

Project FOCI

Non-CO₂ Forcers and their Climate, Weather, Air Quality and Health Impacts: Modelling of Chemistry-Climate Interactions Over Scales

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Natália Machado-Crespo (CU), and FOCI team



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Motivation



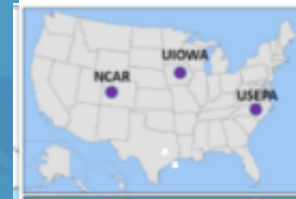
1. Horizon Europe Call HORIZON-CL5-2021-D1-01-01 Improved understanding of greenhouse gas fluxes and radiative forcers, including carbon dioxide removal technologies
 - a) greenhouse gas fluxes and Earth system feedbacks (GreenFeedBack)
 - b) global warming contribution of different, non-CO2 radiative 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

FOCI basic info



Title: Non-CO2 Forcers and their Climate, Weather, Air Quality and Health Impacts
 Partners: 17 (14+3), cooperating institutes over the world

Charles University (CU) - coordinator	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



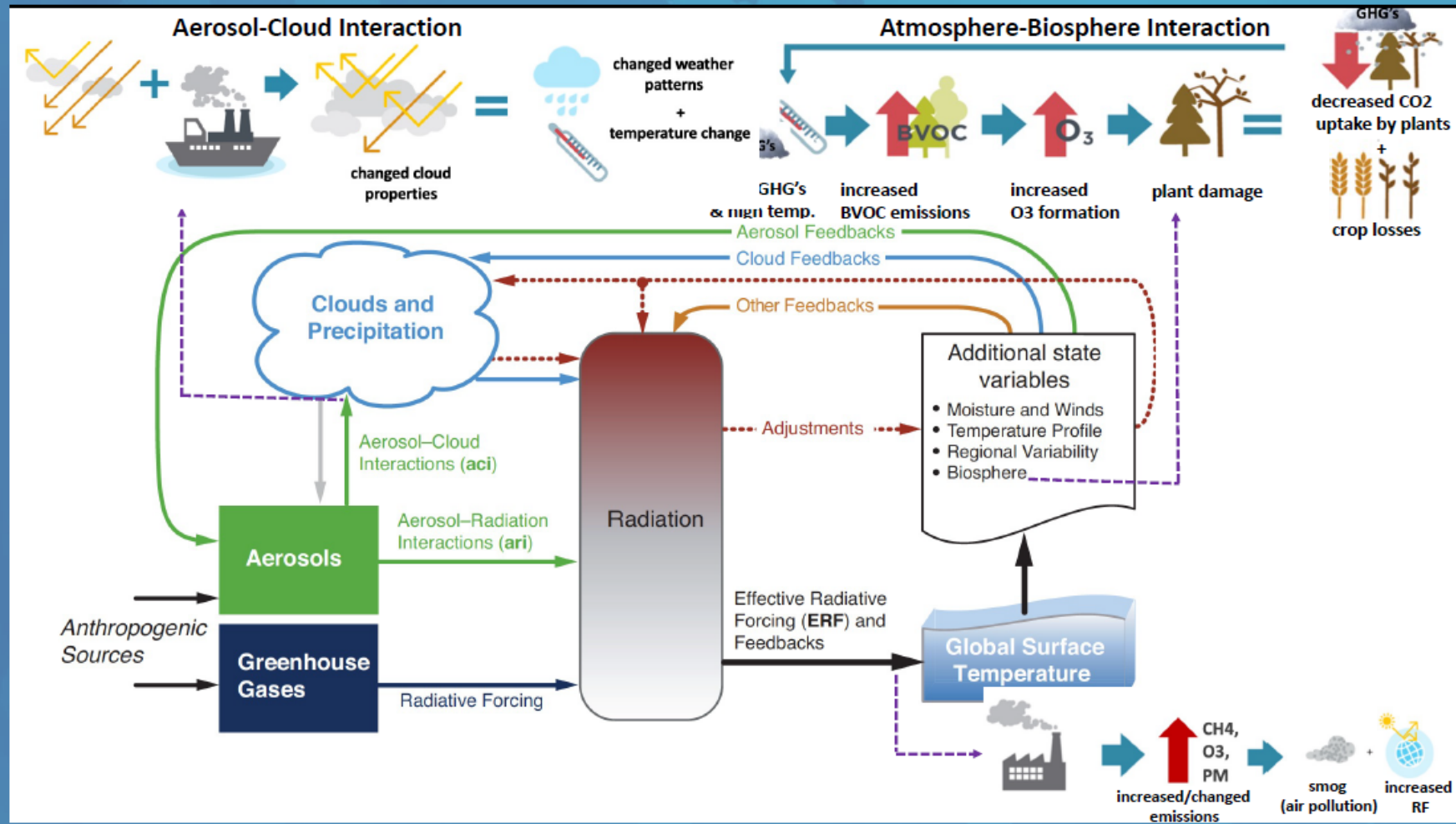
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Budget: nearly 8 M€
 Duration: September 2022 – August 2026



