

# IPSL contribution to CMIP6

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# IPSL-CM ESM structure (same as in CMIP5)

chemistry & aerosols  
**INCA / REPROBUS**

Land and vegetation  
**ORCHIDEE**

Atmospheric physics  
**LMDZ**

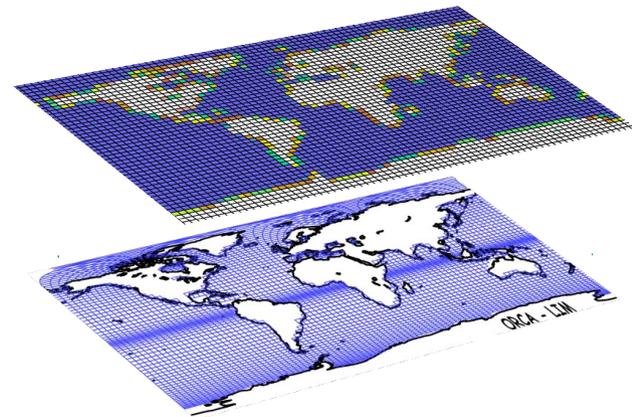
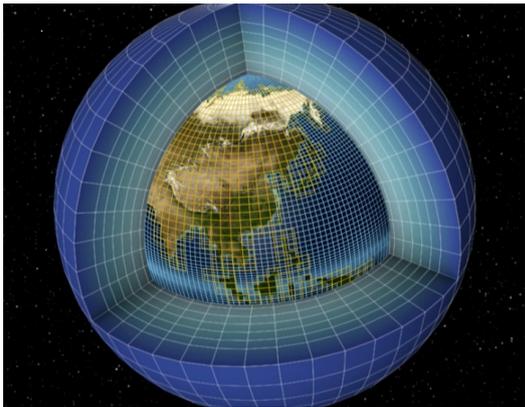
coupler  
**OASIS**

Oceanic physics  
**OPA**

**NEMO**

biogeochemistry  
**PISCES**

Sea Ice  
**LIM**



# IPSL models for CMIP5

LMDZ-ORCHIDEE-ORCA-LIM-PISCES-INCA-REPROBUS-OASIS

Earth System Model (ESM),  
standard physics: **IPSL-CM5A**

Model with new physics  
**IPSL-CM5B**

**Low resolution**  
**IPSL-CM5A-LR**  
(1.9°x3.75°L39)  
Oce: 2°

**Mid-resolution**  
**IPSL-CM5A-MR**  
(1.25°x2.5°L39)  
Oce: 2°

**Low resolution**  
**IPSL-CM5B-LR**  
(1.9°x3.75°L39)  
Oce: 2°

**Mid-resolution**  
(1.25°x2.5°L39)  
Oce: 2°

Simulations

- Core, tier 1, tier 2
- Sensitivity
- With different levels of integration

Simulations

- Core, tier 1, tier 2
- Emission-Driven
- Sensitivity

Simulations

- Core, tier 1, tier 2

# IPSL Models for CMIP6

## IPSL-CM6 ESM

**AOGCM:** Two resolutions:

**LR** : Atm: 2.5x1.5° (144x144) L79

Oce: 1° L75

**MR** : Atm: 1.3x0.6° (280x280) L79

Oce: 0.25° L75

### Configurations

- standard: physical + carbon cycle + prescribed aerosols and O<sub>3</sub>
- standard with interactive aerosol

**HR** : Atm with new dynamical core DYNAMICO 0.6°

## IPSL-CM5A-AerChem

Continuity with IPSL-CM5A used in CMIP5

Interactive chemistry and aerosols, Paleoclimate

**VLR** : Atm: 3.75x1.9° (96x95) L39

Oce: 2° L31

# A short list of ocean-related improvements

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- Resolution
  - Lateral: atm (96 → 144), ocean (ORCA2 → ORCA1, ORCA025)
  - Vertical: 2x
- Ocean circulation model (ORCA -> eORCA)
  - Grid extended to include regions under ice shelves (some shelf seas)
  - New parameterizations, refinements for eORCA1 and eORCA025
  - Tide-induced mixing
  - Freshwater distribution within water column
  - Parameters adjusted to reduce small-scale effects and improved deep-ocean ventilation
- Ocean BGC model
  - PISCES v2 (Aumont et al., 2015, GMD)
- New techniques:
  - MPI / OpenMP & XIOS: use of 1000 cores
  - Compression of output
  - Workflow: automated QC, CMORization, data publishing (CF)
  - Supervision by HERMES

