PRESENTATION
OF THE ARCTIC CLIMATE IMPACT ASSESSMENT OVERVIEW REPORT
AND INTERNATIONAL WORKSHOP ON CLIMATE CHANGES
IN THE ARCTIC AND INTERNATIONAL POLAR YEAR 2007/2008
IN THE RUSSIAN ARCTIC

30 March – 1 April, 2005

Arctic & Antarctic Research Institute, St. Petersburg, Russia

ABSTRACTS

Санкт-Петербург
2005

TABLE OF CONTENTS

ARCTIC CLIMATE – PAST AND PRESENT

Alekseev G.V.
Arctic and Antarctic Research Institute, Russia
alexgv@aari.nw.ru

The Arctic climate is a complex system with multiple interactions with the global climate system. Arctic is connected with the global system by heat and moisture, salt and water transfer which maintain their energy balance and intensify/attenuate climate changes under the influence of positive /negative feedback.

The observational database for the Arctic is quite limited. Sparse observational dataset and high variability makes it difficult to distinguish with confidence between the signals of climate variability and change.

Atmospheric circulation impact on the arctic climate strongly. The phase of the Arctic Oscillation was at its most negative in the 1960s, exhibited a general trend toward a more positive phase from about 1970 to the early 1990s, and has remained mostly positive since. The Pacific Decadal Oscillation (PDO) was in a negative (cool) phase from 1947 to 1976, while a positive (warm) phase prevailed from 1977 to the mid – 1990s. As with the AO/NAO, the physical origins of these long-term changes are currently unknown.

It is very probable that the Arctic has warmed over the past century, although the warming has not been uniform. Land stations north of 60° N indicate that the average surface temperature increased by approximately 0.09 °C/decade during the past century, which is greater than the 0.06 °C/decade increase averaged over the Northern Hemisphere.

It is not possible to be certain of the variation in mean land-station temperature over the first half of the 20th century because of a scarcity of observations across the Arctic before about 1950. However, it is probable that the past decade was warmer than any other in the period of the instrumental record. Although it is difficult to assess trends in some areas, air temperature appears to have increased throughout the Arctic during most of the 20th century. The average trend between 1966 and 2003 over the Arctic was 0.4 °C/ decade, approximately four times greater than the average for the century. While trend most pronounced in winter and spring, all seasons experienced an increase in temperature over the past several decades with some cooling around southern Greenland. As a whole Arctic SAT trends for 1900–1999 are depended from season and geography. The instrumental record of land-surface air temperature is qualitatively consistent with other climate records in the Arctic. For instance, temperatures in the marine Arctic (as measured by coastal land stations, drifting ice stations, and Russian North Pole stations) increased at the rate of 0.05 °C/decade during the 20th century. Evidence of polar amplification depends on the timescale of examination. Over the past 100 years, it is possible that there has been polar amplification, however, over the past 50 years it is probable that polar amplification has occurred.

It is very probable that atmospheric pressure over the Arctic Basin has been dropping, and it is probable that there has been an increase in total precipitation over the past century at the rate of about 1% per decade. Trends in precipitation are hard to assess because it is difficult to measure with precision in the cold arctic environment. It is very probable that snow-cover extent around the periphery of the Arctic has decreased.

It is also very probable that there have been decreases in average arctic sea ice extent over at least the past 40 years and a decrease in multi-year sea-ice extent in the central Arctic.

Reconstruction of arctic climate over the past thousands to millions of years demonstrates that arctic climate can vary substantially. There appears to be no natural impediment to anthropogenic climate change being very significant and greater in the Arctic than the change at the global scale. Especially during past cold periods, there have been times when temperature transitions have been quite rapid – from a few to several degrees change over a century.

Climate changes in the Arctic are consistent with projections of climate change by global climate models forced with increasing atmospheric GHG concentrations, but definitive attribution is not yet possible.

Changes in the Arctic are very likely to have significant impacts on the global climate system. For example, a reduction in snow-cover extent and a shrinking of the marine cryosphere would increase heating of the surface, which is very likely to accelerate warming of the Arctic and reduce the equator-to-pole temperature gradient. Freshening of the Arctic Ocean by increased precipitation and runoff is likely to reduce the formation of cold deep water, thereby slowing the global thermohaline circulation. It is likely that a slowdown of the thermohaline circulation would lead to a more rapid rate of rise of global sea level, reduce upwelling of nutrients, and exert a chilling influence on the North Atlantic region as Gulf Stream heat transport is reduced. It would also decrease the rate at which CO_2 is transported to the deep ocean. Finally, temperature increases over permafrost areas could possibly lead to the release of additional CH_4 into the atmosphere; if seabed temperatures rise by a few degrees, hydrated CH_4 trapped in solid form could also escape into the atmosphere.

Although it is possible to draw many conclusions about past arctic climate change, it is evident that further research is needed. The complex processes of the atmosphere, sea-ice, ocean, and terrestrial systems should be further explored in order to improve projections of future climate and to assist in interpreting past climate. Reconstructions of the past have been limited by available information, both proxy and instrumental records. The Arctic is a region of large natural variability and regional differences and it is important that more uniform coverage be obtained to clarify past changes. In order for the quantitative detection of change to be more specific in the future, it is essential that steps be taken now to fill in observational gaps across the Arctic, including the oceans, land, ice, and atmosphere.

COMPLEX QUALITY CONTROL PRINCIPLES OF UPPER-AIR DATASETS

Alduchov O.A.
Russian Research Institute of Hydrometeorological Information – World Data Center
aoa@meteo.ru

Atmospheric and ocean measurements are taken worldwide everyday at oceanographic and meteorological stations. The observations are used for many operational tasks including local weather forecasting, supporting civilian aviation, and military applications. Nearly all data are collected at regional centers in special datasets, which may be used for many purposes. These datasets are used to study the variability and dynamics of the atmosphere and oceans. It is very important to use observations with minimal errors, to avoid incorrect conclusions. Unfortunately, all datasets contain errors in the data or/and metadata, because of unavoidable "noise" at many stages of data processing (observing, data transfer, data storage, etc.). The primary way to remove errors from any dataset is to use Quality Control (QC) procedures before analyzing the data. Continual increase of computer power allows the use of more complex and sensitive QC procedures. Nevertheless, it is important to understand the nature of the used QC methods and their ability to reject erroneous data and to keep correct data. This task is especially important for historical global datasets, which may contain data from many sources and contain a large variety of errors. This makes the QC task of such historical global datasets much more complex as compared to QC procedures for operational data such as done, for example, at the National Climate Prediction Center, where only the current state of the observational network is taken into account and the only goal is to produce the best weather forecast.

It is easy to detect the very rough errors (large magnitude), but the critical and complex task is to make the correct decision when the data are unusual but plausible: is it an erroneous observation or an actual extreme event? This decision making process is especially important for datasets destined for use in scientific research (for example, such as climatic trend detection).

All QC procedures are based on information redundancy in the data including the total sum of human knowledge about physical processes of the atmosphere. The more redundancy is in the data the greater our ability to quality control the data. On the other hand, the more redundancy the less important these data are to society because most of the information is already known from other sources. Hence, QC developers have to keep a balance between old, well known, knowledge and new knowledge, when quality controlling a dataset. A well-known example is the high wind speeds found in the jet stream, first detected during World War II, these observations were rejected as erroneous for several years.

It is possible to define three logical stages for any QC procedure (some of the steps may be combined for simple QC methods):

1) detection of an error presence;
2) localization of the error;
3) correction of the detected error.

The most challenging problem in any QC algorithm consists of the opposite requirements of the first and third stage, which are both needed to make accurate estimations of each data point. The second stage, localization of the error, is difficult because we do not know a priori which datum is erroneous – the target datum or the reference composite of neighbor data. It means that QC developers have to keep a careful balance between the use of very accurate methods of data interpolation (using data from many stations or levels in a sounding) and using simple and inaccurate methods, using fewer data points.

The next critical problem is to keep a balance between number of accepted erroneous values and the number of rejected correct values, the goal is to minimize both numbers. If we will use very "strong" criteria during QC we may significantly reduce the number of accepted erroneous values, but at the same time, many correct observations will be rejected. However, if a "soft" criteria is used than many erroneous may be accepted values as correct.

All these considerations show that the QC problem is a complex and difficult task, because QC developers have to take into account many conflicting factors to maximize removal of "trash" from dataset and to minimize the rejection of correct values.

Before consideration of specific QC procedures, it is necessary to understand which kind of "errors" we are going to detect. We will use two classifications. First, classification will be based on the origin of the errors. We distinguish between observational errors and rough (or gross) errors. Second classification may be based on statistical properties of errors – random or systematical error. The main subject for QC methods is random, rough/gross errors larger than observational errors. But, at least with respect to upper-air data, we may have a long list of various types of random rough errors and various QC methods may have various sensitivity for every type of errors. QC methods itself may be classified in various ways.

The following conclusions can be made.

1. Any simple (one criterion based) QC method always produces many α and β-errors. This may be not a big problem if we have to QC one hundred or even one thousand values. However, it is a serious problem if we need to QC millions or billions of observations.

2. Consecutive use of simple QC methods is helpful only in the case where one wants to guarantee that not a single erroneous value is accepted as correct. A consequence is many correct values will be rejected as erroneous. It is obvious that such methods of data quality control are appropriate for certain situations.

3. Only way to find a universal solution is to apply CQC methods using all knowledge of applicable processes, including any physical and statistical characteristics. The CQC developer should be very careful with use of any hypothetical knowledge or censuring of the data (jet streams, ozone hole), because it may result in the rejection of correct data.

4. The more components used in CQC the more reliable the results should be, limited by the ability to develop correct DMA's for many CQC components.

5. CQC should contain both type 1 (climatic data) and type 2 (current data) QC methods. With respect to upper-air data, these include climatic checks and methods based on space/time auto and cross-consistency/correlations of observed data for all upper-air variables.

6. CQC should use the most sensitive QC components to detect the presence of errors in any subset of data. At the same time, the CQC components should separate values into subsets with a minimum of common members (with, ideally, one value in the intersected sets) to pinpoint an erroneous value from a subset of suspected values.

7. All erroneous values (identified by any CQC component) should be submitted to the rehabilitation procedure using results of the other CQC components.

8. All potentially correct values (based on the decision of any CQC component) should be checked by all other CQC components.

9. Due to the inhomogeneous characteristics of the atmosphere, it is very desirable (to guarantee reliable QC results) to use the statistical properties determined for each station's data.

10. Continual monitoring of the CQC process is essential as unanticipated types of error may appear in the data and changes will be required in the DMA, because CQC can reliable detect only known or expected types of error.

GEOCHEMISTRY OF THE NIVAL-GLACIAL COMPLEXES OF SVALBARD AND NOVAYA ZEMLYA

Arkhipov S.M.[1], *Hubberten H.-W.*[2], *Vanshtein B.G.* [3], *Meyer H.*[2], *Leibman M.O.*[4], *Ananicheva M.D.*[1]

[1] *Institute of Geography RAS, Moscow, Russia,*
[2] *Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany,*
[3] *VNII Oceangeologia, St.-Petersburg, Russia,*
[4] *Earth Cryosphere Institute SB RAS, Tyumen-Moscow, Russia*

arkhipov@gol.ru

The origin of buried tabular ice is still an open problem. One possible way of its solution is to determine the regular differences in composition of modern surface and ground ice of different but definite and known origin. We consider very useful the elaboration of a general model for isotope-geochemistry transformation of accumulated solid precipitation into relatively solid ice and formation of melt water run-off. The estimates of the content, quality, and consequently, possible anthropogenic pollution of natural waters in general are also of widespread interest to researchers. We studied the main isotopic- geochemical characteristics ($\delta^{18}O$, δD, pH, HCO_3^-, CO_3^{2-}, SO_4^{2-}, Cl^-, Na^+, Mg^{2+}, Ca^{2+}, K^+) and their variability for different water-ice objects of Svalbard and Novaya Zemlya: snow and firn cover, snow patches, glacier (including congelation and buried ice), wedge ice, icings, river, lake and bog waters. The emphasis has been on the study of marginal parts of glaciers (including proglacial areas) and comparative analysis of modern and old (buried) glacier ice. Compound nival-glacial complexes (NGC) forming at the contact of glacier ice with non-glacier surfaces (the glacial marginal zones) could be the most probable source of buried glacier ice.

All types, almost all classes and families of natural ice and waters of Nordenskiцld Land have individual set of geochemical characteristics. Variations of these characteristics within majority of the families are extremely large as 10–20 and even > 100 times. The «semiquantitative» analysis of maximum and minimum values allowed distinguishing the natural ice of different origin and understanding the main regularities and formation stages of its geochemical characteristics.

This work was supported by INTAS Project 01-2211 untitled as “Comparison of composition and structure of various modern natural ice types as indicators of origin of ancient tabular ground ice and Pleistocene-Holocene climate history of the Western Arctic”.

DEEP DRILLING OF GLACIERS: RUSSIAN PROJECTS IN ARCTIC 1975–1995 (Version 2000)

Arkhipov S.M.
Institute of Geography RAS, Moscow, Russia
arkhipov@gol.ru

The data bank ґDeep Drilling of Glaciers: Soviet-Russian* Projects in Arctic, 1975–1995[a] (Version 2000) is governed by the following basic considerations:

– incorporation in bank of all deep (>100 m) drilling projects on Arctic glaciers, using data of (*a*) publications; (*b*) archives of IGRAN (Institute of Geography, Russian Academy of Sciences); (*c*) personal communications of project participants;

– entering in bank of all studied parameters of bore holes and ice cores (including an additional information – drilling type, position of drilling sites and other);

– when systematic discrepancy of data in different publications or authors occur – presentation of all available data on the same parameter (with appropriate references to sources); accuracy and comparability of available data and techniques applied to determine different parameters are not evaluated in this stage; it also is to be taken into attention, that the accuracy of a lot of geochemical parameters (up to1984 and heavy metalls[a] especially) is very uncertain. Most reconstructions of ice core age and of annual layer thickness are discussed, in the lower part of holes, especially;

– wide use of digitizing of published diagrams (in case, when original or mean numerical data are not available) and subsequent data conversion to equal-range series and adjustment to the common units.

