# Actual Context – Anthropogenic Impacts on Climate

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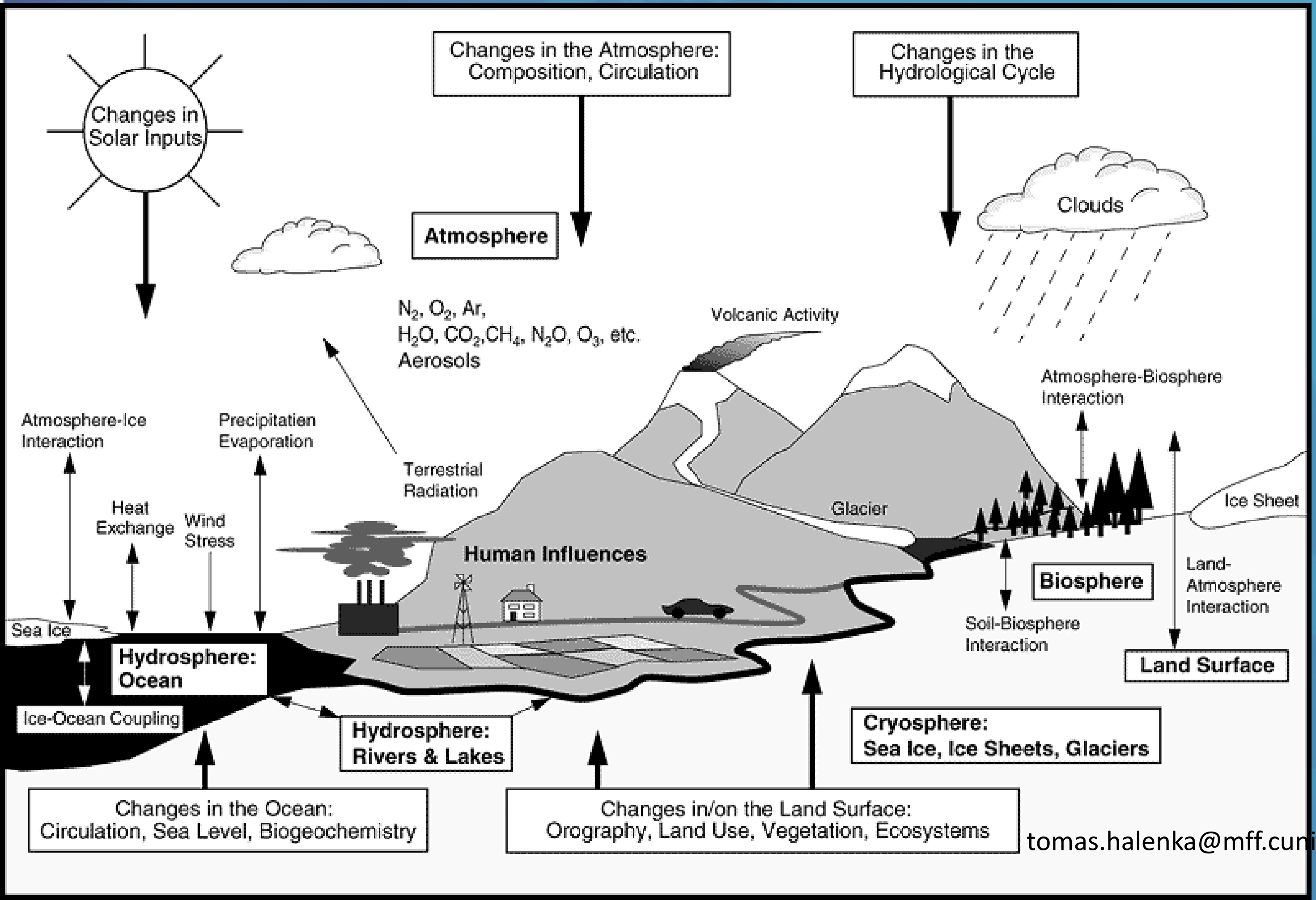
# Socio-economic aspects in global (climate) change

