ECMWF COPERNICUS REPORT

Copernicus Climate Change Service

Urban SIS
D441_Lot3.7.2 Access, download and visualisation of Urban SIS data

Issued by: Swedish Meteorological and Hydrological Institute (SMHI)

Date: 30/06/2017

Ref: C3S_D441_Lot3.7.2_201706_UrbanSIS_portal.docx

Official reference number service contract: C3S_441_Lot3_SMHI_2017/SC2

IMPLEMENTED BY ECMWF

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1. Introduction

This report gives an overview of the technical solution and implementation of the Urban SIS portal. The portal has been implemented and is available at http://urbansis.climate.copernicus.eu. It currently contains historical data from the project, climate scenario data will be added as they are produced in the project during the fall of 2017.

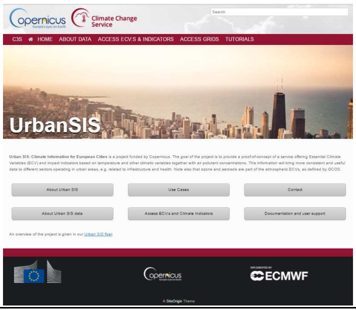
The report starts with a general overview of the Urban SIS web pages, including the web based information pages and the portal to be used for the data storage and visualization. We describe the main functionality available to explore data and metadata. After this the report focuses on the technical solution, the general architecture, an overview of packages used for the implementation and details about representation of metadata in NetCDF. We also provide a discussion on our experiences made on the work with THREDDS, NetCDF and the large amount of datasets using local projections. Our aim has been to focus on information useful for anyone implementing a similar system. More details as well as source code can be made available on request.

2. General overview

Technically the Urban SIS portal consists of two parts, the data portal and the general project information pages. The data portal contains the data storage and functionality for visualisation and data download. The produced data is represented and stored as NetCDF, therefor we have chosen to base the data portal on the THREDDs (http://www.unidata.ucar.edu/software/thredds/current/tds/) data server.

The information pages contain supporting information and guidelines for end users of the portal. The information is mainly text based and should be easy to extend and for that purpose we use the Wordpress (https://wordpress.org/) content management system for this part. An overview of the two parts of the portal is given in table 1. As requested, the look and feel of the web pages follows the style of the Copernicus Climate site (http://climate.copernicus.eu/).

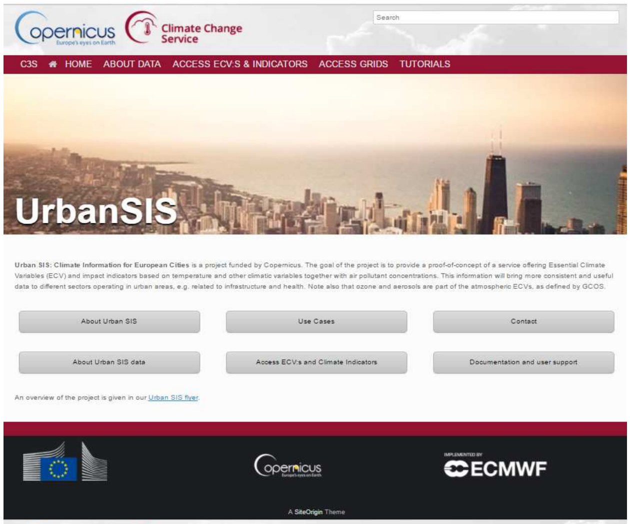
Table 1 - Overview of the Urban SIS web pages

	Information pages	**Data portal**
Start page		
Content	Project information pages. Main entrance to the project pages which contain links to the data portal.	Visualisation and download of the Urban SIS data. Data are stored as NetCDF following convention CF-1.6.
Technical solution	Implemented using the Wordpress content management system (https://wordpress.org/).	The data portal is implemented with a server side based on THREADDS Data Server (http://www.unidata.ucar.edu/software/thredds/current/tds/) and a web client for visualization and download based on HTML and Java Script

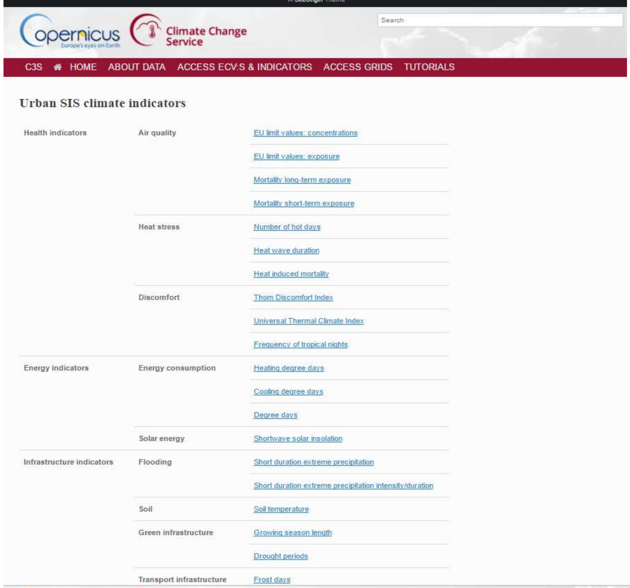
3. Information pages – main functionality

The information pages contain a general presentation of Urban SIS together with detailed information on the datasets and how they have been computed. The information will be extended during the fall as new data and results from the project are produced.

