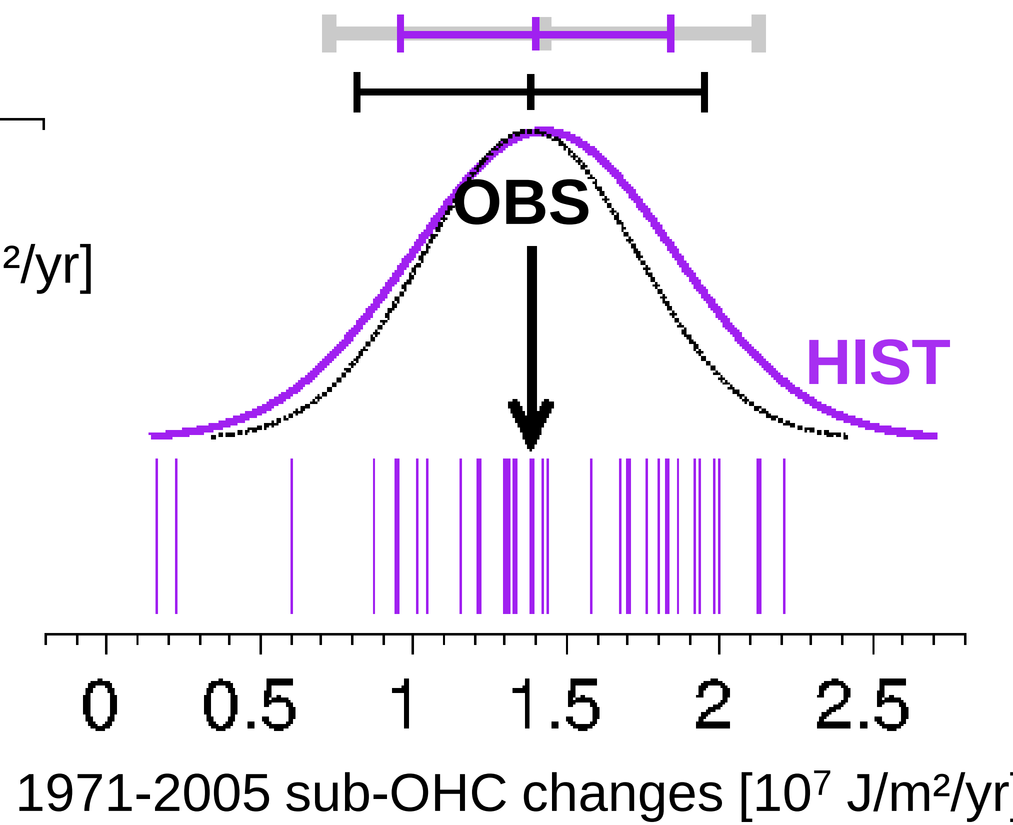
Number of measurements in the 0-700m depth layer

