New Approaches for Delivery of Data and Information Products to Consumers and External Systems in the Field of Hydrometeorology

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Abstract. The delivery of data and information to consumers by subscription e-mail or by placing it on an ftp server for further upload to external information systems is currently one of the most sought functions of information systems. In the field of hydrometeorology, this function is using in individual organizations and systems, requires a more systemic approach to its development for information support to consumers. An analysis of the methods of delivery data to consumers is presenting. The features of data automatic delivery to external systems and consumers using the Unified state system of information on the condition in the World Ocean are considered. New for hydrometeorology approaches automatic delivery of information about the different threats, visualizing the state of the current situation indicators in the form of a dashboard, the data delivery to external information systems of the enterprises with automatic loading into the data bases are proposed. The full implementation of these approaches will make it possible to organize the more effective hydrometeorological support for consumers. Prospects are development of indicators for evaluating the delivery of data (number of consumers are on service; number of transferring, etc.).

Keywords: Threat Identification, Data Transferring, Disaster Indicators.

1 Introduction

A data dissemination system and of information products in the field of hydrometeorology are standardized at the international level in the framework of the global telecommunication system (GTS), which operates under the auspices of the World Meteorological Organization. All countries contribute to the GTS with their observations and information products based on observed data. The amount of information circulating in the GTS is tens of GB per day.

In each country develops its own system of hydrometeorological support (HMS) to consumers who use observational data, as well as global and regional forecasts issued by leading centers of forecasting and transferred on the GTS.

The development of web-technologies has created new opportunities for the development of HMS. Websites have is created in each hydrometeorological

organization. Facilities presentation of dynamic pages are using on many web sites. The new guide on HMS [4], based on existing methods and tools, identified promising areas is, of development concerning the use of modern information systems (ISs) the Unified State System of Information on the Condition in the World Ocean (ESIMO[1]) [12] and "North" [3].

One of the functions of ESIMO is the delivery of information resources (IRs) by subscription. The IR - this individual file(s) in ISs (libraries, archives, data bases (DBs), depositories and others) having same spatial and temporal scales of resolution of the data, the same data structure; are storing in one organization on one type of medium. IRs delivery by subscription carried out via e-mail, and through ftp-server for further use the consumer. To analyze the state of the service by subscription in a system has a component that monitors the delivery status and prepares corresponding report. Analysis of reports shows that this function is using not very effectively. This is because data delivery is carrying out for IR. It is necessary to transfer only those data attributes, for those areas or points (settlements) that the consumer ordered; data should transfer to Internet-device of consumers immediately after updating the data. Delivery to consumers with each delivery of the entire information resource leads to an increase in the volume of transmitted data, duplication of part of the data previously already transmitted to the consumer in previous message, the transfer of attributes that are not needing by the consumer, to difficulties for determining the relevance of the data.

Subscribing to data delivery is a most sought function of many systems. It is most acceptable function for most consumers. Subscriptions are usually using for the regular delivery of data / metadata files or links to geo-services. In order to increase the effectiveness of HMS for heads of enterprises and the population, it is necessary to switch to automatic data delivery provided when threshold values of threats indicators are exceeding.

"Delivery data and information to consumers is a process consisting in converting of data flow, information that affects the course of this process into a form that ensures prompt and error-free perception by the consumer and the direct issuance of information". This term are using in standard [2]. In hydrometeorology, the term "Delivery of data and information" is understood as:

- Transfer of hydrometeorological data to heads of enterprises, representatives of public organizations and population on a regular basis.
- Prompt notification of government officials and the public about the emergence of threats in the form of natural disasters.
- Interaction of the population and enterprises heads with interactive applications to obtain detailed information about the state of the hydrometeorological situation.

The presented research is devoted to the development of these directions. In this work the first time in hydrometeorology in a single technological complex by integrated, distributed and heterogeneous data, it is proposed:

- To organize personalized delivery of information about disasters to enterprise heads on mobile Internet devices, taking into account local threshold values,

[1] http://esimo.ru – Unified State System of Information on the Condition in the World Ocean

levels of dangerous, with the possibility of further automatic data uploading directly to enterprise ISs.