# IPSL model and CMIP6 Protocol

## CMIP6 : 28 MIPs, 228 experiments, 2280 CMOR variables, 49 tables,...

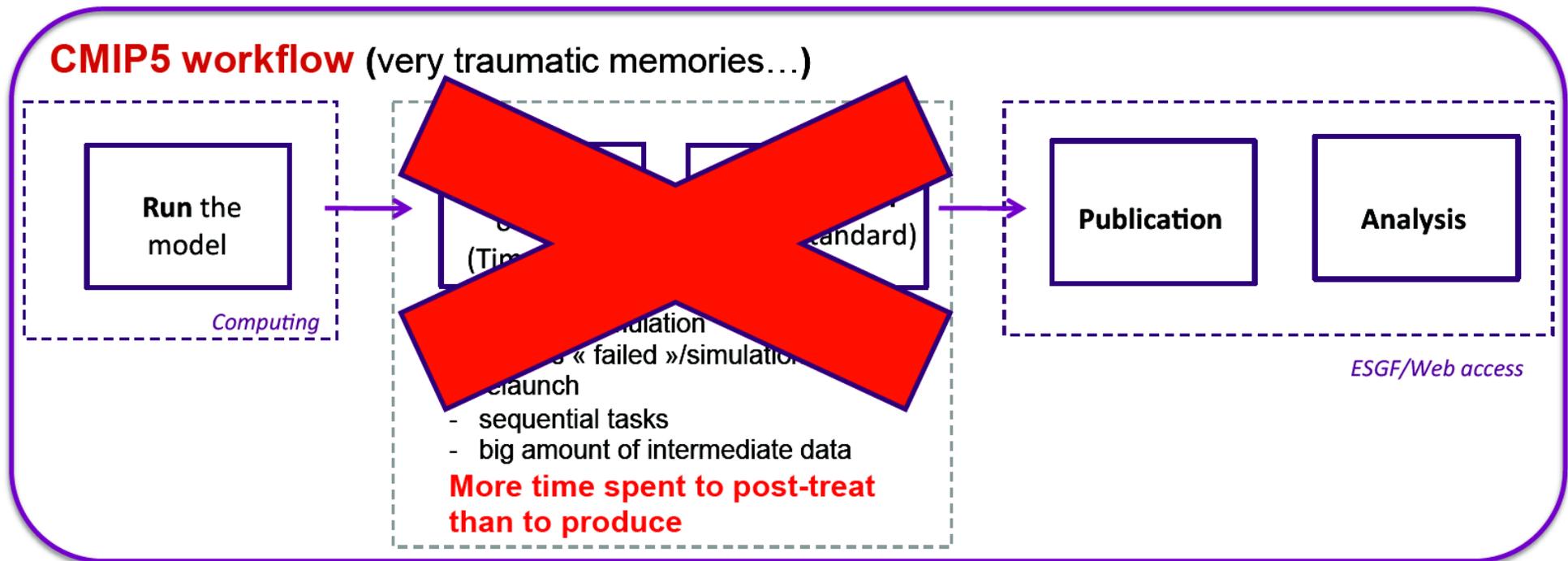
- 40 000 years of simulation to perform
- **Data Request (XML file)**
  - Specifying the variables which are needed for each experiments.
  - High variability in the DRQ: from one experiment to the other, from one simulated year to the next one, from a modelling group to an other depending on the MIPs it is engaged in,...

