PAN EURASIAN EXPERIMENT (PEEX)
– TOWARDS A NEW MULTINATIONAL, MULTIDISCIPLINE
CLIMATE, AIR QUALITY AND ENVIRONMENT
RESEARCH EFFORT IN ARCTIC AND BOREAL
PAN-EURASIA REGIONS

ATMOSPHERIC-ECOSYSTEM OBSERVATION NETWORKS & MODELLING PLATFORM Implementation Plan

Conceptual design and technical requirements

- Document

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PEEX Observation Networks :

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Pan Eurasian Experiment (PEEX)

OBSERVATION NETWORKS

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CONTENTS

1. EXECUTIVE SUMMARY

Aim of this task is to establish a process towards high level Pan-Eurasian Observation Networks, which is based on a hierarchical SMEAR-type (Stations Measuring Atmosphere-Ecosystem Interactions) integrated land-atmosphere observation system. The ground based observation setup is complemented by the remote sensing infrastructure. The first set of PEEX labeled ground stations is foreseen in operation within a 5 year time frame. This task is motivated by the fact that Pan Eurasian region represents one of the Earth most extensive areas of boreal forest (taiga) and the largest natural wetlands, thus being a significant source area of trace gas emissions, biogenic aerosol particles, and source and sink area for the greenhouse gas (GHG) exchange in a global scale. Pan-Eurasian area is fragile for environmental change and the anthropogenic activities are envisioned to increase in terms of sea traffic, industrial and mining activities. However, particularly Siberian region is currently lacking a coordinated coherent ground based atmosphere-ecosystem measurement network crucial for observing and predicting the effects of climate change in the Northern Pan-Eurasian region.

The initial phase of the Pan-Eurasian Observation Networks is based on the existing research infrastructures. Altogether <15 to-be-confirmed> stations or areas have been selected for the Preliminary Phase of PEEX Observation network. The list of stations includes the SMEAR-type stations in Finland (SMEAR-I-II-II-IV stations), in Estonia (SMEAR-Järviselja) and in China (SMEAR-Nanjing) and 8 stations in Russia and ecosystem station network in China. The stations selected for the PEEX network are situated in different vegetation and climate zones such as hemi-boreal, boreal, and arctic regions. The PEEX labeled ground station network will be initiated with the hierarchical station network-concept. This means that the super-sites cover a full suite of instruments and data systems for monitoring the material and energy flows in the land–atmosphere continuum whereas some stations have a targeted instrumentation for a specific topics and/or regions for providing spatial variance of the parameters.

We envision that the PEEX Observation Network - Preliminary Phase Program, targeted for the years 2014-2019 includes the following actions:
1) to identify the on-going measurement routines of the PEEX Preliminary phase ground stations
2) to analyze the end-user requirements of the global and regional-scale climate and air quality modeling communities in the PEEX domain,
3) to provide an outline for the PEEX labeled network incl. the measurement and data product - archiving - delivery requirements for each station category,

4) to identify the key gaps in the initial phase observational network including long-term observational activities within PEEX domain, in Europe, in China and globally,
5) to initialize harmonization of the observations in the PEEX network following e.g. accepted practices from World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) programme or European observation networks,
6) to improve satellite observations over the PEEX domain of interest (such as problems are low sola rzenith angle, availability of light, detection of clouds over high-reflecting surface (desert, snow, ice)
7) to develop methods and methodology for inter-platform comparisons between the ground based and satellite observations,
8) to establish PEEX-education program of the measurement technique and data-analysis for young scientists and technical experts.

The most relevant collaborators in the Preliminary Phase of establishing the network are the Russian institutes and universities and their global collaborators already conducting long-term observations in the Pan European domain. Furthermore, strong connection and collaboration will be established with global programmes, initiatives and observational networks, including the WMO Global Atmospheric Watch (GAW), Future Earth (iLEAPS / IGBP), GEO / GEOSS and EU-ESFRI and FP7 IR (research infrastructure) projects and ESA and EU projects for satellite observations.

The PEEX network will utilize existing knowledge ON WHAT? , WMO-GAW recommendations and guidelines for establishing the long-term, highly standardized network system (Lund et al. 20109. The iLEAPS-IGBP project (Future Earth) will enhance the international visibility of the PEEX network and opens up opportunities for the PEEX office to act as a regional node for Future Earth in the Arctic and boreal zone. The Global Earth Observation System of Systems (GEOSS) connects PEEX to the GEO Cold Regions activity and PEEX is listed along with the international programs enhancing the Arctic Data-Information coordination for Cold Regions within global research infrastructures and programs such as SAON, SIOS, INTERACT, ABDS-ABA/CAFF, and Cryoclim. EU ESFRI (ICOS) & FP7 projects (ACTRIS, ANAEE, ENVRI, COOPEUS) provide the framework for the harmonized data products development and calibration of network measurements with international standards. ESA's Climate Change Inititative (CCI) programme provides validated and improved satellite observations of atmospheric, land and ocean parameters.

The PEEX network funding scheme is built on a multilateral approach and is foreseen to be based on (i) national funding, (ii) bilateral funding and (iii) Nordic and (iv) European funding with matching funds concept. ?Russian, Chinese?

As an outcome of the PEEX infrastructure Preliminary Phase, the PEEX observation network will fill the current observational gap in the Siberian region. Furthermore the program will bring the observation setup into international context with the standardized or comparable procedures. It is the basis for the long-term continuation of advanced measurements on aerosols, clouds, GHGs and trace gases in the Northern Pan-Eurasian area to be operated by PEEX educated scientific and technical staff capable of answering the research questions arising from the PEEX science community.

As a part of the PEEX initiative, for the purpose of supporting the PEEX observational system and answering on the PEEX scientific questions, a hierarchy/ framework of modern multi-scale models for different elements of the Earth System integrated with the observation system is needed. As the first outcome of the PEEX Modelling Platform Preliminary Phase, the PEEX modeling team will make an inventory of available modeling tools fitting the PEEX purposes, illuminate the main existing gaps in the modeling tools and suggest a plan for their developments and improvements.

The PEEX modelling platform (MP) is characterized by:

- Complex integrated Earth System Modelling (ESM) approach in combination with specific models of different processes and elements of the system on different time and space scales.
- An ensemble approach with the integration of modelling results from different models, participants, countries, etc.
- A hierarchy of models; analysing scenarios; inverse modelling; modelling based on measurement needs and processes.
- Model validation by remote sensing data and assimilation of satellite observations to constrain models to better understand processes, e.g., emissions and fluxes with top-down modelling.
- Geophysical/chemical model validation with experiments at various spatial and temporal scales.
- Assimilation of measurement data by models.
- Analysis of anticipated large data volumes coming from PEEX models and sensors should be supported by developed dedicated virtual research environment.

Contributing institutes <TABLE – to-be-checked>

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7. **<TBD>**	Baikal - Irkutsk – Ulan Ude region	**<TBD>**
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11. Institute of Atmospheric Physics, CAS, CH	China ecosystem network	Xunhua Zheng
12. Nanjing University, CH	SMEAR-Nanjing, CH	Aijun Ding
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17. Ift , GR	**<TBD>**	Ali Wiedensholer

2. GROUND STATIONS

2.1 TECHNICAL REQUIREMENTS AND DESCRIPTIONS HIERARCIAL STATIONS

TABLE. 1 STATION REQUIREMENTS - LIST OF PARAMETERS

BASIC STATIONS (like weather stations)	FLUX STATIONS (like fluxnet stations)	FLAG SHIP STATIONS
<paramater list>		- comprehensive stations + sources and sinks for greenhouse gases, trace gases, aerosols - different environments

2.1.1 BASIC STATIONS

2.1.2 FLUX STATIONS

The tall tower network is supported by a flux tower network. A flux tower utilizes eddy covariance (EC) method, which is a direct micrometeorological flux measurement technique with high time resolution and it provides exchange rates (fluxes) at ecosystem scale, extending 100 m – 1 km away from a tower (Aubinet et al., 2000). Additional measurements of ancillary parameters on air, plants and soil (or water body) are also made within this footprint area. The surface can consist of bare soil, vegetation or water. Ideally, the surface around the tower should be homogeneous so that the measured fluxes are representative of the surface irrespectively of the wind direction. Additional data collected at the station vary depending on type of ecosystem but generally they include continuous measurements of micrometeorological quantities such as temperatures, humidity, radiation components, concentrations of greenhouse gases and precipitation, and ancillary information such as biomass, vegetation and soil carbon and nutrients, management and site history. The purpose of the ancillary measurements is to support process studies and to help to understand the physical and biotic factors controlling the fluxes of the trace gases.

2.1.3 FLAG SHIP STATIONS – COMPREHENSIVE STATIONS

To monitor gradual changes of GHG concentrations as well as to catch short-term exceptional episodes the long-term continuous measurements are needed. The impacts of various ecosystems on the atmospheric GHG loads can be estimated by top-down and bottom-up approaches. The top-down approach is based on tall towers combined with inversion from concentrations to sinks/sources. The bottom-up approach is based on flux towers with up-scaling.

The tall tower is an observatory established to measure continuously the GHG and other trace gas (e.g. CO) concentration variability due to regional and global fluxes. The tower must be at least 100 m high to reach over the atmospheric surface layer most of the time. A site chosen for installing a tall tower will be typically representative of a footprint area of more than 1000 km^2. Additional stations, with a more local footprint for instance located in areas of high local emissions will be associated. From the spatial differences of concentrations determined by a tower network combined with the atmospheric transport model, the surface sinks and sources can be estimated by mathematical inversion methods. Furthermore, if the anthropogenic sources are known the sinks/sources of natural ecosystems are obtained.