- To present the indicators of the hydrometeorological situation in the compact form on a dashboard with indication of the level of their danger and visualization of graphs of changes in parameters for time.

2 Methods for Delivery of Hydrometeorological Data and Information to Consumers

In Russia, information is delivery to consumers by research institutions and territorial offices of Roshydromet carried out in written and electronic forms, as well as in the form of oral messages through the media. Regular bulletins, reviews, monthly, yearbooks, and climatic generalizations on the state of the environment are publishing.

Previously, the delivery of data was carried out by copying paper sources of data and information, and sending them by regular mail, by fax, by courier. Since the seventies of the last century, technical media (magnetic tapes, floppy disks, magnetic cartridges, compact disks, flash drives) have been widely used to data transfer. With the advent of data telecommunicate capabilities in the nineties; relatively small data amounts (up to 1 MB) began to transfer and to exchange data by e-mail. A significant leap forward was the ability to access DBs online in the early 2000s of the 21st century. At the same time, a subscription service to various news channels appeared. And here the term "Delivery of news and other information products" has already been used, when the consumer is given either a file with the news, or a link to the address of the site where this news is located. That is, consumers in the “self-service” mode receive information products.

In Roshydromet such a subscription use only for delivery of the observed and forecasting information to the consumer's Internet device[2]. Most consumers prefer to go to weather websites and choose the forecast date themselves and get an answer for a specific point. Of course, there are other methods of delivery data and information to consumers. For example, modern research vessels are equipped with VSAT broadband satellite communications Iridium NEXT (developed by the Federal State Unitary Enterprise "Cosmic Communications"), which provides a prompt exchange of information in real time, including the results of numerical models of meteorological information processing from forecasting centers.

The corporate broadcasting network of Roshydromet "Meteoinform" is also using for data dissemination, which provides data transmission using geostationary communication satellites. "Meteoinform" is an official member of the WMO Integrated Global Circular Data Dissemination System based on MITRA (Multiaddress Information Transmission) technology. Speed of transferring 1 Mbps. This system is used both by regional divisions of Roshydromet to receive information from data collection and processing centers, and by large users to obtain complex hydrometeorological and other information productions.

[2] http://www.meteorf.ru/product/Mobile/

Information about disasters is detected by weather forecasters and forecast in the forecasting centers of Roshydromet[3], and then they are transfer to the Russian Emergencies Ministry, where this information is distributed to the public via SMS. Such delivery of data slows down the process of alerting the population and heads of enterprises.

Realized in ESIMO[4] variant data dissemination is automatic delivery of integrated data on schedule. This is a subscription and a receiving regular alert about the data update on e-mail, or the loading of change on the ftp-server. In addition to the subscription user can downloads data is, after them of visualization by the web-portal. IRs are not always updated with that frequency, with which the set schedule for them transferring. Between previous and next, nearest to him point in time on the schedule, can occur a change in the metadata (but no updating of data), that is means of data delivery will acting idle. When IR updated, than is adding just only one or a few records, and the unit of IR storage and transmission of data is a set of records for a specified period of time (day, ten days, a month, etc.). Not less important with the point of view of optimizing the transferred volume of data, so and reduce of the information noise, is renouncement from the subscription on attributes, which no need.

Scheduled delivery leads to the following situations:

- Some IRs updated regularly and no always in a declared time, pointed in the metadata. It can happen after a session of data transferring, then have until the next session in the consumer this IR will be irrelevant, which leads to the use of irrelevant data. For example, a storm warning may appear in any moment, and the transfer of warning shall be made immediately after the receipt of such message. However, update IR takes place one time in 10 minutes. That is, the system already has a delay up to 10 minutes. The less frequently of data delivery schedule, the more likely such a situation.
- Business users do not control the relevance of data and getting information about what data were transferred, produce their action on their further processing.
- Volume of data transmitted in the framework of a single session of transferring, may be very large (e.g., data of short-term prediction basic meteorological parameters are several to 10 GB). Of time before begin following the transmission simply not enough for processing of received data (only download in the DB can hold up to one hour). As a result, some IRs reach to the consumer with a significant delay, but consumers will be confident in the fact that they received a relevant data.

