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Copernicus Climate Change Service

Urban SIS
D2.1 Input for historical period and validation

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Edited by: SMHI (Heiner Körnich, WP2 leader)

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Introduction

There are three downscaling models to be executed in order to produce the Urban SIS climate information: the climate model, the air quality model and the hydrological model. The climate model will require initial and boundary conditions from a European scale model output and also detailed information of the urban surface as input to the urban sub-models that determine the fluxes between the ground and the atmosphere. The air quality dispersion model equally requires chemical initial and boundary conditions from a European-scale dispersion model result and detailed emissions from the city itself. The meteorological forcing and surface characteristics are taken from the downscaled climate model output. The hydrological downscaling, finally, requires hydrological boundary conditions from a regional-scale hydrological model, output of climate variables from the downscaled climate model, additional data concerning urban watersheds and soil characteristics.

The purpose of this report is to document the input data to be used for the historical period. A later report (D2.2, to be submitted 31 August, 2016), will give the same information for the future period (climate scenario).

The present report will also include an overview of the validation data that are available. Most attention will however be given to the description of the different European scale model outputs that will be used as boundary conditions, this since these data are fundamental for the urban downscaling, but they are not generated within Urban SIS and will not be described in detail in other deliverables. When it comes to the input data to the surface and urban model, emission data for the air quality model and the additional hydrological input data required, there will only be a summarized description in this report. More information will be given in the WP3 deliverables describing the three types of urban downscaling. The same goes for validation, which will be presented in detail in the WP5 validation reports.

The ongoing work in WP4 to define the impact indicators to be delivered together with ECVs, may also imply additional input data requirements. An example just discussed with health sector specialists is population data to allow exposure and impact calculations. The impact indicators will be finally defined in October 2016, which means that some input data may be added to those presented and discussed in this report.

The process of selecting input data

The choice of input data affects how the urban climate information can be validated and how it can address the actual end-user requirements. In order to select the input data, discussions were conducted with the project partners and invited end-users on the WP4 workshops in Stockholm and Bologna (see participants in Appendix 2). The following aspects were taken into account:

- Period, depending on computational costs, availability of input data and of observations for validation
- Domain, depending on computational costs, local topography, and location of observations
- Model, depending on compatibility with input data and coupling of the different models for meteorology, air quality and hydrology

Open questions from these discussions were solved via email communication.

Climate model: Lateral boundary and initial conditions

SMHI will use the meso-scale Numerical Weather Prediction system HARMONIE (Hirlam Aladin Research on Meso-scale Operational NWP in Euromed) for the meteorological downscaling both for the historical period and the climate projections. HARMONIE is developed in the HIRLAM-ALADIN consortium by 26 countries in Europe and Northern Africa. Within HARMONIE, we will use the non-hydrostatic convection-permitting AROME (Applications de la Recherche à l'Opérationnel à Méso-Echelle) model (Seity et al. 2011).

For the lateral boundaries full output from a meteorological host model covering entire Europe is required. The horizontal resolution of the host model should not be coarser than a factor of about 10 to 15 of the downscaled target resolution of 1 kilometre. For the vertical resolution it is desirable to use full model level output from the host model in order to maintain maximum vertical information at the boundaries. The vertical information on model levels is also vital for the chemical downscaling on the European scale providing precise chemical transport calculations at the boundaries of the urban air quality model. The temporal resolution of the boundaries should be at least 3-hourly, preferably 1-hourly.

The initial conditions in the upper air and at the surface of the urban-scale climate model will be extrapolated from the European-scale host model. In order to prevent spin-up problems for the surface model and to initialize the surface state at a higher resolution, we are conducting additionally a surface data assimilation scheme for the historical period, based on the optimal interpolation scheme using CANARI (Code for the Analysis Necessary for ARPEGE for its Rejects and its Initialization) and SURFEX (Surface Externalisée). Observations of near-surface temperature and relative humidity from SYNOP- and airport (METAR) stations are assimilated.

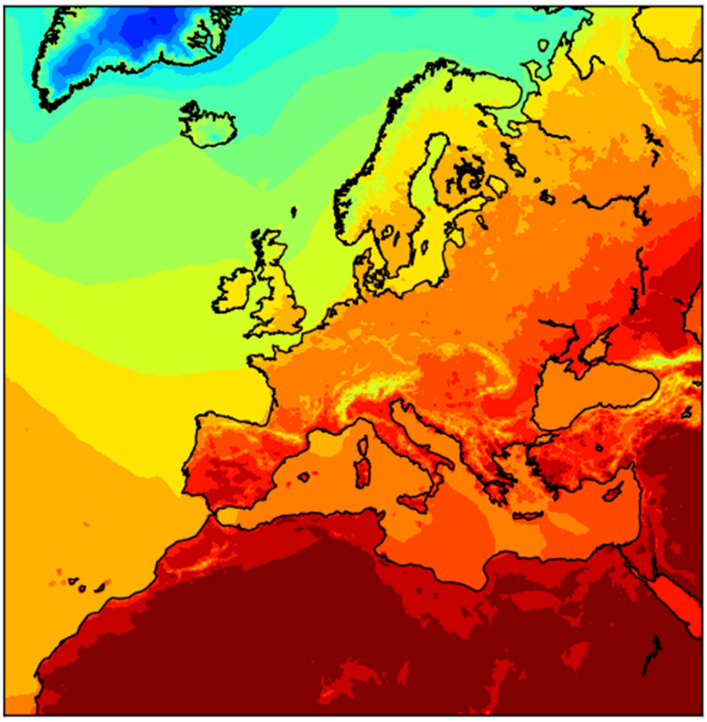

Figure 1: Mean 2m-temperature for UERRA-HARMONIE ALADIN reanalysis for July at 12 UTC. The data were averaged over the years 2006 to 2010.

For the European-scale host data, the European-reanalysis UERRA-HARMONIE will be employed. UERRA (Uncertainties in Ensembles of Regional ReAnalysis) is run from 2014 to 2017 as a project of the European Commission's 7th framework programme and it serves as a preparation to the Copernicus Climate Service. The UERRA-HARMONIE reanalysis will be produced with the physics package ALADIN at a horizontal spacing of 12 km for the period from 1960 to 2015. The domain of the model can be seen in the mean 2m-temperature for July at 12UTC as shown in Figure 1. For a shorter period from 2006 to 2010, an additional reanalysis with the physics package ALARO will be generated in order to assess uncertainties of the reanalysis products. As a producer of the UERRA-HARMONIE reanalyses, SMHI can ensure the storage of the above mentioned required fields for downscaling such as surface model data, all vertical model levels and 1-hourly output. Furthermore, the downscaling is expected to work with less spin-up issues, as the host and the high-resolution model are closely related.

