www.bsc.es

Chapel Hill, 25 October 2017

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

CALIOPE-urban: coupling R-LINE with CMAQ for urban air quality forecasts over Barcelona

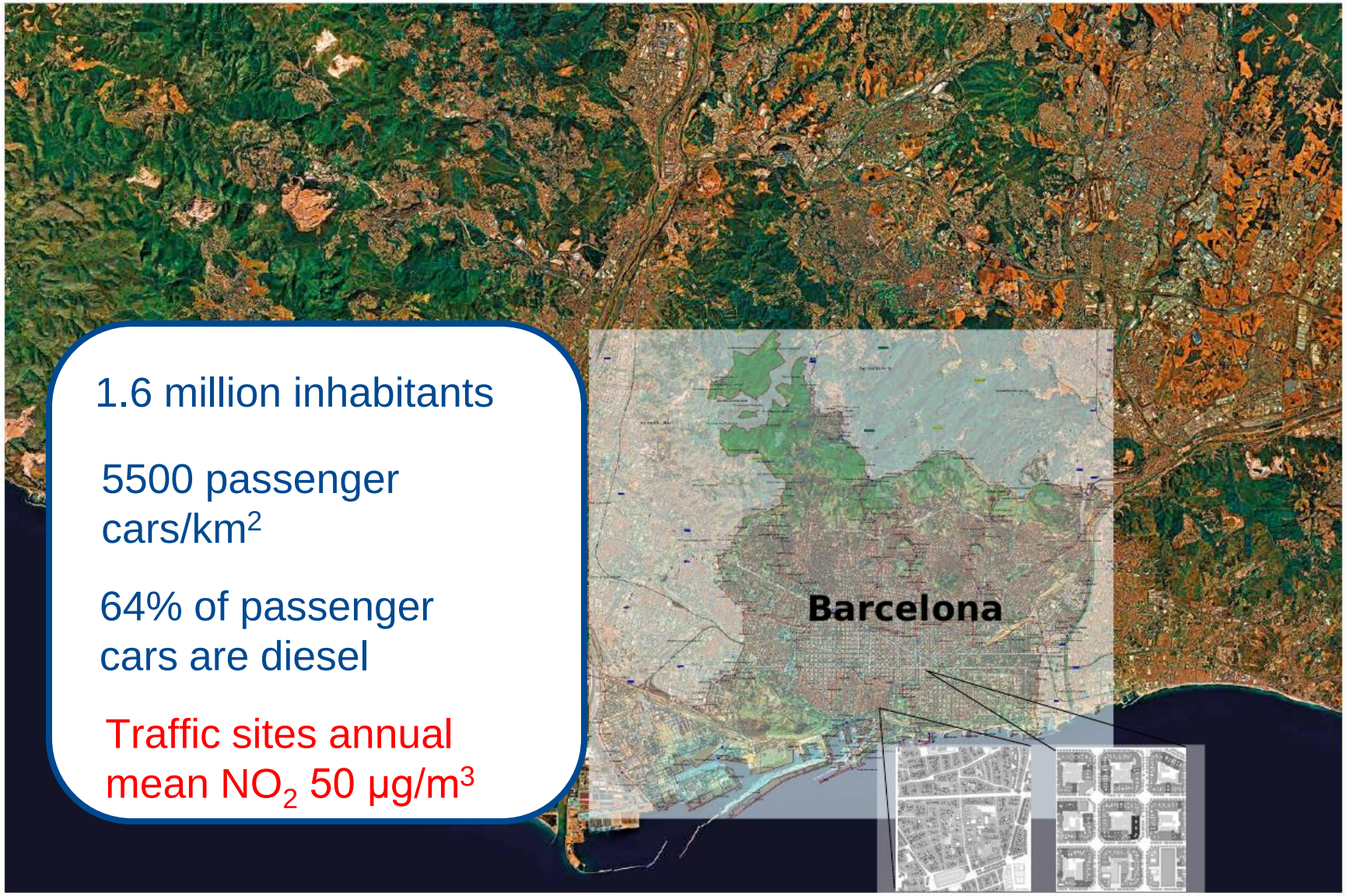
Jaime Benavides[1], Michelle Snyder[2], Marc Guevara[1], Carlos Pérez García-Pando[1], Albert Soret[1], Oriol Jorba[1], Fulvio Amato[3] and Xavier Querol[3]

1.Earth Sciences Department, Barcelona Supercomputing Center, BSC-CNS, Barcelona, Spain
2.Institute for the Environment, The University of North Carolina, Chapel Hill, NC, USA
3.Institute of Environmental Assessment and Water Research, IDAEA-CSIC, Barcelona, Spain

Jaime developed part of this work as research visitor at the Institute for the Environment at UNC in collaboration with Michelle Snyder.