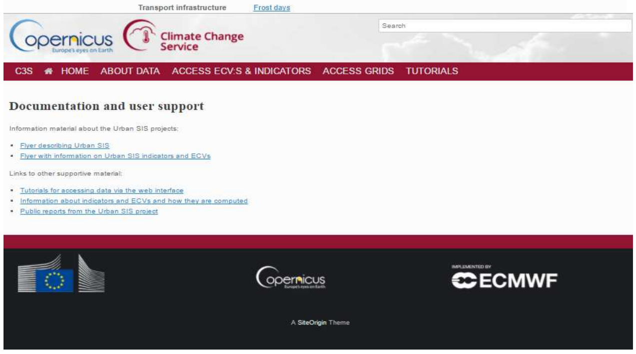
The main entry page for the project contains links to all relevant information available related to the project and produced data. The most important parts are the data portal with access to data, the pages with extensive information about the data and the supportive pages with tutorials and manuals. In addition to this the information pages contain general information about the project and its use cases. The Urban SIS homepage is available at: http://urbansis.climate.copernicus.eu/



One of the most important parts of the information pages is information reached under ***About data***. These pages contain a thorough description of provided dataset that complements the short meta-data information provided in the data files. Currently the information is based on D4.3 describing the indicators. The pages will be updated with information from WP3, describing the ECVs and results of the of the validation process. The main page for this information is: http://urbansis.climate.copernicus.eu/urban-sis-climate-indicators/



Supportive material can be reached through the button *Documentation and user support*. In this section the user can find tutorials, general information about the project and deliverables from the project. This information can be reached from: http://urbansis.climate.copernicus.eu/documentation-and-user-support/.



4. Data portal - main functionality

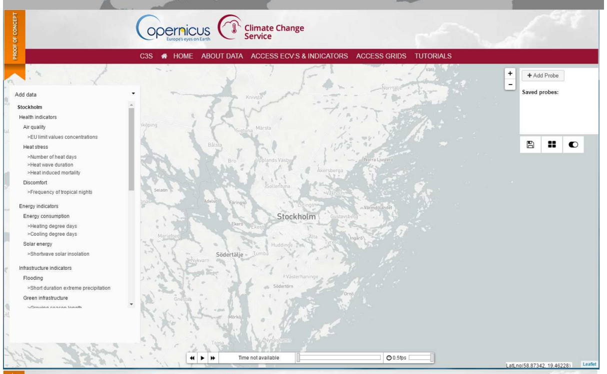
The data portal can be used to explore Urban SIS data and to download datasets or selections of dataset. The implemented functionality follows the design described in D4.4 Visualization of Urban SIS data. We have implemented all features described in the deliverable except the possibility of splitting the view into two maps.

In this section we give a brief overview of the main functionality. The data portal is available at http://urban-sis.smhi.se/ and a user guide is available in the information pages (http://urbansis.climate.copernicus.eu/tutorials/) that gives more details on the functionality of the data portal.

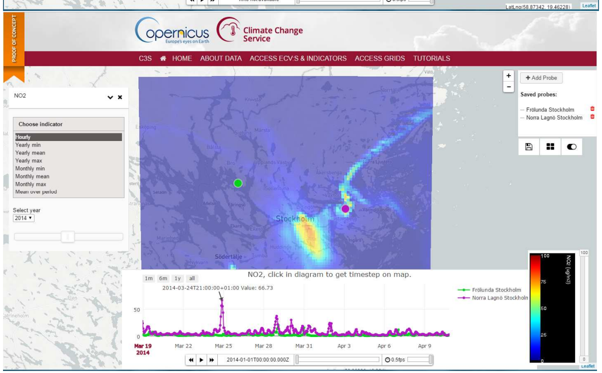
4.1 Explore data

When opening the data portal a first page shows the available cities. From this page the user can select the city of interest. We have assumed that the user is mainly interested in working with one city at the time, however it is possible to switch to another city by choosing it in the top menu. It is also possible to open a new city as a separate tab in the browser if the user wants to compare data between cities.

When a city has been selected a map centred over the area is shown. The user can zoom and pan in the map using the mouse. To the left a menu is available that shows the available datasets. This menu contains climate indicator groups as well as indicators.

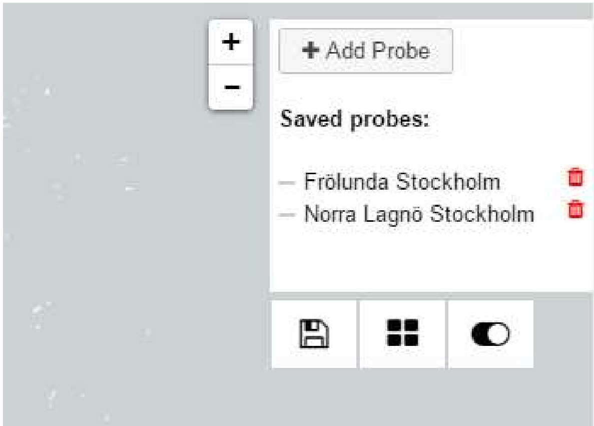


When selecting an indicator group or ECV the user is presented with a further selection of indicators and relevant statistics. When selecting one of them the first time step of the corresponding dataset is visualised. The users can click on the map to visualise time series for selected points. To further explore the data it is possible to zoom into the time series and select time slots for visualisation.

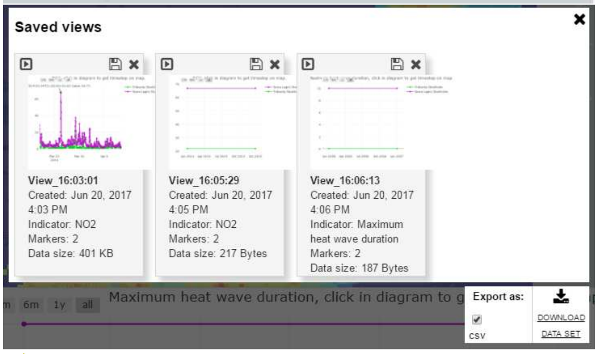


4.2 Download data

Any time the user has found a view with an interesting dataset and selected points he can save it by clicking on the save button. The button to the right of the save button shows a list of all saved views during a session.