Results

Detection of a trend oustide the IV

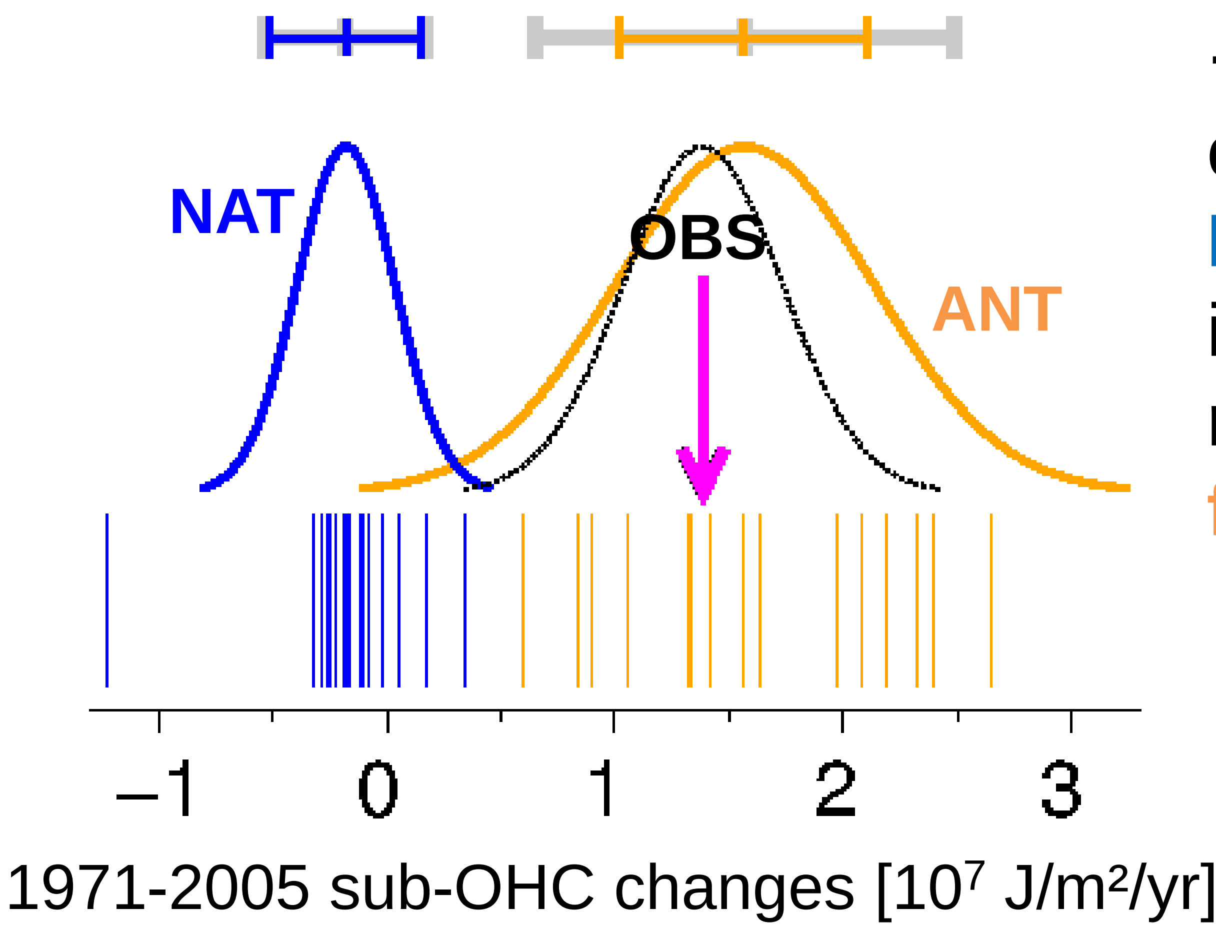


→ The observed trend cannot be explained by the IV alone



→ The observed trend is consistent with the response to all forcings

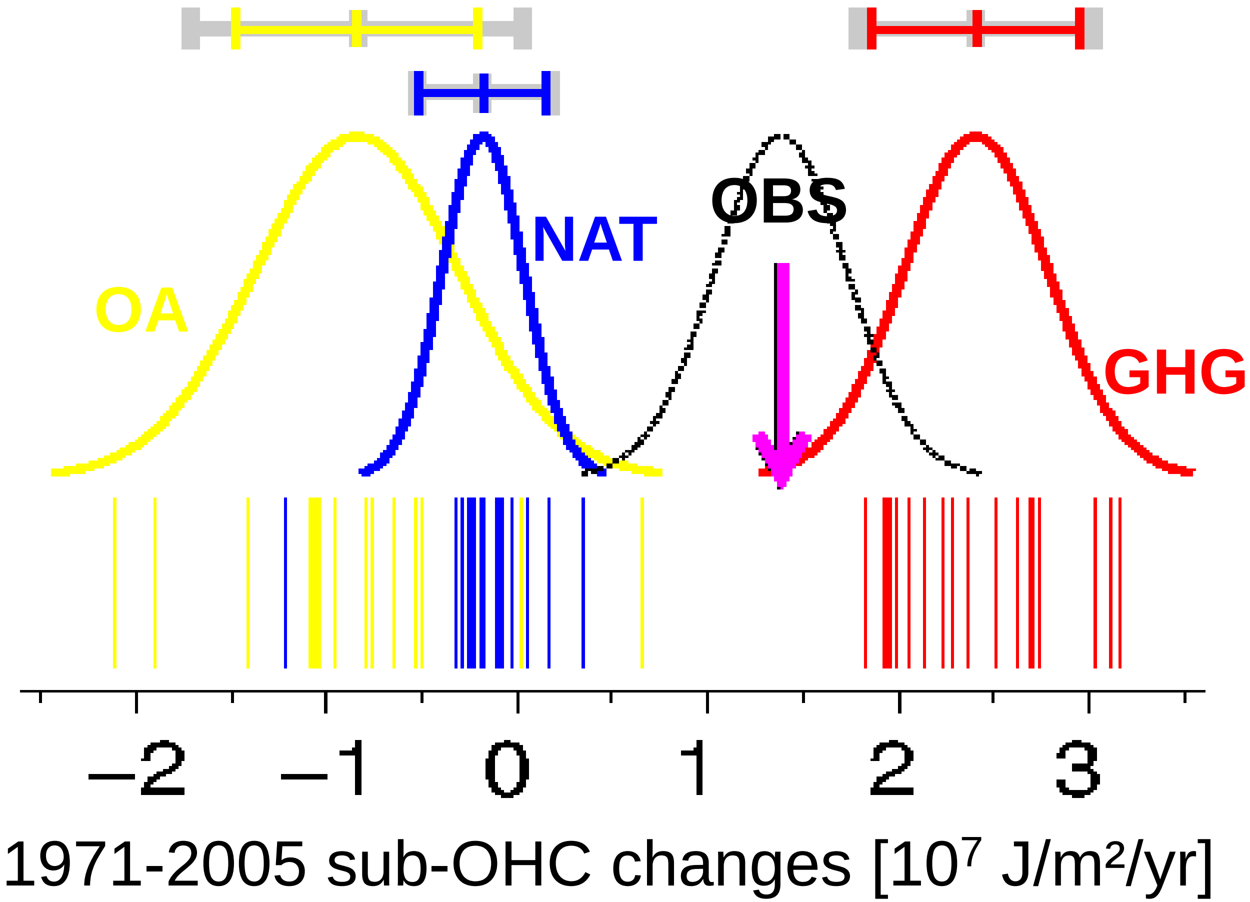
Attribution to NAT+ANT forcings



→ The observed trend cannot be explained by **NAT-forcing** alone, but is consistent with the response to **ANT-forcing** alone

Reduction of uncertainties with the D&A model (standard deviation):
NAT: -5 % ; ANT: -41 %

