First report on the range of products and services following user requirements

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About this document

Work package in charge: WP1: Identification of User's Needs and Service Design

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1. Abstract /publishable summary

AQ-WATCH will co-develop and co-produce tailored products and services derived from space and in situ observational data. The purpose of these products and services is to help mitigate air pollution and its effect on health. The capabilities of the products and services will be demonstrated in three different populated regions of the world to establish their potential for their on-going widespread adoption beyond the lifetime of the project. The prototype products/services are developed in close dialogue with prime users in the pilot regions, to better identify their specific needs and to establish if the proposed products/services attend their needs. This development by AQ-WATCH partners is based on a "Spiral process". With this process, dynamic interactions between the developers of the prototype products/services and the prime users in the 3 pilot regions of the world will take. The process by which value is added to space and in situ data will be modulated by the input of these users and will involve successive iterations during which feedback reactions will be collected, analysed and included in the new development. This deliverable follows the requirements listed in D5.1. The modules have received two rounds of feedback by the project prime users (D1.1 and D6.1) and have been improved and adapted according to their evaluation. The AQ-WATCH partners have discussed this feedback received from prime users, and this deliverable D1.2 builds on the description of products as highlighted in D5.2.

2. Conclusion & Results

AQ-WATCH is developing a supply chain leading to the generation of seven innovative downstream products and services for improving air quality forecasts and attribution. These products, assembled around five modules, are based on existing observational (space and in situ) and modelling data of air quality and tailored to the identified needs of international users. These innovative products and services are aimed at improving public health and optimizing renewable energy in different regions of the world. This deliverable follows the requirements described in Deliverable 5.1. AQ-WATCH has also developed dynamic interactions between the developers of the prototype products/services and the prime users in three regions of the world. The process by which value is added to observational and modelling data has been modulated by the input of these users and will involve successive iterations during which feedback reactions are collected and analysed and included in the new development.

3. Project objectives

This deliverable contributes directly and indirectly to the achievement of specific objectives indicated in section 1.1 of the Description of the Action:

Specific objectives of the project	**Contribution of this deliverable?**
[1] To design and produce new global and regional air pollution atlases that include the climatological distribution of chemical pollutants complemented by quantities such as the diurnal and seasonal variations, air quality and related health indices, premature mortality exceedance frequency, long-term trends, etc.	Yes
[2] To develop software packages with the capability to provide more accurate daily forecasts of air quality at the regional scale including tailored high-resolution fire smoke and wind-blown dust forecasts; downscaling of air quality forecasts to 2 km resolution in urban areas.	Yes

[3] To develop a source apportionment service to mitigate air pollution and hence increase the life expectancy of the population in different regions of the world, with special focus on the role of agricultural sources of air pollution and the potentially important effects of fracking operations.	Yes
[4] To develop a new tool-box that will be user-friendly and accessible to decision-makers to evaluate the efficiency of proposed mitigation measures in different industrial sectors on the resulting level of air pollutants in three different regions of the world. This will establish the basis for their wider adoption and generalization.	Yes
[5] To co-design, co-produce and co-evaluate for the first time prototype products and services with prime users in three regions of the world chosen for their specific level of economic, social and environmental development.	Yes

This deliverable directly contributes to the achievement of specific objectives indicated in the description of the Work Packages.

Objectives of WP1	**Relevance in this deliverable?**
1.1 Identification of the User's Needs and elaboration of the User Requirement Document	No
1.2 Identification of Improved Products based on Users' feedbacks	Yes
1.3 Identification of the final products for commercialisation consistently with the business model	No

4. Detailed report on the deliverable

4.1. Prototype modules

Together with the three international prime users[1], AQ-WATCH has identified the products and services that would best respond to stakeholder's needs and is working on the potential commercial value of these products and services. The developed modules, consisting of seven downstream applications and information services that will add value to space and in situ observational data, and modelling datasets of air quality, can be categorized as follows:

1. Global and regional climatological information on air quality based on the integration of space and ground-based observations.
2. Information and forecasts for decision-makers to help avoid acute regional air pollution episodes and for individual citizen to enable them to adapt their behaviour to reduce the health impacts of such episodes.
3. Attribution of major pollution sources and the making of policy recommendations for the mitigation of air pollution and its related health effects.

The five modules (containing the seven services) presented here are:

[1] The prime users in AQ-WATCH are: the Colorado Department of Public Health and Environment (CDPHE), in Colorado, USA; the Taoranting Subdistrict Office (TRT) in Beijing, China; and, the Chilean Association of Renewable Energy and Storage (ACERA, in Spanish), in Chile.

Module 1 - Air Quality Global and Regional Atlas - an air quality map of the world which allows the user to understand and research the historical and current pollutants worldwide and in a high resolution in specific areas.

Module 2 - Air quality attribution and mitigation - the purpose of this module is to provide information on the dominant sources of pollution and simulate the impact of potential reduction scenarios.

Module 3 - Dust and fire forecasting - the purpose of this module is to provide information on airborne dust, dust deposition accumulation and solar irradiance forecast products, as well as predictions of the degradation of air quality and reduction in visibility caused by the occurrence of wildfires.

Module 4 - Fracking analysis - the purpose of this module is to provide information on the expected release and dispersion of pollution as a result of emissions from oil and natural gas extraction activities.

Module 5 – Air Quality Forecast: the purpose of this module is to provide the user with 96-hour air quality forecast in the core regions of the AQ-WATCH project: Santiago de Chile, Colorado and the BTH region.

The modules have received feedback by the prime users and their designs have been improved and adapted according to their evaluation. Further dialog and evaluation will improve the conceptual design and usability of the products and services in the future. The AQ-WATCH consortium has also identified the whole supply chain for each of the products, showing which partners are involved in the development part and data production, and which datasets are available and will be used in the delivery of the products. This will facilitate future discussions on the transfer of the products to a reliable and sustainable commercial entity.

An application prototype has been developed. It is divided into five modules which incorporate the seven products. The user will be able to examine all products on the same website by switching between the different module tabs in the top bar shown in Figure 1:

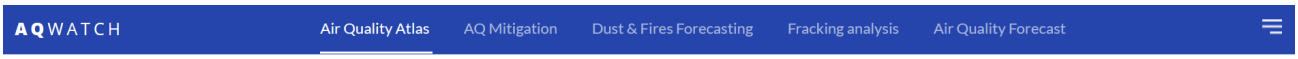

Figure 1 - Module tabs in the top bar of the AQ-WATCH toolkit

4.1.1. Module 1 - The Global and Regional Air Quality Atlases

Module 1 presents the Global and Regional Air Quality Atlases. It allows users to easily understand the air quality and its change over time in different areas in their country or region. This will help policymakers and local authorities to take informed decisions to improve air quality, provide NGOs with necessary information to act, and grant researchers and students easy access to global and regional air quality data. It includes global and regional atlases of individual air pollutants, graphical and numerical information on the regional climatology of air pollutants based on the Copernicus CAMS model global reanalysis and regional reanalyses for three regions, the Contiguous United States (CONUS), Chile and China, as well as satellite information on AOD and NO_2.