From the list of saved views the user can choose to either return to a view, download the data from the view or to remove a view. Data can be saved either as csv, for all probes in a single view or as NetCDF, where it is possible to select a subset of the original dataset. In addition, the user can save data from selected points in all views by using the bottom selection.

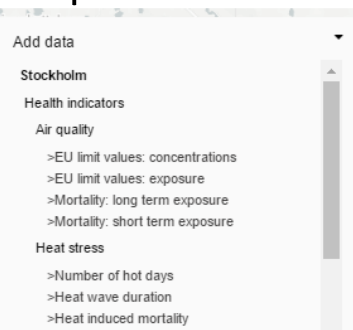


A second possibility to access and download data from the portal is to directly access the underlying THREDDS server that provides the date using the link: http://urban-sis.smhi.se/thredds/. This option makes data available in all formats supported by THREDDS and is mainly intended for expert users that want to use the data form other services.

5. Meta data representation

The data portal and the Information pages are designed to have parallel structures to describe each dataset. Each downloaded NetCDF file from the data portal will be coupled with information necessary to understand the provenance of the data. On the information pages we will, on the other hand, have the possibility to give an extensive description of the calculations made together with information on uncertainty fetched from the data portal. The information on the information pages will be continuously updated during the fall as information is being produced in the project. Below we give an example using the indicator hot days.

Data portal

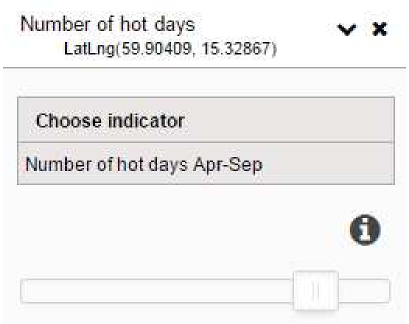


Information pages

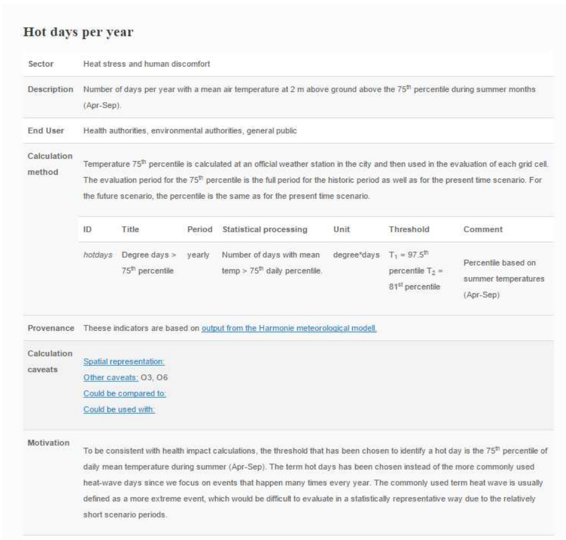
Urban SIS climate indicators

Health indicators	Air quality	EU limit values: concentrations
		EU limit values: exposure
		Mortality long-term exposure
		Mortality short-term exposure
	Heat stress	Number of hot days
		Heat wave duration
		Heat induced mortality
	Discomfort	Thom Discomfort Index

The main menu on the data portal for choosing data (e.g. http://urban-sis.smhi.se/indicator.html?city=Stockholm) and the information about data (e.g. http://urbansis.climate.copernicus.eu/urban-sis-climate-indicators/) follows the same structure.




```
:CDI = "Climate Data Interface version 1.8.0 (http://mpimet.mpg.de/cdi)" ;
:history = "Tue May 23 12:34:12 2017: cdo -L yearsum
         indicators/stockholm_110_historic_hotdayselect.nc
         indicators/stockholm_110_historic_hotdays.nc\nTue May 23 12:34:12 2017:
         cdo -L gtc,291.2 indicators/stockholm_110_historic_airtempavgdaily.nc
         indicators/stockholm_110_historic_hotdayselect.nc\nTue May 23 12:33:44
         2017: cdo -L daymean
         /nobackup/smhid12/sm_chras/UrbanSIS/grib_extractor/stockholm/timeseries
         /stockholm_110_historic_T2M.nc
         indicators/stockholm_110_historic_airtempavgdaily.nc\nCreated on Mon 10
         Apr 13:36  2017" ;
:source = "{\'Downscaling Model\': \'HARMONIE cy40h1.1\',
            \'Forcing/Boundary conditions\':
                \'UERRA re-analysis over Europe with HARMONIE (11x11 km2)\',
            \'UrbanCanopyModel\': \'SURFEX 7.3\',
            \'Landuse\': \'ECOCLIMAP II updated with Urban Atlas 2012\',
            \'DownscalingArea\': \'240x240 km, 1x1 km resolution\'}" ;
:Conventions = "CF-1.6" ;
:institute = "Swedish Meteorological and Hydrological Institute (SMHI)" ;
:title = "UrbanSIS: Downscaled historic climate" ;
:frequency = "year" ;
:CDO = "Climate Data Operators version 1.8.0 (http://mpimet.mpg.de/cdo)" ;
}
```



Hot days per year

Sector	Heat stress and human discomfort
Description	Number of days per year with a mean air temperature at 2 m above ground above the 75th percentile during summer months (Apr-Sep).
End User	Health authorities, environmental authorities, general public
Calculation method	Temperature 75th percentile is calculated at an official weather station in the city and then used in the evaluation of each grid cell. The evaluation period for the 75th percentile is the full period for the historic period as well as for the present time scenario. For the future scenario, the percentile is the same as for the present time scenario.