2.2 PRELIMINARY PHASE NETWORK - GROUND BASED STATIONS IN SIBERIAN AREA

2.2.1 GROUND BASED STATIONS SELECTED FOR THE PEEX PRELIMINARY PHASE

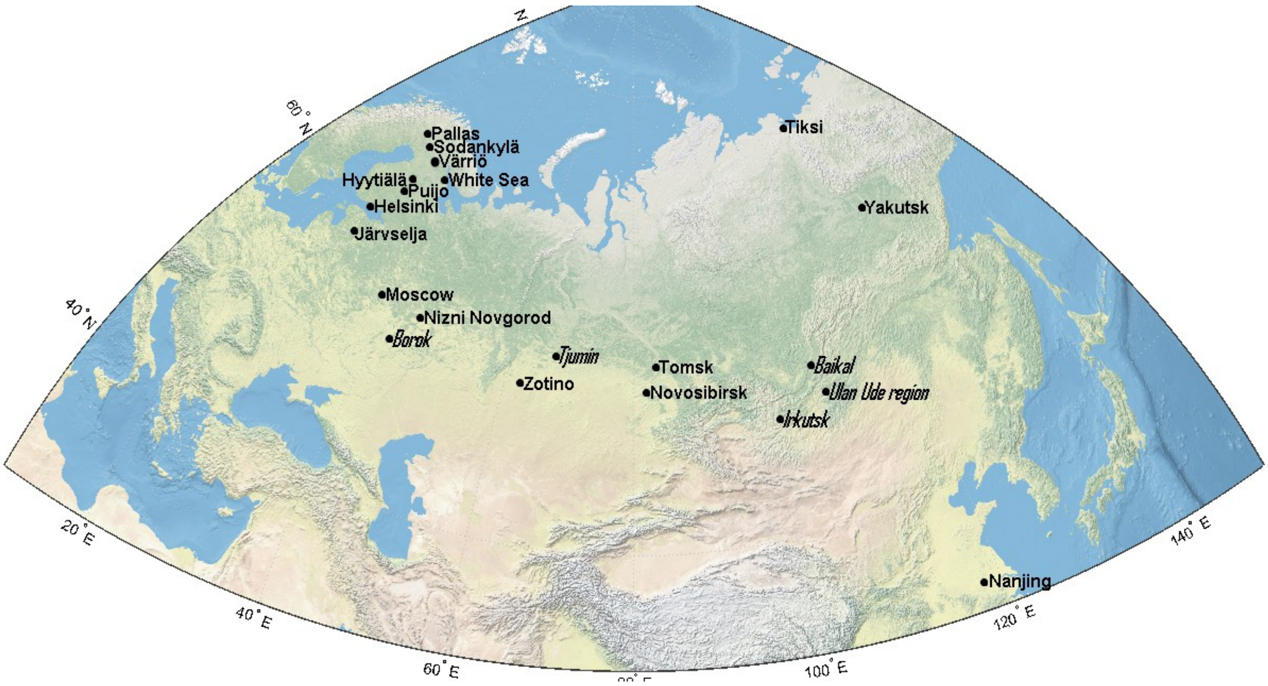
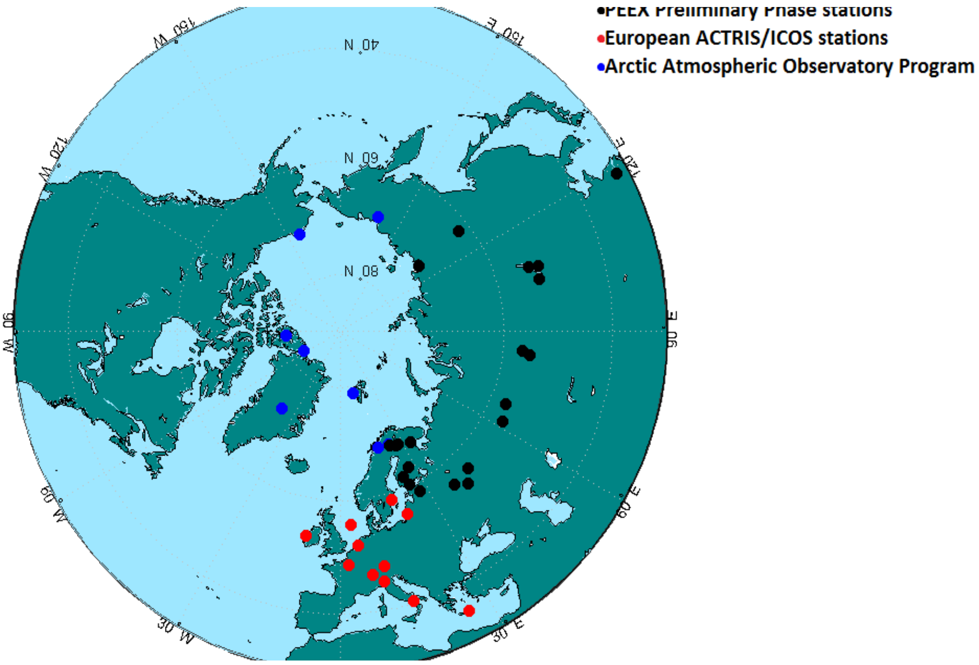


Fig. Preliminary list of PEEX Atmophere-Ecosystem -Observation network sites/stations. Värriö- SMEAR-1 / FINLAND, Hyytiälä-SMEAR-II / FINLAND, Helsinki-SMEAR-III (urban) / FINLAND, Puijo-Kuopio-SMEAR-IV / FINLAND, Järviseljä-SMEAR / ESTONIA, China ecosystem network (CERN) Zheng, Yakutsk /CHINA, Nizni Novgorod-Moscow-Borok (Evgeni Mareev) /RUSSIA, Tomsk (Mihail Arshinov),/ RUSSIA, Kola Arctic / White Sea (Schevchenko) /RUSSIA, Tiksi (Makshtas, Laurila, Asmi) /RUSSIA, Novosibirsk (Sergej Dubtsov) /RUSSIA, Zotino (Institute of Forest, Krasnojarsk, MPI Jena) /RUSSIA, Tjumin (Vladimir Melnikov) /RUSSIA, Baikal - Irkutsk – Ulan Ude region (Eugene Mikhailov). /RUSSIA, Nanjiing-SMEAR /CHINA. Detailed descriptions of quantities measured by the potential phase stations are presented in APPENDIX-1.

2.2.2 OTHER POTENTIAL STATIONS TO BE CONNECTED TO PEEX PRLIMINARY PHASE NETWORK



2.3 TECHNICAL RECOMMENDATIONS – SYNERGY WITH THE INTERNATINAL NETWORKS

2.3.1 GAW

2.3.2 EUROPEAN AND NORDIC RESEARCH INFRASTRCTURES

At the first phase the current ongoing research activities in Northern Nordic? countries or in Europe can contribute to building up the research collaboration through, e.g. providing up-to-date results on relevant research topics in the arctic regions or know-how, how to start the designing the next-generation research infrastructures in a coherent manner. These types of arctic activities are part of the Nordic Centers of Excellence CRAICC (Cryosphere-atmosphere interactions in a changing Arctic climate) and DEFORST (Impacts of a changing cryosphere- depicting ecosystem-climate feedbacks from permafrost, snow and ice) funded by the Nordforsk Top Level Research Initiative.

The new organization of the European research infrastructures (RI) towards world class research facilities and data services is under way. The European Union has set the roadmap, how the European research communities should organize and project their research facilities, data collection and services for a long-term, high-quality operative activity. As a part of building the European Union research area and to ensure Europe's competitiveness in "frontier" research, EU is listing the European world class research infrastructures in the European Strategy Forum on Research Infrastructures (ESFRI) roadmap. The ESFRIRoadmap identifies and determines the pan-European Research Infrastructures (RIs) and their services for European research communities for the next 10 to 20 years. The successful ESFRI projects will construct their services towards operational systems in a process, which will go on for four to five years. To step in the process towards European world class infrastructure requires a well-established observation network with harmonized services in the research area of interest. The successful completion of the EU-FP-7 Infrastructure Projects demonstrates the type of readiness for the RI process.

3. REMOTE SENSING

Satellite observations provide information on regional to global scales with spatial resolution varying from meters to tens of km, depending on the instrument and technique used. Likewise, spatial coverage and repeat time depend on the swath width and orbit. Of particular interest in the context of PEEX are land, lake and atmospheric observations. The atmospheric observations are complementary to those from the stations described above in that they provide information on atmospheric concentrations of aerosols, trace gases and GHG. As for the flag ship stations, techniques are being developed to derive information on the emission of atmospheric components from natural and anthropogenic sources as well as forest fires using inverse modelling. As part of ESA's Data Users Element (DUE) programme, this is applied to emissions of aerosols, NO2, SO2, CO, isoprene, VOCs, while satellite-derived GHG emissions are provided as part of the Copernicus project MACC-II. These emissions are derived from instruments such as OMI (trace gases), AATSR and MODIS (Aerosol) with default spatial resolutions of 13x24 km^2 and 10x10 km^2, respectively. Spatial disaggregation techniques are being developed to provide high resolution emission Maps. Currently these efforts do not have a specific focus on the PEEX area of interest, although part of it is already covered. Satellites have a limited lifetime but the availability will in the future be guaranteed from the operational Sentinel missions. Other uses of satellite observations will be discussed in Chapter 3.

3.1 AN INVENTORY OF SATELLITES AND THEIR PRODUCTS

- UV/VIS, infrared, radar, hyperspectral, pol& multiview
- Atmosphere: Aerosol properties, Trace gases, GHG, Cloud properties, UV & other radiation fields
- Land: Sfc reflectance, Land cover, Vegetation, Snow cover, Forest fires and dispersion of smoke, biomass
- Water: Pollution, Ice cover, water ways

Satellites contribute a wealth of information from instruments using passive of active techniques. Passive techniques are used to measure the upwelling radiation at the top of the atmosphere (TOA) at different wavelengths. TOA radiances at wavelengths in the UV, Visible (VIS), and near-infrared are due to solar radiation transmitted through the atmosphere and reflected at the surface and by aerosol particles and cloud droplets. The radiances at longer wavelengths are mainly due to thermal emission of the Earth surface and atmospheric constitutents. The measurements can be made at selected wavelengths in small or wider bands (radiometers), or it can be spectrally resolved (spectrometers, hyperspectral). Furthermore, some instruments provide two or more viewing directions. Few instruments also measure the polarization direction of the reflected light. Spectrometers provide information on atmospheric constituents such as greenhouse gases (GHG), trace gases, or aerosols. Radiometers are used for aerosol and cloud detection, which is more accurate as more wavelengths are available, preferably over wide range from the UV to the TIR, and the use of multiple viewing angles and / or polarization improve the aerosol and cloud retrieval. However, radiometers are often designed for other purposes such as obtaining information on land or sea surface temperature, ocean colour, snow and ice cover, land cover and land use, surface albedo, above ground biomass etc. (please add other applications). Active instruments include radar and lidar. Can someone write a few words about radar. Radar systems are mostly independent of cloud conditions and provide information of the three-dimensional structure of the earth surface. Depending on the operating wavelength, Radar – or Synthetic Aperture Radar (SAR) systems – imaging radar backscatter can be applied for surface roughness and soil moisture mapping or vegetation mapping. In particular, SAR systems are highly effective for above ground biomass retrieval. Lidars provide information on aerosol and cloud properties as a function of height, but for a very small swatch and with a very long return time. An overview of instruments used for atmospheric remote sensing and applications can be found in Burrows et al. (2011). SEE APPENDIX for Table Sat1 provides an overview of instruments proposed to be used in PEEX and Tables Sat2-Sat4 provide a list of parameters provided by each instrument for atmosphere, land and water.