## Anthropogenic impacts on climate and climate impacts on human, ecosystems




Anthropogenic impacts → Climate change → Climate impacts

# Scenarios concept

**Socioeconomic scenarios** → **GHG scenarios** → **Climate change scenarios**

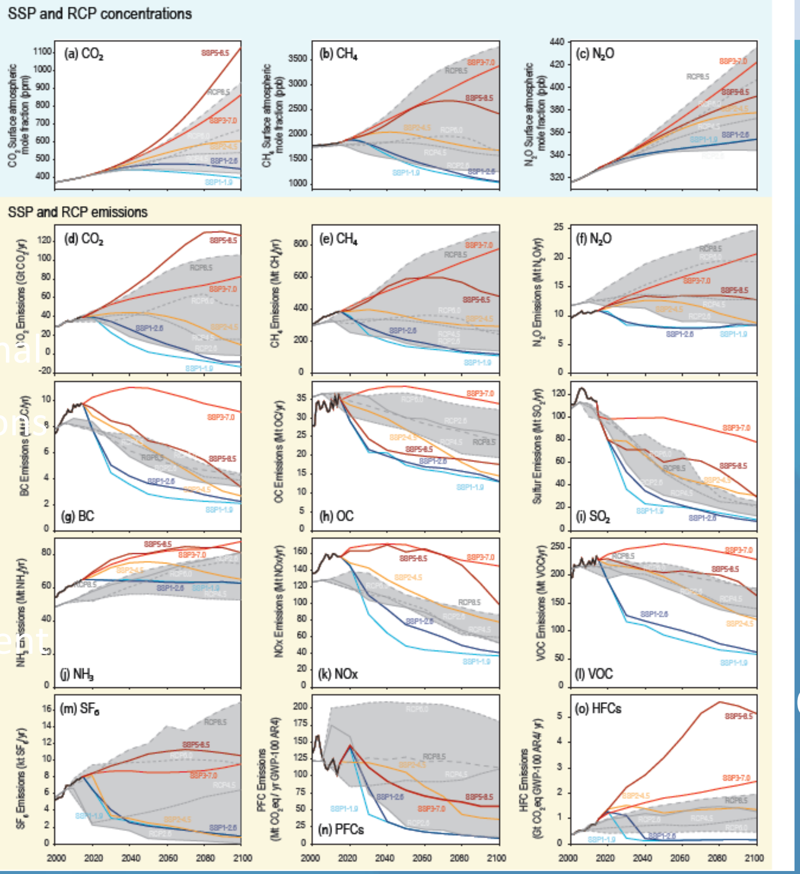
original IS92 scenarios of IPCC - SRES

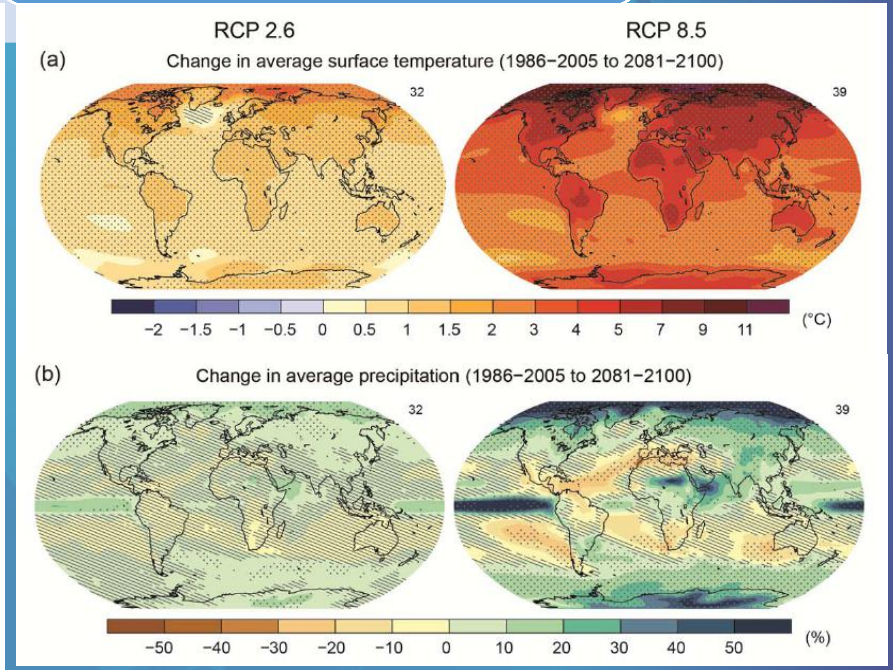
not resolving problems of environment

| | | |
|---|---|---|
| Global solutions | **A1** | **A2** | 
| | **B1** | **B2** |

Global solutions — Regional solutions

Accent on resolving problems of environment




or downscaled, storylines, etc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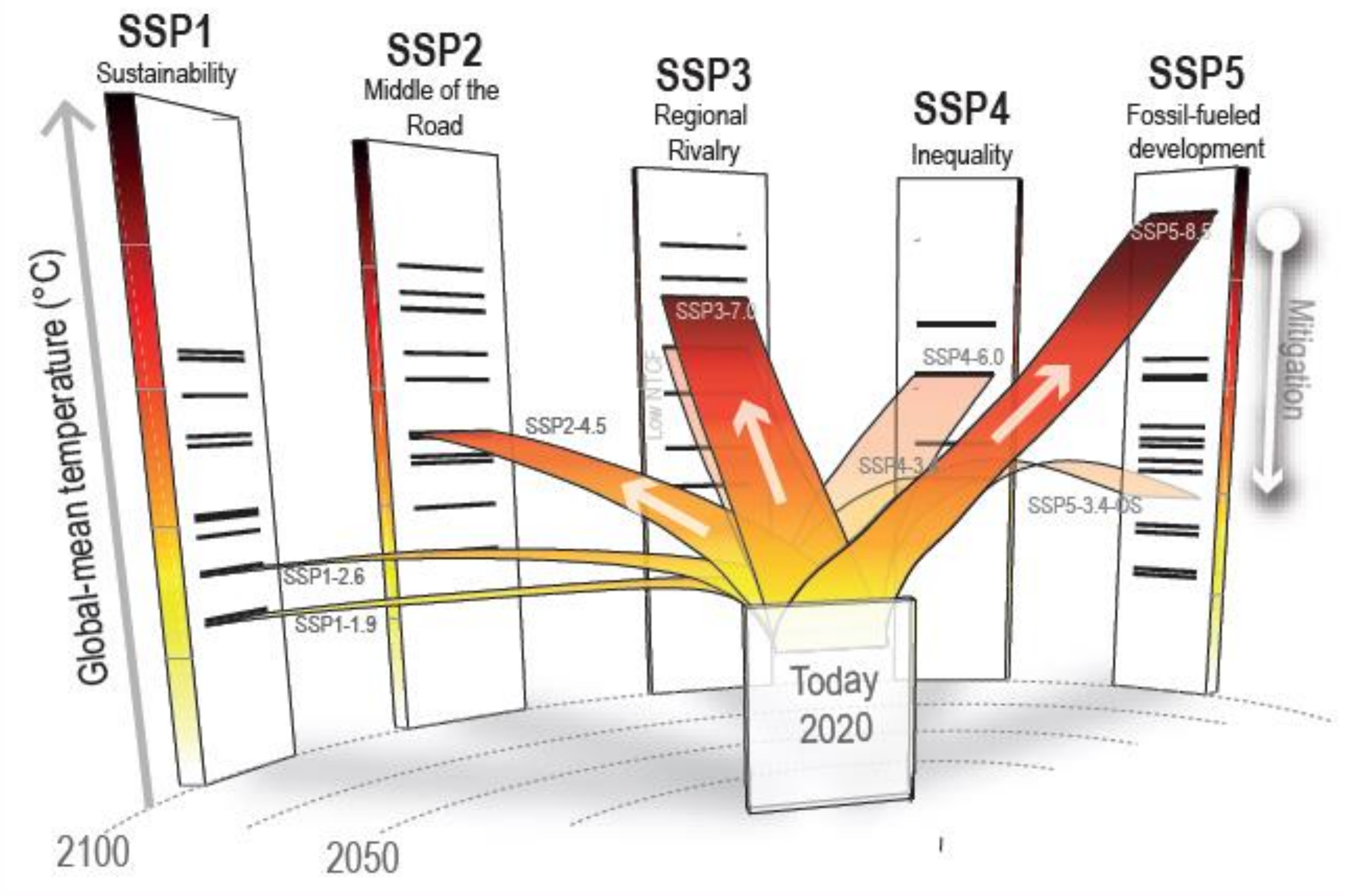
# SSPs (Shared Socioeconomic Pathways) scenarios

Returning back to classifying the scenarios by the socioeconomic development (SRES) but keeping the advantage of RCPs


The indicative temperature evolution is shown (adapted from Meinshausen et al., 2020). The black stripes on the respective scenario family panels indicate a larger set of IAM-based SSP scenarios that span the scenario range more fully, but are not used in this report.

