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Strategic Observatories for Climate Change in Northern Eurasia and Northern America

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This paper summarizes the achievements of a major European-Russian cooperation project on multi-sensor concepts for greenhouse gas accounting and develops an observation scenario in the context of global climate change. Improved carbon model estimates using Earth Observation input underline the proposed strategy to cope with northern hemisphere global change challenges.

The northern circumpolar boreal biome with its transition ecozones is a ”hotspot” of the global climate system. Small perturbations in the energy balance may be strongly amplified through physical and biogeochemical feedback mechanisms. In turn, changes triggered at high northern latitudes will have a direct and profound impact on the climate and on the development of Europe. At present, despite a number of modelling studies all pointing out the key importance of boreal regions, we unfortunately lack

1. a coherent regional observing system, particularly in the Eurasian sector, that would enable us to detect and quantify changes;

2. a coordinated modelling strategy to analyse and forecast high latitude changes and the controlling processes.

Although many long-term systematic observations of marine, terrestrial and atmospheric parameters already exist, these data of diverse nature and source (e.g. *in situ*

and remote sensing) lack cohesive coordination (particularly in Russia and other new independent states), hindering their use in models and linkage to the broader scientific and management community.

To improve that situation, six strategic observatories are suggested connected by activities which concentrate on interfaces, interoperability, integration and tightly coordinated linkages between observing systems and other data sources in the high latitudes of two continents: Eurasia and North America, which together constitute the core of the Group on Earth Observations (GEO).

The six complementary observatories are designed to address the following critical areas where climate change is already occurring and is expected to increase: **1**- Permafrost (e.g. thermal state and carbon dynamics), where degradation processes are already underway with increasing impacts on infrastructure, greenhouse gas emissions, hydrology and ecology. **2**- Spatial and seasonal patterns of vegetation, snow and albedo, where alterations of the associated radiative and biogeochemical balances have major land surface and atmospheric feedbacks under climate change. **3**- Disturbances, particularly fire, where complex ecological and biogeochemical feedbacks modulate the greenhouse gas balance of northern forests, bogs and tundra and their interaction with climate change. **4**- GreenHouse Gas balances (especially carbon dioxide and methane), where northern latitudes are known to be a primary agent in positive global feedbacks between the climate system and terrestrial biogeochemical cycles. **5**- Atmospheric composition of reactive gases and aerosols, where biogenic emissions from fires and atmospheric composition changes affect land surface properties. **6**- Freshwater balance of the northern latitude hydrological systems and their export of freshwater into the Arctic Oceans, in combination sea-ice dynamics, where changes are increasingly modifying ocean salinity and energy fluxes.

Since these processes are driven and completely intertwined with climate, they must be integrated within a coherent and ambitious Earth System Observation and Modelling Strategy, in accordance with the recommendations of key European and international monitoring initiatives (GMES, GEO, IGOS), and supporting regionally the G3O's (GCOS/GTOS/GOOS) planned implementation of coordinated climate, terrestrial and land-ocean delivery observations.

The above suggested strategy was developed on the experience of the Canadian continental climate change observation programme, the recommendations of NASA's Northern Eurasian activity and the results of the EC-project SIBERIA-II. The main objectives of SIBERIA-II are the integration and combination of multi-sensor, spectrally and temporally diverse, remotely sensed data and ecological regional models in order to assess the impact of terrestrial biota on the budget of major greenhouse gases

(GHGs) in Northern Eurasia. The following surface parameters are available from Earth observation data: land cover, Leaf Area Index, Fraction of Photosynthetic Active Radiation, snow, freeze/thaw, phenology, water bodies, fire scars, Af-Re-Deforestation products. Cross analysis of these products have shown the strong enhancement of observations on the surface processes. For ecological time switches for example, the joint use of the freeze/thaw, snowmelt and phenology products appears crucial to improve the knowledge in ecological processes of GHG fluxes. This contributes both to improved carbon and Earth system models and to the ongoing efforts in model-data fusion. Substantial progress has been achieved specifically on the implementation of the land cover product and comparison of its impacts on the C budget, (2) implementation of extended model Plant Functional Types (PFT), (3) optimization of the phenology model using SPOT-VGT data, and (4) EO-model interfaces of fire and snow.