D2.1 Demonstration and validation methodology

WP2 – Demonstration & Validation

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Figure 1: CLARITY Disclamer

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CLARITY Project Overview

Urban areas and traffic infrastructure are highly vulnerable to climate change. Smart use of existing climate intelligence can increase urban resilience and generate added value for businesses and society at large. Based on the results of FP7 climate change, future internet and crisis preparedness projects (SUDPLAN, ENVIROFI, CRISMA) with an average Technical Readiness LEVEL (TRL) of 4-5 and following an agile and user-centred design process, end-users, purveyors and providers of climate intelligence CLARITY co-creates an integrated Climate Services Information System (CSIS) to integrate resilience into urban and traffic infrastructure.

As a result, CLARITY provides an operational eco-system of cloud based climate services to calculate and present the expected effects of Climate Change (CC)-induced and -amplified hazards at the level of risk, vulnerability and impact functions. CLARITY offers what-if decision support functions to investigate the effects of adaptation measures and risk reduction options in the specific project context, and allow the comparison of alternative strategies. Four demonstration cases showcase CLARITY climate services in different climatic, regional, infrastructure and hazard contexts in Italy, Sweden, Austria and Spain; focusing on the planning and implementation of urban infrastructure development projects.

CLARITY provides the practical means to include the effects of CC hazards and possible adaptation and risk management strategies into planning and implementation of such projects, focusing on increasing CC resilience. Decision makers involved in these projects will be empowered to perform climate proof and adaptive planning of adaptation and risk reduction options.

Abbreviations and Glossary

A common glossary of terms for all CLARITY deliverables, as well as a list of abbreviations, can be found in the public document "CLARITY Glossary" available at CLARITY.eu. Following table has been generated from http://cat.clarity-h2020.eu/glossary?machine_name%5B%5D=abbreviations_and_acronyms on 17/04/2018 and contains the complete abbreviations that are used in the project.

Name	Term description
AAO	Appraisal of Adaptation Options
ADM	Architecture Development Method
AHF	Anthropogenic Heat Flux
AJAX	Asynchronous JavaScript and XML
AR	Assessment Report
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
BB	Building Block
BC	Bias Correction
C3S	Copernicus Climate Change Services
CA	Consortium Agreement
CBA	Cost-benefit-analysis
CC	Climate Change
CCA	Climate Change Adaptation
CCD	Consecutive Dry Days
CCH	Climate Change Hazards
CDD	Consecutive Dry Days
CERN	Conseil Européen pour la Recherche Nucléaire
CFS	Climate Forecast System
CKAN	Comprehensive Kerbal Archive Network
CLARITY	Integrated Climate Adaptation Service Tools for Improving Resilience Measure
CLC	CORINE Land Cover
Climate-ADAPT	European Climate Adaptation Platform
CMIP	Coupled Model Intercomparison Project
COSMO-CLM	COnsortium for Small-scale MOdelling - Climate Local Model
COTS	Commercial Off-The-Shelf
CRISMA	Modelling crisis management for improved action and preparedness
CRM	Continuous Risk Management
CS	Climate Service
CSIS	CLARITY Climate Services Information System
CSS	Cascading Style Sheets

CSV	Comma Separated Values
CSW	Catalogue Service for the Web
CTA	Constructive Technology Assessment
DC	Demonstration Case
DC	Dublin Core
DEM	Digital Elevation Model
DFO	Dartmouth Flood Observatory
DHI	Danish Hydraulic Institute
DM	Decision Maker
DMP	Data Management Plan
DoA	Description of the Actions (Annex 1 to the Grant Agreement)
DOI	Digital Object Identifier
DOM	Document Object Model
DPA	Data Protection Agency
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DV	Dynamic Vulnerability
DWD	Deutscher Wetterdienst
EC	European Commission
ECA&D	ECA&D European Climate Assessment & Dataset
ECMWF	European Centre of Medium-Range Weather Forecasts
ECV	Essential Climate Variable
ECW	Enhanced Compression Wavelet
EE	Evaluation of Exposure
EEA	European Environment Agency
EFFIS	European Forest Fire Information System
EFTA	European Free Trade Association
EGI	European Grid Infrastructure
EM	Exploitation Manager
EM-DAT	Emergency Events Database
EO	Earth Observation
EPS	Ensemble Prediction System
ERA40	ERA 40-year Reanalysis
ERDDAP	Environmental Research Division's Data Access Program
ESD	Empirical Statistical Downscaling
ESDAC	European Soil Data Centre
ESGF	Earth System Grid Federation

ESM	Earth System Model
EU-GL	Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient (Document)
EU-MACS	European Market for Climate Services
FP7	7th Framework Programme
FTY	Forest Type
FUA	Functional Urban Areas
FWI	Fire Weather Index
GA	General Assembly
GCM	Global Climate Model
GDAL	Geospatial Data Abstraction Library
GDP	Gross Domestic Product
GeoJSON	Geographical JavaScript Object Notation
GEOSS	Global Earth Observation System of Systems
GeoTIFF	Geographic Tagged Image File Format
GFCS	Global Framework for Climate Services
GIS	Geographic Information System
GML	Geography Markup Language
GPM	General Project Manager
GPS	Global Positioning System
GPX	GPS Exchange Format
H	Human
HC	Hazard Characterisation
HRL	High Resolution Layers
HRU	Hydrological Response Unit
HTML5	Hypertext Markup Language, version 5
HTTP	Hypertext Transfer Protocol
HWMI	Heat Wave Magnitude Index
IA	Impact Assessment
IAAP	Integration of Adaptation Action Plan
IAO	Identification of Adaptation Options
ICMS	Integrated Crisis Management Middleware
ICT	Information and Communication Technologies
IFS	Integrated Forecast System
IPR	Intellectual Property Rights
JMA	Japan Meteorological Agency
JRA-25	Japanese 25-year ReAnalysis

JRC	Joint Research Centre
JSON	JavaScript Object Notation
MCDA	Multi-Criteria Decision Analysis
MMU	Minimum Mapping Unit
MRU	Minimum Reference Unit
MUKLIMO_3	Mikroskaliges Urbanes Klimamodell 3D
NaTech	Natural Hazard Triggering Technological Disasters
NCEP	National Centers for Environmental Prediction
NDSM	Normalized Differential Surface Model
NetCDF	Network Common Data Format
NGO	Non-Governmental Organization
NWP	Numerical Weather Prediction
OAI-PMH	Open Archive Initiative – Protocol Metadata Harvesting
OGC	Open Geospatial Consortium
OGR	OpenGIS Simple Features Reference Implementation
OpenAIRE	Open Access Infrastructure for Research in Europe
OpenDAP	Open-source Project for a Network Data Access Protocol
OSM	Open Street Maps
PDF	Portable Document Format
PDSI	Palmer Drought Severity Index
PHP	PHP Hypertext Preprocessor
POPD	Protection of Personal Data
PPEA	Precipitation Potential Evaporation Anomaly
QA	Quality Assurance
QAP	Quality Assurance Plan
RA	Risk Assessment
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
RDBMS	Relational Database Management System
REST	Representational State Transfer
RIA	Rich Internet Application
RS	Reference Scenario
S2D	Subseasonal-to-Decadal
SD	Statistical Downscaling
SMS	Scenario Management System
SOS	Sensor Observation Service
SPA	Single Page Application

SPBS	Stochastic back-scatter scheme
SPI	Standardized Precipitation Index
SPPT	Stochastically perturbed parameterized tendency
SPS	Sensor Planning Service
SQA	Software Quality Assurance
SQAP	Software Quality Assurance Plan
SQL	Structured Query Language
SSR	Seasonal Severe Rating
STL	Street Tree Layer
SUDPLAN	Sustainable Urban Development Planner for Climate Change Adaptation
SWD	Staff Working Document
SWICCA	Service for Water Indicators in Climate Change Adaptation
TC	Test Case
TCD	Tree Cover Density
TL	Task Leader
TM	Scientific & Technical Manager
TOC	Table of Content
TOGAF	The Open Group Architecture Framework
TRL	Technology Readiness Level
UN	United Nations
uncertML	Uncertainty Markup Language
UNGA	United Nations General Assembly
UNISDR	United Nations Office for Disaster Risk Reduction
UrbanSIS	Climate Information for European Cities
US	User Story
VA	Vulnerability Analysis
VC	Vulnerability Curve
WFS	Web Feature Service
WHO	World Health Organization
WMO	World Meteorological Organization
WMS	Web Map Service
WMTS	Web Map Tile Service
WP	Work Package
WPL	Wok Package Leader

Executive Summary

This deliverable is intended to give a complete outline of the activities to be carried out in WP2 “Demonstration& Validation”to ensure a successful implementation of CLARITY Demonstration Cases (DCs). WP2 “Demonstration & Validation” deliverables, as output of a joint effort from CLARITY scientific, technical and end-user partners, are drafted with the aim of reducing the technical and scientific complexity of the information enclosed. In this sense, they constitute a first reference guide also for further applications of CLARITY CSIS on other DCs. Main objectives of WP2 – Demonstration & Validation – include:

- Develop a harmonised methodology for data collection across the different DCs linking end-user’s requirements from WP1 “CO-Creation” with modelling and software needs in WP3 “Science Support” and WP4 “Technology Support”
- Monitor the implementation of CLARITY DCs
- Deliver input data to CLARITY models (WP3 “Science Support”) and tools (WP4 “Technology Support”) for each DC
- Collect climate and adaptation scenarios and tailor them to the specific needs of the DCs
- Validate the tools implemented in WP4 “Technology Support”
- Demonstrate the fulfilment of requirements and the application potential of the tools, providing feedback to WP1 “CO-Creation”and WP4 “Technology Support”

The envisaged approach for a successful achievement of the WP’s objectives identifies a comprehensive workflow across the different WP2 tasks, which can be summarized as follows:

- T2.1 (Data requirements definition, data collection concept, demonstration and result validation concept), through the present report, constitutes a reference guide to structure the process leading to the implementation and validation of CLARITY DCs, starting from the data collection and identification of models required to respond to key requirements from each DC, as specified in the User Stories developed in WP1 “CO-Creation”.
- T2.2 (Demonstrator-specific data collection) will ensure the proper implementation of the data collection process for the different DCs. The successful finalization of this step will be constituted by the complete inclusion of all datasets needed for the implementation of test cases in each DC in the CLARITY Catalogue (http://cat.clarity-h2020.eu/demo_cases/datasets), which will be reported in D2.2 “Catalogue of local data sources and sample datasets”.
- T2.3 (Demonstration), through the deliverables D2.3 “CLARITY Demonstrators Implementation and Validation Report v1” and D2.4 “CLARITY Demonstrators Implementation and Validation Report v2”, will ensure the proper implementation of the DCs, monitoring the process from the point of view of the: modelling workflow(s) performed (WP3 “Science Support”), level of compliance to user expectations and co-design requirements (WP1 “CO-Creation”), implementation of required software features on the CLARITY CSIS (WP4 “Technology Support”).
- T2.4 (Validation), through the deliverables D2.3 “CLARITY Demonstrators Implementation and Validation Report v1” and D2.4 “CLARITY Demonstrators Implementation and Validation Report v2”, this task will ensure the validation of CLARITY framework and tools, in terms of compliance with requirements and functionalities identified, and the potential uptake (impact) of CLARITY in providing an improved capacity for exploiting climate services in the EU.

The report is structured according the articulation of Tasks within WP2 “Demonstration & Validation”:

Section 1 describes the Data Collection methodology in relation to the modelling workflow as defined in D3.1 “Science support plan and concept”. It provides an outline of data sources available at EU level from public repositories and previous projects, and of the different categories of datasets needed to perform risk assessments and impact scenarios analyses.

Section 2 outlines the main objectives of the 4 CLARITY DCs, discussing the needed data sets and identified data sources in relation to the CLARITY methodology and modelling workflow as defined in D3.1 “Science support plan and concept”.

Section 3 illustrates the main end-user requirements and expectations in relation to the implementation of the CLARITY test cases, with reference to the DC-specific workshop activities carried out and the User Stories.

Section 4 define the proposed methodology for the validation of results according DC end-user requirements.

In Annex, the datasets to be collected for each DC are mapped in relation to the EU-GLs and modelling workflow steps.

Introduction

This deliverable provides a methodology and plan for (1) the collection of required data in task T2.2 “Demonstrator-specific data collection”; (2) conducting the demonstrations in T2.3 “Demonstration”; and (3) validating the results in T2.4 “Validation”.

It represents the main output from task T2.1 - Data requirements definition, data collection concept, demonstration and result validation concept.

Task T2.1 aims at defining data requirements to provide the climate services and preparatory work. The following sections provide the methodology for a harmonized approach for data collection (climate signals, urban land use, transport and urban environment data, inventory of elements at risk, sensitivity, exposure, etc.) across the different demo cases to support the transferability, scalability and replicability of CLARITY climate services in different EU contexts.

This approach will be part of the guidelines on how to set-up CLARITY climate services. The proposed methodology is adapted from previous EU and national project, and is oriented towards the integrated management of multi-scale information in a GIS environment.

The report describes the different categories of data types, which include hazard, exposure and vulnerability parameters, as well as information on the spatial units of analysis, which precise the level of detail and resolution of data according to the territorial extensionunder examination.

The data collection process is strongly related to the expected results of simulations as identified by CLARITY DC end-users. Thus, relevant data types and sources are mapped in relation to the hazard/impact models to be used and the requirements as outlined by the User Stories.

The required input of models (WP3 “Science Support”) and tools (WP4 “Technology Support”) are systematically identified for the individual demo cases, with reference to the specific climate hazards and elements at risk. The result will allow to effectively carry out the data collection in task T2.2 “Demonstrator-specific data collection”.

The datasets mapping included in Annex represents a reference guide for the data collection process, to ensure that the required input of the different models used is made available for each of the DCs.

1. Data collection methodology

The data collection methodology is intended to provide guidance on how to ensure that the process leading to the implementation of the needed steps from EU-GL framework [1] is controlled since the early stage of CLARITY DCs development in line with the modelling workflow defined in WP3 “Science Support” (Figure 2).