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Need of full ESM with chemistry



adapted from IPCC AR5, 2013



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FOCI Aims



The overall aim of FOCI is to improve our knowledge of individual and cumulative contribution of non-CO₂ radiative forcers and their precursors.

Main goals are

- To assess the key **non-CO₂** 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}/PM₁₀, CCN and their components (e.g., POA, SOA, BC/EC, SIA, dust), O₃ (and its precursors NO_x, VOCs, SO₂, carbon monoxide (CO)), CH₄, and N₂O in the context of the warming potential of all key GHGs.

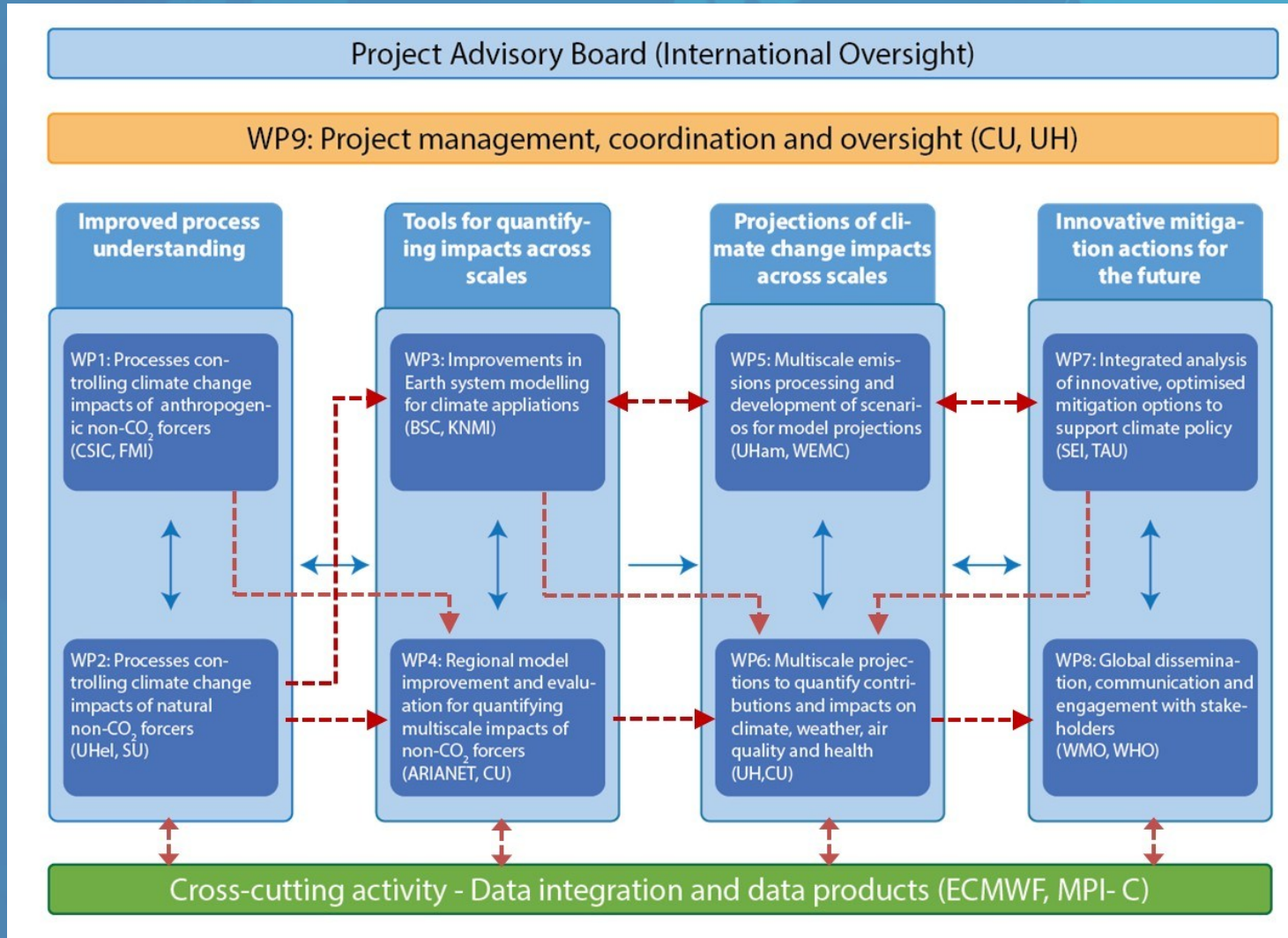


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FOCI scheme



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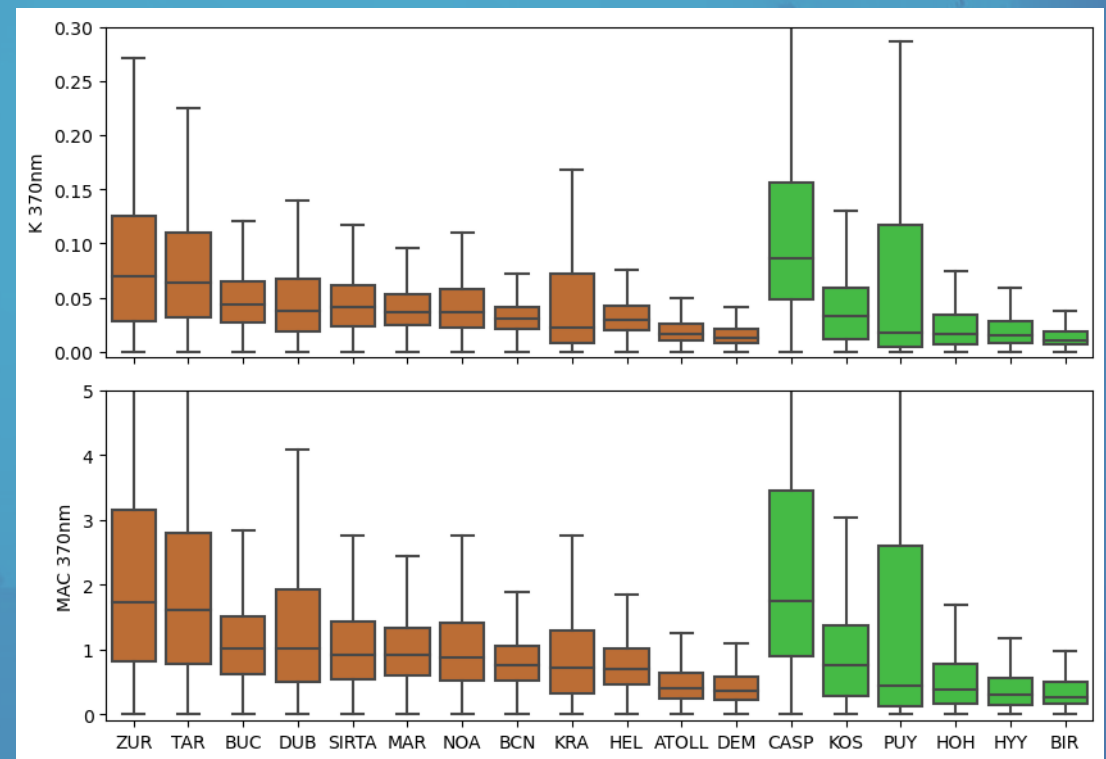
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First results – WP1