## Computing and storage resources

- 300 millions computing hours
  - 200 millions for development
  - 100 millions for production
- Production of 14 PB of data
- Distribution of 2 PB of data (ESGF)

| Version                                   | Atm resolution | Ocean resolution   | SYPD      |
|---|----------------|--------------------|-----------|
| <i>IPSL-CM6-VLR<br/>(atm chem, paleo)</i> | 3°, L39        | 2°, L31            | 75        |
| <b>IPSL-CM6-LR</b>                        | <b>2°, L79</b> | <b>1°, L75</b>     | <b>16</b> |
| IPSL-CM6-MR                               | 1°, L79        | 0.25° or 1°<br>L75 | ??        |
| IPSL-CM6-HR<br>(DYNAMICO)                 | 0.6°, L79      | 0.25°, L75         | ??        |

# In CMIP5, running the model was the easy part

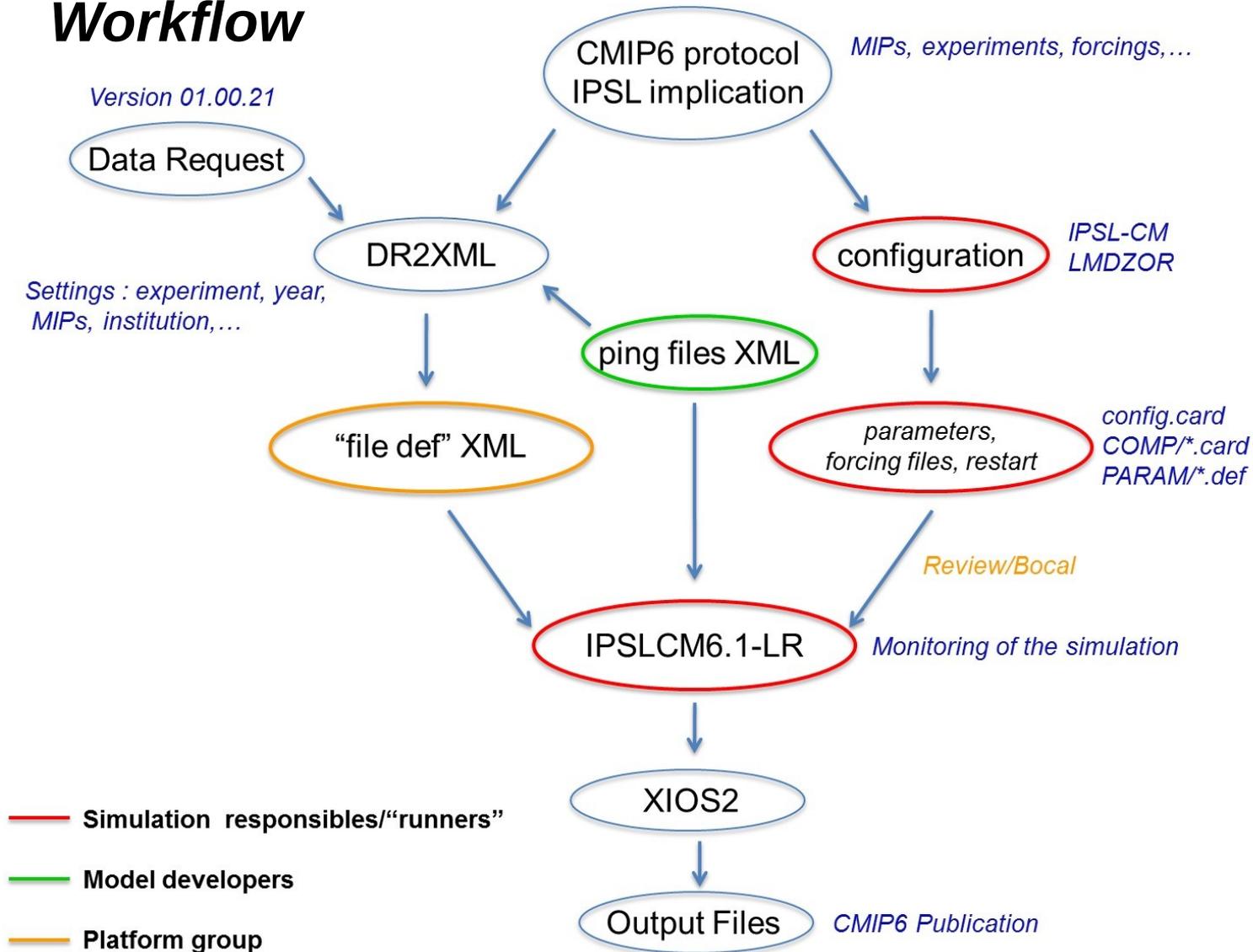


## the Dream:

- avoid all post-treatment
- publish directly (CMIP6 ready)