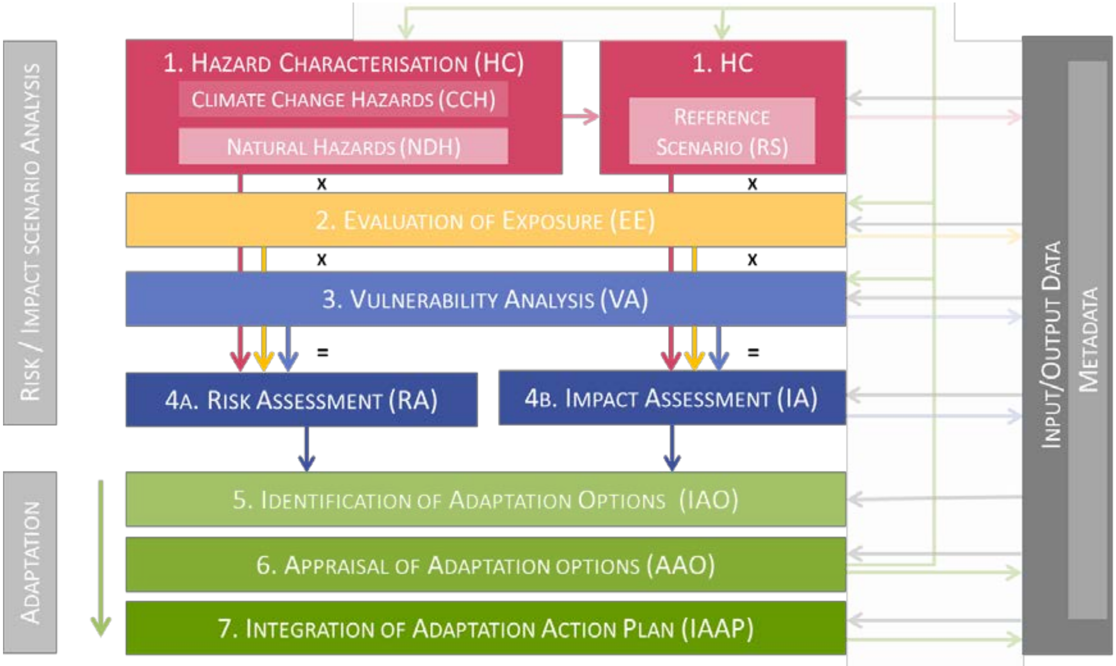

Figure 2: CLARITY modelling methodology.

The methodology consists in the preliminary mapping of models and datasets with respect to the objectives of the DCs as outlined by the user stories, identifying the required workflows in relation to the corresponding EU-GL steps taken into account. The 7 steps of the EU-GL logic are updated within CLARITY in relation to the modelling framework as defined in IPCC-AR5, identifying 5 operational macro-steps characterized by different data flows in relation to the models and tools made available through the CLARITY CSIS (Figure 3, Table 1, see D3.1 “Science support plan and concept”).

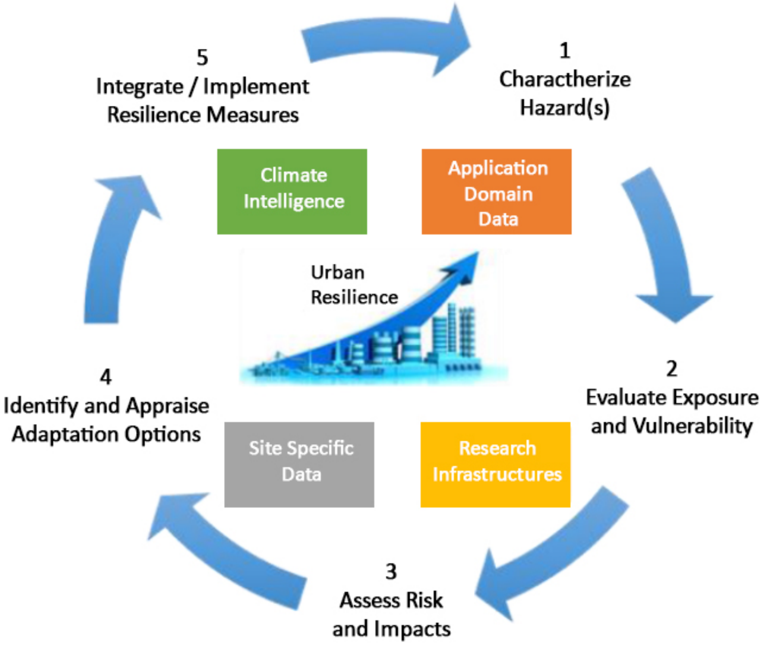

Figure 3: EU-GL logic update in CLARITY.

Updated EU-GL step	CLARITY macro-step	Main input data types
1. Hazard Characterization (HC)	1. Characterize Hazard(s)	• Historical meteorological data • Climate projections, climate indices • Other hazard(s) data (multi-risk) • Historical events records
2. Evaluation of Exposure (EE) 3. Vulnerability Analysis (VA)	2. Evaluate Exposure and Vulnerability of elements at risk	• Geometry (including terrain) • Typological, technical, construction data • Transport environment • Land use and building functions data • Socio-economic data
4. Risk / Impact Assessment (RA / IA)	3. Assess Risk and Impact	• Output from macro-steps 1, 2 • Economic data
5. Identification of Adaptation Options (IAO) 6. Appraisal of Adaptation Options (AAO)	4. Identify and Appraise Adaptation Options	• Adaptation options catalogue (includes cost and performance indicators) • Project-specific data (functional program, design documents, etc.)
7. Integration of Adaptation Action Plan (IAAP)	5. Integrate / Implement Resilience Measures	• Output from macro-steps 1, 2, 3, 4

Table 1: Correlations between EU-GL steps and CLARITY macro-steps in relation to the main input data types to be collected.

The methodology requires a preliminary identification of models to be used for each step in the different DCs, mapping the data sources in relation to the models' input/output (see Section 3 and Annex I). This first screening constitutes a reference for the DC-specific data collection in task T2.2 "Demonstrator-specific data collection", where datasets will be formally collected within the CLARITY catalogue, based on the specific data types and format as defined in WP3 "Science Support" and technical specification from WP4 "Technology Support" (Figure 3).

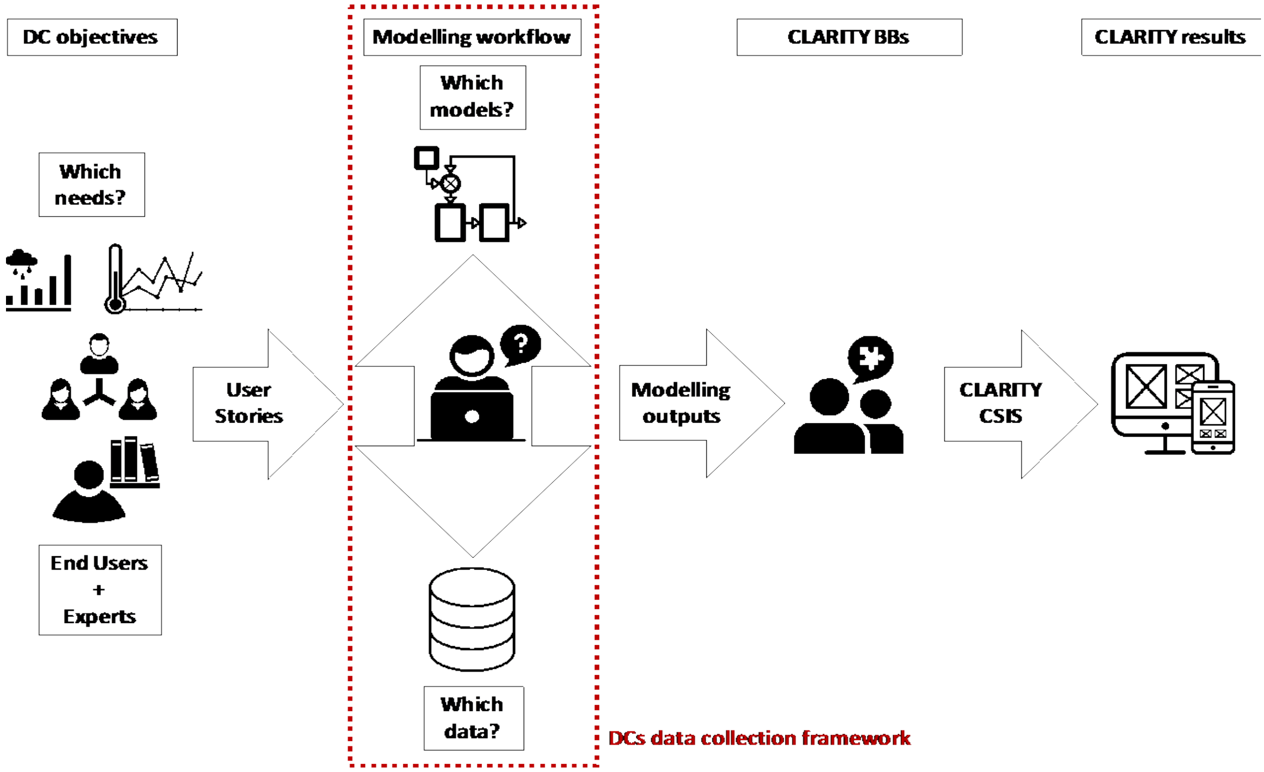

Figure 4: Data collection phase within DC implementation workflow.

During T2.2 "Demonstrator-specific data collection", an identification of the data sources, being external data (that which will not be stored by CLARITY) or internal data (that which will be stored by CLARITY) will be performed. This will cover the required data for User Stories, Test Cases and Exploitation Requirements for each of the DCs. Data to be stored in CLARITY's central repository will be identified along with guidelines to ensure the availability of all needed resources for the successful fulfilment of the DCs. For external data, it will also be needed to gather information on their location, storage, and use during the life-cycle of the project. The definition and the development of the guidelines will rely on a detailed description of each of these DCs, both in terms of the steps involved and the data needed in each one. Another important information that will need to be considered and registered is the metadata for both types of data, preferably in standard metadata formats.

Some pieces of these information have already started to be registered and analysed on T2.1 "Data requirements definition, data collection concept, demonstration and result validation concept", as can be seen in Annex I. Although, the bulk of the work is planned to be performed during T2.2 "Demonstrator-specific data collection".

1.1 Background

1.1.1 EU level data sources

A considerable part of datasets on the European level, that are relevant for the CLARITY project is openly available from various European services and projects and provides a solid baseline for climate change information and hazard characterisation. Some datasets originate from climate and environmental monitoring, while others are results from numerical model simulations. Data will be used within the project in various manners: 1) as baseline for the current climate situation; 2) to analyse future climate projections; 3) as input for model applications; and 4) as baseline for hazard mapping.

Observational data from European space observation and land monitoring stations will be used to obtain an overview about current climate conditions and to provide a baseline for pan-European hazard, exposure and vulnerability assessments in relation to climate change (see D3.1 “Science support plan and concept”). The data may be further used as input for various model applications.

The European Climate Assessment & Dataset (ECA&D) project, which was founded by the European Climate Support Network in 1998 provides a database of quality-controlled daily meteorological data from measuring stations across Europe and derived indices of climate extremes with the objective of monitoring and analysing climate change. Additionally, a high-resolution gridded dataset (E-OBS) that is based on the ECA&D observational data is available [2].

Long-term climate projections that are available from various regional climate simulations are important for climate change impact analysis and may be further used as input for local scale analysis.

The EURO-CORDEX project, which is a branch of the international CORDEX initiative, produces regional climate change projections for the European domain based on multiple dynamical and statistical downscaling models forced by multiple global climate models and considering different representative concentration pathways. The model data can be used for analysing long-term climate projections on a European level or on the local level via further downscaling [3].

Part of the information that is available from EU level data sources will be used as input for local/regional models addressing urban hazards.

The Copernicus Land Monitoring service provides information about land cover and related variables at a global, a pan-European and a local level, the two latter being coordinated by the European Environment Agency. The database includes: the Urban Atlas (2012) land use dataset, which provides comparable, high-resolution land cover data for 695 cities across EU and EFTA (European Free Trade Association) countries; a high-resolution imperviousness layer (2012); a high-resolution tree cover density layer (2012); and a European settlement map (2016) [4]. The European Environment Agency further provides a Digital Elevation Model (DEM) on EU scale with a horizontal resolution of 30 m [5]. These datasets are openly available as raster or vector data and may serve as a baseline for high-level screening or as input for urban climate models.

Some information on existing climate and hazard mapping is already available on an EU scale. Datasets will be directly used for hazard analysis on the EU level and will further serve as an input for high-resolution analysis on an expert level within the framework of demonstration case specific issues.

The following list has to be considered as not exhaustive of the EU level data sources taken into account (see D3.1, Section 4.3 “Science support plan and concept”). Further data sources, which include climate projections will be considered to complement static datasets.

Floods

The **SWICCA** (Service for Water Indicators in Climate Change Adaptation) project offers water-related climate impact data and aims to bridge the gap between data providers on the one side and water managers and policy makers on the other side. Different climate (impact) indicators are openly available for visualisation and/or download at different spatial resolutions [6].

Landslides

The **European Soil Data Centre** (ESDAC) is part of the Joint Research Centre, led by the European Commission, and offers various datasets dealing with soil threats at a European level. Information about landslide susceptibility and occurrence at a continental scale is provided by a corresponding GIS dataset that is available for download [7].

Wildfire

The **European Centre for Medium-Range Weather Forecasts** (ECMWF) is an independent intergovernmental organisation founded in 1975 and supported by 34 states which produces global numerical weather forecasts worldwide. Within the range of datasets available, ECMWF has produced, as part of the Copernicus Atmosphere Monitoring Service (CAMS), The Global Fire Assimilation System (GFAS) [8]. The system assimilates fire radiative power (FRP) observations from satellite-based sensors to produce daily estimates of biomass burning emissions. It has been extended to include information about injection heights derived from fire observations and meteorological information from the operational weather forecasts of ECMWF. GFAS data includes: Fire Radiative Power (FRP), dry matter burnt and biomass burning emissions. Data are available globally on a regular latitude-longitude grid with horizontal resolution of 0.1 degrees from 2003 to present. The features of the current version of GFAS (GFAS v1.2) are:

- Injection height daily data (Mean altitude of maximum injection and Altitude of plume top) as provided by a Plume Rise Model
- Pixel based quality control for MODIS/Aqua and Terra and SEVIRI observations
- Statistical regression of the output when assimilating only Aqua or Terra observations so as to preserve consistency with data obtained assimilating Aqua and Terra observations

Heat wave

Mapping of heat waves will be performed by using EURO-CORDEX regional climate projections, for example by calculating the Heat Wave Magnitude Index (HWMI) [9].

Drought

EURO-CORDEX data can be further used to derive the Standardized Precipitation Index (SPI) [10], which is a measure for meteorological droughts.

Air pollution

The MACC (Monitoring Atmospheric Composition & Climate) project [11], as part of Copernicus, provides information about European air quality, datasets on atmospheric composition for the resent years, for present conditions as well as forecasts of key components for a few days ahead. It combines state-of-the-art atmospheric modelling with Earth observation data.

Another information service for air quality in Europe is provided by EEA and the European Commission. The European Air Quality Index, based on the five key pollutants PM2.5, PM10, O3, NO2 and SO2 shows local air quality levels at station level for more than 2000 monitoring stations across Europe [12].

Storms

The Windstorm Information Service (WISC) [13], as part of the Copernicus Climate Change Service (C3S), provides a historical database on key indicators, like the number of European winter windstorms per year, average maximum wind speed of winter windstorms and average storm severity

Information on future projections of windstorms, e.g. in terms of changes in extreme windspeed, can be obtained from regional climate models, like EURO-CORDEX data. *Volcanic eruption*

The Smithsonian National Museum of Natural History offers a database [14] of those volcanoes active during the last 10,000 years including caldera-forming events. The information recorded includes a detailed description of the caldera geographical location (e.g. world region, sub-region, latitude, longitude, elevation), the volcano number according to the Catalogue of Active Volcanoes of the World (CAVW), a brief description of the geological history and a photograph. "Volcanoes of the World" is a database describing the physical characteristics of Holocene volcanoes and their eruptions. This search returns a list which may be filtered based on a volcano name, volcano type, features, evidence of recent activity, location (set using a map), country, rock types, population within various distance ranges, or the availability of images. Name and country searches will also return sub-feature names and synonyms; using other filters will result in only primary volcano names being returned. A standard set of fields is shown on the screen display, but full results with additional content may be downloaded into an Excel spreadsheet.

