

- 1) Development of the in-house **NMMB/BSC-CTM**, an online **multi-scale non-hydrostatic chemical weather prediction system** that can be run either globally or regionally.
- 2) **Model evaluation** including data from satellites, and lidar, Sun-photometer and in-situ networks, both for gaseous and aerosol species, covering multiple time-scales.
- 3) Development of an **ensemble-based data assimilation** system for aerosols using data from satellites and ground-based observations.
- 4) Development of the in-house **emission model HERMES** for Spain and other selected regions
- 5) **Air quality in urban areas**: enhancing modeling approaches, emissions, source attribution and impacts
- 6) Understanding aerosol processes and effects, with emphasis on **mineral dust**
- 7) Contribution to a variety of in-house and external **forecasting activities**:
 - **WMO Sand and Dust Storm Warning Advisory and Assessment System** Regional Center (WMO SDS-WAS RC) for Northern Africa, Middle East and Europe.
 - International Cooperative for Aerosol Prediction (**ICAP**).
 - **CALIOPE** air quality system (“CALidad del aire Operacional Para España”), which provides high-resolution air quality forecasts over Europe.

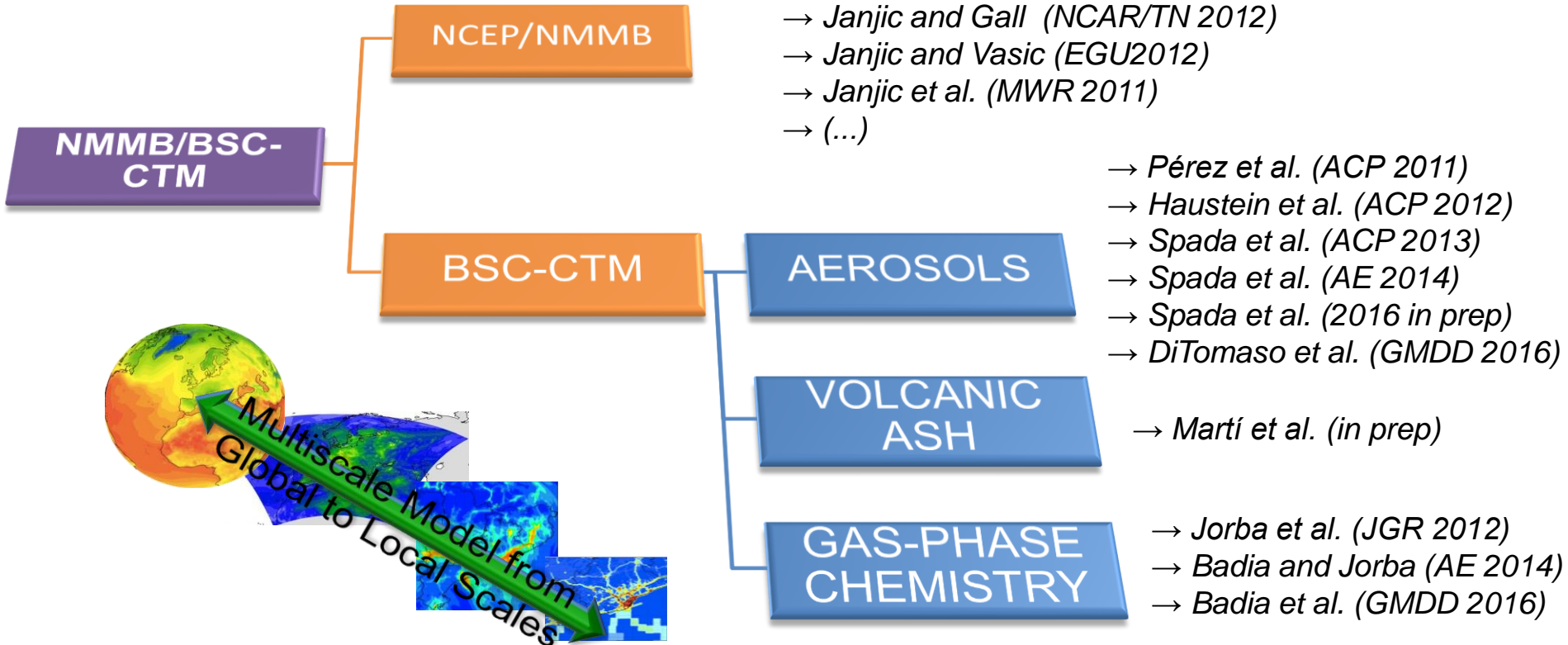
Development of the NMMB/BSC-CTM

Multiscale: global to regional scales allowed (nesting capabilities)

