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Contributors

CAMBRIDGE ENVIRONMENTAL RESEARCH CONSULTANTS (CERC) LTD
Amy Stidworthy
Mark Jackson
David Carruthers

SIA ESTONIAN, LATVIAN & LITHUANIAN ENVIRONMENT (ELLE)
Aiga Kāla
Valts Vilnitis
Julija Doktorova

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Introduction

According to the World Health Organisation (WHO), air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. The WHO also estimates that air pollution in both cities and rural areas caused 3 million premature deaths worldwide in 2012. While air pollution levels are normally low across most parts of most modern European cities, it helps people to know when and where air pollution levels are likely to increase; people are then able to ensure they have any necessary medication at hand and prepare their day ahead to minimise their exposure.

The Riga airTEXT service is a street-scale local air quality forecasting service for the Latvian capital city of Riga that has been developed by CERC and ELLE in consultation with stakeholders, the Latvia Ministry of the Environment and Riga City Council. The development phase and two-year market trial phase of the service is being funded by CAMS under the contract CAMS_95e_CERC.

The Riga airTEXT service uses the CAMS regional ensemble air quality forecast product as boundary conditions for street-scale local air pollution modelling and uses CAMS forecasts of UV index and pollen to provide 3-day air pollution, pollen, UV and temperature forecasts for the general public of Riga. The operational service includes the following: a dedicated 'Riga airTEXT' website, translated into English and Latvian; high-resolution maps of overall air quality, NO_2, PM_{10}, $PM_{2.5}$ and ozone, for the region enclosed by the Riga city boundary, expressed using a colour-coded Air Quality Index (AQI) system; air quality alerts for seven Riga districts separately, which are sent directly to subscribers at no cost to them by SMS text and email and broadcast using RSS, Twitter and Facebook; a free smartphone app with colour-coded zone-specific forecasts of air pollution, UV, pollen and temperature range; and finally the 3-day forecasts for each zone are also available an API for integration with third-party websites and services.

This public report marks the end of the development phase of the service and the beginning of the two-year market trial phase. During the coming months CERC and ELLE will be gathering more extensive feedback from existing stakeholders with a view to refining the service further. Regular validation of the operational air quality forecasts against available local monitoring data will be carried out to assess and improve the accuracy of the service. A public launch event is currently being planned for the latter part of February 2018, to which the existing stakeholders, local and national media organizations, health organizations and other interested parties will be invited.

1. What is the Riga airTEXT air quality forecasting service?

1.1 Overview

Riga *air*TEXT is a free service for the public providing air quality alerts by SMS text message and email and 3-day forecasts of air quality, pollen, UV and temperature. Riga *air*TEXT is an independent service, operated by Cambridge Environmental Research Consultants (CERC) Ltd and SIA Estonian, Latvian & Lithuanian Environment (ELLE) in partnership with the Riga City Council and the Latvia Ministry of the Environment and Regional Development.

The central hub of the Riga airTEXT service is the Riga airTEXT website, www.rigaairtext.lv, which is available in Latvian and English. Here, members of the public can see pollution forecast maps for today, tomorrow and the next day, UV, pollen and temperature forecasts for the same period, they can find out if any pollution alerts are in force, they can sign up to receive air pollution alerts by SMS text or email and they can find out information about the service and about how the forecasts are produced.

1.2 Street-scale air pollution forecasts

The Riga airTEXT service provides air pollution forecast maps at street-scale resolution for today, tomorrow and the next day for four major pollutants (NO_2, PM_{10}, $PM_{2.5}$ and O_3) using the recently-published 5-point European Air Quality Index (AQI) scale, with pollution bands from "Good" through to "Very Poor"; information about how the forecasts are produced is given in Section 2.1.The Riga airTEXT website (Figure 1) provides maps of NO_2, PM_{10}, $PM_{2.5}$ and O_3 and an 'overall' pollution map, which is the highest of the four pollutants at every location. The default map view covers all of Riga city, but the user can zoom in to view the air pollution forecast for an individual street. The background map uses the popular Google Maps and includes various interactive functions to improve the user experience, such as options to display notable places and alert zones and a slider to change the transparency of the pollution map. The legend to the right of the map shows the AQI bands; the legend colours change with the map transparency setting so that the map colours always match the legend colours.

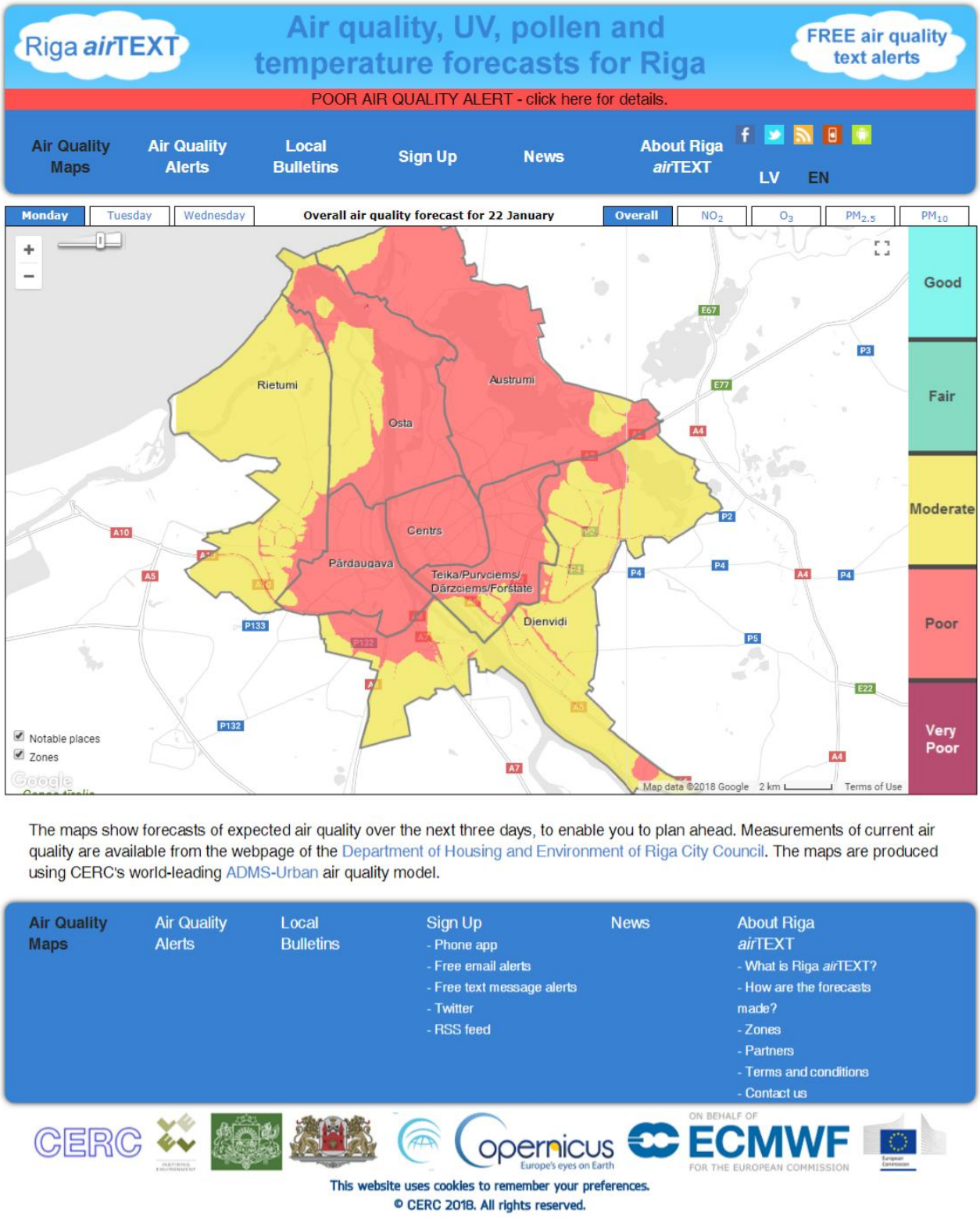

Figure 1 Screenshot of the Riga airTEXT website, showing the text in English.