The most important requirements for subscribing to data are the ensuring guaranteed data delivery and monitoring of this process, which allows to quickly responding to any failures, makes it possible to find and fix the error. External IS pick up received messages from e-mail or from an ftp server, which again leads to the need to use a schedule, since it need to periodically check the receipt of new data. That is, it is necessary to load the data directly to external IS and transfer them using web services immediately after receiving them in integrated DB. At the same time, the ISs, that received the updated data, should confirm its receipt, relevance and completeness.

[3] https://meteoinfo.ru/

[4] http://esimo.ru/portal/auth/portal/esimo-user/data

It is obvious that the delivery of data, occurring by event wins as compared to the delivery by schedule. This increases a relevant of data for all IS, it realize principle of guaranteed delivery of data and creates the opportunity to promptly react to failures. Solutions for the processing of data with zero latency are the best response to the needs of consumers.

To develop maximally effective delivery of data must be implemented next features: delivery of data directly in the DB of other IS; organization of data delivery past the event of updating data in the IR; fast receipt of the notifications on any failures to immediate their removal, in order to not allowing for the impact of the effects on the business processes; realization of monitoring of all delivery of data.

The creation of a software complex for the task of delivery of data by the subscription is relevant in connection with development from consumers modern ISs. Subscribe need to alert the representatives of power and the public about the occurrence of disasters, climate changes and impacts of environment on the industry and the population [7]. Using of synchronously and asynchronously delivery of messages are discussing about in papers [8, 9].

ESIMO [12] integrate, systematize and provides information for analysis of environment state on objects of economic activity. This information can use to highlight the various threats. For this is required:

- To develop a technology for an integrated and targeted information services by the automatic delivery of information to heads of enterprises, public authorities and the public, for assessment of the impact of threats, and the possible changes in climate in the various economic sectors.
- To create tools of estimates indicators for the levels of danger of the objects industry, types of activity with a yield to more detailed consideration of situations (maps of prognostic, observed parameters).
- To carry out automatic delivery of messages about threats and information on exceeding the threshold values of indicators of environmental.
- To develop a program-agents to automatically launch application on mobile Internet devices of heads and inform consumers in case of exit of values of parameters behind the threshold values.
- To delivery to consumers no content of IR, and required current, and or prognostic, or climate information with parameters for the particular industrial enterprise and not on the initiative of the consumer, and by automatic delivery on any Internet device.

3 Subscriptions of Consumers on the Requested Data

For the organization of HMS, including subscription, it is necessary to have the coordinates of the point or region, the composition of the parameters; the type of information, the type of object, type of activity, the threshold values of indicators of threats, e-mail address or the number of mobile phone, to which it need transfer the data. This information should allow determining:

- Geographical area.
- Category of data (observation, analysis, forecast, climate).

- Data period (only last arrivals, last receipts + forecast, last receipts+ forecast + climate).
- For what the necessary data (replenishment of times series, tables with analytical and or prognostic data, decision-making, et al.).
- Threshold values of indicators for the various types of industrial facilities, types of activities, for every threats.
- IRs about the state of the environment, based on which threats determine.

If the object is a geographical region, then min and max values of latitude and longitude or trajectory coordinates of dynamic object motion are introducing. When the description of the object enter information about threats, impact on the enterprise, it is necessary from the proposed threats list select parameters for which it need keep track of the excess of the threshold values. Local threshold values for four danger levels (green, yellow, orange, and red - "traffic light") are recording in the Threshold values DB. After selection of parameters the system automatically determines, in which IRs are these parameters. The administrator of the system should clarify based on the IR metadata, as far as these resources satisfy conditions its application (completeness, relevance, temporal resolution, the area of interest, and others) and register them. Further, these IRs are including in the regular process for identifying threats by threshold values or, if the resource is already there in the processing, then for it adding new conditions to identify threats for the registered enterprise and type of activity.