This module will have a wide geographical coverage. For the Global Atlas, all countries of the world will be included. For the Regional Atlas, Chile, the CONUS area and China will be available and other regions may be developed afterwards depending on the demand.

4.1.1.1. Module 1 layout

The layout of Module 1 is shown in Figure 2 below.

In the topmost part (A), the user can choose between the Global and the Regional Atlas, select the country and target city or region, the data type and the time frame and resolution. In (B), user can choose between a pre-defined area (country) or select specific data grids. Below, (C) the user can choose between a statistical summary at country level or from a manually selected area. The atlases both consist of a map (C) with zooming capability for each of the pollutants, a time series and statistical analysis tools. In the Global Atlas, air quality maps of the entire world at 80 km grid resolution are shown based on historical Copernicus Atmosphere Monitoring Service (CAMS) reanalysis data, NO2 column integrated data from the satellite-based Ozone Monitoring Instrument (OMI) and aerosol optical depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS).

The Regional Atlas allows the user to understand and research historical and current air pollutants in a specific area. It is based on modelling data from the WRF-Chem and SILAM models, and satellite-based observations of NO2 from OMI and the TROPOspheric Monitoring Instrument (TROPOMI) and AOD from MODIS. Depending on the selection, in (D) a summary (mean, standard deviation and total relative change within the chosen time frame) and in (E) a time series for each pollutant are shown below, averaged either for the selected country or the area selected on the map. For the time series, two pollutants can be chosen to be shown on the graph.

If the Country Data tab was selected above, the last plot (F) sets the selected country in relation to other countries. Countries can be selected on the right side of the plot.

If the Surface Data tab was chosen, grid points can be selected on the map in (C). The Pollutant Summary graph (D) below shows then the overview of all pollutants for the selected area (mean, standard deviation and total relative change within the chosen time frame), the Pollutants Time Series graph (E) shows the absolute levels of each pollutant with time in the selected area.

The data can be exported by clicking on the Export Data button (G) on the bottom of the page.

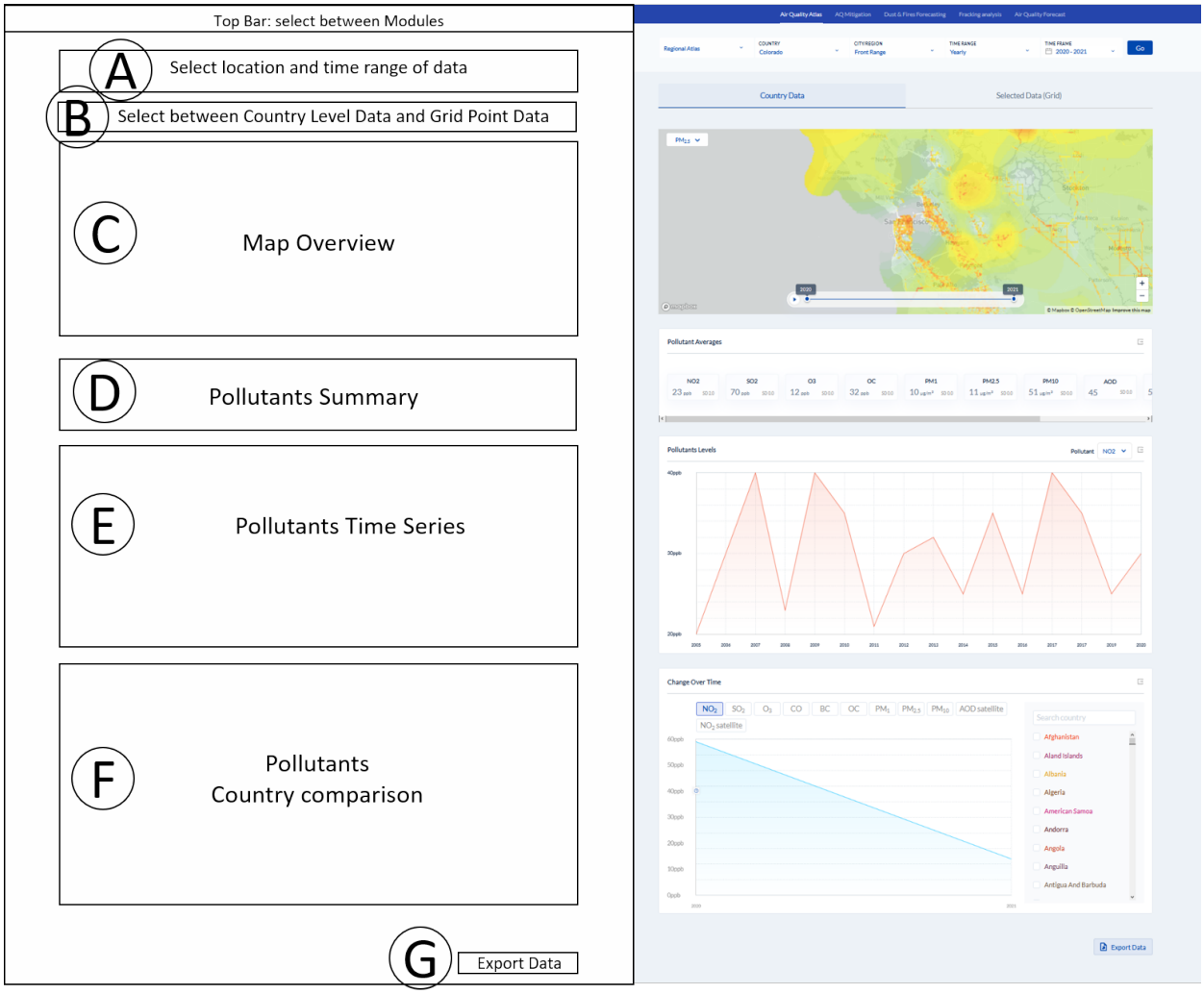

Figure 2 - Layout of Module 1

4.1.1.2. Module 1 supply chain

Figures 3 and 4 show a graphical representation of the supply chains for the Global and Regional Atlases.