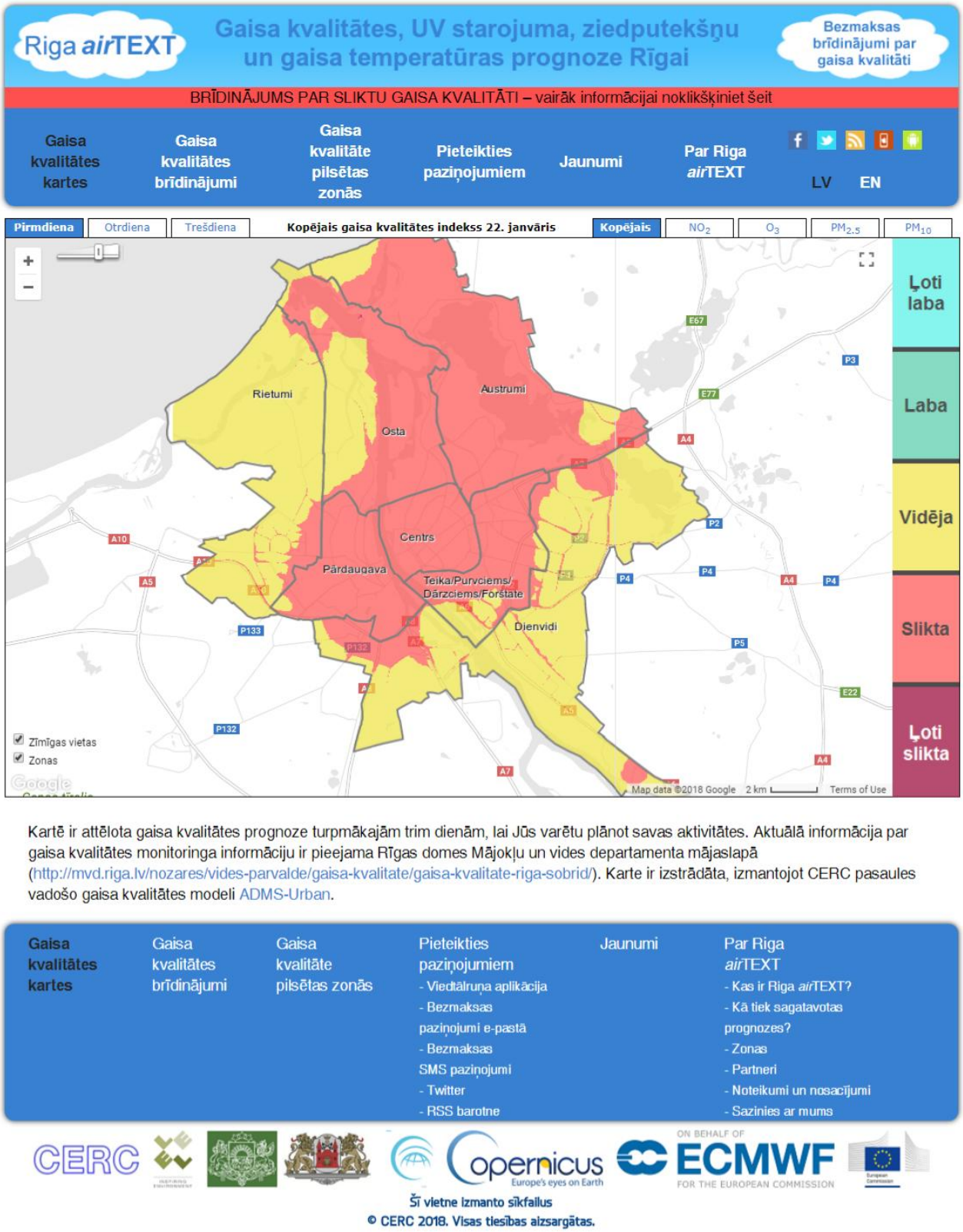

Figure 2 Screenshot of the Riga airTEXT website, showing the text in Latvian.

1.3 Air quality alerts

Riga airTEXT issues air quality alerts when the air quality forecast is 'Poor' or 'Very Poor' according to the Air Quality Index (AQI) scale. The alerts are provided separately for seven alert 'zones'. These zones have been defined in close consultation with local stakeholders to ensure that they represent areas with which members of the public can identify. The air pollution alert status for a particular zone for a particular day is defined by the pollution levels forecast for the most polluted 10% of each zone; for example, if more than 10% of the area within a zone is forecast to have 'Poor' overall air pollution today, but less than 10% of the zone is forecast to have 'Very Poor' overall air pollution today, then the air pollution alert status for that zone for today will be 'Poor'. This reflects the likely experience of members of the public within the city; it means that in city centre zones with a high density of roads, where people have little opportunity to avoid busy roads, air quality alerts are more frequent than in zones with a more sparse distribution of roads; and in zones with fewer busy roads, if the air pollution alert status is raised then this means that air pollution is forecast to be elevated in the quieter areas of the zone as well as near to any busy roads.

The air pollution alerts are disseminated through the Riga airTEXT website and through SMS text and email alerts sent directly to subscribers. The coloured banner across the top of the Riga airTEXT website shows the maximum alert level across all zones across the full 3-day forecast period and the 'Air quality alerts' page provides information about the location and duration of the alert. Each morning, 3-day alert emails in Latvian (Figure 4) are sent to email alert subscribers if the alert status for their zone is 'Poor' or 'Very Poor' on one or more days during the 3-day forecast period. SMS text alerts in Latvian (Figure 3) are sent to subscribers either in the evening or in the morning (according to the subscriber's preference) if the air pollution in the subscriber's zone is forecast to be 'Poor' or 'Very Poor' either the same day (morning alerts) or the following day (evening alerts).

In addition to the air quality alerts, the 3-day air quality forecast for each zone is posted on Twitter and Facebook every morning and every evening. Each alert zone has its own Twitter account (Figure 8). The 3-day forecast for all zones is posted on the Riga airTEXT Facebook page (Figure 7).

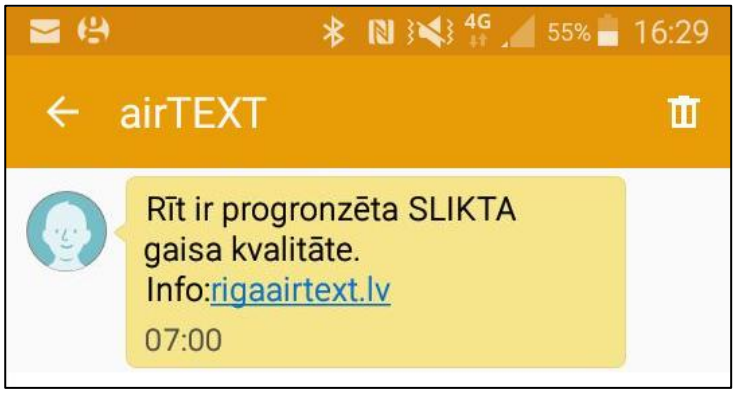

Figure 3 An example of a 'Poor' ('Slikta' in Latvian) air quality SMS alert message (in Latvian).

Slikta gaisa kvalitāte zonā "Osta"

Atvērt šo e-pastu interneta pārlūkprogrammā

Riga airTEXT

Gaisa kvalitātes, UV starojuma, ziedputekšņu un gaisa temperatūras prognoze Rīgai

Sliktākais prognozētais gaisa kvalitātes līmenis no 12.10.2017 līdz 14.10.2017 ir:

Slikta gaisa kvalitāte zonā "Osta"

Brīdinājums sagatavots: 12.10.2017 17:01

Gaisa kvalitātes prognoze trīs turpmākajām dienām zonā "Osta":

ceturtdiena, 12. oktobris	piektdiena, 13. oktobris	sestdiena, 14. oktobris
Slikta	Vidēja	Laba

Uzzināt vairāk par prognozēto gaisa kvalitāti zonā "Osta" var šeit.

Projekta vajadzībām Rīgas pilsēta ir sadalīta 7 zonās. Zonā "Osta" ir iekļautas šādas Rīgas pilsētas apkaimes: Spilve, Voleri, Bolderāja (daļēji), Daugavgrīva (daļēji), Mangaļsala (daļēji), Vecmīlgrāvis, Kundziņsala, Sarkandaugava.