Therefore, the equal-range series were calculated from original data (′*rc*[a], see below) or converted from digitized chart values (′*rc*[a]). For the methodological purposes, while conversion procedure was performed, the equal-range series obtained from original and reconstructed data were compared repeatedly: the systematic difference was less then 5–7% as a rule.

Special attention should be given to the fact, that, as in another projects, the data representativity for individual ice core parameters varies strongly, because some parameters were originally measured or registered as practically continuos records, but other ones – only fragmentary, i.e., with 2–10 m step or more and in 0.2–2.0 m length samples, some others – not along all section, and so on. Therefore, as a rule the parameters were converted in equal-range (with depth) series using 2 m step, it is assumed, that if for the specific depth interval (2 m length) or its part:

– two or more parameter values were determined, then the mean-weighted (i.e. accounting the sample length) value is assigned to the entire interval;

– one parameter value was determined, measured or registered independently from the parameter values in depth intervals which over- and underlie it, then the value is assigned to the entire interval;

– one parameter value was determined, measured or registered for two adjoining depth intervals at once, then the specific value is assigned to the depth interval, which represents >75% of sample length; if each of adjoining depth intervals represents <75% of sample length, then the correspondent parameter value is assigned to both intervals of depth.

---

* *a*) In 1975–1990 the separate Projects were carried out not only by Russian scientists, but their colleagues from other republics of USSR as well, which now become the independent states; *b*) Including projects with Russian participants, but without Russian financial support.

DATA BANK CONTENTS

DATA BANK "THE GLACIERS OF SVALBARD AND RUSSIAN ARCTIC ARCHIPELAGOS AND ISLANDS" (Version XI. 98)

Arkhipov S.M.
Institute of Geography RAS, Moscow, Russia
arkhipov@gol.ru

Data bank contents:

– name of region (archipelago or island) and of island;

– name of main drainage region (sea or sea gate);

– name of island subregion, mountains or plateau;

– ice body identification number as defined by the World Glacier Monitoring Service's convention (World Glacier Inventory);

– ice body ordinal number as defined by the "Catalogue of Glaciers of USSR" (by separate islands or regions);

– ice body class by WGMS (6-digit code);

– main type of ice body (glacier part, glacier or glacier complex);

– main morphotype of ice body and any additional morphological characteristics;

– name of ice body;

– name of the glacier complex, which part is a glacier part, a glacier or a subordinate glacier complex;

– latitude (North) and longitude (East);

– year of the topographic map, year and type of photo used for measurements of the most ice body parameters;

– total area of the ice body;

– maximum length of the ice body;

– thickness and volume of the ice body;

– maximum, mean and minimum elevation;

– aspect (mean direction for the slope) of the accumulation and ablation area;

– ablation area;

– altitude of the snow-line or of the equilibrium line (estimated with the location of the lateral moraine);

– main type of the snow-line, type and date of its altitude measurements;

– open ice area, maximum length and minimum elevation;

– moraine type;

– probable errors;

– references.

The year to which the data belong, coincides with the year indicated in the column MAP YEAR, as a rule.

The year is indicated in the title of separate columns in following cases:

– if the year to which the data belong, does not coincide with the year indicated in the column MAP YEAR;

– if two or more columns exist, which have data of the same kind, belonging to different years.

Depending on the quantity and the quality of the data, the structure of the files by separate regions and /or appendices may vary.

Regions:

NAME	TYPE	ABB
JAN MAYEN	Island	JNM
SVALBARD	Archipelago	SVL
VICTORY	Island	VIC
FRANZ-JOSEF LAND	Archipelago	FJL
NOVAYA ZEMLYA	Archipelago	NVZ
USHAKOVA	Island	USH
SEVERNAYA ZEMLYA	Archipelago	SVZ
DE-LONGUE	Islands (the part of Novosibirskiye islands)	DLN
VRANGELYA	Island	VRN

Appendices:

ABB	CONTENTS
MAIN	Detailed characteristic of glacier parts and glaciers (all known parameters), the composition (structure) of glacier complexes.
EQL	Detailed characteristic of the altitude and type of the snow-line, date and type of altitude measurements (by glacier parts and glaciers).
GLX	Detailed characteristic of all ice dome-caps, ice caps, flat-summit and comb-cap glaciers, ice cap-sheets and ice sheets (including reticular) which are separate ice bodies and parts of the glacier complexes of higher class. Total characteristic of all other glaciers and glacier complexes which are conjugated or not conjugated with ice cap-sheets and ice sheets.
REG'AREA	Total area and quantityof islands and of ice bodies (by islands). The distribution (by islands) of ice dome-caps, ice caps, flat-summit and comb-cap glaciers, ice cap-sheets and ice sheets (including reticular) by quantity and areas.
REG'VOL	Total volume of all ice bodies (by regions), cb km.
REG'ASPECT	The distribution of total areas of ice bodies by aspect.
REG'THK	Maximum and minimum elevation (altitude of the highest point) of ice bodies, in meters (m) at sea level.
REG'ELV	Maximum thickness of ice bodies, measured by drilling and/or radio echo-sounding, m.
REG'ELA	The altitude or location of the equilibrium line or of the snow-line (the lower boundary of firn or of the superimposed ice), at sea level, m.

PALEOCLIMATE OF THE ARCTIC IS A KEY TO UNDERSTANDING CURRENT AND FUTURE CLIMATE CHANGES IN THE EARTH'S NOTHERN POLAR AREA

Bolshiyanov D.Yu., Fedorov G.B., Pavlov M.V.

Arctic and Antarctic Research Institute, Russia

bolshiyanov@aari.nw.ru

The traditional for the AARI paleo-climate studies allow revealing the direction and cyclicity of climate changes in the polar regions throughout the time intervals that are much greater than a short-term period of instrumental observations. A possibility appears to increase the meteodata series by scores of time without which the analysis of climatic variability for the forecasting purpose is impossible.

Based on the study of glaciers, bottom lacustrine sediments, peat bogs and other types of quaternary sediments, climate reconstructions throughout the Holocene (for the last ten thousand years) and the last millennium were made.

Curves of the oscillations of relative summer air temperature were constructed in 14 sectors of the circumpolar Arctic for 10 000 years based on the analysis of all available data on spore-pollen analysis of the Holocene deposits (Fig. 1). On the basis of a comprehensive study of bottom sediments of the Russian Arctic lakes, knowledge on the spatial and temporal changes in the course of the Little Ice Age was obtained (Fig. 2).

For the last 10 000 years, climate cooling occurs in the Arctic. The warmest phase of the Interglacial has been passed and it was noted at different time. In the Atlantic paleo-climate province, the Holocene climatic optimum took place during the period 7–4 kyr BP and in the Siberian-Canadian – during the period 10–8 kyr.

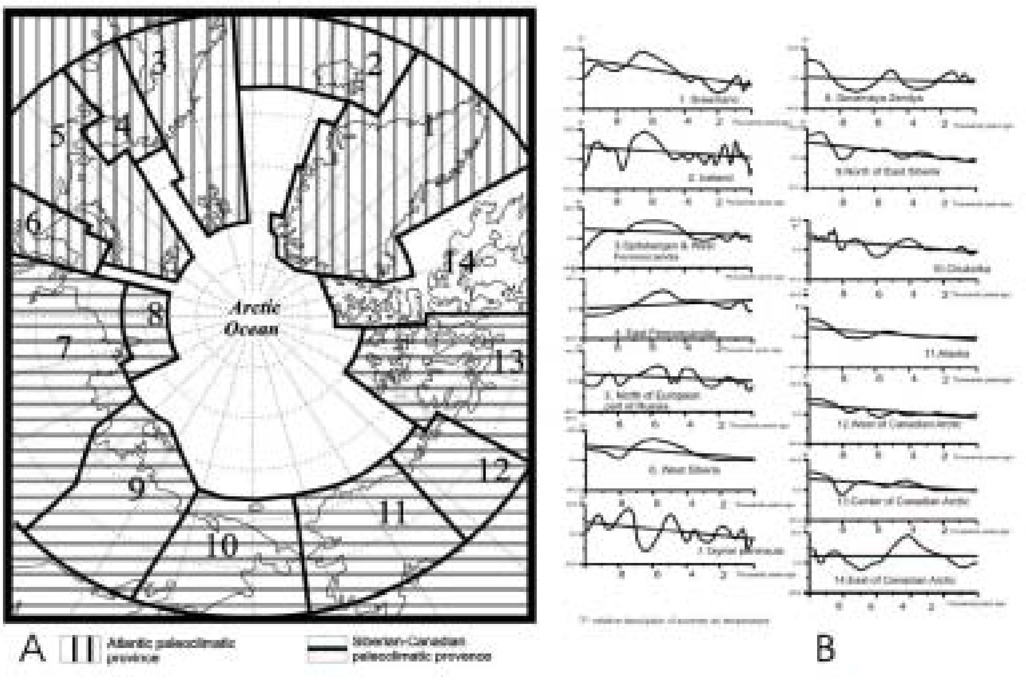

Fig. 1. *A* – paleoclimatic provences & sectors of the Arctic; *B* – summer temperature fluctuations in the Arctic during the Holocene (last 10000 years)

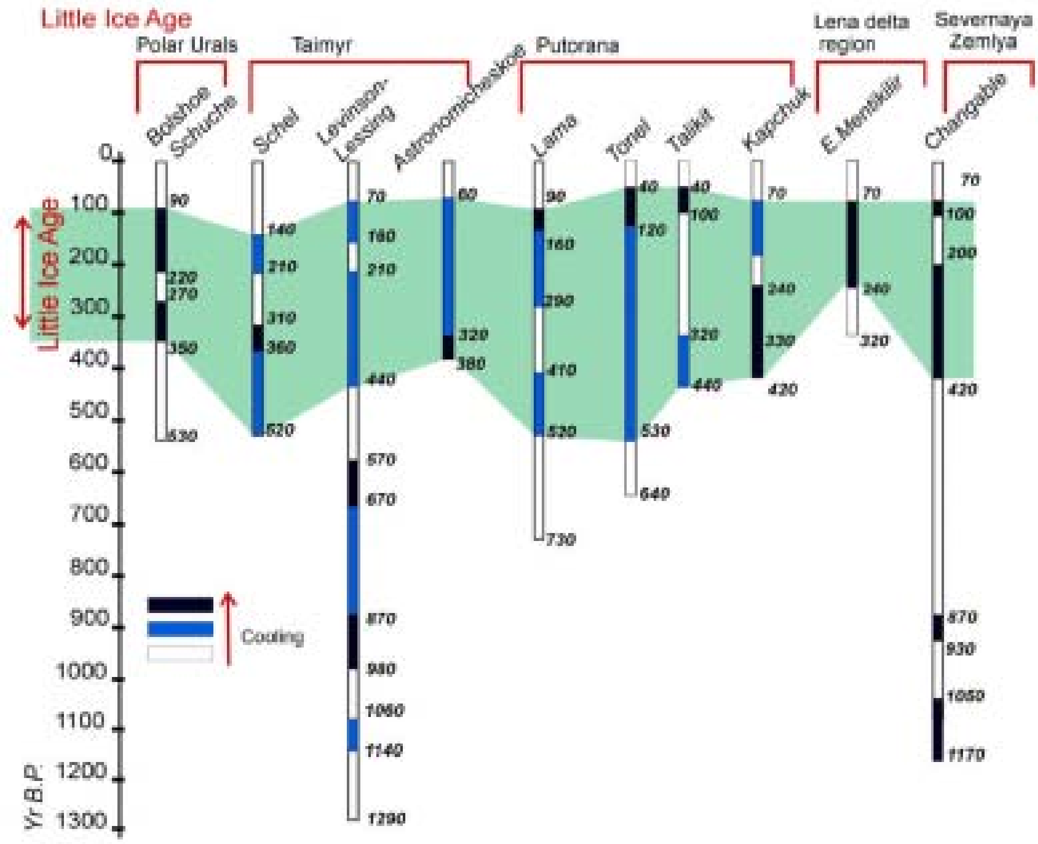

Fig. 2. Little Ice Age time in the Russian Arctic based on lake sediments studying

The climatic oscillations occur asynchronously even in a separately taken considered sector.

The climate oscillations are also asynchronous throughout the last millennium. The beginning of the Little Ice Age in the investigated regions of the Russian Arctic was in 1480 and the end in 1860–1960. The time of the beginning and end of the Little Ice Age differs significantly in different regions of the Arctic. At the time of cooling, a phase of warming is recorded with duration of 20 to 100 years. During the last 140–40 years, a warming event occurs. Due to its manifestation before the onset of the technogenic era and the presence of cyclic alternating cooling and warming events during the earlier time intervals of the last millennium, a conclusion can be made that the last warming event is of a natural character and will be again replaced by cooling in the near future.

CLIMATIC CHANGES OF CLOUDINESS AND SOME UPPER-AIR PARAMETERS IN ARCTIC REGION

Chernykh I.V., Alduchov O.A.
All-Russian Research Institute of Hydrometeorological Information – World Data Center, Russia
civ@meteo.ru

The problem of climate warming at the surface level and in the troposphere is close to problem of clouds changes due of their effects on solar radiation and terrestrial radiation. But it is not all clear about the effect of cloudiness changes because cloudiness is very complex object for study. Different cloud types are forming in the different atmosphere levels. Effects of cloudiness on solar radiation and terrestrial radiation depend from height of low and high cloud boundaries, its thickness, and cloud amount.

Last time changes of cloud amount and parameters of its vertical macrostructure were detected in global and regional scale. Changes of frequency of some clouds types in different regions of globe were detected also. Changes of cloud amount have been detected on base as surface and satellite observations. However increasing of cloud amount for some regions and decreasing for other regions were determined on base surface observations. Decreasing of global cloud amount was founded on base ISCCP dataset. At present time these results can not be fully explained.

The study of climatic changes of cloud layers vertical structure in different atmospheric layer and main upper-air parameters at standard levels for Arctic region is presented for improving our understanding of cloudiness changes. CARDS date set was used for the research. CE-method developed by Chernykh and Eskridge for cloud layers determination on base temperature and humidity profiles was used. Knowledge of the variations in cloudiness and main upper-air parameters will contribute to improving our understanding in contemporary climate change in atmosphere over Arctic region.

