Working out of the basic network for monitoring of natural and climatic processes in Siberia

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Major factors of a state of natural and climatic systems

• The state of natural and climatic systems are defined by set of dynamic meteorological and hydrological characteristics.

• It is necessary to spend a complex of measurements of parameters on the points of supervision distributed in space in which parameters atmospheres, hydrospheres and soils characterizing would be defined.

• At complex realization of measurements of atmospheric parameters really to receive indexes which would reflect all factors influencing development of natural and climatic processes.
Monitoring of natural and climatic processes

• Creation of a basic network of tool monitoring of a dynamic status of atmosphere, hydrospheres, soils and vegetation.

• Creation of the distributed network of off-line and field independent information-measuring systems of monitoring for maintenance of the landscape analysis of processes.

• Development of physical, geochemical, hydrological and bioindicator methods of the landscape analysis of natural and climatic processes in the present and the past.

• Creation of information-modelling system for monitoring, the analysis, modelling and the forecast of natural and climatic processes.
The basic network

Typical station for the network of monitoring of natural-climatic processes

- Platform for remote sounding of atmosphere
- Pole mast with sensors for gradient measurements
- Pavilion for placing of systems of registration, communication and technical maintenance
- Platform for standard meteorological measurements
- Platform for aerosol & radiation measurements
- Platform for ecosystem supervision
The basic network

Typical station for the network of monitoring of natural-climatic processes

• **Standard meteorological station** (the international certificate, Vaisala, Finland) – for the control of meteorological conditions in a ground layer of atmosphere and a binding to network meteorological supervision as a part of a world network.

• **30-metre pole mast with sensors for gradient measurements** (sensors AWS, the departmental certificate, IMCES, Russia) – for gradient measurements of wind speed, temperature, pressure, humidity and calculations of vertical transfer of heat and moisture in a ground layer of atmosphere.
The basic network

Typical station for the network of monitoring of natural-climatic processes

• Platform for remote sounding of atmosphere:
  aerosol lidar (IAO & IMCES) – for the control of transfrontier transport of an aerosol;
  minisodar (IMCES) for the control of turbulent characteristics in an atmosphere boundary layer;
  station of aerologic radio sounding (the international certificate, Vaisala, Finland) for the control of profiles of a wind, temperature and humidity to heights about 30 km.

Addition: the automated laser measuring instrument of characteristics of overcast.
The basic network

Typical station for the network of monitoring of natural-climatic processes

- **Platform for aerosol-no-radiating measurements:**
  - UV-radiometers *(the international certificate, NILU Products, Norway)*;
  - aerosol spectrometers *(the international certificate, Grimm Aerosol Technik, Germany)* - for the control of photochemical and photosynthetic processes;
  - solar spectrophotometer *(IAO)* - for the control of the maintenance atmospheric aerosol in all thickness of atmosphere.
The basic network

Typical station for the network of monitoring of natural-climatic processes

• **Reference platform for ecosystems supervision:**
gas analyzers greenhouse and others significant gases for the control of photosynthetic and soil processes;
measuring instruments for a precipitations, a soil moisture and a snow cover for the control of soil processes.
The basic network

Factors of natural processes

The climatic factor

The atmospheric block
- Wind
- Humidity
- Temperature
- Radiation
- Aerosol
- Clouds

The soil block
- Soil moisture
- Temperature
- Bioindication
Wind

- Ultrasonic anemometer
- Sounding balloon: H ~ 25000 m
- Doppler lidar: H ~ 7000 m
- Ozone lidar: H ~ 10000 m
- Microwave radar: H ~ 300 m