ID	Title	Period	Statistical processing	Unit	Threshold	Comment
hotdays	Degree days > 75th percentile	yearly	Number of days with mean temp > 75th daily percentile.	degree*days	T_1 = 97.5th percentile T_2 = 81st percentile	Percentile based on summer temperatures (Apr-Sep)

Provenance	Theese indicators are based on output from the Harmonie meteorological modell.
Calculation caveats	Spatial representation: Other caveats: O3, O6 Could be compared to: Could be used with:
Motivation	To be consistent with health impact calculations, the threshold that has been chosen to identify a hot day is the 75th percentile of daily mean temperature during summer (Apr-Sep). The term hot days has been chosen instead of the more commonly used heat-wave days since we focus on events that happen many times every year. The commonly used term heat wave is usually defined as a more extreme event, which would be difficult to evaluate in a statistically representative way due to the relatively short scenario periods.

When selecting an item on the menu, in this case *Number of hot days*, a submenu is displayed, showing all available indicators. The info button leads to the page reached by choosing same item on the information pages. This page shows information on how the items on the submeny is calculated and how it has been validated (eg. In this case http://urbansis.climate.copernicus.eu/hot-days-per-year/). The NetCDF itself contains meta-data with the most important information (bottom left). More details about this meta-date is given in the **Data requirements** section below.

6. Data portal – architecture

An overview of the technical architecture is shown in Figure 1 and follows the architecture designed in D7.1. The dark blue parts in the figure have been implemented. The main parts of the architecture consist of a platform providing data access and an application side providing the user interface and functionality. The light blue parts of the figure shows that the solution is extendible if new kinds of functionality need to be added. The application side consist of a web client implemented in JavaScript and HTML. The platform side provides the basic for data storage and exposes the THREDDS server which makes it possible for other interesting partners, such as the Climate Data Store to build their own applications on the available Urban SIS data, indicated in green in the figure.

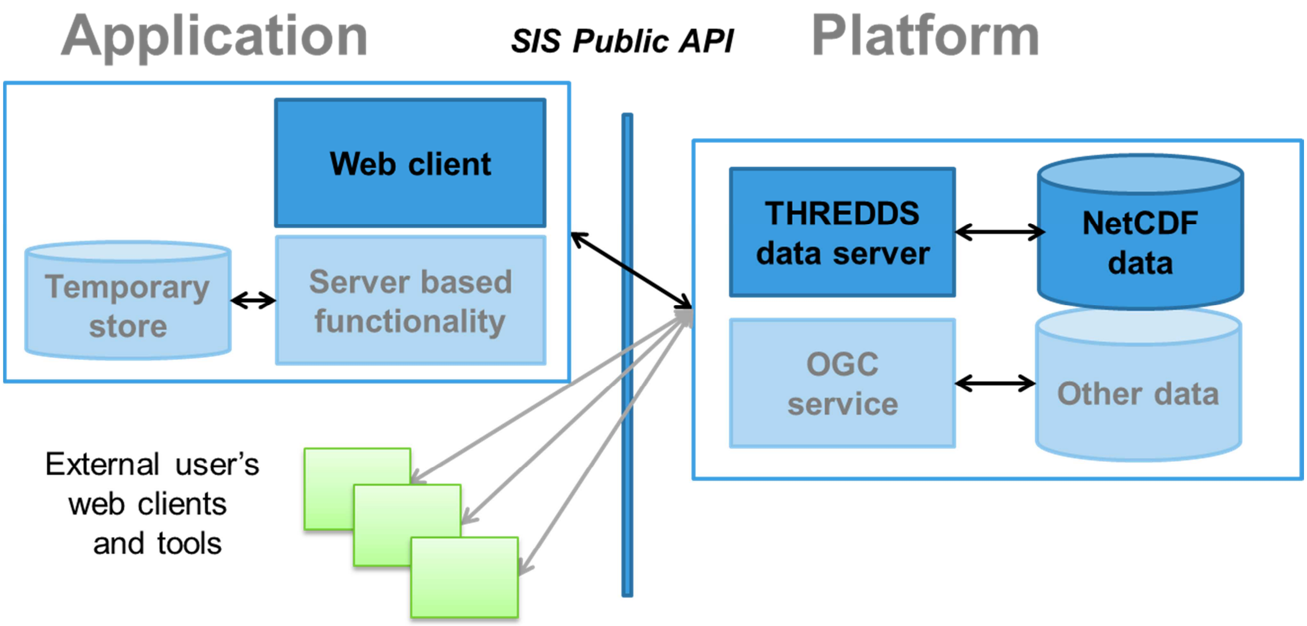


Figure 1 - Technical architecture of the Urban SIS data portal

6.1 Use of external services and open source code

THREDDS Data Server enables efficient access and manipulation of NetCDF files following convention CF-1.6. In particular it provides functionality for selecting subsets of the NetCDF files and reformatting and downloads of data to a large number of specified formats, including OPENDAP, WMS and HTTP. For the project we use our one installation of THREDDS. The source code is available at: http://www.unidata.ucar.edu/software/thredds/current/tds/TDS.html

Maps: The maps used in the Urban SIS portal are fetched from Mapbox. Their tool Mapbox Studio makes it easy to customize maps according to user needs. The service is available at: https://www.mapbox.com/maps/

Map management is implemented using Leaflet. Leaflet is one of the most used open-source JavaScript library for mobile-friendly interactive maps. It is available for all major desktop and mobile platforms and has a well-documented API. Leaflet is available at: http://leafletjs.com/index.html

Geographical names: In order give the user feedback on which geographical points they selected we present names fetched from the GeoNames service. The GeoNames geographical database is available for download free of charge under a creative commons attribution license. The data is accessible free of charge through a number of web services and a daily database export. It covers all countries and contains over ten million place names. It service is available at: http://www.geonames.org/

Graph management: For visualization and management of time series we use Plotly. It is built on top of D3.js and stack.gl and is a high-level, declarative charting library. Plotly is available at: https://plot.ly/javascript/