UNC INSTITUTE FOR THE ENVIRONMENT

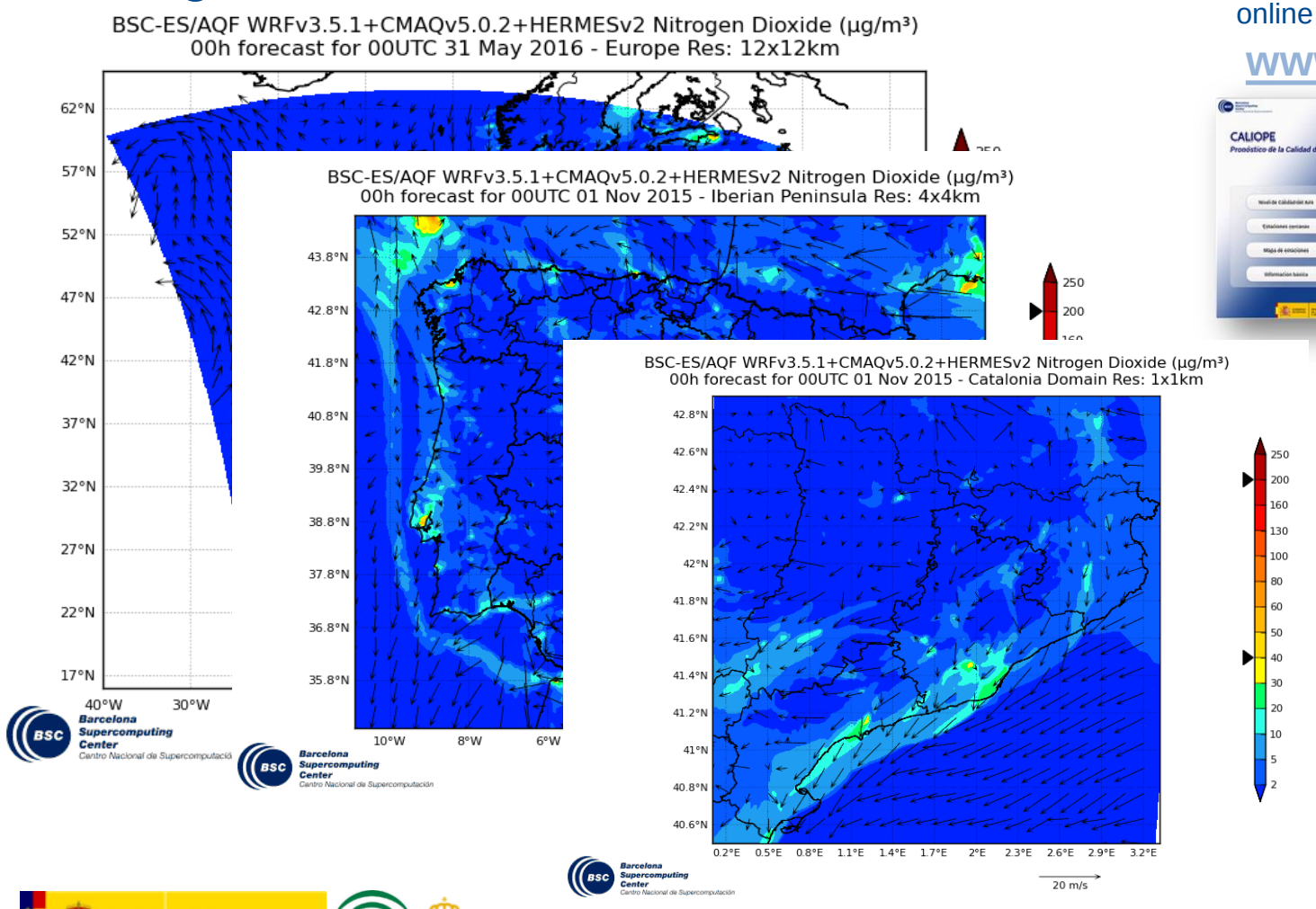
Area of study: Barcelona



CALIOPE: Air Quality Forecasting System

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

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



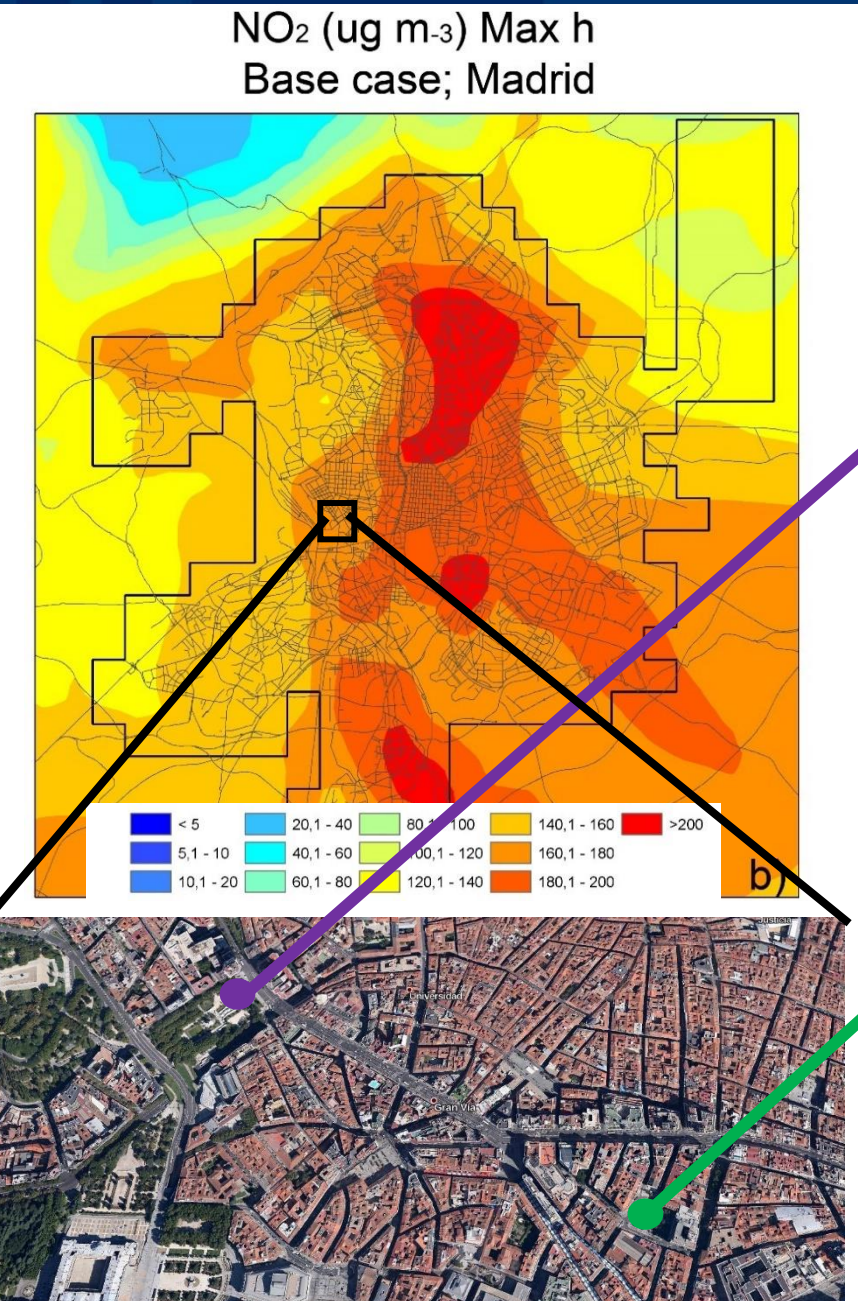
Information is delivered using both online or custom applications:

www.bsc.es/caliope

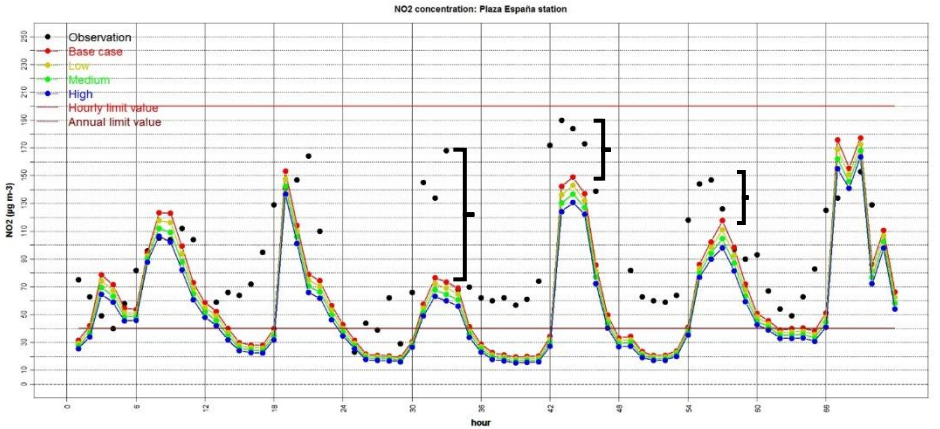
ANDROID APP ON Google play

Available on the App Store

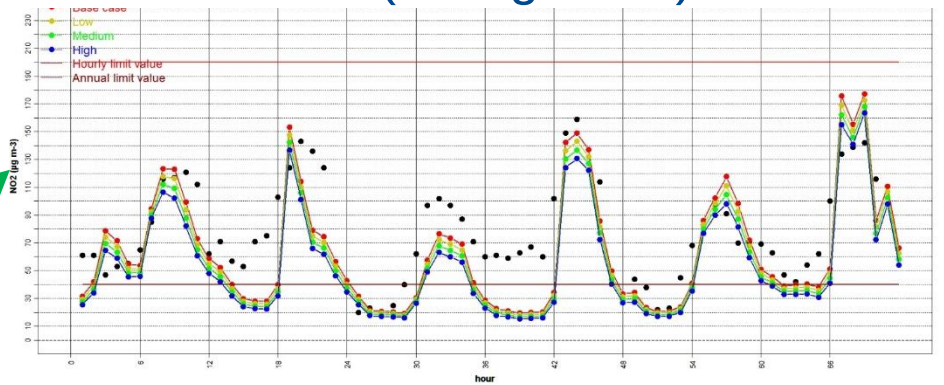
Problem definition



NO_2 hourly concentration. Plaza de España station (traffic)



NO_2 hourly concentration. Plaza del Carmen station (background)



Soret et al. (2014)

Methodologies

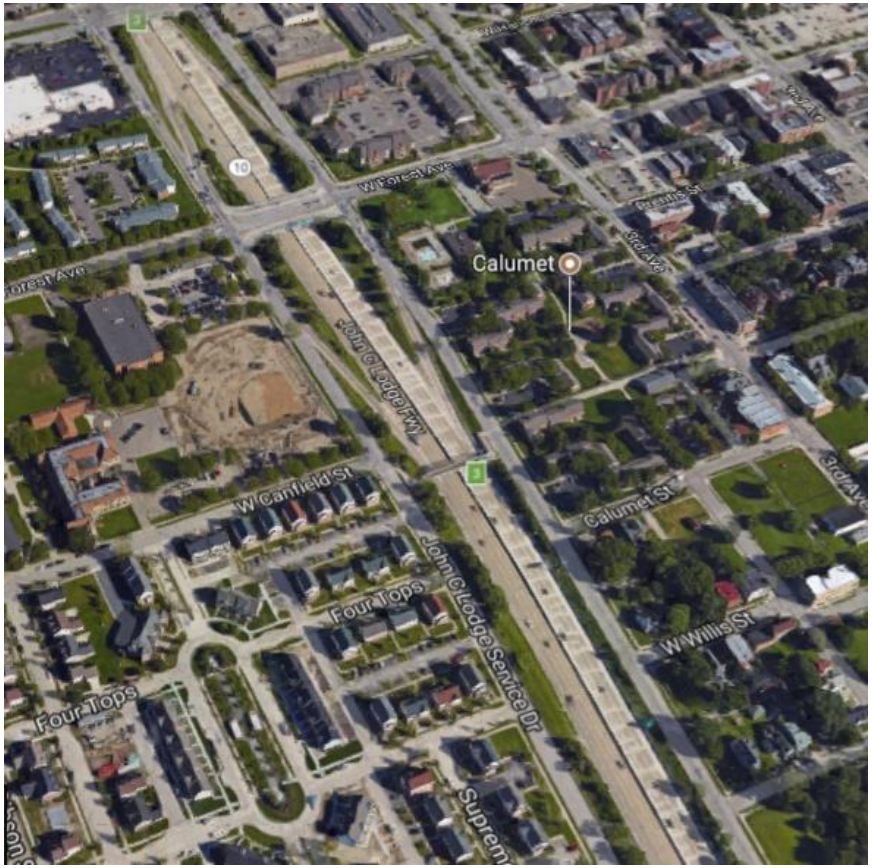
Source: Carlos Orti (2015)

Observational data for calibration and evaluation

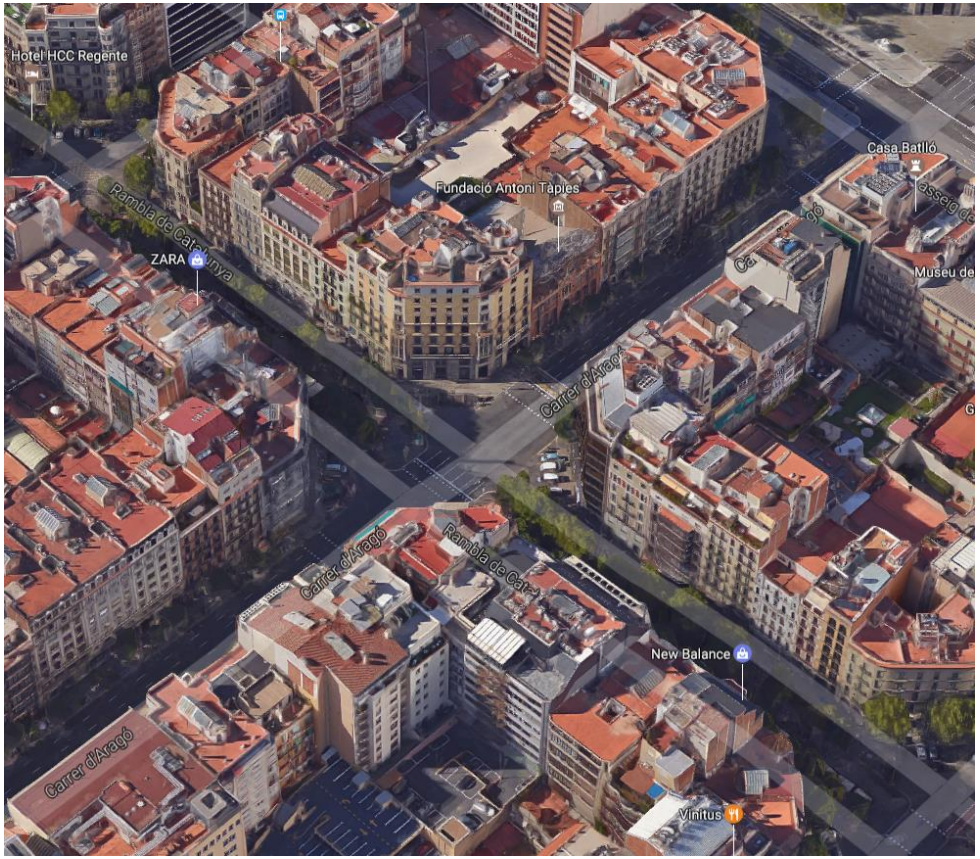
- Meteorological and air quality measures. Amato et al. (2014)
- April 2013 presents a 7-day air pollution episode