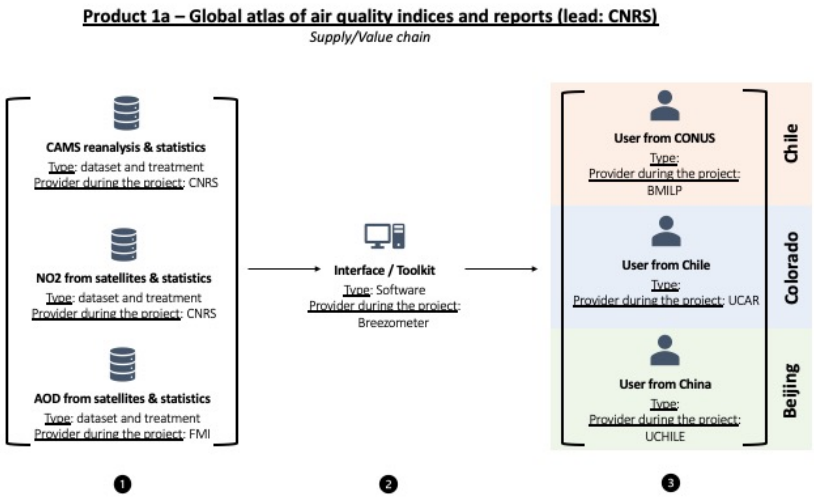

Figure 3 - Graphical representation of the supply chain for the Global Atlas

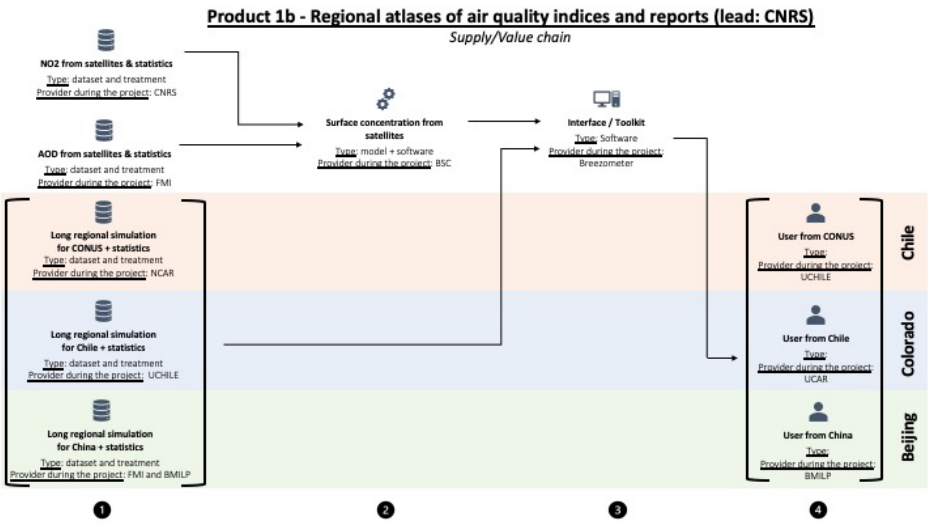

Figure 4 - Graphical representation of the supply chain for the Regional Atlas

4.1.2. Module 2 - Air Quality Mitigation

The purpose of Module 2 is to provide information on various sources of air pollution and simulate potential changes in air quality in response to proposed mitigation strategies. It allows the user to reduce the emissions of one type of pollution source and demonstrates the effect on the pollution levels in the area. Furthermore, it provides attribution information of air pollution in regard to different sectors (e.g. agriculture, traffic, industry) and to different regional origins (e.g. countries or states, local versus transboundary), allowing more informed decisions on an air pollution mitigation strategy.

It includes two products as support for air quality policy: the product #6 providing information on the attribution of emission sources for different regions and economic sectors with emphasis on the role of agricultural emissions, and the product #7 allowing the assessment of the efficiency of alternative actions to mitigate air pollution as well as the development of effective strategy options for air pollution abatement.

4.1.2.1. Module 2 layout

The layout of Module 2 in shown in Figure 5 below.

In the upper most part (A) of the module the user can choose the location (Santiago de Chile, Chile; Colorado, USA; Beijing, China). Below, a map (C) shows the current level for a chosen pollutant or the change over time. On the panel left of the map (B), the user can individually reduce different emission sources (agriculture, traffic, combustion etc.). The resulting pollution levels are then displayed on the map. After that, the user can choose a location on the map and the following graphs below show the results for that location. Directly below the pollutant map, a time series (D) shows the actual concentrations as well as the simulated concentrations if the pollution source is reduced on the panel next to the map. When hovering over the lines in (D), a popup appears summarizing the mitigated pollutant concentrations at a certain moment in time.

The "Country/Region Contribution" panel (E) indicates the contribution by various regions/countries to the concentration level of the selected pollutant at the chosen location:

- Santiago de Chile: PM, NO_2 (+ possibly at a later stage SO_2/ health index): Santiago, Chile, all South American countries separately, Intercontinental (from outside South America)
- Front Range, Colorado: PM, NO_2 (+ possibly at a later stage SO_2/ health index): Colorado, neighbouring states, other US, Canada, Mexico, other
- Front Range, Colorado CO: U.S. anthropogenic sources, U.S. biomass burning, non-U.S. fires, non-US total, CO transported from Asia.

Hereby, the health indices will follow the definition of the respective countries.

The "Sector Contribution" panel (F) shows the source contribution by sector for the chosen pollutant. The contribution of the following sectors will be shown:

- Santiago and Colorado (for PM and NO_2): Agriculture, residential combustion, road traffic, non-road traffic, power plants, industry, mining and extraction, wildfires, marine, dust, boundary
- Front Range Colorado (CO only): Anthropogenic, fires, chemical, boundary, boundary fires
- Beijing (PM, O_3, NO_2): Traffic, Industry, Residential.

The data can be exported by clicking on the Export Data button (G) on the bottom of the page.