3.2 INFRASTRUCTURE

- Sodankylä Receiving Station (FMI)
- China satellite Receiving station, Beijing, Sanya, & Kashi stations (RADI)
- Aerosol-cci data provider (CCI)
- Ground based remote sensing networks (Cloud radars, lidar) (FMI, UHEL, RADI)
- Satelite data sharing (Jena, RADI)

- Network of receiving stations across Russia (AEROCOSMOS)
- Real time information on forest fires (25 / day) (AEROCOSMOS)
- Airborne Remote Sensing Centre of RADI operates two Cessna Citation S/II Airplanes and have two new advanced Airplanes ARJ 21-700ER with 10 new sensors.
- Two new Remote Sensing Aircrafts:Equipped with 10 state-of-the-art remote sensors: visible, infrared, and microwave remote sensors and a high-performance data processing system, including Airborne atmospheric laser radar,Digital CCD camera, Airborne whiskbroom imaging spectrometer
- (0.45 µm-12.5µm);Airborne 3-D light detection and ranging, Airborne X-band interferometry SAR, Airborne pushbroom imaging spectrometer (0.45m-2.5m).

4.PEEX MODELLING PLATFORM

The PEEX modelling platform (MP) is characterized by:

- Complex integrated Earth System Modelling (ESM) approach in combination with specific models of different processes and elements of the system on different time and space scales.
- An ensemble approach with the integration of modelling results from different models, participants, countries, etc.
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- Assimilation of measurement data by models.
- Analysis of anticipated large data volumes coming from PEEX models and sensors should be supported by developed dedicated virtual research environment.

As the part of the PEEX initiative, for the purpose of **supporting the PEEX observational system and answering on the PEEX scientific questions, a hierarchy/ framework of modern multi-scale models for different elements of the Earth System integrated with the observation system is needed**.

One of the acute topics in the international debate on land-atmosphere interactions in relation to global change is the Earth System Modeling (ESM). The question is whether the ESM components actually represent how the Earth is functioning. The ESMs consist of equations describing the processes in the atmosphere, ocean, cryosphere, terrestrial and marine biosphere. ESMs are the best tools for analyzing the effect of different environmental changes on future climate or for studying the role of whole processes in the Earth System. These types of analysis and prediction of the future change are especially important in the Arctic latitudes, where climate change is proceeding fastest and where near-surface warming has been about twice the global average during the recent decades.

The processes, and hence parameterization, in ESMs are still based on insufficient knowledge of physical, chemical and biological mechanisms involved in the climate system and the resolution of known processes is insufficient. Global scale modeling of land-atmosphere-ocean interactions using ESMs provides a way to explore the influence of spatial and temporal variation in the activities of land system and on climate. There is a lack, however, ways to forward a necessary process understanding effectively to ESMs and to link all this to the decision-making process. Arctic-boreal geographical domain plays significant role in terms of green-house gases and anthropogenic emissions and as an aerosol source area in the Earth System.

Added value of the comprehensive multi-platform observations and modeling; network of monitoring stations with the capacity to quantify those interactions between neighboring areas ranging from the Arctic and the Mediterranean to the Chinese industrial areas and the Asian steppes is needed. For example, apart from development of Russian stations in the PEEX area a strong co-operation with surrounding research infrastructures in the model of ACTRIS network needs to be established in order to obtain a global perspective of the emissions transport, transformation and ageing of pollutants incoming and exiting the PEEX area.

To meet challenges related to growing volumes of global and PEEX domain environmental data archives creation of virtual research environment (VRE) is required. This should enable researchers to process structured and qualitative data in virtual workspaces. VRE should integrate data, networks and computing resources providing interdisciplinary climatic research community with opportunity to get profound understanding of ongoing and possible future climatic changes and their consequences for the targeted region.

The PEEX-MP aims to simulate and predict the physical aspects of the Earth system and to improve understanding of the bio-geochemical cycles in the PEEX domain, and beyond. The environmental change in this region implies that, from the point-of-view of atmospheric flow, the lower boundary conditions are changing. This is important for applications with immediate relevance for society, such as numerical weather prediction. The PEEX infrastructure will provide a unique view to the physical properties of the Earth surface, which can be used to improve assessment and prediction models. This will directly benefit citizens of the North in terms of better early warning of hazardous events, for instance. On longer time-scales, models of the bio-geochemical cycles in the PEEX domain absolutely need support from the new monitoring infra-structure to better measure and quantify soil and vegetation properties.

In the most basic setup, the atmospheric and oceanic Global Circulation Models (GCMs) are connected to each other, sharing e.g. fluxes of momentum, water vapour and CO_2. Traditionally, the land compartment has been an integral part of the atmospheric model, but in most modern ESMs the land model has been clearly separated. In most cases, the GCMs are complemented by other additional submodels covering, for example, atmospheric chemistry and aerosols, biogeochemistry or dynamic vegetation. Although the models can communicate also directly with each other, usually a separate coupler is used as an interface between different submodels.

Evaluation of process-models to improve GCM parameterizations

One of the main PEEX modelling activities is to evaluate process-models of chemistry-biota-atmosphere interactions in Pan Eurasian region and to improve GCM parameterizations. PEEX scientific plan is designed to serve as a research chain that aims to advance our understanding of climate and air quality. It can be seen through a series of connected activities beginning at the molecular scale and extending to the regional and global scales. Past variations in climate in Pan Eurasian region and corresponding forcing agents would be revealed by analysis of firn and ice cores in glaciers and ice sheets.
A combination of direct and inverse modelling will be applied to diagnosing, designing, monitoring, and forecasting of air pollution in Siberia and Eurasia (Penenko et al., 2012). Regional models coupled with the global one by means of orthogonal decomposition methods allow one to correctly introduce data about the global processes onto the regional level where environmental quality control strategies are typically implemented (Baklanov et al., 2008).

Proceeding from the above mentioned limitations, a new concept and methodology considering the concept of 'one-atmosphere' as two-way interacted meteorological and chemical processes is suggested (Baklanov et al., 2011; Zhang et al., 2012). The atmospheric chemistry transport models should include not only health-effecting pollutants (air quality components), but also green-house gases (GHG) and aerosols effecting climate, meteorological processes, etc. Such concept requests a strategy of new generation integrated chemistry-climate modelling systems for predicting atmospheric composition, meteorology and climate change. The on-line integration of meteorological/ climate models and atmospheric aerosol and chemical transport models gives a possibility to utilise all meteorological 3D fields at each time step and to consider feedbacks of air pollution (e.g. aerosols) on meteorological processes and climate forcing, and further on the chemical composition (as a chain of dependent processes). This promising way for future atmospheric simulation systems (as a part of and a step to ESMs) will be considered in PEEX. It will lead to a new generation of models for climatic, meteorological, environmental and chemical weather forecasting (EuMetChem, 2012: www.eumetchem.info).

SCIENCE QUESTIONS, REQUESTED INTEGRATED ESM APPROACH

- An urgent question to address as northern latitude regions are expected to experience temperature changes higher than the global mean while being large enough to feedback to regional and global climate systems. Our understanding of the relevant physical processes has been hampered by a lack of concurrent measurements of aerosols, clouds, radiation, snow, and sea-ice processes.
- How can we describe BVOC emission responses to of air chemistry related impacts (CO2 impact, ozone induction, nitrogen dependency) mechanistically considering the phenological and physiological state of the plant as well as immediate climatic conditions?
- How can we quantify the deposition of air pollutants (i.e. ozone) into the vegetation and how can we distinguish explicitly between stomatal- and non-stomatal deposition (incl. chemical deposition by BVOC emission, ozone impact on stomata)?
- What are the current and future effects of biomass burning /wild forest fires / ship emissions on radiative forcing and atmospheric composition in the Arctic and Siberia?

SOCIO-ECONOMIC MODELS

Socio-economic development of the region depends upon a number of global and macro-economic processes such as future development of the world's energy production and consumption, the national and global demand on natural resources, specifics of the national policies in developments of northern territories, or policies with respect to small ethnic communities. Expected climate changes will play a substantial role in the overall socio-economic predictions and assessments, as will the existing climate policy that already influences economic development. The post-Soviet period of dynamics of the regions was characterized by many negative social tendencies and processes like substantial migration of population from the northern regions, decline of thousands of taiga settlements due to the collapse of the soviet forest industry, destruction of transport connections, substantial worsening of social services like medicine and education, supply of first-necessity goods etc., particularly in remote territories.

The crucial prerequisite of socio-economic development of the region, particularly in high latitudes, is transition to sustainable development aiming at creation of acceptable standards of human life and maintenance of environment and regional stability of the biosphere. In Russia, this transition is declared as a starting point of national and regional policies of natural resources management. However, the reality is far from such declarations. The ecological and environmental situation in large regions of Northern Eurasia should be characterized as the ongoing severe ecological crisis initiated by unregulated anthropogenic pressure on nature and explosive increase of production and transport of natural resources, mostly fossil fuel. Altogether, this results in the decreasing quality of major components of environment – air, water, soil, and vegetation, - and generates many risks. The region is one of the most vulnerable regions of the globe.