Meteorology: Adaptation of R-LINE to Barcelona

R-LINE world view
open terrain, one meteorological input



Barcelona reality
complex terrain, each street specific meteorological patterns



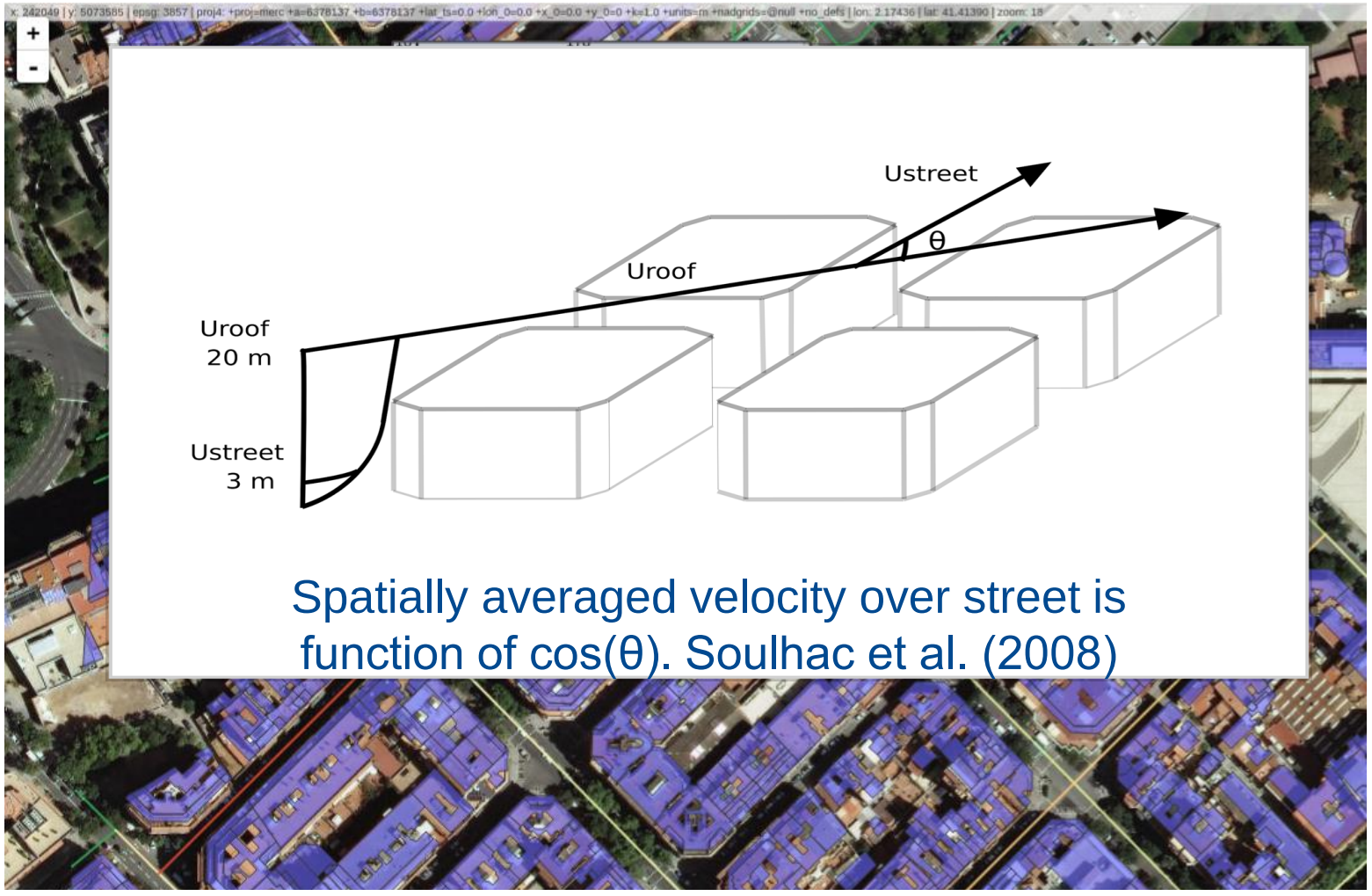
Adapting R-LINE meteorology to Barcelona

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

1. z0 and dh using geometry

2. Ustar and Monin-Obukhov length

3. Adjust meteorology



Spatially averaged velocity over street is function of cos(θ). Soulhac et al. (2008)

Emissions: HERMES model

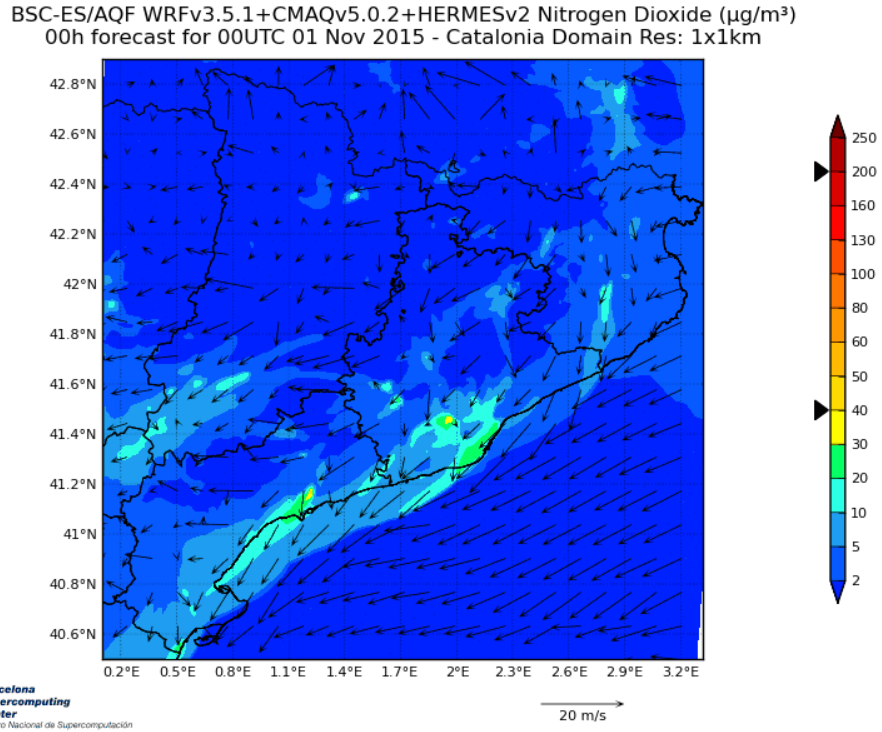
Bottom-up emission model for Spain (resolution: 1x1 km^2 x1h)