Gaisa kvalitātes prognoze attēlo paredzamos līmeņus nākamajām trīs dienām, lai Jūs varētu plānot uz priekšu. Pašreizējās gaisa kvalitātes mērījumu dati ir pieejami Rīgas pašvaldības Mājokļu un vides departamenta mājaslapā.

RSS Twitter Riga airTEXT mājaslapa

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Vai vēlaties mainīt to, kā saņemat šos brīdinājumus ? Jūs varat mainīt savus izvēlētos iestatījumus vai atteikties no šo brīdinājumu saņemšanas e-pastā.

Figure 4 An example of the type of alert email (in Latvian) that will be sent to subscribers if the air quality forecast is 'Poor' or 'Very Poor' on any of the three days of the forecast for the selected zone.

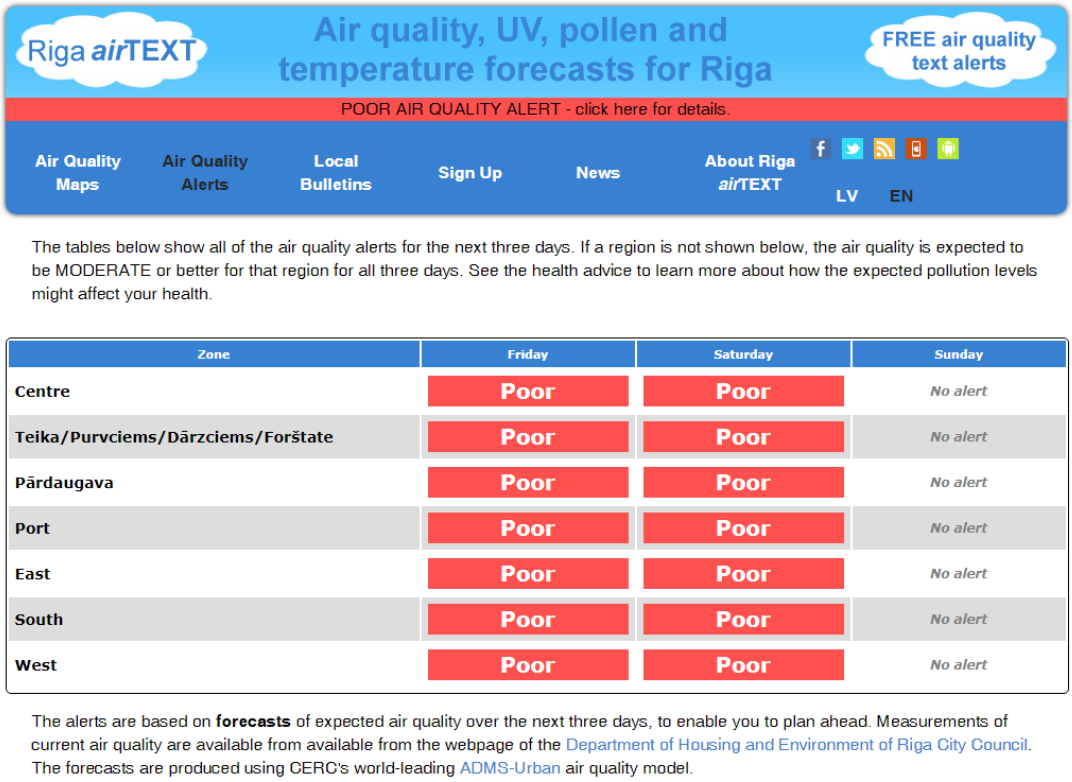


Figure 5 Screenshot of the Riga airTEXT website 'Air Quality Alerts' page, showing text in English.

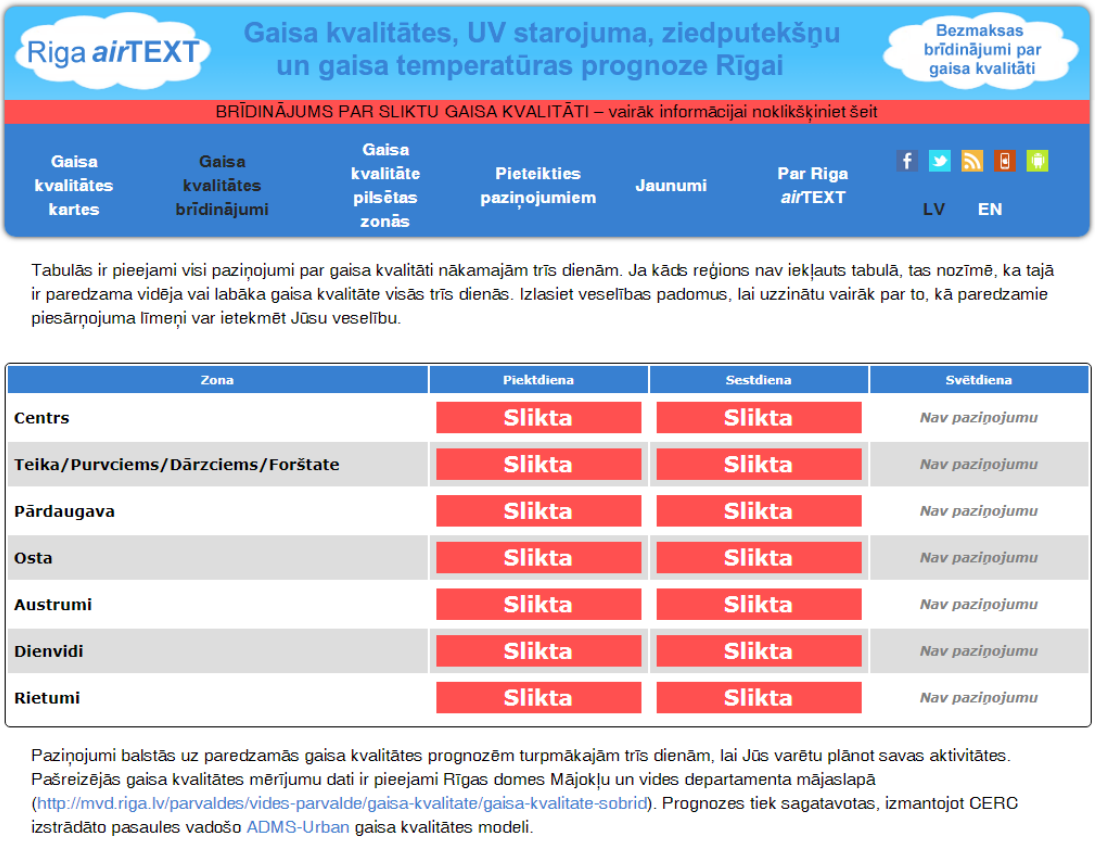


Figure 6 Screenshot of the Riga airTEXT website 'Air Quality Alerts' page, showing text in Latvian.