Taken complexity and uncertain character of predictions of the socio-economic development of the region, PEEX will widely use with this respect integrated modeling as a major modeling tool. Integrated modeling combines consideration of problems of different nature – economic, ecological and social. One of the planned ways is use of integrated clusters like IIASA ESM Integrated Modeling Cluster (http://www.iiasa.ac.at/web/home/research/researchPrograms/ EcosystemsServicesandManagement/Integrated-Model-Approach.en.html). The cluster integrates different models – economic model GLOBIOM (Havlik et al., 2011), forest specialized model G4M (Rametsteiner et al., 2007), agricultural model EPIC (Izaurradle et al., 2006) and others, which are combined in a common modeling framework. The cluster could be modified and adapted for the region's conditions and problems.

The another promising approach deals with the application of combining agent-based and stock-flow modeling approaches in a participative analysis of the integrated land system that allows to illustrate various paradigms in studying the complexity of ecological-social systems. In essence, an agent-based model is a system designing a collection of individual, heterogeneous decision-makers referred to as agents, who consider their options in their respective environment to form decisions on the basis of a pre-defined set of rules working in an environment of on internal and external factors and different scenarios. Finally, taking different perspectives of different stakeholders or decision-makers, other techniques of socio-economic modeling and research will be examined, particularly using real options modeling for investigating the impact of uncertainty emerging from a lack of information. In questions relating to adaptation and mitigation strategies and development, a variety of social science methods will be employed in order to gain a better understanding of how these political processes take place and how they can be best supported. This includes a variety of participatory methods to include relevant stakeholders.

VIRTUAL RESEARCH ENVIRONMENT FOR REGIONAL CLIMATIC AND ECOLOGICAL STUDIES SUPPORT

Volumes of environmental data archives are growing immensely due to recent models, high performance computers and sensors development. It makes impossible their comprehensive analysis in conventional manner on workplace using in house computing facilities, data storage and processing software at hands. One of possible answers to this challenge is creation of virtual research environment (VRE), which should provide a researcher with an integrated access to huge data resources, tools and services across disciplines and user communities and enable researchers to process structured and qualitative data in virtual workspaces (De Roore and Goble, 2007). Thematic VRE should integrate data, network and computing resources providing interdisciplinary climatic research community with opportunity to get profound understanding of ongoing and possible future climatic changes and their consequences.

First steps of development of PEEX domain VRE elements aimed at regional climatic and ecological monitoring and modeling as well as at continuous education and training support were done in course of FP6 EC Eviro-RISKS project (Baklanov and Gordov, 2007). The interactive web-system for regional climate assessment on the base of standard meteorological data archives was developed and launched into operation (http://climate.risks.scert.ru). On this basis the experimental software and hardware platform "Climate" was recently developed aimed at integrated analysis of heterogeneous georeferenced data (http://climate.scert.ru; Gordov et al., 2013; Shulgina et al., 2013; Okladnikov et al., 2013). It can be used as a PEEX VRE element prototype and approach test bench. Currently the VRE element is accessible via developed geoportal at the same link (http://climate.scert.ru) and integrates the WRF and «Planet Simulator» models, basic reanalysis and instrumental measurements data and support profound statistical analysis of storaged and modeled on demand data. In particular, one can run the integrated models, preprocess modeling results data, using dedicated modules for numerical processing perform analysis and visualize obtained results. New functionality recently has been added to the statistical analysis tools set aimed at detailed studies of climatic extremes occurring in Northern Asia. The VRE element is also supporting thematic educational courses for students and post-graduate students including relevant trainings (Gordova et al., 2013). Developed VRE element "Climate" provides specialists involved into multidisciplinary research projects with reliable and practical instruments for integrated research of climate and ecosystems changes on global and regional scales. With its help even a user without programming skills can process and visualize multidimensional observational and model data through unified web-interface using a common graphical web-browser.

PEEX VRE to be developed should integrate on the base of geoportal distributed thematic data storages, processing and analysis systems and set of models of complex climatic and environmental processes run on supercomputers. VRE specific tools should be aimed at high resolution rendering on-going climatic processes occurring in Northern Eurasia and reliable and found prognoses of their dynamics for selected sets of future mankind activity scenario.

Taken into account the diversity and integrated character of research which intends to be done by PEEX, it is relevant to have a solid georeferenced basis which would contain all available accumulated information about landscapes, terrestrial ecosystems, water bodies, biological productivity of the biosphere and its interaction with the lower troposphere, etc. Such a base will be realized in form of an Integrated Land Information System (ILIS) for Northern Eurasia (Schepachenko et al. 2010) as a multi-layer GIS with corresponding attributive databases. The georeferenced background of the ILIS is represented by a hybrid land cover which is developed by using multi-sensor remote sensing concept and all available ground information (forest and land state accounts, monitoring of disturbances, verified data of official statistics, measurements in situ etc.). The basic resolution of the ILIS is 1 km2. Finer resolution could be used for regions with rapid change of land cover. Initial version of the ILIS will be developed by state for 2011. The ILIS is planned to be used: (1) for introduction of a unified system of classification and quantification of ecosystems and landscapes; (2) as a benchmark for tracing the dynamics of land-use land cover; (3) for empirical assessment of fluxes of an interest (CO2, CH4, VOC, NOx, aerosols, etc.); (4) for use in different models and for models' validation; (5) for understanding of gradients for up scaling of "point" data.

The methodology for multidisciplinary probabilistic environmental risk and vulnerability assessments elaborated in ArcticRisk-NARP and FP6 Enviro-RISKS projects (Baklanov et al., 2006abc; Mahura et al., 2005, 2008) can be refined and applied as a web-based tool for evaluation of potential impact on environment and population in the PEEX region. The GIS and Google-Earth components of such tool could provide a more valuable representation. On an on-line web-request, for selected geographical locations of continuous emissions, accidental releases, planned constructions and operations, etc. the short- and long-term (ranging from a day up to several days, months, and up to one year) simulations with trajectory and dispersion modeling approaches can be used to construct various indicators of potential impact. These can include dominating atmospheric transport pathways, airflow probabilities, maximum reaching distances, fast transport, precipitation factor, time integrated air concentration, dry, wet, and total deposition patterns as well as other indicators. The results of these simulations are also applicable for integration and input for further evaluation of doses, impacts, risks, short- and long-term consequences for population and environment from potential sources. Risks evaluations and mapping will be important for decision making processes and for analyzis of environmental, social, economical, etc. consequences for different geographical areas and various population groups taking into account social-geophysical factors and probabilities, and using demographic and administrative databases. All these can be provided through the web-portal.

LIST OF MODELS AVAILABLE FROM PARTNERS:

1. HadGEM3-ES EARTH SYSTEM MODEL
2. EnviroHIRLAM/HARMONIE online integrated chemistry-meteorology modeling system
3. ???

5. SYNERGY SATELLITES & GROUND BASED & MODELS

- Synergy, complementarity**,** ground truth, accurate, precise, calibration, high quality and confidence**,** Spatial coverage vs few supersites
- Synergy satellites – ground based observations and modeling

Interpretation, parameters needed for models, constraints (data ass.), inverse modeling,
Data management for satellites & ground, models

- Extreme weather and climatic events monitoring
- Megacities (Moscow, Beijing) vs boreal forest:
  - Data available / sparse
- Links to other projects as pre-cursor for PEEX, e.g. Marco Polo (FP7) AQME II phase 2, ZAPÁS (FP7)
- Matrix of param & specs, data access
- Matrix param and their usefulness for PEEX-users
- Data sharing & management, format, description, easy access, meta data (one geoportal solution could be similar to the Siberian Earth System Science Cluster (SIBESSC) http://www.sibessc.uni-jena.de

Define demonstration projects on sat data use

- Marco Polo (EU FP7) as precursor project
- urban megacities (Moscow, Beijing)
- ZAPÁS (EU FP7) (Forest Monitoring) (Jena)
- BIOMASAR-II (ESA DUE project, Jena)
- Drought, fires, flooding monitoring and assessment in Asian region (RADI,CAS-TWAS)
- Comparison Study of Remote Sensing for Global Environment Change from four countries including Australia, Brazil, Canada and China (ABCC). (RADI)
- PEEX in China project (RADI)

Interpretation, parameters needed for models, constraints (data ass.), inverse modeling,
Data management for satellites & ground, models

- Extreme weather monitoring
- Megacities (Moscow, Beijing) vs boreal forest:
  - Data available / sparse
- Links to other projects as pre-cursor for PEEX, e.g. Marco Polo (FP7) AQME II phase 2, …
- Matrix of param & specs, data access
- Matrix param and their usefulness for PEEX-users
- Data sharing & management, format, description, easy access, meta data

Define demonstration projects on sat data use

AB: I suppose here we can link this task with the new FP7 EU-China project MarcoPolo and also with a new initiatives of WHO and WMO. Gerrit, Alexander M., please, add a few tasks based on the MarcoPolo planned activities with some further extention to the Siberia and the Arctic and Northern Asia.

6. CAPACITY BUILDING – TRAINING

7. DATA ARCHIVES

Relevant aspects related to the development of PEEX data-infrastructure

- Common PEEX database to store and provide all measurement data; How to share data? Model validation using data, e.g. AQMEII
- Data distribution - open data access vs. IPR rights;
- Procedures for data quality (standardization of instruments, methods, observations, data processing)
- Determination of input data products for integrated models
- Development of a calibration infrastructure for the inland water bodies - remote sensing

LIST OF Main Russian data sources

NAME	ACRONYM	WEBSITE
Transcontinental Observations Into the Chemistry of the Atmosphere	TROICA	http://www.ifaran.ru/troica/biblio/troica-en.pdf
Assessment and Monitoring of Forest Resources in the Framework of the EU-Russia Space Dialogue	ZAPAS	http://zapas.uni-jena.de/
Airborne Extensive Regional Observations in Siberia	YAK-AEROSIB	https://yak-aerosib.lsce.ipsl.fr/

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APPENDIX-1 LIST OF QUANTITIES MEASURED BY THE PEEX PRELIMINARY PHASE STATIONS

Fig. Map of Finland with SMEAR-stations

	AEROSOLS	TRACE GASES	RADIATION
VÄRRIÖ, SMEAR-1	Total Concentration Size Distribution	CO_2, H_2O, NO_X, O_3, SO_2	Global Radiation PAR UV-B UV-A
HYYTIÄLÄ, SMEAR-2	Aerodynamic Particle Sizer Aerosol Optical Depth Aerosol Particle Number Size Distribution Aerosol Particle Scattering Coefficient Aethalometer Air Ion Mobility Distribution Black Carbon Particle Mass Concentration Burkard Bio Aerosol Sampler	CH_4, CO, CO_2, H_2O, NH_3, N_2O, NO_X, O_3, SO_2 Radon	Ambient Radiation Diffuse Radiation Global Radiation Longwave Radiation In Longwave Radiation Out Net Radiation PAR Distribution in the