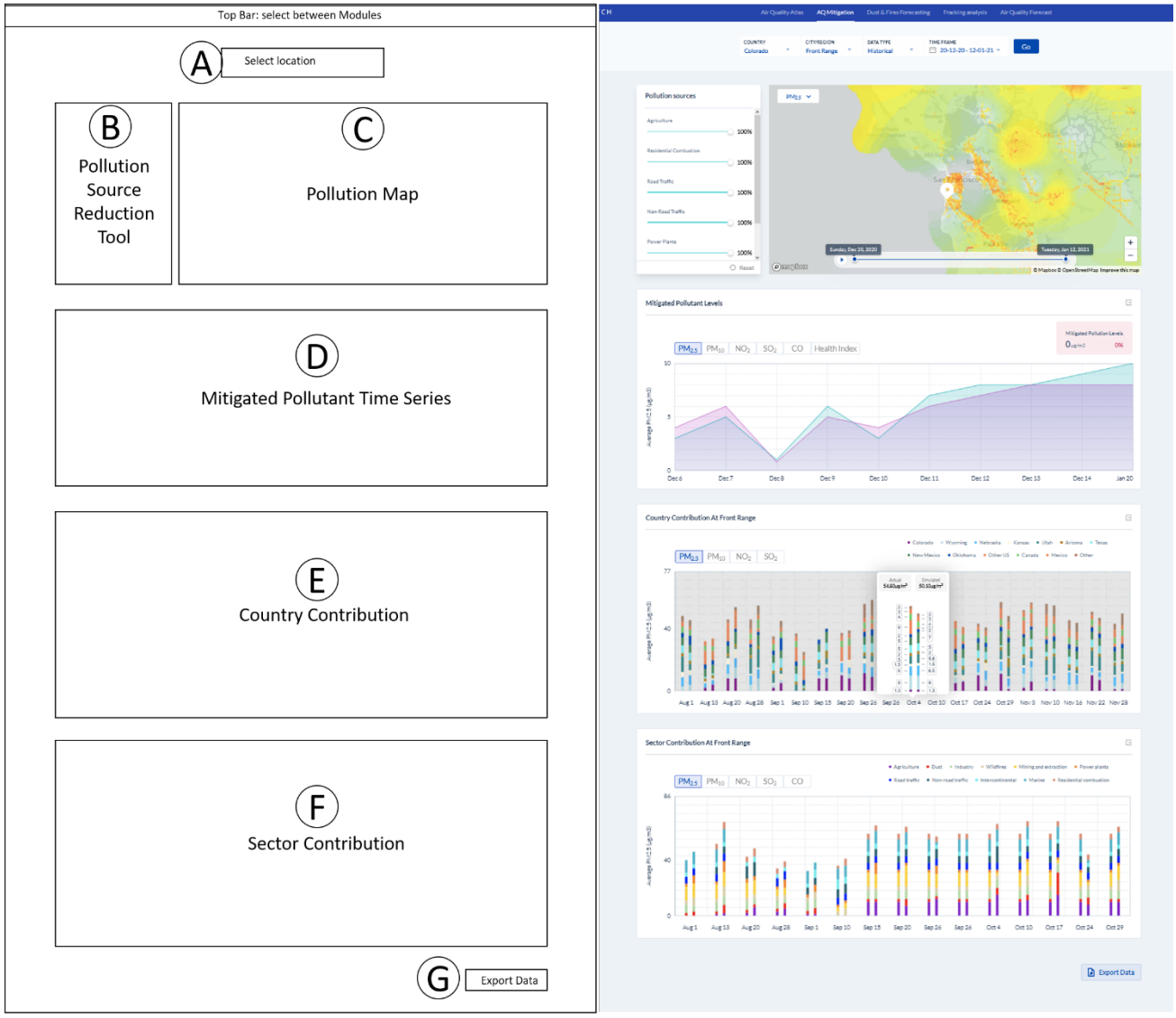

Figure 5 - Layout of Module 2

4.1.2.2. Module 2 supply chain

Figures 6 and 7 show a graphical representation of the supply chains for the products that are part of the AQ mitigation module.

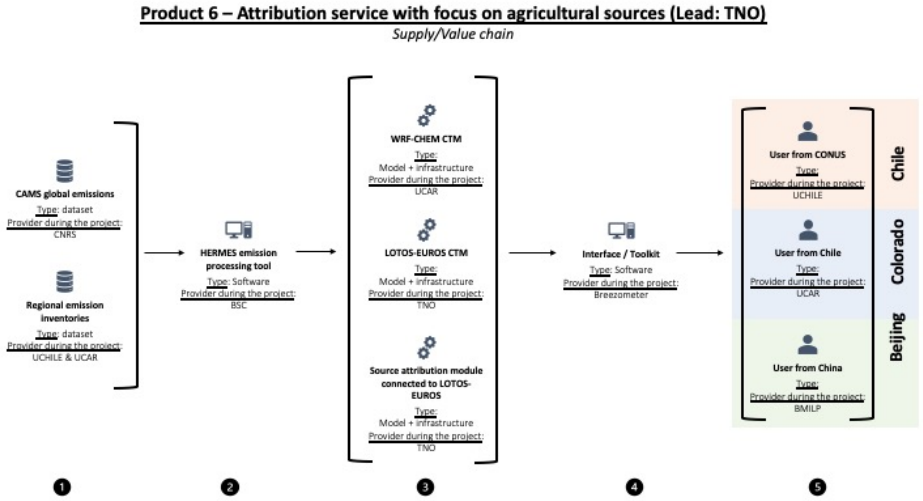

Figure 6 - Graphical representation of the supply chain for the attribution service

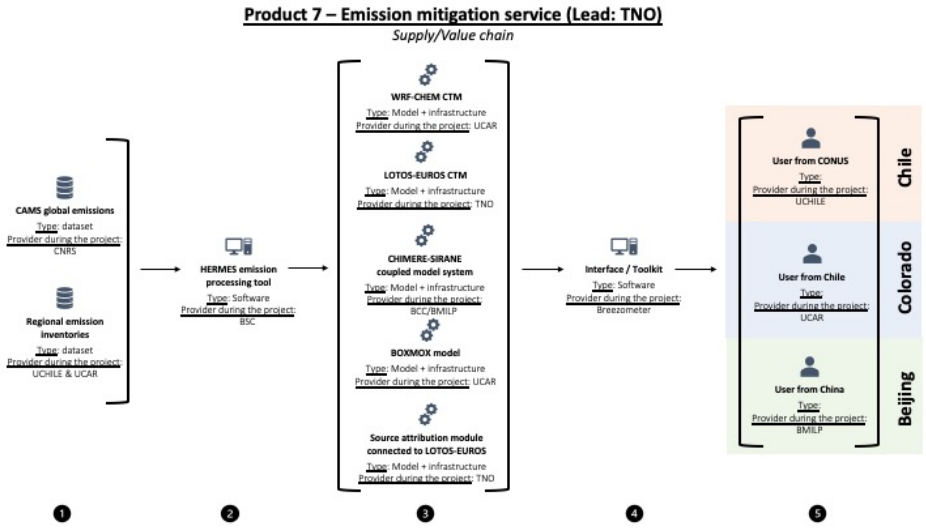

Figure 7 - Graphical representation of the supply chain for the emission mitigation service

4.1.3. Module 3 - Dust & Fire Forecasting

The purpose of this module is to provide information on the occurrence of episodic events such as dust storms and wildfires. This product aims to help air quality and solar energy stakeholders by providing predictions of the degradation of air quality and reduction in visibility caused by dust storms and wildfires.

It includes two products:

4.1.3.1. Dust product

The purpose of this product is to provide information on airborne mineral dust, mineral dust deposition and solar irradiance forecast products. These products are providing added-value information to assist air quality and solar energy stakeholders, for example in planning cleaning and maintenance times of solar panels.