Concerning the period for downscaling, a limiting factor is the availability of the UERRA-HARMONIE reanalysis, as it is currently generated. As a first deliverable of the UERRA-project, the mini-ensemble for the years 2006 to 2010 was produced. Unfortunately, this first version contained a bug in the data assimilation scheme. This bug was fixed in the beginning of 2016 and the period 2006 to 2010 is being produced for the second time. Since we have tested the meteorological downscaling with the first version, it is worth to note that the differences between the first and the corrected second reanalysis are small, as can be seen for the 2m-temperature for October 1999 at 06 UTC in Figure 2. At this time of day, the errors were largest.

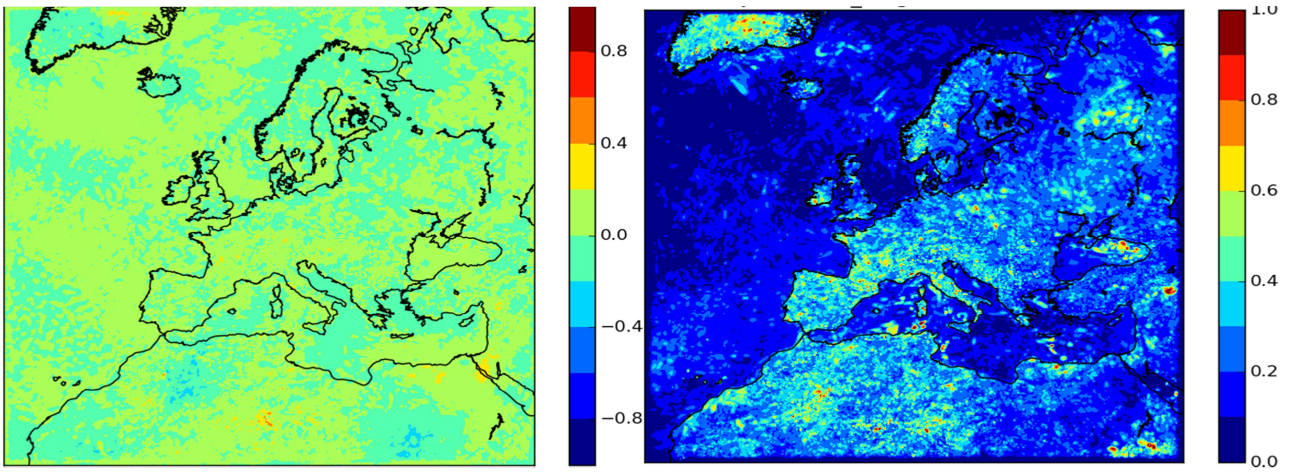

Figure 2: Monthly mean difference (left) between the first and second version of UERRA-HARMONIE reanalysis (see text) and its standard deviation (right) for the 2m-temperature in October 1999, 6 UTC.

During the workshop discussions, the partners in Bologna stressed that the best air quality observations are available for the period 2012 to 2014 due to local campaigns. Due to this request, we have started the UERRA-production for this period. However, no ensemble information is planned for this period and it is not certain, when the period will be available. Thus, the principal baseline period will be 2006 to 2010, as this period is being produced as part of the UERRA-project and as it will contain two reanalyses for uncertainty estimates. Given the small effect of the bug in the first UERRA-HARMONIE reanalysis, we could even fall back onto this first version for the demonstration of the urban climate information.

Climate model: Interaction with the surface

There is strong scientific evidence (e.g., Grimmond et al., 2010) showing that urban morphology, building materials, vegetation, and human activity are key drivers of urban climate, generating distinct microclimates even within the city. In Urban SIS we are interested in knowing how, and to what extent, urban design and planning can potentially affect the response of a city to the climate signal, with consequences over human health and infrastructures. For this purpose, and aiming at accurately capture the complex dynamics of urban surface fluxes, we use the Town Energy Balance (TEB) model (Masson et al., 2013) available in the land and ocean surface platform SURFEX (version 7.3), which is coupled to HARMONIE.

In TEB major physical processes are taken into account, namely, the trapping of longwave and shortwave radiation by the canyon, including the shadowing effect, the anthropogenic sensible heat flux, the interception of rain and snow by roofs and roads, the conduction and storage of heat in buildings walls and roofs or the interaction of the built surfaces with the canyon air through the transfer of momentum, heat and water.

SURFEX receives the necessary meteorological forcing from HARMONIE using a generalized coupling method between the atmosphere and the surface. These data are listed in Table 1.

Table 1: Input data describing the atmospheric forcing in TEB-SURFEX.

	Input parameter	**Unit**
Atmosphere	Air temperature above canopy	K
	Specific humidity above canopy	kg kg^{-1}
	Incoming solar radiation	W m^{-2}
	Infrared solar radiation	W m^{-2}
	Air pressure	Pa
	Rainfall rate	kg m^{-2} s^{-1}
	Snowfall rate	kg m^{-2} s^{-1}
	Wind speed	m s^{-1}
	Wind direction	deg/North

With this input, averaged fluxes for momentum and sensible and latent heat are computed by SURFEX and returned to the atmosphere with the addition of radiative terms like surface temperature, surface direct and diffuse albedo (for each wavelength) and also surface emissivity. This information is then used as the lower boundary condition for atmospheric radiation and turbulence schemes. For the description of the surface, SURFEX uses a tile approach, which allows accounting for sub-grid heterogeneity. The four main tiles characterizing the land use in each grid cell are the following:

- ‘Town’: buildings, roads and transportation infrastructures, gardens;

- ‘Nature’: bare soils, rocks, permanent snow, glaciers, natural vegetation and agricultural landscapes;

- ‘Lake’: inland waters (including lakes and rivers);

- ‘Sea’: including both sea and ocean.

Specifically in the town tile, the data shown in Table 2 is needed as input.

Table 2: Input data describing the surface in TEB-SURFEX.