	Charged and Non-Charged Particles Dekati ELPI Dekati PM 10 Impactor Hygroscopic and Non-Hygroscopic Particles Neutral Air Ion Spectrometer Number of Particles Able to Form into Cloud Droplets Particle Concentration PM10 Particle Mass Concentration Size Segregating Number Concentration Flux of Aerosol Particles Total Number Concentration Flux of Aerosol Particles UV-Aerodynamic Particle Sizer Volatility DMPS		Cuvette PAR Distribution Within the Canopy Reflected Global Radiation Reflected Spectrum of Pine Needles Reflected, Diffuce, Direct and Total PAR Solar Radiation on the Ground Solar Radiation Spectrum UV-A UV-B
HELSINKI, SMEAR-3	Aerosol Particle Concentration Total Number Concentration Flux of Aerosol Particles	CO, NO_X, O_3, SO_2	Global Radiation Longwave Radiation In Longwave Radiation Out PAR Reflected Global Reflected Global PAR Reflected PAR
KUOPIO, SMEAR-4	Total Size Distribution Number Concentration Interstitial Size Distribution Light Absorbing Coefficient Light Scattering Coefficient Aerosol optical depth (and other aerosol optical properties)	NO, O_3, SO_2	Global, Diffuse and Direct Components of Spectral Solar Irradiance
JÄRVSELVA	Aerosol Optical Depth Electrical Aerosol Spectrometer Neutral Air Ion Spectrometer	CH_4, CO, CO_2, NO_X, O_3, SO_2	Global Radiation Solar Radiation Spectrum PAR

			Radon
NANJING	Particle Number Size Distribution Particle Scattering Coefficient Aethalometer Air Ion Mobility Distribution PM Mass Concentration PM2.5 mass concentration	CO, CO_2, NO_X, O_3, SO_2	Net Radiation UV
PALLAS	Aerodynamic Particle Sizer Aerosol Particle Number Size Distribution Aerosol Particle Scattering Coefficient Aethalometer Air Ion Mobility Distribution Black Carbon Particle Mass Concentration PM10 Particle Mass Concentration Aerosol Hygroscopicity	CO_2,CH_4, N_2O, H_2, NO_X, O_3, SO_2, CO, Deposition, atmospheric conc. Inorganic Ions, Hg, PAH, POPS,	Global radiation Reflected global Longwave radiation in Longwave radiation out PAR Reflected PAR Net radiation
SODANKYLÄ	Aerosol optical depth, Lidar aerosol profile	CO_2,CH_4, O_3, CO, Radon, Ozone soundings, Total ozone, TCCON total column CO_2,CH_4	Global radiation Reflected global Longwave radiation in Longwave radiation out PAR Reflected PAR Net radiation UV Solar spectrum Canopy radiation spectra
TIKSI	Aerosol optical depth, Aerodynamic Particle Sizer Aerosol Particle Number Size Distribution Aerosol Scattering Coefficient Aethalometer Black Carbon Particle Mass Concentration	CO_2, CH_4, O_3, SO_2, Total ozone	Global radiation Reflected global Longwave radiation in Longwave radiation out PAR, Reflected PAR Net radiation

APPENDIX-2 LIST OF ATMOSPHERIC OBSERVATION NETWORKS RELEVANT TO PEEX

NAME	ACRONYM	WEBSITE
International Network Measuring Terrestrial Carbon, Water and Energy Fluxes	FLUXNET	http://fluxnet.ornl.gov/
Global Atmosphere Watch	GAW	http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html
Global Climate Observing System	GCOS	http://www.wmo.int/pages/prog/gcos/

Global Terrestrial Observing System	GTOS	http://www.fao.org/gtos/
The International Arctic Systems for Observing the Atmosphere	IASOA	http://iasoa.org/iasoa/index.php?option=com_frontpage&Itemid=1
International Network for Terrestrial Research and Monitoring in the Arctic Interact		http://www.eu-interact.org/
Network for the Detection of Atmospheric Composition Change	NDACC	http://www.ndsc.ncep.noaa.gov/
Multidisciplinary Research Station in Kenya	TAITA	http://www.ileaps.org/index.php?option=com_content&view=article&id=1013%3Ataita-research-station-full-description&catid=69&Itemid=200
Total Carbon Column Observing network	TCCON	https://tccon-wiki.caltech.edu/
Observation Platform in South Africa	WELGEGUND	http://www.ileaps.org/index.php?option=com_content&view=article&id=1011%3Awelgegund-observation-platform-project-full-description&catid=69&Itemid=200

APPENDIX-3 LIST OF ONGOING EU-RI / ESRFI PROJECTS RELEVANT TO PEEX ATMOSPHERIC-ECOSYSTEM RI DEVELOPMENT

- **ESRFI- ICOS**: The development of the greenhouses gases research infrastructure, the integrated carbon. ICOS is a research infrastructure to decipher the greenhouse gas balance of Europe and adjacent regions.
- **ESRFI- ANAEE Infrastructure for Analysis and Experimentation on Ecosystems** experimentation in terrestrial ecosystem research
- **ESRFI- LIFEWATCH**
- **ESRFI- EXPEER** experimentation in terrestrial ecosystem research

- **EU-FP7-ACTRIS-I3** (Aerosols, Clouds, and Trace gases Research Infrastructure Network-project 2011-2015) and ICOS. ACTRIS-I3 is aiming at integrating European ground-based stations equipped with advanced atmospheric probing instrumentation for aerosols, clouds, and short-lived gas-phase species.
- **FP7-ENVRI-project** "Common Operations of Environmental Research Infrastructures. The organization of databases, data products and formats will be made in collaboration of ongoing European and European-USA activities. Most relevant projects in years 2013-20XX are to the ongoing EU-FP7-projects: FP7-ENVRI-project "Common Operations of Environmental Research Infrastructures" in Europe a collaboration effort of the ESFRI Environment Cluster and to develops common e-science components and services for their facilities
- **FP7-COOPEUS-project** "Transatlantic cooperation in the field of environmental research infrastructures" between Europe and USA. The aim of these research infrastructure projects is the identification of next generation user friendly data structures and formats. The key institute in European scale is Norwegian Institute for Air research, NILU (Norway), where major part of the atmospheric relevant dataset/ products are currently stored and distributed.

APPENDIX-4 LIST OF ONGOING PROGRAMMES COLLABORATORS RELEVANT TO PEEX

EU Life+ Mitigation of Arctic warming by controlling European black carbon emissions project	MACEB	http://en.ilmatieteenlaitos.fi/maceb
Advancing the Integrated Monitoring of Trace Gas Exchange Between Biosphere and Atmosphere	ABBA	http://www.abba.ethz.ch/
Aerosols, Clouds, Precipitation and Climate Research Program	ACPC	http://www.ileaps.org/multisites/acpc/
Aerosol Robotic Network	AERONET	http://aeronet.gsfc.nasa.gov/
African Monsoon Multidisciplinary Analyses	AMMA	http://amma-international.org/
Arctic Climate Stability and Change Arctic	ECRA	http://ecra-climate.eu/index.php/collaborative-programmes/arctic-ecra
Collaboration Network on EuroArctic Environmental Radiation Protection and Research	CEEPRA	http://www.stuk.fi/stuk/tiedotteet/2011/en_GB/news_668/
Center for International Climate and Energy Research-Oslo	CICERO	http://www.cicero.uio.no
ESA Climate Change Initiative	CCI	http://www.esa-cci.org/ 13 projects incl GHG, trace gases, land use, forest fires, etc,
ESA GlobEmission project	GlobEmission	http://www.globemission.eu/
Global Emissions InitiAtive	GEIA	http://www.geiacenter.org/
Ileaps?		
International Global Atmospheric Chemistry	IGAC	http://www.igacproject.org/
Land-Use and Climate, Identification of robust	LUCID	http://www.ileaps.org/index.php?

impacts		option=com_content&task=view&id=99
Land Use and Land Cover Change	LULCC	http://lcluc.umd.edu/
Cryosphere-atmosphere interactions in a changing Arctic climate NCoE	CRAICC	http://www.atm.helsinki.fi/craicc/
Impacts of a changing cryosphere: depicting ecosystem-climate feedbacks from permafrost, snow and ice NCoE	DEFROST	http://www.ncoe-defrost.org/
Nordic Strategic Adaptation Research NCoE	NORD-STAR	http://www.nord-star.info/
Marine Ecosystems and Resources under Climate Change NCoE	NorMER	http://www.toppforskningsinitiativet.org/en/programmer-1/program-1/prosjekter/ncoe-nordic-centre-for-the-study-of-climate-change-effects-on-marine-ecosystems-and-resource-economics
Stability and Variations of Arctic Land Ice NCoE	SVALI	http://www.ncoe-svali.org/
How to preserve the Tundra in a warming climate NCoE	Tundra	http://www.ncoetundra.utu.fi/
Northern Eurasia Earth Science Partnership Initiative	NEESPI	http://neespi.org/
Strategic Action Program for the protection of the Arctic environment SAP	Arctic	http://projects.csg.uwaterloo.ca/inweh/display.php?ID=5047
Remote Sensing Aerosols, Clouds, Precipitation and Climate Interactions	Sat-ACPC	http://www.ileaps.org/multisites/acpc/index.php?option=com_content&view=article&id=24&Itemid=24
Surface Ocean Lower Atmosphere Study	SOLAS	http://www.solas-int.org/
Weather Research and Forecasting (WRF) model coupled with Chemistry	WRF-Chem	http://ruc.noaa.gov/wrf/WG11/
Water Regulations Advisory Scheme	WRAS	http://www.wras.co.uk/
WWRP Polar Prediction Project WMO		

- **M.V. Kabanov ppt helsinki**

A network planned for monitoring of climatic and natural processes in Siberia

Reference monitoring stations

1. **Tomsk (city)**
2. **Tomsk (Vasyuganie)**
3. **Ulan-Ude (Boyarskaya)**
4. Chita (Arakhley)
5. Krasnoyarsk (Zotino)
6. Barnaul (Aktru)
7. Novosibirsk (Chany)
8. Kyzyl (Dolinnaya)
9. Yakutsk (Spasskaya Pad')
10. Irkutsk (Mondy)
11. **Khanty-Mansiisk (Muchryno)**
12. Nadym (Polyarnaya)

APPENDIX-5 OVERVIEW OF INSTRUMENTS PROPOSED TO BE USED IN PEEX

Table Sat1.