# Streamlined production of IPSL's CF-compliant CMIP6 data

## Workflow



# Automatic compliance with CF / CMOR

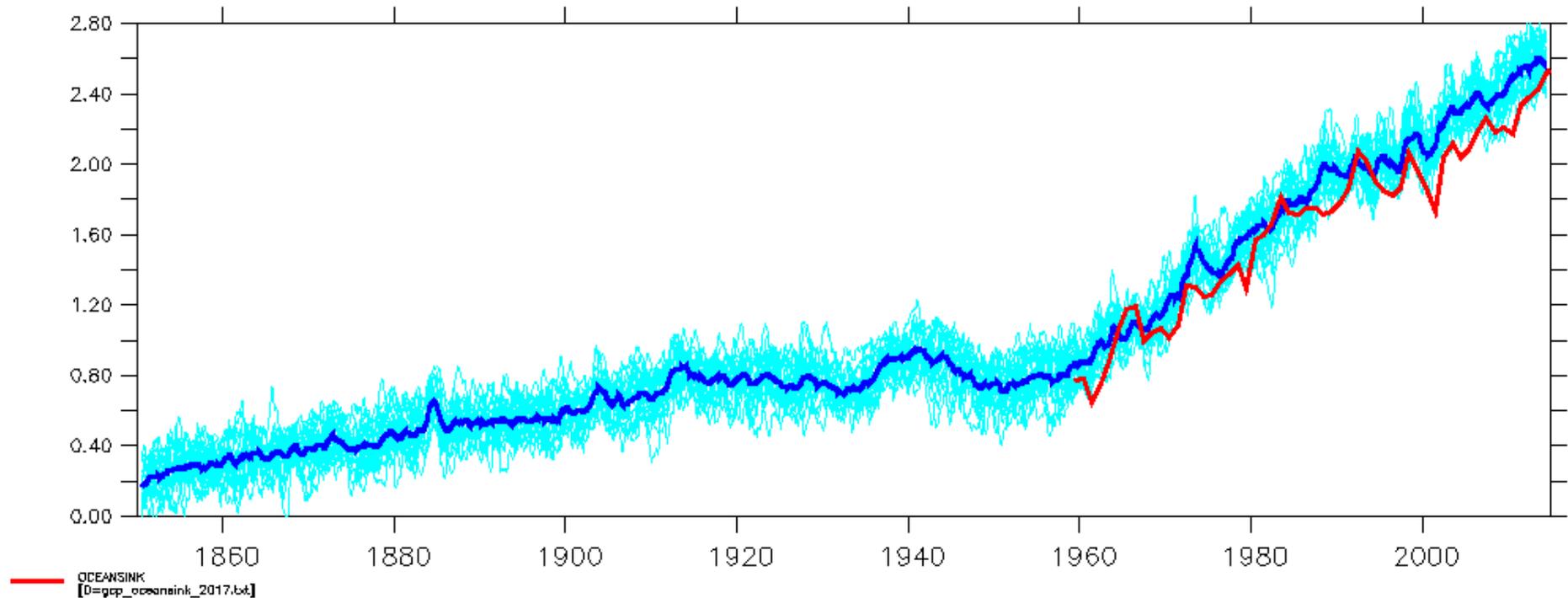
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- XIOS output fully CF 1.7 compliant
  - Axis & coordinates
  - Variables and associated metadata
  - Time axis management
- DR2XML generate automatically CMOR compliant XML input files for XIOS
  - CMOR specific global file attributes
  - CMOR specific associated metadata of variables
  - Renaming of axis & coordinates as required by Data Request
- Automatic time series management
  - One file by variable
  - Automatic generation of UUID (tracking\_id)
  - Automatic chunk splitting at a given frequency specifically to an output file
    - Constant size for chunk of file variable
    - Automatic file name suffix corresponding to the period of chunk
  - An output file can be reopen and appended by the next run