4.1.3.1.1. Module 3 (dust) layout

Figure 8 shows the layout for the dust product of Module 3. The user can select the location and submodule type (i.e., dust or fire product) in (A). This module will be available for three regions in the first phase:

- Chile (78°W – 60°W; 32°S – 17°S)
- Colorado (124°W – 102°W; 25°N – 46°N)
- Beijing, China (72°E – 128°E; 26°N – 52°N

In the upper part of the module a map (B) presents the mineral dust or solar irradiance parameters on a 0.2°x0.2° grid. The map presents one of the following:

Dust products:

- Dust concentration at the surface for different size fractions:
  - Dust $PM_{2.5}$
  - Dust PM_{10}
- Dust surface extinction at 550 nm
- Dust Optical Depth at 550 nm (Dust AOD)
- Wet dust deposition
- Dry dust deposition

Solar Radiation products:

- DNI (Direct Normal Irradiance)
- GHI (Global Horizontal Irradiance)

After the user selects a location on the map, additional graphs are presented below the map: The Dust Forecast Graph (C) presents a time series of 72 hours of forecast on an hourly time resolution and a daily refresh rate for the dust concentrations at the surface ($PM_{2.5}$ and PM_{10}) and the AOD. The Solar Radiation Graph (D) presents a time series of the 72 hours of forecast for DNI (Direct Normal Irradiance) and GHI (Global Horizontal Irradiance).

The data can be exported in (E).

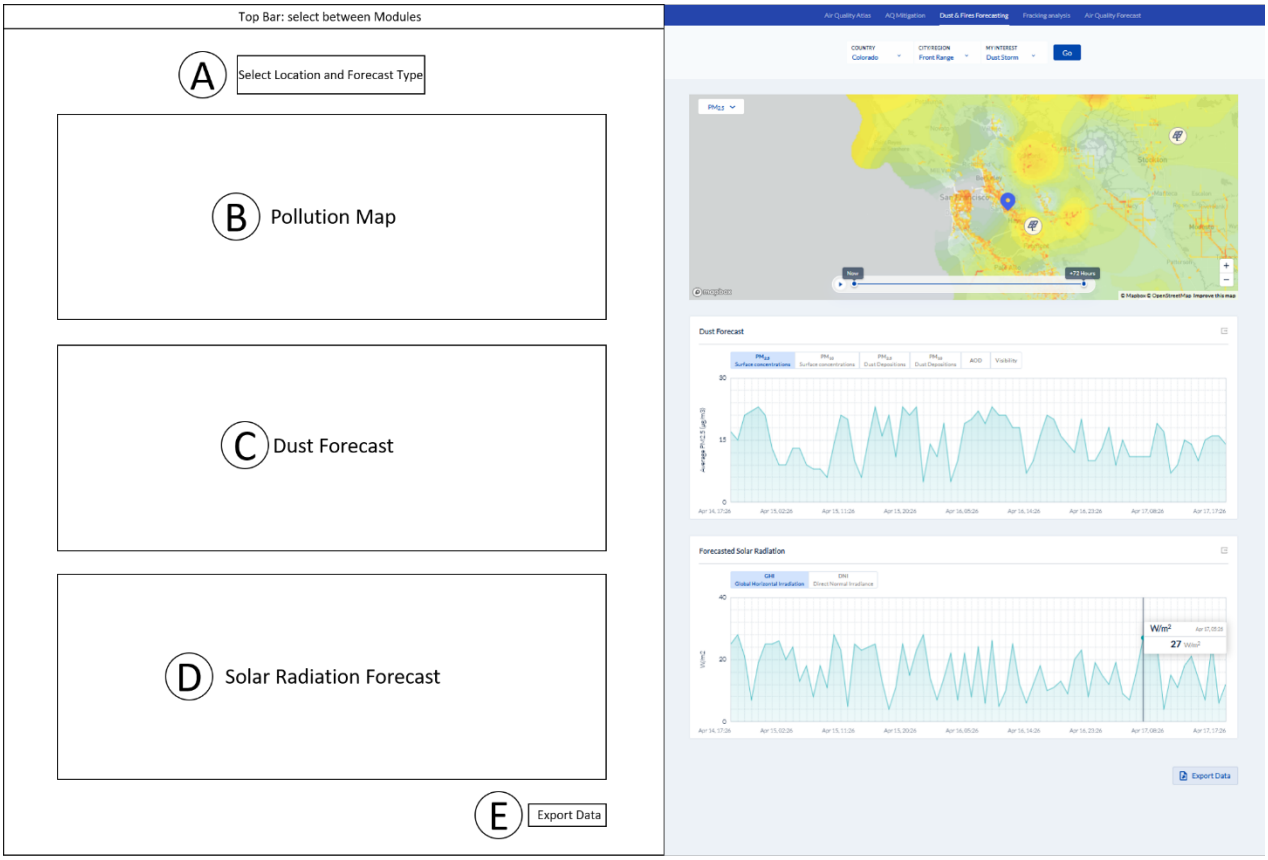

Figure 8 - Layout of Module 3 (dust product)

4.1.3.2. Fire product

The purpose of this product is to provide a forecast of air pollution data related to wildfires. The service will assist stakeholders such as policymakers, local authorities and emergency services by providing prediction of the degradation of air quality and reduction in visibility caused by the occurrence of wildfires and the development of a related regional alert system. The product will be available for Front Range Colorado, Northern Chile and China at the end of the project. Other regions may be developed afterwards depending on the demand.

4.1.3.2.1. Module 3 (fire) layout

The layout of the fire forecast module is presented in Figure 9 below. The user first needs to select the location and the forecast type in (A). At the top of the fire product a map (B) shows the location of fires and the distribution of air pollutants (PM2.5, PM10, AOD) on a grid resolution of 10 km. A time lapse will show forecasted progress of the fire and the pollution dispersion for the next 96 hours. After the user chooses a location on the map a summary of the pollutants is presented in (C). Below the Summary Panel, the "Pollution Forecast" panel (D) shows a time series of either PM2.5, PM10 or AOD. When hovering over the lines a pop-up appears presenting the current pollutant level and the pollutant level forecasted at that moment in time. The data can be exported in (E).