To obtain a reliable estimation of changes in cloud parameters, it is necessary to have long time series of detailed cloud data (amount, bases, and tops, thickness and etc.). A database of global radiosonde observations (CARDS dataset), accumulated for a relatively long period, and CE-method for determining cloud boundaries and cloud amount give possibility to produce reliable and objective data describing the longtime changes in cloud structure. But all results about cloud parameters changes were obtained only for central month of season due not enough computer power.

Fortunately, at present time the increasing of computer power allows the creation of longtime dataset of cloud vertical macrostructure parameters on base longtime dataset of standard radiosonde observations for Arctic region (or for Globe) by using of CE method for determination of cloud boundaries and amount. This dataset will contain time series of cloud boundaries and cloud amount for cloud layers. On base of this dataset everyone can obtain monthly or yearly averaged mean values for many parameters of clouds: cloud base and top, frequency, thickness and number of cloud layers with different cloud amount: 0–20%, 20–60%, 60–80%, 80–100%, 0–60%, 0–80%, 0–100%, 20–80%; 20–100%, 60–100% of the sky in different atmospheric layers: 0–2 km, 2–6 km, 6–10 km, 0–6 km, 2–10 km, 0–10 km which correspond to low, middle and high cloud levels and its combination. This dataset will be useful for understanding cloudiness changes obtained on base surface and satellite observations. Creation of

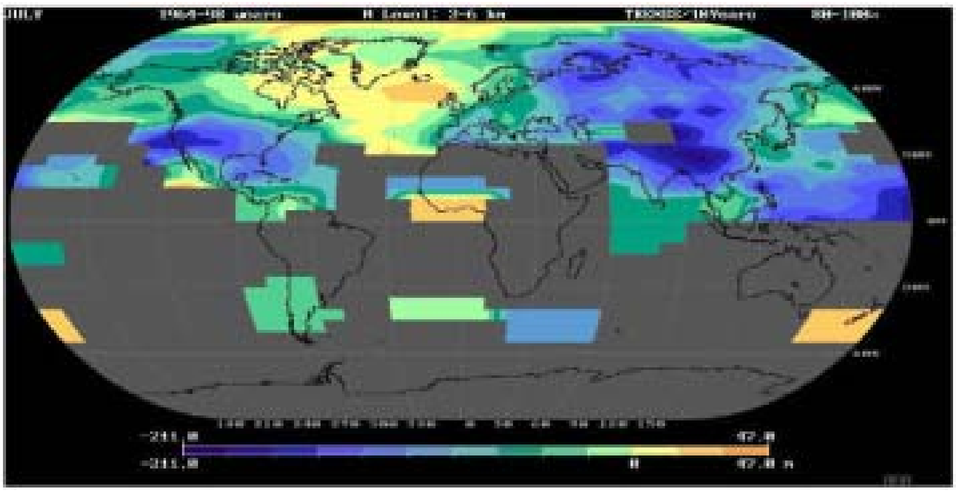

Figure 1. Pattern of the decadal changes calculated from linear trend model of middle cloud layers thickness. CARDS. July. 1964–1998.

such dataset will give possibility to get new knowledge about clouds, its changes, in different atmospheric layers and answer on the question: “What are the interrelations between climate change of temperature, humidity, and wind regimes, polar ice melting, and changes in cloudiness at polar regions?” Also this dataset will be useful for civilian aviation and validation of satellite instrumentation.

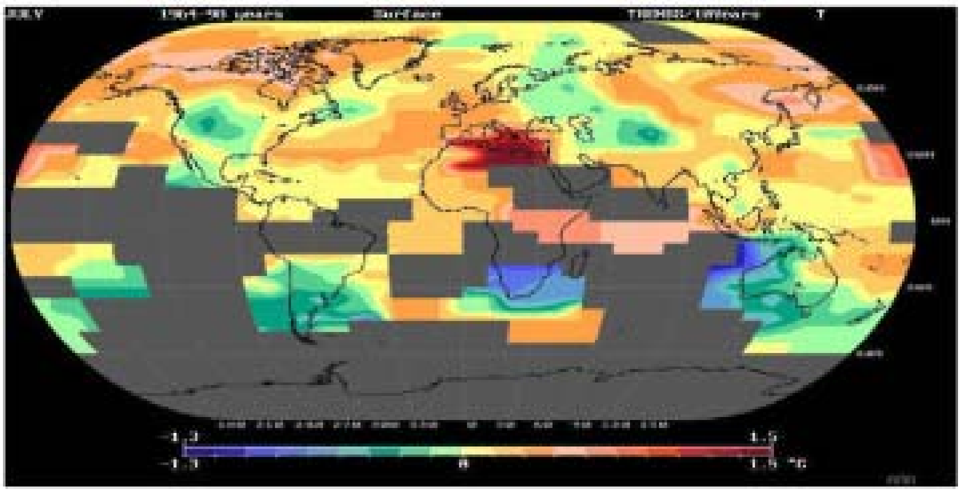

Figure 2. Pattern of the decadal changes calculated from linear trend model of temperature at surface level. CARDS. July. 1964–1998.

Creation of this cloud parameters dataset will give more objective cloud data compared to visual observations (for example, for middle and high clouds when overcast low clouds are present). Determination of clouds by CE method has same skill day or night independently of visibility. This is especially important in the Arctic and Antarctic regions which have half a year of darkness.

At present time for complex study of clouds changes it is necessary to have complex of longtime datasets, obtained on base different platform of observations due every method of observations has some specific limitation of used instrumentation.

International collaboration in cloud changes study will be very useful.

LONG TERM CHANGES IN UV IRRADIANCE OVER MOSCOW REGION AND COMPARISONS WITH UV ESTIMATES FROM TOMS AND METEOSAT

***Chubarova N.E.*[1], *Nezval E.*[1], *Verdebout J.*[2], *Krotkov N.*[3], *Herman J.*[4]**

[1]*Moscow State University, Russia,*

[2]*European Commission, Joint Research Center, Institute for Health and Consumer Protection, Ispra, Italy,*

[3] *Goddard Earth Sciences and Technology Center, University of Maryland Baltimore County?*

[4]*Laboratory for Atmospheres, NASA Goddard Space Flight Center, USA*

chubarova@imp.kiae.ru

We analyzed long-term changes in ultraviolet irradiance 300-380nm during 1968–2003 period in Moscow (55.7°N, 37.5°E) which has been obtained by broadband MOMSU ultraviolet radiometer. In addition we examined variability of UV erythemally-weighted (EW) irradiance during 1999–2003 over Moscow and Moscow suburb with the help of UVB-1 (YES, Inc) instruments. In order to evaluate the significance of different factors influencing UV radiation we used the empirical model updated from Chubarova and Nezval' [JGR, 2000] which accounts for the physical dependence of UV on cloud parameters (amount and optical thickness), surface albedo, total ozone and aerosol properties of the atmosphere. The calculated UV variability reveals a satisfactory agreement with ground UV measurements. On the whole, long-term UV irradiance variability has detected distinct drop in 1980s and the increase towards the late 1990s (Figure 1).

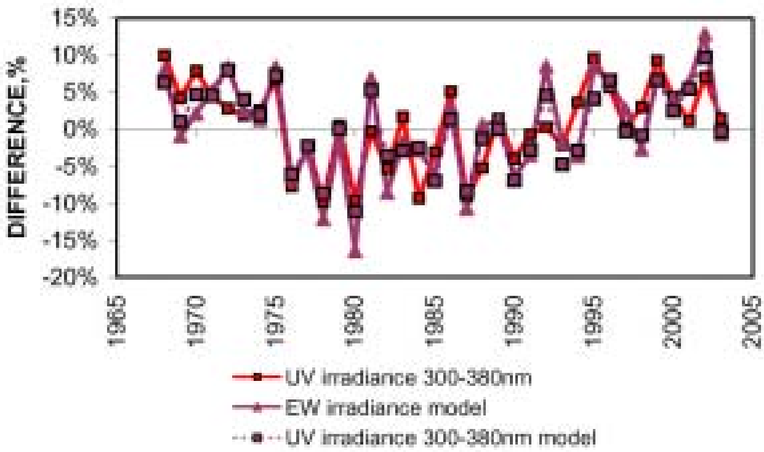

Figure 1. Interannual variability in UV 300–380nm and EW irradiance according to measurements and model reconstruction. Warm period.

At the same time the analysis of observations as well as of model reconstruction of both UV irradiance 300-380nm and EW irradiance did not reveal any trend for the period analyzed. In addition, the results of the empirical model as well as of the ground UV measurements were compared with UV datasets over Moscow obtained from different satellite instruments: from the Total Ozone Mapping Spectrometer (TOMS) new data (version 8) since 1979 and from METEOSAT since 1984. For TOMS UV retrievals we used the UV program (version 1.5) according to Krotkov et al. [Opt. Eng., 2002] while for METEOSAT the JRC UV algorithm proposed by Verdebout [JGR, 2000] has been applied. There is a satisfactory agreement in both day-to-day and interannual variability in TOMS, Meteosat and ground-based measurements during warm period. During cold period a poor correlation is observed between both TOMS and standard Meteosat UV retrievals with ground UV irradiance 300-380nm time series (r = 0.24 and r = 0.19). Even negative correlation takes place between UV retrievals from both satellite instruments (r = –0.37). There is a large negative bias between standard JRC UV retrievals and ground UV irradiance 300–380nm. The application of right aerosol properties of the atmosphere in JRC algorithm instead of standard aerosol retrievals from ground visibility data has led to the elimination of both seasonal and temporal shifts and has significantly improved the agreement with ground based data especially during cold period (r = 0.56). On the whole, both satellite algorithms shows an agreement with ground- based data during warm (snow-free) period (mean difference lies within ±8 %) if we apply "right" aerosol atmospheric properties in JRC algorithm.

Chubarova N., Nezval Ye. Thirty year variability of UV irradiance in Moscow, J. Geophys. Res., Atmospheres, 105, 12529–12539, 2000.

Krotkov N. et al. Version 2 total ozone mapping spectrometer ultraviolet algorithm: problems and enhancements. Opt. Eng. 41, 12, 3028–3039, 2002

Verdebout J. A method to generate surface UV radiation maps over Europe using GOME, Meteosat, and ancillary geophysical data, J. Geophys. Res., [Atmos.] 105, 5049–5058, 2000.

IMPACTS OF A WARMING ARCTIC: THE FINDINGS OF THE ARCTIC CLIMATE IMPACT ASSESSMENT

Corell R.W.
American Meteorological Society Atmospheric Policy Program
global@dmv.com

The ACIA is a comprehensively researched, fully referenced, and independently reviewed evaluation of arctic climate change including changes in ultraviolet radiation and their impacts for the region and for the world. The assessment has involved an international effort by hundreds of scientists and other experts over four years and includes the special knowledge of indigenous peoples. The assessment documents that the arctic climate is changing rapidly now and that the impacts are both of global importance and regional significance.

Earth's climate is changing, with the global temperature now rising at a rate unprecedented in the experience of modern human society. While some historical changes in climate have resulted from natural causes and variations, the strength of the trends and the patterns of change that have emerged in recent decades indicate that human influences, resulting primarily from increased emissions of carbon dioxide and other greenhouse gases, have now become the dominant factor.

These climate changes are being experienced particularly intensely in the Arctic. Arctic average temperature has risen at almost twice the rate as the rest of the world in the past few decades. Widespread melting of glaciers and sea ice and rising permafrost temperatures present additional evidence of strong arctic warming. These changes in the Arctic provide an early indication of the environmental and societal significance of global warming.

An acceleration of these climatic trends is projected to occur during this century, due to ongoing increases in concentrations of greenhouse gases in the earth's atmosphere. While greenhouse gas emissions do not primarily originate in the Arctic, they are projected to bring wide-ranging changes and impacts to the Arctic. These arctic changes will, in turn, impact the planet as a whole. For this reason, people outside the Arctic have a great stake in what is happening there. For example, climatic processes unique to the Arctic have significant effects on global and regional climate. The Arctic also provides important natural resources to the rest of the world (such as oil, gas, and fish) that will be affected by climate change. And melting of arctic glaciers is one of the factors contributing to sea-level rise around the globe.

Climate change is also projected to result in major impacts inside the Arctic, some of which are already underway. Whether a particular impact is perceived as negative or positive often depends on one's interests. For example, the reduction in sea ice is very likely to have devastating consequences for polar bears, ice-dependent seals, and local people for whom these animals are a primary food source. On the other hand, reduced sea ice is likely to increase marine access to the region's resources, expanding opportunities for shipping and possibly for offshore oil extraction (although operations could be hampered initially by increasing movement of ice in some areas). Further complicating the issue, possible increases in environmental damage that often accompanies shipping and resource extraction could harm the marine habitat and negatively affect the health and traditional lifestyles of indigenous people.

Climate change is taking place within the context of many other ongoing changes in the Arctic, including the observed increase in chemical contaminants entering the Arctic from other regions, overfishing, land use changes that result in habitat destruction and fragmentation, rapid growth in the human population, and cultural, governance, and economic changes. Impacts on the environment and society result not from climate change alone, but from the interplay of all of these changes. This assessment has made an initial attempt to reveal some of this complexity, but limitations in current knowledge do not allow for a full analysis of all the interactions and their impacts.

The impacts of climate change in the Arctic addressed in this assessment are largely caused from outside the region, and will reverberate back to the global community in a variety of ways. The scientific findings reported here can inform decisions about actions to reduce the risks of climate change. As the pace and extent of climate change and its impacts increase, it will become more and more important for people everywhere to become aware of the changes taking place in the Arctic, and to consider them in evaluating what actions should be taken to respond.

The changes already underway in arctic landscapes, communities, and unique features provide an early indication for the rest of the world of the environmental and societal significance of global climate change. As this assessment illustrates, changes in climate and their impacts in the Arctic are already being widely noticed and felt, and are projected to become much greater. These changes will also reach far beyond the Arctic, affecting global climate, sea level, biodiversity, and many aspects of human social and economic systems.

As the scientific results presented in this assessment clearly illustrate, climate change presents a major and growing challenge to the Arctic and the world as a whole. While the concerns this generates are important now, their implications are of even greater importance for the future generations that will inherit the legacy of the current actions or inaction. Strong near-term action to reduce emissions is required in order to alter the future path of human-induced warming. Action is also needed to begin to adapt to the warming that is already occurring and will continue. The findings of this first Arctic Climate Impact Assessment provide a scientific basis upon which decision makers can consider, craft, and implement appropriate actions to respond to this important and far-reaching challenge. Climate change in the Arctic thus deserves and requires urgent attention by decision makers and the public worldwide.