Time player: For variables such as precipitation it is of interest to follow the time extent of the data. For this purpose a time player is included in the Urban SIS portal. It is implemented using a plugin to Leaflet (Leaflet TimeDimension). TimeDimension manages the time component of a layer. It can be shared among different layers and it can be added to a map, and become the default time dimension component for any layer added to the map. TimeDimension is available at: http://apps.socib.es/Leaflet.TimeDimension/

Date management: Is implemented using Moment.js. This package manage parsing, validation, manipulation, and display of dates and times in JavaScript**.** Link https://momentjs.com/

User interactivity: Is implemented using JQuery and mustache.js jQuery is a fast, small, and feature-rich JavaScript library. It provides an API for managing HTML document traversal and manipulation, event handling, animation, and Ajax. JQuery is available at https://jquery.com/

Mustache.js is an implementation of the mustache template system in JavaScript.
Mustache is logic-less template syntax. It can be used for HTML, configuration files, and source code. It works by expanding tags in a template using values provided in a hash or object.
Mustache.js is available at https://github.com/janl/mustache.js

7. Data requirements for Urban SIS data files

In this section we describe the basic data requirements imposed for Urban SIS data.
With few exceptions ECV or impact indicator will be stored as NetCDF files. Basic meta-data will be included in the NetCDF files and represented using the convention CF-1.6. (http://cfconventions.org/Data/cf-conventions/cf-conventions-1.6/build/cf-conventions.html). This defines the most essential information for each dataset. However extensions to these basic conventions have been defined to meet the Urban SIS requirements. An example of the full meta-data definition for one data item is found in Appendix 1. Here we will discuss some of the most important parts of the definition used in our implementation in more detail.

7.1 General information about the dataset

The baseline for provided meta-data is the definitions made when defining the KPIs in deliverable 5.4.1. This definition has been adapted to the NetCDF convention 1.6. One aim has been to make the meta-data coupled with the NetCDF file as condensed as possible. As described above more elaborate information, describing data processing, and validation of data is available on the information pages and will be further updated based on remaining deliveries in the project.

The example below shows an excerpt of meta-data for the general description of precipitation over Stockholm. Note especially the description under source, describing details of the Harmonie setup used to produce the dataset.

```
:Conventions = "CF-1.6" ;
:institute = "Swedish Meteorological and Hydrological Institute (SMHI)" ;
:history = "Created on Thu 20 Apr 17:24  2017" ;
:title = "UrbanSIS: Downscaled historic climate" ;
:source = "{\'Downscaling Model\': \'HARMONIE cy40h1.1\',
            \'Forcing/Boundary conditions\':
                     \'UERRA re-analysis over Europe with HARMONIE (11x11 km2)\',
             \'UrbanCanopyModel\': \'SURFEX 7.3\',
             \'Landuse\': \'ECOCLIMAP II updated with Urban Atlas 2012\',
             \'DownscalingArea\': \'240x240 km, 1x1 km resolution\'}" ;
```

A second example shows the corresponding metadata for the Indicator Hotdays. In this example note in particular the history attribute, giving a description of the processing chain used to compute the indicator.

```
:CDI = "Climate Data Interface version 1.8.0 (http://mpimet.mpg.de/cdi)" ;
:history = "Tue May 23 12:34:12 2017: cdo -L yearsum
         indicators/stockholm_110_historic_hotdayselect.nc
         indicators/stockholm_110_historic_hotdays.nc\nTue May 23 12:34:12 2017:
         cdo -L gtc,291.2 indicators/stockholm_110_historic_airtempavgdaily.nc
         indicators/stockholm_110_historic_hotdayselect.nc\nTue May 23 12:33:44
         2017: cdo -L daymean
         /nobackup/smhid12/sm_chras/UrbanSIS/grib_extractor/stockholm/timeseries/
         stockholm_110_historic_T2M.nc
```

```
          indicators/stockholm_110_historic_airtempavgdaily.nc\nCreated on Mon 10
          Apr 13:36  2017" ;
:source = "{\'Downscaling Model\': \'HARMONIE cy40h1.1\',
            \'Forcing/Boundary conditions\':
                \'UERRA re-analysis over Europe with HARMONIE (11x11 km2)\',
            \'UrbanCanopyModel\': \'SURFEX 7.3\',
            \'Landuse\': \'ECOCLIMAP II updated with Urban Atlas 2012\',
            \'DownscalingArea\': \'240x240 km, 1x1 km resolution\'}" ;
:Conventions = "CF-1.6" ;
:institute = "Swedish Meteorological and Hydrological Institute (SMHI)" ;
:title = "UrbanSIS: Downscaled historic climate" ;
:frequency = "year" ;
:CDO = "Climate Data Operators version 1.8.0 (http://mpimet.mpg.de/cdo)" ;
}
```

The amount of metadata that should be included in the NetCDF data is a proposal based on what was most important for the Urban SIS data. It is easy to extend or exchange parts of the meta-data to adapt to future requirements from Copernicus or the Climate Data Store.

7.2 Technical metadata

The implementation of the Urban SIS data portal makes some further assumptions about meta data, to be able to visualise the files correctly. In particular we require the dataset to use the following parameters as specified:

- The name of the main variable is used to define the legends in the visualisation. This makes it possible to use the same legends for datasets with similar needs, such as temperature and various statistics of temperature and different legends for datasets with different needs.
- The variable must have the attributes long_name and units set, as these appears as information to the user when the dataset is visualised.
- We use the attribute missing_value to specify when there are no values for some parts of the dataset, for instance when the hydrological domain do not cover the full dataset. In most cases this value is also used as _FillValue during creation of the dataset.