When specifying threat indicators, other types of indicators can used, in addition to threshold values:

- Repeatability climatic values - the number of cases the measurements of the parameters in predetermined intervals (for example, the level of water in St.-Petersburg <150, 151-200, >200 cm) for a certain period in percent).
- Aggregated characteristics of the state of the environment - average value or sum for the considered temporal and spatial resolution, for example, the amount of precipitation for a certain period of time (for a month >100 mm, season >300 mm, year <50 mm, etc.).
- Relative deviation - value allowable deviation in percentage, is triggering, if the value of indicator changed greater than at a predetermined magnitude percent by comparison with the previous period.

In those cases where the value or time manifestations indicators of threats depend on the geographical position and or time of the year, assessment indicator is making in type of deviation from the norm or trend:

- Anomaly - the deviation values of the parameter from the climatic values, triggered if the difference between current and climatic value indicator larger set number (for example, for temperature air pressure, humidity, and other parameters).
- Tendency - speed, magnitude and direction of indicator change - a relatively stable direction of change for the indicator of a process for a certain period, shows if the indicator increases, decreases or is monotonous at a selected time interval (for example, change tendency of atmospheric pressure).

To assessments the hydrometeorological situation, special indicators are used:

- Comprehensive indicator of fire danger on the current day - represents a cumulative amount of difference of temperature air and point of dew.

- Bodman indicator of severity of the climate - depends on the temperature of the air, the speed of the wind, shows the degree of dangerous to human life.
- Normal equivalent-effective temperature - an indicator of thermal sensitivity, taking into account the influence of wind for a dressed person.

For each indicator, algorithms and methods of preparation are developing. The organization scheme for HMS of heads in case of threats is the increasing information of enterprise heads, quick familiarization with the current situation by:

- Selection and delivery of received storm alerts.
- Delivery of information on detected threats, including providing of information on the impacts and recommendations for decision support.
- Detailed acquaintance with the hydrometeorological situation by maps, figures and tables.
- Delivery of information into the ISs with automatic loading into DB.
- Receiving of information about possible damage and cost of preventive actions before disaster.

4 Applications for Determining the Level of Danger

This tool is designing to identify threats based on select of values in flow of observed and forecast data, which exceed thresholds and, the automatic location of the geographical area of disaster manifestation. Threat identification involves the creation of detection methods based on existing threshold values or other types of indicators characterizing threats, spatial-temporal analysis of measurement data, existing tools for integrated monitoring of the environment and operational display of hydrometeorological, ice conditions in the form of observed, of analytic, forecasting and climatic data. Identification are making based on IRs, for the selected object and threshold values of threats. The result of work this application is a constantly updated DB with dangerous situations for each object and type of activity (Fig. 1).

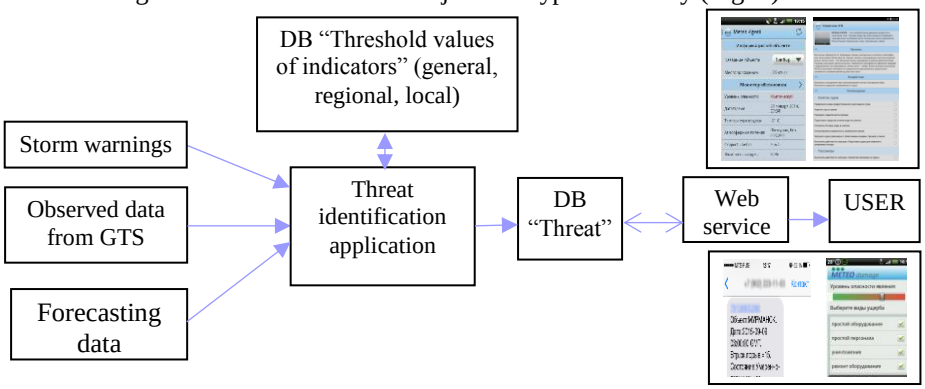

Fig. 1: The scheme for identifying and delivery information for disaster to consumers [10].