- Pole mast: H ~ 30 m

First stage | Second stage | Long-range goal
---|---|---
The basic network
Wind

WindTracer® System

**WindTracer® System Performance Specifications**

<table>
<thead>
<tr>
<th>Measurement Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility</td>
<td>High spatial resolution wind and aerosol measurement</td>
</tr>
<tr>
<td>Maximum Range</td>
<td>&gt;12 km for $1 \times 10^4 \text{ m}^3 \text{ sr}^{-1}$ volume backscatter coefficient</td>
</tr>
<tr>
<td>Minimum Range</td>
<td>400 m</td>
</tr>
<tr>
<td>Operating Wavelength</td>
<td>1.6 micron wavelength eye-safe infrared laser</td>
</tr>
<tr>
<td>Radial Velocity</td>
<td>$\pm 38 \text{ m/s}$, accuracy better than 1 m/s</td>
</tr>
<tr>
<td>Maximum Range Resolution</td>
<td>30-40 m</td>
</tr>
<tr>
<td>Scan Modes</td>
<td>PPI, RHI, arbitrary coordinate scans</td>
</tr>
<tr>
<td>Maximum Scan Rate</td>
<td>20 deg/sec</td>
</tr>
<tr>
<td>Line of Sight Update Rate</td>
<td>&lt;1 to ~15 Hz (user-selectable)</td>
</tr>
<tr>
<td>Clutter Suppression</td>
<td>No side lobe removal necessary. Automatic illuminated obstacle removal</td>
</tr>
<tr>
<td>Pulse Repetition Frequency</td>
<td>250, 500, 1000 Hz</td>
</tr>
<tr>
<td>Average Power</td>
<td>1.5 Watt (2 mJ pulse @ 750 Hz)</td>
</tr>
<tr>
<td>Beam Diameter</td>
<td>10 cm, collimated</td>
</tr>
<tr>
<td>Aerosol Measurement Parameters</td>
<td>Specifications</td>
</tr>
<tr>
<td>Minimum Aerosol Size</td>
<td>$\sim 0.5 \mu m$ for typical aerosol size distributions</td>
</tr>
</tbody>
</table>

A display of horizontal wind and aerosol fields during gust front passage. Wind field includes map and wind vector overlays.
Wind

Yankee Environmental® Systems
Wind

The control of vertical transfer of ozone lidar
Humidity

First stage  Second stage  Long-range goal

The basic network

Radiometer  Hygrometer  Sounding balloon  Raman lidar  DIAL lidar

Integral criterion  Pole mast H ~ 30 m  H ~ 25000 m  H ~ 2000 m  H ~ 6000 m
Humidity
Remote control of water vapor profiles by Raman and DIAL lidars

Water vapor vertical profiles, measured by radiosonde (dotted), Raman lidar (dashed), DIAL – Ti:Sa-0.72 μm (solid)

Ratio of integrated water vapor measured by Raman lidar and DIAL for five 12-hours periods during Intercomparison campaign

Time – height cross section of the water vapor density. Temporal resolution is 10 s, vertical resolution is 60 m.
Temperature

First stage
- Ultrasonic anemometer
  - Pole mast $H \sim 30\,\text{m}$

Second stage
- Sounding balloon
  - $H \sim 25000\,\text{m}$
- Microwave radiometer
  - $H \sim 300\,\text{m}$

Long-range goal
- Raman lidar
  - $H \sim 2000\,\text{m}$

The basic network
Profiles of temperature of the atmosphere received by means of Raman lidar and radiosonde
Radiation

IR-radiometer  Radiation balance gauge  UV-radiometer  Ozonometer

First stage  Second stage  Long-range goal

The basic network
Aerosol

First stage

Second stage

Long-range goal

The basic network

Counter

Spectrophotometer

Lidar

Pole mast

Aerosol depth

H ~ 30 м

H ~ 10000 м

The basic network
Clouds

Panoramic photometer - Extent & speed of the clouds
Lidar - Clouds height
2 wave weather radar - Liquid water content in clouds

First stage
Second stage
Long-range goal
The basic network
Off-line and field monitoring of natural and climatic processes

Field information-measuring systems for monitoring of atmosphere

Portable automatic weather station

<table>
<thead>
<tr>
<th>Measurable parameter</th>
<th>Measurement range</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal wind speed</td>
<td>0.1 ÷ 30 m/s</td>
<td>&lt; 0.37 m/s</td>
</tr>
<tr>
<td>Vertical wind speed</td>
<td>-15 to +15 m/s</td>
<td>&lt; 0.37 m/s</td>
</tr>
<tr>
<td>Horizontal wind direction</td>
<td>0 ÷ 360°</td>
<td>± 2°</td>
</tr>
<tr>
<td>Air temperature</td>
<td>-50 to +55 °C</td>
<td>&lt; 0.37 °C</td>
</tr>
<tr>
<td>Relative air humidity</td>
<td>15 ÷ 100 %</td>
<td>± 2.5% at T &gt; 0 °C; ± 5% at T ≤ 0 °C</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>520 ÷ 800 mm Hg</td>
<td>1 mm Hg</td>
</tr>
</tbody>
</table>
Off-line and field monitoring of natural and climatic processes