**DR2XML generate ~90 000 XML code line by experiment**

# IPSL now has large ensemble for CMIP6 historical run

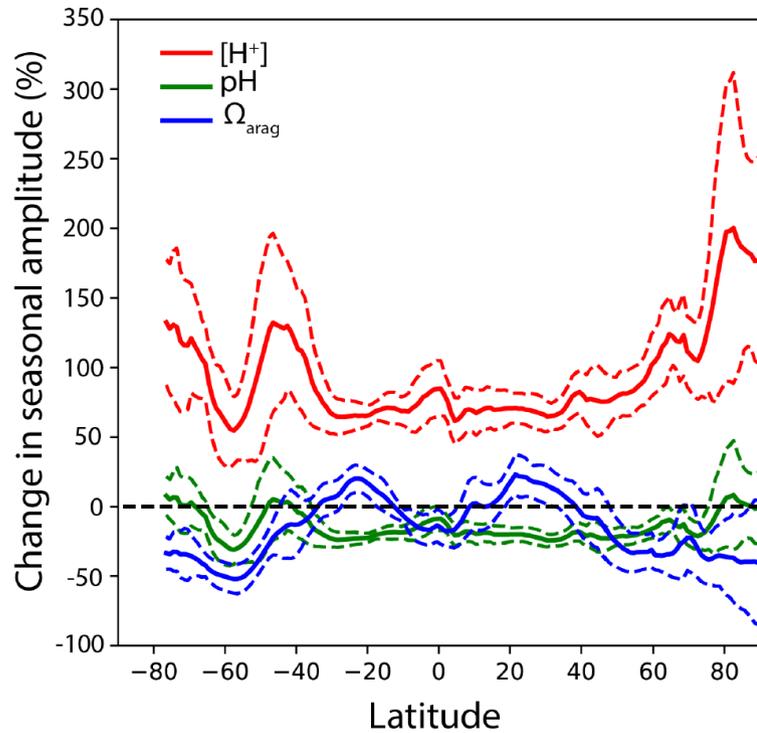
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IPSL-CM6A-LR: 30 ensemble members (cyan), ensemble-mean (blue) vs. estimate from GCP (red, Le Quéré et al. 2018)

