MEMBER COUNTRY: RUSSIA

National Report to SCAR for 2014/2015

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A BRIEF SUMMARY OF SCIENTIFIC HIGHLIGHTS

PHYSICAL SCIENCES

Meteorology/Climate

Current six-hourly Russian Antarctic Automatic Weather Station network data are collected and quality controlled for June 2014 – June 2015 period using both historic and observational Russian Antarctic manned station data, and for SCAR READER database regular update procedure.

The local Lake Untersee (East Antarctica) surface meteorological conditions were investigated on the base of an US automatic weather station (AWS) data which were compared with data of Novolazarevskaya station taking into account the recent austral summer season 2014-2015 data. The annual degree-days above freezing for the total AWS observation period and the extreme weather event parameters, including strong southward katabatic wind speed are estimated. The main lake ice mass loss processes due to surface layer severe thermal and dynamic regime (when lake ice is sublimating rather than melting) are described.

In the frames of Joint Indian -Russian cooperation the interaction between Central Antarctic area surface layer and upper atmosphere geophysical processes are investigated based on high resolution Vostok station data and satellite information.

Atmosphere

In the period of seasonal observations during 59th Russian Antarctic Expedition onboard r/v “Akademik Treshnikov” (February 1-June 9, 2014) and r/v “Akademik Fedorov” (November 5, 2013 – May 16, 2014), the following measurements of optical and microphysical aerosol characteristics were continued: aerosol optical depth (AOD) in the wavelength range of 0.34-2.14 μm; aerosol mass and number concentrations; “black carbon” mass concentration in the near-water air layer, and the total ozone content. Concentrations of minor gas constituents (MGCs) of the atmosphere, i.e., CO, NO, NO_2, SO_2, and O_3, were additionally measured onboard r/v “Akademik Treshnikov”.

It was found that the spatial distribution of aerosol characteristics, obtained in 59th RAE, is in the good agreement with multiyear data measured in 51st–58th RAEs (2005–2012). Near-ground ozone concentration (NOC) decreased fivefold on the rout from Northern Hemisphere mid-latitudes to

Antarctica (February-March). On the backward route (the second half of April - May), the latitudinal distribution had been transformed under the influence of seasonal factor: the average NOC level had been practically the same in Northern and Southern Hemispheres i.e. 30 $\mu g \cdot m^{-3}$, on average.

There were the following specific features of concentrations of other MGCs: (a) the NO concentrations showed the widest (almost two orders of magnitude) latitudinal-seasonal variability range, the NO_2 concentration varied by a factor of 18, and CO and SO_2 concentrations varied by about a factor of 8; (b) the concentrations of NO, NO_2, and CO were higher in the Northern Hemisphere; (c) the average Northern/Southern Hemisphere difference is a factor of 85 for concentrations of NO, a factor of 5.7 for CO, a factor of 2.3 for NO_2, and a factor of 1.2 for SO_2; (d) a salient feature of SO_2 is that its concentration grows from high latitudes to equator, both on the forward and backward routes.

Physical oceanography

In January – February 2015 during 59th Russian Antarctic expedition (RAE) three CTD/O2 transects were made from r/v Akademik Fedorov in the Prydz Bay area. First transect included 18 soundings along 70° E (at the same station's positions as in 2011, 2012 and 2013 surveys). High spatial resolution of the section along 70° E at the shelf break and above the upper steep detailing of mesoscale peculiarities of the near-slope convective plumes. Section along 70° E was part of the slope has allowed repeated eight times during the period 2004 – 2015. Second section (22 stations) was made in the central part of the bay. Third section (12 stations) was situated along the Amery Ice Shelf edge. Oceanographic stations were performed by "Sea Bird 911+" probe with water sampling to determine the nutrients on the particular horizons. Two additional sections with 21 stations were made in the northern part of Bransfield Strait and on the continental slope of the South Shetland Islands in the southern Drake Passage.