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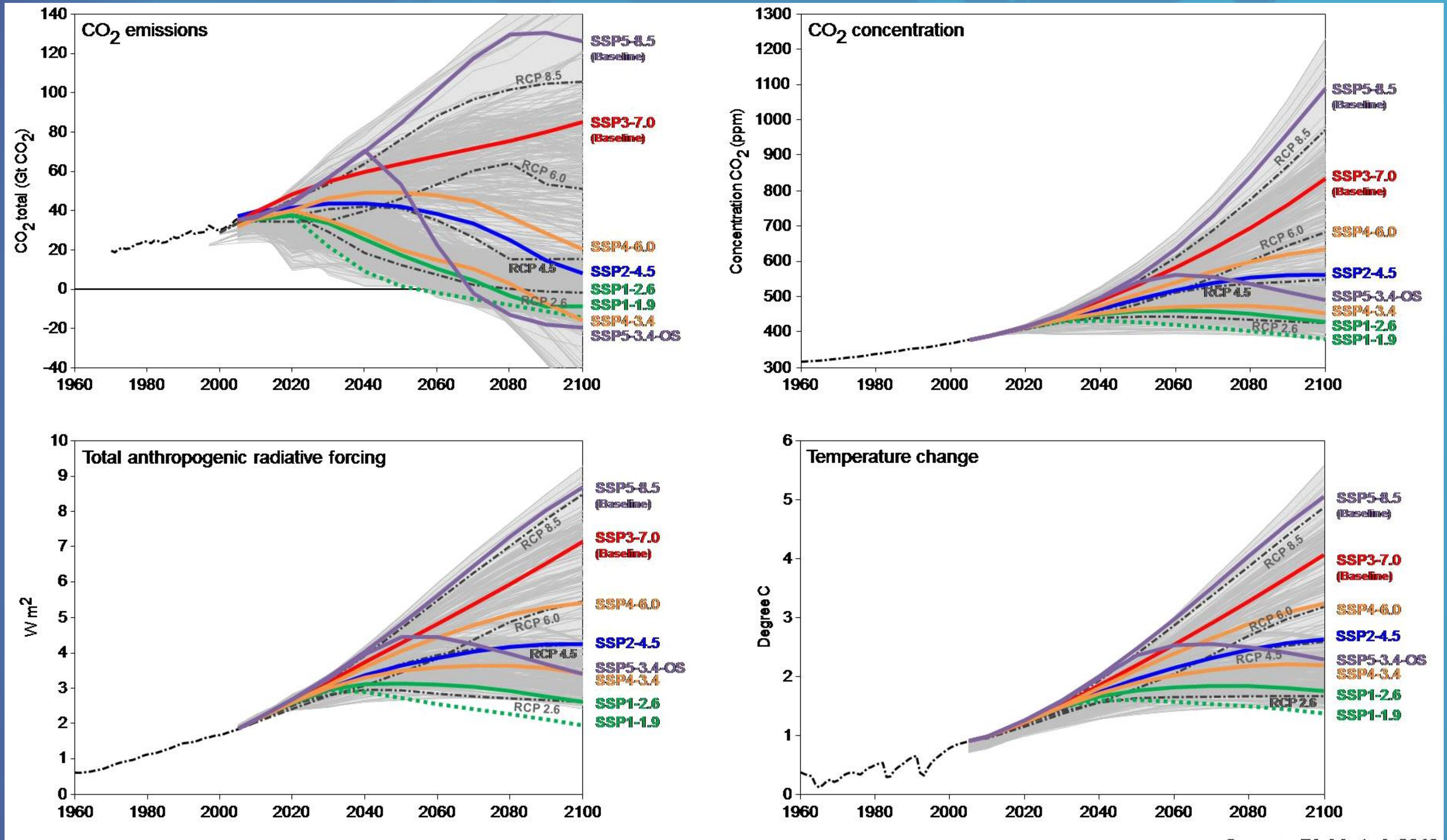
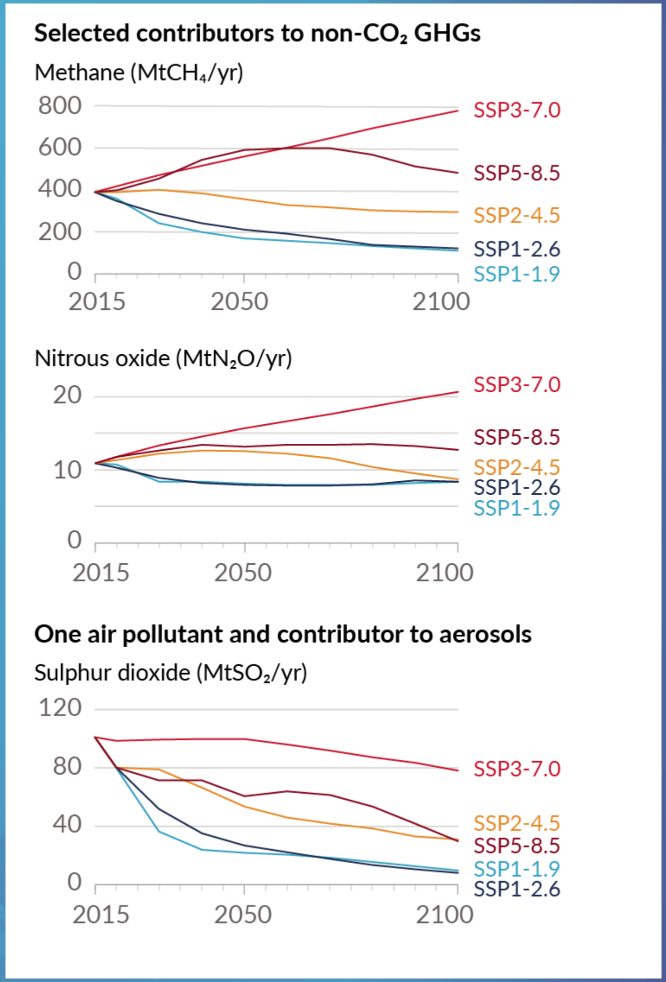
# SSP scenarios




Source: Riahi et al, 2016

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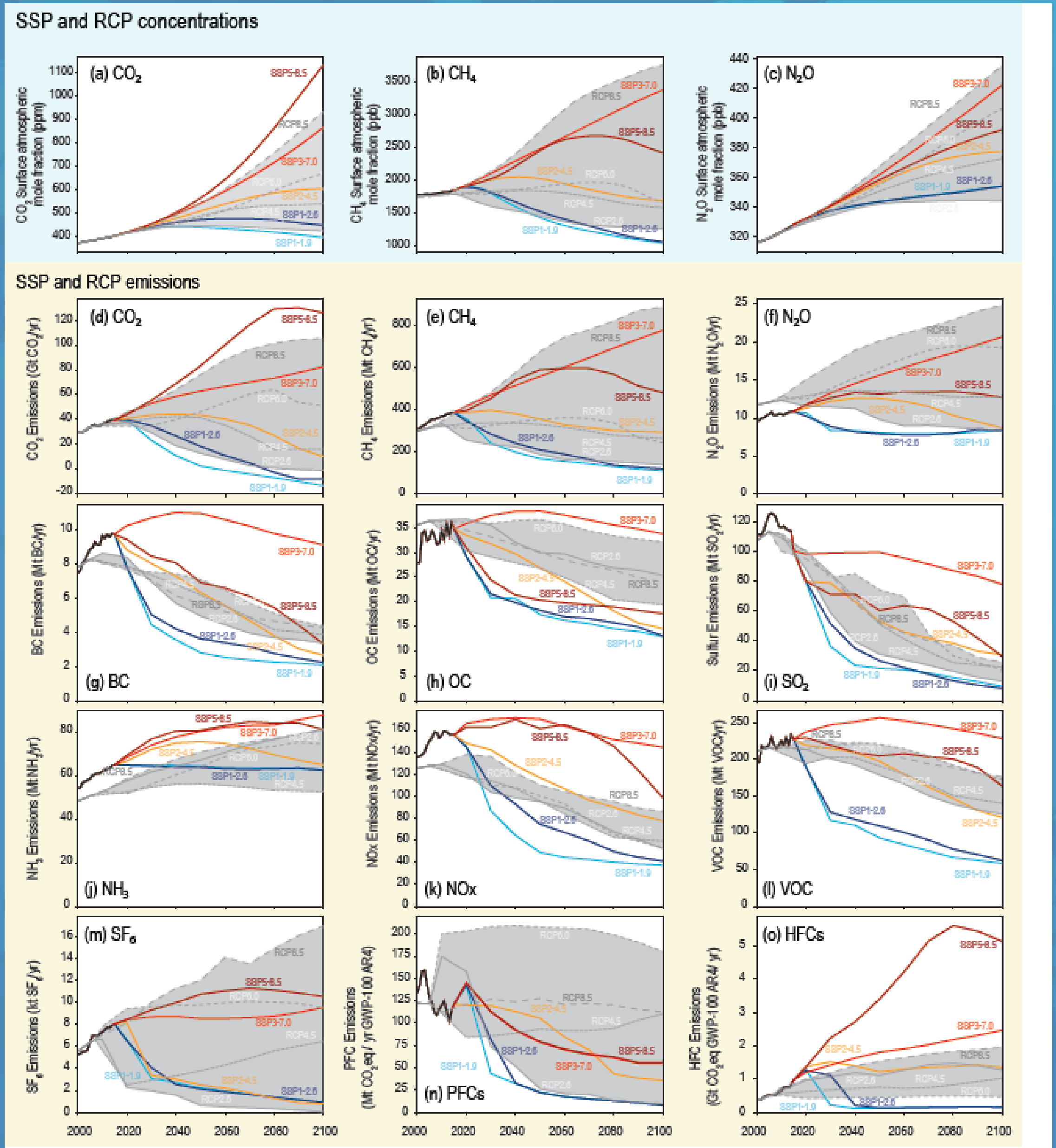
# SSP scenarios

