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Prototype of city environmental monitoring system based on geoportal technologies

A A Kadochnikov[1,2]**, A V Tokarev**[1,2]**, V V Zavoruev**[2,3] **and O E Yakubailik**[1,2,3]

[1] Federal Research Center Krasnoyarsk Science Center of the SB RAS, Krasnoyarsk, Russia
[2] Institute of Computational Modeling SB RAS, Krasnoyarsk, Russia
[3] Siberian Federal University, Krasnoyarsk, Russia

E-mail: scorant@icm.krasn.ru

Abstract. The development of a real-time environmental monitoring system based on the integration of data from various sources is considered. To create this system, a geoportal technology platform is used to collect, process and present data from various observations. During the implementation of the development, the data transmission from a number of sources with information on air pollution and meteorological data was configured. The system operates in pilot operation mode in Krasnoyarsk. The generated spatial database contains the specified information on all available measurement points for the last few years. Geoportal map services and web applications provide interactive visualization of data in the form of tables, graphs and thematic maps in standard web browser. Source data can also be loaded for analysis in spreadsheet software such as Microsoft Excel or displayed in GIS packages through standard Open Geospatial Consortium map services.

1. Introduction

Monitoring the state of environmental pollution is an important basis for environmental engineering. Environmental and air monitoring systems in particular are being created and implemented in many cities of the world both abroad and in Russia [1, 2]. In Krasnoyarsk a number of organizations of federal and regional levels monitors the state of air pollution on the basis of their own methods and technologies of data processing. The variety of solutions used, interdepartmental and organizational disunity lead to the fact that a comprehensive analysis and rapid assessment of the entire array of recorded information is currently technically difficult and practically not carried out. The data collected are often published late and are not widely understood.

The use of international standards would greatly facilitate the collection and analysis of observations from different sources. Currently, monitoring systems are being implemented in different countries of the world, based on a network of sensors distributed throughout the territory [3, 4]. However, today the situation in Krasnoyarsk and Russia as a whole is far from ideal. In most cases, access to operational observations is limited and there are no specialized tools for obtaining such data.

It should be noted that today the regional authorities, together with Federal services, are trying to create a unified system for monitoring air quality. An example is the "Unified information system of monitoring of pollution of atmospheric air of Krasnoyarsk" (http://www.feerc.ru/uisem/krasnoyarsk/).

However, using such a system it is impossible to analyze operational data, because the system provides only average daily data for the air pollution.

2. Research methods and tools

Sensor Web Enablement (SWE) from the Open Geospatial Consortium (OGC) has long been of particular importance due to its maturity and broad support from scientists and industry. SWE is committed to providing open standards and protocols to improve communication between different platforms and data providers. This initiative aims to facilitate search, improve accessibility and provide real-time monitoring of various sensors via the Internet [5–7]. SWE consists of seven standards: sensor model language (SensorML), observations & measurements schema (O&M), transducer markup language (TML), sensor observations service (SOS), sensor planning service (SPS), sensor alert service (SAS), web notification service (WNS) [8]. The goal of SWE is to enable all types of Web and/or Internet-accessible sensors, instruments, and imaging devices to be accessible and, where applicable, controllable via the Web. The vision is to define and approve the standards foundation for "plug-and-play" Web-based sensor networks.

The most interesting and useful tool for analyzing the environmental situation in Krasnoyarsk would be a tool based on the standard Sensor Observation Service (SOS) [9]. This standard describes a service that provides access to measurement results from a sensor or sensor network. The specification provides for the possibility of obtaining data on the capabilities and parameters of the sensor, the quality of measurements. In other words, SOS groups a collection of possible heterogeneous sensors and provides their measurements through a standardized service interface. SOS specification defines the operations offered by a specific sensor. The minimum set of methods includes GetCapabilites, DescribeSensor and GetObservation that return information about the observations and measurements supported by SOS. The types of data provided by the sensor and the sensor types themselves can be obtained from the sensor registry.

3. Data collection technology

As a result of the analysis of the current situation in Krasnoyarsk, a list of several sources of operational information on the state of atmospheric air, which can be obtained and analyzed, was formed. However, these data have to be extracted by special tools and in most cases the collection of data from external sources can be divided into several groups:

1. Data is presented in the form of web services that transmit information in a structured form, for example, in csv, json, xml formats. Such data is easy to process and check for errors. This block includes data provided within the OGC SOS standard.