	Input parameter	Unit
Land Use	Urban area fraction	–
	Nature area fraction	–
	Lake area fraction	–
	Sea area fraction	–
Urban morphology and building thermal and radiative characteristics	Building area fraction (within the urban fraction)	–
	Road area fraction (within the urban fraction)	–
	Garden/park area fraction (within the urban fraction)	–
	Wall surface / building and road surface	m
	Building height	m
	Urban roughness length	–
	Number of wall layers	–
	Number of roof layers	–
	Number of road layers	m
	Wall layers depth	m
	Roof layers depth	m
	Road layers depth	$J\ m^{-3}\ K^{-1}$
	Wall layers specific heat	$J\ m^{-3}\ K^{-1}$
	Roof layers specific heat	$J\ m^{-3}\ K^{-1}$
	Road layers specific heat	$W\ m^{-1}\ K^{-1}$
	Wall layers thermal conductivity	$W\ m^{-1}\ K^{-1}$
	Roof layers thermal conductivity	$W\ m^{-1}\ K^{-1}$
	Road layers thermal conductivity	–
	Roof albedo	–
	Road albedo	–
	Wall albedo	–
	Roof emissivity	–
	Road emissivity	–
	Wall emissivity	
Anthropogenic heat releases	Anthropogenic sensible and latent heat flux released by traffic	$W\ m^{-2}$
	Anthropogenic sensible and latent heat flux released by Industry	$W\ m^{-2}$
Vegetation	Area fraction of bare soil	–
	Area fraction of low vegetation	–
	Area fraction of high vegetation	–
	Leaf Area Index (for each veg. Type and month)	–
	Vegetation roughness length (for each veg. type and month)	m
	Vegetation characteristics for photosynthesis and vegetation growing (for each veg. type)	

The physiographic characterization is driven by the global, 1 km resolution land cover database ECOCLIMAP-II (Faroux et al., 2013). Aiming to assure that land cover data used as input to HARMONIE over cities are the "best available" we have produced high-resolution gridded data (1x1 km^2 resolution) that provide enhanced surface characteristics to ECOCLIMAP-II database. These include, for each urban grid cell, more detailed description of the following quantities:

- fraction occupied by the urban, nature, sea and lake tiles;
- heights of buildings and trees;
- seasonal variation of Leaf area index (LAI).

The selection criterion for the sources was based on the accuracy, resolution, and availability of the information. We have also privileged the use of Copernicus products. This resulted in the selection of the following open-access databases and respective products, see Table 3:

Table 3: Input data sources for TEB-SURFEX.

Input data type	Product	Spatial resolution (m)	Source data type	Webpage
Spatial coverage of land cover types	Copernicus Land Monitoring Services: Urban Atlas 2012	100	Satellite data PROBAV v1.4	http://land.copernicus.eu/local/urban-atlas
Building polygons	OpenStreet Map	nd	Different sources	https://www.openstreetmap.org
Building/ tree heights	Swedish Forest Agency	12.5	Lidar measurements	http://www.skogsstyrelsen.se/Myndigheten/Om-oss/Oppna-data/
Time-series of LAI	Copernicus Global Land Service	1000	Satellite data	http://land.copernicus.eu/global/themes/vegetation

For building heights, there are no detailed data available for the whole of Europe. The data for building heights given in the table above is only available for Sweden. Alternative data sources will be searched for in the Bologna and Netherlands domains. As a fall back solution the building heights will be estimated through a GIS analysis of high resolution land use data.

The resulting product is shown, as an example for Stockholm, in Figure 3 with the density of impervious surfaces, and in Figure 4 with the heights of buildings.

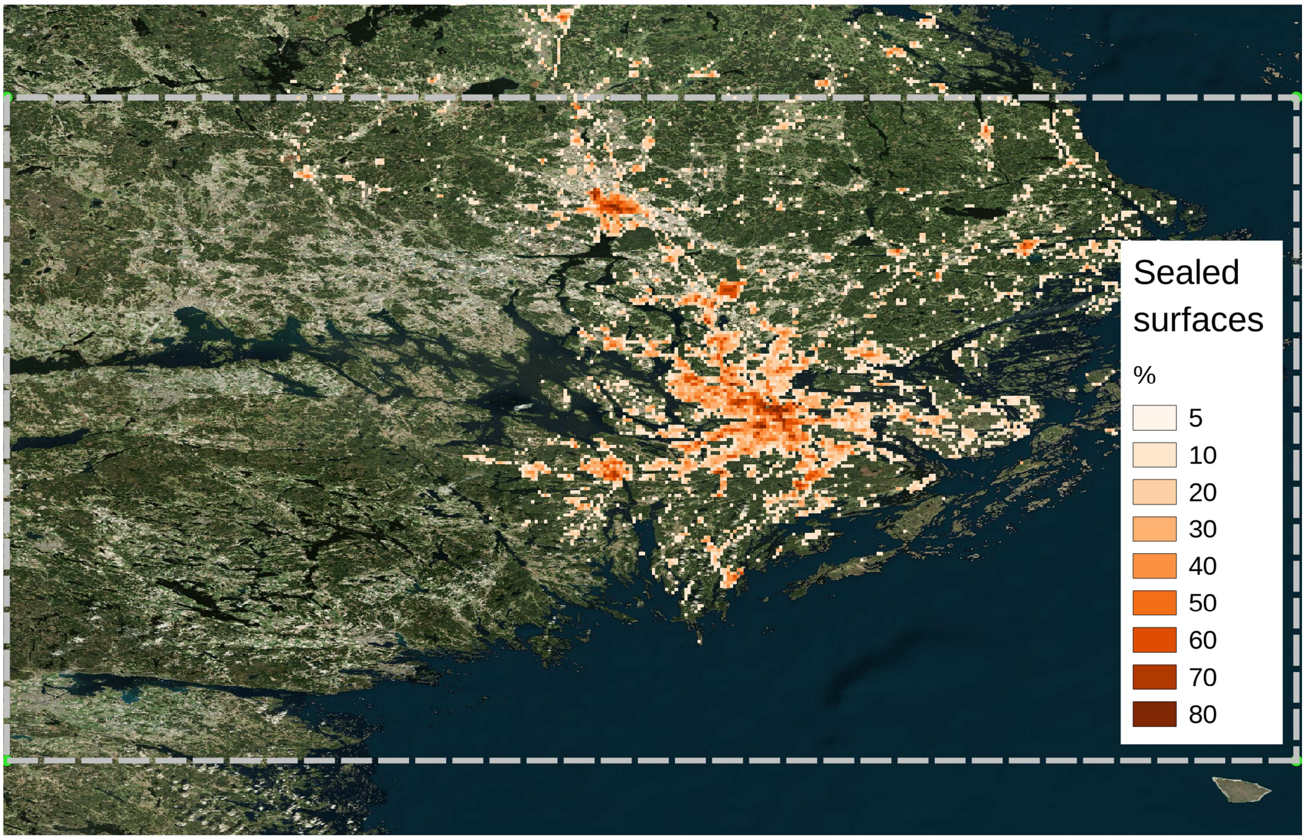

Figure 3: Spatial coverage of impervious surfaces (buildings and roads) in Stockholm given by fraction of grid cell occupied.