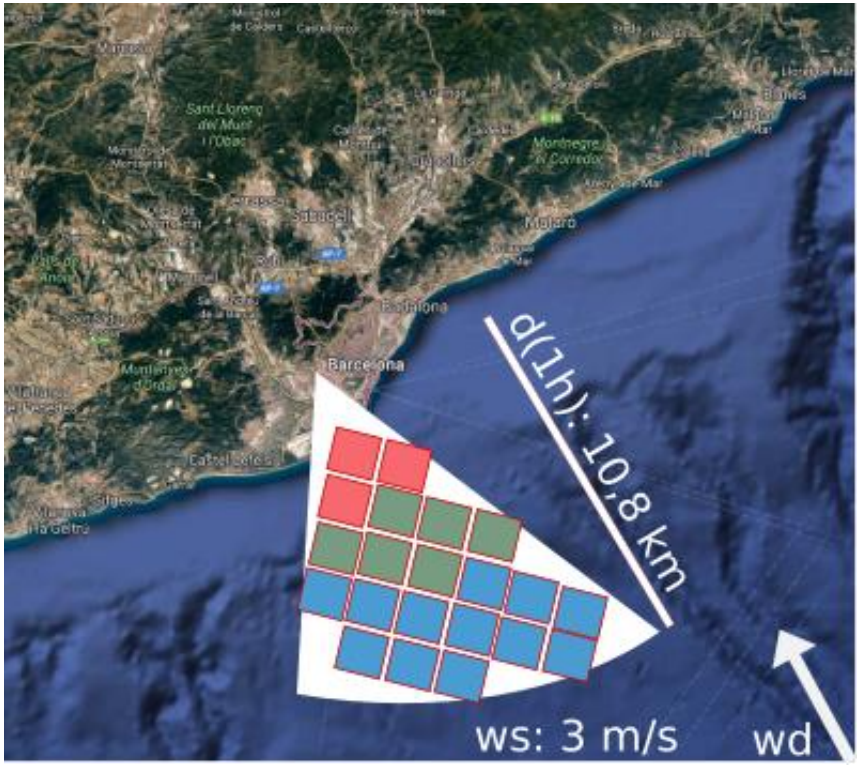
Baldasano et al. (2008); Guevara et al. (2013)

Road transport, emission estimation:

- COPERT IV → Exhaust emissions (hot&cold), evaporative emissions, tyre/break/road wear
- Resuspension (Pay et al., 2010)
- Updated for years 2011, 2012, 2013 and 2014

Upwind urban background scheme





High spatial (1x1 km^2) and temporal resolution (1h) over Barcelona

Select concentrations from CMAQ depending on the wind speed and direction provided by WRF. Based on Berkowicz (2000)

Results on poster “Influence of NO_2 - O_3 urban background on nitrogen dioxide concentration near roadway sources in Barcelona city (Spain)”

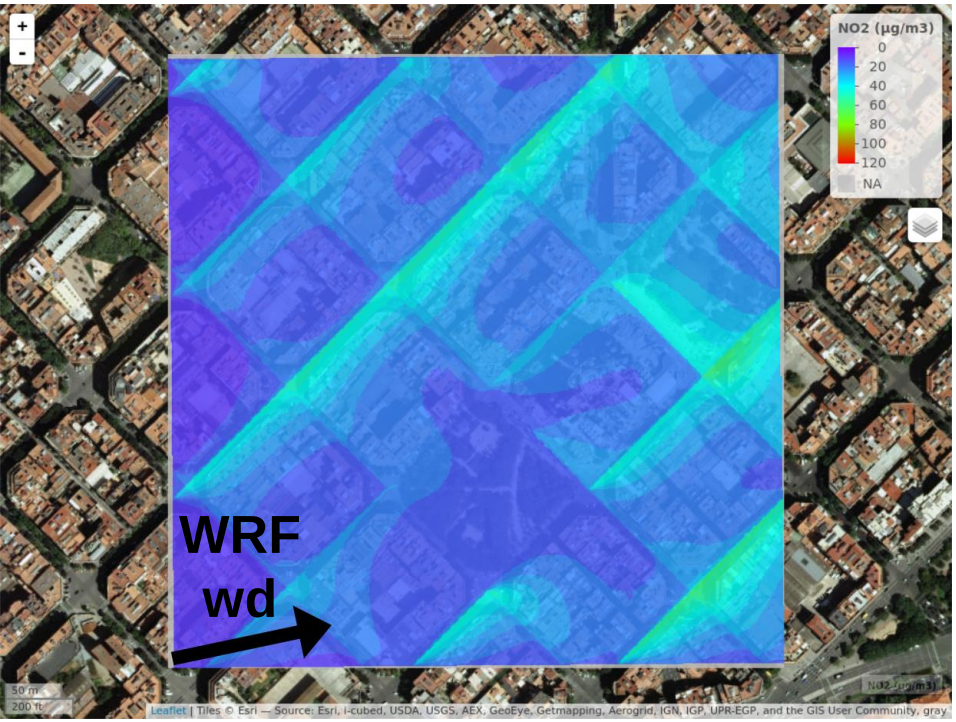
Results

Source: Carlos Orti (2015)

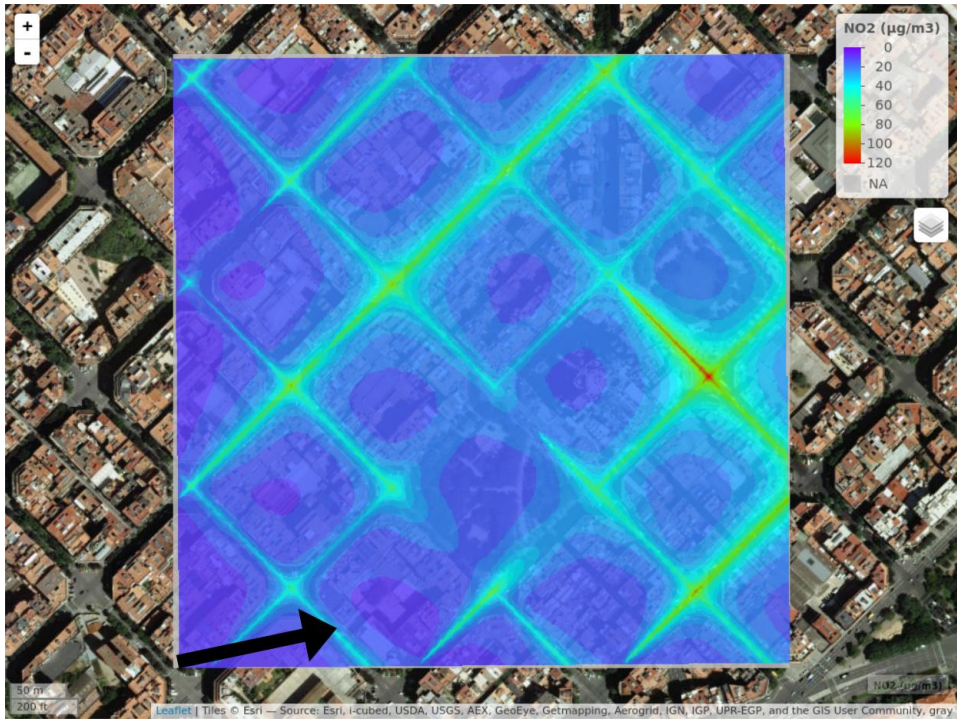
Meteorology

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Open terrain
R-LINE (Snyder et al. 2013)