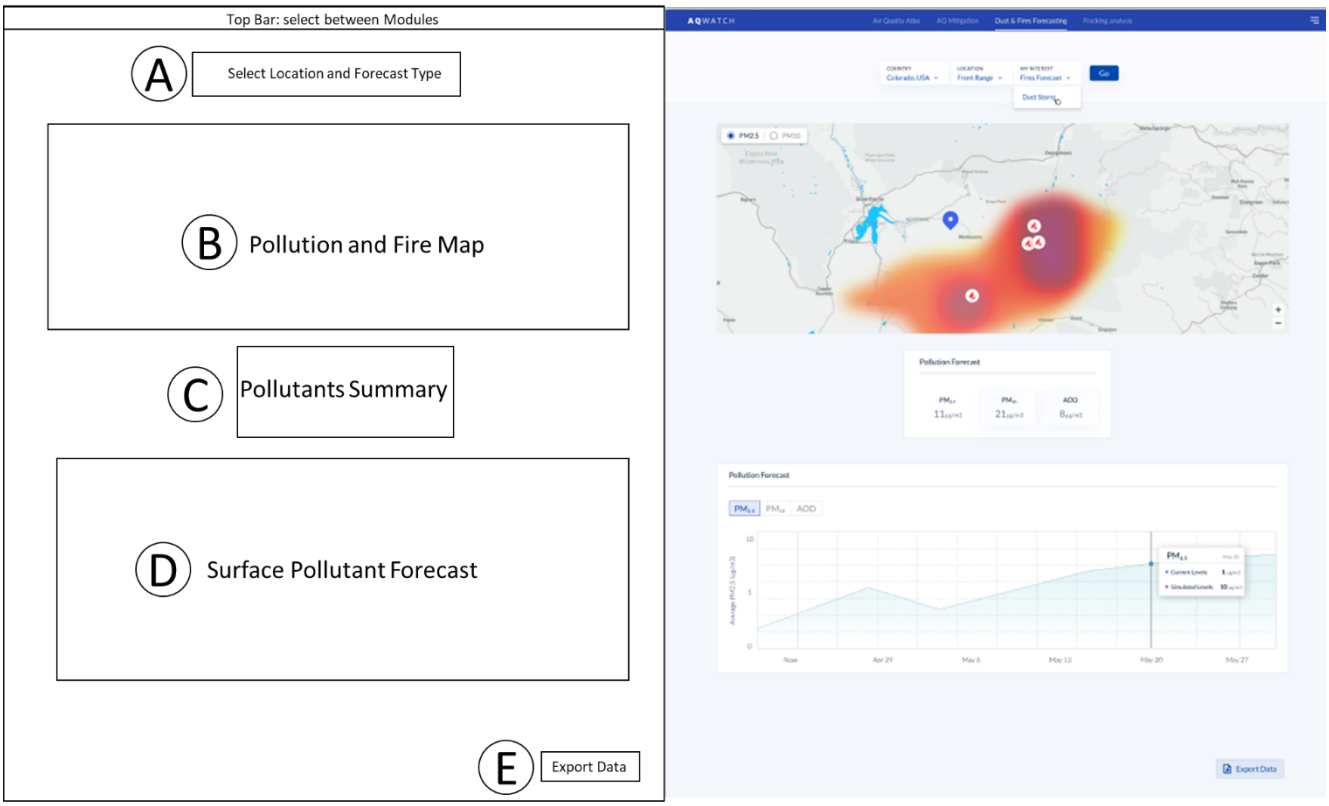

Figure 9 - Layout of Module 3 (fire product)

4.1.3.3. Module 3 supply chain

Figures 10 and 11 show a graphical representation of the supply chains for the products that are part of the dust and fire module.

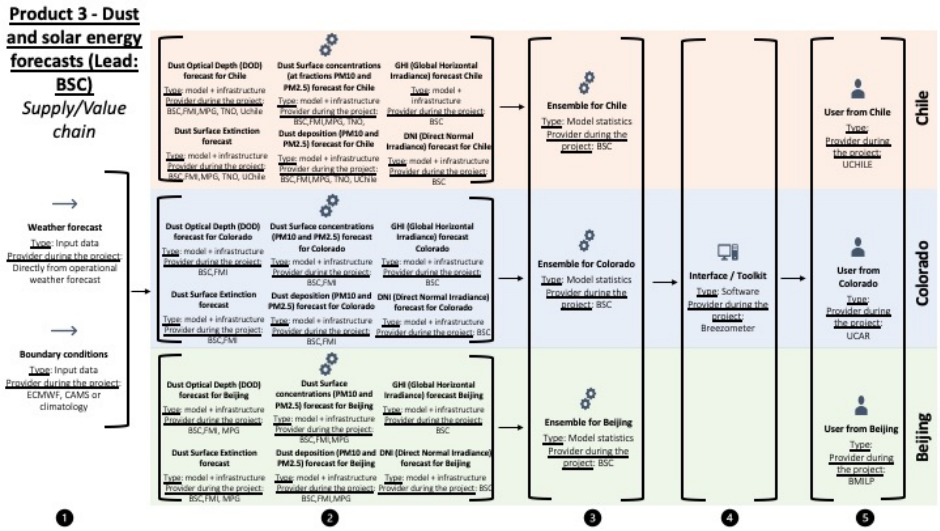

Figure 10 - Graphical representation of the supply chain for the dust product

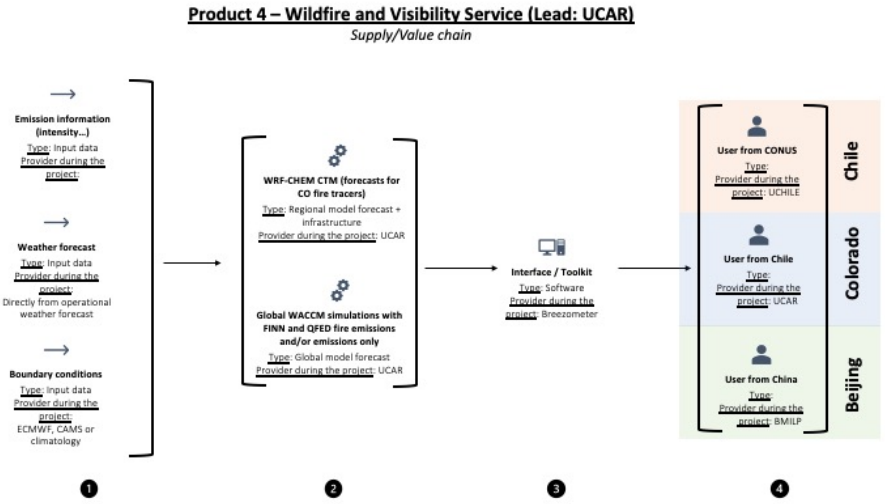

Figure 11 - Graphical representation of the supply chain for the fire product

4.1.4. Module 4 - Fracking analysis

Module 4 is mainly an informative tool on the effects of fracking on air pollution. The purpose of this module is to provide information on the possible impact of fracking activities (or more general oil and gas extraction activities) on the air quality in nearby and distant areas. As opposed to the other modules in the AQ-WATCH system, this module is not real-time and is rather an informational tool. For this module, we are demonstrating the abilities of the tool for a specific region (Front Range, CO, USA) and showing the impact on neighbourhoods near the fracking and related activities and distant to them as well as on sensitive locations (e.g. hospitals, schools). The product provides predictions of the potential impact on regional air quality (e.g., ozone levels) due to fracking and related operations and determination of the exposure of the local population to related emissions of hydrocarbons.

