# CMIP Forcings – GHG concentrations

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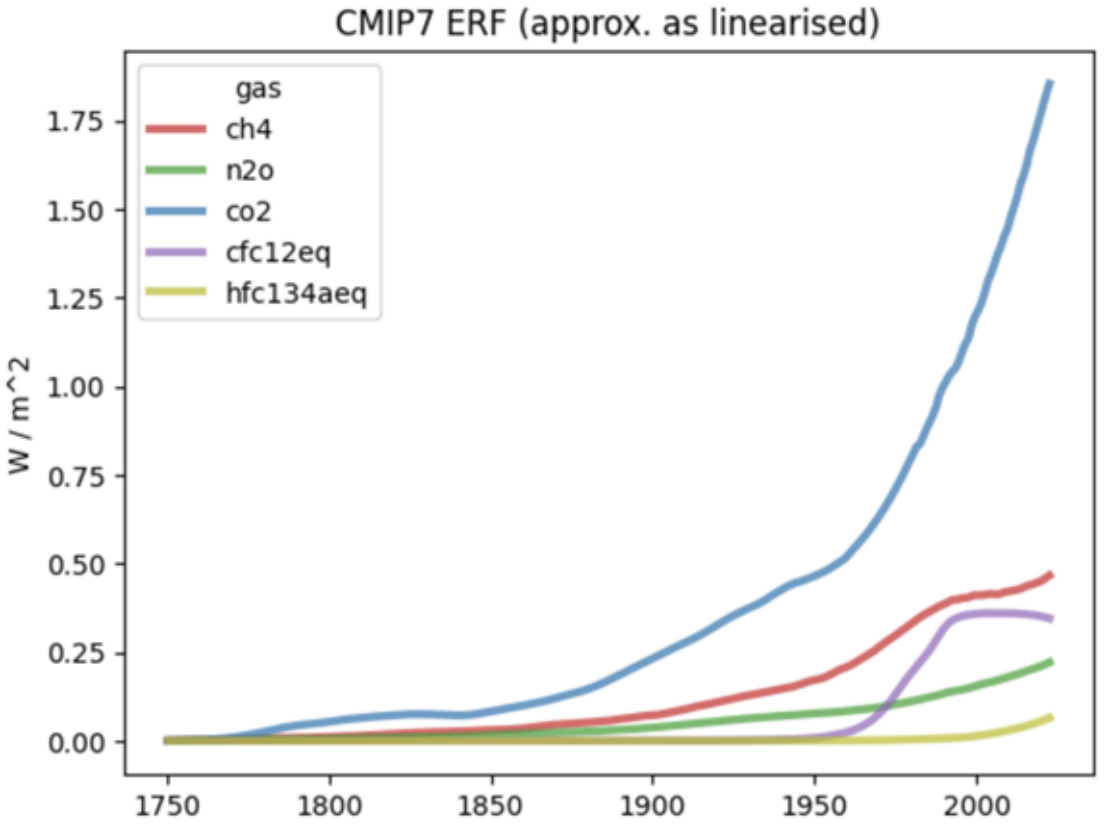
# CMIP GHG Concentrations objectives

- ITT: ESA-EOP-SC-CM-2024-30, “GHG Forcing for CMIP”
- Goals:
  - Delivering updated GHG concentration forcing datasets for CMIP7
  - Incorporating satellite XCO2 and XCH4 data into the production of GHG concentration forcing datasets for CMIP
  - Developing a roadmap for sustainable operationalisation of GHG concentration forcing datasets to drive earth system models – including using EO information for other gases (N2O, F-Gases)
- Timeframe:
  - Delivered first updated dataset in 2025
  - Incorporation of EO data, next update and roadmap in 2026
- Connections:
  - Coordinating with WCRP’s CMIP Climate Forcings Task Team
  - CMIP feeds into climate science and policy at all stages (e.g. IPCC assessment reports)
  - Also involved in CMIP REF (rapid evaluation framework) (e.g. via HE FUTURA project), ECMWF scenario forcings delivery