Deep drilling at Vostok and glaciological studies

In the 2014-2015 austral season (the 60th Russian Antarctic Expedition) the drilling of deep hole 5G-3 at Vostok Station was resumed and extended to the bottom of ice sheet. On January 25 2015, subglacial Lake Vostok was unsealed for the second time at a depth of 3769.15 m. The experience gained from the first lake unsealing was taken into account during the second one which allowed improving the performance of the operation. The strict fluid pressure and level controls ensured a moderate water rise in the hole close to the desired height (about 50 m). However, the rapid (almost instantaneous) formation of a bright white solid substance in the drilling fluid-water interaction zone was observed in both cases and prevented any attempt to sample liquid lake water. This substance was preliminary identified as a mixture of ice and clathrate-hydrate of the hydrochloroflurocarbon (HCFC-141b), the densifier of the drilling fluid. After the second lake unsealing this solid matter filled up more than 10 meters of the borehole length separating the drilling fluid from the frozen lake water.

As a result of the drilling activity at Vostok, three replicate cores from holes 5G-1, 5G-2 and 5G-3 became available for detailed and revalidation analyses of the 230 m thickness of the accreted ice, down to its contact with water at 3769 m below the surface. The study reveals unexpectedly low concentration of gases to be present in the water beneath Vostok. A clear signature of the melt water in the surface layer of the lake, which is subjected to refreezing on the icy ceiling of Lake Vostok, has been discerned in the three different properties of the accreted ice: the ice texture and fabric, the isotopic and gas content of the ice. All sets of data indicate in concert a poor mixing of the melt (and hydrothermal) water with the residence lake water and pronounced spatial and/or temporal variability of local hydrological conditions. The latter implies that the surface water is not representative

enough to study Lake Vostok's behavior, and that direct sampling of the lake at different depths is needed in order to move ahead with our understanding of the lake's hydrological regime.

Glaciological investigations in the mega-dune area located 30 km to the east from Vostok Station, which were launched during the 58th and 59th Russian Antarctic Expedition, were continued in January 2015. Snow accumulation rate was measured and the surface snow sampled for the isotope and chemical analyses along the 2 km profile across the mega-dune ridge. The data shows that the accumulation rate regularly changes by an order of magnitude within the distance less than 1 km, with the reduced accumulation at the leeward slope of the dune and increased accumulation in the hollow between the dunes. The snow isotope content is in negative correlation with the snow accumulation, which could be explained by the post-depositional snow modification and/or by enhanced redistribution by wind of winter precipitation comparing to summer precipitation. Since the spatial anomalies of snow accumulation and isotope content are supposed to drift with the dune at a speed of 5.5 ± 1.3 m yr^{-1} (as estimated from the precise GPR data), an ice core drilled in the mega-dune area is expected to exhibit the non-climatic 340 year cycle of these and other geochemical properties of firn. In order to test this hypothesis, in January 2015 the 20 m long firn core was drilled at the beginning (on the leeward side) of the mega-dune prof

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GEOSCIENCES

ORGANIZATIONS INVOLVED:

Federal Research Institute for Geology and Mineral Resources of the World Ocean, VNIIOkeangeologia (Ministry of Natural Resources and Ecology, Federal Agency for Mineral Resources).
Polar Marine Geosurvey Expedition, PMGE (Ministry of Natural Resources and Ecology, Federal Agency for Mineral Resources).

FIELD ACTIVITY

Marine geophysics (PMGE, VNIIOkeangeologia).
Region: Cosmonaut Sea (area between 34E and 50E; 60S and 68S).
Data: 3100 km of MCS data, c. 5800 km of magnetic and gravity data; 10 OBS (along 2 MCS lines crossing the continental rise). MCS data were recorded with a 560-channel, 7-km-long digital streamer and airgun array of 40 Liters in total volume.