An example of how the technical metadata can be specified is given below.

```
float PRECIP(time, y, x) ;
  PRECIP:_FillValue = -999.f ;
  PRECIP:long_name = "15-min precipitation" ;
  PRECIP:units = "mm/15 min" ;
  PRECIP:grid_mapping = "projection" ;
  PRECIP:ModelAttributes = "{\'Downscaling Model\': \'HARMONIE cy40h1.1\',
         \'Forcing/Boundary conditions\': \'UERRA re-analysis over Europe with
         HARMONIE (11x11 km2)\', \'UrbanCanopyModel\': \'SURFEX 7.3\',
         \'Landuse\': \'ECOCLIMAP II updated with Urban Atlas 2012\',
         \'DownscalingArea\': \'240x240 km, 1x1 km resolution\'}" ;
  PRECIP:missing_value = -999.f ;
  PRECIP:valid_min = "-1" ;
  PRECIP:valid_max = "500" ;
  PRECIP:coordinates = "lon lat" ;
```

In the NetCDF files time is defined as seconds since 1970-1-1, as exemplified below. When visualized on the portal times will be shown as the local time, i.e. taking the hourly shift from UTC into account.

```
double time(time) ;
  time:standard_name = "time" ;
  time:long_name = "valid time" ;
  time:bounds = "time_bnds" ;
  time:units = "seconds since 1970-1-1 00:00:00" ;
  time:calendar = "standard" ;
  time:axis = "T" ;
```

7.3 Projections

Based on user requirements the projection is defined for each city, so that all data for the city follows this projection. As many countries and regions have a preferred projection that they usually work with, the projection is chosen based on this preference. The projection is different for the three use case cities in Urban SIS. Moreover, the projections are not the same as is used for the HARMONIE simulations, which means that data will be re-projected before being added to the portal. This will cause minor loss of information, but is considered an important requirement from the end-users.

Below we give an example on how the projection is defined for each of the three cities. For Stockholm we use the national Swedish coordinate system SWEREF99 1800 and for Bologna UTM 32. Both these are using the Transverse Mercator projection. For Amsterdam/Rotterdam the grid is based on a stereographic mapping.

For use f Urban SIS data it is crucial to provide additional information to support the use of the datasets. In particular it is important to provide compatibility with GDAL (Geospatial Data Abstraction Library) and ESRI© ArcGIS when it comes to spatial referencing system. Unfortunately the NetCDF standards are under development and different tools support different formats for describing the projections. Therefore Urban SIS contains the same geospatial information in three ways, the WKT format, supported by many tools including QGIS (parameter *spatial_ref*), the proj4 format required by many other tools (parameter *proj4*), as well as the NetCDF 1.6 convention.

Stockholm:

```
int projection ;
    projection:grid_mapping_name = "transverse_mercator" ;
    projection:proj4 = "+proj=tmerc +lat_0=0 +lon_0=18 +k=1 +x_0=150000 +y_0=0
     +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs" ;
    projection:scale_factor_at_central_meridian = 1. ;
    projection:longitude_of_central_meridian = 18. ;
    projection:latitude_of_projection_origin = 0. ;
    projection:false_easting = 150000. ;
    projection:false_northing = 0. ;
    projection:semi_major_axis = 6378137. ;
    projection:inverse_flattening = 298.257222101 ;
    projection:spatial_ref =
     "PROJCS[\"unnamed\",
             GEOGCS[\"GRS 1980(IUGG,1980)\",
```

```
          DATUM[\"unknown\",
                SPHEROID[\"GRS80\",6378137,298.257222101],
                TOWGS84[0,0,0,0,0,0,0]],
   PRIMEM[\"Greenwich\",0],
   UNIT[\"degree\",0.0174532925199433]],
   PROJECTION[\"Transverse_Mercator\"],
   PARAMETER[\"latitude_of_origin\",0],
   PARAMETER[\"central_meridian\",18],
   PARAMETER[\"scale_factor\",1],
   PARAMETER[\"false_easting\",150000],
   PARAMETER[\"false_northing\",0],
   UNIT[\"Meter\",1]]" ;
```

Bologna:

```
int projection ;
    projection:grid_mapping_name = "transverse_mercator" ;
    projection:proj4 = "+proj=utm +zone=32 +ellps=WGS84 +datum=WGS84 +units=m
                    +no_defs" ;
    projection:scale_factor_at_central_meridian = 0.9996 ;
    projection:longitude_of_central_meridian = 9. ;
    projection:latitude_of_projection_origin = 0. ;
    projection:false_easting = 500000. ;
    projection:false_northing = 0. ;
    projection:semi_major_axis = 6378137. ;
    projection:inverse_flattening = 298.257223563 ;
    projection:spatial_ref =
      "PROJCS[\"UTM Zone 32, Northern Hemisphere\",
               GEOGCS[\"WGS 84\",
                      DATUM[\"WGS_1984\",
                      SPHEROID[\"WGS 84\", 6378137,298.257223563,
                               AUTHORITY[\"EPSG\",\"7030\"]],
                      TOWGS84[0,0,0,0,0,0,0],
                      AUTHORITY[\"EPSG\",\"6326\"]],
                      PRIMEM[\"Greenwich\",0,AUTHORITY[\"EPSG\",\"8901\"]],
                      UNIT[\"degree\",0.0174532925199433,
                           AUTHORITY[\"EPSG\",\"9108\"]],
                      AUTHORITY[\"EPSG\",\"4326\"]],
               PROJECTION[\"Transverse_Mercator\"],
               PARAMETER[\"latitude_of_origin\",0],
               PARAMETER[\"central_meridian\",9],
               PARAMETER[\"scale_factor\",0.9996],
               PARAMETER[\"false_easting\",500000],
               PARAMETER[\"false_northing\",0],
               UNIT[\"Meter\",1]]" ;
```