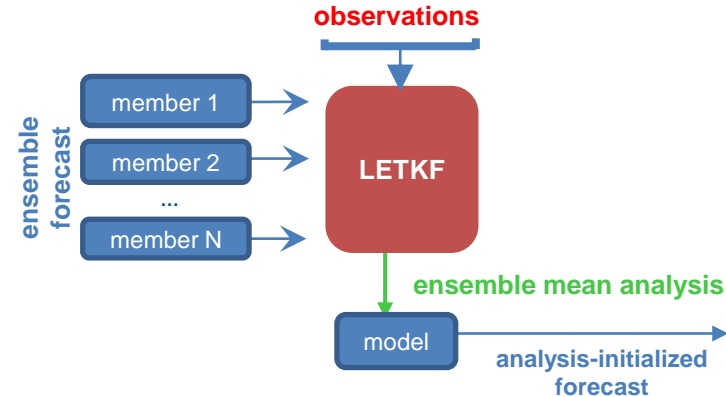
Non-hydrostatic dynamical core: single digit kilometre resolution allowed

On-line coupling: weather-chemistry feedback processes allowed

Ensemble-based data assimilation system for aerosols



NMMB/BSC-CTM coupled with a Local Ensemble Transform Kalman Filter (**LETKF**) for the assimilation of aerosol optical depth observations

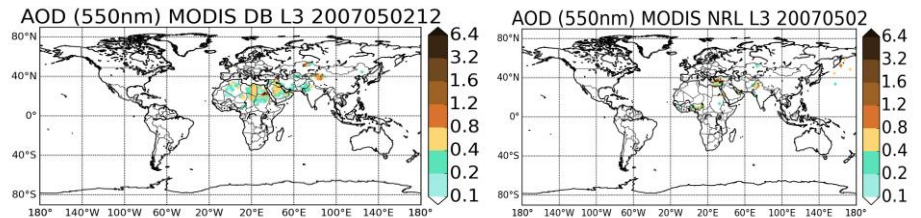


Mineral dust application

The ensemble forecast is based on uncertainties in the dust emission scheme

- vertical flux,
- size distribution at emission
- threshold on friction velocity

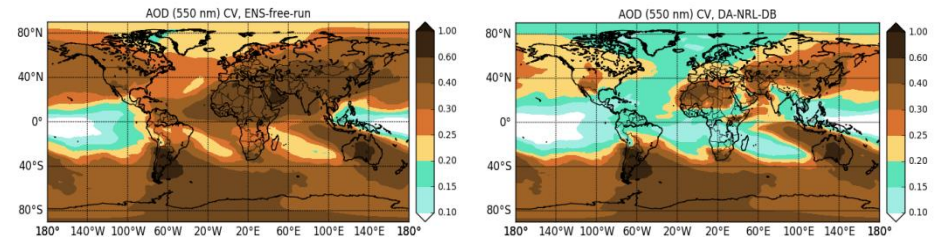
Assimilated satellite observations, filtered for dust