Off-line information-measuring systems for monitoring

Independent measuring instrument of a profile of temperature

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of measured temperature, °C</td>
<td>-55… 65</td>
</tr>
<tr>
<td>Absolute error measurement of temperature, °C</td>
<td>±0.1</td>
</tr>
<tr>
<td>Source voltage, V</td>
<td>3.0 - 3.6</td>
</tr>
<tr>
<td>Maximum quantity of sensors in a measuring instrument, units</td>
<td>16</td>
</tr>
<tr>
<td>Volume of non-volatile memory, Mb</td>
<td>2</td>
</tr>
<tr>
<td>Consumption current in a radio exchange mode, mA</td>
<td>5…10</td>
</tr>
<tr>
<td>Consumption current in a mode of interrogation of gauges and radio reception, mA</td>
<td>1…2</td>
</tr>
<tr>
<td>Consumption current in a dream mode, mA</td>
<td>0.02</td>
</tr>
<tr>
<td>Average time of off-line operation with a regular battery supply, months</td>
<td>12</td>
</tr>
</tbody>
</table>
Monitoring of processes of desertification

Information-measuring systems for monitoring of a status of soil

**Soil Moisture Sensors: TRIME-PICO64 sensor with internal TDR-electronics**

**TRIME** (Time domain Reflectometry with Intelligent MicroElements) is based on the TDR-technique (Time-Domain-Reflectometry), and was developed to measure the dielectric constant of a material.
Bioindication

Taxonomical analysis of fossil pollen and diatoms

Correlation of pollen diagrams from 3 lakes in Central Altai (Ulagan district)

1 - Larix, 2 - Picea, 3 - Abies, 4 - Pinus sibirica, 5 - Pinus sylvestris, 6 - Betula, 7 - Salix, 8 - Betula nana, 9 - Artemisia, 10 - Chenopodiaceae, 11 - Poaceae.
Bioindication
and landscape modelling of processes in the past

3200 BP

5300 BP

8000 BP

10000 BP
Bioindication and landscape modelling of processes in the future

Contemporary climate

2020

2050

2080
Bioindication

Conceptual flow chart for the working steps Of bioinformation group

**Calibration dataset**
- Surface sediment samples and water samples from 20 lakes
  Collecting of modern wood samples

**Measurements**
- Water chemical analysis, taxonomical analysis of pollen, diatoms and chironomids.
  Dendroclimatological investigations

**Empirical modelling**
- Multivariate analyses and establishment of transfer functions

**Lake sediment coring**
- Coring of lake sediments from four different regions
  in areas of ecotones
  Collecting of fossil wood samples

**Measurements**
- Dating of sediments, taxonomical analysis of fossil pollen, diatoms and chironomids,
  sedimentological measurements
  Dendroclimatological investigations

**Quantitative palaeoclimate reconstructions**
- Quantitative reconstructions of palaeotemperatures, precipitations, salinity and alkalinity since
  Late Glacial

Climate modelling and recognition of areas of potential risk of desertification
Monitoring of natural and climatic processes

• Instrumental provision of monitoring stations (on the basis of SB RAS stations) located in characteristic climatic zones to monitor glacial processes in mountains and desertification processes in southern latitudes, for monitor processes in forest-bog ecosystems in middle latitudes and cryosphere processes in the north of Siberia.

• Provision of new ground monitoring stations with modern information technologies for monitoring, modeling and management of natural and climatic systems in stationary, mobile and remote observations (ac. Yu. Shokin).

• Methodical provision of unified set of measuring devices, regulations and formats for the main measured parameters which will be applied at monitoring stations network. This network will have status of spatially distributed Center of Corporate Use (leading organization: IMCES SB RAS).
Thanks for your attention!

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