Figure 7 Screenshot of the Riga airTEXT Facebook page

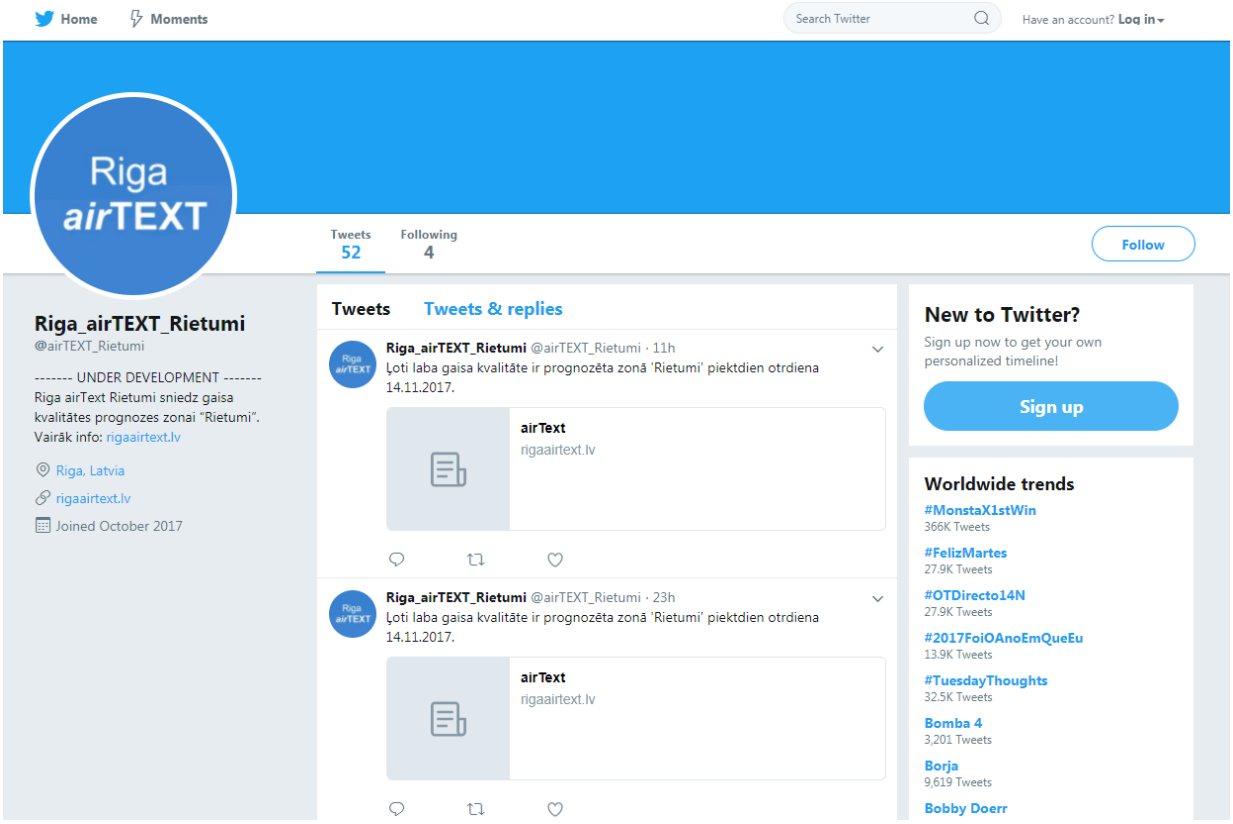


Figure 8 Screenshot of the Riga airTEXT Twitter feed for the 'Rietumi' zone

1.4 Local bulletins

The Riga airTEXT website 'Local Bulletins' page provides 3-day air quality, UV, pollen and temperature forecasts for each of the air quality alert zones (Figure 9, Figure 10).

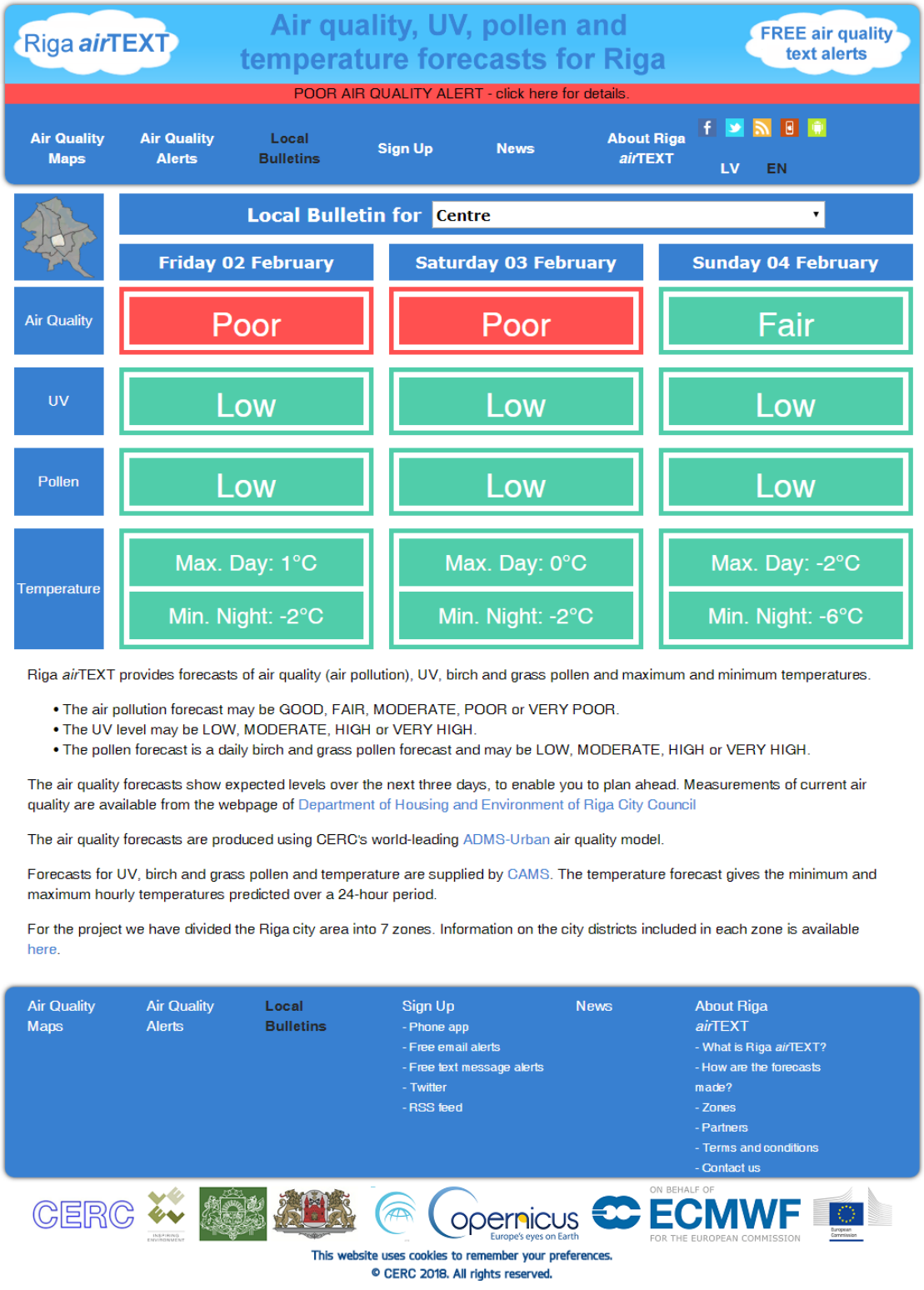
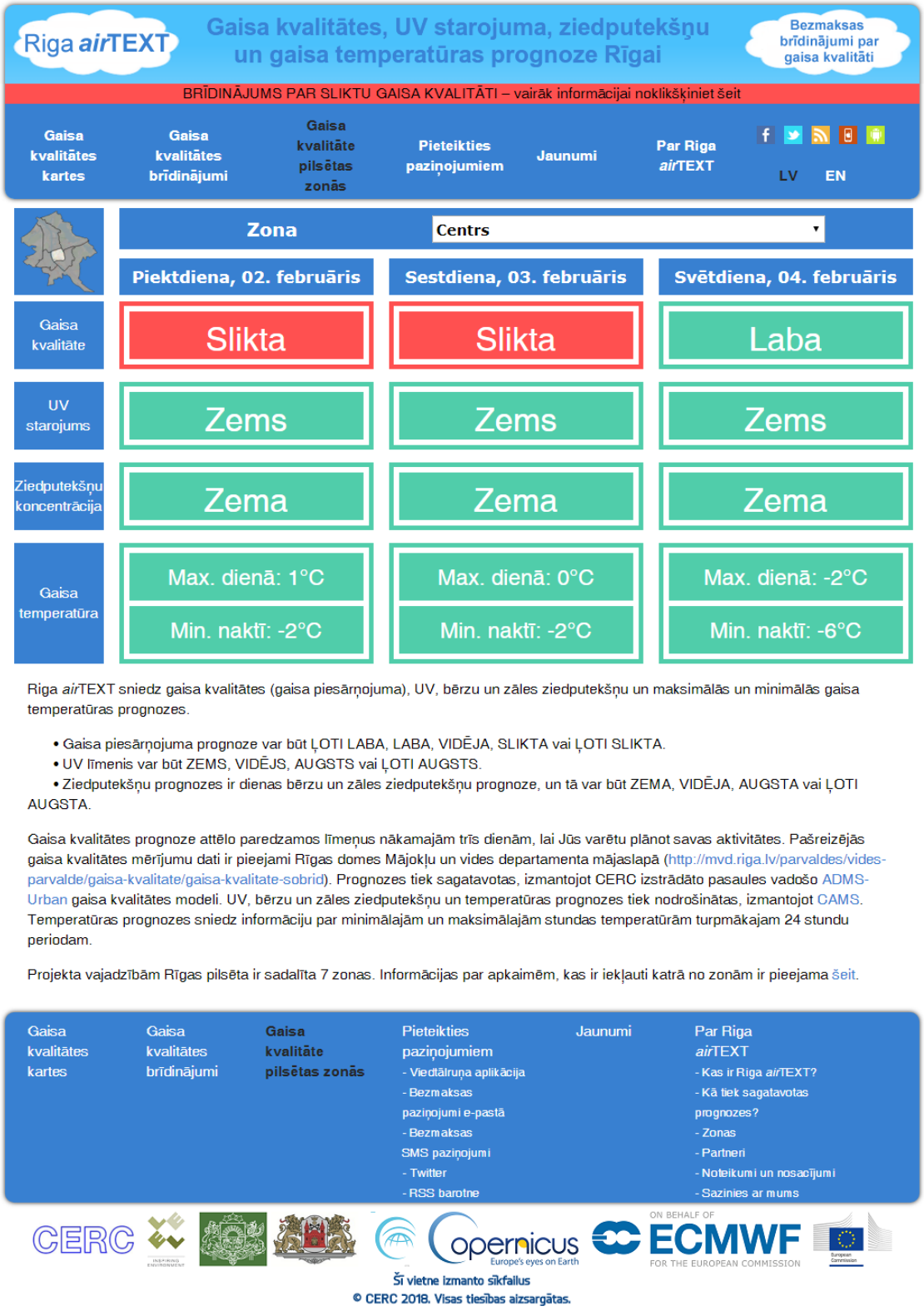