RUSSIAN PROGRAM OF THE IPY-2007/2008 STUDIES IN THE ARCTIC

Frolov I.Ye., Danilov A.I., Dmitriev V.G., Priamikov S.M., Klepikov A.V.
Arctic and Antarctic Research Institute,
v_dmitriev@aari.nw.ru

The Russian Arctic plays a key role in the formation of the environmental conditions of the entire Arctic not only due to its large area, but primarily to a significant continental runoff, development of the processes of ocean/atmosphere interaction, vast sea ice volumes, large area of permafrost and also presence of glaciers. It is noted that in addition to natural changes, the environment of the Arctic regions experience anthropogenic impacts. Pollutants transferred to high latitudes through the atmosphere, river and sea waters influence the ecosystems and Man in the end. This can affect the population of the Arctic, whose way of life is closely connected with their specific environmental circumstances. The changes expected in the Russian Arctic due to global warming will have a noticeable impact on the environment, human life and economic activities in these areas.

The Russian studies of the Arctic are carried out by the research institutes of Roshydromet, Russian Academy of Science, Ministry of Natural Resources, Russian Polar Foundation and other ministries and agencies. The main source of data on polar regions is a state system of routine observations. It is based on a network of land-based hydrometeorological stations in the Arctic which includes 48 stations. The synoptic observations are carried out at all stations including upper-air observations at 6 stations, with data of 23 stations reported in real-time to GTS of WMO. At all stations, environmental pollution monitoring is conducted. In addition, Roshydromet organizes on a systematic basis the scientific expeditions in the Arctic to study physical oceanography and the sea ice in the Central Arctic Ocean and in the shelf seas, to investigate the state of marine environment pollution, and to obtain new data necessary for decision-making, including the development of transport systems, exploration of mineral resources of the continental shelf and marine environment protection. In spring of 2003 after a long interruption, the Russian research drifting station "North Pole-32" was landed on the ice and its operation was organized. In September of 2004 ice drifting station "North Pole-33" was launched.

In the framework of the development of national IPY programme a preliminary proposal packet on the activity of the scientific organizations of Russian Federation during the period of 2007/2008 IPY was formed and submitted to the IPY International Programme Office. It is proposed to complete a vast complex of field studies during the period of 2007/2008.

Russian proposals Statistics include:

Disciplines	**Number of Projects**
Polar Environment Multidisciplinary Studies	7
Climate and Palaeoclimate	3
North Polar Atmosphere	5
Ocean and Seas	3
Space and Upper Atmosphere	4
Cryosphere	2
Litosphere	9
Ecosystems	1
Observation System	1
Total	35

In the Arctic region the work carried out by the joined efforts of AARI, Institute of oceanology RAS, VNIIOceangeology and other organizations in the Arctic Ocean will include high-latitude expeditions on board the r/v «Akademik Fedorov» and drifting station "North Pole", as well as several expeditions in the Arctic seas in the framework of Russia – Germany (the Laptev Sea) and Russia – the USA (the Laptev, the East-Siberian and the Chuckchi Seas) cooperation programmes. A complex of observations will be conducted to the benefit of climate, ecosystem and other projects. Environmental conditions assessment of various Arctic Ocean and bordering regions will be obtained. The Arctic hydrometeorological stations observation data are of great importance. It is proposed to implement a partial modernization of a number of stations, prepare and space the automatic meteorological stations and drifting buoys. In the framework of Roshydromet and NOAA (USA) collaboration it is planned to organize in Tiksi an observatory for long-term climate monitoring that will be included in the network of 3 or 4 like stations (Alaska, North Canada, Greenland).

Climate research in the Arctic will include paleoclimate information and modern climate change data collecting. It is planned to organize work at Elgytgytgyn lake on sedimentary rock sampling that contain climate and other types of information on the changes during the recent million of years, as well as to conduct research of a number of glaciers and glacier cupolas that serve Arctic climate change indicators and Arctic icebergs sources. Oriented climate research will be conducted on the Spitsbergen archipelago (Barentsburg, Ny-Alesund), Franz Josef Land arch. (Kheisa Island), Novaya Zemlya Island (Malye Karmakuly station). The Arctic atmosphere research comprise the radiation and thermal regime parameters, cloudiness, trace gases and aerosol component, greenhouse gases concentration, ozone and boundary atmospheric layer parameters observation.

A series of projects involving AARI and RAS organizations is oriented at the near-earth space processes research. This comprises the study of magnetosphere dynamics and geomagnetic activity, polar and subpolar ionosphere physical processes, high-latitude charged particle fluxes monitoring etc, using the surface geophysical network observation and space facilities. The Arctic environmental pollution and polar ecosystems research including the sea ice ecosystems, bottom and deep-sea research are important working direction. A considerable part of MNR and RAS organizations projects is aimed at the Arctic lithosphere research. The work is planned basing on the federal and departmental programmes aims and objectives.

In the scientific aspect, the expected results will permit the preservation of national heritage: the outcomes of the various generations of Russian and Soviet Earth polar researchers activity aimed at further implementation will create a potential for scientific research development and information supply activities in the polar regions, contribute to national and world science development, provide an opportunity for understanding the scale of natural climate system variability and estimate the trend of future climate changes, as well as become a base for increasing the possibility of projecting the natural environmental conditions.

CURRENT OPERATION OF THE "NORTH POLE" DRIFTING STATIONS AND FUTURE PLANS

Frolov I.E., Sokolov V.T.
Arctic and Antarctic Research Institute, Russia
frolov@aari.nw.ru, svt@aari.nw.ru

In 2003, Russia resumed the program of high-latitudinal studies of the Arctic Ocean on the basis of the "North Pole" drifting stations.

In April 2003, a new Russian "North Pole-32" drifting station was opened. It was organized on the basis of the decision of the Roshydromet Board as proposed by the Association of Polar Explorers and the Arctic and Antarctic Research Institute. The scientific program was prepared and supervised by the Arctic and Antarctic Research Institute. The investor and the main logistics supplier was a Non-Commercial Partnership "Polyus" Center. A team of 12 people worked at the station (10 people from the AARI staff and 2 people from the "Polyus" Center).

The station was organized using aviation method on drifting ice of the Arctic Ocean. Landing of the station on drifting ice began on April 16, 2003. The station was opened on April 25, 2003.

A complex of meteorological observations, ozone measurements (in the summertime), oceanographic sounding of the ocean, investigations of currents and dynamic characteristics of the ocean in the drift area, study of physical processes in ice, biological and ecological studies and sampling over a wide range of parameters was conducted at the station. The station operated for 309 days.

Specialists of the AARI, RAS IO, MGO and SPbSU participated in creation and implementation of the research program.

During its operation from April 16, 2003 to March 3, 2004, the station passed a total route of 2306 km with a mean speed of 7.5 km/day. The general drift comprised 772 km.

The ice, meteorological and oceanographic studies that began at the "North Pole-32" drifting station served as the starting point for reconstruction of the long-term program of the Russian high-latitudinal studies from drifting ice of the Arctic Ocean.

In accordance with the perspective plans for year-round observations by contact methods in these regions of the Arctic, the AARI has prepared a Program of two-year basic studies at the "North Pole-33" drifting station and obtained approval of Roshydromet and the Scientific Council of the Russian Academy of Science on the Arctic and Antarctic studies.

The work at the NP-33 drifting station aims at comprehensive studies at the natural observation ice platform in high latitudes of the Arctic. This complex of observations is unique since it realizes a series of controlled experiments on ice and hydrometeorological parameters in the high-latitudinal Arctic in the annual cycle of studies.

The station was prepared and organized on drifting ice of the high-latitudinal Arctic in the first 10 days of September 2004 by a ship method. The AARI research expedition vessel "Akademik Fedorov" with the support of the atomic icebreaker "Arktika" and helicopter conducted this operation during a 55-day high-latitudinal Arctic cruise.

The official opening of the station was on September 9, 2004. A team of 11 specialists who carry out the basic research program works at the station.

The main goals of the drifting station operation include a complex of environmental studies, monitoring of hydrometeorological parameters and pollution, study of the climatic variability of the region and acquisition of new data on the Arctic basin of the Arctic Ocean on the water mass characteristics; hydrometeorological and ice processes; radiation processes in the "atmosphere-sea ice-upper sea layer" system, hydrobiology, cryobiology, cytology, ice cover

structure and local dynamics in the high-latitudes of the Arctic, physical-mechanical, radiation and thermal-physical properties of the snow cover and sea ice characterizing the current state and variability of the ice cover, and changes in the state of the Arctic ecosystems.

The indicated objectives are achieved in the framework of the following sub-programs: physical oceanography and hydrochemistry; meteorological observations, sea ice studies (including sub-satellite experiments); geochemical and ecosystem studies and hydrobiological studies.

From spring of 2005, the research program at the NP-33 is expanded by both the AARI specialists on ice research problems, ozone measurements and radiation processes in the sub-ice layer and sea ice, and scientists of the Norwegian Polar Institute (NP) on the problems of validation of satellite sea ice images and IARC (the USA) on the study of carbonate system dynamics.

An important aspect of further development of investigations at the “North Pole” drifting stations is their use for the formulation and implementation of the Program for IPY 2007/2008. Creation of a new international drifting station (or continuation of the currently operating Russian station) will become a basis for undertaking a complex of environmental studies, monitoring of hydrometeorological parameters and pollution, study of the climatic variability of the region and acquisition of new data on the Arctic Ocean.

A very significant aspect in establishing and maintaining the work of the drifting stations is the logistics since organization of the station on ice and maintaining it in the operation mode makes it necessary to use ice class ship and atomic icebreaker during the period of organization, create conditions for the flights of airplanes to the ice floe (this will require remote bases on the Arctic Islands) and set up a combined air group with the corresponding permits and licenses for provision of flights.

The delivery to the drifting station of personnel, scientists and specialists, instruments and equipment requires in each specific case a special decision and is determined by multiple factors.

The currently available data on the state of the Arctic environment confirm the existence of significant changes in the environment of the region, the consequences of which can influence during the next decades the nature and the social-economic activity both locally and globally.

The results obtained at the drifting stations will allow us to collect extremely important data on the natural environment of the Arctic Basin under the conditions of climatic system modification.

Conducting complex studies on drifting ice of the high-latitudinal Arctic has a unique character for the entire structure of projects of the IPY 2007/2008 and can play a special role since the implementation of experiments in this difficult-for-access region will allow obtaining a wide range of data on most environmental parameters in the annual cycle of the studies.

RUSSIAN ARCTIC AND SIBERIA GREENHOUSE GASES STUDY: MEASUREMENTS AND MODELLING

Jagovkina S.V.[1], Karol I.L.[1], Lagun V.E.[2], Reshetnikov A.I.[1], Paramonova N.N.[1], Privalov V.I.[1], Zinchenko A.V.[1]

[1]Main Geophysical Observatory, [2]Arctic and Antarctic Research Institute, Russia

svetlana@main.mgo.rssi.ru

Russian Arctic and Siberian region is among the most intensive sources of green house gases (GHG). Large gas fields are located and marshes occupy the most part of this area. At the same time direct measurements of GHG are rare, unhomogeneously distributed in space and as a rule describe a small area. Therefore it seems reasonable to use the empirical relationships between local measurements of high precision and some external parameters of surroundings. Due to warming conditions observed in Arctic especially important seems the influence of temperature change on the flux intensity. The warming of surface air is accompanied by warming in upper soil layer, with largest trends in permafrost regions. Under warming conditions the methane fluxes can be increased essentially not only due to surface temperature growth but also due to expansion of thawing areas and deepening of thawing layer. 3D regional model is used for verification of GHG flux parameterisations. Numerical estimations of spatial distribution of natural methane fluxes from Greatest Siberian wetland area were executed using available local statistical dependence between methane fluxes intensity and wetland environment parameters (water table, temperature regime, marshes type). This parameterisation was input into specially developed 3D regional atmospheric transport model (Jagovkina et al., 2000). The four types of boreal wetland ecosystems parameters were generalised for methane emission calculation: polygonal oligotroph wetland, hummock oligotroph wetland, Sphagnum bog, evtroph and mesotroph wetland (sedge bog) based on 30-years field expedition results and NCAR/NCEP meteorological data (Lagun et al., 2002). The results of 3D regional transport model are verified by direct measurements of methane concentrations and methane fluxes in West Siberian region. It allows estimate spatial distribution of CH_4 fluxes with high resolution. Summer natural methane emission from Northern part of West Siberia (58–73° N, 62–82° E) is estimated as ~10.5 Mt CH_4/year. Regional natural emission and gas deposits leak was determined based on combination of field measurements data and numerical modelling results. Quasi-permanent greenhouse gases monitoring network is provided in Russian North. It includes the background station Teriberka (69°12′ N, 35°6′ E, located at Kola Peninsula), Voeikovo station (59°57′ N, 30°42′ E) located to the East from Saint-Petersburg, Cape Kamenny (68°28′ N, 73°35′ E) / Novy Port (67°41′ E, 72°53′ E) stations, both located on the West shore of Ob bay (Yamal Peninsula). This station set is a part of Russian Arctic greenhouse gases monitoring net. Original results of direct methane mixing ratio measurements during field expeditions in West Siberia, Arctic Seas and Northern Pole area give additional information of methane concentration distribution. Laboratory analysis of flasks air probes is carried out at the gas-chromatographic installation by the methodology recommended by WMO for measurements in Global Atmospheric Watch stations network. Methane concentration time-series for Russian Northern stations are shown in Fig. 1. These data provide the basis for study of seasonal and interannual variation of methane content formation mechanisms. The long continues set of data obtained in Voeikovo station allows study the diurnal course of methane concentrations in details (Zinchenko et al., 2002).