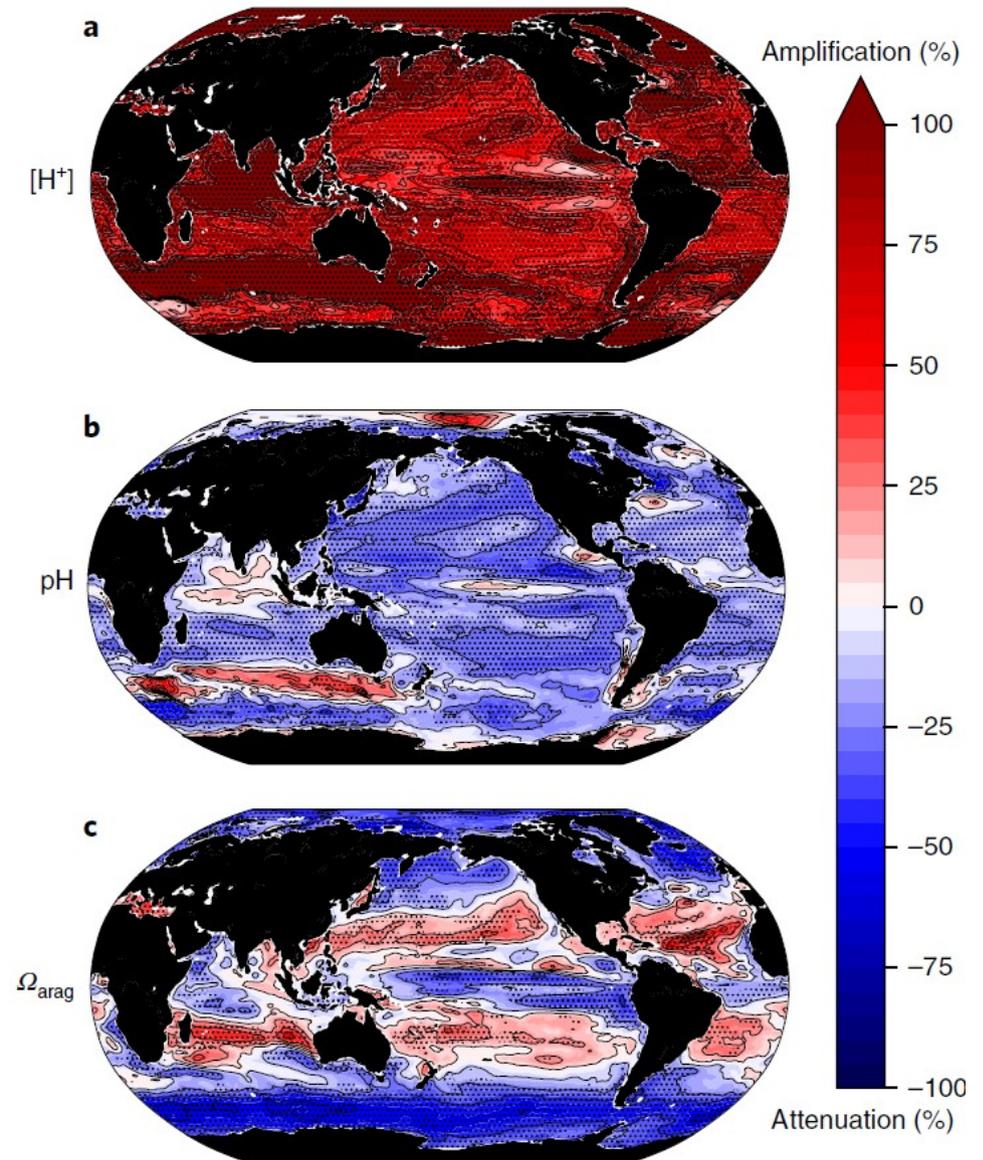
# In CMIP6, we also aim to further assess extremes & variability and their potential future changes

CMIP5 assessment (9 models):  
21<sup>st</sup> century increase  
in [H<sup>+</sup>] seasonal amplitude