The NOAA Significant Volcanic Eruption Database [15] is a global listing of over 500 significant eruptions which includes information on the latitude, longitude, elevation, type of volcano, and last known eruption. A significant eruption is classified as one that meets at least one of the following criteria: caused fatalities, caused moderate damage (approximately $1 million or more), with a Volcanic Explosivity Index (VEI) of 6 or larger, caused a tsunami, or was associated with a major earthquake. For a complete list of current and past activity for all volcanoes on the planet active during the last 10,000 years, please see Smithsonian Institution's Global Volcanism Program (GVP).

The worldwide Collapse Caldera Database [16], currently formed by 473 calderas and 28 variables, updates the current field based knowledge on calderas, merging together the existing databases, complementing them with new examples found in the bibliography and leaving it open for the incorporation of new data from future studies. The information included in the CCDB can be classified into the following classes: caldera depression (e.g. dimensions, morphology, and age), caldera-forming deposits (e.g. volume and thickness of the deposits), associated magmatic system (e.g. magma composition), geodynamic setting where the caldera is located (e.g. crustal type and plate tectonic setting), type of pre-caldera volcanism, caldera-forming eruption sequence (deduced from the sequence of deposits) and post-caldera evolution (e.g. post-caldera volcanism, resurgence, and caldera erosion). The reader is addressed to the original paper and the CCDB website to get more information on each class.

Earthquake

European-Mediterranean Seismological Centre [17] collects real time parametric data (source parameters and phase pickings) provided by 70 seismological networks of the Euro-Med region. These data are provided to the EMSC either by email or via PDL (Product Distribution Layer). The collected data are automatically archived in a database, made available via an autoDRM, and displayed on the web site. The collected data are automatically merged to produce automatic locations which are sent to several seismological institutes to perform quick moment tensors determination.

ORFEUS [18] is the European infrastructure for seismic waveform data and station metadata. It coordinates the infrastructure for distributed seismic data archives in the European Integrated Data Archive (EIDA). ORFEUS provides access to high quality seismic waveforms and station metadata from EIDA and strong motion products. The Rapid Raw Strong Motion (RRSM) is an entirely automated system that uses open data from EIDA. It provides earthquake information and strong motion parameters including PGA and PGV within minutes of any event. The Engineering Strong-Motion database (ESM) is a reviewed archive of accelerometric waveforms from events with magnitudes above 4.0 recorded in Europe and the Middle-East since 1969. It provides unprocessed acceleration time-series, manually processed acceleration, velocity, and displacement waveforms, acceleration and displacement response spectra, and other relevant engineering parameters.

The USGS ANSS Comprehensive Earthquake Catalogue [19]) contains earthquake source parameters (e.g. hypocentres, magnitudes, phase picks and amplitudes) and other products (e.g. moment tensor solutions, macroseismic information, tectonic summaries, maps) produced by contributing seismic networks. This comprehensive collection of seismic information will eventually replace the ANSS composite catalogue hosted by the Northern California Data Center; however, historic regional seismic network catalogues have not yet been fully loaded.

The above list of data sources is only indicative at this stage of the project. Other relevant datasets (e.g. Copernicus data store) will considered taking into account their availability, as well as data consistency and harmonisation of datasets for their use within CLARITY modelling framework (e.g. different spatial resolutions, time scales).

1.1.2 Data collection in previous and ongoing national and EU Projects

Within the framework of several Austrian national projects, a well-founded analysis of urban climate, including climate change projections and simulations of possible adaptation scenarios, has been provided for some cities in Austria, serving as solid database for further investigations on an expert level.

The **SISSI-I+II** project (BMWFW, 2010-2011) [20] provides a database for climate change scenarios for selected urban areas in Austria. Besides information about the historical and present climatological situation in the cities, high-resolution climate projections have been carried out by the urban climate model MUKLIMO_3, estimating the change in heat load for the coming decades.

The **FOCUS-I** project (ACRP/KLIEN, 2011-2013) [21] aimed to estimate the impact of climate change on urban heat island in Vienna and to investigate different adaptation strategies for reducing urban heat load. The efficiency of possible urban planning measures (e.g. increase of albedo, green and blue infrastructure) was tested systematically through an implementation of various sensitivity experiments.

Within the **KELVIN** project (FFG Cities of Future, 2014-2015) [22], different concepts for a reduction in urban heat load were presented and their efficiency with regard to energy savings that may result from a cooler microclimate was tested.

The **SUDPLAN** project (Sustainable Urban Development Planner for Climate Change Adaptation, FP7-247708, 2010-2012, www.sudplan.eu) provided a methodology to integrate climate change effects into long term urban planning.

The recent **Copernicus Climate Change Services (C3S)** has a vision to be an authoritative source of climate information for Europe and various ongoing projects aim at streamlining the C3S services for a more effective use of climate data in long-term planning.

The already mentioned **SWICCA** (2015-2018) project, coordinated by SMHI, served as a proof-of-concept for a Sectorial Information Service (SIS) on water management, providing data and guidance for climate impact assessments in the water sector and ensuring that the available information is useful for water management at local and regional scales across Europe. The project aimed at bridging the gap between institutes that provide climate-impact data on one side, and water managers and policy makers on the other.

The C3S proof-of-concept project **Urban SIS** (2015-2017), also coordinated by SMHI, aimed at delivering climate and impact indicators, with a focus on the infrastructure and health sectors, at fine resolution over selected European urban areas (Stockholm, Bologna and Amsterdam/Rotterdam). This information was recently delivered in a format useful for urban planners, engineers, consultants and scientists, as input to local models or dimensional calculations addressing urban hazards driven by intense rainfall, heat waves and air pollution. This dataset will be in the basis for the high-resolution climate-related data over Stockholm (DC2).

The parallel project **HazardSupport**, founded by the Swedish Civil Contingencies agency, addresses many questions relevant for CLARITY. The aim of the project is to produce risk-based decision support for adaptation to future natural hazards with particular emphasis on developing a new method for decision-makers and climate experts to tailor information about the impacts of climate change on natural hazards for adaptation decisions. The goal of the project is to produce guidelines for climate adaption studies directed towards stakeholders and climate experts as well as an arena for collaboration and mutual learning on climate. The project focuses on three case studies on heat waves and flooding addressing similar problems as the CLARITY DC2 user stories. In particular, there is a link to the user story US-DC2-210 ("Urban vegetation in Stockholm as a climate adaptation tool"), where different planning scenarios for Stockholm, with different penetration rates of urban green infrastructure, are being simulated with the meteorological model HARMONIE-AROME.

RECLIP:century was a national research project funded through the ACRP program, carried out during2007-2010by AIT (coordinating), ZAMG, BOKU-Met and Wegener Center to generate 10x10 km resolution transient regional climate simulations for the Greater Alpine Region applying various SRES scenarios and different forcing data till 2100 by using COSMO CML RCM and MM5 RCM. Detailed uncertainty assessment has been carried out using the ENSEMBLES simulations as reference data sets. During the last years AIT carried out a 4x4km simulation for Austria using the HADCM3-based scenario results.

Based on the 4x4km results, urban climate simulations have been carried out recently for Vienna conducted by a special version of Cosmo-CLM (cclm_4.8_clm19_c6) which includes selected urban extensions. The 4x4km simulation results will also serve as input for the urban climate simulations for the Linz area which are currently processing.

RIMA-ROCC (Risk Management for Roads in a Changing Climate) [23] is a trans-national joint research programme that was initiated by **ERA-NET ROAD** (Coordination and Implementation of Road Research in Europe), a Coordination Action in the 6th Framework Programme of the EC. The objective of the RIMA-ROCC project was to develop a common ERA-NET ROAD method for risk analysis and risk management with regard to climate change. The purpose was to support decision making concerning adaptation measures in the road sector. To facilitate the work of end users the method was compatible with general existing methods for risk analysis (and management) within the ERA-NET ROAD funders and other relevant methods. The project focus was on Risk Analysis – with risk assessment, risk management in cost-benefit analysis and level of acceptable risk, and on Risk management options.

The **ROADAPT** (Roads for today, adapted for tomorrow) project is part of the CEDR Call 2012 'Road owners adapting to climate change' [24] in which was stated that one of the most important tasks of the road owners is the prioritisation of measures in order to maximize availability with reasonable costs. This includes a risk based approach addressing causes, effects and consequences of weather related events to identify the top risk that need to be taken action on with mitigating measures.

ROADAPT further developed the RIMAROCC framework into practical and useful methods for road owners and road operators. Output of the ROADAPT project was one ROADAPT-RIMAROCC integrating guideline containing five parts:

1. Guidelines on the use of climate data for the current and future climate
2. Guidelines on the application of a QuickScan on climate change risks for roads
3. Guidelines on how to perform a detailed vulnerability assessment
4. Guidelines on how to perform a socio economic impact assessment
5. Guidelines on how to select an adaptation strategy

All ROADAPT guidelines can be used individually, but should be seen as interdependent and fitting within the broader RIMA-ROCC framework. The RIMA-ROCC framework itself namely provides all necessary steps to be taken to adapt to climate change in an explicitly risk based way. It also provides uniformity with clear definitions. Only on specific points the ROADAPT guidelines use different definitions; if this is the case it is clearly written in the specific guidelines.

One of ROADAPT outcomes was a **database of adaptation techniques** for different threats establishing measures that take into account the threats involved, climate parameters and adaptation measures.

1.2 Climate signals and hazards

The collected data needed for the characterisation and identification of climate signals and hazards will be used at various spatial and temporal scales. Thus, a harmonized and consistent data collection methodology is essential for the development of CSIS and for the implementation of DCs and besides that, it is indispensable for organizing multi-scale information.
High-level pre-feasibility analysis can be obtained by an integration of existing knowledge of the main hazards for the whole Europe, based on the available EU-level data sources introduced in 2.1. This includes **observational data** and derived **climate extreme indices**, long-term regional **climate projections** from numerical model simulations, **hazard maps** and other relevant environmental data. These datasets can be integrated in the CLARITY project with the aim of providing a pan-European overview on climate signals and hazards.
Going a step further, additional datasets are needed to meet the end-user requirements by applying various downscaling procedures. Analysing climate signals and hazards on the local level can be obtained by the implementation of regional and urban models, like the regional model COSMO-CLM and the urban models MUKLIMO_3 (for heat waves) or HYPE (for hydrological hazards). The required model input data can be taken from already existing high-resolution datasets, e.g. **land cover data** from Urban Atlas or **soil sealing layer**, provided by the Copernicus Land Monitoring Service. Long-term regional climate projections, i.e. **EURO-CORDEX data** can be used as input for further downscaling of climate scenarios to a local/urban scale.
Furthermore, specific datasets are provided by end-users in accordance with pre-defined user stories, including city-specific data like **zoning plans** or **green area inventories**. This facilitates high-resolution analysis of climate-related hazards on an expert level in consideration of the DCs (see Sections 3.1-3.4).

1.3 Exposure, inventory of elements at risk and Vulnerability

In risk analyses, 'Exposure' and 'Vulnerability' are strictly connected. 'Exposure' is the quantitative and qualitative characterization of different elements at risk, which characterize the examined area (people, buildings, urban areas, infrastructures, etc.), whose physical conditions and/ or functioning can be damaged, altered or destroyed by climate events. "Vulnerability" is the probability that these elements at risk suffer injury, damage, or other changes in the status quo following impacts from one or more events.

More specifically, the exposure data collection (or inventory of elements at risk) must be carried out, by retrieving information on their localization and distribution from existing database at European, national and local level. If needed, these data can be integrated by survey activities *in situ* or by analyses of panoramic photos through web services (i.e. Google Street View). This process should include the filling *ad hoc* forms, describing the 'vulnerability factors' of element at risk under effect of a specific climate hazard (i.e., for heat waves, the vulnerability factors affecting people's indoor and outdoor comfort conditions in urban areas considered could be: population density, construction density, albedo and roughness of surface materials, presence of urban canyons, thermal inertia of building envelope, vegetative cover, etc.).

The following step consists in the elaboration of data collected with the aim to group the elements exposed with similar vulnerability (or behaviour) under effect of individual climate hazard in categories called "vulnerability classes", generally indicated, for decreasing vulnerability, with A, B, C,..., according to the classification of the seismic behaviour of buildings (EMS '98).

On the territory investigated, the percentage distribution of vulnerability classes must be assessed with reference to a geographical Minimum Reference Unit (MRU), which coincides with the minimum space unit of analysis of input and output elements of the model. According to different objectives, the risk analysis can be developed at national or territorial (regional or sub-regional) scale. Generally, for evaluations at national scale, MRU is the Municipality, while at regional scale, where greater detail is required, it can be taken as a sub- municipal area, constituted, for example, from a cell (contained in a mesh) of the order of 500x500m or even smaller up to 250x250m according to the reliability of the input data available.

Once the exposure is known (through the geographical distribution of vulnerability classes), it is possible to assess the vulnerability of each vulnerability classes under effect of single climate hazard. It can be evaluated through a typical instrument, the “vulnerability curves”, which express the probability that a given “vulnerability class” exceeds a certain level of damage, given a level of climate hazard magnitude (see D3.1 “Science support plan and concept”).

2. Demo Cases data sources overview

This Section outlines the main objectives of the 4 CLARITY DCs, discussing the needed data sets and identified data sources in relation to the CLARITY methodology and modelling workflow as defined in D3.1 "Science support plan and concept".

2.1 DC1 - Adaptation Scenarios for Metropolitan Resilience Planning in Naples

In order to meet the requirements of end-users in agreement with the user stories, the current and future climate situation in Napoli will be evaluated through regional model results from **EURO-CORDEX** project**;** simulated with the urban model **MUKLIMO_3** to explore heat island patterns as well as microclimatic sensitive areas and to evaluate possible adaptation strategies against heat wave hazards; and possibly the surface flood models (such as **CADDIES** and/or **HYPE**, or other locally available simplified models) to identify key factors at local scale aggravating the impact of extreme precipitation events leading to pluvial flood risk conditions.

In line with the requirements defined through the user stories, the opportunity of integrating climate change issues within multi-risk assessments and impact scenario analyses that take into account the combination of geophysical (earthquake, landslides, volcanic phenomena) will be addressed where applicable. It will be based on the logical integration of PLINIVS tools (**SIS - Seismic Impact Simulation; VIS - Volcanic Impact Simulation; LIS - Landslide Impact Simulation**; **CEI - Cascading effects impact model**) within the modelling workflow.