Rotterdam:

```
int projection ;
    projection:grid_mapping_name = "stereographic" ;
    projection:proj4 = "+proj=sterea +lat_0=52.15616055555555
          +lon_0=5.38763888888889 +k=0.9999079 +x_0=155000 +y_0=463000
          +ellps=bessel +units=m +no_defs" ;
    projection:latitude_of_projection_origin = 52.1561605555556 ;
    projection:longitude_of_projection_origin = 5.38763888888889 ;
    projection:scale_factor_at_projection_origin = 0.9999079 ;
    projection:false_northing = 463000. ;
    projection:spatial_ref =
       "PROJCS[\"unnamed\",
```

```
GEOGCS[\"Bessel 1841\",
DATUM[\"unknown\",
      SPHEROID[\"bessel\",6377397.155,299.1528128]],
PRIMEM[\"Greenwich\",0],
UNIT[\"degree\",0.0174532925199433]],
PROJECTION[\"Oblique_Stereographic\"],
PARAMETER[\"latitude_of_origin\",52.15616055555555],
PARAMETER[\"central_meridian\",5.38763888888889],
PARAMETER[\"scale_factor\",0.9999079],
PARAMETER[\"false_easting\",155000],
PARAMETER[\"false_northing\",463000],UNIT[\"Meter\",1]]" ;
projection:false_easting = 155000L ;
```

7.4 Additional data formats

The climate indicators for intensity, duration and spatial extension of extreme precipitation - Intensity-Duration-Frequency (IDF) curves and Areal Reduction Factors (ARFs) - are calculated as two diagrams for each city. These diagrams are representing the whole geographic area around the city, i.e. there is only one diagram for each Urban SIS domain. Therefore, we have chosen not to represent them as NetCDF, instead we use a simple ASCII representation. On the portal the indicators will be visualized as a graph and the underlying data will be available for download.

8. Notes on the technical development

This section contains some notes on experiences made during the development of Urban SIS that can be useful for other developers using NetCDF and the THREDDS data server.

8.1 NetCDF conventions

We have used NetCDF convention 1.6 for representation of Urban SIS data as far as possible. However, for the local projections used within the project, the NetCDF convention 1.6 does not cover all specifications required. For instance, for the projections used in Bologna and Stockholm convention 1.6 do not allow specifying whether the projection is cylindrical and spherical, whereas THREDDS assumes cylindrical as default causing the data to be wrongly projected. This forced us to define the projection by using the attributes *semi_major_axis* and *inverse_flattening*. For more details, please see the projection specifications in the previous section.

As already mentioned, different tools for handling NetCDF data implements different descriptions of the geographic projection. For this reason we have decided that data from Urban SIS must contain information on the geographic projection described in WKT and proj4 in addition to convention 1.6. This makes it possible to import and visualize the data correctly in several tools.

For the future, we expect this situation to improve. For instance the format WKT is introduced in NetCDF conventions 1.7, which makes it more likely that future versions of tools implement similar metadata descriptions of geography. However, according to the current proposal for convention 1.7, there will be another name of the attribute holding the WKT definition in the NetCDF files. there might be a problem with backward compatibility of data.

8.2 Use of CDO for data processing

As described in deliverables D3.1-D3.3, most of the statistical processing of ECVs and indicators are done using the Climate Data Operators (CDO) which provides statistical processing of NetCDF files. However, the CDO package changes the meta-data information provided with the original file, also for parts that should remain the same, for instance the projection information. Thus, it is important to add the correct meta-data in files produced with the CDO package.

8.3 Adding new data to the portal

The ECVs, indicators and statistically processed variables produced within Urban SIS constitute several hundred NetCDF files. Each of these need to be quality managed all the way from production of the raw data until correct visualisation and download on the portal. To support this process we have designed a process chain so that project members involved in the data production can upload and test produced files on a local version of the portal.

The local server reads data from a dedicated file service. Information on which file on the service that corresponds to a specific menu has been broken out from the actual software and can be specified requiring only limited knowledge of the software on the portal. The same holds for details about how data is visualised, such as legends. New versions can easily be made available to the whole project team via GIT versioning and the Jenkins build server.

When this has been set up, the local version of the portal reads and visualizes the actual NetCDF files that are stored on a dedicated file server accessible to everyone in the project team. Whenever a new version of a data file has been produced, it can immediately be uploaded to this server and tested on the local portal.

This working process has not only speeded up the production of data. It has also made the portal a powerful tool for quality management of data as it is easy to add new datasets.

8.4 Additional formats for download

Currently the portal provides download of data as NetCDF (time series of grids) and as CSV (time series in receptor points). This allows easy export of part of the NeCDF file and of the time series for selected points. In addition, there have been user requests to provide export of single time steps, in particular GeoTIFF has been discussed. THREDDs support a number of additional formats for download, but do currently not support GeoTIFF or any other format suitable for this particular need. It is, however, planned for futures version why we have chosen not include GeoTIFF in the version of the portal delivered within Urban SIS.

9. Remaining work

The implementation of functionality of the portal has been almost completed. The remaining work mainly consists of adding new data and information. In particular we will:

- Revise the final indicators for historical conditions
- During the fall of 2017 add remaining datasets for the climate scenario as soon as they are produced.
- Possibly include smaller additions to the functionality, based on requirements for the climate scenario datasets.
- Update the information pages with results from the validation reports, as these will guide the user in what concerns the validity and uncertainty of the data.
- Elaborate and improve guides and tutorials on how to exploit the Urban SIS portal.
- When the use cases have been finalized, update the information pages describing the four use cases that demonstrate the usefulness of Urban SIS.

The information pages have been set up so that it produces statistics over visitors via Google analytics. Currently the report only covers visitors to the main Urban SIS site and do not include data and document downloads. This will be added when the final Urban SIS data have been uploaded to the portal (end of 2017).