MODIS Deep Blue

MODIS Dark Target

Ensemble spread reduction where obs are present



Ensemble free run

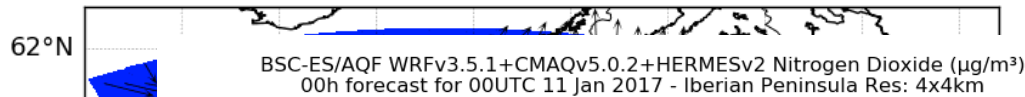
DA run

CALIOPE real-time air quality forecasts

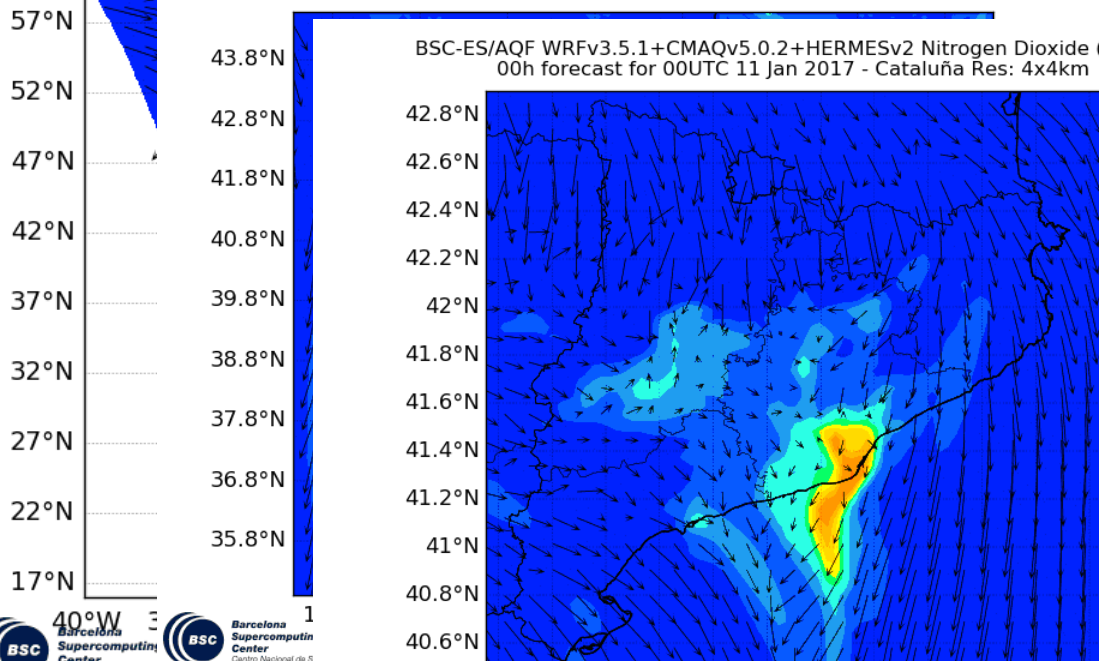


Provides air quality related information for the coming days and for the application of short term action plans for air quality managers.

BSC-ES/AQF WRFv3.5.1+CMAQv5.0.2+HERMESv2 Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)
00h forecast for 00UTC 11 Jan 2017 - Europe Res: 12x12km



BSC-ES/AQF WRFv3.5.1+CMAQv5.0.2+HERMESv2 Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)
00h forecast for 00UTC 11 Jan 2017 - Iberian Peninsula Res: 4x4km



0.14°E 44°E 74°E 04°E 34°E 64°E 94°E 24°E 54°E 84°E 14°E 44°E

20 m/s

Information is delivered using both online or custom applications:

www.bsc.es/caliope

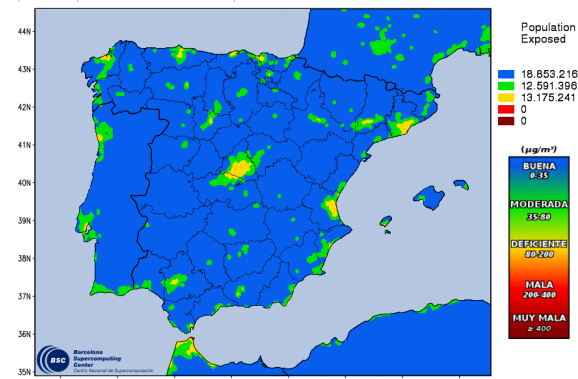


Smart city platform



Air quality index & population exposed

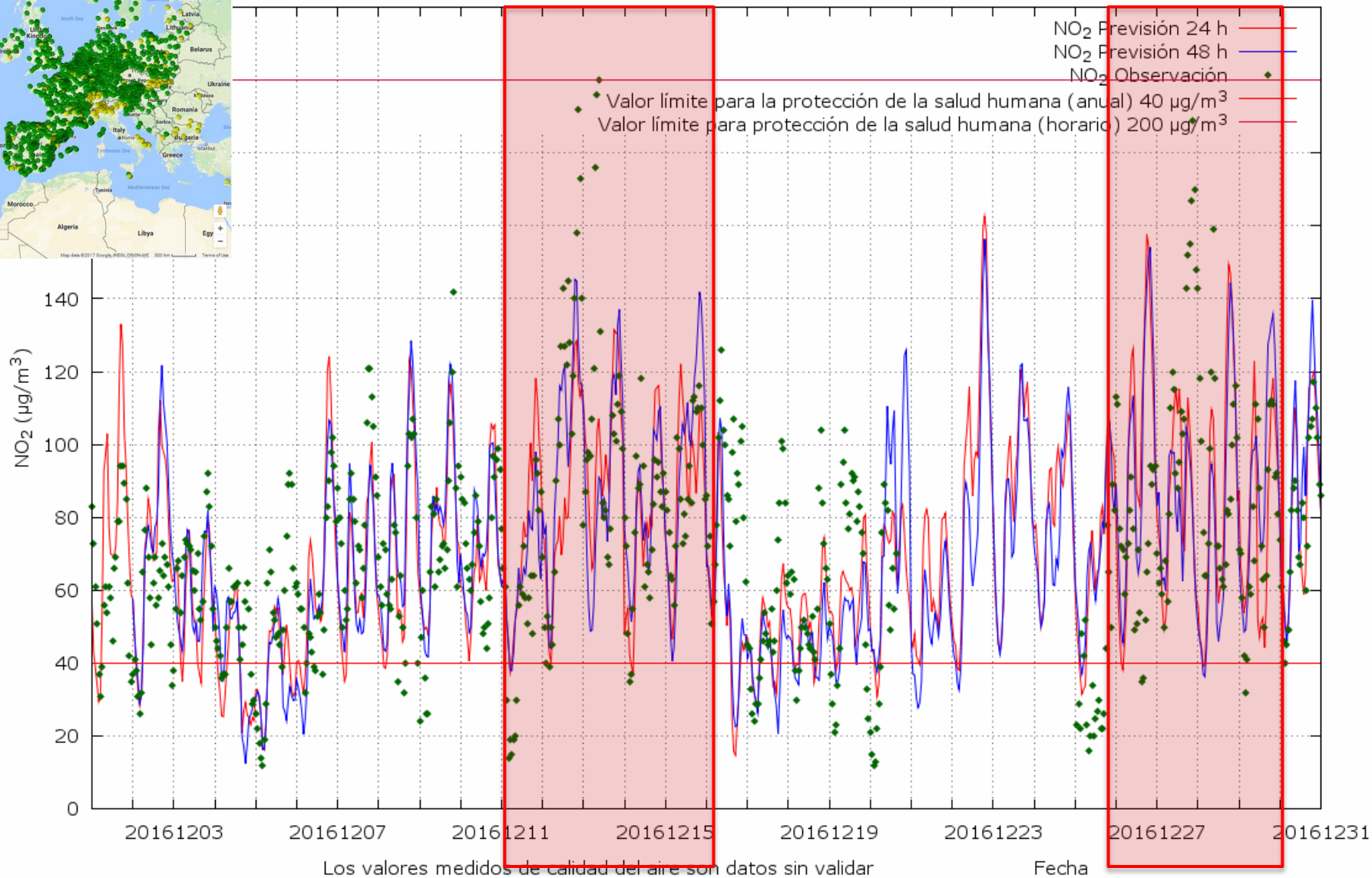
BSC-ES/Air Quality Forecast WRFv3.5.1+CMAQv5.0.2 NO2 MAX 1-hr
Population Exposed for 03 NOV 16 over Spanish Iberian Peninsula + Balearic I. Res:4x4km



CALIOPE : near real time evaluation system



NO₂ KF --- 20161201 - 20161231 --- Est: Barcelona (Eixample) - UT --- Res: 4x4km

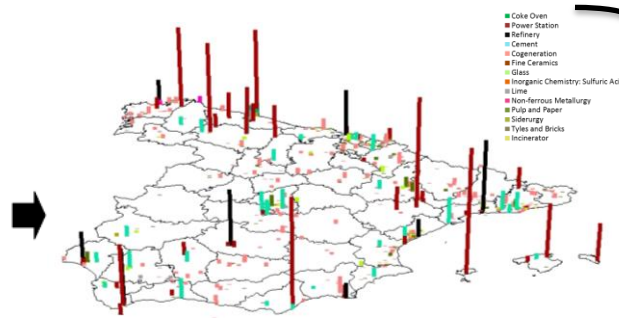


HERMESv2.0:

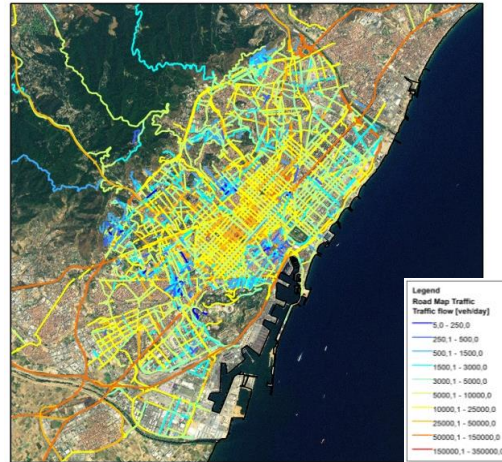
An high resolution emission model for Spain



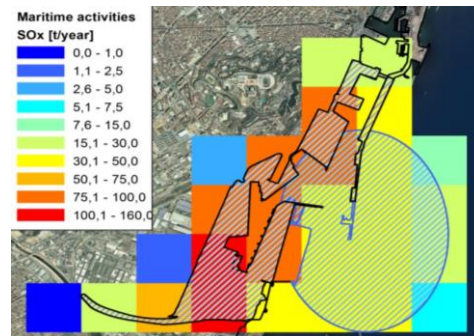
Point Source
 P
 (x, y)