2. There are no special web services for receiving data, but there are service services of the resource necessary for its operation. For example, services for plotting or output tabular data in a web interface, tools, data export, etc. Such services can also be used to retrieve the data, but it is necessary to develop a number of tools for data analysis, including the inspection of changes in the structure of the data, changing internal IDs of the format of the output data, the dimensionality of the data, etc.

3. The data is presented in the form of html pages on the Internet. To obtain such data, you need to analyze the page in order to find some reference text blocks, with which you can always find the necessary information on the page. In this case, a specific text block is extracted from the page and processed further. In some cases, these page fragments can be treated as xml, making it easier to extract information.

In some cases, a combination of the above methods can be used because the services may require service information contained in the page itself. Special attention should be paid to structural changes in the received data, developing a series of verification units, including changes in the number of sensors and monitoring stations, the integrity and completeness of the transmitted data, and so on.

For operational improvement of software modules for data collection, the special software should be created for logging text information and alerts, for example, by e-mail. Such tools allow you to

constantly receive information about changes on a remote resource and its status. Prompt corrections to the program code can ensure the integrity and correctness of the information received.

There are a number of systems in the world for accessing observational data. For example, the Smart Emission platform (https://data.smartemission.nl/data), 52°North project (https://52north.org/), the OpenSensorHub project (https://opensensorhub.org/), istSOS OSGeo project (http://istsos.org/), et al. A number of successful projects based on the technologies under consideration have been implemented [10-11].

4. Results and discussion

On the basis of the geoportal of the Institute of Computational Modeling of SB RAS, a unit of scientific and research monitoring was developed for the collection, processing and presentation of data from various observations [12]. Metrics from external data sources are collected on the SensorCollector collection server. Data sources can be either individual sensors or external databases and information systems through additional adapters. There are several ways to fill the data: active, performing periodic polling and loading data from the source and passive, providing only the reception of data on the initiative of the source through the provided API. Automatic aggregation is performed for the obtained observations with different periods, and the calculation of derived indicators is also supported. After the data is collected and aggregated, it can be viewed through the built-in web interface or used in external systems via the API.

The organization of access to observation data is carried out by various applications and services, including viewing tabular data, export, viewing data on maps with the ability to select time intervals and access using generally accepted standards (OGC WMS, SOS) [13]. The general scheme of data collection is shown in figure 1.
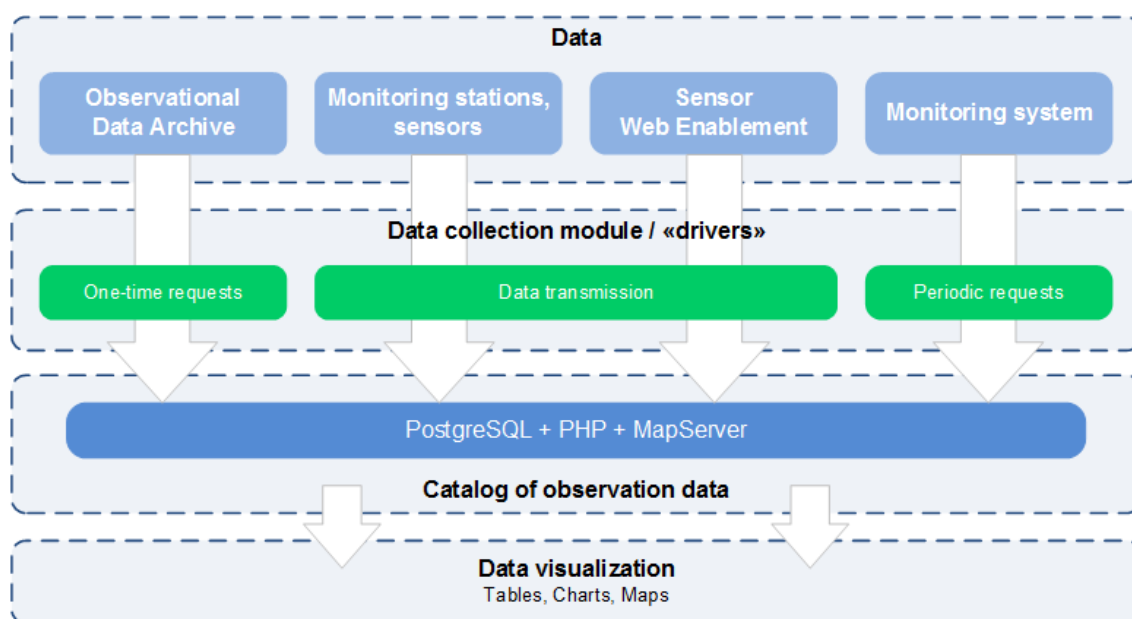

Figure 1. Scheme of data collection observations.