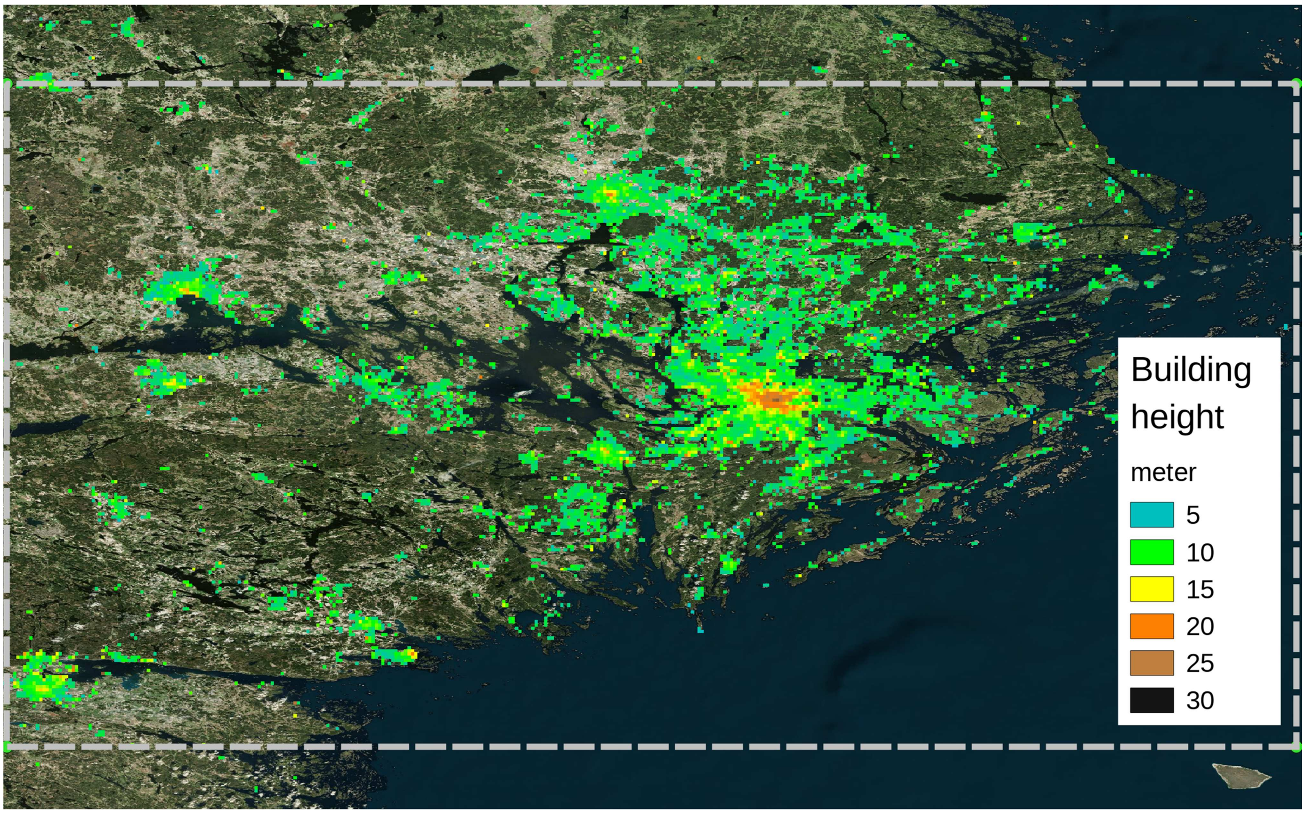

Figure 4: Building height over Stockholm domain

Climate model: Validation data

The availability of validation data for Bologna and Stockholm were investigated already in the D5.4.1 Proposals for KPIs report, delivered in February 2016. The number of stations with historical climate data useful for model output evaluation was required to allow an estimation of target values for KPIs related to downscaled ECVs. The KPIs for ECVs measure the number of downscaled ECVs that have been compared to observations. As an example the target value for meteorological ECVs was specified to five, meaning that we expect at least five out of a total of nine meteorological ECVs to be possible to evaluate against measurements in a typical European city like Bologna and Stockholm.

As a guideline for selecting the stations to be included in the validation, we will strive for having both within-city and more suburban or rural stations (like e.g. those commonly found at airports. It is important that the stations have a spatial representativity similar to the spatial scale of the climate model (1x1 km^2). Selected stations will be presented both in WP3 reports as well as in the D5.1 validation report. It should be noted that validation for non-assimilated parameters, such as wind, precipitation and radiation, is straight forward. For assimilated parameters such as temperature and relative humidity it is important to use independent observations, e.g. from Swedish climate stations and road weather stations.

The review of available measurements performed in D5.4.1 (Appendix 1) shows that there will be sufficient validation data to allow the KPI target values to be fulfilled for Bologna and Stockholm. This revision has not been performed for the third downscaling in Amsterdam-Rotterdam, however through earlier and ongoing cooperation with the meteorological community in the Netherlands, we are confident to have access to a similar amount of observational climatic data.

Air quality model: Chemical boundary conditions

The air quality in a city is highly affected by influx of air pollution from sources outside the city itself. The flux is not constant over time but dependent on the meteorological conditions and chemical environment. To accurately model the air quality in a city, or any other confined region of Europe, it is therefore important to also describe the formation and subsequent transport of air pollution from sources several 1000 km away from the region of interest.

To this end we will, for each 5-10 year time windows to be delivered (i.e. 2006 through 2010 and possibly also 2012-2014) , run a European scale set-up of the chemical transport model MATCH (Multi-scale Atmospheric Transport and Chemistry) forced by meteorology from the UERRA re-analysis and pan-European emissions from the Copernicus Atmosphere Monitoring Service (CAMS). Boundary concentrations for this set-up of MATCH will likely be taken from our standard set of seasonally varying climatological concentrations of the chemical species of relevance. The MATCH set-up will be close to what is used in CAMS, except that we drive our model with meteorology from UERRA to minimize meteorological and chemical discontinuities at the boundaries of the city-scale domains. The European scale simulation will be performed on the same geometry as the 12 km UERRA re-analysis. The European scale MATCH simulation will generate hourly three-dimensional fields of all chemical species of interest across Europe and this data shall be used as boundaries for all the different urban downscalings.