# Context – Forcings for ESMs

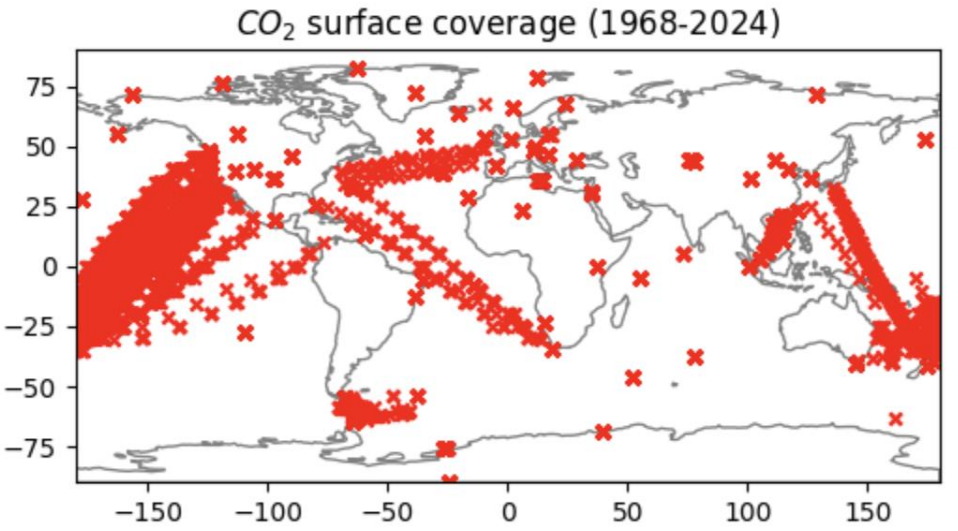


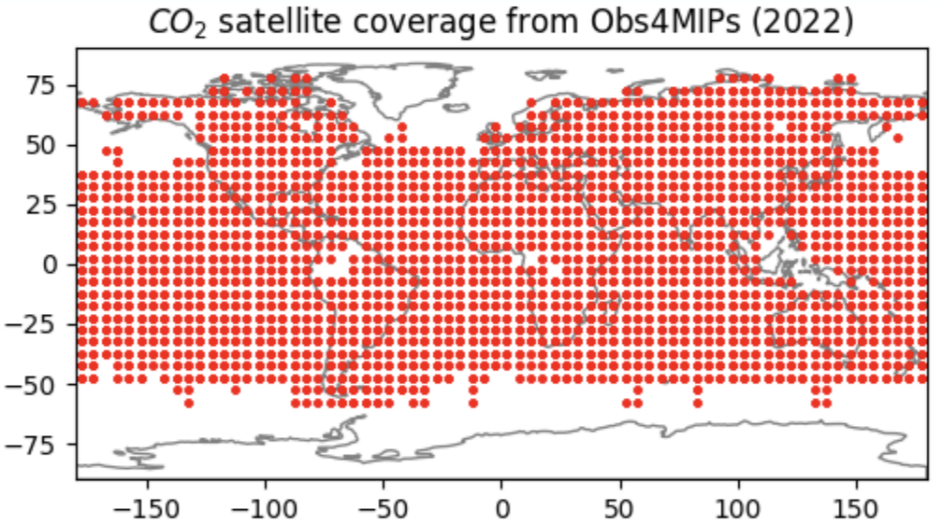

Note: shown here is effective radiative forcing to make gases comparable; model input are concentrations

- Forcings – model input / boundary conditions for earth system models
- Key forcings: Concentrations of GHGs, CO2 most important
- Datasets:
  - global-, annual-means
  - monthly-, latitudinally resolved (only interesting for gases with strong gradients, e.g. CH4)
- Need a complete dataset from 1750
- No single method (surface flask measurements, ice cores, EO, etc.) can provide this
- Composite product
- Before project: EO not used; existing ground-based network partly under pressure (US)

# Approach for incorporating EO results

- Other methods have limited spatial and temporal resolution
- Need interpolation, extrapolation, numerical modelling to arrive at full dataset
- EO attractive due to high spatial and temporal resolution
- EO Limitations:
  - Only recent past
  - Provides column totals; we need surface concentrations
  - Relatively large uncertainties
  - “Gaps” in coverage
- Preliminary plan: use EO data to improve longitudinal, temporal estimates
- Basis for future research