Instrument	Platform	Technique	spectral range	other	swath	availability
ATSR-2	ERS-2	Radiometer	7-channel VIS/IR radiometer with dual view for accurate atmospheric corrections. 0.55 µm 0,659 µm 0.865 µm 1.61 µm	Resolution 1 km	500 km	2002-2012

			3.70 µm 10.85 µm 12.00 µm			
AATSR	ENVISAT	Radiometer	7 channels: 0.55 µm 0,659 µm 0.865 µm 1.61 µm 3.70 µm 10.85 µm 12.00 µm	Two views (close-to-nadir and fore- for accurate atmospheric corrections), 7 channels, balanced VIS, NIR, SWIR, MWIR, TIR, narrow swath Resolution 1 km.	500 km	2002-2012
SLSTR	Sentinel-3	Radiometer				
MODIS	Terra	Radiometer	36-channel VIS/IR spectro-radiometer 0.645- 14 nm	Resolution 0.25 km (two channels), 0.5 km (5 channels), 1.0 km (29 channels)	2330 km 2330 km	1999-present Operation al
	Aqua					2002-present Operation al
POLDER	PARASOL	Radiometer	9 wavelengths: 443.5 µm 490.9 µm 563.8 µm 669.9 µm 762.9 µm 762.7 µm 863.7 µm 907.1 µm 1019.6 µm	3 polarisations at 3 wavelengths; total: 15 channels Resolution 6.5 km	2400 km	1996-2013
OMI	Aura	UV/VIS grating imaging spectrometer	three bands, 1560 channels total 270 - 314 µm	Resolution: 13 x 24 km^2 associated to	2600 km - Zoom mode	10/2004-present Operation

			306 - 380 µm 350 - 500 µm	2600 km swath, reduced to 36x48 km^2 for profiles. 13x12 km^2 in zoom	available, with swath 725 km	al
TROPOMI	ESA/GMES Sentinel 5P	UV/VIS/NIR/SWIR Grating spectrometers	3 sprectral bands: UV/VIS 270-500nm NIR 675-775 nm SWIR 2305-2385 nm	To be launched; Resolution 7 km at s.s.p.	2600 km	From 2015
GOME-2	METOP-A and B	UV/VIS/NIR Grating Spectrometer	four bands, 4096 channels, with 200 polarisation channels 240-315 nm 311-403 nm 401-600 nm 590-790 nm 312-790 nm	Tandem instruments, Metop-B since September 2012 Resolution 40 x 40 km^2 associated to 960 km swath or 40 x 80 km^2 associated to 1920 km swath	Metop-A: 960 km Metop-B: 1920 km	2007-present
IASI	Metop	Interferometer	8461 channels, with one embedded IR imaging channel 8.26-15.50 µm 5.00-8.26 µm 3.62-5.00 µm 10.3-12.5 µm	Resolution 4 x 12-km IFOV close to the centre of a 48 x 48 km^2 cell (average sampling distance: 24 km)	2130 km	2006-present
CALIOP	CALIPSO	Cloud-Aerosol Lidar	Two-wavelengths (532 and 1064 nm), measurements at two orthogonal polarisations	Resolution: Horizontal: 70 m IFOV sampled at 333 m intervals along track. Vertical: 30 m		2006-present
GOMOS	Envisat	UV/VIS/NIR grating spectrometer	three bands, ~ 1000 channels, two broadband channels for scintillations.	Resolution: Vertical: 1.7 km, in the altitude range 20-100 km.		2002-2012

			248-693 nm 750-776 nm 915-956 nm 466-582 nm 644-705 nm	Horizontal effective resolution: ~ 300 km (limb geometry)		
ASAR	ENVISAT	Radar	Microwave: C-band, with choice of 5 polarisation modes (VV, HH,VV/HH, HV/HH, or VH/VV)	C-band SAR, frequency 5.331 GHz, Resolution: depending on operation mode 30m, 150m, 1km.	100 km 405 km depending on operation mode	2002 - 2012
VIRR,IRAS, MWTS,MWHS,MERSI,ERMSBUS,TOU,SIM	FY-3A,B	UV/VIS/TIRSpectrometer Microwave/Thermometer/hygrometer etc				
geostationary meteorological satellites	FY-2 E,D					
TANSO-FTS	GOSAT	Fourier-Transform Spectrometer	3 narrow bands (0.76, 1.6, and 2 µm) 1 wide band (5.5-14.3 µm) with 0.2 cm^{-1} spectral resolution.			2009-now
ASTER	Terra	Radiometer	0.52-0.60 µm 0.63-0.69 µm 0.76-0.86 µm 1.60-1.70 µm	Resolution: 15m - 0.56µm, 0.66 µm, 0.81 µm;	60x60 km	1999-2013 Operational

			2.145-2.185 µm 2.185-2.225 µm 2.235-2.285 µm 2.295-2.365 µm 2.360-2.430 µm 8.125-8.475 µm 8.475-8.825 µm 8.925-9.275 µm 10.25-10.95 µm 10.95-11.65 µm	30m - 1.65µm, 2.165 µm, 2.205 µm, 2.260 µm 2.330 µm 2.395 µm; 90m - 8.30µm, 8.65 µm, 9.10 µm, 10.60 µm, 11.30 µm		
MOPITT	Terra	Spectrometer	3 bands, 8 channels. For CO: 4.62 µm (four channels) and 2.33 µm (two channels); for CH4: 2.26 µm (two channels)	Resolution 22 km IFOV	640 km	1999-2013 Operational
Hyperion	(EO-1)	VIS/NIR/SWIR grating spectrometer	220 channels, in two groups covering the ranges 0.4-1.0 µm and 0.9-2.5 µm respectively; channels bandwidths 10 nm	Resolution 30 m IFOV	7.5 km	2000-2014 Operational
AMSR-E	AQUA	Radiometer		Large antenna, 6 frequencies / 12 channels in the range 6.9 to 89 GHz	1450 km	2002-2013 Operational
TIRS	Landsat-8	Radiometer	2 TIR channels 10.3 - 11.3 µm 11.5 - 12.5 µm	Resolution 120 m	185 km	2013-2018
MISR	Terra	Radiometer	Assembly of 9 cameras, each one with 4 spectral VIS/NIR channels, each camera with different pointing: 446 nm 558 nm 672 nm 866 nm	Resolution Selectable: 275 m or 550 m or 1100 m	360 km	1999-2013 Operational
AVHRR	NOAA	Radiometer	4-channel radiometer covering VIS, NIR, MWIR, TIR 0.615 µm 0.912 µm 3.74 µm 11.0 µm	Resolution 1.1 km IFOV s.s.p.	2900 km	1978-2012
AVHRR/3	Metop	Radiometer	6-channel radiometer covering	Resolution 1.1 km s.s.p.	2900 km	2012-2018

			VIS, NIR, SWIR, MWIR and TIR: 0.630 µm 0.862 µm 1.61 µm 3.74 µm 10.80 µm 12.00 µm	IFOV		
MI	COMS-1	Radiometer	VIS/MWIR/TIR channels: 0.675 µm 3.75 µm 6.75 µm 10.8 µm 12.0 µm	Resolution: 1 km IFOV in 1 VIS channel, 4 km IFOV in 4 IR channels		2010-2018
IMAGER	GOES	Radiometer	5 channels covering VIS, MWIR and TIR: 0.65 µm 3.90 µm 6.55 µm 10.70 µm 13.35 µm	Resolution: 4.0 km for IR channels; 1.0 km for the VIS channel		2001-2020
MSU-MR	Meteor-M	VIS/IR Imaging Radiometer	VIS/NIR/SWIR/MWIR/TIR channels: 0.60 µm 0.90 µm 1.70 µm 3.80 µm 11.00 µm 12.00 µm	Resolution: 1.0 km IFOV	2800 km	2009-2020
SEVIRI	Meteosat	IR Radiometer	12 channels: 0.635 µm 0.81 µm 1.64 µm 3.92 µm 6.25 µm 7.35 µm 8.70 µm 9.66 µm 10.8 µm 12.0 µm	11 narrow-bandwidth, 1 high-resolution broad-bandwidth VIS Resolution: 4.8 km IFOV, 3 km sampling for narrow		2002-2022

			13.4 µm	channels; 1.6 km IFOV, 1 km sampling for broad VIS channel		
AIRS	AQUA	IR Grating spectrometer	4 supporting channels in VIS/NIR 3.74 - 4.61 µm 6.20 - 8.22 µm 8.80 - 15.4 µm 0.41 - 0.44 µm 0.58 - 0.68 µm 0.71 - 0.92 µm 0.49 - 0.94 µm	Resolution: 13.5 km IFOV for the spectrometer; 2.3 km IFOV for VIS/NIR channels	1650 km - Along-track: one 13.5-km line each 2.67 s	2002-2013 Operational
HIRDLS	EOS-Aura	Radiometer	21-channel filter radiometer; range 6.12-17.76 mm	Resolution: Vertical: 1 km, in the altitude range 10-100 km. Horizontal effective resolution: ~ 300 km (limb geometry)	2600 km	2004-2013 Operational
MLS	EOS-Aura	Microwave Limb Sounder	bands / 36 sub-bands: 118 GHz (9 sub-bands), 190 GHz (6 sub-bands), 240 GHz (7 sub-band), 640 GHz (9 sub-bands) and 2500 GHz (5 sub-bands)	Resolution: Vertical: 1.5 km in the altitude range 5-120 km. Horizontal effective resolution: ~ 300 km (limb geometry)		2004-2013 Operational
TES-limb	EOS-Aura	Спектрометр	four bands, 162162 channels 11.11-15.38 µm 8.70-12.20 µm 5.13-9.09 µm 3.28-5.26 µm	Resolution: Vertical: 2.3 km in the altitude range 0-37 km; horizontal effective resolution: ~ 300 km (limb geometry)		2004-2013 Operational
TES-nadir	EOS-Aura	Spectrometer	four bands, 43,750 channels 11.11-15.38 µm 8.70-12.20 µm 5.13-9.09 µm 3.28-5.26 µm	Resolution: Cross-track mode: 0.53 x 0.53 km at s.s.p.	885 km	2004-2013 Operational
NAOMI (AlSat)	AlSat-2	VIS/NIR Radiometer	5 VIS/NIR channels including one panchromatic 0.485 µm 0.565 µm 0.655 µm 0.825 µm	Resolution 10 m multispectral, 2.5 PAN, at s.s.p.	17.5 km addressable within a field of regard of 800 km	2010-2013 Operational