Attribution to NAT+GHG+OA forcings

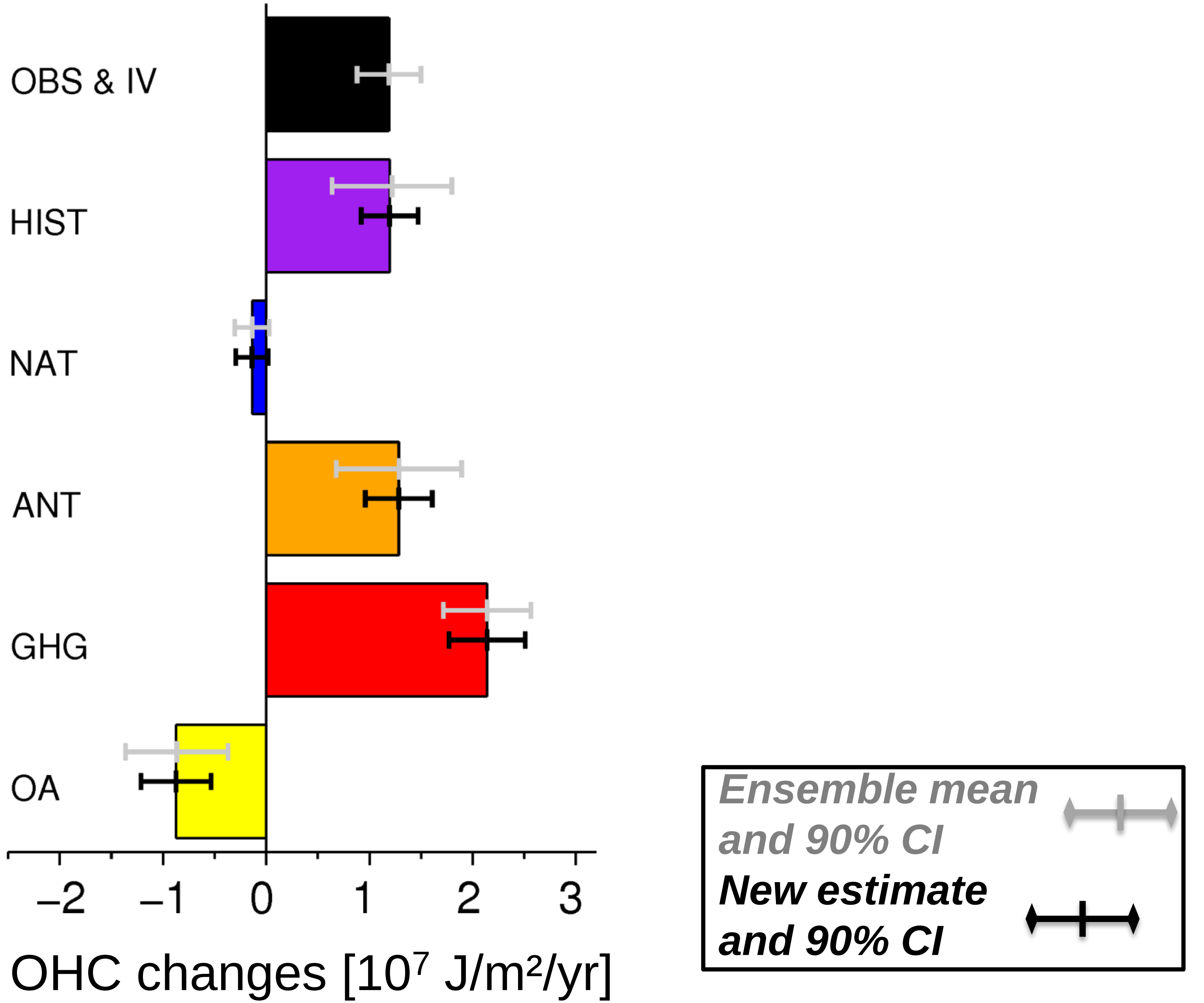


→ The observed trend cannot be explained by one single forcing