Figure 9 Riga *air*TEXT 'Local Bulletins' page, showing the text in English



Riga *air*TEXT sniedz gaisa kvalitātes (gaisa piesārņojuma), UV, bērzu un zāles ziedputekšņu un maksimālās un minimālās gaisa temperatūras prognozes.

- Gaisa piesārņojuma prognoze var būt ĻOTI LABA, LABA, VIDĒJA, SLIKTA vai ĻOTI SLIKTA.
- UV līmenis var būt ZEMS, VIDĒJS, AUGSTS vai ĻOTI AUGSTS.
- Ziedputekšņu prognozes ir dienas bērzu un zāles ziedputekšņu prognoze, un tā var būt ZEMA, VIDĒJA, AUGSTA vai ĻOTI AUGSTA.

Gaisa kvalitātes prognoze attēlo paredzamos līmeņus nākamajām trīs dienām, lai Jūs varētu plānot savas aktivitātes. Pašreizējās gaisa kvalitātes mērījumu dati ir pieejami Rīgas domes Mājokļu un vides departamenta mājaslapā (http://mvd.riga.lv/parvaldes/vides-parvalde/gaisa-kvalitate/gaisa-kvalitate-sobrid). Prognozes tiek sagatavotas, izmantojot CERC izstrādāto pasaules vadošo ADMS-Urban gaisa kvalitātes modeli. UV, bērzu un zāles ziedputekšņu un temperatūras prognozes tiek nodrošinātas, izmantojot CAMS. Temperatūras prognozes sniedz informāciju par minimālajām un maksimālajām stundas temperatūrām turpmākajam 24 stundu periodam.

Projekta vajadzībām Rīgas pilsēta ir sadalīta 7 zonas. Informācijas par apkaimēm, kas ir iekļauti katrā no zonām ir pieejama šeit.

Figure 10 Riga *air*TEXT 'Local Bulletins' page, showing the text in Latvian

1.5 Phone app

The Riga airTEXT phone app is in Latvian and is available free of charge for iPhone and Android phones on the Apple App Store and the Google Android Play Store. The app provides 3-day forecasts of air quality, UV, pollen and temperature range for each of the Riga city air pollution alert 'zones' (only the air quality forecast varies between zones). The menu at the bottom of the display (Figure 11) allows the user to switch between the 'Home' screen (Sākums) and the 'About' screen (Par projektu). The Sākums page (Figure 12) displays the forecasts for the selected zone. The user can select their zone from the dropdown at the top of the display (Figure 13), or by pressing "Karte" and selecting the required zone from the displayed map of Riga (Figure 14). The user can select the forecast for today, tomorrow or the day after using the tabs below the dropdown (Figure 15).

Figure 11 Riga airTEXT phone app menu

Figure 12 The Riga airTEXT phone app Home (Sākums) screen

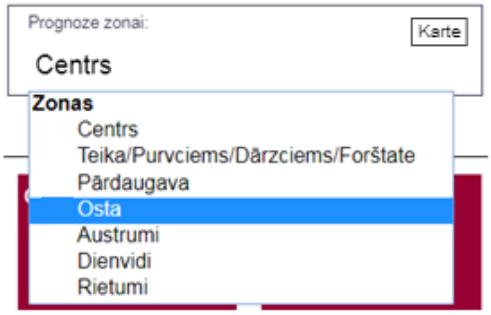


Figure 13 Zone selection drop-down list

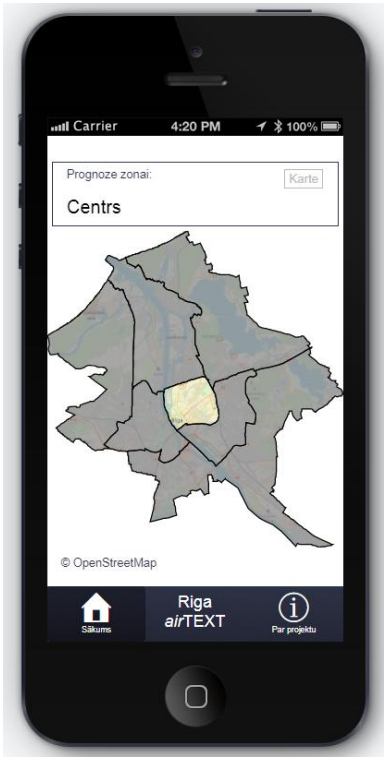


Figure 14 Zone selection map

Figure 15 Forecast day selection

The four coloured squares below the day tabs show the air quality (top left), UV (top right), pollen (bottom left) and temperature (bottom right) forecasts for the selected zone and day. The squares are coloured by the forecast level. The images in Figure 16 show the possible forecasts.

Figure 16 Possible forecasts available from the Riga airTEXT phone app for the selected zone

Tapping on one of the information buttons on the coloured squares displays more information about the forecast (Figure 17). Clicking “Par projektu” gives general information about the forecasts (Figure 19 and Figure 20), including how the service uses CAMS services, and states that CAMS is funding the development phase and 2-year market trial phase of the Riga airTEXT service. The CAMS logo is displayed at the bottom of the about page.