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# FOCI Motivation

1. Horizon Europe Call HORIZON-CL5-2021-D1-01-01 Improved understanding of greenhouse gas fluxes and radiative forcers, including carbon dioxide removal technologies
   a) greenhouse gas fluxes and Earth system feedbacks (GreenFeedBack)
   b) global warming contribution of different, non-CO2 radiative forcers (FOCI)
   c) climate and Earth system responses to climate neutrality and net negative emissions (RESCUE)
2. IPCC AR6 WGI: Well mixed CO2, and its impacts on global to continental scales well understood with a high level of confidence, however, there are knowledge gaps concerning the impact of many other non-CO2 radiative forcers leading to low confidence in the conclusions:
   a) anthropogenic and natural precursor emissions of short-lived GHGs, aerosols effects
   b) subsequent effects on atmospheric chemistry and climate, through direct emissions dependent on changes in e.g., agriculture and technologies based on scenarios for future development as well as feedbacks of global warming on emissions, e.g., permafrost thaw
   c) albedo changes connected to land-use and land-cover can play a role, depending on the adaptation or mitigation measures included in different scenarios.
3. Strong group based around air quality modelling (R. Sokhi), with some contacts to ESM groups

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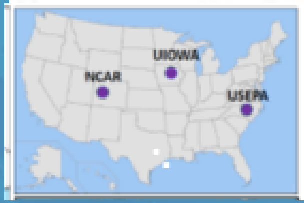
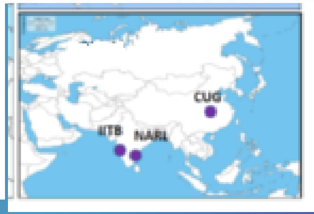
# FOCI - Non-CO2 Forcers and their Climate, Weather, Air Quality and Health Impacts

FOCI

Partners: 17 (14+3), cooperating institutes over the world

| | |
|---|---|
| Charles University (CU) - cooerdinator | Czech Republic |
| Max Planck Institute – Chemistry (MPI-C) | Germany |
| Finnish Meteorological Institute (FMI) | Finland |
| University of Hamburg (UHam) | Germany |
| Consejo Superior de Investigaciones Científicas (CSIC) | Spain |
| Koninklijk Nederlands Meteorologisch Instituut (KNMI) | The Netherlands |
| Barcelona Supercomputing Center (BSC) | Spain |
| World Meteorological Organization (WMO) | International |
| University of Helsinki (UHel) | Finland |
| Tel Aviv University (TAU) | Israel |
| European Centre for Medium-Range Weather Forecasts (ECMWF) | International |
| World Health Organisation (WHO) | International |
| ARIANET (R&D Industrial partner) | Italy |
| Stockholm University (SU) | Sweden |
| University of Hertfordshire (UH) – co-coordinator | UK |
| Stockholm Environment Institute, University of York (SEI) | UK |
| World Energy and Meteorology Council (WEMC) – SME | UK |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Budget: nearly 8 M€

Duration: September 2022 – August 2026

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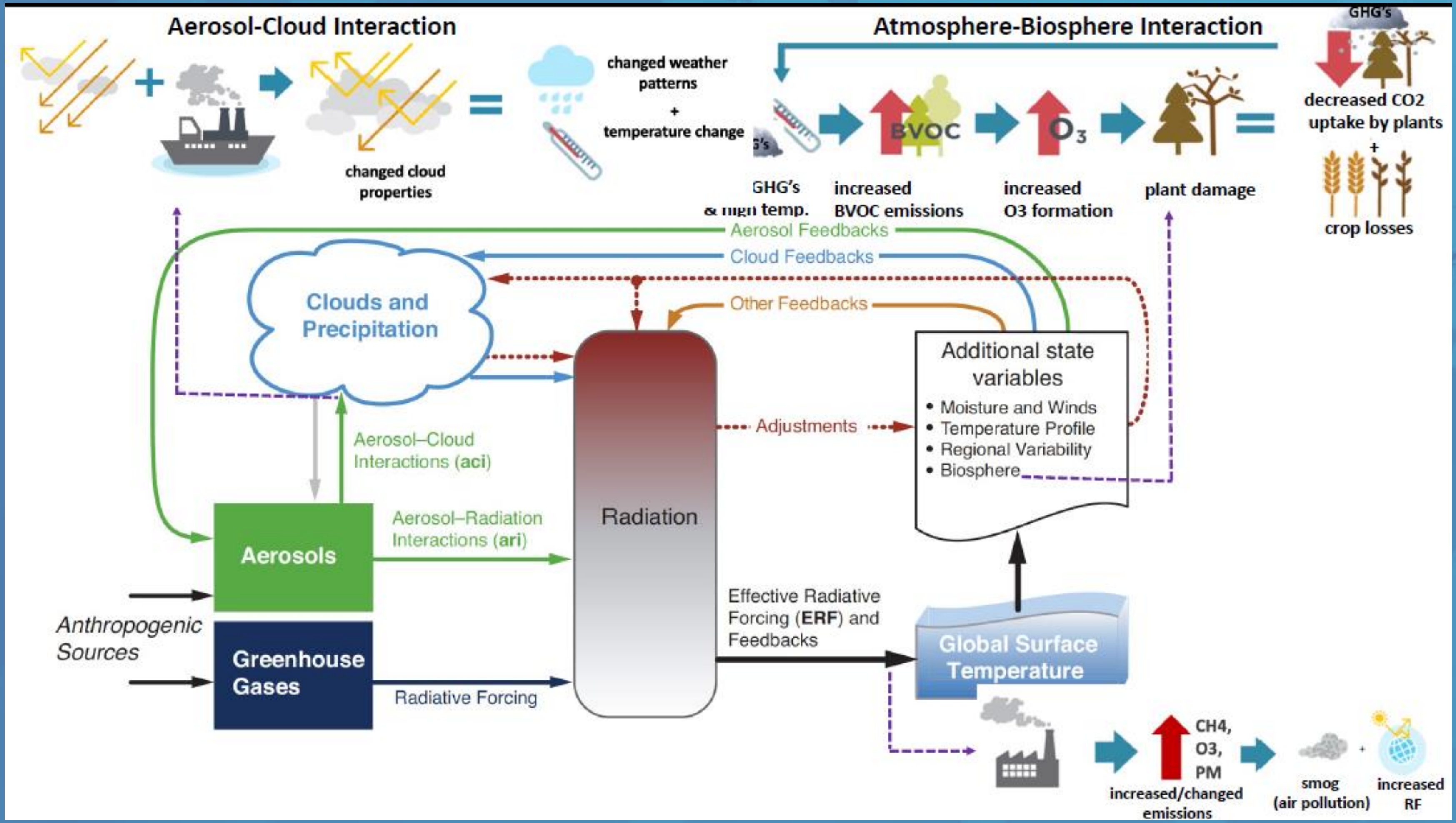
# Need of full ESM with chemistry