Figure 5 provides an excerpt of European scale NOx emissions from CAMS that will be used in the European scale simulation of air quality.

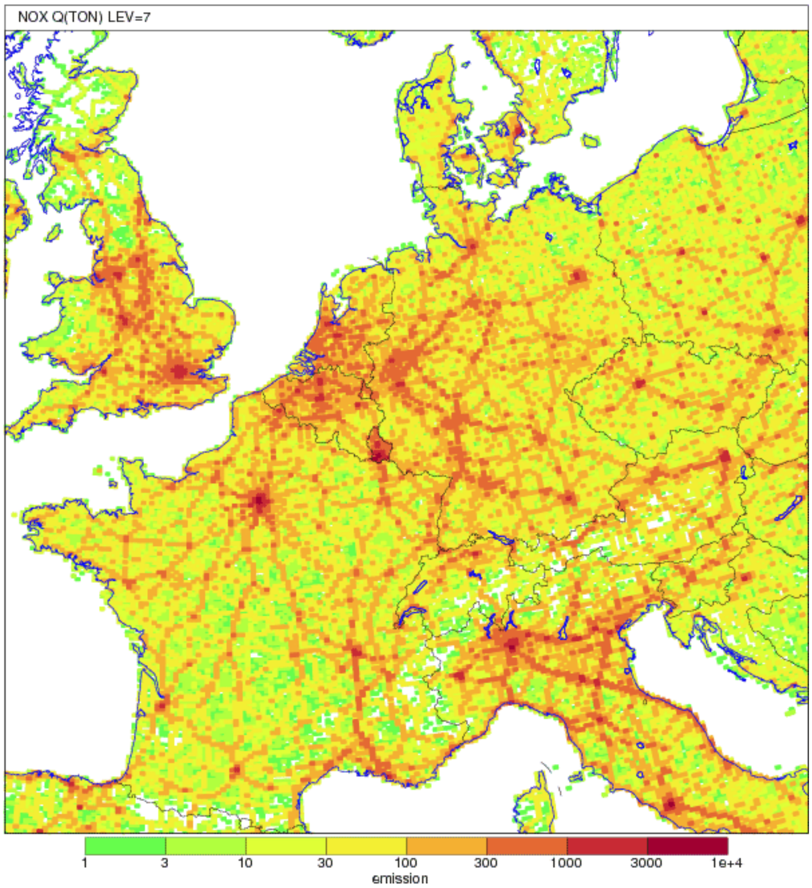

Figure 5: European NOx emissions from road traffic during 2009 (approximately 10x10 km^2 spatial resolution).

Air quality model: Required output from the climate model

SMHI will use its three-dimensional off-line model MATCH, to simulate air quality both on the regional scale and on the urban scale. The off-line model needs two- and three-dimensional meteorology which resolves the diurnal cycle, which means at least 3-hourly data. For the urban-scale application we will use the 1 km resolution meteorology from HARMONIE while we use the 12 km data from UERRA for the European scale application. Table 4 provides a summary of the meteorological data needed to run MATCH.

Table 4: Minimum set of meteorological data needed to run MATCH.

Parameter	Comment
U-component of wind	Three-dimensional field
V-component of wind	Three-dimensional field
Temperature	Three-dimensional field
Absolute or relative Humidity	Three-dimensional field
Fractional cloud Cover	Three-dimensional field
Cloud water content	Three-dimensional field
Turbulent Kinetic Energy*	Three-dimensional field
Surface pressure	Surface field (two-dimensional)
Surface temperature	Surface field (two-dimensional)
2m Temperature	Surface field (two-dimensional)
2m relative or absolute humidity	Surface field (two-dimensional)
10m u-wind	Surface field (two-dimensional)
10m v-wind	Surface field (two-dimensional)
Total precipitation	Surface field (two-dimensional)
Fraction ice covered water	Surface field (two-dimensional)
Fraction snow cover or snow depth	Surface field (two-dimensional)
Surface albedo	Surface field (two-dimensional)
Total cloud cover	Surface field (two-dimensional)
Net flux of Sensible	Surface field (two-dimensional)
Net flux of Latent heat	Surface field (two-dimensional)
Boundary Layer thickness*	Surface field (two-dimensional)

* Will only be used in the urban scale application of MATCH.

The MATCH model also requires physiography data (i.e. semi-static information on the characteristics of the surface: vegetation type, surface roughness, soil characterization etc.). This data will be extracted from the TEB-SURFEX data set (Table 1b above).

Air quality model: Emissions

As explained above the European scale air quality simulations will use the CAMS emission data which is available on a similar resolution as the UERRA re-analysis. The CAMS data comes as annually averaged emissions divided into so-called SNAP sectors. In MATCH we use standard profiles to convert the annual totals into seasonal, weekly and daily profiles. The temporal profiles are different for the different sectors. Additionally, we distribute the emissions vertically based on sectors, e.g. emissions from power plants (SNAP 1) are released much higher above ground than emissions from road transport (SNAP 7).

The CAMS emissions data is available at ca. 10 km resolution, see Figure 5. For most urban areas this resolution is too coarse and we also want to benefit from locally generated emission data that is typically more relevant for the particular region in question. In the normal case we will ask for annually accumulated emissions in SNAP sectors for each city to be modelled but it will also be possible to utilize time varying (hourly or seasonal emissions) or data on other sectors with locally determined temporal and vertical profiles. As fall-back solution we will spatially distribute the CAMS emissions on a finer resolution using GIS tools and land-use data.

For Stockholm we will have the possibility to merge the locally generated emissions from Stockholm on very high resolution with the national SMED (Svenska MiljöEmissionsData, Swedish Environment Emission Data) data base which is available on a 1 km x 1 km grid over the whole of Sweden. Through partner ARPAE we will have a similar access to high resolution gridded emission data not only for Bologna, but for the whole Po valley. High resolution emissions from the Amsterdam-Rotterdam area will be searched for through our professional networks into the Netherland air quality community.