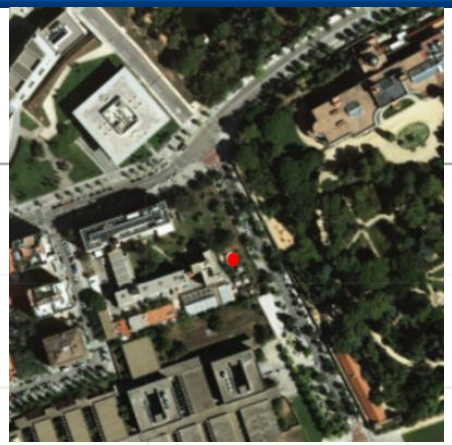


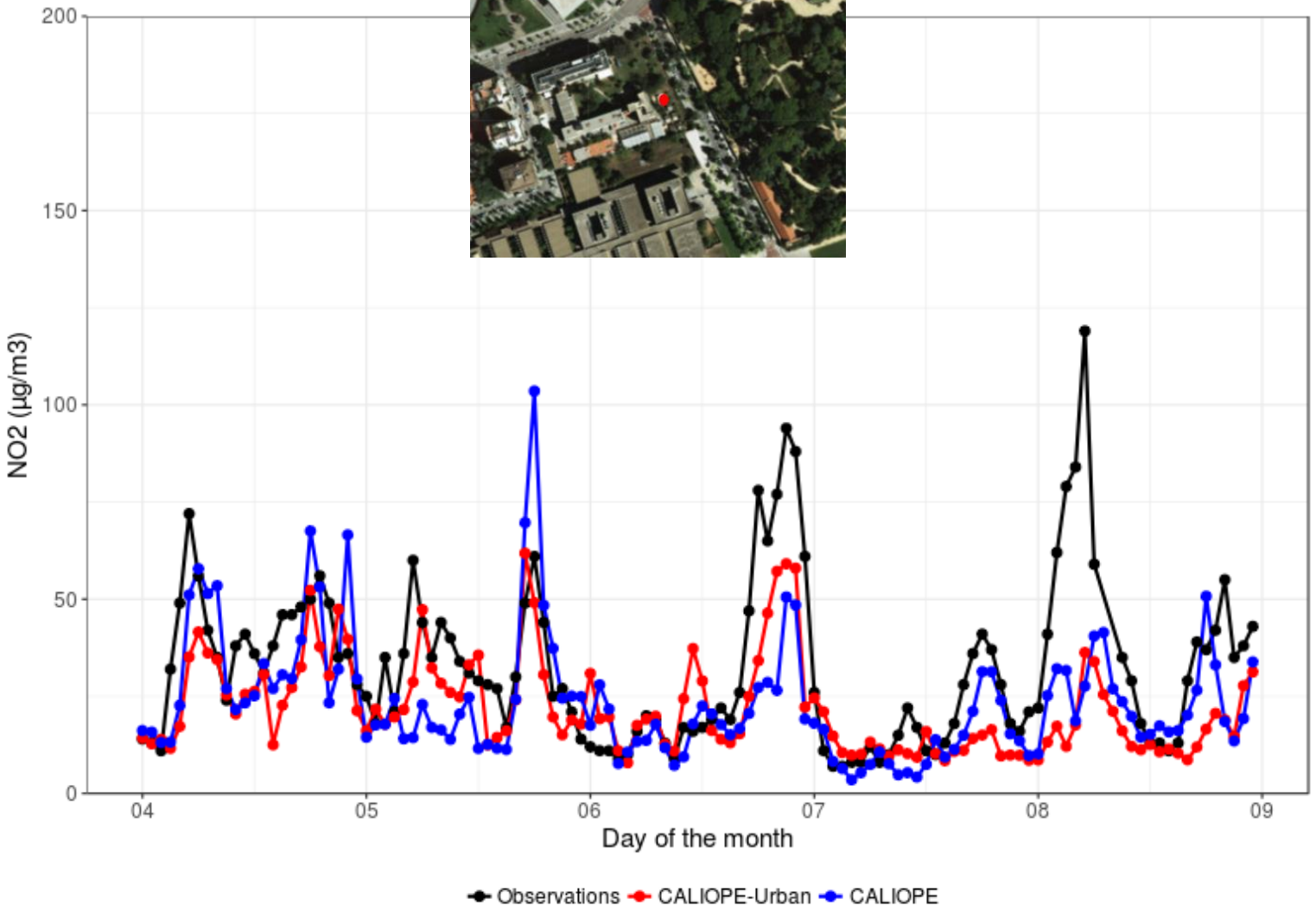
Channelled winds
R-LINE Local



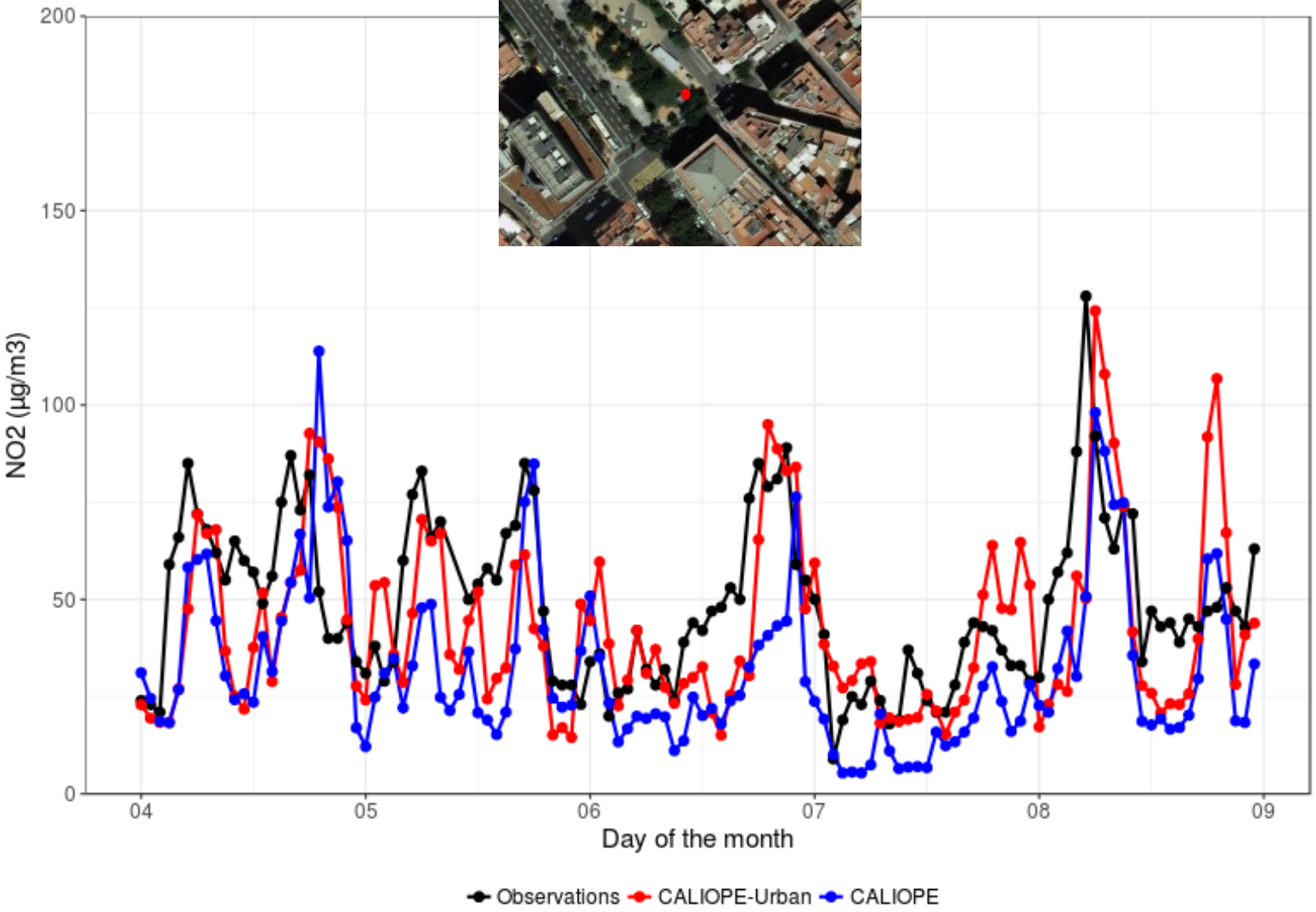
Additional results presented by Michelle Snyder poster on “Adaptation of meteorology and R-LINE to street canyon micro-climates: Application in Barcelona city (Spain)”