Specific vulnerability models for heat waves (population) and extreme precipitation (buildings, open spaces, transport infrastructure), experimentally developed at PLINIVS, will be applied to produce impact scenarios according to the hazard conditions identified, through the application of the **PLINIVS HW** (Heat Wave) and **PLINIVS SF** (Surface Flooding) impact models.

Multiple scales of analysis will be taken into account, subject to data availability, including urban planning, neighbourhood scale regeneration and building/open spaces retrofitting, aiming at reducing aggravating factors due to urban and territorial conditions (e.g. obsolescence of building stock and transport networks, urban canyons, lack of green cover, lack of maintenance of river basins and channel, etc.), able to strongly amplify the effect of temperature and precipitation extremes.

In line with what envisaged in the DoA, the DC will be oriented to the exploitation of advanced climate services provided by the CLARITY platform with the following objectives:

- the support to public administration at Metropolitan City and Municipal level(s) in developing the local adaptation plan based on EU Directives and the National Plan for Climate Change Adaptation (MATTM, 2017);
- the definition of short- to long-term adaptation options for urban environment (buildings, open spaces and infrastructure) to reduce the impact of relevant climate-related hazards in strategic areas for urban redevelopment in the Municipality of Napoli (Bagnoli-Coroglio and East Napoli areas);
- the implementation of guidelines for public and private investments in urban regeneration and for the updating of local building codes in a climate-oriented perspective, following the ongoing process of building code update implemented by the municipality of Naples.

These objectives are connected to key features required to the CLARITY CSIS, such as:

- the creation of a GIS environment for the visualization of climate change impact scenarios and vulnerability levels of selected elements at risk;
- the implementation of a set of performance indicators to assess the potential multi-sectoral benefits of adaptation options;
- the implementation of cost-benefit assessment of alternative adaptation scenarios;

Local data sources will be used to provide high resolution information on elements at risk exposed and their vulnerability features, according to the level of analysis envisaged. Main local data providers identified at the current stage of development are:

- ISPRA Ambiente – Historical meteo data
- Ministry of Environment Italy – elaboration of relevant parameters (e.g. albedo of roofs) from satellite surveys
- ISTAT National Institute of Statistics Italy – Census data of population, business and industry
- Campania Region - Topographic database (Building/open spaces geometry; typological, technical, construction; land use and building functions); Aerial photogrammetry
- Naples Metropolitan City - LIDAR dataset (DEM, DSM, DTM)
- Naples Municipality - Building typologies classification (historic centre); Vegetation and Land Use;
- Urban Masterplan and priority areas for public and private initiatives for urban redevelopment
- PLINIVS - Building typologies and open spaces classification (including vulnerability classes)

Models	Datasets – sources
RCM (regional downscaling)	n/a (models output already available at EURO-CORDEX database)
MUKLIMO_3 (heat - urban microclimate)	• DEM – NaplesMetropolitan City (Lidar) • Mean building height – Naples Metropolitan City (Lidar) • Building typology classification; Wall area index; Fraction of impervious surface between buildings; Surface roughness of the non-built-up areas – Campania Region; Naples Municipality; PLINIVS • Vegetation parameters (Tree height, Stem height, Leaf area density, Vegetation height of the canopy layer, Tree cover, Vegetation cover) – Campania Region; EU Urban Atlas • Albedo of the walls, roofs and impervious parts of the canopy layer – MATTM • K-value of the building walls and roofs; Area heat capacity of the building walls and roofs - PLINIVS
HYPE/CADDIES (surface flood)	• DEM – NaplesMetropolitan City (Lidar) • Land use /Land cover data – CORINE data set and high resolution Urban Atlas data for urban regions • Soil data – European Soil Data Base augmented with Campania Region soil information
PLINIVS HW / SF Vulnerability model	• Census data; Geometry (including terrain); Typological, technical, construction data; Land use and building functions data; Socio-economic data - Ministry of Environment; ISTAT; Campania Region; Naples Metropolitan City; Naples Municipality; PLINIVS
PLINIVS HW / SF Impact model	MUKLIMO / CADDIES output; PLINIVS HW / SF Vulnerability model output

Table 2: Mapping of models and datasets needed for DC1 implementation.

2.2 DC2 - Fostering adaptation of large scale infrastructure in Sweden to local climate change effects

The use case is coordinated by SMHI and based on exploring data from two Copernicus Climate Change Services (C3S) projects, SWICCA (on water management) and Urban SIS (on urban climate and air quality). The demonstration will be focused on two sites in Sweden (the County of Jönköping and Stockholm city), where the use of indicators (in the scope of flooding, heat waves, and air/water pollution) in the process of building-up resilience on multi-million-euro development projects will be tested.

One main data source for the Swedish case will be the SWICCA dataset. SWICCA contains information for historical and future climate from an ensemble of climate and hydrological models. Data of interest includes air temperature, precipitation, and runoff.

For Stockholm one main interest is the impact of city development on the urban climate. The city is growing fast and new housing is needed. Intensive impervious sealing of surfaces and human densification are important drivers of the urban microclimate and how it will respond to climate change in the future. For investigating how the new plans will impact on the urban climate we will use a high-resolution (temporal: 1 hour and spatial: 1 x 1 km^2) dataset from the Urban SIS project. This is an extensive dataset of ECVs and sectoral indicators. This dataset includes: air temperature, air humidity, radiation, comfort indices (such as the Universal Thermal Climate Index - UTCI), precipitation, air quality, etc. The already available data will be extended with 1 km resolution climate data for selected planning scenarios over Stockholm that will be produced under the HazardSupport project, funded by the Swedish Civil Contingencies Agency (MSB).

Another main interest is to investigate the risk for flooding in both areas. The municipality of Jönköping with its residential city is situated at the very southern border of the second largest water reservoir in Sweden, lake Vättern. Due to lake tilting (geological influence), in combination with high water levels, the lake may reach hazardous levels for the city. Stockholm city is located at the border between the large lake Mälaren and the Baltic Sea, thus highly sensitive to future changes in river runoff, as well as lake and sea levels. For both cases it is interesting to investigate the future impact of events from intense precipitation, river flooding and changes in lake and sea levels together with worse case scenarios of combined events.

These questions can be addressed using the SWICCA dataset mentioned above. However, in many cases higher level resolution data is needed. For this purpose, we will produce climate information for future hydrological conditions using a continuous hourly hydrological model (S-HYPE) available at SMHI. In addition to these sources we have access to precipitation data for Sweden (hourly, daily, seasonal and annual), from several data sources: SLB-analysis, Stockholm Water Co. and SMHI Open databases that can be used as needed. For expert studies this data may need to be combined with local information such as land use maps, elevation data, drainage systems, and sites of pumping activity.

In addition, special datasets can be of interest for investigating special questions. One example is related to the historical maps of drained areas and levels of lakes that have been lowered, where regulation strategies may be needed to investigate the impact of wetlands as water reservoirs. Another example is the need for customizing indicators for health and environment which will be based on the general data described above but where the user would be able to tailor the information in various ways based on local knowledge.

Models/tools	Datasets – sources
RCM HARMONIE (urban downscaling)	n/a (models outputs for Stockholm region already available at SMHI from the Urban SIS C3S project and the national project HazardSupport)
S-HYPE (hydrology)	• Meteorological data – Radar based hourly precipitation and corresponding temperature from MESAN reanalysis system (from SMHI) • Land use /Land cover data – CORINE data set and high resolution Urban Atlas data for urban regions • Soil data – European Soil Data Base augmented with Swedish soil information • Hourly river discharge data – SMHI's discharge data archive, data from local authorities (Stockholm Vatten)
MIKE (MIKE11 and MIKE21)	• DEM - 3D city model with buildings– Lidar data (2 m resolution) from the Swedish real property register (Lantmäteriet) • Land use map from the Swedish real property register (Lantmäteriet) • Soil map from the geological survey of Sweden (SGU) • Information about structures (dams and bridges) that affect the flow from the Swedish transport system (Trafikverket) and municipalities • Information about bathymetry (data need to be measured or can be available from the municipality).
Green Area Factor (GAF)	• Area occupied by a specific type of vegetation • Total land area • Data on buildings, streets and parks, both planned and existing (Lantmäteriet)

Table 3: Mapping of models and datasets needed for DC2 implementation.

2.3 DC3 - Urban heat waves, urban heat islands, air ventilation in Linz

The data collection required for the implementation of the Austrian demonstration case is listed in the respective table (*Linz – heat waves*) in Annex I.

In order to meet the requirements of end-users in agreement with the user stories, the current and future climate situation in Linz will be simulated with the regional model **COSMO-CLM** and the urban model **MUKLIMO_3**in order to explore heat island patterns as well as microclimatic sensitive areas and to evaluate possible adaptation strategies. Microclimatic analysis for selected case study areas can be further conducted by the **ENVIMET** model. For this purpose, various datasets are needed for the demo case implementation, depending on the type of model application.

General model input data are partly available from open data sources on a European level, like **Urban Atlas 2012** land cover data, a **30 m digital elevation model** and a **20 m soil sealing layer**. Besides that, the province of Upper Austria provides **10 m digital elevation model** data for Linz and its surroundings and a **zoning plan**. Both of them can be openly accessed.

Further large scale geospatial data have been collected, improved, generated and compiled for Linz and surroundings: a vegetation layer, derived from a satellite image classification, a 20m resolution soil sealing density layer based on satellite data, a building layer derived from Linz cadastral map, Lidar data (a height point data set) and open street map data, a normalized digital surface model combining terrain model and building elevation model, and finally a LOD1 3D building model for Linz and surroundings.

Long-term observational data, provided by ZAMG, is available from the two monitoring stations *Linz Hörsching* and *Linz Stadt*. The daily meteorological data can be used as input for analysing the historical climatological situation in the city of Linz by applying a dynamical-statistical downscaling technique, called the cuboid method, and as reference data for model validation.

EURO-CORDEX data and the regional model **COSMO-CLM** are used for the analysis of heavy precipitation. The EURO-CORDEX simulations can be further used to derive high-resolution urban climate scenarios, based on model output from MUKLIMO_3 and by applying the cuboid method.

As a result of intense discussions with city planners, the city of Linz has further provided the following additional datasets: **3D point-cloud data**, a **digital surface model** and **green area inventory** data. A **building footprint model** with means heights of the city's buildings, **tree distribution** with respective height information, as well as further **vegetation** with height information has been generated by AIT (see 3.3).

Datasets can be used to calculate different scenarios according to the user stories and considering the following measures: unsealing of land, roof greening and tree cover densification. Furthermore, the effects of new settlement areas on urban climate can be simulated and different adaptation scenarios can be calculated to make recommendations in terms of resilient urban planning.

AIT is working in support of the Linz DC on transient urban climate and microclimate modelling.

- AIT started simulations with an Urban Climate Model at 1-km resolution. It runs with the Regional Climate Model (RCM) Cosmo-CLM. The domain of the simulations covers the greater Linz area with 100x100 raster cells covering an area of 100 x 100 km2. The historical control run, which is required for model validation is based on ERA40 and ERAInterim data from the ECMWF, covering the years 1959 to 2015, is finished. The main feature of this simulation is the usage of a RCM with a special urban extension comprising a high-resolution surface sealing layer and anthropogenic heat emission. This enables the RCM to reproduce the urban heat island (UHI) effect in a satisfying manner.
- Extraction of relevant meteorological parameters like temperature, precipitation, humidity, wind speed and radiation out of the simulation result dataset has already been started.
- In parallel, a scenario run using HadCM3-A1B GCM-results as forcing data was launched. This time series will cover the period from 1960 up to 2100 and reveal a possible development of the future regional and

urban climate, providing temperature, precipitation and wind field data at an hourly basis. This can be used for further high-resolution microclimate modelling at block-scale and wind field modelling at neighbourhood to block-scale for impact assessment and adaptation scenarios.

Models	Datasets – sources
RCM (regional downscaling)	(models output already available at EURO-CORDEX database)
COSMO-CLM (regional downscaling)	• Reclip-century simulations 1959 to 2015 10km resolution for Alpine Space, 10km resolution for Alpine Space, 4km for Austria, based on ECMWF ERA-40 & ERA Interim-forcing data • IPCC A1B Reclip-century simulations 2010 to 2100, 10km resolution for Alpine Space, 4km for Austria, based on HADCM3 A1B climate simulations • Based on this - CLARITY simulations at 1x1km resolution to be carried out for Greater Linz area area.
MUKLIMO_3 (heat - urban microclimate)	• Historical meteo data – ZAMG, RCM scenarios EURO-CORDEX • Digital Elevation Model: 1m DEM for the City of Linz (2009), 5m DEM for Upper Austria (2009), 30 m for Europe from EEA • Land cover data (CORINE & Urban Atlas 2006, 2012), Zoning Plan for Upper Austria (2017) • Mean building height estimated from LIDAR data for the City of Linz (2009), LIDAR point cloud data, providing altimeter information for the City of Linz (2011) and derived 3D-Building model (LOD 2) and footprint model for the city of Linz (2011) • Building typology classification; Wall area index; Fraction of impervious surface between buildings; Surface roughness of the non-built-up areas – data from City of Linz, Copernicus Land Monitoring Data • Vegetation parameters (Tree height, Stem height, Leaf area density, Vegetation height of the canopy layer, Tree cover, Vegetation cover) – based on areal photo classification and storey information at building level from Linz; EU Urban Atlas • Albedo of the walls, roofs and impervious parts of the canopy layer– data from the City of Linz, if available

ENVIMET	• 10 m digital elevation model • LIDAR - 3D point-cloud data • normalized digital surface model • A building footprint model with building height information (LOD1) • Vegetation inventory • Soil sealing data • Street network from Urban Atlas dataset • Open street map data • gridded input layers for Envimet at 2, 5, 10m resolution for 4 selected case study areas in Linz • See annex for details

Table 4: Mapping of models and datasets needed for DC3 implementation.

2.4 DC4 - Transport Infrastructure in Spain

This demo case will address the adaptation of a subset of the Spanish network of highways and railways to future impacts due to climate change. The selected subset of roads comprises 26,038 km, representing 15.7% of the Spanish network. For the purpose of this demo case a representative section has been selected: the second section of an important transport axis (A2) connecting Madrid and Barcelona cities. This four-lane highway section is 73 km long, running from Guadalajara city (PK-62) to Alcolea del Pinar (PK-135), sitting in the province of Guadalajara. This section has been selected as a good example of the network conditions in central Spain, which eventually can be extrapolated to others. The chosen region has a typical Continental-Mediterranean climate with long, dry and very hot summers, and equally long and severe winters. Springs and autumns are short and mild.

There has also been selected a subset of railways which includes 3,143 km of the high-speed train network (AVE). It is expected that climate change will entail negative impacts in both railways and highways in all stages of the life-cycle of these infrastructures (planning, design, construction, maintenance, and exploitation).