GHOST database

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

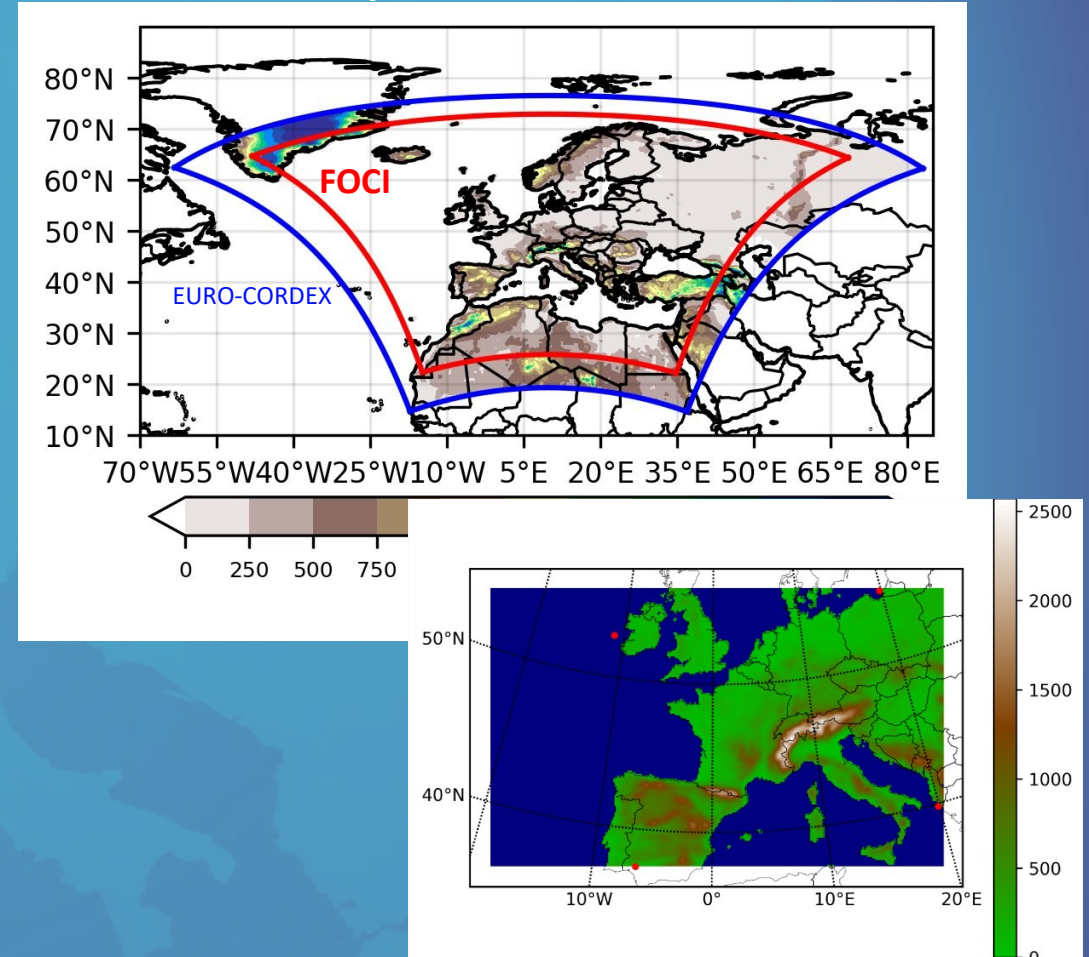


First results – WP4

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