Palau Reial: Urban background

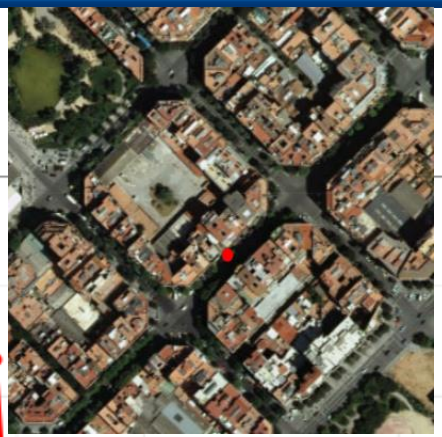


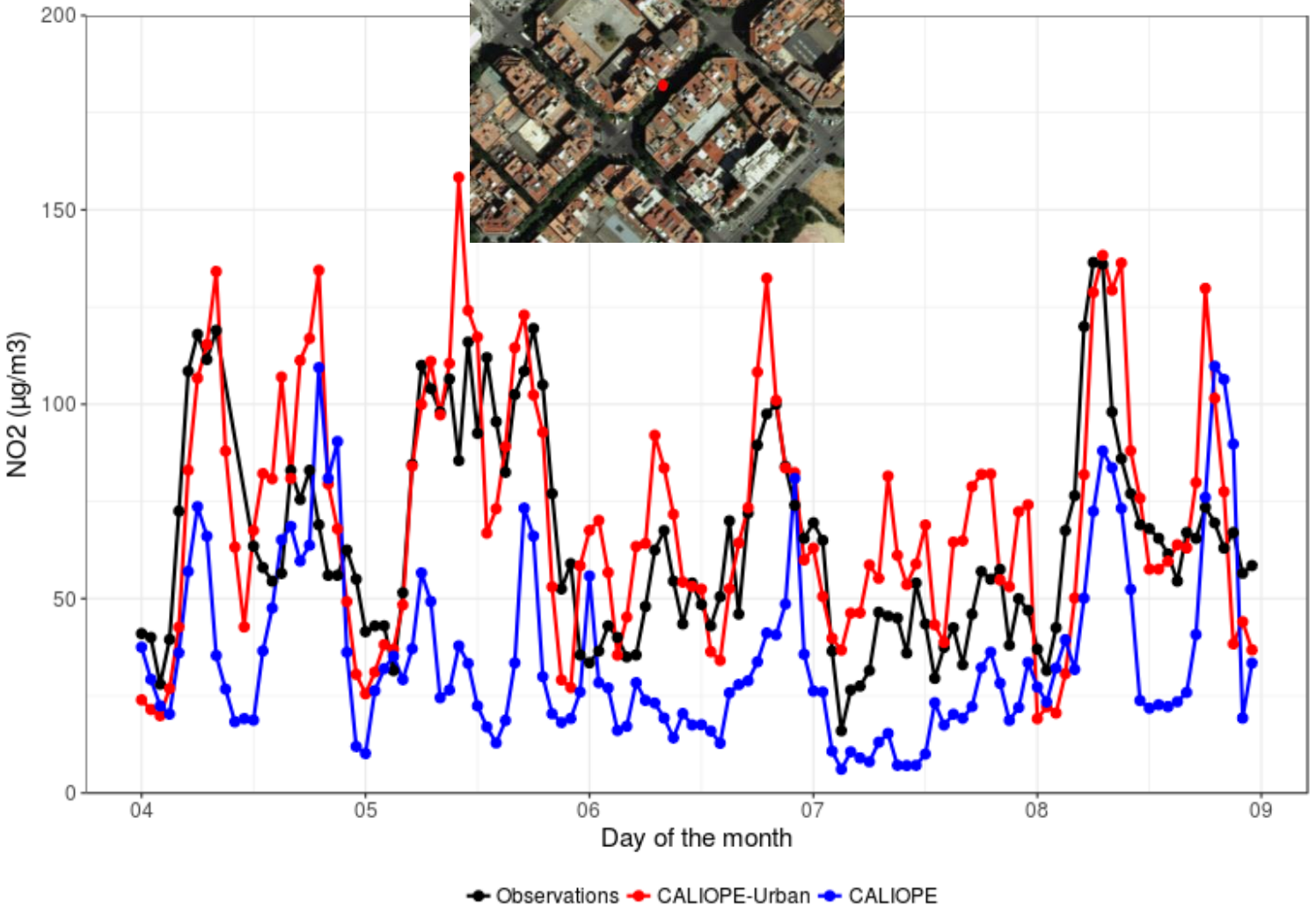


Gracia: Traffic



Valencia Street: High traffic

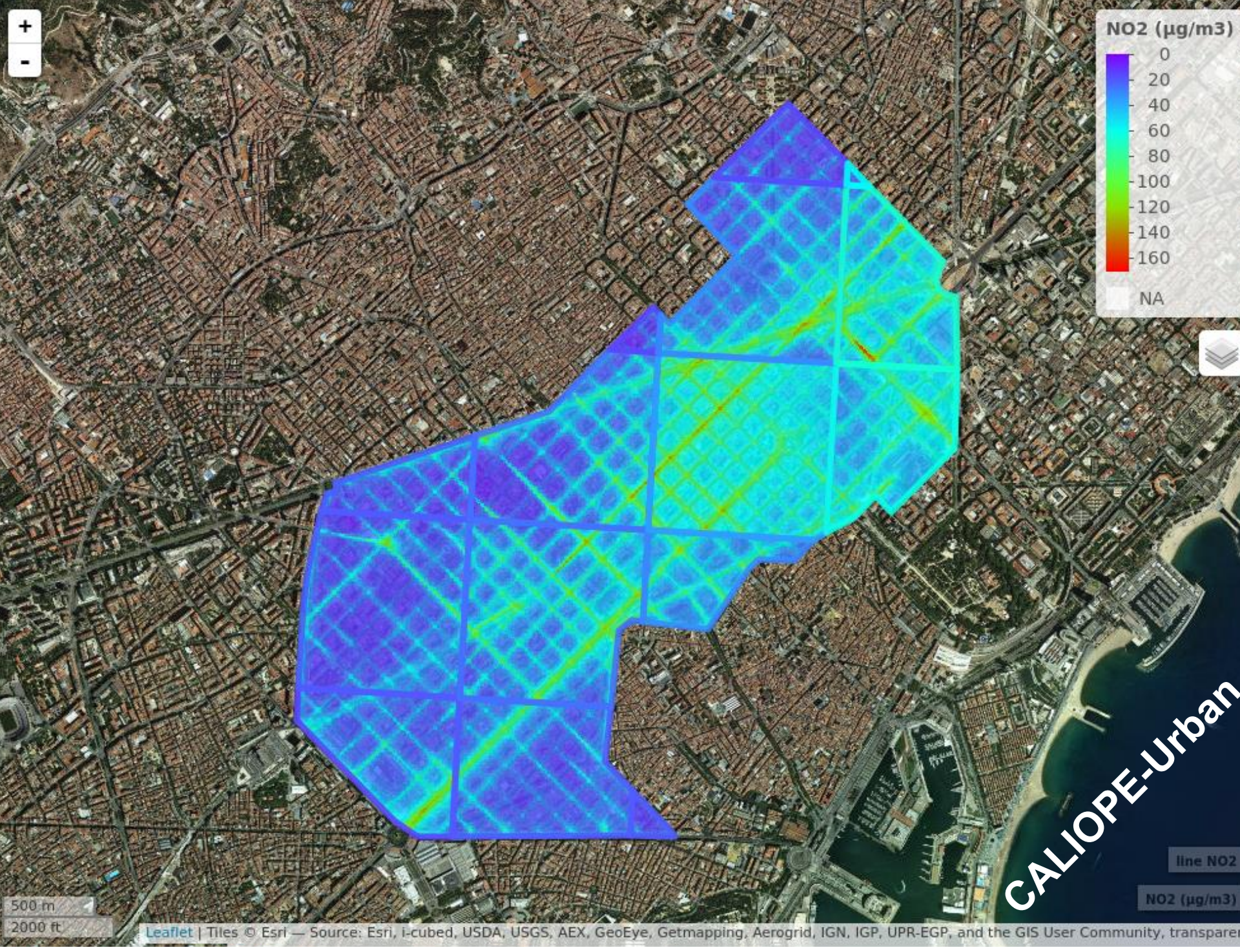




NO_2 summary statistics from 3 to 24 April 2013

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

		FAC2	MB	RMSE	r
	CALIOPE	0.70	-4.08	27.86	0.55
	CALIOPE-Urban	0.66	-8.26	27.72	0.47
	CALIOPE	0.58	-13.97	34.33	0.50
	CALIOPE-Urban	0.73	-3.36	33.85	0.42
	CALIOPE	0.55	-20.99	37.81	0.53
	CALIOPE-Urban	0.91	5.02	28.93	0.57


+
-
NO2 (µg/m3)
0
20
40
60
80
100
120
140
160
NA
CALIOPE-Urban
line NO2
NO2 (µg/m3)
500 m
2000 ft
Leaflet | Tiles © Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community, transparer

Conclusions and open questions

- Urban NO_2: **Street scale system** results are similar to mesoscale system in background sites and **better than mesoscale in traffic sites** but street system correlation to observations is lower in sites where urban NO_2 is highly influenced by background NO_2. How to improve system performance under these conditions?

- Meteorology: **R-LINE meteorology channels dispersion within streets** providing more realistic spatial detail but wind speed is overestimated. How to improve wind speed without reducing overall efficacy?

- Background: **Upwind urban scheme couples CMAQ with R-LINE, avoiding double-counting emissions and using directly CMAQ outputs as input without re-executing CMAQ** but urban NO_2 estimated with R-LINE using observations as background gives better results. How to reduce differences between observed background and scheme results?

- System evaluation: CALIOPE-Urban works well for April 2013 in traffic sites but it has not been evaluated during a longer period over the entire city. What is its performance for a year over the entire city?

www.bsc.es

Thank you Michelle for your collaboration

jaime.benavides@bsc.es

BSC researchers acknowledge the grants CGL2013-46736-R, CGL2016-75725-R and COMRDI15-1-0011-04 of the Spanish Government. J. Benavides PhD work is funded with the grant BES-2014-070637 from the FPI Programme and the mobility grant EEBB-I-17-12296 both by the Spanish Ministry of the Economy and Competitiveness. Jaime developed part of this work as research visitor at the Institute for the Environment at UNC. IDAEA-CSIC acknowledges the Barcelona City Council for the support to the experimental campaign.