			0.675 µm (PAN)			
CMT	VNREDSat-1A BJ-1	Radiometer	0.5-0.8 µm (PAN)	Resolution IFOV: 4 m	24 km possible to be pointed in a field of regard of 800 km	2005-2013 Operational
SLIM6	BJ-1	Radiometer	3-channel VNIR radiometer 520 - 620 nm 630 - 690 nm 760 - 900 nm	Resolution 32 m (22 m for Deimos-1, UK-DMC-2 and NigeriaSat-X)	Swath of each set of 3 channels: 320 km; combined swath: 600 km	2002-2018
IIR	AlSat-1 Deimos-1 NigeriaSat UK-DMC-2 CALIPSO	Infrared Radiometer	Three-channel IR radiometer 8.65 µm 10.60 µm 12.00 µm	Resolution 1 km	64 km	2006-present
WFC	CALIPSO	Radiometer	Single VIS channel (620-670 nm)	Resolution 125 m	60 km	2006-present
PAN (CartoSat-1)	CartoSat-1 (IRS-P5)	Radiometer	Single VNIR channel (0.50-0.85 µm)	Resolution 2.5 km s.s.p.	30 km	2005-2013
PAN (CartoSat-2)	CartoSat-2	Radiometer	Single VNIR channel (0.50-0.85 µm)	Resolution < 1 m s.s.p.	9.6 km	2007-2012 Operational

SLSTR	CartoSat-2A	Radiometer	9-channels with dual viewing directions for accurate atmospheric corrections: 0.555 μm 0.659 μm 0.865 μm 1.375 μm 1.61 μm 2.25 μm 3.74 μm 10.85 μm 12.0 μm	Resolution: IFOV: 0.5 km for short-wave channels, 1.0 km for thermal IR	Conical oblique, with cross-nadir swath of 1675 km, fore-viewing swath of 750 km	2014-present
	CartoSat-2B					
	Sentinel-3					
TOMS	Meteor	Spectrometer	6 channels: 312.5, 317.5, 331.3, 339.9, 360.0 and 380 nm, 1 nm bandwidth	Resolution 50 km at s.s.p.	3000 km	1978-2013
	ADEOS					
	Nimbus-7					
	TOMS Earth Probe					
MWR	Envisat	Micro-Wave Radiometer		2 frequencies, 23.8 and 36.5 GHz Resolution 20 km		1995-2012
MIPAS	Envisat	Michelson interferometer	4.15-14.6 μm	Resolution: Vertical: 3 km, in the altitude range 5-150 km. Horizontal effective resolution: ~ 300 km (limb geometry)		2002-2013
RA-2	Envisat	Radar Altimeter		two-frequencies (3.2 and 13.6 GHz)		2002-2012

				Resolution: 20 km IFOV		
SCIAMACHY-limb	Envisat	UV/VIS/NIR/SWIR grating spectrometer	214-334 nm 300-412 nm 383-628 nm 595-812 nm 773-1063 nm 971-1773 nm 1934-2044 nm 2259-2386 nm 310-2380 nm	Eight bands, 8192 channels, with 7 polarisation channels Limb scanning of ± 500 km horizontal sector is provided		2002-2012
SCIAMACHY-nadir	Envisat	UV/VIS/NIR/SWIR grating spectrometer	214-334 nm 300-412 nm 383-628 nm 595-812 nm 773-1063 nm 971-1773 nm 1934-2044 nm 2259-2386 nm 310-2380 nm	Eight bands, 8192 channels, with 7 polarisation channels. Resolution 16 x 32 km^2 nadir-scanning component	1000 km	2002-2012
MERIS	Envisat	Spectro-radiometer	15 channels: 412.5 nm, 442.5 nm, 490 nm, 510	Basic IFOV 300 m, reduced resolution for	1150 km	2002-2012

			nm, 560 nm, 620 nm, 665 nm, 681.25 nm, 708.75 nm, 753.75 nm, 760.625 nm, 778.75 nm, 865 nm, 885 nm, 900 nm	global data recording: 1200 m		
HRVIR	SPOT-4	Radiometer	0.50 - 0.59 µm 0.61 - 0.68 µm 0.61 - 0.68 µm 0.79 - 0.89 µm 1.58 - 1.75 µm	VIS/NIR/SWIR multi-spectral (MS) channels, one also panchromatic (PAN) Resolution: 20 m (MS), 10 m (PAN)	60 km (MS), 117 km (PAN)	1998-2013
SAGE-3	Meteor-3M	Spectrometr	UV/VIS/NIR/SWIR (290-1550 nm)	Resolution: 300 km (horizontal), 1-2 km (vertical)		2001-2006

APPENDIX-6 LIST OF PARAMETERS PROVIDED BY EACH INSTRUMENT FOR ATMOSPHERE

Parameter group	properties	spatial resolution	Frequency	Instrument	Provider (POC)	Comment
Aerosol properties	AOD (vis & NIR), AE, FM-AOD, mixing ratio, ssa			ATSR-2, AATSR, SLSTR	FMI : Aerosol-cci via ICARE website	1995-2012
	Aerosol Optical Depth (AOD), Total column atmospheric	10x10 km		MODIS (Terra/Aqua)	http://ladsweb.nascom.nasa.gov	Data from 2004
		5ºx5º		MISR (Terra)	https://eosweb.larc.nasa.gov/	Data from 2000
		13x24 km		OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
		1.1 km		AVHRR (NOAA)	http://ghrsst.jpl.nasa.gov	Data from 2009
		5 km		CALIOP (CALIPSO)	https://eosweb.larc.nasa.gov	Data from 2006
		1 km		МСУ-МР	http://www.vniiem.ru	Data

				(Meteor-M №1,2) / MSU-MR (Meteor-M №1,2)		from 2013-present
Cloud properties	Fraction, COT, CTH, Reff, LWP, cloud albedo			AATSR, FY-series	FMI & Aerosol-cci	
	lwCDSup cloud albedo, fraction, Cloud Ice/Water flag	13x24 km		OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
		45 km		AIRS (Aqua)	http://mirador.gsfc.nasa.gov	Data from 2004
		100 m		TIRS(Landsat-8)	http://earthexplorer.usgs.gov/	Data from 2013
				CLOUDSAT CALIOP	UHEL	
Trace gases	NO2	13 km x 24 km	Almost daily global coverage	OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	SO2	13 km x 24 km	Almost daily global coverage	OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	O_3		240 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
		13x24 km		OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	O3 profiles			GOMOS, OSIRIS	FMI	
	O3 column	13 km x 24 km	Almost daily global coverage	OMI	NASA	Similar products from GOME-2 but higher

						spatial resolutio n
	O3			FY-series	RADI	
	HCHO	13x24 km		OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	BrO		640 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
		13x24 km		OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	OClO	13x24 km		OMI (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	ClO		640 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	CO		240 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
		22x22 km		MOPITT (Terra)	http://reverb.echo.nasa.gov	Data from 2000
	H_2O	Horizontal : 16 – 198 km Vertical: 1,5 – 7 km		МТВЗА-ГЯ (Meteor-M №1,2) / MTVZA-GY (Meteor-M №1,2)	http://www.vniiem.ru	Data from 2013-2015
			190 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	HCl		640 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	HCN		190 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	HNO_3		190 и 240 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	HO_2		640 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	HOCl		640 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	N_2O		190 GHz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
	OH		2,5 THz	MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
		0.5x5 km		TES (Aura)	http://reverb.echo.nasa.gov	Data from 2004

	NH3	0.5x5 km		TES (Aura)	http://reverb.echo.nasa.gov	Data from 2004
GHG	CO2	Diameter about 10.5 km	3 days to reach the same point	GOSAT/TANSO	GOSAT website ?	
	CH4	Diameter about 10.5 km	3 days to reach the same point	GOSAT/TANSO	GOSAT website ?	
		0.5x5 km		TES (Aura)	http://reverb.echo.nasa.gov	Data from 2004
Surface temperature	Surface skin temperature	45 km		AIRS (Aqua)	http://mirador.gsfc.nasa.gov	Data from 2002
		1 km		TES (Aura)	http://reverb.echo.nasa.gov	Data from 2004
		1.1 km		AVHRR (NOAA)	http://ghrsst.jpl.nasa.gov	Data from 2009
		1 km		MODIS (Terra/Aqua)	http://ladsweb.nascom.nasa.gov	Data from 2004
		100 m		TIRS (Landsat-8)	http://earthexplorer.usgs.gov/	Data from 2013
		60 m		KMCC (Meteor-M №1,2) / KMSS (Meteor-M №1,2)	http://www.vniiem.ru	Data from 2013-2015
		90 m		ASTER (Terra)	http://reverb.echo.nasa.gov	Data from 2000
Air temperature	Atmospheric temperature, Temperature surface	5 km		MLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2004
		0.5x5 km		TES (Aura)	http://reverb.echo.nasa.gov	Data from 2004

	Air Vertical profiles of temperature	Horizontal: 16 – 198 km Vertical: 1,5 – 7 km		МТВЗА-ГЯ (Meteor-M №1,2) / MTVZA-GY (Meteor-M №1,2)	http://www.vniiem.ru	Data from 2013-2014
		45 km		AIRS (Aqua)	http://mirador.gsfc.nasa.gov	Data from 2002
		35 km		ИКФС-2 (Meteor-M №1,2) / IKFS-2 (Meteor-M №1,2)	http://www.vniiem.ru	Data from 2013-2015
Lightning						
UV radiation near the surface[1]					FMI (Arola)	
SW radiation near the surface[1]						