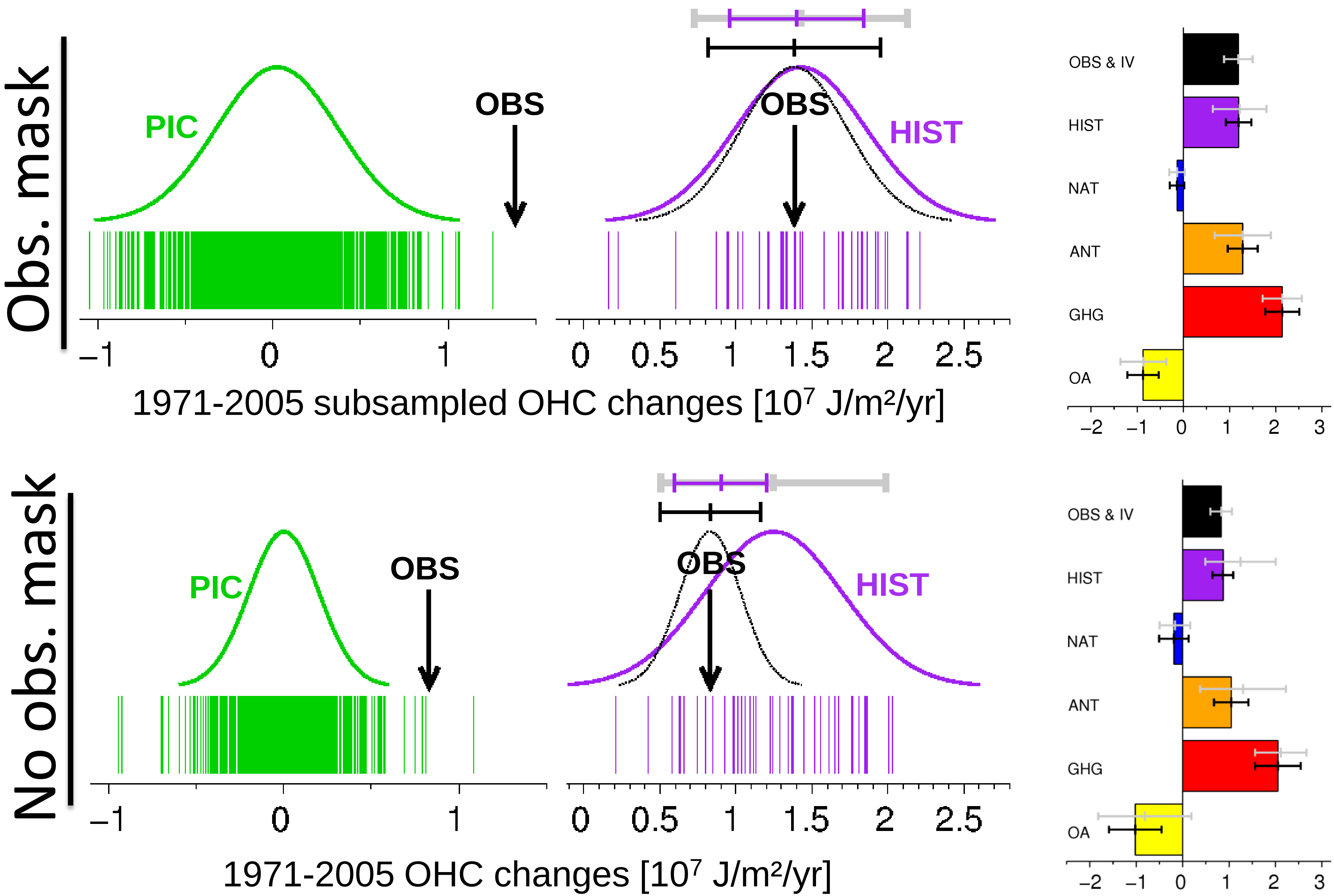
Reduction of uncertainties with the D&A model (standard deviation):