In parallel, several climatic projections and climate change scenarios have been developed by the Spanish Meteorological Agency (AEMet, Ministry of Environment) as part of the PNACC (Plan Nacional de Adaptación al Cambio Climático). These include three emission scenarios (SRES-A2, SRES-A1B and SRES-B1) defining 2050 and 2100 as temporal horizons. These scenarios have highlighted several factors that need to be taken into consideration when studying the effect of climate change on the transport infrastructures. These relevant factors are:

- The average air temperature will increase about 2ºC in summer and 1.2ºC in winter.
- The maximum and minimum temperatures will show more extreme values and the variation will be higher than for average temperature.
- The number of frost days will be reduced.
- The daily thermal oscillation will be broader.
- It is expected than around the next mid-century the number of heat waves will double.
- The relative humidity will generally diminish by a 5%.
- Total cloudiness will be reduced for all regions, with the exception of those in the North-East of Spain.
- Annual accumulated precipitation will decrease in all regions: about 5% in the North and in the East, and around 10% in the South and in the West.
- The number of intense rainfall events will increase most likely entailing floods.
- The number and length of drought episodes will increase, particularly in summer.

The DC4 implementation will allow end users to acquire a set of design guidelines applicable to the multi-risk conditions (climate and transport network design) of the Spanish Road Network and specifically to the selected highway section managed by ACCIONA. In order to achieve a better understanding of the intended use of the data and activities within this Demo Case, a classification according to the business process they will solve has been done. Additionally, all the data identified will be included in a table related to the user stories in which they are needed.

All the spatial framework data gathering is being performed into WP2 tasks and will be completed by M18. It will all be reported in D2.2.

Business processes taken into consideration are:

- Operation of the management and maintenance concession for a highway section.
- Simulation for an invitation to tender for the management and maintenance concession of a highway section.
- Simulation for an invitation to tender for the construction/design of a new highway section.
- Recommendations on Regulations/Revision of design conditions.
- Monitoring of fires, bridges, drainage, and slopes (landslides).

Operation of the management and maintenance concession for a highway section

- Data gathered from meteorological stations: temperature, precipitation, relative humidity, snow, wind, asphalt temperature.
- Detailed highway design: highway orography, ditches, embankments, drainage capacity, vegetation, signposting and horizontal signage.
- Concrete foundation and asphalt.
- Surrounding forest fuel model.
- Forest fire forecast and fire behaviour.
- Vegetation condition on ditches and median strips.
- Digital Elevation Model and LIDAR point cloud data providing altimeter information.
- Normal operation conditions for asphalt and signage: thermical range, drainage capacity.
- Mid term meteorological forecasting: NOAA and ECMWF (restricted exploitation license) model ensembles' outputs. NOAA's GEFS and ECMWF Ensembles.
- Seasonal models:
    - NOAA Climate Forecast System (CFSv2).
    - ECMWF System4 (S4 based on IFS with 36r4 cycle), available on COPERNICUS
    - Statistical model based on teleconnections –developed by RESCCUE.

Simulation for an invitation to tender for the management and maintenance concession of a highway section. The goal is to assess operational and maintenance costs under the expected climate conditions.

- Invitation to tender data/Highway design data/Vulnerable elements and signalling/Normal operation conditions for the existing elements.
- Vegetation on ditches and surrounding the highways.
- Digital Elevation Model.
- Surrounding forest fuel model.
- Forest fire forecast and fire behaviour.
- Current climate atlas.
- Future climate projections/Detailed downscaling on nearby stations.
    - Decadal models outputs (CMIP5).
    - Climate models outputs (Euro Cordex, AEMet-Spanish official projections-, ad-hoc modelizations CMIP5).

Simulation for an invitation to tender for the construction/design of a new highway section.

- Invitation to tender data/Planned highway layout data/Design regulations.
- Current climate atlas.
- Digital Elevation Model and LIDAR point cloud data providing altimeter information.

- Future climate projections/Detailed downscaling on nearby stations.
  - Decadal models outputs (CMIP5).
  - Climate models outputs (Euro Cordex, AEMet-Spanish official projections, ad-hoc modelizations CMIP5).

Recommendations on Regulations/Revision of design conditions.

- Current climate atlas.
- Spanish Transport Network layers including all types of roads and railways.
- Digital Elevation Model.
- Future climate projections/Detailed downscaling on nearby stations.
  - Climate models outputs (Euro Cordex, AEMet-Spanish official projections, ad-hoc modelizations CMIP5).

Monitoring of fires, bridges, drainage, and slopes (landslides).

- Location of the monitored elements.
- Satellite imaging, COPERNICUS, Sentinel.
- Driving conditions data.
- Digital Elevation Model and LIDAR point cloud data providing altimeter information.
- Surrounding forest fuel model.
- Spanish Transport Network layers including all types of roads and railways.
- Forest fire forecast and fire behaviour.
- Mid term meteorological forecasting: NOAA and ECMWF (restricted exploitation license) model ensembles' outputs. NOAA's GEFS and ECMWD Ensembles.
- Seasonal models:
- NOAA Climate Forecast System (CFSv2).
  - ECMWF System4 (S4 based on IFS with 36r4 cycle), available on COPERNICUS
  - Statistical model based on teleconnections – developed by RESCCUE.

Models	**Datasets – sources**
ESD (empirical statistical downscaling)	decadal models output already available at EURO-CORDEX database
FICLIMA (regional downscaling)	• Digital Elevation Model: 5m DEM for Spain, 30 m for Europe from EEA • LIDAR point cloud data • Historical meteo data – AEMet, • RCM scenarios EURO-CORDEX
AEMet SD model (statistical downscaling model)	• Official Spanish Scenarios for daily temperature, precipitation, wind and snow. • Spanish Transport Network layers
OSD (operational statistical downscaling)	• Seasonal forecast • Digital Elevation Model • Meteo observations • Spanish Transport Network layers
OSD (operational statistical downscaling)	• Ensembles forecast • Digital elevation model • Meteo observations • Acciona detailed cartography

WildFire analysis module	• Ensembles forecast • Seasonal forecast • Vegetation Fuel model • Digital Elevation Model: 5 DEM for Spain

Table 5: Mapping of models and datasets needed for DC4 implementation.

3. Demo cases implementation methodology

This section illustrates the main end-user requirements and expectations in relation to the implementation of the CLARITY test cases, with reference to the DC-specific workshop activities carried out and the User Stories (see also D1.1 “Initial workshops and the CLARITY development environment”).

3.1 DC1 - Adaptation Scenarios for Metropolitan Resilience Planning in Naples

DC1 implementation is oriented through the exploitation of CLARITY CSIS Expert Services. Thus, the modelling workflow and related data collection will be targeted to the acquisition of local datasets, complemented through EU-level data sources where relevant local datasets are not available.

DC1 “high-level” user stories (*US-DC1-100 Climate adaptive planning* and *US-DC1-200 - Climate adaptive design guidelines and building regulations*) outline the key objectives for the implementation.

The main focus is oriented to different scales of application:

1. Identification of climate risk prone areas at Metropolitan City level (including consideration on multi-risk conditions from earthquakes and volcanic phenomena) and identification of potential adaptation pathways following the addresses of the Italian National Climate Change Adaptation Plan (MATTM, 2017).
2. Long term adaptive planning in ex-industrial areas (Bagnoli-Coroglio and East Naples) in the Municipality of Naples, based on climate impact scenario analysis to define alternative scenarios, implement risk assessment and prioritize actions for sustainable and resilient redevelopment.
3. Update of building code of Municipality of Naples (currently in an update process to be adapted to the national standardized model, to be completed by the end of 2018) aimed at regulating private activity by promoting adaptive retrofitting of building and open spaces. The transferability of the building code update to other municipalities in the metropolitan area will be also taken into account.

This will allow to evaluate the requirements needed for urban regeneration, new construction and building retrofitting in high densely populated areas, by integrating the inevitable constraints (due to traditional building techniques, landscape preservation requirements, effective cost of retrofitting) with a new approach based on climate modelling, directing to the use of sustainable materials and technologies aimed at climate adaptation. At the same time, the DC1 implementation will allow end-users to acquire a set of design guidelines applicable to the multi-risk conditions (climate, seismic, hydrogeological, volcanic) of the Metropolitan area, so to promote an integrated approach to Climate Change Adaptation and Disaster Risk Reduction within public policies and private investments.

To this aim, a network of potential users of climate services within Naples Municipality organization has been implemented, involving technical departments of *Building Control*, *Planning* and *Energy Improvement and Efficiency*. A series of workshops have been carried out to identify specific requirements for the application, expressed by DC1 user stories. CLARITY timeline has been discussed in relation to the ongoing institutional activities by Municipality of Naples, to assess the feasibility of using the outcomes of the projects as actual input of such activities. The compliance with current needs and requirements for a successful implementation of ongoing institutional activities represents in this sense and added value of CLARITY solution, responsible officers from Municipality of Naples have welcomed a set of new tools to gain a more data driven decision in the field of climate adaptation. The network of local end users may be extended to other municipalities in the metropolitan areas following the implementation of DC1 and the next planned workshops. A further added value and complementarity with ongoing institutional activities is the requirement of making available CLARITY tools to local end users by integrating relevant results within the current redevelopment of geographic based technologies for the Metropolitan and municipal services, which is now in progress (OP-Metro funding for metropolitan areas).

Level 2 user stories (see D1.1 “Initial workshops and the CLARITY development environment”) clearly identify the requirements in relation to the 7 steps of EU-GL, covering the entire cycle from Hazard Characterization

(HC) to the Integration of Adaptation Action Plan (IAAP). Through the support of CLARITY experts, DC1 modelling workflows have been designed, thus allowing to define the datasets needed to fully implement the demonstrations.

The process of data collection started in advance with respect to the timeline defined by WP2 tasks, given the complexity of modelling and data calibration needed to perform the CLARITY Expert Services. All data gathered, produced by Campania Region, Metropolitan City of Naples, Municipality of Naples and PLINIVS have been acquired and integrated in a GIS. The data are set in formats compatible with the technical infrastructure for GIS services of Municipality of Naples.

The modelling logic has been designed towards flexibility and scale-independency. Data from National and/or EU sources will be used if local data are not available, and adapted through statistical methods if too coarse or too detailed to the objectives to be achieved.

The ongoing data collection process, to be completed by M18 and reported in D2.2 “Catalogue of local data sources and sample datasets”, included the following activities so far:

- Analysis of adequate datasets, descriptive of the municipality sites, selected for the case studies. Extraction of datasets in use for GIS activities in Naples Municipality (topographic data, land use data, hydrogeological risk data, wood fire cadastre data) and license agreements needed to share data with other partners;
- Definition of a temporary use contract between Naples municipality, Regione Campania (regional level government) and PLINIVS research unit to use topographical database ref. 1:5000 (DBT), aerial photos and other cartographic data for the Research and request for a copy of the dataset;
- Analysis of relationships between the Research and the drafting of building regulations now discussed in Naples; kick off meeting on Oct 10, 2017, 2nd meeting on Oct. 24, 2017. 3d meeting Nov. 7th, 2017;
- Drafting of a list of parameters relevant to the building rules that may be potential output coming from the Research;
- Analysis of DBT data and selection of relevant layers; spot checking to assess data quality;
- LIDAR data downloading from Metropolitan City of Naples website;
- Mosaic and map algebra operations to obtain building height evaluation;
- Volume calculations derived from building stock data.

Level 1 US	Level 2 US	Requirement	Objective	EU-GL Scope:
US-DC1-100 Climate adaptive planning	US-DC1-110	Visualize heat wave, landslide and pluvial flood hazard maps in relation to climate change projections for the area of the Metropolitan City of Naples	Identify the most exposed areas in terms of buildings and population density, considering the expected hazard exposure variation due to climate change.	RA / IA Decision Support
	US-DC1-120	Quantify the impact of heat waves, landslides and pluvial floods (based on climate projections) in relation to the following elements at risk: population, residential buildings, strategic buildings, critical transport infrastructures, local economy for the area of the Metropolitan City of Naples.	Understand the effect of extreme climate events in the area in relation to climate change projections considering the expected impact variation due to climate change.	IA
	US-DC1-130	Results of simulations and climate services to be applied to both existing conditions and design scenarios, with different levels of details in relation to the area object of the analysis (e.g. Metropolitan City vs. city	Use the system in different operational contexts, depending on the role of the Municipality of Napoli (e.g. direct design/planning activity, consultation, evaluation of projects	RA / IA IAO AAO Integration Decision Support Action Plan

		neighbourhood), to the available datasets and to the scope of the analysis (e.g. preliminary planning vs. final planning).	presented by private entities or other public authorities).	
	US-DC1-140	acquire detailed information on climate adaptation potential of alternative planning scenarios in specific redevelopment areas, by applying the model to different proposed options which may include variations in the volumetric distribution of new buildings, the hydraulic and sewerage system, the urban surfaces and vegetation.	prioritize the design scenarios and identify the benefits of climate adaptive solutions, and measure the cost-effectiveness of investments in relation to both short- and long-term benefits (current conditions and variation due to climate change).	IA IAO AAO
	US-DC1-150	Results of simulations and climate services to be visualized as Georeferenced maps	Use the maps as official planning documents for the redevelopment projects to be directly implemented by the Municipality of Naples	RA / IA Integration
	US-DC1-160	The results of simulations and climate services to be visualized as synthetic document (e.g. pdf with text and images).	Use the results as consultation documents for the redevelopment projects to be implemented jointly with Regional or State level authorities.	RA / IA IAO AAO Integration Decision Support Action Plan
US-DC1-200 - Climate adaptive design guidelines and building regulations	US-DC1-210	Acquire a set of design guidelines to integrate climate adaptive solutions within current building regulations, addressing at the same time the relevant set of existing constraints, such as 1) landscape protection; 2) volcanic risk from Vesuvius and Campi Flegrei, east and west of Naples; 3) landslide floods and hydrogeological issues; 4) earthquakes.	Address ongoing structural retrofitting interventions, both in public policies and private investments, to include climate adaptation within a multi-hazard resilience perspective and evaluate the opportunity of climate financial incentives (e.g. reflective or green facade materials following a seismic/landslide structural improvement).	IAO AAO Integration Decision Support
	US-DC1-220	Acquire a set of benchmarks and assessment tools for alternative DRR and CCA techniques.	Evaluate projects presented by private entities for new buildings and retrofitting actions (for permit release, incentives quantification, etc.).	IAO AAO Decision Support

Table 6: Synthesis of requirements and objectives from DC1 USs.

3.2 DC2 - Fostering adaptation of large scale infrastructure in Sweden to local climate change effects

This DC has 2 parent (Level 1) user stories and 6 more specific (Level 2) user stories:

US-DC2-100 Water hazards and supply: This is a parent story that summarizes common information needs for all water related user stories for Sweden in CLARITY. The focus of the parent story is to capture the common description in the pre-study phase, whereas the descriptions for each of the more specific story focuses on the expert phase. The goal is to provide input to city planners to both present city structure and when planning new buildings, infrastructure and other actions related to water supply.

- **US-DC2-110 Flooding of the city centre of Jönköping:** This user story examines the future flooding risk for the city of Jönköping. The goal is to provide input to city planners to both present city structure and when planning new buildings, infrastructure and actions for preventing hazards. The user story has already been explored in SWICCA and by the Swedish Civil Contingencies Agency. For more information about the original user story see http://www.swicca.eu/start/implemented-cases-of-local-change-adaptation/impact-based-flood-risk-assessment-in-present-and-future-climate/. The goal in CLARITY is to extend the study by adding information on lake level rise, higher resolution of climate information and combined effects of events including entrapped areas arriving in a risk assessment (cost – benefit analysis) and flood mitigation measures.