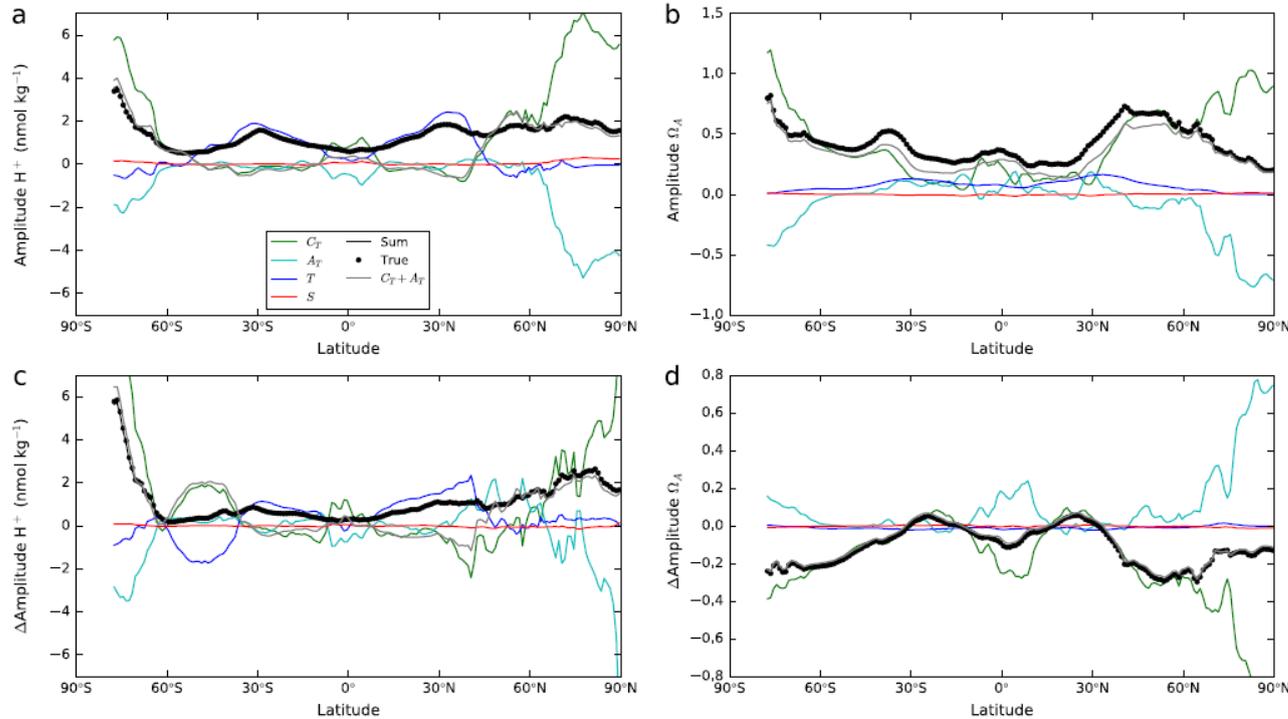
$$d \text{ pH} = \frac{-1}{2.303} \frac{d[\text{H}^+]}{[\text{H}^+]}$$

Kwiatkowski & Orr (2018)