NAT: -4 % ; **GHG: -13 %** ; **OA: -28 %**

New contributions with D&A method

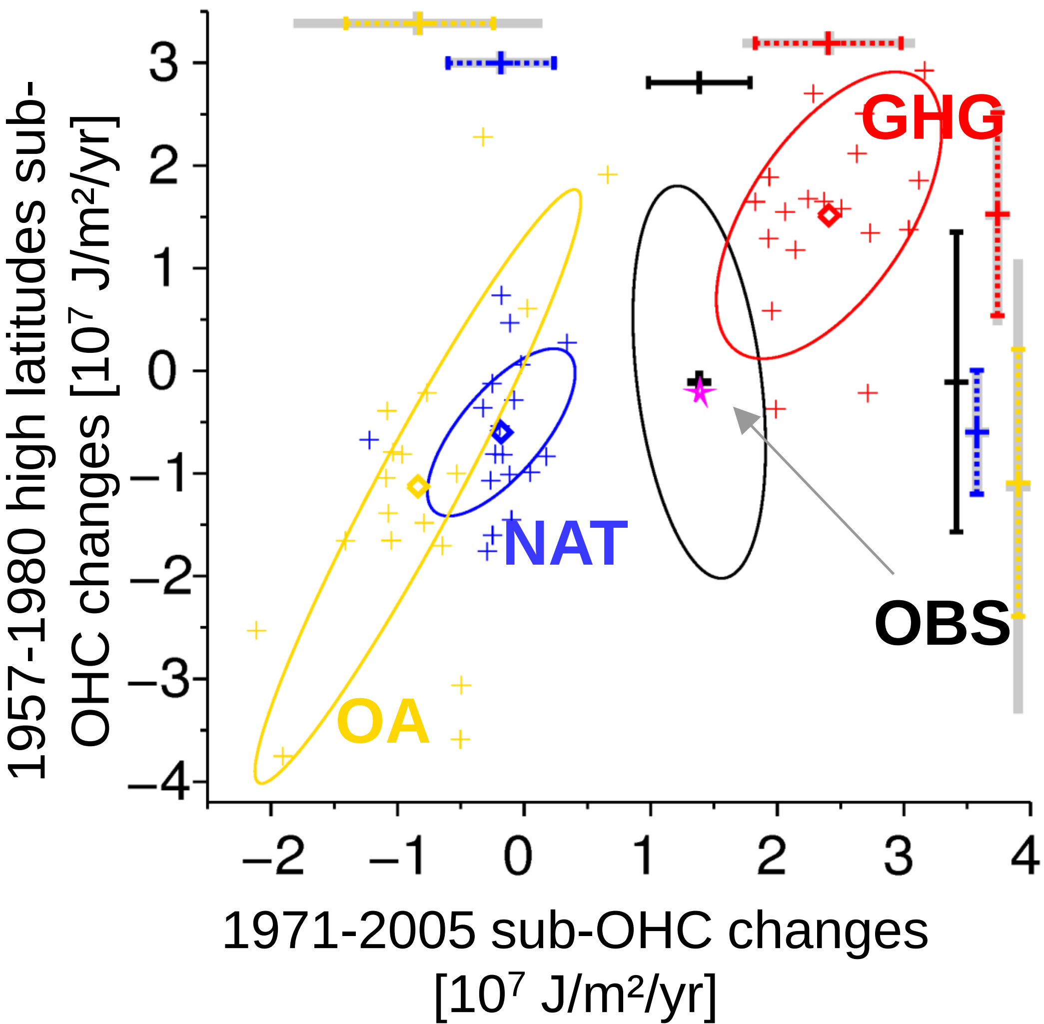


Without the observational mask



Adding a regional constraint

The optimal second variable for OA contribution is the 1957-1980 OHC change at high latitudes >40°N



