Atmospheric Composition

Variations in atmospheric pollutants such as ozone and aerosols affect air quality, weather and climate. The Atmospheric Composition group aims to better understand and predict the spatiotemporal variations of atmospheric pollutants along with their effects upon air quality, weather and climate. We address this goal through the development and use of the Multiscale Nonhydrostatic Atmosphere Chemistry model (NMMB-MONARCH). The group is the research backbone of the well-known CALIOPE system, which provides high-resolution short-term air quality forecasts for Europe, with a special focus on Spain and its main urban areas using the in-house HERMES emission model. The group is also the research backbone of the WMO Regional Specialized Meteorological Center for Atmospheric Sand and Dust Forecast, the Barcelona Dust Forecast Center.

Our models and forecasts are enhanced by an intensive use of up-to-date observations, both for model evaluation and to feed our aerosol ensemble-based data assimilation system. Our research focuses on urban air quality, and atmospheric chemistry and aerosols from regional to global scales, with an emphasis on mineral dust. Since October 2016, the group hosts an AXA Chair on Sand and Dust Storms. This 15-year research programme is not only intended to support the WMO Regional Center based at BSC, but also to widen the scope and relevance of the mineral dust research in the group.

We interact closely with the Computational Earth Sciences group on the optimization of model codes, pre- and post-processing tools, and operational model settings, with the Climate Prediction group on the links between atmospheric aerosols and climate, mainly in the framework of the EC-Earth model, and with the Earth System Services group to enhance the use of our forecasts products in key socio-economics sectors.

Objectives
Atmospheric chemistry research and model developments

- Refinement of model schemes (e.g. on-line natural emissions, dry and wet deposition, aerosol size distributions, optical properties, convective transport, stratospheric boundary conditions).
- Development and implementation of currently missing species and processes (e.g. marine POA, anthropogenic OA, dust mineralogy, heterogeneous chemistry, cold pools for dust emission).
- Enhancement of the HERMES emission model by integrating global and regional emission inventories, implementing new sources, pollutants and methodologies.

Observations, evaluation and data assimilation

- Development of a standardized model evaluation procedure including data from satellites, and lidar, Sun-photometer and in-situ networks, both for gaseous and aerosol species, as well as meteorological parameters, and covering multiple time scales, from days to months.
- Enhancement of the ensemble-based data assimilation system for aerosols using data from both satellite and ground-based (i.e. lidar and Sun-photometer networks) instruments, including adequate validation and comparison with other analyses, and development of a real-time capability to initialise the operational air quality forecasts.

Forecast systems and reanalysis

- Delivery of global air quality forecasts at ~50 km resolution with nested regional domains at ~10 km resolution (Northern Africa, Europe and Middle East) and ~ 4 km resolution (Spain).
- Generation of aerosol forecast and reanalysis products using ensemble-based data assimilation.

Air quality in urban areas: enhanced modeling approaches, emissions, source attribution and impacts

- Combination of air quality mesoscale simulations with street canyon models to accurately reproduce the dispersion of pollutants along streets in urban environments.
- Use of crowd-sourced data (floating car data) and microscale models (PTV Vissim + EnViVer) to improve the estimation of urban traffic emissions at the street level.
- Determination of the origin of air pollution problems through source apportionment and source sensitivity techniques.
- Assessment of the impact of air pollutants on human health over urban areas, in collaboration with health specialists.

AXA Chair on Sand and Dust Storms

- Expand our understanding of dust sources, emission, transport, and variability across multiple time scales
- Better understand and quantify dust effects upon weather, climate, atmospheric chemistry and ocean biogeochemistry
- Improve and develop dust forecasts, predictions and reanalysis datasets
- Assess and mitigate dust impacts on key sectors of society and economy
- Promote capacity building, technology transfer, dissemination and public engagement.

Barcelona Supercomputing Center - Centro Nacional de Supercomputación