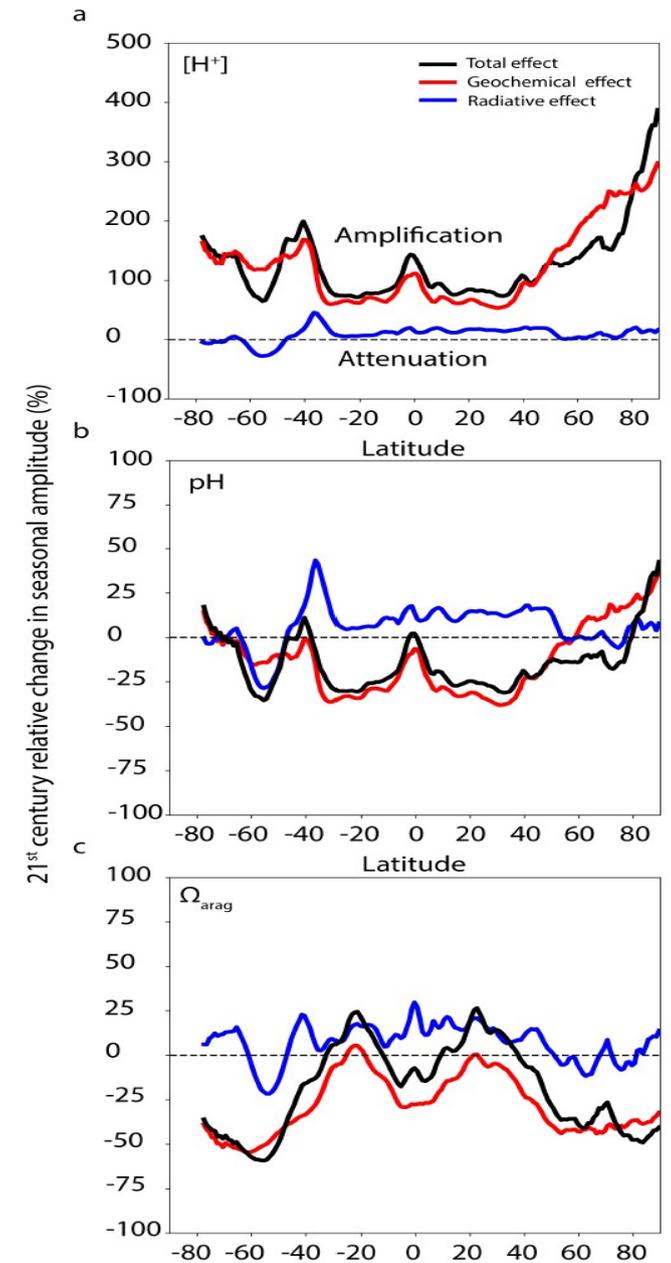


# ... while assessing driving mechanisms with idealized simulations, deconvolution techniques, ...

## Taylor decomposition

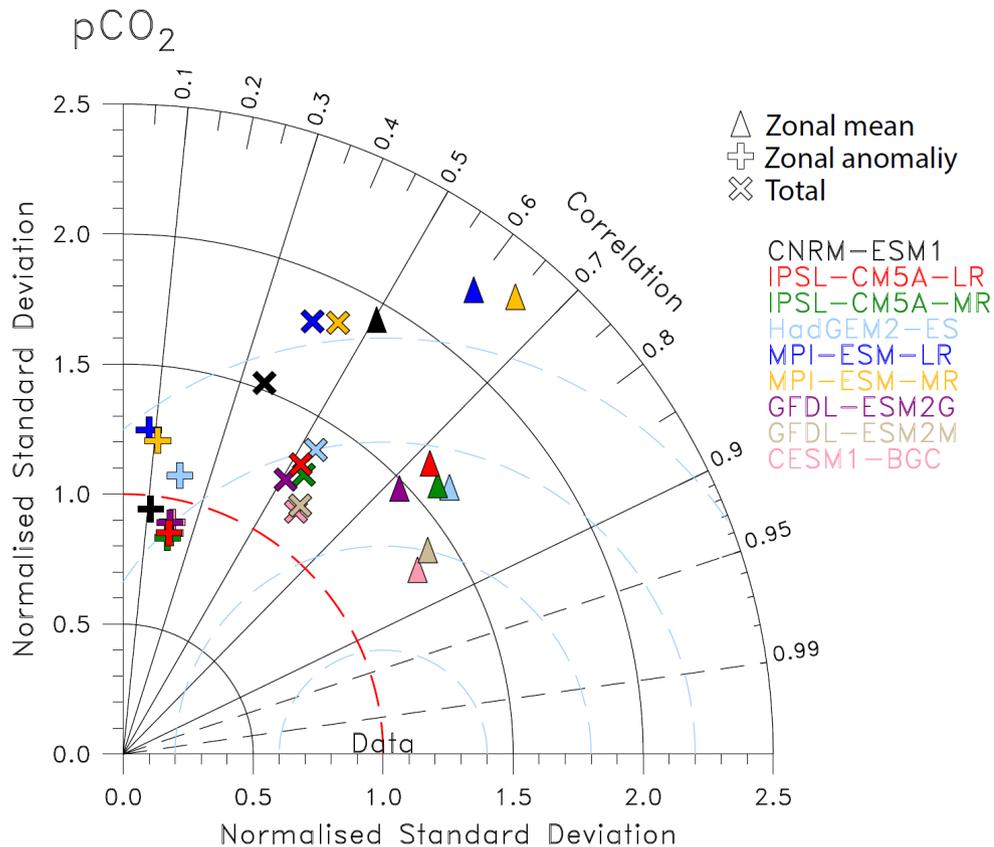


## Idealized simulations (1% / yr<sup>-1</sup>)



Kwiatkowski & Orr (2018)

# We also aim to help improve standard diagnostics used to assess CMIP6 models



*Kwiatkowski & Orr (2018)*