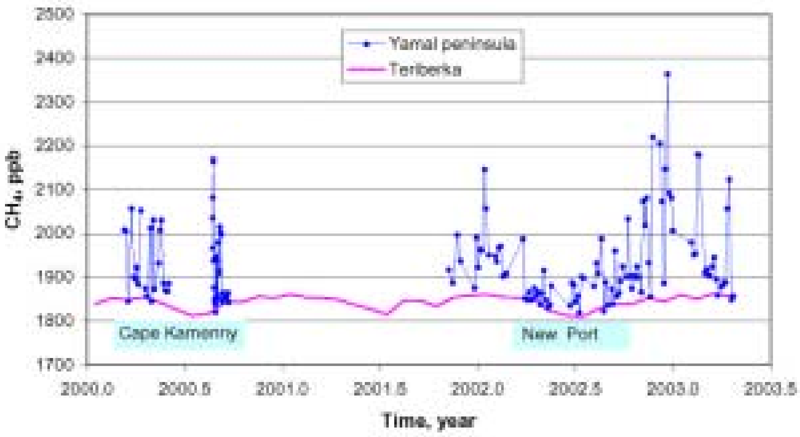

Fig.1. Results of CH_4 concentration measurements at two stations located at Yamal Peninsula relative to the Teriberka background level

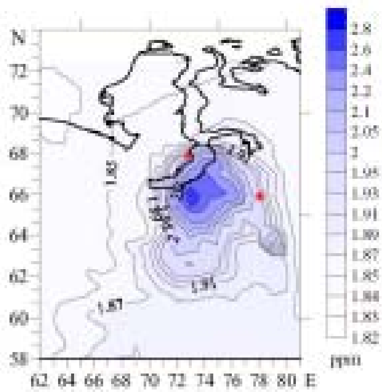

Fig. 2. Geographical distribution of methane mixing ratio for h ~ 20 m for September 9, 2004, 22:00. Asterisks indicate the places of sampling.

An example of regional modelled methane concentration distribution is presented in Fig.2. Modelled methane concentration agree well with data in points of measurements for different seasons of modelling experiments. Because the natural methane emission can be accelerated by atmospheric warming processes our further study will be aimed at numerical estimates of seasonal and multiyear variations of methane emission in West Siberia and other Russian Arctic regions and at quantitative estimates of possible future emission changes due to climate warming (based on IPCC scenarios).

Jagovkina S., Karol I., Zubov V., Lagun V., Reshetnikov A., Rozanov E. Reconstruction of the Methane Fluxes from the West Siberia Gas Fields by the 3D Regional Chemical Transport Model. Atmospheric Environment. 2000, v. 34, N 29-30, pp. 5319–5328.

Zinchenko A.V., Paramonova N.N., Privalov V.I., Reshetnikov A.I. Estimation of methane emissions in the St. Petersburg, Russia, region: An atmospheric nocturnal boundary layer budget approach. J. Geophys. Res., 2002, v. 107 (D20), 4416, doi:10.1029/2001JD001369.

Lagun V.E., Jagovkina S.V., Karol I.L. Western Siberia natural methane emission assessment based on experimental data analysis and 3d regional modeling. Non-CO_2 Greenhouse Scientific Understanding, Control Options and Policy Aspects. Eds van Ham J., Baede A.P.M., Guicherit R., Williams-Jacobse J.G.F.M. Rotterdam. Milpress. 2002. pp. 107–108.

INTERANNUAL TOTAL OZONE VARIATIONS OVER THE RUSSIAN TERRITORY IN 1973–2002 AS MEASURED BY GROUND BASED STATION SYSTEM

Karol I.L., Syrovatkina O.A., Shalamyansky A.M.
A.I.Voeikov Main Geophysical Observatory, Russia
karol@main.mgo.rssi.ru

The interannual variations of mean annual and of December-March Total Ozone (TO) measured of the ground based stations in the five regions of Russia are considered. Their connections are studied with Arctic and sub-Arctic stratospheric temperature and circulation oscillations such as QBO, NAO-AO and with PSC occurency. The high statistical significance is established as for the mean annual TO difference between the years with warm (cold) Arctic stratosphere with weak (strong) polar night border jet as for December-March one. Some implications for TO interannual projections are outlined and discussed.

ARCTIC CLIMATE IN THE 21ST CENTURY: MODELLING AND SCENARIOS

Kattsov V.M.
A.I.Voeikov Main Geophysical Observatory, Russia
kattsov@main.mgo.rssi.ru

1. The Arctic in the context of global climate change

The Arctic is a region characterized by complex and still insufficiently understood feedbacks in the climate system. Many feedbacks are introduced by the cryosphere and, in particular, by sea-ice with all complexities of its thermodynamics and dynamics. The vigorous internal dynamics of the polar atmosphere-ice-ocean system; the atmospheric boundary layer with its inversions, multilayer clouds and radiative effects; the unusual thermohaline structure of the ocean add to the great challenge, which the Arctic poses from the view point of 3D climate modelling. On the other hand, the potential importance of the processes and feedbacks between them implies that the Arctic climate system must be properly represented and successfully simulated by global models intended to provide credible projections of future climate change.

Atmosphere-Ocean General Circulation Model (AOGCM) projections of the climate response to anthropogenic green-house gas (GHG) concentrations increase in the atmosphere indicate at a pivotal role of the Arctic in the global warming. This is revealed, particularly, in polar amplification of increases of air temperature in the lower troposphere and precipitation, and usually is attributed to positive feedbacks in the climate system. Meanwhile, it is in high latitudes, that AOGCMs demonstrate the largest inter-model scatter in quantification of the 21st century change. The main reasons of this scatter are: (1) uncertainties in future emissions of GHG and aerosols (emission scenarios), and in conversion of the emissions to atmospheric concentrations and to radiative forcing of the climate; (2) different sensitivity of the AOGCM to the same external forcing (due to differences in model description of processes and feedbacks in the climate system); (3) internal variability of the climate system.

2. Emission scenarios and climate models chosen by ACIA

Emission scenarios are plausible representations of the future development of emissions of radiatively active substances (GHG, aerosols), based on a coherent and internally consistent set of assumptions about demographic, socio-economic, and technological changes and their key relationships in the future. Emission scenarios are converted into concentration scenarios which are used as input into climate models to compute climate projections. The latter should be distinguished from climate predictions – much stronger statements about climate behaviour in the future, which implicitly presumes the prediction of the social and economic development. The most recent IPCC SRES (Special Report on Emission Scenarios) scenarios (Nakicenovic et al., 2000) were built around four narrative storylines that describe the evolution of the world in the 21st century. Altogether, 40 different emission scenarios were constructed. Six of these (A1B, A1T, A1FI, A2, B1 and B2) were chosen by the IPCC as illustrative marker scenarios. No probabilities are assigned to the various SRES scenarios. For the Arctic Climate Impact Assessment (ACIA), two scenarios A2 and B2 were chosen.

AOGCMs are widely acknowledged as the main tool for projecting future climate. The IPCC (McAvaney et al., 2001) has stated that the varying sets of strengths and weaknesses that AOGCMs display leads to conclusion that no single model can be considered “best” and it is important to utilize results from a range of coupled models. For ACIA, five recent and comprehensive AOGCMs, whose outputs were available from the IPCC Data Distribution Centre (DDC), were chosen: CGCM2 (CCCma, Canada); CSM 1.4 (NCAR, USA); ECHAM4/OPYC3 (MPI, Germany); GFDL_R30_c (GFDL, USA); and HadCM3 (UKMO, UK). All of the models are well documented; participate in major international model intercomparison projects; have their pre-SRES simulations analyzed for the Arctic region and published.

3. Simulations of the observed Arctic climate

A key characteristic of Arctic primary climatic variables simulated by the AOGCMs is their large across-model scatter. Biases in surface air temperature and atmospheric pressure spatial distribution, and the oversimulation of the Arctic precipitation are among the most important systematic errors. On the other hand, compared to the five individual simulations, the 5-model ensemble means show reasonable agreement with available observations, at least in the area averages. The assessment of the ability of the AOGCM ensemble to simulate the observed current climate supports the ensemble suitability for use in constructing the 21st century climate change scenarios for the Arctic region. The suitability is further supported by the ability of some AOGCMs, driven by historical radiative forcing, to reproduce the observed evolution of the Arctic surface air temperature and precipitation during the 20th century, which underscores the credibility of the Arctic future climate changes projected by these models.

4. Projections of the Arctic climate change for the 21st century

Climate projections, using IPCC AOGCMs (IPCC, 2001) and comparing with the present climate, show a global average warming of 1.4 °C in the mid-21st century for both the A2 and the B2 scenarios. Towards the end of the century, the globally averaged warming is 3.5 °C and 2.5 °C for the A2 and B2 scenarios, respectively. Over the Arctic region the warming is larger: for the region northward of 60°N, by mid-21st century, ACIA models project 2.5 °C for the both scenarios. By the end of the 21st century, the Arctic warming is 7 °C and 5 °C for A2 and B2, respectively. The enhanced Arctic warming is accompanied by a large model to model scatter and a considerable interdecadal variability. Precipitation over the Arctic region is generally enhanced. The models also show a substantial decrease of snow and sea-ice cover over most parts of the Arctic area by the end of the 21st century.

5. Outlook for decreasing uncertainties of climate change projections for the Arctic

To increase credibility of climate change scenarios for the Arctic, further development is required of several aspects of climate modeling. Among these aspects, the urgency is most apparent of the improving physical parameterisation schemes (in particular, through process oriented observation programmes in the Arctic), as well as incorporating by AOGCMs new interactive components (e.g. atmospheric chemistry) and improving resolution of Arctic processes in AOGCMs (including better representation of the stratosphere). A part of uncertainty associated with the large natural variability in the Arctic climate system cannot be eliminated simply by model development and a refinement of the descriptions of physical processes. Therefore, ensemble projections are needed, where both initial states and uncertain model parameters are varied within a realistic range associated with a probability distribution. Ensembles will allow to assess climate change probability distributions, including frequencies of winter storms, temperature extremes etc.

Local climate change information needed for impact studies can be provided by different downscaling techniques, particularly by computationally expensive high resolution regional models and statistical methods. Further research and development efforts in these areas is urgently needed.

TOWARDS A HIGH-QUALITY DATA BASE OF RUSSIAN ARCTIC METEOROLOGICAL OBSERVATIONS

Lagun V.E.
Arctic and Antarctic Research Institute, Russia
lagun@aari.nw.ru

The warming signal in Arctic and sub-Arctic areas is remarkable and is indicated in different time-series obtained for the Arctic and Siberia. The numerical study of climatic variability formation mechanisms requires information about the statistical structure of meteorological fields. Such investigation became possible after the creation of a database with current surface and quality-controlled daily upper-air measurements at North-European, Arctic and Siberia network for the period of observations. The AARI Arctic climate data management has the goal of creating a definitive, high quality data base of meteorological observations for use in climate change studies. Systematization and generalization of meteorological observations over permanent permafrost regions of Russia allows to fill the most important gaps in data on climate change impacts relevant to the Russian Arctic, which helps Arctic community to synthesis the knowledge about climate variability, climate change and their consequences. Russia has unique multiyear meteorological records of Arctic stations data that can be analysed for obtaining the numerical estimate of the level of tolerance that permafrost systems have to climate variability and what the past impacts have been. The current form of the data (notebooks, hard copies of observation books and so on) needs to be digitized in standard formats compatible with current analysis techniques. The AARI scientists in close co-operation with experts from other Russian institutions started to prepare an information resource about Arctic atmosphere for the Arctic Climate Impact Assessment Program development (Lagun, 2004).

The initial sources of data are the North Pole (NP) drifting stations, including routine meteorological data (NP-5 – NP-33 for 1955–2005 period) and upper air data (NP-2 – NP-31 for 1950–1991 period), Arctic and Siberian meteorological stations (1932–2003) located in permanent permafrost area. The 6-hourly and daily mean meteorological data and twice-daily sounding data are collected and important statistics including climatic change parameters are calculated. With the resources available a following key set of meteorological variables is assembled: surface temperature, maximum and minimum surface temperature, prepared by Russian Hydrometeorological Institute-World Data Center (*http://www.meteo.ru*) and corrected according to AARI manuscript archive; corrected precipitation data for Northern stations network, based on comprehensive bias-correction model (Bogdanova at al., 2002); sea level pressure; relative humidity; snow cover parameters (depth and density), total solar radiation, surface albedo, frequency of exceeding threshold surface temperatures (the number of days with daily mean temperatures exceeding prescribed threshold values is calculated for each year for monthly and seasonal periods, for instance, a number of cold days per month with temperatures below -20 °C); annual data characterising the steady positive temperature duration period (number of days, dates of spring and autumn temperature transition over 0 °C, the beginning of the steady positive temperature period) for 1935–1995; soil moisture dataset contains the gravimetric measurements from agrometeorological, meteorological, heat-balance and water-balance stations over Siberia for 1978–1985 with 10 days temporal resolution. This dataset contains plant available soil moisture for the upper soil layer; upper air parameters (air temperature, geopotential height, relative humidity and wind speed at 16 standard levels).

Metadata files contain the list of type of measurements tools used for observations, description of meteorological place changes, changes of observing practice and changes of preliminary data processing. To remove the false trends in climatic time-series the time series homogeneity analysis was provided, using different inhomogeneity testing procedures.

During the preparation these data sets were updated, the gaps in historical data were filled up, some non-measured parameters were recalculated and data quality control procedure was applied. The most important point was the returning to individual measurements results based on initial data digitization procedure from hard copy observation books.

Russian scientist V.Yu.Vize was the first one who started to study the phenomena of Arctic warming in 1920–1930. He suggested the existence of the relationship between this warming and changes of synoptic climatology parameters, for instance, prevailing shifts of extra-tropical cyclone trajectories. In anomaly warm conditions, which have been observed during 1980–2002 period, a pronounced trend is detected in interannual variations of cyclonic activity, corresponding to the growing cyclonic frequency, speed of displacement and deepening and decreasing of the square of cyclonic vortices. Thus, the synoptic eddy activity increases due to decreasing of the polar atmosphere vertical stability in global warming regime (Lagun, 2001).

The very positive example of international cooperation for high quality polar regions climate data set formation is presented by SCAR READER (REferece Antarctic Data for Environment Research) Project (Turner et al. 2004, www.antarctica.ac.uk/met/programshosted.html/READER). The realization of analogous Project for Arctic area is very actual scientific problem.

Lagun V.E. Russian Arctic meteorological dataset for ACIA program development / ACIA International symposium on climate change in the Arctic. 2004. Session B1: paper 1. –P. 1–3.