  Main problems/challenges are identified:

  - Flooding of important infrastructure such as the E4 highway, parts of present city.
  - Planning of new areas for new houses and infrastructure in a way that minimize the risk of flooding.
  - Evaluate if current modelled maximum lake level needs to be changed for future conditions.
  - Evaluate the combined risk of precipitation, high lake levels and high discharge in rivers.
- **US-DC2-120 Flooding of the city centre of Stockholm:** This user story examines the future flooding risk for the city of Stockholm. The aim is to be able to combine effects of lake level with precipitation and runoff and to be able to handle cloud burst events in dense city areas (also where important infrastructure is located). This would allow to evaluate the effects of adaptation measures, analyse risks associated with high precipitation, provide input to the Green Area Factor and analyse the relative importance of high precipitation, high sea level, and high lake level (Mälaren) in the future climate.

  Main problems/challenges are identified:
  - Planning new residential areas and infrastructure in a way that minimizes the risks of flooding.
  - Handling runoff from cloudburst events in the dense inner city area of Stockholm.
  - Flooding of existing infrastructure such as railways, highways and parts of the Inner city due to extreme water levels in Lake Mälaren and the Baltic Sea.
  - How to evaluate the effects of implemented adaptation measures, and the use of the city´s Green Area Factor.
- **US-DC2-130 Hydrological buffers in the landscape as ecosystem service:** This user story focuses on studying the potential in wetlands to act as buffers to prevent negative effects high flows at a drainage area basin level, i.e. by promoting specific areas to be flooded in order to protect other areas. The goal is to meet the governmental instructions of the subject on a regional level to minimize negative effects on public services like drinking water supply during periods of draughts, to point out specific drainage areas that are more sensitive to high and low flow regimes and localize specific areas to be flooded and act as hydrological buffers

  Main problems/challenges are identified:

  - Wetlands may not be accessible to restore due to new land use, polluted areas etc.
  - Water regulation i.e. power plants have impact on natural flows.
  - Specific thresholds within the water coarse may have great impact and need to be identified.
- **US-DC2-200 Health and environment:** This is a parent story that summarizes common information needs for all user stories in Sweden related to human health and the environment. The focus is at the pre-study phase, whereas the related sub-stories zoom in to the detailed level and require tailored expert analysis. The goal is to provide general input, in the form of suitable indicators, to decision makers from municipalities or professionals dealing with urban planning in the context of climate change and its interaction with human health and well-being and the status of the environment.

- **US-DC2-210 Urban vegetation in Stockholm as a climate adaptation tool:** The focus is to optimize the role of urban vegetation in Stockholm as a climate adaptation tool. In particular we want to validate the Green Area Factor (GAF) in Stockholm, add and combine air pollution in the GAF, add and combine hydrology in the GAF (with a link to US-DC2-220).
  Main problems/challenges identified:
  - To quantify impacts of green infrastructure on air quality for different climate conditions.
  - To translate the quantified impacts into the index scheme of the GAF.
- **US-DC2-220 Climate and health indicators for Stockholm**: Analysing the impacts of climate change and future land use (including large scale infrastructure projects) on the health of the population and the status of the environment.
  Main problems/challenges are identified:
  - Health-related effects of climate change and urban planning are not considered today.
  - Neither are the health risks due to both heat waves and air pollution well known, nor the efficiency of climate adaptation to reduce such risks.
- **US-DC2-230 Climate and environmental indicators on a regional level (Jönköping County):** The goal isto produce a new tool to present historical as well as modelled future outcome of a selected number of important indicators used in explanation for observations in environmental monitoring. With knowledge of selected critical parameters, predictions can be made on population levels for different organisms/habitats etc. The tool is to be projected on different regional levels like drainage area basin, height above sea level, exposure to rain/rain shadow, county etc. In a second step, the system must be applicable to other regions.
  Main problems/challenges are identified:
  - Combination of historical data with modelled future data in a user-friendly way.

Level 1 US	Level 2 US	Requirement	Objective	EU-GL Scope:
US-DC2-100 Water hazards and supply	US-DC2-110	Tools for investigating: -Intense precipitation and expected changes in the future. - Flooding caused by the river and how this can be expected to change in the future. - Flooding caused by lake level rise due to land rise in Sweden, including increased water levels due to wind effects Can be made as an off-line expert study.	Investigates precipitation, high flow in rivers, lake level changes and combined events and how they affect Jönköping.	Risk Analysis RA - Hazards RA - Exposure RA - Vulnerability RA - HxExV Decision Support Action Plan
	US-DC2-120	Tools for investigating: Cloudburst modelling, 2-D surface runoff mapping (DHI MIKE21-model) Estimation of changes in intense precipitation by the year 2100. Lake and sea level (daily, seasonal and annual mean) Return time for extreme levels Effects of new Slussen lock construction for Lake Mälaren Can be made as an off-line expert study.	Investigates precipitation, high flow in rivers, sea level changes and combined events and how they affect Stockholm. Special interest in how green areas will affect the flood risk.	Impact Scenario Analysis IA - Hazards IA - Exposure IA - Vulnerability IA - HxExV Decision Support
	US-DC2-130	Tools for investigating: - Historical distribution of wetlands - Flow regimes in a future climate - Water regulation by e.g. power plants	Focus on how restorations of wetlands can prevent droughts and flooding in the future.	Impact Scenario Analysis IA - Hazards IA - Exposure IA - Vulnerability

		Can be made as an off-line expert study		IA - HxExV AO - Identification AO - Appraisal
US-DC2-200 Health and environment	US-DC2-210	Tools for investigating: - Modelling some reference cases in Stockholm using high-resolution building resolving models (e.g., Computational Fluid Dynamics – CFD). - Assess results in relation to current Green Area Factor scheme Can be made as an off-line expert study	Focus on how the Green Area Factor can be used as a tool to plan changes in the city.	IA - Exposure IA - Vulnerability AO - Identification AO - Appraisal Decision Support
	US-DC2-220	To provide an on-line tool where the user can investigate: heat waves, possibly intensified by Urban Heat Island (UHI), with potential consequences on human health and air pollution events, possibly combined with heat waves, with potential consequences on human health The goal is to improve urban planning evolution in the future	Focus on providing a set of health related indicators used to estimate future threats in the city.	RA - Exposure RA - Vulnerability IA - Exposure IA - Vulnerability AO - Identification AO - Appraisal
	US-DC2-230	The data are already today being produced for a selected number of indicators. The demonstration case needs a visualisation portal including maps, diagram an possibility of downloading data	Focus on providing a set of indicators that can be used to understand how weather related phenomena can be used to explain ecological variation and how this can be used as a prediction into the future.	RA - Exposure RA - Vulnerability Decision Support

Table 7: Synthesis of requirements and objectives from DC2 USs.

3.3 DC3 - Urban heat waves, urban heat islands in Linz

DC3 Linz represents the second-largest metropolitan area in Austria with a total of 772.000 inhabitants. The city is situated in the Danube valley and to some extent affected from continental climate with hot summers and cold winters. As a consequence of climate warming, continuous growth of residential areas, densification of the city centre, loss of vegetation and sealed surfaces, heath waves and heath islands are one climate related concern in the Linz region. Due to the common urban structures and large-scale climate change impacts, the result of the Austrian DC is relevant for a number of cities in Central Europe and may serve as a base for development of operating procedures and climate services for other Central European cities.

During discussions with end-users, it turned out that flooding is not seen as a severe issue for the future as quite some adaptation measures have been applied already, addressing upstream retention areas as well as dams.

Most severe climate impact is expected from temperature increase and heat waves. Hence, the exploration of urban heat island and the ventilation in order to provide fresh air to the central city areas are the main issues to be addressed. Regarding the spatial framework, a change of the urban fabric is expected through socioeconomic activities and new policy strategies: further densification of the city by increasing the general building height as well as soil sealing. This is a severe issue that may have distinct impact on the local climate even if no temperature increase will happen.

Thus, the DC3 (Level 1) user stories (US-DC3-100 – Heat island adaptation measures and US-DC3-200 – Ventilation pattern adaptation measures) outline the key objectives for the implementation.

To provide climate services for these DC3 user stories following activities will be (and partly have already been) carried out:

1. Identification of general climate risk due to temperature increase at the urban region and city level by simulation of urban climate scenarios through:
   - COSMO urban Climate Modelling for Greater Linz area (decadal and century simulations till 2100 based on following forcing data:
     era40 and era interim till 2015
     reclip:century simulations with HADCM3 (Hadley Centre Coupled Model, version 3) as forcing data, referring to IPCC AR4 SRES-scenario A1B
   - MUKLIMO_3 Urban Climate Modelling at 100m resolution, providing high-resolution climate analysis (current and future). This is accomplished by applying a dynamical-statistical downscaling procedure that is based on high-resolution model output in combination with long-term climatological data or regional climate projections (e.g. EURO-CORDEX simulations).
2. Identification of urban heat islands as hot spots requiring adaptation through local measures
   - UHI hot spots will be addressed through hot summer day and tropical night frequency patterns in the city
   - Local exposure as well as mitigation alternatives through adaptation will be addressed through high resolution ENVIMET 4.0 microclimate simulations (2 - 10 m grid spacing)
3. Modelling of ventilation patterns under current climate and current spatial framework as well as future spatial framework conditions testing and applying alternatively
   - Urban climate simulation (COSMO CML – 1 km grid spacing)
   - Local climate modelling (MUKLIMO_3– 100 m grid spacing)
   - Microclimate simulation (ENVIMET 10 m grid spacing)
4. Preparation of an urban land use model as well as a 3D city model, vegetation model and a soil- and surface property model as spatial framework for applying the German VDI “Klimatopen” concept for climate sensitive city planning. This will be related to urban climate and microclimate simulation as well as to particular wind field modelling and impact assessment for related adaptation measures. 3D city model data help to understand the microclimatic effects of building changes in urban regeneration or densification measures in order to integrate these aspects in urban planning processes. Vegetation and soil data will help to understand the effects of greening measures in existing settlement areas in order to make them climate-resilient for the future and to plan/set (from a microclimatic perspective) optimised greening measures.
5. Data acquisition for mapping distribution and types of buildings, as well as distribution of population and age classes to address. This will allow exploring exposure and elements at risk as well as assessing the vulnerability and finally allocate and evaluate the adaptation needs (urban regeneration, building construction and retrofitting, heat island mitigation and assuring ventilation paths in densely built-up and populated areas).

Thus, the DC3 implementation will allow end-users to acquire a set of design guidelines applicable to the multi-risk conditions (climate, and urban design) of the Metropolitan area of Linz, to promote an integrated approach to Climate Change Adaptation and Disaster Risk Reduction within public policies and private investments.

The process of data collection started right by the launch of the project with respect to the timeline defined by WP2 tasks, given the complexity of modelling and data calibration needed to perform the CLARITY Services. All spatial framework data gathered have been acquired and additional datasets have been generated (e.g. 3D data) and integrated in a GIS. The data are provided in formats compatible with the technical infrastructure for GIS services of the City of Linz.

The ongoing data collection process, to be completed by M18 and reported in D2.2 “Catalogue of local data sources and sample datasets”, included the following activities so far:

- Discussion on Linz-specific data starting during the first Linz-workshop in July 27th 2017. In November 23rd AIT obtained first data from the City of Linz via sFTP transfer.
    - LIDAR 3D point-cloud data
    - Digital Surface Model
    - Green area inventory data
- Parallel to the discussion with the City of Linz, AIT compiled a set of data as far as available from open data repositories:
    - Urban atlas land use data 2006
    - Urban atlas land use data 2012
    - Linz Zoning plan (recent)
    - Streets network and building footprints from (Open Street Map data (OSM))
    - 10 m DEM (from OGD Upper Austria),
    - 20 m high-resolution soil sealing layer (a Europe-wide data set from the European Environment Agency EEA.
- Based on this information AIT has generated additional vector / point datasets
    - Building footprint model with mean-heights (a simple LOD1 3D model of the city's buildings)
    - tree distribution with height information
    - further vegetation with height information

    The building and vegetation information is suitable for application with the MUKLIMO_3 or ENVIMET input.
- Exposure and vulnerability assessment
    - Here additional data have been identified to allocate the elements at risk. They will be collected in the next period.

Below, the use cases with the requirements and the related objectives are carried out.

Exposure allocation and vulnerability assessment will be added when fully discussed with the city of Linz authorities. Exposure addresses the elements at risk which are in DC3 buildings as well as population.

Vulnerability regarding heat related health risk will be identified through population age classes and their spatial distribution within Linz.

Level 1 US	Level 2 US	Requirement	Objective	EU-GL Scope:
US-DC3-100 measures for reducing heat exposure	US-DC3-110	Indicators/maps showing the general microclimatic patterns in the city, especially revealing microclimatic sensitive areas	Apply the German VDI "Klimatopen" concept to the city of Linz for climate sensitive city planning based on thoroughly analysed indicators which are commonly accepted and comparable among cities	IA Decision Support
	US-DC3-120	Quantify the effects of changes in the building heights and density on the microclimate in existing settlement areas – exemplary for hot spot areas in Linz	Understand the microclimatic effects of building changes in urban regeneration or densification measures in order to integrate these aspects in urban planning processes	IA Decision Support
	US-DC3 - 130	Show the effects of unsealing and greening measures on the microclimate in existing settlement areas – exemplary for hot spot areas in Linz	Understand the effects of greening measures in existing settlement areas in order to make them climate-resilient for the future and to plan/set optimal (from a microclimatic	IA Decision Support

			perspective) greening measures.	
	US-DC3-140	Get recommendations on how to plan climate resilient new settlement areas	Provide guidelines and give clear instructions to developers/city planners for developing settlement areas with high quality and high climate resilience even in 50 years.	Decision Support
US-DC3-200 – Ventilation pattern adaptation measures	US-DC3-210	Get information on the ventilation patterns in Linz based on the current urban fabric and the expected changes over time through density increase	**1)** Adapt the masterplan to cope better with the air conditions in the city under future climate conditions ☐ adaptation of existing urban fabric **2)** Simulate effects of urban densification (changes in the building heights and density) and of single construction projects on ventilation patterns in the City of Linz	IA Decision Support

Table 8: Synthesis of requirements and objectives from DC3 USs.

3.4 DC4 - Transport Infrastructure in Spain

The objective of this DC case is to improve the resilience of existing transport infrastructure, through the development of climate proofing infrastructure and to facilitate the planning and management of maintenance tasks on the Spanish ground transport networks thanks to the development of indicators that contribute to their operation safety, profitability and sustainability in both the short and long term.

The results of this demonstration case will help managers, whether they are public administration or licensed companies, to the efficient and cost-effective planning of resources and budget for the design and implementation of climate-driven impacts adaptation measures in the Spanish railway and highway networks.

This DC has two parent (Level 1) User Stories, US-DC4-800 and US-DC4-900, that are divided into three and four children (Level 2) User Stories, respectively.