At the moment, the portal has implemented the collection of operational data from several sources and created the following sections:

Monitoring system of air quality in the city of Krasnoyarsk.

- Subsystem of monitoring of atmospheric air of "Center for implementation of measures for environmental management and protection of the Krasnoyarsk Territory" (KVIAS system).
- Monitoring system data of the Federal State Budgetary institution "Middle Siberian Department of Hydrometeorology and Environmental Monitoring».

- Data of hydrological observations in the Krasnoyarsk region from Russian «Unified State System of Information on the Situation in the World Ocean» (ESIMO system).

Data are collected from the air monitoring stations of the Federal Research Center "KSC SB RAS". The data is collected at one minute intervals from 24 posts using the API to access the measurement device data of the automated air quality monitoring information system. The installed devices allow to obtain measurement data of suspended solids in the air (PM2.5, PM10) and basic meteorological parameters: temperature, humidity and pressure.

The flow of data on atmospheric air from the Regional departmental information and analytical system on the state of the environment of the Krasnoyarsk Territory is set up (http://krasecology.ru/Air/). Air quality observations are carried out at 11 automated observation posts, 9 of which are located in Krasnoyarsk. To download data from the KVIAS system website, a software module with an appropriate "driver" for processing and converting input data has been prepared, which provides periodic loading of observations from this system through a web service. Now, most of the downloaded data on the fixed observation posts on the remote server is generated every 20 minutes. Data from mobile laboratories appear once a day, after processing by employees.

Weather data from the website of the Federal Central Siberian Department for Hydrometeorology and environmental monitoring (http://meteo.krasnoyarsk.ru/) are loaded in automatic mode, with a frequency of 1-3 hours. Data are collected on the following indicators: atmospheric pressure, humidity, wind direction, wind speed, air temperature. The archive has been maintained since the beginning of 2013.
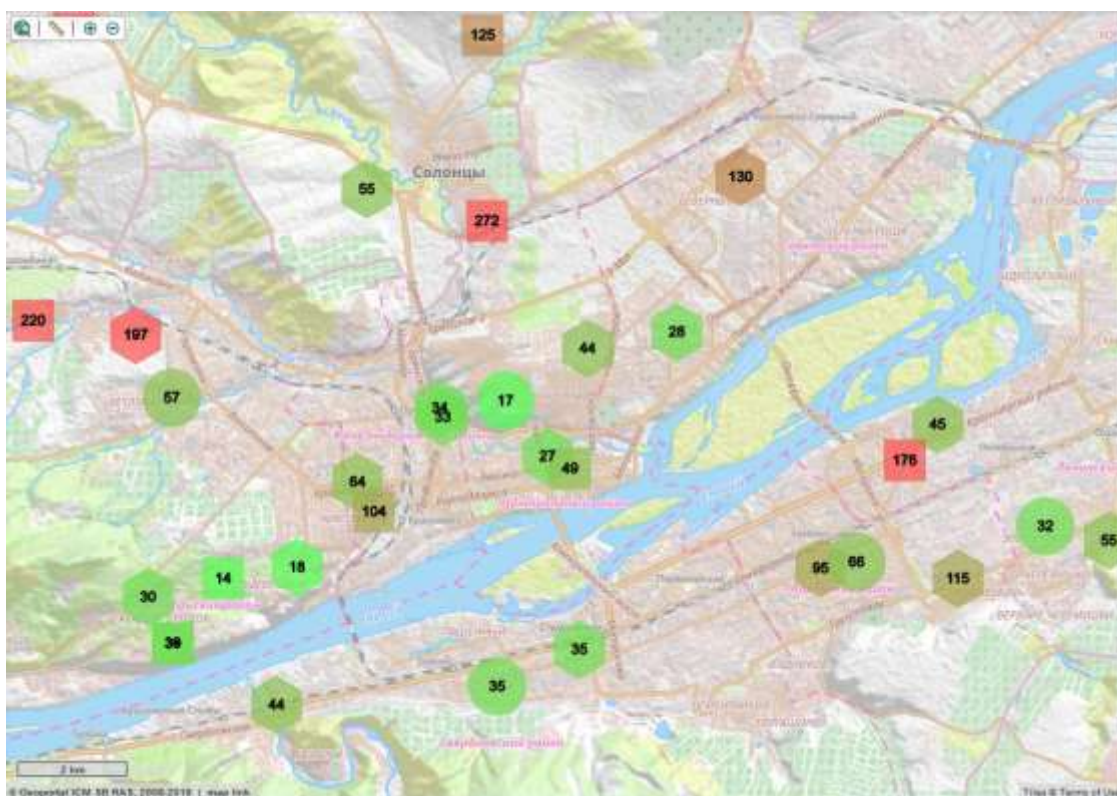