First results – WP4

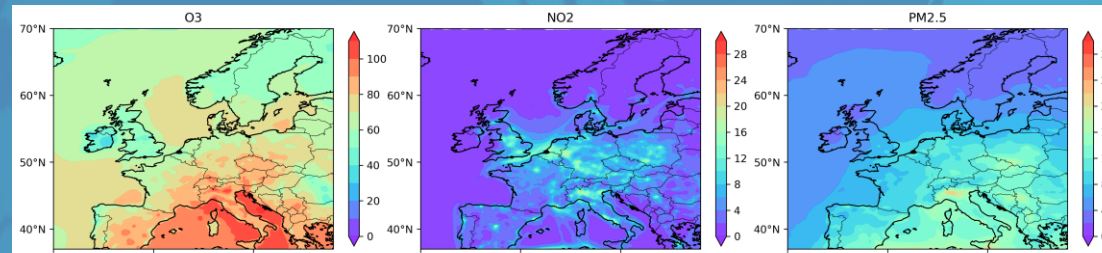


Biases of species –
CAMS/CEDS emissions
(JJA 2015)

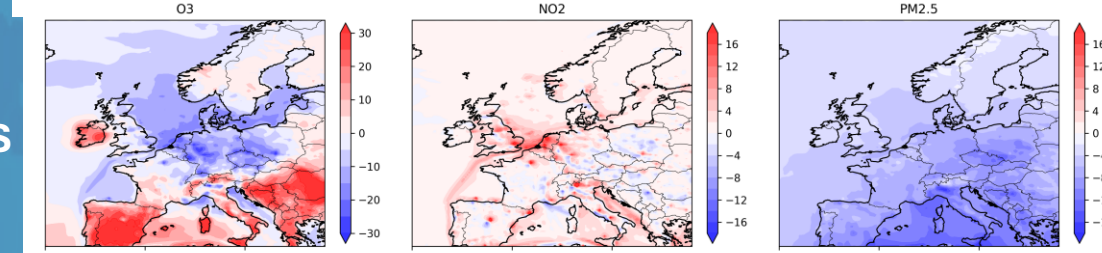
Underestimation of
particulate matter (PM)