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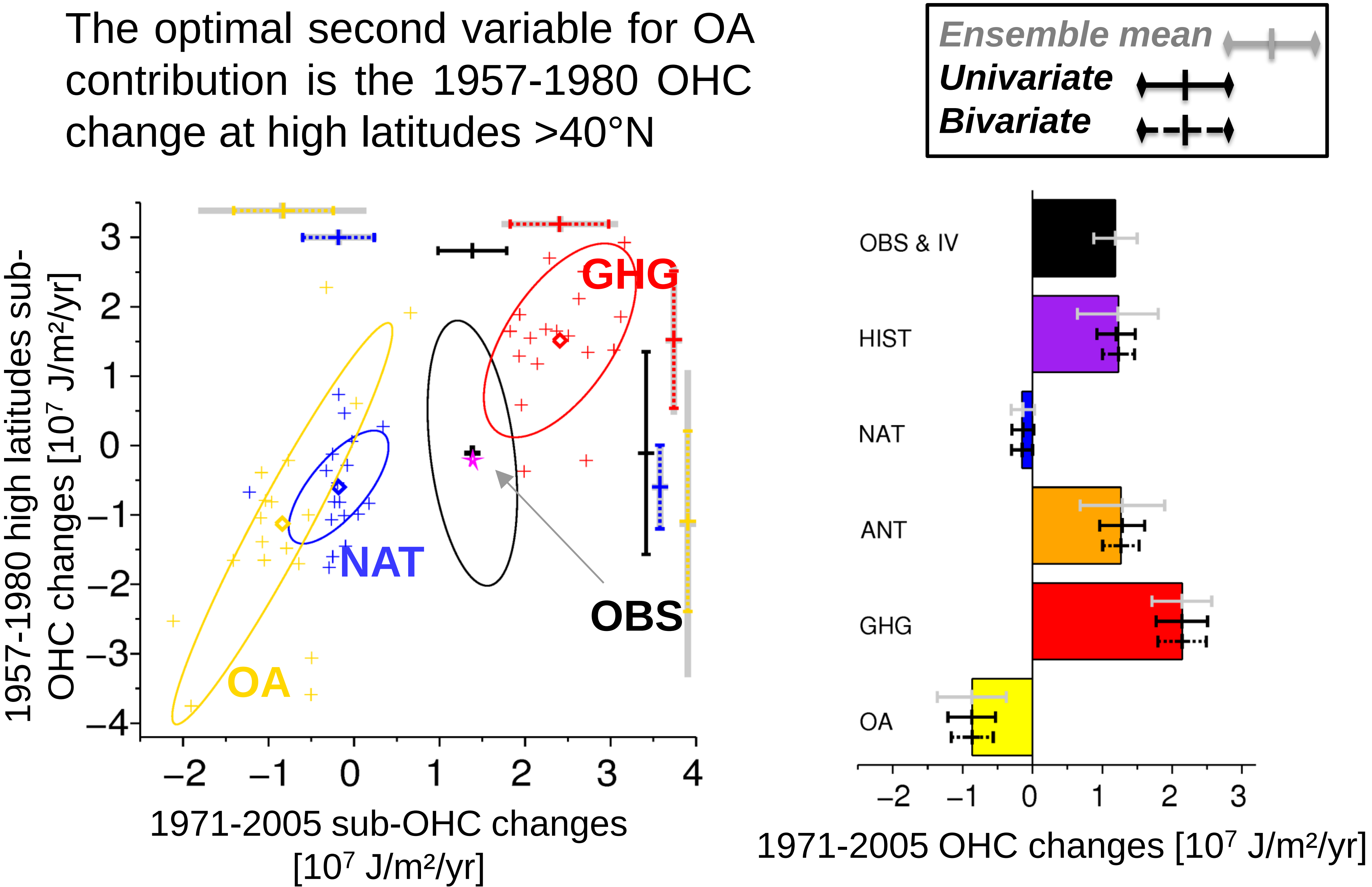
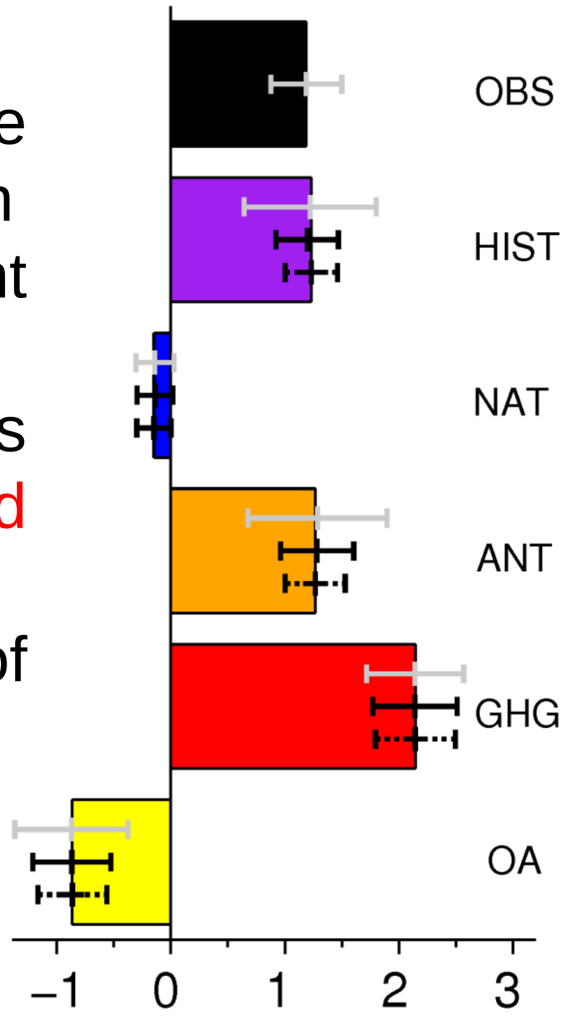


Conclusion

- General distribution is confirmed with more accurate estimates of each forcing contribution
- Observational mask brings better agreement between observations and simulations
- Bivariate mode of Ribes et al. (2015) allows decorrelating OHC response to GHG and aerosols forcings
  → It will allow precising the future response of sea level to GHG only



Outlook

- Continue this analysis at regional scale, using multivariate mode
- Apply this method to the full sea level, using tide gauge and satellite data