Line Source
 S
 a
 $\{P_1, \dots, P_n\}$



Area Source
 F
 A
 $\{S_1, \dots, S_n\}$



SOURCES OF INFORMATION

Generalitat de Catalunya
 Departament de Territori
 i Sostenibilitat

Generalitat de Catalunya
 Institut Català d'Energia

Ajuntament de
 Barcelona
 Comissió d'Ecologia,
 Urbanisme i Mobilitat

Ajuntament de L'Hospitalet

Ajuntament
 de Sabadell

Port de Barcelona

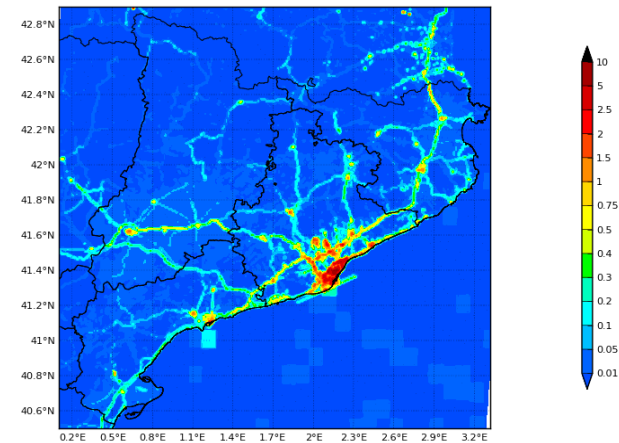
Aena

MINISTERIO
 DE AGRICULTURA, ALIMENTACION
 Y MEDIO AMBIENTE

nexus
 geografics

DGT

BSC-ES/HERMESv2 Emissions NO₂ (kg/h)
 Emissions for 08UTC 25 Feb 2016 - Catalonia Domain Res: 1x1km

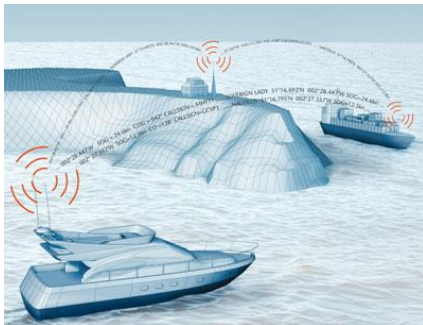


HERMESv2.0: Current and Future Works

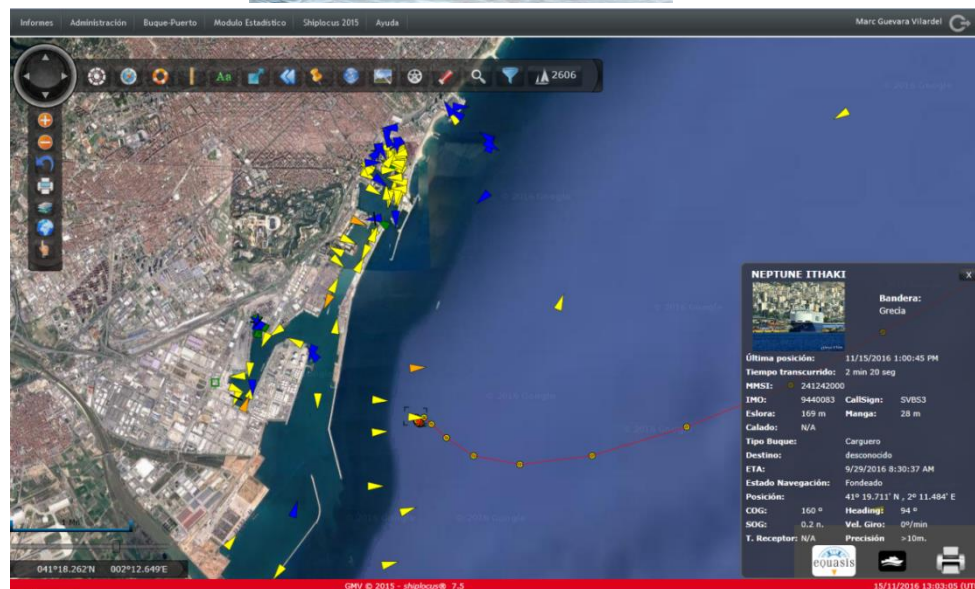


Crowd source data for emission estimation:

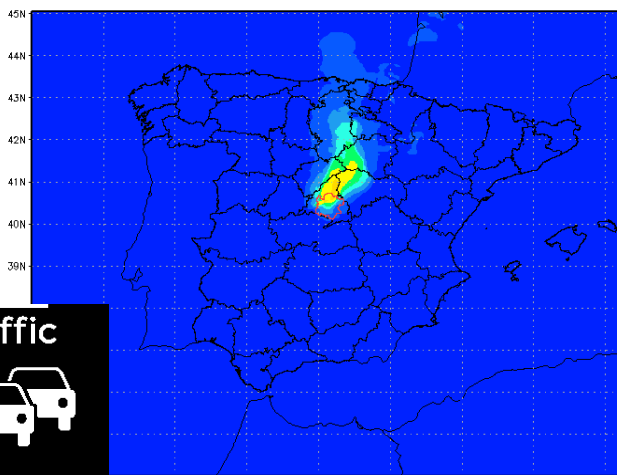
- Vehicle activity data using Floating Car Data (FCD)
- Maritime activity data using Automatic Identification Systems (AIS)



Floating Car Data (FCD)



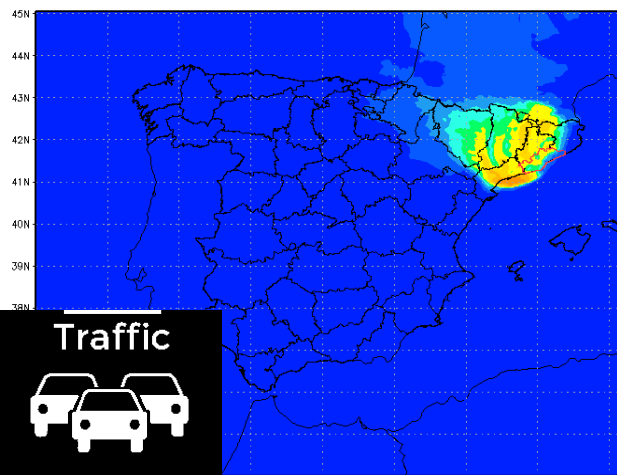
19 AUG 2012 Max O₃ (µg/m³)



Traffic

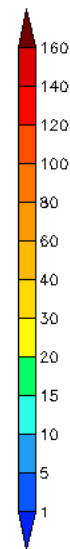
Madrid

19 AUG 2012 Max O₃ (µg/m³)

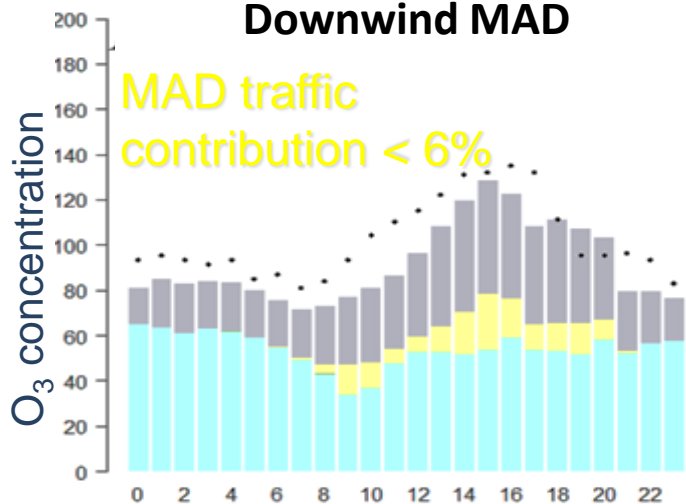


Traffic

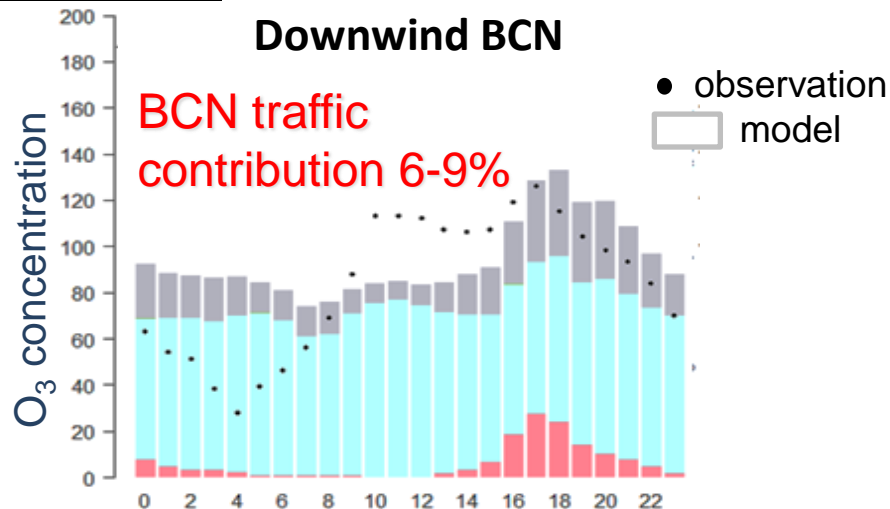
Barcelona



Downwind MAD



Downwind BCN



● observation
□ model

Modelled O₃ contribution from: ■ BCN ■ MAD ■ boundaries ■ remaining sources

Mineral dust: forecasting and services



- ✓ Daily dust operational forecast (global and regional)