Relatively good
representation of NO2

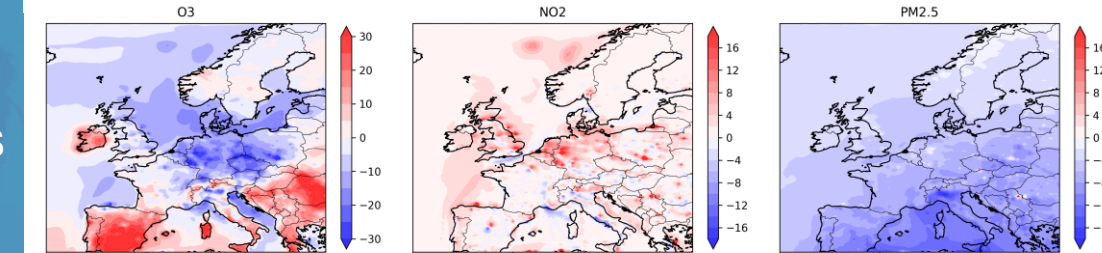
CAMS European air
quality reanalyses



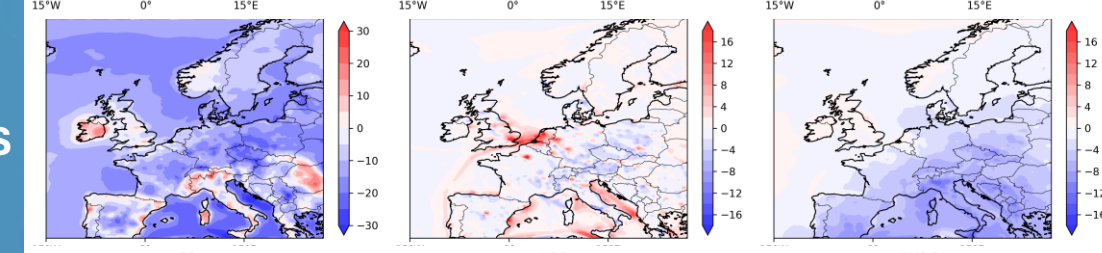
CAMS



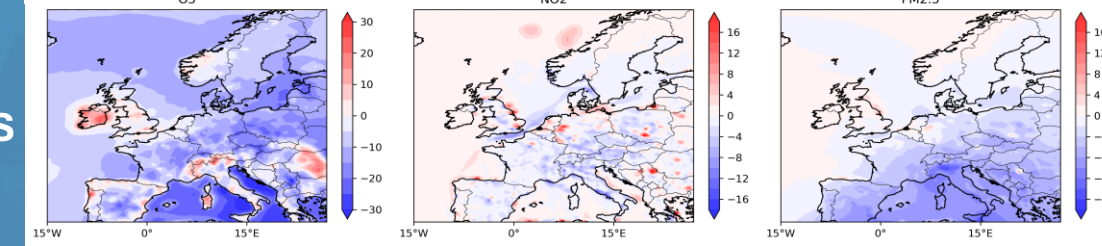
CEDS



CAMS



CEDS



RegCM-chem

WRF-chem



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Unit: $\mu\text{g}/\text{m}^3$



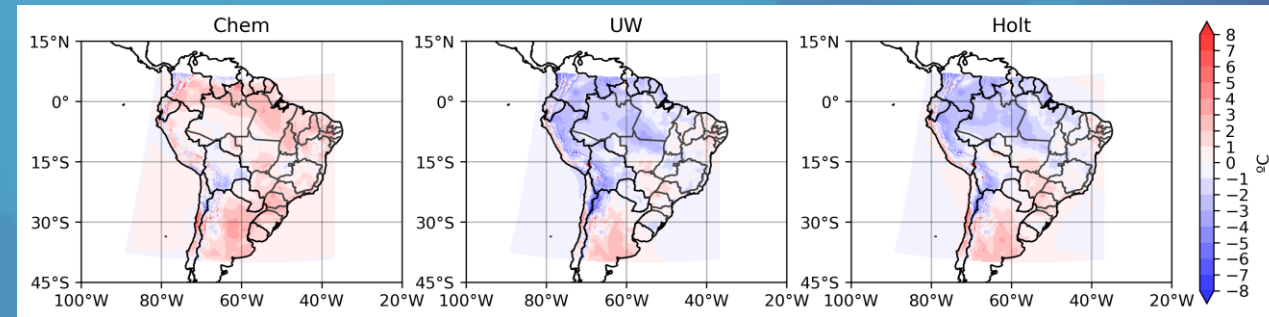
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First results – WP4