For the functioning of the threat monitoring system, the use of integrated environmental data obtained from existing data sources is necessary. The input information to determine the impact of threats on objects and them activities is the values of the measured parameters at the point (fixed hydrometeorological station, or of a regular grid).

The DB creation of threshold values of threat indicators (Table 1) is performed according to the following scale - green (normal situation), yellow (moderately disturbed situation), orange (dangerous situation), red (catastrophic situation) taking into account the type of enterprise and the type of activities, performed at the enterprise.

To prepare the necessary information, integrated data is regularly processed (filtering, select, reduction to one structure, unit of measurements, etc.). After updating the data in the IR, they are automatically delivery to the applications. The results of the processing are documenting and can be subjecting to new aggregation.

The threats description include the following attributes: a short name of the threat; type and name of geographical area; date and time of the start and completion of threat; type of data generalization - observation, forecast, climate; name of the indicator; date and time of observation or analysis and forecast; values of the indicator; text description; the coordinates of the point or area; objects, on which impacts threat; the intensity of threat; kind of activity on which reflect the impact of the threat; enterprise management level; date of creating and change the description.

Table 1. The threshold values of threats indicators to the individual objects.

Lat, min	Lat, max	Long, min	Long, max	Object	Climate zone	Season	Types of activity	Threat Indicators	Values	
40	90	7	180	Vessel	Marine		Transition	Wind: speed, m/s	0	14.9
40	90	7	180	Vessel	Marine		Transition	Wind: speed, m/s	15	19.9
40	90	7	180	Vessel	Marine		Transition	Wind: speed, m/s	20	>20
40	90	7	180	Vessel	Marine		Transition	Wave: height, m	0	1.9
40	90	7	180	Vessel	Marine		Transition	Wave: height, m	2	4.9
40	90	7	180	Vessel	Marine		Transition	Wave: height, m	5	> 5
40	90	7	180	Vessel	Marine	Winter	Transition	Air temperature,°C	-5	-10.1
40	90	7	180	Vessel	Marine		Transition	Air temperature,°C	-10	+24.9
40	90	7	180	Vessel	Marine		Transition	Air temperature,°C	25	5
40	90	7	180	Vessel	Marine		Transition	Visibility, m	0	100
40	90	7	180	Port	Marine		Crane operation	Wind: speed, m/s	0	4.9
40	90	7	180	Port	Marine		Crane operation	Wind: speed, m/s	5	11.9

Threats are determined both at the level of unit of observations (excess of indicator recorded in one point), so and the region (the threat is registered in several points of observations). When this is using as warnings of the territorial offices of Roshydromet

of threats, so and threats, which identified automatically based on observed and forecast data.

The output should satisfy the following requirements:

- Minimum amount of information issued to the head.
- Increasing the granularity of data as the spatial scale of its presentation increases.
- Presentation in a form directly for use without the need for intermediate calculations.
- Automatic detection of threats, related to the excess of the local threshold values.

In result, head is no need to be constantly at the computer in order to monitor the situation. Color and sound signaling helps to the timely to draw attention to the message received. Decreasing amount of data, provided to the head in the message window of the threat, makes it easier acquaintance with the situation.

Head of the enterprise may disconnect message threats, if he considers that the threat for its object not having any adverse effects. At the same time in one settlement may be a few threats. If the signal of second threats has a more high level of danger, then the situation is assigning a more high level of risk. There are the following situations associated with delivery information about threats:

- Message may be not receive, and threats would occur.
- Message was, but the head ignored it for some reason.
- Message was, and the head acknowledged its receipt.
- Disaster finished, the head not received the confirmation about its cancellation or he no sent an answer about the receiving of a cancel message.

Therefore, in the system must definitely make a mark on the fact that the enterprise head received message. He must have opportunity to reconfigure the composition of the monitored threats and must have possible an update of threshold values. When detecting a threat the reason of her occurrence is established. Knowledge of the reason of threat allows predicting its development and the emergence of new threats, a reason of occurrence of which can be the first disaster.