Bogdanova I.G., Ilyin B.M., Dragomilova I.V. Application of a Comprehensive Bias-Correction Model to Precipitation Measured at Russian North Pole Drifting Stations Journal of Hydrometeorology. 2002, v. 3, N 6, pp.700–713.

Lagun V.E. Climatic variability of the synoptic activity in the Arctic. ACIA Workshop on Russian climate research and monitoring in the Arctic 27-30 May, 2001. Abstracts. St.-Petersburg. 2001, p. 41.

Turner J., Colwell S., Marshall G., Lachlan-Cope T., Carleton A., Jones P., Lagun V., Reid P., Iagovkina S. The SCAR READER Project: Toward a High-Quality Database of Mean Antarctic Meteorological Observations, Journal of Climate. 2004, v. 17, N 14, pp. 2890–2898.

THE ARCTIC SEA ICE ECOSYSTEM IN RECENT ENVIRONMENTAL CHANGES

Melnikov I.A.
P.P.Shirshov Institute of Oceanology, RAS
migor@online.ru

Recently, in the Arctic Ocean, there have been observing remarkable melting of sea ice, and, as a consequence, decreasing in thickness and surface of sea ice cover, and warming and freshening of underlie water layer. These events are definitely marked in the Canada Basin where sea ice concentration is decreased to 30% but temperature and salinity are varied to 0.2°C and 4‰, consequently, within 30-m mixed layer related to the middle of 70th. Recent observations of sea ice biota shown that species composition of sea ice flora and fauna is also remarkable changed: species abundant of diatoms (Bacillariophyta) is noticeable decreased but dinoflagellates (Dinophyta) as well as freshwater species from groups Chlorophyta and Cyanophyta are increased.

Invertebrate animals like nematods, turbellarians, and small copepods are also decreased by numbers and species. The main explanation is in changes of physic-chemical environmental factors influencing the freshening of ice. Besides that the decreasing in ice thickness and increasing in snow precipitation went to an activation of infiltration processes in the Arctic Ocean connected with a development of sea ice algae in the ice-snow interface. It is, so named, infiltration ice that is typical for the Southern Ocean but it was unknown for the Arctic Ocean where the sea ice algae are associated mainly with the ice-seawater interface. Furthermore environmental changes can be caused to reconstruction of productive and trophyc parameters of the arctic sea ice ecosystem.

A.M.OBUKHOV INSTITUTE OF ATMOSPHERIC PHYSICS ACTIVITY IN ARCTIC REGIONS DURING IPY

Mokhov I., Repina I.
A.M.Obukhov Institute of Atmospheric Physics RAS, Russia
mokhov@ifaran.ru

A.M.Obukhov Institute of Atmospheric Physics IPY activity is proposed. Following directions are discussed:

– Modelling and diagnostics of climate in polar and sub-polar latitudes and their changes.

– Experimental investigation of air-surface interaction in polar regions

– Investigation of nitrogen dioxide (NO_2) in the polar stratosphere.

– Research of a temperature regime and structure of a middle atmosphere at heights of 85-100 km in high and middle latitudes by emissions of hydroxyl, sodium and a green line of atomic oxygen.

– Minor gaseous and aerosol species, large-scale transport, photochemical processes, mass and heat exchange in the Arctic lower and middle atmosphere.

MODELING OF THE ARCTIC OCEAN WATER AND SEA ICE CIRCULATION

Neelov I.A., Klepikov A.V.
Arctic and Antarctic Research Institute, Russia
neelov@aari.nw.ru

Ocean circulation and ice cover simulated by coupled sea ice-ocean model of the North Atlantic and the Arctic Ocean. The model is capable to reproduce the long -term mean state and the inter-seasonal variability. The sea ice model used in this study includes both dynamics and thermodynamics (Hibler,1979). The ice thermodynamics is determined from an energy budget at the ice surface following Parkinson and Washington (1979) and the zero-layer approximation of Semtner (1976) for heat flux through the sea ice. The ocean model is based on the primitive equation, z-coordinate, free surface model of Neelov and Chalikov (1981) adapted to the Arctic (Neelov, 1996). Taken from the ERA-40 archive, 6-hourly sea level pressure

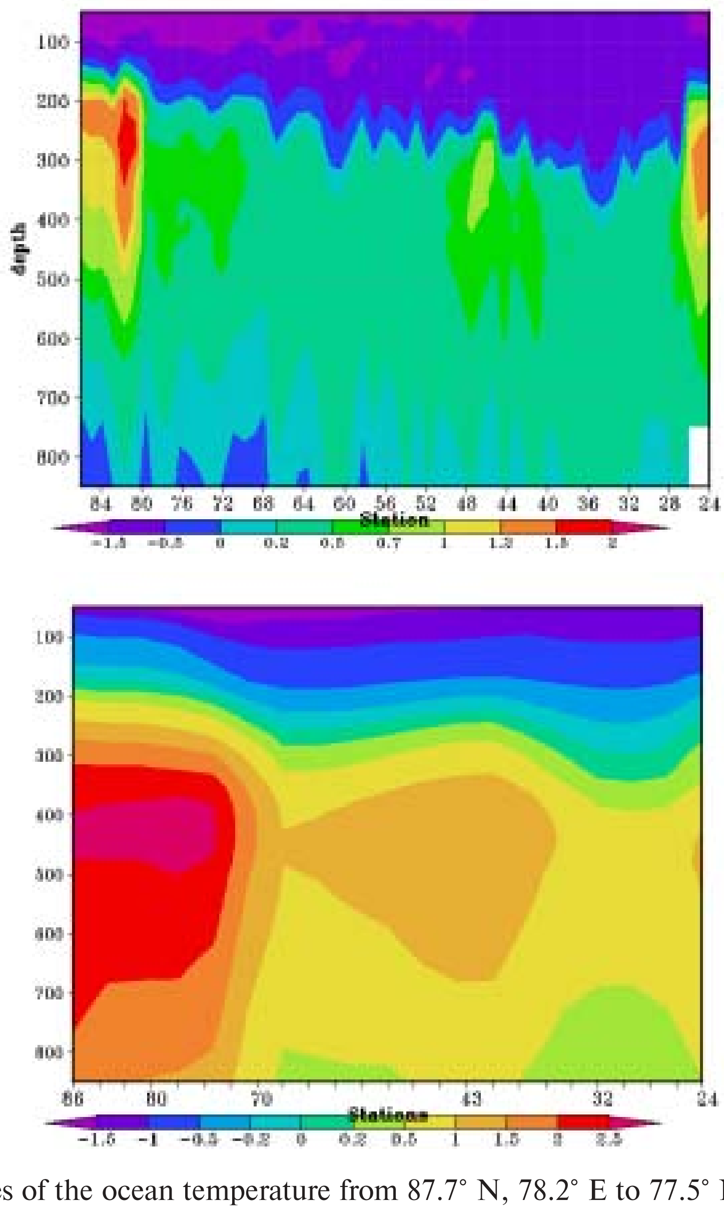

Fig.1. Vertical profiles of the ocean temperature from 87.7° N, 78.2° E to 77.5° N, 173.9° E in April 1995: *a* – measured (SCICEX'95); *b* – simulated.

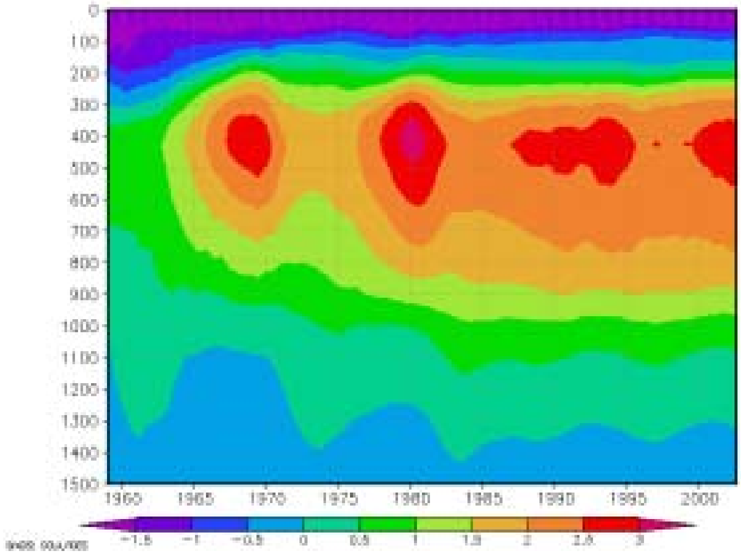

Fig.2. Time – depth distribution of simulated temperature at point 87.7° N, 78.2° E.

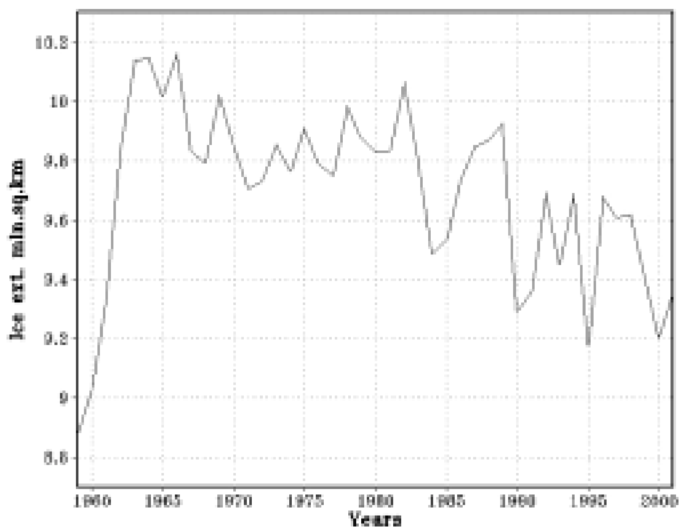

Fig.3 Simulated annual mean sea ice extent (mln.sq.km)

and daily air temperature, cloudiness, dew point temperature, precipitation for the time period 1957–2002 are used for the model forcing. The river discharges are climatic monthly values. The horizontal resolution is 56 or 28 km. In vertical, the model has 75 unevenly spaced level. Initial conditions for potential temperature and salinity were taken from the Levitus et. al. (2001) data set. At the open boundary monthly climatic temperature, salinity and free surface have been used. The free surface here was taken from the diagnostic run of the global ocean circulation model. Initial condition for three-dimensional ocean temperature and salinity fields are September means of Levitus et. al. (2001). The sea ice model was initialized by assuming ice thickness and concentration to be 4 m and 99% respectively at latitudes higher then 80° N. Sea ice extent, water and ice discharge from the Fram and Danish Strait and some other values have been computed. The model results and the results of field studies of North-76 Experiment in April 1976 and American submarine cruise in April - May 1995 are in a good agreement.

THE CHANGING ARCTIC CLIMATE: HISTORICAL OBSERVATIONS AND A NEW PARADOX

Overland J.E., Rodionov S.
NOAA/Pacific Marine Environmental Laboratory
James.E.Overland@noaa.gov

Recent warming in the Arctic has similar magnitude as several historical events, but has greater geographic extent. Changes in atmospheric circulation play the crucial role.

Temperature anomalies in the last 15 years are unique in the Arctic instrumental record (1880—2003). Historically, there were regional/decadal warm events during winter and spring in the 1930s to 1950s, but meteorological analysis shows that these surface air temperature(SAT) anomalies are the result of intrinsic variability in regional flow patterns, as contrasted with the Arctic-wide Arctic Oscillation (AO) influence of the 1990s. The recent decades are unique in having the greatest longitudinal extent of SAT anomalies and in their associated weather patterns.

These changes are primarily driven by changes in atmospheric circulation, and thus are subject to north/south gradients in hemispheric radiative forcing. Atmospheric circulation is sensitive to forcing in the sub-tropics from volcanic aerosols, insolation cycles and CO_2 increase. Temperature advection in the North Atlantic establishes wintertime temperature anomalies, while the zonal/annular character of the AO in the remainder of the Arctic must break down in spring to promote meridional temperature advection.

Change is likely to be irreversible over the next decades, as the Arctic has locked in 20% reductions in tundra and sea ice, northward shifts in ocean temperature, and ozone chemistry. Cumulative effects over the last two decades have produced changes in surface conditions. Long-term trends in many Arctic variables support the concept that current conditions are moderating the former year-to-year range of Arctic weather, and thus provide persistence to current trends.

EXPERIMENTAL INVESTIGATION OF ENERGY EXCHANGE ABOVE INHOMOGENEOUS SURFACES IN ARCTIC REGIONS

Repina I.A.
A.M.Obukhov Institute of Atmospheric Physics RAS, Russia
repina@ifaran.ru

The main objective of the present work is studying of processes which govern radiation and heat conditions in ice-snow cover and in the atmospheric layer above. The following types of underlaying surfaces can be distinguished in this regions: waveless open water, developed waves and storm conditions; compacted ice cover without leads (smooth ice, ice covered by hummocks and snow); melting ice; ice covered by polynyas and leads; ice of different stages of development and thickness; ice of land origin with complex topography (Repina, Smirnov, 2000). The interest to processes in sea ice is determined by its important role in shaping the large scale ocean and atmospheric processes. Ice cover is responsible for changes in albedo, heat and moisture fluxes and dynamical interaction between ocean and atmosphere. The present work is focused on studying the effects of structural and thermal non-uniformity at the ice covered surface on heat ad momentum exchange between atmosphere and underlaying surface. Transformation of air flow caused by change of the underlaying surface type (ice – open water, fast ice – thin one year ice) is also envisaged (Repina et al., 2002).