Preliminary tests for South America

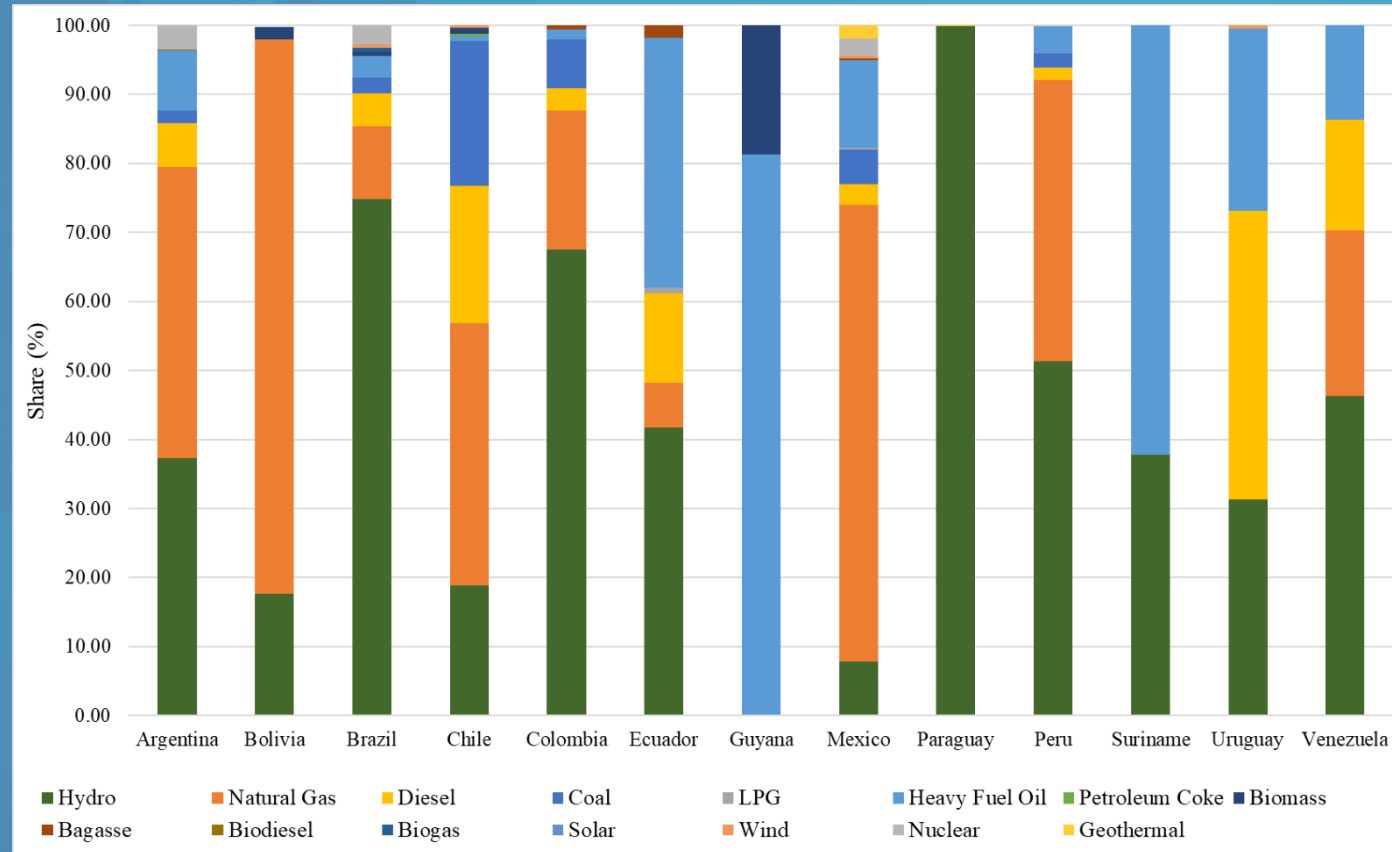
- The fifth generation of the Regional Climate Model System (RegCM5; Giorgi et al., 2023) is used for both climate and climate-chemistry mode simulations.
- Driven boundary conditions: atmospheric variables - ERA5 (Hersbach et al., 2020); assimilated chemistry - Copernicus Atmosphere Monitoring Service (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, n° 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	-



First results – WP5 and WP6 plans

Electricity generation mix by country by 2021 for South America



WP6 progress

Regional EuroCORDEX 27km, regional
12km, local (urban) CP in 3km

	ERA5, CAMS, EC-EARTH3 AerChem
2004-2019	ERA5
2004-2019	ERA5/CAMS
2004-2014	historical
2015-2019	SSP 3-7.0
2045-2055	SSP 3-7.0
2045-2055	SSP 3-7.0-low-NTCF



Summary, conclusions

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



AIR QUALITY

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



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Wish us good luck!

FOCI



THANKS FOR YOUR ATTENTION !

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