4.1.4.1. Module 4 layout

The layout of Module 4 is shown in Figure 12 below. The location can be chosen in (A). The top part of the module shows a map (B) where fracking activities are indicated and the concentration of several pollutants either with or without the fracking activities are shown as well as the absolute and relative difference between the situation with or without the fracking activities. The grid resolution of the map is 4 km. The user will be able to choose between the following pollutants to be displayed:

- O_3
- Benzene
- Toluene
- NOx
- Ethane
- Propane
- HCHO

Below the map the pollutant levels at the chosen location are shown for the situation with or without fracking activities. The last plot (D) is a time series of each pollutant with and without the impacts of oil and gas

extraction based on the same location that the user chooses on the map. When hovering over the lines, a pop-up shows the pollutant levels with vs. without the fracking activities at the chosen point in time.
The data can be exported in (E).

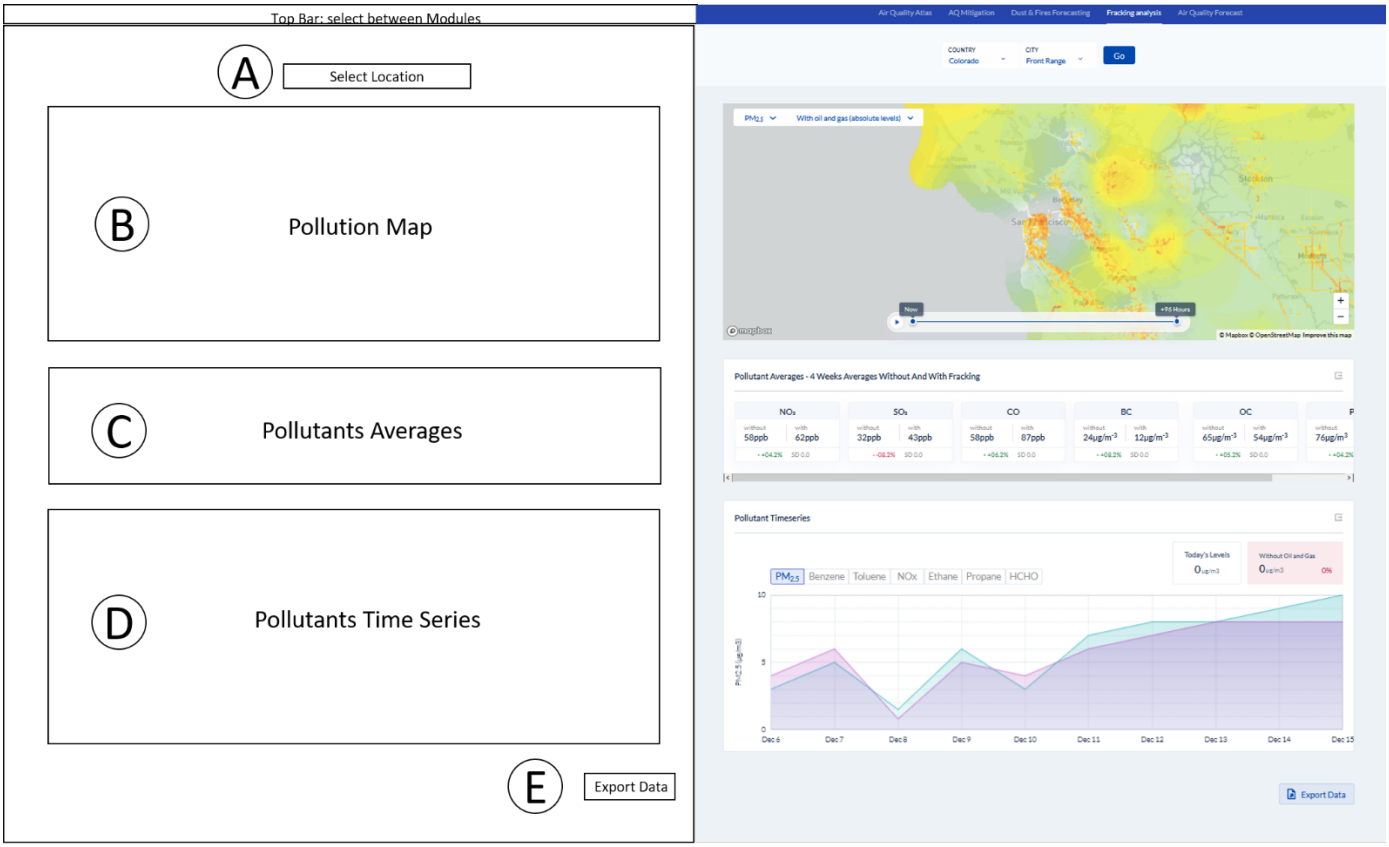

Figure 12 - Layout of Module 4

4.1.4.2. Module 4 supply chain

Figure 13 shows a graphical representation of the supply chain for the product that are part of the fracking analysis module.

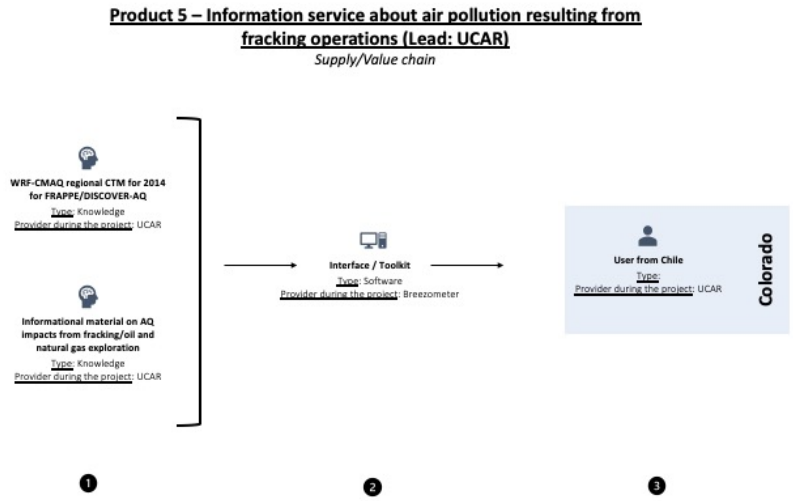

Figure 13 - Graphical representation of the supply chain for the fracking service

4.1.5. Module 5 – Air quality forecasts

Module 5 provides the user with an air quality forecast in the core regions of the AQ-WATCH project: Santiago de Chile, Colorado and Beijing. It consists of an air quality map which allows the users to understand and research the forecasted AQ statistics in a specific area including forecast of air pollution at the regional scale, giving a graphical and numerical representation of the six main air pollutants for the next 96 hours. The forecasts are based on a multi-model ensemble system, with contribution from the following models: SILAM, LOTOS-EUROS, WRF-Chem-MPI, WRF-Chem-UCAR, CHIMERE-Chile, CHIMERE-China. The air quality forecast will allow local authorities and municipalities to better plan countermeasures against air pollution, (e.g. pass emergency regulations such as bans on driving or target certain emitting industries,) or warn their citizens of upcoming air pollution events. Members of the impacted industries such as from the health care sector will have the ability to better prepare for air pollution-related emergency events.