adapted from IPCC AR5, 2013

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# FOCI Aims

FOCI

**The overall aim of FOCI is to improve our knowledge of individual and cumulative contribution of non-$CO_2$ radiative forcers and their precursors.**

Main goals are

- To assess the key **non-$CO_2$** radiative forcers, where and how they arise, the processes of their impact on the climate system.
- To find and test an efficient implementation of these processes into global Earth System Models and into Regional Climate Models, eventually coupled with CTMs, and finally to use the tools developed to investigate mitigation and/or adaptation policies incorporated in selected scenarios of future development targeted at Europe and other regions of the world.
- To target specifically species with the greatest uncertainty in determining their impact on climate change and the associated influence on weather patterns (e.g., atmospheric and ocean circulation and extreme weather events), air pollution episodes and health impacts.
- To focus in integrated observational and modelling analysis on the radiative forcing properties of $PM_{2.5}$/$PM_{10}$, CCN and their components (e.g., POA, SOA, BC/EC, SIA, dust), $O_3$ (and its precursors $NO_x$, VOCs, $SO_2$, carbon monoxide (CO)), $CH_4$, and $N_2O$ in the context of the warming potential of all key GHGs.

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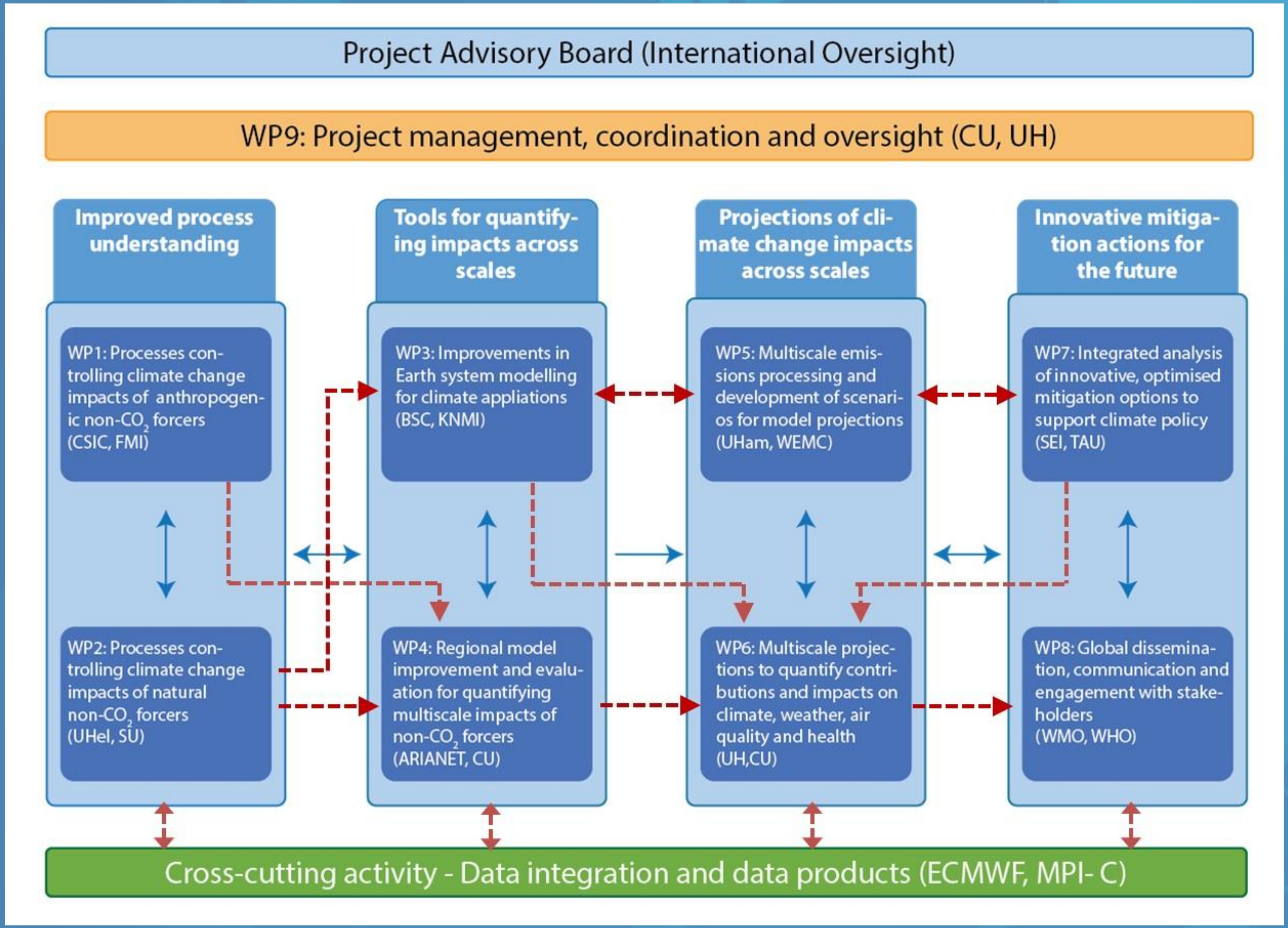
# FOCI scheme