Airborne geophysics (PMGE)
Region: Princess Elizabeth Land (area between 83E and 88E; 66.75S and 67.5S).
Data: c. 5600 km of airborne survey including magnetic and radio-echo sounding observations.
Short-range airplane AN-2 was used for data acquisition in both seasons. The RES studies were carried out using a 60-MHz radio-echo sounder with a dynamic range of 180 dB and a pulse width of 750 ns. Flight lines were generally oriented north-south and spaced 5 km apart.

Ground-based geophysics (PMGE)
Activity (region): refraction seismic experiment in the central part of Lake Vostok.
Data: seismic data were acquired along the S-N striking line. Explosives (up to 900 kg) were used as seismic source (offset: 1-60 km).

Geological studies/mapping (PMGE, VNIIOkeangeologia).

Rregion: Southern Prince-Charles Mts. (Stinear Mt., Rymill Mt), East Antarctica

INTERNATIONAL AND NATIONAL INDOOR PROJECTS (VNIIOkeangeologia)

Commission for Geological Map of the World (CGMW). Subcommission for Antarctica.
http://www.ccgm.org

The explanatory notes booklet to the Tectonic Map of the Antarctic at 1:10 M published in 2012 is under preparation and is expected to be submitted for publication by CGMW in 2016.

A new project "Geological and Geophysical Maps of the Lambert Glacier Area" was launched in 2014 by the CGMW Subcommission for Antarctica. This project is aimed to integrate all available geological and geophysical data in the area of Lambert Glacier and to compile geological and geophysical maps at 1:2.5M Scale (bedrock topography map, magnetic anomaly map, gravity anomaly map, geological map, tectonic map).

Antarctic Digital Magnetic Anomaly Map (ADMAP). SCAR Expert Group.
The draft of new ADMAP version has been compiled in VNIIOkeangeologia and presented at XII ISAES Meeting in Goa.

Past Antarctic Ice Sheets (PAIS). SCAR Program

The map of thickness of Cenozoic sediments on the East Antarctic margin has been compiled. This map is planned to be used for estimation of pre-Cenozoic paleotopography of the Antarctic.

Enderby Land Project (National Project).

The project was launched in January 2014 and aimed to integrate all available geological and geophysical data in the area of Enderby Land and to compile maps at 1:1 M Scale.

SELECTED PUBLICATIONS OF 2014-2015

Leitchenkov G.L., Lipenkov V.Ya., Antonov A.V., Bulat S.A., Charlot F., Aleokhina I.A., Belyztsky B.V. 2014. The nature of microparticles found in the borehole after unsealing of Lake Vostok. Problems of Arctic and Antarctic. No 1, pp. 114-122 (In Russian with Abstract in English).

Leitchenkov G. L., Guseva Y.B, Gandyukhin V.V., Ivanov S.V. Crustal structure, tectonic evolution and seismic stratigraphy of the Southern Indian Ocean (Antarctica). St.-Petersburg. VNIIOkeangeologia. 200 p. (In Russian with Contents and Figure Captions in English).

Leitchenkov G., Antonov A., Luneov P., Lipenkov V. Geology and environments of subglacial Lake Vostok // Phil. Trans. R. Soc. A. 2015. Vol. 373, 20140303. (doi: 10.1098/rsta.2014.0303). In press.

Mikhalsky E.V., Belyatsky B.V., Presnyakov S.L., Skublov S.G., Kovach V.P. ,Rodionov N.V., Antonov A.V., Saltykova A.K., Sergeev S.A. 2015. The geological composition of the hidden Wilhelm II Land in East Antarctica: SHRIMP zircon, Nd isotopic and geochemical studies with implications for Proterozoic supercontinent reconstructions. Precambrian Research, V. 258, P. 171–185.

Scheinert M., Ferraccioli F., Schwabe J., Bell R., Studinger M., Damaske D., Jokat W., Aleshkova N., Jordan T., Leitchenkov G., Blankenship D. D., Damiani T. M., Young D., Cochran J. R., Richter TD. New Antarctic Gravity Anomaly Grid for Enhanced Geodetic and Geophysical Studies in Antarctica // Geoph. Res.Let. 2015. In press.

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