Figure 17 Information seen after tapping one of the blue information buttons

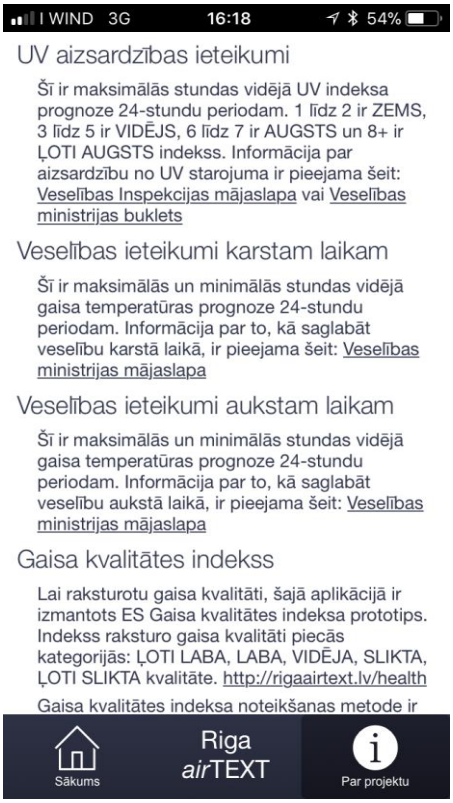


Figure 18 Middle section of the 'About' screen

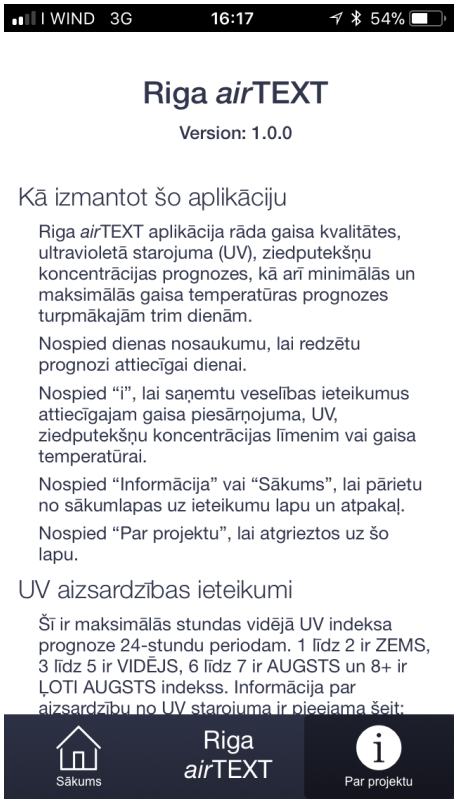


Figure 19 Top section of the 'About' screen

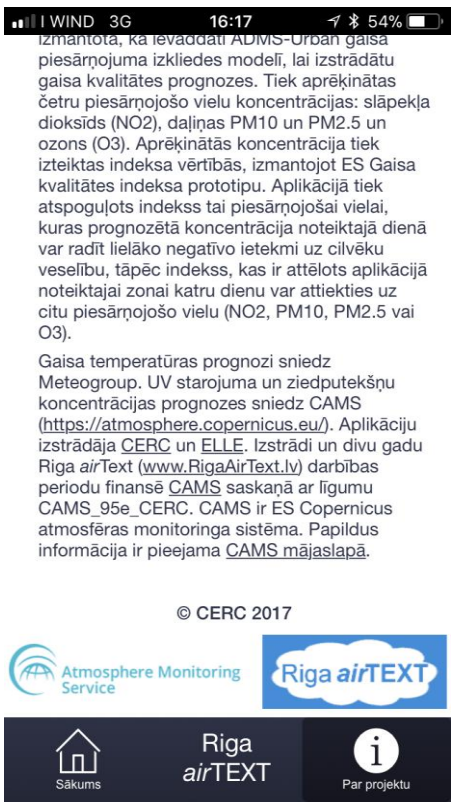


Figure 20 Bottom section of the 'About' screen

2. How are the Riga airTEXT air quality forecasts produced?

2.1 Air pollution

Three-day street-scale forecasts of NO_2, PM_{10}, $PM_{2.5}$ and ozone are produced for Riga City twice a day in CERC's offices in Cambridge, UK, using CERC's ADMS-Urban air pollution dispersion model, an emissions inventory prepared by ELLE for the year 2014, boundary conditions from the CAMS Regional Ensemble air quality forecast product and commercial meteorological forecast data for Riga airport procured from Meteogroup. The implementation uses CERC's existing ADMS-Forecast system (Figure 21).

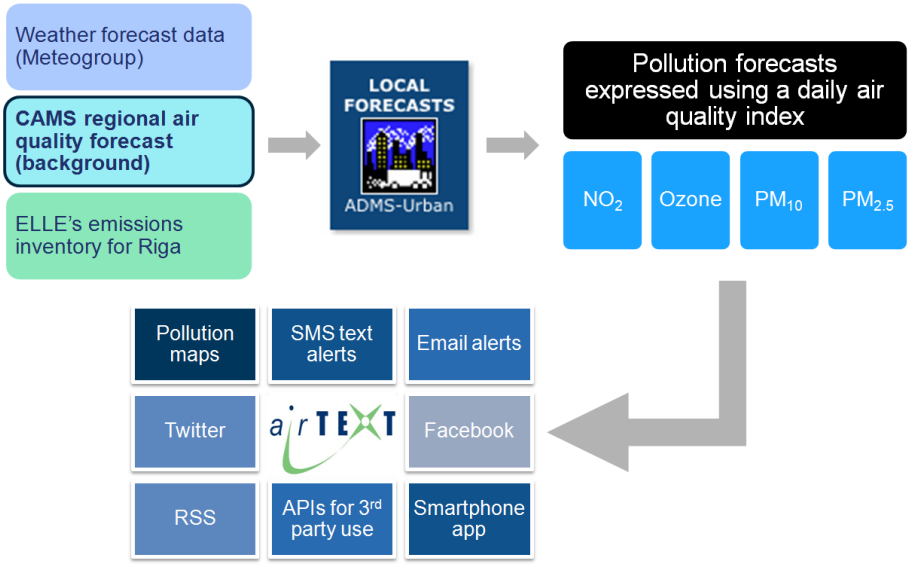


Figure 21 Infographic of the data flow within the Riga airTEXT air quality forecasting service

The local emissions inventory and ADMS-Urban implementation for Riga for NO_2 and PM_{10} was developed and validated by ELLE as part of their work on the 2016-2020 Riga Air Quality Action Plan (AQAP); it was extended during the implementation phase of this application to include $PM_{2.5}$ and ozone and the road traffic part of the emissions inventory was updated from 2014 to 2015. The implementation was further developed to optimise computational efficiency and the key elements of the resulting local emissions inventory implemented in ADMS-Urban for Riga airTEXT are as follows (Figure 22): 2,162 road sources, 269 industrial sources (15 point, 236 area and 18 volume sources) and 550 1-km grid source cells. Emissions from road traffic, shipping, rail, domestic heating and industry are included. Local variations in surface roughness are modelled using the FLOWSTAR model, which is integrated into ADMS-Urban. The effect of the urban environment on local atmospheric stability is accounted for by applying a minimum value of the Monin-Obukov length of 30 m. Hourly concentrations of NO_2, PM_{10}, $PM_{2.5}$ and ozone are calculated at 127,120 receptor points across the city, with a higher density of receptor points close to roads where concentration gradients can be very steep. Street canyons are modelled (Figure 23), as are the photochemical reactions between NO, NO_2 and ozone.