4.1.5.1. Module 5 layout

The layout of Module 5 is shown in Figure 14. In the top bar the user can select the country and cite/region for which an air quality forecast should be shown. Below, a map with a time slider shows the forecast of the six main pollutants for 96 hours ahead. The user can choose a location on the map and the values of the pollutants at that location are shown in the Pollutant Current Level Graph in (C). A time series plot in (D) finally shows the forecasted pollutant levels at the chosen location. Two different pollutants can be plotted on the same graph. The user is able to export the data in (E).

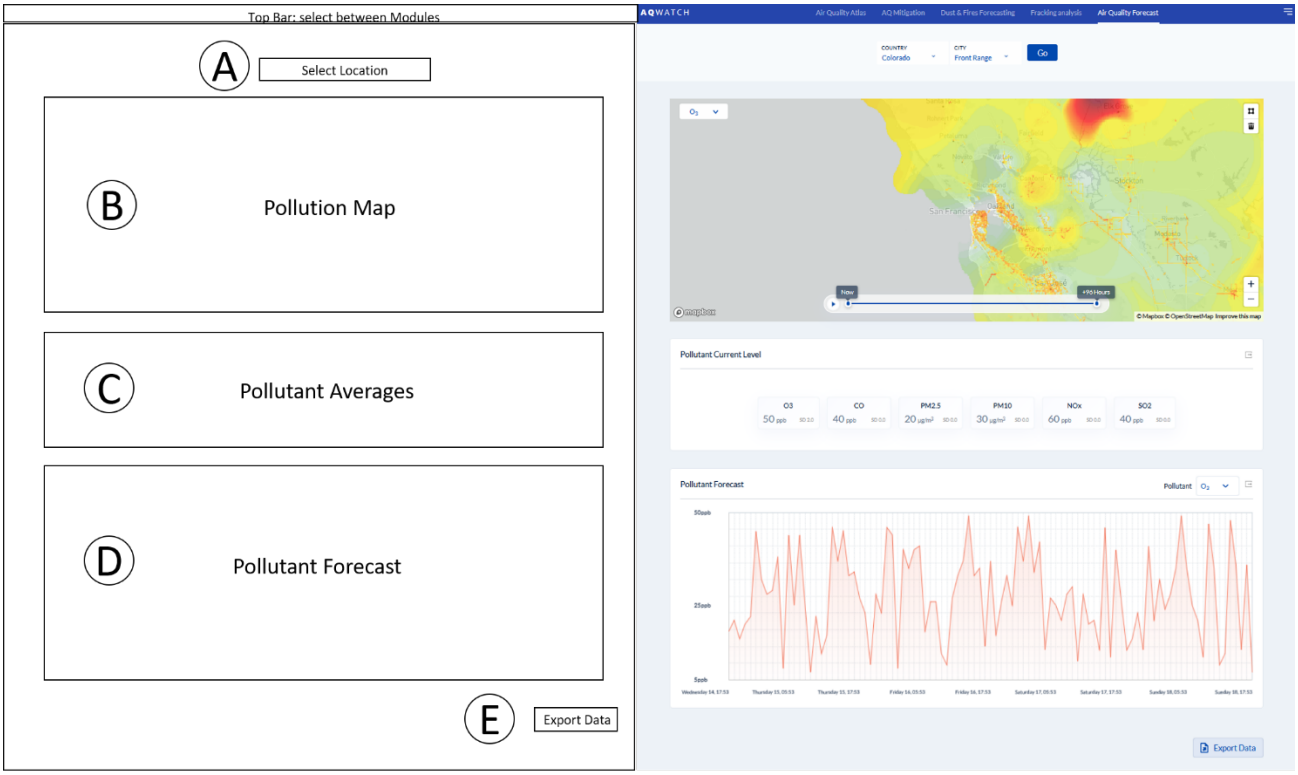

Figure 14 - Layout of Module 5

4.1.5.2. Module 5 supply chain

Figure 15 shows a graphical representation of the supply chain for the product that are part of the air quality forecast module.

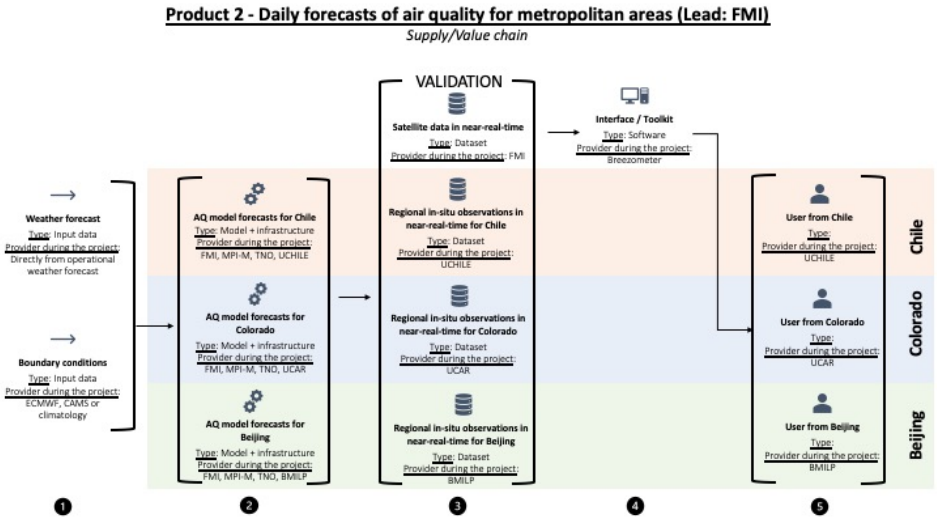

Figure 15 - Graphical representation of the supply chain for the AQ forecasts

5. Dissemination and uptake

5.1. Uptake by the targeted audience

As indicated in the Description of the Action, the audience for this deliverable is

X	The general public (PU)
	The project partners, including the Commission services (PP)
	A group specified by the consortium, including the Commission services (RE)
	This report is confidential, only for members of the consortium, including the Commission services (CO)

5.2. This is how we are going to ensure the uptake of the deliverables by the targeted audience

This deliverable will guide AQ-WATCH partners on the development of the products and will be used for consultation with prime users, as described in the proposal. This deliverable follows the product specification (Deliverable 5.1).

6. Deliverable timeliness

Is the deliverable delayed?

☒ Yes ☐ No

Justification: The second interaction with the prime users was dependent of the full development of the prototype of the toolkit, which was finished in December 2020 (D5.2). Therefore, full feedback from prime users (China, USA and Chile) only took place in the first quarter of 2021. Only after that, it was possible to implement changes that are described in this deliverable. In addition to that, AQ-WATCH wanted to make sure that appropriate internal review took place before submission.

7. Sustainability

Not relevant

8. Full track of dissemination activities

Not relevant

9. Full track of publications and IP

Not relevant