1 Although radiation fields are not atmospheric components, they are included in this table

APPENDIX-7 LIST OF PARAMETERS PROVIDED BY EACH INSTRUMENT FOR ATMOSPHERE (ARCHIVE DATA)

Parameter group	properties	spatial resolution	Frequency	Instrument	Provider	Comment
Aerosol properties	Aerosol Optical Depth (AOD), Total column atmospheric	1 km		SAGE-III (Meteor-3M)	https://eosweb.larc.nasa.gov	Data from 2002-2005
		30 m		Hyperion (EO-1)	http://reverb.echo.nasa.gov	Archived data
Cloud properties	lwCDSup cloud albedo, fraction, Cloud Ice/Water flag	1 km		SAGE-III (Meteor-3M)	https://eosweb.larc.nasa.gov	Data from 2002-2005
		25 km		IASI (MetOp-A)	http://www.eumetsat.int	Archived data
		0.25ºx0.25º		AMSR-E (Aqua)	https://earthdata.nasa.gov/	Archived data
		1x1 km		AATSR (ENVISAT)	http://www.vniiem.ru	Archived data
		60 km		HRVIR (Spot-4)	http://reverb.echo.nasa.gov	Archived data
Atmospheric	NO_2	1ºx1º		HIRDLS (Aura)	http://mirador.gs	Data from

gases					fc.nasa.gov	2005-2008
		1.2 km		HIRDLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2005-2008
		20-25 km		SAGE-III (Meteor-3M)	http://www.vniiem.ru	Archived data
	SO_2	20-25 km		SAGE-III (Meteor-3M)	http://www.vniiem.ru	Archived data
		1.25ºx1º		TOMS (Meteor, ADEOS, Nimbus-7)	http://mirador.gsfc.nasa.gov	Data from 1978-2005
	O_3	1 km		HIRDLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2005-2008
		1.25ºx1º		TOMS (Meteor, ADEOS, Nimbus-7)	http://mirador.gsfc.nasa.gov	Data from 1978-2005
		20-25 km		SAGE-III (Meteor-3M)	http://www.vniiem.ru	Archived data
	H_2O	1 km		HIRDLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2005-2008
		20-25 km		SAGE-III (Meteor-3M)	http://www.vniiem.ru	Archived data
		1 km		HIRDLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2005-2008
	N_2O	1-1.2 km		HIRDLS (Aura)	http://mirador.gsfc.nasa.gov	Data from 2005-2008
	CO_2	90x90 km		AIRS (Aqua)	http://mirador.gsfc.nasa.gov	Data from 2002-2012
Surface temperature		25x25 km		AMSR-E (Aqua)	http://podaac.jpl.nasa.gov	Data from 2002-2011

	Surface skin temperature	1x1 km		AATSR (ENVISAT)	http://podaac.jpl.nasa.gov	Data from 2008-2012
		25 km		IASI (MetOp-A)	http://www.eumetsat.int	Archived data
		1 km		SAGE-III (Meteor-3M)	https://eosweb.larc.nasa.gov	Data from 2002-2005
		25 km		IASI (MetOp-A)	http://www.eumetsat.int	Archived data

Applications (Atmosphere)

- Forest fires detection and emissions (AEROCOSMOS; FMI)
- Atmospheric monitoring Megacities (26 satellites)
- Atmospheric aerosol –cloud –precipitation interaction (RADI)
- Ship emission monitoring
- Capabilities of satellite instruments in monitoring pollution from small sources and at high latitudes

RADI: Instittue of Remote Sensing and Digital Earth ,Chinese Acadmey of Sciences.

APPENDIX-8 LIST OF PARAMETERS PROVIDED BY EACH INSTRUMENT FOR LAND

Parameter group	properties	spatial resolution	Frequency	Instrument	Provider	Comment
Surface reflectance	vis to swir	30 m – 1 km		Landsat, MODIS, Sentinel-2	NASA, USGS, ESA	
Land cover	vis to swir	300 m – 1 km	2000, 2006, 2009, 2012	MERIS, AVHRR, MODIS, Sentinel-2, RADI	ESA GlobCover, MODIS Land Cover, GLC 2000	Merge Land cover and vegetation? Or add the tree cover product?
Vegetation	Tree cover continuous field	30 m	2000 - 2005	Landsat, RADI	GLCF	
Snow Cover				RADI		
Forest Fires				RADI		
Smoke dispersion				RADI		
Biomass	SAR	1 km	2010	ASAR, RADI	Jena	

APPENDIX-9 EARTHOBS-PRODUCTS_FORMODELSWP1_V4_12112010

Parameter	Scale	Data and available products	Spatial resolution	Temporal resolution	Time Series	Modeller's Request
Land Cover (incl. Species)	Pan-Arctic Regional	GLOBCOVER MODIS Land Cover MODIS NELDA Russian Land Cover (Terra Norte) SYNMAP MODIS VCF NA LC (CEC) GLC 2000	300 m 500 m 500 m 1 km/500 m 1 km 500 m 250 m 1 km	- yearly - - - yearly - -	2005/2009 since 2000 2005 2000/2005 1990/2000 2000 – 2005 2005 2000	**WP1** (e.g. SHI-model) **WP2** (WP2 – Modell) **WP3** (LPJmL)
Vegetation Dyna-mics, Phenology & Treeline shift	Pan-Arctic	MODIS LC Dynamics MODIS NDVI/EVI MODIS FAPAR GLOBCARBON LAI GLOBCARBON VGC GLOBCARBON FAPAR NOAA-AVHRR (GIMMS)	500 m 1 km 1 km 1 km 10 km 1 km 8 km	bi-yearly monthly 8-day monthly yearly monthly bi-monthly	2001 – 2006 since 2000 since 2000 1998 – 2007 1998 – 2007 1998 – 2007 since 1982	**WP1** (e.g. SHI-model) **WP3** (LPJmL)
Vegetation Structure	Pan-Arctic	ASAR Wide-Swath/Global Mode JERS-1	300 m/1 km 50 m	yearly yearly	since 2002 1992 –	**WP3** (LPJmL)

Parameter	Scale	Data and available products	Spatial resolution	Temporal resolution	Time Series	Modeller's Request
		PALSAR	50 m	46-daily	1998 since 2006	
Vegetation **Burned area** **Forest/non-Forest** **Vegetation structure**	Regional	Landsat ERS Tandem ASAR PALSAR TerraSAR-X	15/30 m 25 m 12,5/25/300/1000 m 6.5/12/25 m 1/3/7 m	16-daily 1-day repeat pass cycle 35-daily 46-daily 11-daily	since 1982 1995 – 1998 since 2002 since 2006 since 2007	**WP1** (e.g. SHI-model) **WP3** (LPJmL)
Fire Disturbances	Pan-Arctic	GLOBSCAR (ATSR WFA) MODIS burned area GLOBCARBON burned area AVHRR (regional Russia) Terra Norte (Spot) (regional Russia)	1 km 500 m 1 km 1 km 1 km	monthly monthly monthly yearly monthly	since 1995 since 2000 1998 – 2007 1996 – 2002	**WP3** (LPJmL) **WP4** (RUHL)

Parameter	Scale	Data and available products	Spatial resolution	Temporal resolution	Time Series	Modeller's Request
					2000 – 2006	
Land Surface Temperature	Pan-Arctic	MODIS LST AVHRR	1 km 8 km	daily monthly	since 2000 since 1982	**WP1** (CryoMod , CryoGrid, SHI-model) **WP3** (YASSO, LPJmL)
Water Bodies	Local-Regional-Pan-Arctic (upscaled)	Corona Rapideye Quickbird Ikonos Palsar PRISM RADARSAT Landsat ETM+ MODIS MERIS	2-7.5 m 5-6.5 m 1-4 m 6.5/12/25 m 10 m 2.5 m 11/28 m 15/30 m 250/500 m 300 m	- daily (off-nadir) 14-daily 46-daily 46-daily 46-daily 24-daily 16-daily daily 3-days	1959 – 1975 since 2008 since 2006 since 2005 since 2006 since 2006 since 1995 since 1982 since 2000 since 1998	**WP2** (WP2 – Modell) **WP3** (LPJmL)
Soil Moisture (incl.	Pan-Arctic	ASCAT	12.5/25.5 km	day	since 2006	**WP1**

Parameter	Scale	Data and available products	Spatial resolution	Temporal resolution	Time Series	Modeller's Request
Freeze Thaw)		AMSR-E	250 m	day	since 2000	(e.g. SHI-model) **WP3** (LPJmL)
Snow	Pan-Arctic	GlobSnow - SWE GlobSnow - Snow Extent MODIS Snow Cover	25 km 1 km 500 m	day/week/monthly day/week/monthly day/8day	1978 – 2010 1995 – 2010 since 2000	**WP1** (Snowpack, SURFEX) **WP3** (YASSO, LPJmL)
Ocean Parameter (Sea Ice &Temp-erature and Chlorophyll Concentration)	Pan-Arctic	MODIS Sea Ice Extent SeaWiFS (Chlorophyll Concentration) AVHRR Sea Surface Temperature	1 km 9 km 4 km	day day/8-day/monthly/seasons day/5-day/7-day/ 8-day/monthly/annual	since 2000 since 2007 since 1985	**WP2** (WP2 – Modell) **WP3** **(LPJmL)**

Applications (Land)

- Biomass mapping, forest resources and change (Jena)
- Permafrost (Jena, AEROCOSMOS)
- Land use and land cover (LULC) changes and trends (Jena,RADI)
- Ecosystem changes (Jena, RADI)
- Forest fire detection (AEROCOSMOS, RADI)
- Arctic (coastal, ice) monitoring and anthropogenic impacts (AEROCOSMOS, RADI)
- Treeline & trends (AEROCOSMOS, Jena)
- Surface reflectance (AEROCOSMOS, FMI)
- Permafrost (AEROCOSMOS)
- Carbon and Nitrogen dynamic (RADI)
-
-

APPENDIX-10 LIST OF PARAMETERS PROVIDED BY EACH INSTRUMENT FOR WATER

Parameter group	properties	spatial resolution	Frequency	Instrument	Provider	Comment
Pollution						
Ice cover						
water ways						

Applications (Land)

- Ice movements (AEROCOSMOS)
- Waterways and shipping lanes (AEROCOSMOS)
- Algae blooms – drinkikng water (AEROCOSMOS)
- Water budget of cross-border river (RADI)