Emission inventories are typically not very accurate and emissions normally change only slowly. It is therefore not necessary to include year-to-year variations in the annual emissions over a simulated 5-year period.

Table 5 summarizes for which species we need emissions in order to simulate the regulated species O3, NO_2, PM2.5 and PM10 over each city.

Table 5: Minimum set of species with emissions data needed to run MATCH.

Species	Comment
SO_2	Used both for SO_2 and sulphate
NO_2	Used both for NO and NO_2
CO	
Total NMVOC	Should be split among different hydrocarbons with different ozone generating potential.
NH_3	
PM	Should include and optimally discriminate between all types of primary emitted particles (e.g. EC, OC, soot, dust, etc.). Also good if these data are available for the different sizes of PM of interest.

Air quality model: validation data

The air quality model will be validated against data collected within each urban area. The data should be collected such that it represents the 1 km x 1 km grid-square that the CTM operates on, i.e. representing the urban background. The CTM is not expected to resolve the highest concentrations in the most affected traffic situations or the gradient perpendicular to highways. Monitoring data should be available on hourly resolution to resolve the diurnal variation as well as synoptic situations when air pollution is advected into the urban domain.

An overview of available air quality data was made as part of the D5.4.1 report and the estimated number of stations with useful data in Bologna and Stockholm is given in Appendix 1 of the present report. Partner ARPAE has made clear that more observations are available from a later period 2012-2014. The final selection of air quality stations to be used will be presented in the D5.2 validation report.

Hydrological model: Required output from the climate model

The hydrological model (HYPE; Lindström et al., 2010) requires precipitation and temperature from the atmosphere/climate model as input variables. A potential issue is the size and extension of catchments upstream of the city. Sometimes, all upstream catchments will be included in the downscaling domain and if so all HYPE model input can be retrieved from the downscaled climate data. However, in some cases the upstream area will extend outside of the downscaling domain, such as in Stockholm (Figure 6). In this case, it is intended to use the UERRA reanalysis, providing the boundary conditions for the climate model, as HYPE model input to simulate the upstream inflow to the city. This will then become a hydrological boundary condition at the edge of the downscaling domain. The technical solution and accuracy of this "upstream approach" is however not verified at the time of writing this report, but it will be developed and tested later in 2016.

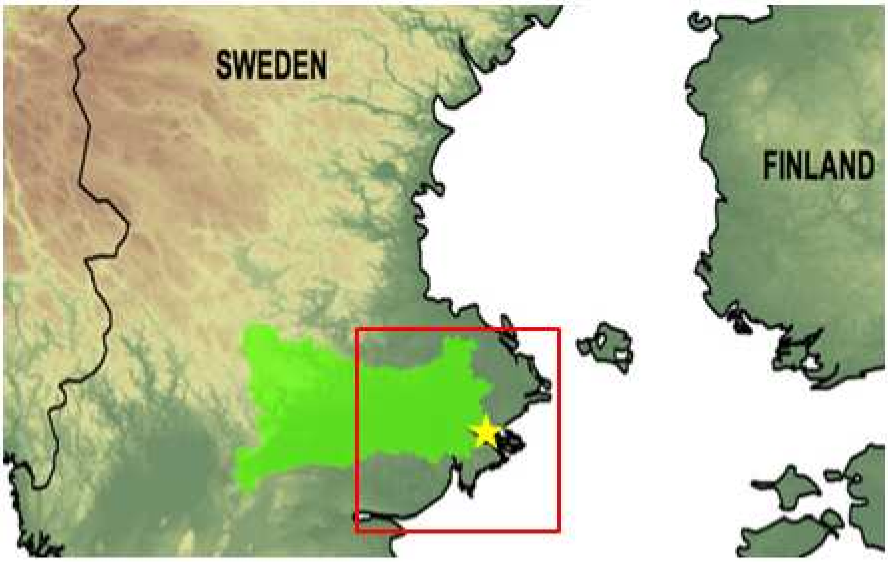

Figure 6: Stockholm City (yellow star), its upstream catchment (green area) and the approximate location of the Urban SIS downscaling domain (red line).

Hydrological model: Additional input

Besides the meteorological forcing, the HYPE model requires a wide range of inputs for catchment characterization as well as simulating water quantity and quality in various regions. Table 6 below shows the data sources used in the European HYPE set-up – E-HYPE (Donnelly et al., 2016) – which is the basis of the hydrological modelling in Urban SIS.

For the urban sub-models, more detailed land-use data from the EEA Urban Atlas will be used. Further, it will be attempted to develop generalized procedures for incorporating local information on e.g. sewer systems and detention ponds.

Table 6: E-HYPE data sources and characteristics.

Characteristic/Data type	Info/Name	Provider (references below)
Total area (km^2)	8.8 million	-
Number of sub-basins	35408 (mean size 215 km^2)	Tailored by SMHI from topography
Topography (routing and delineation)	Hydrosheds and Hydro1K (for latitude > 60°)	WWF & USGS
Soil characteristics	ESD DSMW	Panagos (2006) http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en
Land use characteristics	CORINE GLC2000 (for areas not covered by CORINE) Euroland Soil Sealing for urban area	http://www.eea.europa.eu/publications/COR0-landcover http://bioval.jrc.ec.europa.eu/products/glc2000/data_access.php Produced by: GeoVille, Planetek, Infoterra
Lake and wetland	GGLWD for lake area and distribution	Lehner and Döll (2004)
Irrigation	EIM, EU scale GMIA, global scale Siebert et al. (2010), global scale FAO-56, regional scale	Wriedt et al. (2009), Siebert et al. (2005)
Type of crop, demand of water	CAPRI, MIRCA2000, FAO-56	Portmann et al. (2010)
Discharge	Global Runoff Data Centre European Water Archive (EWA) Baltex Hydrological Data Centre (BHDC)	http://www.bafg.de/GRDC http://www.bafg.de/GRDC/EN/04_spcldtbss/42_EWA/ewa_node.html http://www.smhi.se/sgn0102/bhdc/
Precipitation	WFDEI	Weedon, G. P. et al.(2014)
Temperature	WFDEI	Weedon, G. P. et al.(2014)
Snow	GlobSnow Former Soviet Union Hydrological Snow surveys	1. http://www.globsnow.info/ 2. Krenke, A. (1998, 2004)
Glacier fluctuations	World Glacier Monitoring Service (WGMS)	Zemp, M. et al. (2012)
Evapotranspiration	MODIS satellite	http://modis.gsfc.nasa.gov/data/dataprod/dataproducts.php?MOD_NUMBER=16
Waste water	Hyde (population), EEA (treatment levels)	Goldewijk et al. (2011), http://www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment/urban-waste-water-treatment-assessment-3
Atmosperic N deposition	MATCH model simulations	SMHI
Industrial point sources	European Pollutant Release and Transfer Register	http://prtr.ec.europa.eu/
Crop statistics	CAPRI	Britz et al. (2007)
Riverine nutrient concentrations	National data sets and GEMS Water	http://gemstat.org