FOCI

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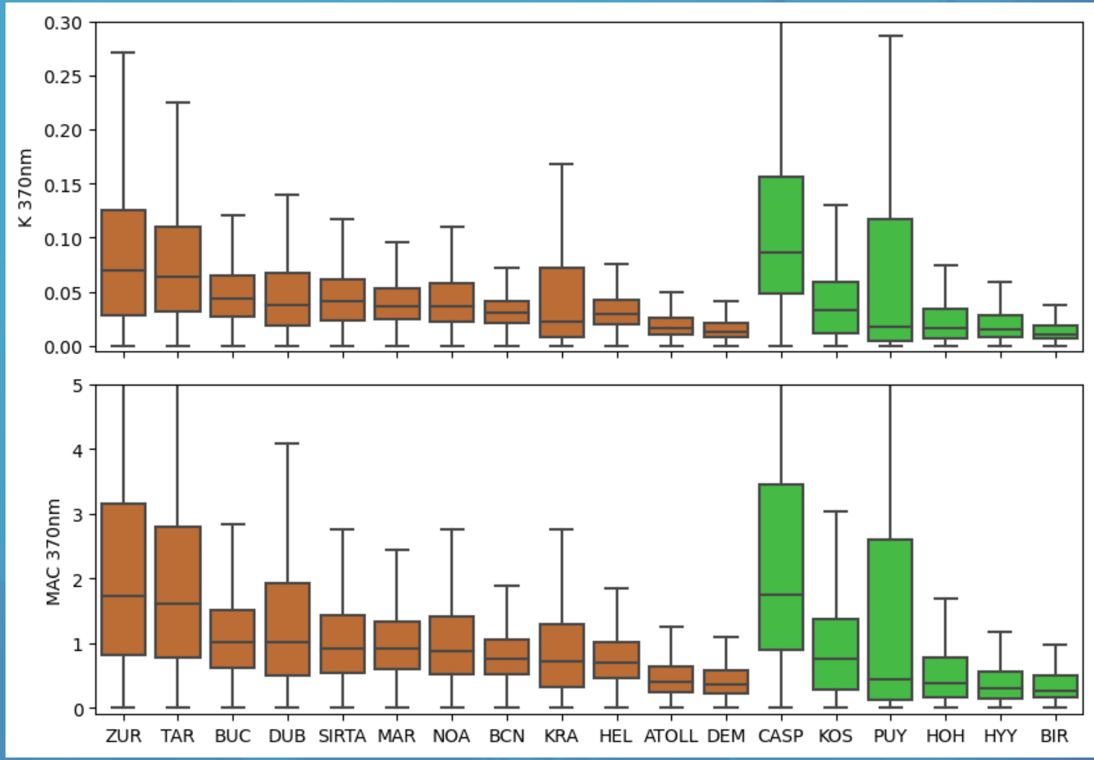
# First results – WP1

## GHOST database

- Integration of aerosol information from different sources (in-situ, remote, satellite)
- Follow with the analyses of properties, especially optical, but other important onesimportant for climate forcers

Imaginary refractive index (k) and mass absorption cross section (MAC) of OA particles at 370 nm for a subset of measuring stations.

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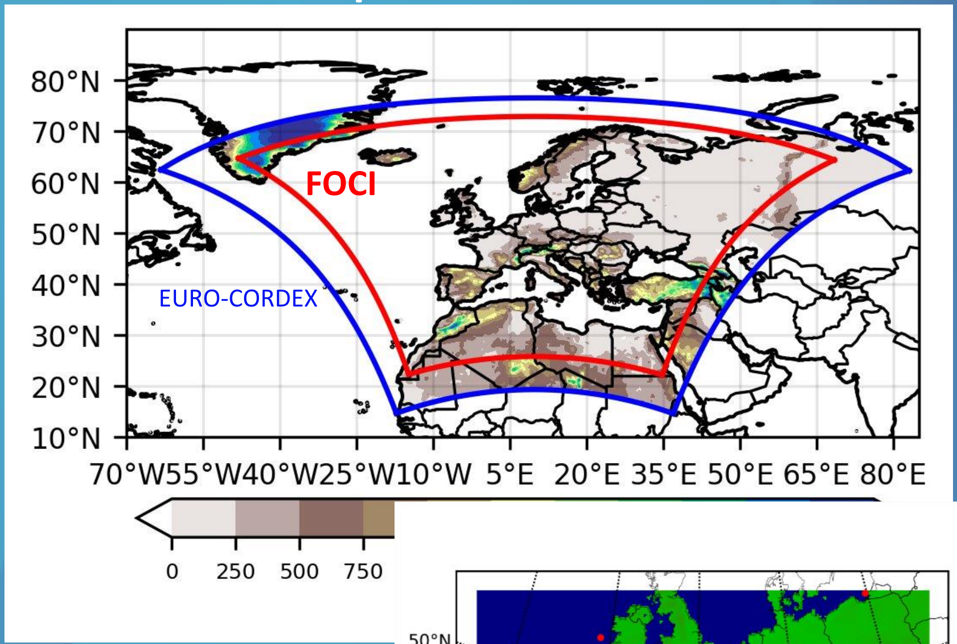
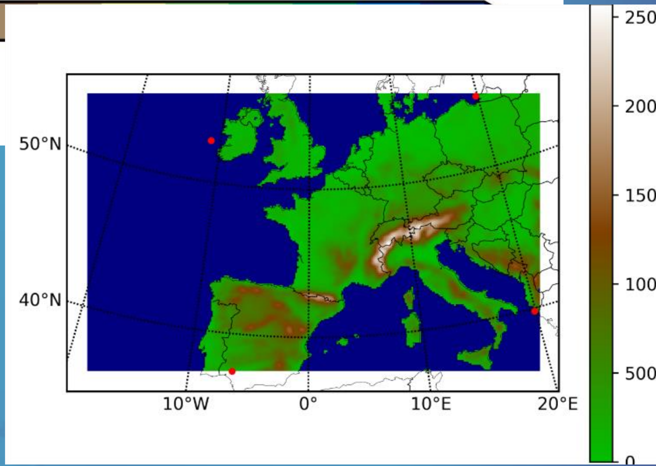
# First results – WP4

## Coupled multiscale modelling framework

- EC-Earth ESM, with chemistry, providing CMIP6 outputs for driving regional simulations
- WRF-Chem and the fifth generation of the Regional Climate Model System RegCM5 (Giorgi et al., 2023, with chemistry) are used for both climate and climate-chemistry mode simulations.
- Multiple nesting: full EuroCORDEX Europe domain (about 27km resolution), intermediate domains – larger Central/Western Europe (9-12km), local urban scale in CP mode (e.g. Prague, London, Milan) at 3km resolution
- Evaluation: ERA5 driving, with CAMS emissions
- Historical: EC-Earth driven downscaling with CEDS emissions
- Scenarios: selected SSPsC and variations
- Periods: evaluation 2004-2019, historical 2004-2014, future 10 years time intervals