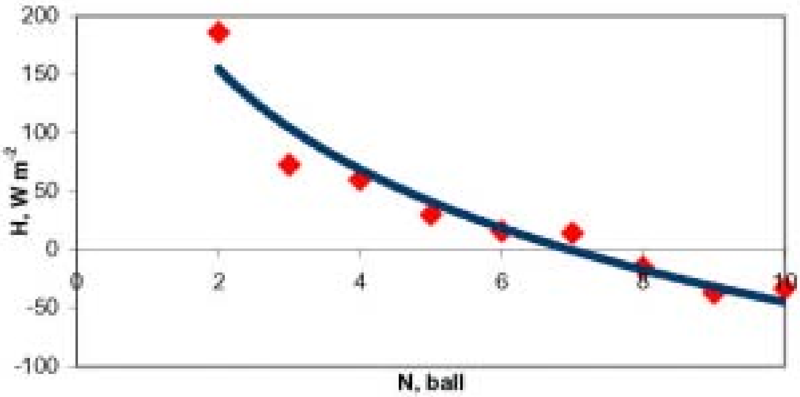

Fig. 1. Relationship between measured sensible fluxes (*H*) and ice concentration (*N*) (Laptev sea, September 2004)

The results of direct measurements atmospheric turbulence in polar areas above different types of ice are used. (Fig.1) The influence structural and temperature inhomogeneous on a surface covered with ice on an exchange with a heat and a momentum between an atmosphere and a spreading surface is considered. The dependence of the statistical characteristics atmospheric turbulence from a type of a surface and stratification of an atmosphere is investigated. The attempt of a theoretical estimation of influence of ridges hummock on structure of an air flow is undertaken on the basis of the decision of the closed system of the equations describing variability of an air flow above a non-uniform surface. (Fig.2) The given work confirms necessity of realization of target experiments on research of interaction of an atmosphere with a spreading surface in polar areas. The results of modeling, basically, well describe processes occurring in surface layer of an atmosphere is necessary by ice and snow.

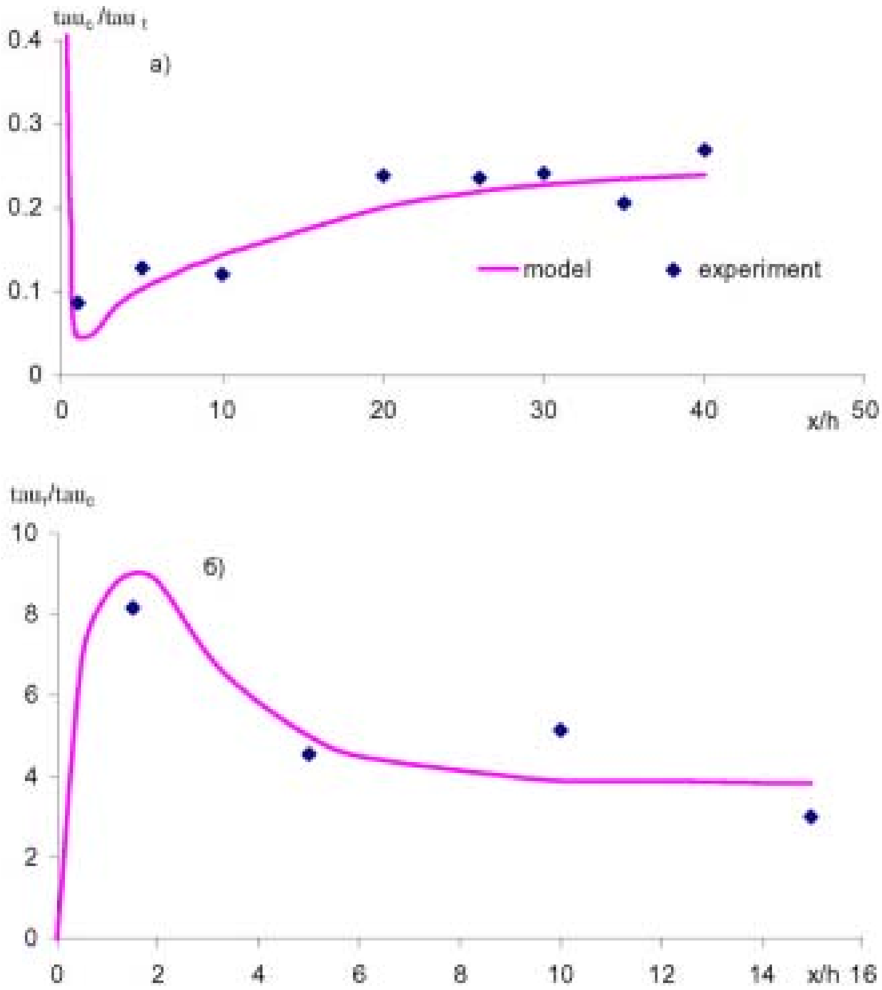

Fig 2. Momentum fluxes relate changes. (*a*) – air flux is moved from hummock to smooth snow surface; (*b*) – air flux is moved from smooth snow surface to hummock. Tau_t –momentum fluxes above hummock; tau_c – momentum fluxes above smooth surface. *X* – distance, *h* – high of hummock.

Repina I.A., Smirnov A.S. Heat and momentum exchange between the atmosphere and ice from the observational data obtained in the region of Franz Josef land. *Iz*vestia AN, Fizica Atmosfery i Oceana. V.36, No 5, 2000, pp. 672–680 (Russian, translated. English: Atmospheric and Oceanic Physics. V.36, No5. 2000, pp. 618—626)

Repina I.A., Smirnov A.S., Volkov Yu.A. The influence of surface structure in polar regions on heat and momentum exchange between atmosphere and ocean. Surface and internal waves in Arctic seas, 2002, pp. 189–214. (In Russian).

MEASUREMENTS OF TOTAL OZONE CONTENT AND UV RADIATION ON ROSHYDROMET NETWORK: THE CURRENT STATE AND DEVELOPMENT

Shalamiansky A.M.
A.I.Voeikov Main Geophysical Observatory (MGO), Russia

Total ozone (TO) measurements over Russian Federation and former USSR countries, were carried out during IGY period (1957–1958 гг.). To the beginning of 1970s the filter composition for ozonometer M-83 was finally selected (the same filters are used in ozonometer M-124 now), calibration system of TO measurement and methods of measurements result processing were elaborated, and finally the network from 45 ozonomethric stations was organized. Presently TO measurements are carried out at 27 ozonometric stations in Russia and at 3 Antarctic stations. All stations are equipped by ozonometer M-124 (three ozonometers per station). Technical equipment, metrologic and methodical providing of TO measurements carried out by MGO. Station ozonometers (taken by turn) once per two years are calibrated in MGO using standard – Dobson spectrophotometer N 108, which, in turn, participates in procedure of comparison with WMO standard once per 4 years. From beginning of regular intercalibration procedure applying (since 1984) the decline of Dobson spectrophotometer from WMO standard does not exceed 1 %. The errors of TO measurements carried out by ozonometer M-124 are less than 5 %. Developed by MGO method of measurements permits to execute TO measurements by zeniths of clear and cloudy sky practically without measurement error increasing. It should be taken in account, which a one half of stations is located northerly 60° N and measurements are provided under any weather conditions (without precipitation), when the sun is higher than 5°over horizons. Because ozonometer filter are solarizated with time, the control system is applied, which allows to reveal the decline of measurement scale at stations timely. Presently the record length of homogenious time-series, obtained using uniform methods for TO data at Russian stations is more than 30 years. Last years at some stations ozonometers are equipped by special correcting device (Larshe sphere) for UV-B radiation measurements.

Though M-124 ozonometers are used at stations more than 20 years, their production is closed, because there is the necessity to replace them by modern devices. In MGO with participation of Saint-Petersburg optical organizations an experimental model of UV ozone spectrophotometer was developed and produced. This device made on the base of polychromator registers specters of UV radiation in the range of 250–420 nm with resolution of about 1 nm. It allows to register the spectral distribution of direct solar, total and diffused radiation, total ozone content by Sun and zenith sky and spectral distribution of optical density of the aerosol. During 2002–2004 were carried out the laboratory and field tests in Voeikovo and in Caucasus (peak Terskol). The modified version of spectrometer is being produced, aimed for measurements at polar stations especially.

THE AARI OCEANOGRAPHIC DATABASE AND ITS USE IN INVESTIGATIONS

Sokolov V.T., Karpiy V.Yu., Lebedev N.V., Garmanov A.L.
Arctic and Antarctic Research Institute, Russia
svt@aari.nw.ru

The Oceanographic Database of the Arctic Ocean and the adjoining water areas has been generated at the AARI for 15 years. It is based on the observations of Russian oceanographic expeditions that operated in the Arctic onboard the research vessels from 1920 up to present, in the high-latitudinal airborne "Sever" expeditions during the period 1937–1993, at the drifting "North Pole" stations from 1937 to 1991, data of coastal stations and drifting buoys and also on the available information from other sources. In general, the materials included to the database cover the late 19^{th} century - present time period.

The database structure is comprised of the blocks of thermohaline characteristics, hydrochemical characteristics, calculated fields, vertical profiles and transects. The database numbers more than 400 thousands of primary and non-duplicated oceanographic stations. For generation of the database, a multi-level control was carried out both by the statistical methods and the expert checking performed by a group of experts for each specific region. An important aspect in creation of any database is elimination of backup information provided different sources are used for the database construction. In our case, the control for duplicates was made by the equality of dates, time, coordinates and codes of ships. Preference was given to the stations with the largest number of observations on temperature and salinity or at the equal number of observations, to the stations with more complete information on ships.

The statistical control of temperature and salinity values was conducted in each standard horizon. For calculation of mean temperature and salinity values and standard RMS deviations, the Arctic Ocean area was divided into squares in the following way:

– squares with 1000×1000 km sides of the initial grid were subdivided into four squares;

– the number of measurements of thermohaline characteristics and the number of years when these observations were made were calculated;

– if in each of four new squares the number of measurements were more than 31, and the number of years was more than 5, each of them was also subdivided into four squares;

– the subdivision into smaller squares continued until the prescribed criterion by the number of observations and the number of years in which these observations were fulfilled (31 observations and 5 years) was not met in one of the new squares;

The values of mean multiyear thermohaline characteristic (X) and the RMS deviation (S) were calculated in the obtained squares. The values of the characteristic beyond the $X \pm S$ bound were marked and were not used in further work.

In addition, the statistical characteristics (number of observations, number of years in which observations were made, mean, dispersion, RMS deviation, asymmetry coefficient, excess coefficient and coefficient of regression plane equation were calculated. Calculation of statistical characteristics in the squares was performed by means of the scripts developed for this purpose using the Visual FoxPro DBMS.

For creating the database, the software and scripts were developed and improved in order to provide oceanographic database management at different stages of its generation, supplement, administration, maintenance and also to provide operational calculations meeting various requirements of users and to create different analytical, calculated and graphical materials for reference-books and atlases.

The software products and scripts were created by means of programming languages: xBASE and SQL (in the MS Visual FoxPro v. 3.0 environment), C++ (in the MS VisualC v. 4.0 environment), JavaScript (in the Macromedia Dream Weaver v. 3 environment), GS Scripter32 (GS Surfer v. 6.04, v. 7.0 and GS Grapher v.2.0 environments). The work was carried out in the following directions:

– elaboration and improvement of software packages for data loading and conversion;

– software for data control;

– scripts (software) for visualization and analysis of thermohaline measurement data.

The following software packages for visualization and analysis of thermohaline measurement data were devised:

Software for generation of a by-voyage (by-expedition) catalogue for a prescribed period of time with a subsequent display of the layout of stations at the chart of the selected voyage (expedition), software MatSklon for the analysis and classification of the vertical temperature and salinity profiles, which allows us to:

– create a catalogue of the expeditions;

– depict the location of oceanographic stations at the chart of the Arctic Ocean (with seabed relief) with indication of the types identified at the formal stage for the chosen expedition;

– visualize the temperature and salinity profiles for the chosen station (both at logarithmic and linear depth scale) taking into account the types identified at the formal stage;

– visualize the *T, S*-diagram for the chosen station;

– look through the numerical characteristics of temperature, salinity and density values and their gradients for the chosen station;

– identify finally the type of thermohaline structure for the chosen station and make record of the type to the file created for this purpose.

The database materials have been used for generating the oceanographic atlases on the basin and the seas of the Arctic Ocean and for conducting a series of research studies. On the database basis, climatic and annual seasonal fields for the ocean water area were constructed.

The proposed presentation contains information on the DBMS developed on the basis of the VISUAL FoxPro DBMS and the quality and quantity of available oceanographic information in the database as well as the results (atlases, climatic estimates and reconstructions) and the components of the products derived using the database in the framework of the projects carried out on its basis.

The following was made based on the Oceanographic database**.**

Studies of the active layer of the Arctic Basin were carried out, estimates of variability of the active layer thickness and mean temperature and salinity were obtained for the seasonal and interannual variability scales.

Estimates of the contributions of different factors to the variability of the active layer characteristics were derived.

Assessments of the freshwater balance components of the seas of the Siberian shelf and the Arctic Basin were performed. The Russian-US electronic climatic atlas "Oceanographic Atlas of the Arctic Ocean" (winter period – 1997, summer period – 1998) and the Russian –US electronic "Hydrochemical Atlas of the Arctic Ocean" were published. For the first time for the Arctic Basin region, fields of mean salinity of the upper 100-m layer, freshwater content in the 100 and 200-m surface layer, upper and lower boundaries of Atlantic water for the years with a low number of observations were reconstructed and continuous series of the fields of these characteristics for the last 45 years were derived. Using modern processing procedures for observation data that were used by the Russian and western partners in preparation of the Russian-US "Oceanographic Atlas of the Arctic Ocean", water temperature fields of the Arctic Basin and the Arctic Seas in standard horizons from the surface to the bottom were reconstructed for the winter season over the last 45 years.

The variability of thermohaline characteristics in the area of the Arctic Seas in the 20th century was evaluated.

The AARI oceanographic database of the Arctic Ocean База is a basis for climatic studies in the Arctic region and for undertaking experimental programs and expedition studies of the Institute for the future.

ACIA AND IPY 2007/2008 AND THEIR SIGNIFICANCE FOR ARCTIC RESEARCH

Tsaturov Yu.
Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
tsaturov@mecom.ru

The *Arctic Climate Impact Assessment / ACIA* programme is a programme of assessment the climate change on the ecosystem, biodiversity and economic activity in the whole Arctic region.

Climate change has become an issue of great importance in the Arctic in recent decades. Anthropogenic impact as a result of increased economic activity and the observed warming trend may lead to the permafrost melting, thermokarst shape relief formation, decrease in biodiversity and changing the indigenous population residential conditions. Taking into account the current climate change trends (the global warming), possible future climate changes may cause serious negative impacts.