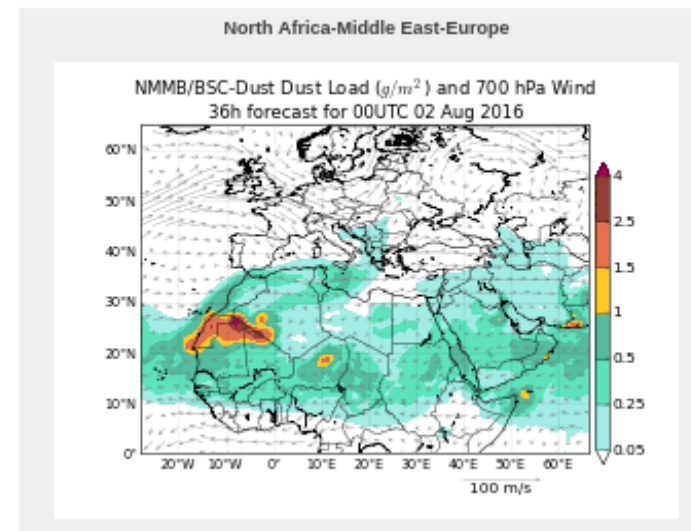
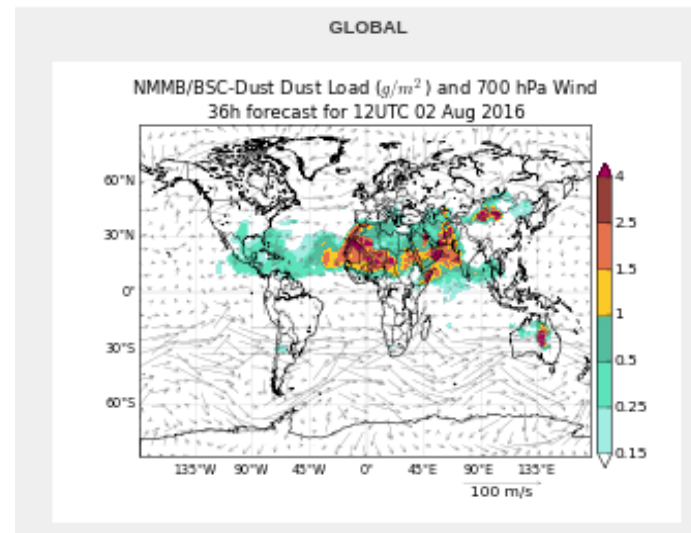
<http://www.bsc.es/earth-sciences/mineral-dust/nmmbbsc-dust-forecast>

- ✓ Contribution to the ICAP multi-model ensemble (global)

<http://icap.atmos.und.edu>

✓ WMO Dust Centers

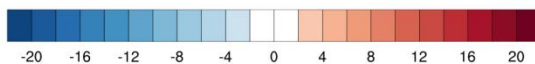
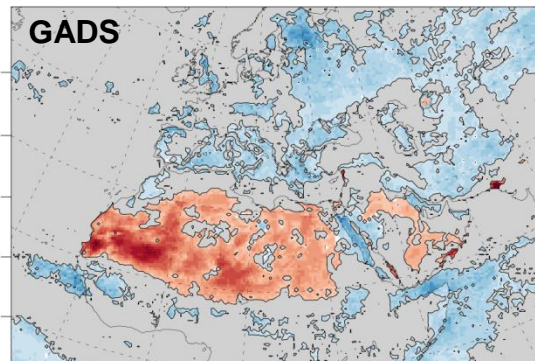
- Sand and Dust Storm Warning Advisory and Assessment System Regional Center for North Africa, Middle East and Europe (SDS-WAS RC) <http://sds-was.aemet.es>
- Barcelona Dust Forecast Center (BSFC): First specialized WMO Center for mineral dust prediction <http://dust.aemet.es>



Mineral dust: radiative effects

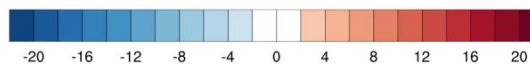
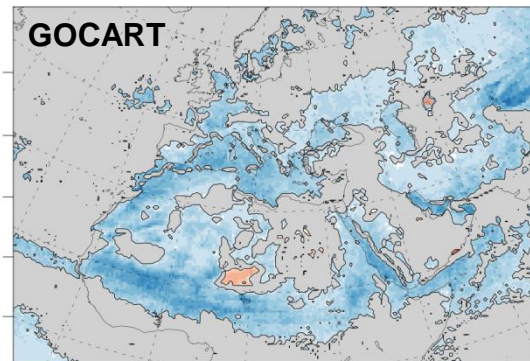
NMMB/BSC-CTM
NAMEE_OPAC 0.44 res.