On the basis of ESIMO IRs, not only automatic threat detecting based on all integrated data may organized, but also notification of heads about emerging threats at the initiative of the system through the development of an application MeteoAgent that works on the mobile Internet-device. Application uses all available sources of observation, forecast and climatic data. The threats are detecting by threshold values for each object and type of activity.

Information should be obtained in the form of a spatial representation, based on a grid data, or a time series at a point (graphs of indicators in time). Trends and anomalies are calculating for time series. The results of processing indicators of the hydrometeorological situation should use for an operational assessment of the objects state and types of activities at the object; of output of color and sound alerts about threats; of building graphs of indicators with the identification of dangerous trends or high anomalies of indicators. Having the coordinates of the point or region and the location of the objects, well as information about the threats for him, can see in GIS what part of a spatial is the threat, and how far the object is from the epicenter of threat. Based on this information, it is required to compose a message, in which will indicate the level of danger for each object located in the danger area. Compliance with the data types and functions to detect threats has been representing in Table 2.

Table 2. Correspondence of data types and functions.

Data type	Functions
Observed data	Analysis of IRs with the observed data, transmitted over the GTS in the codes SYNOP, SHIP, BUOY, SEA, WAREP, and etc.
	Calculation of abnormal deviations of the observed values from climatic data
	Trend calculating of change values of parameters
Forecast data	Analysis of IRs with prognostic data
	Trends calculating change prognostic values of parameters
Storm alerts	Detection of storm warnings for any objects

5 Tools of Delivery of Information for the Threats

5.1 Software for the Selection and Transmission of Storm Warnings

For HMS, it is necessary, first, to use the official "Storm warnings and alerts" of organizations of Roshydromet. These warnings are compiled by observers on station or synoptics in territorial offices Roshydromet, transmitted via GTS and collected in the ESIMO DB. In first case of information about threats ah identified by observers at the hydrometeorological station and transmitted in code WAREP via the GTS. These messages can be using to identify objects that threats affect.

The second option is, when the synoptic in the territorial offices of Roshydromet and research institutions (Arctic and Antarctic Research Institute, Hydrometeorological Center of Russia), based on analysis of the current situation, weather maps and other materials, are forecast threats and pass them to interested enterprises.

These threat forecasts and warnings be using to identify objects and activities that they are influencing. Each type of economic activity has its own activity limitations, for example, those associated with strong winds, which may not coincide with the gradations of strong winds established in the guides [5, 6]. Identified messages for a specific object (district) are stored in the DB and must transfer to consumers using SMS. These messages can be view for a certain period on the map as one of the IR.

5.2 Application for Delivery Information about Identified Threats

Application for automatic delivery of information about the various threats (MeteoAgent) is intending for visualization of information about threats based on the received SMS with the address of the software for link [1, 10, 11]. The message includes the name of the object, the type of activity, and the name of the indicator, its value, and danger level. The message contains a link to the MeteoMonitor application for more detailed information about the current hydrometeorological situation. In addition to impacts and recommendations, the consumer can be able to assess the possible damage and calculate the costs of preventive measures. This application is installing on the smartphone of enterprise head and is activating when SMS is receiving. The consumer configures the MeteoAgent application for a specific object, hydrometeorological station, threshold values of threat indicators. The application MeteoAgent should

conduct monitoring of alerts about threats in real time. The availability of information on mobile phone numbers registered at base stations located in the threat zone allows providing prompt alerts and instructions the owners of mobile phones located in any region.

5.3 Application in the Form of a Dashboard

In addition to SMS messages, the head should see the state of indicators of the current situation. To do this can use the application to form indicators as a dashboard. The application must in an interactive mode to show values of observed and prognostic parameters celebrated on icons meteorological instruments, with indication of the level of danger, Fig. 2. Beside each, parameter value should be the graphic changes of anomalies and of trends. When updating data in the sources, they update on the dashboard automatically.