The Arctic Council Ministerial Meeting in Barrow, Alaska in October 2000 developed and adopted the ACIA programme that identified its objectives as follows:

– synthesizing and evaluating knowledge on natural climate variability, anthropogenic climate changes, global, regional and local climate change and ultraviolet radiation impacts on the Arctic environment;

– supplying the Arctic States governmental organizations with reliable information for the development of well-founded managerial decisions and the Arctic region managerial strategies in under the changing climate conditions, including the environmental, population health, economic and social sphere impact issues.

During the following four years more than 250 key Arctic scientific researchers and other experts representing 15 countries carried out the ACIA programme work. The available scientific research results and indigenous population knowledge on the Arctic and Subarctcic climate change were collected and analyzed, and the impact of these changes on the polar and circumpolar regions and worldwide.

The ACIA programme is most important for the Russian Arctic. The continental part of the Russian Arctic covers more than six millions km^2 north of the continuous boreal forest line and constitutes approximately 40% of the circumpolar terrestrial Arctic. The Russian Arctic is inhabited by 11 indigenous minority peoples, which have lived on the land for thousands of years. Together with 5 other northern indigenous minority peoples that live close to or partly within the Arctic region, the indigenous minority population within Arctic Russia numbers some 67 000 individuals, which still rely extensively on hunting, herding, gathering and other traditional activities for their subsistence. In terms of biodiversity, the Russian terrestrial Arctic provides nearly half of the habitat at the circumpolar level and serves as the feeding ground for millions of migratory birds and mammals from the Asian, African and European continents. The Northern territories of Russia possess the vast timber, mineral, hydrocarbon resources and metal deposits, being of great value both at present and for future prosperity and economic security of Russia.

The ACIA programme successful implementation will allow to fill in the most significant gaps in global, regional and local Russia Arctic climate changes data and knowledge and as a result to develop managerial decisions aimed at securing the regional economic activity adaptation to the climate change, ensuring the Nothern indigenous minority peoples prosperity and preserving the biodiversity in the Russian Arctic.

There exists a wide range of opinions on the current climate changes causes and the future changes scenarios. Further Arctic climate researches and large-scale discussion of the results that will allow to clear the pending and debatable issues are required. The International Polar Year 2007/2008 programme work will significantly contribute to the issue.

INVOLVING ARCTIC RESIDENTS IN SOCIAL ASSESSMENT OF CLIMATE CHANGES IMPACTS

Vlassova T.K.
Institute of Geography, Russian Academy of Sciences, Russia
marianna@orc.ru

Introduction

The ACIA project implementation has demonstrated the great significance of the traditional ecological knowledge and revealed vast abilities of the indigenous peoples of the Circumpolar North including numerically small Indigenous Peoples of the Russian North, Siberia and the Far East (IPRN) united under RAIPON not only to observe climate changes but to assess its significant impacts on the sustainable development of their traditional activities and lifestyle (ACIA Chapters 3 12, 17). In order to understand the global picture of climate change impacts on sustainable development, there is the need to develop common approaches and methods to carry out such kind of social assessments by broader groups of arctic residents, including all stakeholders permanently living in the Arctic. For this purpose the idea of the Arctic Residents Network of socio-environment assessment and education for sustainable development (ARN) appeared. The ARN proposal idea has been supported by the Arctic Council at its meeting in May, 2004 in Reykjavik.

Approach

The suggested approach to social assessment of climate changes impacts is based on critical analysis of the previous experience gained during the implementation of several projects, the aim of which was to gather and analyse the traditional ecological knowledge (Sulyandziga et al.,2001; Bogoyavlensky, 2002; Vlassova, 2001,2002,2003). **The basic principle which we follow now is that in order to elaborate mitigation and adaptation strategies to climate change, climate change issues should be addressed for the arctic (including indigenous) residents observations and assessment in a broader context of socio-economic problems and sustainable development plans elaboration.** Sustainable development plans elaboration, starting from the local community and administrative level foresees the identification and solution of key problems leading to vulnerabilities in the whole human-nature system. If the system is oriented to sustainability, it should properly react, respond to both natural disturbances (climate changes impacts, etc.) and human driving forces, as well as consequences of their interaction. In this respect arctic residents' assessments are valuable in identifying key problems (and indicators) leading to vulnerability and arising under the influence of **four kinds of forces** acting within the nature-social system: 1) climate/ecological changes impacts; 2) human activities impacts; 3) drivers in human decision realm; 4) cumulative consequences of both human and climate/ecological changes impacts;

Results based on previous investigations

The approach of assessing key problems acting in the human-nature system and influencing its vulnerability within four kinds of forces (and their interactions) is illustrated by the data, based on traditional ecological knowledge, gathered during structured, unstructured interviewing and interactive educational workshop with the IPRN (2001–2003).

1. The assessment of climate, ecological changes impacts tells us that at average climate and ecological changes impacts takes the forth place in IPRN pool of concern after economic, social and problems concerning “good governance”. Nevertheless, in some settlements (for example in Lovozero), the significance of ecology improvement for saami people is even greater than the importance of housing conditions improvement, although housing conditions are rather poor in this settlement. In spite of the fact that there are some regional geographical peculiarities of observed ecological changes, most answers in interviewed settlements situated in the taiga-tundra and boreal forest bioms are ranked in the following order: animals and plants decrease and disappearance of some species; climate changes; water quality decrease; forest and shrub area decrease. Arctic resident’s assessments of whether climate is becoming more or less suitable and what are main indicators that bring to discomfort are very valuable. The saami and evenk people complain that climate is getting more variable and unpredictable and this makes risks to reindeer herding; summers are becoming colder and shorter, but people want them to be warmer in order to have greater yields of vegetables; winter climate is getting wetter and warmer, although people want it to be less wet (wet winters are bad for both- human health and wild animals survival). IPRN assessments provided us also with the information on natural (ecological) disasters as they are registered and perceived by the indigenous peoples. Rather new types of perceived natural disasters, such as drying up of surface water reservoirs or so called event as “acid rains” are becoming common to the IPRN in several localities and need scientific interpretation.

2. The assessment of human activities impacts can concentrate the attention of local plans developers on those problems that are most essential for the IPRN traditional activities and well-being. The IPRN rank these problems in the following order: poaching; forest fires; industrial logging; clearing of forests for firewood; water pollution by industrial wastes and discharges. The comparison of the first and this second kinds of forces tells us that many events happening within nature (disappearance or invasion of species) are not only due to natural processes (including climate changes impacts), but are tightly connected with social, economic and management factors. This could be illustrated by such human impact as poaching, leading to decrease of valuable species vital for traditional food and culture as well as biodiversity as a whole.

3. The assessment of commutative negative consequences of both human and climate/ecological changes impacts. In many cases climate/ecological changes impacts and human change impacts lead to the same negative commutative consequences frequently aggravating each other. They are ranked by the IPRN assessments in such an order: less fish; absence of the harvest of wild plants; lack of the harvest of cultivated crops; reindeer pastures degradation, pasture’s areas shrink, reindeer herd decreases.

4.The identification and assessment of forces in human decision realm which are increasingly becoming the cardinal reason for climate change and socio-environmental degradation. Among these forces the IPRN mention: improper policy and management; disobey of laws; the lack of public awareness; weak public participation in decision-making; poor ecological education and public control; inappropriate local administration control (especially of poaching, and industrial companies activities), etc. It is very helpful using local peoples’ knowledge and assessments to identify those stakeholders and institutions which are inflicting the greatest harm to the environment. The IPRN consider poachers and after them the natural resource extraction companies and the forest managers to present the greatest threats. Also it is possible to gather the arctic residents’ assessments of the role of the different stakeholders in the protection of the environment: people in the settlement, environmental protection agencies; public organisations, the local administration, the indigenous community regional authorities; the federal government; international organisations. Although the IPRN of each settlement have unique views on this question, in many cases they believe, not trusting especially to local administrations, that only they themselves could improve the socio-environmental situation in their settlements. Among essential measures to improve the environmental situation they mention the need to improve the level of environmental education and public awareness and tighten enforcement of environmental laws. The interviewing can also tell us about conflict situations arising between different groups of arctic residents. The highest frequency for the IPRN are conflicts with local administration (95 % of all conflicts in interviewed settlements), regional authorities (53%), local private companies (51%) or national private companies (20%). There are rare conflicts on nature resources use with the federal government (7%). It may seem strange but the new kind of conflict appears between the IPRN and the wildlife conservation institutions.

Perspectives and recommendations

The assessments of the IPRN are very valuable for the identification of key problems and indicators of vulnerability on the vast territory of the Russian Arctic, as these peoples are leading their traditional way of life approximately on 60% of this territory. Nevertheless IPRN constitute only 2% of all northern residents of Russia and 4% of the Russian Arctic, and it is very important to collect assessments from other arctic residents (also larger groups of indigenous peoples, and other stakeholders living permanently in the Arctic) and to include their values and assessments into local plans of sustainable development. Taking into account the global character of climate change issues and its impacts on sustainability, organisation of a comprehensive Arctic Residents Network and Socio-environment assessment for achieving sustainability is recommended (ARN). The IPY project is now in the process of elaboration and going to be discussed also at this meeting. The proposed approach to gathering local and traditional knowledge and assessments of climate change issues can be discussed as one of ways towards the construction of the meta-data base for such an international Arctic Residents' Network.

ARCTIC RESIDENT'S NETWORK OF SOCIO-ENVIRONMENT ASSESSMENT AND EDUCATION FOR SUSTAINABLE DEVELOPMENT (ARN)

Vlassova T.K.
Institute of Geography, Russian Academy of Sciences, Russia
marianna@orc.ru

Motivation and goals

The input of local people knowledge (including traditional ecological knowledge), Arctic residents observations and assessments into circumpolar monitoring systems should make possible not only to increase a degree of predictive capacities far beyond our present efforts, but to achieve larger level of Arctic societal-nature systems sustainability and ways of their adequate response to contemporary changes and risks (climate changes, socio-economic, etc).

The ARN proposal is aimed to broaden the participation of Arctic residents (indigenous and non-indigenous) in the assessment of socio-environmental situation and changes that is necessary for the Sustainable Development Plans elaboration through local to circumpolar levels. The assessments and the information will be gathered from the Arctic residents point of view, their knowledge and perceptions and then this information will be balanced with the interpretations of scientists and decision-makers.

The comprehensive assessment and establishment of a monitoring system of key indicators of sustainable development with continuous update of the information will be organised. This will help to establish a circumpolar database and regional databases to anticipate and respond to socio-environmental changes and risks in the Circumpolar region.

The ARN, based on the integration of local and traditional knowledge with science and such modern technologies as remote sensing will help in elaborating the mitigation and adaptation strategies and tools for sustainable development at the local, regional and circumpolar levels.

Partnership relations and cooperation between local authorities, regional and federal governments, different cultural, social and professional groups of Arctic residents for conflict resolution and sustainable development of natural and land resources will be developed. The ARN will help to establish better understanding and cooperation between the non-indigenous and indigenous population in the regions of the Arctic.

The ARN will promote capacity building, including education for sustainable development, information/knowledge and experience exchange among Arctic residents which could strengthen the programmes of the University of the Arctic, intensify the need and use of Information and Communication Technology (ICT) in remote arctic settlements and communities.

The ARN will improve self-management capacities, to manage and regulate natural resources in areas of traditional land use.

The ARN with the help of a specially established Circumpolar website will serve in the dissemination of relevant local experience in achieving sustainable development to all residents of the Circumpolar region. For this purpose requirements for ICT should be satisfied.

Approaches and methods

The body of the ARN will be made by Local Sustainable Development Assessment and Monitoring Sites (LOSDAMS), situated in different circumpolar regions of the Arctic States. Several of them should be chosen at the initial stage, as representative pilot sites. The approaches for launching the ARN are based on several unique methods of obtaining, storing and disseminating of information, communication and their combinations: interviewing; participatory workshops; educational/training workshops; the joint scientific–traditional/local knowledge field experiments (for example community mapping with remote sensing images).

INTEGRATED APPROACH TO MANAGEMENT OF SEA DATA FOR ARCTIC CLIMATE RESEARCH

Vorontsov A.A.
National oceanographic data centre (NODC) of Russian Federation
All-Russia Research Institute of Hydrometeorological Information -World Data Centre, (RIHMI-WDC), Russia
aav@meteo.ru

Last decade is characterized by increase of requirements of all world community in the new information on a condition of the World Ocean, including Arctic regions. It, in turn, leads to growth of attention to problems of creation and use of information resources on various aspects of a marine environment, main from which is a research of a climate.

RIHMI-WDC which fulfills the functions of Russian Nation Oceanographic Data Center holds the following marine data for World ocean:

– hydro-meteorolodgical surface data;
– Nansen hydrological/hydro-chemical, CTD and bathytermographic data;
– current meter data;
– hydrometeorological coastal stations data;
– marine chemical pollution data.

The general information about marine data sets of the RIHMI-WDC data holdings gave in table. Moist part of data belongs Nansen hydrological/hydro-chemical, CTD and bathytermographic observations.

The largest amount of data refers to the period of 1970–1980. During this period the institute received, on average the materials from more them 1000 national R/V and 600–800 foreign R/V cruises in year.

Space distribution of oceanographic data are shown on the figure. Map of oceanographic data distribution allows concluding that data more or less equally distributed over the World ocean.

The largest amount of data are stored on technical carriers for frame-computer and PCs (magnetic tapes, CD-ROMs) and are ready to use for research applications. Nevertheless, given a swift spread of information over the world, information providing of marine research is interpreted in a wider sense than merely preparing and providing data on computer-compatible media. Therefore to obtain complex and adequate information for studying the World Ocean, we accepted the approach aimed at the integration of various marine data flows which is used as a fundamental concept of data management in Russian NODC.

The use of integrated scheme for acquisition, accumulation and complex analysis of marine data is the modern way for environmental data management. New information technologies (IT) along with data and information cover knowledge and mathematical models. Much attention is given to a basic part of information technologies which represents a regular sequence of actions and operations with data to achieve the objective.

The practical realization of the considered concept will give the possibility to meet requirements of modern users concerning the data content, the speed of access, the speed of access to data, data processing and analysis, form of presentation of output products.

Today Russian NODC on the basis of IT creates new information products, among which special DB for research of a mode, handbooks, materials for climatic atlases and sets of thematic cards in the electronic kind, prepared on the basis of GIS. Examples of practical realization IT and the target production meeting modern requirements of users are resulted.