**FOCI European domain**

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# First results – WP4

CAMS **European air quality reanalyses**

**RegCM-chem**

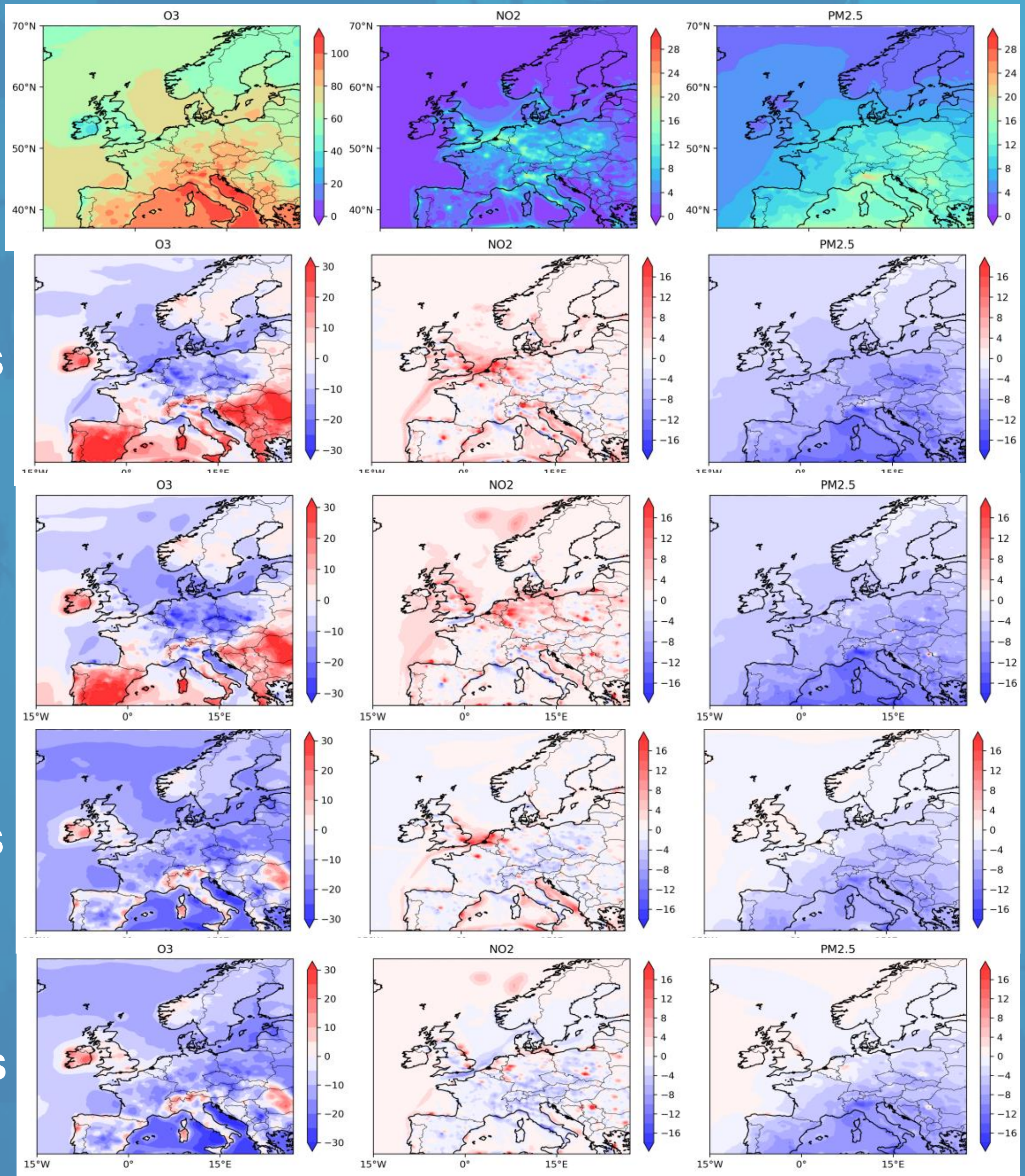
**WRF-chem**

**CAMS**

**CEDS**

**CAMS**

**CEDS**




Biases of species – CAMS/CEDS emissions (JJA 2015)

**Underestimation of particulate matter (PM)**

**Relatively good representation of NO2**

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Unit: ug/m$^3$

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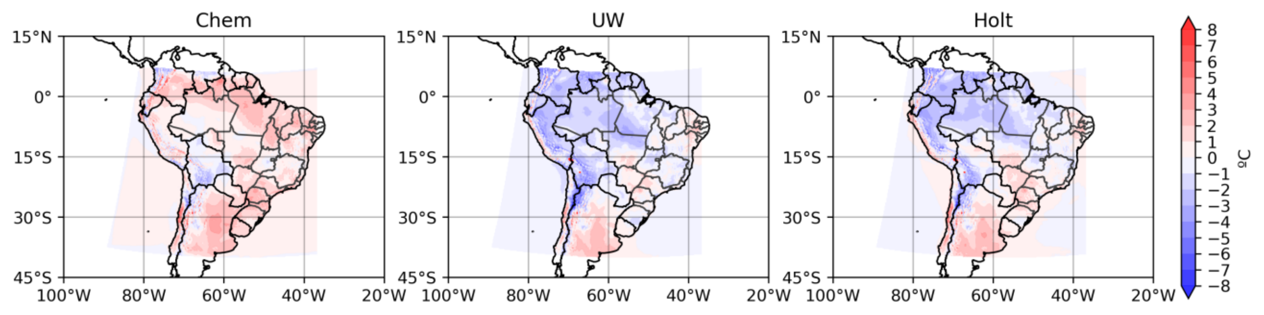
# First results – WP4

## Preliminary tests for South America

- The fifth generation of the Regional Climate Model System (RegCM5; Giorgi et al., 2023) is used for both climate and climate-chemistry mode simulations.
- Driven boundary conditions: atmospheric variables - ERA5 (Hersbach et al., 2020); assimilated chemistry - Copernicus Atmosphere Monitoring Service (CAMS; Inness et al., 2019)
- Period: the whole year of 2010
- Reference dataset for the evaluation: the Multi-Source Weighted-Ensemble Precipitation (MSWEP; Beck et al., 2019) and Multi-Source Weather (MSWX) (Beck et al., 2022)

| Experiment | Dynamical core, Microphysics, Convection, Radiation, Surface scheme, nº of grid points (i,j,k) | PBL | Chemistry |
|---|---|---|---|
| Reg-chem | MOLOCH, NoTo, Tiedke, CCM3, CLM4.5, 235 x 261 x 31 | Holtslag | DCCB: Activate CBMZ (gas phase and sulfate) +DUST (4 dust bins scheme) +CARB (4 species black/anthropic carbon simulations) |
| Reg-Holt | | | - |
| Reg-UW | | UW | - |