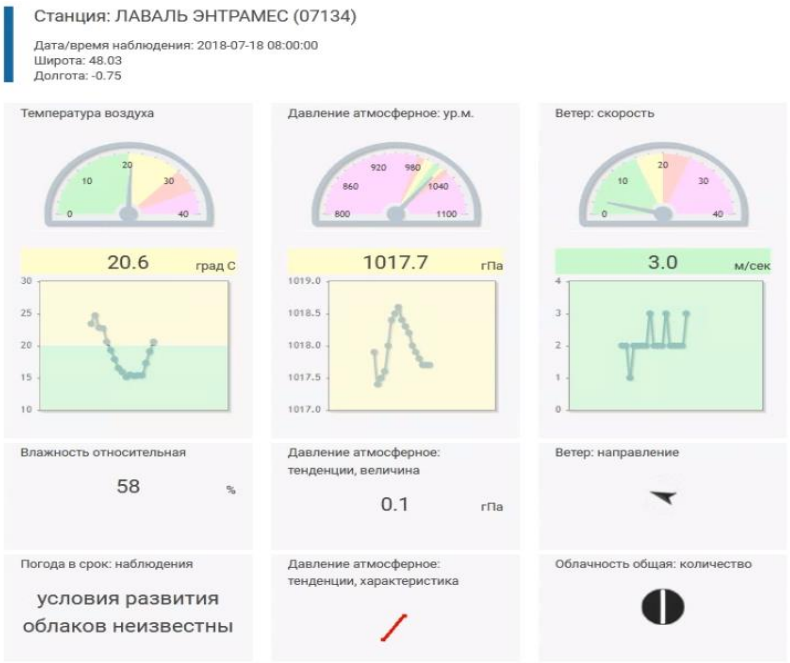

Fig. 2. Scheme reflection hydrometeorological conditions with an indication of threshold values on the dashboard.

In such an application, information is displaying on the screen in a more compact form. One glance at this form will be enough to understand the current hydrometeorological situation. If necessary, the head can get detailed information on the ESIMO portal for the district by application MeteoMonitor.

5.4 Application MeteoMonitor

Application MeteoMonitor is software for more detailed acquaintance with the hydrometeorological situation at a point or in a spatial. The program interface of this application should provide the following forms of presentation of information:

- Maps of the spread of threats in spatial.
- Graphs of changes in threat indicators in form time series.
- Tables of values of environmental parameters in a particular observation point or closest point on regular grid.
- Values, showing the status of indicators of threats, for individual objects and types of activities on them.
- Messages about threats.
- Warning about disasters via sound, color.

When updating data in the sources, the relevance of the data in the MeteoMonitor application automatically ensuring.

5.5 Application for the Delivery of Information to the IS of Enterprise with Automatic Loading into the Database

At the present time it is necessary to hydrometeorological data are using in the automated business processes of enterprises, such as accounting of speed and direction of wind during the unloading of coal in the seaport, located on the territory of the city or the planning of loading and unloading of perishable products. In this case, the head of the enterprise subscribes to the delivery of the necessary data. Depending on the business process, data can be transferred for a point, region or trajectory.

If the enterprise is to a point, then the observed hydrometeorological information available from hydrometeorological station, which is located closer from the enterprise, and prognostic information - on the nearest point of grid. If the enterprise has distributed in spatial, then for each object selected by points of observations and the results of interpolation at the grid point, how, and in the previous case. If the enterprise is a dynamic object (vessel), then observation points and grids point along the entire route of the vessel are selected for it.

The observed and prognostic data are updating in accordance with the time resolution of these IRs. Moreover, the data of previous observations are not repeating in messages, only those parameters will be send, that are necessary for the operation of business processes of enterprises.

6 Conclusions

New for hydrometeorology approaches automatic delivery of information about the different threats, visualizing the state of the current situation indicators in the form of a dashboard, the data delivery to external ISs of the enterprises with automatic loading into the DB are proposed. Full implementation about these approaches must permit to organize the hydrometeorological support of enterprises and population that is more effective.

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