Hydrological model: Validation data

The main type of validation data for the HYPE model is discharge observations, potentially derived from water level observations in combination with a rating curve. It may be mentioned that discharge measurements from highly urbanized areas are often very limited but observation stations are located in the peripheral, less exploited parts of the city. In central parts, the flow in open watercourses is often influenced by technical modifications through the operation of sewer systems, pumping stations, etc. This type of (hydraulic) interference is not considered in the HYPE model, which is designed for rainfall-runoff simulations in natural conditions, but during this proof-of-concept phase of Urban SIS the possibility to take hydraulic interference into account in a simplified way will be explored. Then it may be possible to use also other types of validation data such as inflows to treatment plants, but this remains to be demonstrated.

Additional potential validation data include snow cover and soil moisture, see further Appendix 1 which summarizes the review of available validation data performed as part of the D.5.4.1 Proposal for KPIs. More details on stations finally used for validation will be given in the D5.3 Hydrological validation report.

Summary

For the historical period, urban ECVs will be generated by downscaling with three specific models for meteorology, air quality, and hydrology. Each model needs appropriate boundary and initial conditions as well as detailed description of urban land surface, watersheds and chemical emissions. For this input we will strongly utilize data from Copernicus services. The meteorological boundary and initial conditions will be provided by the UERRA-project. UERRA-reanalysis data will also be used with regional scale chemical-transport and hydrological models in order to generate chemical and hydrological boundary conditions. Specific urban surface description will be taken from Copernicus land services and national archives. Emission data is provided by Copernicus on the regional scale and by national services on the finer scale. Fallback solutions have been identified for input with uncertain availability or quality.

The period and domains for the downscaling were defined in dependence on availability of input data and consistent local modelling. The baseline historical period for Urban SIS spans from the years 2006 to 2010 due to availability of UERRA data. Additional periods might be provided in order to cover specific requests, e.g. 2012 to 2014 for Bologna due to air quality campaigns during those years.

For the validation of the urban ECVs, different observational networks have been determined through contact with our partners in Stockholm and Bologna as well as with the National agencies in the Netherlands.

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Appendix 1: ECV validation data

Meteorology

BOLOGNA					
ECV	Area	Number of stations etc.	Time resolution	Data period	Owner
Air temperature	Inside city	2	hourly	2005-now*	ARPAE Emilia Romagna
a), b)	Outside city	60	daily	1971-now	ARPAE Emilia Romagna
Precipitation - gauge	Inside city	3	Daily, hourly and 15 min	1971-now**	ARPAE Emilia Romagna
c), d)	Outside city	250	daily	1971-now	ARPAE Emilia Romagna
Precipitation - radar	Inside city	0			
	Outside city	2	5 min	1994-now***	ARPAE Emilia Romagna
Relative humidity	Inside city	1	hourly	2005-now	ARPAE Emilia Romagna
a)	Outside city	68	hourly	2001-now	ARPAE Emilia Romagna
Wind	Inside city	1	hourly	2005-now	ARPAE Emilia Romagna
a)	Outside city	35	hourly	2001-now	ARPAE Emilia Romagna
Boundary layer height	Inside city	0			
	Outside city	1	hourly	2012 - 2014	ARPAE Emilia Romagna
Snowfall	Inside city	1	daily	1971-now****	ARPAE Emilia Romagna
	Outside city	21	daily	1971-now*****	ARPAE Emilia Romagna
Global radiation	Inside city	1	hourly	2005-now	ARPAE Emilia Romagna
a)	Outside city	32	hourly	2001-now	ARPAE Emilia Romagna
Direct shortwave rad.	Inside city	1	hourly	2005-now	ARPAE Emilia Romagna
	Outside city	9	hourly	2005-now	ARPAE Emilia Romagna
Diffuse shortwave rad.	Inside city	1	hourly	2005-now	ARPAE Emilia Romagna
	Outside city	9	hourly	2005-now	ARPAE Emilia Romagna

STOCKHOLM					
ECV	Area	Number of stations etc.	Time resolution	Data period	Owner
Air temperature	Inside city	2 (Observatoriekullen, KTH)	hourly	from 1996 (kullen)...	SMHI
	Outside city	2 (Bromma, Arlanda)	hourly		SMHI
Air temperature	Inside city	2 (Torkel, Högdalen)	hourly	2006=>	Slb
	Outside city	3 (N Malma, Uppsala-Märsta, Eskilstuna)	hourly	2006=>	Slb
Precipitation - gauge	Inside city	1 (SMHI), ? (SV)	15-min	1996-now	SMHI
	Outside city	~10 (SMHI)	15-min	1996-now	SMHI
Precipitation - radar	Inside city	2x2 km	5-min	2000-now	SMHI
	Outside city	2x2 km	5-min	2000-now	SMHI
Relative humidity	Inside city	2 (Observatoriekullen, KTH)	hourly	from 1996 (kullen)...	SMHI
	Outside city	2 (Bromma, Arlanda)	hourly		SMHI
Relative humidity	Inside city	2 (Torkel, Högdalen)	hourly	2006=>	Slb
	Outside city	3 (N Malma, Uppsala-Märsta, Eskilstuna)	hourly	2006=>	Slb
Wind	Inside city				
	Outside city	2 (Bromma, Arlanda)	hourly		SMHI
Wind	Inside city	2 (Torkel, Högdalen)	hourly	2006=>	Slb
	Outside city	3 (N Malma, Uppsala-Märsta, Eskilstuna)	hourly	2006=>	Slb
Boundary layer height	Inside city				
	Outside city				
Snowfall	Inside city				
	Outside city				
Global radiation	Inside city	1 (Stockholm KTH)	hourly	sedan 2013 endast!	SMHI
	Outside city				
Global radiation	Inside city	2 (Torkel, Högdalen)	hourly	2006=>	Slb
	Outside city	3 (N Malma, Uppsala-Märsta, Eskilstuna)	hourly	2006=>	Slb
Direct shortwave rad.	Inside city				
	Outside city				
Diffuse shortwave rad.	Inside city				
	Outside city				