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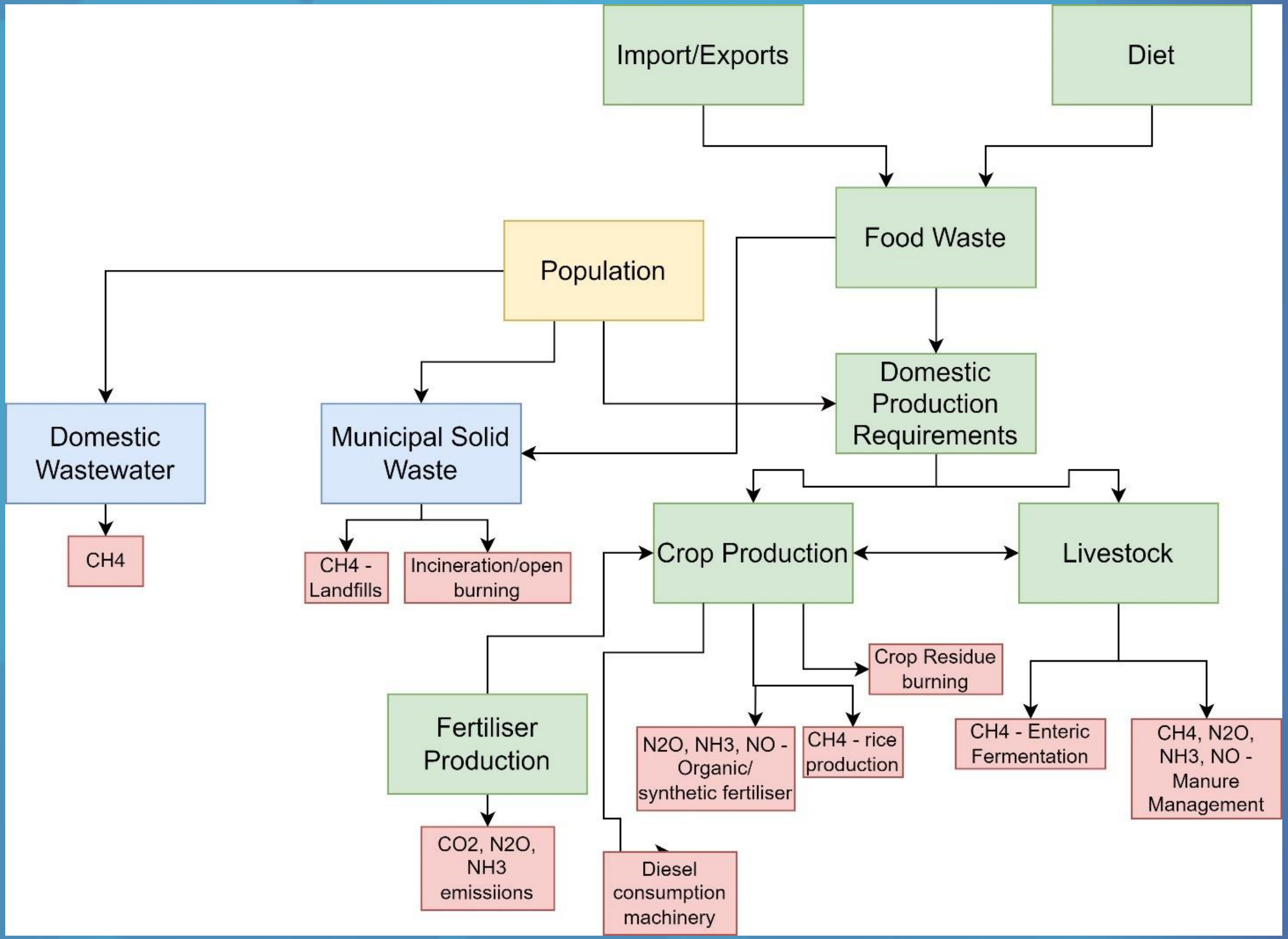
# WP5 results

Modelling framework to estimate historic and future emissions from the agriculture and waste sectors

- Green boxes - modules within the agriculture model,
- blue boxes - waste sector modules
- red boxes - emission sources from the agriculture and waste sectors quantified in the modelling framework.

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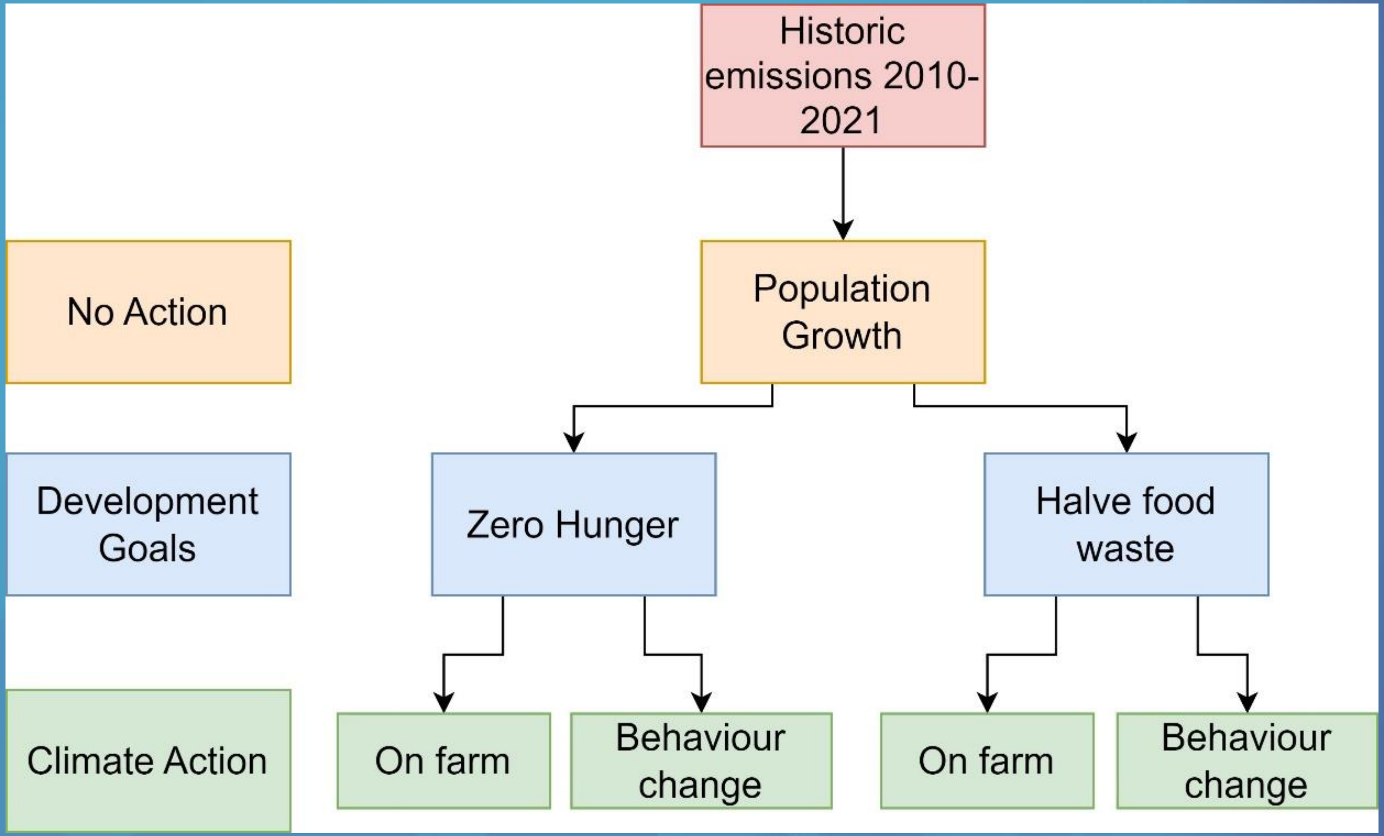
# Framework for future scenario development for agriculture and waste sector emissions

Assumptions used to project activity variables into the future for the baseline scenario for each source sector.

| Source Sector | Activity Data | Baseline scenario projection | Source of data |
|---|---|---|---|
| **4A Solid Waste Disposal on Land** | Per Capita waste generation rates<br>Waste Composition<br>Waste collection rates<br>Treatment of waste<br>Urban/Rural population | Generation of waste increases with population change | UN Population Projections |
| **4D Liquid Waste** | Wastewater treatment systems | Generation of waste increases with population change | UN Population Projections |

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# Summary, conclusions

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- Not yet final results
- Preliminary indication of effects of chemistry-climate interaction on radiation and temperature
- Expected especially in local scales – urban effects

Prague 2026 AIR QUALITY

**International Air Quality Conference – Science and Applications to be held in Prague, 1-5 June 2026**

AQ26

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# Wish us good luck!

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THANKS FOR YOUR ATTENTION !


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