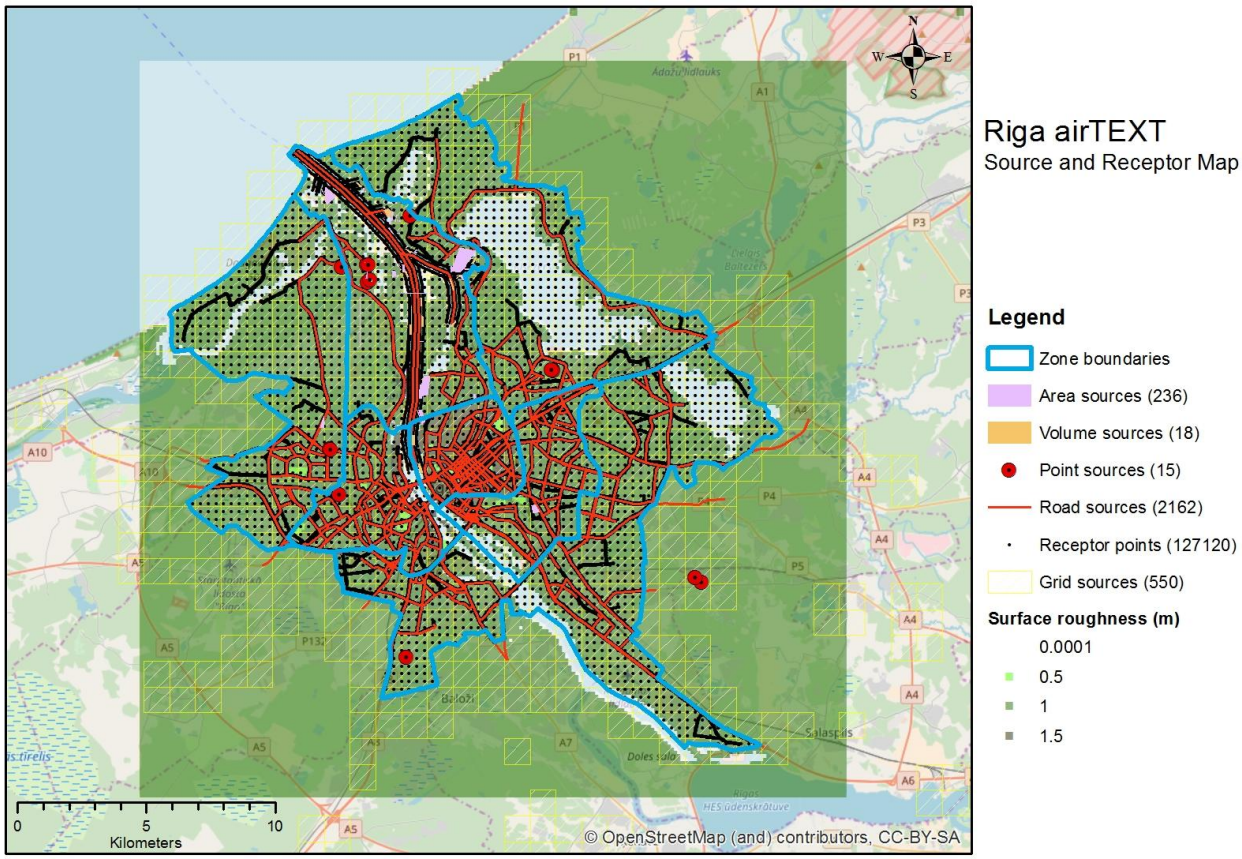


Figure 22 Map of all emissions sources and receptor points included in the local modelling for Riga airTEXT

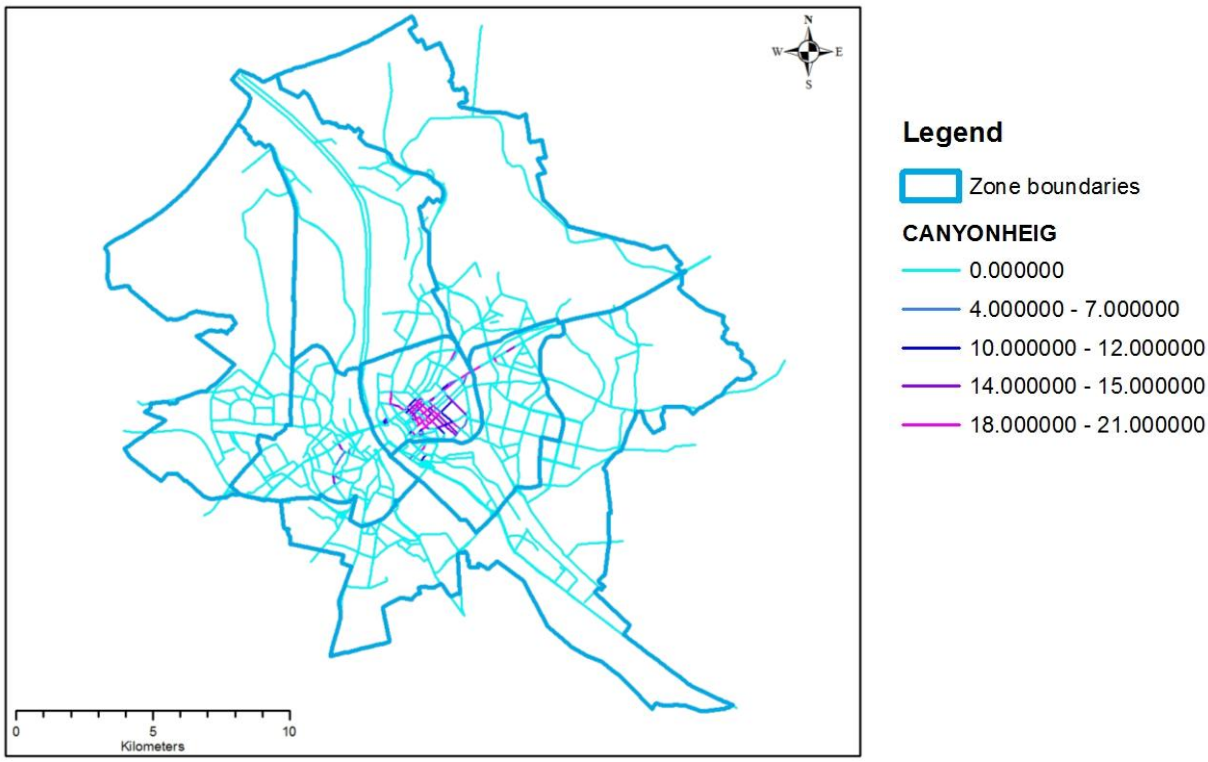


Figure 23 Map of Riga airTEXT explicit road sources; the colour of the road represents the canyon height (m)

The resulting hourly concentrations are converted to a daily air quality index (AQI) using the 5-point scale given in Table 1; maps and alerts are produced from the AQI results as described in Section 1.3.

Table 1 Pollution concentration bands (in units of µg/m^3) for the 5-point Air Quality Index (AQI) scale. The Air Quality Index methodology is published by the European Environment Agency.

Band Descriptor	**Ozone (O_3)**	**Nitrogen Dioxide (NO_2)**	**Particulates < 10µm (PM_{10})**	**Particulates < 2.5µm ($PM_{2.5}$)**
	Maximum 1-hour mean	*Maximum 1-hour mean*	*24-hour mean*	*24-hour mean*
Good	0-80	0-40	0-20	0-10
Fair	81-120	41-100	21-35	11-20
Moderate	121-180	101-200	36-50	21-25
Poor	180-240	201-400	51-100	26-50
Very Poor	>240	>400	>100	>50

The Riga *air*TEXT ADMS-Urban model configuration has been validated using all available local monitoring data for a 12-month period from June 2015 to May 2016. Unfortunately, no ground level NO_2 or O_3 monitoring data were available for central Riga for this period, only PM_{10} and $PM_{2.5}$. Therefore only modeled concentrations of PM_{10} and $PM_{2.5}$ have been validated. The operational model configuration was run with hourly observed meteorological data from Riga airport and hourly background concentrations of PM_{10} and $PM_{2.5}$ for 15km upwind of central Riga, taken from the CAMS Ensemble Reanalysis dataset, which combines regional-scale modelled data, in situ observations and satellite observations to give a 'best guess' picture of pollution levels at 0.1 degree resolution across Europe. Riga *air*TEXT modelled concentrations were compared with measurements from Kronvalda urban background monitoring station in central Riga and the results of the comparison are shown in Table 2. The operational Riga *air*TEXT forecasts will be assessed for accuracy continuously over the coming months by comparing the forecasts with all available surface-level monitoring data in Riga city centre.

Table 2 Model validation statistics for PM_{10} and $PM_{2.5}$ at Kronvalda urban background monitoring site for the period from 1st June 2015 to 31st May 2016.

	Units	**Statistic**	**Mean (obs)**	**Mean (mod)**	**Mean bias**	**NMSE**	**R**	**Fac2**
PM_{10}	µg/m^3	Daily mean	19.8	21.7	1.95	0.20	0.49	0.82
$PM_{2.5}$	µg/m^3	Daily mean	15.9	16.6	0.74	0.23	0.60	0.83

2.2 UV Index

The Riga airTEXT service is the first ADMS-Forecast implementation to incorporate the CAMS global UV index forecast (Figure 24); the implementation extracts the CAMS 'total sky' (cloud-adjusted) UV index forecast for a gridpoint near to the centre of Riga using a WMS GetFeatureInfo request, which returns the 3-hourly forecast data in JSON format.

The Riga airTEXT forecasts of UV are forecasts of maximum 3-hourly cloud-adjusted UV index over a 24-hour period. 1 to 2 is LOW, 3 to 5 is MODERATE, 6 to 7 is HIGH, 8+ is VERY HIGH. The 'UV index' is defined by the WHO.