Figure 2. Map with observations for PM2.5 in Krasnoyarsk on 04.03.2019.

Nebo community project data (https://nebo.live/), created by environmental activists from Krasnoyarsk, are also registered in the database. This project collects data from 22 instruments measuring the content of suspended substances in atmospheric air PM2.5 and basic meteorological parameters: temperature and humidity.

An example of a custom application based on geoportal components and APIs is shown in figure 2. The map shows the concentration of suspended particles (PM2.5) in the atmosphere of the city obtained from various surveillance systems.

5. Conclusions

For operational monitoring and analysis of the environmental situation in Krasnoyarsk, data collection from various sources was organized into a single system, «Operational monitoring data», which is an integral part of the ICM SB RAS geoportal.

The developed software for importing observation data from various resources allows you to import data automatically, regardless of how access to this data is organized. In case of any changes and import errors, emails are sent that allow you to quickly make changes to the import program or to the data on the sensors and their composition. In the future, an opportunity is being considered to organize access to observational data in the city of Krasnoyarsk using the international standard OGC SOS. Unfortunately, in Russia this standard is practically not supported by monitoring data providers.

References

[1] Ashitko A G and Manshina I V 2014 A system for monitoring the state of atmospheric quality Air in Kaluga *Vestn. Kaluga University* **22(1)** 5–9

[2] Azemov D 2016 St. Petersburg Atmospheric Air Monitoring System *Environment of St. Petersburg* **2(2)** 8–14

[3] Hu L, Yue P, Zhang M, Gong J, Jiang L and Zhang X 2015 Task-oriented sensor web data processing for environmental monitoring *Earth Sci. Inform.* **8** 511-25

[4] Savu T, Jugravu B and Dunea D 2017 On the development of a PM2.5 monitoring network for real-time measurements in urban environments *Revista de Chimie* **68** 796-801

[5] Botts M, Percivall G, Reed C and Davidson J 2008 OGC Sensor Web Enablement: Overview and High Level Architecture. In: Nittel S, Labrinidis A, Stefanidis A (eds) GeoSensor Networks. GSN 2006 *Lecture Notes in Computer Science* **4540**

[6] Kamel Boulos *et al.* 2011 Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples *International Journal of Health Geographics* **10** 67

[7] Schmitt R H and Voigtmann C 2018 Sensor information as a service – component of networked production *J. Sens. Sens. Syst.* **7** 389–402

[8] 2007 *In OGC Sensor Web Enablement: Overview And High Level Architecture - OpenGIS White Paper OGC 07-165* ed Botts M *et al. (*Open Geospatial Consortium, Inc).

[9] 2007 *In Sensor Observation Service - OpenGIS Implementation Standard OGC 06-009r6* ed Na A, Priest M (Open Geospatial Consortium, Inc)

[10] Wiemann S, Brauner J, Karrasch P, Henzen D and Bernard L 2016 Design and prototype of an interoperable online air quality information system *Env. Modelling & Software* **79** 354-66

[11] Ghodousi M, Atabi F, Nouri J and Gharagozlou A 2017 Air quality management in Tehran using a multi-dimensional decision support system *Pol. J. Env. Stud.* **26** 593-603

[12] Yakubailik O E, Kadochnikov A A and Tokarev A V 2018 *Optoelectronics, Instrumentation and Data Processing* **54** 243–49

[13] Kadochnikov A A 2015 Features construction geospatial web applications and services for the environmental monitoring systems *Journal of Siberian Federal University. Engineering & Technologies* **8** 908-16