Effective Radiative Anomaly at TOA (Wm⁻²)
19942013 JJA



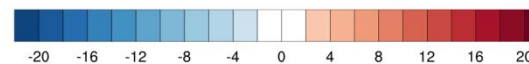
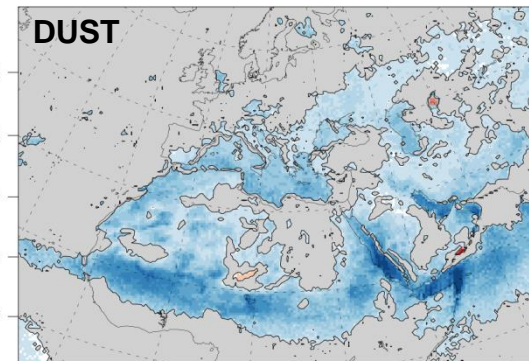
NMMB/BSC-CTM
NAMEE_GOCART 0.44 res.

Effective Radiative Anomaly at TOA (Wm⁻²)
19942013 JJA



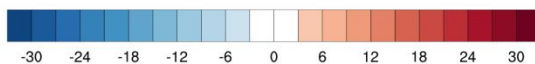
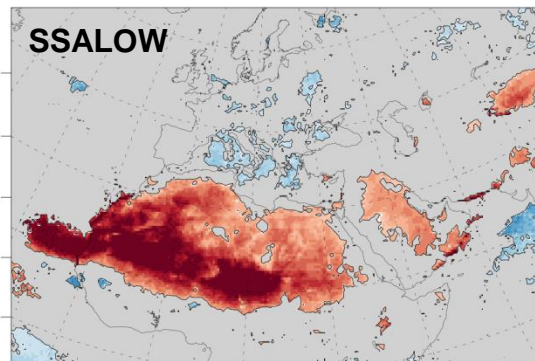
NMMB/BSC-CTM
NAMEE_DUST 0.44 res.

Effective Radiative Anomaly at TOA (Wm⁻²)
19942013 JJA



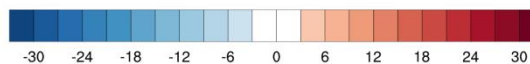
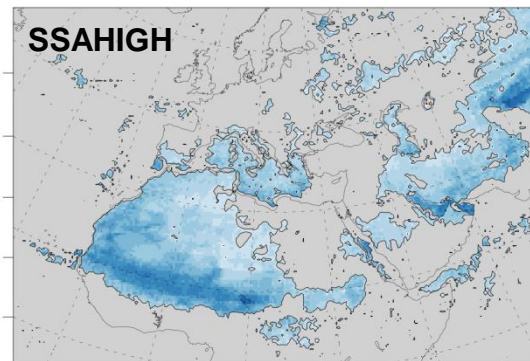
NMMB/BSC-CTM
NAMEE_SSALOW 0.44 res.

Effective Radiative Anomaly at TOA (Wm⁻²)
19941998 JJA



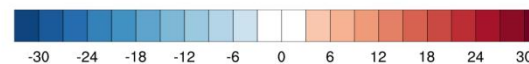
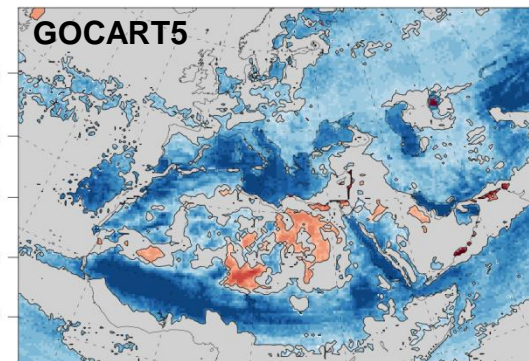
NMMB/BSC-CTM
NAMEE_SSAHIGH 0.44 res.

Effective Radiative Anomaly at TOA (Wm⁻²)
19941998 JJA



NMMB/BSC-CTM
NAMEE_GOCART5 0.44 res.

Effective Radiative Anomaly at TOA (Wm⁻²)
19941998 JJA



Radiative anomaly at TOA with different absorption