US-DC4-800 Infrastructure planning and design: This US summarizes common information needs for the design and planning of roads. The focus of this parent US is on the pre-study phase, whereas the focus of the descriptions for each of the more specific sub stories is on the expert phase. The goal is to provide inputs to road planners in both present road structure and when planning new roads, and other actions related to the transport network. This US has three sub stories:

- **US-DC4-810 Development of climate indicators for road infrastructure:** this US examines the future climate for Spanish roads. The goal is to provide input for hazard prevention to road planners for both present road infrastructure and in planning new roads. Its main aim is to create a Spanish Atlas with the climate variables and indices related to each of the hazards considered.

  Main problems/challenges identified:

  - Definition of the spatial variation of each climate variable for the whole Spanish territory.
  - Identification and representation of all vulnerable elements for the Spanish roads.
  - Definition of indicators that show the climate impact for each vulnerable element.
  - Spatial representation of the indicators for present and future climate in Spain.

- **US-DC4-820 Climate indicator and data monitoring:** this US monitors the effects of climate change that have already taken place to establish a set of best practices of adaptation for the future. The goal is to provide input to road planners for both present road infrastructure and in planning new roads in order to prevent hazards. The user story aim is to create an early warning system.

  Main problems/challenges are identified:

  - Automation of climate data collection and the state of vulnerable elements.
  - Seasonal and weather forecasting integration.
  - Generation of warnings and alerts on potential risks.
  - Generation of good practices based on the observed impact.

- **US-DC4-830 Catalogue of adaptation measures:** this US should provide a set of measures that best help in the adaptation to the future climate conditions, taking into account economic, social and environmental factors. The aim is to offer a project manager a catalogue of measures so that they can select the most convenient.

  Main problems/challenges are identified:

  - Identification of risk and impact adaptation measures.
  - Systematization of possible solutions to be incorporated into roads.
  - Decision-making support.

US-DC4-900 Infrastructure maintenance and construction: The main goal of this US is to gather information on the future (long, medium and short-term) climate to maintain current roads and built new ones, so that maintenance activities can be scheduled or better adjust bidding conditions in tendering and plan for more resilient infrastructure in the construction of new roads. So, this user story examines the future climate for Spanish roads in order to provide input to road planners to both present road maintenance and for building new roads for preventing hazards. This US is divided into four:

- **US-DC4-910 Winter road/driving scenario:** this US examines the future climate for Spanish roads. The goal is to provide input to road planners to both present road maintenance and when building new roads in terms of hazard prevention so that they can plan, design, develop construction and maintenance techniques taking into account climate change focused on winter scenarios.

  Main problems/challenges are identified:

  - Identify climate variables and hazards that pose a risk to roads in winter scenarios, such as ice or snow on the road, safety, road degradation or poor visibility due to fog.
  - Determine the indicators and thresholds from which climate variables generate a hazard.
  - Quantify the levels of vulnerability of road infrastructure to such climate hazards.
  - Quantify a probable and maximum level of impact for each study scenario and for each element analysed.

- **US-DC4-920 Hydric risk scenario:** this US examines the future climate for Spanish roads. Its main aim is to provide input to road planners for preventing hazards when performing road maintenance and when building new roads considering hydric risks.

  Main problems/challenges are identified:

  - Identify the climatic variables and hazards that generate a hydric risk scenario on roads, derived from the volume and frequency of precipitation (rainfalls) or from the overflowing of rivers (river floods) as well as the associated threats, such as landslides and landslides caused by accumulated water.
  - Determine the indicators and thresholds from which climate variables generate a hydric hazard for road infrastructures.
  - Analyse the expected evolution of these hazards.

- Quantify the levels of vulnerability of road infrastructure to such climate hazards
- Quantify a probable and maximum level of impact for each study scenario and for each element analysed.

- **US-DC4-930 Heat waves scenario:** this US examines the future climate for Spanish roads. The goal is to provide input to road planners to both present road maintenance and when build new roads for preventing hazards. Its aim is to provide tools so that project managers can plan, design, and develop construction and maintenance techniques taking into account climate change focused on heat waves.

  Main problems/challenges are identified:

  - Study and analysis of the hazards derived from heat waves in road infrastructures and their consequences, such as road degradation and road safety.
  - Analyse the expected evolution of these threats.
  - Quantify the levels of vulnerability of road infrastructure to such climate hazards
  - Quantify a probable and maximum level of impact for each study scenario and for each element analysed.
- **US-DC4-940 Growth of vegetation scenario:** this US examines the future climate for Spanish roads. The goal is to provide input to road planners to both present road maintenance and when build new roads for preventing hazards focusing on the risks posed by the growth of vegetation surrounding roads. Its main goal is support during plan, design, and development of construction and maintenance techniques taking into account climate change.

  Main problems/challenges are identified:

  - Study and analysis of the threats arising from the growth of vegetation adjacent to road infrastructure and its consequences, such as the danger of nearby fires, smoke damage, reduced visibility and road safety.
  - Analyse the expected evolution of these threats.
  - Quantify the levels of vulnerability of road infrastructure to such climate hazards
  - Quantify a probable and maximum level of impact for each study scenario and for each element analysed.

Level 1 US	Level 2 US	Requirement	Objective	EU-GL Scope:
US-DC4-800 Infrastructure planning and design	US-DC4-810	- Intense precipitation, snow, wind, or storms and the expected changes in the future on road elements. - Flooding and droughts caused by water supply from precipitation or rivers on road elements. - Intense frost and expected changes in the future on road element - Intense fog and expected changes in the future on road element - Intense soil erosion and expected changes in the future on road element - Intense desertification and expected changes in the future on road element	Obtain all relevant climate indicators that affect road maintenance and construction (T, rainfall, humidity, snow and frost).	RA - Hazards
	US-DC4-820	- Intense precipitation, snow, wind, or storms and the expected changes in the future on road elements.	Develop a system to store and visualize climate indicators and data	Integration Decision Support

		- Flooding and droughts caused by water supply from precipitation or rivers on road elements. - Intense frost and expected changes in the future on road element - Intense fog and expected changes in the future on road element - Intense soil erosion and expected changes in the future on road element - Intense desertification and expected changes in the future on road element		
	US-DC4-830	- Economic cost (construction and maintenance) - Comfort and road safety - Environmental impact	Develop measures for adapting to the future climate.	Adaptation Options AO - Identification AO - Appraisal Integration Decision Support
US-DC4-900 Infrastructure maintenance and construction	US-DC4-910	- Road degradation due to temperature oscillation below 0 - Snow melting and drainage problems - Other vulnerable elements - Temperature evolution (long, medium, and short climate term) - Density of fog (long, medium, and short climate term) - Snowfall (long, medium, and short climate term) - Anticipated replacement cost and adaptation	Obtain relevant climate winter indicators (T, rainfall, humidity, snow and frost)	Risk Analysis RA - Hazards RA - Exposure RA - Vulnerability RA - HxExV Impact Scenario Analysis IA - Hazards IA - Exposure IA - Vulnerability IA - HxExV Adaptation Options AO - Identification AO - Appraisal
	US-DC4-920	- Recover mechanical properties of slopes. - Improve slope resistance - Specific digging systems, particular retention systems, hydric resources economy. - Precipitations / Storms evolution for long term, medium term, and short term. - Rain falls for long term, medium term, and short term. - Anticipated replacement cost and adaptation	Obtain all relevant hydric indicators such as precipitation, river data, and wetness and aridity.	Risk Analysis RA - Hazards RA - Exposure RA - Vulnerability RA - HxExV Impact Scenario Analysis IA - Hazards IA - Exposure IA - Vulnerability IA - HxExV Adaptation Options AO - Identification AO - Appraisal
	US-DC4-930	- Recover mechanical properties of the road surface. - Know the required composition of the asphalt mixture and painting in accordance to the climate conditions.	Obtain all relevant climate winter indicators (T and thermal amplitude).	Risk Analysis RA - Hazards RA - Exposure RA - Vulnerability RA - HxExV

		- Temperature evolution (long term, medium term, and short term) - Anticipated replacement cost or cost of quality improvement		Impact Scenario Analysis IA - Hazards IA - Exposure IA - Vulnerability IA - HxExV Adaptation Options AO - Identification AO - Appraisal
	US-DC4-940	- Know the progression of vegetation growth. - Know the frequency of the intervention related to vegetation. - Estimate the fire risk and to provide alternative routes. - Maintenance cost	Obtain relevant climate indicators for vegetation growth.	Risk Analysis RA - Hazards RA - Exposure RA - Vulnerability RA - HxExV Impact Scenario Analysis IA - Hazards IA - Exposure IA - Vulnerability IA - HxExV Adaptation Options AO - Identification AO - Appraisal

Table 9: Synthesis of requirements and objectives from DC4 USs.

4. Validation methodology

Service Validation and Testing defines the testing of the services during the Service Demonstration phase of the project. This is meant to ensure that the new Climate Services are *fit for purpose* (utility) and *fit for use* (warranty). It should be noted that a "hard" technical validation is beyond the scope of this task, although the teams involved in the technical development of the system will produce the necessary documentation assessing the steps and technical tests that they will be following during the development phases of each component. For this purpose, T1.4 "Industrialization and Support" provides an integrated development and testing environment that is used by WP4 "Technology Support" for (test-driven) development of the CSIS Building Blocks (see D4.1 "Technology Support Plan").

Climate Change scenarios validation is also **out of the scope of this task** and it should be taken into account as one of the activities performed following EU-GL guidelines.

Model validation is matter of the expert activities and uncertainty assessment / documentation. Uncertainty assessment must refer in a first step to the forcing data in which the local models are embedded and must address the range of model results at the larger scale which is the basis for the local scale modelling.

The validation and testing will take into consideration the **Key Performance Indicators** (KPIs) developed for T7.4 "Impact Measurement and Project objective validation" as they will be developed to measure and communicate the project's impacts and requirements defined on other tasks.

The **Service Validation** main goal is to make sure that the activities delivered add value to the Business User's processes in order to be compliant with the requirements stated in the User Stories (utility) definition and later reflected in the Test Cases laid out (warranty). If testing is not carried out properly, misunderstandings may appear and the expectations of end users may not be properly addressed. The objective is to ensure these concepts of service utility and warranty, and that the users understand the added value they will provide during their decision-making process, the limitations stemming from the current state of the art of climate services and how to handle the associated uncertainty. Validation will assess efficiency of the CSIS design, appraisal and implementation of climate adaptation strategies, with specific reference to the EU-GL.

From a **User Perspective**, the project will consider different methods of achieving this goal: from workshops to work sessions and questionnaires (web or on site). As already mentioned, the approach should ensure the utility of the climate services validating if they fit the purpose that the users stated in the User Stories and also for use according to the functionality and performance described in the Test Cases.

During the EC&EASME networking event on climate services (Nov 29-30, 2017) it was agreed to create a Task Force, the work of which is initially limited to ca. 6 months, set to explore the synergies and shared interests across the H2020 projects (especially those funded under the call SC5-01a/b-2016-2017) with respect to the evaluation of climate services from users' perspective. CLARITY representatives have joined this Task Force and will include any results obtained on this task. The Task Force is expected to present the results of the joint work by October 2018 during the Climateurope innovation festival.

From a **Business Perspective**, validation tests should be developed in order to estimate if they fit with the Exploitation Requirements (see D5.1 "Exploitation Requirements and Innovation Design v1"), to what extent the services are offering added value, if the users are willing to pay for them and if the defined business models are reliable and believable.

There are a number of activities for Services Validation, these include:

- Validation and Test management: this consists of planning and managing/controlling and then reporting on the activities that have taken place during all phases to ensure they are fit for purpose/use.
- Planning and Design: test planning and design activities will take place in the early stages of the Service Lifecycle. These correlate to resources, supporting services, scheduling milestones for delivery and acceptance.
- Verification of Test Plan and Design: test plans and designs are validated to ensure all activities are

complete. Test models are also verified to minimize the risks during the test gathering sessions.
- Test workshop environment: prepare and make a baseline of the test environment, identify the stakeholders to whom they are directed and ensure that they are offered enough information to test the service and understand the meaning and objective of the tests.
- Testing: tests are carried out using the testing techniques and procedures more adequate to each type of test. All results are registered.
- Evaluate Exit Criteria and Report: actual results are compared with projected results when available.

A more thorough description of the validation tasks is out of the scope of this document and will be developed on T2.4 “Validation” during the second year of the project.

5. Conclusions

The objective of Task 2.1 “Data requirements definition, data collection concept, demonstration and result validation concept” and the related D2.1 “Demonstration and validation methodology” has been to define data requirements for the climate services and the preparatory work, as well as to provide a harmonized approach for data collection across the different DCs, to support the transferability, scalability and replicability of CLARITY climate services in different EU contexts.

In order to fulfil this task, the methodology include the preliminary mapping of datasets and models, in line with the modelling workflow as defined in WP3 “Science Support”, necessary to achieve the objectives of the different CLARITY DCs. End-users requirements, needs and expectations, in relation to the implementation of the CLARITY TCs, are at the base of the implementation of DCs and will constitute the basis for the validation of methodology and results. To identify the specific application requirements expressed by user stories, a series of end-user workshops have been carried out.

A large number of data sets relevant for the project, covering information on climate change, urban land use, transport and environmental data, inventory of elements at risk, sensitivity, exposure, are available at European level from public archives and previous European projects. These data, necessary for the characterization and identification of signals and climatic hazards, for risk assessment and impact scenarios analysis, will be used at various spatial and temporal scales as baseline for hazard mapping and as input for local/regional models that address specific climate risks for individual DCs.

To achieve the objectives of the 4 CLARITY DCs, the risk/impact models have been identified for each case and will be used to simulate the current and future climate situation, to explore heat island patterns and areas sensitive to the microclimate and to model the surface flood in order to identify the key factors that could lead to flood risk conditions. These models will be applied to produce impact scenarios based on the identified hazard conditions. More scales of analysis will be considered, depending on data availability.

The assessment methodology of climate services will serve, on one hand, to evaluate the correspondence of the achieved results with the purpose declared by users in the USs and their actual use based on the functionality and performance described in the TCs, on the other to evaluate the effective commercial exploitation of the climate services offered.

The collection of specific data for the different DCs is planned in T2.2 “Demonstrator-specific data collection”, where the datasets will be formally collected within the CLARITY catalogue, based on the specific data types and format defined in WP3 “Science Support” and technical specifications from WP4 “Technology Support”. However, due to the complexity of modelling and data calibration needed to perform the CLARITY services, for DC1 and DC3, the process of data collection and integrating these in a GIS has started in advance with respect to the timeline defined by WP2 “Demonstration &Validation” tasks.