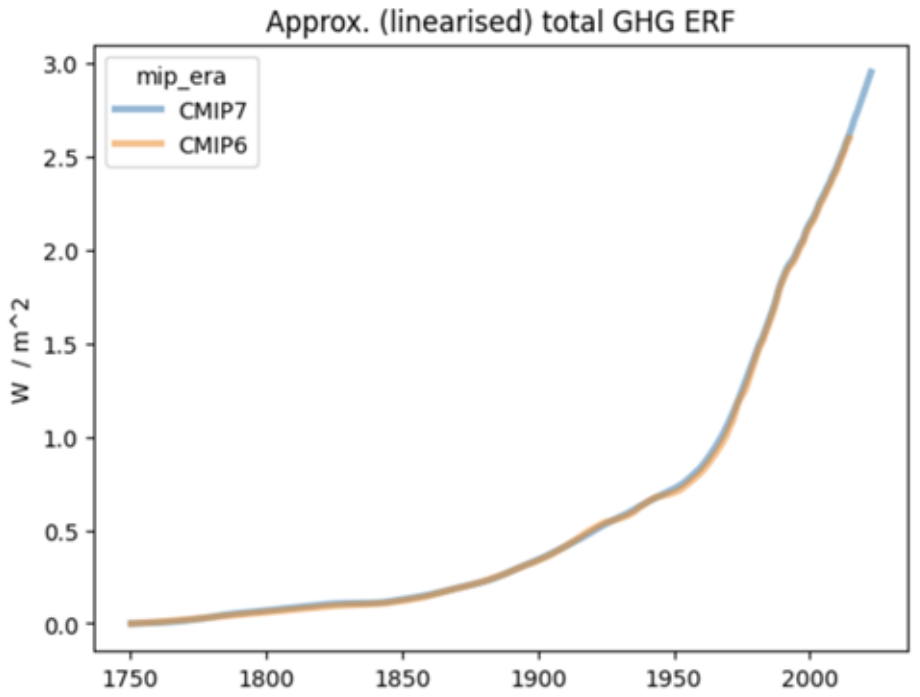



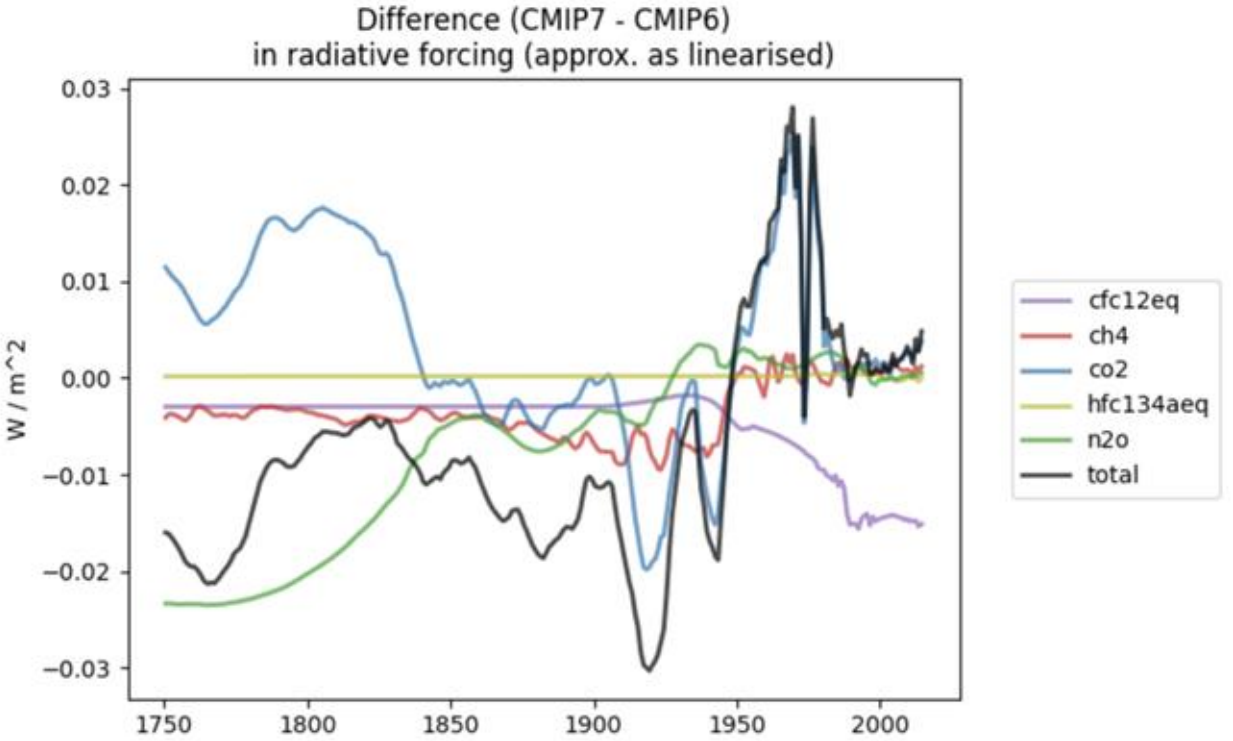
# ECVs being used

- We use obs4MIPs XCO2 and XCH4 L3 datasets based on EMMA L2 datasets
  - Original intended use: ESM model evaluation
  - Familiar file formats
  - Already gridded, time averaged by satellite experts
  - Great to work with
- Could always use smaller uncertainties, retrieval of vertical profile (no idea how hard these would be)
- However, remaining GHG concentration uncertainties are small - leading uncertainties for ESM model output are elsewhere (e.g. biomass burning emissions)
- Orthogonal idea:
  - Are there observables derived from satellite measurements which are better suited as ESM model input than surface concentrations?
  - Historically, surface concentrations were the only available input, so models use these as input.

# Results & relevance to the CCI community

- “Pre-satellite” results for CMIP7 – small changes




- Data available on ESGF, user guides available as jupyter notebooks for historical and scenario forcings