10. Conclusions

This report describes the technical implementation and architecture for providing access, download and visualization of data from the Urban SIS project. The solution implements the main part of the functionality described in D4.4 Visualization of Urban SIS data. An overview of the implemented functionality and the technical solution has been given. Our experience during the development and data creation phases has been that the most time consuming part of the implementation and data production has been to understand the details on how to specify the meta-data in the NetCDF files and how various tools (including THREDDS) use this information. Therefore we have chosen to describe this in more detail in the report.

Presently the web pages are available at http://urbansis.climate.copernicus.eu/ and the portal contains historical data that can be explored, visualized and downloaded. New releases with additional datasets covering a climate scenario will be made during the fall of 2017. The coming releases will also include an update of the meta-data pages to make information of the validity and uncertainty of the datasets that are available in the Urban SIS portal.

Appendix 1: Sample NetCDF metadata for precipitation

```
netcdf bologna_110_historic_PRECIP {
dimensions:
	time = UNLIMITED ; // (175346 currently)
	bnds = 2 ;
	y = 110 ;
	x = 110 ;
variables:
	double time(time) ;
		time:long_name = "valid time" ;
		time:units = "seconds since 1970-1-1" ;
		time:bounds = "time_bnds" ;
		time:calendar = "standard" ;
		time:standard_name = "time" ;
		time:axis = "T" ;
	double time_bnds(time, bnds) ;
		time_bnds:units = "seconds since 1970-1-1" ;
		time_bnds:calendar = "standard" ;
	float x(x) ;
		x:standard_name = "projection_x_coordinate" ;
		x:long_name = "x coordinate of projection" ;
		x:units = "m" ;
		x:axis = "X" ;
		x:_CoordinateAxisType = "GeoX" ;
	float y(y) ;
		y:standard_name = "projection_y_coordinate" ;
		y:long_name = "y coordinate of projection" ;
		y:units = "m" ;
		y:axis = "Y" ;
		y:_CoordinateAxisType = "GeoY" ;
	float lon(y, x) ;
		lon:long_name = "longitude" ;
		lon:units = "degrees_east" ;
		lon:standard_name = "longitude" ;
		lon:_CoordinateAxisType = "Lon" ;
	float lat(y, x) ;
		lat:long_name = "latitude" ;
		lat:units = "degrees_north" ;
		lat:standard_name = "latitude" ;
		lat:_CoordinateAxisType = "Lat" ;
	char projection ;
		projection:grid_mapping_name = "transverse_mercator" ;
```

```
		projection:proj4 = "+proj=utm +zone=32 +ellps=WGS84 +datum=WGS84 +units=m
+no_defs" ;
		projection:scale_factor_at_central_meridian = 0.9996 ;
		projection:longitude_of_central_meridian = 9. ;
		projection:latitude_of_projection_origin = 0. ;
		projection:false_easting = 500000. ;
		projection:false_northing = 0. ;
		projection:semi_major_axis = 6378137. ;
		projection:inverse_flattening = 298.257223563 ;
		projection:spatial_ref = "PROJCS[\"UTM Zone 32, Northern Hemisphere\",GEOGCS[\"WGS
84\",DATUM[\"WGS_1984\",SPHEROID[\"WGS
84\",6378137,298.257223563,AUTHORITY[\"EPSG\",\"7030\"]],TOWGS84[0,0,0,0,0,0,0],AUTHORITY
[\"EPSG\",\"6326\"]],PRIMEM[\"Greenwich\",0,AUTHORITY[\"EPSG\",\"8901\"]],UNIT[\"degree\",0.
0174532925199433,AUTHORITY[\"EPSG\",\"9108\"]],AUTHORITY[\"EPSG\",\"4326\"]],PROJECTION[
\"Transverse_Mercator\"],PARAMETER[\"latitude_of_origin\",0],PARAMETER[\"central_meridian\",
9],PARAMETER[\"scale_factor\",0.9996],PARAMETER[\"false_easting\",500000],PARAMETER[\"fals
e_northing\",0],UNIT[\"Meter\",1]]" ;
	float PRECIP(time, y, x) ;
		PRECIP:_FillValue = -999.f ;
		PRECIP:long_name = "15-min precipitation" ;
		PRECIP:units = "mm/15 min" ;
		PRECIP:grid_mapping = "projection" ;
		PRECIP:ModelAttributes = "{\'Downscaling Model\': \'HARMONIE cy40h1.1\',
\'Forcing/Boundary conditions\': \'UERRA re-analysis over Europe with HARMONIE (11x11 km2)\',
\'UrbanCanopyModel\': \'SURFEX 7.3\', \'Landuse\': \'ECOCLIMAP II updated with Urban Atlas
2012\', \'DownscalingArea\': \'240x240 km, 1x1 km resolution\'}" ;
		PRECIP:missing_value = -999.f ;
		PRECIP:valid_min = "-1" ;
		PRECIP:valid_max = "500" ;
		PRECIP:coordinates = "lon lat" ;

// global attributes:
		:Conventions = "CF-1.6" ;
		:institute = "Swedish Meteorological and Hydrological Institute (SMHI)" ;
		:history = "Created on Thu 20 Apr 17:24  2017" ;
		:title = "UrbanSIS: Downscaled historic climate" ;
		:source = "{\'Downscaling Model\': \'HARMONIE cy40h1.1\', \'Forcing/Boundary
conditions\': \'UERRA re-analysis over Europe with HARMONIE (11x11 km2)\',
\'UrbanCanopyModel\': \'SURFEX 7.3\', \'Landuse\': \'ECOCLIMAP II updated with Urban Atlas
2012\', \'DownscalingArea\': \'240x240 km, 1x1 km resolution\'}" ;
}
```

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