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Annex I – Data sources mapping template

Napoli – Heat Wave

Dataset	Access	Owner	Permalink	Format	Area coverage	Resolution /scale	Date of survey	Type	Use within modelling workflow	Used as input for	Notes
Temperature (°C, daily mean, minimum, maximum)	Restricted	IspraAmbiente	n/a	Table (no geometry)	Regional / Metropolitan	n/a	1986-2015	Meteo data	HC-Regional; HC-Microclimate	MUKLIMO_3 – cuboid method	30-year climate observations from monitoring stations
Wind speed (m/s, daily mean)	Restricted	IspraAmbiente	n/a	Table (no geometry)	Regional / Metropolitan	n/a	1986-2015	Meteo data	HC-Regional; HC-Microclimate	MUKLIMO_3 – cuboid method	30-year climate observations from monitoring stations
Wind direction (°, 3 daily intervals: 7h, 14h, 21h)	Restricted	IspraAmbiente	n/a	Table (no geometry)	Regional / Metropolitan	n/a	1986-2015	Meteo data	HC-Regional; HC-Microclimate	MUKLIMO_3 – cuboid method	30-year climate observations from monitoring stations
Relative humidity (%, daily mean)	Restricted	IspraAmbiente	n/a	Table (no geometry)	Regional / Metropolitan	n/a	1986-2015	Meteo data	HC-Regional; HC-Microclimate	MUKLIMO_3 – cuboid method	30-year climate observations from monitoring stations
Precipitation (mm, daily sum)	Restricted	IspraAmbiente	n/a	Table (no geometry)	Regional / Metropolitan	n/a	1986-2015	Meteo data	HC-Regional; HC-Microclimate	Climate analysis (ZAMG)	30-year climate observations from monitoring stations

EURO-CORDEX ensemble climate simulations	open	CORDEX	https://esgf-data.dkrz.de/search/cordex-dkrz/	netcdf	27N – 72N, ~22W – 45E	0.11 degree	2006 - 2100	ensemble climate simulations, based on different GHG emission scenarios		Modelling of future climate scenarios; MUKLIMO_3 – cuboid method	
Topographic database	Restricted	Campania Region	n/a	Vector .shp	Regional / Metropolitan	1:5000	2011	Geometry (including terrain) Typological, technical, construction data	HC-Microclimate, EE	MUKLIMO_3 - Wall area index MUKLIMO_3 - Surface roughness of the non-built-up areas MUKLIMO_3 - Fraction of impervious surface between buildings MUKLIMO_3 - Vegetation parameters MUKLIMO_3 - Albedo of the impervious parts of the canopy layer	
Orthofoto AGEA	Restricted	Campania Region	n/a	Raster .ecw	Regional / Metropolitan	1:5000	2014	Other (see notes)	HC-Microclimate, EE; VA	MUKLIMO_3 - Albedo of the roofs MUKLIMO_3 - Fraction of green roof	Aerial photogrammetry
LIDAR dataset DSM – DTM	Open	Naples Metropolitan City	http://sit.cittametropolitana.na.it/lidar.html	Raster ASCII	Regional / Metropolitan	density 4 p/mq, elevation precision	2009/2012	Geometry (includi	HC-Microclimate, EE; VA	MUKLIMO_3 - Mean building height	

						15 cm. - 1mx1m resolution.		ng terrain)			
Building typologies classification	Restricted	PLINIVS	n/a	Vector .shp	Regional / Metropolitan	1:5000	1990-2017	Typological, technical, construction data	HC-Microclimate, EE; VA	MUKLIMO_3 - Building fraction per building type MUKLIMO_3 - Wall area index per building type MUKLIMO_3 - Mean building height per building type MUKLIMO_3 - Albedo of the walls MUKLIMO_3 - K-value of the building walls MUKLIMO_3 - K-value of the building roof MUKLIMO_3 - Area heat capacity of the building walls MUKLIMO_3 - Area heat capacity of the building roof PLINIVS HW Vulnerability model	surveyed data on ≈80k buildings, statistical correlations at Regional level
Building typologies classification (historic centre)	Open	Naples Municipality	http://www.comune.napoli.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/29759	Vector .shp	Municipality	1:5000	2016	Typological, technical, construction data	HC-Microclimate, EE; VA	MUKLIMO_3 - Building fraction per building type MUKLIMO_3 - Wall area index per building type MUKLIMO_3 - Mean building height per building type	

										MUKLIMO_3 - Albedo of the walls MUKLIMO_3 - K-value of the building walls MUKLIMO_3 - K-value of the building roof MUKLIMO_3 - Area heat capacity of the building walls MUKLIMO_3 - Area heat capacity of the building roof PLINIVS HW Vulnerability model	
Land Use (Urban Atlas)	Open	EEA	https://www.eea.europa.eu/data-and-maps/data/urban-atlas	Vector .shp	Regional / Metropolitan	1:5000	2012	Land use and building functions data	HC-Microclimate, EE; VA	MUKLIMO_3–land use map	
Imperviousness (Urban Atlas)	Open	EEA	https://www.eea.europa.eu/data-and-maps/data/urban-atlas	Vector .shp	Regional / Metropolitan	10km from 1km cube	2012	Typological, technical, construction data	HC-Microclimate, EE; VA	MUKLIMO_3 - Fraction of impervious surface between buildings	
Vegetation and Land Use (Municipality of Naples)	Open	Naples Municipality	http://www.comune.napoli.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/26127	Vector .shp	Municipality	1:5000	1997	Typological, technical, construction data	HC-Microclimate, EE; VA	MUKLIMO_3 - Vegetation parameters MUKLIMO - Surface roughness of the non-built-up areas MUKLIMO - Fraction of impervious surface between buildings	

ISTAT census data - population	Open	ISTAT National Institute of Statistics Italy	https://www.istat.it/it/archivio/104317	Vector .shp	Regional / Metropolitan	n/a	2011	Socio-economic data	EE; VA; RA/IA	PLINIVS HW Vulnerability model PLINIVS HW Impact model	
ISTAT census data - business and industry	Open	ISTAT National Institute of Statistics Italy	https://www.istat.it/it/archivio/104317	Vector .shp	Regional / Metropolitan	n/a	2011	Socio-economic data	EE; VA; RA/IA	PLINIVS HW Vulnerability model PLINIVS HW Impact model	
Urban Masterplan + 2nd level public and private initiatives	Open	Naples Municipality	http://www.comune.napoli.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/27621	Vector .shp	Municipality	n/a	2015	Land use and building functions data	IAO/AAO; AAP	PLINIVS HW Impact model	

Sweden – Heat and Flooding

Dataset	Access	Owner	Permalink	Format	Area coverage	Resolution /scale	Date of survey	Type	Use within modelling workflow	Used as input for	Notes
SWICCA (temperature, precipitation, hydrological variables=	Open	Copernicus	http://swicca.climate.copernicus.eu/	Excel/ NetCDF	Europe	Three periods	2020, 2050, 2080	hydrological data	DC2 workflows	Pre-study, expert studies	Ensemble of hydrological effect studies
Urban SIS (meteorological, air-quality and hydrological variables)	Open	Copernicus	http://urbansis.climate.copernicus.eu/	NetCDF / csv	Stockholm	Hourly	Historical, Present (around 2000), Future (around 2050)	Meteorological, air quality and hydrological data	DC2 workflows involving Stockholm	Indicator tool, expert studies	
Hydrological dataset of future conditions in Sweden.	To be decided	SMHI	n/a	Excel/ QGis	Sweden	Hourly	To be decided	Hydrological data	DC2 workflows	Pre-study, expert studies	To be produced in Clarity
Heat scenarios over Stockholm	To be decided	SMHI	n/a	NetCDF	Stockholm	Hourly	To be decided	Meteorological data	DC2 workflows involving Stockholm	Pre-study, expert studies	To be produced in a parallel project
Urban land-use and physiography over Stockholm	Restricted	SMHI	n/a	Raster ASCII	Stockholm	Approx. 300x300 m2	2012	Urban physiography	DC2 workflows involving Stockholm	Expert studies	Produced within UrbanSIS

Open Swedish data	Open	Swedish institutes	To be defined	Varying	Sweden	Varying	Varying	Several types	DC2 workflows	Expert studies	Will be further specified when work has started
Local datasets	Restricted	Swedish municipalities and consultancy companies	n/a	Varying	Stockholm/Jönköping	Varying	Varying	Several types	DC2 workflows	Expert studies	Will be further specified when work has started

Linz – Heat Waves, Heat Island effects, Ventilation

Dataset	Access	Owner	Permalink	Format	Area coverage	Resolution/ scale	Date of survey	Type	Use within modelling workflow	Used as input for	Notes
Temperature (°C, daily mean, minimum, maximum)	Restricted	ZAMG	n/a	Table (no geometry)	-	Daily	1961 - 2010	Meteorological data	HC-Microclimate	MUKLIMO_3 – cuboid method	Climate observations from monitoring stations
Wind speed (m/s, daily mean)	Restricted	ZAMG	n/a	Table (no geometry)	-	Daily	1961 - 2010	Meteorological data	HC-Microclimate	MUKLIMO_3 – cuboid method	Climate observations from monitoring stations
Wind direction (°C, 3 daily intervals: 7h, 14h, 21h)	Restricted	ZAMG	n/a	Table (no geometry)	-	Daily	1961 - 2010	Meteorological data	HC-Microclimate	MUKLIMO_3 – cuboid method	Climate observations from monitoring stations
Relative humidity (%, daily mean)	Restricted	ZAMG	n/a	Table (no geometry)	-	Daily	1961 - 2010	Meteorological data	HC-Microclimate	MUKLIMO_3 – cuboid method	Climate observations from monitoring stations
Digital Elevation Model data over Europe (EU-DEM)	Open	EEA, European Commission	https://www.eea.europa.eu/data-and-maps/data/eu-dem#tab-original-data	Raster (.tif)	EU	30 m	2000	Elevation data	HC-Microclimate	MUKLIMO_3, COSMO-CLM	Derived from remote sensing data
Urban Atlas	Open	Copernicus Land	https://www.eea.europa.eu/data-and-	Vector .shp	European Cities (> 100.00	10 m	2012	Land use data	HC-Microclimate	MUKLIMO_3, CSMO	Derived from remote sensing data

Landcover 2012		Monitoring Service	maps/data/urban-atlas#tab-gis-data		0 inhabitants)					CML, ENVIMET	
Soil sealing layer (0-100%)	Open	EEA (European Environment Agency)	https://www.eea.europa.eu/data-and-maps/data/eea-fast-track-service-precursor-on-land-monitoring-degree-of-soil-sealing	Raster (.tif)	Europe	20 m	2009	Degree of soil sealing	HC-Microclimate	MUKLMO_3, COSMO-CLM, ENVIMET	Derived from remote sensing data
EURO-CORDEX ensemble climate simulations	Open	CORDEX	https://esgf-data.dkrz.de/search/cordex-dkrz/	netcdf	27N – 72N, ~22W – 45E	0.11 degree	1961 - 2100	Ensemble climate simulations, based on different GHG emission scenarios	HC-Regional, HC-Microclimate	Modelling of future climate scenarios; MUKLIMO_3 – cuboid method	Climate simulation
Zoning Plan Upper Austria	Open	OGD Upper Austria	https://www.land-oberoesterreich.gv.at/171835.htm	Vector (.shp)	20X21 km around Linz		2016	Zoning plan	HC-Microclimate	Modelling of future climate scenarios and future land use changes	Based on DKM (Digital Katastralmappe)
Digital Elevation Model data for Linz and its surroundings	Open	OGD Upper Austria	https://www.land-oberoesterreich.gv.at/124923.htm	Raster (.tif)	20X21 km around Linz	10 m	2013	Elevation data	HC-Regional, HC-Microclimate	MUKLMO_3, COSMO-CLM	Derived from remote sensing data
Green area inventory	restricted	City of Linz	n/a						HC-Microclimate, IAO/AAO	MUKLIMO_3	Created from orthophotos
3D point-cloud data	restricted	City of Linz	n/a				2011		HC-Microclimate	Envimet	Lidar data

Building footprint model with mean-heights	restricted	City of Linz/AIT	n/a				2017	LOD1 3D model of the city's buildings	HC-Microclimate, IAO/AAO	MUKLIMO_3, Envimet	Merge of footprint and LIDAR data
Tree Vegetation distribution with height information	restricted	City of Linz/AIT	n/a						HC-Microclimate, IAO/AAO	MUKLIMO_3, Envimet	

Spain – Road driving conditions – Summer and winter extremes, snow, hydrology and wildfire conditions

Dataset	Access	Owner	Permalink	Format	Area coverage	Resolution/ scale	Date of survey	Type	Use within modelling workflow	Used as input for	Notes
Meteorological observation data	Restricted	Acciona	N/A	CSV files	-	Hourly		Meteorological data	Statistical Downscaling	FICLIMA method	Climate observations from monitoring stations
Meteorological observation data	Restricted	AEMet	N/A	CSV files	-	Daily	1961-2010	Meteorological data	Statistical Downscaling	FICLIMA method	Climate observations from monitoring stations
Digital Elevation Model data over Europe (EU-DEM)	Open	EEA, European Commission	https://www.eea.europa.eu/data-and-maps/data/eu-dem#tab-original-data	Raster (.tif)	EU	30m	2000	Elevation data			
EURO-CORDEX ensemble climate simulations	Open	CORDEX	https://esgf-data.dkrz.de/search/cordex-dkrz/	netcdf	27N – 72N, ~22W – 45E	0.11 degree	1961 - 2100	Ensemble climate simulations, based on different GHG emission scenarios		Modelling of future climate scenarios	
Detailed highway design	Restricted	Acciona	N/A								

Spanish forest fuel model	Restricted	MAPAMA	N/A	Raster (.tif)							
Spanish fire forecast	Restricted	Clarity	N/A	Raster (.tif)							
Fire behaviour	Restricted	Clarity	N/A	Raster (.tif)							
Vegetation condition on ditches and median strips	Restricted	Acciona	N/A								
LIDAR point cloud data providing altimeter information	Open										
Mid term meteorological forecasting, NOAA	Open	NOAA		grib	worldwide	6h / 1 degree	Last 10 years	Ensemble prediction	Statistical Downscaling		
Mid term meteorological forecasting, ECMWF	Restricted	ECMWF	N/A	grib	Worldwide	6h / 0.28 degree	1992 - present	Ensemble prediction	Statistical Downscaling		
NOAA Climate Forecast	Open	NOAA	http://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2_body.html	grib	Worldwide	Variable	2011 – present	Climate data			

System (CFSv2)											
ECMWF System4	Open	Copernicus	https://www.ecmwf.int/en/forecasts/documentation-and-support/evolution-ifs/cycles/seasonal-forecast-system-4	grib	Worldwide	1 degree		Ensemble climate simulation	DC4 workflows		
Current climate atlas	Open	AEMet	http://www.aemet.es/en/serviciosclimaticos/datosclimatologicos/atlas_climatico	Raster (.tif)	Spain & Portugal		1971-2000	Climate data			
Spanish Transport Network layers	Restricted	CEDEX	N/A	.shp							
Decadal models outputs (CMIP5)	Open	CMIP	https://cmip.llnl.gov/cmip5/	netcdf	Worldwide	-	-	Climate data prediction			
AEMet-Spanish official projections	Open	AEMet		Raster (.tif)				Climate data projection			
CMIP5 climate projections	Open	CMIP	https://cmip.llnl.gov/cmip5/	netcdf	Worldwide	-	-	Climate data projection			