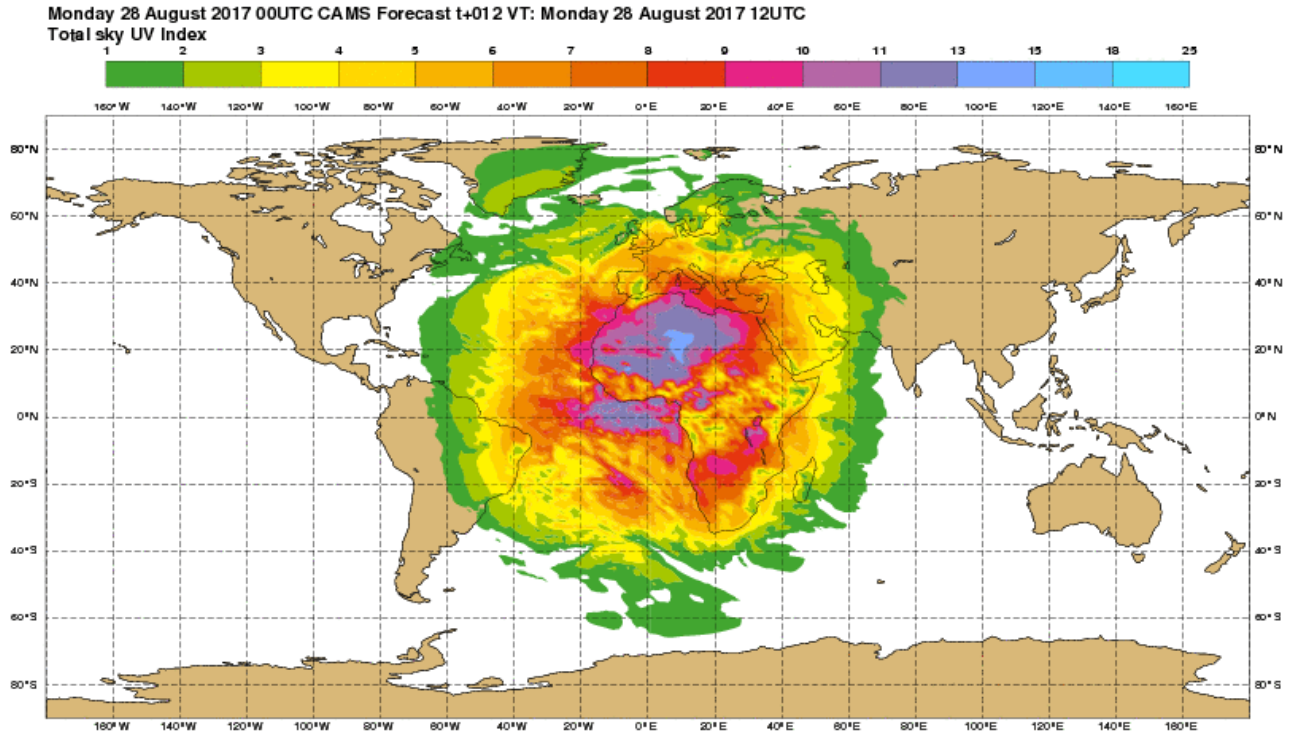


Figure 24 Example of the CAMS global 'total sky' (cloud-adjusted) UV index forecast, for 12:00 on 28/8/2017

2.3 Pollen

The Riga airTEXT service is the first ADMS-Forecast implementation to incorporate the CAMS regional ensemble pollen forecast. CAMS provides pollen forecast data (birch pollen, grass pollen and olive pollen) in the same format as the regional pollution forecast, meaning that the same ADMS-Forecast tools can be used to extract pollen forecast data as are used to extract pollution forecast data; pollen forecast data are extracted from CAMS for gridpoints around Riga and linearly interpolated to provide a forecast for the centre of Riga city. CAMS provides pollen forecast data in units of grains per cubic metre; to communicate the forecast to the public through Riga airTEXT these pollen concentrations are converted to a 4-point index scale from 'Low' through to 'Very

high', using pollen concentration thresholds that are already in use in Latvia[1] (Table 3). This scale is used to convert the CAMS birch and grass pollen count forecasts to text forecasts and the resulting 'pollen' forecast for the public is the highest of the birch and grass pollen text forecasts. CAMS provides pollen forecasts during the pollen season only, which is defined as from 1st March to 30th June for birch pollen and from 1st March to 31st August for grass pollen. Therefore the Riga airTEXT pollen forecasts outside of the pollen season will always be 'Low'. CAMS olive pollen forecasts are not used by the Riga airTEXT service, since levels in Riga are always very low; olive pollen is found predominantly in Mediterranean areas.

Table 3 Birch and grass pollen season dates and forecast bands, in terms of pollen grains per cubic metre

	Season	Low	Moderate	High	Very High
Birch pollen	1st March – 30th June	1 – 10	11 – 100	101 – 1000	≥1001
Grass pollen	1st March – 31st August	1 – 10	11 – 30	31 – 100	≥101

2.4 Temperature

Riga *air*TEXT provides forecasts of minimum and maximum surface air temperature for each day in the 3-day forecast period. This forecast is derived from the hourly meteorological forecast data for Riga airport obtained from Meteogroup that are used as input to the ADMS-Forecast system. The temperature display is colour coded for very cold (minimum night-time temperature is -33°C or below) to very hot (maximum day-time temperature is 33°C or above).

[1] CERC and ELLE are very grateful to Olga Ritenberga, an aerobiologist from the Faculty of Geography and Earth Sciences at the University of Latvia, for providing these pollen concentration thresholds.

3. Who are the developers and stakeholders in the Riga airTEXT air quality forecasting service?

3.1 Overview

The Riga *air*TEXT air quality forecasting service has been developed by Cambridge Environmental Research Consultants (CERC) Ltd in partnership with SIA Estonian, Lithuanian and Latvian Environment (ELLE).

3.2 CERC

Since the 1990s CERC (www.cerc.co.uk) has been licensing, marketing and providing user support for its environmental software. The different versions of CERC software, the Atmospheric Dispersion Modelling System (ADMS), have many hundreds of current users worldwide and the company has a customer base of over a thousand. Many of these users have been provided with helpdesk support and training or have attended regular user group meetings. CERC also offers a comprehensive consultancy service in environmental modelling and interacts strongly with universities and research institutes on a diverse range of research projects.

CERC has conducted high resolution air quality forecasting since 2000; activities have included *air*TEXT (first launched in London in 2008) and participation in ESA's PROMOTE project and in MACC, MACCII, MACCIII and CAMS (end user interaction). In addition to London CERC's ADMS-Forecast air quality forecasting system is currently operational for Budapest (Hungary), Barcelona (Spain), and Beijing (China). Previous forecasting clients have included Vienna in Austria, and the following UK locations: Wakefield, Liverpool, Sheffield and York. CERC's French partner Numtech provides air quality forecasts using ADMS-Urban for about twenty French cities, in addition to Dubai and Casablanca.

3.3 ELLE

SIA Estonian, Latvian and Lithuanian Environment (ELLE, www.environment.lv) is an international environmental consultancy company with offices in Riga in Latvia, Tallinn in Estonia and Vilnius in Lithuania. CERC and ELLE have had a close relationship since 2002. In partnership with CERC, ELLE recently completed an ADMS-Urban modelling study for the 2016-2020 Riga Air Quality Action Plan (AQAP) on behalf of the City of Riga. The emissions inventory for Riga developed by ELLE during that project formed the basis of the local air quality modelling component of the Riga airTEXT system.

3.4 Stakeholders

During the six-month design and development phase for the Riga *air*TEXT service (April – September 2017), CERC and ELLE have worked closely with local stakeholders Riga City Council and the Latvian Ministry of Environment to ensure that the service meets the needs of its users. Over the coming months, CERC and ELLE will continue this fruitful collaboration with the stakeholders to promote the service and encourage members of the public to subscribe for alerts.

Copernicus Atmosphere Monitoring Service

ECMWF - Shinfield Park, Reading RG2 9AX, UK

Contact: info@copernicus-atmosphere.eu