Air quality

BOLOGNA					
ECV	Area	Number of stations etc.	Time resolution	Data period	Owner
O3 concentration	Inside city	2	hour	from 2001	ARPAE Emilia Romagna
	Outside city	15	hour	from 2001	ARPAE Emilia Romagna
NO2 concentration	Inside city	4	hour	from 2001	ARPAE Emilia Romagna
	Outside city	20	hour	from 2001	ARPAE Emilia Romagna
PM10 concentration	Inside city	4	day	from 2006	ARPAE Emilia Romagna
	Outside city	15	day	from 2006	ARPAE Emilia Romagna
PM2.5 concentration	Inside city	2	day	from 2009	ARPAE Emilia Romagna
	Outside city	10	day	from 2009	ARPAE Emilia Romagna
STOCKHOLM					
ECV	Area	Number of stations etc.	Time resolution	Data period	Owner
O3 concentration	Inside city	1 (Torkel)	hourly	2006=>	Slb
	Outside city	2 (N Malma, Aspvreten)	hourly	2006=>	Slb
NO2 concentration	Inside city	1 (Torkel)	hourly	2006=>	Slb
	Outside city	1 (N Malma)	hourly	2006=>	Slb
PM10 concentration	Inside city	1 (Torkel)	hourly	2006=>	Slb
	Outside city	2 (N Malma, Aspvreten)	hourly	2006=>	Slb
PM2.5 concentration	Inside city	1 (Torkel)	hourly	2006=>	Slb
	Outside city	2 (N Malma, Aspvreten)	hourly	2006=>	Slb
PM10 concentration	Inside city				
	Outside city	1 (Uppsala)	daily	några år	IVL
PM2.5 concentration	Inside city	1 (Stockholm)		några år	
	Outside city	1 (Uppsala)	hourly	några år	Slb

Hydrology

BOLOGNA					
ECV	Area	Number of stations etc.	Time resolution	Data period	Owner
Local runoff	Inside city	???			
	Outside city	???			
Surface runoff	Inside city	???			
	Outside city	???			
Evapotranspiration	Inside city	2 (A)	daily	1971-now	ARPAE Emilia Romagna
(B, C)	Outside city	60	daily	2001-now	ARPAE Emilia Romagna
River discharge	Inside city	1	30 min/1 hour	2012-now	ARPAE Emilia Romagna
	Outside city	1	30 min/1 hour	1993-now	ARPAE Emilia Romagna
Soil moisture	Inside city	0			
(D)	Outside city	10	daily	2001-now	ARPAE Emilia Romagna
Snow cover	Inside city	(E)	variable: from daily to 15	2005-now	ARPAE Emilia Romagna
	Outside city	(E)	variable: from daily to 15	2005-now	ARPAE Emilia Romagna
STOCKHOLM					
ECV	Area	Number of stations etc.	Time resolution	Data period	Owner
Local runoff	Inside city				
	Outside city				
Surface runoff	Inside city				
	Outside city				
Evapotranspiration	Inside city				
	Outside city				
River discharge	Inside city	?	?	?	Stockholm Vatten
	Outside city	~15	various	various	SMHI
Soil moisture	Inside city				
	Outside city				
Snow cover	Inside city	1	daily	2013-now	
	Outside city	2	daily	2013-now	

Appendix 2: External participants at the two WP4 workshops

Stockholm WP4 workshop: 17 December, 2015

Bologna WP4 workshop: 5 February, 2016

Participant	Affiliation	Role / field of expertise
Daniel Hellström	Svenskt vatten	R & D management
Joakim Pramsten	Stockholm water	Urban flooding, water treatment etc.
Magnus Sannebro	Sthlm city env. department	Environment
	Norconsult	Consultant
Lars Marklund	Tyréns	Consultant
Hans Hammarlund	Tyréns	Consultant
Johan Kjellin	Tyréns	Consultant
Daniel Knös	Länsförsäkringar	Insurances
Karin Willis	Stockholm County Administrative Board	Climate adaptation, urban planning
Karin von Sydow	Stockholm County Administrative Board	climate adaptation, urban planning
Ulrika Postgård	Swedish Contingency Agency	senior advisor, natural hazards
Hans Bäckman	The Swedish Water & Wastewater Association	R&D
Maria Tengvard*	City of Stockholm	urban planning
Christina Wikberger*	City of Stockholm	urban planning
Cari Andersson	SMHI	Consultant
Paola Altobelli	Autorità Bacino Reno	General Manager/river basin authority
Paola Angelini	RER - Emilia-Romagna Region Health Direct.	Regional Officer/health/new illnesses
Germana Benassi	COBO – Bologna City Civil protection Dep.	civil protection
Chiara Caranti	COBO - Bologna City Env. Department	Urban environment
Emanuele Cimatti	RER – Emilia-Romagna Region Env. Directorate	Protection of water resources
Marisa Corazza	COBO – Bologna City Env. Department	Urban environment
Giovanni Fini	COBO - Bologna City Env. Department	Manager of the environmental and planning unit of the municipality of Bologna
Marco Folegani	MEEO	Consultant/ project manager
Angelo Giselico	COBO - Bologna City Civil protection Dep.	Head of the Municipal unit for civil protection
Raffaella Gueze	COBO - Bologna City Env. Department	Urban planning/CC adaptation
Fabio Marchi	Consorzio della Chiusa di Casale	River basin authority/Manager
Nicola Mezzadri	NIER Ingegneria	consultant
Paolo Pandolfini	AUSL Bologna – Local Public Health system	Manager of the Epidemiology Unit
Stefania Pasetti	MEEO	consultant
Cristina Ricci	NIER Ingegneria	consultant
Simonetta Tugnoli	RER – Emilia-Romagna Region Env Directorate	Air quality
Paolo Marzaroni	AUSL Bologna – Local Public Health system	Epidemiology Unit/heat waves
Stefano Tibaldi	CMCC – EuroMediterranean Centre for Climate Change	Climate change and CC impacts
Vincenzo Periangeli	AUSL Bologna – Local Public Health system	Epidemiology Unit/heat waves
Elisa Stivanello	AUSL Bologna – Local Public Health system	Epidemiology Unit/heat waves

*Interviewed separately in connection to the workshop

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